Laser based applications: Existing and Future Solutions.

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New Challenges in Safeguards

Surveillance, containment and NDA measurements

>> "Continuity of Knowledge" (CoK) between 2 inspections

Facilities are getting more and more complex

• Number and complexity of facilities are increasing
• Number of inspections days should be reduced..
New Challenges in Safeguards

IAEA SG needs to address these 2 challenges: continuously improve the effectiveness.

New techniques need to be:
- evaluated,
- presented to the operators
- implemented.

Laser based application present wide variety of possibilities:
- Some are already used
- Some are future – but very promising test results
Laser based applications: Existing and Future Solutions:

- 3 Dimensional Laser Range Finder (3DLR)
- Outdoor Verification system (OVS)
- Combined 3DLR with radiation map
- Laser Item Identification System for UF6 Cylinders,
- Laser Mapping for fuel packaging,
- Laser Surface Authentication for metal seals verification
- Light Detection and Ranging (LIDAR)
- Tunable Diode Laser Spectroscopy (TDLS)
Laser based applications: Existing and Future Solutions.

Design Information and Verification (DIV):

- in vast and complexes facilities,
- with infrequent access possibility,
- loss of knowledge along the years,
- rotation of inspectors,
- huge amount of data…

Facilities are getting more and more complex

- Improving DIV activities
- required a “tool“.
Laser based applications: Existing and Future Solutions.

The Tool & the Need:

Automate the capture of the design:
- To increase the accuracy of the Design Information original verification,
- To increase DIV effectiveness.

Automate the verification of the design:
- To reduce the data acquisition time at facility,
- To reduce the data processing effort.
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Dedicated tool:

- based on a 3 dimensional laser range finder,

- with safeguard adapted software (developed under the European Support Program to the IAEA).

IAEA Inspector setting up the 3DLR acquisition.

Courtesy of the EC/ IPSC/ JRC Ispra, IAEA SGTSR.
Laser based applications: Existing and Future Solutions.

The 3DLR is used in Rokkasho reprocessing plant since May 2003 first demonstration.

Cells were scanned during construction and again just before closing,

Design Information data were compared, then stored at facility under joint seals.

IAEA Inspector performing a 3DLR verification.
Courtesy of the EC/ IPSC/ JRC Ispra, IAEA SGTSR.
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In 2007, what is new?

© Combined 3DLR with radiation map

Merging 3D models with:

- Gamma ray map,
- Infra red map...

Courtesy of the EC/IPSC/JRC Ispra, LLNL and ORNL.
-AVI animation can be presented after the presentation-
In 2007, what is new?

Outdoor 3DLR?

Perform eventual outside facilities building DIV.

Use the same concept:
- 3-Dimensional laser range finder
- with broader range,
- coupled to digital camera
- linked to a positioning system → enabling scanning in movement
The 3D-laser scanner image of the reflection of the object function of the light intensity

Entrance from the Vienna International Center; IAEA headquarters
Scan courtesy of the EC/IPSC/JRC Ispra
The digital camera mounted on the top of the laser scanner captures 7 pictures at each scanning point, during the data processing overlaid on top of the 3D data.
Construction of a 3D model:

*virtual but almost real!*
Laser based applications: Existing and Future Solutions.

Outdoor 3DLR demonstration: IAEA head quarters in Vienna

11 range scans
77 colour pictures,

Making of movie
Can be presented
After the presentation.

Courtesy of the EC/ IPSC/ JRC Ispra IPSC, V Sequeira.
Scanning points

- G-3 and driving around F&G
- A28
- D22
- Gate 1

© Outdoor 3DLR
Laser based applications: Existing and Future Solutions.

Item tracking

- Number of facilities is increasing
- Number of inspections days should be reduced.

- Develop or improve
- New surveillance and containment techniques
Item tracking: UF6 cylinders identification:

• in Enrichment facilities,
• monitoring the UF6 cylinders movement,
• without relying on any
  ✓ existing or
  ✓ additional tagging.
UF6 cylinders identification:

Systematically referencing of all UF6 Cylinders:

- delivered (shipping in)
- declared to be used in the coming months.

Unattended scan of transported cylinders entering and exiting the process area.

IAEA/ SGTS/ M Lang.
UF6 cylinders identification:

The Technique:

- based on a triangulation laser scanner
- with safeguard adapted software (developed under the European Support program to the IAEA).

The Laser Item Identification System (L2IS)

UF6 cylinders identification: Laser Item Identification System (L2IS)

First application: trial in Rokkasho enrichment plant September 14th – November 9th 2007.

UNIT 1 Records & Identifies all cylinders declared to be “used” by the operator

UNIT 2 Verifies that all cylinders “used**” by the operator are matching the declaration list of operator’s declaration.

Under Trial
UF6 cylinders identification: Laser Item Identification System (L2IS)

Standard video surveillance (SDIS camera)

L2IS UNIT2 cabinet.

