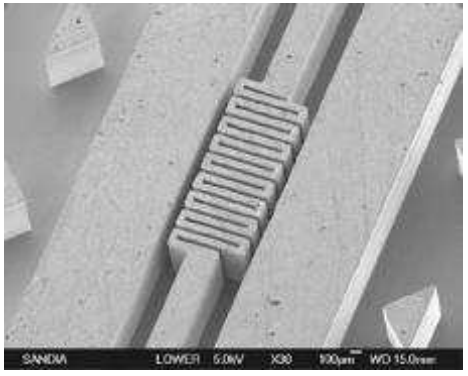
SAND2011-2643C

Challenging Design Projects at Sandia National Laboratories

April 2011



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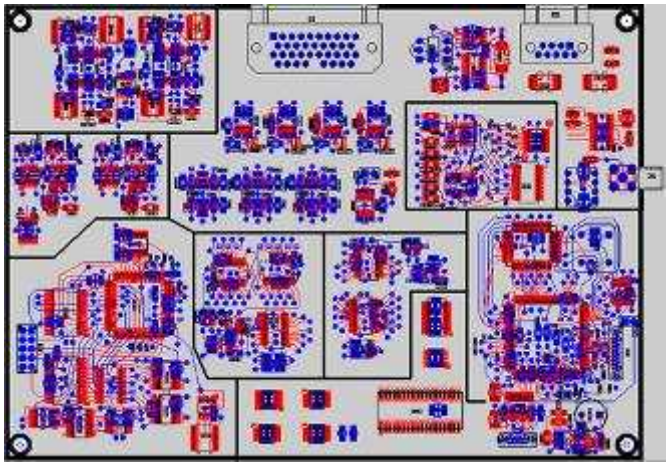
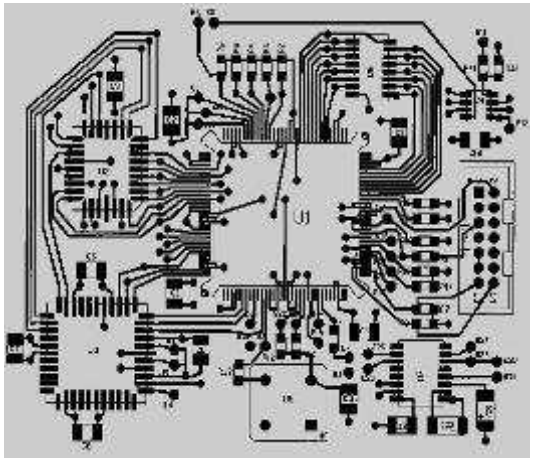
Sandia National Laboratories

Outline

- Engineering at Sandia National Laboratories
- Engineering challenges in national defense
- Engineering for arms control and nonproliferation

Electrical Engineering & Materials Science at Sandia National Laboratories





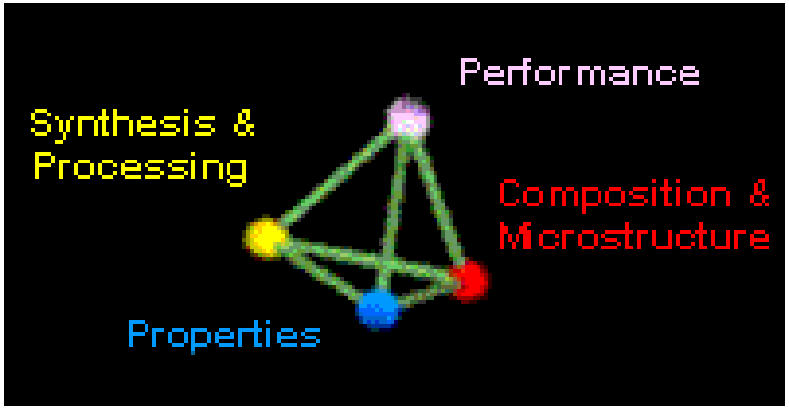
Sandia National Laboratories

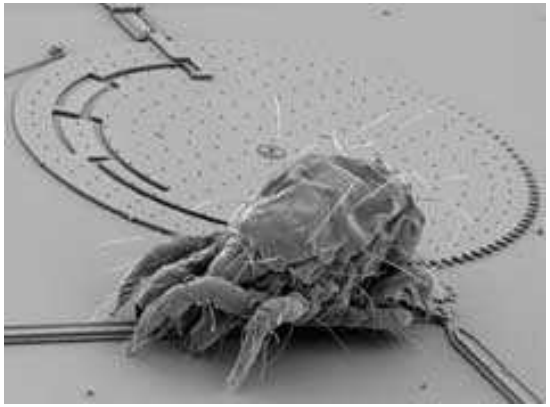
What electrical engineers do at Sandia National Laboratories

