



**L3HARRIS**

FAST. FORWARD.

## **CAPABILITIES FOR ORBITAL SPACE DEBRIS TRACKING**

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The Institute of  
**OPTICS**

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# Outline of Capabilities for Orbital Debris Tracking

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## 1. L3Harris Overview

## 2. Novel concepts for orbital debris tracking modalities enabled by:

- Libraries of custom wave propagation and interaction models that feed end to end mission performance models
- First principal benchmarked models of RF Rydberg sensors, and state of art laboratories for testing

## 3. Translating debris field data to risk, damage, and mitigation assessments for specific spacecraft










## 4. Satellite payload design, construction, and testing

## 5. Mission integration

# L3Harris Overview



Three mission-aligned segments

Integrated Mission Systems	Space & Airborne Systems	Communication Systems
\$6.8B	\$5.8B	\$4.4B
		
 <b>Sean Stackley</b> President, Integrated Mission Systems Leading technology integrator to U.S. and international militaries for complex ISR airborne and maritime platforms, and provider of advanced avionics and training solutions for commercial markets	 <b>Ed Zoiss</b> President, Space & Airborne Systems Mission solutions and networked systems for space and airborne domains with defense, intelligence and commercial applications	 <b>Dana Mehnert</b> President, Communication Systems Secure ground and airborne communications and network systems for U.S. military, international forces and commercial customers
<b>Headquarters</b> Palm Bay, Florida 	<b>Headquarters</b> Palm Bay, Florida 	<b>Headquarters</b> Rochester, New York 

Global footprint



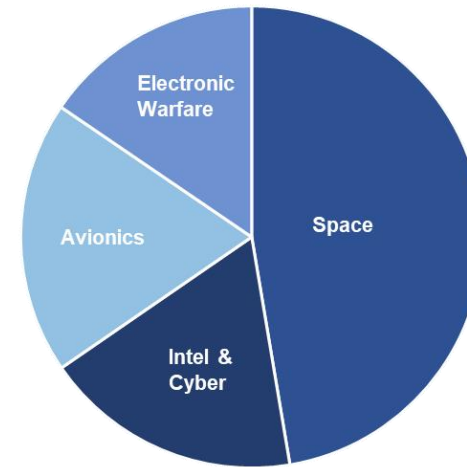
**300** LOCATIONS 
**100** COUNTRIES  CUSTOMERS IN MORE THAN

