LOCKHEED MARTIN

Advanced Technology Center Overview

OST Face-to-Face

June 2017

Greg Feller

Advanced Technology Center

Lockheed Martin Space Systems Company

Lockheed Martin Business Areas

Aeronautics

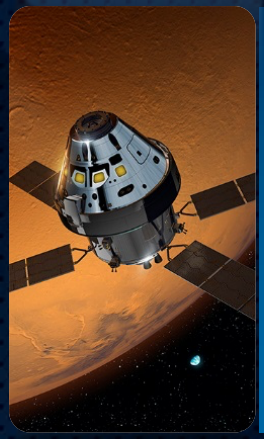
- Tactical Fighters
- Tactical /Strategic Airlift
- Advanced Development
- Sustainment Operations

Missiles and Fire Control

- Air and Missile Defense
- Tactical Missiles
- Fire Control
- Combat Maneuver Systems
- Energy

Rotary and Mission Systems

- Naval Combat Systems
- Radar and Surveillance Systems
- Aviation Systems
- Training and Logistics Solutions
- DOD Cyber Security



Space Systems

- Surveillance and Navigation
- Global Communications
- Human Space Flight
- Strategic and Defensive Systems
- Strategic / Operational Command & Control Systems

Space Systems Company Portfolio

Strategic & Missile Defense


Adv Programs


Strategic Missiles


Missile Defense

Civil Space


NASA Human Exploration


Planetary Exploration


Weather & Environment

Special Programs

Military Space

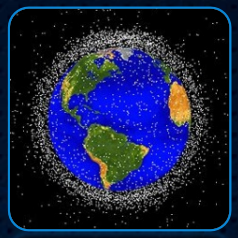

Protected Comms


Narrowband Comms


Navigation


Weather


Early Warning


Space Protection

Mission Solutions


End-to-End Mission Systems


Geospatial Technologies

Commercial Space

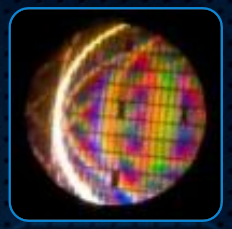

Remote Sensing

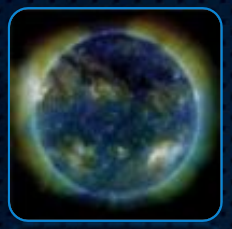

Commercial SATCOM


Wind Energy Management

Advanced Technology Center


Optics, RF & Photonics


Adv. Materials & Nano Systems


Space Sciences & Instruments

Subsidiaries

AWE
Sandia National Laboratories
ULA United Launch Alliance
ASTROTECH SPACE OPERATIONS
ZETA ASSOCIATES

Advanced Technology Center (ATC)

- SSC's R&D Laboratory; ~500 Scientists and Technologist – 2/3rd with Advanced Degrees
- Technology Invention & Innovation
- Contracted and Independent R&D
- Payloads and Payload Technologies
- Space and Earth Science
- Classified Advanced Development
- Key Partnerships: Engineering, Universities, and Other R&D Institutions

Creating the Generation After Next

Payload Centers of Excellence

RF PAYLOAD CENTER OF EXCELLENCE

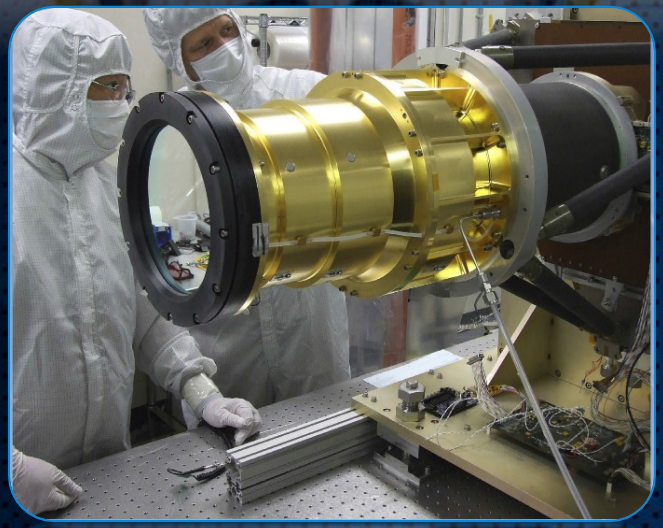
The RF Payload Center of Excellence, is shaping the future of space-based RF and Communications payloads.