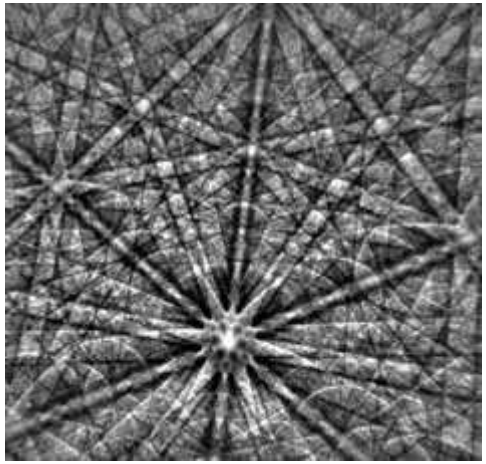
- RF
- Analog
- Digital
- Signal processing
- Embedded controllers
- Modeling & simulation
- Sensors & microsystems

What materials scientists do at Sandia National Laboratories

- Aging studies & prediction
- Materials compatibility
- New materials development
  - foams, composites, adhesives
- Test and characterization
- Materials chemistry
- Modeling & simulation
- Failure analysis







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Unmanned Aerial Vehicles – Global Climate Studies

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Flight Test Instrumentation for ICBM

- Shock
- Weight

- Volume
- Bandwidth
- Power, power, power

- Budget, schedule, performance
- Reliability

Engineering Challenges in National Defense

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Fleet Ballistic Missile Submarines: Trident SSBN's

Design Challenges

- Confined environment
- Salt water
- Continuous vibration
- Shock
- Radiation

- Virtually undetectable
- Extremely survivable
- Over 50% of US nuclear deterrent

Submarine Launched Ballistic Missiles

- Trident I SLBM Design Challenge
  - limited volume in submarine
  - non-aerodynamic shape
- Solution
  - aerospike mitigates shock

Submarine Launched Ballistic Missiles: 1st Sea Trial of Trident II (oops)

- Lessons learned
  - Unknown unknowns
  - Test, test, test (the Hubble Space Telescope syndrome)
- The problem
  - Water slams into nozzle
- The fix
  - Downselected from 26 ideas

Bombers & Gravity Bombs

- **B61 Bomb**
  - **parachute retardation or spin stabilized**
  - **high altitude or impact burst**

B-2 Bomber

Design Challenge

- **Discriminate a crash from deployment in war**
- **Solutions**
  - **Unique signal**
  - **Unique enviroment**
  - **Precise event timing**

Tomahawk Cruise Missile

- Design Challenges
  - Small payload
  - Wide temperature range
  - Launch shock
  - Long shelf life

If you were a weaponeer on nuclear weapons . . .

Case Study:

. . . safety

. . . safety

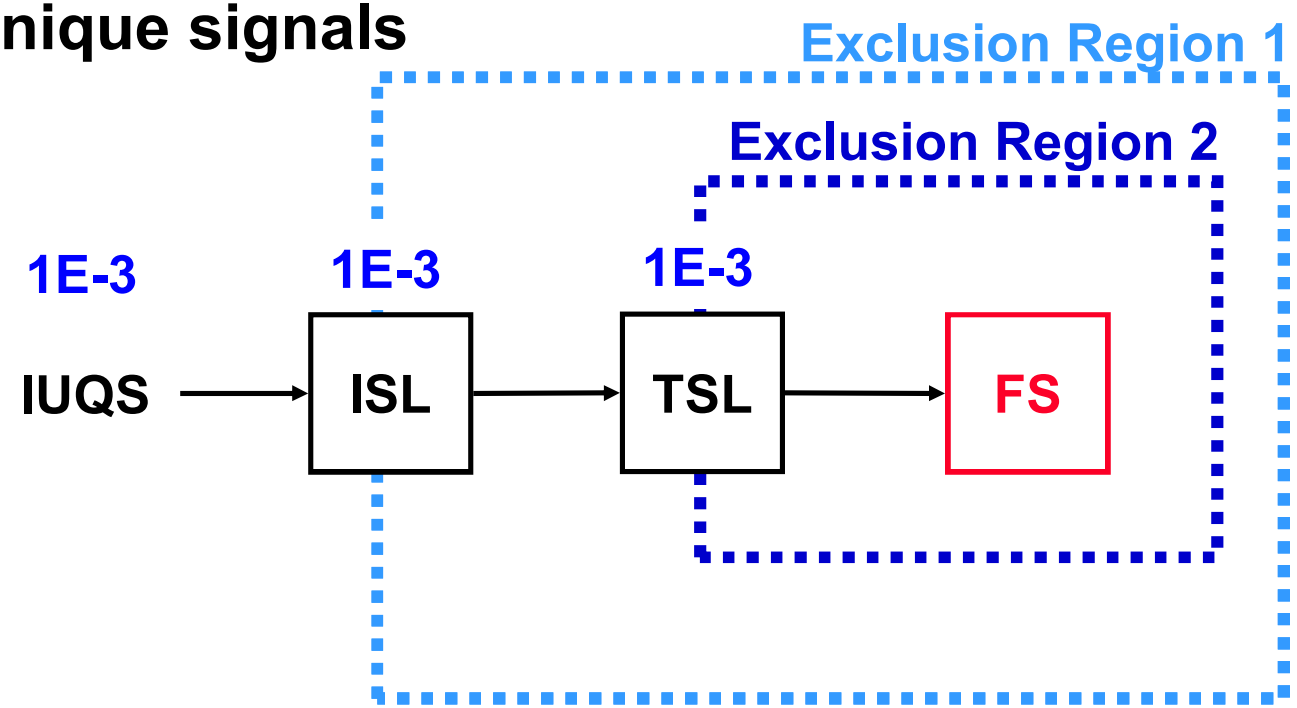
. . . safety

Sometimes, stuff happens . . .

