IAEA
International Atomic Energy Agency

IAEA School on Nuclear and Radiological Leadership for Safety

Standard Syllabus 2022

VIENNA, 2022

TRAINING COURSE SERIES 75

IAEA SCHOOL ON NUCLEAR AND RADIOLOGICAL LEADERSHIP FOR SAFETY

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TRAINING COURSE SERIES No. 75

IAEA SCHOOL ON NUCLEAR AND RADIOLOGICAL LEADERSHIP FOR SAFETY

STANDARD SYLLABUS 2022

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2022

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IAEA SCHOOL ON NUCLEAR AND RADIOLOGICAL LEADERSHIP FOR SAFETY
IAEA, VIENNA, 2022
IAEA-TCS-75
ISSN 1018–5518

Printed by the IAEA in Austria
December 2022

FOREWORD

The International School on Nuclear and Radiological Leadership for Safety was developed to support the IAEA Member States in their capacity building activities in nuclear safety. The leadership school uses IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety, as the basis for its training programme.

This is the first publication of the leadership school and serves to support the facilitators in implementing the programme. This publication provides an introduction to the leadership school and outlines its objectives, curriculum, instruction methodology and the evaluation used for the training programme. It contains specific information on selected case studies used in the leadership school. Each case study describes a case scenario and its learning objectives, specifies the challenges and milestones in the development of the case scenario, and identifies the main actors and their roles. This publication also outlines the methodology of leadership games used in the leadership school programme.

The IAEA wishes to express its gratitude to all those who participated in the work of the International School on Nuclear and Radiological Leadership for Safety. The leadership school's programme is implemented by the IAEA and the school is funded in part by the European Union. The IAEA officer responsible for this publication was M.J. Moracho-Ramirez of the Office of Safety and Security Coordination.

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CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

The IAEA and its Member States have recognized the importance of leadership for safety in the IAEA fundamental safety principles established in IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [1]. Principle 3 of SF-1 [1] states that "**Effective leadership and management for safety must be established and sustained in organizations concerned with, and facilities and activities that give rise to, radiation risks.**"

Requirement 2 of IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [2], relates to "demonstration of leadership for safety by managers". The requirements established in GSR Part 2 [2] apply to a wide range of facilities, activities, and organizations. They also apply throughout the lifetime of facilities and the duration of activities.

The IAEA's efforts to promote and provide assistance in the area of leadership for safety have increased since 2011. Lessons and observations from implementing the IAEA Action Plan on Nuclear Safety [3] and those contained in the Fukushima Daiichi Accident report [4] identified leadership for safety as a priority.

Member States have also requested the IAEA to support and further develop training programmes and capacity building events in this area through General Conference resolutions (i.e., GC (64)/RES/9 from September 2020) and IAEA's Steering Committee on Regulatory Capacity Building and Knowledge Management.

In assessing capacity building needs for young professionals, the IAEA has identified the necessity to strengthen training opportunities for junior and mid-level professionals to raise awareness of the leadership for safety from the early stages of their careers.

In 2016, the IAEA commenced the development of the concept of a School on Nuclear and Radiological Leadership for Safety. The focus of this development was to provide training for early to mid-career professionals from regulatory bodies, operating organizations, technical support organizations and research institutes.

The training's overarching objective is to develop the participants' safety leadership potential through a better understanding of leadership for safety in nuclear and radiological working environments considering their inherent complexities and often competing considerations. Consistent with the requirements specified in GSR Part 2 [2], the programme is based on a progression of learning objectives applied to complex real-life situations. The training is based on case studies, presentations, keynote addresses, leadership games and discussions.

During 2017, 2018 and 2019, the Leadership School concept was further developed and reviewed: the review included the teaching methodology and additional case studies. The IAEA implemented the Leadership School at national and inter-regional levels in various Member States. From each training event, feedback has been collected, evaluated, and the lessons learned have been fully incorporated for continuous improvement.

1.2. OBJECTIVE

The purpose of the publication is to describe the methodological framework and tools for preparing and implementing the Leadership School.

This publication is intended to be used as a training guide for lecturers and facilitators of the Leadership School and as advanced reading material for participants. Member States could also use it to design, develop and implement their leadership for safety training initiatives oriented to young and junior professionals from organizations regulating and operating nuclear and radiological facilities and activities.

1.3. SCOPE

This publication covers:

(a) The framework for discussions and use of terms consistent with the leadership for safety requirements established in GSR Part 2 [2]. Establishing this framework is essential to facilitate productive discussions, knowledge sharing and understanding on an international level and across different organizational and cultural patterns.
(b) The content of practical case studies, emphasizing root and contributing causes related to nuclear and radiological leadership for safety. The case studies illustrate, through examples, possible techniques and methods for reducing, managing, and handling the tensions that competing considerations within safety decision making could induce.
(c) The value of discussing and sharing experiences, which will lead to more self-reflection and strengthen a mindset that fully embraces nuclear and radiological safety leadership concepts.
(d) The scenarios for role play, where the use of tools and techniques demonstrates the application of nuclear and radiological safety leadership in challenging situations (e.g., in which tensions are created due to competing considerations such as operational demands and resource limitations).
(e) Dynamics for team discussions, group dialogues that include exercises for the whole class to work through to develop a deeper understanding of the case study.
(f) Conclusion and lessons learned, which are meant as a space for reflection and analysis of ultimate learning from the case study.
(g) Evaluation and feedback.
(h) Training requirements for experts that could be future facilitators for the Leadership School.

1.4. STRUCTURE

This publication consists of six Sections and eight Appendices. The first Section covers the background, objectives, scope, and structure of the publication. The second Section identifies the IAEA safety standards related to leadership for safety. The third Section discusses management and leadership concepts and nuclear and radiological safety models. The fourth Section introduces the Leadership School concept and logistics. The fifth Section introduces the learning methodology and the utilization of case studies. The sixth Section addresses the dynamics for group discussions and showcases the role of facilitators in these activities. The seventh Section explains the evaluation of lessons learned, and the eighth Section elaborates on future developments, e-learning, the virtual adaptation of the Leadership School and its sustainability.

The Appendices include the outline of the training programme, demonstrate the organization of the Leadership School and give practical examples of the programmes and agendas. Additionally, the Appendices showcase selected case studies; each of those includes a scenario description and learning objectives. This Appendices also include a comprehensive list of the leadership games used in the programme.

2. MAIN IAEA SAFETY STANDARDS RELATED TO LEADERSHIP FOR SAFETY

Leadership for safety is one of the fundamental safety principles established in SF-1 [1]. Fundamental Safety Principle 3 of SF-1 [1] states that "**Effective leadership and management for safety must be established and sustained in organizations concerned with, and facilities and activities that give rise to, radiation risks.**"

> Requirement 2 of GSR Part 2 [2] states that "**Managers shall demonstrate leadership for safety and commitment to safety.**"

Requirement 1 of IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety [5] states:

> "**The government shall establish a national policy and strategy for safety, the implementation of which shall be subject to a graded approach in accordance with national circumstances and with the radiation risks associated with facilities and activities, to achieve the fundamental safety objective and to apply the fundamental safety principles established in the Safety Fundamentals.**"

Paragraph 2.3 of GSR Part 1 (Rev. 1) [5] states that "In the national policy and strategy, account shall be taken of…The promotion of leadership and management for safety, including safety culture."

3. LEADERSHIP MODELS FOR NUCLEAR AND RADIOLOGICAL SAFETY

Management and leadership are two distinct concepts; therefore, it is important to understand their differences.

Management is a formal, authorized function for ensuring that an organization operates efficiently, and that work is completed in accordance with requirements, plans and resources. Management focuses on short-term objectives, goals, and achievements. It deals with planning, budgeting, organizing, staffing, task distribution and assessment. It involves supervision and problem solving. Managers at all levels need to be leaders for safety.

Leadership is a practice that involves the application of an individual's capabilities and competencies to direct individuals and groups and influence their commitment to achieving the fundamental safety objective and applying the fundamental safety principles through shared goals, values, and behaviour. [2] Leadership is a relationship that creates shared understanding as a driver for change and excellence. It defines current and expected situations by aligning people, motivating, influencing, and inspiring them. The leader defines reality (where we are today), vision (where we want to be), and strategy (how to get there). There are numerous styles of leadership that are appropriate to different situations, and extensive research has been conducted on the subject [6].

Generally accepted and common attributes of a good leader include trustworthiness, positivity, ability to build confidence in others, intelligence, ability to problem solve and administrative capability. Good leader's qualities also involve excellence and honesty, fairness and good organization, dynamism, ability to motivate others, decisiveness, excellent communication, and coordination, reliability, knowledgeability, ability to negotiate.

It is beyond this publication to review the evolution of leadership approaches. This Section provides information based on the contributions and experiences from the Leadership School's experts and facilitators.

However, for this publication, it is worth noting that in the past, leadership was practised mainly at the most senior level of the organization and management roles went solely to well-educated or wealthy individuals; both were the domain of the elites of the society. The direction, knowledge and vision came from the top-down, and only the highest levels of the organizations were considered able to make decisions. In the early industrial model, workers were generally uneducated and not assigned complex responsibilities. The operation was divided into smaller sections, with individual workers responsible only for their defined tasks. Work processes were highly standardized and needed little to no reasoning. Additionally, work required little to no collaboration or teamwork. Workers were motivated by economic needs and other external factors.

Leadership and management in the 21st century bring vision, motivation, and strategy into a workplace, which consists of a more educated and diverse workforce. Workplaces have become increasingly influenced by internal and external stakeholders.

Effective leadership needs to reflect: (a) the employees' perceptions of the integrity of leadership, as well as leadership behaviours such as communication and workforce motivation; (b) the interpersonal relationship between worker and supervisor, including trust, respect, and support; and (c) employees' feelings of motivation, and competency relating to their role in the workplace. In addition, workforce engagement and joint responsibility for results achieved are fundamental driving forces to ensure a positive culture for safety.

During the Leadership School, the facilitators explain the above aspects and link them to the discussions within the case studies and exercises.

4. LEADERSHIP SCHOOL CONCEPT AND LOGISTICS

The overarching objective of the Leadership School is for early to mid-career professionals to develop their safety leadership potential through a better understanding of what leadership means in practice in nuclear and radiological working environments with their inherent complexities and often competing considerations.

This Section defines the Leadership School methodology and the participants' profile, and describes the implementation of the methodology, taking into account the adaptable character of the training.

4.1. METHODOLOGY

The Leadership School's methodology is based on a pedagogic progression of learning objectives, starting from goals, values and attitudes, engagement, and then covering thorough comprehension of more complex real-life situations grounded in the case studies, lectures, keynote presentations and discussions. Games and interactive activities additionally enable an easier understanding of the diverse concepts and tools taught during the course. Finally, the methodology provides the knowledge and skills relevant to participants' future roles and responsibilities.

The Leadership School's programme applies innovative training methods and focuses on experiential learning. The programme additionally includes a theoretical component, through lectures, to provide the foundation and concepts of leadership for safety as presented in GSR Part 2 [2] and practical

application of the concepts. Senior international experts with diverse backgrounds deliver the lectures by sharing their extensive knowledge and experience.

The framework for discussion and the use of terms is consistent with the leadership for safety requirements established in GSR Part 2 [2]. This approach is vital to ensure productive discussions, knowledge sharing, and understanding of international perspectives and various organizational and cultural norms. The methodology enables the discussion of nuclear and radiological leadership for safety without specifying or endorsing any specific leadership model.

The principal learning component in the Leadership School is the dynamic application of real-life case studies, with emphasis on root causes and contributing causes related to nuclear and radiological leadership for safety. The case studies use real-life scenarios to introduce techniques and methods for reducing and managing tensions occurring in a workplace, often connected to competing considerations in safety related decision making. It is important to emphasize that there will be no correct answer or technique to the challenges depicted in case studies. Instead, the learning value derives from discussing and sharing experiences. It leads to more self-reflection and strengthens a mindset that fully embraces nuclear and radiological safety leadership concepts. The development of the case studies relies on the expertise in safety leadership, safety culture and knowledge of the areas including nuclear, radiological safety, and emergency preparedness and response.

The programme applies role play, where tools and techniques are explored to demonstrate the application of nuclear and radiological safety leadership in challenging situations. Those situations include those in which tensions arise due to competing considerations such as operational demands and resource limitations.

Case studies consist of detailed and comprehensive documents. The description of each case study provides technical details, multiple characters, a complex narrative, and considerations for participants to contemplate. Furthermore, as these case studies present examples of practical safety leadership, they include supporting information meant to augment their realism. These documents provide background details (e.g., organizational charts), website content, correspondence between characters, or licence conditions.

The components of the case studies are as follows:

- Analysis of the scenario, including both independent review by participants ahead of class work as well as a short recap at the beginning of class work by facilitators. The participants receive the case studies material 2–3 weeks prior to the conduct of the Leadership School;
- Team discussions for participants in small groups, including sharing their opinions and ideas about the case study. It broadens the understanding of the case study and challenges any preconceived notions participants might hold;
- Class dialogues led by the facilitators: these dialogues include various small exercises for the whole class to work through to develop a deeper understanding of the case study. They are highly dynamic and challenge participants' understanding of the case study and their perceptions of leadership for safety;
- Conclusion and lessons learned, which provide a time for reflection and ultimate learning from the case study.

4.2. FLEXIBILITY AND IMPLEMENTATION

The Leadership School's programme can be tailored to suit the needs of the hosting Member State (hereinafter referred to as the "host") or an IAEA region.

Implementation is in coordination with the host. Responsibilities for the implementation will vary based on the host's needs, project funding sources, and other factors. As part of the adjustments to suit the host's needs, the duration of the programme can vary from one to two weeks, and the content can be adapted to focus on a smaller number of topics. Participants can be from a single Member State (National Leadership School) or from several Member States within a particular region (Regional Leadership School). In addition, the training content can be adapted to focus on topics of interest to the host, such as nuclear power, radiation safety, or other topics. The Leadership School can be delivered in face-to-face and virtual formats. Both formats involve certain arrangements: the face-to-face programme involves a large teaching space with flexible furniture arrangements, whereas the virtual programme requires participants to make their own arrangements to participate actively throughout the training. Furthermore, the Leadership School is complemented by e-learning modules.

4.3. PARTICIPANTS' QUALIFICATIONS AND BENEFITS

School participants are expected to hold a university degree and occupy junior to mid-level technical or management positions. The positions could include nuclear facility engineers working on safety related functions, heads of unit/service, and radiation protection officers. In addition, they are expected to have leadership potential, demonstrated by achievements in current and past assignments. The participants could be from regulatory bodies, associated technical support organizations, or operating organizations. They usually have from five to fifteen years of professional experience. For each Leadership School, the cohort size is from 20 to 30 participants. Admission is determined by achievements, responsibilities, and demonstrated leadership potential.

The diversity of experiences and backgrounds of each Leadership School cohort is an asset of this training as it provides many various perspectives and approaches. Leadership School participants develop an increased ability to:

- Lead for safety in inherently complex nuclear and radiological environments, in routine and emergency scenarios;
- Engage and influence others on safety procedures and methods and related matters;
- Apply leadership for safety concepts as part of their jobs, now and in the future;
- Implement IAEA safety standards and other international standards and requirements related to leadership and management for nuclear and radiological safety;
- Use an international perspective and networking, including knowledge sharing, to strengthen their leadership for safety.

These benefits enable the participants to identify how individuals interact at all levels with technology and organizations in real-life situations and how the nuclear and radiological safety leadership concepts can be implemented to resolve the tensions that can result from these interactions. From a broader perspective, the knowledge and experience sharing among participants and specialists from countries with mature nuclear experience contribute to strengthening nuclear safety worldwide.

5. LEARNING OBJECTIVES AND CASE STUDIES

5.1. LEARNING OBJECTIVES

Each learning objective of the Leadership School is linked to GSR Part 2 [2]. The following are the overarching learning objectives and the associated elements.

(a) Learning objective 1 involves setting goals for safety; it includes the following elements:
    (i) Dealing effectively with competing goals;
    (ii) Effectively seeking information as a leader;
    (iii) Making decisions for safety;
    (iv) Communicating the basis of safety relevant decisions;
    (v) Effectively seeking support for regulatory decisions;
    (vi) Building trust and encouraging the reporting of safety related issues;
(b) Learning objective 2 concerns developing values and attitudes for safety, more specifically, how to develop an organizational culture that:
    (i) Supports and encourages collaboration, consultation, and communication;
    (ii) Builds trust;
    (iii) Develops individual and institutional values and expectations for safety throughout the organization;
    (iv) Encourages and supports individuals to act safely;
(c) Learning objective 3 deals with engagement and continuous improvement, more specifically, how to:
    (i) Develop a shared understanding with internal and external stakeholders;
    (ii) Communicate technical information in a way that relevant parties understand it;
    (iii) Balance timeliness, accuracy, and completeness in sharing information;
    (iv) Engage individuals in enhancing safety performance.

Six case studies have been developed to consolidate the understanding of the learning objectives. These case studies are used in the Leadership School's programme, depending on the host profile and region.

5.2. CASE STUDY DEVELOPMENT STEPS

The first step to developing a new case study is the identification of the relevant requirements from GSR Part 2 [2] to be covered. This step is followed by the determination of the learning objectives, which reinforce the chosen requirements, then the development of important events, situations, or issues that emphasize the learning objectives, and the selection of a scenario that presents the key events or issues. The next step is a high-level storyboard and timeline to integrate the key events and issues as well as the design of the main characters and players and their dominant features. These steps are followed by the development of a detailed storyline and the outline of the crucial acquired knowledge and takeaways organized by learning objectives (conclusions) by a subject matter expert. The last step in this process is to build the document following the established templates.

Each case study is built from the following elements:

— Introduction presentation;
— Participants' handout consisting of the detailed storyline of the case study;
— Teacher's notes;
— Conclusions presentation;
— Group activities.

5.3. CASE STUDIES SUMMARY

This Section provides a brief overview of the case studies' thematic scope and learning objectives. It is important to note that each case study is based on fictitious situation and characters. Case studies 1–3 and 5 are presented in full in Appendices III–VII. Furthermore, as part of this publication a bibliography consisting of suggested background reading for case studies is included.

5.3.1. Case study 1: Unintended medical exposure

The situation described in the case study occurs within a hospital and deals with a radiation safety situation that develops over several months. The learning objective of the case study focuses on goal setting, and it also looks at different relationships between the actors and the organizational culture.

Case study 1R is based on the same storyline as the unintended medical exposure and introduces a new role from the regulatory perspective. The primary learning objective of this case study focuses on the ability to effectively seek support for regulatory decisions.

5.3.2. Case study 2: Challenges during a nuclear power plant outage

This case study deals with a hoisting event where a large load is dropped in the containment building. This case study introduces competing goals and objectives. It also adds to the complexity of the situation by introducing a third-party contractor. The learning objective of this case study focuses on values and attitudes.

5.3.3. Case study 3: Response to a leak of radioactive material to the environment

This case study continues to challenge the participants as it takes place during an emergency. There are several affected parties, many of which are non-nuclear professionals. The learning objective of this case study focuses on engagement and communication with internal and external stakeholders.

5.3.4. Case study 4: Illicit traffic during the transport of radioactive material

This case study considers a loss of control of a radioactive source during transport. This case study is meant to deal with a key aspect of leadership for security, such as effectively seeking the information as a leader, making decisions for security while faced with resource management issues.

5.3.5. Case study 5: Development of the legislative framework for safety

This case study addresses the challenges of lacking an adequate legislative framework for safety. Learning objectives are related to developing values and attitudes for safety as part of an organizational culture that supports and encourages collaboration, consultation, and communication.

5.3.6. Case study 6: Effective establishment of the regulatory body

This case study deals with challenges that a newly established regulatory body faces. Learning objectives are related to organizational culture and the development of values and attitudes for safety and graded approach based on radiation risks associated with facilities and activities.

6. DYNAMICS FOR GROUP DISCUSSIONS AND THE ROLE OF FACILITATORS

Prior to each Leadership School session, the participants are expected to conduct a preparatory self-guided study of the case studies and related references.

Facilitators create the dynamics for the case study sessions and circulate among the groups tutoring the discussions. This involves the following:

— Presentation of the case study, which takes approximately 30 min.
— Assigning working groups' tasks, which takes approximately 45 min:
    - Typically, five persons are assigned per working group;
    - The working group assignments include analysing issues, reaching group consensus, and presenting groups' results;
— General discussion, dialogues, and exercises to facilitate learning and consolidate the take-home messages, which takes approximately 90 minutes.

Each case study storyline consists of the same elements described under the headings below.

6.1. SETTING THE SCENE

'Setting the scene' is a title used for the first part of each case study. It includes the outline of the situation, description and structure of relevant organizations involved, and a description of the relevant facilities and activities. It includes as many actors and stakeholders as possible.

The second element of 'setting the scene' is a description of the main actors involved in the case. It is important to note that while facilitating the group discussions during the Leadership School, facilitators steer the group away from overly technical discussions and facilitate interaction between participants.

6.2. DESCRIPTION OF THE CHALLENGE

'Description of the challenge' follows the 'setting the scene' part of each case study. Firstly, it describes a sequence of events. These could be as follows: incident; corporate decision or change; the conditions that lead to the necessity for a leader to take action, make decisions and influence others, to best implement Principle 3, Leadership and Management for Safety established in SF-1 [1].

The challenge includes circumstances and various factors (e.g., cultural, organizational, technical, historical, personal factors) that could affect the individual's actions, ability to make decisions, or judgement. These factors add to the complexity of the challenge. They include time pressure, mental wellbeing, personal or organizational interactions, communication or reporting gaps, and routine matters.

6.3. LEADERSHIP ASPECTS IN CASE STUDIES

The final component of the case study structure is 'leadership aspects' and it consists of the following:

(a) Description of the leadership issues involved in the case study;
(b) Identification of leadership strategies and methods, communication, leading by example, involvement;
(c) Factors influencing leadership:
    (i) Communication manner;
    (ii) Respect;
    (iii) Social and professional hierarchy;
    (iv) Language and perception of safety within the local culture, both individual and group cultures;

(v) International or local nature of the organization (employees' relocation, international or multi-disciplinary companies);

(d) Outcomes of the scenario and end of the story;

(e) Case study conclusion and the lessons learned (given to participants after group work).

An important consideration to be followed by facilitators is to avoid criticizing any culture and recognize the impact of cultural differences.

7. EVALUATION

This Section provides an overview of the different evaluation methods designed and created for the Leadership School, and instructions for their utilization. It also describes the process of designing, implementing, and analysing the results of different evaluations performed and provides an assessment of the experience gained in applying them. Additionally, the review can serve as the basis for evaluating forthcoming sessions of the Leadership School.

The current evaluation process includes two main elements:

— The first element incorporates the evaluation that focuses on the first two levels of Kirkpatrick's evaluation model [7], as follows:
  - Reaction, through the participants' perception about the quality, usefulness and appealing of the training activity to their jobs;
  - Learning, through the knowledge delta gained at the course.

The first part of the evaluation is based on the experience from the Pilot Leadership School held in Nice, France, in 2017, and the Leadership School organized in Mexico in November 2018.

— The second element incorporates the evaluation made several months after each Leadership School and focuses on the upper two levels of Kirkpatrick's evaluation model [7], as follows:
  - Behaviour, through the participants' perception of how they had personally benefited from the knowledge acquired during training;
  - Results, through the participants' perception on how they had contributed to their organization based on the knowledge acquired during training.

The second part of the evaluation was developed and launched in 2020.

7.1. BACKGROUND AND DEVELOPMENT OF THE EVALUATIONS

The Leadership School hosted in Mexico in 2018 was the first to implement a two-week programme and the first conducted in Spanish. Therefore, it was essential to receive direct input from the participants. As a result, the feedback was collected on their existing and acquired knowledge. The evaluation additionally incorporated the sessions' content, methodology, and delivery tools.

The initial conception was to measure the knowledge gained by the participants during the course. Therefore, a quiz survey on general safety culture aspects was created to allow for this assessment. This evaluation tool is called the Start and End Quiz. The quiz consisted of questions on general aspects such as leadership for safety, safety culture, human and organizational factors, and relevant international aspects. This test took place on the first and last day of the course, and in both instances, it was identical in order and answer options.

