IAEA SAFEGUARDS EQUIPMENT

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IAEA

Atoms for Peace: The First Half Century
1957–2007

Safeguards Objectives

Safeguards are applied by the IAEA to verify the *correctness and completeness* of declarations made by States about the *exclusively peaceful use* of their nuclear material and activities and thereby reducing the risk of proliferation of nuclear weapons.

SG Implementation

- ~ 900 locations worldwide with various NM (different chemical/physical properties)
- ~ 2,100 inspections/year
- Limited funding ~ 130 Mio Euro annual budget
- Growing workload with limited budget increase
- Discovery of clandestine nuclear programmes

  → Strengthening efficiency and effectiveness

  - Additional Protocol
  - Integrated Safeguards (IS)

IAEA SG equipment/techniques in use

Wide variety of safeguards equipment/techniques such as:

- **Non Destructive Assay (NDA)**
- **Containment and Surveillance (C/S)**
  - **Seals**
  - **Cameras**
  - **Containment verification**
- **Destructive Analysis (DA)**
- **Environmental Sampling (ES)**

Non-Destructive Assay equipment

~100 different types of NDA equipment :

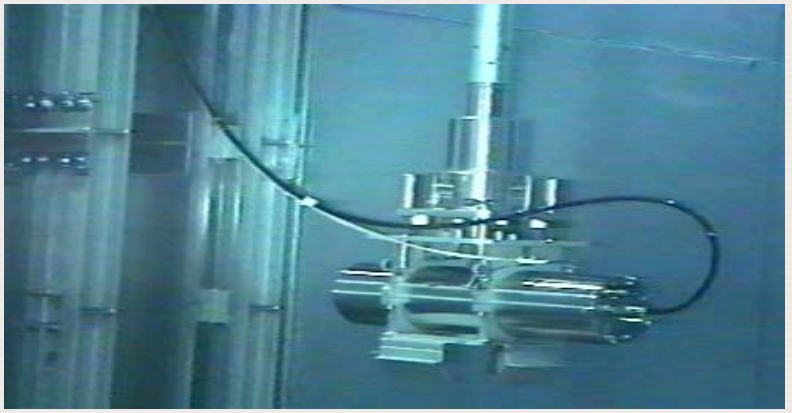
- Quantitative and qualitative verification of Plutonium and Uranium in nuclear materials
- Gamma and neutron radiation detection
- Other physical property measurements (e.g. weight, volume, light, sound, heat)
- Attended and unattended mode

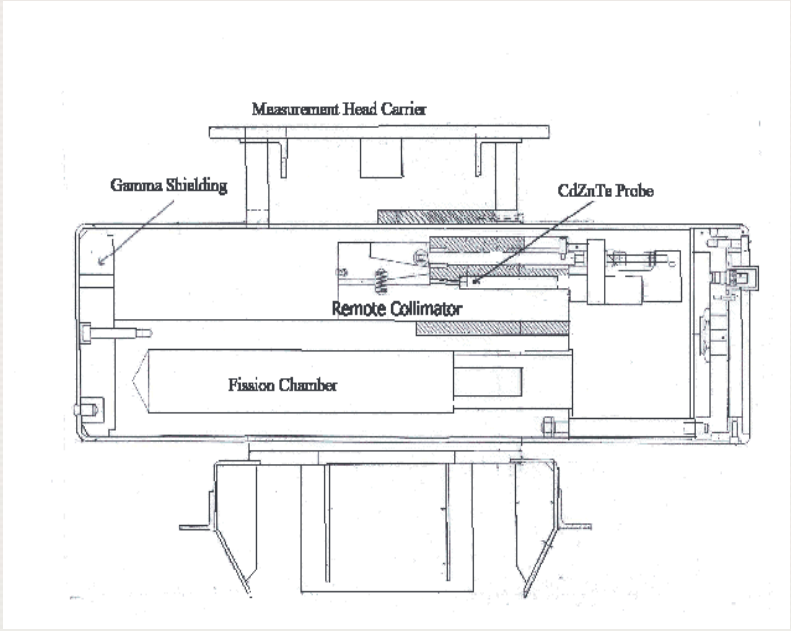
HM-5 Hand-Held Assay Probe

Portable hand-held gamma detectors for detecting presence and identifying nuclear and other radioactive materials