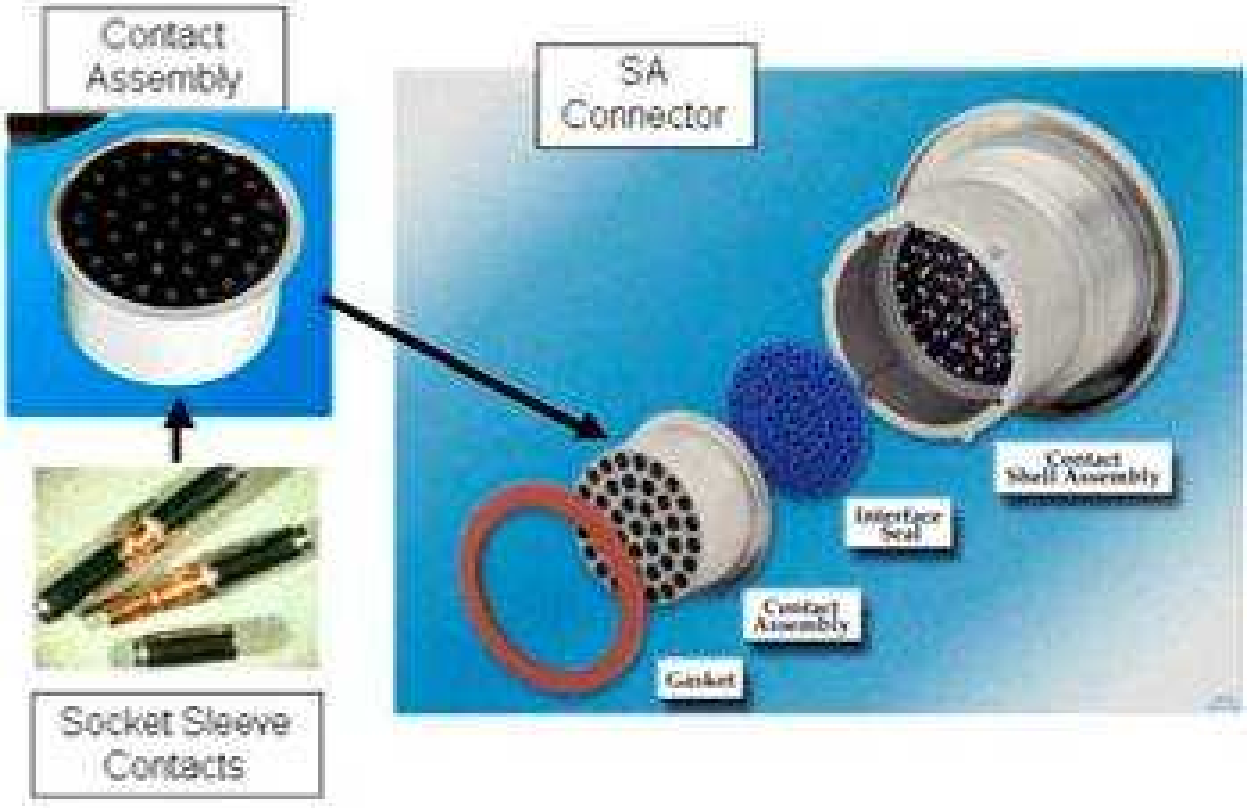
Sandia National Laboratories

Because stuff happens . . .

- Nuclear Safety:
  - Weak links vs. strong links
  - Exclusion regions
  - Unique signals



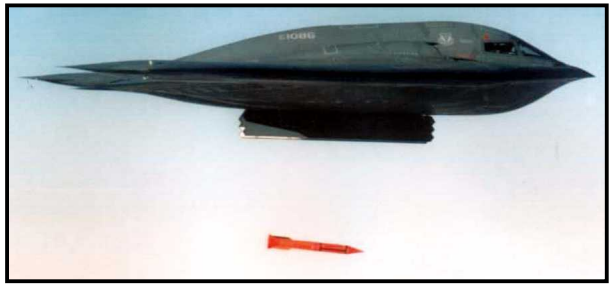
Q: What happens if lightning strikes a nuke?
A: Nothing.



- **"Lightning Arrestor Connectors" divert lightning or inadvertent high voltage from vital internal components.**

SNL is the nation's nuclear weapons stockpile steward

- The stockpile contains: cruise missiles, gravity bombs, ICBMs, SLBMs
- Sandia's responsibility includes:
  - Ensure safe, reliable and credible deterrent
  - Upgrade weapons as needed with modern technology
  - Test stockpile every year to ensure continued reliability and safety across all military environments



Sandia National Laboratories

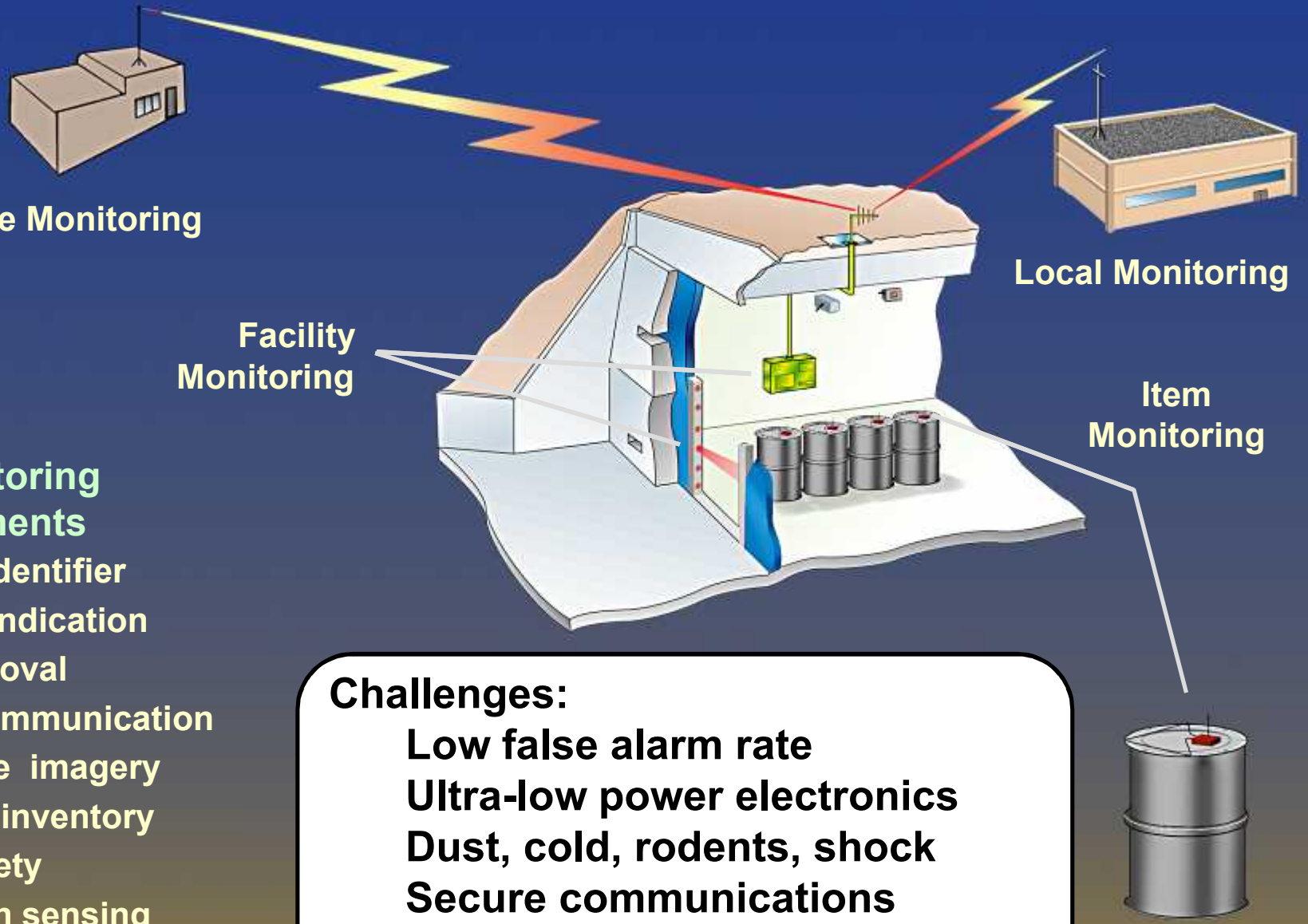
Engineering for Arms Control and Nonproliferation