The Leadership School's programme focuses on learning through experience, and case studies are a vital part of this approach. Hence, another evaluation was explicitly created to assess the understanding of the leadership for safety and safety culture concepts that the case studies are based on. This evaluation tool is called the Thematic Evaluation. It was designed to be performed following the completion of all case studies. It consists of fifteen questions: two about each case study used during a particular training programme and five more related to topics studied and used during the case studies.

The final evaluation tool was created to assess the training and its methodology used. This evaluation tool is called the Feedback Questionnaire. The evaluation consists of 19 questions, combining close answer questions with a continuum (strongly agree to strongly disagree) with open questions and questions on the methodology used. The participants can provide feedback on which tools they found useful. The chosen delivery method was to conduct the evaluations via an online tool which had the following advantages:

— The training was designed with a table-free and open-space environment;
— The agenda allowed for evaluation times to ensure that the participants filled in all questionnaires;
— The electronic collection allowed for quick statistics and quantification of results almost in real-time.

The Thematic Evaluation and Feedback Questionnaire are currently conducted online using the e-learning platform. The participants can access it by a link received in an e-mail or instant messaging application for smartphones.

In November 2020, a new survey was conducted with the questionnaire based on previous Leadership School evaluations as well as other training assessments conducted at the IAEA. This new survey is conducted every 1–2 years. The survey was shared with all alumni of Leadership Schools held to date, with intention to obtain relevant information about the real impact and benefit that the training produces, in terms of leadership for safety, on the participants and their organizations.

7.2. HOW TO CONDUCT THE EVALUATION

At the preparatory meeting ahead of each Leadership School, the facilitators review and define the test and feedback questionnaires that are uploaded to a virtual platform. As of 2021, for the quizzes, Mentimeter is the online commercial platform used by the IAEA, and the Leadership School questionnaires are hosted on the e-learning platform.

As part of the training preparation, before the venue finalization, it is vital to confirm that there is proper internet connectivity. It is advisable for facilitators to ensure that the number of participants matches the final number of questionnaires received on the platform for both face-to-face and virtual training.

7.3. THE QUESTIONNAIRES

The latest set of four different questionnaires is a collection of the inputs from facilitators, the IAEA staff, and the application experience. The facilitators review all questionnaires before each Leadership School to update, correct and reformulate them when needed and ensure they reflect the programme adjusted to specific training.

7.4. START AND END QUIZ

The Start and End quiz questionnaire measures the acquired knowledge on general leadership for safety and safety culture issues. It consists of questions on different topics, each allowing four possible choices, with only one correct answer. The quiz can be adjusted to each teaching programme. The participants complete an identical questionnaire at the beginning and the end of the course.

The Start Quiz is introduced during the first day of the programme. For the best measurement of the initial level of knowledge, the ideal timing is before the teaching begins.

The End Quiz is performed on the last day of the training. The preferable timing for it is after the last teaching session. A brief discussion on the correct answers to ensure deeper understanding among participants follows the finalization of the quiz.

The Start and End Quiz are completed using an online tool, Mentimeter.

7.5. THEMATIC EVALUATION

The Thematic Evaluation has been designed to measure the level of knowledge acquired by completing of the case studies and the thematic lectures. It consists of up to twelve questions with four choices, with only one correct answer. The number of questions varies depending on the duration of the Leadership School.

The preferable timing for this evaluation is during one of the final sessions, when all the case studies and thematic sessions have been concluded.

7.6. FEEDBACK QUESTIONNAIRE

The Feedback Questionnaire measures the participants' satisfaction with the programme and delivery methods. Therefore, in contrast to the other questionnaires, it does not assess knowledge and has no correct answers. Instead, it is used to collect feedback and opinions.

7.7. GENERAL REFLECTION SURVEY

The General Reflection Survey is a questionnaire that was created in 2020 to obtain relevant information from the participants of all the Leadership Schools held to date.

7.7.1. Scope and background

The survey measures the results and benefits produced by the training on the participants and their organizations.

The survey was also designed with demographic and geographic questions to produce an adequate segmentation for analysis [7]. The collected information allows the establishment of a baseline for future evaluations as well as assisting in identifying elements for improvement. The survey uses different types of questions:

- Multiple choice questions;
- Dropdown questions;
- Likert scale questions;
- Open-ended questions;
- Single answer multiple choice question with a comment field.

7.7.2. Results

The perception conveyed by the participants through the survey was that the Leadership Schools have been hugely successful and had a positive impact on their careers. The results showcase that the programme demonstrates theoretical knowledge while using practical methods and tools. These are helpful for the participants to commit to leadership for safety. In addition, the skills gained during the training contribute to participants' active role in the improvements in their organizations by facilitating a better understanding of systemic issues.

Over 90% of the respondents indicated that the training increased their knowledge of leadership for safety, and they used it at work. In comparison, over 80% of them agree that the Leadership School increased their understanding and awareness of the IAEA safety standards as well as their ability to apply them in real life situations. Furthermore, over 95% of the respondents agreed that the Leadership School provided ideas on effective engagement and constructive influence on others for safety. Additionally, more than 90% of the answers were positive when asked about the use of the knowledge acquired during the training for performance improvement; comparable answers were given in response to a statement that experience gained during the Leadership School was helpful in daily work.

The questions regarding professional development additionally demonstrate the lasting impact the training had on the participants. Over 30% of the respondents indicated they have been promoted to a more senior position or advanced onto higher education studies since participating in the Leadership School.

Moreover, the survey highlights the role of networking during the training, as over 80% of participants agreed that the Leadership School increased their international perspective and that they have kept in touch with fellow participants and facilitators when suitable.

Furthermore, the survey respondents have provided specific examples of actions they took at their organizations since attending the Leadership School. They described performance that they perceived have been positive and effective.

Positive perception of the Leadership School was also demonstrated by suggestions that respondents would welcome further courses and digital learning support.

8. FUTURE DEVELOPMENT AND SUSTAINABILITY

This Section describes the current and future developments planned for the Leadership School. It includes elements that ensure the sustainability of the training and its adaptability to various formats and requirements.

8.1. LIBRARY OF CASE STUDIES

The case studies serve as the foundation for the Leadership School's learning objectives and instructional methodology; therefore, the development of additional case studies will continue to provide more flexibility for the delivery of the programme. Additional case studies will be developed to cover a range of facilities and activities from different perspectives and stages of development. A library of case studies to choose from will enable each implementation of the Leadership School to be tailored to the exact need of its host.

These case studies will be built by an appropriate senior expert with experience in the corresponding field. This measure ensures the case study is technically correct and benefits from years of experience.

The Leadership School is intended to be a sustainable learning opportunity for the development of future leaders in the areas of nuclear and radiation safety. To achieve that, it is envisioned that the Leadership School will undergo continuous improvement. New elements will be added over time to improve effectiveness and efficiency, resulting in sustainability.

Using feedback from the evaluations from each implementation of the Leadership School, the IAEA will continue to refine and supplement the library of materials. It will allow for the offering of a sustained, high-quality programme that is contemporary, relevant, and impactful for all participants.

8.2. TRAIN-THE-TRAINERS

The Leadership School uses a dynamic and thought-provoking instructional methodology that relies upon fully engaged and well-prepared participants as well as talented and committed facilitators. Therefore, while the selection criteria assist in ensuring the best possible participants, the IAEA needs to guarantee a list of competent facilitators with the necessary experience in nuclear and radiation safety, leadership for safety, as well as instructional skills.

Therefore, the IAEA developed a train-the-trainer approach that instructs potential facilitators in the materials and methodology of the Leadership School. The train-the trainers programme consists of a distinct training for new facilitators as well as a 'learning by doing' approach during the preparatory meetings ahead of each Leadership School.

This Section outlines the proposed selection criteria for expert facilitators for the Leadership School, as follows:

- Over 20 years of experience in a nuclear or radiological leadership position. Experts from the following disciplines could be considered as expert facilitators: leaders in nuclear power generation, nuclear materials, or nuclear medicine industries; organizational psychologists or coaches with safety culture relevant practical nuclear leadership experience; experienced staff from regulatory bodies; IAEA professionals with relevant nuclear leadership experience;
- Demonstrated excellent verbal communication skills in English and other IAEA Languages as appropriate;
- Demonstrated experience as an instructor or facilitator;
- Demonstrated potential to communicate well in an international and diverse environment;
- Background and experiences that are commensurate with the Leadership School's objectives and with the relevant requirements of GSR Part 2 [2].

In addition to the facilitators' qualification, due to the teaching methodology, a preparatory event to train the facilitators in the Leadership School concept and optimize the final programme is good practice. Typically, the facilitators will discuss the content, exercises and practice the activities before the course. Together with a trainer's support package including teaching notes, it helps to prepare for exercises and conclusions and ensures that the facilitators are aligned and fully prepared. This strategy establishes the quality of the course and the application of the Leadership School's full potential using the interactive teaching methodology. An example of the train-the-trainer's agenda can be found in Appendix I.

The train-the-trainers programme includes:

— Orientation for expert facilitators on GSR Part 2 [2] objectives;
— Orientation for expert facilitators on methodology, objectives, and structure.

Before any Leadership School begins, the facilitators are expected to master the material in case study teachers notes and the case study dialogues, as well as to demonstrate facilitation skills, with coaching. Additionally, the facilitators are expected understand the impact of cultural diversity on a Leadership School's facilitation.

8.3. E-LEARNING DEVELOPMENT

E-learning means that training or part of it is delivered electronically. In traditional training, a facilitator conveys knowledge in a physical classroom, otherwise called synchronous training. Learners listen, watch, and interact with the facilitator in person at a set time and pace of the facilitator's choosing. With e-learning, participants consume the training material virtually. One of the beneficial characteristics of e-learning is that it is self-paced and asynchronous. It means there is no set time for the learning to take place.

The Leadership School applies a blended approach with e-learning as a supporting leadership training tool. The e-learning platform used is the IAEA's Learning Management System. The purpose of the Leadership School's e-learning is to support participants' progress within the training programme. Participants' preparedness contributes to the success of the Leadership School. To achieve it, the function of the e-learning platform is mainly preparatory. To ensure that goal is reached, the participants receive access to the learning platform 2–3 weeks ahead of their training.

The main objective of e-learning is to support the core training and help participants to find the materials needed for preparation in one place and in an accessible format. Other objectives to be achieved by e-learning are the introduction to the Leadership School and the theoretical ideas for the training.

The e-learning materials used for the Leadership School vary from SCORM (Sharable Content Object Reference Model) packages (highly interactive modules covering the main topics) and case studies to videos and infographics. In addition, the e-learning includes a section with facilitators' biographies. All these materials follow the IAEA style guidelines. Additionally, the participants can post information about themselves in a video or written text format.

The second objective of e-learning is to reinforce the knowledge obtained during the training as well as ensure that participants engage with the material from the live training. It is achieved by adding content from the sessions, including group work outputs, presentations, photos, posters, and graphics.

Lastly, two elements of the training evaluation can be completed via the e-learning platform - the Thematic Evaluation, and Feedback Questionnaire.

E-learning is under constant improvement. A library of various e-learning modules is being built for sustainability. It will allow for greater flexibility and compatibility with different training programmes.

8.4. VIRTUAL LEADERSHIP SCHOOL

The Leadership School is compatible with the traditional face-to-face and virtual formats.

In 2021, given the changes and challenges caused by the Covid-19 pandemic, the IAEA started developing a virtual adaptation of the Leadership School. Experts from various backgrounds were involved, including senior experts from operating organizations and regulatory bodies, as well as behavioural scientists. Since then, face-to-face activities have been transformed to a remote-friendly technique, and template four-day and seven-day programmes have been created.

The virtual format was tested in a pilot Virtual School on Nuclear and Radiological Leadership for Safety, which took place from 28 June to 1 July 2021, with the participation of 16 young nuclear professionals, with diverse work backgrounds, from across the IAEA Secretariat. The pilot virtual Leadership School's objective was to examine the participants' engagement with the virtual activities as well as test the online programme and tools chosen for its implementation.

The virtual Leadership School uses a conferencing tool for hosting the training. All activities that include group work are coordinated using breakout rooms. For activities that the face-to-face format would facilitate using post-it notes and group brainstorming, an online whiteboarding tool, Miro, is used. Additionally, for polling, to measure the mood of the cohort, or for exercises that can benefit from visually attractive material, an interactive real-time feedback tool, Mentimeter, is used. For one specific exercise, entitled 'Subarctic Survival Situation', a platform hosted by Human Synergistics is used. It was concluded that communication with the participants prior to the training and their commitment to full participation are essential to the success of the virtual Leadership School.

The assessment of the first virtual adaptation of the Leadership School was conducted using two different evaluation tools. Firstly, during the last day of the programme, the facilitators conducted a live feedback session during which the participants raised positive experiences and areas for improvement. The second tool used for evaluation was a post-training feedback questionnaire. This questionnaire was announced during the training and sent to the participants shortly after the training. The survey had 76 thematic questions. Each activity included a question connected to the tools used (if any) and space for participants' comments. The questionnaire focused on evaluating virtual delivery, online tools, and newly introduced e-learning. The overall feedback indicated that all participants felt engaged during the training. Most of the participants rated all exercises as 'Excellent' or 'Very good'. In addition, the use of the various online tools (Miro, Mentimeter, and Human Synergistics platform) was rated 'Excellent' or 'Very good' in all exercises.

The lessons learned from the pilot virtual Leadership School were used to improve the virtual programme of the Leadership School.

8.5. CAPACITY BUILDING PROGRAMMES

Ultimately, the long-term goal for the Leadership School is to have a continued, sustainable product that runs itself. Therefore, in addition to a library of case studies and train-the-trainer programme, the IAEA will endeavour for the Leadership School to form part of relevant capacity building projects. This vision involves the utilization of mechanisms such as the IAEA's Technical Cooperation Programme as well as Regional Training Centres to propagate the Leadership School and its learnings further.

Furthermore, as the learning and understanding of leadership for safety evolves, the IAEA will ensure that the Leadership School's learning objectives remain linked the IAEA safety standards and latest

relevant knowledge. To that end, the IAEA will attempt to use the Leadership School as a platform for continued research and development in leadership for safety. The training is only as good as the concepts upon which it is based; to that end, the IAEA will endeavour to link with research institutions, learning organizations, and universities in the continuous development of the Leadership School.

APPENDIX I. GENERAL ELEMENTS OF THE PROGRAMME, PREPARATION, AND EXAMPLES OF AGENDAS

The training programme varies, depending on whether the Leadership School is national or regional (also referred to as international). This Appendix showcases the programme elements and includes some example schedules. The basic concept underlying the programme is to allow a modular approach and flexibility to implement the Leadership School. The duration of the training can be of one or two working weeks containing the following sessions:

- An opening session includes a welcome address, an introduction of all participants and facilitators utilizing an 'icebreaker' session, and a senior guest speaker on their own real-life experience in nuclear and radiological safety leadership. The session illustrates the potentially grave impact of decisions, in terms of environmental, social, and human consequences, that those responsible for nuclear and radiological safety could have. The intent is to reinforce the participants' individual commitment to safety and to energize them ahead of the training programme.
- Presentations on the Leadership School's methodology, framework for discussion and use of terms, and nuclear and radiological safety leadership concepts as defined by GSR Part 2 [2].
- A series of two or three case studies each focused on a specific learning objective. These include nuclear and radiological examples and involve a range of scenarios (e.g., routine operations, emergencies) as well as the perspectives of the regulatory body and operating organizations. The case studies are representative of the different environments that could be encountered by the participants. They allow the participants to discuss the impact of the nuclear and radiological safety leadership factors in the unfolding story of each case study and to learn how the use of the IAEA guidance in this field could have been maximized. These discussions consider the context of different competing considerations which motivate the decision processes and shape events unfolding in each case, creating positive or negative 'tensions' within organizations.
- Group discussions allow participants, with the support of the facilitators, to reflect on the first three case studies and their understanding of the three studied aspects of leadership for safety, as well as to explore more complex situations where additional factors may apply (e.g., security or legal aspects).
- Finally, facilitators lead a general discussion allowing the participants to reflect on the issues from the previous days. This session, which could include a keynote presentation, prepares the participants to integrate the knowledge gained into their own professional experience, and prepare them to make use of the resource as part of their ongoing development.

I.1. COMPONENTS OF THE PROGRAMME

This part of the Appendix showcases the theoretical and empirical components of the Leadership School. The curriculum of every Leadership School follows a certain structure which is based on the below modules.

(a) MODULE 1: IAEA safety standards relevant to leadership for safety:
  (i) Safety Fundamentals, SF-1 [1] and setting a positive safety culture;
  (ii) GSR Part 2, Leadership and Management for Safety [2] (focus on goal setting, values and attitudes, and engagement) [2];
  (iii) GSR Part 1, Governmental, Legal and Regulatory Framework for Safety [3];
  (iv) Other relevant safety standards can be included;

(b) MODULE 2: Leadership models for nuclear and radiological safety:
    (i) Introduction of various leadership models;
    (ii) Impact of leadership styles on safety culture;
    (iii) Leadership and management systems;
    (iv) Systemic approach to safety;
    (v) Institutional strength in depth;
(c) MODULE 3: Learning methodology and utilization of case studies:
    (i) Presenting a case study focusing on goal setting:
        — Dealing effectively with competing goals;
        — Effectively seeking information as a leader;
        — Making decisions for safety;
        — Communicating the basis of safety relevant decisions;
    (ii) Presenting a case study focusing on values and attitudes:
        — Supporting and encouraging collaboration, consultation, and communication;
        — Building trust;
        — Developing individual and institutional values and expectations for safety throughout the organization;
        — Encouraging and supporting individuals to act safely;
    (iii) Presenting a case study focusing on stakeholder engagement:
        — Developing a common understanding with internal and external stakeholders;
        — Communicating technical information in a way that it is understood by relevant parties;
        — Balancing timelines, accuracy, and completeness in sharing information;
        — Engaging individuals in enhancing safety performance;
    (iv) Techniques and tools for experiential learning:
        — Log in and log out, reflection team, group dialogues, and specific dynamic activities;
(d) MODULE 4: Evaluation of lessons learned:
    (i) Evaluation of knowledge acquired:
        — Start and End Quiz;
        — Thematic Evaluation;
    (ii) Evaluation of course effectiveness:
        — Formal immediate survey–Feedback Questionnaire;
        — Long term surveys;

The modules include options that are chosen and adapted to each training session. The following list includes the elements that can be used:

(a) Case studies – depending on the profile of the country or region, the length of the programme and other factors, appropriate case studies are chosen for the programme;
(b) Topical lectures and exercises;
    (i) Introduction:
        — Introduction to the Leadership School;
        — IAEA safety standards for leadership and safety culture;
        — Ice-breaking exercise;
    (ii) GSR Part 2 [2] and leadership in the field:
        — Exercise on observation for leaders in the field;
        — Exercise on coaching on behaviours in the field;

(iii) Leadership:
- Leadership attributes, characteristics, and definitions;
- Leadership for safety activities, Globe, and other relevant models;
- Systemic approach to safety;
- Leadership models and the role of leaders;
- Signs of declining safety;
- Exercise on declining safety;

(iv) Safety Culture:
- Safety culture - example of nuclear accidents;
- Safety culture - example of radiological accidents;
- Safety culture and safety management systems;

(v) Communication with the public:
- Communication with the public;
- Exercise on communication with stakeholders;

(vi) Human and organizational factors:
- Human and organizational factors;
- Internal communication;
- Exercise on internal communication and organization;

(i) Shared Space and Leadership Models:
- Shared Space;

(c) Games – the description of all games can be found in Appendix IX:
(i) Log in/ Log out;
(ii) Appreciative Inquiry/Let me introduce you to;
(iii) Emotional Thermometer;
(iv) Reflective Team;
(v) Exercise on Leadership (Triangle);
(vi) Team Building Activity (Cup Play);
(vii) Master Frogger;
(viii) Press Conference;
(ix) Safety Path;
(x) Shock Therapy (Manolito);
(xi) The Bonds of Leadership (The Rope Exercise);
(xii) Aircraft Company - Safety Our Priority Aircraft Manufacturer Company (SAMCO);
(xiii) Field Exercise - locate and rescue a lost radioactive source;
(xiv) Tribes of Different Cultures/The chosen three;
(xv) Coaching exercise (SMART);
(xvi) Observing points;
(xvii) Change your cap change your mind;
(xviii) Ball together;

(d) Revision of tools;

(e) Evaluation:
(i) Start/End Quiz;
(ii) Thematic Evaluation;
(iii) Feedback Questionnaire.

I.2. PREPARATORY TRAIN-THE-TRAINERS MEETING

The preparatory train-the-trainers meeting aims to design the programme and build the team of experts and assign roles and responsibilities, in accordance with the priorities of the region, implementation constraints and the best use of the skills and expertise of the available team of experts.

Table 1 demonstrates a template four-day agenda for the preparatory train-the-trainers meeting.

TABLE 1. TEMPLATE FOUR DAY AGENDA FOR THE PREPARATORY TRAIN-THE-TRAINERS MEETING

Time	Name of presentation/activity
Day 1	
Objective: Introduction and discussion of the main elements of the Leadership School programme	
09:30–09:40	Welcome and opening remarks Introductions
09:40–11:00	Presentation and walk through of the preliminary draft two-week programme
11:00–11:15	Coffee break
11:15–13:15	Discussion on case studies, dynamic exercises, and games to be used
13:15–13:45	Lunch break
13:45-16:00	Discussion on the theory component to be included in the programme and on the evaluation questionnaires
Day 2	
Objective: Production of the draft detailed agenda for the Leadership School programme and discussion of the facilitators' roles	
09:30–09:40	Log in
09:40–10:45	Development of the draft detailed agenda
10:45–11:00	Coffee break
11:00–13:30	Development of the draft detailed agenda and discussion on the facilitators team: assignment of roles and responsibilities
13:30-14:00	Lunch break
14:00-16:00	Development of the draft detailed agenda and discussion on the facilitators team: assignment of roles and responsibilities
Day 3	
Objective: Revision of the meeting's outputs and plan of further actions	
09:30–09:40	Log In
09:40–10:45	Final assignment of roles and responsibilities
10:45–11:00	Coffee break
11:00-13:30	Final assignment of roles and responsibilities
13:30-14:00	Lunch break
14:00–16:00	Finalisation of roles and responsibilities, and the revision of the meeting's outputs and plan of future actions and e-learning platform presentation
Day 4	
Objective: Discussion on the logistics and arrangements for the Leadership School	
09:30–09:40	Log in
09:40–10:10	Schedule of the Leadership School in [place]
10:10–10:25	Coffee break
10:25–13:30	Site visit planning
13:30-14:00	Lunch break
14:00–14:45	Recruitment of participants
14:45–16:00	Logistics and arrangements
16:00	Adjourn

I.3. MODEL LEADERSHIP SCHOOL PROGRAMMES

This part of the Appendix includes examples of the programmes from past Leadership Schools.

Table 2 demonstrates a two–week programme that was adopted in Mexico in 2018 and Table 3 a one–week programme adopted in Brazil in 2018.