SMOPY Measurement Head

- Room temperature γ-spectrometry
- high efficiency FC
- Compact design (F160 mm, L 600 mm, weight 40kg)
- fits fuel handling tool and storage racks (positioning accurate with 0.5 cm)





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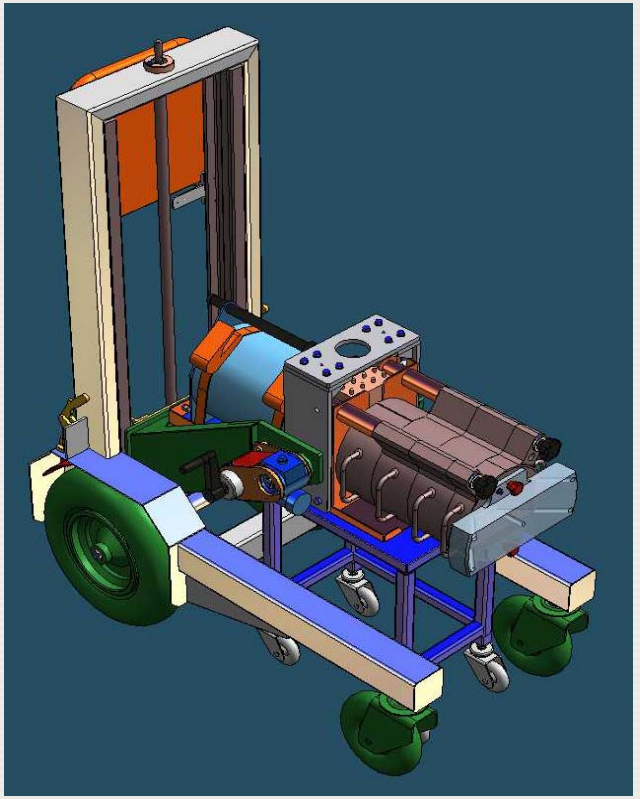
ISOCS (In-Situ Object Counting System)

- **Numerically calibrated Off-the-shelf spectrometric gamma system introduced in the Agency in 2003 for LEU hold up and waste measurements**



High Level Neutron Coincidence Counter - HLNC

Neutron Coincidence Counter, with He-3 detectors and coincidence counter electronics for verification of Pu bearing materials

Physical Measurements (Examples)

- Weighing for quantification
- Cerenkov light for spent fuel verification
- Volume and Concentration for solutions, e.g. reprocessing plants
- Laser based technologies
  - Identification (UF6 cylinder)
  - Tunable Diode Laser Spectroscopy (TDLS), HF monitoring, enrichment in UF6

Improved Detection Capabilities (General)

Considerations:

- Miniaturization bulky -> smart portable
- Robust with multi-purpose detection functions
- Wireless transmission to enhance inspectors' mobility
- Continuous gamma/neutron screening function with positioning information
- Neutron/gamma imaging and coincidences
- Use of liquid scintillators
- Increase in resolution and efficiency (CdZnTe, $LaBr_3$)
- Pattern recognition for Unattended Radiation Monitors (URMs)

Unattended NDA systems

Modern nuclear facilities, e.g. reprocessing, Pu fuel fabrication, are automated, implying:

- **Limited access to nuclear materials**
- **Networking and integration of verification and containment/surveillance**
- **Large amount of safeguards data to be securely handled**
- **highest level of reliability and quickly available resources for repair**
- **Standardization by universal acquisition platforms for containment/surveillance and non-destructive assay**

Unattended NDA systems

Increasing number of spent fuel (SF) transfers to dry storages require verification prior loading

- **Only unattended non-destructive assay and containment/surveillance can significantly reduce inspection effort:**
  - **Loading of spent fuel (VXI-based Flow Monitor(VIFM) + underwater TV)**
  - **Transfer of spent fuel (mobile unattended neutron-detector (MUND))**
  - **Loading to dry silo (direction sensitive silo entry gamma monitor (SEGM))**