IAEA

Note: The technologies described here are prototype concepts provided to the IAEA to demonstrate technology capabilities. We do not mean to imply actual national policy.

Sandia National Laboratories

Storage Monitoring for Treaty Verification



Monitoring Elements

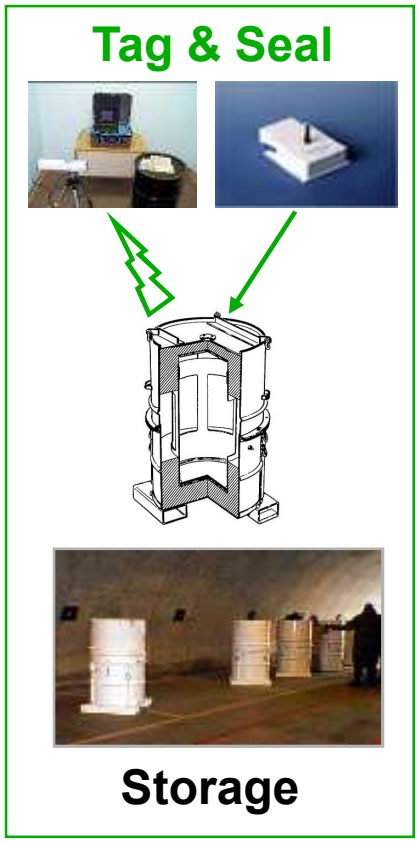
- Unique identifier
- Tamper indication
- Item removal
- 2-way communication
- Real-time imagery
- Periodic inventory
- Data surety
- Radiation sensing

Challenges:

- Low false alarm rate
- Ultra-low power electronics
- Dust, cold, rodents, shock
- Secure communications
- Cost vs. low volume production