TABLE 2. TWO–WEEK LEADERSHIP SCHOOL PROGRAMME, MEXICO 2018

	Monday	Tuesday	Wednesday	Thursday	Friday
First week of the programme					
Session name	Session 1: Opening and keynote speakers	Session 3: Why Leadership for safety?	Session 5 What is Leadership for safety?	Session 7: Safety and Security Culture and Management systems	Technical visit 1: Instituto Nacional de Investigaciones Nucleares (ININ)
Activities included	Presentation and round table included presentation by the Spanish regulator on its safety culture and leadership programme	Safety, Security and Radiological Experience exercises and lectures	Leadership Models and Systemic Approach to Safety	Lecture and exercises	Technical visit and emergency exercise
Session name	Session 2: Getting to know each other, self-assessment, and expectations	Session 4: IAEA safety standards	Session 6: Case study	Session 8: Case study (Security)	–
Activities included	Ice breaker, exercises, and Start Quiz to test initial knowledge	IAEA Safety Standards and Security guidance	Case study activities: "Challenges during a Nuclear Power Plant Outage"	Case study activities: "Loss of Control of a Radioactive Source"	–
Second week of the programme					
Session name	Session 9: Case study	Technical visit 2: Hospital Radiotherapy (RT)	Session 11: Case study (continued)	Session 13: Case study	Session 15: Closing session, Evaluation and Conclusions
Activities included	Case study activities: "Emergency Incident in a Nuclear Facility"	Presentation of treatments, training and regulations followed by the RT service Services.	Case study activities: "Unintended Medical Exposure"	Case study activities: "Unintended Medical Exposure" Regulatory Approach	Final presentation, End Quiz, and feedback questionnaire
Session name	Session 10: Shared space and communication with the public	Session 11: Case study	Session 12: Human and Organizational Factors and Safety Culture	Session 14: Evaluation	Session 16: Closing Ceremony
Activities included	Lecture and exercises	Case study activities: "Unintended Medical Exposure"	Lecture and exercises	Thematic evaluation of the case studies and subject matters	Ceremony, attendance certificate, closing and conclusions

TABLE 2. ONE–WEEK LEADERSHIP SCHOOL PROGRAMME, BRAZIL 2019

	Monday	Tuesday	Wednesday	Thursday	Friday
Session name	Session 1: Opening and introduction	Session 3: Why Leadership for safety?	Session 5: Safety Culture and Integrated management systems	Session 7: Case study	Session 9: What have we learned?
Activities included	Opening activities and keynote speakers	Safety, Security and Radiological Experience: exercises and lectures	Leadership Models and Systemic Approach to Safety	Case study presentation and group dynamics: "Response to a leak of Radioactive Materials to the environment"	Safety and Security Culture Management systems
Session name	Session 2: Getting to know each other, IAEA Safety Standards	Session 4: Case study	Session 6: Case study	Session 8: Engagement and Communication	Session 10: Closing Ceremony
Activities included	Ice breaker, exercises, and Start Quiz to test initial knowledge	Case study presentation and group dynamics: "Unintended Medical Exposure" Regulatory Approach	Case study presentation and group dynamics: "Challenges during a Nuclear Power Plant Outage"	Lecture and exercises, evaluation included in this session	Ceremony, attendance certificate, closing and conclusions

APPENDIX II. LEADERSHIP SCHOOL ORGANIZATION

Extensive planning is needed prior to each Leadership School. This Appendix showcases the organizational details of the Leadership School. It consists of lists of responsibilities for the host and for the IAEA for the training preparation, as well as requirements for the facilities, facilitators, and translation.

II.1. RESPONSIBILITIES OF THE HOST

The following list states the responsibilities that the IAEA shares with the host of the Leadership School.

(a) Participants:
  (i) It is assumed that the host will accept responsibility for funding the attendance of their participants:
    — In case of a National Leadership School, this would include all participants;
    — In case of a Regional Leadership School, this would generally be approximately half of the participants;
  (ii) The proportion of participants funded by the host could be reduced if the Leadership School forms part of an IAEA technical Cooperation programme;
  (iii) The IAEA can provide criteria to aid in the selection of participants;

(b) Facilities:
  (i) It is assumed the host will provide all facilities needed to conduct the training, which includes:
    — One main room with a capacity of 45 people, which includes a computer, projector, and microphone;
    — Two smaller break-out rooms each with a capacity of 20 people;
  (ii) It is important to note that tables and chairs in all rooms need to be able to be rearranged to accommodate group learning and the Leadership School's dynamic instructional method;
  (iii) Local facilitators;
  (iv) It is hoped that the host would provide one or two facilitators at their expense to assist in the delivery of the Leadership School:
    — These facilitators are expected to be experts in leadership for safety in the field of nuclear or radiation safety, preferably with backgrounds in dynamic facilitation and instructional techniques;

(c) Translation.

While the Leadership School's materials are available in English and Spanish, the programme is being developed for other official languages of the IAEA. If the host wishes to have live translation during the conduct of the training, the host will have to assume responsibility and provide funding.

II.2. RESPONSIBILITY OF THE IAEA

The below list specifies the responsibilities of the IAEA in the organization of the Leadership School.

(a) Preparatory train-the-trainers meeting:
    (i) The meeting is hosted 2–4 months prior to the Leadership School, either at the IAEA's headquarters in Vienna, or virtually;
    (ii) All facilitators are involved (including local facilitators) to discuss and decide upon:
        — Roles and responsibilities of each facilitator;
        — Training of new facilitators;
        — Participant's backgrounds;
        — Selection of case studies and associated group dialogues;
(b) Concerning facilitators and speakers, the IAEA provides for each implementation of the Leadership School:
    (i) One IAEA senior staff member for the opening and closing sessions;
    (ii) 3–5 facilitators for the week:
        — Assumed to be 1 or 2 IAEA staff members, with 2–3 external experts;
        — Local facilitators;
    (iii) Keynote speakers:
        — The IAEA is open to suggestions as to any potential keynote speakers for the Leadership School;
        — Funding for the attendance of keynote speakers might need to be negotiated depending on location, cost, and other factors;
(c) Participants:
        — The IAEA provides funding for the attendance of all participants who need it and are not covered by the host funding. All participants are selected in coordination with the host.

II.2.1. Audience and facilitators

It is proposed to limit the number of participants to approximately thirty professionals to facilitate the depth of interaction between the participants and the facilitators. In addition, participants are expected to come from different countries and various professional backgrounds to enrich the dialogues and maximize the learning experience.

The target audience is early to mid-career professionals who have already been identified for their leadership potential through their achievements in their current and past assignments. The selection process will include a call to the Member State(s), followed by selection based on their personal achievements and current responsibilities and their English language capability, to achieve a well-balanced mix (gender, countries, activity sectors).

As the Leadership School is based on experiential learning, the facilitators would usually be senior professionals, experienced in training activities, who can transfer practical knowledge during the exercises and case studies.

II.2.2. Location

The organization of successive Leadership Schools in different regions and languages is encouraged, taking into account the respective countries and professional communities (regulatory bodies, technical and scientific support organizations, operating organizations in the nuclear industry and other fields like healthcare, industry, research) and the needs for consolidating nuclear and radiation leadership for safety.

II.2.3. Timing

Future training requests are being processed, scheduled, and implemented by the IAEA. In addition, as the programme is expanding, a training programme for future facilitators is being developed and implemented to expand the team of experts who can assist in presenting the programme.

APPENDIX III. CASE STUDY 1: UNINTENDED MEDICAL EXPOSURE

III.1. LEARNING OBJECTIVES

This case study deals with a key aspect of leadership for safety, namely, setting goals for safety. It includes the following elements:

— Dealing effectively with competing goals;
— Effectively seeking information as a leader;
— Making decisions for safety;
— Communicating the basis of safety relevant decisions.

III.2. SETTING THE SCENE

III.2.1. National nuclear profile (as relevant to the case study)

This case study takes place in a State with a developed nuclear energy sector. It has several nuclear research facilities as well as nuclear applications in industry, agriculture, science, transport and (most importantly for this case study) medicine. The most significant facility in the medical field is the National Oncological Hospital, a unique public service institution owned by the government.

The National Oncological Hospital (hereinafter – 'the Hospital') provided diagnostic services and treatments for a wide range of patients with cancer. In addition to different non-radiological technologies, the Hospital provides radiotherapy, nuclear medicine, and diagnostic radiology services.

The radiotherapy service has the following equipment:

— Teletherapy equipment with cobalt-60 radioactive sources;
— High Dose Rate (HDR) brachytherapy equipment with iridium-192 radioactive sources;
— Three linear accelerators;
— Two computed tomography unit for the planning of teletherapy treatment;
— One conventional X-ray unit for positioning in brachytherapy treatments.

The number of patients the Hospital processes is high as it is the only service of its kind in the country. The situation has led to the establishment of two 5-hour shifts for cobalt-60 teletherapy. The first shift starts at 07:00 and ends at noon; the second shift starts at 13:00 and ends at 18:00.

The remaining equipment is used during regular working hours, 07:00 to 16:00.

The calibration of the equipment is performed by the physicists of a service belonging to the National University. The repair and maintenance of the equipment are carried out by a national entity belonging to the Ministry of Health.

The Nuclear Regulatory Authority (NRA) in the country is well-established and deals with all nuclear-related activities (from research reactors to radiation sources), covering both safety and security. A recently conducted IAEA Integrated Regulatory Review Service (IRRS) mission on the NRA was positive and did not report any significant deficiencies.

The NRA performs a three-day inspection of the Hospital once every two years to verify compliance with the licence granted and that safety conditions and requirements are met.

The Hospital's licence is valid for five years. The working regime of the cobalt-60 teletherapy equipment as given in the licence provides for the two established shifts (see in supporting information number III.5.1.: Excerpts of the hospital's licence). There is a licence requirement to notify the NRA of any significant change to the operation of any licence specified equipment.

III.2.2. Main actors involved in the case study

The individuals participating in safety-relevant decision-making at the Hospital include:

— Hospital Director;
— Head of Radiotherapy Services;
— Radiation Protection Officer, who is a direct subordinate to the Director.

The Hospital Director is a world-renowned Professor, E. Smart. His background is oncology and neurosurgery, and he is still treating patients and consulting on complicated cases all over the world.

The Head of Radiotherapy Services is Marion. She is 36 and the first woman to hold this position at the Hospital. Her appointment received positive media coverage as young women professionals rarely hold managerial positions in the country. However, it was not well received by some of the specialists within the Hospital. As a result, they preferred to directly address their ideas and concerns to Professor Smart, even if it was under Marion's responsibility. That was particularly true in case of a radiotherapist named Carlos, who is older and considers himself more qualified.

Radiotherapy Services have the following staff:

— Head of Service (i.e., Marion);
— Radiotherapists;
    - Prescribe treatments and follow-up with patients;
— Medical physicists;
    - Plan treatments and do daily checks of equipment parameters;
— Radiotherapy technicians;
    - Operate the equipment;
— Dosimetrists;
    - Calculate doses to be given to patients;
— Nurses;
    - Assist patients as required.

Staffing for Radiotherapy Services is considered adequate to use the available equipment. All staff have received the required training and have had their individual licences granted by the NRA.

One of the most experienced and skilled radiotherapy technicians is Mark, who has had no complaints from patients or doctors for almost 20 years.

Radiotherapy Services has a Quality Assurance Programme as well as Working Instructions for all staff positions and, while it satisfies regulatory requirements, staff perceive them as formal as opposed to working documents.

This perception also applies to the Radiation Protection Officer, Manuel, whose role in daily operations is limited to the endorsement of safety relevant documents and preparation of papers as requested by the NRA. Manuel, who took the position a long time ago, is now approaching retirement age and is not interested in intervening unless directly requested.

For the NRA, the individual participating in safety-relevant decision-making is the Head of the Radiation Sources Safety Unit, David. He was appointed a few years ago and is also relatively young. He prefers to be personally involved in regulatory activities concerning the most important licensees, such as the Hospital. He is well-educated and follows the latest regulatory practices, such as considering of the licensee's management system as an essential safety factor.

Within the country, David's views are not shared by all radiation source users as most of them consider matters such as management systems and leadership for safety to be unnecessary and overly bureaucratic burdens. As such, most work in these areas is limited to the preparation of paperwork, which is generally forgotten after regulatory endorsement is given (as is the case for the Hospital).

An organization chart for the hospital is provided in Fig. 1 in the supporting information.

III.3. DESCRIPTION OF THE CHALLENGE

III.3.1. Hospital considering how to meet the increased demand for Cobalt-60 radiotherapy treatments within the existing budget

Starting in 2011, the demand for radiotherapy treatment showed steady growth and sometimes the schedule for cobalt-60 teletherapy was so full that it resulted in some treatments being postponed. There are two private clinics in the country able to provide such treatment, but most patients cannot afford that option. By September 2016, the issue became a nearly everyday occurrence, resulting in patients (as well as their families) complaining. Even the NRA received a few complaints, which they forwarded to the Hospital. By the end of September 2016, Professor Smart sent a letter to the Ministry asking for an additional budget to enhance services to meet demand (the letter is available in the supporting information).

In November 2016, the NRA completed its standard biennial inspection with David as Team Leader. The inspector was generally satisfied with the Hospital's safety performance, and everything appeared to be in place, including, Radiation Protection Officer, instructions, certificates, appropriate updates to comply with the latest regulatory requirements. No actions were deemed necessary following the inspection. However, the growing demand for radiotherapy treatment was discussed between David and Marion over coffee, with David stating explicitly not to extend a Cobalt-60 radiotherapy shift beyond five hours due to safety reasons.

Meanwhile, complaints concerning the unavailability of radiotherapy services continued to the extent that the Hospital eventually received a letter from the Minister himself requesting the Director do something without additional money for equipment or staff (the letter is available in the supporting information).

Professor Smart discussed the request with the Hospital's Chief Accountant to find a potential solution within the given parameters. They found that they could manage a rearrangement of staff to make an additional technician available to operate the cobalt-60 teletherapy equipment during a third shift. Professor Smart decided to add that third shift from 18:00 to 22:00. This shift would operate with a single radiotherapy technician as the number of patients was not expected to be as high as the other two shifts.

The Radiation Protection Officer was not consulted prior to the decision, nor were staff informed. Aside from the discussion between Professor Smart and the Chief Accountant, the decision was not analysed for any potential impact of the decision on patient safety and/or safety in general. In the end, nobody questioned the decision as it was implemented.

The NRA was not provided with any notification, as required by the licence issued to the Hospital.

III.3.2. Introduction of the third shift and the initial months following its implementation

Professor Smart directed Marion, as Head of Radiotherapy Services, to implement the third shift beginning January 2017 (the internal memo is available in the supporting information section). As directed, the third shift began its operations with a single radiotherapy technician, Mark, who volunteered to work without any support on the condition of agreed financial compensation.

Shortly after implementation of the third shift, Marion was informed by her Administrative Assistant about complaints from patients receiving treatment during the third shift (e.g. see III.5.6 in the supporting information). However, Marion did not report or investigate the complaints as she did not consider them relevant.

Further to these complaints, in late January 2017, Professor Smart received notification from a radiotherapist, Carlos, concerning a patient, Mr D, who was prescribed Cobalt-60 radiation therapy in both the right hip and the thoracic-lumbar spine to be completed on different dates (the transcript of a phone call is available in supporting information section). The patient, who was initially being treated on the morning shift, was recently moved to the new third shift. After the patient had finished their treatment to the spine, the technician mistakenly continued treatment, unaware of the note in the Patient Treatment Sheet (PTS) that it had been completed, meaning that the patient received an exposure that was double the intended dose. The error was also not detected during the routine review of the PTS performed by the medical physicists. Carlos only noticed the situation at a follow-up appointment. The problem was identified, but no lessons had been learned, and neither Marion nor Manuel, the Radiation Protection Officer, were informed.

Following the event, in early February 2017, Professor Smart received a written complaint from another patient's wife who reported that her husband received the wrong treatment during the third shift (the letter of complaint is available in the supporting information). The incorrect treatment was delivered even though the husband expressed concern to the Radiotherapy Technician.

Professor Smart passed the complaint to Marion, who interviewed the Radiotherapy Technician, Mark, to determine what had happened. Mark reported that several patients were included in that shift, and he had not previously treated them, meaning he was not familiar with the treatments. However, through the interview, it was confirmed that there was an identification error. Mark called the patient, Mr K, by name and started treatment as prescribed without recognizing that it was a different person with different prescribed treatment. This situation occurred because Mark does not usually take any steps to confirm the identity of the patient (not even looking at the photograph on the PTS). In addition, when the patient was positioned for therapy, Mark admitted he had confused freckles on the patient's back as the tattoo marks used for positioning. Ultimately, the treatment was provided incorrectly. Marion asked Mark to be more attentive, rescheduled the patient to the morning shift, and did everything possible to assure the patient's wife that steps were being taken to prevent a recurrence. Following that, Marion called Professor Smart to assure him that steps had been taken to ensure that such problems would not occur again.

Professor Smart decided not to inform the NRA or other patients, fearing the legal and financial implications. Furthermore, he was concerned about the potential loss of recognition and social prestige for the Hospital.

Following the events given above, operations continued without further problems for some time. Then, however, the rumours began circulating about the decrease in inpatient care within the

Radiotherapy Services at the Hospital. It resulted in an article published by an investigative reporter in the popular local newspaper at the beginning of April 2017 (the newspaper article is available in the supporting information).

III.4. LEADERSHIP FOR SAFETY CONSIDERATIONS

This case study is considered primarily from the viewpoints of Marion, Head of Radiotherapy Services at the Hospital. The participants' task is to analyse and discuss the situation described. Provided below are some questions the teams could consider during their discussions. These questions are not meant to be an exhaustive list but an aide to the analysis:

- What were the main issues or tensions within the case study that created problems?
- What actions were taken (or not taken) in response to these issues or tensions?
- What could have been done differently?
- How do you perceive Marion as a decision-maker in relation to safety, and what would you do differently in her role?
- Why do you suppose nobody questioned the decision to introduce a third shift from the very beginning and after problems began to appear?

III.5. SUPPORTING INFORMATION

III.5.1. Excerpts of the Hospital's Licence

NUCLEAR REGULATORY AUTHORITY

LICENCE # 132 of November 25, 2014

Issued to: National Oncological Hospital

Licenced activity and facilities — medical application of the following facilities:

- Teletherapy equipment with cobalt-60 radioactive sources;
- High Dose Rate (HDR) brachytherapy equipment with iridium-192 radioactive sources;
- Three Linear Accelerators;
- Two CT (Computer Tomography) units for planning of teletherapy treatment ;
- One conventional X-ray unit.

Licence conditions:

- skipped -

4. staff members involved in operation of the licenced equipment are not allowed to work unless they have passed the radiation safety training and certification as specified by regulation.

- skipped -

6. Maximum 5 hour shifts of operation are allowed for the cobalt-60 teletherapy equipment.

- skipped -

9. a proper Management System in accordance with the relevant IAEA Safety Standards is to be implemented.

- skipped -

11. the Nuclear Regulatory Authority is to be notified within 5 working days about any changes significant to safety, including upgrades and/or replacement of equipment as well as management changes.

- skipped -

Licence valid until: November 25, 2019.

III.5.2. Organization Chart

Figure 1 shows the organizational structure of the hospital and a simplified structure for the regulatory body.

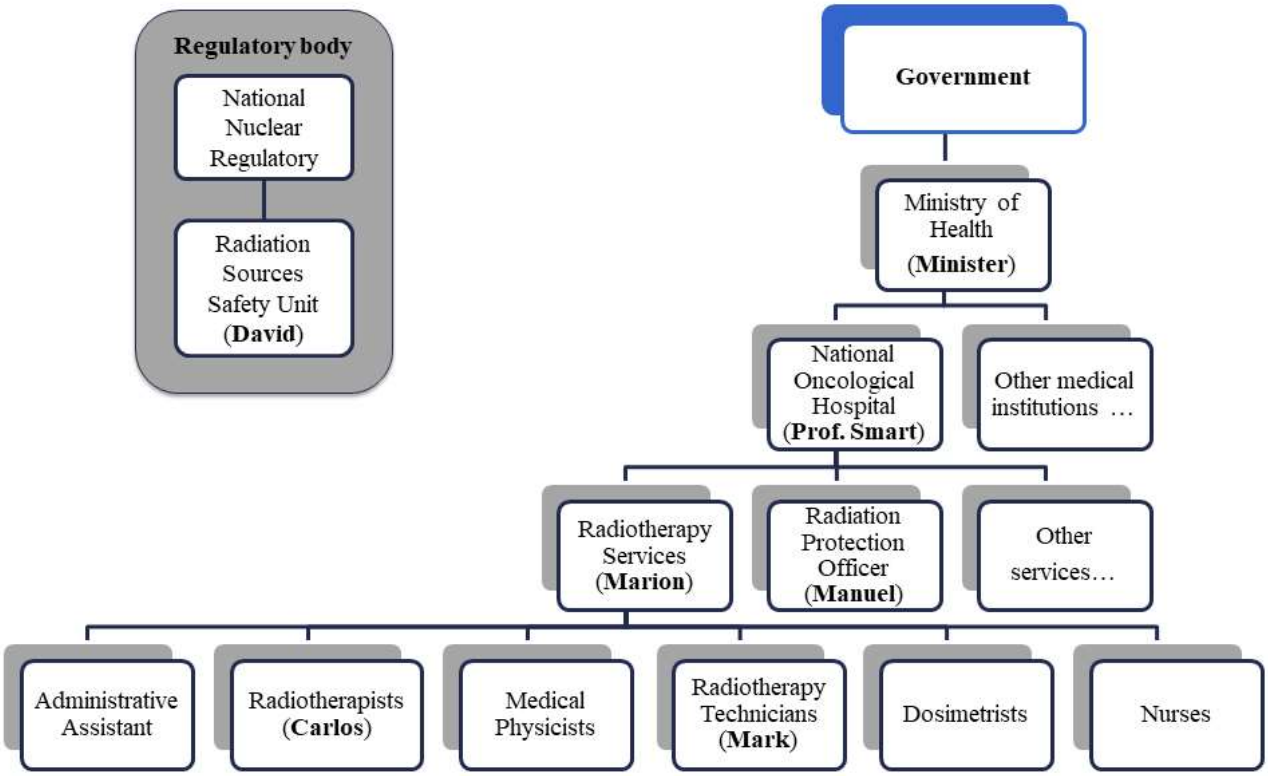

FIG. 1. Organization charts for the regulatory body and the hospital

III.5.3. Letter from the Director to the Minister

National Oncological Hospital

September 25th, 2016

To: Minister of Health

Re: Request for resources for the radiotherapy service.

Dear Minister,

Starting in the year 2011, the demand for radiotherapy treatment has shown steady growth and from time to time the schedule for cobalt-60 teletherapy has been full resulting in some treatments being postponed.

In the current month, the problem has become frequent enough that patients (as well as their families) have started complaining.

The board of the hospital has analysed the situation and decided to request resources to improve this situation.

For those reasons, we request that the Ministry assign the resources to our hospital to buy new Cobalt-60 equipment for radiotherapy treatment.

Recognizing the great service provided by the National Oncological Hospital to the Nation, I request your support to solve this situation and maintain the excellent standard of care our patients have come to expect.

Recognizing that September is late for such a request, we propose as a temporary solution to establish a third shift with the current equipment. Therefore, I further request additional financing from the reserve fund for contracting at least one radiotherapist and two radiotherapy technicians (calculations enclosed — this is not included in this handout).

We are confident that you will resolve this issue.

Best regards,

Signed

Professor E. Smart, Director

III.5.4. Letter from the Minister to the Director

MINISTRY OF HEALTH

December 12, 2016

To: Director of the National Oncological Hospital, Professor E. Smart

Dear Professor Smart,

Recognizing the great service of the National Oncological Hospital to the Nation, I still need to express some concern as the Ministry has received a number of complaints concerning the unavailability of radiological services for people in dire need.

I suggest we could rely on you in solving this problem within the already approved budget for the next fiscal year.

Please consider and report on measures taken.

Sincerely yours,

Minister of Health

Attached: complaints on 34 pages — this is not included in this handout.

III.5.5. Note from the Director to the Head of Radiotherapy Services

National Oncological Hospital – Internal Memo

From: National Oncological Hospital Director

To: Head of Radiotherapy Services

Date: December 19, 2016

Re: Third shift for the cobalt-60 teletherapy equipment from 18:00 to 22:00

Dear Marion,

Over the past several months, the demand for radiotherapy treatment has increased and it is becoming increasingly clear that the two shifts using the cobalt-60 teletherapy equipment are not sufficient to respond.

I have been asked by the Ministry of Health to find a solution to this problem while keeping the standard of care at its current consistently high standard. Therefore, I ask you to organize a new shift at the cobalt 60 teletherapy equipment, from 18:00 to 22:00.

Considering our limited resources and that the number of patients seen during this shift would not be as high as it would be for the other two shifts, I ask you to dedicate one of your most skilled and experienced radiotherapy technicians to this new third shift. This technician will work alone without support from the radiotherapist and other staff. Of course, he will receive compensatory payment for working odd hours.

Please implement this change at your earliest convenience.

Best regards,

Professor E. Smart

III.5.6. **Example Complaint from a Patient**

To: Head of Radiotherapy Service

Dear Ms Marion,

I am a patient receiving radiotherapy treatment and started my treatment one month ago during the morning shift. During my treatment, my radiotherapist found some signs of concern on my skin and decided to stop the treatment for five days.

Last Monday I came to the hospital to restart my treatments and your Administrative Assistant notified me that I will now receive my treatments during your new third shift.

Yesterday, while receiving treatment during this third shift, I notified the technician that I needed to see the doctor as I felt ill. He responded that a radiotherapist was not available. He further explained that the evening shift is new and that he is alone, and if I wish to see a radiotherapist, I needed to return in the morning.

I have a complaint concerning this situation. I don´t understand why nobody except a single technician is available for this new shift.

I would appreciate a prompt response.