Containment and Surveillance (C/S)

Complements Nuclear Material Accountancy:

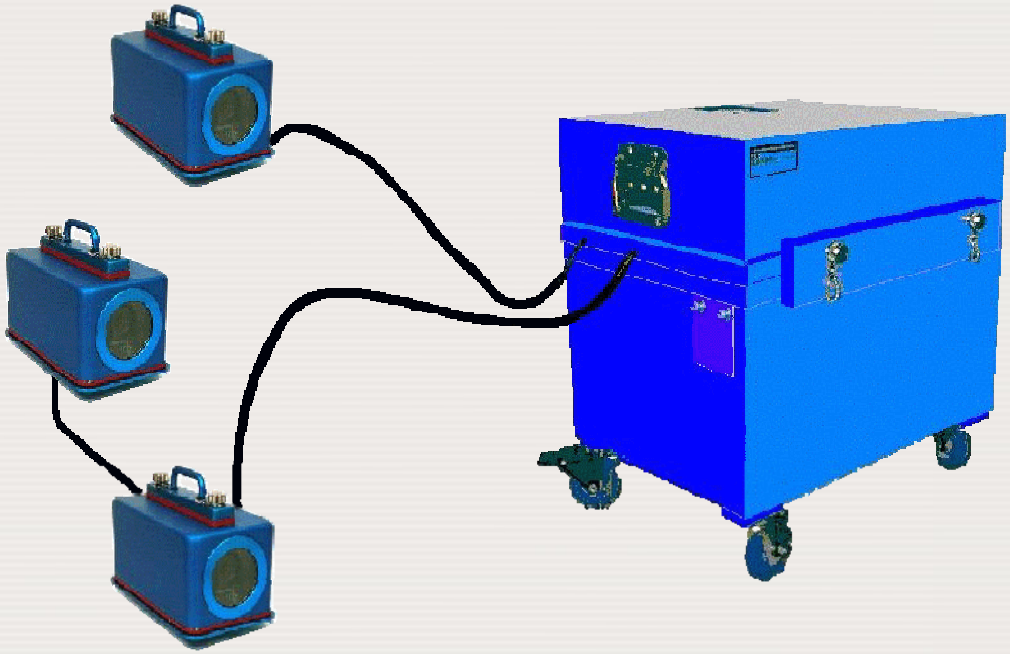
- Access controls to nuclear materials assuring continuity of knowledge and absence of undeclared operations
- Reduction of intrusiveness and inspection effort to carry out verification
- Monitoring of movements of nuclear materials, e.g. spent fuel
- Capability to detect diversion for some strategies not covered by Nuclear Material Accountancy verification
- Tamper indication

Surveillance

- ~ 1,000 cameras in use
- Single camera systems and multi-camera systems
- Radiation tolerant
- Main power but also some battery operated
- Based on DCM-14 digital camera module
  - includes transmission and storage of authenticated and encrypted digital images
- Increasing number for remote data transmission
- Will soon reach end of expected lifetime cycle
  - Next generation of surveillance systems (NGSS)

SDIS

(Server Digital Image Surveillance)