The Item Monitor Must Detect Tampering

Long-Term Storage

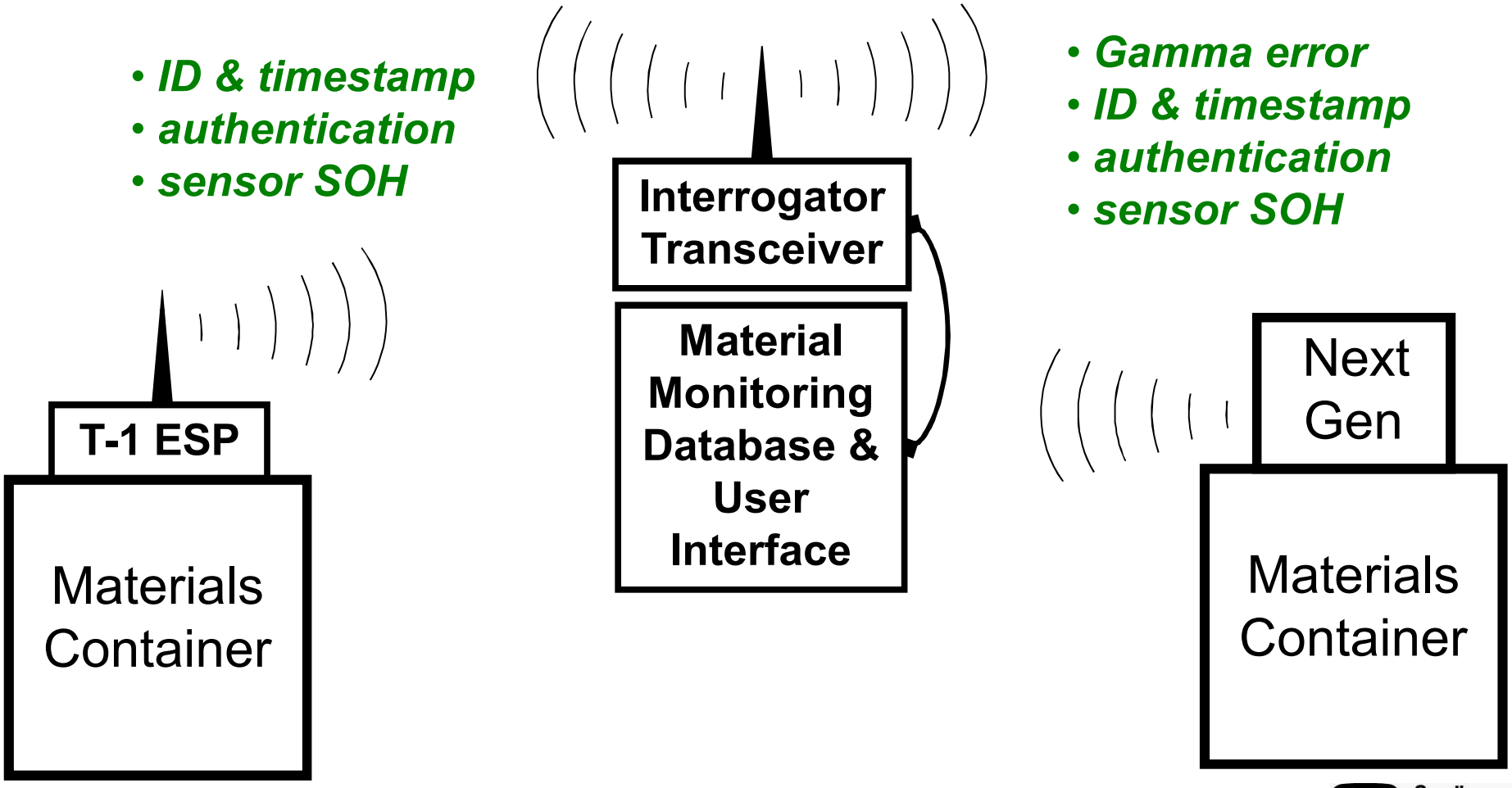


- Detect any alteration of the materials container
- Monitor itself to detect tampering
- Authenticate all transmitted messages to prevent spoofing
- Collect no classified information
- Other requirements:
  - Long life
  - Storage, handling & transportation environments
  - Very low false positive rate
  - High reliability

Features of the T-1 Electronic Sensor Platform Remote Monitoring System

- authenticated RF messages to IT
- tamper sensors
  - fiber optic seal
  - motion sensors
  - case tamper switches
  - high/low temperature
- tamper resistant housing
  - gloss coating
  - compound mechanical joints
- state-of-health sensors (temperature, battery voltage, transportation mode)

