US START TID DEVELOPMENT PROGRAM

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THE QUEST FOR EXTREME SECURITY UNIQUE IDENTIFIERS

1986-1992

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Personal Perspective / Credentials

- 20-year career in the arms control and nonproliferation business…all “starting” with this problem
- Program manager on assignment to DOE 1990-1992, with TIDs as one element of portfolio
  - Initiated and served as portfolio manger of DOE warhead dismantlement and fissile material control R&D program
  - DOE representative to TID selection START interagency process (Verification R&D Working Group - the VRDWG)
- Funded and then became second (of two) chair of DOE Tagging Laboratory Advisory Group (TAGLAG)
- Executive secretary to 1992 Robinson Committee (Committee on Nuclear Warhead Dismantlement and Fissile Material Control)
  - Among several issues, TIDs for strategic nuclear items considered at the SCI level…including peer review by JASONS group

Chronology

- START (I) negotiations began: 1982…*Trust but Verify* environment
- Sandia National Lab contracted by DOE to develop tag for first-stage rocket motors: *mid-1980's*
- Initial version of Sandia tag defeated under Joint Staff/VRDWG auspices: *1988-89 time frame*
- More extensive TID program initiated at DOE labs focused on very high security, rocket motor tag
  - Without much, if any, formal criteria
- DOE TAGLAG established for coordination and civility
  - With DoD (DNA, NSA) membership
  - Many methods investigated and formally red-teamed
  - Two methods survived process
- Two methods accepted by VRDWG: *1991-92*
  - Systems engineered and multiple copies fabricated by DoD…and inspection agency training initiated
  - Culmination of $30 M investment over 6 years by USG
- End-game under Bush I Administration resulted in inspecting party high-technology tagging being sacrificed
  - START IPA-6 finalized ("host supplied, host applied" non-repeating unique identifiers)
  - Issue of how inspected skirted (inspecting party shall have the right to "read the data from" the unique identifiers)
  - START I signed by US and USSR *July 31, 1991*

The US START TID development probably effort still represents the penultimate effort to develop tamper-proof unique identifiers for cooperative environments.

START TID Development Assumptions and Criteria

- Technology to tag the first-stage ICBM and SLBM rocket motors, and perhaps cruise missiles
- US technologists assumed a very high degree of cheating sophistication available to the treaty partner… with unlimited budget and no inspecting party continuous presence
- Full technology transparency
  - No hidden features
- Technologists did not assume inspecting-party application of TID, but believed this to be more reliable and secure approach
  - Policy makers judged methods and systems as if there would be inspecting- party application and reading…by non-scientists
  - Policy makers had keen eye on TLI impacts, as well as collateral intel issues
- Degree of TID tamper protection initially subjective…informally quantified later
- Assumed that TID reading system could be adequately protected by inspecting party
- Only methods that had no obvious defeat mode were funded, and only systems that could not be counterfeited or removed without damaging the TLI passed muster
- Methods that passed TAGLAG muster became sensitive prior to completion of START
  - Much was classified as secret, especially defeat approaches and successes

Very Active Interagency Involvement

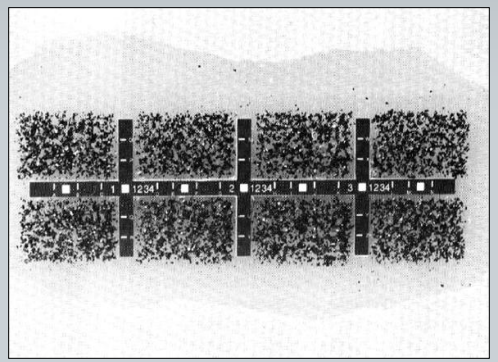
- Bush I Administration had an “Ungroup” comprised of select key and trusted interagency personnel who derived considerable informal authority via there relationship to a special advisor to the president
  - Group members chosen for their ability to work together while still representing their agency’s interest…were very effective and influential
- Ungroup in-turn established DoD-led Verification Technology R&D working group (infamous VRDWG)
  - Monthly Pentagon meetings devoted almost exclusively to TLI tagging, and attended by several members of the Ungroup
  - JF represented DOE
- All was not as it seemed, as various equities being protected… and not often obvious to the scientists what these were
- The bottom line was that the ONLY way any TID technology developed by the labs would be considered by the US for inclusion into START would be through a positive assessment by the VRDWG
  - Our target was not always static

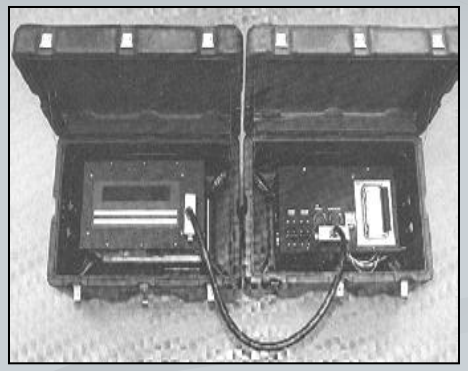
Scientific Community Response
The US TAGLAG