Best regards,

Mr T

January 15, 2017

III.5.7. Transcript of a Phone Call between the Director and a Radiotherapist

Thursday, January 26, 2017, 2:40 pm

Professor Smart, Hospital Director (PS): Smart speaking.

Radiotherapist, Carlos (C): Good afternoon, Professor, it's Carlos from Radiotherapy.

PS: Carlos, I'm busy; what is going on?

C: Professor, this morning I had a routine check of with a patient, Mr D, who was prescribed cobalt-60 radiation therapy to the right hip to be completed in two weeks and the thoracic-lumbar spine, which was completed two weeks ago.

PS: Ok, but why are you informing me about this routine procedure? Are you going to call about each patient?

C: Not at all, Professor. We have a real issue with this one and I think you need to know.

PS: Ok, but please make it short.

C: This patient has been treated on the morning shift, but a week ago he was reassigned to the new evening shift. Basically, it looks like Mark mistakenly continued treatment in the spine area unaware of the note in the PTS that treatment in that area had been completed. Unfortunately, the error was

also not detected during the routine review of the PTS performed by the medical physicists. What I'm telling you is the patient received double the intended exposure to the spine.

PS: This is not good. What now?

C: I'm dealing with it personally sir. We'll proceed with the treatment of Mr D as prescribed and I'll fix the issue with Mark. I don't think that Mr D understood what's happened, so we'll probably have no problem with him.

PS: A small miracle really. Please ensure that Mark will be more careful from now on. Anything else?

C: No, just this. I thought you needed to be informed.

PS: You did the right thing. But please keep this to yourself – we don't need any bad publicity. Have a good day.

C: No problem, sir. Good day to you as well.

III.5.8. Letter of Complaint to the Director from a Patient's Wife

To: Director of the National Oncological Hospital

From: Mrs K

My husband is currently receiving cobalt-60 radiation therapy at your hospital, and we did not complain after my husband was reassigned to the night shift, even though it did not suit us well. However, this reassignment has caused real harm to my husband's health.

During my husband's last treatment, the Technician, who was alone except for other patients, started positioning him in the wrong way. My husband expressed his concern to the Technician while he was being positioned, but the Technician argued that the doctor had reviewed his Treatment Sheet and confirmed that everything was correct.

The fact is nothing was correct! First thing in the morning we asked our doctor for an emergency appointment during which he confirmed that my husband was right. It appears that when my husband was being positioned for treatment, freckles on his back were confused for tattoo marks used for positioning the treatment. To make matters worse, my husband does not have any tattoos and that the Technician was referring to the wrong treatment sheet, which is inexcusable!

I just hope that my husband will survive this treatment.

We request that my husband be put back on the morning shift immediately. Hopefully, the availability of all appropriate staff will ensure such stupidity that could harm patients does not happen again.

Signed

Mrs K, 8th February 2017

III.5.9. Newspaper Article Concerning the Hospital

What is wrong with our famous hospital?

By: NN, Investigative reporter

We all — from the President to the low-wage workers — rely on our National Oncological Hospital for high-end medical service. However, it looks like complacency could negatively impact it in the near future.

This past autumn, I heard of problems at the Hospital with respect to providing radiotherapy treatment for everyone in need as, these days, more and more people are diagnosed with some form of cancer which could be stopped by radiation. As such, I decided to set about investigating the issue in order to support the Hospital in the fight for budgetary allowances from seasoned bureaucrats managing public money. However, a solution appeared shortly into my investigation, and I thought (perhaps naively) that our bureaucrats spared some money for people in need.

This was not the case. Instead, they elected for the cheap solution, to introduce an additional night shift with a technician working alone. Nobody cared to look at possible implications to safety and, ultimately, the health of people.

It doesn't take a genius to understand that whenever a patient receives treatment involving radiation, it requires careful measurement and application such that the benefit of the treatment overweighs the harmful effects of radiation. It means that doctors need to think of not only healing patients but also the patient's safety.

From the beginning of the introduction of the night shift, patients were surprised that the only health care professional present was a lonely technician who knows nothing about human beings and treats patients like a piece of machinery to be repaired. Patients complained to the Hospital, but to no avail.

Unfortunately, cases of mistreatment soon became routine. This resulted in overdoses to healthy areas of patients while the cancer did not receive proper treatment.

Look at this — sadly, it is real:

[copy of complaint letter] this is included in previous point

Has anyone at the Hospital investigated? Have any corrective measures been taken? Unfortunately: no on both accounts. It would appear our much-esteemed Hospital is not taking this matter seriously and is far too busy hushing up their wrongdoings to act responsibly.

What are they waiting for? Multiple deaths due to incompetence? Lawsuits?

And where, during all this time, is our Nuclear Regulatory Agency, the government regulator's responsible for the oversight and safe operation of the Hospital? Remember – all of these mistreated patients have paid taxes to have somebody watching out for their safety. Perhaps it is time to request this tax money back.

I sincerely hope that the decision makers within the National Oncological Hospital as well as the Ministry of Health and Nuclear Regulatory Agency realize that this newspaper and the public at large are eager for their comments, actions, and apologies for this situation.

We are even more eager to get back the National Oncological Hospital we were once proud of and could rely upon.

APPENDIX IV. CASE STUDY 1R: UNINTENDED MEDICAL EXPOSURE FROM THE REGULATORY PERSPECTIVE

This case study follows the same storyline as Case Study 1: Unintended Medical Exposure. The following information is a supplement to that provided in Case Study 1.

IV.1. LEARNING OBJECTIVES

This case study deals with a key aspect of leadership for safety; namely setting goals for safety. It includes the following elements:

- Dealing effectively with competing goals;
- Effectively seeking information as a leader;
- Making decisions for safety;
- Communicating the basis of safety relevant decisions;
- Effectively seeking support for regulatory decisions;
- Building trust and encouraging the reporting of safety related issues.

IV.2. ADDITIONAL INFORMATION: REGULATORY PERSPECTIVE

IV.2.1. Email from David to his boss (Director of the NRA)

End of November 2016

Dear Director,

I have enclosed the report of our last inspection to the National Oncological Hospital, and I would like to take the opportunity to inform you of an issue that arose in the closing interview of this inspection, which I understand can lead to decisions that compromise safety.

The Radiotherapy Service has been receiving an increasing demand, and even patient complaints, for lack of attention by personnel in the Co-60 unit. Apparently, there is a potential issue about the concerns of patients, although there are no decisions made yet. I have strongly reminded Marion of the restrictions imposed by the licence authorizing operation of the Co-60 unit.

I want to point out to you that the installation's technical staff is currently able to meet all operational requirements.

I remain at your disposal for any additional information or action that you request or propose.

With kind regards,

David

IV.2.2. Profile of David’s boss

Age: 40 years.

Industrial Engineer comes from the steel industry with previous performance in private companies.

He came to office with the last change of government two years ago. He has expressed prudence and willingness to listen to the more experienced staff. However, he is not prone to take initiatives that could have a political cost because he aims to scale positions within the ministry.

IV.2.3. Continuity of regulatory action

David's email to the Director has no answer.

David continues to worry as he is contacted by other medical centres under regulatory control. He learns that the addition of an extra shift continues to solve the growing demand in the Radiotherapy Service. He decides to make an unofficial call to the RPO of the Hospital, whom he knows from previous inspections, and he has always shown himself to be collaborative.

David can only find out that the Director of the Hospital has been communicating directly with the Minister of Health to ask for an additional budget to solve the problem. That initiative has failed, because the Director has been instructed to solve the matter with the regular budget.

The information further contributes to David's concerns, but he decides not to continue to raise this issue with his boss. He knows that from the position of a Director of a Ministerial Unit (fourth hierarchical level of the Ministry of Energy and Environment) he will not want to create situations of controversy, especially considering that Ministerial decisions have already been made and that there is lack of reliable information.

There is no further regulatory action until April 2017 when the press article brings the subject to the public attention.

April 2017

David’s boss calls him to an urgent meeting.

On his desk David sees the newspaper headlines covering the Hospital’s teletherapy process and a copy of the email that David sent him in November 2016.

The following short conversation takes place:

Boss (pointing at the printed email): How right you were, David! What course of action would you propose we take? Obviously, we are already running behind those news stories, but we have to take steps. If not, this can get even uglier!

David: I'm preparing an inspection that will start in an hour. Whatever we say needs to be based on reliable information and not on pressure from the press.

Boss: Okay, start as soon as possible and keep me informed.

IV.2.4. Summary of the Inspection Report

(a) Operation of a third night shift in the Co-60 teletherapy is confirmed to have involved only one operator technician (a violation of the licence conditions).
(b) During the interview with a technician, he offers excuses for his mistakes as well as criticisms aimed at the organization for sending patients to the night shift.
(c) During the interview with the Head of the Service, Marion she claimed that she was simply limited to following the orders of the Director of the Hospital, and she was pressured by the need to ensure access of patients to the service as well as by the lack of resources.
(d) During the interview with the Hospital Director, he referenced his letter to the Minister and referred to the Minister’s response denying extra resources. He claimed that he put the issue in the hands of the Head of the Service whom until that moment he had greatly respected. He

claims the Chief of the Service did not adequately inform him of the various oversights during the night shift until he received a complaint letter from a patient's wife. He again referred the Chief of the Service, who after claiming she would deal with the problems did not report any irregularities until the newspaper article.

With the inspection report in hand, the Head of the NRA, calls a meeting with David and the legal representative to define next steps.

APPENDIX V. CASE STUDY 2: CHALLENGES DURING A NUCLEAR POWER PLANT OUTAGE

V.1. LEARNING OBJECTIVES

This case study deals with a key aspect of leadership for safety, namely developing values and attitudes for safety in accordance with GSR Part 2 [2]. More specifically, the case study questions how to develop an organizational culture:

- That supports and encourages collaboration, consultation, and communication;
- Builds trust;
- Develops individual and institutional values and expectations for safety throughout the organization;
- Encourages and supports individuals to act safely.

V.2. SETTING THE SCENE

V.2.1. Outline of the situation

The case study is set at the Mancuso Nuclear Power Plant (MNPP), a commercial nuclear power plant (NPP). MNPP consists of two pressurized water reactor (PWR) units, generating 1,300 MWe. Unit 1 was first connected to the grid in February 1991, followed by Unit 2 in August 1993.

The incident described takes place during a refuelling maintenance outage. Outages at PWR NPPs are very costly as they require production to be halted. Therefore, to save time, outages are planned with tight timelines. In addition, 24-hour working is normal, and several tasks are done simultaneously by many different work teams.

To work well, an outage needs to be planned carefully, and all actors need to collaborate well throughout the process of planning and implementation. Due to the technical complexities associated with an NPP, it is common to find unexpected challenges needing to be explored further during an outage. To not lose time, schedules are usually adapted as the situation dictates. If the schedule is altered due to delays by one or more work teams, it generally affects other teams as their tasks are likely to be interconnected. Before and during an outage, decisions constantly need to be made.

An outage increases the number of people on the site (i.e., due to additional contractors) by approximately 200%. Contractors come from several different companies, and the relationship with MNPP personnel has been built over a number of years. However, for this outage, a new and unfamiliar contractor, Total Management Performance (TMP), was brought onto the site to play a leading role.

For this case study, a rudimentary understanding of the PWR Containment Structure, Refuelling Operations, and Polar Crane Operations is needed (pictorial aids provided in supporting information).

The PWR Containment Structure is a 170 thousand cubic meter round, multi-level reinforced concrete building which houses the reactor, refuelling equipment, safety systems, reactor (reactivity) control systems, and a high-capacity round (polar) crane for lifting equipment during an outage.

Nuclear fuel has to be replaced during a refuelling outage. The operation occurs in the refuelling pool, such that fuel remains submerged under at least 6 meters of water to ensure proper cooling and radiation shielding. A refuelling machine uses a small hoist, a moving bridge assembly, an up-ender (to lay the fuel horizontal), and a transfer system to a spent fuel pool located outside of containment.

The refuelling operation is generally conducted by a combination of plant operating personnel and specialists in plant refuelling. It is conducted once the reactor vessel head is removed, and the pool is raised to the correct level.

A high capacity round rotating crane with a Main (heavy) hoist and Auxiliary (medium) hoist is located near the top of the containment structure and is used for heavy lifting such as movement of the reactor vessel head and reactor internal structures as well as large pumps and valves. It is also used to move heavy pieces or radiation shielding, as needed during the outage. The use of this crane is usually a constant, well-orchestrated process during any refuelling outage.

V.2.2. Main actors involved in the case study

This case study is to be considered primarily from the viewpoint of Pierre, the Outage Project Manager.

The following individuals are relevant to this case study:

Chief Executive Officer (CEO), Ms Ballard. She sent a new year's message 18 months prior to the outage and introduced MNPP's new business partner, TMP (the letter is available in the supporting information).

Director of Corporate Strategy and Logistics, Wendy Jones. She sent a letter to the Outage Project Manager, Pierre, on 12 September 2016 highlighting performance expectations for the upcoming outage (the internal memo is available in the supporting information).

Outage Project Manager (OPM), Pierre. He has been rising very quickly in the organization, from field operator to reactor operator to senior reactor operator in just five years. He serves as the link between contractors, operations staff, engineering staff and maintenance staff during the outage. It is his first time leading an outage (appointed September 2016), and he wants to show that he is very capable of doing this. He has been explicitly asked several times to ensure the project goes well, as the previous outage did not. Pierre is slightly disappointed that TMP has been given several project-management tasks for this project.

Maintenance Manager, Mike. He is very experienced, having worked for MNPP for more than 20 years. He informed everyone at a large maintenance and operations meeting prior to the outage that they had an enormous workload for this outage, asking everyone to do their very best. He now feels disappointed and frustrated that the outage schedule and key milestones have not been met, especially by his maintenance team. He recalls that his team has not made any big mistakes, but several unexpected tasks have arisen with which they have had to deal. Mike is also unsure about TMP and does not trust that they will do a good job.

Safety Engineer, Julia. She is responsible for providing approval for certain safety aspects of work, such as crane work, fire permits and confined space entry. She is also responsible for performing safety observation audits.

Technical Materials Officer, Rafik. He is the technical engineer responsible for civil engineering aspects of the plant, including radiological shielding block plugs. He is also the only person who would know the composition of the shielding block. He is usually needed in many plant meetings; however, he often misses these meetings, which leads to his being seen by others as not being able to provide time to support in-field personnel.

Supervisor, Lin. She is the TMP supervisor who is responsible for providing oversight of TMP personnel and ensuring they follow all MNPP procedures and policies.

Crane Operator, Carey, and Crane Spotter, Suzanne are the TMP contractors assigned to the shielding block lifting.

Regulatory inspector, Rick. Traditionally, he inspects key aspects of an outage and reviews the outage planning. He recently challenged the large changes in outage scope to the outage plan to reduce the outage duration stating that they increased outage risk to the availability of key safety equipment.

An organization chart that illustrates the above is provided in Fig. 5 in the supporting information.

V.3. DESCRIPTION OF THE CHALLENGE

V.3.1. Initial conditions

More than a year before the event, MNPP's CEO sent a corporate message to all staff, stressing that the company is in a challenging business environment. As a result, the company was taking several actions, including introducing a new business partner, TMP (the letter is available in the supporting information).

Presently, MNPP is undergoing a planned 42-day refuelling outage. Pierre is managing this outage for the first time in this role. Prior to the outage, Pierre receives a letter from Wendy, Director of MNPP Corporate Strategy and Logistics, stressing that this outage is a high priority for the company and that there will be greater regulatory scrutiny (the internal memo is available in the supporting information).

As of today, the outage is on day 37 and seven days behind schedule, due to personnel safety issues and maintenance rework. Refuelling work is in progress, with 150 of 180 assemblies having been installed, and work continues on a 24-hour basis.

Concerning the outage plan, core refuelling and reactor reassembly is a 'critical path'. 'Critical path' is the most important job at the time, and any delay to those tasks will extend the completion of the outage. In addition, the containment is currently sealed for other maintenance.

Based on results from the last inspection. The regulatory inspector questioned why all cranes had not been inspected prior to the outage. Rick had also sent MNPP a letter prior to the outage pointing out weaknesses in the rigour in following regulatory requirements, as demonstrated during recent incidents (the letter is available in the supporting information).

V.3.2. Sequence of events

It was decided during a routine maintenance outage activity on Friday afternoon, 7 July 2017, that a heavy radiation shielding block needed to be lifted and moved to a lay down area in the containment. The move was to allow access to an important piece of equipment to perform maintenance. The shielding block move would be conducted the next day.

Early the next day, the OPM, Pierre, determined that there were two available time slots to complete this job. The first time slot was within the next eight hours, but the load path would be directly over the refuelling pool as well as over the personnel conducting core refuelling. The second time slot was 24 hours later after scaffolding associated with other work had been removed, allowing the load to move without passing directly over the refuelling pool. If the second window were selected, it would

impact the length of the outage and the outage bonuses. Figure 6 in the supporting information shows the two load movement paths.

Pierre had a tense and emotional discussion with the Maintenance Manager, Mike, who viewed the job as a routine task done many times before. Mike was in a hurry to get it done as he hoped to make up for lost schedule time. Pierre raised concerns to Mike about moving the load over the refuelling pool, but these concerns were quickly dismissed. Pierre had always been intimidated by Mike; the organization had always seen him as the person one can depend on to "get the job done". Pierre wants to be viewed similarly by the organization. Ultimately, Pierre made the decision to perform the movement during the first time slot.

Pierre hastily called an urgent staff meeting to discuss the job. The meeting was scheduled for 30 minutes but only lasted five. The Technical Materials Officer, Rafik, was required by procedure to be at the meeting but was not in attendance due to a conflict with a budget meeting. Pierre presented the planned task and hurriedly asked if there were any comments. Pierre informed that the reason for the decision to use the first window was to ensure that the lifting and moving of the shielding block would not impact the length of the outage and worker bonuses. TMP Supervisor Lin asked whether there had been any recent issues with previous lifts. Pierre responded, "I understand that you are new to the job, but this is routine. We had some recent issues, but we have addressed those already." Lin left the meeting feeling that her question had been dismissed without an answer being provided.

Typically, the main polar crane would be used for this type of operation. However, as the task was being prepared, engineering personnel notified Pierre that the inspection certificate for the main polar crane had expired and that using it would require an exemption from the regulatory body. In addition, Pierre knew that the regulatory inspector had recently stated in an inspection report that MNPP needed to follow instructions more rigorously than during the last outage and ensure that cranes were correctly tested and certified before any plant refuelling outage.

Pierre contacted Rick via phone to explore the prospect of receiving an exemption for the crane. Rick informed Pierre that at least six hours would be needed to consider and process such an exemption. Mike explicitly reminded Pierre during the meeting that morning that it was important for this task to be performed during his shift, and it could not be delayed.

As a result, Pierre decided to carry out the lift using the auxiliary polar crane to save time. It was presumed that either crane had sufficient load capacity to move the shielding block safely.

Pierre checked the approved work permit (including the risk assessment) and saw that the Safety Engineer, Julia, was more focused on the load capacity of the crane and the use of additional lifting straps as opposed to the load movement path. Julia was not aware of current work activities occurring beneath the load as it moved (i.e., refuelling in progress and scaffold interference). Julia determined that the load was expected to be composed primarily of concrete with a weight of approximately 3500 lbs (c. 1.6 t.). Therefore, the lift could be completed by three 2500 lbs (c. 1.1 t.) lifting straps, which would provide more than an adequate safety margin. Julia also felt confident since she knew that the lifting straps had an additional safety margin of two.

Carey, the Crane Operator, commented to her colleague, Suzanne, the Crane Spotter, that she had several concerns after visiting the job site. Her first concern was that the load had no weight markings. The second concern was that the auxiliary crane load cell was out of service. She had inquired if the load cell could be repaired but this was dismissed, having been told it would require three to four hours to complete. Her final concern was that the certifications on two of the three lifting straps had expired. As a result of her concerns, Carey felt that she would not accurately indicate the amount of

weight being lifted and that she had never been asked to complete a lift under these circumstances. Carey decided to bring up her concerns during the pre-job brief.

As the pre-job brief was getting started (conducted by Lin), Mike arrived and expressed great surprise that the job was not yet done. He then firmly told everyone to ensure the job was completed by the end of the morning shift. Following these comments, he questioned the TMP contractor team while laughing, “Come on guys, don’t you know how to do a routine lift?” After hearing it, Carey decided she would not delay the pre-job brief with her concerns and assumed that everything had been addressed as a valid work permit was approved. Lin noticed that Carey seemed uneasy but decided not to say anything due to the attendance and demeanour of Mike.

Prior to the lift, Julia, who was conducting a safety observation, was approached by Carey. She shared her concern that the auxiliary crane load cell was broken and that she would be more comfortable if it was properly repaired. Carey also reminded Julia that it was a requirement of the lifting procedure. Julia considered it a potential safety issue and raised it with Pierre who dismissed it as non-consequential because he did not want to jeopardize the job proceeding as planned.

V.3.3. Event occurred

As the shielding block was being moved over the refuelling pool, the lifting straps failed. It caused the shielding block to fall onto the refuelling bridge and into the refuelling pool, hitting the reactor vessel flange and resting on top of the fuel. As a result, all three refuelling operators were thrown from the refuelling bridge and into the refuelling pool, resulting in varying injuries. Bubbles were then seen emanating in the water in the vicinity of the shielding block. Containment area radiation monitors began to alarm. It led to the evacuation of the containment.

Pierre was shocked and terrified to see the situation! He was thinking, “How could this happen? It was just a routine operation! Why were they not able to successfully complete this job? What went wrong? What did I miss?”.

V.4. LEADERSHIP FOR SAFETY CONSIDERATIONS

The participants’ task is to analyse and discuss the situation described. Provided below are some questions the teams could consider during their discussions. These questions are not meant to be an exhaustive list but an aide to the analysis.

- What were the main issues or tensions that created problems within the case study?
- What actions were taken (or not taken) in response to these issues or tensions?
- What could have been done differently?
- How would a positive culture for nuclear safety have affected each of the interactions in advance of the event?
- What is your assessment of trust in this organization? Did organizational trust have any impact on this event?
- Analyse the values and attitudes of each of the key personnel in the case study. How did each contribute to the event? How did the values and attitudes of the organization contribute to the event?
- How would you evaluate the leadership of Pierre? If you were Pierre in this scenario, at what point would you have decided to slow down or stop the lift?

V.5. SUPPORTING INFORMATION

V.5.1. Pictograms

Figures 2, 3 and 4 are images that help the participants without experience of NPPs to understand the case study.