**~47K** EMPLOYEES 
**~30** COUNTRIES  LOCATIONS IN

## Space and Airborne Systems

2020 Revenue **\$5.8B**

2020 Op Margin **~15.5%**



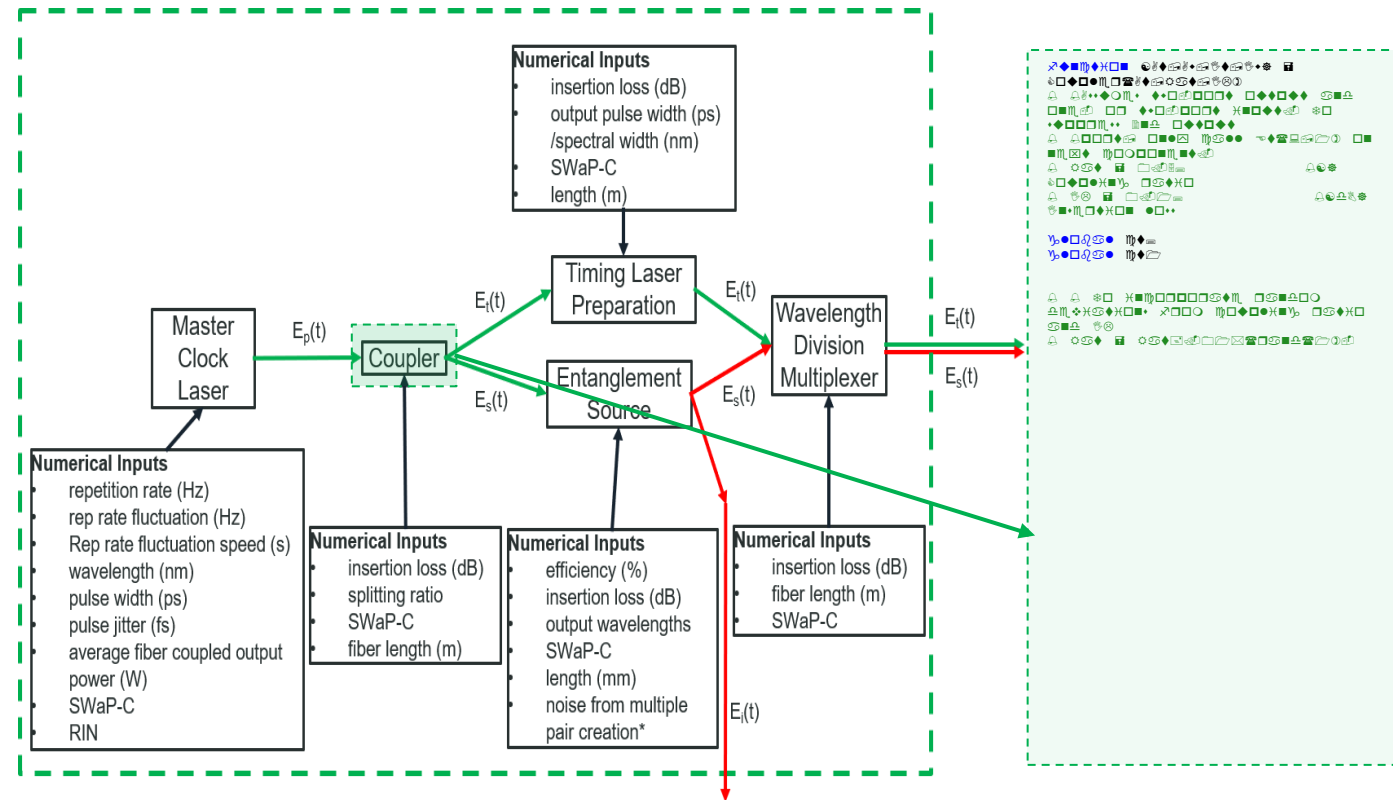
	<b>Space Systems &amp; Solutions</b> Payloads, sensors and full-mission solutions for classified, civil and commercial customers
	<b>Intel and Cyber</b> Situational awareness, optical networks and advanced wireless solutions
	<b>Mission Avionics</b> Sensors, hardened electronics, release systems, data links and antennas supporting fixed wing and rotary platforms
	<b>Electronic Warfare</b> Multi-spectral situational awareness, threat warning and countermeasures capabilities for airborne and maritime platforms
	<b>Mission Networks</b> Communications and networking solutions for air traffic management

# Novel Orbital Debris Detection Modalities Enabled By:



## Proprietary modeling software for end to end mission performance models from custom components describing propagation of waves across custom channels

- Based on spatiotemporal wave propagation models, covering RF, optical, with plasma propagation components in development
- Extensive component libraries feed modularly built models for quickly assessing and optimizing trade spaces.
- Enables full field simulation of phenomena that COTS or custom lumped loss software can't handle



Generic example of linking custom components together with the modeling architecture

# Novel Orbital Debris Detection Modalities Enabled By:



## Benchmarked RF Rydberg sensing models

- Promise for high sensitivity across extremely broad bandwidths (MHz – THz)
- Receiver minimum size not constrained by RF frequency
- Proprietary solutions for applying sensors for orbital debris detection

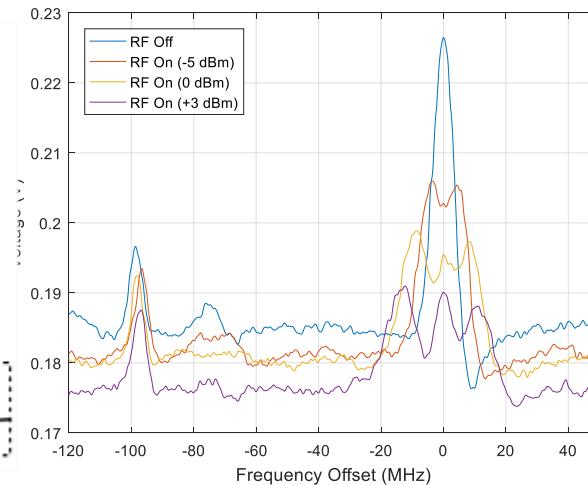
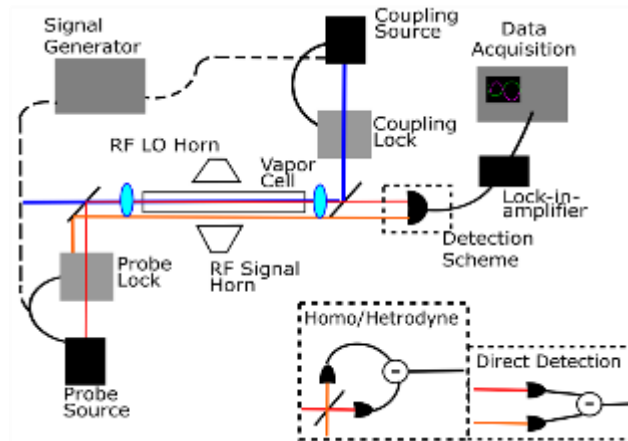
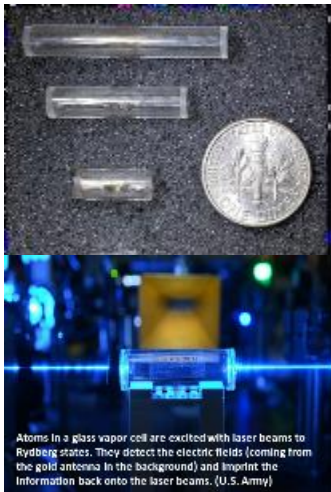
Atomic state populations:

$$\begin{aligned} \rho_{11} + \rho_{22} + \rho_{33} + \rho_{44} &= 1 \\ \dot{\rho}_{11} &= i \frac{\Omega_p(t)}{2} (\rho_{12} - \rho_{21}) + \Gamma_{21}\rho_{22} + \Gamma_{31}\rho_{33} + \Gamma_{41}\rho_{44} \\ \dot{\rho}_{22} &= -i \frac{\Omega_p(t)}{2} (\rho_{12} - \rho_{21}) + i \frac{\Omega_c(t)}{2} (\rho_{23} - \rho_{32}) \\ &\quad - \Gamma_{21}\rho_{22} + \Gamma_{32}\rho_{33} + \Gamma_{42}\rho_{44} \\ \dot{\rho}_{33} &= -i \frac{\Omega_c(t)}{2} (\rho_{23} - \rho_{32}) + i \frac{\Omega_{RF}(t)}{2} (\rho_{34} - \rho_{43}) \\ &\quad - (\Gamma_{32} + \Gamma_{31})\rho_{33} + \Gamma_{43}\rho_{44} \\ \dot{\rho}_{44} &= -i \frac{\Omega_{RF}(t)}{2} (\rho_{34} - \rho_{43}) - (\Gamma_{41} + \Gamma_{42} + \Gamma_{43})\rho_{44} \end{aligned}$$

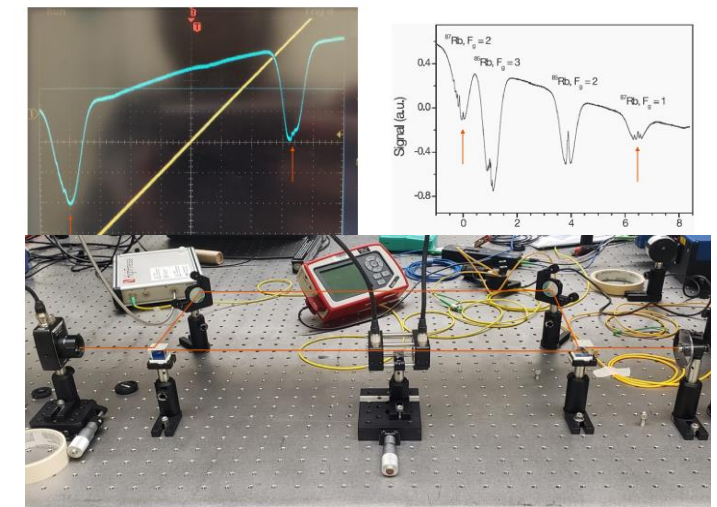
Coherences:

$$\begin{aligned} \dot{\rho}_{21} &= i \frac{\Omega_p(t)}{2} (\rho_{22} - \rho_{11}) - \frac{i\Omega_c(t)}{2} \rho_{31} - (\gamma_{21} + i\Delta_1)\rho_{21} \\ \dot{\rho}_{31} &= i \frac{\Omega_p(t)}{2} \rho_{32} - \frac{i\Omega_c(t)}{2} \rho_{21} - \frac{i\Omega_{RF}(t)}{2} \rho_{41} - (\gamma_{31} + i\delta)\rho_{31} \\ \dot{\rho}_{41} &= i \frac{\Omega_p(t)}{2} \rho_{42} - \frac{i\Omega_{RF}(t)}{2} \rho_{31} - (\gamma_{41} + i\Delta)\rho_{41} \\ \dot{\rho}_{32} &= \frac{i}{2} \Omega_c(t) (\rho_{33} - \rho_{22}) + \frac{i}{2} \Omega_p(t) \rho_{31} - \frac{i}{2} \Omega_{RF}(t) \rho_{42} - (\gamma_{32} + i\Delta_2)\rho_{32} \\ \dot{\rho}_{42} &= \frac{i}{2} \Omega_c(t) \rho_{43} + \frac{i}{2} \Omega_p(t) \rho_{41} - \frac{i}{2} \Omega_{RF}(t) \rho_{32} - (\gamma_{42} + i(\Delta_2 + \Delta_3))\rho_{42} \\ \dot{\rho}_{43} &= \frac{i}{2} \Omega_{RF}(t) (\rho_{44} - \rho_{33}) + \frac{i}{2} \Omega_c(t) \rho_{42} - (\gamma_{43} + i\Delta_3)\rho_{43} \end{aligned}$$

## State of art laboratories for receiver testing



Rb 87 fine and hyperfine lines

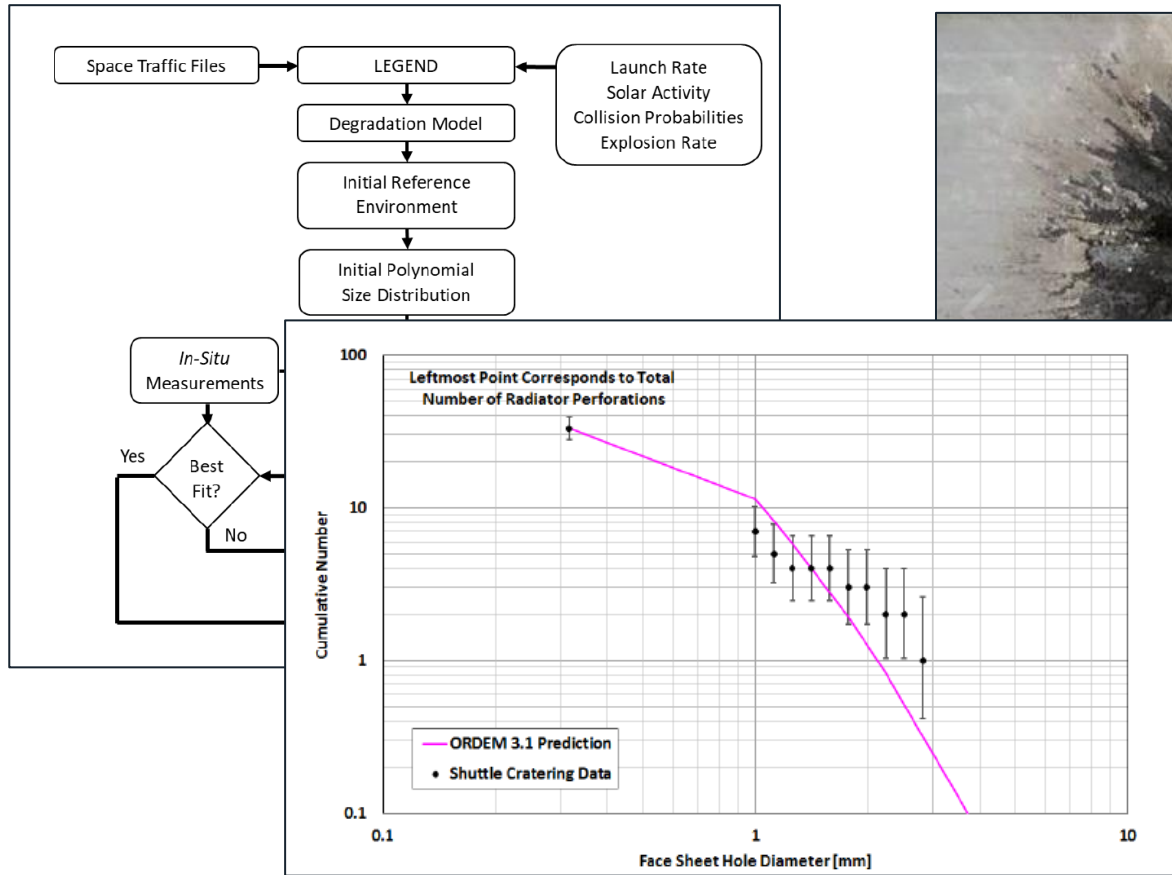


Meyer, D. H., Castillo, Z. A., Cox, K. C., & Kunz, P. D. (2020). Assessment of Rydberg atoms for wideband electric field sensing. *Journal of Physics B: Atomic, Molecular and Optical Physics*, 53(3), 034001.

