International Conference on

Human and Organizational Aspects of Assuring Nuclear Safety

22–26 February 2016 Vienna, Austria

Programme and Abstracts

Organized by the

IAEA
International Atomic Energy Agency

CN-237

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International Atomic Energy Agency

Atoms for Peace

International Conference on

Human and Organizational Aspects of Assuring Nuclear Safety

Exploring 30 years of Safety Culture

22–26 February 2016 Vienna, Austria

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Version: February 23, 2016, web enabled

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Colophon

This book has been assembled from the abstract sources submitted by the contributing authors via the Indico conference management platform. Layout, editing, and typesetting of the book, including customized TEX & LATEX macros, was done by Dr. P. Knowles, LogrusData, Vienna, Austria.

This book is PDF hyperlinked: activating coloured text will, in general, move you throughout the book. Names generally link to biographies, whereas dates, session names, and contribution ID's will help you navigate the timetables and abstracts.

Introduction

Thirty years ago, the International Nuclear Safety Advisory Group concluded, in its investigation of the Chernobyl accident, that one of the key lessons to be learned from that accident was the importance of a strong safety culture to maintain safe operations. Almost five years have now passed since the accident at the Fukushima Daiichi nuclear power plant, and the need to implement a systemic approach to safety that takes into account the complex and dynamic sociotechnical systems comprising nuclear infrastructure is one of the main lessons emerging from investigations. This conference will allow an international audience to take a step back and reflect upon the knowledge accumulated in the areas of human and organizational factors (HOF), safety culture and leadership for safety over the past 30 years. The objectives of the conference are to:

- Review the experience gained with regard to HOF, safety culture and leadership for safety;
- Share and gather experiences related to current developments, approaches, methods and research in the areas of HOF, safety culture and leadership for safety; and
- Identify the future needs for building organizational resilience capabilities in order to further strengthen defence in depth for nuclear facilities and activities.

The special focus of the conference will be on safety culture and the past 30 years of developments in this area.

Audience

The target audience of the conference comprises representatives of nuclear organizations worldwide, including operating organizations, regulatory bodies, governmental institutions, technical support organizations, vendors and other stakeholders.

Topics

The conference will cover the following expert areas:

- Human and Organizational Factors
- Safety Culture/Culture for Safety
- Leadership and Management for Safety
- The Systemic Approach to Safety (The Interaction between Human, Technical and Organizational Factors)
- Resilience Engineering
- High Reliability Organizations

These areas will be reflected upon in the following perspectives:

- Lessons learned from the Three Mile Island, Chernobyl and Fukushima Daiichi accidents; other major events in the nuclear industry; and other high hazard sectors and industries
- Current research and development
- Current approaches and practices
- Future demands and needs to assure safe performance

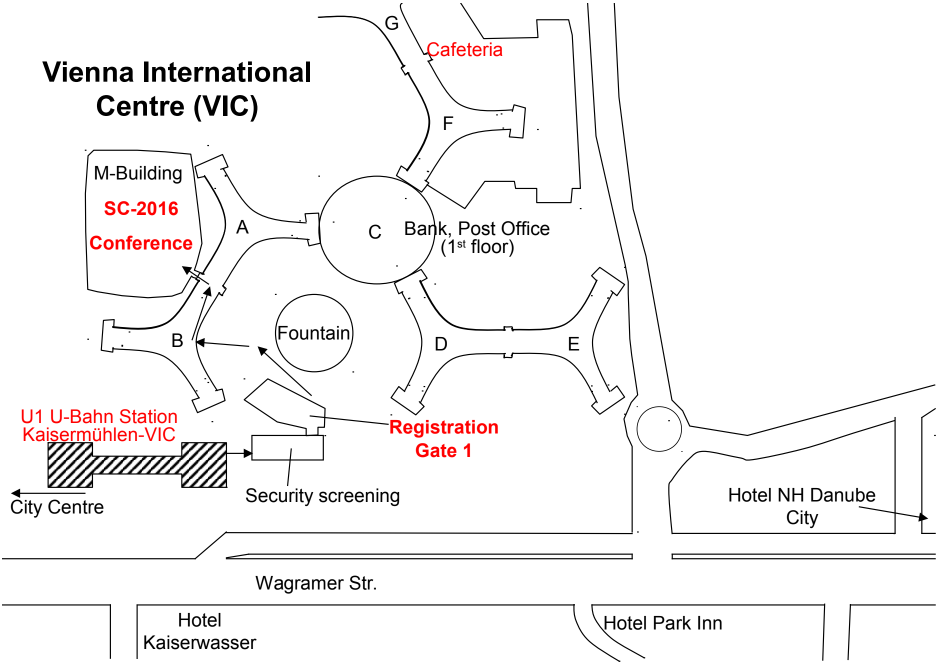
Participation in an IAEA Scientific Meeting

Governments of Member States and those organizations whose activities are relevant to the meeting subject matter are invited to designate participants in the IAEA scientific conferences and symposia. In addition, the IAEA itself may invite a limited number of scientists as invited speakers. Only participants designated or invited in this way are entitled to present papers and take part in the discussions.

Scientists interested in participating in any of the IAEA meetings should request information from the Government authorities of their own countries, in most cases the Ministry of Foreign Affairs or national atomic energy authority.

Conference Location

International Atomic Energy Agency (IAEA)
Vienna International Centre (VIC)



Working Language & Resolutions

Working Language: English
Resolutions: No resolutions may be submitted for consideration on any subject; no votes will be taken.

IAEA Publications

All IAEA publications may be ordered from the
Marketing and Sales Unit,
International Atomic Energy Agency,
PO Box 100, 1400 Vienna Austria
Fax: (+43 1) 2600–29302
sales.publications@iaea.org
www.iaea.org/Publications/index.html

Security and Registration

Participants will be issued photo badges by the UN Security and Safety Service (UNSSS), at the Gate One entrance, on Monday, 22 February 2016, 09:00–16:00 and throughout the week from 08:00–16:00. An official photo identification document (e.g., passport) is necessary for the creation of your pass, and the pass is required to access the VIC.

The conference registration desk (where participants will complete a short registration form, and receive their conference material) is located at the ground floor entrance of the M–Building. No registration fee is charged.

Information for Participants

The conference website contains links to many helpful guides. Notably, the Indico conference system is used for all correspondence concerning contributions. Follow us on twitter at #safetyculture2016.

Presentation and Abstract Book

This book contains all abstracts accepted for the conference. Abstracts have been edited for style uniformity. The views expressed remain the responsibility of the named authors. No responsibility is held by the organizers for any material reproduced, or linked, in this book. Presentations, as far as they are available, will be posted on the conference website during, or after, the conference.

Exhibits

Equipment and services, including commercial products, will be exhibited in the M–Building.

Reception

Participants are cordially invited to an Evening Reception on Monday 22 February 2016 from 18:00 to 20:00 in the M–Building.

Hosted Coffee Breaks

Hosted coffee breaks are offered in the morning from Tuesday until Friday on the M–Building First Floor (M01).

Coffee, tea, and snacks can be purchased at any time from the M–Building snack bar on the ground floor (M0E).

Conference Secretariat

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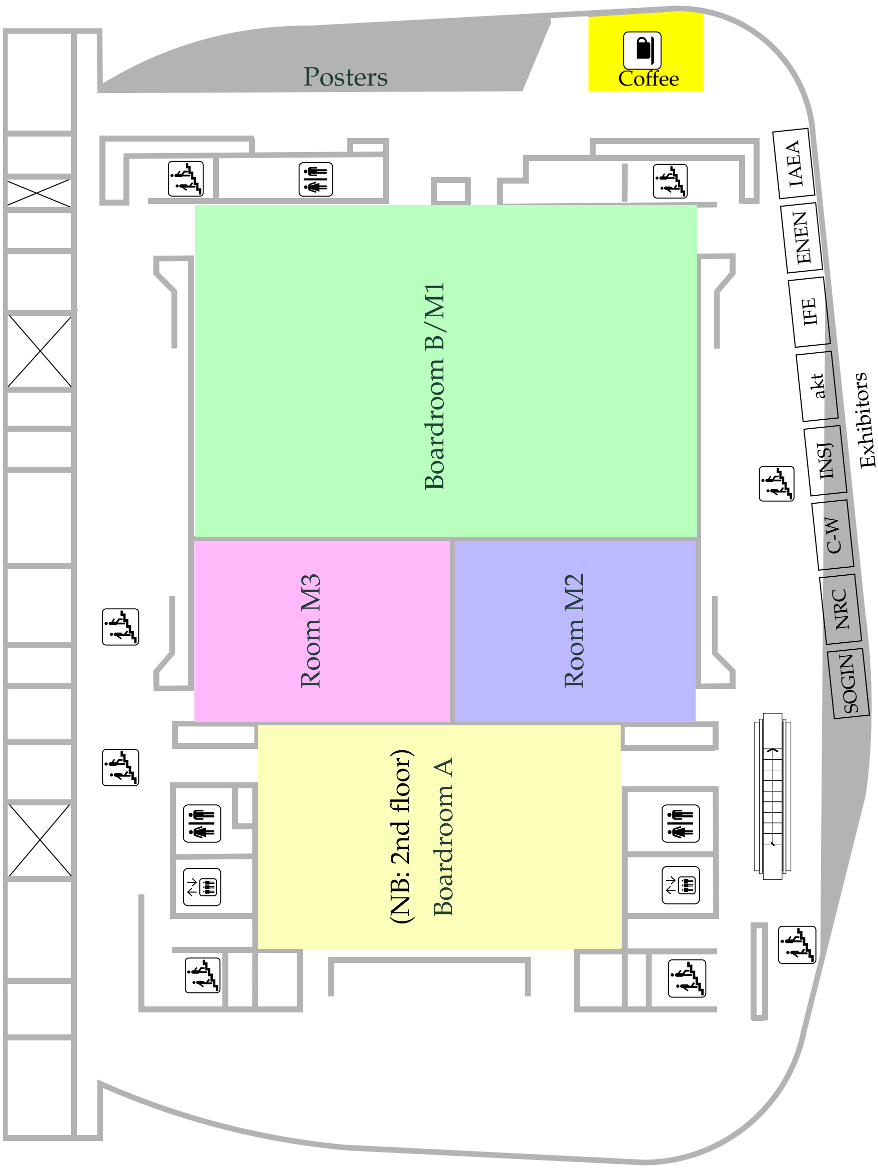
Abbreviations

EC	European Commission
EU	European Union
HOF	Human and Organizational Factors
HRA	Human Reliability Analysis
HRO	High Reliability Organizations
HTO	Human, Technical and Organizational
IAEA	International Atomic Energy Agency
INPO	Institute of Nuclear Power Operations
JRC	Joint Research Centre
NKM	Nuclear knowledge management
MTO	Man Technology Organization
NPP	Nuclear power plant
NSNI	IAEA, Division of Nuclear Installation Safety
OECD	Organisation for Economic Co-operation and Development
OECD–NEA	OECD – Nuclear Energy Agency
PRA	Probabilistic Risk Assessment
SC	Safety Culture
TMI	Three Mile Island Accident, March 28, 1979
TSO	Technical safety organization
UNSSS	UN Security and Safety Service
WANO	World Association of Nuclear Operators

M–Building, Ground Floor

M–Building, First Floor

SOGIN	SOGIN S.p.A
NRC	U.S. Nuclear Regulatory Commission
C-W	Curtiss-Wright
INSJ	International Nuclear Safety Journal
akt	akt Productions Ltd.
IFE	IFE/OECD Halden Reactor Project
ENEN	European Nuclear Education Network
IAEA	International Atomic Energy Agency



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24 February 2016</th><th>Thursday
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10:20</td><td rowspan="4">Registration: 09:00 – 16:00</td><td>PL1: Retrospective Lessons</td><td>PL2: The Current Status</td><td>PL3: Future Perspectives</td><td rowspan="8">CP: Closing Plenary

CP–01: M. Weightman
CP–02: A. Kawano
CP–03: L. K. Clewett
CP–04: J. Paries
11:00 – 11:30 Break
CP–05: M.-S. Yim
CP–06: W. E. Carnes
CP–07: C. A. Hart
CP–08: B. M. Tyobeka
N. Ahn
A. J. González
F. Dermarkar
CP–09: M. Weightman
CP–10: Transfer
CP–11: J. C. Lentijo

14:00 Conference End</td></tr>
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12:00</td><td>PL1: Retrospective Lessons
. . . continued</td><td>PL2: The Current Status
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. . . continued</td></tr>
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12:00 – 13:00</td></tr>
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15:15</td><td>OP: Opening Plenary
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OP–05: N. Stavropoulos
Break: 14:45–15:15</td><td>Parallel Sessions:
LM1 SA1 HR1 TO1</td><td>Parallel Sessions:
LM2 SA2 HR2 TO2</td><td>Parallel Sessions:
LM3 SA3 HR3 TO3</td></tr>
<tr><td></td><td rowspan="3">OP: Setting the Scene
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OP–07: M. Alvesson
OP–08: E. H. Schein
OP–09: M. Weightman</td><td colspan="3">Break and Posters: 15:15 – 15:45</td></tr>
<tr><td>15:45
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17:00</td><td>DS1: Dialogue Sessions</td><td>DS2: Dialogue Sessions</td><td>DS3: Dialogue Sessions</td></tr>
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17:30</td><td colspan="3">Daily Summary by the Chairman</td></tr>
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09:00 – 16:00: Conference Registration

OP: Opening Plenary: Setting the Scene

Chair: M. Weightman (UK) *Boardroom B/M1* **(13:00 – 17:45)**

Time	Id	Presenter		Title
13:00	OP–01	Y. Amano	IAEA	Opening Remarks
13:10	OP–02	M. Weightman	UK	Chair's Opening Address
13:20	OP–03	M. Haage	IAEA	About this Conference
		H. Rycraft	IAEA	
13:45	OP–04	IAEA	IAEA	Safety Culture Film
14:00	OP–05	N. Stavropoulos	USA	Safety Culture: It's More Than Ticking-the-box
		Break: 14:45 – 15:15		
15:15	OP–06	S. Cox	UK	Safety Culture & Beliefs in the Nuclear Industry: Looking Forward, Looking Back
16:00	OP–07	M. Alvesson	Sweden	The Risk of Hyper-Culture: How to Avoid It and Work With Real Organizational Culture
16:45	OP–08	E. H. Schein	USA	Unique Problems of Nuclear Technology and the Need for Humble Inquiry
17:30	OP–09	M. Weightman	UK	Reflections by the Chair

18:00 – 20:00: Welcome Reception, M–Building ground floor (M0E)

Tue

Registration: 08:00 – 16:00

PL1: Plenary Session: Retrospective Lessons

Chair: M. Weightman (UK) *Boardroom B/M1* **(09:00 – 12:00)**

Time	Id	Presenter		Title
09:00	PL1–01	M. Weightman	UK	Daily Remarks
09:10	PL1–02	M. Haage	IAEA	Plenary Dialogue: The Human Side of Safety
	Panellists:	V. N. Abramova	Russian Fed.	(See PL1–04)
		B. Stoliarchuck	Ukraine	
		A. Kawano	Japan	(See CP–02)
09:40	PL1–03	M. Haage	IAEA	Individual Reflection
09:45	PL1–04	V. N. Abramova	Russian Fed.	What Needs to be Changed based on Lessons Learned from Chernobyl

Break and Posters 10:20 – 10:50

NB: All posters will be on display for the full duration of the conference.

Time	Id	Presenter		Title
10:50	PL1–05	A. Kawano	Japan	The Human Aspect of the Fukushima Daiichi Accident
11:25	PL1–06	Y. Hah	OECD–NEA	OECD–NEA's New Approach to Human Aspects of Nuclear Safety

Lunch break 12:00 – 13:00

LM1: Parallel Session: Leadership, Management and Culture for Safety

Chair: B. M. Tyobeka (South Africa) *Boardroom B/M1* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	LM1–01	S. B. Haber	USA	From Safety Culture to Culture for Safety — What is it that we Still Haven't Learned
13:30	LM1–02	B. M. Tyobeka	South Africa	Leadership for Safety in Practice: Perspectives from a Nuclear Regulator
14:00	LM1–03	F. González	Spain	Experience of Tecnatom in Developing a Strong Leadership for Safety and Performance
14:30	LM1–04	J. A. Julius	USA	Use of Human Reliability Insights to Improve Decision-Making
15:00	LM1–05	B. M. Tyobeka	South Africa	Co–Chair's Reflections

Break 15:15 – 15:45

SA1: Parallel Session: Systemic Approach to Safety

Chair: N. Ahn (Korea, Rep. of) *Boardroom A* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	SA1–01	N. Meshkati	USA	Operators' Improvisation in Complex Technological Systems: The Last Resort to Averting an Assured Disaster
13:30	SA1–02	M. Haage K. Heppell-Masys	IAEA Canada	Fukushima Daiichi Nuclear Accident: A Matter of Unchallenged Basic Assumptions
14:00	SA1–03	F. L. de Lemos	Brazil	Evaluating Safety Culture Under the Socio-Technical Complex Systems Perspective
14:30	SA1–04	N. Gotcheva	Finland	Enhancing Safety Culture in Complex Nuclear Industry Projects
15:00	SA1–05	N. Ahn	Korea, Rep. of	Co–Chair's Reflections

Break 15:15 – 15:45

HR1: Parallel Session: Other High Reliability Organizations' Approaches to Safety

Chair: A. J. González (Argentina) *Room M2* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	HR1–01	R. H. Taylor	UK	Managing the Organizational and Cultural Precursors to Major Events — Recognising and Addressing Complexity
13:30	HR1–02	S. Elegba	Nigeria	Evolution of Radiation Safety Culture in Africa: Impact of the Chernobyl Accident
14:00	HR1–03	D. M. Minnema	USA	Historical Foundation for Safety Culture and High Reliability Organizations
14:30	HR1–04	R. Amalberti	France	Patient Safety, Present and Future
15:00	HR1–05	A. J. González	Argentina	Co–Chair's Reflections

Break 15:15 – 15:45

TO1: Topical Parallel Session: Learning from the Past, Going Forward

Chair: M. Steinberg (Ukraine) *Room M3* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	TO1–01	N. Mataji Kojouri	I. R. Iran	Enhancing Organizational Effectiveness in Research Reactors
13:30	TO1–02	P. H. Seong	Korea, Rep. of	An Evaluation Method for Team Competencies to Enhance Nuclear Safety Culture
14:00	TO1–03	E. Gisquet	France	Interrogations to Learn from the Fukushima Accident
14:30	TO1–04	P. Kotin	Ukraine	Developing and Strengthening of Safety Culture at Ukrainian NPPs: Experience of NNEGC "Energoatom"
15:00	TO1–05	M. Steinberg	Ukraine	Co–Chair's Reflections

Break 15:15 – 15:45

DS1: Dialogue Sessions: Talking with the Presenters

Shared Space — semi–formal dialogues **(15:45 – 17:00)**

Room	Id	Facilitator	Topic
B/M1	DS1–01	*D. Engström*	**37 Years of Systemic Approach to Safety**
See: LM3–03		W. E. Carnes (CP–06)	F. L. de Lemos (SA1–03)
B/M1	DS1–02	*K. Heppell-Masys*	**The Human Side of Accidents**
See: SA1–02		A. Kawano (CP–02) E. Gisquet (TO1–03)	B. Stoliarchuck V. N. Abramova (PL1–04)
B/M1	DS1–03	*S. B. Haber*	**30 Years of Safety Culture**
See: LM1–01		A. J. González	M. Alvesson (OP–07)
M0E–03	DS1–04	*A. N. Afghan*	**Learning from the Past**
See: HR3–04		R. H. Taylor (HR1–01)	M. Ylönen (DS–01)
M0E–05	DS1–05	*D. Tasset*	**Recent IRSN Expertise, Practices and Research Related to HOF**
See: DS–02		N. Dechy (HR3–03) O. Chanton (DS–03)	L. Menuet (DS–02)
M0E–07	DS1–06	*C. Ryser*	**Lessons Learned Related to Leadership**
See: DS–07		B. M. Tyobeka (LM1–02)	F. González (LM1–03)
M0E–10	DS1–07	*K. Koves*	**Proactive Safety Culture Approaches**
		P. Kotin (TO1–04) S. Elegba (HR1–02)	N. Mataji Kojouri (TO1–01)
M0E–12	DS1–08	*D. McHarg*	**HTO Approach and Applications**
		J. A. Julius (LM1–04)	E. Volkov (DS–04)
M0E–13	DS1–09	*C. Kopisch*	**Lessons Learned from Other HROs**
See: TO2–05			R. Amalberti (HR1–04)
M0E–15	DS1–10	*L. Kecklund*	**Complexity and Safety**
See: HR2–01		N. Gotcheva (SA1–04)	N. Meshkati (SA1–01)
M0E–16	DS1–11	*K. Mrabit*	**Interfaces between Security and Safety Culture**
See: DS–17		K. Hamada	
M0E–18	DS1–12	*L. Carlsson*	**New Developments in OECD–NEA**
See: DS–05		L. Axelsson (LM3–01)	Y. Hah (PL1–06)
M3	DS1–13	*T. Bannerman*	**Deepwater Horizon: Experience the Events That Led to This Accident, Follow the Investigation as They Uncover the Human Factors**
See: DS–06			

Daily Summary

Chair: M. Weightman (UK) *Boardroom B/M1* **(17:00 – 17:30)**

Recap of the day by the Conference Chairman

PL2: Plenary Session: The Current Status

Chair: M. Weightman (UK) *Boardroom B/M1* **(09:00 – 12:00)**

Time	Id	Presenter		Title
09:00	PL2–01	M. Weightman	UK	Daily Remarks
09:10	PL2–02	H. Rycraft	IAEA	Plenary Dialogue: The Organizational Side of Safety
	Panellists:	M. Griffon	USA	(See HR2–04)
		G. Grote	Switzerland	(See PL2–04)
		M. Nishizawa	Japan	(See PL3–05)
		R. H. Taylor	UK	(See HR1–01)
09:40	PL2–03	H. Rycraft		Individual Reflection
09:45	PL2–04	G. Grote	Switzerland	Social Science for Safety: What Is It and Why Do We Need It?
		Break and Posters 10:20 – 10:50		
10:50	PA2–05	M. A. Habib	Pakistan	PNRA: Practically Improving Safety Culture within the Regulatory Body
11:25	PL2–06	C. A. Hart	USA	The Power of Collaboration for Improving Safety in Complex Systems
		Lunch break 12:00 – 13:00		

LM2: Parallel Session: Leadership, Management and Culture for Safety

Chair: B. M. Tyobeka (South Africa) *Boardroom B/M1* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	LM2–01	F. Guarnieri	France	Entering into the Unexpected: Managing Resilience in Extreme Situations
13:30	LM2–02	S. A. Adamchik	Russian Fed.	Safety Culture in Rosatom State Atomic Energy Corporation
14:00	LM2–03	B. Zronek	Czech Republic	Safety Culture Monitoring: How to Assess Safety Culture in Real Time?
14:30	LM2–04	D. J. Williams	INPO	Leadership and Safety Culture: An INPO Perspective
15:00	LM2–05	B. M. Tyobeka	South Africa	Co–Chair's Reflections
		Break 15:15 – 15:45		

SA2: Parallel Session: Systemic Approach to Safety

Chair: N. Ahn (Korea, Rep. of) *Boardroom A* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	SA2–01	M. Weightman	UK	Institutional Strength in Depth
13:30	SA2–02	A. Edland	Sweden	Systemic Approach to Safety from a Regulatory Perspective
13:45	SA2–03	J. Svenningsson	Sweden	Making Safety Culture a Corporate Culture
14:00	SA2–04	F. Meynen	Switzerland	Perspective on Human and Organizational Factors (HOF) - Attempt of a Systemic Approach
14:30	SA2–05	G. Watts	Canada	Reinforcing Defence in Depth: A Practical
		J. Misak	Czech Republic	Systemic Approach
15:00	SA2–06	N. Ahn	Korea, Rep. of	Co–Chair's Reflections

Break 15:15 – 15:45

HR2: Parallel Session: Other High Reliability Organizations' Approaches to Safety

Chair: A. J. González (Argentina) *Room M2* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	HR2–01	L. Kecklund	Sweden	Safety Culture: A Requirement for New Business Models — Lessons Learned from Other High Risk Industries
13:30	HR2–02	C. Goicea	Romania	Current Approaches of Regulating Radiological Safety of Medical and Industrial Practices in Romania
14:00	HR2–03	M. Fleming	Canada	Regulatory Body Safety Culture in Non-nuclear HROs: Lessons for Nuclear Regulators
14:30	HR2–04	M. Griffon	USA	Safety Culture: Lessons Learned from the US Chemical Safety and Hazard Investigations Board
15:00	HR2–05	A. J. González	Argentina	Co–Chair's Reflections

Break 15:15 – 15:45

TO2: Topical Parallel Session: Safety Culture Oversight

Chair: I. Kubáňová (Czech Republic) *Room M3* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	TO2–01	K. Heppell-Masys	Canada	Contemporary Approaches to Safety Culture: Lessons from Developing a Regulatory Oversight Approach
13:15	TO2–02	A. Smetnik	Russian Fed.	Safety Culture Activities of Russian Regulator (Rostechnadzor) TSOs
13:30	TO2–03	J. T. Kim	Korea, Rep. of	Insight and Lessons Learned on Safety Culture from Analysis of Inspection Findings and Events
13:45	TO2–04	P. Oedewald	Finland	Regulatory Oversight of Safety Culture in Finland: A Systemic Approach to Safety
14:00	TO2–05	J. Beck	Germany	The Regulatory Approach for the Assessment of Safety Culture in Germany: A Tool for Practical Use for Inspections
14:15	TO2–06	B. Bernard	Belgium	Lessons Learned from a Five-year Evaluation of the Belgian Safety Culture Oversight Process
14:30	TO2–07	M. Tronea	Romania	Improvements of the Regulatory Framework for Nuclear Installations in the Areas of Human and Organizational Factors and Safety Culture
14:45	TO2–08	D. J. Sieracki	USA	U.S. Nuclear Regulatory Commission Safety Culture Oversight
15:00	TO2–09	I. Kubáňová	Czech Republic	Co–Chair's Reflections

Break 15:15 – 15:45

DS2: Dialogue Sessions: Talking with the Presenters

Shared Space — semi–formal dialogues **(15:45 – 17:00)**

Room	Id	Facilitator	Topic
B/M1	DS2–01	*D. Engström*	**Defence in Depth, Version 2.0**
See: LM3–03		M. Weightman (SA2–01); J. Misak (SA2–05); G. Watts (SA2–05)	
B/M1	DS2–02	*C. Ryser*	**Regulatory Frameworks for Safety Culture**
See: DS–07		C. Goicea (HR2–02); M. Fleming (HR2–03); Y. H. Nurwidi Astuti (DS–08)	
B/M1	DS2–03	*D. J. Sieracki*	**Safety Culture Oversight in Practice**
See: TO2–08		V. Goebel (TO2–01); A. Smetnik (TO2–02); J. T. Kim (TO2–03); P. Oedewald (TO2–04); J. Beck (TO2–05); M. Tronea (TO2–07); B. Bernard (TO2–06)	
M0E–03	DS2–04	*W. E. Carnes*	**Reflection on Complacency and Resistance to Learning**
See: CP–06		S. Cox (OP–06); C. A. Hart (PL2–06); J. Paries (CP–04)	
M0E–05	DS2–05	*A. N. Afghan*	**Practicality of a Good Theory**
See: HR3–04		G. Grote (PL2–04); F. Meynen (SA2–04); M. Mattson (DS–09)	
M0E–07	DS2–06	*K. Koves*	**Progress Based on Lessons Learned**
		D. J. Williams (LM2–04); M. Griffon (HR2–04)	
M0E–10	DS2–07	*L. Kecklund*	**On the Leading Edge of Safety Culture Improvement**
See: HR2–01		S. A. Adamchik (LM2–02); C. Rusconi (DS–10)	
M0E–12	DS2–08	*K. Heppell-Masys*	**Being Open to Culture Change — an Executive View**
See: TO2–01		M. A. Habib (PL2–05); S. A. N. Bhatti (Post–01)	
M0E–13	DS2–09	*O. Makarovska*	**Current Safety Culture Developments in Non-Nuclear Countries**
		S. Elegba (HR1–02)	
M0E–15	DS2–10	*D. McHarg*	**Application of a Systemic Approach to Safety**
		A. Edland (SA2–02); J. Svenningsson (SA2–03); F. Guarnieri (LM2–01)	
M0E–16	DS2–11	*S. B. Haber*	**Assessing and Monitoring Safety Culture**
See: LM1–01		B. Zronek (LM2–03); C. Sheen (DS–11); P. H. Seong (TO1–02)	
M0E–18	DS2–12	*M. Haage*	**Shared Space and the Power of Dialogue**
See: DS–14		S. Brissette (DS–13)	

Daily Summary

Chair: M. Weightman (UK) *Boardroom B/M1* **(17:00 – 17:30)**

Recap of the day by the Conference Chairman

PL3: Plenary Session: Future Perspectives

Chair: M. Weightman (UK) *Boardroom B/M1* **(09:00 – 12:00)**

Time	Id	Presenter		Title
09:00	PL3–01	M. Weightman	UK	Daily Remarks
09:10	PL3–02	M. Haage	IAEA	Plenary Dialogue: The Human and
		H. Rycraft	IAEA	Organizational Side of Safety
	Panellists:	A. N. Afghan	Pakistan	(See HR3–04)
		E. Fischer	Germany	(See LM3–02)
		A. Kawano	Japan	(See CP–02)
		J. Paries	France	(See CP–04)
		J. Ward	Australia	(See SA3–04)
09:40	PL3–02	M. Haage	IAEA	Individual Reflections
		H. Rycraft	IAEA	
09:45	PL3–04	G. Rzentkowski	IAEA	IAEA's Approach to Leadership, Management and Culture for Safety
		Break and Posters 10:20 – 10:50		
10:50	PL3–05	T. B. Melnitckaia	Russian Fed.	The Psychological Aspect of Safety Culture: Application of the Theory of Generations for the Formation of Safety Culture Among Personnel
11:25	PL3–06	M. Nishizawa	Japan	Risk Communication: A Key for Fostering a More Resilient Safety Culture

Lunch break 12:00 – 13:00

LM3: Parallel Session: Leadership, Management and Culture for Safety

Chair: B. M. Tyobeka (South Africa) *Boardroom B/M1* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	LM3–01	L. Axelsson	Sweden	NEA/CSNI Working Group on Human and Organizational Factors, WGHOF
13:30	LM3–02	E. Fischer	Germany	Leadership and Safety Culture: Leadership for Safety
14:00	LM3–03	D. Engström	Sweden	Limitations of Managing Safety by Numbers
14:30	LM3–04	L. Hu	China, P. R.	Cultivating and Development — 30 Years Practice of Safety Culture in China
15:00	LM3–05	B. M. Tyobeka	South Africa	Co–Chair's Reflections

Break 15:15 – 15:45

SA3: Parallel Session: Systemic Approach to Safety

Chair: N. Ahn (Korea, Rep. of) *Boardroom A* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	SA3–01	T. Coye de Brunélis	France	Operational HOF Practices in the AREVA Group to Face New Challenges
13:30	SA3–02	C. Packer	Canada	Storytelling and Safety Culture
14:00	SA3–03	N. Ahn	Korea, Rep. of	Innovative Modelling Approach of Safety Culture Assessment in Nuclear Power Plant
14:30	SA3–04	J. Ward	Australia	The Application of Systemic Safety for Smaller Nuclear Installations
15:00	SA3–05	N. Ahn	Korea, Rep. of	Co–Chair's Reflections

Break 15:15 – 15:45

HR3: Parallel Session: Other High Reliability Organizations' Approaches to Safety

Chair: A. J. González (Argentina) *Room M2* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	HR3–01	L. Suhanyiova	UK	Product Safety Culture: A New Variant of Safety Culture?
13:30	HR3–02	E. Nystad	Norway	Human and Organisational Safety Barriers in the Oil & Gas Industry
14:00	HR3–03	N. Dechy	France	Learning Lessons from TMI to Fukushima and Other Industrial Accidents: Keys for Assessing Safety Management Practices
14:30	HR3–04	A. N. Afghan	Pakistan	Understanding Nuclear Safety Culture: A Systemic Approach
15:00	HR3–05	A. J. González	Argentina	Co–Chair's Reflections

Break 15:15 – 15:45

TO3: Topical Parallel Session: Building Culture for Safety

Chair: F. Dermarkar (Canada) *Room M3* **(13:00 – 15:15)**

Time	Id	Presenter		Title
13:00	TO3–01	T. Reiman	Finland	Safety Culture in New Build Projects
13:30	TO3–02	A. M. Bomben	Argentina	The FORO Project on Safety Culture in Organizations, Facilities and Activities With Sources of Ionizing Radiation
14:00	TO3–03	R. J. Duncan	INPO	INPO Perspectives and Activities to Enhance Supplier Human Performance and Safety Culture
14:15	TO3–04	D. Dennier	Canada	Addressing the Challenges of Sharing Lessons Learned Amongst Suppliers in a Fragmented and Competitive Marketplace
14:30	TO3–05	L. K. Clewett	Canada	Utility Expectations for Human Performance and Safety Culture in the Supplier Community
14:45	TO3–06	B. de L'Epinois	France	Developing Nuclear Safety Culture within a Supplier Organization: An Insight from AREVA
15:00	TO3–07	F. Dermarkar	Canada	Co–Chair's Reflections

Break 15:15 – 15:45

Thu

DS3: **Dialogue Sessions: Talking with the Presenters**

Shared Space — semi–formal dialogues **(15:45 – 17:00)**

Room	Id	*Facilitator*	**Topic**
B/M1	DS3–01	*L. Kecklund*	**Nuclear Safety in Transition**
See: HR2–01		E. Fischer (LM3–02); M.-S. Yim (CP–05)	A. N. Afghan (HR3–04)
B/M1	DS3–02	*D. Engström*	**Resilience in Practice**
See: LM3–03		J. Ward (SA3–04)	J. Paries (CP–04)
B/M1	DS3–03	*C. Ryser*	**Storytelling and Safety Culture**
See: DS–07		M. Nishizawa (PL3–05)	C. Packer (SA3–02)
M0E–03	DS3–04	*C. Kopisch*	**Building Safety Culture**
See: TO2–05		E. Nystad (HR3–02); A. M. Bomben (TO3–02)	T. Reiman (TO3–01); L. Hu (LM3–04)
M0E–07	DS3–05	*D. J. Sieracki*	**New Perspectives to Embrace**
See: TO2–08		T. B. Melnitckaia (PL3–04)	L. Suhanyiova (HR3–01)
M0E–10	DS3–06	*A. Al Khatibeh*	**Looking Ahead, What Are the Needs for Installing Safety Culture in Non-Nuclear Countries?**
		S. Elegba (HR1–02)	A. J. González
M0E–12	DS3–07	*K. Heppell-Masys*	**Modelling Safety**
See: SA1–02		N. Ahn (SA3–03)	
M0E–13	DS3–08	*H. Rycraft*	**Capturing Inputs and Requests to the IAEA and Introducing the New Developments in Harmonizing Safety Culture Frameworks**
		K. Koves	
M0E–16	DS3–09	*D. McHarg*	**Safety Management Practices**
		N. Dechy (HR3–03); J.-F. Vautier (Post–30)	T. Coye de Brunélis (SA3–01)
M3	DS3–10	*F. Dermarkar*	**Safety Culture Across Organizational Boundaries (Suppliers and Contractors)**
		R. J. Duncan (TO3–03); B. de L'Epinois (TO3–06)	L. K. Clewett (TO3–05); D. Dennier (TO3–04)
M2	DS3–11	*M. Haage*	**IAEA Member State Support on Safety Culture; Leadership and Management for Safety**
See: DS–14		G. Rzentkowski (PL3–03); C. Spitzer	P. Tarren; S. Magruder

Daily Summary

Chair: M. Weightman (UK) *Boardroom B/M1* **(17:00 – 17:30)**

Recap of the day by the Conference Chairman

CP: Closing Plenary: The Future is in Our Hands

Chair: M. Weightman (UK) *Boardroom B/M1* **(09:00 – 14:00)**

Time	Id	Presenter		Title
09:00	CP–01	M. Weightman	UK	Daily Remarks
09:10	CP–02	A. Kawano	Japan	Progress in Nuclear Safety Reform of TEPCO
09:50	CP–03	L. K. Clewett	Canada	Leadership Actions to Improve Nuclear Safety Culture
10:30	CP–04	J. Paries	France	Should Nuclear Safety Care About Resilience Engineering?
		Break 11:00 – 11:30		
11:30	CP–05	M.-S. Yim	Korea, Rep. of	Safety Culture and the Future of Nuclear Energy
12:00	CP–06	W. E. Carnes	USA	Reflection, Interrogatory, Provocation
12:30	CP–07	C. A. Hart	USA	Presentations from Dialogue Sessions: Determining the Future
12:50	CP–08	B. M. Tyobeka	South Africa	Co-Chairpersons' Summary
		N. Ahn	Korea, Rep. of	
		A. J. González	Argentina	
		F. Dermarkar	Canada	
13:20	CP–09	M. Weightman	UK	Chairperson's Summary
13:40	CP–10	From Chair to IAEA		Conference Outcomes
13:50	CP–11	J. C. Lentijo	IAEA	Closing Statment

Post: **Stories from Around the World**

1st Floor Concourse **(Open)**

NB: All posters will be on display for the full duration of the conference.

Id	Presenter		Title
Post–01	S. A. N. Bhatti	Pakistan	Safety Culture Assessment at Regulatory Body – PNRA Experience of Implementing IAEA Methedology for Safety Culture Self Assessment
Post–02	H. Blazsin	France	Practical Reason, Another Approach of Safe Action
Post–03	Z. Bódis	Hungary	Promotion and Support of Strong Safety Culture at the Hungarian Regulatory Body
Post–04	A. M. Borras	Philippines	A Glance on the Safety Culture in Industrial Gamma Radiography in the Philippines: Regulatory Body Perspective
Post–05	E. D. Chernetckaia	Russian Fed.	The Experience of Psychological Service of Rosenergoatom in Ensuring the Reliability of the Human Factor
Post–06	T. Coye de Brunélis	France	Safety Assessment in the AREVA Group: Operating Experience from a Self-Assessment Tool
Post–07	P. B. S. Eshiett	Nigeria	Human and Organizational Factors
Post–08	M. Farcasiu	Romania	Study on the Man-Machine-Organization System Interfaces in Nuclear Facility Operation
Post–09	B. G. Göktepe	Turkey	Building a Safety Culture in New Comers — A Case for Turkey
Post–10	M. Solymosi	Hungary	Fewer can be More: Nuclear Safety and Security Culture Self-Assessment in the Hungarian Public Ltd. for Radioactive Waste Management
Post–11	P. Janko	Slovakia	Nuclear Safety Culture & Leadership in Slovenske Elektrarne
Post–12	S. Jovanovic	Montenegro	Nuclear Knowledge and Competence: Fundamental Prerequisites for the Safe Utilization of Radiation Sources in a Small Non-Nuclear Country — Experience of Montenegro
Post–13	S. J. Jung	Korea, Rep. of	Regulatory Oversight of Safety Culture — Korea's Experience and Lessons Learned
Post–14	M. M. Kandil	Egypt	The Role of the Regulator in the Field of Safety Culture to Shun Nuclear Accident

Id	Presenter		Title
Post–15	A. Vasilishin	Russian Fed.	TSO Role in Supporting the Regulatory Authority in View of Safety Culture
Post–16	Y.-H. Lee	Korea, Rep. of	A Recent Revisit Study on the Human Error Events of Nuclear Facilities in Korea
Post–17	A. Merino Hernández	Mexico	Verification of Human Factors in Mexican Nuclear Facilities, Experience Gained During 20 Years
Post–18	M. E. Mustafa	Egypt	Human Factors in Nuclear Reactor Accidents
Post–19	E. A. P. do Prado	Brazil	Neuropsychological Aspects Observed in a Nuclear Plant Simulator and its Relation with Human Reliability Analysis
Post–20	M. A. Qamar	Pakistan	Safety Culture Evaluation at Research Reactors of Pakistan Atomic Energy Commission
Post–21	E. A.-F. I. Eisawy	Egypt	Human Factors Reliability Analysis for Assuring Nuclear Safety Using Fuzzy Fault Tree
Post–22			Withdrawn
Post–23	K. Sepanloo	I. R. Iran	National Nuclear Safety Department Experience of Supervision over Safety Culture of BNPP-1
Post–24	D. Serbanescu	Romania	On Some Issues Related to the Models of Human and Organizational Factors and their Use in the Decision Making Process
Post–25	J. Situmorang	Indonesia	Evaluation of Influence Factors within Implementing of Nuclear Safety Culture in Embarking Countries
Post–26	A. Smetnik	Russian Fed.	Management Systems and Safety Culture in the Nuclear Energy Sector (ISO 9001 & GS-R-3)
Post–27	A. Smetnik	Russian Fed.	Asphology — the Birth of a New Science
Post–28	A. Smetnik	Russian Fed.	The 4th Missing Element of the ITO Systemic Approach to Safety
Post–29	M. Stručić	EU	Overview of Recent Activities on Safety Culture and Human and Organizational Factors Carried Out at the Joint Research Centre of the European Commission
Post–30	J.-F. Vautier	France	A Synchro-Diachro Approach to Question the Development of a Human and Organizational Factors (HOF) Network

Id	Presenter		Title
		Post-Deadline Contributions	
Post–31	I. Kuzmina	IAEA	Probabilistic Safety Assessment: An Effective Tool to Support "Systemic Approach" to Nuclear Safety and Analysis of Human and Organizational Aspects

Contents

OP: Opening Plenary: Setting the Scene

This plenary session opens the conference and welcomes all the participants to the conference. The IAEA and the conference chairperson will set the scene for the conference content. The keynote speakers will introduce the main themes of the conference and share their personal views of these important areas for the safe operation of nuclear installations.

Safety Culture: It's More Than Ticking-the-box

N. Stavropoulos[1]

[1] *Pacific Gas and Electric Company (PG&E), San Francisco, CA 94105, USA*

Corresponding Author: N. Stavropoulos, www.pgecorp.com/aboutus/our_team/NStavropoulos.shtml

Nick Stavropoulos is the President, Gas, at PG&E. Nick is an engaging and passionate speaker, and he will provide practical advice on how companies can improve their culture. Nick will share PG&E's experience of creating safety first culture. PG&E have dramatically improved their safety performance and this improvement involved a cultural change.

Safety Culture & Beliefs in the Nuclear Industry: Looking Forward, Looking Back

S. Cox[1]

[1] *Lancaster University Management School, Bailrigg, Lancaster, LA1 4YX, UK*

Corresponding Author: S. Cox, s.cox@lancaster.ac.uk

This Keynote considers the role that the notion of safety culture has played in management of safety in the nuclear industry over recent decades. It does so through the lens of the industry's beliefs about how such a notion might be applied to better understanding and preventing safety failures.

Over the last 30 years, the nuclear industry has come to accept both the concept of safety culture and the possible role that it might play in safety management and safety failure. This development is to be welcomed in general terms but is not without its shortcomings in practice. These largely concern the operationalization of the concept and the way that it is often measured and managed. So what are the issues around the way that much of the industry currently believes that the notion of safety should be applied?

The Keynote addresses this question. In doing so, it explores the changes that might be necessary for a fair test of the utility of safety culture in determining the quality of safety management and performance. The final point raised in this Keynote, is fundamental but missed by some. However cast, measured and managed, the concept of safety culture was never promoted as the sole determinant of safety management or the sole reason for safety failure. Therefore, judging the utility of the concept in relation to the quality of safety management in the nuclear industry can only be done logically in the context of those of the other factors involved.

The Risk of Hyper-Culture: How to Avoid It and Work With Real Organizational Culture

M. Alvesson[1]

[1] *Lund University, SE–221 00 Lund, Sweden*

Corresponding Author: M. Alvesson, mats.alvesson@fek.lu.se

The talk addresses the issue of work with organizational culture often circling around nicely formulated, vague and idealistic words — hyper culture. These look good on powerpoint presentations and in policy documents. They seldom work well in practical use. But senior managers, consultants, staff people and educators like the nice-sounding. It is good for status and self-esteem. And we all like what is pedagogical, astetic and reassuring. The talk addresses the phenomenon of hyper culture. And points at ways to avoid these and work with organizational practices in relation to culture.

The talk draws on the presenter's book THE TRIUMPH OF EMPTINESS. Oxford University Press.

Unique Problems of Nuclear Technology and the Need for Humble Inquiry

E. H. Schein[1]

[1]*Professor Emeritus, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA, USA*

Corresponding Author: E. H. Schein, scheine@comcast.net

The concept of Safety Culture is widely accepted but not very well understood. In this paper I argue that the components of safety culture all hinge on whether the executives in the nuclear plant actually create the climate of trust and openness that the other attributes hinge on. The right kind of executive behaviour is especially important in nuclear plants and sites because of the unique characteristics of nuclear technology. In order to create the climate of trust and openness that is required I explain the concept of Humble Leadership as the essential characteristic needed in nuclear plan executives.

PL1: Retrospective Lessons

This plenary session reflects on past lessons and identifies the challenges the industry faces to ensure that those lessons continue to be addressed. The Plenary Dialogue within the session will remind participants of the human side of safety, with panellists sharing their experiences of the realities of an accident.

Plenary Dialogue: The Human Side of Safety

M. Haage[1]

[1] *International Atomic Energy Agency (IAEA), Vienna, Austria*

Plenary Facilitator: M. Haage, M.Haage@iaea.org

What Is the Human Side of Learning from the Past?

This plenary dialogue allows a conversation between key participants about the nature of lessons learned from past major accidents and the personal impact on their life and career. They will reflect on the actions that the industry took in the response to the accidents and discuss the human side of accident causes and the aftermath.

The aim of the dialogue is to bring the human dimension of an accident to the attention of the audience and provide insight into personal impacts of being involved in a significant event.

The central question around the human side of accidents is to explore whether the industry gives equal weight to learning about the human lessons alongside the technology questions, during investigations and prevention actions.

The audience will have the opportunity to ask questions to the panel and share their views.

Panellists:

V. N. Abramova	Russian Fed.	PL1–04
B. Stoliarchuck	Ukraine	
A. Kawano	Japan	CP–02

What Needs to be Changed based on Lessons Learned from Chernobyl

V. N. Abramova[1]

[1] *Science Research Center Prognoz, Russian Federation*

Corresponding Author: V. N. Abramova, v.n.abramova@gmail.com

Direct and root causes of Chernobyl accident have a complex character because many different events having independent origin happened jointly. The catastrophe occurred due to a systemic combination of objective and psychological factors, each of which was, in itself, not a source of danger. Human factor influence on the situation was net so much like operative personnel activity result but as activity of many workers on when previous phases of the plant life cycle. Systemic combination of those factors intensified their influence.

Chernobyl operators erroneous actions could be classified as mistakes. The direct cause of the erroneous actions were a mistaken understanding of the neutron physics processes occurring in the reactor vessel. Theoretically operators could prevent the explosion if they would place faster absorbent rods in five seconds before they pushed "Automatic Defence — 5" button. It is known that human error probability in that conditions, in 5–10 seconds, is practically unity. The root cause of the human errors was based on the fact that operation regulations provided the reactor unit safety. The regulations permitted (i.e., did not prohibit) the conditions the reactor unit was in before the accident in 1986.

Examination of Chernobyl personnel motivation and attitude characteristics has shown that conflict "Human – Technology – Organization" could be presented quantitatively like motivation parameter. The conclusion is very important to solve a problem of the operator reliability. It has directed a search for psychological professional fitness criteria to the activity motivation and attitudes quality and also has drawn nearer nuclear unit safety concept and safety culture concept understanding. Operative personnel job descriptions and daily work practice formed attitude to diligence first of all.

Presented approach in psychological analysis of the personnel activity when accident situation is developed by the comparison between personal aspect, cognitive and operational structures and formalized notation about personnel regulation activity.

The researches have shown that individual psychological data of Chernobyl NPP personnel, which could be a direct cause of wrong actions and lead to the accident, were not differ from another nuclear power plant personnel ones.

Analysis of psychological aspects of Chernobyl accident and investigation of plant personnel motivation changes in the accident consequences elimination environment confirm the necessity to develop concept of careful relation to worker. It is necessary to develop psychological support methodology to form human capital both in two aspects: professional personality formation and human resource management.

The history asks the following questions: have the Chernobyl lessons been learned? Are our contemporaries and next generation ready to provide safety in the nuclear power plants? The terrorist attacks, military actions in the states who have nuclear power plants makes more complex problem of nuclear power plant, all mankind safety.

The Human Aspect of the Fukushima Daiichi Accident

T. Anegawa[1] and ***A. Kawano***[1]

[1] *Tokyo Electric Power Company (TEPCO), Tokyo, Japan*

Corresponding Author: T. Anegawa, www4.tepco.co.jp/en/other/contact/general-e.html

Recognizing itself as the main party involved in the nuclear accident triggered by the Tohoku-Chihou-Taiheiyo-Oki Earthquake on March 11, 2011, Tokyo Electric Power Company (TEPCO) has performed accident investigation from various aspects. Results of the investigation are reported mainly in two reports; (1) Fukushima Nuclear Accident Analysis Report (June 20, 2012), which identified the timeline and the proximate causes of the accident, and (2) Summary of Fukushima Nuclear Accident and Nuclear Safety Reform Plan (March 29, 2013) to set forth the results of the investigation and provide an analysis of the background factors surrounding the accident and countermeasures taken.