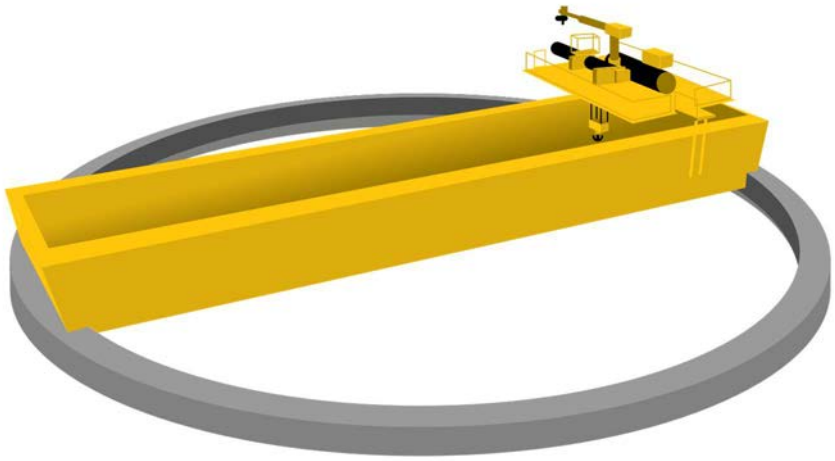

FIG. 2. Refuelling hoists

FIG. 3. View from underneath hoists

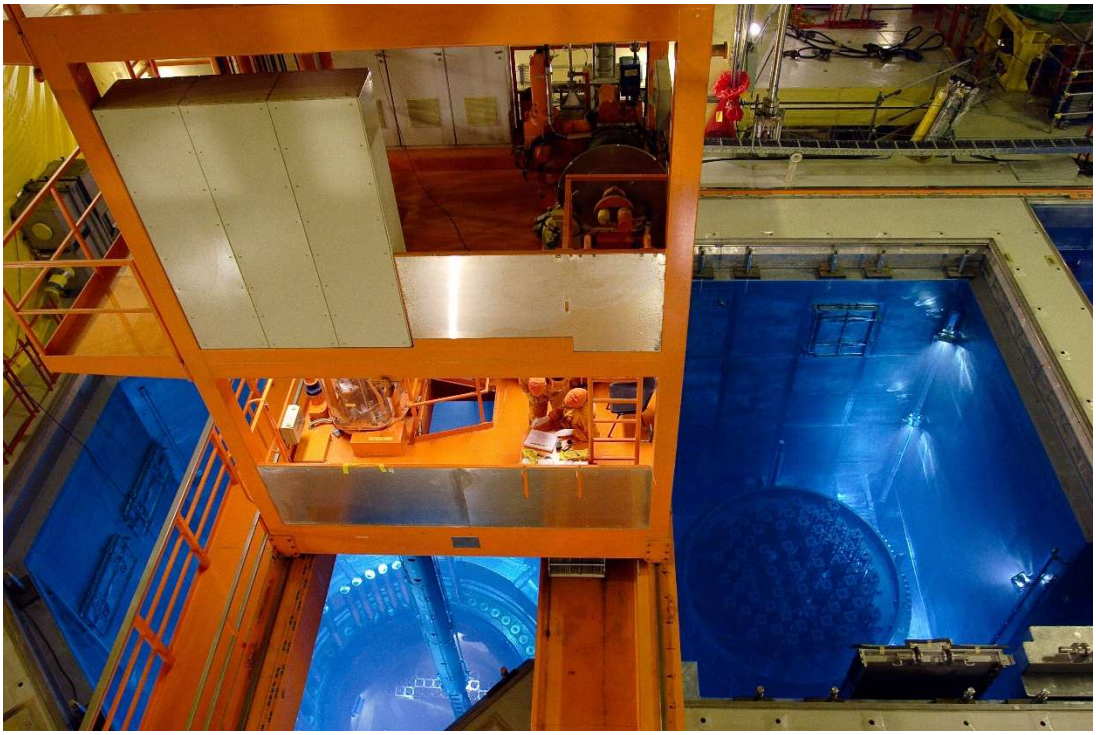

FIG. 4. Overhead view of a refuelling pool (Photograph courtesy of BrazilPhotos / Alamy Stock Photo)

V.5.2. Letter from MNPP CEO to all Staff

From the Desk of Tracy Ballard

Subject: New Year

January 1, 2016

Dear Colleagues,

I wish you and your families a happy and prosperous New Year. The year 2016 will be an important year for the future viability of the Mancuso Nuclear Power Plant. We have forged a new relationship with Total Management Performance (TMP) to improve the economics of our refuelling outages. We are also realigning our leadership team to improve refuelling outage performance such that all performance indicators can be met or exceeded.

We find ourselves in a very difficult business environment and I believe with the new direction and focus on efficient business practices that we will be able to compete and provide high value to our stakeholders.

We have already begun planning for the June 2017, 42-day refuelling outage. The Mancuso Leadership Team and TMP will ensure that we are successful in refurbishing the plant, replacing spent fuel, and returning the plant to full power in accordance with the plan. Our last refuelling outage was a disappointment, as we missed many of our performance goals. For each day, the outage is extended beyond the plan, the company absorbs a loss of over US $ 800 000.

These are exciting times in our business, and I trust that all of you will rise to the occasion to help achieve future success.

Thank you again for all you do!

Signed,

Tracy Ballard

Chief Executive Officer, Mancuso Nuclear Power Plant

V.5.3. Internal Memo from Corporate to Outage Project Manager

MNPP Memorandum from 12 September 2016.

To: Pierre Simone, Outage Project Manager

From: Wendy Jones, Corporate Strategy, and Logistics Director

Subject: Mancuso NPP 2017 Outage Performance Expectations

As discussed in the planning meeting for the 2017 major refuelling outage at Mancuso, you have been appointed the Outage Project Manager. The 2017 refuelling outage will replace or refurbish vital plant safety equipment, complete the necessary testing of plant equipment, and refuel the reactor for the next cycle. As you know, we will be employing a new contractor (Total Management Performance — TMP) to complete the bulk of the outage maintenance activities, additionally, we will use new planning software to improve outage efficiency and save money.

I plan to work closely with you to ensure that TMP supplies the resources that you need while ensuring that the work is completed in the most economical fashion. The outage is scheduled for a total duration of 42 days, and this CANNOT be exceeded. All work has to be completed in that time frame and the unit returned to 100% power in advance of the summer season.

The company has entrusted you with its financial viability and we trust that you will provide the skill and effort to meet or exceed all performance goals.

As a member of the Senior Leadership Team at Mancuso, I remind you that you are eligible for significant individual monetary incentives if outage performance goals are met.

Do not hesitate to contact me if you require assistance.

V.5.4. Organization Chart

Figure 5 shows the organizational structure of the Mancuso Nuclear Power Plant.

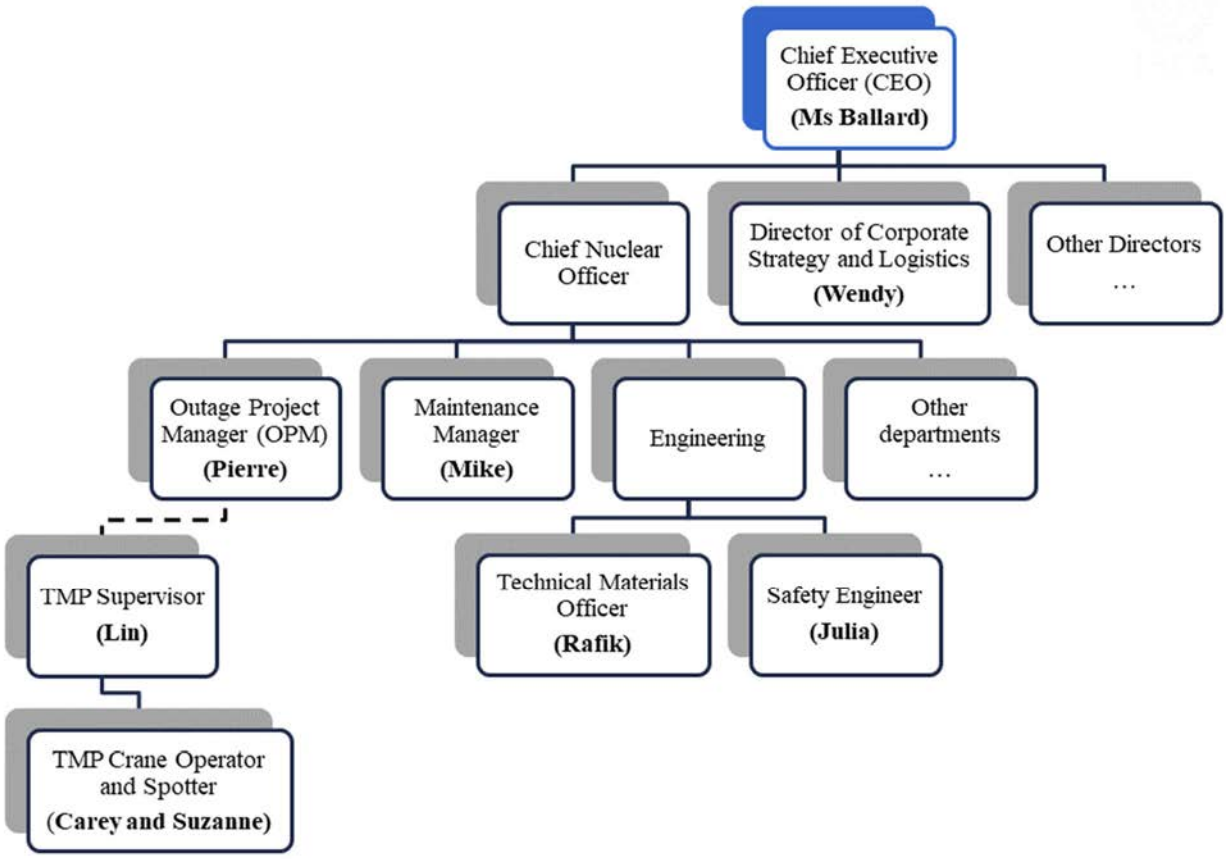

FIG. 5. Organization Chart

V.5.5. Letter from the regulatory body

NUCLEAR REGULATORY AGENCY

25 October 2015

Ms Ballard, Chief Executive Officer, Mancuso Nuclear Power Plant

SUBJECT: INSPECTION REPORT 2015003

Dear Ms Ballard,

On 9 October 2015, the Nuclear Regulatory Agency (NRA) completed an inspection at the Mancuso Nuclear Power Plant.

The inspection covered one or more of the key attributes of the nuclear and radiological safety principles. The inspector reviewed selected procedures and records, observed activities, and interviewed station personnel.

This letter is to inform you that the NRA is documenting one violation of NRA requirements with low safety significance in this report. Specifically, Mancuso did not adhere to station procedures and ensure that all station cranes completed all required safety testing and certification. Additionally, inspectors identified an increasing trend in incidents that were a direct result of weaknesses in procedural use and adherence. The trend is being brought to your attention for your awareness and action.

You are not required to respond to this letter. However, if you contest the violation or its significance, you need to provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the NRA.

The enclosed inspection report (this is not included in this handout) documents the inspection results, which were discussed with you and other members of your staff.

If you have any questions regarding this letter, please contact Mr. Rick Lew, at the Nuclear Regulatory Agency.

Sincerely,

Rick Lew, Regulator, Nuclear Regulatory Agency

V.5.6. Potential Load Movement Paths

Figure 6 showcases the layout of the fuel handling area as well as the potential load movement paths.

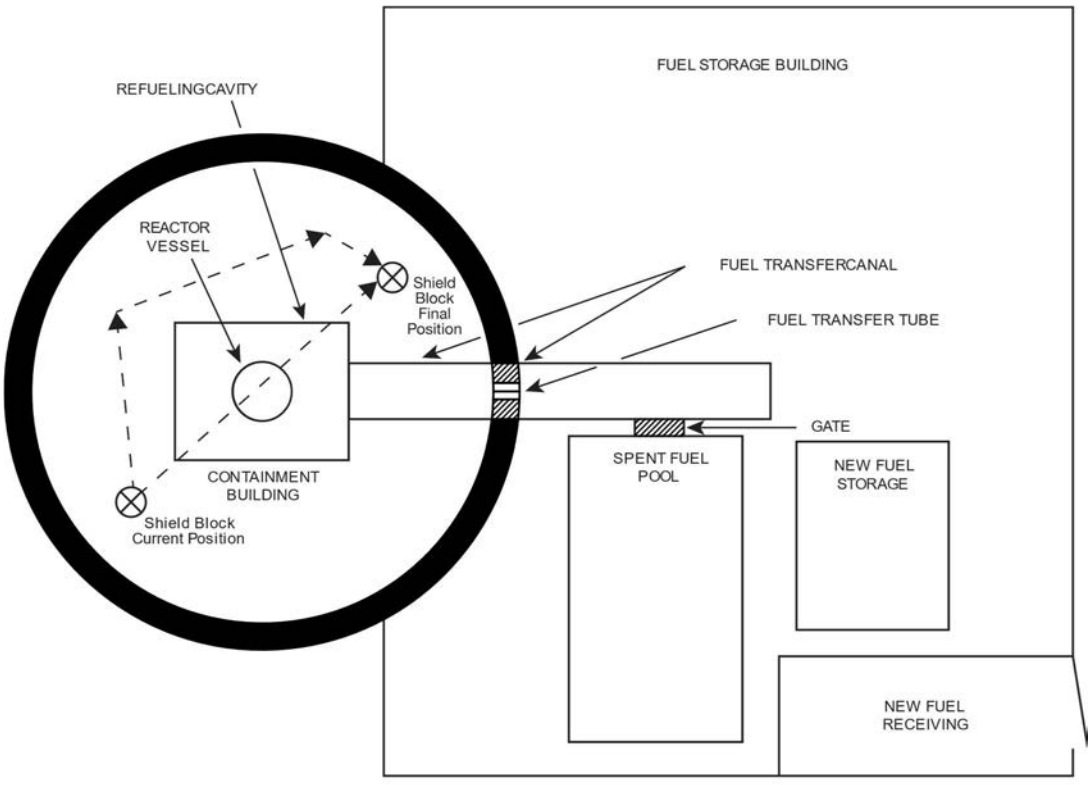

FIG. 6. Potential load movement paths

APPENDIX VI. CASE STUDY 3: RESPONSE TO A LEAK OF RADIOACTIVE MATERIALS TO THE ENVIRONMENT

VI.1. LEARNING OBJECTIVES

This case study deals with a key aspect of leadership for safety, namely, engagement and continuous improvement in accordance with GSR Part 2 [2]. More specifically, the case study questions how to:

— Balance timeliness, accuracy, and completeness in sharing information;
— Engage individuals in enhancing safety performance;
— Develop a shared understanding with internal and external stakeholders;
— Communicate technical information such that it is understood by relevant parties.

VI.2. SETTING THE SCENE

VI.2.1. Outline of the situation

This case study deals with the response to an emergency by public authorities at a facility operated by Prime Technology Company (PTC). Their activities include, among others, dealing with the decontamination of materials and the recovery of uranium. PTC's facility is located within a large nuclear complex cooled by a large river, which includes a multi reactor nuclear power plant as well as nuclear fuel production facilities. PTC specializes in:

— Maintenance and dismantling of nuclear materials;
— Treatment of nuclear and industrial liquid effluents resulting from several activities at the complex before being released into the environment;
— Management and treatment of nuclear waste from small-scale producers, such as hospitals and laboratories.

The effluents generated by these activities are treated to remove uranium before being discharged into a canal near the facility.

The main consequence of the incident described in the case study is the release of untreated effluents into the environment, potentially affecting part of the local hydrographic network and agricultural production. The incident occurs within a large nuclear complex and in a tourist region during the summer. Therefore, even though the radiation risk is extremely low (i.e., due to the low amount of radioactivity released and the low toxicity of uranium), there is a lot of public concern, which is further heightened by local media coverage. Therefore, local emergency management decision-makers face intense national pressure to respond quickly and correctly.

VI.2.2. Description of the national safety management system under routine operations and during a nuclear emergency

The Nuclear Safety Authority (NSA) handles the regulatory oversight of the PTC facility. Inspections are carried out regularly to verify the safety of the facility, the protection of workers, and compliance with authorized limits on discharges to the environment.

Environmental monitoring in the facility's surroundings is the responsibility of PTC. It is the subject of a programme that has to comply with the NSA's requirements on radioactive releases. The hydrographic network is subject to routine chemical and radiological monitoring by PTC. Monitoring includes:

— The underground water table upstream of, at, and downstream of the PTC facility;
— Surface water, sediments, and stormwater.

Regarding food produced in the area, as part of the food safety scheme, the local governmental Agriculture Services are responsible for the implementation of monitoring and control plans. These control plans include all possible contaminants of food, including radionuclides. The control plans aim to monitor the contamination of primary animal and vegetable production, food of animal origin, and animal feed.

Water monitoring is organized in a regulatory framework by the Ministry of Health and implemented by the Ministry's local Health Services.

The Technical Support Organization (herein referred to as the 'TSO'), which provides expertise on radiation protection and nuclear safety to the NSA, also performs continuous monitoring of the levels of radioactivity in different environmental materials (such as air, water, soil, food). Furthermore, it also contributes to the accreditation process of laboratories responsible for radiological water monitoring.

In case of an accident at the PTC facility, an emergency organization has to be set up in accordance with national emergency preparedness guidelines.

The Regional Governor has to direct the emergency response operations, particularly of public safety and civil protection. The Regional Governor has to ensure the coordination of the various actions in response to the emergency as well as communicating/informing the public and elected officials. The Regional Governor can activate a local emergency centre, which involves all local government services competent in radiological emergency management (including NSA, local health and agriculture services as well as civil security services).

The local NSA office has to assist the Regional Governor in protecting the local population as well as supervise the on-site operations to ensure the facility is safe (if it is accessible or does not constitute a hazard).

The local services of the State also have responsibilities in a radiological emergency in relation to their 'routine' responsibilities:

— Civil security is responsible for implementing actions intended to protect the public;
— Health Services are responsible for drinking water management;
— Agricultural Services are responsible for the management of potentially contaminated food;
— The TSO centralizes the results of environmental measurements and can mobilize an environmental monitoring mobile unit that can go directly into the field to organize measurements and provide local authorities with the results of such analysis.

Emergency response is a multi-actor operation at the decision-making as well as the operational level. Therefore, it is complex to manage, especially when there is strong public and political pressure. In order to facilitate smooth operations, national and local emergency exercises are regularly organized to test the emergency management system and enable the various actors to practise their responsibilities in the event of a nuclear emergency.

However, the incident analysed in this case study, while having relatively small potential consequences from a radiological perspective, is different to the scenarios generally used to train and exercise the different actors in emergency management. Therefore, it places actors in a situation where the usual procedures for emergency management are not always appropriate.

VI.2.3. Main actors involved in the case study

In case of an accident at the PTC facility, an emergency organization has to be set up and includes:

(a) The Regional Governor, Stephane:
  (i) Principle representative of the government in the region;
  (ii) Responsible for protecting people, law and order, the environment, water, and agriculture in the area. Also responsible for making decisions throughout the emergency;
  (iii) He is a young manager who was nominated in the region only a few weeks before the accident. He is not familiar with nuclear emergency management and has only participated in one nuclear emergency exercise in his career;
  (iv) The challenge for him is to make justified decisions that are proportional to the incident, while his intuitive perception of radioactivity and its effects tends to be, as is frequent for members of the public, quite disproportionate. He perceives the incident as extremely serious and potentially dangerous;

(b) The Head of the local NSA, Natalie:
  (i) A mid-career manager having several years of experience in nuclear safety and radiation protection;
  (ii) Responsible for an inspector team of twenty nuclear safety and radiation protection experts, which oversees several nuclear power plants, hospitals, and industrial facilities that use radioactive sources;
  (iii) She regularly participates in nuclear emergency exercises and has also faced several local nuclear emergencies (e.g., accidental contamination of a public area, the discovery of an old, polluted site). Therefore, she is familiar with the procedures applied in an emergency and has strong beliefs in continuously improving the emergency response system;

(c) State local services, including:
  (i) The Head of the local Health Services, Adeola, a mid-career manager, has never participated in a nuclear emergency exercise in a region with nuclear facilities. Therefore, she is not familiar with dealing with radioactivity in drinking water;
  (ii) The Head of the local Agricultural Services, Sophie, a mid-career manager, has several years of experience of food safety management. She is aware of the food problems that might arise during and after a nuclear emergency. She has participated, with her teams, in the emergency planning stage, especially concerning the implementation of food bans;
  (iii) The Head of Civil Security Services, David, is a highly experienced nuclear crisis pacification and management. His position places him close to the Regional Governor, who relies on him for many routine operational responsibilities in maintaining law and order;

(d) The Head of Radiological Measurement Services of the TSO, Catherine:
  (i) Responsible for a large team that performs radiological measurements with mobile units that can be sent directly to affected areas to determine the levels of contamination in the environment;
  (ii) These teams participate regularly in national exercises, and occasionally in international nuclear emergency exercises.

Figures 7 and 8 in the supporting information illustrate the organization of the actors during routine and emergency operations, respectively.

VI.3. LOST SOURCE INCIDENT

The actors described above – with the notable exception of the Regional Governor, Stephane, who has been recently appointed – have vivid memories of another radiological incident that occurred a year prior to the PTC incident (on which this case study focuses). The previous incident involved a loss of a radioactive source in the region, which became a highly publicized event within the media and the general population.

On 4 March, the NSA was informed of the loss of a package. It contained a radioactive source of promethium-147 with an activity of 18.5 GBq. The radioactive source was destined for a weighing machine used in the paper industry. Promethium-147 emits low penetrating beta radiation. However, it presents a hazard in the event of prolonged direct contact if the source is removed from its transport package. Therefore, a press release was issued by regional authorities to alert anyone who might find the package. In addition, the NSA had notified the IAEA of the loss of source to inform the other Member States.

The source had been lost around a vulnerable part of the drinking water network. Therefore, the head of the local Health Services, Adeola, advised the Regional Governor (Stephane's predecessor) to take the conservative decision of shutting down that part of the network without checking the results of the radioactivity monitoring systems or consulting with the NSA. Unfortunately, the shutdown led to a loss of supply of drinking water to several local villages, which in some places lasted for several weeks due to various technical problems even though the water had never been contaminated.

This situation was mainly because some of the actors with responsibilities in a radiological emergency were not familiar with the nature of the risks associated with the situation and, as a result, did not apply the emergency plans appropriately.

The incident received a lot of negative media coverage at the national level. The resulting public backlash ultimately resulted in the resignation of the Regional Governor.

After the incident, the head of the local NSA, Natalie, took the initiative to hold information sessions for local actors and various other stakeholders concerning practical radiation protection. These meetings were very fruitful and led to all involved understanding their responsibilities in case of an emergency, including actions to be taken. These sessions also allowed all the stakeholders to develop an understanding of the appropriate radiation protection procedures and to adopt good working habits for nuclear emergency management. A meeting report is provided in the supporting information. Natalie also conducted meetings with her nuclear safety and radiation protection inspectors and urged them to participate in exercises as often as possible to become familiar with and exchange information with new counterparts, with whom they did not routinely work with.

Three months after this incident, Stephane was appointed as the new Regional Governor. Shortly after the appointment, Natalie reached out to Stephane to invite him to a briefing of Nuclear Safety related issues in the region (the email exchange is available in the supporting information).

VI.4. DESCRIPTION OF THE CHALLENGE

VI.4.1. The accident, the initial consequences, and the actions taken

Over the previous months, the uranium treatment process at the PTC facility has been undergoing major work to modernize and improve key safety features. It included the installation of new effluent storage to replace the oldest storage containers.

On the night of 10 July at approximately 01:00, a storage tank at the PTC facility overflowed and leaked a large quantity of solution containing uranium to the environment. The leak occurred when trying to drain storage tank A into the neighbouring storage tank B. However, during this transfer, the valve located under storage tank C was not completely closed, enabling effluent to inadvertently be transferred from this tank too. The pump, therefore, transferred the effluents contained in storage tanks A and C into storage tank B, the capacity of which was insufficient for all the effluents.

Storage tank B overflowed into a retention area below. Due to the modernization work, a part of the overflow retention area was being dismantled, and a temporary wall had been erected to ensure the effectiveness of the retention capacity. However, during recent mechanical operations, the integrity of this retention wall had been damaged in a way that was not visible to the operating personnel. It resulted in a failure of the retention system and part of the overflow draining into the stormwater network, which eventually joins a local river, meaning the overflow could diffuse directly into the water table.

After having been alerted at 01:30, the PTC operating personnel took the first actions to limit the consequences of the accident. Those actions consisted of isolating the water network at the site, carrying out measurements locally, and, as far as possible, pumping contaminated water into other storage tanks to limit dispersion to the environment. PTC alerted the local authorities immediately after taking these initial actions.

VI.4.2. Activating the Emergency Centre and initial actions implemented by the public authorities

The PTC facility operating organization alerted the new regional governor, Stephane, at 04:00. Stephane immediately called the head of the civil security services, David. Stephane knew that David was a highly experienced person and had complete confidence in his skills to manage the situation, as Stephane himself felt quite stressed and confused.

David immediately activated the emergency centre at 05:00. In addition, given the uncertainties of the situation and the sensitivity of the public to the potential presence of radioactivity, he decided, with the permission of Stephane, to rapidly implement actions intended to protect the general public, which include:

- Banning the consumption of drinking water from private wells;
- Forbidding agricultural irrigation;
- Prohibition of water-related activities and bathing;
- Banning fishing and consumption of fishery products.

These measures were announced early morning to the local residents through loudspeakers mounted on fire department vehicles.

The head of the local NSA, Natalie, as well as the heads of the local Health and Agricultural services, Adeola, and Sophie, alerted their respective teams and quickly joined the emergency centre. In the

meantime, the teams activated their planned radiological measurement procedures for drinking water in a radiological emergency.

Upon arriving at the emergency centre, Natalie called PTC to determine the state of the facility and the nature of their first corrective actions. Judging that PTC's first actions were satisfactory, she decided to alert his teams and asked them to begin preparing for a reactionary inspection of the damaged facility. In addition, Natalie began to consider the aspects that needed the most attention during the inspection, which she intended to lead with the support of TSO experts.