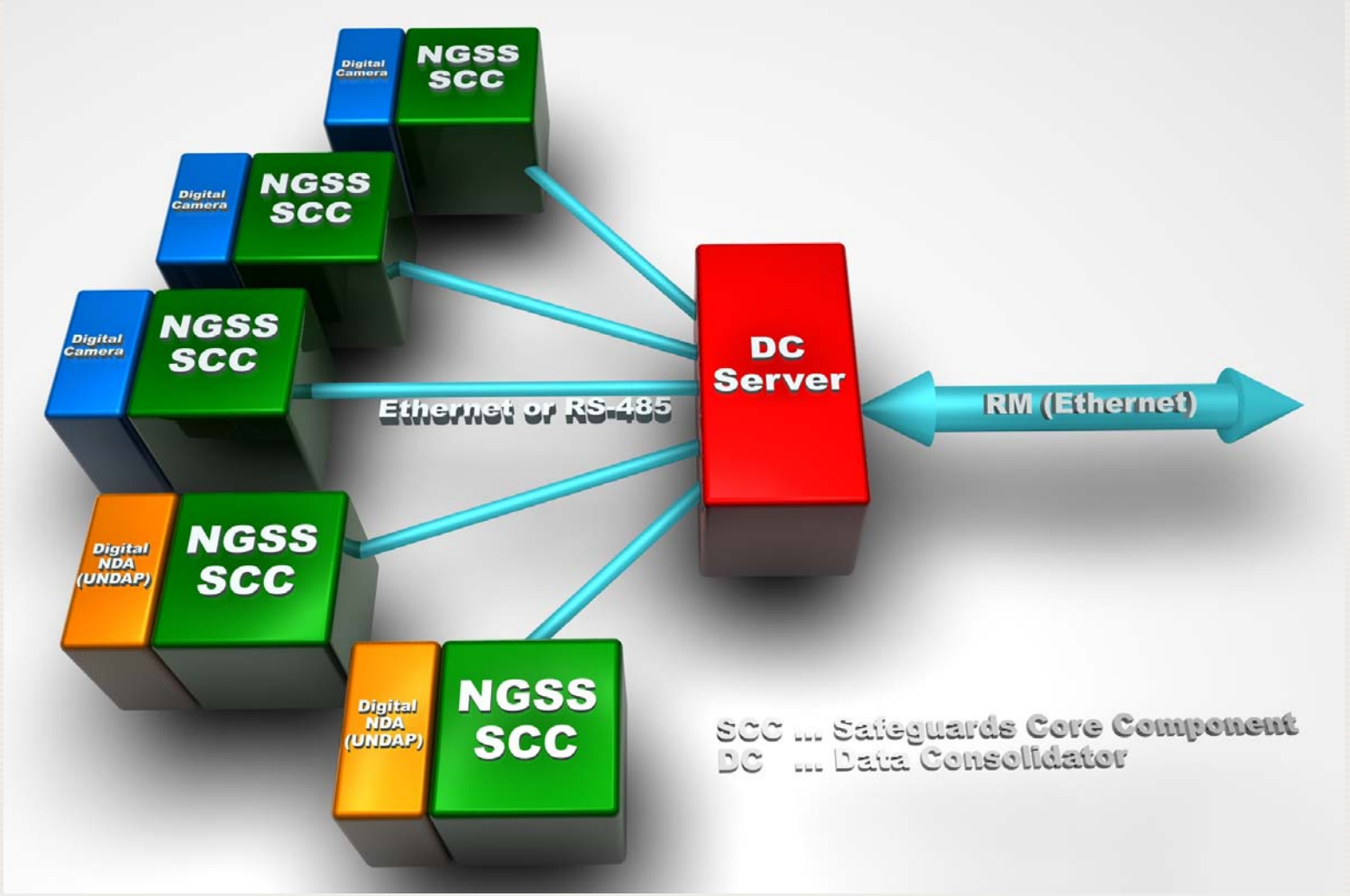


For Remote Monitoring and Unattended Monitoring applications in complex facilities requiring multiple (up to 6) cameras

Next Generation Surveillance Systems Design Goals

- Integration of camera head with the safeguards core component to diminish vulnerabilities
- Picture Taking Interval as fast as 1 image per second
- Support for high resolution and full color images
- TCP/IP networking over Ethernet
- Scalable removable storage media
- Low power consumption (48 hours on battery)
- High reliability under harsh environmental conditions (e.g., radiation)
- Co-existence of NGSS with DCM-14 (DIS)
- Commercial off-the-shelf and non-proprietary components where possible

NGSS Structure



Seals and Containment Devices

- Sealing system = containment+seal+wire
- Ensures continuity of knowledge of identity and quantity of sealed nuclear materials
- Every year IAEA applies ~ 20,000 metal seals, 15,000 adhesive seals and ~ 2,500 in situ verifiable seals
- Passive seals:
  - metal seal, paper seal
- Active seals:
  - Fiber-optic (COBRA, VACOSS, EOSS)
  - Ultrasonic (ARC)