This presentation will first provide overview of the accident response at Fukushima Daiichi and Daini Nuclear Power Stations. Voices from the first responders at the sites will be introduced in order to share thoughts of individuals involved in the emergency response. Summary of retrospective study of the accident by one of the shift supervisors at the time of the accident will be presented in order to share the facts that happened at main control rooms.

The shift supervisor and his crew had to manage the situation for extended period of time that exceeded the scenarios that they had been trained, in a situation with no lightning and high radiation condition. During the accident response, shift supervisors had to decide to dispatch some of his crew members to the field to open valves, check the status of equipment etc., in the situation where the high radiation exposure is foreseen. The presentation will include conflict of shift supervisors and crew focusing on the human aspects.

In addition, actions being taken at the Emergency Response Centers (ERC) set up at the seismic-isolated building on-site and the Headquarters in Tokyo will be shared focusing on the human aspects related to the accident progress. This includes difficult decisions to dispatch first responders to the field, in the situation where a large number of aftershocks were observed and associated tsunami cautions were announced from time to time. Due to the occurrence of the SBO (Station Black Out), first responders had to engage in field works in the complete darkness while the field were scattered with damaged equipment, vehicles and other debris caused by the tsunami and explosions. Eventual loss of effective communication tools such as paging and PHS also hampered communication between the field, main control rooms and the ERC. In spite of the loss of effective communication tool and other equipment prepared for emergency response, the ERC personnel and shift crew members had to deal with concurrent event progress at six units at the same time; where sometimes the accident progress at one unit (e.g., explosion of the reactor building) also inversely affected the accident response at the adjacent units.

Communication within the ERC and between the site and the Headquarters as well as outside the company (e.g., Cabinet, regulatory authority) became more and more complicated and caused further confusion as the progress of accident at 6 units in Fukushima Daiichi and 4 units in Fukushima Daini NPSs. The presentation will describe actions and decisions being taken in such extreme circumstances, to highlight the key lessons learned; such as importance of establishing strong command and control functions, data sharing system etc.

Learning from the accident, TEPCO has introduced new command and control system and staff are being trained with the new system. Also, reflecting the lessons from the accident response by shift crew at main control rooms and the field, training program for shift workers and first responders has been revised and more extensive and frequent emergency drills are conducted. In the presentation, such activities currently performed by TEPCO will be addressed.

OECD–NEA's New Approach to Human Aspects of Nuclear Safety

Y. Hah[1]

[1]*Organisation for Economic Co-operation and Development, Nuclear Energy Agency (OECD–NEA), 92100 Boulogne-Billancourt, France*

Corresponding Author: Y. Hah, yeonhee.hah@oecd.org

Fukushima Daiichi accident in 2011 in Japan has brought us new challenge to deal with "human" aspects of nuclear safety which have always been crucial elements of safety, but which often receive less attention than technical and equipment issues.

The key factors thet led to the accident were not only a huge tsunami following a massive earthquake, but also a variety of human failures: organizational decision-making, safety culture of the plant staff and the regulator, training to assure that operators are well prepared for a wide range of possible challenges.

In order to fully understand and respond to the lessons learned from the Fukushima accident, the OECD–NEA created a new Division of Human Aspects of Nuclear Safety (HANS) which is focusing on the human issues related to nuclear safety. The Division of HANS is responsible for supporting the relevant work programmes of the NEA; fostering greater focus and building expertise in areas vital to effective nuclear safety such as safety culture, personnel training policies and practices; and safety-related public communication and stakeholder engagement.

In 2014, NEA produced the Green Booklet on the Characteristics of an Effective Nuclear Regulator noting that the characteristic of "safety focus and safety culture" was one of the four fundamental principles from which all regulatory body actions should be derived. Based on this understanding, in 2015, NEA published the follow up Green Booklet, Safety Culture of an Effective Nuclear Regulatory Body, providing main principles and attributes to be benchmarked for the regulatory bodies to encourage them to enhance their effectiveness as they fulfil their mission to protect public health and safety.

Many challenges exist to regulatory bodies' safety culture which must be recognised, understood and overcome. Continuing collective efforts could help turn these challenges into opportunities to further strengthen the overall health of the safety culture of regulatory bodies. To achieve this we need to ensure a continuing and consistent effort at national and international level.

LM1: Leadership, Management and Culture for Safety

A session looking at the opportunities for learning and how organizations put these lessons into action.

From Safety Culture to Culture for Safety — What is it that we Still Haven't Learned

S. B. Haber[1]

[1]*Human Performance Analysis, Corp., New York, NY 10069, USA*

Corresponding Author: S. B. Haber, sonjahaber@gmail.com

In April 1986 the Chernobyl Accident happened. Several years later in 1991 the IAEA Independent Nuclear Safety Advisory Group published INSAG-4 and the concept of safety culture was defined for the nuclear community because of its relationship to the accident. Where the Three Mile Island Accident in 1979 had brought human factors issues in procedure development, human performance, and training to light, the Chernobyl Accident was discussed in terms of management, supervision, and safety culture. Work in the nuclear community evolved around the concept of safety culture although a clear understanding of what was actually meant was often missing. Methods to evaluate and assess safety culture were developed and efforts to integrate the findings of those evaluations into more traditional nuclear tools, such as probabilistic risk and safety assessment were attempted as well. Safety culture became thought of as a process that could be written into a procedure, measured by performance indicators and fixed in a corrective action program. The changes that organizations saw as a function of their safety culture improvement programs though were often just changes in some behaviors. Short term improvements in safety performance and the metrics to measure them were observed and many concluded they had really changed their safety culture. The changes were often not sustainable. The efforts did not include an in depth understanding of why individuals thought or behaved in the way that they did.

In March 2011 the Fukushima Daiichi Accident happened. Initially it was accepted to explain it as a natural disaster. While the earthquake or the tsunami could not be prevented, there were things that could have been done before, during and immediately after the natural phenomena that would have helped to mitigate the consequences of the accident. The IAEA conducted an in-depth analysis of the human and organizational factors of that accident and drew a number of conclusions but none so critical as the finding that while the same natural phenomena might not occur in every nuclear facility location around the world, the same human and organizational issues could. What is taken for granted and what is assumed represents culture and will influence behaviors, decisions, and what is attended to. This paper will discuss what is needed for the nuclear community to move forward now in the way it thinks about safety culture. By thinking about culture as the foundation for the shared beliefs and values in any organization the realisation that improvement programs will not succeed with short term efforts but rather will require time and commitment, will be evident. By working within the organizational culture to achieve and maintain safety performance a more realistic and sustainable outcome will result. It is time 30 years after the Chernobyl Accident to shift the thinking in the nuclear community from safety culture to culture for safety. It is the necessary step for each organization to try to move forward to achieve long term sustainable safety performance.

Leadership for Safety in Practice: Perspectives from a Nuclear Regulator

B. M. Tyobeka[1]

[1] *National Nuclear Regulator (NNR), Cape Town, 7441, Republic of South Africa*

Corresponding Author: B. M. Tyobeka, BMTyobeka@nnr.co.za

The principal responsibility for a nuclear regulator is to assure compliance with regulations and safety standards by operators. One of these requirements is demonstration of, and adherence to, nuclear safety culture by the operators. At the same time, the regulators themselves are expected to live the talk and practice what they preach, i.e., demonstrate highest levels of nuclear safety culture within their organizations. Consequently, it is recognised that leadership is important in the creation of a culture that supports and promotes a strong nuclear safety performance of an organization. The leaders of a regulatory body are vital in inspiring employees to a higher level of safety and productivity, which means that they must apply good leadership attributes on a daily basis. This paper will attempt to bring forth and share attributes for strong leadership role in promoting a safety culture within a nuclear regulatory body by surveying world-wide practices and examples in developing and advanced nuclear countries.

Experience of Tecnatom in Developing a Strong Leadership for Safety and Performance

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This paper presents experience and insights of Tecnatom in the support of internal and external clients to develop a strong Leadership for Safety. Several cases are presented briefly:

(a) The leadership and culture change activities for a utility, a radwaste company, and for Tecnatom itself. One important characteristic of the work performed is the detailed consideration of the underlying organizational culture that underpins the safety culture. Measurable improvements have been achieved and some of the key insights are shared in this paper.

(b) The development and implementation of a leadership model with 17 competencies, including safety explicitly. One benefit of this model is that allows to perform a quantitative assessment of leadership effectiveness, something vital to be able to ensure that leadership development actions are truly supporting safety. The model uses an approach to development oriented to strengths and the use of companion competencies to further develop leadership. Moreover it aims to produce significant improvements on safety but also on performance, since both are not competing goals when the proper leadership model is selected. The training material prepared was shortlisted in the 2014 Nuclear Training Awards.

(c) The design and implementation of a training development program on Safety Culture, and required competencies of Leadership, for Top Managers of the nuclear industry, as part of the project NUSHARE of the European Commission's 7th research framework program. The program is sensible to the reduced time availability of Top Managers and uses a combination of learning approaches (webinars, micro-e-learnings, web meetings) that provide higher flexibility for the learner, but complemented with other proven methods (group dialog, journaling, mentoring, etc.) to ensure that the program is effective.

All these experiences reveal that to improve the organizational Safety Culture we need to enhance Leadership for Safety and Performance.

Use of Human Reliability Insights to Improve Decision-Making

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This paper describes the use of insights obtained during the development and application of human reliability analysis (HRA) as part of a probabilistic risk assessment (PRA) to support decision-making, including improvements to operations, training, and safety culture. Insights have been gained from the development and application of HRA as part of a PRA for nuclear power plants in the USA, Europe and Asia over the last two decades. These models consist of Level 1 and Level 2 PRA models of internal and external events, during full power and shutdown modes of plant operation. These insights include the use of human factors information to improve the qualitative portion of the HRA. The subsequent quantification in the HRA effectively prioritises the contributors to the unreliability of operator actions, and the process facilitates the identification of the factors that are important to the success of the operator actions. Additionally, the tools and techniques also allow for the evaluation of key assumptions and sources of uncertainty. The end results have been used to effectively support decision-making for day-to-day plant operations as well as licencing issues. HRA results have been used to provide feedback and improvements to plant procedures, operator training and other areas contributing the plant safety culture. Examples of the types of insights are presented in this paper.

SA1: Systemic Approach to Safety

A session looking at the complex interactions within an organization that affect safety performance, as identified by looking at the lessons from the past.

Operators' Improvisation in Complex Technological Systems: The Last Resort to Averting an Assured Disaster

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When complex technological systems, such as nuclear power plants, move from routine to non-routine (normal to emergency) operation, the control operators need to dynamically match the system's new requirements. This mandates integrated and harmonious changes in information presentation, changes in performance requirements in part because of operators' inevitable involuntary transition to different levels of cognitive control, and reconfigurations of the operators' team (organizational) structure and communication.

In order to survive, a technological system must have the ability to respond to operational anomalies before any undesirable consequences, which the system seeks to avoid, can occur. That is, the control structure must run at a faster rate than the environment it seeks to control; else-wise, the system will lose control. However, a hierarchically structured team has only a limited control model of the system, which oversees. For instance, in the case of a power plant particularly during an emergency, the operators not only comply with EOPs, they must also respond to the changing system environment. To the extent that every possible deviation in this environment has not been foreseen by the "hierarchy", control is transferred to the work domain level — to operators — and due to their survival needs and instincts the system's control team inevitably embraces structural forms that fit the situational demands, often the more naturalistic form such as "self-organizing". Moreover, the hierarchical team structure becomes even more counter-productive when decisions need to be made by the whole team using the "team mind".

As task uncertainty increases in complex systems, (typical in "non-normal" or emergency situations), the number of exceptions to routine operations increases, overloading organizational hierarchy. In order to meet the new challenges, the organization must use another mechanism to sustain itself. Furthermore, the "normal function" of tightly coupled technological systems is to operate on the boundary to loss of control. That is, people are involved in a dynamic and continuous interaction with failure and hazard (Rasmussen, 1989). Thus, "touching the boundary to loss of control is necessary (e.g., for dynamic "speed-accuracy" trade-offs)" (Rasmussen, Pejtersen, & Goodstein, 1994). This is a rapidly changing environment, and in order to survive it, the system should be able to respond in a safe and effective manner. Occasionally, it may require an improvised response from the operator(s), but it should certainly be coordinated and in concert with others' activities and stay within the boundaries of acceptable work performance (Rasmussen, 1989). Otherwise, it would be just noise in the control of the system and could lead to errors. It must also be able to flexibly reconfigure and synchronize all of its system elements to address the threatening issues.

The brining the four nuclear reactors at the Fukushima Daini plant to the cold shut down, after the Tōhoku earthquake, tsunami and station black out of March 11, 2011, was nothing short of a miracle. The heroic act of a dedicated group of human operators, who went out of their way and by encountering multiple sources of hazard and harm, taking personal risk, and by relying on their ingenuity, teamwork, and dedication despite all odds, brought all four reactors to cold shutdown and consequently averted the second assured nuclear disaster in Fukushima prefecture with serious implications for travelling fallouts to Tokyo and its subsequent evacuation.

The Superintendent of the Fukushima Daini Nuclear Power Station, Mr. Naohiro Masuda, and his operators resorted to improvisation to save the day after experiencing station black out; and their improvised acts are too numerous to mention. Nevertheless, the most memorable noteworthy ones include, "flexibly applying EOPs" and "Temporary cable of 9 km length was laid by about 200 personnel within a day. Usually this size of cable laying requires 20 personnel and more than 1 month period". Their personal sacrifices and dedication of staying in the plant and continuing working in dire conditions, while not knowing whether their families survived the earthquake and tsunami, and working relentlessly to bring the four reactors to the cold shutdown state, are of epic proportion. These operators, who certainly are unsung heroes, deserve to also be considered as national heroes of Japan. Their problem solving behavior was the perfect examples for a successful knowledge-based level of cognitive control.

Fukushima Daini operators once more verified and exemplified the notion that at the time of a major accident at a complex, large scale technological systems, such as a nuclear power plant, human operators always constitute both society's first and last layer of defense. For the foreseeable future, despite increasing levels of computerisation and automation, human operators will have to remain in charge of the day-to-day controlling and monitoring of these systems, since system designers cannot anticipate all possible scenarios of failure.

Fukushima Daiichi Nuclear Accident: A Matter of Unchallenged Basic Assumptions

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As part of the IAEA Fukushima Daiichi Accident Report published in September 2015, a systemic analysis of the Human and Organizational Factors based on the IAEA Safety Culture Assessment Methodology was conducted by 11 international experts to answer the question of why the accident happened. This accident occurred under the backdrop of the international nuclear community's progress in nuclear safety, brought about by internationally agreed upon safety standards, comprehensive review services, and the development of sound regulatory frameworks.

The assumptions on nuclear safety by the main organizational stakeholders involved in the accident at the Fukushima Daiichi NPP were examined in detail. Through the systemic analysis, it was shown how the actions of these stakeholders were interrelated and interconnected, and thereby reinforced basic assumptions about nuclear safety that prevented an adequate preparing for, and prevention of, the accident on 11 March 2011. These basic assumptions corresponded to the deepest level of safety culture and which formed the basis of safety culture upon which the stakeholders acted — and hence the basis from which decisions were made and actions taken well before the March 2011 events. The analysis presented in the report is concluded by two main observations and seven lessons learned deriving from these. The presentation will also include further details on these findings.

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Evaluating Safety Culture Under the Socio-Technical Complex Systems Perspective

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Since the term "safety culture" was coined, it has gained more and more attention as an effort to achieve higher levels of system safety. A good deal of effort has been done in order to better define, evaluate and implement safety culture programs in organizations throughout all industries, and especially in the Nuclear Industry.

Unfortunately, despite all those efforts, we continue to witness accidents that are, in great part, attributed to flaws in the safety culture of the organization. Fukushima nuclear accident is one example of a serious accident in which flaws in the safety culture has been pointed to as one of the main contributors.

In general, the definitions of safety culture emphasise the social aspect of the system. While the definitions also include the relations with the technical aspects, it does so in a general sense. For example, the International Nuclear Safety Advisory Group (INSAG) defines safety culture as: "The assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receives the attention warranted by their significance." By the way safety culture is defined we can infer that it represents a property of a social system, or a property of the social aspect of the system. In this sense, the social system is a component of the whole system. Where, "system" is understood to be comprised of a social (humans) and technical (equipment) aspects, as a Nuclear Power Plant, for example. Therefore, treating safety culture as an identity on its own right, finding and fixing flaws in the safety culture may not be enough to improve safety of the system. We also needed to evaluate all the interactions between the components that comprise all the aspects of the system.

In some cases a flaw in the safety culture can easily be detected, such as an employee not wearing appropriate individual protection equipment, e.g., dosimeter, or when basic safety procedures for equipment operation are ignored. However, when it comes to more subtle interactions between system components, it becomes harder to detect potentially hazardous situations that are hidden, and can lead the system to hazardous states. For example, leaders can take decisions that are in conflict with decisions taken by other colleagues at a very different department, and without knowing, be contributing to future unintended consequences to the system. Such a situation may not be easily detected by direct observation.

This explains why having a good safety culture seems not to be enough to assure the safety of the system. According to STAMP principals, safety is a problem of flaws in the control of the interactions between components of the system, and not only a problem of failures of components of the system. Remember that safety culture defines a property of part of the system, which could be considered as a component of the system. We can find examples of companies that, even having well evaluated safety culture, or organizational culture, fail to keep their high safety standards.

In this work we propose a methodology that integrates safety culture in the control structure of the system. It is based on STAMP: Systems Theoretic Accident Models and Processes, and the Three Lenses: Strategic, Political and Cultural Approaches. It can help evaluate either the existing safety culture of a Nuclear Power Plant or the implementation of new safety culture projects. STAMP is based on the assumption that accidents are a result of flawed control over the interactions between components of a system. Where, control structure is a model of the system in terms of control loops. To understand how the control structure of a system can be corrupted, and therefore, leading the system to hazardous conditions, the methodology of the Three Lenses is applied. By following this approach it becomes possible to keep all the safety culture traits but, instead of focus on safety culture itself as a quality of a social system, the proposed approach integrates the safety culture traits into the control structure of a broader system, the socio-technical complex system.

A practical example, based on the Davis-Besse Nuclear Power Plant head degradation event, is presented.

Enhancing Safety Culture in Complex Nuclear Industry Projects

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This paper presents an on-going research project "Management principles and safety culture in complex projects" (MAPS), supported by the Finnish Research Programme on Nuclear Power Plant Safety 2015–2018. The project aims at enhancing safety culture and nuclear safety by supporting high quality execution of complex projects in the nuclear industry.

Safety-critical industries are facing new challenges, related to increased outsourcing and complexity in technology, work tasks and organizational structures (Milch and Laumann, 2016). In the nuclear industry, new build projects, as well as modernisation projects are temporary undertakings often carried out by networks of companies. Some companies may have little experience in the nuclear industry practices or consideration of specific national regulatory requirements. In large multinational subcontractor networks, the challenge for assuring nuclear safety arises partly from the need to ensure that safety and quality requirements are adequately understood and fulfilled by each partner. Deficient project management practices and unsatisfactory nuclear safety culture in project networks have been recognised as contributing factors to these challenges (INPO, 2010). Prior evidence indicated that many recent major projects have experienced schedule, quality and financial challenges both in the nuclear industry (STUK, 2011) and in the non-nuclear domain (Ahola *et al.*, 2014; Brady and Davies, 2010).

Since project delays and quality issues have been perceived mainly as economic problems, project management issues remain largely understudied in safety research. However, safety cannot be separated from other performance aspects if a systemic view is applied. Schedule and quality challenges may reflect deficiencies in coordination, knowledge and competence, distribution of roles and responsibilities or attitudes among the project participants. It is increasingly understood that the performance of the project network in all lifecycle phases has implications for the defence in depth. Recently, the Radiation and Nuclear Safety Authority in Finland (STUK) has issued new YVL guides, which specify requirements on project management and safety culture of suppliers and subcontractors (STUK, 2014). International nuclear institutions have also paid attention to safety culture in networks of organizations (e.g., INPO, 2010; Royal Academy of Engineering, 2011; IAEA 2012).

Culture has been predominantly studied in safety research as an intra-organizational phenomenon. Thus, it remains unclear how to apply safety culture models in large-scale project networks, consisting of multiple heterogeneous actors with somewhat conflicting objectives. Cultural approaches traditionally emphasise that creating a culture takes time and continuity, which does not reflect well the short time frames, high diversity and temporal dynamics typical for such projects. Each project partner brings own national and work cultural features and practices, which create a complex amalgam of cultural and sub-cultural influences on the overall project culture. Recently, Gotcheva and Oedewald (2015) summarised safety culture challenges in different lifecycle phases of large nuclear industry projects, and many of them relate to inter-organizational setups. Project governance deals with this inter-organizational space as it aims at aligning multiple diverse stakeholders' interests to work together towards shared goals (Turner and Simister, 2001).

The current study utilises a mixed-methods approach for understanding and enhancing safety culture in complex projects, focusing on management principles, cultural phenomena and simulation modelling. The need to integrate knowledge on safety culture and project governance to support safe and effective execution of complex nuclear projects is highlighted. The study advances the concept of safety culture and its applicability in project contexts by directing the attention to inter-organizational complexity in contemporary nuclear power industry.

HR1: Other High Reliability Organizations' Approaches to Safety

A session looking at what other industries have learned from their events and the common lessons for all complex high hazard industries.

Managing the Organizational and Cultural Precursors to Major Events — Recognising and Addressing Complexity

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Research at the University of Bristol, Safety Systems Research Centre [1] has drawn out the key organizational and cultural precursors leading to major events in several industries (nuclear, petrochemical, transport and major civil engineering projects). It has shown that these are strikingly similar. The research built on preliminary work reported to the IAEA in 2004 [2].

Organizational and cultural findings contributing to each event were assembled from the published reports for twelve events and grouped under eight generic headings. These were:

1. leadership issues;
2. 'local' operational attitudes and behaviours (operational 'culture');
3. the impact of the business environment (often commercial and budgetary pressures);
4. oversight and scrutiny;
5. competence and training (at all levels);
6. risk assessment and risk management (also at all levels);
7. organizational learning;
8. communication issues.

From the findings, sets of 'Expectations' were then developed as statements of good practice, which if recognised and implemented, should enable organizations to build stronger defences against the occurrence of future events. To probe operational reality, these were reformulated and developed into sets of draft 'penetrating' questions which explore whether 'reality aligns with expectation'. Initial work has been carried out to refine some of these expectations and question sets by working with industry and further work is planned. The questions can be used by both duty holders and regulators to assess the vulnerability of organizations ('condition monitoring'). Examples will be given in the presentation and full paper.

To enable organizations to address these often neglected factors, new tools are being developed that can be employed to address the risks systematically. This might be regarded as analogous to the use of systematic processes (e.g., fault and event trees) to assess risks arising from engineering and human factors-related issues. An illustration will be given of the use of Hierarchical Process Modelling (HPM) to develop a vulnerability tool using the question sets. However, to understand the issues involved more fully, requires the development of models and associated tools which recognise the complexity and interactive nature of the organizational and cultural issues involved.

Various repeating patterns of system failure appear in most of the events studied. Techniques such as System Dynamics (SD) can be used to 'map' these processes and capture the complexity involved. This highlights interdependencies, incubating vulnerabilities and the impact of time lags within systems. Two examples will be given.

In almost all of the events studied, there has been a strong disconnect between the knowledge and aspirations of senior management and those planning and carrying out operations. There has, for example, frequently been a failure to ensure that information flows up and down the management chain are effective. It has often led to conflicts between the need to maintain safety standards through exercising a cautious and questioning attitude in the light of uncertainty and the need to meet production and cost targets. Business pressures have led to shortcuts, failure to provide sufficient oversight so that leaders are aware of the true picture of process and nuclear safety at operational level (often leading to organizational 'drift'), normalisation of risks, and the establishment of a 'good news culture'. The development of this disconnect and its consequences have been shown to be interdependent, dynamic and complex.

A second example is that of gaining a better appreciation of the deeper factors involved in managing the supply chain and, in particular, of the interface with contractors. Initiating projects with unclear accountabilities and to unrealistic timescales, together with a lack of clarity about the cost implications when safety-related concerns are reported and need to be addressed, have been identified as particular vulnerabilities. Initial work on modelling has shown that the factors involved are both complex and inter-related, but learning from the research is being used to develop good practice. Examples will be given of the use of SD to provide new insights into the dynamics and complexity involved, and to provide new tools for assessing the implications of making changes ('flight simulation'). It should also enable more informed choices to be made about the most useful indicators to measure before actions are taken which can have unintended consequences — leading, in the worst scenarios, to major events.

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Evolution of Radiation Safety Culture in Africa: Impact of the Chernobyl Accident

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The use of ionizing radiation in Africa is more than a century old but the awareness for radiation safety regulation is still a work in progress. The nuclear weapon tests carried out in the Sahara Desert during the early 1960's and the resultant radiation fallout that drifted into West Africa with the northeasterly winds provided the first organized response to the hazards of ionizing radiation in Nigeria. The Nigerian Government in 1964 established the Federal Radiation Protection Service (FRPS) at the Physics Department of the University of Ibadan but without the force of law. In 1971, draft legislation on Nuclear Safety and Radiation Protection was submitted to Government for consideration and promulgation. It never went beyond a draft until June 1995 only after IAEA intervention!

The April 1986 Chernobyl nuclear accident unfortunately did not provoke as much reaction from African countries, probably because of geography and climate: Africa is far from Ukraine and in April the winds blow from SW–NE, unlike if it had happened in December when the wind direction would have been NE–SW and Africa would have been greatly impacted with little or no radiation safety infrastructure to detect the radiation fallout or to respond to it; and weak economic infrastructure to mitigate the economic impact of such radioactive deposits on agriculture and human health.

Africa was shielded by both geography and climate; but not for long. By 1988, some unscrupulous businessmen exported to Nigeria and to several African countries radiation contaminated beef and dairy products which were meant for destruction in Europe. This led to the establishment of laboratories in several African countries for the monitoring of radiation contamination of imported foods. Fortunately, the international response to the Chernobyl accident was swift and beneficial to Africa and largely spurred the establishment of radiation safety infrastructure in most if not all African Member States.

Notably amongst the IAEA interventions towards the establishment of radiation safety infrastructure are the RAPAT missions and the Model Project on "Strengthening Radiation Protection Infrastructure". The Model Project (1994–2004) aimed at assisting Member States in meeting the requirements of the international basic safety standards. The Model Project achieved much but its closure in 2004 compelled regulatory bodies in Africa to search for alternative mechanisms for building on the success of the Model Project and find ways and means of expanding the scope of the Model Project but without the sole sponsorship of or promotion by the Agency by taking ownership of radiation safety infrastructure in their countries. This resolution led to several discussions and consultations among regulatory bodies in the region which culminated in 2009 into the formation of the Forum of Nuclear Regulatory Authorities in Africa. The IAEA RASSIA Missions and the IRRS Missions provide the opportunity to peer-review the radiation safety infrastructure and promote continuous improvement.

The ultimate goal of all these efforts is the emplacement of a sustainable radiation safety culture, which is a fabric that can be woven with different fibres: legislation, institutions, manpower, national and international support, etc. Development of radiation safety infrastructure in Africa and indeed the evolution of the radiation safety culture in the region is indeed work in progress.

Patient Safety, Present and Future

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Healthcare tends to oversimplify patient safety concepts. We tend to think about patient safety as a linear dimension that is only associated with the progressive reduction in the number of errors and accidents, with the simple notion that fewer are always better. We consider figures in isolation from the underlying context and prerequisites that drive safety models and the reality of the clinical fields. There is no one ultimate reference model of safety, but many models that can be adapted to fit the various clinical fields requirements and constraints. It is therefore not necessarily a bad result to observe a lower safety figure in a medical domain compared to the figures obtained in nonmedical ultra-safe models. The poor figures may represent the best local safety optimization while coping with the special healthcare requirements such as a high frequency of unplanned and nonstandard challenges. The paper distinguishes three classes of safety models that fit different field demands: the resilient and adaptive model, the high reliability (HRO) model, and the ultra-safe model. The lecture benchmarks the traits of each model while highlighting the specific dimensions for optimization. The conclusion is that firstly, that since the task requirements dictate the relevance and choice of the model and not the other way around, it is counterproductive to impose a model that is inadequate for the task requirements. Either you move the requirements and change the model, or you keep the constraints, and try to locally optimize the model to the clinical and organizational needs.

TO1: Learning from the Past, Going Forward

In this session, speakers share their own organizations' stories of learning from the past and what can be improved for the future.

Enhancing Organizational Effectiveness in Research Reactors

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Bearing in mind even one simple definition of "organization" as a social unit of structured people working together in a managed manner to achieve some common goal which is the purpose of establishing that organization, we can understand the importance of the matter in achieving goals. Organization of the nuclear complex shall be considered, by all stakeholders not only in national scale but also in international relations and communities, as one of the most important pillars of the effective and reliable, safe and secure use of the nuclear technology. Effectiveness of the nuclear technology is obtained through a good, safe and secure technology, skilled and committed personnel who work well in interaction with technology and a good and established organization which conducts and regulates activities upon whole of the complex system via management and leadership in harmonised manner. Although, effectiveness of the nuclear complex is a complicate function of the above mentioned affecting factors, but a good organization besides solving its day to day business, can minimise the problems, resolve or eliminate unnecessary challenges and save resources and energies and help to identify issues and difficulties.

Simply viewed, any organization has a theoretical base and consists of necessary elements. In order to be effective one organization first of all shall include good theoretical base, then armed with good instruments and then shall be run well. Enhancing the effectiveness of any organization can be achieved by enhancing any of the above mentioned elements individually or collectively in a harmonic way.

For improving the Research Reactors effectiveness as a nuclear complex or facility in order to satisfactorily meet research and production needs, we must work in some different areas in parallel and simultaneously including technical, administrative, organizational and human resource issues. First we should identify and fix the real situation in all interested subjects and areas and to identify gaps and problems, in other words a comprehensive self-assessment. After identifying and fixing the issues we should investigate solutions for each issue and decide about the best recommended solutions. During this period we should determine some necessary requirements for each solution to be able to evaluate and assess each solution individually and in comparison with others and to make decision. After decision and introducing solutions to the system and implementing them for a limited period as a "testing instrument" we should use feedbacks and identifiers in order to evaluate the selected solution.

For enhancing the effectiveness of the organization in relation to human resource activities, we introduced some changes in the following areas: organizational chart, internal working procedures, establishing consultancy committees and some activities in direct relation with human resources including spiritual, training and education programs as well as the job trainings. Currently work is implemented and after that we shall evaluate the results, but up to now briefly we understood that selected way helped us to improve our organization.

An Evaluation Method for Team Competencies to Enhance Nuclear Safety Culture

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Safety culture has received attention in safety-critical industries, including nuclear power plants (NPPs), due to various prominent accidents such as concealment of a Station Blackout (SBO) of Kori NPP unit 1 in 2012, the Sewol ferry accident in 2014, and the Chernobyl accident in 1986. Analysis reports have pointed out that one of the major contributors to the cause of the accidents is 'the lack of safety culture'. The term, nuclear safety culture, was firstly defined after the Chernobyl accident by the IAEA in INSAG report no. 4, as follows "Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted their significance."

Afterwards, a wide consensus grew among researchers and nuclear-related organizations, that safety culture should be evaluated and managed in a certain manner. Consequently, each nuclear-related organization defined and developed their own safety culture definitions and assessment methods. However, none of these methods provides a way for an individual or a team to enhance the safety culture of an organization. Especially for a team, which is the smallest working unit in NPPs, team members easily overlook their required practices to improve nuclear safety culture. Therefore in this study, we suggested a method to estimate nuclear safety culture of a team, by approaching with the 'competency' point of view.

The competency is commonly focused on individuals, and defined as, "underlying characteristics of an individual that are causally related to effective or superior performance in a job."

Similar to safety culture, the definition of competency focuses on characteristics and attitudes of individuals. Thus, we defined 'safety culture competency' as "underlying characteristics and outward attitudes of individuals that are causally related to a healthy and strong nuclear safety culture". Based on individual safety culture competency, team safety culture competency was defined similarly, but more focused on shared values among team members. The definition of team safety culture competency is defined as follows; underlying and sharing characteristics, outward attitudes, and pattern of behavior of team members that are causally related to a healthy and strong nuclear safety culture.

In the first step of this study, we derived team safety culture competencies. To this end, the strategic success modeling (SSM) method was used to satisfy the criteria of existing international and domestic safety culture assessment methods. Through SSM, we derived a total 52 competencies for a general team in NPP.

In order to evaluate the competencies of a team, Social Network Analysis (SNA) was chosen, which a strategy for investigating the relationship through the use of network and graphical elements. SNA has a strength in that the pre-modeling of composing elements is not required. The result of SNA itself shows the relationship among elements of team safety culture competencies.

Observation data of a team is gathered from a qualified observer, within a given observation criteria. Data are arranged in rows for each team member and in columns for the numbers of observed inappropriate team safety culture competencies. Then the matrix is operated to derive the density of team members, and the degree centrality of team safety culture competencies, which could represent the degree of deficient team safety culture competencies among team members, in numerical and graphical ways.

It is expected the proposed evaluation method of team safety culture competencies not only provides concrete practices to enhance safety culture, but also enables to analyze the shared values and the underlying characteristics of team safety culture.

Interrogations to Learn from the Fukushima Accident

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On March 11, 2011, an earthquake in eastern Japan caused the reactors in operation at the Fukushima Daiichi nuclear power plant (NPP) to trip. The emergency generators started and then suddenly failed following the tsunami. The cooling water injection system no longer worked. Suddenly plunged into total darkness, the operators had to manage the accident.

Starting from the official reports and testimonies on the Fukushima accident, IRSN has conducted a survey "Human and Organizational Factors Perspective on the Fukushima Nuclear Accident."

Four years after the accident, however, as more witness accounts become available, IRSN feels it useful to return to the human and organizational response to the accident inside the NPP itself. To what extent can the participants act and coordinate their actions when faced with such a dramatic situation? To what degree did their actions contribute to the disaster?

Rather than looking at the causes of the accident, this study examines the unfolding of the crisis, particularly in the most urgent early stages, and draws lessons for safety culture from the decisions and actions of key actors. The main results would be presented in three key areas:

1. How to make sense of the situation? People had to make sense of what happened and create new indicators. Since instruments and controls, as well as many communication technologies, were knocked out by the tsunami, all the standard means of determining the status of the reactors were impossible. Although they were under normal circumstances almost completely dependent on these indicators, and although (or because) their lives were most directly at risk, the operators managed this uncertainty through various means that will be successively presented.
2. What are the challenges for the emergency structure? The Emergency Response Center (ERC) operations team was responsible for being in contact with the operators in the control rooms and providing them technical support as needed. The ERC support was more difficult to provide than expected due to the conditions of the emergency. Different key issues would be proposed to support ERC for coordination and innovation in extreme situations.
3. What is the dynamic decision of the crisis? Beyond the firm's organization will be examined the relationship of the utility with a still larger organization involved in the response to the accident: the Japanese government. How the different stakeholders are able to cooperate in addressing the challenges entailed by the accident, adjusting their actions and making decisions accordingly?

Developing and Strengthening of Safety Culture at Ukrainian NPPs: Experience of NNEGC "Energoatom"

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The moratorium, which was introduced in Ukraine after the Chernobyl accident, for the construction of new nuclear power plants at the legislative level, was broken in 2004, when two new power units at Khmelnytsky and Rivne nuclear power plant were put into operation. Currently, the nuclear energy sector plays the main role for electric power industry of Ukraine. Ukraine has the intention to finish the construction of two new units at the Khmelnitsky nuclear power plant. NAEC "Energoatom", as the operating organization, is aware that the attitude and behavior of top management as well as organizational features and activities have a significant impact on the safety culture. In the management statement dedicated to nuclear safety establishment, NAEC declares the absolute priority of safety over other objectives, in accordance with the principles of safety culture.

Beginning with 2009, in scope with the IAEA recomendations, and based on the introduced in Ukraine in 2008 of the new revision of safety rules "General Safety of nuclear power plants", NAEC "Energoatom" activities for improving the safety culture are being carried out under special programs. There are three levels of management for this activities:

- Council on safety culture (top management);
- Working Group (representatives of all divisions of NAEC);
- Committees on safety culture (all NPP sites).

The programs are developed and updated every two years and the implementation of measures is provided on three levels of responsibility:

- Technical policy for the safety;
- responsibility and leadership obligations;
- personal responsibility and duties of every employee.

The main achievement of these programs has been to define and establish the strategy and a set of permanent measures which are aimed at improving the safety culture.

On the basis of corporate programs the plants developed the programs of concrete actions aimed at the establishment and development of a safety culture, including:

- Self evaluation of safety culture;
- Questioning the staff;
- Independent audits of safety culture.

NAEC "Energoatom" seeks to take into account international experience, and to participate in conferences (such as this one), seminars and workshops held under the auspices of the IAEA, as well as to follow the guidelines and standards of the IAEA in the organization of activities to improve the safety culture. Other sources of international experience in this field are the EU-funded projects of "soft" assistance and guidance of other authorised international nuclear industry organizations such as WANO. In this regard, it should be mentioned WANO guidance document GL 2002-02 "Principles of effective personnel organization" that identifies five fundamental principles relating to human factors, and important for the development of a sustainable safety culture in the organization:

- Even the best experts make mistakes;
- A situation fraught with errors is predictable, manageable and preventable;
- Human behavior is determined by organizational processes and values;
- Highest efficiency operation is achieved through the promotion and support;
- Violations can be avoided by understanding the causes of errors and implementing lessons learned.

Within the framework of the international programs of EC "soft" aid in recent years, the projects that contribute to the development of a safety culture in the NAEC "Energoatom" have been either carried out or are ongoing.

These projects include the solution of certain problems (for example, in the area of human factor — the task of "no punishment for error" approach establishment), as well as more common tasks of improving overall safety culture, such as:

- Implementation of programs to inform senior staff and management, including the essential features needed to create a strong culture of safety; creating conditions for the improvement of the organizational and managerial impact on the safety of nuclear power plants and the development of a deep understanding of the importance of safety approach and the practical realisation of the principles of safety culture in production activities;
- Creating an atmosphere of fruitful cooperation between management and staff, the improvement of collective action and of the behavior, developing a positive safety culture;

Currently NAEC "Energoatom" is making efforts to improve the effectiveness of the implementation of these projects; to analyse the emerging issues in the implementation of project both at the pilot nuclear power plant and during its subsequent extension to the rest of the NPP; to conduct generalization, systematisation and integration of the results of these projects into a single management system of safety culture for NAEC "Energatom".

Realizing the importance of safety culture to achieve the goals of safety, as well as performing for many years a whole range of measures to improve safety and to improve the safety culture, NNEGC "Energoatom" considers the need for constant attention to safety culture at all organizational levels to be the key to success, and the main driving mechanism of progress and development in this area — wide awareness of international experience and achievements in improving the safety culture, their integration and implementation in your organization.

PL2: The Current Status

This plenary session shares lessons on organizational aspects of safety and looks at the current complexities of improving safety culture both in operating and regulatory organizations.

Plenary Dialogue: The Organizational Side of Safety

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Are We Concentrating on the Right Issues?

This plenary dialogue allows a conversation between key participants who have spent many years in the nuclear industry, are engaged in continuous improvement, and have applied different ways of promoting safety and safety culture within different nuclear organizations.

The aim of the dialogue is to allow the audience an insight into their thinking and their responses to each other's perceptions and spoken endeavours.

The central question "Are we concentrating on the right issues?" allows the conversation to explore whether the nuclear industry is distracted into the "easily fixed" or the "fashionable topics the day" which means we are not addressing wider issues or exploring new ideas and knowledge.

The audience will have the opportunity to ask questions to the panel and share their views.

Panellists:

M. Griffon	USA	HR2–04
G. Grote	Switzerland	PL2–04
M. Nishizawa	Japan	PL3–05
R. H. Taylor	UK	HR1–01

Social Science for Safety: What Is It and Why Do We Need It?

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Many prominent authors have distinguished several eras in safety science based on the predominant focus of safety measures taken. A technical focus was followed by attention devoted to human factors, which has now broadened to an organizational or socio-technical focus. Along with this changing focus the role of social science has changed. The move from the technological era to the human factors era was spurred by the increasing awareness that human strengths and limitations need to be taken into account when designing advanced technical systems. The subsequent broadening to an organizational perspective followed the general trend in management research where describing organizations as mechanistic, technology-driven systems was left behind in favor of capturing the complex interaction between social and technological processes that generates individual and organizational performance. As a consequence the knowledge from the social sciences that is relevant for promoting safety has expanded considerably. Not only psychological knowledge concerning individuals' abilities and attitudes as they relate to operating technical systems is important, but a broad range of theories and empirical findings from work and organizational psychology and social psychology, from the sociology of work and organizations, and even from political science in view of power relations in organizations and regulatory regimes.

Embracing the wealth of knowledge in the social sciences and applying it in the service of improved safety is a complex interdisciplinary endeavor. Most fundamentally it requires openness to different worldviews and the readiness to challenge long-held basic assumptions. Core to any safety management strategy are decisions on risk control. Different options for managing risk and uncertainty have different theoretical assumptions and belief systems embedded in them. Minimizing uncertainty is grounded in a mechanistic understanding of organizations, giving priority to central control. Acknowledging the inevitability of uncertainty in complex socio-technical systems leads to decentralising control capacity in order to empower local actors for handling uncertainty. From the perspective of learning organizations, even creating uncertainty may be considered desirable to enlarge adaptive capacity and foster innovation. The different conceptions of risk control tend to be prevalent in different professional (sub)cultures within organizations. While engineers and executives believe in uncertainty reduction through design and planning, operative personnel are acutely aware of the need for resilience in the face of only partially controllable uncertainties. Social scientists finally argue for promoting learning and innovation, thereby even adding uncertainty.

In the talk, examples of the wide range of relevant social science knowledge and its implications for safety management are given and methods discussed to stimulate the dialogue between different professions in ways that foster perspective taking and cross-learning. There is no turning back from the realisation that effective safety management has to build on evidence from technical and social sciences. The task ahead is to establish a culture of interdisciplinary appreciation which permits a truly integral approach to safety.

PNRA: Practically Improving Safety Culture within the Regulatory Body

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The prevalence of a good safety culture is equally important for all kind of organizations involved in nuclear business including operating organizations, designers, regulator, etc., and this should be reflected through the processes and activities of these organizations. The need for inculcating safety culture into regulatory processes and practices is gradually increasing since the major nuclear accident of Fukushima, Japan. Accordingly, several international fora in last few years repeatedly highlighted the importance of prevalence of safety culture in regulatory bodies as well. The utilisation of concept of safety culture remained applicable in regulatory activities of PNRA in the form of core values. After the Fukushima accident, PNRA considered it important to check the extent of utilisation of safety culture concept in organizational activities and decided to conduct its "Safety Culture Self-Assessment (SCSA)" for presenting itself as role model in-order to endorse the fact that safety culture at regulatory authority plays an important role to influence safety culture at licenced facilities.

Considering the complexity of cultural assessment starting from visual manifestations to the basic assumptions at the deeper level, PNRA decided to utilise IAEA emerging methodology for assessment of culture and then used modified IAEA normative framework (made it applicable for regulatory body) for assessing safety culture at a regulatory body. PNRA SCSA team utilised safety culture assessment tools (observations, focus groups, surveys, interviews and document analysis) for collecting cultural facts by including all level of personnel involved in different activities and functions in the organization. Different challenges were encountered during implementation of these tools which were tackled with the background of training on SCSA and with the help of experts during support missions arranged by IAEA. Before formally starting the SCSA process, pre-launch activities were carried out in order to prepare the organization for the cultural assessment activity.

After completion of safety culture self assessment at PNRA, the communication strategy was defined to share outcome of this assessment in the organization with the focus on developing dialogue and shared understanding. The safety culture improvement activities were designed to maintain and enhance strong areas of safety culture at PNRA and to address those areas that need attention in order to enhance safety consciousness.

This paper presents PNRA's experience of using IAEA emerging methodology for safety culture self assessment, challenges faced during the process and lessons learnt for further improvement in order to implement it more effectively in future. The paper also highlights strategy utilised for conveying outcomes of SCSA in the organization at different levels along with safety culture improvement activities.

The Power of Collaboration for Improving Safety in Complex Systems

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Many potentially hazardous industries involve systems that consist of a complex array of subsystems that must work together effectively in order for the entire system to perform. Often the subsystems are coupled, such that changes in any one subsystem can affect other subsystems. "System Think" refers to an awareness of the impacts throughout a system of changes in any subsystem.

The U.S. commercial aviation industry, in its continuing endeavor to improve safety, uses a collaborative approach to accomplish System Think — bringing all of the key parts of the industry together to work in a collaborative manner to identify and address potential safety concerns. The collaborative approach resulted in an 83% reduction in the fatal accident rate in only 10 years. It also demonstrated that, contrary to conventional wisdom that safety improvements usually hurt productivity, safety improvements that result from a collaborative approach can simultaneously improve productivity. Last but not least, it minimised one of the continuing challenges of making changes in complex systems, which is unintended consequences.

The purpose of this presentation is to describe the collaborative approach and to discuss its transferability to other potentially hazardous industries that are seeking to manage their risks more efficiently and effectively.

LM2: Leadership, Management and Culture for Safety

A session where organizations share their current activities for monitoring and developing leadership, management and culture for safety.

Entering into the Unexpected: Managing Resilience in Extreme Situations

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The popularity of the concept of safety culture has provided useful support for deterministic approaches to safety. The inclusion of 'beyond design' cases in severe accident management guidelines opened up the debate on the precautionary principle. However, a reflexive and vibrant safety culture should not stop there: even the most precautionary measures can prove to be lacking.

Our discussion therefore focuses on the management of radical disruption caused by the collapse of pre-established frameworks for action. It goes beyond any objectivist consideration of the necessary conditions for rational decision-making in the event of an accident. Here, we are interested in 'extreme situations'. Specifically, a management situation faced by operators who, should they lose control of their production facility, must take action despite the hazards and the lack of critical resources. They must respond to a social emergency that, if not satisfactorily resolved, will lead to damage on a scale never before seen. The Fukushima Daiichi accident is a useful case study of such a scenario. The short period from 11 to 15 March 2011 contains all of the ingredients of an extreme situation that was the result of an unexpected event.

From the perspective of the management of engineering organizations, the question of entry into resilience arises. Prior to any normative prescription, this concerns the poorly-understood mechanisms through which collective action develops in response to hazards and social pressure. In particular we study the sensemaking process through which actors regain control of the situation, and create an informal and ephemeral organizational kernel. The issue is addressed in terms of the human being as a whole, a subject whose actions are consistent with a defined purpose and affects and who is endowed with a representational capacity.

Our epistemic perspective is constructivist and relies on the latest theoretical developments related to sensemaking. In terms of methodology, we take an interdisciplinary approach driven by a narrative analysis tool for designing cognitive models, which is useful for the analysis and exploration of phenomena. The approach is comparative and rooted in the contextual examination of cases; theory is developed using a process that iterates between empirical data and concepts from a broad range of disciplines (sociology, history, philosophy, science and technology studies).

Our work shows the need to go beyond a purely cognitive sensemaking approach, and integrate the macro and meso scales, the material context and the embodied dimension of the making of sense. We propose an interpretative model that integrates these aspects and captures the transition from a 'normal' situation to a crisis. We also identify some initial lessons in terms of the management of extreme situations and propose some avenues for future research.

Safety Culture in Rosatom State Atomic Energy Corporation

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The paper presents Rosatom State Atomic Energy Corporation (hereinafter "Rosatom") current activity in safety culture enhancement. After the Chernobyl accident individual commitment to safety, organizational factors influencing on safety were put under more significant attention. Safety culture (hereinafter "SC") should be considered like a resource to provide safety in nuclear facilities. The resource potential is in minimisation of breaches by development and existing that patterns of human performance and organizational behavior which form attitude to safety as an overriding.

During 2013–2015 Rosatom implemented the following arrangements and activities:

1. Project "SC enhancement system introduction" has been prepared and started;
2. VIII International nuclear forum with main focus on SC issues;
3. Training courses on SC are developed and agreed with Rosatom;
4. Strategic sessions on SC enhancement system introduction;
5. Rosatom policy on SC enhancement developed;
6. List of Rosatom Values developed and introduced. Safety is one of them;
7. List of KPI related to SC enhancement activity for managers developed and introduced;
8. Implementation of local SC related projects;
9. Trainings implementation.

Nowadays in Russian Federation legislation there are few documents which regulate SC activity in nuclear industry:

- State Policy Basics to support nuclear and radiation safety up to 2025 (approved by President of Russian Federation in March 2012);
- Federal Regulation "Basics of nuclear facility safety support" (approved by regulatory body in 2006);
- Safety Culture Assessment Guide (approved by regulatory body in 2006);
- Regulation on nuclear facility psychological laboratory to support personnel reliability (approved by government in August 2000).