# Using sensor data to improve mission outcomes

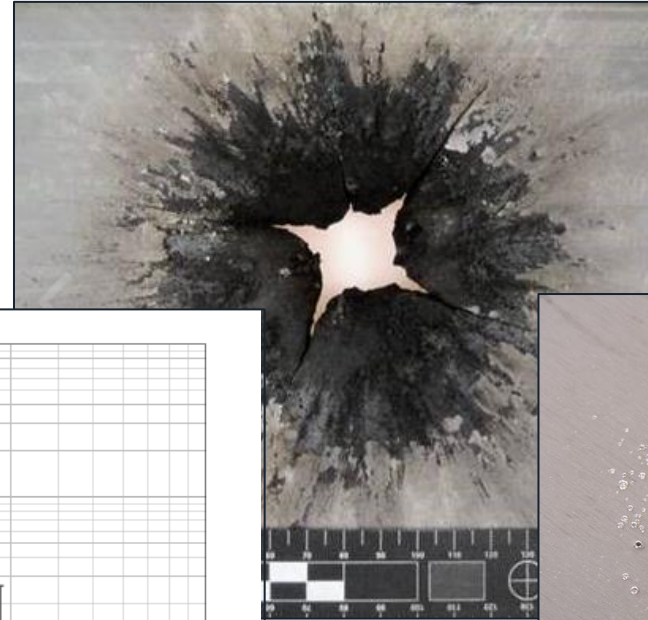


## Extract debris properties from sensor data



## Probability of critical failure

## Damage assessments

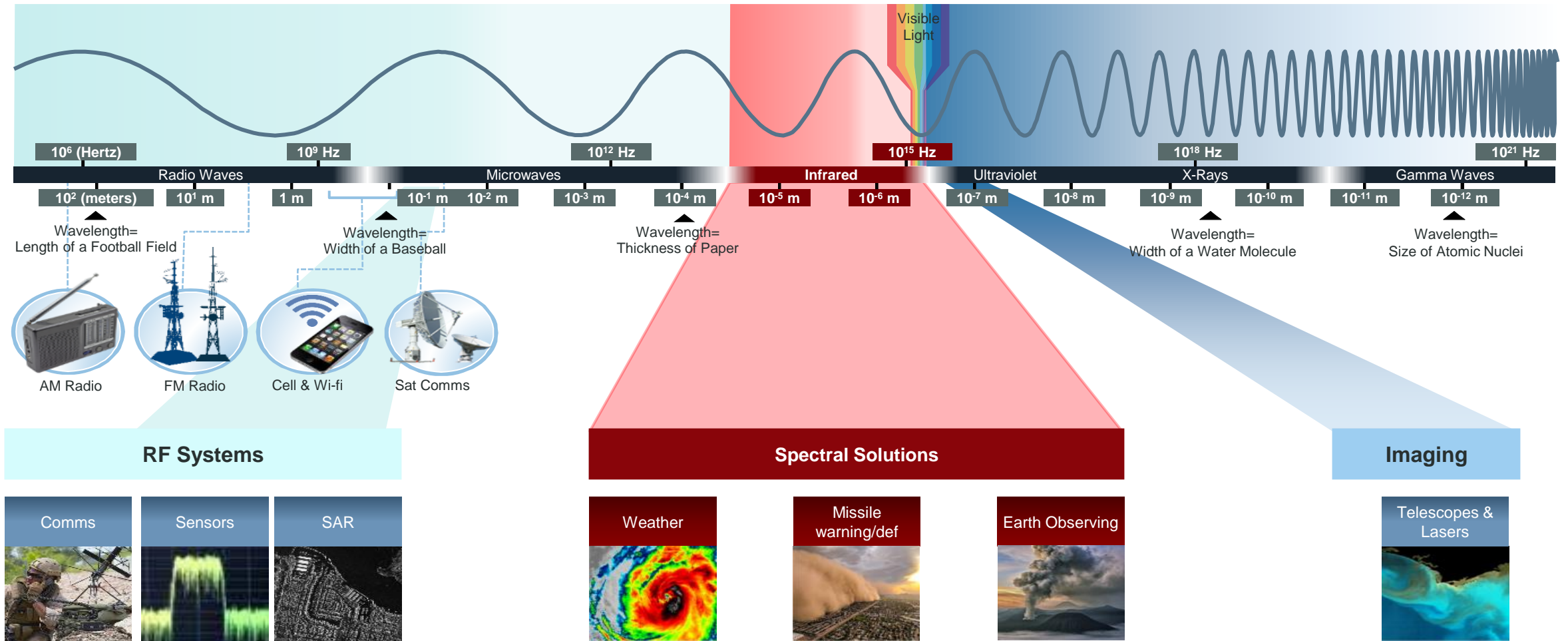


## Mitigation Strategies - Shielding

hvit.jsc.nasa.gov. Exit hole of ISS crew module penetration test – performed to test repair techniques.

Manis, A., Matney, M., Vavrin, A., Seago, J., Gates, D., Anz-meador, P., ... & Xu, Y. L. (2022). NASA Orbital Debris Engineering Model (ORDEM) 3.1 Model Process. NASA Technical Publication.

# L3Harris provides payloads across every mission area



Depth and breadth has enabled us to become Responsive Prime market leader

# Spacecraft and Payload Provider



## HIGH COMPACTION RATIO ANTENNA (HCR)

- > 1m to 5m diameter apertures
- > Designed for S- to Ka-band frequencies
- > 100:1 compaction ratio is ideal for smallsats

## CENTER-FED RADIAL RIB REFLECTOR

- > Up to 9m+ diameter apertures
- > Offers up to Ka-band frequencies
- > Optimized for frequent re-point missions