- This center combines a proven, integrated team with new talent and facilities – collocating design, manufacturing and testing of all types of RF systems, products and antennas

OPTICAL PAYLOAD CENTER OF EXCELLENCE

The Optical Payload Center of Excellence, is defining the future of imaging in Space

- A network of experts and facilities headquartered Palo Alto, California the Center of Excellence is focused on advancing Lockheed Martin capability, efficiency and agility in optical technologies and products



World Class Facilities

Core infrastructure in place to execute space-based missions

Advanced Simulation

Environmental Tests

Virtual Design & Production

Clean Rooms

Payload Development

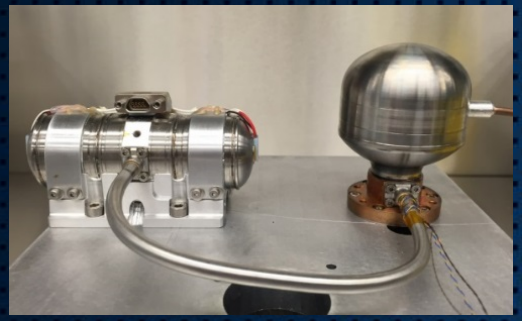
Manufacturing/ Assembly

Satellite Integration

Decades of Industry and Government Investment

Lockheed Martin Cryocoolers

- Lockheed Martin ATC Thermal & Energy Sciences has over 40 years experience in Space Cryogenics
  - 45 years in Space Cryogenic Dewars and Cryostats (WISE, GP-B)
  - 20 years in Mechanical Cryocoolers
- Industry leader in simple, robust space cryocoolers for cooling below 10 K
- Lockheed Martin has a well-defined path forward to demonstrate required OST cooling with a simple pulse tube cryocooler



The Case for Non-Contact Payload Isolation

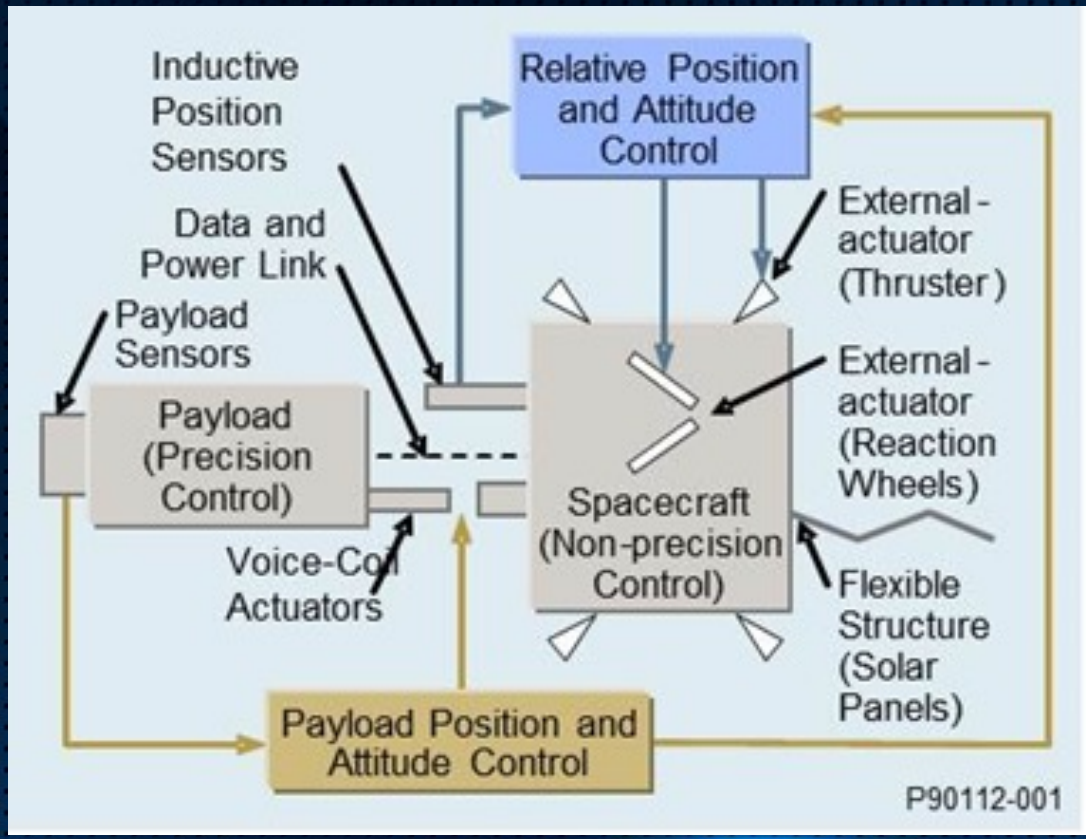
- The need for high payload dynamic stability is an overarching technology need to ensure the performance of future large optical systems
  - The large 8-15 meter OST Primary Mirror will require very low levels of mechanical vibration to meet its wavefront error stability requirements and 40 mas rms jitter requirement
- Previous passive architectures will be hard-pressed to achieve the dynamic WFE stability requirements of systems like OST
  - Passive isolation disturbances is limited at low frequency, and complicated by internal structural resonances of the isolation system itself
  - Active cancellation of LOS error arising from disturbances has sensing, mechanism and control challenges
- Lockheed Martin has developed and tested a Disturbance Free Payload (DFP) technology, that fundamentally separates the optical telescope from spacecraft disturbances