Realizing State Policy Basics Rosatom developed and plans to introduce SC Enhancement System for all nuclear facilities in Russian Federation. Rosatom General Inspector Service is responsible to manage the activity. In order to reach the goal the project "SC Enhancement System Introduction" was lunched with a main goal: to create conditions for continuous SC enhancement: on organizational level, to provide organizations with processes and tools addressed to form and develop commitment for safety when human performance; on manager level, to provide with competences to develop "cultured" people; on individual level, to provide clear understanding of strong SC characteristics and attitude for safety as realised need.

The project outcomes:

- regulations and guides on SC enhancement (regulations: policy in SC, regulation on SC formation and improving; guides: SC enhancement system introduction, SC level monitoring, organizational factors influencing on SC, personnel commitment to safety improvement, informational support of safety culture issues);
- training courses;
- corporate knowledge base on SC issues;
- reports on SC enhancement system introduction;
- safety culture improvement plan;
- web-site on safety culture issues;
- safety commitment visualisation means (memo, booklets, posters, videos);
- results of introducing SC enhancement system in main Rosatom divisions: nuclear energetic complex, nuclear weapon complex, uranium concentration, nuclear ice breakers, nuclear fuel manufacturing, uranium mining. The project outcome: local policies, local regulations, generalized SC models, organizational chart, trained personnel, external SC assessment reports.

Nowadays the project is in progress. In the same time some of nuclear facilities implemented activities in SC area. Moreover Joint Stock Company "Rosenergoatom", Joint Stock Company "Rusatom Overseas", other ROSATOM organizations implement local SC related activity.

There are few organizations in Russian Federation who support nuclear facilities in SC issues: Rosatom central institute for continuing education and training (CICET), Science Research Center "Prognoz", Scientific and Engineering Centre for Nuclear and Radiation Safety (SEC NRS).

Main goal of CICET activity is to support nuclear facilities in competitiveness and safety increasing by personnel training, science researches and science-technical arrangements in accordance with customer's requirements and Rosatom corporate standards. In SC area CICET has developed few training courses. Moreover, CICET starting from 2012 holds International Summer School on SC. The mission of the school is to promotion and development of the methodology and SC practice in organizations that use dangerous technology to provide high reliability and effectiveness their operations. Also there are few R&D organization which support Rosatom organizations: Science Research Center "Prognoz", Scientific and Engineering Centre for Nuclear and Radiation Safety (SEC NRS). In the nearest future ROSATOM plans to begin SC enhancement process integration into ROSATOM management system: introduce SC Policy like a part of Safety Policy, develop and introduce regulations, instructions and guides on SC enhancement.

Safety Culture Monitoring: How to Assess Safety Culture in Real Time?

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Do you know what is current level of safety culture in your company? Are you able to follow trend changes? Do you know what your recent issues are?

Since safety culture is understood as vital part of nuclear industry daily life, it is crucial to know what the current level is. It is common to perform safety culture survey or ad hoc assessment. This contribution shares Temelin NPP, CEZ approach how to assess safety culture level permanently. Using behavioral related outputs of gap solving system, observation program, dedicated surveys, regulatory assessment, etc., allows creating real time safety culture monitoring without the need to perform any other activities.

Leadership and Safety Culture: An INPO Perspective

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The mission of INPO is to foster a culture of safety and reliability in the nuclear industry and it has been supporting nuclear power plants for over 30 years. Although our industry is characterised by long-term success, plants sometime exhibit performance decline, often slowly, but in some cases, quickly. The link between the presence of effective leadership teams and high levels of sustainable performance is supported by numerous examples throughout our industry's history. Unfortunately, at times, site and corporate leaders are either unaware of the declines or are slow to react to them.

INPO has identified that weak leadership teams and weak organization cultures have continued to challenge industry performance and have been identified as key drivers of plant declines. After reviewing industry strengths and areas for improvement, interactions with high-performing organizations, and applicable research, nine leadership attributes and five team attributes were commonly associated with high performance. INPO has captured these attributes in the document "INPO 15–005, Leadership and Team Effectiveness Attributes" to help the industry more quickly identify weak leadership behaviors to help prevent plant performance declines.

This presentation covers the rationale behind the development of INPO 15–005 and the contents of the model. It identifies the standards of effective leadership and teams within the framework of the commercial nuclear industry and describes observable attributes seen in effective organization.

SA2: Systemic Approach to Safety

A session that shares the current developments of taking a systemic approach to safety into practice. Different systemic assessments will be presented and how the outcome can practically support enhancement of safety performance.

Institutional Strength in Depth

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Much work has been undertaken in order to identify, learn and implement the lessons from the TEPCO Fukushima Daiichi nuclear accident. These have mainly targeted on engineering or operational lessons. Less attention has been paid to the institutional lessons, although there have been some measures to improve individual peer reviews, particularly by the World Association of Nuclear Operators, and the authoritative IAEA report published in 2015 brought forward several important lessons for regulators and advocated a system approach. The report noted that one of the contributing factors the accident was the tendency of stakeholders not to challenge. Additionally, it reported deficiencies in the regulatory authority and system. Earlier, the root cause of the accident was identified by a Japanese independent parliamentary report as being cultural and institutional. The sum total of the institutions, the safety system, was ineffective.

While it is important to address the many technical and operational lessons these may not necessary address this more fundamental lesson, and may not serve to provide robust defences against human or institutional failings over a wide variety of possible events and combinations.

The overall lesson is that we can have rigorous and comprehensive safety standards and other tools in place to deliver high levels of safety, but ultimately what is important is the ability of the nuclear safety system to ensure that the relevant institutions diligently and effectively apply those standards and tools — to be robust and resilient. This has led to the consideration of applying the principles of the strength in depth philosophy to a nuclear safety system as a way of providing a framework for developing, assessing, reviewing and improving the system.

At an IAEA conference in October 2013, a model was presented for a robust national nuclear safety system based on strength in depth philosophy. The model highlighted three main layers: industry, the regulator and stakeholders. Crucial elements in the model included the interactions between the various layers and an underlying commitment of all players to strong leadership for nuclear safety (involving openness, transparency, accountability and challenge), and the nurturing of safety cultures in all. This has since been explored in more detail by INSAG, and various crucial components have been investigated at Cambridge University and elsewhere. This talk presents an update on this work in the context of the recent authoritative IAEA report.

Systemic Approach to Safety from a Regulatory Perspective

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In Sweden and especially in the Swedish oversight of nuclear power plants there has been a strong commitment to the interactions between Man–Technology–Organization (MTO) for many years. Safety issues and the importance of working with these issues have often been highlighted in specific oversight actions. Since 30 years there has been a tradition and a development of experience in Sweden taking a systemic MTO approach to safety. Inspection teams have been created with both psychologists and technical expertise in order to cover the whole MTO perspective during oversight inspections at the nuclear power plants.

Safety is based on preventive actions where both technology and human behaviour are taken into account. To do this, it is important to have knowledge about the different factors that influence the performance of individuals, groups and organizations. However, it is also important to remember to not only discuss humans, management and organizations in terms of their limitations, errors and shortcomings but also in terms of their strengths in stopping a chain of events, in learning, inventing and improving.

Having an integrated view of safety, focussing on the relations between human, technology and organization (MTO) refers to a systemic perspective on how radiation safety are affected by the relationship between: Human's abilities and limitations; Technical equipment and the surrounding environment; The organization and the opportunities this provides.

The Section of Man–Technology–Organization in the Swedish authority consist today of 12 Human factors specialists with behaviour science education. The section is responsible for the oversight at nuclear power plants in many areas; safety management, leadership and organization, safety culture, competence assurance, fitness for duty, suitability, education and staffing, knowledge management, working conditions, MTO perspective/ergonomics of control room work and plant modification, incident analysis and risk analysis from the MTO-perspective and learning from experience (operational experience).

The SSM (Swedish NS Authority) regulations concerning safety in certain nuclear facilities have explicit requirements and general recommendations in the above-mentioned areas. These requirements and general recommendations are to a large extent based on the IAEA safety standards.

Making Safety Culture a Corporate Culture

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Safety Culture is something that we have actively worked with in the nuclear industry for a long time. Formally, it has been on the agenda since the Chernobyl accident. However, the work with creating a safe organizational culture can of course be traced back even further in time. Over the years a lot has happened in how we are approaching the concept of safety culture and especially how we look upon the human being as a part of the system and how we as humans interact with the organization and technology.

For an organization to have a culture that promotes safety it is essential to create an ownership of safety with all workers within the site. To create this ownership it is vital to have the undivided commitment of the management. It all starts with the fundamental values of the organization. These values must then be concluded in firm expectations of behaviors that apply to all workers and management. This could be referred to as expectation of a Professional Behavior that allows us to live up to the company values.

At OKG nuclear power plant, a successful Business Improvement Program was recently carried out with intention to develop and contribute to the maturity of the organization in terms of safety. One of the sub-programs of the program was called Professional Behavior – With purpose of making safety into a corporate culture. At OKG, Safety culture is something that systematically been addressed and worked with since 2004. Even though the Safety Culture program could be considered to already have reached a certain level of maturity the Business Improvement program helped the organization to lay the foundation for further development by clarify expected behaviors that was firmly cemented in to the corporate values.

There are of course many aspects that are important to help us create an organizational climate which will promote the safety culture efforts. It is not as easy as just stipulating a number of values and expectations of behavior. This could only be considered the foundation for success. Hence, to get a positive effect it is very important to have a certain frame of mind when it comes to safety and the development of a safety conscious organization. First of all safety is nothing that "we have" safety is something that we continually "do"! Furthermore, Safety is not only the absence of accidents and incidents; Safety is to understand what normally makes us succeed with what we do every day!

To help keep this organizational frame of mind alive there are a few helpful attributes for integrating state of the art safety in the outline for the future work within the field of safety culture. Examples of these traits are:

- Human error seen as symptom and not as cause. Human error is a symptom of trouble deeper inside a system. This means that apart from the human error identified, there are explanations for the factors that influenced human performance. (This does not cancel responsibility and accountability of workers and managers.)

- Avoidance of hindsight bias. We try to understand the course of events from the place of the actors and not as external observers.
- Shared responsibility. Both good and adverse outcomes result from interdependencies and interactions of all organizational functions.
- Focus on success rather than solely on failures. We need to understand how employees perform well under constantly changing conditions and conflicting goals.

These attributes (or tools) should lay as a foundation in the view of how the organization will reach higher and safer effects regarding safety culture efforts.

Accidents or "bad things" in the organization are not created by a combination of latent and active failures; they are the result of humans and technologies operating in ways that seem rational at a local level but unknowingly create unsafe conditions within the system that remain uncorrected. From this perspective, simply removing a 'root cause' from a system will not prevent the accident from recurring. To further develop our safety Culture efforts a more holistic approach is required whereby safety deficiencies throughout the entire system must be identified and addressed. An understanding of this is significant for the future development of our Safety Culture.

We must also stop treating safety as something we have or not-have. Safety is something that we continually are doing! This culture is set by the corporate management through Values and Behavioral expectations. The ownership of this culture is however something that must be in every workers possession!

Perspective on Human and Organizational Factors (HOF) - Attempt of a Systemic Approach

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The presentation will raise questions concerning current conceptions and practices related to human and organizational factors and will focus on the need of a more systemic view and approaches in the nuclear industry.

In practice, attention is often focused unilaterally on technical aspects, neglecting the interactions and interfaces between the organization, the people and the technology. The work in the different areas takes place with different approaches, based on different technical backgrounds but also on different cultures of the country, the company, the plant, etc. Also within the concept of defence-in-depth the attention normally lies on the technical safety levels, although similar provisions exist in the organizational field.

While the technical systems are always evolving and their reliability increases, the question of their implications for the organizations and the people who work with these systems is not always analysed in depth. Also, it should not be focused only on the staff in the control room. Attention must be directed also to the support organizations (maintenance, analysis, monitoring, etc.) and to the manufacturer, which play a significant and sometimes underestimated role in the overall system as well.

Further, there is a tendency to reduce the complexity by looking at individual aspects such as “safety culture”, “resilience”, “management systems”, “training”, “organizational structure”, etc., often without going beyond into a systemic approach. This requires the involvement of all different disciplines. Hence, dealing with the issue of HOF also means creating a basis to understand the complexity of the interactions between human, organizational and technical aspects. For this a very good knowledge and solid experience in these different fields are required.

The presentation will give some examples from other industries and the three major nuclear accidents of Three Mile Island, Chernobyl and Fukushima as an illustration with the focus being laid on the organizational causes.

Reinforcing Defence in Depth: A Practical Systemic Approach

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The concept of defence in depth for ensuring nuclear safety of nuclear installations is often oversimplified and interpreted as a set of physical barriers, whose integrity is ensured by safety provisions in the form of the plant systems implemented independently at various levels of defence. However, the provisions established at each level of defence should in general terms include not only hardware components (active and passive systems), but more comprehensively, also inherent safety characteristics, safety margins, operating procedures and guidelines, quality assurance, safety culture, staff training, and many other organizational measures as parts of management of safety.

Many of the above mentioned provisions belong to the category of human and organizational factors. While various hardware components are typically specific for different levels of defence, human and organizational factors may have an impact on several levels of defence. These factors are associated with large uncertainties and can result in latent weaknesses. Their implementation can negatively affect several levels of defence at the same time. The proposed paper will underline the need for a more comprehensive view of the defence in depth concept in order to provide a practical and effective tool for a systemic approach to safety.

The paper will consist of two main parts. The first part will introduce a screening method developed by the IAEA as a tool for facilitating the assessment of the comprehensiveness of defence in depth. The method uses screening of safety provisions at five levels of defence to ensure integrity of the physical barriers and achievement of safety objectives at each level of defence. The second part of the paper will focus on human and organizational factors considered as provisions for reliable performance of safety functions. It will explain the significant shift in the demands on the human system between levels 3 and 4 of the defence in depth framework, and will emphasise the necessity of cultivating a strong human system during normal operating conditions in order to be able to deliver needed resilience at levels 4 and 5. Directions for further strengthening of the role of human and organizational factors in the defence in depth will be indicated.

HR2: Other High Reliability Organizations' Approaches to Safety

A session that shares the approaches to enhance resilience capacities and safety culture in other industries and regulators, and compares with the nuclear industry.

Safety Culture: A Requirement for New Business Models — Lessons Learned from Other High Risk Industries

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Technical development and changes on global markets affects all high risk industries creating opportunities as well as risks related to the achievement of safety and business goals. Changes in legal and regulatory frameworks as well as in market demands create a need for major changes. Several high risk industries are facing a situation where they have to develop new business models. Within the transportation domain, e.g., aviation and railways, there is a growing concern related to how the new business models may affects safety issues. New business models in aviation and railways include extensive use of outsourcing and subcontractors to reduce costs resulting in, e.g., negative changes in working conditions, work hours, employment conditions and high turnover rates. The energy sector also faces pressures to create new business models for transition to renewable energy production to comply with new legal and regulatory requirements and to make best use of new reactor designs. In addition, large scale phase out and decommissioning of nuclear facilities have to be managed by the nuclear industry.

Some negative effects of new business models have already arisen within the transportation domain, e.g., the negative effects of extensive outsourcing and subcontractor use. In the railway domain the infrastructure manager is required by European and national regulations to assure that all subcontractors are working according to the requirements in the infrastructure managers SMS (Safety Management System). More than ten levels of subcontracts can be working in a major infrastructure project making the system highly complex and thus difficult to control. In the aviation domain, tightly coupled interacting computer networks supplying airport services, as well as air traffic control, are managed and maintained by several different companies creating numerous interfaces which must be managed by the SMS. There are examples where a business model with several low-cost subcontractors can turn out to be much more expensive due to interface proliferation. Other negative effects are social dumping by external contractors and loss of competence if procurement requirements are not taking quality and safety issues into account.

Based on MTO Safety's extensive experience in the nuclear domain and work on safety management and safety culture in the aviation, railway and maritime domain, the paper will present lessons learned which are applicable to the nuclear industry for facing the major challenges ahead.

Assuring safety is a fundamental requirement for obtaining a licence to operate a business in nuclear power, aviation and railways, thus safety culture is an essential requirement for a successful business. Therefore safety culture must be part of any new business model in high risk industries. In the future safety culture and leadership commitment and skills in creating safety culture will be even more important. The paper will discuss how companies and public utilities are to achieve this and how the regulators are to assess this where learning across industries is a key success factor.

Current Approaches of Regulating Radiological Safety of Medical and Industrial Practices in Romania

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The principal document regulating the radiological safety of ionizing radiation application in Romania is the "Fundamental Norms for Radiological Safety". These norms establish the requirements concerning the assurance of radiological safety of occupational exposed workers, population and environment, in accordance with the provisions of Law 111/1996 on the safe deployment of nuclear activities, republished. Justification of practices for all new practices which lead to exposure to ionizing radiation shall be justified in writing by their initiator, underlining their economic, social or other nature advantages, in comparison with the detriment which they could cause to health. CNCAN authorise these practices, provided that they consider the justification as being thorough.

The applicant, respectively the authorisation holder, has to demonstrate that all actions to ensure radiation protection optimization are undertaken, with a view to ensure that all exposures, including the potential ones, within the framework of practice developed are maintained at the lowest reasonable achievable level, taking into account the economic and social factors: ALARA principle.

Specific provisions are set in order to ensure that radiological safety principles are integrated into all the activities, and that safety is a clearly recognised value. Limitation of doses and dose constraints for exposed workers (including during pregnancy and breastfeeding women) and for population are set. In exceptional circumstances, excluding radiological emergencies, CNCAN may authorise individual occupational exposure of some identified workers exceeding the effective dose limit.

Exposure of the population as a whole, caused by the nuclear practices, is kept as low as reasonably achievable, the economic and social factors being taken into account. General requirements for medical surveillance of occupational exposed workers are also set. The significant increase of exposure due to natural radiation sources is identified through measurement and verification, consequences are to be evaluated.

Specific regulations are developed for medical and industrial activities and practices, including norms on operational radiation protection for the development of the non-destructive testing practice with the ionizing radiation apply to the those NDT practices, which involve the risk of exposure to ionizing radiation arisen from the use of the: devices that contain sealed sources, X-ray generators, and electron accelerators. There are provisions in the Operational Radiation Protection System, describing the organization structure, and clearly indicating the authority and responsibilities for radiation protection and radiological safety. The licencee shall establish and implement a training program that includes the description of the system of radiation protection operational procedures, the risk to human health associated with the deployed activity, significance of the warning means, instructions on the use of installations and dosimetric monitoring devices etc.

Radiation Safety Norms in Radiotherapy Practice are applicable to human medical radiotherapy practice, involving the risk of ionizing radiations exposure, when using the radiotherapy equipment. According to the provisions of these norms, in every medical unit where radiotherapy is performed, a safety culture shall be implemented, in order to encourage an active attitude and the wish to learn how to improve the safety and radiation protection knowledge and to discourage the self-complacency. In order to comply with these requirements, the authorisation holder shall draw into an effective safety and protection policy, especially at management level and shall effectively and actively support the persons with radiation protection responsibilities. This commitment shall be expressed by a written policy statement stipulating the importance of radiotherapy protection safety and emphasising that the main aim is the medical treatment and patient safety. This policy statement shall be known by the management of the medical unit, by the medical personnel and has to be followed by a radiation protection program that shall include a quality management program and by maintaining a safety culture in the institution.

Norms of Radiological Safety on Diagnostic and Interventional Radiology Practices detail and complete the basic requirements for radiological safety established in "Radiological Safety Fundamental Norms", and other applicable national norms. In these regards, in every facility in which diagnostic and interventional radiology practices are in use, a safety culture is to be implemented and maintained in order to encourage an active and learning attitude to protection and safety and to discourage complacency. To comply with this requirement, the licencee shall be committed to an effective protection and safety policy, particularly at managerial level and by clear demonstrable support for the persons with direct responsibility for radiation protection. This commitment shall be expressed in a written policy statement that clearly assigns prime importance to protection and safety in the radiology services, while recognising that the prime objective is the medical diagnostic, health and safety of the patients. This policy statement shall be made known to the medical personnel and shall be followed by establishing a radiation protection programme, which includes a quality management programme and by fostering a safety culture in hospital.

Regulatory Body Safety Culture in Non-nuclear HROs: Lessons for Nuclear Regulators

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Regulator safety culture is a relatively new area of investigation, even though deficiencies in regulatory oversight have been identified in a number of public inquiries (e.g., Piper Alpha, Deep Water Horizon). More recently the IAEA report into the Fukushima disaster specifically identified the need for regulatory bodies to have a positive safety culture. While there are clear parallels between duty holder safety culture and regulator safety culture there are also likely to be differences. To date they have been no published studies investigating regulator safety culture. In order to develop a framework to understand regulator safety culture we conducted a literature review and interviewed safety culture subject matter experts from a range of HRO domains (e.g., offshore oil and gas).

There was general consensus among participants that regulatory safety culture was an important topic that was worthy of further investigation. That there was general agreement that regulatory safety culture was multi-dimensional and that some of the elements of existing safety culture models applied to regulator culture (e.g., learning and leadership). The participants also identified unique dimensions of regulator safety culture including commitment to high standards and ethics, transparency and perceived role of the regulator. In this paper we will present the results of the interviews and present a model of regulator safety culture. This model will be contrasted with models being used in the nuclear industry. Implications for assessing regulatory safety culture will be discussed.

Safety Culture: Lessons Learned from the US Chemical Safety and Hazard Investigations Board

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The U.S. Chemical Safety and Hazard Investigation Board (CSB) investigation of the 2005 BP Texas City Refinery disaster as well as the Baker Panel Report have set the stage for the consideration of human and organizational factors and safety culture as contributing causes of major accidents in the oil and gas industry. The investigation of the BP Texas City tragedy in many ways started a shift in the way the oil and chemical industry sectors looked at process safety and the importance of human and organizational factors in improving safety. Since the BP Texas City incident the CSB has investigated several incidents, including the 2010 Macondo disaster in the Gulf of Mexico, where organizational factors and safety culture, once again, were contributing causes of the incidents.

In the Texas City incident the CSB found that "while most attention was focused on the injury rate, the overall safety culture and process safety management (PSM) program had serious deficiencies." The CSB concluded that "safety campaigns, goals, and rewards focused on improving personal safety metrics and worker behaviors rather than on process safety and management safety systems."

The Baker panel, established as a result of a CSB recommendation, did a more extensive review of BPs safety culture. The Baker panel found that 'while BP has aspirational goals of "no accidents, no harm to people" BP has not provided effective leadership in making certain it's management and US refining workforce understand what is expected of them regarding process safety performance.' This may have been in part due to a misinterpretation of positive trends in personal injury rates as an indicator of effective process safety. The panel also found that "at some of its US refineries BP has not established a positive, trusting and open environment with effective lines of communication between management and the workforce, including employee representatives."

In 2010 when the CSB began to investigate the Macondo incident, it became clear that there were similarities with the BP Texas City situation. In 2014 the CSB released two other investigation reports, Tesoro, Anacortes, WA and Chevron, Richmond, CA, which noted deficient safety cultures as contributing to the incidents.

The on-going trend of a great deal of focus on personal safety and a lack of adequate focus on process safety was recently discussed in a DNV-GL report. DNV-GL, an international oil and gas technical consulting group, concluded that personal injury rates in offshore oil and gas operations have shown a ten-fold magnitude of improvement. The report concluded that the available data for looking at process safety in the last five years shows no unified global trend toward improved performance.

This presentation will examine the lessons learned from the CSBs investigations regarding safety management systems and safety culture as contributing factors to some major incidents in the oil and gas and chemical industrial sectors.

TO2: Safety Culture Oversight

This session shares a number of different regulators' approaches to safety culture oversight.

Contemporary Approaches to Safety Culture: Lessons from Developing a Regulatory Oversight Approach

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The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials to protect health, safety, security and the environment, and to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public.

In the late 1990s, the CNSC conducted research into an Organization and Management (O&M) assessment method. Based on this research the CNSC conducted O&M assessments at all Canadian nuclear power plants and conducted additional assessments of nuclear research and uranium mine and mill operations. The results of these assessments were presented to licencees and used to inform their ongoing actions related to safety culture. Additional safety culture outreach and oversight activities provided licencees with opportunities to develop effective safety culture assessment methods, to share best practices across industry, and to strive for continual improvement of their organizations.

Recent changes to the Canadian Standards Association (CSA) management system standard have resulted in the inclusion of requirements associated to safety culture and human performance. Representatives from several sectors of Canada's nuclear industry, as well as participation from regulators such as the CNSC took part to the development of this consensus standard. Specifically, these requirements focus on monitoring and understanding safety culture, integrating safety into all of the requirements of the management system, committing workers to adhere to the management system and supporting excellence in workers' performance.

The CNSC is currently developing a regulatory document on safety culture which includes key concepts applicable to all licencees and specific requirements related to self-assessment, and additional guidance for nuclear power plants. Developing a regulatory document on safety culture requires consultation and fact finding initiatives at the national and international levels and includes active dialogue between all stakeholders on developing effective methods to achieving desired results across wide range of licenced activities and organizations.

Safety Culture Activities of Russian Regulator (Rostechnadzor) TSOs

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Currently, the Federal Environmental, Industrial and Nuclear Supervision Service of Russia (Rostechnadzor) has two Technical and Scientific Support Organizations (TSOs):

- FSUE VO "Safety";
- Scientific and Engineering Centre for Nuclear and Radiation Safety (SEC NRS).

Both TSOs provide Rostechnadzor with scientific and technical support in the area of safety culture.

In November, 2013 the IAEA follow-up regulatory review mission was held in the Russian Federation. Rostechnadzor developed an action plan on the implementation of recommendations and suggestions provided upon follow-up mission results. The plan also presupposes the development of a safety guide including recommendations concerning NPP safety culture. SEC NRS develops the safety guide on safety culture assessment in cooperation with FSUE VO "Safety" specialists. When developing the safety guide, requirements of federal regulations in the field of atomic energy use [1], IAEA documents [2, 3], RF national standards [4, 5] are taken into account. Besides, FSUE VO "Safety" is developing a training course "Safety Culture for Rostechnadzor Inspectors and Personnel". The program of the training course includes the following issues:

1. Introduction to safety culture course. Origin and development of safety culture concept;
2. Regulations in the field of safety culture. Safety culture definition;
3. Safety culture as a part of organizational culture;
4. Causes of accidents at nuclear facilities and their investigation;
5. Psychological aspects of safety culture and human factor;
6. Main stages of safety culture development in organizations;
7. Role of management system in the development and support of strong safety culture;
8. Approaches to safety culture assessment.

During the development of the training course special attention is paid to safety culture assessment, where it is understood as a complex of activities related to self-assessment, independent assessment (for instance, IAEA OSART mission [6]) and check (inspection) of nuclear facilities safety culture.

It is impossible to overestimate IAEA role in the development of safety culture concept in world atomic energy field. Owing to this concept IAEA Member States have an opportunity to learn about new approaches to ensuring safety of nuclear facility and to apply the approaches in practice.

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Insight and Lessons Learned on Safety Culture from Analysis of Inspection Findings and Events

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Safety culture has been a main subject of scrutiny in major accidents of modern complex technologies. The Fukushima accident also plausibly has its root cause deep into weak safety culture. After the Fukushima accident in Japan 2011, many critics have searched for cultural factors that caused the unacceptable negligence pervaded in Japan's nuclear society. Renewed emphasis has also been placed on rebuilding strong safety culture by operators, regulators, and relevant institutions worldwide. Significant progress has been made in approach to safety culture and this led to a new perspective different from the existing normative assessment method both in operators and regulatory side. Regulatory expectations and oversight of them are based on such a new holistic concept for human, organizational and cultural elements to maintain and strengthen the integrity of defense in depth and consequently nuclear safety.

In Korea, a change in regulatory position about safety culture oversight was made before and after a station black out event cover-up in Kori unit 1 occurred in early 2012. The oversight of licencee's safety culture becomes an important issue that attracts great public and political concerns recently in Korea. Beginning from the intended violation of rules and regulations, a series of corruptions, document forgeries and disclosure of wrongdoings made the Korean public think that the whole mindset of nuclear workers has been inadequate. Thus, the public demands that safety culture be improved and that the regulatory body shall assume more roles and responsibilities for improving safety culture and conducting oversight. After the event, Korea regulator concluded that safety culture aspects were not properly managed by licencee and therefore minimum requirements should be imposed on. Based on the implications and lessons from the events, Korean regulatory authority announced the initiative of regulatory oversight and launched pilot inspection program and research project to develop oversight system and methodology.

This paper introduces, as an effort of regulatory side, recent changes in the role of regulators in safety culture, safety culture components with regulatory expectations on them to achieve desired status of licencee's safety culture. Also, human error-related events and inspection findings with these safety culture components were analyzed, respectively. Comparison of the analyzed results between human error-related events and inspection findings was performed. And lessons learned and insight from perspectives of organizational factors and safety culture were derived.

TO2

From the results for analyzing human error-related events and inspection findings, safety culture components were analyzed that should be improved to enhance safety culture of licencee in Korea. The results will be used to identify suitability and to verify the validity of the concept of overall safety culture improvement mechanism. Also, these will encourage the self-assessment of licencee's safety culture management system corresponding to regulatory safety culture oversight.

The results and insights obtain from this research will provide inputs and lay foundations in regulatory infrastructure and system for plant oversight, which are based on operating experiences and lessons learned on the aspects of organizational factors and safety culture.

Regulatory Oversight of Safety Culture in Finland: A Systemic Approach to Safety

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In Finland the Radiation and Nuclear Safety Authority STUK specifies detailed regulatory requirements for good safety culture. Both the requirements and the practical safety culture oversight activities reflect a systemic approach to safety: the interconnections between the technical, human and organizational factors receive special attention. The conference paper aims to show how the oversight of safety culture can be integrated into everyday oversight activities. The paper also emphasises that the scope of the safety culture oversight is not specific safety culture activities of the licencees, but rather the overall functioning of the licence holder or the new build project organization from safety point of view.

The regulatory approach towards human and organizational factors and safety culture has evolved throughout the years of nuclear energy production in Finland. Especially the recent new build projects have highlighted the need to systematically pay attention to the non-technical aspects of safety as it has become obvious how the HOF issues can affect the design processes and quality of construction work. Current regulatory guides include a set of safety culture related requirements. The requirements are binding to the licence holders and they set both generic and specific demands on the licencee to understand, monitor and to develop safety culture of their own organization but also that of their supplier network. The requirements set for the licence holders has facilitated the need to develop the regulator's safety culture oversight practices towards a proactive and systemic approach.

The overall picture of the licencee's or plant project's safety culture is formed by assessing inputs from several different sources. Organizational capabilities and practices are evaluated, e.g., as a part of technical inspections, document reviews and daily activities carried out by the resident inspectors. A database is utilised to coordinate observations related to organizational factors. In addition to that, periodic inspections by inspectors with expertise in safety management, safety culture and leadership are carried out. STUK also utilises external experts' independent safety culture assessments and can launch event investigations to gain more in-depth understanding of the safety culture when needed. In order to select future focus points for oversight the knowledge and observations from experts of all disciplines and graded approach principles are utilised in a systematic manner.

The need for broadening the conception of systemic approach to safety has become evident recently. One of the lessons learned from the Fukushima Daiichi accident was that the regulator is part of the system which creates safety, or lack thereof. Therefore, the regulator needs to be able to critically reflect on its own safety culture and the regulatory practices. As the regulatory framework evolves gradually and is influenced by the national culture and the history of the nuclear domain in each country, it may be challenging to question its taken-for-granted premises. The national culture differences surface in a concrete manner in the multinational new build projects. STUK has supported research to understand the specific national features that the Finnish culture brings to the regulatory oversight.

The Regulatory Approach for the Assessment of Safety Culture in Germany: A Tool for Practical Use for Inspections

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Need for methods to assess licencees' safety culture has been recognised since the Chernobyl accident. Several conferences organized by IAEA and OECD–NEA stated the need for regulatory oversight of safety culture and for suitable methods. In 2013, IAEA published a Technical Document (TECDOC 1707) on the process of safety culture oversight by regulatory authorities which leaves much room for regulators' ways of performing safety culture oversight. In response to these developments, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) as the federal regulatory body commissioned GRS in 2011 to develop a practical guidance for assessing licencees' safety culture in the process of regulatory oversight. This research and development project was completed just recently. The publicly available documentation comprises a shorter guidance document with the indispensable information for an appropriate, practical application and a report with more detailed information about the scientific basis of this guidance. To achieve best possible adaptation to regulators' needs, GRS asked members of the regulatory authority of Baden-Wuerttemberg (one of the federal states of Germany) for comments on a draft of the guidance which was then finalised by duly considering this highly valuable and favorable feedback. Decisions regarding future use rest with German regulatory authorities.

Guidance is focused on measures and actions by which licencee personnel in charge of leadership and management tasks can foster safety culture (in short: "leadership for safety culture"). Focus on leadership is due to its important function of organizing and supporting subordinates' activities in such a way that best possible safety performance will be achieved. Guidance is based on a synthesis of ca. 70 years (1940s to 2013) of empirical research findings about the effects of leadership on personnel's engagement and resulting observable performance related to safety, quality, and similar goals. Synthesizing of these findings resulted in five domains and a total of seventeen aspects of "leadership for safety culture"

Leaders (from top management down to personnel being temporarily in charge of leadership tasks)

- create best possible conditions of task performance (e.g., explain safety policy, ensure good human factors design);
- coach, direct, and supervise personnel effectively (e.g., make clear decisions, are present on the shop-floor);
- build a powerful learning organization (e.g., investigate errors thoroughly, encourage suggestions for improvement);
- duly reward and recognise safety-culturally correct behaviour, sanction safety culturally incorrect behaviour (e.g., show by appropriate feedback that safety matters);

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- foster trustworthy relationship to and within team (e.g., try to settle conflicts, keep their word).

Guidance is provided for two oversight approaches. The first one supports the analysis and assessment of "leadership for safety culture" in the context of oversight activities by safety authorities (in particular plant visits) which provide insights into how safety culture is fostered by licencee personnel in charge of leadership tasks, even if the primary goal of the oversight activities (e.g., technical inspections) is not the collection of information about "leadership for safety culture" ("en passant-approach"). Observation of, e.g., a periodic test will offer inspectors both the opportunity to watch personnel's use of written procedures, response of team leaders to questions by personnel etc., and of asking personnel about how and why they are doing what they are doing in order to perform their task (culture is often characterised as "ways of doing things"). Continuous application of this approach will provide lots of individual pieces of information about "leadership for safety culture" to be analyzed and summed up by the regulatory authority and discussed with licencee management (e.g., during regular meetings). The second approach supports the analysis and assessment of "leadership for safety culture" in the context of an investigation which is focused on this leadership and which is to provide more systematic and detailed information than an "en passant-approach" about "leadership for safety culture" at a particular point in time. Approaches of both types have been in use in different countries, they can be combined, and they can be applied in combination with other methods for the analysis and assessment of safety culture. Guidance comprises a description of the process by which both approaches can be implemented.

In both approaches, guidance is neither to be used as a checklist nor as a questionnaire but as a set of topics for inspectors' observations, questions, and discussions with the licencee regarding strengths and weaknesses of his safety culture. Licencee remains fully responsible for safety culture and of measures to be taken in response to these discussions.

Project results and implications for the role of the regulator in its approach to safety culture will be discussed in detail especially considering the current situation in Germany four years after the decision to finally phase out of nuclear energy by 2022.

Lessons Learned from a Five-year Evaluation of the Belgian Safety Culture Oversight Process

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The Belgian Regulatory Body has implemented a Safety Culture oversight process since 2010. In a nutshell, this process is based on field observations provided by inspectors or safety analysts during any contact with a licencee (inspections, meetings, phone calls, etc). These observations are recorded within an observation (excel) sheet — aiming at describing factual and contextual issues — and are linked to IAEA Safety Culture attributes.

It should be stressed that the purpose of the process is not to give a comprehensive view of a licencee safety culture but to address findings that require attention or action on the part of a licencee. In other words, gathering safety culture observations aims at identifying cultural, organizational or behavioural issues in order to feed a regulatory response to potential problems. Safety Culture Observations (SCO) are then fully integrated in routine inspection activities and must be seen as an input of the overall oversight process. As a result, the assessment of the SCO is inserted within the yearly safety evaluation report performed by Bel V and transmitted to the licencee. However, observing safety culture is not a natural approach for engineers. Guidance, training and coaching must be provided in order to open up safety dimensions to be captured. In other words, a SCO process requires a continuous support in order to promote a holistic and systemic view of safety.

A SCO process also requires continuous improvement in order to enhance the capacity of a Regulatory Body to go deeper within the cultural dimension of safety. Therefore, after a first self-assessment in 2012, the Belgian regulator reinforced its process through a new procedure, a guidance document for inspectors ("How to observe") and the opening of a Safety Culture Coordinator position (in charge of process monitoring and assessment of SCO).

The process is now fully operational. Nevertheless it is also time to deeply review the process in order to gain from experience. The aim of this paper is then to present the main strengths and the limits of this kind of tool for safety culture oversight. Based on a five-year evaluation of the Belgian SCO process, the paper intends to take stock of the main findings of this review. More particularly, some issues will be highlighted such as the efficiency and the effectiveness of a SCO process, the way to improve the input of the process (better observations, dedicated inspections, etc.), the integration level of the process within the overall oversight process (how to better use the Safety Culture Observations for defining scope of inspections and performing safety evaluations) and the impact of the SCO process on the licencees Safety Culture.

Next steps to enhance a SCO process will be pointed out.

Improvements of the Regulatory Framework for Nuclear Installations in the Areas of Human and Organizational Factors and Safety Culture

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The paper presents the development of regulatory requirements in the area of human and organizational factors taking account of the lessons learned from major accidents in the nuclear industry and in particular of the factors that contributed to the Fukushima Daiichi accident and the improvement of the regulatory oversight of nuclear safety culture. New requirements have been elaborated by the National Commission for Nuclear Activities Control (CNCAN) on the nuclear safety policy of licencees for nuclear installations, on independent nuclear safety oversight, on safety conscious work environment and on the assessment of nuclear safety culture. The regulatory process for the oversight of nuclear safety culture within licencees' organizations operating nuclear installations and the associated procedure and guidelines, based on the IAEA Safety Standards, have been developed in 2010–2011. CNCAN has used the 37 IAEA attributes for a strong safety culture, grouped into five areas corresponding to safety culture characteristics, as the basis for its regulatory guidelines providing support to the reviewers and inspectors, in their routine activities, for recognising and gathering information relevant to safety culture. The safety culture oversight process, procedure and guidelines are in process of being reviewed and revised to improve their effectiveness and to align with the current international practices, using lessons learned from the Fukushima Daiichi accident. Starting with July 2014, Romania has a National Strategy for Nuclear Safety and Security, which includes strategic objectives, associated directions for action and concrete actions for promoting nuclear safety culture in all the organizations in the nuclear sector. The progress with the implementation of this strategy with regard to nuclear safety culture is described in the paper. CNCAN started to define its own organizational culture model and identifying the elements that promote and support safety culture. This action has been taken based upon a recommendation received from the 6th Review Meeting of the Contracting Parties to the Convention on Nuclear Safety, to have assessments of the safety culture of the regulatory authority, acknowledging that the culture of the regulator may have an influence on the safety culture of the licencees. A limited exercise for a safety climate survey has been implemented for CNCAN staff involved in the regulatory review and inspection activities for nuclear installations. The same 37 attributes of a strong safety culture promoted by the IAEA have been used, in a slightly adapted form, also for the safety climate survey for CNCAN staff. The experience with the development and improvement of the regulatory framework, regulatory oversight process and safety culture in the regulatory organization are all described in the paper and may prove useful for regulatory authorities of other countries.

U.S. Nuclear Regulatory Commission Safety Culture Oversight

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The NRC recognises that it is important for all organizations performing or overseeing regulated activities to establish and maintain a positive safety culture commensurate with the safety and security significance of their activities and the nature and complexity of their organizations and functions. The NRC's approach to safety culture is based on the premise that licencees bear the primary responsibility for safety. The NRC provides oversight of safety culture through expectations detailed in policy statements, safety culture assessor training for NRC inspectors, the oversight process, and the Allegations and Enforcement Programs.

The NRC's Safety Culture Policy Statement (SCPS) sets forth the Commission's expectation that individuals and organizations establish and maintain a positive safety culture commensurate with the safety and security significance of their activities and the nature and complexity of their organizations and functions. The SCPS is not a regulation. It applies to all licencees, certificate holders, permit holders, authorisation holders, holders of quality assurance program approvals, vendors and suppliers of safety-related components, and applicants for a licence, certificate, permit, authorisation, or quality assurance program approval, subject to NRC authority.

The NRC provides training to inspectors to become qualified as Safety Culture Assessors for general safety culture assessments or Inspection Procedures (IP) 95003 inspections. This qualification requires a firm understanding of both safety culture and inspection skills, and is an essential part of the NRC's oversight of safety culture.

The Reactor Oversight Process (ROP) is the NRC's program for assessing the performance of operating commercial nuclear power reactors. In 2004, the NRC took steps within the ROP to strengthen the agency's ability to detect potential safety culture weaknesses during inspections and performance assessments. In 2006, guidance and procedures for inspecting and assessing aspects of licencees' safety culture were included in the ROP. In 2014, revisions were made to the ROP based on the common language initiative. The ROP uses inputs from performance indicators and inspection findings to develop conclusions about a licencee's safety performance. Performance is evaluated systematically and on a continuous basis through planned inspections, and mid-year and end of year assessment meetings. The Construction Oversight Process (CROP) for new reactors, and the Fuel Cycles Oversight Process (FCOP) were modelled after the ROP.

In addition to the oversight processes, the NRC's Allegation and Enforcement Programs address safety culture through the use of Chilling Effect Letters (CEL) and Confirmatory Orders (CO). CELs are issued when the NRC has concluded that the work environment is "chilled," (i.e., workers perceive that the licencee is suppressing or discouraging the raising of safety concerns or is not addressing such concerns when they are raised). The number and nature of allegations received at the NRC, including allegations related to discrimination for raising safety related concerns help inform the NRC's decision to send a

CEL. COs are issued by the NRC to document agreements on specific corrective actions made by the licencee in response to inspection findings.

PL3: Future Perspectives

This plenary session reflects upon the future of nuclear safety and the keynote speakers will share their innovative work within the area, identifying new challenges and new ideas.

Plenary Dialogue: The Human and Organizational Side of Safety and the Way Forward

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What Does Safety Culture Look Like in the Year 2046?

This plenary dialogue allows a conversation between key participants who have spent time working to identify the future challenges and new ways of thinking about safety within the nuclear industry and other high hazard industries.

The aim of the dialogue is to glimpse into the future development of safety management and safety culture, particularly as the world industry is building new power stations and other new nuclear installations. This is alongside other installations that will have been shut down and decommissioned. Also the use of radioactive material may change in other industries as technology develops.

The central question of "What will safety culture look like in 2046?" looks 30 years into the future to try and imagine the changing needs of the industry in terms of safe operations both with regard to technology and those that work in the industry.

The audience will have the opportunity to ask questions to the panel and share their views.

Panellists:

A. N. Afghan	Pakistan	HR3–04
E. Fischer	Germany	LM3–02
A. Kawano	Japan	CP–02
J. Paries	France	CP–04
J. Ward	Australia	SA3–04

IAEA's Approach to Leadership, Management and Culture for Safety

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In this session the director of the Division of Nuclear Installation Safety (NSNI) will describe the division's approach to leadership, management and culture for safety and outline the strategy adopted for this work. The IAEA has developed a safety culture foundation framework which is used to support all installations' and organisations' work for continuous improvement to achieve excellence in nuclear safety performance. The framework has been developing since 1986 through the work of the IAEA and the nuclear community, and is based on nuclear organisations' experiences (both in practices applied and events experienced) and the development of scientific knowledge on human and organisation factors that support nuclear safety performance.

The main aim for the IAEA is to assist the Member States to translate the knowledge into practical and successful practise, and to further enhance the safety on nuclear installations.

The Strategy of the division is to share the common foundation of the framework across the different nuclear sectors and ensure that application of improvement activities are firmly based on knowledge and appropriate context based solutions.

A description of the work streams currently in place includes:

- Revision of the IAEA Safety Standards to incorporate the integration of leadership, management and culture for safety in the requirements. The IAEA is also creating and revising guides to share the good practices end experience found across Member States;
- Scientific missions to assist Member States in their understanding of how the IAEA safety culture framework applies in their nuclear organisations;
- Safety culture assessment for both operators and regulators;
- Leadership for safety development workshops for managers (including a specific workshop for senior managers) in the nuclear industry;
- Harmonization of the different safety culture frameworks as used by the nuclear industry, to promote common understanding;
- The development of the understanding of how safety and security can be harmonized in terms of practices to ensure the safe and secure operation of nuclear installations; and
- Activities that develop understanding and application of IAEA Safety Standards and practices in the area of human and organisational factors, including human factors engineering.

With an IAEA programme that provides support to all types of facilities and activities that give rise to radiation risks, the IAEA aims to support Member States in their pursuance of excellence in safety performance by ensuring they are supported in their leadership, management and culture for safety activities.

The Psychological Aspect of Safety Culture: Application of the Theory of Generations for the Formation of Safety Culture Among Personnel

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The formation of safety culture is an attempt of constructive influence on the socio-psychological atmosphere of the team and the behavior of employees. By way of creating specific settings, the value system for the organization staff as part of the organizational culture, it is possible to forecast, plan and promote the desired behavior. However, it is necessary to take into account the corporate culture spontaneously established in the organization. The leaders often try to establish a safety culture, where the progressive values, norms are declared, and the results obtained are not those expected. This is partly because the organizational norms and values implemented come into conflict with reality and, therefore, are actively rejected by many members of the organization. The theory of generations developed by the American scientists (N. Howe, W. Strauss) helps in the analysis and consideration of the staff values formed under the influence of many factors, depending on the age of employees, in the course of safety culture formation.

Risk Communication: A Key for Fostering a More Resilient Safety Culture

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It is widely agreed that the accident of the Fukushima Daiichi nuclear power plant was not only triggered by natural events combined with technical failures, but was a human induced disaster [1, 2]. From the bitter lessons, we have learned that human and organizational factors associated with emergency planning, response and decision-making for nuclear safety need to be more carefully reviewed and enhanced. Elements of social sciences, especially, risk management and risk communication here play a key role.

Risk communication is an established concept within risk analysis frameworks. It is a vital tool to convey the meaning of scientific assessment and risk management, share safety-related information, and exchange views and values amongst varying stakeholder groups. Risk communication aims at building trust through this process and human interactions.

However, it would not be an overstatement that the essence of risk communication is not fully understood. As a result, it is either partially integrated into risk management practice or remains unconducive. The marginalisation of risk communication is observed in a variety of risk communication practices, or more evidently, in perception gaps between lays and experts about risks.

In order to address the pressing issue and suggest how risk communication can help create shared awareness about the safety of nuclear energy, this talk will show the results of two empirical studies in Japan conducted after the Fukushima accident between 2011 and 2015. The presenter was directly involved in both studies.

The first study concerns a series of risk communication practices designed for the evacuees from a disaster-affected region, Iitate Village of Fukushima Prefecture between 2001 and 2012. Drawn from empirical data, it investigates why communication between professionals and laypersons often fails and can lead to mistrust, rather than building trust. It argues that common communication failures are identified not in scientific information itself, but in the ways science is conveyed to the layman. Scientists primarily try to explain science by the use of numbers and logic, whilst laypersons understand safety information by images and emotions. Attendees of communication practices in Fukushima felt frustrated as the safety information provided by the scientists was either too difficult to grasp, or not necessarily relevant to what they wanted to obtain.

This layman–expert gap needs to be more readily acknowledged, and in order to fill this discrepancy, experts need to deliver the information that the audience need, and attempt to tailor their languages to be more readily understood by non-experts.

The second study concerns a citizen panel, stakeholder dialogue on the safety of the Hamaoka nuclear plant conducted in Shizuoka in 2015. The presenter directed the process and acted as facilitator. The deliberation served as the first sort of large-scale deliberative practice in Japan after the Fukushima accident. The discourse helped both laymen and experts acknowledge the need for active dialogue to share not only facts, but to improve mutual understanding and, more importantly, share responsibilities for a safe neighborhood and secured energy supply.

The talk will conclude that the creation of public "spheres" for science-laymen encounters is to be more rigorously sought in noncrisis situations. But more fundamentally, risk communication needs more attention of the side of science and technology to improve capacity-building and fostering a more resilient culture in nuclear safety.

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LM3: Leadership, Management and Culture for Safety

This session shares the thinking of how we can approach the future challenges.

NEA/CSNI Working Group on Human and Organizational Factors, WGHOF

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Human and organizational factors (HOF) systemic and cross cutting, implicated in all major accidents in nuclear and other high reliability industries.

Leadership and Safety Culture: Leadership for Safety

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Following the challenge to operate Nuclear Power Plants towards operational excellence, a highly skilled and motivated organization is needed. Therefore, leadership is a valuable success factor.