The TSO dispatched a mobile radiological measurement team, with Catherine as its head. The team is based approximately three hours away by road. Therefore, the arrival and conduct of the first measurements are planned for approximately 11:00.

By 07:00, most of the actors had joined the emergency centre. Stephane called them together for an initial assessment of the situation and a summary of the actions taken. David informed the group of the protective actions taken during the night and of progress on their implementation. Natalie relayed her conversation with the operating organization and announced the expected arrival of Catherine's team. Adeola and Sophie indicated that measurements of water and food were underway. All agreed that the protective actions taken seemed sufficient at that stage. They did not even consider asking the facility for help in taking samples and in providing information that would aid in responding to the accident. The meeting ended at 08:00.

VI.4.3. Mounting pressure and confronting uncertainty

Following the meeting, David recommended that Stephane give a first press conference outlining all information available to that point. The media had begun reporting on the incident, and the local population was beginning to worry. Moreover, due to the presence of foreign tourists in the region, some neighbouring countries were beginning to request more precise information about the situation as well as risks to the public and the environment.

However, Stephane did not feel ready at that stage for a press conference and asked David to write a press release instead. Although David thought that it was insufficient for the situation, he quickly drafted a press release with the help of Natalie that summarized all information available to them at that time. The press release was ready for publication at 09:00. Stephane approved it after removing some details he thought to be too technical. The communiqué was released at 09:20 (the press release is available in the supporting information).

As the morning progressed, many questions began to emerge rapidly. Elected representatives of the surrounding municipalities wanted to know why the population had not been adequately protected, as is sometimes done in a radiological or nuclear emergency. Local businesses, mainly agricultural, also wanted to have radiological controls applied to their products in order to remove any doubt of potential contamination. Their concerns stemmed from the fact that irrigation was cut immediately after the incident to limit the risk of subsequent contamination of locally produced food. However, if there had already been any contamination, it would have severe consequences on their businesses, and even the suspicion of contamination can cause such consequences.

At 10:30, Stephane summoned all the emergency management actors again to assess their progress. Unfortunately, no new information was available to answer the questions above. They advised that investigative efforts needed to continue. Therefore, it was necessary to maintain the restrictions initiated at the beginning of the emergency, even though it seemed at that stage that the risks to the population were very low. Stephane suspended the meeting at 11:00, showing some frustration about the lack of information about the radiological situation in the field.

At 11:30, Catherine's team arrived on-site and began performing comprehensive environmental measurements, first for surface water (including private wells) and then for underground water. The main difficulty encountered by the measurement team at that stage of the emergency was that, while the contamination of the environment was most likely relatively low, certain areas might concentrate the radioactivity (for example sediments and fauna). Therefore, sampling needs to be carried out quite extensively. Moreover, since uranium is an emitter of alpha radiation, the counting times for the measurements are quite long (a few hours to a few days, see the supporting information).

Resuming the emergency meeting after the lunch break, Stephane begins to show serious signs of fatigue and impatience. In particular, he does not understand why the radiological measurements are taking so long. Stephane continues asking the teams to give him the final results. He even verbally attacks Natalie, whom he considers to be partly responsible for the leak as Natalie is from the NSA, who oversees the regulation of the PTC facility. Natalie, who is used to tensions that can emerge in an emergency, chooses not to react directly. Seeing that, David takes Stephane aside and advises him to take a break instead of waiting in the emergency centre for the measurement results. David takes the role of leader within the emergency centre for the few hours Stephane is absent.

VI.4.4. Diagnosis of the situation to assess the radiation risks

As Catherine and Natalie have a good working relationship following years of working together as TSO and NSA, respectively, she keeps her informed of her team's progress, and Natalie keeps her informed of the decisions taken at the crisis centre. Natalie is also regularly informed of the work carried out by her teams to quantify the leak to the environment and minimize the consequences of the accident as well as preparations for the reactionary inspection.

Regarding the inspection, the NSA has already identified an inspection team and contacted technical experts from the TSO that will assist the inspectors in understanding the problems for further actions.

At approximately 15:00, the initial results of the TSO's water measurements indicate a steady decrease in the concentration of uranium in the river downstream of the facility, reaching a value close to normal, i.e., of the order of a few micrograms per litre. For groundwater, no uranium is found; however, these results need to be extended and refined before lifting the restrictions on water use. The TSO publishes their results via press release (the press release is available in supporting information section).

At the end of the day, Stephane returns to the emergency centre and calls all relevant actors together again to examine the first measurement results. The total amount of natural uranium is estimated by PTC to be approximately 70 kg. Furthermore, the radiological monitoring plan put in place by PTC shows that:

- In surface waters, the guideline value recommended by the World Health Organization (WHO) for water intended for human consumption was exceeded by a factor of 1000 for a short period;
- After a peak of activity in the morning, the results at the different measurement points have returned to their usual levels, which are below the guidance level for uranium in drinking water as defined by the WHO;
- Uranium concentrations in lakes and wells did not escalate; they are consistent on average with the natural state in watercourses.

Stephane, once rested, seemed to have better control over both himself and the situation. After consulting David and apologizing to Natalie, he decides to organize a short press conference. He plans to inform the public of the consequences of the accident, explain that the protective actions are conservative because of the risks associated with the incident and that more comprehensive and

accurate information will be available tomorrow. He asks Natalie to accompany him to the press conference to answer any potential technical questions on the safety of the installation and radiation protection. Finally, he again delegates the management of the emergency centre to David.

However, while preparing for the press conference, Stephane and his team are informed that members of an anti-nuclear NGO have announced that they are beginning to carry out their own radiological measurements in the area surrounding the PTC facility. The emergency management team has never dealt with such a situation as it was not part of their procedures or exercises. It was especially surprising for Stephane as he was unsure whether he needs to try to coordinate with the NGO or how the public would respond to the NGO's information, which would certainly counter his official information.

VI.4.5. The challenge of announcing a decision to lift the temporary radiation protection measures

Starting the second day (11 July), the question of lifting the restrictions based on the PTC and expert environmental monitoring results is tabled. One of the consequences of the announcement of the accident was a decline in the tourist traffic on a nearby motorway during the peak season. Moreover, some local agricultural products, which are typically exported, also saw a fall in sales. Therefore, these economic sectors want a lifting of the restrictions as quickly as possible.

However, the measurement teams were still in the field and the analysis of samples could take several days. Therefore, even if the risks are low, Natalie advises that it is necessary to wait for an overall picture of the contamination to the environment prior to removing the restrictions. As far as food products are concerned, Sophie supported Natalie's assessment. She had been in contact with the leading local agricultural producers the day before, and they expressed a real need for assurances concerning the radiological quality of their products before putting them back on the market. They felt it would be more penalizing to market non-compliant products than to sacrifice a few products, regardless of whether they are contaminated. They were willing to accept a loss to gain public and consumer confidence.

At 10:30, Natalie and her NSA/TSO team (4 inspectors and two technical experts) arrived at the site to carry out an in-depth reactionary inspection of the PTC facility. The inspection's main goals were to fully understand the reasons for the incident and to assess the corrective and monitoring actions taken by PTC. The NSA publishes a press release supporting of their inspection (the press release is available in the supporting information).

At 11:00, the anti-nuclear NGO, having carried out their radiological measurements the day before, summoned the media to present their results. Furthermore, they question the effectiveness of the actions taken by the local authorities to protect and correctly inform the population (the NGO's press release is available in the supporting information).

The press release has put additional pressure on Stephane as the concerns put forward by the NGO seem reasonable to him not having a technical background. Natalie then asked Catherine via phone to discuss with Stephane in the emergency centre to explain the constraints related to radiological measurements, especially in a complex environmental situation. In particular, to ensure Stephane is made aware that uranium concentration measurements take quite a long time to conduct, especially if the levels of contamination are low (as is currently the case). Catherine prepares a shortlist of potential questions with corresponding response elements for Stephane (the questions are available in supporting information section) for his subsequent interactions with the media and public.

By midday, Stephane was once again unsure how he and his team were managing the emergency, how his superiors in the Capital were evaluating his performance and actions so far, as well as what this incident meant for his career. Furthermore, he was also concerned about how he will manage the press and local media in his upcoming press conference. Finally, he also felt unsure of how he would publicly justify lifting protection measures, which the experts and his services had concluded to be appropriate at that stage.

VI.5. LEADERSHIP FOR SAFETY CONSIDERATIONS

This case study is to be considered primarily from the viewpoints of two leading players, Stephane, the local government decision maker, and Natalie, head of the local office of the National Safety Authority. The participants' task is to analyse and discuss the situation described. Provided below are some questions the teams could consider during their discussions. These questions are not meant to be an exhaustive list but an aide to the analysis.

- What were the main issues or tensions that created problems within the case study?
- What actions were taken (or not taken) in response to these issues or tensions?
- What could have been done differently?
- What are the major differences between the lost source incident and the accidental release to the environment?
- What are the main issues and related challenges that Stephane and Natalie need to address?
- What is your analysis of the leadership style and behaviours of Stephane? How effective or ineffective was he in taking charge of and mobilizing the emergency management team and generating responses?
- What is your analysis of the leadership style and behaviours of Natalie? How effective or ineffective was he in taking charge of and mobilizing the crisis management team and generating responses?

VI.6. SUPPORTING INFORMATION

VI.6.1. Organization during routine operations

Figure 7 shows the organization during routine operations.

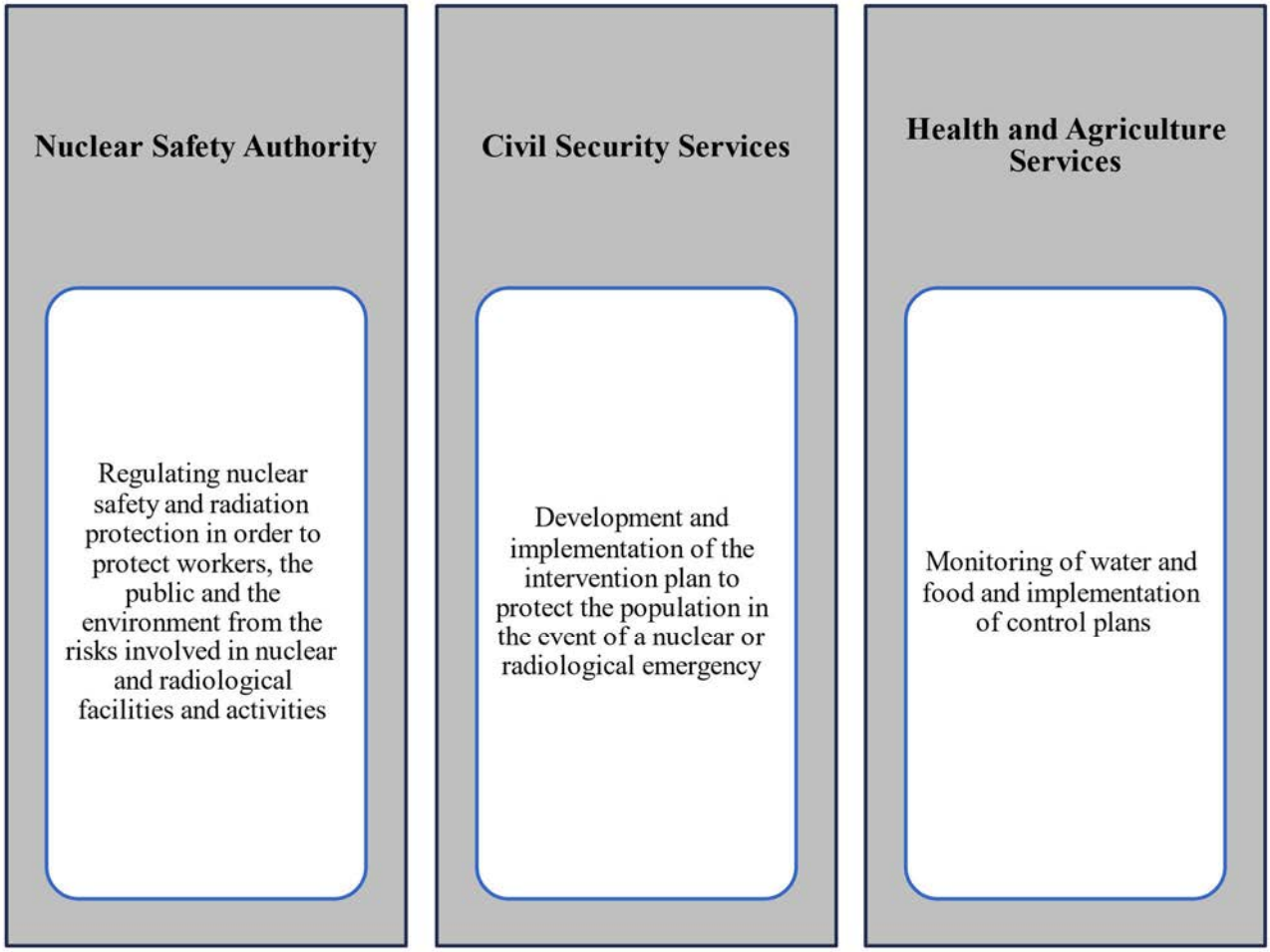

FIG. 7. Organization during routine operations

VI.6.2. Organization during an emergency

Figure 8 shows the organization during emergency operations.

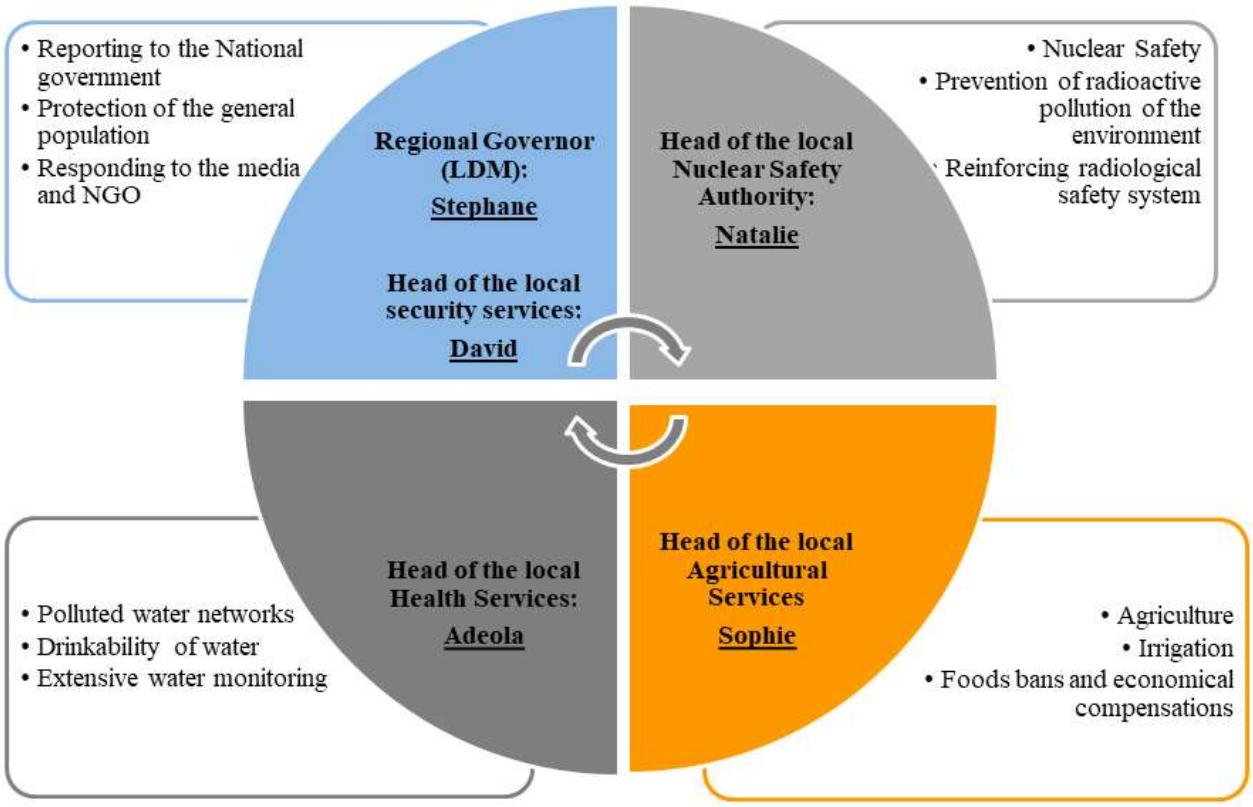

FIG. 8. Organization during an emergency

VI.6.3. Meeting report

Territorial Division of the Nuclear Safety Authority

Re: Management of nuclear or radiological emergencies

Date: 15 May 2017

Participants: departmental prefect services, civil security services, Regional Health agency, agricultural and veterinary services, TSO mobile unit.

The purpose of this meeting was to inform all state services present on the nature of the nuclear and radiological risks that these services would be likely to encounter during an emergency.

An incident involving the loss of a radioactive source occurred last year, and it became clear that the services responsible for its management were not sufficiently familiar with nuclear and radiological risks. The lack of knowledge could have led to these services reacting poorly, resulting in a level of media attention disproportionate to the actual risks caused by the incident.

It is therefore important to learn lessons from this incident for better management of potential future emergencies. The TSO was also present to answer any technical questions and to establish links, at the local level.

Main subjects of presentations:

— Risks linked with radioactivity, irradiation and contamination, specific risks associated with the facilities in the area and the transport of radioactive material;
— Risks associated with radiological emergencies and main actions to protect first responders and the public as well as specific protective actions associated with specific risks;
— Respective responsibilities in emergency situations and discussions with the services present about the difficulties they could encounter in carrying out their respective tasks.

The subjects for discussion were:

— Radiological measurements have to be carried out in the environment (that includes the drinking water networks, locally produced food). Some stakeholders thought that they would not be able to integrate and coordinate all the information. The role of the TSO, as national expert and coordinator of environmental measurements was explained.
— Some services (like veterinary and water management) have to go into the field but are concerned with working in contaminated areas and could even consider not doing field work as they feel their own protection against radiation is not assured. However, the information session was a good way to reassure these people.

The meeting was very fruitful, and it was decided that information sessions would be organized in a similar format 1–2 times a year in order to maintain the link between the different services and possibly to include new ones.

VI.6.4. Email exchange between NSA and the Regional Governor

To: Archer, Stephane

From: Sisko, Natalie

Date: 02 June 2017

Re: Coordination on Nuclear Safety

Dear Governor,

At your meeting yesterday for the heads of the regional administrative services, you stated that your highest priority was the safety and security of our citizens and the environment and reminded us all that it could only be achieved through close and continuous cooperation between services. You mentioned in particular the unfortunate management of the accident which occurred three months ago and expressed your commitment to avoid any repetition of such events.

To this end, I confirm my full support to this cooperative spirit and take this opportunity to suggest that we meet at your earliest convenience. If possible, we need to meet before the next nuclear emergency exercise in our region (scheduled for 20 July) to brief you on current nuclear safety challenges and priorities for our division. Furthermore, I would be more than happy to inform you about the initiatives taken together with the head of security services (David) to improve the coordination and mutual understanding of regional services during the management of any nuclear incidents.

Again, my personal congratulations on your appointment as Governor and I am looking forward to meeting with you again.

Best regards,

Natalie, Regional Division Director Nuclear Safety Authority

To: Sisko, Natalie

From: Picard, Janet

Date: 3 June 2017

Re: RE-Coordination on Nuclear Safety

Dear Director,

The Governor thanks you warmly for your kind message.

He will be most interested in the information you wish to share with him; however, unfortunately his agenda will not allow for such a meeting in the next weeks. We will come back to you as soon as possible to fix a date.

In the meantime, the Governor invites you to liaise with David on any issue of your competency which could require coordination at the regional level, particularly for the preparation of the next exercise.

Best regards,

Janet

Director, Regional Governor's Office

VI.6.5. Press release from the Emergency Centre

STATE OF EMERGENCY AND ACTIONS BEING TAKEN

As you are all surely aware, an incident has occurred at the site of the Prime Technology Company (PTC) facility yesterday evening. The incident involved the potential release of radioactive material to the environment.

In response to this incident, we have activated the local emergency response plans. These plans include an emergency team with all relevant technical expertise and procedures for the characterization of the incident. Based on the competencies of our team and results of our analysis, we will act in order to protect the population and environment.

As of now, we have taken the conservative measures of banning the consumption of drinking water from private wells, restricting agricultural irrigation, prohibiting nautical activities, and putting a temporary halt on fishing and consumption of fishery products. At the same time, we have dispatched environmental monitoring teams to take samples and properly characterize the nature and severity of the incident. Based on their analysis, we will adjust our actions. However, this work takes time and in the interim I ask you to remain calm and patient.

In addition to the work, representatives from our local Nuclear Safety Authority are working with PTC to understand what happened and ensure that all actions taken on their end are thorough and appropriate.

We will keep you apprised as the situation develops.

SIGNED

Stephane Archer, Regional Governor

VI.6.6. Specific information on uranium

Uranium is a naturally occurring metal in the environment. It is found in varying quantities in rocks, water, air, plants, animals, and human beings. There is, for example, an average of 1–2 mg of uranium per kg of soil and a few nanograms to micrograms per litre in surface waters and sometimes much more in some mineral waters (up to a few tens of micrograms per litre).

Persons can be exposed to ionizing radiation from a source outside of the body; this is called external exposure. Persons can also be exposed from a source that has entered inside the body; this is called internal exposure.

- External exposure could result from natural uranium due to beta and gamma emissions. For example, the gamma dose rate at 30 cm from 1 gram of uranium is 0.04 μSv/hr;
- Internal exposure could result through the inhalation of particles present in the atmosphere, or ingestion of contaminated water or food. For example, the daily consumption of water containing 1 microgram per litre of natural uranium leads to an effective dose of 1 μSv.

Monitoring of internal exposure can be performed by direct measure of the activity retained in the human body (especially where intakes are high) or by analyses of uranium excreted in either the urine or faeces (especially where intakes are low).

According to the techniques used, the limits of detection of uranium in urine vary from some nanograms per litre to a few micrograms per litre. The limit of detection is about 5 to 10 mg for direct measurement of lung content.

According to the he World Health Organization (WHO) the concentration of radionuclides in drinking water for . uranium,is30 micrograms per litre [8].published guidance values for

Analytical methods for uranium in a water sample permit either the determination of the concentration of total uranium expressed as microgram per litre or the determination of the radioactivity of the different isotopes (U-234, U-235, U-238) expressed in Becquerels per litre.

The results of measurements of samples taken from the site environment will be available:

- Within 24 hours, if the concentration exceeds 100 micrograms /litre.
- Within 48 hours, if the concentration exceeds 1 microgram /litre.
- Within one week it will be possible to know the isotopic composition within the detection limits.

VI.6.7. Information on the PTC characterization of the leak

To: Sisko, Natalie

From: Geordi, Wesley

Date: 10 July 2017

Re: Uranium leak

Dear Natalie,

I can report that PTC engineers have confirmed that the faulty containment has been cleaned and repaired and that safety procedures have been reinforced to avoid any new accidental flow of untreated waste into the containment area.

I can also confirm that we estimate that a maximum of 70 kg of uranium in liquid has been dispersed to the environment; mostly into the drainage canal and some (difficult to evaluate at this stage) into the surrounding soil. Considering the amount of liquid that PTC was able to retrieve from containment, we estimate the volume of the leak to the environment to be approximately 28 m^3.

Many thanks,

Inspector – Nuclear Safety

VI.6.8. Press Release from the TSO

INFORMATION NOTE

LEAK OF URANIUM-CONTAINING SOLUTION

ENVIRONMENTAL MONITORING ACTIONS

We recall that the accidental release of a uranium solution at the PTC facility led to pollution of the storm drainage network which joined the river and the river next to it and pollution of the soils under the facility itself. Our measurement teams are now deployed throughout the territory affected by the pollution. These teams have put in place a monitoring plan including pond water, river water, and groundwater on site and around the site.

Figure 9 shows the monitoring actions of the measurement teams.

FIG. 9. Monitoring activities by measurement teams

Regarding surface water withdrawals for irrigation purposes, the values of uranium measured in the waters of the rivers concerned show a steady decline in uranium content, which is now below the WHO guidance value for uranium in drinking water. The transfer of uranium to crops appears to be negligible.