Item Monitor RF Communication in Storage Facility

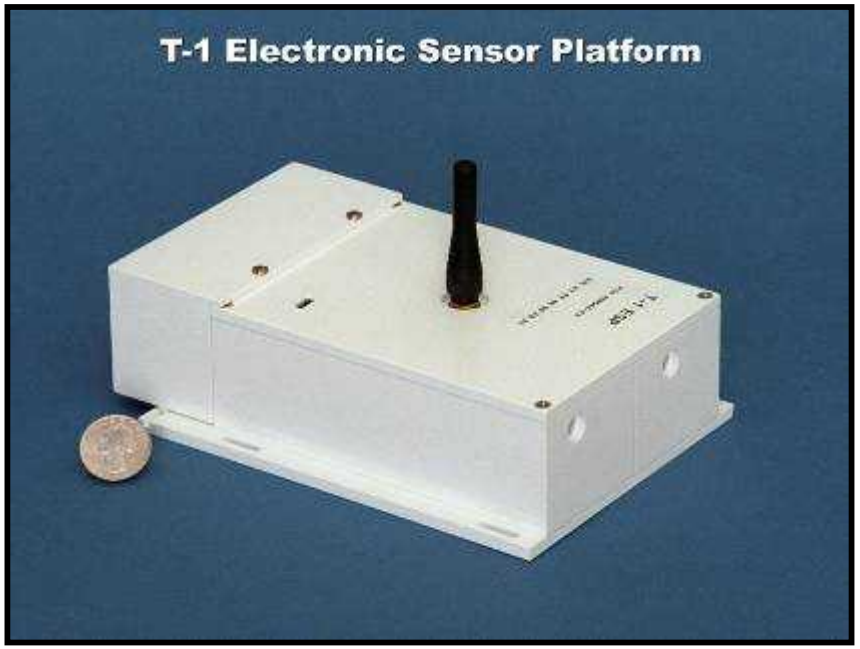


T-1 ESPs in Production Since 2QFY99

- In production at Allied Signal since early 1999
- Evaluation by IAEA in Russia (at Arzamas-16), Switzerland, Italy, Canada for international materials monitoring applications
- Evaluation by DOE at Savannah River Plant for inventory management