On the other hand a well-engineered safety orientated design of NPP's is necessary. Once built, an NPP constantly requires maintenance, ageing management and lifetime modifications. E.ON tries to keep the nuclear units as close as possible to the state of the art of science and technology. Not at least a requirement followed by our German regulation. As a consequence of this we are continuously challenged to improve our units and the working processes using national and international operational experiences too. A lot of modifications are driven by our self and by regulators. That why these institutions — authorities and independent examiners — contribute significantly to the safety success. Not that it is easy all the day. The relationship between the regulatory body, examiners and the utilities should be challenging but also cooperative and trustful within a permanent dialog. To reach the common goal of highest standards regarding nuclear safety all parties have to secure a living safety culture. Without this attitude there is a higher risk that safety relevant aspects may stay undetected and room for improvement is not used. Nuclear operators should always be sensitized and follow each single deviation.

Leaders in an NPP-organization are challenged to create a safety-, working-, and performance-culture based on clear common values and behaviours, repeated and lived along all of our days to create a least a strong identity in the staffs mind to the value of safety, common culture and overall performance.

Limitations of Managing Safety by Numbers

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Work, especially in a complex, dynamic workplaces, often requires subtle, local judgment with regard to timing of subtasks, relevance, importance, prioritization, etc. Still, people in the nuclear industry seem to think safety results from error counts and people just following procedures. In the wake of failure it can be tempting to introduce new procedures and an even stricter "rule following culture". None, or at least very little, attention is given to tacit knowledge and individual skills. I am aiming to highlight the inadequacy of putting too much trust in formalization and that reporting and trending of events will contribute to increased learning, an increased nuclear safety and an efficient operational experience. The ability to interpret a situation concrete depends on proven experience in similar situations, analogical thinking and tacit knowledge. I intend to problematize the introduction and use of so-called Corrective Action Program (CAP) and computerised reporting systems linked to CAP in the nuclear industry. Categorization and trending in computerised reporting systems is only based on the direct or triggering cause and not based on any analyzes, so the question we have to ask is what the trends are really telling us, if anything at all.

During my master studies I began to realise that the whole industry, from regulators to licencees, seems stuck in the idea that the scientific perspective on knowledge is the only "true" perspective. This leads to an exaggerated belief in that technology and formalized work processes and routines will create a safer business. The computerised reporting system is costly but will not, as the idea was from the beginning, contribute to increased nuclear safety since the reports is based on the trigger and not the underlying causes and in-depth analysis. Managing safety by numbers (incidents, error counts, safety threats, and safety culture indicators) is very practical but has its limitations. Error counts only uphold an illusion of rationality and control, but may offer neither real insight nor productive routes for progress on safety.

The question is why the CAP, error counts and computerised reporting systems have had such a big impact in the nuclear industry? It rests after all, on too weak foundations. A part of the answer is that the scientific perspective on knowledge is the dominating perspective. What people do not seem to understand is that an excessive use of computerised systems and an increased formalization actually will create new risks when people lose their skills and ability to reflect and put more trust in the system than in themselves.

This does not mean that people should stop reporting completely, it only means that organizations that use these kinds of computerised reporting systems need to understand the limitations of the system and the trending. Putting 5000-10 000 reports in to a system every year to seek a trend might, in best case, help an organization to discover concrete problems but it will not help organizations discover the latent organizational weaknesses which eventually will lead to a severe nuclear accident. I fear that the nuclear industry puts too much trust into these reporting systems and trends and that it might make the organizations blind to the real threats against nuclear safety.

Cultivating and Development — 30 Years Practice of Safety Culture in China

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The safety culture has been cultivated and promoted in China since its very beginning by IAEA. The 1st stage — stage of start and exploration — was from 1984 to 2007, in which the international concept of safety culture was imported and studied, with the process of combination and convergence with the positive elements of Chinese traditional culture. The basic ideas, such as the principles and directing ideas for the nuclear safety, were established in China. The 2nd stage — stage of practice and growing — was from 2007 to 2014, where safety culture was promoted by the Government, and the regulatory body NNSA established its basic supervision value based on the safety culture. The Chinese nuclear industry was encouraged to develop their of safety culture in a vivid form of presenting. The 3rd stage — stage of fast development — is from 2014 to now. The Chinese president Xi announce the Chinese Nuclear Safety View in The Hague in March 2014, showing the states position regarding the nuclear safety and safety culture. The policy declaration was issued and the nuclear safety promotion special action was carried out by NNSA. Safety culture is widely accepted and acknowledged by the nuclear and radioactivity relevant industry.

SA3: Systemic Approach to Safety

This session shares future ways of developing and applying a systemic approach to safety and looks at the paradoxes that future leaders will face.

Operational HOF Practices in the AREVA Group to Face New Challenges

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Operating experience from TMI and and more general experience from three decades of nuclear facility operations, have shown the value of safety culture's contribution to nuclear risk management. More than ever, this particular aspect of human and organizational factors (HOF) is central to the AREVA group's concerns as it faces new challenges.

The first generation of operators comissioned the facilities and optimized their operation. This first phase gave them a better understanding of operations and related limits, particularly through testing and start-up operations and the responses that were found for all of the technical issues that arose. All of these interactions offered opportunities to make the safety challenges of processes and facilities tangible and directly perceptible. The young operators of those bygone years are now the ones who are "in the know" in the organizations, the ones with unique technical know-how and a multi-layered perception of the risks involved. Those first generations of operators, with their unique operational knowledge, are gradually leaving the industrial world. Replacing those skills creates a new set of challenges. Concomitantly, the French nuclear safety authority benefitted from these facility start-ups to increase its skills by sharing in the learning process concerning the facilities' operational realities and in the construction of a safety configuration program, and by gaining a concrete perception of risk. This fostered the mutual trust that is vital and integral to facility safety.

Added to this generation change are constraints such as the social acceptability of risk-related activities, requiring transparency and the need for ongoing nuclear operations to be carried out in an acceptable economic framework, which in turn requires assurance of an appropriate level of industrial performance while ensuring that safety levels remain in line with prescribed standards.

AREVA has created specific training measures, qualification programs and organizations to ensure that all of these developments are under proper control. Presented in this article, these measures address the specific traits of new generations of operators: their value systems, their risk perception and the image they have of facility reliability. The setting for this work is characterised by a proliferation of regulatory requirements, even though the facilities themselves have integrated in their process some benefits from continuous safety improvement. Historically, safety arose from a weighted balance of managed safety (defined by best practices from experience and recognised by all) and regulated safety (defined by regulatory requirements), we are now seeing regulated safety assume a dominating role. The sharp increase of regulatory requirements in France makes one wonder about their real impacts in terms of continuous safety improvement. In fact, applying this volume of requirements to operations is a heavy burden for operators. The assimilation of each new measures is an issue, and finding and validating responses proportionate to the stakes involved in the operational application of the requirements remains a challenge.

Storytelling and Safety Culture

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The paper uses a five-part model of nuclear safety as the basis for discussion of how the oral culture in an organization contributes to (or can potentially undermine) the understanding of safety, the commitment to safe practices and the formation of group identity which is the product of effective cultural leadership. It explores some differences between oral and literate forms of expression, how these interact, and why both are essential parts of nuclear safety culture. It looks at how oral forms impact safety culture, and how by understanding the power of the oral culture leaders can be more effective in shaping people's understanding and commitment to the essential practices of nuclear safety.

Oral forms of expression in cultures are highly stable because they are repeated as "stories" and as ritualistic patterns. They are the only forms of language that "live inside us", so they are essential for things such as communicating principles and forming a sense of group identity. Oral forms can be exceptionally long-lasting and can (and do) influence cultures sometimes decades after they first come into being. In other words, (and for good and bad) they have an exceptional ability to survive change. This is because oral stories are like magic flowers. Every time the story is told its seeds spring out and scatter, and are planted in every hearer. Then any one of those listeners can carry the story forwards into the future and retell it so another magic flower is born. Compelling stories are therefore always alive, they only die when they are replaced with a more compelling story.

Literate forms such as technical terms, documents and written communications dominate organizations, but although the jargon of technocratic life are necessary, they are largely sterile and void of emotional meaning. Jargon demands that people understand its precise meaning — that is its purpose. But more human language allows people to give something of their own meaning to the words. Oral culture therefore always contains more human language, and this language will come from the stories people tell themselves or that they hear from the leaders. Sometimes these stories are in competition, but the prevailing oral culture (in part the "winning story" in the minds of individuals and groups) is always on display when interviews or group discussions are held. This means that a large part of safety culture assessment work is carried out through listening for, and listening to, the oral culture and then discerning how this is affecting nuclear safety.

Some of the stories in organizations are unhealthy for safety culture, but it needs an attentive leader to hear the "counter-stories" and to take action to replace them with different stories (which may well fail unless they can be made into oral forms). Leaders operate between the current situation and the possible futures. And the only way of describing a future is through words and images which themselves inevitably carry meaning from the past. Therefore, effective leaders are always intensely involved in a process of interpreting the past to illuminate the future. These kinds of interpretations are most effective (and sometimes only effective) when they are put forward in oral forms. Then they can become the magic flowers of the stories about "who we are" and "who we are becoming".

Innovative Modelling Approach of Safety Culture Assessment in Nuclear Power Plant

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A culture is commonly defined as the shared set of norms and values that govern appropriate individual behavior. Safety culture is the subset of organizational culture that reflects the general attitude and approaches to safety and risk management. While safety is sometimes narrowly defined in terms of human death and injury, we use a more inclusive definition that also considers mission loss as a safety problem and is thus applicable to nuclear power plants and missions. The recent accident reports and investigations of the nuclear power plant mission failures (i.e., TMI, Chernobyl, and Fukushima) point to safety cultural problems in nuclear power plants. Many assessment approaches have been developed by organizations such as IAEA and INPO based on the assessment of parameters at separate levels — individuals, groups, and organizations.

However, recent reports from the Korean nuclear industry show that there is a need to understand multi-level interactions that are more complex and dynamic. One such example is the workload of employees, which is one of the main factors that deteriorate safety culture in nuclear power plants. This is due to the organizational complexity that results from poor management of institutional complexity such as export and new power plant construction. The individual complexity arises from not being able to cope with this. Excess workload occurs due to poor resource allocation policy and conflicting goals of performance versus safety. Excess workload increases the stress of employees in power plants, leading to more corner-cutting in their work, which ultimately increases the likelihood of accidents. In management science, interruption theory is known to explain this relationship between performance and productivity of employees in terms of work stress. According to this theory, employees in organization can maintain their productivity up to a certain point, from which the productivity deteriorates and causes accidents in power plants. I incorporate this theory into a dynamic modeling approach to assess the safety culture in nuclear power plants.

Based on the interruption theory of stress, the System Dynamics modeling approach that I use rests on a new way of thinking about accidents. It integrates all aspects of risk, not only individual-level risk but also organizational and social aspects. Systems are viewed from a new perspective as interrelated components that are kept in a state of dynamic equilibrium by feedback loops of information and control. A socio-technical system is not treated as a static design, but as a dynamic process that continually adapts to achieve its ends and reacts to changes in itself and its environment. Accidents then are viewed as the result of flawed processes involving interactions among people, societal and organizational structures, engineering activities, and physical system components.

I argue that safety culture can be modeled, analyzed and engineered just like physical systems. The models will be useful in designing and validating improvements to the risk management and safety culture, evaluating the potential impact of changes and policy decisions, assessing risk, detecting when risk is escalated to unacceptable levels, and in performing root cause analysis. Prescriptions for preventing accidents include designing a control structure encompassing the entire socio-technical system, which will enforce the necessary requirements to mitigate accidents from occurring in the system.

The Application of Systemic Safety for Smaller Nuclear Installations

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This paper will provide an outline of ARPANSA's approach to systemic safety as applied to smaller hazard nuclear installations. It will describe ARPANSA's effort to enable licence holders to better understand the principles of systemic safety so that they may make improvements for themselves. In regard to human and organizational factors, inspections are more often used to highlight areas where performance can be improved to meet best practice rather than strictly as a compliance tool. This takes account of a graded, risk informed approach and is undertaken in a collaborative way that places a premium on openness, clarity, reliability and efficiency.

The paper will discuss the challenges faced by the approach, and how ARPANSA is currently managing these. It will describe ARPANSA's regulatory guidance and inspection processes. The significant stages in ARPANSA development of the systemic approach are provided briefly in the following paragraphs.

Outline of ARPANSA's Systemic Approach: In 2011 work commenced to develop a holistic approach to safety that considers the technological aspects of safety alongside organizational and human factors. The work was influenced by research into common contributing causes of accidents which indicated that the interrelationships between technology, human and organizational factors were the key to robust controls for safety that builds safer operations.

In 2012 ARPANSA made available its regulatory guidance on holistic safety via the ARPANSA website that explains the basis for the holistic approach. This guidance was informed by modern safety science including published academic research, and the implementation of similar approaches by nuclear regulators and operators as well as other high reliability organizations. ARPANSA's guidance is based around seven key characteristics for safety, namely:

- Human aspects;
- Non-technical skills;
- Defence in depth;
- Management Systems;
- Resilience;
- Safety Culture;
- Protective Security and Nuclear Security Culture.

The original website has since been supplemented with additional material including tools for gauging the holistic safety of an operator. The tools are designed to assist licence holders in understanding and improving the safety of their operations. These tools are freely available to be used by licence holders as well as by regulatory staff.

Alongside the ARPANSA role of assuring compliance to legislation, it has been actively socialising the holistic approach to safety and promoting its benefits. This is in-line with an approach of fostering a healthy and robust safety culture through collaboration with licence holders.

ARPANSA has also implemented a specialist thematic inspection programme that was aimed at examining the organizational and human factors associated with specific business activities and across divisional boundaries within a licence holder. In 2015 following a general updating of the ARPANSA inspection programme, the thematic inspections were placed on hold in favour of a new inspection approach that examines human and organizational aspects of safety against a set of performance objectives and criteria.

Regulatory staff involved in the development of the holistic approach is closely involved in the new inspection programme. Staff participate directly in inspections, analyse inspection performance, develop inspector training, and where a need is identified may undertake augmented inspections to address specific issues.

HR3: Other High Reliability Organizations' Approaches to Safety

This session shares the thinking around resilience and the application of safety culture inside different industries and extreme situations.

Product Safety Culture: A New Variant of Safety Culture?

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Product safety culture is a new research area which concerns user safety rather than worker or process safety. The concept appears to have emerged after the investigation into the Nimrod aircraft accident (Haddon-Cave, 2009) which echoed aspects of NASA's Challenger and Columbia crashes. In these cases, through a blend of human and organizational failures, the culture deteriorated to the extent of damaging product integrity, resulting in user fatalities. Haddon-Cave noted that it was due to a failure in leadership and organizational safety culture that accidents such as the Nimrod happened, where the aircraft exploded due to several serious technical failures, preceded by deficiencies in the safety case. Now some organizations are starting to measure product safety culture.

This is important in day-to-day life as well, where a product failure as a result of poor organizational safety culture, can cause user harm or death, as in the case of Takata airbags scandal in 2015. Eight people have lost their lives and many were injured. According to investigation reports this was due to the company's safety malpractices of fixing faulty airbags and proceeding to install them in vehicles, as well as secretly conducting tests to assess the integrity of their product and then deleting the data and denying safety issues as a result of the company's cost-cutting policies. As such, organizational culture, specifically the applications of safety culture, can have far-reaching consequences beyond the workplace of an organization.

Existing research into worker and process safety culture has examined specific dimensions and measured their effectiveness in relation to recordable safety outcomes and worker safety behaviour. The main cultural dimensions appear to include management commitment to safety, safety systems and communication. But do the same cultural factors affect product safety? There may also be need to involve the aspect of technology (such as equipment used to produce a product or a service) in safety systems when considering the manufacture and usage of products. Perhaps this also applies within safety culture in general to ensure safe and efficient productivity of an organization through good understanding and appropriate safety practices and operation of relevant equipment. Due to the impact of human behaviour on product safety, it would be pertinent to examine whether the dimensions relevant to worker and process safety culture are also components of product safety culture. It is proposed that this would require approaching the subject more from the safety systems perspective, considering that company policies and safety procedures are highly relevant in informing appropriate product safety practices, including workers' behaviours that affect product safety. This would be critical in high reliability organizations to mitigate further accidents and improve the overall safety culture of an organization, such as in the nuclear industry.

Additionally, management commitment to safety should not be considered separately within the organization but rather integrated into the aspect of safety systems. The reason for this is that management commitment to product safety is a result of organizational safety culture policies (therefore derived safety systems) that focus on appropriate worker practice and procedures. To summarise, product safety culture should be considered as the interplay between human factors and technology (i.e., work equipment used in product assembly) affecting the organization's safety culture to determine whether the influences of safety systems of an organization's safety culture impact product safety through human behaviours and practices.

This paper will attempt to establish how product safety culture could be accurately defined and whether it is a variant of safety culture in general. Relevant literature, such as food safety culture and patient safety culture studies will be used to examine the impact of worker behaviour on product/service safety. Major product safety failures will illustrate which aspects of organizational culture were implicated. The established safety culture dimensions will be compared to those which appear to underpin product safety culture to see if they match or if there are distinct dimensions that should be considered for product safety culture. This would be relevant also to explore the potential impact on product safety behaviour of workers or product safety outcome measures (i.e., failures, malfunctions). Such findings could be relevant to the nuclear industry as it considers 30 years of research into safety culture.

Human and Organisational Safety Barriers in the Oil & Gas Industry

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The oil & gas industry is a safety-critical industry where errors or accidents may potentially have severe consequences. Offshore oil & gas installations are complex technical systems constructed to pump hydrocarbons from below the seabed, process them and pipe them to onshore refineries. Hydrocarbon leaks may lead to major accidents or have negative environmental impacts. The industry must therefore have a strong focus on safety.

Safety barriers are devices put into place to prevent or reduce the effects of unwanted incidents. Technical barriers are one type of safety barrier, e.g., blow-out preventers to prevent uncontrolled release of hydrocarbons from a well. Human operators may also have an important function in maintaining safety. These human operators are part of a larger organisation consisting of different roles and responsibilities and with different mechanisms for ensuring safety. This paper will present two research projects from the Norwegian oil & gas industry that look at the role of humans and organisations as safety barriers.

The first project used questionnaire data to investigate the use of mindful safety practices (safety-promoting work practices intended to prevent or interrupt unwanted events) and what contextual factors may affect employees' willingness to use these safety practices. Among the findings was that employees' willingness to use mindful safety practices was affected more by factors on a group level than factors at an individual or organisational level, and that the factors may differ depending on what is the object of a practice — the employee or other persons. It was also suggested that employees' willingness to use mindful safety practices could be an indicator used in the assessment of the safety level on oil & gas installations.

The second project is related to organisational safety barriers against major accidents. This project was based on a review of recent incidents in the Norwegian oil & gas industry, as well as interviews with personnel from the oil & gas industry with competence on major accidents. The purpose was to develop requirements to the properties of organisational barriers to ensure the effectiveness of the barriers, e.g., demands to capacity, functionality or reliability. A method for monitoring the organisational barriers was also developed. This method may be applied as a way to monitor the risk for major accidents in an organisation, and may also be used to communicate major accident risks across organisations or companies.

The projects and their findings are discussed in light of their relevance to the nuclear industry.

Learning Lessons from TMI to Fukushima and Other Industrial Accidents: Keys for Assessing Safety Management Practices

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The main objective of the paper is to discuss and to argue about transfer, from an industrial sector to another industrial sector, of lessons learnt from accidents. It will be achieved through the discussion of some theoretical foundations and through the illustration of examples of application cases in assessment of safety management practices in Nuclear Power Plant (NPP).

The nuclear energy production industry has faced three big ones in 30 years (TMI, Chernobyl, Fukushima) involving three different reactor technologies operated in three quite different cultural, organizational and regulatory contexts. Each of those accident has been the origin of questions, but also generator of lessons, some changing the worldview (see Wilpert and Fahlbruch, 1998) of what does cause an accident in addition to the engineering view about the importance of technical failures (human error, safety culture, sociotechnical interactions). Some of their main lessons were implemented such as improvements of human-machine interfaces ergonomics, recast of some emergency operating procedures, severe accident mitigation strategies and crisis management. Some lessons did not really provide deep changes. It is the case for organizational lessons such as, organizational complexity, management of production pressures, regulatory capture, and failure to learn, etc.

Other high risk industries have had their major accident cases too in the last decades: e.g., aviation accidents such as Tenerife aiport planes crash (1977) and loss of Rio-Paris flight (2009); space shuttles losses with Challenger (1986) and Columbia (2003); train accidents, e.g., Paddington trains collision (1999); process industries with Flixborough (1974), Seveso (1976), Bhopal (1984), Toulouse (2001), Texas City (2005), Buncefield (2005), or offshore with Piper Alpha (1988), Deepwater Horizon (2010), etc. Similar lessons can be learned from those accidents.

Nevertheless, in-depth learning remains difficult as exemplified by some institutions which repeated similar accidents (e.g., NASA and BP) or difficulties to learn from previous accidents (e.g., with Fukushima) or from previous incidents (TMI, Columbia, Texas City). Several question could or should arise:

- How to go beyond the implementation of lessons case by case?
- Is it possible to use the knowledge of the main case studies of industrial accidents?
- Could this knowledge change our mindset and practices of accident prevention?
- How to use knowledge of the past accidents to apply it to organizational diagnosis of safety in normal and future operations, especially in the nuclear sector?

Remarkably, the systematic study of industrial accidents since the mid-70's by few researchers has shown some recurring patterns in the incubation of accidents (Turner, 1978), latent errors (Reason, 1990), and their systemic and organizational root causes (Bignell and Fortune, 1984; Reason, 1997) and this whatever the accidents and their different occurrence contexts (industrial sector, country regulation, culture, history). Beyond the retrospective bias, this empirical observation, has open the possibility of capitalising generic lessons of accidents such as accident patterns, but also about the causes with the concept of pathogenic organizational factors (Dien *et al.*, 2004). Later, the concepts of new Knowledge and Culture of accidents were proposed (Dechy *et al.*, 2010) to distinguish the issues of knowledge construction, its transfer and use according the actions targeted (during assessment or daily management of safety).

In parallel, major methodological outbreaks were observed in accident investigations of Paddington trains accident (1999), Columbia space shuttle loss (2003) and Texas City refinery explosion (2005) and provided valuable lessons, especially on their organizational aspects. It validated the possibility of the capitalisation of a methodology strongly linked with pathogenic organizational factors, the organizational analysis and diagnosis approach (Dien *et al.*, 2004, 2012; Rousseau and Largier, 2008), both for accident investigation and normal operation assessment.

After this literature review and theoretical developments synthesised in the first part of the paper, efforts have been made, for more than ten years, to translate those lessons into new framework of analysis (e.g., production pressures, see Montmayeul, 2006, organizational learning, see Dechy *et al.*, 2009) and into practices for nuclear safety assessment. Two examples of assessment conducted by IRSN relying on organizational diagnosis in several NPP are presented: safety management in normal operation and organizational issues during outages for maintenance.

The second part of the paper will give therefore some examples of the use of the knowledge of accidents during organizational diagnosis, but will also show more recent developments in the learning from incidents.

To conclude, rationale for using lessons from accidents is stressed (“gift of failure” (Wilpert, 2011), “royal road” (Llory, 1996)). Some perspectives to these developments and transfers are then discussed with also some limits and barriers in theory and practice.

Understanding Nuclear Safety Culture: A Systemic Approach

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The Fukushima accident was a systemic failure (Report by Director General IAEA on the Fukushima Daiichi Accident). Systemic failure is a failure at system level unlike the currently understood notion which regards it as the failure of component and equipment. Systemic failures are due to the interdependence, complexity and unpredictability within systems and that is why these systems are called complex adaptive systems (CAS), in which "attractors" play an important role. If we want to understand the systemic failures we need to understand CAS and the role of these attractors.

The intent of this paper is to identify some typical attractors (including stakeholders) and their role within complex adaptive system. Attractors can be stakeholders, individuals, processes, rules and regulations, SOPs etc., towards which other agents and individuals are attracted. This paper will try to identify attractors in nuclear safety culture and influence of their assumptions on safety culture behavior by taking examples from nuclear industry in Pakistan. For example, if the nuclear regulator is an attractor within nuclear safety culture CAS then how basic assumptions of nuclear plant operators and shift in-charges about "regulator" affect their own safety behavior?

Complex Adaptive Systems and Attractors: According to complexity theory, [Gell-Mann, 1994; Senders, 1998; Antonacopoulou, 2005; Stacey, 1995; Reiman 2014; Chan, 2001] all social systems, including "safety culture", are CAS. CAS are nonlinear with increasing number of independent heterogeneous agents who constantly interact in unpredictable and interdependent ways. CAS are dynamic and self-organizing systems, where changes take place system wide (like a butterfly effect) and new structures and shapes emerge and disappear ("Perking" by Senders, 1998). The agents within CAS adapt to new information and actions of other agents. Attractors shape self-organizing, co-evolution behavior and new emergence within systems and help us predict system behavior. To understand CAS, we need pattern recognition skills to identify opportunities in an evolving system by conducting systemic analysis of all possible attractors.

Safety Culture is a complex adaptive system with a mix of individuals, organizations and technological systems. When the system is complex, there is higher internal friction, unpredictability and unknown risks (Kauffman, 1993). Moreover, peoples' perceptions and understanding of their situation continuously evolve and lead them to adopt new behavior. Hence, there is fundamental difference between fixed law of physics and dynamic patterns within CAS. We cannot study CAS by dividing it into smaller parts or through traditional systematic and analytical thinking. CAS can only be understood when seen as a whole with complex interdependences and interactions, i.e., systemic approach.

Systemic Analysis of Possible Attractors in Nuclear Safety Culture in Pakistan: There could be a number of attractors within nuclear safety culture CAS. The analysis of basic assumptions about safety culture of different attractors can help us see the safety culture from a systemic approach. The following human, organizational and technological attractors were identified within Pakistan's nuclear organizations:

1. Plant Management;
2. Operator Top Leadership;
3. National Nuclear Authority;
4. Nuclear Regulator;
5. Integrated Management System, SOPs etc.;
6. Accident reporting;
7. Regular Operational Meetings;
8. Stories of Seniors;
9. Training and Mentorship;
10. Learning and adaptation from safety exercises and IAEA reports;
11. HR Systems;
12. Public and Society.

Attractors build new assumptions and behaviors and change the old ones within safety culture. Assumptions of one attractor about "safety culture" influence behavior of other attractor at systemic level. To consider an analysis of attractors' assumptions and behaviors, the following are a few desirable and not-so-desirable assumptions of plant-operators about nuclear regulator

1. Regulator will accept what we report to them as they are part of national nuclear system;
2. No need to report this event to regulator;
3. We always report all events and assessments results to regulator since our regulator is very knowledgeable about operations;
4. Do not expect strict regulatory actions in case of serious violation;
5. Regulator is weak and dictated by Authority;
6. Regulator is captured;
7. Regulator lacks competence;
8. Regulator lacks legal basis.

Desirable Safety Culture Assumption, Behaviors and Consequences: Assumption: We always report all events and assessments results to regulator since our regulator is very knowledgeable about plant operations; Behavior: Open, trustworthy communication between plant operators and regulators; Consequence: Regulator is in better position to conduct safety oversight.

Not-so-desirable Safety Culture Assumption, Behavior and Consequence: Assumption: Regulator will accept what we report to them they are part of national nuclear system; Behavior: Lack of respect for regulatory oversight among operators; Consequence: Poor and ineffective regulatory oversight and high risk of nuclear accidents;

It is very important to have desirable, shared and common basic assumptions about nuclear safety culture for all attractors. Conflicting and not-so-desirable basic assumptions among attractors within nuclear safety culture system will increase the safety risks and unpredictability within this CAS.

TO3: Building Culture for Safety

This session shares the developing approaches for building safety culture in new build projects and suppliers.

Safety Culture in New Build Projects

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The concept of culture emphasises the social factors that have an effect on the way hazards are perceived, risks are evaluated, risk management is conducted, the current safety level is interpreted, and what is considered normal and what abnormal. It also contributes to defining the correct ways to behave in situations and correct ways to talk about safety, risks or uncertainty. Culture is something the company has created for itself that then has an effect on the company. This effect is not necessarily perceived by the company itself, since the members of the organization consider all things that happen according to their cultural taken-for-granted assumptions ("business as usual"). Thus, safety culture can either hinder or advance nuclear safety. This depends on what the shared values and assumptions are, and how they are in line with, and influence, the organizational structures, practices, personnel and technology.

Safety culture requires constant and systematic development, monitoring and review during the entire life-cycle of a nuclear facility. The pre-operational phase sets many unique requirements for nuclear safety culture. For example, some of the organizations and individuals involved in the project may have no insight on how safety culture relates to nuclear power plants. Companies that work in the conventional industry typically associate safety with occupational safety issues, not with nuclear safety. Further, it may be unclear how the construction phase affects nuclear safety of an operating plant. When workers are asked to perform their work differently than previously (e.g., in conventional construction sites), explanation has to be given. For example, structures, systems and components may have different functions during emergency that exceed or differ from their quality requirements during normal operation. The strict quality requirements and use of certain methods and procedures, documentation requirements, etc., may seem unimportant if nuclear safety is not considered. It has to be constantly reminded that many of the decisions and actions made during the design and construction phases can have consequences years, if not decades, later. The promotion of nuclear safety culture must also take into account cultural and language differences often prevalent at the construction site.

The presentation illustrates how the shared values, beliefs and assumptions about nuclear safety are influenced by four processes: Communication, safety leadership, climate, and interaction patterns. The shared values and the social processes in turn are embedded in and influenced by the organizational structures, organizational practices, tools and technology, as well as the individual employees. Aligning these different elements and developing them in unison in the complex project environment is challenging. The presentation gives some guidance on those challenges and proposes solutions to improve safety culture in pre-operational phases of nuclear power plants.

The FORO Project on Safety Culture in Organizations, Facilities and Activities With Sources of Ionizing Radiation

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The aim of this paper is to present the Ibero-American Forum of Nuclear and Radiological Regulatory Authorities' (FORO) Project on Safety Culture in organizations, facilities and activities with sources of ionizing radiation developed by experts from the Regulatory Authorities of Argentina, Brazil, Chile, Cuba, Spain, Mexico, Peru and Uruguay, under the scientific coordination of the International Atomic Energy Agency (IAEA).

Taking into account that Safety Culture problems have been widely recognised as one of the major contributors to many radiological events, several international and regional initiatives are being carried out to foster and develop a strong Safety Culture. One of these initiatives is the two-year project sponsored by the FORO with the purpose to prepare a document to allow its member states understanding, promoting and achieving a higher level of Safety Culture.

Safety approaches have had similar developments in almost all sectors of the industry and services with associated risks. Usually the occurrence of accidents or disasters has marked the beginning and the transition to higher stages, because they revealed expiration, failure or vulnerability of the philosophies, concepts and methods to address safety, existing at that time, leading to its renewal and to qualitatively better approaches.

In general, it can be considered that approaches to safety have gone through three phases. A first phase, characterised by a focus on technology to guarantee safety. Later, it was more relevant the contribution of individual human error during operation, leading to the human factors phase. Finally and after the analysis of some accidents occurred during the 80's decade, a new vision leads to the next and most recent phase of safety approaches, the organizational phase. It is in the latter where the Safety Culture is framed.

Several international documents and events have recognised the contribution of problems of Safety Culture in the occurrence of radiation events. Widespread and intense efforts have been undertaken to develop the theme of Safety Culture in nuclear and other sectors such as oil, aerospace, civil aviation and the health sector. The assimilation and the practical incorporation of the concept of Safety Culture in organizations carrying out activities with radiation sources has expanded considerably.

The FORO document on Safety Culture has been written in Spanish and is available free of charge at the FORO website. The document covers theoretical approaches and practical guidance on Safety Culture, adapted to the environment in which radiological activities are carried out. Some innovative elements are introduced in this document like a Safety Culture concept which considers that the radiological protection culture and the security culture are inextricable linked.

Several existing approaches and criteria in other risky sectors or activities were reviewed and analyzed. As result of this work, 10 Basic Elements of Safety Culture were established:

1. Priority of safety;
2. Visible leadership and commitment of top management with safety;
3. Timely identification and proper solution of safety problems;
4. Permanent focus on safety;
5. Responsibility, involvement and individual behavior in respect to safety;
6. Effective communication on safety;
7. Free reports on safety concerns;
8. Fair treatment for individual behaviors in respect to safety;
9. Continuous organizational learning about safety;
10. Environment of trust and partnership on safety.

These 10 Basic Elements are interrelated and they all must be present to achieve a strong safety culture. The 10 Basic Elements provide a conceptual framework to orient the actions and efforts for promotion and development and also for the evaluation, progress and monitoring.

The document also includes proposals for Safety Culture evaluation, Safety Culture indicators and provides a conceptual framework for internal Safety Culture in the Regulatory Authorities. This document can be a valuable tool to reach and maintain a strong Safety Culture for organizations and institutions in the Iberoamerican region and all over the world.

INPO Perspectives and Activities to Enhance Supplier Human Performance and Safety Culture

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Within their own organizations, utilities have made significant improvements in human performance and safety culture, supported by a strong community of practice through INPO and WANO. In recent years, utilities have been making increasing use of suppliers for design, construction, inspection and maintenance services in support of their NPPs. Many of these suppliers do not have the benefit of being members of a community of practice when it comes to human performance and safety culture. To help the supplier community make improvements similar to what the utilities have achieved, INPO has recently expanded its Supplier Participant program to address the issue of human performance and safety culture in the supplier community. The intent of this paper will be to share the INPO's perspectives and activities in helping suppliers of services and products to NPPs enhance their human performance and safety culture.

TO3

Addressing the Challenges of Sharing Lessons Learned Amongst Suppliers in a Fragmented and Competitive Marketplace

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Historically, COG member utilities largely drew from in-house supporting functions or the original plant designers, allowing active sharing of operational and human performance experience amongst a small number of relevant parties. As the industry has evolved, utilities have increasingly drawn upon a greater number of independent external suppliers to provide goods and services. This diversification in supplier base within a competitive environment changes operating dynamics, as a safety culture-focused supplier must remain mindful of developing and retaining competitive advantages over other suppliers. A market-driven perspective may undermine the likelihood of sharing certain lessons learned and best practices for fear of weakening competitive position. Utility procurement procedures must ensure fair markets to be effective, but in doing so may limit opportunity for collaboration between supplier and utility compared to historic levels. Vibrant competitive markets attract a large number of suppliers, which adds to the complexity of effective sharing and absorption of industry lessons learned. This paper will explain the activities underway through the COG Supplier Participant program to remove impediments and share industry-wide operational lessons learned and best practices.

Utility Expectations for Human Performance and Safety Culture in the Supplier Community

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Canadian NPPs, like many others around the world, make use of suppliers for the design and execution of major projects, and to support on-going inspection and maintenance activities. The work performed by suppliers today represents a significant portion of the work performed at utility NPPs, and, at times, can even exceed the work performed by utility staff. It is imperative for both the utility and the supplier workforces to work in collaboration to ensure that the probability of consequential errors impacting plant safety or contributing to broader enterprise risk is kept very low. An important element for keeping the risk low is for utilities to work with their suppliers to develop a high degree of confidence that the supplier workforce is performing to the same standards of human performance and safety culture as its own staff. This paper will provide a senior utility executive's expectations and perspective on achieving excellence in supplier human performance and safety culture.

Developing Nuclear Safety Culture within a Supplier Organization: An Insight from AREVA

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AREVA is present throughout the entire nuclear cycle, from uranium mining to used fuel recycling, including nuclear reactor design, equipment delivery and operating services. AREVA is recognised by utilities around the world for its expertise, its skills in cutting-edge technologies, and its dedication to the highest level of safety. This presentation will focus on the ways the safety culture applies to the supplier missions, along with the traditional focus on quality, costs and schedule. It will develop how the safety culture traits developed for nuclear operators by, for example, WANO or the IAEA, can be adequately be imported and embedded into the supply industry. This will be illustrated with some examples in this field.

DS: Dialogue Sessions

The Dialogue Sessions are designed to provide interactive forums enabling the exchange of perspectives, ideas, thoughts, and practices. The conference speakers and subject matter experts have all been appointed to co-facilitate a dialogue session based on their contributions to the conference. Within each dialogue session, an appointed lead-facilitator will trigger inquiring questions to support a fruitful dialogue. The aim is to allow time for conversations and reflections that will provide new insights which can be materialized to improve safety performance. At the end of each dialogue session the lead-facilitator will sum-up the highlights from the conversations. These will be forwarded to the Conference Chair for the plenary session.

The concept of shared space is a common theme throughout the conference (see DS–14). A central objective of the dialogue sessions is to introduce how shared space works in practice, and the difference it can make to help people communicate and understand each other better.

Conference participants are welcome to attend multiple dialogue sessions depending on interest and willingness to contribute. The below abstracts are authored by subject matter experts who contribute directly to the dialogue sessions.

Learning from Fukushima: Institutional Isomorphism as Constraining and Contributing Nuclear Safety

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This paper is an analysis of the international institutional isomorphic pressures and lessons learned from the Fukushima accident. The recent upgrading of nuclear safety requirements at the international and national level, as well as harmonisation attempts of nuclear reactor safety by the Western European Nuclear Regulators' Association (WENRA), show serious efforts to improve nuclear safety and implement lessons learned from the Fukushima accident. After Fukushima new requirements for the new nuclear power plants were set, such as preparedness for natural hazards, multiple failure and core melt situations. In addition, improvement of safety culture was emphasised, as well as strengthening of independence of the regulatory body from external pressures, and increasing of independence between different levels of defence in depth safety. However, learning from accidents is often affected by institutional factors, which may both contribute and hamper safety and learning.

The objective of this study is to gain insights into some institutional factors that have affected learning at international and national level. At the international level the International Atomic Energy Agency (IAEA) and WENRA revisions of safety requirements are examined, whilst at the national level the focus is on the analysis of learning of the Radiation and Nuclear Safety Authority of Finland. Research questions are the following: What kind of learning has occurred at international and national level? What kinds of isomorphic mechanisms have contributed or constrained learning? What kinds of innovations are going on within the Finnish regulatory body as regards Fukushima and lessons learned?

The data consist of safety standards of the IAEA and the WENRA reference levels, interviews with 18 nuclear safety inspectors in Finland. Content analysis is deployed as the method of analysis. As a theoretical tool, the concept of institutional isomorphism is applied. Institutional isomorphism refers to the phenomenon by which organizations become structurally or strategically more homogeneous. Isomorphic pressures, stemming from international or national institutional patterns or professionalisation of certain sectors affect the what, the how and who of safety-related action, and thus preconditions for learning. Isomorphism is important to the extent that it may strengthen and spread effective understandings of, and approaches to, safety. However, it may also engender an inability to detect specific needs and requirements or it may lead to contrasting understandings and approaches among bodies involved in nuclear safety that are exposed to different isomorphic pressures.

The findings show that institutional isomorphic mechanisms, such as close co-operation and exchange of knowledge between organizations, such as the IAEA, WENRA, and the national regulatory bodies have strengthened similar efficient understanding of safety. On the contrary, some institutional mechanisms have constrained learning by making it more schematic and this may mean that learning has not been as efficient as it could have been.

The findings show that learning has been gradual. At the national level there are relevant innovations going on that are replies to the problem of proceduralisation and governance of safety requirements and safety culture.

Criticality Risk Management: Why Analysis of Operating Practices Matters

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The criticality risk is an unwanted neutron chain reaction that could lead, if not under control, to a criticality accident resulting in a high release of energy accompanied by an intense emission of neutron and gamma radiation. Thus, the management of criticality risk in Fuel Cycle Facilities relies mainly on a set of prescriptions and requirements established by the licencees for achieving safety objectives.

This paper intends to show that, beyond prescriptions and requirements, a socio-technical approach is essential to define a relevant set of criticality safety rules favouring efficient and safe human activities. Indeed, a thorough knowledge of staff operating practices, beyond contributing significantly to the definition of appropriate technical and organizational provisions, enhances safety management combining "rule-based safety" and "managed safety". Rule-based safety (top down definition of the rules) can be achieved by anticipating undesirable situations and defining provisions to avoid and manage them in daily practices. On the other hand, managed safety (integration of local characteristics) develops the socio-technical system capacity to anticipate, recognise and formulate appropriate responses to unexpected scenarios that were not foreseen by the organization, or to rules that are not applicable to the operational realities. Thus, an effective safety management relies on human expertise, on the skills of individuals, on the quality of initiatives, and on the way teams and organizations perform the operations on a daily basis, interact and coordinate to integrate and regulate both ruled-based safety and managed safety.

We will pay specific attention to showing that risk analyses and criticality safety frameworks need to be considered in the light of diversity of working situations and complexity of their organizational interfaces. We will show that introducing and maintaining efficient and safe practices in the long term relies on appropriate staff risk awareness. For achieving this, in addition to the deployment of a relevant training program, the role played by local management and the support of criticality safety experts to operational staff is essential in order to make operating practices safer. Indeed, procedures and rules prepare the system for configurations that have been anticipated and play a major role in the ability to manage these situations. But situations also arise that are unforeseen or not (yet) analysed (hazards, evolutions following process modifications, degraded situations, etc.). The way the system responds to these will depend on organizational lines of defence which allows the local resources of the teams and the management to be available in real time.

Formalizing the rules is necessary to manage foreseeable work situations especially when criticality risk is involved. Nevertheless, formalizing the response to foreseeable situations does not guarantee the relevance of the response to unforeseen situations. Worse still, organizations that base their entire safety policy on prescriptive formal procedures can find their robustness brought into question when a new or unforeseen situation arises.

Safe production occurs only because each person manages many sources of variation while

performing their tasks, with expertise acquired through experience. As a consequence, global performance of a system in terms of production quality and safety is dependent upon interaction between social and technical components in workplaces. Finally, an organization contributes efficiently to safety when it facilitates an interaction between the formal rules, which provide general expertise, and the knowledge of specific operating situations and practices, which is held by the operators and managers on the field.

The paper refers to an example of an event that occurred in a French fuel fabrication, event involving non-compliance with rules and procedures to prevent criticality risks relative to conditioning, storage and internal transfer of containers which hold manufacturing scrap containing fissile material.

After the Fukushima Daiichi Accident, Extending the Human and Organizational Factors (HOF) Framework to Safety Regulation

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The accident of Fukushima-Daichi is regarded as a product of multiple failures of the nuclear risks regulation system in Japan and more particularly as a failure of the regulatory system (authorities, regulator and operator) to take into account seismic risks and flood risks caused by tsunamis. This statement conducted the French institute for radiological protection and nuclear safety (IRSN) to develop a research program dedicated to the study of the way the French nuclear regulatory system developed and addresses flood risks.

A regulatory system rests upon a number of institutional and organizational devices and upon normative tools, such as technical standards or guidelines. The aim of these normative tools is to guide NPP operators during both stages of risks identification and characterisation and of the design of protections against risks. These instruments have profound and multiple effects on the stakeholders involved. They affect the design of nuclear facilities, significantly influence the safety demonstration of a plant, but also the manner in which the actions implemented by the operator are evaluated and their reality controlled by the regulator.

DS

Our research began with an important work aiming to reconstruct the genealogy of the guidelines developed in France to address flood risks for NPPs. The design of these guidelines took place during the second part of the 2000's and was achieved by their publication in 2013 replacing those published in 1984. This work helped to highlight important evolutions in the way flood risks are conceived, as well as the important role played by the flood occurring on the Blayais NPP, in 1999. This work also emphasise the importance of the institutional developments related to the progressive independence of the safety authority and of its technical safety organization (TSO) and the promulgation of the law on transparency and nuclear safety (TSN law), with, in particular, the creation of the nuclear safety agency (ASN) in France.

The approach developed can be considered as a risk regulation analysis from the point of view of the human and organizational factors (HOF). Indeed, it appears to be fruitful to transpose the HOF framework usually used to analyze the safety management of the French NPP operators by IRSN, and to extend this framework to the analysis of the activities defining the French risk regulatory system. This extension presents many challenges: identifying the characteristics of the system and control activities, understanding the social and cognitive mechanisms involved in these activities, identifying the contribution of the normative tools in developping the effectiveness of this regulation and, of course, adapting the HOF conceptual framework to carry out these analyses.

One of the fundamental issues raised in our paper is the effectiveness of the regulation instruments such as standards and technical guides. Our main assumption is that legitimacy is one of the essential keys to the effectiveness of regulatory tools and is the product of a plurality of factors and characteristics of the regulatory system. We will present in particular three modes of legitimation (based on examples concerning flood risk management): legitimacy based on specific knowledge and demonstration about safety, legitimacy based on the procedures specifically developed or adapted for the elaboration of the regulatory tool and legitimacy based on the existing institutional system and particular arrangements built for this purpose.

HTO Approach Applications in ROSATOM CICET

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The paper presents Rosatom Central Institute for Continuing Education and Training (CICET) (hereinafter "CICET") current activity in areas of nuclear facilities personnel training and relevant research.

CICET has a strategic goal to get the "Safety Culture" competence centre for ROSATOM organizations. Safety culture ensures for nuclear organization to achieve both the business goals and high safety level. Safety is a state of ergatic [sic] system when influence of internal and external factors impact does not lead to its operation deterioration or stoppage. Dramatic history of world nuclear energetics shows that HOF the main assembly of factors influencing on safety. Individual work performance and organizational processes are visible, "artefact" part of the organization culture. Approaches and tools to enhance human and organization behavior are under CICET activity focus.

In safety culture area CICET has develop and apply four training courses. The set of training courses implementation allows to form understanding: What Safety Culture is? What is the Safety Culture model (attributes, indicators) for the organization? How organize Safety Culture Enhancement System? Who (roles, resources) must implement the activity? What methods and tools should be used?

Course 1: "Safety Culture in nuclear facilities concept". The course contains three main topics: history and modern description of safety culture concept; requirements to safety culture on government, senior management, line managers and individual levels; safety culture characteristics in complex social technical systems.

Course 2: "Safety culture enhancement in high risk facilities". The course contains the following topics: safety culture enhancement organization; safety culture enhancement implementation and the activity assessment and further improvement.

Course 3: "Safety culture enhancement: human performance improvement". The course contains two main topics: personnel reliability concept and system to support personnel reliability in nuclear facilities.

Course 4: "Safety culture enhancement: the process description, development and integration to the organization management system; safety culture enhancement regulations and guides development; safety culture enhancement process introduction."

Moreover, CICET, starting from 2012, holds the International Summer School on Safety Culture. The mission of the school is the promotion and development of the methodology and safety culture practice in organizations that use dangerous technology to provide high reliability and effectiveness their operations.

The school highlights many practical applications inside those following topics:

- Modern view on Safety Culture;
- Safety Culture influence on a personnel reliability and an organization effectiveness;
- Safety Culture continuous improvement system;
- Safety Culture assessment approaches and tools;
- Practical method on Safety Culture commitment formation;
- Leadership for Safety;
- Management for Safety;
- Nuclear Knowledge management in Safety Culture context;
- Systemic safety and managing for the unexpected.

Most training courses developed base of on system approach, field researches and methodological applications. For example, CICET has developed taxonomy of factors (including HOF) influencing on human performance. The model is applied now to implement inspection activity and could be used in training materials development, root cause analysis, risk management and safety culture models building.

OECD–NEA's Green Booklet on an Effective Nuclear Regulatory Body

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The fundamental objective of all nuclear safety regulatory bodies is to ensure that, within their countries, activities related to the peaceful use of nuclear energy are carried out in a safe manner, consistent with appropriate domestic and international safety principles and with full respect of the environment. In order to effectively achieve this objective, the nuclear regulatory body requires specific characteristics that will allow it "to do the right thing well and efficiently". A healthy safety culture within the regulatory body is a fundamental characteristic of an effective regulator.

Although the national regulator plays an essential role in each country, operating experience has shown that accidents may impact other countries and may involve other national regulators. Safety is therefore not bounded by national borders. The implications of this global nuclear safety approach should be taken into account when addressing the safety culture of the national regulator.

Deepwater Horizon: Experience the Events That Led to This Accident, Follow the Investigation as They Uncover the Human Factors

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With the Key themes of leadership, culture, reputation and risk, process safety and the human and organizational factors inside partnership and joint ventures, this session run by AKT immerses you into the situation on board the Deepwater Horizon drilling rig in the Gulf of Mexico on the day of the disaster 20 April 2010. The sequence of events are acted out and then we follow the investigation as they uncover negligence, poor regulation, inadequate maintenance, and catastrophic decision making and what the US authorities called "a reckless disregard for safety". This session will show how this type of workshop event has been used in different organizations, and the actors run the session to show how the facts of the disaster can be used to enhance knowledge of managers and senior leaders of factors that can trigger a major event.

The Regulatory Body's Perspectives on Safety Culture

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Safety Culture has traditionally been treated as an issue primarily related to the operators of nuclear (and other) installations. Although there is still a lack of consensus on many aspects of safety culture, there is meanwhile a large consensus on the importance of a good safety culture in each and every nuclear installation. As the Fukushima accident clearly highlighted, though, it is not enough to focus merely on licencees. There is a need to adopt a broader view on the entire overall system of stakeholders (such as manufacturers, contractors, international organizations, regulatory authorities, research organizations, as well as political institutions, the media and the public, etc.) and on how the participants in this overall system mutually influence each other. Each participant in the system has its own specific (safety) culture, but at the same time it is part of the overall culture based on general societal norms and values.