- 1988-1992
- Under auspices of DOE program manager (Fuller: 1990-1993)
- Seven DOE labs represented
  - Initially led by Dye from LLNL, then Fuller from PNNL
  - Outside agency participation minimized to reduce interagency pre-emptions
- Lots of dialog resulting in the selection of one lab to pursue a particular approach and another lab to red-team same
- Seal technology included to some degree
  - *All seals are tags, but not vice versa*
- Extensive funding available
  - Probably due to Ungroup pressure and urgency/embarrassment of initial technology's defeat
- Initial conclusions were that no commercial devices met security needs

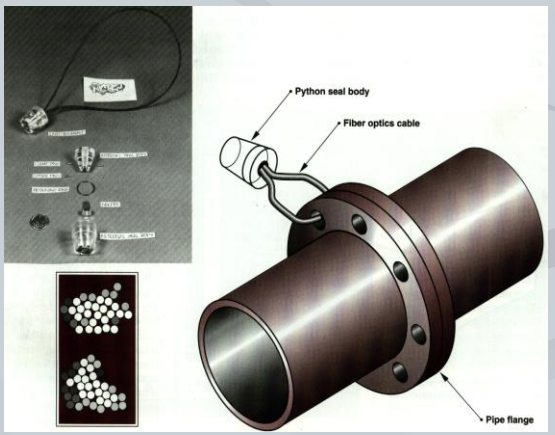
START-Era R&D Undertaken

- Reflective particle tag (RPT) - Sandia National Labs (SNL)
  - Defeated on the sly by LLNL for Joint Staff
  - Improved version subsequently red teamed by Livermore National Laboratory (LLNL)
    - Led to informal tamper criteria



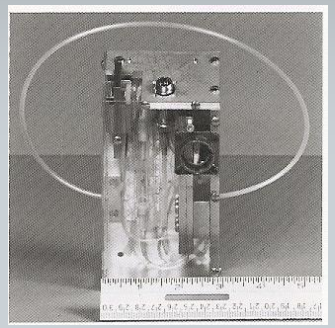


- Python fiber optic seal - by SNL
  - Red teamed by INEL
  - Predecessor to Cobra seal



START-Era R&D Undertaken

- Star fiber-optic seal - by LLNL
  - Based on random optical cross talk in fiber bundle



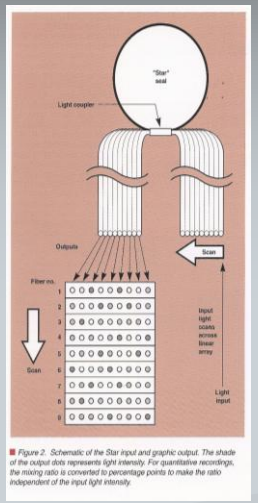
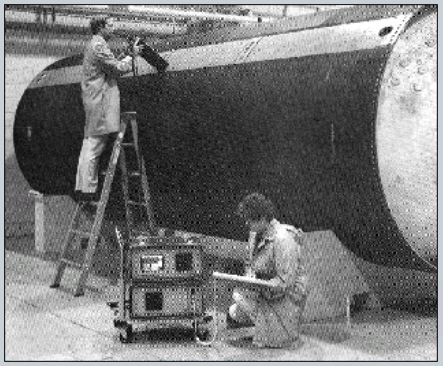


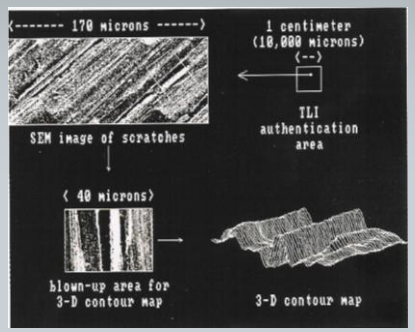
Figure 2. Schematic of the Star input and graphic output. The shade of the output dots represents light intensity. For quantitative recordings, the mixing ratio is converted to percentage points to make the ratio independent of the input light intensity.