EOSS Sealing System

Design Information Verification

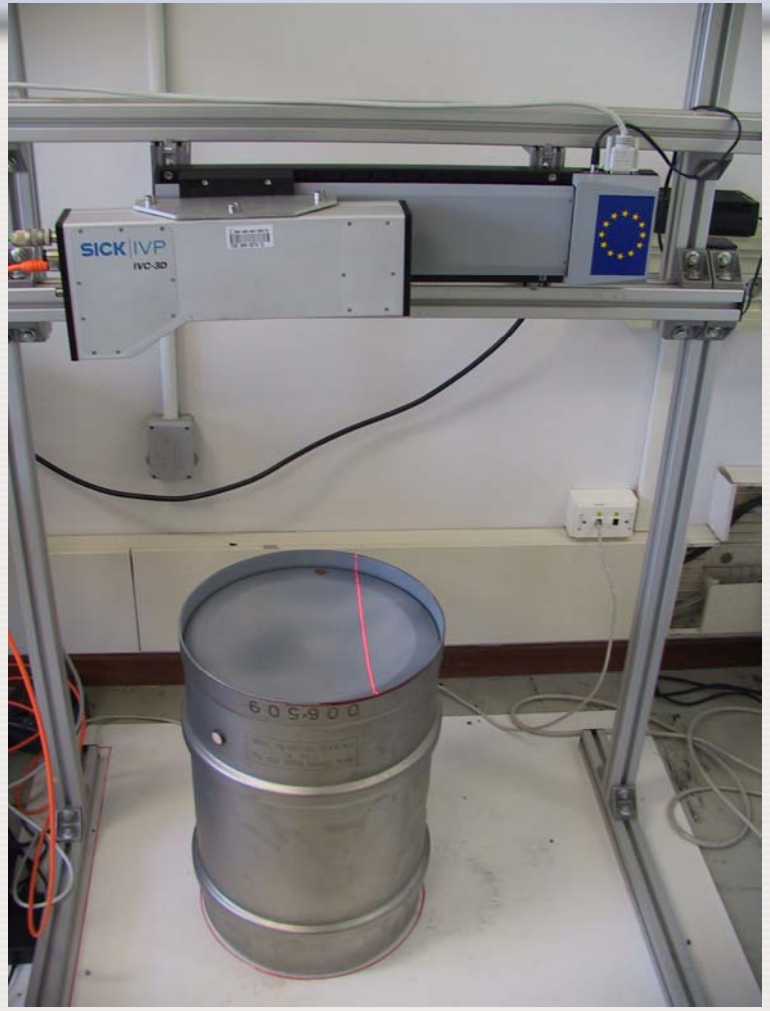
Design Information Verification (DIV) activities confirm that existing facilities are used as declared:

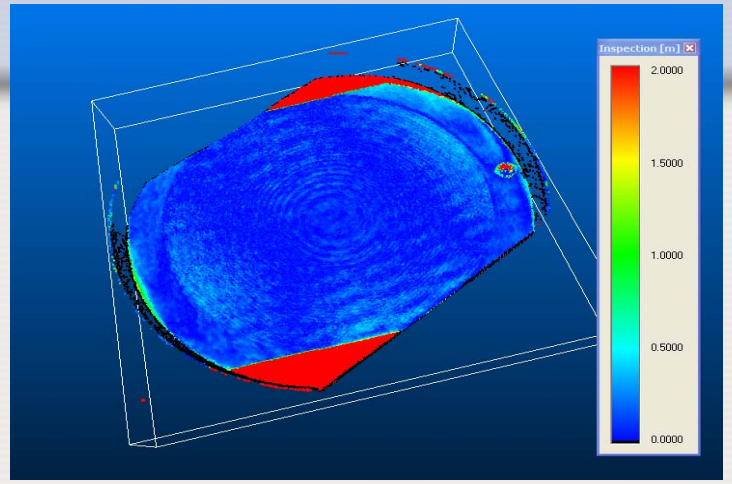
- **Past and present usage of nuclear materials by Environmental Sampling**
- **3D Laser range finder for structural changes**
- **Ground penetration radar to detect hidden objects/structures**