Among the stakeholders who play an important role in the overall "nuclear system" and interact with the licencees are the regulators. They are concerned with the safety culture of the organizations they oversee and develop approaches and tools for oversight in the domain of safety culture. But this is only one perspective.

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The regulators' also deeply impact the licencees' safety culture. Their underlying values and norms concerning safety which manifest themselves in their regulatory approaches and activities, in the nature of relationships they cultivate with the licencees, in the issues they do or do not address in oversight etc., influence the licencees' safety culture, either positively or, in the worst case, even negatively. In other words, the regulatory body's own safety culture has an important effect on the licencees' safety culture.

Therefore, the regulatory body needs to take different perspectives on the issue of safety culture:

1. Safety culture as an oversight issue, with the need and challenge to develop suitable approaches and tools for oversight on the licencees' safety culture;
2. Safety culture as an issue of self-reflection, in order to understand how the own (regulatory) safety culture (or oversight culture) influences the licencees' safety culture and to develop and apply appropriate regulatory approaches capable of positively influencing the licencees' safety culture.

It will be shown how ENSI has embraced these two perspectives on safety culture. ENSI's approach and practices on oversight of safety culture will be presented, as well as ENSI's project which has been conducted over three years after the Fukushima accident in order to initialise and institutionalise a self-reflection process on its own oversight culture.

Safety Culture Implementation in Indonesian Nuclear Energy Regulatory Agency (BAPETEN)

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The Indonesia Nuclear Energy Act no. 10 of 1997 clearly stated that Nuclear Energy Regulatory Agency (BAPETEN) is the Nuclear Regulatory Body. This is the legal basis of BAPETEN to perform regulatory functions on the use of nuclear energy in Indonesia, including regulation, authorisation, inspection and enforcement. The Independent regulatory functions are stipulated in Article 4 and Article 14 of the Nuclear Energy Act no. 10 (1997) which require the government to establish regulatory body that is reporting directly to the president and has responsibility to control of the use of nuclear energy. BAPETEN has been start fully its functioning on January 4, 1999. In it roles as a regulatory body, the main aspect that continues and always to be developed is the safety culture. One of the objectives of regulatory functions is "to increase legal awareness of nuclear energy of the user to develop safety culture" (Article 15, point d), while in the elucidation of article 15 it is stipulated that "safety culture is that of characteristics and attitudes in organizations and individual that emphasise the importance of safety".

In year 2000 the activities related to the safety culture began to be implemented in the form of a simple activites such as training on safety culture Implementation to the radiation protection officer and a dissemination to the licencee, several workshop and seminar on safety culture, and also promote an independent assessment of safety culture implementation to the nuclear installation. In addition, the Implementation of Safety culture in BAPETEN and as decision making process is outlined in the BAPETEN Management System and in the strategic planning.

Associated with the safety culture framework, BAPETEN has prepared a guide for the licencee as set out in BAPETEN Chairman Regulation (BCR) No. 4 year 2010 on Management system for facility and activity, as well as Government Regulation (GR) No. 33 (2007) on the Safety Ionizing Radiation and the Security of Radioactive Sources, Article 7, also in 2006 BAPETEN published Technical Document on Guidance of Safety Culture Implementation. Nuclear Safety Policy Statement by Chairman of BAPETEN, June 2000, have purpose to provide the framework for regulatory authority to manage the regulatory control of nuclear energy with due respect to safety, security, healthy of workers, environmental protection and peaceful use and to improve the professionalism in nuclear regulatory activities. The assurance of nuclear safety should be given a first priority in the utilisation of nuclear energy, and organization, utilities, companies and individuals engaged in all aspect of nuclear energy utilisation should adhere to the safety principles as top priority.

The development and implementation of safety culture within the regulatory body is a concern all of the stakeholders. This is necessary because BAPETEN as regulatory bodies should provide a good example for the licencee related to the Safety culture. Based on recommendations from several international meeting such as International Conference for Regulatory Effectiveness, IAEA Report on Strengthening Nuclear Regulatory Effectiveness in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant and also IRRS mission Recommendation, BAPETEN has set a numbers of things that must be followed in the implementation of safety culture in its own internal BAPETEN. Actions to be taken by BAPETEN include:

- Consider safety culture program within the regulatory body by developing a safety culture policy, and training senior management and staff in their respective roles and responsibilities in its implementation incorporating safety culture in the regulatory processes;
- Conducting safety culture self-assessment under the Integrated Management System continuous improvement program. BAPETEN take into consideration the elements of safety culture into their decision making processes;
- Engage in ongoing dialogue with licencees to enhance the understanding of safety culture aspects and to seek licencees' commitment to perform self and independent peer assessments of safety culture on a regular basis;
- Regulatory framework for promoting and oversight of safety culture in the operating organizations that is in nuclear installations and radiation facilities and activities.

Ecosystem view is an opportunity for regulator to achive the mission of nuclear safety culture within the national nuclear program, and Regulator is responsible and acountable for nuclear system. One of the BAPETEN mission related to safety culture program is to realise the national safety and security culture in accordance with the personality and character of the nation, so that BAPETEN has important role to fostering Nuclear Safety culture in the use of nuclear energy in Indonesia.

The Role of Leadership in Fostering Employee Safety Behaviors

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During the last decades significant improvements have been achieved when it comes to raising the level of safety in high-risk organizations. However, many organizations are still suffering from safety related problems such as lacking employee safety behaviors and high injury rates. Research has indicated that leadership can have a vital role in promoting safety. Most of the studies investigating the relationships between leadership styles and organizational safety have tended to focus on the role of a single leadership style, such as transformational leadership or transactional leadership. A few studies have also examined the association between safety-specific leadership, that is, a leadership style that specifically emphasises the promotion and enhancement of safety, and workplace safety outcomes. Still, no study up to date has investigated the relative importance of these three leadership styles. In addition, previous research on leadership and safety have provided ambiguous or only weak support for leadership styles being related to accident and injury frequencies.

Based on this background, the first aim of the present study was to investigate the relative importance of three different leadership styles for employee safety behaviors and injury rates in a high-risk organization. The three investigated leadership styles were transformational leadership, transactional leadership, and safety-specific leadership. The second aim of the study was to examine whether a relationship between leadership style and injury frequency could be found when the occurrence of minor injuries was measured in addition to that of major injuries.

Data was collected through a web-based survey responded by 269 employees at a paper and pulp mill in Sweden in 2013. The results from a hierarchical multiple regression analysis showed that safety-specific leadership contributed more than the other styles to overall safety, since it was most strongly related to both safety compliance and safety initiatives among employees. Although transformational leadership was slightly related to improvements in employee safety initiative behaviors, it did not contribute to any safety outcome over and above that of a safety-specific leadership. Transactional leadership was found to be negatively associated with safety, in that it contributed to less safety initiative behaviors and to an essential increase in the frequency of minor injuries. None of the leadership styles showed any significant relationship with major injuries.

The results imply that general transformational leadership can be beneficial for safety to a certain extent, but in order to achieve more extensive safety improvements it is imperative for leaders to engage in behaviors specifically focusing on promoting safety. The main conclusion is therefore that the extent to which a leader exhibits leader behaviors associated with the promotion of safety among his or her subordinates, regardless of the behaviors' transformational or transactional character, is the most important leadership factor affecting safety outcomes. Another important conclusion to be drawn from the results is that an overly correcting and controlling leadership style can under certain circumstances have a negative influence on safety. The fact that an association was found between at least one leadership style (transactional) and minor injuries, but not between any of the leadership styles and major injuries, also gives support for the benefits of registering and measuring minor and seemingly insignificant injuries and accident in addition to more severe injuries and accidents. This way the identification of relevant relationships between organizational factors and safety outcomes can be facilitated.

By broadening our understanding of the relative impact of different leadership behaviors on various safety outcomes, the findings in the present study contribute to a number of both practical and theoretical implications for the achievement of increased safety within high-risk organizations.

Knowledge Management Methodologies for Improving Safety Culture

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Epistemic uncertainties could affect operator's capability to prevent rare but potentially catastrophic accident sequences. Safety analysis methodologies are powerful but fragile tools if basic assumptions are not sound and exhaustive.

In particular, expert judgments and technical data could be invalidated by organizational context change (e.g., maintenance planning, supply systems etc.) or by unexpected events.

In 1986 accidents like Chernobyl, the explosion of Shuttle Challenger and, two years before, the toxic release at Bhopal chemical plant represented the point of no return with respect to the previous vision of safety and highlighted the undelayable need to change paradigm and face safety issues in complex systems not only from a technical point of view but to adopt a systemic vision able to include and integrate human and organizational aspects.

In a well-known article about his experience in the Presidential Commission on the Space Shuttle Challenger Accident (Feynman, Richard P. (1987) "Mr. Feynman Goes to Washington". Engineering and Science, 51 (1). pp. 6–22) Feynman stated: "So my theory is that the loss of common interest — between the engineers and scientists on the one hand and management on the other — is the cause of the deterioration in cooperation, which, as you've seen, produced a calamity".

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Taking the cue from Feynman's observation, we could say that one fundamental condition to set a common interest and then establish a systemic vision is the creation of a common code and a shared and widespread knowledge inside the organization.

This effort is still ongoing but there are some areas where it collides with current trends in organizations operating on edge technologies and high level risks (nuclear, chemical, aerospace etc.). In fact, the over-specialisation required for decision-making in such fields could represent a barrier with respect to a global vision of potential criticalities affecting safety of sytems and plants. This trend could lead to a state of "knowledge fragmentation" where it could be very difficult to find the common interest.

According to metaphor approach, we could say that there is the risk to have stuck "pools" of knowledge rather than a "stream" of knowledge which all areas of organization can draw from.

The activation of this stream requires a process of connecting different disciplines and expertise in order to create a common background and an information network. Several software applications make possible to deliver information in a widespread way within the organization, anyway this availability does not result automatically in knowledge creation.

According to complexity theory, culture is an emerging property of organizations and it is the result of a continuous interaction between individual and group viewpoints and of a continuous competition between current and new tools to understand a variable context.

Education and Training (E&T) actions can be very powerful and effective drivers of these processes, because they represent a tool for changing individual and group visions and spreading best practices and updated concepts.

Anyway, E&T actions could be not so effective if they don't aim at shaping the stream of knowledge inside the organization. To reach this goal, it is necessary to adopt an inductive approach that allows each student to access and share individual experience and knowledge using the "keywords" provided by the trainer. This one leads the process of "knowledge finding" through safety-related case studies, role-playing and simulation based on the technique of brainstorming where specialists and experts of different disciplines work together with people coming from all areas of the organization.

In this way, workgroups are "organizations in micro-scale" where different know-how and expertise combine in order to yield best solutions. After, this process is re-played among the workgroups through collaborative and competitive strategies, according to complex systems dynamics and logics as it happens, for example, in growth processes.

A relevant output of knowledge sharing is represented by the role awareness that participants to E&T sessions learn in so far as they acquire a higher view of organizational model and dynamics and recognise their potential contribute to safety culture improvement. This upgrade requires the realisation of a meta-knowledge inside the organization, that is possible through the implementation of a knowledge management system based on interactive processes of Education and Training.

Development of the KINS Safety Culture Maturity Model for Self and Independent Assessment

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Safety culture of an organization is cultivated and affected not only by societal and regulatory environment of the organization, but by its philosophies, policies, events and activities experienced in the process of accomplishing its mission. The safety culture would be continuously changed by the interactions between its members along with time as an organic entity.

In order to perform a systematic self- or independent assessment of safety culture, a safety culture assessment model (SCAM) properly reflecting cultural characteristics should be necessary. In addition, a SCAM should be helpful not only to establish correct directions, goals, and strategies for safety culture development, but should anticipating obstacles against safety culture development in the implementation process derived from the assessment. In practicalterms, a SCAM should be useful for deriving effective guidelines and implementing of corrective action programs for the evaluated organization.

Korea Institute of Nuclear Safety (KINS) performed a research project for six years to develop a SCAM satisfying the above prerequisites for self- and independent assessment. The KINS SCAM was developed based on the five stage safety culture maturity model proposed by Professor Patrick Hudson and was modified into four stages to reflect existing safety culture assessment experiences at Korean nuclear power plants. In order to define the change mechanism of safety culture for development and reversion, the change model proposed by Prochaska and DiClemente was introduced into KINS SCAM and developed into the Spiral Change Model.

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Through the comparison study with the IAEA's three stage development model and Kolb's Learning Model, it was confirmed that the KINS SCAM and Spiral Change Model overcome the limitations of both the IAEA's Model and Kolb's Model by distinguishing the representative characteristics of each stage clearly and supplying an articulate explanation for the mechanism of development and reversion of safety culture. In addition, the spiral change model defines the complacency states in each development stage to establish discriminated strategies against level of safety culture while IAEA's model simply describes complacency state as the second stage of organizational decline. The representative characteristics reflecting the organizational hierarchy of Korean nuclear power plants were defined for each level of safety culture against safety culture components developed by the KINS. The defined characteristics were amalgamated into the modified matrix model proposed by James Reason and Patrick Hudson to analyze assessment results systematically.

Development of effective regulatory intervention strategies based on the results of safety culture independent assessment was one of the main objectives of the research. The fundamental principles for establishing regulatory interventions against four safety culture levels were developed. The regulatory response strategies proposed by OECD–NEA were reflected and integrated into the KINS SCAM. We expect that the developed intervention principles would be applied for evolving detailed regulatory intervention strategies against each level of safety culture.

After the International Nuclear Safety Group (INSAG) introduced firstly the concept of safety culture into nuclear industries, the IAEA and its member countries have devoted considerable effort to develop effective assessment models for nuclear safety culture. According to the IAEA's report for the Fukushima Daiichi accident, the need to implement a systematic approach to safety culture synthesising the interaction between humans, technology and organization has emerged. The KINS SCAM and research experiences would be one of references for development of a systematic approach for safety culture self- and independent assessment.

Critical Conversations and the Role of Dialogue in Delivering Meaningful Improvements in Safety and Security Culture

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Significant scholarship has been devoted to research into safety culture assessment methodologies. These focus on the development, delivery and interpretations of safety culture surveys and other assessment techniques to assure reliable outcomes that provide insights into the safety culture of an organization across multiple dimensions. The lessons from this scholarship can be applied to the emerging area of security culture assessments as the nuclear industry broadens its focus on this topic. The aim of this paper is to discuss the value of establishing mechanisms, immediately after an assessment and regularly between assessments, to facilitate a structured dialogue among leaders around insights derived from an assessment, to enable ongoing improvements in safety and security culture. The leader's role includes both understanding the current state of culture, the "what is", and creating regular, open and informed dialogue around their role in shaping the culture to achieve "what should be".

Meaningful improvements arise when leaders proactively nurture a healthy safety and security culture. The concept of critical conversations is central to the necessary engagement of leaders and provides a basis for leaders to use their own knowledge of the organization to make informed decisions on those activities and approaches that can best influence the culture and support practical improvements. The concept of critical conversations is based on that described in US-based Nuclear Energy Institute's NEI 09-07 REV1, Fostering a Healthy Nuclear Safety Culture.

There are five aspects that will be discussed in this paper; the experience of Bruce Power, a Canadian nuclear power generating company with eight Candu units (6300 MW), will be used to provide practical considerations for implementation. The aspects are aligned to a Plan-Do-Check-Act cycle and support the implementation of an integrated management system, based on International Atomic Energy Agency's (IAEA) GS-R-3, The Management System for Facilities and Activities.

1. Adopt a framework against which to establish a dialogue. This paper will share Bruce Power's experience on the implementation of the "Traits of a Healthy Nuclear Safety Culture" established by the World Association of Nuclear Operators (WANO) and the Institute of Nuclear Power Operations (INPO).
2. Limit the number of improvements, but embrace them across the organization. This paper will address the effectiveness of Bruce Power's experience with limiting the number of improvements following a safety culture assessment, compared to having a more detailed and comprehensive action plan.
3. Create opportunities to engage regularly in Critical Conversations. This paper will address lessons from Bruce Power's implementation of Nuclear Safety Culture Monitoring Panels based on NEI 09-07, where several times per year, mid-level and senior leaders engage in very candid dialogue about safety and security culture.

4. Use existing oversight mechanisms to discuss progress. This paper will provide examples of oversight and monitoring mechanisms at Bruce Power related to safety culture improvement progress and the impact of sustained engagement around assessment findings.
5. Innovate: try new approaches to deepen understanding of culture. This paper will describe some of the exploratory mechanisms used by Bruce Power around safety and security culture awareness and monitoring, the lessons learned and future plans.

Scholarship on techniques used to assess culture is valuable to ensure an accurate understanding of the state of safety and security culture within an organization. However, deepening understanding of "what is" is only the first part of the journey to "what should be". To successfully navigate towards an ever-improving safety and security culture, leadership must create mechanisms to regularly discuss safety and security related cultural topics; be attuned to faint signals of cultural change and take appropriate action; and create the shared space and collegial atmosphere in which to engage in critical conversations about the state of safety and security culture.

Shared Space and the Power of Dialogue

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This dialogue session introduces the concept of shared space and how to work with the quality of interactions between people to improve safety outcomes. Shared Space simply defines the space existing between the individual and the people (individuals, groups) in its surrounding. A good shared space is characterized by:

- Mutual trust and respect;
- Decreased power dynamics;
- Openness — free flow in sharing of thoughts and ideas;
- Individuals who have interest in learning from each other and are curious of different perspectives;
- Individuals who feel able to express views related to their inner thoughts and feelings about a particular issue without fear of recrimination or exclusion;
- Conversations that go deeper than sharing facts; and
- *Dialogue* instead of discussion/argumentation.

A good shared space is an essential part of a strong safety culture as its characteristics create opportunities to build a shared understanding of safety within the culture.

The dialogue session leans on a practical example from Bruce Power, where establishing dialogue and "critical conversations" has been actively used as a tool to deliver meaningful safety and security culture improvements (See S. Brissette DS–13 "Critical Conversations and the Role of Dialogue in Delivering Meaningful Improvements in Safety and Security Culture").

IAEA Member State Support on Safety Culture; Leadership and Management for Safety

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This dialogue session will have IAEA NSNI representatives waiting to talk to Member States on their support needs and answer any questions regarding the support services IAEA has available in the area of leadership and management for safety and safety culture. Questions on peer reviews, scientific missions, workshops and the IAEA approach to the area of work covered by the conference can be answered along with technical questions with respect to standards and guides.

Interfaces between Security and Safety Culture

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This dialogue session is intended to encourage dialogue among IAEA representatives and experts in security culture and safety culture on the interfaces between these cultures. Beginning with several examples of the interfaces between nuclear security and safety that are currently part of the IAEA programme, this dialogue will go deeper to stimulate dialogue on possible approaches to effectively promote and enhance security culture and safety culture in a manner that complements each other.

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Post: Posters

The posters will be on display on the M-Building 1st floor concourse for the duration of the conference. Poster presenters are asked to be available near their posters during the breaks.

Safety Culture Assessment at Regulatory Body – PNRA Experience of Implementing IAEA Methedology for Safety Culture Self Assessment

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The prevalence of a good safety culture is equally important for all kind of organizations involved in nuclear business including operating organizations, designers, regulator, etc., and this should be reflected through all the processes and activities of these organizations. The need for inculcating safety culture into regulatory processes and practices is gradually increasing since the major accident at Fukushima. Accordingly, several international fora in last few years repeatedly highlighted the importance of prevalence of safety culture in regulatory bodies as well. The utilisation of concept of safety culture always remained applicable in regulatory activities of PNRA in the form of core values. After the Fukushima accident, PNRA considered it important to check the extent of utilisation of safety culture concept in organizational activities and decided to conduct its "Safety Culture Self-Assessment (SCSA)" for presenting itself as a role model in-order to endorse the fact that safety culture at regulatory authority plays an important role to influence safety culture at licenced facilities.

Considering the complexity of cultural assessment starting from visual manifestations to the basic assumptions at the deeper level, PNRA decided to utilise IAEA emerging methodology for assessment of culture and then used modified IAEA normative framework (in order to make it applicable for regulatory body) for assessing safety culture at a regulatory body. PNRA SCSA team utilised all tools (observations, focus groups, surveys, interviews and document analysis) for collecting cultural facts by including all level of personnel involved in different activities and functions in the organization. Different challenges were encountered during implementation of these tools which were tackled with the background of training on SCSA and with the help of experts during support missions arranged by IAEA. Before formally starting the SCSA process at PNRA, prelaunch activities were carried out in order to prepare the organization for the cultural assessment activity.

After completion of safety culture self assessment process at PNRA, the communication strategy was defined by SCSA team to share outcome of this assessment in the organization with the focus on developing dialogue and shared understanding. The safety culture improvement activities were designed to maintain and enhance strong areas of safety culture at PNRA and to address those areas that need attention in order to enhance safety consciousness.

This paper will present the PNRA experience of using IAEA emerging methodology for safety culture self assessment, challenges faced during the process and lessons learnt for further improvement in order to implement it more effectively in future. The paper will also highlight strategy utilised for conveying outcomes of SCSA in the organization at different levels along with safety culture improvement activities.

Practical Reason, Another Approach of Safe Action

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Born from the realisation that technology is neither the only source of risk, nor the exclusive solution, the concept of safety culture aimed at reintegrating human action, skills and symbolic productions (representations, beliefs, values, cognitive abilities, etc.) in the preservation of safety. As such it constituted a turning point for risk management and safety studies.

Yet, the concept seems to raise more and more questions, both as a concept and as a practical tool (Simard, 2000; Fuchs, 2012; Edwards *et al.*, 2013; Lopez de Castro *et al.*, 2013). Mostly, these questions revolve around the lack of consensus over one shared definition of safety culture; around the idea that a number of its traditionally accepted characteristics, such as its systemic nature, remain to be demonstrated; finally, and maybe most importantly, that its implementation through such management tools as questionnaires, indicators, dashboards, has deprived safety culture of its substance and diverted from its original purpose, i.e., putting humanity back at the heart of safety (Guldenmund, 2007; Karsh, Waterson, Holden, 2013; Reiman, Rollenhagen, 2013). Indeed such tools lead to classify and quantify reality in an attempt at reproducibility, leaving aside the many aspects of human action that do not fit the associated categories as well as its complexity.

Obviously safety culture has many virtues, in particular its popularity and ability to include all human aspects of action related to safety under one unique umbrella, thereby making it relatively easy to appropriate and ultimately helping balance the technical approach of safety. Yet, as the critics mentioned above suggest, it seems insufficient to translate the specificity of human action, and the reasons why leaving room for this specificity can help preserve safety.

Indeed, the limitations of strictly technical and engineered approaches of risk management, in particular their inability to cope with an environment more complex and unpredictable to the day, have been broadly documented (cf., for instance Hollnagel et al., 2006). As a consequence, in order to preserve safety organizations need to find a balance between the stability necessary to carry out their activity and expressed through rules and procedures, and the flexibility required to manage unpredicted situations, i.e. "slack" or ability of those who face such situations to decide on an ad hoc course of action (Grote, 2015).

If unpredicted, ad hoc action is required to preserve safety, it seems fair to try to develop a better understanding of human action, not only as a cognitive process but also as the result of an intention, i.e., the motivation of a specific individual, in a specific situation, to preserve safety. Indeed it seems that human action is usually considered from the angle of rationality, leaving intention aside. Yet even one of the most prominent authors on rationality, Herbert Simon, stated the role played by importance in decision-making (Simon, 1982).

In this conceptual paper, we call to a French contemporary philosopher, Paul Ricoeur, to analyse intentional action. In particular, we use his concept of "practical reason" (Ricoeur, 1986 (1991)) which is the practical tool individuals use to decide on courses of actions that are simultaneously strategic (i.e., rational) and ethical. Ricoeur defines ethics as “a good life, with and for others, within just institutions” (Ricoeur, 1992). We show that being inherently oriented towards ethics, practical reason is directly favourable to the preservation of safety by individuals. Furthermore, as a specific environment, the “just institution”, is necessary for practical reason to be expressed by individuals in their actions, Ricoeur opens an avenue to conceptualize organizations favourable to practical reason and therefore, preservation of safety by individuals.

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Promotion and Support of Strong Safety Culture at the Hungarian Regulatory Body

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The Hungarian Atomic Energy Authority (HAEA) in 2014 carried out a self-assessment in order to preparation for IAEA IRRS mission. As a result of the SWOT analysis it was concluded that for the promotion, development and improvement of safety culture at the HAEA is displayed only on the policy level. In order to obtain a greater emphasis on safety culture within the organization a working group was created. The task of the working group was to define the proposed actions to develop the organizational safety culture. The working group reviewed the current situation, the international experiences and proposed on this basis the elaboration of a guideline regarding to organizational safety culture, to integrate this guideline into the organizational training program so as to apply to all levels of the organization and presentation of the safety culture as part of the training of new comers.

Results so far: The working group has defined the main tasks and the connecting milestones in order to develop and improve the organizational safety culture at the HAEA. HAEA has elaborated a guideline for performing safety culture self-assessment based on IAEA and other relevant documents.

Future tasks, challenges, assessment: According to the working plan, HAEA will elaborate in the near future the methodology for assessment of safety culture, a questionnaire to assess the organizational safety culture, evaluation criteria for assessment and training materials regarding to safety culture.

Staffing: HAEA has developed a database profiling the available organizational expertise and in the light of the Government's plans to build the Paks-2 new units, it is used to determine the shortfall in staffing. HAEA made a detailed calculation of the necessary capacity and expertise related to the new tasks up to the year 2038. HAEA projects that its staffing needs will increase by an additional 40 staff by 2017 and another 40 by 2021. Due to the on-going recruitment of new staff and loss of senior staff to retirement, training and knowledge sharing is of utmost importance for HAEA.

Organizational changes: Due to the on-going significant tasks regarding to the new units the overall organizational structure of the HAEA is in transition. For this reason HAEA is elaborating a process and guideline for managing organizational changes, including evaluation, classification and justification according to their importance to safety.

Contribution: HAEA is participating in the OECD–NEA CNRA ad-hock working group's work regarding to the elaboration of a document for the development of regulatory safety culture.

A Glance on the Safety Culture in Industrial Gamma Radiography in the Philippines: Regulatory Body Perspective

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The current version of the Code of PNRI Regulations (CPR) Part 11 was published in the Official Gazette on 2010 [1]. It is just a year ahead of the publication of the IAEA Specific Safety Guide No. 11 [2]. In view of these, radiation safety culture in the practice of industrial gamma radiography was not yet fully introduced in the said national regulations in the country. However, it should not be a reflection that the radiation workers in the country specifically in the said field of practice do not exercise positive safety culture. The Nuclear Regulatory Division (NRD) — regulatory arm, although not yet separated from the Philippine Nuclear Research Institute (PNRI0) as mandated by law — the promotional organization, has a well established and systemic regulatory infrastructure. It is attested by several studies and reports [3, 4, 5], among others.

This study aims to assess the status of the existing safety culture in the conduct of industrial gamma radiography in the country through personnel perception survey of the radiation workers, i.e., managers, radiation safety officers, radiographers and radiographer's assistants, based on the IAEA five characteristics of safety culture stipulated in the IAEA Safety Guide No. GS-G-3.5, "The Management System for Nuclear Installations" [6]. It is assessed by the NRD of the PNRI. Also, the study determines the existence of safety culture as to the perspective of NRD through observations on the conduct of radiographic operations and walk-through of the facility while using the three-level Schein Model, i.e., "artefacts", "espoused values" and "basic assumptions" and document reviews, among other [7].

The methodology of the study used was mainly based on the IAEA approaches discussed in the draft of the soon to be published Safety Report Series, entitled "Performing Safety Culture Self-Assessments for Facilities and Activities" [8]. The data gathering tools and technique suggested in the said reference and such other in [9, 10], were applied as the following:

a) Conduct of survey using the Safety Culture Perception Questionnaire (SCPQ) survey questionnaire developed by the IAEA;
b) Review of documents, i.e., regulatory inspection reports and submitted licencing requirements, were consolidated to come up with an acceptable data for analysis and reliable results within a short period of study; and
c) Walk-though of the facility and observation during the conduct of radiographic operations with guided interview.

This study intends to have a better understanding of the current practices and implementation of the above-mentioned field specifics and come up with broader reflections from this. This study seeks: (Objectives of the Study)

1. To establish the updated profile of the licencees in industrial gamma radiography, based on [11]:

2. To determine the status of existing safety culture in the conduct of industrial gamma radiography thru the conduct of perception survey among radiography personnel themselves in accordance with the IAEA safety culture five characteristics and attributes based on IAEA GS-G-3.5, "The Management System for Facilities and Activities";
3. To determine the safety culture in industrial gamma radiography as perceived by the NRD in accordance with the three-level model, i.e., "artefacts", "espoused values" and "basic assumptions" manifested in the semi-structured (guided) interview and observation of the management, and radiation workers and document review of regulatory inspection reports and submitted licencing requirements.

The significance of this report is to serve as a pilot study on assessment of safety culture not only in industrial radiography but in other radiation facilities and activities, eventually to the Regulatory Body, in compliance with the IAEA safety requirements. The data and results of the survey will serve as a baseline data for a future impact evaluation study. However, due to the limitations of this study, an equally the same and more comprehensive future study needs to be conducted by a properly well-trained team, with better preparations and timeframe, and to fully cover the required respondents using the complete methodology as proposed by the IAEA.

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The Experience of Psychological Service of Rosenergoatom in Ensuring the Reliability of the Human Factor

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To ensure the safe and efficient operation of nuclear power plants, since 1982 the laboratories of psycho-physiological support (LPPS) started being established at Russian NPPs [1]. The methodological background for this was later summarised in [2]. The LPPS' activity and professional development of LPPS specialists are currently supported by the scientific-methodological centre "Psycho-Physiological Support of Professional Personnel Reliability" (PPSPPR) of Rosatom Central Institute for Continuing Education and Training (ROSATOM-CICE&T) [3].

The present paper gives the outlines of the main LPPS tasks performed by above mentioned organizations at Russian NPPs:

- psycho-physiological examination of candidates and employees (PFE);
- psychological and physiological support of workers (PPS);
- socio-psychological aspects of safety culture;
- psycho-pedagogical support of the educational process.

The PFE purpose is a psychological selection of NPP candidates and employees and control of psycho-physiological properties and professionally important qualities (PIQ) to detect early signs of psychological maladjustment and other disorders that reduce professional personnel reliability affecting the NPP operating safety.

The purpose of PPS is to recover, maintain and improve the professional performance to prevent wrong actions of the staff. Preventative and corrective measures are taken by PPS in this area.

The socio-psychological aspects of safety culture are implemented in the NPPs activities taking into account the recommendations of the IAEA, WANO, Rosenergoatom [4, 5].

The LPPS specialists perform a psychological analysis of the causes of incorrect actions of employees when the LPPS specialist works in the commission on investigating the violations/deviations in the NPP operation.

The LPPS specialists carry out social and psychological research of the socio-psychological climate of the NPP workforce; on shift staffing, manpower selection and deployment in the NPP divisions with regard to their business and psychological compatibility; on assessment of safety culture at NPPs; provide information and advice to the management and staff of the NPPs, participate in ongoing activities to improve the safety culture at the NPPs, and professional reliability of the personnel.

Within the framework of psycho-pedagogical support of the process of NPP employees training the LPPS's experts conduct group and individual classes on the psychological training of the NPP personnel, carry out psychological and pedagogical support of emergency drills and individual appraisal practice of the operational personnel at a full-scale simulator, develop psycho-pedagogical recommendations on an individual approach to operational personnel education during training to be authorised for the job.

The results of the corporate peer review by WANO, Rosenergoatom have shown that the involvement of LPPS specialists in the investigation of violations, staff selection and preventive management of stressful situations positively affects the operation of nuclear power plants and is one of the strengths of Rosenergoatom. This comprehensive work of LPPS increases the reliability of the human factor and safety of NPPs.

In the framework of implementation of scientific-methodological management of the LPPS activities SMC "PPSPPR" performs the following tasks:

- to develop regulatory documents governing the activity of LPPS specialists;
- to develop guidelines and instructions for implementation of the main activities, training materials, including lesson plans, handouts, videos, etc.;
- to develop and maintain the Unified Knowledge Base on the LPPS activities;
- to conduct training courses for the LPPS specialists;
- to held scientific-practical conferences on sharing the best practices;
- to carry out research work in the field of improving the reliability of the human factor.

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Safety Assessment in the AREVA Group: Operating Experience from a Self-Assessment Tool

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The expression "safety culture" first appeared following analysis of the Chernobyl accident in 1986. It was first defined in INSAG-4 (International Nuclear Safety Advisory Group safety series) in 1991. Other events have occurred in nuclear facilities and during transportation since Chernobyl: Tokai Mura in 1999, Roissy Transport in 2002, Davis Besse in 2002, Thorp in 2005. These events show that the initial approach was too simplistic. Based on this observation, the definition of safety culture was supplemented by including concepts of cultural value (associated with the country and the company) and human and organizational factors, and was integrated in that form with the emergence and implementation of integrated management systems (IMS).

Today, the concept of nuclear safety culture covers a wide set of factors such as safety, quality, corporate culture, defined processes and policies, organizations and related resources. Any assessment of people's safety culture, particularly people directly involved in facility operations, is thus part of a comprehensive policy and contributes to a de facto demonstration of the priority which management assigns to safety.

In facilities considered to be complex systems, safety management is dependent on personnel's level of risk awareness; in other terms, on the level of their safety culture. Safety culture assessment and how it is tracked over the long term thus represent two key objectives for the AREVA group and are integral to its continuous improvement policy.

Accordingly, AREVA developed a tool for the self-assessment of safety culture. Meant for line managers, the tool allows them to form a picture of their teams' level of safety culture, directly and anonymously, thereby giving them additional means to identify areas for safety culture improvement. Through its questionnaire on the operators' work, it also provides a concrete reflection of what the safety culture covers. Processing the results collectively gives the teams the opportunity to discuss safety culture, identify priority issues and, ultimately, improve their performance.

The tool is based on IAEA documents dealing with safety culture and methods for measuring and improving it.

AREVA's safety culture self-assessment tool is presented in this article and in particular its objectives, construction, targets, methods of use and operational deployment. Inter-organizational comparisons and the statistical data processing made possible by the tool are also described. To conclude, the potential for improvements and initial operating experience from the tool's deployment are discussed.

Human and Organizational Factors

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The Human and Organizational Factors Approach to Industrial Safety (HOFS) consists of identifying and putting in place conditions which encourage a positive contribution from operators (individually and in a team) with regards to industrial safety. The knowledge offered by the HOFS approach makes it possible better to understand what conditions human activity and to act on the design of occupational situations and the organization, in the aim of creating the conditions for safe work. Efforts made in this area can also lead to an improvement in results in terms of the quality of production or occupational safety (incidence and seriousness rates) (Daniellou, F., *et al.*, 2011).

Research on industrial accidents shows that they rarely happen as a result of a single event, but rather emerge from the accumulation of several, often seemingly trivial, malfunctions, misunderstandings, incorrect assumptions and other issues. The nuclear community has established rigorous international safety standards and concepts to ensure the protection of people and the environment from harmful effects of ionizing radiation (IAEA, 2014).

A review of major human induced disasters in a number of countries and in different industries yields insights into several of the human and organizational factors involved in their occurrence. Some of these factors relate to failures in:

- Design or technology;
- Training;
- Decision making;
- Communication;
- Preparation for the unexpected;
- Understanding of organizational interdependencies.

Individually, any of these failures can prevent an organization from being proactive in trying to continuously improve nuclear safety. When occurring together in some combination, they become the root causes of accidents. The root causes of nuclear accidents share much in common with the causes of accidents experienced in other industries, and the nuclear community can draw on this experience as a source of lessons learned (IAEA, 2006).

Management of the environment and the measures that ensure safety is a key concern for managers, both for ethical reasons and because safety is a legal responsibility. In order to increase the safety of personnel and manage technological risk, industrial companies have, for many years, implemented measures focused on the optimization of facilities and activities and the implementation of safety management systems. However, safety results seem to have reached a plateau where further improvement goes beyond technical approaches and procedures and requires greater attention to human and organizational factors. Good organization provides the basis for coherent planning and consistent actions. However, it is essential to take the human factor into account, ideally from the outset, to ensure that these actions are relevant and properly implemented ("Leadership in Safety" Working Group, 2013).

The term safety culture is used to designate that part of the company culture that relates to matters of safety in high-risk working environments. More precisely, safety culture can be defined as the set of practices that are developed and learned by the principal parties involved, to manage the risks of their occupation. Within a company, it is often said that "safety is everyone's business".

Nevertheless, some people are more directly affected by issues of occupational or company safety, namely the management teams and the employees working in operations. In fact, management practices with regards to safety often have a greater influence on the culture, because management has the authority and broader decision-making powers to influence the various factors at play in risk management. Human and Organizational Factors of Industrial Safety are not only the preserve of the Safety Department. Like safety in general, they need to be integrated into each of the company's Policies (Daniellou, F., *op. cit.*).

Study on the Man-Machine-Organization System Interfaces in Nuclear Facility Operation

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Nuclear installations are complex socio-technical systems whose reliable operation is based on the success both of the technical equipment and of the human and organizational factors. In this paper a theoretical study of the interfaces in Man–Machine–Organization System (MMOS) was performed. So, in this phase were performed the following:

- The identification of the characteristics of each element (man, machine, organization);
- The identification and analysis of the man-machine interfaces (equipment);
- The identification and analysis of the man-organization interfaces (communication, procedures, work process, training, time, work environment), so that for each interface was developed a circumstances module which can influence positive or negative the MMOS performance in accident conditions.
- The identification and the analysis of the machine organization interfaces (maintenance plan, modification plan, management of aging, state of man-machine interfaces). So that for each interface was developed a circumstances module which can influence positive or negative the MMOS performance in accident conditions.

All interfaces identified in MMOS and the conditions which could be at any given time are in the database records (HUFAD_E: Human Factor Analysis Database English). This database was developed in Microsoft Visual Basic 6.0 environment using SQL language query relational database.

Using the results of the studies, developed database and a software application (it was developed in Microsoft Visual Basic 6.0) a new approach (MMOSA) was developed. This method contents the following phases: the investigation process of the human actions; the appraisal of the possible human errors; the estimation of Basic Human Error Probabilities (BHEP) from generic or/and specific database; the estimation of Conditional Human Error Probabilities (CHEP) by the determination of the dependence level between actions using a positive dependence model; the comprehension of the human actions in MMOS to identify the MMOS interfaces using our qualitative analysis model and the database (the positive or negative conditions which can influence the human action at the analysis moment are identified for each interface); the estimation of the human error probabilities (HEP); the documentation (it is a report which will contain all elements considered in analysis and all results to be incorporated both in PSA study and design process).

Building a Safety Culture in New Comers — A Case for Turkey

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Background: Nuclear safety is a dynamic field. The nuclear power industry has been continuing to improve the safety and performance of operating reactors. However since the Fukushima event, nuclear safety and safety culture has become one of the highest priority issues around the world. Although a safety culture development program is necessary for all nuclear countries and companies, it is especially critical for new comers starting from the pre-operational phase.

Safety Culture Aspects In Newcomers: When a country embarking on a Nuclear Power Program, there are many aspects to consider. Building a national nuclear power infrastructure as one of the priority is a complex issue, requiring several years of planning. Implementation of nuclear safety infrastructure includes various steps. Major progressive steps for ensuring nuclear safety requires the availability of suitably qualified staff and the establishment of an effective safety culture in the country of concern.

However building safety and security culture in new comers is a complex process. It is a challenge! Major questions and debates are mainly on; how to build safety culture? How to assess factors influencing safety culture? How to implement program by utilising lessons learnt from the past experience of nuclear industry in the nuclear power countries and nuclear accidents. What is the best practice for creating a strong, positive, reliable, manageable, sustainable safety culture?

A dynamic newcomer — Case for Turkey: Turkey has undergone through various NPP bidding process during the past five decades. Although previous plans failed, they provided a valuable experience and helped to develop basic nuclear infrastructure required for the implementation of the current NPP projects. Turkey has been developing legal and regulatory framework, human resources, safety security, safeguards, and waste management programs steadily. Also operational radiation safety program to meet the minimum radiation safety requirements of the IAEA's Basic Safety Standards for Radiation Protection. Turkey emerges as a dynamic newcomer with two NPP project (namely Akkuyu and Sinop) under progress. According to the targets of MENR, the share of nuclear generation in the total installed capacity of Turkey is projected to be up to 5% until 2020, 10% until 2023 and as foreseen in national plans it is proposed to increase further in long term.

NUTEK Safety Culture Development Programme (NUSAC) Methodology: Building a safety culture in Turkey and in other new comers is a priority of NUTEK. One of our purpose is to establish a methodology for an integrated strategy aiming at Safety Culture infrastructure for developing countries, non-major power reactor program. The aim of NUSAC (NUTEK Safety Culture) Program is to contribute to improve Turkish industrial safety and occupational health status by building a "safety culture training program" along with the "localisation activities". Starting from the pre-operational phase of the Turkish national NPP program, NUSAC Plan has short, medium and long term objectives and will be implemented in phases progressively.

This comprehensive NUSAC program stipulates the cooperation with key authorities and stakeholders; MENR, regulatory authority, private sector, industrial chambers, universities and related NGOs. Our resources are:

- Highly qualified and experienced national and international network of experts.
- Compilation of IAEA references on safety and security (safety requirements, safety guides and safety standards).

Status of NUSAC under progress consist of:

- Training material modules — prepared in Turkish.
- Case studies on past natural hazards, technological disasters, mining accidents, traffic accidents, etc., occupational accidents and every day incidents in Turkey and in other selected newcomer countries.
- Reliable data base on accidents, analysis of near misses, component and equipment failures.
- Insights gained from the risk perception survey and human performance studies under stress integrated into the training modules.

Concluding Remarks: NUTEK core team members has a broad technical knowledge and experience in nuclear matters including safety and security. In addition, we can draw on our partner's knowledge and experience as well as the members of our network of national and international experts. NUTEK having access to a technical knowledge and experience with its core team and members of network intends this valuable knowledge for the Turkish industry to use as guidelines for training and good practice by individual members for the development of safety and security culture. This knowledge and experience is a valuable assets in developing of safety and security culture in Turkey thru training of all types of stakeholders. Industrial safety conditions and quality standards will be improved with parallel to the implementation of nuclear safety standards and building organizational safety culture in the local industries during preoperational phase of first two NPP projects.

Fewer can be More: Nuclear Safety and Security Culture Self-Assessment in the Hungarian Public Ltd. for Radioactive Waste Management

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The Hungarian regulator and operators show strong commitment towards robust nuclear safety and security culture. The paper discusses the evolution and the basis of the regulation of Hungarian safety and security culture. Because of security considerations nuclear safety incidents have always received and for sure will receive more publicity than malicious acts. That is probably the main reason behind that mostly nuclear safety incidents influence the common beliefs. This kind of primacy is noticeable as well in regulations and also in practice. Although there is a strong connection nuclear safety and security culture, their relationship has not been researched for a long time.

The paper also presents an already achieved, combined nuclear safety and security culture survey type assessment. Survey is a well known type of organizational culture self-assessment. The applied methods, relationship between these two cultures and of course some difficulties of the process are summerized. The presented method is appropriate to combine different guidance and characteristics to measure different attitude in a single survey. The method in practice is shown through the nuclear safety and security culture assessment conducted at Hungarian Public Ltd. Of Radioactive Waste Management.

Nuclear Safety Culture & Leadership in Slovenske Elektrarne

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This presentation shows practically how nuclear safety culture is maintained and assessed in Slovenske elektrarne, supported by human performance program and leadership model. Safety is the highest priority and it must be driven by the Leaders in the field. Human Performance is key to safety and therefore key to our success.

Safety Policy of our operating organization — licence holder, is in line with international best practices and nuclear technology is recognised as special and unique. All nuclear facilities adopt a clear safety policy and are operated with overriding priority to nuclear safety, the protection of nuclear workers, the general public and the environment from risk of harm.

The focus is on nuclear safety, although the same principles apply to radiological safety, industrial safety and environmental safety. Safety culture is assessed regularly based (every two years) on eight principles for strong safety culture in nuclear utilities.

Encourage excellence in all plant activities and to go beyond compliance with applicable laws and regulations. Adopt management approaches embodying the principles of Continuous Improvement and risk Management is never ending activity for us.

Nuclear Knowledge and Competence: Fundamental Prerequisites for the Safe Utilization of Radiation Sources in a Small Non-Nuclear Country — Experience of Montenegro

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Provision of adequate knowledge, competence and expertize represents a major concern when addressing nuclear and radiation safety issues in small countries — if inadequate, safety will eventually be jeopardized. Montenegro is such a small, developing and "non-nuclear" country — the use of radiation sources being modest and limited to a few ordinary applications (primarily in health care). Even though, there is (or will be in the foreseeable future) a significant need in nuclear knowledge, competence and expertize — directly or indirectly related to nuclear/radiation safety and security issues. It goes about the following, the list being not exhaustive: (i) medical applications (diagnostics, radiotherapy, palliation, sterilization of equipment, consumables, blood products, etc.), (ii) radiation protection, including various dosimetry services and QC/QA of radiation sources; (iii) environmental protection (radioecology, analytical and monitoring services, etc.), (iv) low and medium activity radioactive waste management (including a newly licenced storage), (v) industrial, geological, hydrological, agricultural, biochemical and archaeological applications (non-destructive testing, various gauges, radioisotope labeling, harmful insects sterilization, etc.), (vi) scientific and educational uses, (vii) cultural heritage preservation and investigation, (viii) legislative and regulatory aspects, including complying to international safety/security norms and joining international conventions in the field, (ix) preparedness and response to radiological and nuclear emergency situations, (x) combating illicit trafficking of nuclear and other radioactive materials, (xi) nuclear forensics, (xii) security systems based on X-ray and other nuclear methods, (xiii) introduction of some future topics (e.g., nuclear power for electricity generation and sea water desalination), (xiv) public information and communication with media, etc.

The University of Montenegro (UM) is the only state university in the country and the only one providing higher education, scientific research and expertise in natural and technical sciences, including nuclear and radiation-related ones — it is the statutory duty of UM to do so, and to do it in a manner commensurate to the country needs. By far the most relevant expertise in the country is either concentrated at UM or is deriving out of it; it therefore goes without saying that UM has fundamental role in meeting nuclear and radiation related goals (safety included) in Montenegro.

Small issues in big countries are often big issues in small countries. IAEA offers the unique and equal opportunity for all Member States to come up with their issues and seek for cooperation and assistance in order to cope with the problems; numerous modalities are at disposal to addressing the issues.

Networking is becoming increasingly important for building and sustaining a national body of knowledge, competence and expertize. This is particularly valid for those countries whose domestic resources are limited and/or where no critical mass of the above three constituents exists, which could sustain the system on its own. For instance, IAEA-based international networks for nuclear security education (INSEN) and training and support (NSSC), even relatively recent, proved fundamental in this respect. At UM (Department of Physics) we have launched several targeted educational courses at post-graduate level, following INSEN guidelines; the pioneering educational materials developed within the network represent the basic literature for both students' and lecturers' use. We also participate in nuclear knowledge management (NKM) activities and use their information system (INIS) when sourcing relevant data. UM is also national contact point for INES (International Nuclear and Radiological Event Scale) and has trained staff for properly reporting in case of incident/accident. UM participates in IAEA-supported Nuclear Instrumentation Laboratory Network (NILNET) and aims at participating at newly started Internet Reactor Laboratory (IRL).

In concluding, UM is (or is acting towards): (i) becoming national centre of competence and expertise in nuclear/radiation related issues, (ii) assessing, creating, preserving and transferring nuclear knowledge (NK), commensurate to Montenegro needs (nuclear knowledge management: NKM), (iii) offering consultancies and technical support services to all relevant stakeholders, (iv) being advisory body to the government for nuclear/radiation related issues and (v) focal point for dissemination and exchange of NK, in particular with the IAEA and European Union (EU), (vi) promoting nuclear/radiation applications for peaceful purposes, in particular medicine and environmental protection, (vii) being national radiation protection centre, (viii) developing curricula for nuclear/radiation related studies at all levels, (ix) supporting young students and scientists in nuclear/radiation related fields and facilitate their exchange with reputed institutions abroad and (x) giving proper and timely information and comments to the public and media on relevant topics/subjects.

An IAEA NKM expert mission to UCNC in 2009, including representatives from NKM centres in the region, affirmatively reviewed the above goals and encouraged both IAEA and Government of Montenegro to continue supporting its realisation. Ever since, UCNC stays on the above course, while our new visions — following Montenegro EU accession process — extend to EU perspectives, Horizon2020 in particular.

Regulatory Oversight of Safety Culture — Korea's Experience and Lessons Learned

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In Korea, a regulatory oversight program of safety culture was launched in 2012 to establish regulatory measures against several events caused by weak safety culture in the nuclear industry. This paper is intended to introduce the preliminary regulatory oversight framework, development and validation of safety culture components, pilot safety culture inspection results and lessons learned. The safety culture model should be based on a sound understanding of the national culture and industry characteristics where the model will be applied. The nuclear safety culture oversight model is being developed and built on the Korean regulatory system to independently assess the nuclear power operating organizations' safety culture.