In the case of groundwater, for which measurements of uranium concentration do not show abnormal values, knowledge of the flows around the site show that they are slow and that there is no reason to fear excess pollution at a collection point. Furthermore, the surveillance setup needs to allow for timely intervention, if necessary. In this regard, the selected sampling points will aim at rapidly detecting any abnormal increase in uranium content in the upstream waters of individuals and farmers.

We intend to regularly communicate the results of our radiological monitoring of the environment (surface water and groundwater, aquatic plants, fish, sediment, and irrigated crops). Furthermore, we expect the results of these measurements to confirm the negligible nature of the consequences of the accident.

VI.6.9. Press Release from the NSA

Following its inspection, the NSA has taken the following measures.

On the night of 9 to 10 July an incident occurred at the site of the PTC facility. A reservoir at the uranium effluent treatment plant overflowed into its retention tank. This retention tank, being under construction, was no longer watertight, which caused a release or uranium to the environment.

On 11 July, four NSA inspectors accompanied by two experts carried out a thorough inspection of the effluent treatment plant. In particular, they examined the premises, the chronology of events, and the first corrective actions taken by the operating organization.

The inspectors observed that the release had ceased and:

— The safety features in place for preventing further releases are satisfactory;

— The operating conditions at the time of the occurrence were irregular compared to the applicable regulations.

These findings will be presented in a formal report.

The NSA has imposed a suspension on the arrival of effluents to the treatment station until such time that full measures for safety can be assured.

The NSA also requires the operator to make improvement to the radiation safety system, the results of which will be made public.

The incident is ranked as 1 on the International Nuclear and Radiological Event Scale.

VI.6.10. Press release from the NGO

More and more areas of concern and laxity on the nuclear accident.

Our association has always been on the side of the citizens to denounce the lack of information concerning the nuclear installations in our region.

Having been informed of the nuclear accident that occurred on the night of 9–10 July and the potential impact on the environment and water quality, we decided to conduct our own radiological measurement campaign to verify that the consequences will not be hidden from the local population.

We also asked the authorities to make public all the radiological measurements performed by the operator and the TSO following this accident. To date, our requests have not yet been met. However, we know from experience that delays in the publication of radiological measurements do not augur well.

In fact, if the results showed the absence of radioactivity in the environment, they would have already been communicated to us. When there are delays, it usually means that there is will to wait for the values of the radioisotope to decay, giving a more reassuring result.

Some local testimony also indicated that water has been taken from private property without the results being passed on to the owners. The only instructions they were given was to not drink the water from their well.

The Nuclear Safety Authority is no better. One of their recommendations is to ask the operator to reinforce its environmental monitoring plan and to keep the trustees informed of any anomalies. How can they claim to trust the polluter to report possible pollution?!

Finally, it is only now that the inspectors and experts will finally venture to the damaged facility; because it takes time to organize or because they are afraid of the radioactivity?

We reiterate our request that all available information be made public as well as the results of the inspection such that the climate of laxity ceases!

VI.6.11. Press conference response elements

Is the facility dangerous? Could the accident have been avoided?

— Explain the dynamics of the accident and confirm that you have sent the NSA onto the site and are aware of the actual situation;

— Indicate that the NSA will conduct a reactive inspection to clarify the conditions of the incident and ask the operator to make necessary changes to prevent this type of incident in the future.

Are you in a position today to ensure that the protection of the population is assured? Why didn't you recommend giving stable iodine? Why were the people not evacuated?

— In the event of a nuclear accident, actions to protect the population are planned, but they do not always apply. The actions decided upon need to correspond to the specific nature of the risks associated with the facility;
— The specific risks linked to this incident: water contamination by uranium (no iodine in the release and no atmospheric dispersion), do not warrant such measures.

Can the public continue to drink tap water? Can we use running water to wash? Can we swim in the rivers/lakes? Can the water continue to be used for irrigation and livestock watering?

— Upon announcement of the incident, the regional health agency initiated a plan for enhanced monitoring of drinking water as planned for such situations. In addition, the TSO performed measurements in the various waterways in the area. To date, no measurement has shown the need to set up a replacement drinking water system;
— Nevertheless, this monitoring will be continued for as long as necessary and if measurements show the need to take specific actions, you will be informed immediately;
— The agricultural services and the veterinary services are currently carrying out, with the support of the TSO, radiological measurements on agricultural production.

APPENDIX VII. CASE STUDY 5: DEVELOPMENT OF THE LEGISLATIVE FRAMEWORK FOR SAFETY

VII.1. LEARNING OBJECTIVES

This case study deals with leadership holistically, with its inherent tensions and complexities. It centres on leadership in the context of the need to improve safety through strengthening an inadequate national legislative framework and adhering to the relevant international legal instruments. This case study specifically addresses the objective of developing values and attitudes for safety, focusing on how to develop an organizational culture that:

— Supports and encourages collaboration, consultation, and communication;
— Builds trust;
— Develops individual and institutional values and expectations for safety throughout the organization;
— Encourages and supports individuals to act safely.

VII.2. SETTING THE SCENE

VII.2.1. Outline of the situation

The case study is set in Malano, a small island State with a population of 1.5 million. Malano is a parliamentary representative democratic republic. The President is the head of state, and the Prime Minister is the head of government, assisted by a Cabinet of Ministers, which has the supreme authority for making policy decisions for the government.

Malano currently has no nuclear power plants and no fuel cycle facilities. However, radiation sources are widely used for medical and industrial purposes, particularly in the petroleum and mining sectors. Mining of uranium, precious metal, and other ores (in particular rhodium) has in recent years become an increasingly important economic activity. Due to the increasing potential contribution of the petroleum and mining sectors to the Malano economy and their growing significance as a source of state revenue, there is now a strong political constituency in the government, in favour of their continued development.

An ongoing issue in Malano concerns the role of the petroleum and mining industries, their responsibilities for safety and the inadequacy of the national legal basis for regulatory control (Radiation Protection Law No. 13/1977, see Fig. 10), particularly as the country is faced with the challenges of the legacy of disused sealed sources in the petroleum and mining sectors, the management of radioactive waste, as well as related future decommissioning and remediation.

Additionally, a radiological accident recently occurred in Malano, namely at a uranium tailings dam. The activity had been licenced by Malano's regulatory authority, the Radiation Protection Authority (RPA).

The case study does not deal with the actions relating to the accident itself but with the actions relating to the revision of the legal and regulatory framework resulting from the accident. Therefore, for this case study, basic knowledge about the main elements of a national legal framework for safety is needed (see supporting information).

VII.2.2. Main actors involved in the case study

The primary entity regulating activities involving radioactive material in Malano is the Radiation Protection Authority (RPA). The RPA is established and reports to the Ministry of Mines, Industry and Trade (MINT), which chairs the RPA Board. As illustrated in Fig. 10, the main actors involved in the situation are described below.

Head of the Radiation Protection Authority (RPA) — Manning: A highly experienced individual with many years of experience as a civil servant, previously worked in the Ministry of Science and Technology (aged 57). As the Head of the RPA, he is responsible for the policy of the RPA Board and RPA's day-to-day management. Having been recently appointed as RPA Head, Manning is concerned about the Silano Uranium Tailings Dam accident. However, he considered that nuclear issues were not that significant in the mining and petroleum sectors. He viewed the current legislative framework, including Law 13/1977, as far from perfect. However, it served the RPA well over the decades. More particularly, until the accident at the Silano Uranium Tailings Dam, he understood that MINT considered the regulatory framework effective. Having just been appointed and being close to retirement, he did not want to make any drastic institutional changes. He also felt the accident was an operational issue, not legal.

Head of the Legal Office, Radiation Protection Authority (RPA) – Sarah: An experienced lawyer (aged 46). Recently, she became Head of RPA's Legal Office. Since joining the RPA, Sarah had been concerned about the inadequate legislative framework, particularly, law 13/1977, the lack of a legal basis for enforcement actions by the RPA, and the lack of sufficient human and financial resources. Further to the accident at the Silano Uranium Tailings Dam, she recognized the opportunity to work towards strengthening the framework through the Legal and Policy Task Force and the Investigation Committee.

Legal Officer, Radiation Protection Authority (RPA) – Jayne**:** A mid-career professional (aged 35) who joined the RPA a few years ago after being recruited by Sarah. She has a questioning attitude and seeks to strengthen the legislative and regulatory framework. Further to her participation in the IAEA Nuclear Law Institute (NLI), she was aware of the inadequacies of Law 13/1977. Jayne is particularly concerned about several incidents involving poor management and the abandonment of disused radioactive sealed sources used by the petroleum sector in Malano. She has raised these on several occasions with Sarah, who has not been responsive because she does not see that RPA has the authority to address these issues.

Inspector, Radiation Protection Authority (RPA) – David: An experienced inspector now close to retirement, having worked for RPA for over two decades (aged 61). For some time, David has been unhappy about the lack of full inspection and enforcement powers of the RPA. However, he has never seriously raised any of his concerns until after the accident when he voiced them with Sarah. He did not mind doing it since he, like Manning, was also about to retire and wanted to set the record straight considering the work of the Legal and Policy Task Force and the Investigation Committee.

Senior Policy Officer, Radiation Protection Authority (RPA) – Harvey: A mid-career manager having several years of experience in the field (aged 39). Appointed a few years ago, he has risen quickly within the small numbers of RPA staff. Harvey does not feel that the issues raised by Sarah, Jayne or David are that relevant for his career plans. Although there is no evidence to support such claims, some consider that Harvey is protected by senior figures in the RPA and government.

Deputy Minister, Ministry of Mines, Industry and Trade (MINT) – Frederica: A highly experienced senior civil servant. She was recently appointed to the position of Deputy Minister (aged 52) and

follows instructions from the Minister for Mines, Industry and Trade. Frederica does not object, in principle, to a strengthening of the legislative framework, for example, to broaden its scope. However, she is concerned that institutional changes concerning the RPA, particularly, its establishment under another ministry or other body, could negatively impact the existing State-owned petroleum and mining industry enterprises and the growing presence of foreign State-owned and private petroleum and mining industries in the country. Frederica is aware that the government needs to strengthen some aspects of the legislative and regulatory framework following the accident at the Silano Uranium Tailings Dam. She is, however, anxious about the potential for additional regulatory costs if such an institutional change were to occur stemming from compliance with new safety requirements. She has raised her concerns with Manning (RPA Head), an old friend and former colleague from the time they were both in the Ministry of Mines, Industry and Trade (MINT).

Senior Policy Officer, Ministry of Mines, Industry and Trade (MINT) – Massimo: A mid-career manager having several years of experience (aged 40). Considering the accident at the Silano Uranium Tailings Dam, he is generally supportive of proposals to strengthen the inspection and enforcement powers of the RPA but conscious of the opposing views of his senior managers regarding any major institutional changes related to the RPA. Despite the accident, he is admittedly not fully appreciative as to why there need to be major differences in institutional arrangements for regulatory control compared to some other relevant sectors for activities involving ionizing radiation. Massimo and Harvey attended university together.

VII.3. DESCRIPTION OF THE CHALLENGE

VII.3.1. Silano Uranium Tailings Dam accident

Silano is a licensee and well-established state-owned company in the mining sector. During a routine annual inspection of Silano, David (RPA Inspector) was provided with internal reports concluding that the Silano Uranium Tailings Dam was stable but also referring to drainage problems and recommending installing new water pressure monitors. David also made some further recommendations to improve the dam's safety. However, this work was not completed.

David was concerned about the issue, and a written warning was shortly submitted to Silano, seeking the implementation of remedial action to correct the identified deficiencies promptly. The letter stated that the RPA might be obliged to consider several enforcement actions, ranging from suspension or cancellation of the relevant authorization to prosecution. David also unsuccessfully sought to cooperate with MINT colleagues to resolve the issue, as RPA is not empowered to take enforcement actions without its participation. Despite a further RPA letter seeking confirmation of the implementation of the needed remedial actions, no response was forthcoming from Silano.

Not long after the final letter was sent, the Silano Uranium Tailings Dam suddenly collapsed (due to liquefaction), injuring more than ten people (workers and members of the community). The accident released a tailings flow of some 2–3 km downstream with high concentrations of uranium in river water. Some 5 km^2 of land along the river was contaminated. Several power lines were toppled and a gas line ruptured. Some locals were cut-off from the drinking water supply, and the drinking water supply of a few downstream communities was shut down. There was also some contamination of crops in the affected area. The accident sparked debate in the region and more broadly across Malano about safety and the role of the MINT and the RPA in resource projects. In this context, the accident resulted in negative press coverage, which triggered some community-based protest actions against the mining companies. The protests were primarily related to environmental concerns, and the growing inequality in terms of rights and economic power between the local communities and the mining

companies. The accident also resulted in the cancellation of government plans to consider a nuclear power plant programme.

Shortly after the accident, the government established an Investigation Committee on the Silano Uranium Tailings Dam accident. The Investigation Committee was an independent expert group tasked with investigating the accident and determining its cause. The committee's responsibility was also to make policy proposals designed to prevent the recurrence of similar accidents in the future.

Given the seriousness of the situation and because of the establishment of the Investigation Committee, David (RPA inspector) sought the advice of Sarah (Head of the RPA Legal Office). He was also concerned since, in his view, the accident highlighted the continued lack of priority to safety by some licensees in the mining and petroleum sectors. He considered that they did not take the RPA's regulatory role seriously. During the meeting with Sarah, David highlighted the following points:

— The lack of enforcement powers of the RPA and its inspectors;
— The lack of sufficient and competent RPA inspectors needed to verify that the licence holders comply with regulatory requirements and licence conditions;
— The lack of financial resources;
— The lack of effective coordination and cooperation between the RPA and MINT concerning enforcement activities.

In David's view, the lack of competent personnel for carrying out inspections resulted in an almost complete absence of regulatory inspections to existing facilities and activities. For example, at the time of the accident at the Silano Uranium Tailings Dam, the inspection programme was being implemented by David and two other staff with limited training in inspection and enforcement. Given that he was close to retirement and considering the seriousness of the accident at the Silano Uranium Tailings Dam, he now felt it was a good time to voice his concerns. That is something he would not normally do due to RPA's lack of a safety culture. As the responsible RPA inspector, David also feared he could be made a scapegoat for the accident.

VII.3.2. Legal and Policy Task Force meeting

As part of the activities of the Investigation Committee, a Legal and Policy Task Force was created ('Task Force'). Activities of the Task Force included: analysing and commenting on the current applicable national legal framework; and identifying the main features of any relevant international legal instruments. The Task Force included senior and middle-management officials (legal and policy) from the RPA, MINT and other Ministries, as well as the Attorney General's Office. The Task Force met to agree on findings and conclusions to be submitted to the Investigation Committee via the RPA Board.

During the discussions, Sarah presented a report highlighting the key reasons as to why the legislative framework needed strengthening. The report included the lack of independence of RPA and the lack of adequate provisions on safety, security, safeguards, and nuclear liability. In addition, it highlighted which of the instruments adopted under the auspices of the IAEA were of relevance, as well as the benefits and implications of joining them. Jayne (RPA Legal Officer) enthusiastically supported Sarah. Jayne was highly motivated to pursue positive developments, due to her participation in the last annual session of the IAEA Nuclear Law Institute (NLI). Sarah raised all these points to gain greater support for strengthening the legislative framework. She did, however, point out another more limited option, which would be to focus on strengthening the functions of the RPA and ensuring that radiation safety is effectively addressed in the current legislation. That opinion was not supported by Jayne, who advocated for a new comprehensive nuclear law and for RPA to be no longer under the

control of MINT. Instead, she believed that a complete reform of the legislative and regulatory framework was needed. Not only to address the issues which had arisen from the Silano Uranium Tailing Dam accident but also wider radiological safety problems endemic within the petroleum and mining sector in Malano.

David (Inspector, RPA) was generally supportive of Jayne's proposals. Further, he reiterated that the best way forward was to become party to relevant international conventions, which could act as a guide for the development of a national legal framework, such as the Early Notification and Assistance Conventions [9, 10] and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [11].

However, Massimo (MINT Senior Policy Officer) expressed concerns regarding any proposal to move RPA from the authority of MINT. He highlighted that MINT had the requisite human resources and scientific and technical expertise in the field. He also highlighted that a major revision of the legislative framework appeared unnecessary, particularly given the recent decision of the government to postpone its planned nuclear power programme indefinitely in the aftermath of the Silano Uranium Tailings Dam accident. However, he identified that there needs to be better coordination between the RPA and MINT, particularly regarding licensing, inspection and enforcement activities. Harvey (RPA Senior Policy Officer) expressed comparable views, considering that all that was needed were probably only some additional regulations and practical arrangements between RPA and MINT. He also considered that adhering to the international instruments was not a priority, particularly given the indefinite postponing of the programme.

All views and suggestions voiced during the meeting were reflected in the Minutes of the meeting presented to the RPA Board for further transmission to the Investigation Committee.

Before the RPA Board sent out the minutes to the Investigation Committee, Frederica (Deputy Minister, Ministry of Mines, MINT and member of the RPA Board) contacted Manning. During their discussion, Frederica made it clear that any proposals for any revision of the legislative framework were only one possible option among other proposed actions. She told Manning that, when transmitting the Task Force Minutes to the Investigation Committee, the RPA Board needs to focus on the other proposed actions. However, after encouragement by the work of Sarah and Jayne in highlighting the deficiencies of the existing legislative framework, Manning wanted to support the sort of changes they were advocating. He felt it meant he would have greater security regarding the availability of RPA's human and financial resources. Nevertheless, he did not want to upset Frederica or the Ministry. He thought it best to let Frederica do what she wanted and for himself to wait for future opportunities to raise the matter again.

VII.4. LEADERSHIP FOR SAFETY CONSIDERATIONS

The case study is primarily aimed at exploring the differing viewpoints and leadership attitudes within the RPA: of Manning (Head of RPA), Sarah (Head of Legal Office, RPA) and Jayne (Legal Officer, RPA), as well as between these RPA members and Frederica (Deputy Minister, MINT). The participants' task is to analyse and discuss the situation described. Provided below are some questions the teams could consider during their discussions. These questions are not meant to be an exhaustive list but an aide to the analysis.

— What were the principal goals and motivations of each of the actors?
— How did the actors encourage or support each other in improving the safety framework or fail to do so?

— Which actors played a major role in the failure to take formal actions to strengthen the legislative framework? What would you have done differently?
— Which actors exhibit values and attitudes of positive leadership for safety?

VII.5. SUPPORTING INFORMATION

VII.5.1. Report on legal issues to the Legal and Policy Task Force meeting of the Investigation Committee of the Republic of Malano on the Silano Uranium Tailings Dam accident

This report has been developed in the context of the work of the Legal and Policy Task Force of the Investigation Committee of the Republic of Malano on the Silano Uranium Tailings Dam accident. The report contains suggestions for strengthening Malano's legal framework for the regulation of activities involving ionizing radiation by identifying key issues and deficiencies of the Radiation Protection Law No. 13/1977 (hereinafter referred to as "Law 13/1977").

Considering the international legal instruments for safety, security and safeguards, IAEA safety standards and other publications, such as the IAEA's Code of Conduct on the Safety and Security of Radioactive Sources [12], it is suggested that the elements listed below be considered when revising the current legal framework. In this regard, it is suggested that a new comprehensive nuclear law covering safety, security and safeguards be developed, so that all relevant aspects for the regulation of nuclear facilities and activities are covered.

VII.5.1.1. Independence of the regulatory body and separation of regulatory functions

The existence of an independent regulatory body with a set of comprehensive functions for regulatory control pertaining to safety, security and safeguards is crucial for the development of an effective nuclear legal framework. It is important that decisions on safety issues do not become subject to interference from an authority that is involved in the promotion of industries dealing with radioactive material. Assuring that, the regulatory authority is kept free from undue pressure from interested parties. According to the IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety [5], governments are required to create such separation of powers in order to establish an effective framework for safety. As expressed in the IAEA Handbook on Nuclear Law [13], the placement of a regulatory body within the administrative structure of a government department is not problematic *per se*, but there needs to be a clear separation of the regulatory key functions.

In Malano, the RPA has the rank of a Directorate within the MINT. It therefore has no legal personality and is not an independent regulatory authority. The reporting arrangements of the RPA lack transparency and efficiency. The RPA is not allowed to publish safety related information such as reports on incidents at authorized facilities without the MINT's approval. Further to that, the MINT plays a key role in the promotion of Malano's mining industry. It affects the independence of the RPA and creates a risk of an undue conflict of interests.

It is suggested that the law of Malano be revised with the aim of strengthening the RPA's functions as well as ensuring its effective regulatory independence. The legal framework needs to therefore contain provisions establishing the following:

— Institutional separation of regulatory and non-regulatory functions, preferably by establishing the RPA as a separate legal body;
— The RPA's ability to report to a government official or organization without conflicting responsibilities;
— The RPA's unrestricted access to press, media, and the public.

VII.5.1.2. Financial and human resources of the RPA

In line with the IAEA Handbook on Nuclear Law [13], the financial resources of a State's regulatory authority need to be predictable, reliable, and adequate. Also, they are not to be subject to undue control by other entities. Therefore, it is highly recommended that the regulatory authority is granted the ability to develop its own budget.

In Malano, the allocation of financial resources to the RPA does not adequately cover the authority's needs. This affects the RPA's ability to acquire the necessary technical expertise and to hire competent staff.

Due to the lack of financial and human resources of the RPA, it is suggested that the following issues are raised in the process of revising the current legal framework:

— Separate budgetary and employment authority for the RPA;
— Clear provisions ensuring that adequate financial and human resources are being provided to the RPA.

VII.5.1.3. Authorization, inspection, and enforcement powers

Among the most fundamental regulatory functions are the granting, amending, suspending, and revoking of authorizations. International legal instruments as well as the IAEA safety standards recommend these functions to be placed among the competences of the regulatory authority.

In order to determine whether authorized persons comply with the conditions of the respective authorizations, the legal framework needs to enable effective means of inspection. Paragraph 4.50 of. GSR Part 1 (Rev. 1) [5] states:

> "The regulatory body shall develop and implement a programme of inspection of facilities and activities, to confirm compliance with regulatory requirements and with any conditions specified in the authorization. In this programme, it shall specify the types of regulatory inspection (including scheduled inspections and unannounced inspections) and shall stipulate the frequency of inspections and the areas and programmes to be inspected, in accordance with a graded approach."

Requirement 28 of GSR Part 1 (Rev. 1) [5] states that "**Inspections of facilities and activities shall include programmed inspections and reactive inspections, both announced and unannounced.**"

Enforcement measures are a necessary tool for assuring the compliance with national law, regulations as well as terms and conditions of authorizations. In accordance with the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [11] as well as with IAEA safety standards, a State's regulatory body needs to be clearly and explicitly assigned with enforcement powers.

According to the law of Malano, authorizations to conduct activities related to radioactive material are issued by the MINT upon the recommendation of the RPA. The Ministry is also the only entity with the competence of revoking such authorizations.

Inspections of facilities and activities related to radioactive material in Malano are carried out partially by the RPA.

Decisions on enforcement action in case of non-compliance with Law 13/1977, applicable regulations and authorization conditions are taken by the MINT, on the proposal of the RPA. The RPA is not empowered to carry out enforcement measures without the participation of the MINT.

It is suggested that legislators of Malano take steps towards implementing legislation including the following points:

— Establishment of the RPA as the only authority entitled with the granting, amending, suspending, and revoking of authorizations as well as with the inspection of facilities and activities related to radioactive material, including the delineation of powers of inspections;
— Granting the RPA competence of making decisions on inspections and enforcement action without the approval of any other government official or organization;
— Ensuring that the RPA can carry out the required inspections and enforcement measures independently and unconditionally of any other entity's participation;
— Responsibility of the RPA to implement an inspection programme in line with the IAEA Safety Standards.

VII.5.1.4. Other provisions

When revising the legal framework, to ensure that it is comprehensive, the following needs to be considered:

— Providing for the application of the basic principles of radioactive waste management, the responsibilities of authorized persons for the safe and secure management of waste and general requirements for decommissioning, including financial agreements;
— Providing for the elaboration of an on-site emergency plan as a requirement for authorization and for the establishment of a national emergency plan for responding to nuclear and radiological emergencies;
— Clear allocation of responsibilities lined out in the national emergency plan;
— Provisions on periodical reviews, updates, and tests of the on-site emergency plans;
— Establishment of requirements for transport of radioactive material in accordance with the IAEA Regulations for the Safe Transport of Radioactive Material [14];
— Ensuring that nuclear security aspects are incorporated into the regulatory control system of authorization, inspection, and enforcement;
— Providing for the implementation of the State's obligations pursuant to the Comprehensive Safeguards Agreement and the Additional Protocol thereto;
— Establishing a system of export and import controls of nuclear and other radioactive material, nuclear related and other relevant equipment, and technologies.

