Modular Open System Architecture for Reducing Contamination Risk in the Space and Missile Defense Supply Chain

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Elaine Seasly

Contamination Control & Planetary Protection Lead

NASA Langley Research Center

757.864.2173 office

520.609.0889 cell

elaine.e.seasly@nasa.gov

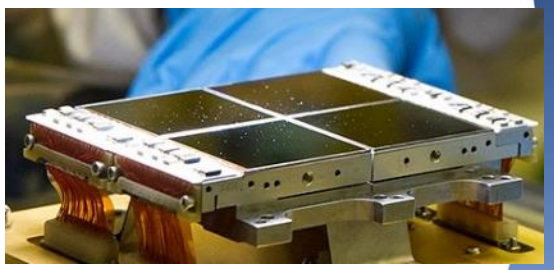
Engineering Directorate

Concept-to-Flight

http://engineering.larc.nasa.gov/

Contamination: A Contributor to Lifetime Hardware Degradation

- **Physical assets are made up of components sourced through a supply chain**
- **Components can degrade over time because of contamination**
  - Particles generated from material aging, wear, flaking, etc.
  - Molecular species outgassing from organic materials and depositing films on surfaces
- **Contamination degrades sensor performance, both for satellites and missile interceptors**
- **Because these systems are interconnected, the contamination issue is further compounded for the decision maker that relies on both systems**



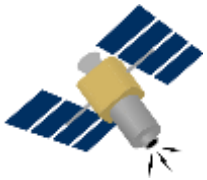
Credit: NASA/Goddard/Chris Gunn

Particulate Contamination on a Focal Plane Array

Credit: NASA/Langley/Elaine Seasly

Molecular Contamination Film

Contamination Risk Propagation through the Supply Chain



Supplier A provides component

Component integrated in satellite and generates contamination:
- Generates particles and/or
- Molecular outgassing

Satellite sensor degraded
- Background noise increases over time

Degraded scene data sent to analyst

Analyst sends degraded analysis to decision maker

Decision maker determines action

Satellite Sensor

TARGET HIT

TARGET MISS

Decision maker calls asset into action

Interceptor sensor degraded
- Background noise increases over time

Component integrated in interceptor and generates contamination:
- Generates particles and/or
- Molecular outgassing

Supplier B provides component

Interceptor Sensor

Statements Heard Throughout the Supply Chain
(From both Customers and Suppliers)

- "You don't buy enough units to justify me meeting your stringent cleanliness requirements"
- "We chose materials from the NASA outgassing website and built the hardware in a cleanroom, so we are fine"
- "We thermal vacuum baked the hardware for over 1000 hours just to reduce the outgassing"
- "We have a blind cavity in the hardware that we can't clean"
- "There are no low-outgassing materials that we can use, so just write a waiver"
- "The only qualified supplier for this material just quit making it"

Considering the Total Potential System Impact

- **Initiatives such as Better Buying Power 3.0 push for greater transition of small business SBIR technologies to acquisition programs**
  - Improvement in cost or performance may be based upon new materials and processes with unknown contamination effects
- **Suppliers within the supply chain need to understand the total potential system impact of their design and manufacturing choices on the overall integrated system**
  - Everything from material selection to manufacturing processes must be considered
  - Parts get integrated into a system that can't be cleaned at the system level
  - The higher the level of the assembly, the higher the risk of contamination on performance

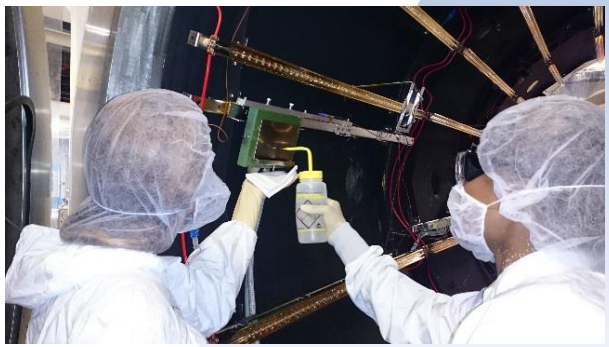
"Build a clean system, rather than clean a built system"

Modular Open System Architecture for Reducing Contamination Risk

- **Goal is to find contamination and mitigate it earlier in the supply chain**
- **Component or subassembly is a module that has been designed, processed, and packaged to reduce risk**
  - *Can we bake it and seal it early?*
  - *Can we make it easier to inspect and clean?*
  - *Can we choose different materials and assembly techniques?*
- **Ideal: Parts are received from suppliers cleaned and sealed**
  - Open interfaces enable the next higher assembly to receive it clean and assemble it clean
- **Rather than a burden, controlling contamination is viewed as a capability that carries over into other industries**
  - Space & Missile Defense = 2 customers
  - Other potential customers: healthcare, pharmaceuticals, electronics, etc.

Exploring New Predictive Modeling Tools and Verification Techniques

- **Collaborative predictive tools for quantifying the degradation effects of contamination**
  - Can be calibrated from NASA data of long-term orbiting assets
  - Can be extrapolated to missile defense predictive models
  - MOSA allows for sensitive data to be de-coupled and protected while benefitting from open source data of calibrated models
- **New modeling tools will allow for the designer to perform material and manufacturing process trades**
  - Determine how to treat and condition materials
    - *How much baking is too much?*
  - Study the interactions of different contaminants
    - Particles and molecular films have always been considered separately
  - Life cycle costs of alternative designs
- **New measurement and verification techniques will change how requirements are specified**
  - Contamination sampling via tape lift and solvent rinse still the norm
    - *Better methods are needed!*
      - In-situ monitoring, real-time data collection, etc.



Credit: NASA/Langley/Elaine Seasly

Contamination Sampling via Solvent Rinse

Collaborative Opportunities

- **Government:** Leverage multi-agency technology investments
  - Adopting new ways to specify and verify requirements
- **Industry:** Insight into risk management challenges and the effectiveness of resulting options
  - Consider lifetime performance and lifecycle cost on par with initial system performance through MOSA
  - Communication of system impacts through the supply chain
- **Small Businesses:** Development of new predictive tools, measurement techniques, and hardware modules
  - Consider multi-agency and multi-industry applications for new technologies
- **Universities:** Characterization of new materials and manufacturing processes
  - Compliments and helps enable technology transition

Each member of the supply chain becomes an informed and active participant in managing risk early in the system lifecycle