The model is developed to focus on the organizational capabilities to maintain, improve and recover the integrity of key elements which play a major role in implementing the concept of defense-in-depth. The four basic areas of prime focus and 13 components are derived as cross-cutting factors. These are decision making, work management, work practice, and resource management for the human performance area, operating experience feedback, problem identification & resolution, and diagnosis and improvement in the management for improvement area, employee protection, information sharing, and just culture for the safety conscious working environment area, and leadership for safety, organizational competency, and changement management for the leadership and organizational control area. It is expected that these 13 SC elements shall be managed by licencee's safety culture management system which itself is composed of three components. For each SC component, characteristics which represent regulatory expectations and reference standard are developed.

The safety culture is defined as an assembly of behavioral patterns, core values and basic beliefs shared by individuals in organization about the importance of safety. The SC of an organization is expected to have meaningful and desired relationship with the nuclear operating organization's safety performance. Therefore, the validity of the SC components are examined with survey data from nuclear power plant employees. Based on the survey on NPP employees in Korea, and statistical analysis using SPSS with the survey result, content, construct, and criterion-related validity are confirmed. The hypothesis of 'safety culture is related to safety performance' is verified as statistically significant in the analysis of survey data. Many promising safety performance metrics are developed, and the relationship structure between SC components and safety performance metrics is identified.

The preliminary oversight program for licencee's safety culture is composed of daily on-site observation, periodic SC inspection, in-depth assessment, and periodic review. For example, the resident inspectors observe the works and activities of managers and employees in daily inspections. Periodic audit on licencee's SC system and activities is carried out. These field observation and inspection results are reviewed to find improvement areas. When safety culture related event happens, in-depth assessment will be carried out and root causes of the event will be analyzed. These observation, inspection, and assessment results will be accumulated into safety culture database. And long-term change of safety culture will be monitored and assessed in every 10 years taking an opportunity of periodic safety review.

Until now, safety culture inspections were carried out at nine NPP sites in Korea and KHNP head office, for two to three days at each site. The objective of pilot inspections is to verify the feasibility and effectiveness of regulatory oversight and to obtain baseline data of licencee's SC status, and to develop infrastructure within both regulators and operators. After several pilot inspections, some areas for improvement compared to current regulatory expectations are identified. For example, in the 'change management' component, it is recommended that organizational changes should be managed properly considering the effects on safety. Also, the oversight of licencee's head office is crucial for successful development of alignment of SC management system in the whole organization, because safety leadership, management, policy and behavioral model come from top level of the corporate. Legal basis of SC oversight will be established in 2016 according to recommendation of IRRS follow-up mission accomplished in December 2014.

The Role of the Regulator in the Field of Safety Culture to Shun Nuclear Accident

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The 2011 accident at the Fukushima Daiichi nuclear power plant in Japan has, as might be expected, led to improvements in equipment at plants around the world that have fortified safety systems and allowed for better protection against rare, extreme natural events. Equally important to the process of improving nuclear safety is the emphasis placed on implementing quality improvements to the human side of nuclear safety, a crucial element that is often not considered by those outside the nuclear sector. Ensuring nuclear reactor safety is not only a question of physical protection against all credible threats, enhancing robustness of important safety systems and increasing redundancy of back-up power and water cooling systems, but also one of making certain that qualified and trained staff are supported by effective procedures. However, these assets are valued only in an organizational culture that places a premium on ensuring high levels of safety, or implementing what is called an effective "nuclear safety culture". Principles, characteristics and factors for effective safety culture are to great extent similar between licencees and regulatory bodies and can be applied for developing RB's safety. Safety is the primary purpose of the regulatory body, Regulator plays a significant role in the field of nuclear safety even though the prime responsibility for safety belongs to the operator, and it is the regulator which actually decides what is considered to be safe. In order to effectively implement the international principle of high level of nuclear safety, nuclear safety culture should be clearly named as an objective in international nuclear legal acts and the regulator's responsibility for promotion of nuclear safety culture should be established. What is more difficult for the regulator is finding the right balance of firmness but fairness in dealing with the operator. In addition to enforcing safety regulations, the regulator should have a positive effect on the operator's safety culture. The regulator can promote safety culture in the operator's organization just through the mere fact of placing it on the agenda at the highest organizational levels. The operator's priorities are influenced by those matters regarded as important by the regulatory body. Thus, the regulator can stimulate the development of a safety culture by providing positive reinforcement for good performance and high quality in plant work processes, by encouraging good safety practices, by promoting the examples of operators having a good safety culture, and by recognising initiatives of industry organizations. Moreover, Safety culture has been identified as having played an important role in allowing precursor conditions at Fukushima to go unaddressed, thus the main goal of this paper is to discuss the role of regulatory body in the field of the safety culture by determining the level of the safety culture and how to promote and assess safety culture. Also, this paper sheds the light on concerned with defining the attributes of a good safety culture and describing how nuclear plant operators can develop those attributes to produce effective nuclear safety culture.

TSO Role in Supporting the Regulatory Authority in View of Safety Culture

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Human and organizational factors are always of paramount importance at nuclear and radiation safety as well as in the safety regulation provision. Major NPP accidents occurred merely reaffirm this fact. The role of an authority that regulates nuclear safety increases each time in the aftermath of accidents perceived as a shock together with the importance of scientific and technical support.

SEC NRS was established in 1987, the next year after the Chernobyl NPP accident aiming to strengthen supervision over works carried out at the nuclear industry enterprises. Currently SEC NRS provides comprehensive scientific and technical support to Rostechnadzor including safety review and regulatory legal documents development to regulate safety along with safety culture.

Fukushima-Daiichi NPP accident of 2011 was undoubtedly a watershed moment to revise the concept of safety culture of regulatory body. In 2013 IAEA has published TECDOC-1707 "Regulatory Oversight of Safety Culture in Nuclear Installations". This document observed outcomes of existing practices in respect to the regulatory oversight of safety culture in nuclear facilities. It was prepared under the scope of projects conducted by the IAEA and OECD–NEA over the last few years.

In line with the provisions of TECDOC-1707, the following criteria are proposed to be applied in selection of practicable regulatory approaches to safety culture oversight:

- accuracy of the resulting safety culture picture in the regulated organizations;
- the regulator's workload;
- involvement of regulator's senior management into safety culture oversight;
- involvement of human and organizational factors and safety culture skills.

In the Russian Federation the issues related to safety culture are covered by nuclear facilities inspection programs; general documents on safety provision (such as NP-001, NP-016-05, etc.) include requirements to building and maintaining of safety culture.

In the course of the fundamental Russian regulatory document updating, performed in 2012–2015, which regulates the NPP safety ("General Safety Provisions for Nuclear Power Plants"), the issue of safety culture received more attention compared to the current revision. The understanding of "safety culture" as a concept is brought in compliance with the international understanding specified, in particular, in INSAG-4. This report stated that safety culture includes characteristics of not only individual persons (performers and senior management) but also characteristics of organizations.

New revision of "General Safety Provisions…" establishes that safety culture is being created and supported through the following:

- NPP safety is to gain priority over economic and operational purposes;
- staff appointment, professional training and competence level maintaining in respect to the senior management and employees involved into any sphere of activity affecting safety;
- strict compliance with discipline within clear power-sharing and personal responsibility of performers and senior management;
- development and strict compliance with the requirements of quality assurance programs, operating procedures and technical specifications, regular updating with taking into account of experience accumulated thereof;
- decision-makers at all levels are to establish the climate of confidence and such teamwork approaches along with the social and living environment of NPP personnel, which are fostering the attitudes conducive to safety;
- employee's understanding of significance of his duties for NPP safety provision as well as the consequences resulted from lack of diligence or non-qualified execution in respect to the requirements of regulatory documents, quality assurance programs, operating and job procedures and technical specifications;
- self-checking performed by employees in relation to their work affecting the safety;
- understanding from every decision-maker and employee in respect to inadmissibility of concealing mistakes occurred in their activity and the necessity to reveal and eliminate their underlying causes; the relevancy of ongoing self-improvement, analysis and introduction of best practices including the foreign ones;
- establishment of rewards and sanctions system on the completion of work activities that motivates the transparent manner of actions and discourage exclusion of mistakes.

Further to "General Safety Provisions. . . " and in correspondence with the recommendations of the IRRS Mission hosted in 2013, drafting of safety guideline dedicated to aspects of safety culture maintaining and assessment at nuclear plants is planned for the next year. SEC NRS as scientific and technical support organization to regulatory authority is tasked to carry out this work.

SEC NRS is also charged with the responsibility to develop regulatory and legal documents of other types of nuclear facilities.

In particular, it is planned to put into force "Safety Culture Assessment Methodology in Nuclear Fuel Cycle Facilities" as safety guideline duly approved by regulatory authority.

Experience accumulated by regulators from different countries clearly demonstrates that the safety culture oversight is a challenging task that requires great efforts and certain knowledge, however such task could be solved. Especially, if an understanding and culture of collaboration between operating organizations is available.

A Recent Revisit Study on the Human Error Events of Nuclear Facilities in Korea

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After Fukushima accident we have launched two new projects in Korea. One is for the development of the countermeasures for human errors in nuclear facilities, and the other is for the safety culture of nuclear power plant itself. There had happened several succeeding events that turned out to be the typical flags of the human and organizational factor issues for the safety of the other socio-technical systems as well as nuclear power plants in Korea. The second safety culture project was an ambitious development to establish an infra system utilising system dynamics, business process modeling and big-data techniques to provide effective and efficient information basis to various interest parties related to the nuclear power plants. However the project has been drastically cancelled last year without any further discussion on the original issues raised before in Korea. It may come not only from the conflicting perspectives among the different approaches to nuclear safety culture but also from the misunderstandings on the human factors for the nuclear safety.

Thereby the first project in Korea is a kind of revisit study on the human errors themselves at first, secondly on the practical hazards that we should cope with in prioritised, and finally on their countermeasures that we could manage in practice. The study has been focused to the human errors especially in unexpected situations of nuclear facilities such as Fukushima accident. Though it is nowadays well known that human error means a crucial consideration for nuclear safety, current works on HRA and human factors verification may not be enough. The rareness of the errors in nuclear and the non-stochastic characteristics still require more cares beyond HRA, and additional considerations over the traditional safety such as occupational safety. For example violation type of human errors in compliance should be considered carefully in case of social/routine/permitted contexts. The key consideration to these human and organizational factors could be that they are not hazardous when separated deeply in the digital technologies and the organizations in terms of culture, climate and etc. in a system, but become critical when structured by the humans and human factors in the system. So a systemic concept/approach may be indispensible to cope with them including at first an infra system such as IMS(integrated management system).

Nowadays we are trying to devise many effective schemes to capture out the structural mechanisms of those hazards based on the database of the human factors characteristics including the personal traits and organizational differences, and proactive new criteria and defensive features that might be plausible and practical against to them.

Verification of Human Factors in Mexican Nuclear Facilities, Experience Gained During 20 Years

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One important insight from studies of the Three Mile Island (TMI), Chernobyl, and other nuclear power plant (NPP) accidents is that errors resulting from human factors deficiencies, such as poor control room design, procedures, and training are a significant contributing factor to NPP incidents and accidents. Plant safety requires defense in depth that encompasses using multiple barriers to prevent the release of radioactive materials, and employs a variety of programs to assure the integrity of barriers and related systems (IAEA, 1999). These programs include conservative design, quality assurance, administrative controls, and human factors.

This presentation describes the main activities and the process carried out by the CNSNS in Mexico, over 20 years to follow up on topics related to Human and Organizational Factors, including the main challenges to be solved by the regulatory body to ensure adequate monitoring of these issues in the Laguna Verde Nuclear Power Plant, for example:

- Diffusion with the licencee of the benefits of development and implementation of a Human Factors program. Results of measurements of noise, lighting and temperature were the first activities on the subject.
- Verify the Detailed Control Room Design Review process and solve all the problems identified during the review, such as: Use of color code to identified Systems and Instrumentation, Darkboard configuration in Alarm Systems, Use of color codes to identify ranges of normal and abnormal operation, Relocation of controls and handles.
- Replacing analogue by digital instrumentation and determine their impact on the actions of the operators in the main control room (Hibrid Control Room).
- Review and improvement of operational procedures to reduce the occurrence of events by inadequate written communication.
- Verification from the point of view of human factors of the areas of process buildings where you want to perform alignments systems, according to the emergency procedures.
- Verification of implementation of analysis tools to determine human errors in the occurrence of operational events at the facility.
- Human Factors Verification during Power Up Rate Project, by modifications in the Main Control Rooms of the facility. Mainly the Human-Machine Interface, in systems with displays and commands in computer screens.

Also describes the main challenges to be solved within the Mexican regulatory body, regarding:

- Formalization, development and management of a regulatory program on Human and Organizational Factors.

- Development of own human resources (experts), on the topics of human and organizational factors.
- As part of the Operating Experience Review, develop a database that allows recording and analyzing the main contributing factors and causes of human error.

Human Factors in Nuclear Reactor Accidents

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While many people would blame nature for the disaster of the "Fukushima Daiichi" accident, experts considered this accident to be also a human-induced disaster. This confirmed the importance of human errors which have been getting a growing interest in the nuclear field after the Three Mile Island accident. Personnel play an important role in design, operation, maintenance, planning, and management. The interface between machine and man is known as a human factor. In the present work, the human factors that have to be considered were discussed. The effect of the control room configuration and equipment design effect on the human behavior was also discussed. Precise reviewing of person's qualifications and experience was focused.

Insufficient training has been a major cause of human error in the nuclear field. The effective training issues were introduced. Avoiding complicated operational processes and nonresponsive management systems was stressed. Distinguishing between the procedures for normal and emergency operations was emphasised.

It was stated that human error during maintenance and testing activities could cause a serious accident. This is because safety systems do not cover much more risk probabilities in the maintenance and testing activities like they do in the normal operation.

In nuclear industry, the need for a classification and identification of human errors has been well recognised. As a result of this, human reliability must be assessed. These errors are analyzed by a probabilistic safety assessment which deals with errors in reading, listening and implementing procedures but not with cognitive errors. Much efforts must be accomplished to consider cognitive errors in the probabilistic safety assessment.

The ways of collecting human factor data were surveyed. The methods for identifying safe designs, helping decision makers to predict how proposed or current policies will affect safety, and comprehensive understanding of the relationship between human factors and the accident were investigated. Finally, recommendations for prevention or minimisation of human errors were provided.

Neuropsychological Aspects Observed in a Nuclear Plant Simulator and its Relation with Human Reliability Analysis

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This paper will discuss preliminary results of an evaluation methodology for the analysis and quantification of errors in manual (human) operation by training cognitive parameters and skill levels in the complex control system operation using Neuropsychophysiology and Neurofeedback equipment.

The research was conducted using a game (nuclear power plant simulator) that simulates concepts of operation of a nuclear plant with a split sample evaluating aspects of learning and knowledge in the nuclear area. Operators were monitored using biomarkers (ECG, EEG, GSR, face detection and eye tracking) and the results were analyzed by Statistical multivariate techniques. An important component in the evaluation of complex systems is the human reliability during operation. Human reliability refers to the probability of the human element perform the tasks scheduled during the defined period for system operation when tested under specified environmental conditions, and additionally not to take any action detrimental to system operation.

The neuro-scientific study of human behavior has advanced greatly in recent decades and today is an invaluable tool when the goal is to study human behavior in various situations, allowing treatment of limitations of methods available for the analysis of the human factor contribution to complex control system operation by identifying and evaluating factors involved in decision making, as the influence of ergonomic factors in the criteria of acquired skills (training) and cognitive. Cognitive ergonomics refers to mental processes such as perception, memory, reasoning and motor response as affecting the interactions among humans and other elements of a system. Relevant topics include the study of mental workload, decision making, specialised performance, man machine interaction, stress and training as correlation between projects involving complex operating systems and human operator.

Taking into account the difficulties imposed by the human profile, the use of cognitive monitoring equipment is an interesting option for the full assessment in training and operating procedures, it is possible to identify and record the patterns of cognitive skills and acquired in each operator as foci attention, reaction ability, level of knowledge and motor actions, which may be assessed later by a monitoring group composed of the most experienced operators, psychologists and engineers linked to the process. After evaluation of operators with the methodology applied, the collected information can be used in a Human Reliability Analysis.

For analysis of the collected data from Eye Tracking, EEG (electroencephalogram), BPM (Cardiac Monitoring) and GSR(Galvanic Skin Response) it will take into account as a model the most capable and experienced operators, aiming to flatten all operators in a high standard of human reliability. It is necessary to observe moments of high workload, when there is a higher probability of micro incidents. Thus, the authors will try to observe state change situations such as shutdowns and planned matches, incidents assumptions and ordinary features of operation.

In this sense, the research related neuropsychological aspects can contribute to improving the techniques available in order to make it more realistic techniques that may eventually be employed in human reliability analysis both in the context of quantitative approaches for regulatory purposes as well as refers to reducing the incidence of human error. Therefore, the research on neuropsychological aspects is a big step to improve techniques and analysis models of human reliability to meet the goal set for this research project. Because the amount of data and the analysis of complexity only initial results will be presented.

Safety Culture Evaluation at Research Reactors of Pakistan Atomic Energy Commission

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The concept of safety culture was presented by IAEA in document INSAG-4 (1991), delineated as "assembly of characteristics and attitudes in organizations and individuals which establish that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance". The purpose of this paper is to describe the evaluation of safety culture at research reactors of the Pakistan Atomic Energy Commission (PAEC). Evaluating the safety culture of a particular organization poses some challenges which can be resolved by using safety culture evaluation models like those of Sachein (1992) and Harber-Barrier(1998).

In PAEC, safety culture is the integral part of management system which not only promotes safety culture throughout the organization but also enhances its significance. To strengthen the safety culture, PAEC is also participating in a number of international and regional meetings of IAEA regarding safety culture.

PAEC and the national regulator Pakistan Nuclear Regulatory Authority (PNRA) are also arranging workshops, peer reviews, sharing operational experiences and interacting with IAEA missions to enhance its capabilities in the field of safety culture. The Directorate General of Safety (DOS) is a corporate office of PAEC for safety and regulatory matters. DOS is in the process of implementing a program to evaluate safety culture at nuclear installations of PAEC to ensure that safety culture is included as a vital segment of the Integral Management System of the establishment. In this regard, training sessions and lectures on safety culture evaluation are normally conducted in PAEC for awareness and enhancement of the safety culture program. Safety culture is also addressed in PNRA Regulations like PAK-909 and PAK-913. In this paper we will focus on the safety culture evaluation in our research reactors, i.e., PARR-1 and PARR-2. The evaluation results will be based on observations, interviews of employees, group discussions, surveys and documents. The evaluation of safety culture will be done by using standard evaluation models which mainly focus on the safety culture evaluation of organizational artifacts, claimed values and basic assumptions. In this regard, guidelines will be sought out from the IAEA technical documents, e.g., IAEA-TECDOC-743 and IAEA-TECDOC-1321.

PAEC management has an extensive vision of the development and maintenance of strong safety culture and is committed to promote a safe working environment through its implementation. PAEC's mission and policy statements reflect its commitments in this respect. After the Fukushima Dai-ichi accident, Pakistan has put more emphasis on safe operation and stringent control on safe usage of nuclear technology. Development and evaluation of safety culture can strengthen this control on nuclear technology. We intend to tread on the same path starting with the evaluation of safety culture in research reactors of Pakistan. The evaluation strategies will provide a feedback mechanism to review and revitalize the implementation of safety culture.

Human Factors Reliability Analysis for Assuring Nuclear Safety Using Fuzzy Fault Tree

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In order to ensure effective prevention of harmful events, the risk assessment process cannot ignore the role of humans in the dynamics of accidental events and thus the seriousness of the consequences that may derive from them. Human reliability analysis (HRA) involves the use of qualitative and quantitative methods to assess the human contribution to risk. HRA techniques have been developed in order to provide human error probability values associated with operators' tasks to be included within the broader context of system risk assessment, and are aimed at reducing the probability of accidental events. Fault tree analysis (FTA) is a graphical model that displays the various combinations of equipment failures and human errors that can result in the main system failure of interest. FTA is a risk analysis technique to assess likelihood (in a probabilistic context) of an event. The objective data available to estimate the likelihood is often missing, and even if available, is subject to incompleteness and imprecision or vagueness. Without addressing incompleteness and imprecision in the available data, FTA and subsequent risk analysis give a false impression of precision and correctness that undermines the overall credibility of the process. To solve this problem, qualitative justification in the context of failure possibilities can be used as alternative for quantitative justification. In this paper, we introduce the approach of fuzzy reliability as solution for fault tree analysis drawbacks. A new fuzzy fault tree method is proposed for the analysis of human reliability based on fuzzy sets and fuzzy operations t-norms, co-norms, defuzzification, and fuzzy failure probability.

National Nuclear Safety Department Experience of Supervision over Safety Culture of BNPP-1

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The analysis of the past major NPPs accidents, TMI, Chernobyl and Fukushima Daiichi shows that causes of these accidents can be explained by a complex combination of human, technological and organizational factors. One of the findings of accident investigations and risk assessments is the growing recognition of the impact of cultural context of work practices on safety. The assumed link between culture and safety, epitomized through the concept of safety culture, has been the subject of extensive research in recent years.

The term "safety culture" was first introduced into the nuclear industry by the IAEA in INSAG-1 to underline the role and importance of the organizational factors. The objective of this paper is to conduct an assessment of some safety culture indicators of Bushehr Nuclear Power Plant (BNPP-1).

The methodology used is based on the IAEA tool, "Tool for Oversight of Safety Culture Attributes (TOSCA)". Currently, TOSCA is being applied in various WWER NPPs in Finland, Hungary, Slovakia and Russia. The basis of this method is to collect safety culture related data by the regulatory bodies in an established procedure. These data are subject to a periodic analysis. The main objectives of this method are:

- Support regulatory bodies in supervising safety culture related issues;
- Provide a systematic approach and coherent framework for collection and analysis of these resulting observation data;
- Allow consolidation and use of observation results within regulatory framework;
- Get unbiased and valid image of licencee's safety culture trends.

For each attribute, certain indicators have been taken into account, for example "staff Responsibilities and authorities" and "system of rewards and sanctions" are the indicators which are considered to be used to evaluate the "Everyone is personally responsible for nuclear safety" attribute. Based on this method, a questionnaire containing 38 questions was prepared. The questionnaire was completed by the BNPP-1 operating staff. Additionally, the staff was interviewed and the plant working documents were studied by the NNSD TOSCA inspection team. Subsequently, all collected data was analyzed by the NNSD TOSCA inspection team.

The results show that there has been remarkable improvement in certain safety culture indicators in the plant in recent years. In addition, some deficiencies in safety culture have been found. Finally, the effectiveness of TSOCA process was evaluated.

On Some Issues Related to the Models of Human and Organizational Factors and their Use in the Decision Making Process

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The paper presents some results from a research on the best approaches to be adopted in order to evaluate the impact of various models used for Human and Organizational Factors (HOF) in nuclear field (nuclear power plants (NPP) and the infrastructure specific for their lifetime cycle — design, operation and extention of operation and decommissioning of a NPP). The work considers that modelling of HOF in integrated models for the whole NPP and its infrastructure was identified as an important issue by all the major accidents in the NPP (for instance, TMI, Chernobyl and Fukushima). However there are fundamental difficulties to develop models for such systems (combined technical-social and economical systems). Previous models used for similar cases in the evaluation of the lessons learnt from major accidents and in the modelling of the security of energy supply aspects were used by the author. In this paper results are presented with the use of three type of models:

- Operational research (using matrix approach) for describing the systems, their elements, the challenges and results of the challenges;
- Expert type approach based on best practice and expertise included in documents and researches of holistic type;
- Risk based evaluations based on methodologies for the Integrated Risk Informed Decision Making.

Post

The three type of approaches mentioned above were applied to three case studies for NPP and their infrastructures (NPPI):

A NPPI in validation of research/design and testing of a prototype;
B NPPI of "middle age" from the postulated lifetime perspective experiencing a major accident;
C NPPI at the end of the initially postulated lifetime experiencing a catastrophic accident.

The results illustrate the strengths and weaknesses of each approach and the areas of their complementarity, which are going to be used in further more detailed studies.

Evaluation of Influence Factors within Implementing of Nuclear Safety Culture in Embarking Countries

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The evaluation of the implementation nuclear safety culture at BATAN has been performed. BATAN is Indonesia's national nuclear energy agency. Nowadays, BATAN is planning to develop an experimental power reactor. To implement the nuclear safety culture BATAN has issued BATAN chairman regulation (Perka BATAN 200).

Perka BATAN is the reference for individuals and organizations to implement nuclear safety culture which includes basic principles, mechanisms, assessment, as well as the implementation of the application of safety culture. It covers the establishment of safety policies, program development, program implementation, development and measurement of safety culture.

Each facilities within BATAN is expected to well implement a safety culture. The implemetation of safety culture is developed by considering the characteristics, attributes and indicators. The characteristics, attributes and indicators referenced are elaborated from the IAEA. The activities to strengthen safety culture are monthly workshop with participants is head of every facilities, safety leadership training and workshop for safety division manager in every facilities. It is also issued a handbook of safety that is distributed to all employees BATAN.

For assessment the implementation, after conducting an explanation of the concept of safety culture implementation, for a facility at BATAN Serpong Nuclear Zone, Ps. Jumat Nuclear Zone, Headquarters, Bandung Nuclear Zone and Yogyakarta Nuclear Zone questionnaire-based data are retrieved. Factors to be considered are how performance of implementation can be monitored and improved as required by driving indicators, monitoring indicators, or indicators feedback. It is obtained that almost facilities are at the level of good enough implementation.

Statistical analysis was performed by factor analysis approach using testing KMO (Kaiser–Meyer–Olkin) criterion which should be greater than 0.5. Rotation technique used is oblique rotation with the presumption to statistical construct a factor consistent with purpose of the characteristics and attributes of reference. As a result, it is obtained that the set of constructs with KMO of 0.951 has a significance level of 0.000.

The results of the attributes is grouped into three groups. The first group is a group of safety management [SCD05, SCD07, SCE01, SCD08, SCE05, SCD09, SCE04, SCE02, SCD06, SCE07, and SCC03] which is a combination of the characteristics of safety integrity and safety as a driver of learning. Although there is an element in which safety accountability (i.e., degree of compliance with the rules and procedures (SCC03)). This group can be expressed as a group of safety management.

The second group is a group of SCB04, SCB05, SCB03, SCB06, SCB08, SCB07, SCB10, and SCC02. This group were declared as safety leadership group. The second group is derived

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from the characteristics of safety with the negative correlation coefficient for supposing the reciprocal or bidirectional affect.

The third group is a group of SCA01 and SCA02 which are derived only from the safety characteristics. Its meant that the third group will be explained only the safety value system and expressed as a factor of safety significance. Safety accountability that inherent in group management and safety leadership has smallest correlation coefficient within its grouping, such that can be ignored in the naming of new obtained factors.

All of the three grouped factors is called as characteristics of BATAN's safety culture implementation. Each characteristic has a number of different attributes, namely safety management, and safety leadership, and the importance of safety characteristic consists of 8, 11, and 2 attributes, respectively, for a total number of attributes of 21. It can be concluded that the importance performance characteristics in BATANs safety culture implementation, namely safety management, safety leadership and the importance of safety.

Management Systems and Safety Culture in the Nuclear Energy Sector (ISO 9001 & GS-R-3)

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Nowadays, the enterprises of the Rosatom State Nuclear Energy Corporation that provides products and services to foreign customers should rely on the requirements to the management systems established by the IAEA Standard GS-R-3 "The management system for facilities and activities". This results from the fact that in order to enter foreign markets, Russian suppliers have to meet foreign requirements related to quality assurance, protection of the environment, nuclear and radiation safety, etc. For instance, the Finnish customer "Fennovoima" requires full compliance of the management systems of the Russian companies involved in the construction of the Hanhikivi-1 NPP with the GS-R-3 Standard.

ISO 9001 quality management systems were widely implemented in the nuclear industry enterprises in Russia. The assessment of compliance of the quality management systems with the established requirements is carried out by the certification bodies. The same relates to the environmental management systems that are implemented at the majority of nuclear industry facilities in Russia. But due to their uniqueness and associated significant risks, the nuclear industry enterprises have to meet current safety requirements and principles established in the IAEA Safety Standards, such as safety culture and risk management.

In GS-R-3, the IAEA uses the approach according to which safety culture is integrated in the management system, i.e., the safety culture assessment should be carried out as a part of the management system assessment.

A nuclear and radiation safety authority (regulatory body) is entrusted by IAEA with the assessment of quality management systems compliance with the GS-R-3 Standard [1].

However, according to the ISO/IEC Standard [2], the compliance assessment of the quality management systems with the established requirements should be carried out by the so-called certification body whose functions differ from the functions of the regulatory body that are provided in GSR Part 1 [3]. Regulatory bodies in many countries have neither resources, nor specialists for the compliance assessment of the supervised organizations.

New Standard ISO/AWI 19443 "Quality Management Systems. Specific requirements for the application of ISO 9001 and IAEA GS-R-3 requirements by organizations in the supply chain of the nuclear energy sector" is currently being developed. It is aimed at harmonisation of the requirements of ISO 9001 and GS-R-3. In comparison with ISO 9001, this Standard has some significant advantages, such as requirements on the safety culture and risk management, and in contrast with the GS-R-3 Standard, it has provisions for the management system certification of organizations in the supply chain of the nuclear energy sector. The main disadvantage is that the Standard does not cover management systems of nuclear facilities, e.g., NPPs.

We consider it reasonable to entrust the certification bodies that have the relevant resources and experience with the assessment of nuclear industry enterprises management systems.

For instance, Bureau Veritas employs 66 500 staff in 1400 representative offices in 140 countries; Intertek (Moody International) employs 38 000 staff in 1000 locations in 100 countries.

The development of ISO Standard for the nuclear industry enterprises management systems is required. Implementation of this standard will make it possible to achieve efficiency of the nuclear industry enterprises management systems and, as a result, high safety culture.

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Asphology — the Birth of a New Science

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Currently, in the field of "safety culture" a great deal of attention is paid to the concept of culture. Culture is an abstraction, yet the forces that are created in social and organizational situations deriving from culture are powerful. If we don't understand the operation of these forces, we become victim to them. Cultural forces are powerful because they operate outside of our awareness. We need to understand them not only because of their power but also because they help to explain many of our puzzling and frustrating experiences in social and organizational life.

Normally, issues related to culture highlight one or another aspect or idea shared by members of a particular group or organization (the latter referred to as organizational culture). Currently, there are more than 30 various definitions of organizational culture. Such diversity results from the fact that culture has not yet been studied enough in group, organizational, and occupational domains to have spawned new theory. It is still an evolving field.

One of the most widely accepted definitions of culture is that given by Edgar Schein: culture of a group can be defined as a pattern of shared basic assumptions learned by a group as it solved its problems of external adaptation and internal integration, which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems.

However, we think that the concept of "safety" also deserves an in-depth study. According the IAEA Safety Glossary, "safety" means the protection of people and the environment against radiation risks, and the safety of facilities and activities that give rise to radiation risks.

The mission to ensure safety of people and society in the context of scientific and technological progress and development of nuclear technologies is a complicated political, scientific and technical, social and economic challenge. Scientists from around the world gradually come to a conclusion that the system of knowledge about protection of people and the environment from hazards of human activities should become a stand-alone theory.

The classic approach to the development of a new theory consists of a sequence of steps: gathering experimental data; defining regularities among the data; formulation of an empirical law; building a system of hypotheses. Such reactive way to develop the theory of safety seems to be too long. From one accident to another empirically humanity takes too short steps towards safety.

Until the accident at Three Mile Island (1979), little attention was being paid to the important role of human factors and human reliability in the operation of nuclear power plants. The Chernobyl accident (1986) highlighted the importance of safety culture and the impact of human and organizational factors on safety performance. After the Fukushima Daiichi nuclear accident (2011) the concept of systemic approach to safety that establishes interconnections among individuals, technology and organization (ITO) is being actively developed.

It should be mentioned that the Fukushima Daiichi nuclear accident was initiated primarily by the tsunami of the Tōhoku earthquake, i.e., from natural external effects. Unfortunately, the ITO concept doesn’t consider the impact of external effects on a nuclear facility as well the impact of a nuclear facility on the environment.

Consequently, new paradigm ITOE should be referred to that would cover interconnections among individuals, technology, organization and the environment.

Thirty years following the Chernobyl accident have given rise to a clear understanding that complicated set of various safety-related issues is the subject of interdisciplinary research.

The aim of in-depth interdisciplinary studies should be not only to obtain a comprehensive and coordinated vision of the full scope of safety issues, but eventually to develop reliable methodological tools applied for the analysis of more specific issues.

In other words, today we need to have a kind of “safety philosophy” or science about safety. We suggest using the term “asphology” or “asphaleology” which means “science about safety”. The new term comes from Greek word ἀσφάλεια “aspháleia” that literally means “safety, protection”.

One may already state that the new science should emerge at the intersection of already existing natural, social and technical sciences.

Asphology should not be understood in a narrow practical way as a methodology of scientific research related to the study of standards and regulations, laws and tools, but should be regarded in a wider sense as a worldview, scientific ideology, a kind of philosophy regulating integrated scientific cognition.

Conclusions: 1) It is necessary to develop the new ITOE paradigm covering interconnections among individuals, technology, organization and the environment. 2) We need a new science called “asphology”, the science about safety.

The 4th Missing Element of the ITO Systemic Approach to Safety

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According to the IAEA Report [1] the Fukushima Daiichi accident was a wake-up call for the nuclear community to recognise the complexity of safety and to respect the entire systems interaction of ITOs. The complexity of nuclear organizations is increasing, and different and more unique approaches are needed to ensure that safety is maintained. The Fukushima Daiichi accident was avoidable, according to the presentations of experts from Japan.

Taking into account the ongoing interaction between all the individual, technical and organizational (ITO) factors reveals the complexity and non-linearity of the operations at a nuclear power plant. It is necessary to better examine how the weaknesses and strengths of all these factors influence one another and to facilitate the proactive elimination of risks.

The International Experts Meeting (IEM) participants [1] emphasised that an integrated approach to safety through consideration of the interaction of ITO systems is needed to complement the more traditional approach to safety. The concept of a systemic approach to safety represents a new way of thinking about safety for some Member States and even for some IAEA activities and services.

Several considerations were identified during the meeting [1] for the development of an integrated approach to safety. In particular, the need to complement the traditional approach to safety with an ITO systemic approach was emphasised. The participants suggested that this approach might include the use of "stress tests" for human and organizational factors (HOFs) and the further exploration of nontechnical aspects of safety. Future analyses should include ITO considerations in an integrated way.

Guidance and training materials for the integration of all elements of HOFs, safety culture, organizational culture, the management system and ITO factors in existing and new nuclear programmes to ensure that the systemic approach is developed and maintained.

It should be reminded that the Fukushima Daiichi nuclear disaster was initiated primarily by the tsunami after the Tōhoku earthquake on 11 March 2011, i.e., by an external natural events.

According to [1] the systemic approach to safety addresses the whole system by considering the dynamic interactions within and among all relevant factors of the system — individual factors (e.g., knowledge, thoughts, decisions, actions), technical factors (e.g., technology, tools, equipment), and organizational factors (e.g., management system, organizational structure, governance, resources).

However, the ITO systemic approach to safety doesn't consider external impacts (floods, cyclones, explosions or fire originating from off-site sources, etc., [2, 3]) on NPPs safety as well as NPPs impacts on the environment (e.g., radioactive discharges to the environment [4]).

One of the key issues in strengthening safety of nuclear facilities is the consideration of new knowledge related to the fact that our understanding of natural hazards continues to evolve, and that systematic, predictable and stable approaches are needed to address the new and significant information as it emerges [3].

In our opinion, the new approach to safety is necessary — the ITOE paradigm with its emphasis on the interrelationships and interactions of the individual (human), technical, organizational and environmental (external) factors.

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Overview of Recent Activities on Safety Culture and Human and Organizational Factors Carried Out at the Joint Research Centre of the European Commission

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The Institute for Energy and Transport (IET) of the Joint Research Centre (JRC) of the European Commission (EC) is since more than ten years active in the field of Safety Culture (SC) and Human and Organizational Factors (HOF).

Several activities related to SC and HOF have been and are carried out in the frame of the EU Nuclear Safety Clearinghouse for Operating Experience Feedback (Clearinghouse). The Clearinghouse was established in 2008 to enhance nuclear safety through the lessons learned from NPP events, and to provide help in Operational Experience Feedback (OEF) process primarily to nuclear safety Regulatory Authorities and to their Technical Support Organizations within the EU. Additionally to these activities, during the Fukushima accident, Clearinghouse has been regularly providing reports on the status and progress of the accident to the EU Regulatory Authorities. Moreover, experts, selected from the JRC staffing, were directly engaged in the EU-wide risk and safety assessments of nuclear power plants known as "the Stress Tests".

After Chernobyl, many projects were funded by the EU to increase the safety of the Ukrainian and Russian NPPs through the TACIS programme. Currently there are several ongoing project directed to enhance the cultural, procedural and technical capability and effectiveness in operating Ukrainian NPPs. Two are directly aiming at improving SC and HOF: 1) "Improvement of Safety Culture Management at NNEGC Energoatom and its NPPs" and 2) "The Enhancement of Nuclear Safety by extending the understanding the influence of human factors". These projects are managed by the EC Directorate-General for International Cooperation and Development (DG DEVCO), with the technical and scientific support of the JRC.

Due to the similarity with the safety approaches in other major hazard industries, Clearinghouse is involved in different activities where the other industries have developed their own Operational Experience Feedback programs. Their repositories of experience, mainly in the form of reports, are a very valuable source for numerous studies ranging from the ones aiming to extract the best lessons learned from individual events to the more comprehensive ones where common areas for improvement are identified on the basis of the assessment of similar events in specific industry branches.

In addition, studies where different industries provide inputs from their databases are performed too. The JRC also contributed to one of the latest concluded international projects carried out by the European Safety, Reliability and Data Association (ESReDA) Project Group for Dynamic Learning from Accident Investigation (PG DLAI). The main objectives of the project were to work out recommendations on how to capture, document, disseminate and implement insights, recommendations and experiences obtained from the investigations of high-risk events.

Finally it is worth mentioning some other JRC projects focused on nuclear safety: Nuclear Reactor Accident Analysis and Modelling (NURAM); Knowledge Management, Training and Education in Reactor design and Operation (CAPTURE); and Support to DG ENER Nuclear Reactor Safety Policy and International Standards (NUSP).

Through all of these projects Safety Culture specific characteristics and attributes are always highlighted to remind all stakeholders of its importance for the safe operation of NPPs.

A Synchro-Diachro Approach to Question the Development of a Human and Organizational Factors (HOF) Network

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First, this communication presents a dual approach to question the development of a HOF network. Next, an illustration of this approach is proposed: the development of the HOF network of the CEA. The dual approach is based on a synchronic way and a diachronic one, hence the name: "synchro-diachro". The illustration presents elements which come from our experience feedback at CEA.

The synchro-diachro approach: The synchronic point of view focuses on the development of a HOF network at one moment of its development. It is like taking a picture. The objective is here to point out some characteristics of the functioning of a HOF network. They are related to the complex systems theory, and especially to the concept of dialogical principle, proposed by Edgar Morin ([1, 2]). These characteristics are dialogical pairs. The elements of this kind of pair are both complementary and antagonist to one another.

Three pairs are presented. They are considered as conditions for the workings of an intermediate aged HOF network. The three pairs are: specialist — nonspecialist actors of the network, centralised — distributed human resources in the network and local — organizational factors levels of HOF methods to analyze the work situations. The first two pairs are related to the organization of a HOF network and the last one is related to the methods which are used to analyze the working situations.

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The diachronic point of view focuses on the development of a HOF network during a period of its development. It is like using a video camera. The objective is here to examine the development of a HOF network from Greiner's model [3] which proposes different steps of the development of organizations. They are called creativity, direction, delegation, coordination, collaboration and extra-organizational solutions.

An illustration: the development of the HOF network of the CEA: The HOF network of the CEA is a set of actors composed of HOF specialists and non HOF specialists called correspondents. The correspondents work inside facilities or inside specific departments dedicated to manage indoor analyses and evaluations of the safety of facilities.

According to a synchronic point of view, the three dialogical pairs are present at CEA:

- specialist: correspondent actors of the network;
- centralised: distributed human resources in the network;
- microscopic: macroscopic levels of HOF methods to analyze the working situations. It is the name at CEA of the local and organizational factors levels of analyzing.

Two aspects of these pairs are considered in this communication:

- the size of the difference between the elements of a pair (for example the qualifications of specialists versus correspondents),
- the balance between the sizes of the elements of a pair (for example the number of specialists versus correspondents in a centre).

Indeed, to continuously improve the three dialogical pairs, it is important to keep the differences which exist between the two elements of a pair and to find and maintain a balance between the two elements of the pairs.

According to a diachronic point of view, the evolution of our HOF network has been considered for more than fifteen years. Nowadays, our network seems to be located in the beginning of the last step even if certain steps like coordination or collaboration were not really passed. Then, one of the main interests of this diachronic point of view is to examine what has been done at CEA according to Greiner's model and what could be interesting to do according to it.

Conclusion: In the communication, the future of our network is also discussed since the step of extra-organizational solutions is currently started at CEA. It means that the HOF network of the CEA becomes an extended network which consists of HOF specialists, correspondents, subcontractors (HOF consultants) and also researchers. Thus some new dialogical pairs should certainly appear too.

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Probabilistic Safety Assessment: An Effective Tool to Support “Systemic Approach” to Nuclear Safety and Analysis of Human and Organizational Aspects

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The Probabilistic Safety Assessment (PSA) represents a comprehensive conceptual and analytical tool for quantitative evaluation of risk of undesirable consequences from nuclear facilities and drawing on qualitative insights for nuclear safety. PSA considers various technical, human, and organizational factors in an integral manner thus explicitly pursuing a true ‘systemic approach’ to safety and enabling holistic insights for further safety improvement. Human Reliability Analysis (HRA) is one of the major tasks within PSA. The poster paper provides an overview of the objectives and scope of PSA and HRA and discusses on further needs in the area of HRA.

Post

CP: Closing Plenary: The Future is in Our Hands

This plenary session draws all the participants together to reflect upon the information shared during the conference and summarises the conclusions and remaining questions; to finally identify the conference outcomes and the way to move forward for nuclear safety.

Progress in Nuclear Safety Reform of TEPCO

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On March 29, 2014, TEPCO issued the Nuclear Safety Reform Plan describing the background cause of our Fukushima Nuclear Accident and our plan to challenge organizational and cultural change to avoid recurrence of such a tragic accident and to pursue the excellence in safety. This report will reflect that background cause with some specific examples and introduce how we are currently implementing this reform plan.

After the TEPCO nuclear scandals were revealed in 2002 TEPCO started the Nuclear Renaissance activities that also pursued the organizational and cultural change, and focused on the leadership training that provided managers and supervisors with communication skills and methods to improve work process and peer group activities to pursue the standardisation of work processes among three nuclear sites. Though these attempts resulted in a certain level of accomplishment, Fukushima Nuclear Accident could not be prevented. The reasons were summarised in the Nuclear Safety Reform Plan as follows:

- There was recognition that nuclear safety had already been sufficiently achieved, and the scandals were not considered to be an indication of the deterioration of safety culture. Therefore, the measures were not ample to methodically improve safety awareness.
- With regard to "safety awareness", there was no specific reform plan for the former nuclear executive management due to the recognition that the cause of scandals was a problem pertaining to middle management and organizations at the nuclear sites, despite the fact that the former nuclear executive management should have taken the initiative to improve "safety awareness" throughout the organization with unwavering resolve.
- Organizational authority and responsibility during an emergency were unclear. However, there was ambiguity regarding managerial authority and responsibility even during normal operation.

In the Nuclear Safety Reform Plan the negative spiral of shortfall in accident preparedness is described. This spiral shows why an organization, whose stated vision of safety as the top priority, could not prevent the Fukushima Nuclear Accident based on the relation and structure of problems on "safety awareness", "engineering capability", and "communication ability", even though there was not a single executive in the former nuclear executive management of TEPCO who did not consider "safety to be the top priority".

The business environment surrounding the electric utility has changed greatly over the last decade or so. In the case of TEPCO, the scandals in 2002 and the Niigata-Chuetsu-Oki Earthquake in 2007 had a major impact on our capacity factor, so our executive management made strong demands on the nuclear power division to increase the capacity factor. We assumed that safety was established after certain measures for severe accidents had been implemented and capacity factor was considered to be an important management challenge.

Consequently, avoiding prolonged reactor shutdown was made into one axis of the risk map that determines work priority. Measures whose effect was difficult to assess and which do not directly contribute to improving the capacity factor, such as measures to make the battery rooms watertight, were not implemented or postponed In such a situation, measures such as SCC and earthquake countermeasures were performed in order to secure, maintain and improve the capacity factor even at an excessive cost, thinking that such expenditures could be recovered as long as the capacity factor was improved, thus our dependence upon manufacturers increased. This results in a decrease in our technological capabilities and a high-cost structure. This degradation of technological capabilities became one factor in our decreasing ability to debate purely technological arguments with regulatory authorities and the ability to disclose the residual risks of nuclear power. The deterioration of communication skills was accelerated by hesitation to engage in risk communication.

The following six pillars of measures were developed in the Nuclear Safety Reform Plan, and the report introduces how each measure is currently being implemented:

- Measure 1: Reform starting from senior management;
- Measure 2: Enhancement of oversight and support for management;
- Measure 3: Enhancement of capability to propose defense in depth;
- Measure 4: Enhancement of risk communication activities;
- Measure 5: Reform of emergency response organization at the power station and Headquarters;
- Measure 6: Change of power station organization during normal operation and enhancement of firsthand technical skills.

Leadership Actions to Improve Nuclear Safety Culture

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The challenge many leaders face is how to effectively implement and then utilise the results of Safety Culture surveys. Bruce Power has recently successfully implemented changes to the Safety Culture survey process including how corrective actions were identified and implemented. The actions taken in response to the latest survey have proven effective with step change performance noted.

Nuclear Safety is a core value for Bruce Power. Nuclear Safety at Bruce Power is based on the following four pillars: reactor safety, industrial safety, radiological safety and environmental safety.

Processes and practices are in place to achieve a healthy Nuclear Safety Culture within Bruce Power such that nuclear safety is the overriding priority. This governance is based on industry leading practices which monitor, asses and take action to drive continual improvements in the Nuclear Safety Culture within Bruce Power.

An important aspect of determining the status of the Nuclear Safety Culture within Bruce Power is effective leadership oversight which sets standards and behaviour expectations for all staff and uses a variety of day to day controls to monitor the operations of the facilities as well as to reinforce the behaviours associated with the expectations of a healthy Nuclear Safety Culture. Evaluation processes identify Nuclear Safety Culture weaknesses and monitor the effectiveness of actions taken. A variety of communications and leadership awareness activities have been implemented to enhance leaders' and employees' knowledge of the framework.

An integral part of Bruce Power's nuclear safety oversight is a Nuclear Safety Culture assessment which is conducted periodically. Numerous changes were implemented prior to the last safety culture assessment to improve the number and quality of respondents. The assessment has been conducted in the past at the facility level, however Bruce Power decided in 2013 that greater information on the character of the Nuclear Safety Culture would be beneficial and decided to conduct an assessment across the entire organization as part of the corporate assessment. The assessment team consisted of experienced individuals led by a senior manager and supported by an external consultant with expertise in assessing Nuclear Safety Cultures at nuclear facilities. The assessment techniques and process included:

- Nuclear Safety Culture Staff Survey;
- Individual interviews conducted with Bruce Power staff throughout the different levels of the organization;
- Focus group interviews conducted with staff from selected departments within Bruce Power;
- Insights from the Nuclear Safety Culture Monitoring process.

The report generated from the data analysis provided the character of the Nuclear Safety Culture and trends at the facilities and across the organization. A thorough review of the results were conducted with a cross departmental team that included individual contributors, supervisors and managers. An executive committee chaired by the Chief Nuclear Officer provided oversight for the entire process. Bruce Power established a number of corrective actions to address the three main focus areas identified as part of the Safety Culture Survey assessment:

- Improve Equipment Health;
- Improve the Corrective Action Program;
- Improve first line manager communications.

A key success factor was the establishment of sponsorship and site wide initiatives to respond to each of the three focus areas. Another success factor was the decision to focus on the top three issues. Oversight on the progress against these actions was also undertaken at the Corporate Corrective Action Review Board (CARB) each quarter, whose purpose is to provide Senior Management Review and oversight of significant corporate level events; ensuring that the causes of these events have been identified and that timely and effective corrective actions have been put in place. The Corporate CARB ensured the proper focus is maintained on Public, Plant and Personnel Safety as well as Generation, Business Plan and Safety Culture.

This integrated framework, which was developed using the experience of external expertise and international industry standards provides a valid characterisation of the Nuclear Safety Culture and drives continual improvement such that Bruce Power maintains a healthy Nuclear Safety Culture. The value of these new methodologies has been validated through various measures, metrics and surveys.

Should Nuclear Safety Care About Resilience Engineering?