Containment Verification

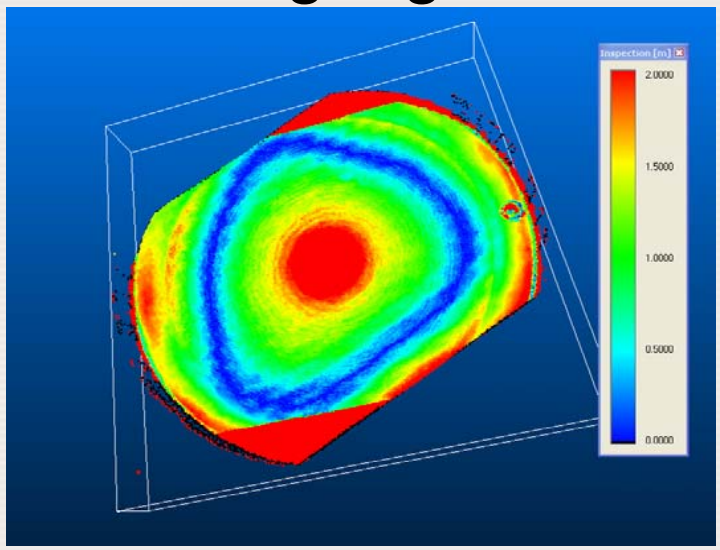
- Verification of entire container surface including welds
- Laser surface mapping system builds 3 dimensional model
- Detects slight imperfections remaining after tamper attack
- Provides unique identification

Laser Surface Mapping





Matching Signatures



Non-matching Signatures

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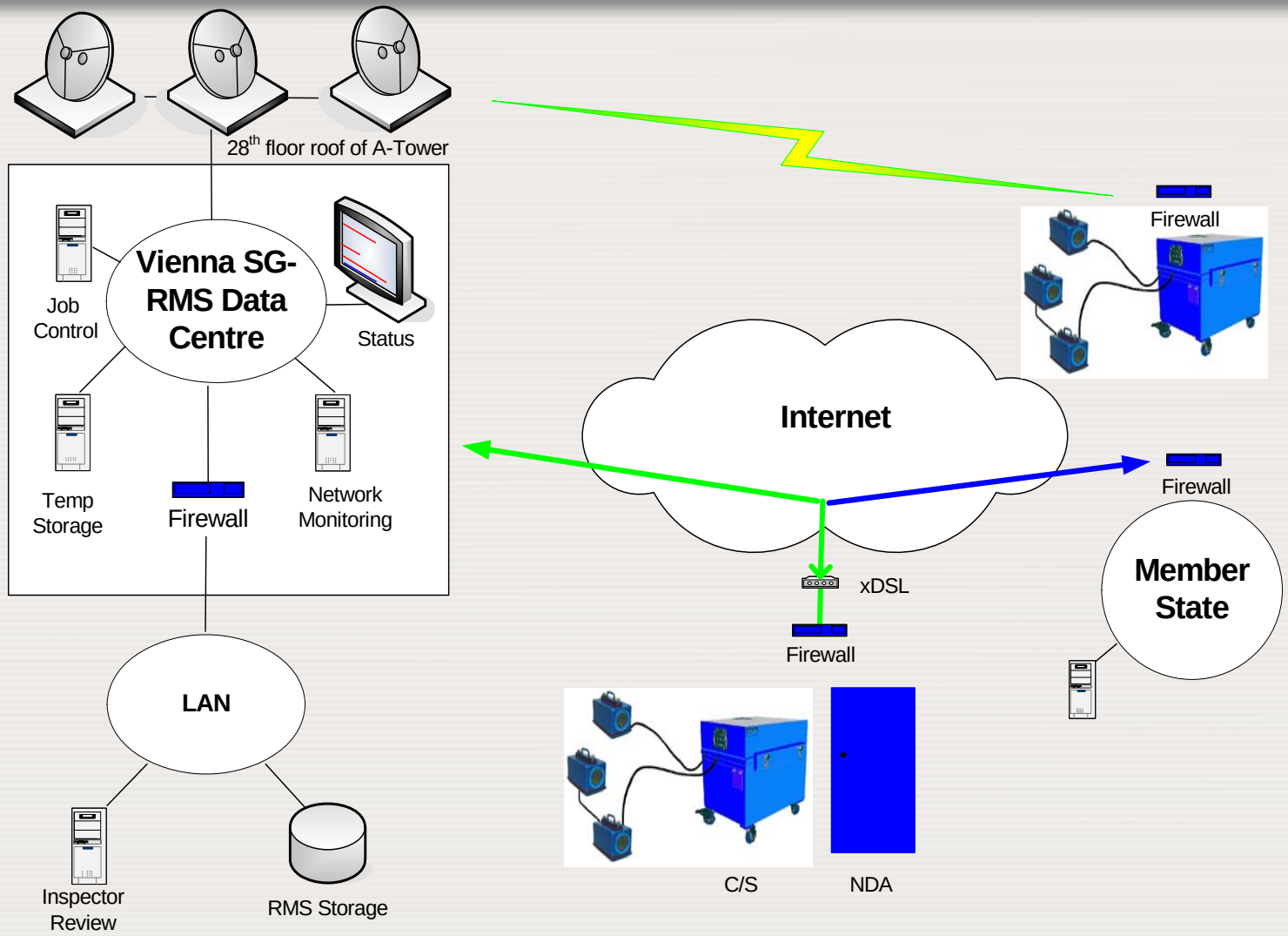
Remote monitoring