VII.5.1.5. Malano's adherence to international legal instruments

In addition to revising legislation at a national level, becoming a party to international legal instruments is also an important step. The report concludes that Malano needs to make efforts to adhere to the following international legal instruments to reiterate its commitment to maintaining high standards of safety and security and to benefit from international cooperation in this highly technical fields:

- Amendment to the Convention on the Physical Protection of Nuclear Material (ACPPNM) [15]: Malano is a party to the CPPNM but not to its Amendment, which entered into force in 2021. The ACPPNM strengthens the provisions of the CPPNM and reduces the vulnerability of States to nuclear terrorism. It helps reduce the risk of a terrorist attack by making it legally binding for States Parties to protect nuclear facilities, as well as nuclear material in domestic

use, storage, and transport. It also increases international cooperation and assistance in locating and recovering stolen or smuggled nuclear material, which could affect all States, even those without such material. By adhering to the ACPPNM, States benefit from and contribute to a strengthened nuclear security regime at the national, regional, and global levels. It is highly recommended that legislators take steps towards updating not only the current legislative framework for nuclear safety, but also for nuclear security, in order to show Malano's commitment to counterterrorism and to regain public trust. This trust was highly impeded after the Silano Uranium Tailings Dam accident, resulting in local protests.

- Convention on Early Notification of a Nuclear Accident (NOT) [9] and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (ASSIST) [10]: NOT strengthens the international response to nuclear accidents by providing a mechanism for rapid information exchange in order to minimize transboundary radiological consequences. ASSIST provides an international framework to facilitate prompt requests for and provision of assistance in the event of a nuclear or radiological emergency and to promote, facilitate and support cooperation between States Parties to that end. By adhering to these conventions, States benefit from an international cooperation mechanism for rapid information exchange and response to a nuclear accident or radiological emergency, the effects of which could reach beyond national borders, as demonstrated by the Chernobyl accident, which led to the adoption of these conventions. Malano would have benefited from the international cooperation and information exchange mechanisms after the Silano Uranium Tailings Dam accident.

- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (JC) [11]: The JC is the first legal instrument to address the issue of spent fuel and radioactive waste management safety on a global scale. It does so by establishing fundamental safety principles and a peer review process. The JC applies to spent fuel resulting from the operation of civilian nuclear reactors and to radioactive waste resulting from civilian applications. It also applies to spent fuel and radioactive waste from military or defence programmes if such materials are transferred permanently to and managed within exclusively civilian programmes, or when declared as spent fuel or radioactive waste for the purpose of the JC by the Contracting Party concerned. In addition, it covers planned and controlled releases into the environment of liquid or gaseous radioactive materials from regulated nuclear facilities. Malano needs to be able to guarantee the safety of workers, the public and the environment with respect to the mining activities that are being carried out in the country. It would therefore be useful for Malano to participate in the peer review process and information exchange mechanisms of the JC, in order to learn from other States Parties to the convention.

- Code of Conduct on the Safety and Security of Radioactive Sources [11: The Code of Conduct aims at helping national authorities to ensure that radioactive sources are used within an appropriate framework of radiation safety and security. The Code is a well-accepted, but non-legally binding international instrument. However, States can make a political commitment to implement the provisions contained in the Code of Conduct. It is suggested that Malano takes the necessary steps towards making a political commitment to the Code of Conduct and its supplementing documents (Guidance on the Import and Export of Radioactive Sources and Guidance on the Management of Disused Radioactive Sources) in order to ensure the physical protection and safe management of radioactive sources as well as to promote safety culture and security culture with respect to radioactive sources.

VII.5.2. Organizational chart

Figure 10 shows the organizational chart for the participants to be able to place the main actors involved in the case study.

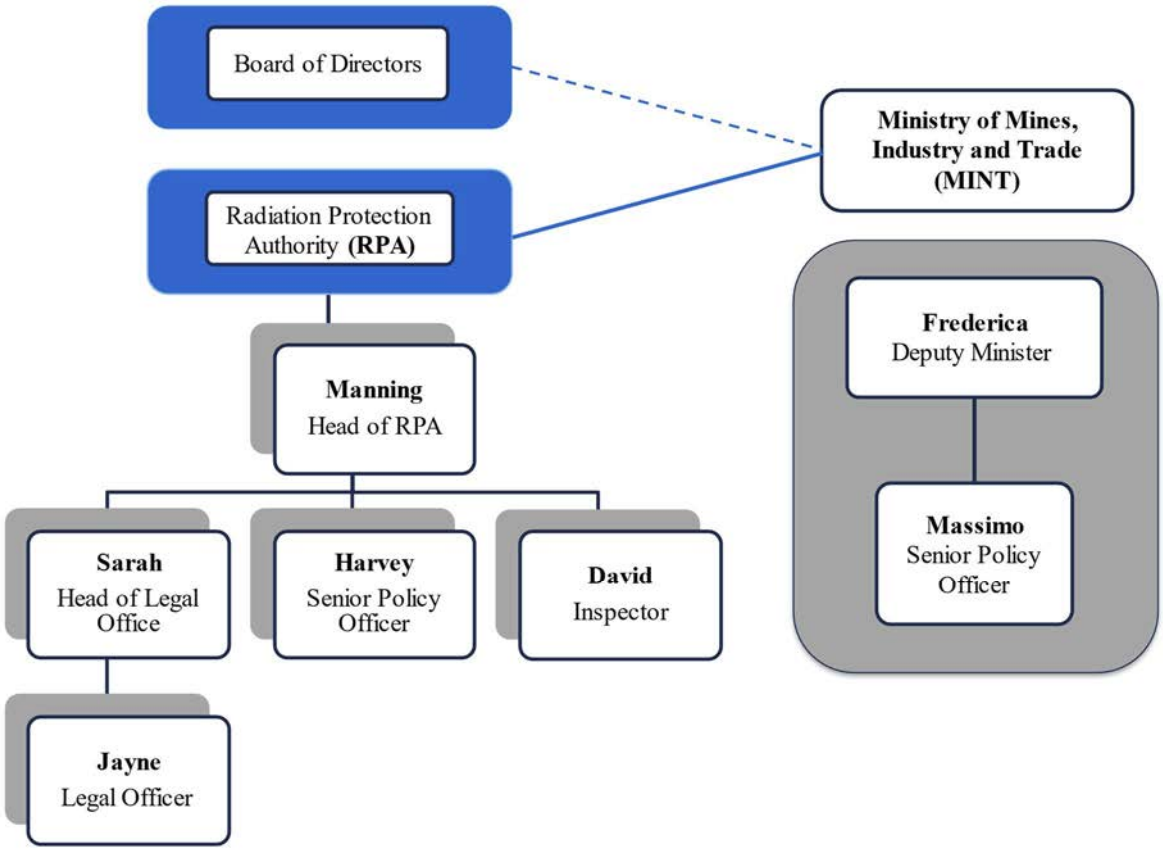

FIG. 10. Organizational chart

APPENDIX VIII. TECHNIQUES, GAMES AND TOOLS FOR EXPERIENTIAL LEARNING

VIII.1. OVERVIEW

The role of innovative and diverse methods in training has grown. New teaching methods have advanced by incorporating group dynamic games into training. These methods support training through creating space for participants to deepen professional relationships and learn about themselves. For leaders, they offer practice and insight into group behaviour from diverse points of view from a socio-psychological perspective. When the specific characteristics of participants are involved, the games described in this Appendix might need modification.

To achieve the enduring impact and promote improved leadership for safety in nuclear facilities, the use of gamification is a key element of the methodology applied in the Leadership School. The games and group dynamics designed for the Leadership School have been created to achieve specific goals as well as expand participants' skills and provide them with a toolbox in teamwork, communication, creative and critical thinking as well as problem solving. These essential skills for becoming a leader are of key relevance, as Leadership School's participants, following the training, have the opportunity to implement them in their working place.

VIII.2. GAMES USED IN THE LEADERSHIP SCHOOL

VIII.2.1. Log in/ Log out

This exercise is used at the beginning or the end of daily sessions, it is intended to open or close a daily schedule. The main objective of the game is for participants to tune into the day or recap and reflect on lessons learned at the end of the day.

In the Log in/Log out exercise, the facilitator asks simple questions to encourage participants in sharing short, concise answers. Example questions include How are you feeling right now? What is your biggest challenge as a leader? What did you learn today?

This exercise also helps the facilitator to get a feeling of the room.

VIII.2.2. Appreciative inquiry ("Let me introduce you to…")

This activity can be used at the beginning of the Leadership School, it works well as an ice-breaking exercise. Its main objectives are for the participants to get to know each other, establish a positive mood in a group, and improve their interaction. In this exercise, participants practise their leadership skills such as active listening, communication, and appreciation of the positive features of another person. It will also provide the first platform to speak in front of other participants.

The participants are given cards or equivalent objects. Their task is to find another person in possession of the same object. Once the participants have identified their partners, they will be asked to conduct short mutual interviews with a set of given questions. The questions are always positive, related to the good aspects of the partner. Example questions include what your hidden superpower is; what you like the most from your organization as well as what is your one expectation for the training. Following the short interview, each participant introduces their partner to the group.

This game provides guidance to engage participants in a thoughtful conversation, impacts positive thinking and shifts their perspectives. The primary purpose for discussing conclusions is to encourage discussions with different and independent ideas supported by reasoning.

VIII.2.3. Emotional thermometer

The main objective of this activity is to construct a graphic illustration of the energy and emotional status of the group. Although the activity is designed to understand and capture the overall mood of the participants, it also assists in reflecting on the impact of emotions on behaviour and results.

Each participant is asked to rate their emotional status on a graph where axis *y* measures energy and axis *x* measures feeling. The final graph illustrates the emotional temperature of most of the group, for example. turquoise will show maximum energy and most pleasant mood. The facilitator uses the emotional thermometer to see the overall mood of the group.

Emotional intelligence is the ability to understand and manage your own emotions and understand those of the people around you. People with a high degree of emotional intelligence know what they are feeling, what their emotions mean, and how these emotions can affect other people and their decisions. For leaders, having emotional intelligence is essential for success. Effective leaders not only manage their own emotions, but they have empathy and effective relationships with their co-workers, family and friends.

VIII.2.4. Reflective team

The main objective of this exercise is to facilitate storytelling and learn from personal experiences from senior facilitators. The purpose is also to share views and understanding through respectful communication that makes it easier to be open to each other.

The activity is based on the senior experts sharing and discussing their personal experiences related to leadership for safety. During the session, the participants are silent but active listeners, and their task is to detect as many relevant details related to leadership in nuclear safety as possible. This part of the exercise is followed by a discussion on key messages drawn from these stories by participants.

This activity aims to show that every organization has stories about heroes and villains, and often new staff are taught about the culture via those stories. The stories a leader shares in the organization or department form its culture. Leaders for safety are responsible for choosing the messages to share. The exercise is based on the fact that people learn through listening and compassionate feelings.

VIII.2.5. Exercise on leadership (leadership triangle)

The main objective of this exercise is to present the importance of connectivity. It aims to bring participants' attention to the interdependency of smaller and bigger parts of the system or organization. This practical activity is designed so that the participants gain a better understanding of the effect that every action, movement, or decision has on the whole system. It promotes a systemic approach and teaches participants to balance the need of performing the task taking into account quality criteria.

The activity starts with participants roaming until told to stop. They are instructed to choose the other two participants and move accordingly to form a perfect equilateral triangle. They cannot speak with each other. They are allowed a couple of minutes, and the facilitator controls whether the triangle is truly equilateral. If anyone in the triangle need to correct their positions, the whole group will have to start again. In the second part of this exercise, the facilitator chooses a sample of participants and asks each one to move to a different position. That creates chaos, and other groups have to move consequently when necessary to form equilateral triangles again.

This session can be followed by personal reflection or group discussion on the importance of connectivity, collaboration and a systemic approach in teamwork and leadership. The activity showcases that in order to achieve the common objective and establish synergy, alignment of strategies, goals and plans are needed.

VIII.2.6. Team building activity (cup play)

The main objective of this activity is to experience team cooperation and practise good communication in difficult situations and under pressure. It also aims to highlight the importance of trust in leadership.

It is an active group exercise that takes place in an open space, where each team is assigned to one maze made of cups. Within each team one member gets blindfolded and is guided towards a set object by the rest of the group. Team members can communicate with their blindfolded colleague following certain rules. For example, only verbal instructions can be used, steering by touching and reorganizing the cups is not allowed. Team that finishes the task first without touching any cup is the winner. During the exercise, the facilitator observes each team's communication, how many team members are giving instructions to their blindfold teammate and what is its impact on that team member. Those observations are reported and discussed in the follow up discussion involving all participants.

This exercise brings the participants' attention to four, important components of leadership; communication, cooperation, ability to build trust and to manage competing goals. Firstly, communicating under pressure is a critical leadership component. Effective communication might be an early causality under stressful conditions. Communication problems can lead to misunderstandings that could cause even more stress and lead to unsafe situations. The words and tone of voice significantly impact on how people perceive the leader. Secondly, teamwork and cooperation are essential parts of workplace success. Learning the value of teamwork and becoming an effective team member is an important first step for developing leadership skills. Furthermore, trust is the foundation of leadership. It is very important that a leader trusts their team, and that the team trusts their leader. To build trust, a leader has to exemplify their qualities and character.

VIII.2.7. Master Frogger

The main objectives of this activity are to reflect on systemic relations in management systems, strengthen cooperation among team members and balance between production and safety.

The facilitator explains that all groups reached a semi-final in the Master Frogger contest. The teams are taught to build an origami jumping frog. Following the introduction, teams are given the instructions. Each group will have to build a set of frogs, paint and decorate them following an exact model. The team members have to keep in mind that the marker pen is radioactive, so any incorrect manipulation like keeping it open too long or not alternating the user "contaminates" the hand next to it and cannot be used in the rest of the exercise. Another rule is for the frogs to jump at least 1 cm. Each team has to 'bet' how many complete, well designed, and jumping frogs can finish in 5 minutes. They are given a limited number of papers to build those, and therefore mistakes are not allowed. During the activity, the facilitators will observe the group dynamic and mark any contaminated hand they see. After 5 minutes, those jumping frogs that are good and well-designed count (usually around up to two points per team).

In the system, all elements are very intricately connected and constantly interact with each other. It needs to be carefully considered while making decisions. It helps to manage the change within the organization or a team.

It is useful for leaders to understand the relationships between every element interacting around them, from personnel and structure to systems and finances. Each minor change in a moment and place has an impact on the other parts of the organization.

VIII.2.8. Press conference

The main objective of this role-play activity is to highlight challenges that are expected to emerge in public communication as well as to bring participants' attention to the importance of developing a shared understanding with internal and external stakeholders. This activity is designed to demonstrate the importance of using plain language in sharing technical information that can be easily understood by all stakeholders including the public.

In the Leadership School, this activity mostly follows Case Study 3: Response to a leak of Radioactive Materials to the Environment. For this exercise, participants are assigned into groups. Their task is to prepare a press release following a specified emergency. Another team plays the role of local authorities or of stakeholder groups with opposing opinions. The task of this team is to prepare difficult and challenging questions. In order to deliver an effective public and media information response to an emergency, communications need to be coordinated at the national level, to avoid contradictory messages and misinformation between national organizations involved in the response. Local authorities are expected to communicate about what they are doing to respond to a radiation emergency. Residents and the media will seek out local officials for both information and services in all phases of the emergency, but most intensively if there is an evacuation or in the recovery phase, where long term measures could be required for the affected community.

This simulation equips the participants with a toolkit for public communications in an emergency. It needs to be followed by the opinion of the observers as well as reflection and group discussion [16].

VIII.2.9. Safety Path

This activity is used to illustrate teamwork and the ways human factors impact processes and work within the organization. It also aims to encourage a better understanding of diversity at the workplace as well as practise the identification of alternative and creative solutions to solve problems.

Each team's task is to carry a small ball from one end of the road to the other without touching the lines that limit it. Everyone has to participate, and each team needs to choose: one blind member, a one-armed team member and one mute person. Two observers evaluate the safety and quality of the opposite team. Reflections and group discussion follow the exercise.

Safety Path showcases that each person within the organization can contribute, and diversity provides different perspectives, and approaches to challenges. It can help foster an environment of cooperation, boosting morale in the process.

VIII.2.10. Shock Therapy (Manolito)

The main objective of this game is to reflect on the effects that unexpected shock can have on our interactions. In addition, it aims to help participants to understand key aspects of leadership for safety related to emotional intelligence and emotional self-control that help manage safety as a leader.

For Shock Therapy, the participants are placed in two symmetric rows facing each other and looking each other in the eye in absolute silence. They are told to approach each other until they reach the limit of their comfort zone. They are informed about the importance of sharing and trust. Then, participants are asked to share a shocking or embarrassing experience, however, they get interrupted

before the sharing can happen. Afterwards, participants are encouraged to share independent ideas on their feelings and reasoning for specific reactions.

This exercise activates the emotional part of the brain, which regulates the fight or flight response. When threatened, it can respond irrationally. This can feel frightening because of a sense of loss of control. In this activity, participants learn how to deal with sudden stress.

VIII.2.11. The bonds of leadership (the rope exercise)

The objective of this exercise is to recognize the importance of leadership when a task needs to be accomplished. It encourages the participants to practise leadership skills in different situations considering the changing environment, lack of information available, as well as group needs. This exercise enables participants to practise communication and organization skills.

At the start of this activity, the participants walk around the room or distribute themselves randomly. They are asked to stop and put on a sleep mask. One end of the rope is given to one of them (this person will be the leader from that moment). They proceed to roll the rope around the participants; each of the participants has to be attached to the rope, creating an interdependent net. The leader then provides instructions to participants to get free of the net following three conditions: every participant has to hold one part of the rope with both hands; the leader has to maintain both extremes of the rope together in every moment during the exercise; only the leader can speak. Participants have to follow these instructions. The exercise is followed by reflections and discussion to uncover lessons learned. This exercise illustrates the importance of vision and communication in leadership.

VIII.2.12. Safety Our Priority Aircraft Manufacturer Company (SAMCO)

This exercise is used to illustrate the priority of safety, using an example from the production process. The main objective of this exercise is to recognize the importance of fostering open and constructive communication in the organization through formal and informal channels. It deepens participants' knowledge in management and change management. It also provides an opportunity to practise leadership tools that can facilitate open and constructive communication as well as improve communication and organization skills.

The participants play different roles in an aeroplane manufacturer, with at least two observers. The new CEO (facilitator) introduces themselves and orders the participants to develop a new aeroplane model. The new model has faults and problems that are discovered, and the organizations need to determine the challenges and solve them. To get the solution the team needs to practise different internal communication approaches.

VIII.2.13. Field Exercise: lost radioactive source

The main objective of this exercise is for the participants to locate and rescue a lost radioactive source. The exercise develops organizational skills, ability to make decisions in stressful situations, analyse roles, communication dynamics and group decisions.

When used during the Leadership School hosted in Mexico, the exercise involved participants split into two teams, each of which had to find and retrieve planted orphan sources (e.g., cobalt, caesium). They had to familiarize themselves with the detection, characterization, and removal tools, organize themselves with different emergency roles and proceed to find and return the source to a safe condition.

VIII.2.14. Tribes of different cultures (the chosen three)

The objective of this game is to improve understanding of the impact culture has on leadership and cooperation. The activity also aims to develop cultural and bias self-awareness and appreciation for diverse standpoints; it also illustrates the influence of culture on individual and group behaviours. Furthermore, it assists participants in recognizing the need for adaptation when the environment changes.

During the exercise, participants are assigned to different teams. Each team has their own culture, and they are given a description of their characteristics. Each culture is hugely different from the rest, with established rules and traditions. Their task is to cooperate closely and build a complex item to save the world. The three civilizations will have to work together to get a common goal: build a rocket, or ship, to leave the planet. The activity is followed by reflections and group discussions.

Every organization develops a culture based on its operational success, which is referred as the 'operator culture'. We can identify an operator culture in a nuclear power plant, a chemical complex, car manufacturing plant, aeroplane cockpit, and the office. Organizations also have designers and technocrats who drive the core technologies, which could be referred as 'engineering culture'. Finally, every organization also has its management, which we refer to as 'executive culture'. Organizations will not learn effectively until they recognize and confront the implications of the three cultures. Until executives, engineers, and operators discover that they use different languages and make different assumptions about what is important, and until they learn to treat the other cultures as valid and normal, organizational learning efforts will continue to fail [17].

VIII.2.15. Coaching exercise (SMART)

This exercise is used to facilitate planning for future use of the tools gained, and lessons learnt.

Participants work in pairs and are asked to come up with two actions they will start in their day-to-day role as a result of the course. Those actions are to reflect their commitment to leadership for safety. Those day-to-day actions are shared with the rest of the group. The goals would follow SMART methodology (specific, measurable, attainable, relevant, time-based). One person changes their role to a mentor and by using questions and comments, helps discuss and verify or rethink the goals to guarantee they are SMART. At the end of this exercise, volunteers share their actions and goals.

This exercise aims to equip the participants with a solid tool to translate goals into commitments and actions. Defining SMART goals makes the probability of success more likely.

VIII.2.16. Observing points

The main objective of this activity is to improve observation as well as coaching skills for promoting better standards of safety. In addition, it encourages the participants to seek consultation, communicate and build trust within the team.

The exercise can be done individually, in pairs or small groups. During the activity, participants will be encouraged to look at photographs from an actual workplace, consider human, technology, organization interdependencies and how they impact safety in the workplace. Their observation is then shared with the group and discussed. Each group or participant will develop a concept on how to coach workers in each of the situations pictured. It is a valuable tool to enhance careful observation of safety at work. It provides the opportunity for leaders not only to understand the situation better but to establish constructive conversations with workers.

This exercise focuses on observational skills, which are another important tool for safety leaders. It provides the opportunity for leaders to observe reality and establish constructive conversations with their teams. The role of leaders is to focus their attention on the technical part of tasks and, also, to see how people behave, where they put their focus and how relations are being developed. The practice of observation will provide leaders with specific facts that will help people to improve and pay attention to what is expected in order to develop individual and institutional values and expectations for safety throughout the organization and encourage and support individuals to act safely.

Additionally, this exercise brings participants' attention to the importance of coaching. Leaders are expected to act as mentors and coaches and help others improve and develop by them. Coaching is based on appreciative inquiry, not only to discover reasons for doing things but also to demonstrate true care and attention to people. During observations in the field, the leader has the perfect opportunity to approach workers in a humble manner to really understand their work, show care for them and provide support for their improvement.

Nuclear safety has traditionally focused on what is going wrong in order to fix it and avoid repetition of events. However, it has been demonstrated that humans learn much better when the focus is put on what they do well, so they can obtain a reward or recognition for that, and consequently, the probability of repeating that behaviour increases. Through the observation and recognition of safe behaviour, leaders have the opportunity to increase the probability that such behaviour will be repeated. In addition, these positive experiences will provoke the enhancement of personal satisfaction and willingness to contribute more.

VIII.2.17. Change your cap, change your mind

This role-playing exercise focuses on observing skills in the field. Its main objective is to enhance observation skills as well as coaching tools to achieve better standards of safety. It also encourages participants to develop individual and institutional values and expectations for safety throughout the organization as well as share those with individuals and support them in acting safely.

The activity requires four volunteers to take up roles of four characters: the supervisor, the worker, the manager of the working area and the observer. After the exercise, the floor opens for a broader group discussion and feedback on what was done well and elements that could be improved.

This exercise supports leaders in developing new tools that includes careful observation, coaching, active listening as well as appreciative inquiry.

VIII.2.18. Ball together

This team-building activity's main objective is to encourage participants to behave like a team to achieve a common goal, practise communication and organizational skills as well as motivate strategic thinking to improve processes at work.

Ball together is an active exercise where participants need to pass balls in the shortest time possible. After the trial run, they are challenged to perform better, and it leads to a change of strategy due to critical thinking and a challenging goal being put forward by the facilitator. After the exercise, participants are asked to reflect on teamwork and critical thinking. Questions that lead the group discussion vary, for example, How do you feel when getting the goal improved? How many of you thought that the goal was not achievable? What happens when we go into a competition or challenging mode? or How is it to think outside of the box?.

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