



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

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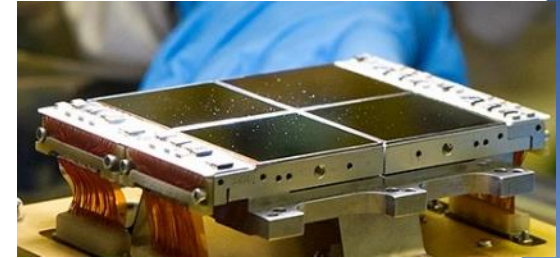
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Contamination: A Contributor to Lifetime Hardware Degradation



- **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**

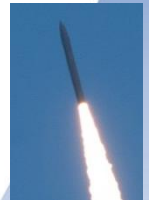
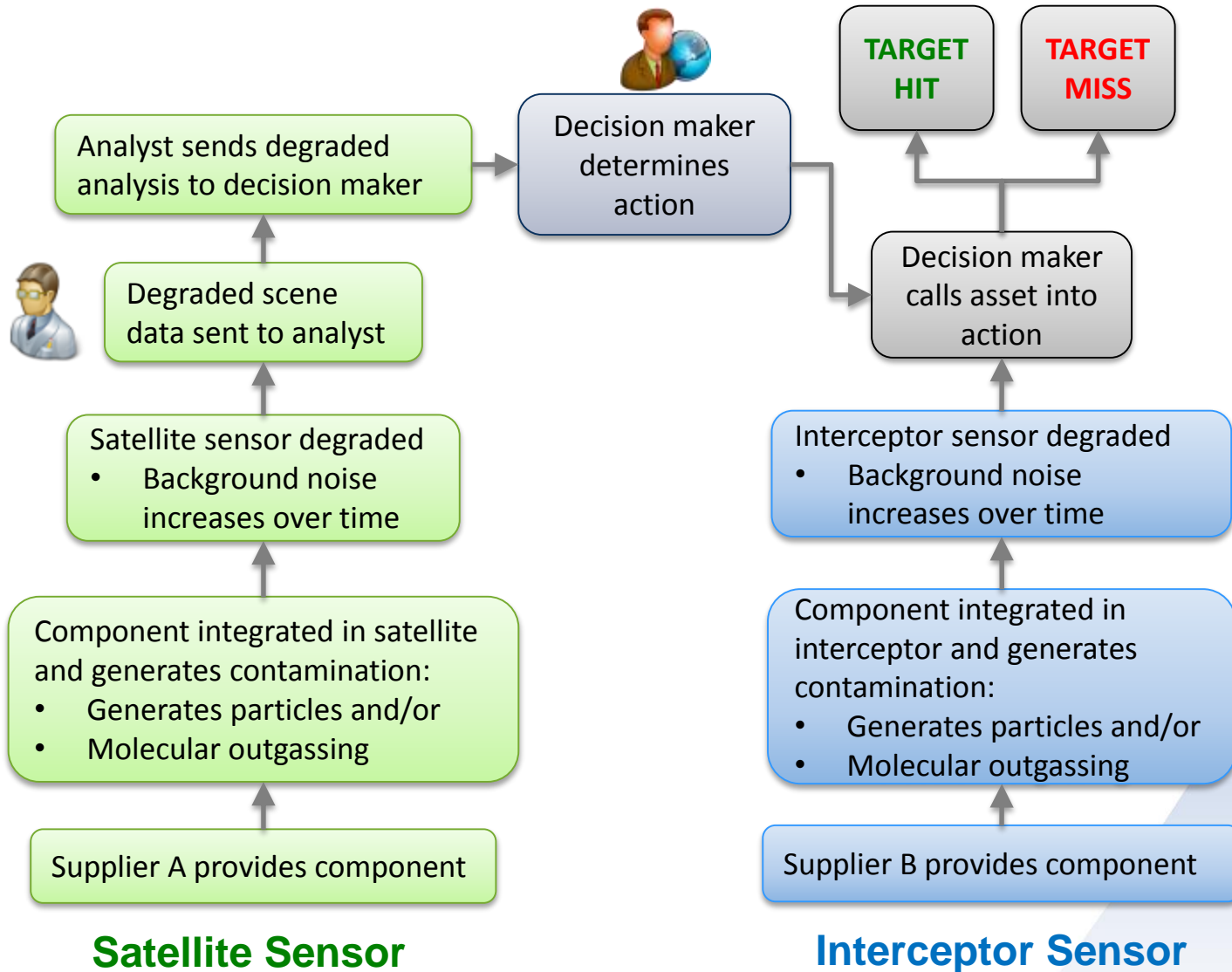


*Credit: NASA/Goddard/Chris Gunn
Particulate Contamination on a
Focal Plane Array*



*Credit: NASA/Langley/Elaine Seasley
Molecular Contamination Film*

Contamination Risk Propagation through the Supply Chain





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

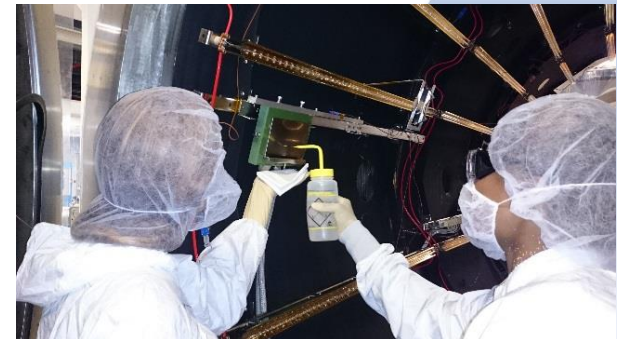
- Can be calibrated from NASA data of long-term orbiting assets
- Can be extrapolated to missile defense predictive models
- MOSA allows for sensitive data to be de-coupled and protected while benefitting from open source data of calibrated models

➤ 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 Seasley
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