Traditional Dynamic Stability Approaches	Drawbacks for OST
Multiple stages of passive isolation	Internal resonances compromise performance at high frequency, and are difficult to predict
Resonant frequency avoidance	Impacts system availability and complicates Conops
Active telescope vibration sensing and cancellation	Complex telescope instrumentation; complex system design; performance limited by sensor noise

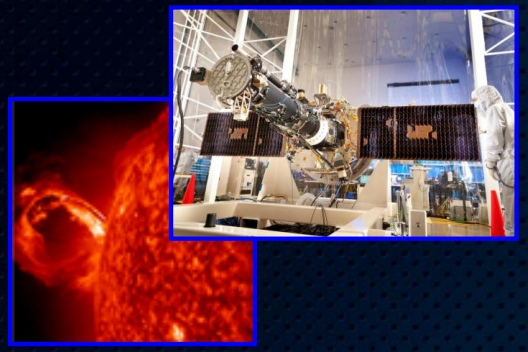
Pedreiro, N., "Spacecraft architecture for disturbance-free payload", US Patent 6,454,215 (2002).

A Disturbance-Free, Non-Contact Architecture

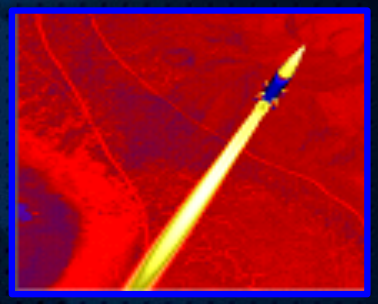
- The DFP isolation system is an entirely novel and revolutionary concept for isolation of a sensitive science payload from the supporting spacecraft mechanisms
  - *A DFP-configured spacecraft is actually two spacecraft flying in close formation*
- The spacecraft measures and controls its attitude using star trackers and reaction wheels'
  - Requirements for control are no more stringent than those for conventional communications satellites
- The payload controls its attitude by pushing against the spacecraft using a set of six non-contact linear-motion, electromechanical Lorentz force actuators



ATC Portfolio of Technical Discriminators

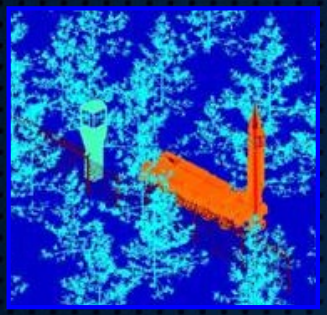


Space Science & Instrumentation



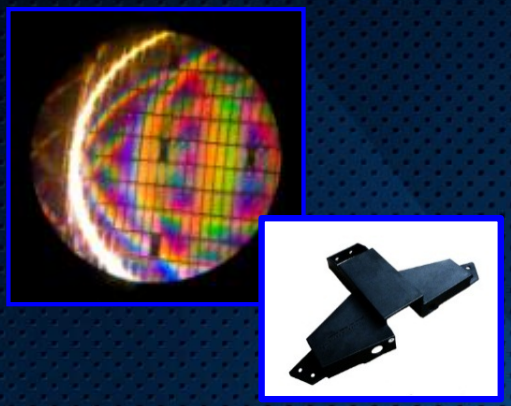
Phenomenology & Sensors Technology

Optics & Electro-Optics



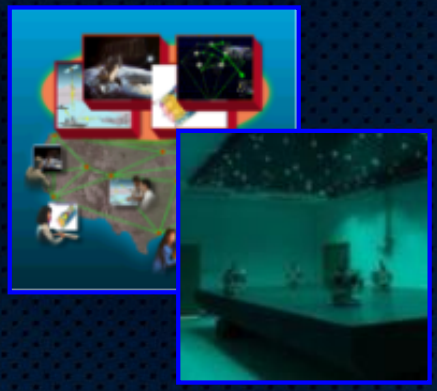
Laser Radar

Enabling Missions of Today and Tomorrow through Innovation

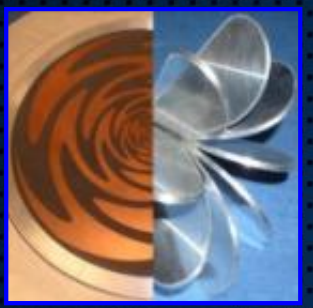


Advanced Materials & Nanosystems

Thermal & Energy Sciences



Control Systems & Information Sciences



RF & Photonics