## RADIAL RIB REFLECTOR

- > Up to 9m diameter apertures
- > UHF to Ka-band frequencies
- > Ideal for higher gain missions

## FOLDED RIB REFLECTOR

- > Up to 18m diameter apertures
- > UHF to Ka-band frequencies
- > Ideal for larger GEO Comm missions

## PERIMETER TRUSS REFLECTOR (PT)

- > Scales from 1m to 22m+, frequencies up to Ka+
- > More compact, and lower mass
- > Ideal for LEO smallsats to GEO Comms

**Broad portfolio of spacecraft, antennas & reflectors to meet the most challenging mission needs**

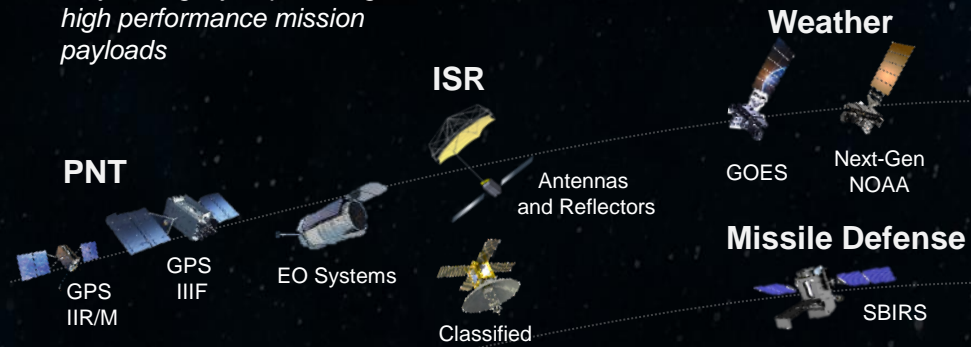


# Mission Integrator: Exquisite and Responsive E2E Mission Solutions



## Exquisite Solutions

60-year legacy of providing high performance mission payloads

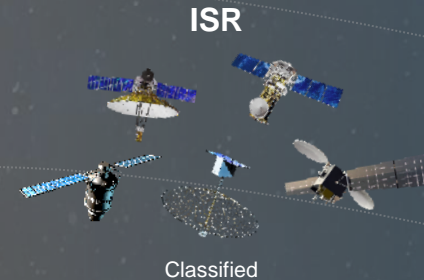
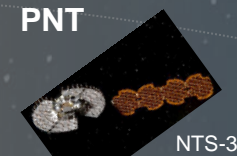


## Responsive Solutions

Augmenting Exquisite Systems with rapid delivery of end-to-end mission solutions

### Keys to Success

- Mission knowledge
- Payload expertise
- Rapid delivery



## Ground

Space tracking & space warfighting



# Contact Information



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