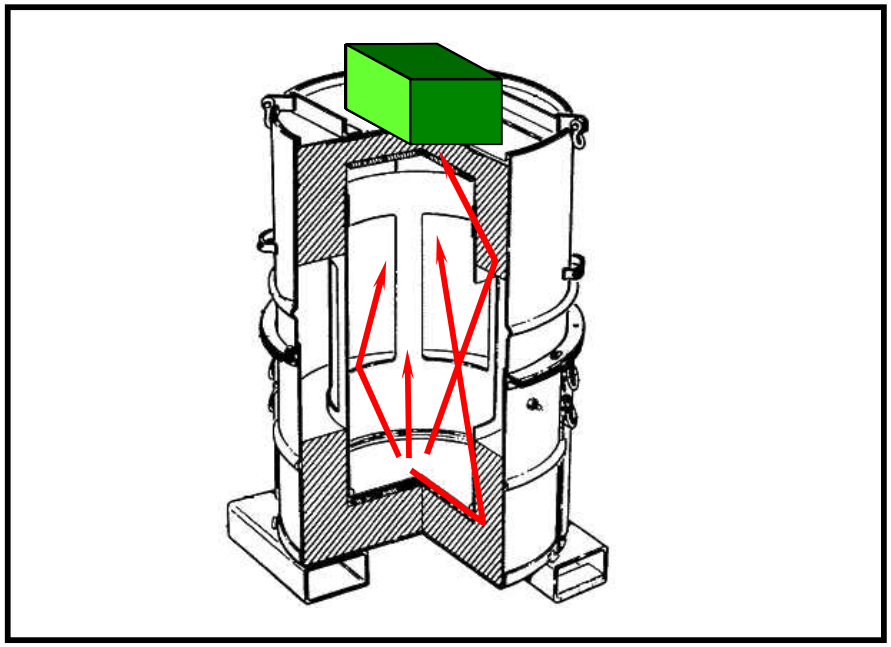
SNL Item Monitor Technology Research

T-1 Electronic Sensor Platform



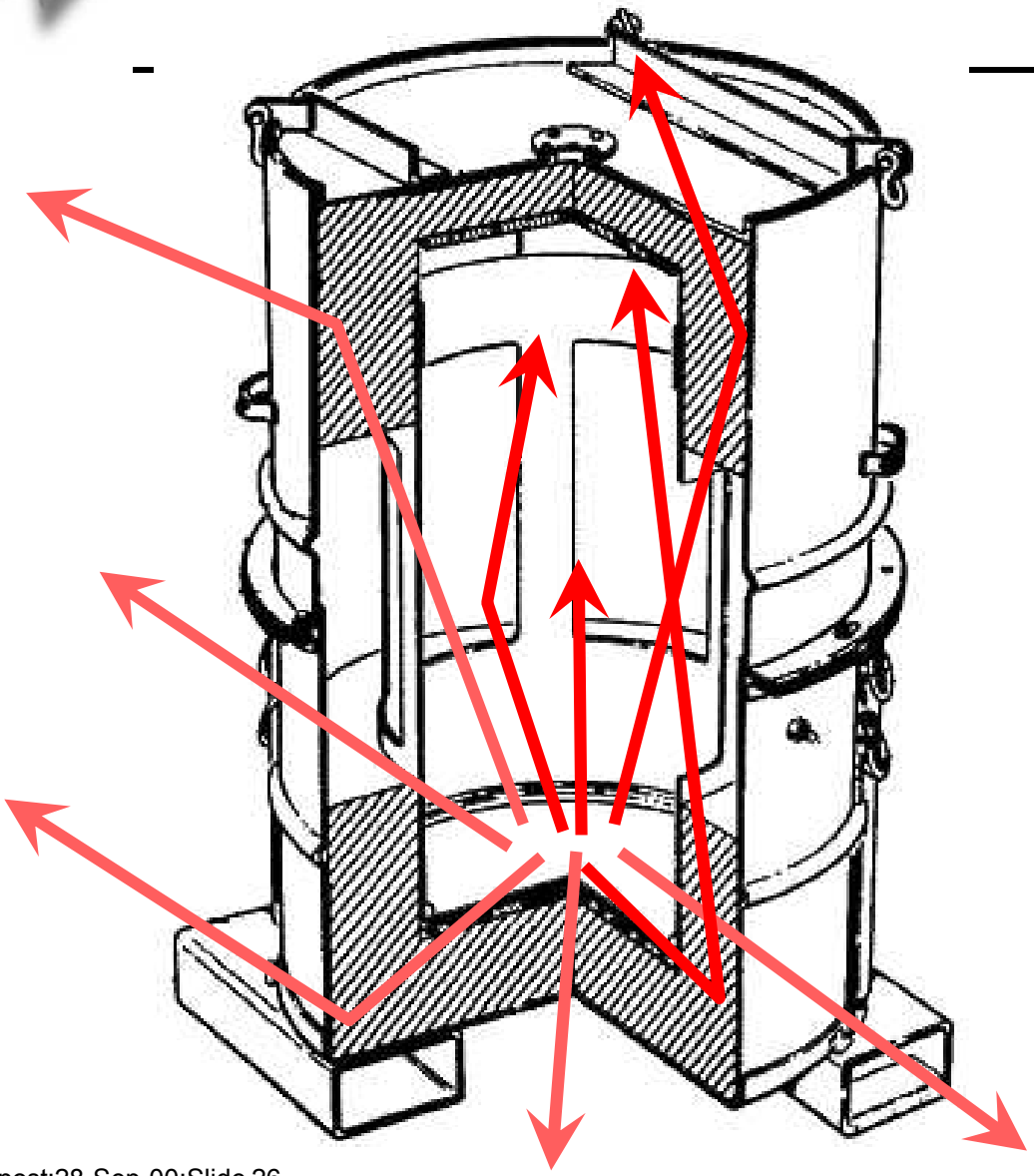
- Monitor container integrity
  - Fiber optic seal
  - Motion detector
  - Tamper detectors

Next Generation with Gamma Radiation Detector



- Monitor container integrity
- Monitor container contents directly

Gamma "Fingerprint" is Distinctive



- Gamma radiation:
  - high energy photons from nuclear transitions
  - emitted from Plutonium and Uranium isotopes
  - penetrate most materials deeply
  - scattered or absorbed by materials within container
- Gamma fingerprint defined by container and the radiation source

Summary

- Engineering & materials challenges in National Defense

- EE Design Skills:
  - RF, Analog, Digital
  - Signal processing
  - Embedded controllers
  - Modeling & simulation
  - Sensors & microsystems

- MatSci Design Skills
  - Aging & compatibility
  - New materials development
  - Materials chemistry
  - Modeling & simulation
  - Failure analysis