- Ultrasonic intrinsic tags - by PNNL
  - Red teamed by ANL
  - Several samples of US and Soviet ICBM and SLBM skins synthesized
    - Metal skin issues solved

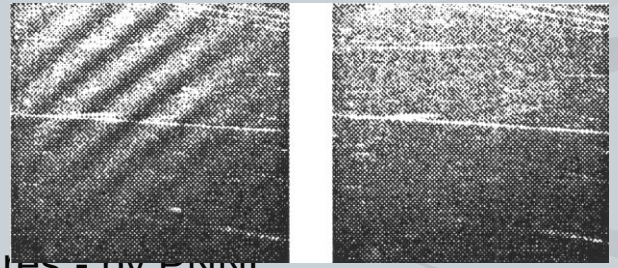


START-Era R&D Undertaken (cont'd)

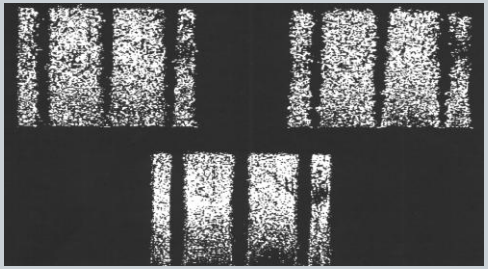
- Plastic casting electron microscopy fingerprints - by ANL
  - Red teamed by LANL



- Holographic correlation tags - by PNNL



- Microvideography of intrinsic or applied features - by PNNL

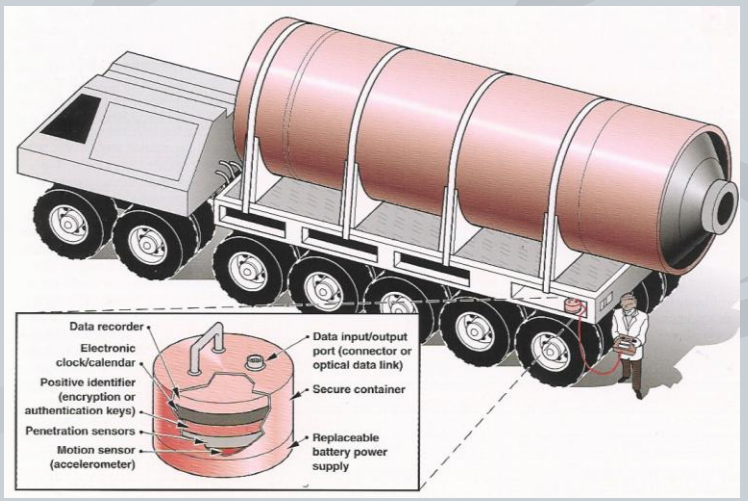


All these surface random feature tags had environmental robustness issues

START-Era R&D Undertaken

- Electronic identification devices - by LLNL and ORNL
  - Passive, capacitively coupled to TLI

- Buddy (electronic) tags - by SNL
  - Active -- battery powered

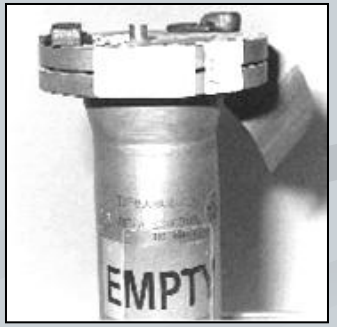


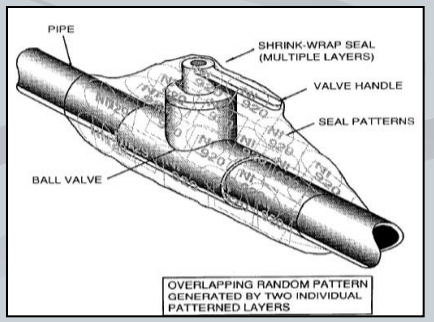
START-Era R&D Undertaken (cont'd)

- Nonlinear junction tags - by INEL
  - Based on multiple random NLJs in common conductive objects
    - E.g. : steel wool sample
    - Plagued by reproducibility issues

- Tamper tapes - by PNNL
  - Red teamed by LLNL

- Shrink wrap seals - by SNL
  - Red teamed by LLNL
  - Random imaged features





Happenings Along the Way

- NSA insights
- White House meeting revealing technology vulnerabilities
  - Sensitivities connected to in-service devices
- Red-herring attacks
  - RPT story
  - UIT story
- Personal conclusions on most secure approaches
  - Buried or whole-item intrinsic features
  - Active electronic approaches

Final VRDWG -Accepted START Technologies

- SNL Improved Reflective Particle Tag
- PNNL Ultrasonic Intrinsic Tag
- Both technologies were readied for deployment by DoD/DNA and OSIA

Unaware of ultimate interagency strategy … though it is quite plausible that both technologies ultimately judged to be too complicated and/or too intrusive by either or both the US and USSR … also plausible that US political expediency ruled the day

Additional Applications

- More robust seals are an ongoing IAEA need
- US Senator Richard Lugar, the father and perennial supporter of Cooperative Threat Reduction wrote *Washington Post* op-ed piece in early 1990's saying that the most important thing we needed to do was to "count" Russian nuclear warheads
  - Still emphasizes this approach to current issues
  - *Counting* implies *accounting,* which necessitates unique identifiers
- START TID research has formed a basis for additional efforts for new issues
  - Mayak FMSF monitoring…fissile material container monitoring
  - Inspection equipment protection
  - Warhead dismantlement monitoring research
  - Used in conjunction with hidden features in non-cooperative environments