SDIS Surveillance server connected to the L2IS unit 2 and transmitting State of health over PSTN line

UF6 Cylinder being moved from/to storage area, to/from the process area

Standard video surveillance (SDIS camera)
Current stage of the trial:
- Portable unit 1 is operational,
- Installed unit 2 needs to be adapted to:
  - Cope with the distance between scanner and smaller cylinders
  - Scan cylinders without stopping the transported cylinders

Milestones:
November 2007: data retrieval after 60 days initial trial period
March 2008: Upgrade of unit 1 and unit 2 to cope with the facilities geometrical constraints (REP)
April 2008: Second phase of aging test
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Develop and implement new containment verification techniques

- between fuel fabrication plant
- and receiving plant
- verifying the surface and welding

Laser surface mapping
Laser based applications: Existing and Future Solutions.

Laser surface mapping for fuel packaging

- Systematically referencing all packaging
  - meant to be used for the fuel shipment
  - Part of sealing arrangement
  - Proof of integrity of the entire container surface incl. welds

- Random verification
  - at receiving facility
  - the surface,
  - and welding

Courtesy of the EC/ IPSC/ JRC Ispra IPSC, V Sequeira.
Laser surface mapping for fuel packaging

1. Tampering
2. Re-welding
3. Painting
4. Verification scan: impossible to hide the surface deformation

Pictures Courtesy of the EC/IPSC/JRC Ispra IPSC, V Sequeira.
Laser surface mapping for fuel packaging

Current stage:
- Demonstration performed September 2007 PFPF.

Milestones:
- November 2007: expected report from EC/JRC Ispra.
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Improve existing containment verification techniques effectiveness

- Automate the metal seals verification
- Offer on site / on the spot verification

**Laser Surface Authentication (LSA®):**

Laser beam produces speckle light from the microscopic surface

→ ‘fingerprint’

[Surface Roughness at Laser Wavelength Scales - Photo Courtesy of Ingenia Technologies Limited.]
Laser Surface Authentication for Metal seal Verification:

- counterfeit resistant signature
- low cost
- Small amount of data

Current stage:
- initial feasibility assessment for LSA successfully completed,
- third party design vulnerability assessment is in progress.

Milestones:
- 2008 First prototypes in IAEA HQ
- on-site and/or in-situ verification …
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Measurement of UF6 at enrichment plants.

Development of an instrument:
- foreseen to determine in UF6 on-site
- expected accuracy < 1% for 235U

Tunable Diode Laser Spectroscopy (TDLS):

Diode lasers access specific regions of the mid-infrared spectrum where most gases of interest have strong absorption while common gases, such as oxygen and nitrogen, do not have strong absorption.
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Tunable Diode Laser Spectroscopy (TDLS):
• Extreme sensitivity (~ ppb concentration range)
• quick measurements
• high spectral resolution in the IR range,
• no special safety measure for operation,
• inside and outside a facility,

 succèsful portable TDLS system was successfully demonstrated to detect ppb concentrations of HF.
Light Detection and Ranging (LIDAR)

Detecting the presence and nature of nuclear process activities at suspected nuclear locations using light detection and ranging (LIDAR)

1. A mobile LIDAR laboratory travels to the vicinity of a suspected location.

2. A laser, tuneable to precise wavelengths, selectively stimulates specific airborne molecules that emanate as gaseous compounds from nuclear processes.

3. A light sensitive telescope scans the stimulated atmosphere, detecting the presence, or absence of the stimulated signature molecules.

4. The returned light from the atmosphere is analysed, identifying the compound type and the location of its source.

Source: RF MSSP
Conclusions

Laser based applications

- Existing: 3DLR, L2IS
- Development / Evaluation: OVS, Gamma Ray mapping, Laser surface mapping
- Future techniques: TDLS, LIDAR.

will play an increasingly role in

- both the provision of appropriate verification
- and detection tools for current and future safeguards activities.
Conclusions

IAEA SG Technical Support’s guidelines:
- Use of the shelves equipment
- Adapt to the technical need
- Comply to the IAEA SG requirements
- Present and install at facilities

Most of these new techniques:
- Part of the SG at enrichment plant’s “toolbox” project,
- Supported by Member state support programs:
  • funding,
  • research institutes and laboratories,
  • trial hosting at facilities.
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• OVS

3D Reconstruction in Nuclear Security
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• 3D Gamma map
Combined Measurements with three Dimensional Design Information verification system and Gamma Ray Imaging
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C Coates, S Smith, J Hines, A C. R. Caiado : ORNL,
V Sequeira, M Fiocco, J Goncalves: ECJRC Ispra-ISP.

• L2IS

• Laser Surface Mapping

• TDLS:
Annual Report-WG-TDLS for IAEA SG
Scan duration (for standard 360° x 182° scan)

Reference scan:
- Super High Resolution 20,000 x 10,111 points 6m 44s
- High Resolution 10,000 x 5,055 points – 3m 22s Average of 6 scans / cell: 1 to 2 hours (access conditions)

Verification scan:
- Super High Resolution 20,000 x 10,111 points – 6m 44s
- High Resolution 10,000 x 5,055 points – 3m 22s
- Middle Resolution 5,000 x 2,527 points – 1m 41s (Mostly used for IAEA SG)