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The current nuclear industry safety paradigm is based on the deterministic and/or probabilistic anticipation of all potential situations, and the predetermination of all the (safe) responses. Even the defense in depth concept, which is the core of the nuclear safety strategy and is intended to handle situations in which part of the control is lost, heavily relies on detailed anticipations. In other words, nuclear safety is mainly expected from the real world's conformity to a designed-to-be-safe world, i.e., a well controlled world, where organizations, processes, hardware, teams, and individuals comply with their rationally predetermined behaviors. In this "command and control" perspective, risk is seen as mainly generated by deviations and variations from rules, procedures, norms, and expectations. However, real operations are complex, even in normal situations, which means that they include some unpredictable events and adaptation behaviors. The traditional "command and control" perspective fail to properly acknowledge the limits to predictability inherent to a complex adaptive system. It actually strives to reduce complexity through tighter compliance to specifications and to improve predictions capabilities through a tighter monitoring of "weak signals" and "precursors". But in a complex world, precursors are usually obvious after the event, while not identifiable before. And the efforts made to reduce complexity may also simultaneously tighten couplings between system's components — hence increase complexity — and reduce the diversity and flexibility needed to respond to it.

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The notion of Safety Culture has developed in the nuclear industry in the aftermath of the Chernobyl disaster as a form of recognition of the limitations of a mere compliance-based approach to safety management. It has rightfully accounted for more complex determinants of collective safety behavior such as values, commitment, risk cognizance, situation awareness, leadership, trust and honesty. However, it still sounds like an added layer to the traditional "command and control" perspective, rather than like a well integrated evolution. It still carries elements of denial towards complexity. It recognises in principle that mechanical compliance cannot do the job — and it calls for knowledge, competence and good judgment, but it does not really tell how to reconcile compliance and intelligence during the course of action (rather than after the event, with the benefit of insight). One of the hard lessons from Fukushima is that there is a need to reconcile predetermination and adaptation in the nuclear safety philosophy, and the notion of resilience may be of some help to achieve this. It first implies to fully recognise complexity and unpredictability: as Scott Sagan sagely expressed, "Things that have never happened before happen all the time". It also implies one must better understand (research) and recognise how the current nuclear organizations and their staff actually handle the unexpected, and get (daily) success rather than (rare) failures. It calls for a targeted effort to reinforce these abilities, including a specific approach to the design of the system (technology, processes, procedures, resources), as well as to the design of the organization (structures, roles, responsibilities, cooperation modes). Typical related issues include the empowerment of front line operators, the management of margins of manoeuver, the development of sense-making and imagination skills, the provision and management of functional flexibility and diversity, the maintenance of stocks, dampers, slack, buffers in all processes.

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Safety Culture and the Future of Nuclear Energy

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The occurrence of the TMI, Chernobyl, and Fukushima accidents in the past gives people a false pretence that nuclear accidents are destined to happen. In fact, these accidents could have been prevented with the presence of strong safety culture. Based on the review of the history of nuclear power and nuclear safety, this talk examines how safety culture evolved over the years and how it can guide the future of global nuclear power development without repeating the past course of accidents.

Reflection, Interrogatory, Provocation

W. E. Carnes[1]

[1] *DOE (retired), USA*

Corresponding Author: W. E. Carnes, wecarnes@gmail.com

This invited paper advances a framing context for considering next steps in HOF and organizational culture in light of the presentations and discussions that occur during the conference. Many of the contributions during the conference will represent results of scholarly research, structured investigations, or formal organizational improvement efforts. This contribution is intended as informal reflection by a 40-year nuclear veteran on themes from other presentations considering questions such as: "Where do we think we are?, Are we better off as an industry based on what we have done?, Where do we think we need to go?, What do we think we need to do?, and, Why do we think these things?"

Our coming together on this occasion marks 30 years since the publication of INSAG-l. As we reflect on the past, perhaps it is time to pose a series of questions. Are we sustainers of a mature technology that is in some places declining and being replaced by other energy sources? If we consider nuclear a mature technology, should we focus most on operational excellence with renewed attention to managing the unexpected? Or, is innovation still a vital part of our industry?

After three decades have we fallen into a pattern of true believers chanting mantras about culture and HOF, or are we actively mindful of the organizations we create and inhabit? Do we see safe operations as something to be maintained, or something to be created daily? Are we aware of what it is like to do work, at all levels within the ecosystem?

Have we matured beyond blaming the workers constraining them with ever more prescriptive rules to the point that the very humanity, innovation, and sense of accomplishment through a job well done is literally squeezed out of people's daily experience? Have we gone beyond the mystique that training, procedures, processes promote perfection; have we begun to recognise, reward and nurture relationships and human interaction as foundational to processes and systems?

With the advent of Big Data do we suffer from quantitative fixation, or measurement myopia? The oft repeated phrase "If you can't measure it, you can't manage it" attributed to Peter Drucker is in fact a myth. His quote was the exact opposite: "It is wrong to suppose that if you can't measure it, you can't manage it — a costly myth." He admonished managers: "It is the relationship with people, the development of mutual confidence, the identification of people, the creation of a community. This is something only you can do. It cannot be measured or easily defined. But it is not only a key function. It is one only you can perform." Are nuclear managers even aware of the significance of subcultures and the uniqueness of each? Do we help managers develop skills of humble inquiry and helping so they can enhance the experience of doing work, as well as the outcomes?

Finally, how do we as a HOF/culture stewardship community perceive ourselves? Are we writers of guidance, analysts, advocates, and sometimes critics? Or do we see ourselves as helping shape the future environment in which new generations of workers in our industry and other high hazard technologies will have different and better experiences of what it is like to do this work? Do we consider the implications of the internet of thing? Likewise do we consider the implications of the values, learning styles and social styles of the Millennial generation? Are we probing how work is changing; can we learn how organizations can manage so that change does not threaten but to the contrary makes life simpler, work more rewarding?

The author William Gibson has suggested that "The future is already here — it's just not very evenly distributed." Does our field work seek to find out what the future looks like? Should we expand collaborative field research? Should we focus less on workers and more on managing organizations and our ecosystem? Might we better contribute and communicate by freeing ourselves from some of the constraints of traditional academic and institutional information channels and controls? Can we be more foresightful; can we acknowledge that other energy industries and technical domains such as health care have built upon our foundations, may now be innovating beyond our industrial structure models, and engage collaborations that view toward the future rather than seeking to cure the past? The conference wrap up will endeavor to process the contributions of other presenters via the lens of such questions, and seek emerging themes that may suggest a framework for future efforts.

BIO: Biographies

Short biographies have been provided, when available, for corresponding and presenting authors.

Vladilena N. Abramova

Supervisor of studies in SRC "PROGNOZ";
Psychology department Professor in OINPE NRNU MEPHI ;

Relevant past working positions
Head of SRC "PROGNOZ"; Head of Psychology department in OINPE NRNU MEPHI;

[1] "The Psychological Resourses of the Safety Culture Enhancement", International Conference on Advances in the Operational Safety of Nuclear Power Plants. IAEA-CN-61/12 Vienna, 4-8 Sept. 1995; 10 p.
[2] "Single Human Failures in Nuclear Power Plants: A Human Factor Approach to the Event Analysis", Monograph, IAEA, Vienna, 25-29 March 1996; (with other authors Baumont G., Frischknecht A., Tolstykh V.) 65 p.

Sergey Anatolyevich Adamchik

Serves current as Inspector General of ROSATOM, having been Deputy Inspector General of ROSATOM in the past. Followed his formation at Tomsk Polytechnic Institute.

Development of the system of ensuring and monitoring nuclear and radiation safety in the organizations of ROSATOM.

Abdul Nasir Afghan

Dr. Nasir Afghan is a faculty member, Director MBA Program and Coordinator MBA Projects at IBA Karachi. Before joining IBA he held faculty position at SDSB, LUMS for seven years. He was also a visiting professor at University of Applied Sciences Graz, Austria (2005–2012). Dr. Afghan holds a Ph.D. in Managerial Effectiveness from University of Twente, the Netherlands, and an MBA in Industrialization and Strategic Management from Maastricht, the Netherlands. He also holds B.Sc. and M.Sc. degrees in Petroleum Geology from University of Karachi. Dr. Afghan has conducted several workshops, trainings and presentations and delivered several keynote speeches at IAEA on Nuclear Safety, Leadership, Safety Culture and Human Resource Development. He was IAEA expert mission team member at Iran Nuclear Power Plant, Bushehr in August 2013 In February 2015 Dr. Afghan was invited by Pakistan Army to give lecture on "Strategic Thinking and Strategic Management" to newly promoted Major Generals at GHQ Rawalpindi, Pakistan. He is author of several case studies, research papers and book chapters.

Namsung Ahn

Invited Professor in Hanyang University; President of Korea Energy Technology Evaluation and Planning; Professor of Solbrige International School of Business; Senior Researcher in Management Research Institute of KEPCO.

B.Sc. in Nuclear Engineering, Seoul National University;
M.Sc. in Nuclear Engineering, University of Wisconsin at Madison;
Ph.D. in Nuclear Engineering at M.I.T.

BIO

Ahmad Al Khatibeh

Ahmad Al Khatibeh acquired his Ph.D. in Nuclear Engineering in the Quadi-i-Azam University, in Islamabad, Pakistan.

Currently he is working in the IAEA as the Head of the Regulatory Infrastructure and Transport Safety Section in the Department of Nuclear Safety and Security.

Previously, from 2005 to 2008, he was the Director of the Nuclear Applications Department of the Supreme Council for the Environment (SCENR) in Qatar. From 1998 to 2005 he was a Radiation Protection Consultant and Head of Radiation Protection Department of SCENR. Prior to that he worked as a Director of the Jordan Nuclear Research Reactor Project, and as the Deputy Director of the Nuclear Energy Department of the Ministry of Energy and Mineral Resources (MEMR) of Jordan.

From 1973–1993 he worked in the Jordanian Airforce, and retired as a colonel.

Mats Alvesson

Mats Alvesson is Professor of Business Administration at the University of Lund, Sweden, at University of Queensland Business School, Australia and at Cass Business School, London. He is mainly studying stupidity in organizations. Research interests include critical theory, gender, power, management of professional service (knowledge intensive) organizations, leadership, identity, organizational image, organizational culture and symbolism, qualitative methods and philosophy of science. Recent books include Reflexive Leadership (in press, w. M. Blom & S. Sveningsson), Understanding Organizational Culture (Sage 2013), The Triumph of Emptiness (Oxford University Press 2013), Qualitative Research and Theory Deveopment (Sage 2011, w. D. Kärreman), Constructing Research Questions (Sage 2013, w. J. Sandberg) Interpreting Interviews (Sage 2011), Metaphor we lead by. Understanding leadership in the real world. (Routledge 2011, ed w. A. Spicer), Oxford Handbook of Critical Management Studies (Oxford University Press, ed. w. T. Bridgman & H. Willmott).

BIO

René Amalberti

Prof. Medicine, MD, Ph.D., French Air Force (1977), permanent Medical Research (1982); Full Professor of Medicine in 1995; Retired (rank of General) February 2008. Currently Senior Adviser Patient Safety, Haute Autorité de Santé director of the FONCSI (Public Foundation on Safety Culture in Industry, Toulouse)

From 1982 to 1992, he was involved in several major European research programs on human error with Jens Rasmussen and Jim Reason. From 1992 to 1999, seconded to the European Aviation Authorities (JAA) and became the first Chief Human factors and Flight safety for the JAA. From 1999 to 2007, he diversified into the fields of risk management in the nuclear, oil, fishing, and ground public transportation industries, and served as chairman or member of numerous National and European scientific boards for Environmental safety and air & land safety transportation systems.

He has published over 100 international papers, and authored (or co-) 12 books on human error and system safety (e.g., Amalberti, "Navigating safety", Springer, (2013)).

Yukiya Amano

Yukiya Amano is Director General of the International Atomic Energy Agency. The IAEA, an intergovernmental organization based in Vienna, is the global centre for cooperation in nuclear applications, energy, science and technology. Established in 1957, the Agency works with its Member States and partners to promote safe, secure and peaceful nuclear technologies and prevent the proliferation of nuclear weapons.

Mr Amano served as Chair of the Agency's Board of Governors from September 2005 to September 2006. He was Japan's Resident Representative to the Agency from 2005 until his election as Director General in July 2009. He assumed his duties as IAEA Director General on 1 December 2009. He has extensive experience in disarmament and non-proliferation diplomacy, as well as nuclear energy issues.

A graduate of the Tokyo University Faculty of Law, Mr Amano joined the Japanese Foreign Ministry in April 1972, when he began a series of international postings in Belgium, France, Laos, Switzerland, and the United States.

Takafumi Anegawa

Takafumi Anegawa joined Tokyo Electric Power Company in 1983. He was in charge of the nuclear safety analysis and fuel design as a nuclear engineer. In 1999, he became the manager of core and fuel group.

In 2001, he moved to the R&D division to enlarge the usage of Electric Vehicle, EV, worldwide. He developed and familiarize the energy charging system known as CHAdeMO.

After the Fukushima Daiichi accident in 2011, he returned to nuclear division and spearheads a variety of special projects, such as "Nuclear Reform Special Task Force".

Now he is the CNO of TEPCO Nuclear Power & Plant Siting Division.

Lars Axelsson

Behaviour scientist, working as a Human Factors Specialist at the Swedish Radiation Safety Authority, focusing on organizational and management issues including oversight of safety culture and safety management and support to the development of the safety culture within the regulator — a position I have held for 14 years.

Other experience include employment at the Federal Authority for Nuclear Regulation FANR in UAE (1.5 years), consultancy work in aviation (mainly airline pilot assessment and selection work) and training in Scandinavia and South East Asia (16 years), and commission as a Communications Officer of the Swedish Air Force Reserve (25 years).

Tim Bannerman

After gaining an MA in English at Cambridge University, Tim trained and worked as a journalist before doing the post-graduate acting course at the Bristol Old Vic Theatre School.

Then followed ten years as an actor, writer and director in repertory, radio, films, corporate videos and TV, before the discovery of an original approach to the use of theatre as a change and development tool led to a change in professional direction.

Tim is a Founder Director of akt Productions Ltd. with responsibilities for marketing, strategic development, programme design and facilitation. He has travelled extensively with a range of programmes, from North America with our work in behavioural safety, to the Middle East with our work for Government, to the Far East with our work in banking.

He is a Fellow of the Royal Society for the encouragement of Arts, Manufactures and Commerce and is intent on restoring the family tradition of cider-making in Herefordshire.

Johannes Beck

Johannes Beck has been a Human and Organizational Factors specialist at GRS since 2012. He was trained and worked as an energy electronics engineer between 1994 and 1999. He obtained his degree in psychology from Technische Universität Berlin. From 2009 to 2011 he worked as a (student) research assistant at the Technische Universität Berlin on the development of a safety culture assessment methodology in nuclear industries (SIKUMETH). He obtained his Ph.D. from Technische Universität München in 2015 for his work on decision-making behavior of experts at nuclear power plants. Currently, his major activities are addressing analysis and evaluation of decisions under uncertainty and the assessment of safety culture.

Benoît Bernard

Benoît Bernard is currently Nuclear Safety Analyst in charge of Human and Organizational Factors at Bel V (since 2011). He is also in charge of the Safety culture oversight process in Belgium. In that regard he has recently been involved in an EU support mission for the Chinese Regulatory Body relating to Safety Culture (2014–2015). He is an ENSTTI trainer (Management System, Safety Culture).

Within Bel V, he serves as the Training and Knowledge Manager. In addition, Mr Bernard was the Bel V project leader for the IRRS mission preparation (hosted by Belgium in 2013) and now in charge of the follow-up (including the strategic and change management issues).

He holds a Ph.D. in Organization Sociology (Université de Liège), a Master degree in Management (HEC) and a Master in Sociology from the Institut des Etudes Politiques de Paris (Sciences-Po Paris). He has previously conducted research and consulting in the fields of organizational development, performance, strategy and public management. He is a part-time Professor of Public Management at the Université Libre de Bruxelles.

Shahbaz Ali Nasir Bhatti

Deputy team leader for Safety Culture Self Assessment (SCSA) team at PNRA. The team is responsible for carrying out SCSA of regulatory body which was started in 2013 and was completed in 2015. The other current assignments include licencing of nuclear power plants since 2011.

Remained resident inspector at nuclear power plant site Chashma from 2006-2011. Performed regulatory oversight including safety culture oversight at NPPs (i.e. operating and under construction NPPs).

Bachelors in Chemical Engineering and One year training at nuclear power plant operation at Chashma Centre for Nuclear Training.

Participated in IAEA Regional Workshop on safety culture and self assessment for the senior management of the regulatory body, 8–10 June 2015, Jakarta, Indonesia as IAEA expert.

Hortense Blazsin

Research Fellow at MINES ParisTech, and Visiting Fellow at King's College London; Holds a Ph.D. in Safety Sciences, and Research Master in Information and Publication Sciences.

[1] Blazsin, H., "An Ethical Perspective on Extreme Situations and Nuclear Safety Preservation", in "Becoming Resilient in Extreme Situations: A New Paradigm of Nuclear Safety", Ahn., J. and Guarnieri, F. (Eds), Springer, in press.
[2] Blazsin H., Guldenmund F., "The Social Construction of Safety: Comparing Three Realities", Safety Science 75 (Part A), pp.16–27, (2015)
[3] Blazsin, H., Guarnieri, F., "Entrusting People, Rather than Organizations, with Safety: 'Practical Safety', a Ricoeurian approach", 31st EGOS 2015 Colloquium, Athens, Greece, (2015).
[4] Blazsin, H., Guarnieri, F., "Practical Safety, an Ethical Contribution to Resilience", 6th Symposium of the Resilience Engineering Association (REA), Lisbon, Portugal, (2015).

Zoltánné Bódis

Current working position: nuclear safety inspector

Previous work included quality system manager of Hungarian Atomic Energy Authority; and quality auditor.

Educational background: Budapest University of Economic Sciences and Public Administration with diploma on public administration,

Creating and full elaboration of guidelines on safety culture for licencees and for regulatory body.

BIO

Ana María Bomben

Currently, working at the Nuclear Regulatory Authority of Argentina (ARN), at the Regulatory Standards Department.

Previous work included the Atomic Energy National Commission of Argentina (1977–1994) and ARN (1994–present) on environmental radiological assessment and radiological control of nuclear medicine facilities. FORO expert on Safety Culture Project.

Educational background as Biochemist and a degree on Pharmacy, including Radiation Protection Postgraduate work.

Professor of radiation protection at different courses. Member of the Executive Council of IRPA (2012–2020). General Secretary of the 12th IRPA International Congress (2008). President of the IRPA Regional Congress (2015).

Alan M. Borras

Senior Science Research Specialist

Science Research Specialist-II and Science Research Specialist-I

Graduate of Master in Public Management (MPM) and Bachelor of Science in Mechanical Engineering (BSME)

[1] Alan M. Borras and Abdul Mannan, “Regional Overview of National Reports on Implementation of the Code of Conduct on the Safety and Security of Radioactive Sources: Asia Region”

[2] Alan M. Borras, “Current Practices and Implementation of Safety and Security of Radioactive Sources in Industrial Radiography in the Philippines”, Proceedings of “International Conference on the Safety and Security of Radioactive Sources: Maintaining the Continuous Global Control of Sources throughout their Life Cycle”, Abu Dhabi, United Arab Emirates, 27–31 October (2013).

Susan Brissette

With almost 25 years' experience in the nuclear industry in Canada and abroad, Ms Brissette has held a variety of senior communication, change leadership, and nuclear oversight positions throughout her career. She has spearheaded the development and implementation of Bruce Power's Integrated Management System since 2008 and has been instrumental in developing the company's approach to Nuclear Safety Culture assessment and monitoring. Ms Brissette has participated as an expert on various IAEA missions and regional workshops. She is a contributor to publications including Nuclear Energy Institute's NEI 09–07 Rev1, "Fostering a Healthy Nuclear Safety Culture", and IAEA NG–T–1.3, "Development and Implementation of a Process Based Management System". As founder of Women In Nuclear (WiN) Canada, Ms Brissette has been actively involved in the leadership of WiN at the national and international level for over a decade. Ms Brissette speaks fluent French and English, is a certified Change Management Professional, and received her MBA from Concordia University in Montreal, Canada.

Lennart Carlsson

Senior Advisor Office of Director General, Swedish Radiation Safety Authority, SSM.

Lennart Carlsson has been the Director of Department of Nuclear Power Plant Safety at Swedish Radiation Safety Authority until 2014. Earlier 1981–2008 he was employed by Swedish Nuclear Power Inspectorate. In late 80's he served at the Safety Assessment section of IAEA. Between 1997 and 2002 he was with OECD–NEA safety department serving the Working Group of Operating Experience, Halden reactor project among, working group of human and organizational factors among other things. His formation was made at Chalmers University of Technology, and University of Arizona (Dissertation).

William Earl Carnes

40+ years in private sector and government evaluating and improving operations for nuclear and other complex technology organizations. Retired as Senior Advisor, High Reliability with the U.S. Department of Energy and as Liaison with the Institute of Nuclear Power Operations.

Multi-disciplinary degrees in Chemistry, Engineering Management and social sciences; specialised certifications in nuclear, biological and chemical emergency management.

Recipient of U.S. Department of Energy Distinguished Career Service Award for contributions to the United States and the Department, and Proclamation of Distinguished Career Service by the Institute of Nuclear Power Operations for contributions to the nuclear industry and the Institute. Practice Associate with the U.C. Berkeley Center for Catastrophic Risk Management.

Olivier Chanton

Olivier Chanton has over 20 years of experience as a researcher in Human and Social Sciences (Philosophy, Linguistics and Sociology) and in Human Factors engineering in different areas such as road safety, conception of safety car systems and, since 2007, in nuclear safety. He has a Ph.D. in experimental and social psychology from Paris–Ouest Nanterre university. His doctoral dissertation thesis analysed the social influence strategies of dissenting social groups (for example, groups opposing the French nuclear development program).

In 2007, Olivier joined the French Safety Authority (ASN), for further developing human factors approaches in the regulation and control activities of the ASN. Since 2009, he works in IRSN, in the nuclear safety directorate, producing organizational and safety assessments. In 2012, he moved to a researcher position.

He is currently in charge of a research program concerning nuclear safety governance and regulation and is a project manager of a research program funded by the national research council, named AGORAS.

Elena Dmitrievna Chernetckaia

Head of the Center “Psychophysiological maintenance of professional personnel reliability” Rosatom central institute for continuing education and training; Researcher, psychologist at nuclear power station. National Research Nuclear University “MEPhI” Obninsk Institute for Nuclear Power Engineering. Specialisation: Labour and engineering psychology (2000–2006, Obninsk). Higher School of Psychology. Professional retraining “Introduction to process-oriented psychotherapy” (2012–2013, Obninsk) Awarded the silver medal "Concern" for achievements in improving the safety of nuclear power stations in 2012. The Winner of All-Russian competition of professional psychologists, law enforcement agencies, “The Power of Soul", 1st place, 2013.

[1] Oboznov A.A., Volkov E.V., Chernetskaya E.D. “Conceptual models in the activities of the operators of complex systems ergatic”, Mechatronics, Automation, Control, (**5**), 2012, pp.21–30.
[2] Oboznov A.A., Bessonova Y.V., Chernetskaya E.D., “Conceptual models of nuclear power plant operators with different professional experience”, Psychological Journal 34 (**4**), pp. 47–57.

Len K. Clewett

Len has more than 30 years of nuclear power operations experience with roles in operations, engineering, projects and maintenance. Len joined Bruce Power in 2009 and was most recently the Vice President of Nuclear Maintenance Services. Len was appointed as Executive Vice President and Chief Nuclear Officer in August 2012.

Prior to joining Bruce Power, Len held senior leadership roles including plant manager, site engineering director and operations manager. Len was previously licenced as a senior reactor operator at a Pressurised Water Reactor and performed in the control room supervisor and shift manager roles. Len spent 14 years with Florida Progress Corporation and came to Bruce Power from Xcel Energy in Minnesota.

Len graduated from Lehigh University, in Bethlehem, Pennsylvania, with a degree in Mechanical Engineering and has also obtained a Masters of Business Administration degree and a Professional Engineer’s licence.

Sue Cox

Sue Cox is Dean Emeritus of Lancaster University Management School (LUMS) and Chair of The Work Foundation. She stood down in September 2015 and was the longest serving dean in a UK business school and was awarded an OBE for services to social science in 2011.

Sue is Professor of Safety and Risk Management and has been actively involved in research on safety culture since 1990, was a member of three UK government nuclear safety committees including The Defence Nuclear Safety Committee, ACSNI and COMARE. Prof Cox also was a member of the MAGNOX Nuclear Safety Advisory Committee and has served on the Sellafield Site Licence Committee for 13 years. She has been involved in a plethora of research projects in the full spectrum of major hazard industries including nuclear, chemical and offshore and has worked with the U.K. Regulators on human factors issues.

Thierry Coye de Brunélis

With a doctor of psychology in cognitive and experimental psychology, Mr Coye de Brunélis currently works as a HOF expert at Safety Quality Environment Department, AREVA. Previous positions include HOF technical leader for the ASTRID project (GEN IV reactor), and senior HOF engineer at AREVA, as well as UAV ground control station project leader, defense domain.

Francisco Luiz de Lemos

Senior technologist at the Nuclear Engineering Center, IPEN, working with applications of systemic approaches to systems safety assessment, in particular, applications of STAMP (Systems Theoretic Accident Model and Processes).

Graduation in Mechanical Engineering, M.Sc. in Nuclear Techniques and Sciences, Ph.D. Environmental Chemistry.

Post Doc at University of Calgary, Canada, 2005, working to develop a ranking methodology for contaminated sites. Post Doc at MIT, USA, 2012: Application of STAMP to the Safety Assessment of Nuclear Power Plants

[1] Evaluating the Safety of Digital Instrumentation and Control Systems in Nuclear Power Plants, MIT, 2013.
[2] Understanding STAMP/STPA through a daily life example, STAMP Workshop, 2015.

Bertrand de L'Epinois

Bertrand de L'Epinois has the rank of ingénieur en chef des Mines. He starts his career in 1989 within the French nuclear safety authority, as head of the 900 MW reactor department. From 1994 to 2002, he worked at the General directorate for energy and raw materials (French ministry of industry), as head of the raw material and subsoil department and then deputy director for oil, gas and raw materials. He joined Thales Under Water Systems in 2002, as competitiveness director and then general sonar study director. He also acted, in this period, as vice-chairman of the maritime technology cluster ("pôle de compétitivité mer"). In 2007 he was appointed director for the SESAR European programme and chairman of the Air Traffic Alliance grouping between Airbus, Thales and EADS. He joined Areva in September 2011 as Senior Vice President for safety standards. He was appointed president of Brussels-based nuclear industry association Foratom in December 2015.

Nicolas Dechy

Specialist in human and organizational factors in the Department of organizational and human factors and learning from experience, in charge of conducting expertise in nuclear safety for the French regulator and research. Since 2010, he conducts organizational and human factors assessment of safety and radiation protection management of maintenance activities, subcontracting, and emergency response in the aftermath of Fukushima.

As an engineer, he has expert experience in the field of accident investigation (Toulouse disaster), risk assessment, emergency response and crisis management in process safety (Seveso) at INERIS, French expert institute in chemical sector, and as a consultant in environment and risk since 1999.

He is co-chairing the ESReDA project group on Foresight in safety, has chaired the accident investigation project group (2001-2008). He has coordinated the IMdR project on weak signals (2013) and written more than 50 papers on learning from accidents, safety and organizational diagnosis.

David Dennier

Mr Dennier is presently Director of Major Component Engineering at Amec Foster Wheeler Nuclear Canada, and is responsible for a team of 40 engineers and analysts that provides risk informed analysis and analytical outage support to power plants on their fuel channels, feeders, and steam generators. Prior to taking this role in 2015, Mr Dennier was Director of Commercial Services at Amec Foster Wheeler Nuclear Canada, where he was responsible for contract management, procurement, and IT operations. Mr Dennier holds a Bachelor of Science (Honours) in Experimental Physics, and Master of Business Administration.

Fred Dermarkar

Fred Dermarkar graduated from the University of Toronto with a degree in Mechanical Engineering. He has worked in the Canadian nuclear industry since 1981, and has held a variety of senior management positions in Nuclear Engineering at Ontario Power Generation in support of Design, Commissioning, Operation and Refurbishment of its CANDU NPPs. His responsibilities included Design Engineering, System Engineering, Component Engineering, Chemistry and Metallurgy, Nuclear Safety Analysis and Probabilistic Risk Assessment. He retired from OPG as the Vice President of Engineering Strategy in February 2014 to assume the role of President and CEO of the CANDU Owners Group. In October 2013, Fred was named the recipient of the prestigious WANO Nuclear Excellence Award.

Eugênio Anselmo Pessoa do Prado

Eugênio do Prado is working on analyze the contribution of the human factor in the operation of complex hybrid systems through the identification and evaluation of factors involved in decision-making, as the influence of emotional factors, attentional and stressors.

Initial proposal of a methodology for the analysis and quantification of human error in the operation of complex hybrid systems to consider, in addition to the factors proposed in the various methods available in the literature, aspects of Supervised Learning, Neuroscience, and Virtual Reality.

The proposal has the support of the analysis laboratory research groups, evaluation and management of risk USP (LabRisco), coordinated by R. Marcelo Martins and the Interdisciplinary Laboratory of Clinical Neurosciences at UNIFESP.

Identification of biomarkers (cognitive and psychophysiological variables) that influence the behavior during the decision-making process for tasks involving risk and uncertainty among a group of a virtual control room operators of a nuclear plant (simulator).

Robert J. (Bob) Duncan

Current position: INPO (Atlanta, GA), VP, Plant Operations & Supplier Support

Past positions:
Duke Energy: VP, Plant Operations;
H. B. Robinson: Site Vice President;
Shearon Harris: Site Vice President and General Manager.

Duncan graduated from the University of Florida at Gainesville with a bachelor's degree in nuclear engineering. He earned a master's degree in business administration from the University of North Carolina at Chapel Hill.

Anne Edland

Anne Edland is the Head of the Man Technology Organization (MTO) section at The Swedish Radiation Safety Authority (SSM). She has a Ph.D. in Psychology and the main focus of her dissertation was Stress and Decision making. After finishing her Ph.D., Anne worked as a Researcher in psychology for several years before she took a position as a Human factors expert at the former Swedish Nuclear regulatory body (SKI) in 1999. In 2004 she became the Section head of MTO and kept that position when the regulatory body merged into SSM in 2008.

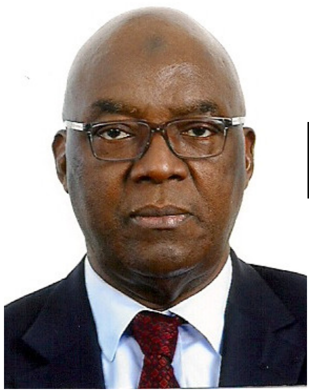
Her work at the Authority is to lead the section consisting of 12 MTO experts in the oversight of Human and Organizational issues, primarily with focus on Safety management, leadership and organization, safety culture, competence, fitness for duty, suitability, education and staffing, knowledge management, Working conditions, MTO perspective and Ergonomics of control room work and plant modification, Incident analysis and risk analysis from the MTO-perspective and Learning from experience towards the Swedish licencees.

Ezzat Abdel-Fattah Ibrahim Eisawy

Mr Eisawy is currently the head of the operational safety and human factors deptment, at the Egyptian Nuclear and Radiological Regulatory Authority (NRRA), based in Cairo. He previously served as the head of the nuclear installation division at that same agency, and continues to serve as Head of the review and assessment committee for NPPs. He holds a Ph.D. in electrical Engineering (safety protection).

[1] H. Sallam, E. Shafei, E. A. Eisawy, "Human Factors Reliability Analysis Using Fuzzy Fault Tree", Int. J. of Engineering and Innovative Technology (IJEIT), V. 4, **10**, pp.145–151 (2015).
[2] H. Sallam, E. A. Eisawy, "Enhancing Reliability of Digital Instrumentation and Control Systems", Int. J. Enhanced Research in Science Technology & Engineering, V. 4 **4**, pp.284–291, (2015).

Shamsideen Elegba



S. B. Elegba is a Professor of Nuclear Physics at the University of Abuja, Nigeria. Obtained a first class M.Sc. Degree in Theoretical Nuclear Physics in 1974 from Kharkov State University, in the former Soviet Union; and a Ph.D. in Theoretical Solid State Physics, at the University of Oregon, USA. Author or co-author of over 200 scientific publications and technical reports. Appointed a professor of physics in 1990 by the Ahmadu Bello University (ABU), Zaria, Nigeria and a Fellow of the Nigerian Institute of Physics. Over 35 years professional practice as a nuclear scientist in both promotional and regulatory activities.

From 1986–1991 he served as the Coordinator and later appointed the Pioneer Director (1991–1998) of the Centre for Energy Research and Training (CERT), one of the two Centres of Excellence for Nuclear Science and Technology in Nigeria.

In 2005, he was appointed member of the Standing Advisory Group on Technical Cooperation (SAGTAC) to the Director General of the IAEA (2005–2014) and appointed its Chair in 2010.

BIO

Diana Engström

Currently, Ms Engström works as a Safety Culture Specialist, at the Swedish Nuclear Fuel and Waste Management Company, having previously held the similar position of Safety Culture and Human Performance Coordinator at Oskarshamn Nuclear Power Plant, Sweden. Her educational background includes a Bachelors Degree in Behavior Science and Masters degree in Skills and Technology.

Peter Bassey Samuel Eshiett

Currently serving as the chief medical imaging scientist and radiation safety officer, at the Federal Medical Centre in Keffi, Nigeria (2006–present). From 2000 to 2006, he worked as a medical imaging scientist, at Aminu Kano Teaching Hospital Kano, Kano State, Nigeria.

His formation includes a B.Sc. in Radiography, PGDiP, and an M. Sc. in Radiation and Medical physics.

[1] Eshiett, P., *et al.*, "Diagnostic Reference level for Adult Brain Computed Tomography Scans: A Case Study of a Tertiary Heath Care Centre in Nigeria", IOSR Journal of Dental and Medical Sciences (IOSR–JDMS) v14, Version VII, pp. 66–75, (2015).

Mita Farcasiu

Mita Farcasiu graduated in Nuclear Engineering in 1991 at the University "Politehnica" of Bucharest, M.Sc. in 2006 at the University of Pitesti, Ph.D. from 2012 at University "Politehnica" of Bucharest. Presently she is a researcher in Reactor Physics and Nuclear Safety Department.

The specific work consisted in event/fault tree development and human reliability assessment (description, representation and quantification of the likely human errors, diagnosis of the abnormal event, recovery factor, the dependence level between the human action and organizational factors analysis). Her activity covers probabilistic safety analysis and human and organizational factors analysis of TRIGA research reactor and CANDU reactors.

Her personal experience related to "Interaction between Individuals, Technology and Organization" can be found in the following paper:
[1] Farcasiu, M. and Nitoi, M., "The organizational factor in PSA framework", in "Nuclear Engineering and Design" v.293, November 2015, pp. 205–211

Erwin Fischer

Currently board member of E.ON Kernkraft GmbH, and COO responsible for Nuclear Operations and Technology. Previously served as site director and plant manager of NPP's "Isar 1" and "Isar 2", Landshut, and as head of technology and head of operations of E.ON Kernkraft, Hannover.

He holds a Ph.D. in Reactor Technology and Master Degrees in Energy Technology and Mechanical Engineering.

Mr Fischer is a member of the German Reactor Safety Commission (RSK), the chairman of the Steering Group of Nuclear Standards Commission (KTA), and chairmen or member of the Supervisory Boards of several NPP's (KWG, KKI, KBR, KRB, OKG) and the KSG/GfS Simulator Training Company.

He is author of different aspects of Nuclear Technology, Nuclear Safety and Operational Excellence of NPP's.

Mark Fleming

Dr. Mark Fleming is the CN Professor of Safety Culture in the Department of Psychology at Saint Mary's University. Mark is an applied psychologist with over 20 years of experience in industrial health and safety management in high hazard industries including the offshore oil and gas, nuclear power, petrochemical, power generation and construction. He is dedicated to developing practical and valid tools to assist organizations to prevent harm.

Currently, Dr. Fleming's research includes investigating methods for measuring and improving safety culture, safety motivation, safety leadership and rail safety. He advises many Canadian and international organizations (e.g., IAEA) on safety culture assessment and improvement. Through his work, Dr. Fleming hopes to provide best practice guidelines to industry and criteria for successful safety programs. He seeks to translate his work on safety culture into usable practices and guidelines by producing practical tools such as Changing Minds Guide and the Cultural Maturity Model.

Elsa Gisquet

Elsa Gisquet is a Ph.D. researcher in sociology at IRSN. She focuses on organizational and human dynamics through decision making process facing tragic situations.

She has been involved in the creation and the management of the national observatory of end-of-life (2010–2013) which provides better information and data on end-of-life situations to enlighten public health policy.

In studies on nuclear crisis manangement, she focused on coordination process among utilities, experts and decision makers. She worked on the Fukushima-daiichi accident case, and is now involved in a national research program on nuclear crisis exercices (AGORAS action 4). The aim of this project is a better understanding of the consequences of the simulation (via crisis exercices) of a nuclear accident.

She coordinated the professional cancer program at the French National Institute of cancer (2005-2010). She conducted the program "New technology, medical devices and Parkinson" (ANR Nanotechnologies-Nanosciences 2004–2007).

Cora Goicea

Since september 2014, Ms Goicea acts as an expert, in the Division for Ionizing Radiation Application, involved the evaluation against Romanian regulations concerning the assurance of radiological safety of occupational exposed workers, population and environment, in accordance with the provisions of the law. The main task is to evaluate the documentation submitted, and issue the licences, according to authorisation procedures published in the Official Gazette. Since 2013, she deals in the health and safety aspects related to day-to-day activities of the personnel (office activities as well as field inspection activities) according to Romanian Legislative framework which is aligned with the European Legislation on occupational health and safety.

Previously, she worked as a senior QA expert in the Division for Nuclear Fuel Cycle (2004–2014) involved in the auditing and evaluation of quality management programs and participation in evaluation and auditing, supporting the licencing process, of Cernavoda NPP, a position that involved the elaboration and review of quality management regulations and participation in evaluation and inspection/audits.

B. Gül Göktepe

Ms Göktepe currently wors as a consultant and project manager and serves as the president of the Turkish chapter of Women in Nuclear(WiN Global). She was a former counsellor (Nuclear Attaché) at the Permanent Mission of Turkey to the UN in Vienna. Her formation includes a B.Sc. in Applied Physics (University of Sussex, UK) and an M.Sc. in Nuclear Reactor Engineering (University of London, UK) followed by experience as a research engineer with the Turkish Atomic Energy Authority, Cekmece Nuclear Research and Training Center.

She is an author of more than a hundred scientific papers presented at national and international meetings, mainly on NPP planning, probabilistic safety and environmental risk assessment. She received several awards and fellowships including the Black Sea Medal awarded for outstanding services to protect the Black Sea environment by UNDP GEF, BSC, BSERP.

Abel Julio González

Mr Abel Julio González is an argentine Academician, expert on the protection against radiation. He is a plenary member of the Argentine National Academy of Sciences of Buenos Aires, of the Argentine Academy of Environmental Sciences and of the Argentine Academy of the Seas. Representative at the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and has served UNSCEAR for more than 40 years. Regular member of the Argentine delegation to General Conference and Board of Governors of the International Atomic Energy Agency (IAEA) and he is member of the IAEA Commission of Safety Standards.

He joined ICRP in 1976 and served as Vice-Chairman from 2008 to 2013. Honoured with several international awards including twice the Morgan Award (2000, 2003), the Sievert Prize (2004), the Lauriston S. Taylor Lecturer Award (2005), the Marie Curie Prize (2008), and the Academician Georgyi A. Zedgenidze medal (2012).

Fernando González

Head of Leadership and Safety Culture.

Industrial Engineer in the branch of Energy Technology (Universidad Politécnica de Madrid). Coach and certificated in several programs related to Leadership by Zenger&Folkman, Aubrery Daniels.

More than 30 years participating and managing national and international projects on Nuclear Safety and Radiological Protection.

Coordinator of the Spanish Working Group "Radiological Protection Culture". This group has participated in the preparation of RP Culture IRPA Guide.

Nadezhda Gotcheva

Dr. Gotcheva is a Research Scientist at VTT Technical Research Centre of Finland Ltd. She holds Ph.D. degree from Tampere University of Technology, Finland (2008), and M.A. degree in psychology from Sofia University, Bulgaria (1998). Her research interests are in human and organizational factors in safety-critical organizations, focusing on safety culture evaluation and development in the nuclear power industry and especially in complex nuclear industry projects.

[1] Gotcheva, N., Oedewald, P., Wahlsrtöm, M., Macchi, L., Osvander, A.-L., and Alm, H., "Cultural features of design and shared learning for safety: A Nordic nuclear industry perspective", Safety Science, v.81, pp. 90–98, (2016).
[2] Oedewald, P., and Gotcheva, N., "Safety culture and subcontractor network governance in a complex safety critical project", Reliability Engineering and System Safety, v.141, pp. 106–114 (2015).

Mark Griffon

Mark Griffon is President of Mark Griffon Consulting LLC, a consulting company focusing on occupational and environmental safety and health and radiation safety. Mr Griffon is a former Board Member of the U.S. Chemical Safety and Hazard Investigation Board, appointed by President Obama in 2010 and completed his five-year term in 2015. Prior to his appointment, Mr Griffon served as a member of the Federal Advisory Board on Radiation and Worker Health that was established to advise the Department of Health and Human Services on occupational illness and compensation policy. Mr Griffon's career has included work in academia, and both the public and private sectors. From 1987 to 2010, Mr Griffon ran a safety consulting firm whose major projects included: radiation site assessment and cleanup work, exposure assessment projects at several Department of Energy (DOE) Weapons Complex sites, and technical support for the United Steelworkers Union. Mr Griffon has a B.Sc. in Chemistry from Rensselaer Polytechnic Institute and an M.Sc. in Radiological Sciences from University of Massachusetts Lowell.

Gudela Grote

Gudela Grote is Professor of Work and Organizational Psychology at the Department of Management, Technology, and Economics at the ETH Zürich, Switzerland. She received her Ph.D. in Industrial and Organizational Psychology from the Georgia Institute of Technology, Atlanta, USA. A special interest in her research is the increasing flexibility and virtuality of work and their consequences for the individual and organizational management of uncertainty. She has published widely on topics in organizational behavior, human factors, human resource management, and safety management. Prof. Grote is associate editor of the journal Safety Science and president of the European Association of Work and Organizational Psychology.

Franck Guarnieri

Professor Franck Guarnieri is the Chair of the Centre for Research into Risks and Crises (CRC) at MINES ParisTech in France. He leads research on Industrial and Nuclear Safety. He focusses on "Engineering thinking" and "ongoing emergency". He is also a designated expert in the French National Research Agency (ANR) and in the European Horizon 2020 program.

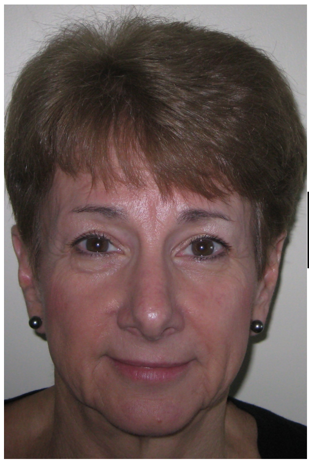
Franck Guarnieri is currently involved for a two years research project with University of California Berkeley (UC Berkeley) on "Nuclear Safety: From accident mitigation to resilient society facing extreme situations". In 2014, he received the prestigious René-Joseph Laufer Prize from the Académie des Sciences morales et politiques of the Institut de France.

Monica Haage

Monica Haage is an international safety culture specialist at the IAEA. Her areas of expertise include HOF, Leadership and Management for Safety and the Systemic Approach to Safety, and HTO. One of her key contributions is the development and application of the new IAEA safety culture assessment methodology and the IAEA Safety Culture Continuous Improvement Process (SCCIP), a systematic process to support Member States in implementing a safety culture continuous improvement programme. Ms Haage was the IAEA technical lead for the human and organizational and safety culture section in the IAEA Fukushima Daiichi Accident Report.

Ms Haage holds degrees in Engineering (Automation) and Social Psychology (Leadership and Organizational Theory). Before joining the IAEA in 2009, she held positions as international EHS manager at ISS, and safety culture and HTO expert at Oskarshamn Nuclear Power Plant. Her career started at the Scandinavian Airlines where she held various positions.

Sonja B. Haber



Sonja B. Haber is President and Executive Consultant of Human Performance Analysis, Corp. She has been conducting work in the area of human performance analysis for over 35 years.

Sonja Haber has been involved in the evaluation and intervention of organizational culture and human performance strategies. For the last 27 years, her work has focused on improving human performance within organizations that must operate with a high degree of reliability. She has been involved in conducting fieldwork for international agencies and commercial entities in efforts related to enhancing organizational culture for safety and human performance. Her work has also included cross-cultural analysis of organizational issues, in the areas of culture for safety and management and supervisory skills.

Sonja Haber conducts organizational culture for safety assessments, provides consultation in organizational interventions including leadership, enhanced communication and observational skills training. She is a part-time consultant for the IAEA. She has a Ph.D. in Psychology.

Mohammad Anwar Habib

Mohammad Anwar Habib is the chief executive of Pakistan Nuclear Regulatory Authority.

He was Member Corporate and Director General (Technical).

He holds an M.Sc. in Nuclear Engineering.

Yeonhee Hah

Yeonhee Hah is the Head of the Division of Human Aspects of Nuclear Safety at the OECD–NEA.

Prior to joining the NEA, she was previously the Head of the International Co-operation Department for several years where she was responsible for leading the Institute's efforts to establish strong, co-operative programmes with other regulatory and multilateral organizations around the world.

From 2010 to April 2014, Ms Hah chaired the NEA's Working Group on Public Communication of Nuclear Regulatory Organizations (WGPC). During her chairmanship, WGPC produced the reports about the "Roadmap for Crisis Communication of Nuclear Regulatory Organizations" and "Social Media as Communication tools".

A Korean national, Yeonhee Hah holds a Master's degree in Communications from Ewha Women's University.

Christopher A. Hart

Christopher A. Hart is Chairman of the National Transportation Safety Board since 2015. He was previously Vice Chairman of the NTSB, after being nominated by President Obama in 2009. The NTSB investigates major transportation accidents In all modes of transportation, determines probable cause, and makes recommendations in an effort to prevent recurrences. He was previously a Member of the NTSB in 1990.

Christopher Hart's previous positions included Deputy Director, Air Traffic Safety Oversight Service and Assistant Administrator for System Safety, at Federal Aviation Administration. He was Deputy Administrator for the National Highway Traffic Safety Administration, Deputy Assistant General Counsel to the Department of Transportation, and Attorney with the Air Transport Association.

Mr Hart has a law degree from Harvard Law School and a Master's Degree in Aerospace Engineering from Princeton University. He is a member of the District of Columbia Bar and the Lawyer-Pilots Bar Association, and he is a pilot with commercial, multi-engine, and instrument ratings.

Kathleen Heppell-Masys

Kathleen Heppell-Masys has been the Director General of the Directorate of Safety Management (DSM) at the Canadian Nuclear Safety Commission (CNSC) since 2009. DSM provides regulatory leadership and specialist advice on Licencees' Management Systems, Training Systems, Personnel Certification, and Human and Organizational Performance, including Safety Culture and Fitness for Duty. Prior to becoming Director General, Kathleen held the positions of Director, Training Program Evaluation Division at the CNSC. She also worked as Senior Nuclear Specialist for the Department of National Defense.

Kathleen began her career with the Canadian Armed Forces as an Aerospace Engineering Officer which allowed her to serve and lead teams in various engineering and maintenance roles with operational aviation fleets. She also spent a tour in academia as a lecturer with the Department of Chemistry and Chemical Engineering at the Royal Military College of Canada, where she previously obtained a Bachelor Degree in Fuels and Materials Engineering, and a Master of Nuclear Engineering.

Liguang Hu

Liguang Hu is the director of the Policy and Technology Division in the Ministry of Environmental Protection (MEP) of the National Nuclear Safety Administration (NNSA) in China. Previous positions included Chief of the Research Reactor Division in MEP(NNSA), Deputy Director of the Nuclear Power Division B in MEP(NNSA), and scientific secretary for the Multinational Design Evaluation Programme (MDEP) in OECD–NEA.

Mr Hu holds a Master's Degree in nuclear reactor engineering from Shanghai Jiaotong University. In his official capacity, he has organizing the creation of the following documents and books: "The 30 year practice of nuclear safety oversight in China", "The Policy declaration of the nuclear safety culture", "The 12th 5-year planning of nuclear safety and radioactivity pollution remedies", and the drafting of the "Nuclear Safety Act".

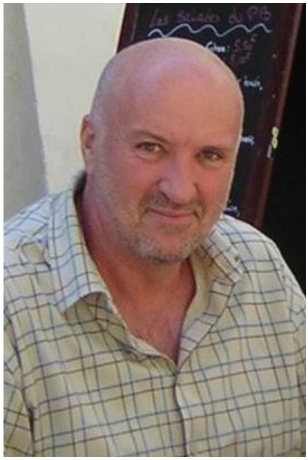
Peter Janko

Peter Janko is a Nuclear Oversight Specialist, at the Slovenske elektrarne. He performed independent monitoring and review of nuclear units in operation and in construction.