Provides containment/surveillance and non-destructive assay data to off-site location (field offices or IAEA HQ):

- **Reduced inspection frequency and shorter inspections**
- **Identification of surveillance failures at an early stage**
- **Corrective actions can be prepared before going to inspection**
- **Possible repair of remote monitoring system by remote control from HQ (no need to send technicians to the field)**
- **Review of data anytime in a clean office environment**
- **presently 140 systems (50 NDA & 90 C/S with 340 cameras).**

RM over Virtual Private Network (VPN) with Data Sharing



Future Challenges

Confirm absence of undeclared nuclear materials and activities:

- Verify non traditional elements/isotopes in Complementary Access activities (tritium, beryllium, americium, neptunium etc.)
- Differential LIDAR (light detection and ranging)
  - Detects from a distance trace level elemental or chemical compounds, e.g. Tributylphosphate
- Novel Technology programme recently established to address such challenges

Future Challenges (continued)

Environmental sampling:

- to determine past and present usage of nuclear materials
  - particle analysis has unmatched sensitivity
  - e.g. detects enrichment activities or reprocessing operations
- Limitations: costly and time-consuming
- Alternatives:
  - laser ablation spectrometers to reduce the increasing number of environmental samples on a case-by-case basis
  - optical stimulated luminescence to investigate the past presence of radiation emitting substances.

Future Challenges (continued)

Advanced Technologies for Enrichment and Reprocessing

- Unattended in-line non-destructive assay equipment to monitor flow and/or enrichment level
- On-site analytical capabilities (e.g. TDLS) for UF_6 measurements to reduce number of destructive analysis samples
- Wider deployment of remote monitoring systems to cope with "nuclear renaissance"
  - Reduce inspection costs and meet timeliness goal
  - High standards of reliability and data security required
- Integration of containment/surveillance and non-destructive assay using common acquisition platform.

Future Challenges (continued)

Verification of Disposition of Excess Nuclear Weapon Material:

- explore verification technology for use in future dismantling of nuclear weapons programs.
- provide a verification tool to draw adequate safeguards conclusions without disclosing and knowing the characteristics of the disposed nuclear material.
  - AVNG: **A**ttribute **V**erification System with information barrier for Plutonium with classified characteristics utilizing **N**eutron multiplicity counting and high resolution **G**amma spectrometry.

Conclusions

- Independent verification is a cornerstone of safeguards.
- Adaptation of existing instrumentation and development of new equipment is a must.
- Additional analytical capabilities, effective NDA and C/S techniques and equipment are indispensable to ensure the continued effectiveness and credibility of the safeguards system.
- Emerging challenges are to verify and detect declared und undeclared nuclear material and activities.
- High priority is given to improve verification techniques for enrichment plants and reprocessing plants.
- There is a clear trend for more extensive use of C/S and in particular of remote monitoring systems for future safeguards.