Previously, Peter was Assistant to plant manager, and before that a turbine operator (trainee).

Peter graduated from Technical University in Kosice (Power Energetics). He obtained further degree at VUJE Trnava (Professional capability for I-st Category) and at the Slovak University of Technology in Bratislava (Safety aspects in operation of Nuclear devices).

Slobodan Jovanovic



Professor of Applied Nuclear Physics, University of Montenegro, and Head of the University Centre for Nuclear Competence and Knowledge Management.

Ph.D. in Nuclear Engineering, University of Ghent, Belgium;
B.L. in Nuclear Law, University of Montpellier 1, France.

More than 120 publication, mainly in gamma-spectrometry, neutron activation analysis, radiation protection, nuclear instrumentation software, nuclear data standardisation.

Author (together with A. Dlabac) of the software package ANGLE for semiconductor detector efficiency characterisation, in use in hundreds of gamma-spectrometry laboratories worldwide, angle.dlabac.com.

Jeffrey A. Julius

Jeffrey Julius is currently the Deputy Director, Safety and Risk, at Scientech. Previously, he was Scientech's Discipline Manager for Human Reliability, Human Reliability Society President and Project Manager for several full scope PRA modeling and application projects.

Jeffrey was a US Nuclear Navy Submarine Officer who graduate of the University of Washington, 1980.

Jeffrey Julius is co-Author of NUREG-1921, Fire HRA Guidelines, of Halden HRA Benchmarking reports, and of EPRI Technical Report 1026294, "A Preliminary Approach to Human Reliability Analysis for External Events with a focus on Seismic".

Su Jin Jung

Su Jin Jung is a Senior researcher in the Department of Safety Policy at Korea Institute of Nuclear Safety. Before joining the Safety Policy Department, she worked at Public Communication Department.

Su Jin Jung had her M.Sc. and Ph.D. degrees in Industrial Engineering from Korea Advanced Institute of Science and Technology.

Her area of knowledge and expertise includes Nuclear Safety Culture, Nuclear Safety Policy Analysis and Regulatory Framework. She is a member of Korean Nuclear Society and authored papers in the field of Nuclear Safety Policy. She is now serving as a project manager in the research project named "Development of Regulatory Infrastructure for the Safety Culture Oversight."

Magy Mohamed Kandil

Magy Mohamed Kandil holds a Ph.D. in Electronic & Communication, Electrical Engineering. She performs Research in safety operation, fault diagnosis, fire protection, safety culture and research, and NPP reactor design, safety assessment for research and NPP reactors, control and instrumentation system for nuclear reactors (research and NPP), computer control of nuclear reactors, fault diagnosis in nuclear reactors, software testing of nuclear reactors for the Egyptian Nuclear and Radiological Regulatory Authority (ENRRA).

She is Member in the committee of review and assessment for the Second Egyptian Research reactor I&C (PSAR–SAR), and for Egyptian Bid 2007–2013 with ENRRA in nuclear power plant at Egypt. She is also member of the committees of review and assessment of Licences, of Mine Regulation, and of Security Regulation for ENRRA.

[1] "Fire detection using a dynamically developed neural network", ELMAR-IEEE Zadar, Croatia, 2010.
[2] "Estimating the number of hidden Layers/Neurons in a Back propagating Network", WORLDCOMP, USA, 2010.

Akira Kawano

Akira Kawano is the General Manager of Nuclear Safety Management Department, at Tokyo Electric Power Company. He holds a B.Sc. in Electrical Engineering, University of Tokyo.

Akira Kawan has 30 years of work experience in nuclear business in TEPCO, has worked at all three TEPCO nuclear sites (1F, 2F, KK), has been a Maintenance Director at 1F five years ago, was involved in ABWR design work at the Headquarters in the late 80's and early 90's, and Nuclear Renaissance activities after their scandal in 2002. He also worked for the NSNI in the IAEA from 1996–1999, and as subhead of the Nuclear Safety Oversight Office.

Lena Kecklund

Lena Kecklund is CEO of MTO Safety and senior consultant in the area of human and organizational aspects/human factors and safety. She obtained a Ph.D. in psychology from Stockholm University studying human factors and nuclear safety. Her areas of expertise include safety culture, HOF/human factors and safety in different domains such as railway safety, nuclear safety, fire safety and evacuation, tunnel safety and accident investigations.

Lena has extensive experience in training and advising managers and leaders in the aviation, railway and nuclear domain. She has also participated in several investigations of major accidents. Lena has published several articles on human factors and safety in peer reviewed publications.

Ji Tae Kim

Ji Tae Kim is currently working in human and organizational factors group of Korea Institute of Nuclear Safety (KINS) as a senior researcher in Korea.

Previously, he worked in operational safety analysis department (Event investigation, OEF) and resident inspection team of NPP.

Ji Tae Kim graduated with a Master degree of Nuclear Engineering in Korea Advanced Institute of Science Technology (majored in human engineering in NPP). He is currently working in a research for regulatory infrastructure and system for NPP oversight.

Christopher Kopisch

Scientific Officer for safety culture, safety management systems and human-technology-organization (HTO). Head of Photovoltaic Project Management, RIO Energie GmbH & Co. KG: Development and standardising of processes and organizational structures. He is the German representative for the Working Group on Human and Organizational Factors (WGHOF) of the Committee on the Safety of Nuclear Installations (CSNI) of the OECD–NEA.

He holds an M.Sc. Physics, University of Karlsruhe, Germany, and an M.A. School Education and Didactics, University of Göttingen, Germany.

[1] "The Role of the Regulator in the Field of Safety Culture", Kopisch, C., Berg, H.P, Proceedings of the SSRAOC Workshop, pp.50–59, Antwerp, Belgium, January 2012
[2] "Safety Culture and its Influence on Safety", Berg H.P., Kopisch C., Journal of KONBiN 3 (23) 2012 ISSN 1895–8281, 17–28, Poznan, 13–16 May 2013

BIO

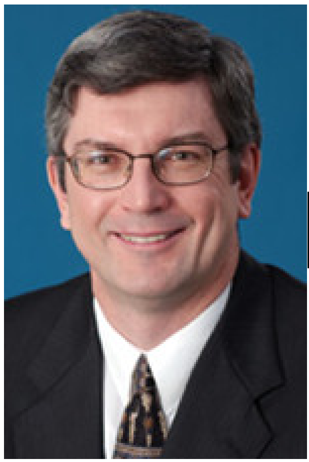
Petro Kotin

Petro Kotin is the Deputy Production Director – Operations Department Head for National Nuclear Energy Generating Company (NNEGC) "ENERGOATOM", Ukraine.

Petro has 30 years of nuclear experience, mostly in Operations at Zaporozhye Nuclear Power Plant, Ukraine, and then in "ENERGOATOM", which is a Corporate Office for all operating Nuclear Power Plants in Ukraine.

He graduated from Moscow Engineering Physics Institute (MEPI), as Thermal Energy Engineer with specialisation in Nuclear Power Plants and Installations. His field of Expertise is in Event analysis and operation experience feedback; planning and control of safety culture improvement measures on a corporate level.

Kenneth Koves



G. Kenneth Koves, Ph.D., is a thought leader, researcher, and global resource regarding nuclear safety culture. He is currently a principle program manager in Organization and Human Performance at the Institute for Nuclear Power Operations (INPO). He received his B.A. in Psychology from Wheaton College in Illinois and his M.S. and Ph.D. in Industrial/Organizational Psychology from the Georgia Institute of Technology in Atlanta.

During his seven year tenure at Sprint as a Sr. Organization Development Consultant, Dr. Koves specialised in the areas of organization culture assessment and change, strategic direction and alignment, organization structure design, and survey development/administration.

He leads domestic and international workshops on defining and assessing safety culture both within the USA and around the world. He has presented to groups in Austria, China, Finland, France, India, Russia, Spain, Ukraine, and the US with additional webinars to Russia and Switzerland.

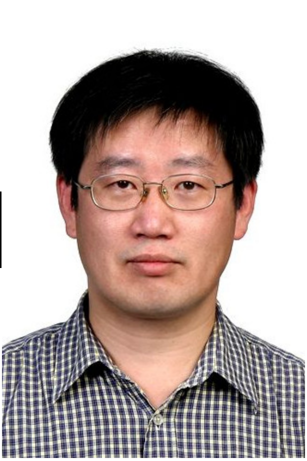
Iva Kubáňová

Iva Kubáňová currently works as Safety Director in the Generation Division of CEZ.

The last few years she worked as Safety and Quality Manager in a new build team; she managed EIA and the siting license process on CEZ' site for the new Temelin NPP. Previously, she worked in different technical and managerial positions in CEZ, in the nuclear regulatory organization and for a key CEZ contractor.

Ms Kubáňová graduated in 1985 from the faculty of Mechanical Engineering, Czech Technical University, nuclear power facilities branch.

Yong-Hee Lee



Principal Researcher and Project Manager of two main R&D projects on human errors and safety culture in Korea.

In charge of Human and Organizational Factors for PSR(Periodic Safety Review) of operating plants in Korea during the decades.

Majored in cognitive system engineering (Industrial & System Eng.) with 30 years as a human factors specialist for various design and safety issues.

Editor of two special volumes of the Journal of the Ergonomic Society of Korea, in topics of Human Errors(2011) and Safety Culture (2016).

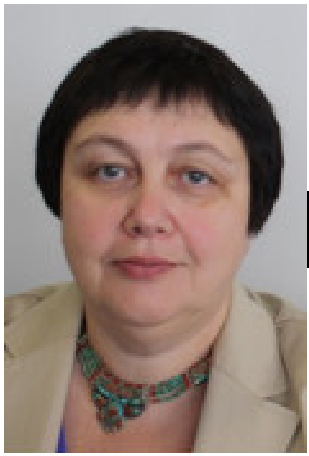
Juan Carlos Lentijo

Juan Carlos Lentijo holds the position of Deputy Director General, Head of the Department of Nuclear Safety and Security, IAEA, since October 2015. He has more than 33 years of experience in the fields of nuclear technology, nuclear safety and radiation protection.

From June 2012 to September 2015, Mr Lentijo was the Director of the Division of Nuclear Fuel Cycle and Waste Technology, IAEA. He served at the "Consejo de Seguridad Nuclear (CSN)", the Spanish Regulatory Body, where he joined in 1984. Main positions included General Director for Radiation Protection (2006–2012), Deputy Director General for Public and Environmental Radiation Protection (2002–2003), Deputy Director General for Emergencies and Physical Protection (1996–2002) and Project Manager for Cofrentes NPP (1984–1986) and Resident Inspector at Cofrentes NPP site (1986–1996).

Mr Lentijo is an Industrial Engineer from the Polytechnic University of Madrid (Spain). He holds a six-year High University Degree, with speciality in Energy and Nuclear Engineering (1982).

Olga Makarovska



Senior Radiation Safety Specialist in the Control of Radiation Sources Unit, Regulatory Infrastructure and Transport Safety Section;
Deputy Chairperson of Ukrainian Regulatory Body — State Nuclear Regulatory Inspectorate;
Nuclear engineering, radiation protection;
Important achievement: Establishment of the national radiation sources regulatory infrastructure.

BIO

Naimeddin Mataji Kojouri

Naimeddin Mataji Kojouri is the General Director of Strategic Planning at the Atomic Energy Organization of Iran (AEOI). Previously he has served as the Director General for Planning and Technical Economical Studies at the AEOI, and positions at the National Nuclear Safety Department and as Deputy Director of the Reactor Research School (INSTRI). He holds a B.Sc. in Applied Physics, and both M.Sc. and Ph.D. degrees in Nuclear Engineering.

Malin Mattson

Malin Mattson is presently working as a consultant at MTO Safety AB, with behavioural and organizational aspects of safety as her special areas of expertise. At MTO Safety AB Malin has been involved in projects related to investigation and development of safety culture and safety management systems within the Swedish Transport Administration, safety critical work processes within the County Council's Public Transport, patient safety within the healthcare sector, and a research project on regulatory control on behalf of the Swedish Radiation Safety Authority. Previously, Malin held the position of Human Resource Consultant at the County Administrative Board of Stockholm, with responsibility for areas such as recruitment, training, leadership and organizational development.

Malin has a master's degree in Human Sciences and a Ph.D. in Work and Organizational Psychology from Stockholm University, Sweden. During her employment at Stockholm University Malin participated in several projects focused on leadership and organizational aspects of safety in sectors such as the nuclear and process industries.

Tatiana Borisovna Melnitckaia

Tatiana Borisovna Melnitckaia is a Leading specialist at the Central Institute for Continuing Education and Training, in Obninsk, Russia. She is also a Professor at the Psychology Department, Obninsk Institute for Nuclear Power Engineering. She is a Leading researcher, Federal state institution "All-Russian research institute on problems of civil defence and emergencies of Ministry of Emergencies of Russia", Moscow, Russia.

Previously, Tatiana was the Head of Management and Leadership Research Laboratory, Obninsk Scientific Research Center "Prognoz". She graduated from Moscow Engineering Physical Institute Specialisation as Engineer-mathematician, and obtained a Post graduate education Specialisation: Practical psychology at Obninsk Institute for Nuclear Power Engineering.

[1] Rybnikov, V. Y., Melnitckaya, T. B., Belyh, T. V. "The psychological concept of safety culture of the population of contaminated areas", Politehnica Service, p.169 (2014)

Lise Menuet

For the past 10 years, Lise Menuet has been working at the Institute for Radioprotection and Nuclear Safety (IRSN) as a human and organizational factors specialist. Her role is to define and manage safety assessments related to HOF in french fuel cycle facilities. She has dealt with numerous projects depending on different phases of the lifecycle of the facilities (such as design, operation, decommissioning)

Lise dedicated the first ten years of her carreer working on a variety of Air Traffic Management projects for French and European experimental centres (CENA and EUROCONTROL), contributing to the design of cooperative support systems for Air Traffic Controllers.

Lise is an ergonomist with degree and masters qualifications in cognitive ergonomics, and a significant 20 years' experience dealing with HOF in hazardous industries.

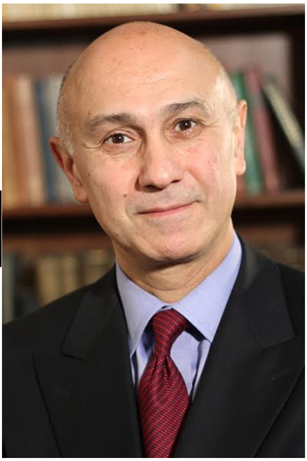
Alfredo Merino Hernández

Alfredo Merino Hernández is the Head of the Performance Verification Branch (2001-Present), at the Nuclear Safety and Safeguards National Commission in Mexico.

Previously, Alfredo was the Technical Advisor of the Operation & Certification Branch (1990-2001).

Alfredo Merino Hernández holds a Mechanical Engineer Degree. He has been participating in the preparation and performance of inspection in the areas of operation, maintenance, Fire Protection, In Service Inspection and Human Factors. Alfredo was the regulatory responsible for the Main Control Room Design Review for Laguna Verde Unit 2 NPP. At present is responsible for the process of evaluating the performance of nuclear facilities based on safety indicators.

Najmedin Meshkati



Najmedin Meshkati is Professor of Engineering and International Relations, at USC.

Previously, he was a Jefferson Science Fellow and a Senior Science and Engineering Advisor, Office of Science and Technology Adviser to the Secretary of State, US State Department, Washington, DC (2009-2010).

Najmedin holds a Ph.D. in Industrial & Systems Engineering (USC, 1983), an M.S. in Engineering Management (USC, 1978), a B.S. in Industrial & Systems Engineering (Sharif Univ of Technology, 1976) and a B.A. in Political Science (Shahid Beheshti Univ, 1976).

Najmedin Meshkati is a Fellow of the Human Factors and Ergonomics Society (HFES), USA; the 2015 recipient of the HFES highest award, the Arnold M. Small President's Distinguished Service Award, for "career-long contributions that have brought honour to the profession and the Society".

Friedrich Meynen

Friedrich Meynen is the Head Human and Organizational Factors Section, at the Swiss Federal Nuclear Safety Inspectorate ENSI.

Friedrich is since 1986 in the nuclear industry. His work was focused on new build nuclear and conventional power stations, electrical maintenance in the oil refinery, creation, evaluation, coordination and execution of training and schooling for shift personnel.

Friedrich is a member in the nuclear plant crisis organization and Nuclear safety engineer for PWR and BWR. Since 2009 he work at the ENSI, and since 2012 as Section Head "MEOS" – Human & Organization.

Friedrich Meynen graduated as Electrical engineer and systems engineer.

Douglas M. Minnema

Dr. Douglas Minnema is currently a senior engineer on the staff of the United States Defense Nuclear Facilities Safety Board, a small independent federal agency tasked with overseeing safety at the Department of Energy's defense nuclear facilities. Doug is a nuclear engineer and a certified health physicist with 37 years of experience in the DoE's nuclear weapons complex. His career includes 16 years as a health physicist and reactor operator at Sandia National Laboratories; 11 years as the senior radiological protection advisor at the National Nuclear Security Administration; and nearly 10 years in his current position. He holds BSE and MSE Nuclear Engineering degrees and an MS in Radiological Health from the University of Michigan, and a PhD in Nuclear Engineering from the University of New Mexico. Doug has operated research reactors, conducted field and environmental radiation studies, performed safety analyses, conducted programmatic and technical assessments of safety programs, and led five DoE accident investigations.

Dr. Minnema has studied, published, presented, and practiced in the areas of health physics, reactor safety, criticality safety, safety culture, and organizational accidents.

Jozef Misak

Jozef Misak, born in Slovakia, graduated with Ph.D. from the Czech Technical University in Prague. 45 years of experience in nuclear engineering/nuclear safety, devoted to development and application of safety assessment tools applicable in design and operation of NPPs. About 30 years of management experience in non-governmental, governmental and international organizations in various posts up to deputy director for nuclear safety, general director of the Nuclear Power Plant Research Institute in Slovakia, and first chairman of the Slovak nuclear regulatory authority 1993-1997. During the period 1998-2004 working in the IAEA as a head of the Safety Development Unit. Since 2005 working in the Nuclear Research Institute Rez as VP for Strategy Development.

Jozef Misak is the author of a large number of research reports, papers and presentations in the area of nuclear safety, and a member of the several professional organizations and advisory bodies.

Khammar Mrabit

Khammar Mrabit is Director of Nuclear Security, at IAEA. He is responsible for development of Nuclear Security Guidance publications and provision for their use and application, and leads international cooperation activities in nuclear security and liaises with States and other International Organizations, Summits, and Initiatives, to enhance coordination, cooperation and outreach of nuclear security activities.

Dr Mrabit has more than 30 years of experience in nuclear and radiation safety, and nuclear security. He spent about five years working at the French Operating Organization (Electricity of France) and the Moroccan Ministry of Energy and Mines (the Regulatory Body for Nuclear Safety). He joined the IAEA in 1986, where he has been involved in and assumed responsibility for many safety and security programmes.

Khammar Mrabit holds a Ph.D. in Nuclear physics applied to nuclear power.

Mohammed Elsayed Mustafa

Mohammed Elsayed Mustafa is a Reactor Manager, and was previously a Shift Engineer, Operation Head.

Mohammed holds B.Sc., M.Sc., and Ph.D. degrees in Nuclear Engineering.

His topics of interest are in Ageing Management, which were presented at an MIT Conference in 2015. He performed some 10 MW Research Reactor Simulations and work on Operation Envelope Establishment of a 10 MW Research Reactor.

Mariko Nishizawa

Mariko Nishizawa is Risk communication consultant, Director, Litera Japan Co., Lecturer, Tokyo Institute of Technology.

Mariko holds an M.Sc. in Environmental Policy (Lancaster University, UK), a Ph.D. in Risk communication and risk policy (Imperial College London).

She was an Alexander von Humboldt Scholar (2002–2004), and a Research Fellow, University of Stuttgart (2000–2005).

Mariko Nishizawa was an associate Member of the Science and Technology Council of Japan Risk communication advisor to Iitate Village of Fukushima 2011–2012.

[1] Mariko Nishizawa "Risk Communication" (2013) Energy Forum (Japanese).

Yusri Heni Nurwidi Astuti

Yusri Heni Nurwidi Astuti is currently a Senior Safety Culture specialist at the Indonesian Nuclear Energy Regulatory Agency (BAPETEN). Previously, she was the Director for Planning Program.

Yusri Heni holds a Bachelor's in Chemical Engeneering and a Master degree in System & Technology Energy.

[1] "Improving Our Safety Culture" Book, 2011.
[2] Several publication of Safety Culture , safety leadership, and Safety Management for Seminar or conference, 2004 - 2015.
[3] Coordinator for publication of Guidance Safety Culture Implementation for Nuclear Instalation, 2006.

Espen Nystad

Espen Nystad is a senior research scientist with a background in psychology. He has worked on a number of research and consultancy projects related to human and organizational factors in the nuclear and oil & gas industries.

Pia Oedewald

Pia Oedewald works a senior inspector at STUK –Radiation and nuclear safety authority in Finland. She is responsible for safety culture oversight of the Finnish licencees and the new build projects. Her educational background is in psychology.

Prior joining the regulatory body she worked as a researcher at VTT for 15 years where she studied organizational culture and safety management in various safety critical domains including nuclear, mining and chemical industry, health care and transportation. Her aim as a researcher was to bridge modern safety science theories and the practical needs of organizational safety evaluations. She has been especially interested in the phenomenon of safety culture; most recently her interests have focused on safety culture in a multinational new build projects and design activities. In addition to the scientific work she has carried out multiple in-depth safety culture evaluations and supported the power companies and regulators in the practical organizational development and oversight challenges.

Charles Packer

Charles Packer is President of Cherrystone Management, a small consulting company specialising in safety culture improvement and nuclear leadership. He has worked in the nuclear industry since 1974, in the UK & Canada. He has held many positions including Shift Manager, and was the VP in charge of the four-unit Darlington nuclear station in the late 1990s.

Charles has developed methodologies and conducted more than thirty safety culture assessments in the past 12 years. He has gathered insights from over 30,000 safety culture surveys and 2,000 interviews. He has contributed to the work of the IAEA in the fields of nuclear safety culture, nuclear security culture, management systems and leadership. He was the general chair of the IAEA conference on safety culture in Rio, Brazil in 2002.

Charles studied mechanical engineering at London University. He is the chair and head of operations of the Deep River and Area Food Bank, which is a volunteer organization providing food to those in need. He was awarded The Queen's Diamond Jubilee Medal in 2012 for his work.

Jean Paries

Jean Paries is the President of the Dedale company, Paris & Melbourne.

Mr Paries was Deputy Head of the French civil aviation Bureau Enquêtes Accidents.

Jean Paries graduated as an Aviation Engineer. He is the President of the Resilience Engineering Association and the Co-editor of the book "Resilience Engineering In Practice" (Ashgate Publishing, 2011).

Muhammad Abbas Qamar

Muhammad Abbas Qamar is looking after safety and regulatory matters of nuclear installation of PAEC (power and research reactors, medical and agriculture centres etc.) for the last 30 years. Currently working as Director, Safety Oversight in the corporate office of PAEC.

Previously, he has worked as Manager Nuclear Safety Oversight, Manager Regulations and Manager Licencing. He has also worked at Chashma NPP site as resident Nuclear Safety Inspector (DNSRP/PNRA Inspector) from 1999-2001.

He has M. Phil. in Physics, Postgraduate Course in Health Physics, various courses and on the job foreign trainings in the area of nuclear safety review, evaluations and inspections.

He has prepared a program for safety culture assessment of nuclear installation of PAEC. He has actively participated in IAEA meeting and training course in the field of safety culture and integrated management systems in 2009 and 2011.

Teemu Reiman

Teemu Reiman is currently working as a Safety Culture Manager at the new Finnish nuclear power company Fennovoima.

Dr. Reiman has a doctoral degree in psychology from the University of Helsinki, and is Adjunct Professor at the Aalto University. Reiman made his dissertation in 2007 on safety culture evaluations of nuclear power plant maintenance organizations.

Teemu has previously worked as a Senior Scientist at VTT Technical Research Centre of Finland. At VTT Reiman acted as a project manager and a researcher in several national and international research and consultancy projects covering a wide range of topics from safety culture and management to resilience and properties of complex adaptive systems.

Teemu Reiman has experience from various safety-critical domains including nuclear power, conventional power, transportation, metal industry, oil industry and healthcare. Reiman has over 80 scientific publications in international journals, books and conference proceedings.

Carlo Rusconi

Carlo Rusconi is the senior safety expert and safety culture trainer within Radwaste Management School of Sogin group. He is also a safety analyst, consultant and trainer in industrial sector and public health, as well as a professor of chemical and physical risk at Master courses in Safety and Security. Carlo holds a Master in Safety & Security, a Master's degree in Nuclear Engineering and a Ph.D. in Energy Studies, from "La Sapienza" University of Rome.

[1] Rusconi C. "Training labs: a way for improving Safety Culture" in Transactions of the American Nuclear Society, **109**, Washington, D.C., November 10-14, 2013.
[2] "Interactive training: a methodology for improving Safety Culture" in 2013 at "International Experts' Meeting on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant".
[3] "Complexity and safety. Training methodologies for developing a systemic vision" in 2015 at the Technical Meeting on Developing Improvement Programmes for Safety Culture. (Chairman).

Helen Rycraft

Helen Rycraft has degrees in engineering, psychology and an MBA and has worked in the area of Human Performance and Organizational Factors in the Nuclear Industry since the 1980s, using and developing assessment and improvement methods for different types of facilities. She has worked with the International Atomic Energy Agency (IAEA) for a number of years developing Safety Culture assessment and intervention methods to improve Organizations in their approach to safety within their business. She has carried out investigations into major events with a focus on leadership behaviours and decision making, and organizational factors that led to the accidents. Her experience ranges from quantitative and qualitative analysis of human reliability within tasks and management systems both in normal and emergency conditions, through to assessment of equipment and system interfaces.

Helen is currently a IAEA Senior Nuclear Safety Officer in the Operational Safety Section and project lead in the area of Leadership, Management and Safety Culture.

Cornelia Ryser

Cornelia Ryser is a Senior Human and Organizational Factors (HOF) Expert at the Swiss Federal Nuclear Safety Inspectorate ENSI, in HOF Section since 2002.

Previously, Cornelia was a researcher at Swiss Federal Institute of Technology in Zurich at the Institute of Work Psychology. She graduated with Master degree in Applied Psychology and Ph.D. in Psychology from Zurich University.

Her main working fields and activities at ENSI is the development of oversight concepts and tools for oversight related to safety culture and their implementation in oversight practice. She is also the project leader on ENSI's project on "oversight culture", i.e. the regulatory body's own safety culture (2011-2014).

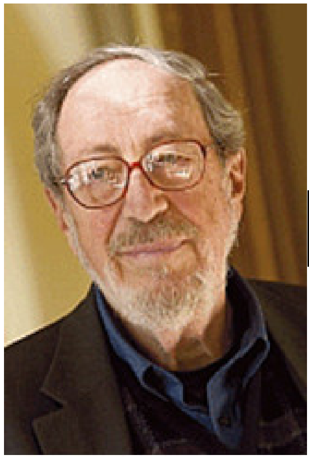
She participated to the analysis of HOF of the Fukushima accident (within ENSI as well as participation in IAEA Fukushima Report).

Grzegorz (Greg) Rzentkowski

Greg Rzentkowski joined the IAEA as Director of Nuclear Installation Safety in March 2015. His nuclear career began in 1989 at Ontario Hydro, as a Senior Research Engineer for plant equipment dynamics and plant safety analysis. After joining the Canadian Nuclear Safety Commission (CNSC) in 1995, he has held progressively responsible positions in management of technical and regulatory programs, including reactor safety analysis and design assessment, and licensing of new reactors. In 2008, he was named Director General of the Directorate of Power Reactor Regulation. Greg chaired the CNSC Fukushima Task Force which developed Canada's action plan for implementing changes based on lessons learned from the Fukushima accident.

Greg holds a Doctor of Philosophy in Mechanical Engineering from Memorial University of Newfoundland and has served as Adjunct Professor at McMaster University in Hamilton, Canada. He published several research papers in scientific journals and conference proceedings, and proprietary reports prepared for the Nuclear Industry.

Edgar Henry Schein



Edgar Schein was educated at the University of Chicago; at Stanford University, where he received a MA in psychology; and at Harvard University, where he received his Ph.D. in social psychology in 1952. He is Sloan Fellows Professor of Management Emeritus at MIT's Sloan School of Management. Previously, he was chief of the Social Psychology Section of the Walter Reed Army Institute of Research while serving in the U.S. Army as Captain from 1952 to 1956. He joined MIT's Sloan School of Management in 1956 and was made a professor of organizational psychology and management in 1964. He was honored in 1978 when he was named the Sloan Fellows Professor of Management, a Chair he held until 1990.

Edgar Schein has been a prolific researcher, writer, teacher, and consultant. Besides his numerous articles in professional journals, he has authored fourteen books. He has consulted extensively on career development and corporate culture in the United States and abroad. Edgar Schein received multiple Lifetime Achievement Awards with the latest from the International Leadership Association (2012).

Poong Hyun Seong

Poong Hyun Seong is currently a Professor in Nuclear Engineering at KAIST, Korea and also the president of Korean Nuclear Society (KNS). Poong Hyun Seong had his B.Sc. degree from Seoul National University in 1977, and M.Sc. and Ph.D. degrees in nuclear engineering from Massachusetts Institute of Technology in 1984 and 1987, respectively. He worked as the chief editor of "Nuclear Engineering and Technolog" from 2003 to 2008. He was a commissioner of the Korea Nuclear Safety Commission from 2006 to 2009. He was the chair of the HFICD (Human Factors and Instrumentation and Control Division) of the ANS (American Nuclear Society) from 2006 to 2007.

He is now an editorial board member of "Reliability Engineering and System Safety". His research interest includes Digital Instrumentation and Control systems developments for Nuclear Power Plants, Software V/V, Human Reliability Analysis, Cognitive Systems Engineering and Safety Culture. He published numerous technical papers and he published a book "Reliability and Risk Issues in Large Scale Safety-critical Digital Control Systems", Springer in 2009.

Kamran Sepanloo

Director of National Nuclear Safety Department, Iranian Nuclear Regulatory Authority (INRA), Atomic Energy Organization of Iran (AEOI), 2014–presnt;

Director of Reactors and Accelerators R&D School of AEOI, Head of R&D section of NNSD/INRA, AEOI.

Ph.D. in Nuclear Engineering, Amir-Kabir University, Tehran/Iran (1987–1998), Thesis: Integration of Error Tolerant Systems into the Design of Control room of Nuclear Power Plants.

Published more than 35 papers in national and international Journals in the field of nuclear safety, Published 3 books, Extensive experience in PSA and DSA methods.

Dan Serbanescu

Dan Serbanescu is member of the Group of Interdisciplinary Researches-DLMFS-CRIEFST — Romanian Academy.

He is also an expert in safety and risk for the European Commission and the technical coordinator for gas reactor PBMR risk project at the national nuclear regulator Romania. He was project manager for manufacturing nuclear pumps, safety report authoring, safety and licencing activities for utility, and thermal power plant shift supervisor.

Dan graduated with a Ph.D. in nuclear engineering from Central Institute of Physics Romania and Moscow Power Institute NPP.

Dan has publications on selected topics in risk analyses for some energy systems.

Cheol Sheen

Cheol Sheen has been working as a principle researcher for KINS since 2001 after receiving a Master's degree in the field of nuclear engineering from Kyunghee university in the Republic of Korea. He has been doing his research on the development of nuclear Safety Culture Assessment Model (SCAM) since 2009. He made a SCAM by applying Safety Culture Maturity Model.

He presented his research result to the PSA2011 conference. His present paper is the results from modifications of Professor Patrick Hudson's model to the nuclear industries. The model divides levels of safety culture into four stages and defines distinguishable characteristics of each level. The model tries to overcome the limitations of the IAEA's SCAM by defining the spiral shaped nonlinear model for culture change. The model also tries to derive holistic insights from safety culture assessment results by applying a modified matrix model to establish strategies, guidelines for corrective action plan. The model developed regulatory strategies with defined level of safety culture. Finally the paper presents the results of application to safety culture assessment of Korea NPP.

Diane J. Sieracki

Diane Sieracki is the Senior Safety Culture Program Manager in the Office of Enforcement at the U.S. Nuclear Regulatory Commission (NRC). She functions as the lead for the Agency's safety culture efforts related to the external regulated communities, including all licencees and certificate holders.

Ms Sieracki assisted with authoring the NRC's Safety Culture Policy Statement, NUREG-2165, Nuclear Energy Institute's NEI 09-07, and various IAEA Technical Documents.

Diane Sieracki has over 29 years of experience in the nuclear industry; prior to the NRC, as the Senior Manager of Employee Concerns for a large nuclear power company.

She holds a Master of Science Degree in Management and Organizational Behavior.

Johnny Situmorang

Johnny Situmorang is a researcher for Reactor Safety and Technology, at the Center for Reactor Safety and Technology, Indonesia National Nuclear Energy Agency (BATAN, Badan Tenaga Nuklir Nasional).

Prior to his present position Johnny was member of the Batan's Safety Culture Working Group. He graduated as Engineer from the Gadjahmada University.

[1] "Path Analysis of BATAN's Safety Culture Characteristics"
[2] "Evaluasi Budaya Keselamatan untuk prioritisasi pentingnnya karakteristik/atribut pada instalasi nuklir dengan teknik AHP" (Analitic Hierarchy Process)

BIO

Alexander Smetnik

Alexander Smetnik has been working for the FSUE VO "Safety" (TSO of Russian Regulator – Rostechnadzor) since 2009 as the Head of Scientific and Engineering Support Department. His area of expertise includes Human and Organizational Factors. Before his position in FSUE VO "Safety" he worked as the Head of Radioactive Waste Management Laboratory (2000–2005) at FBU "SEC NRS" (Scientific and Engineering Centre for Nuclear and Radiation Safety). Mr Smetnik has a degree in Engineering and a degree in Biology. He is a Doctor of Science.

He participated in development of IAEA and OECD–NEA Safety Guides:
[1] SG-1. Classification of Radioactive Waste: General Safety Guide. Vienna: IAEA, 2009;
[2] SG-14. Geological Disposal Facilities for Radioactive Waste: Specific Safety Guide. Vienna: IAEA, 2011;
[3] OECD–NEA Regulatory Guidance Report 17 "Safety Culture of an Effective Nuclear Regulatory Body". OECD–NEA Publishing, Paris, 2016.

Máté Solymosi

As a part of his Ph.D. work, he has assessed the nuclear security and safety culture of Hungarian Public Limited Company for Radioactive Waste Management.

Currently, Máté is the project lead, mainly office working and in situ filter measurements in Paks NPP, including Radiological measurements of technical equipment. Previously worked at the Public Ltd. for Radioactive Waste Management as a public procurement expert.

[1] J. Csurgai, M. Solymosi, K. Horváth, Gy. Vass, "Nuclear Security Culture Self-Assessment in a Radioactive Material Associated Facility", AARMS 14(3) (2015);
[2] J. Csurgai, M. Solymosi, "Measurements of the effectiveness of aerosol filters", I. HADMÉRNÖK X(1) (2015);
[3] J. Csurgai, M. Solymosi, "Thoughts on the Book Nuclear Reactor Safety", AARMS 13(1) (2014).

Nick Stavropoulos

Nick Stavropoulos is President, Gas, at Pacific Gas and Electric Company and a member of the utility's board of directors. He is responsible for the end-to-end delivery of safe, reliable, affordable and clean gas service to 16 million people in northern and central California. Additionally, Stavropoulos oversees PG&E's enterprise IT and Safety & Shared Services organizations.

Nick Stavropoulos has more than 35 years of experience in the gas industry. Prior to President, Stavropoulos served as Executive VP, Gas Operations, leading a multi-billion dollar maintenance, construction and restoration effort to enhance the company's gas system and operations, and he earned ISO 55000 and PAS 55001 international certifications for the company's enhancements in gas asset management. Previously, Nick served as Executive VP and CO Officer for National Grid where he was responsible for all aspects of its U.S. gas distribution business. Prior to this role, Stavropoulos was President of KeySpan Energy Delivery.

Mr Stavropoulos holds a Bachelors degree in accounting from Bentley College and earned his MBA from Babson College.

Mykola (Nikolai) Steinberg

Mykola Steinberg is now retired. He was chief engineer at Chernobyl NPP in 1986.

Mykola holds the position of deputy chairman at the nuclear regulatory authority of the USSR and the chairman of the nuclear regulatory authority of Ukraine. Among multiple other position, he also worked at the deputy minister at the ministry of fuel and energy of Ukraine.

Mykola was educated at Moscow Power Institute, and became a nuclear engineer in 1971.

BIO

Borys Stoliarchuk

Mr Borys Stoliarchuk is currently the Head of Nuclear Installations within the Safety Assessments Department at the State Nuclear Regulatory Inspectorate of Ukraine.

Mr Stoliarchuk was Lead engineer of reactor control at Chernobyl NPP unit 4. Present at the MCR during the Chernobyl NPP unit 4 accident.

Holds a Diploma of Thermoenergy Engineer from Odessa Polytechnic Institute.

Miodrag Stručić

Miodrag Stručić graduated as Nuclear Energy engineer on Electrical Department of University of Zagreb, Croatia in 1989. In the same year he started to work in Krško NPP in Slovenia. His duties cover different areas such as: Root Cause Analyses; Corrective Action Program; Performance Indicators; Internal Audits and Interdisciplinary Focused Self-assessments.

Since 2010 he is working in European Commission, Joint Research Centre (EC JRC) Institute for Energy and Transport in the Nuclear Reactors Safety Assessment Unit. He is involved in activities of European Clearinghouse on NPP Operational Experience and Nuclear Reactor Accident Analysis and Modelling actions.

Lucia Suhanyiova

Lucia Suhanyiova is currently a Ph.D. student at the Industrial Psychology Research Centre at the University of Aberdeen, Scotland. Appointed to the Ph.D. studentship funded by Economic and Social Research Council and BAE Systems in October 2014 under the supervision of Emeritus Professor Rhona Flin and Dr Amy Irwin, as well as industrial supervisor Des Burke.

Lucia is currently examining Product Safety Culture in the defence industry as an aspect of general organizational safety culture, considering the user health as a result of product safety outcomes.

She previously completed a Bachelor of Science in Psychology and a Masters of Research in Psychology at the University of Aberdeen, in 2013 and 2014, respectively.

Johan Svenningsson

Johan Svenningsson currently holds positions as Country Chairman Uniper Sweden, COO Nuclear Uniper, and CEO of Sydkraft AB and Sydkraft Nuclear Power AB. Former positions held include CEO of OKG AB, deputy CEO Swedish Technical Research Institute AB, and different management positions within Westinghouse and ABB Nuclear.

Johan Svenningsson holds a Master of Science in Mechanical Engineering from Chalmers Institute of Technology.

Daniel Tasset

Daniel Tasset has over 35 years of experience in Ergonomics and Human Factors engineering, in different areas such as military systems, aeronautics, and since 1995 in nuclear safety. He holds a Master of Ergonomics from Paris 5 and a Master of Management from Paris 1 Universities.

Daniel has worked in IRSN from 1995 to 2004 for safety assessment of projects of new reactors in France such as N4 plants and EPR. In 2004, he joined the French Safety Authority (ASN), for developing human factors in the regulation and control activities of the ASN.

Daniel is now Deputy Head of HOF and Operating Experience Feedback Department at IRSN. He is supervising some assessments such as the validation of EPR control room and the implementation of post-Fukushima actions for Frenchs NPPs, and is in charge of developing a training session and guidelines on HOF for IRSN staff. He is a member of the CSNI Group on HOF at the OECD–NEA and the IAEA Group for safety guide on HOF in the Design of NPPs. He is an expert at the IAEA for improving regulatory oversight of HOF in safety authorities.

Richard H. Taylor

Professor Taylor has been leading research into the cultural and organizational precursors to significant events at the University of Bristol as a Visiting Professor for several years and carrying out other research into the cost-effectiveness of safety measures. Until last year, he was a Non-executive Director of the UK Health and Safety Executive for nearly 4 years. Formerly, he was a Corporate Head of Safety, Health and Environment at Magnox Electric plc and then BNFL plc, and before this, Head of Operational Safety at Nuclear Electric plc.

He is a physicist by background with a Ph.D. in solid state physics followed by several years of research in both physics, energy studies and engineering. He is the author of two books and nearly 100 published papers/articles. He is a Fellow of four institutions and learned bodies in the UK.

For several years, he was a member of INSAG and led work on several INSAG publications. He also led the international team which formulated the International Nuclear Event Scale (INES) for the IAEA.

Madalina Tronea

Madalina Tronea currently work as the coordinator of the Nuclear Regulations and Standards Unit in the Nuclear Fuel Cycle Division of CNCAN. She have been working in CNCAN since 2014. Her main duties are the development of nuclear safety regulations, regulatory guides and procedures and the performance of safety reviews and inspections. She is also involved in the licencing of operating and management personnel for nuclear installations.

Madalina is an engineering physicist. For the past 7 years, she has invested a significant amount of work in developing review and inspection guidelines for supporting the regulatory oversight of safety culture in organizations operating nuclear installations.

Madalina's hobbies are related to her work and in her free time she manages an International Nuclear Safety Journal which publishes articles on a large variety of topics, including nuclear safety culture.

Bismark Mzubanzi Tyobeka

Bismark Tyobeka is the Chief Executive Officer at the National Nuclear Regulator, South Africa. He started his nuclear career 14 years ago as a reactor Physicists at Eskom Enterprises, before moving on to the roles of Senior Physicist at Eskom Enterprises, Chief Nuclear Engineering Analyst at PBMR Pty Ltd and Nuclear Engineer and Unit Head: Gas-Cooled Reactors at the IAEA.

At the IAEA, Dr. Tyobeka was advising Member States in the development of new nuclear power programmes. He has also been a visiting Scholar at the Nuclear Research and Consultancy Group (Netherlands) and the International Research Associate (Idaho National Laboratory, USA).

Bismark Tyobeka holds a Ph.D. in Nuclear Engineering from the Pennsylvania State University, USA, a Master's degree in Applied Radiation Science and Technology from North-West University, South Africa, a Master's degree in Management specialising in Project Management from Colorado Technical University in the USA, and a Bachelors' degree in Physics and Chemistry from the North West University in South Africa.

Jean-François Vautier

Jean-François Vautier is the coordinator of the HOF network of the CEA since 1998 and Professor assistant at INSTN (National Institute for Nuclear Science and Technology). He was an human factors expert at the General Delegation for Armaments (DGA) from 1986 to 1998. Jean-François holds a Ph.D. in sciences.

[1] Quiblier S., Dutillieu S., Hernandez G., Tosello M. and Vautier J.-F. (2015) "Five unexpected effects of HOF actions of improvement in risk industries", 19th Congress of the International Ergonomics Association (IEA), Melbourne, 9-14 August 2015.
[2] Tosello M., Lévêque F., Dutillieu S., Hernandez G. and Vautier J.-F. (2012) "Conditions for the successful integration of Human and Organizational Factors (HOF) in the nuclear safety analysis", Work, **41**, 2656 – 2660.

Eduard Volkov

Eduard Volkov currently work as an international cooperation expert at ROSATOM Central Institute for Continuing Education and Training (CICET) and as the director at the science research centre "Prognoz".

Eduard was previously the principal manager of CICET "Safety Culture development" project office. He worked for around 20 years in the nuclear industry. His educational background is in mathematics and industrial psychology.

Eduard is an expert for many IAEA and WANO missions on Safety Culture issues. He is an organizer and the head of International Summer School on Safety Culture.

BIO

John Ward

John is the Manager, Continuous Improvement Section at the Australian Radiation and Nuclear Safety Agency (ARPANSA). John is registered as a professional engineer at incorporated level by the UK Engineering Council and is a member of the UK based Institution of Engineering Designers. His formal qualifications are in mechanical and production engineering, and include 30 years' experience in the nuclear industry.

In 2005 John joined ARPANSA, to work on the regulation of the Australian research reactors. John instigated the development of the ARPANSA's holistic (systemic) approach to safety including the promotion of holistic safety to licence holders, an approach considered by ARPANSA to be best practice. As Manager of Continuous Improvement, John is leading ARPANSA's holistic safety approach and the incorporation of this into ARPANSA's regulatory practices. Those activities include the improvement of ARPANSA's regulatory performance through the monitoring and assessment of internal metrics and external metrics relating to its external, regulated stakeholders.

Germaine Watts

Germaine started her career in the worker's compensation field. Over the past 25 years she has held various management positions within the cancer treatment system and the nuclear power industry. For the past 5 years she has served as partner and CEO of a niche management consulting firm. The majority of her early career focused on management and leadership development as well as workforce design, team design and resourcing for specific functionality. More recently she has devoted her effort to defining organization design and resourcing methods in the context of process-based management systems. She is actively engaged with developing the leading-edge theory and practice for working with propensities. For the past 7 years Germaine has also been instrumental in the development of IAEA's approach to safety culture assessment and continual improvement, and has supported missions to over 20 countries to introduce management for safety, safety culture and leadership concepts. Her primary area of interest is the systemic and systematic evolution of human systems in alignment with organizational purposes and goals.

Michael Weightman

Michael Weightman is an Independent Nuclear Consultant, MWA Ltd; a Visiting Professor, Engineering Department, Cambridge University; the Non-executive director, National Nuclear Laboratory; and the Independent Advisor to the Japanese NRA and NDF.

Retired in 2013 from Post of HM Chief Inspector of Nuclear Installations, Chief ONR, UK.

Michael holds B.Sc., M.Sc., and D.Phil degrees, and is Fellow of the Royal Academy of Engineering, Fellow of the Institute of Physics, Fellow of the Institute of Materials, Minerals and Mining; Honorary Fellow of the Safety and Reliability Society; Chartered Engineering, Chartered Physicist.

Member of INSAG, Chair of the NEA's CNRA, Leader of the IAEA International Expert Fact Finding Mission to Japan (May–June, 2011).

Debbie Williams

Debbie Williams is the director of Industry leadership at INPO. She joined INPO in June 2008 in the Engineering/Configuration Management Department, and qualified as a team leader in September 2013. While at INPO, Debbie was the section manager for Digital Systems, which included cyber security.

Prior to coming to INPO, Ms Williams worked for 17 years for Duke Energy Corporation at McGuire and Oconee Stations. During her career at Duke, she held the positions of design engineering manager at Oconee station, business manager at McGuire station, systems engineering supervisor, design engineering supervisor and engineer at McGuire. She began her career working for Parsons designing digital control systems for Savannah River Site.

She received a bachelor's degree in electrical engineering from the University of North Carolina at Charlotte and a master's degree in business administration from the University of North Alabama. Ms Williams received SRO training in pressurised water reactors at McGuire Nuclear Station.

Man-Sung Yim

Professor and Head, Department of Nuclear and Quantum Engineering, KAIST, 2011-present; Director, Nuclear Nonproliferation Education and Research Center, KAIST, 2013-present;

Senior Researcher, Korea Atomic Energy Research Institute, 1987–1990; Lecturer, Massachusetts Institute of Technology, 1994; Assistant/Associate Professor, North Carolina State, 1995–2011; Advisory Committee member of Korean Nuclear Safety and Security Commission, 2011-2015

B.Sc&M.Sc. Nuclear Engineering, Seoul National University, 1981/1983
Ph.D. Nuclear Engineering, University of Cincinnati, 1987
SM/Sc.D. Environmental Health Science, Harvard University, 1991/1994

Interdisciplinary technical and policy studies to enhance safety and security of nuclear power

Marja Ylönen

Marja Ylönen is a Senior Scientist for the Safety Critical Organizations, at the Technical Research Centre of Finland (VTT). She was a post-doctoral researcher at the University of Jyväskylä, Finland. She holds a Doctorate in Social Sciences.

[1] Ylönen, M. and Litmanen T. "Signaled and Silenced Aspects of Nuclear Safety – A Critical Evaluation of International Nuclear Safety Thinking". Journal of Risks, Hazards and Crisis in Public Policy **vol 6, No 1**. 2015, Pp. 22-43.
[2] Ylönen, M., Litmanen, T., Kojo, M. and Lindell P. "The (de)politicisation of nuclear power: The Finnish discussion after Fukushima. Public Understanding of Science". DOI: 10.1177/0963662515613678 2015, pp. 1-15.

BIO

Bohdan Zronek

Bohdan Zronek is the Temelin NPP Director (2 × 1080 MW, VVER) since 2015.

He has 21 years of nuclear experience, started as licenced reactor operator during the Temelin NPP commissioning, experienced all MCR and Plant shift supervisor positions, operations manager till 2012. During the period 2012–2014, he was the Safety Director at Corporate (Division Generation) level.

Bohdan Zronek studied at Czech Technical University in Prague, Faculty of Electrical Engineering. He is the Co-creator of Czech Post Fukushima National Action Plan, Division Generation Safety section redesign 2012/2013.

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