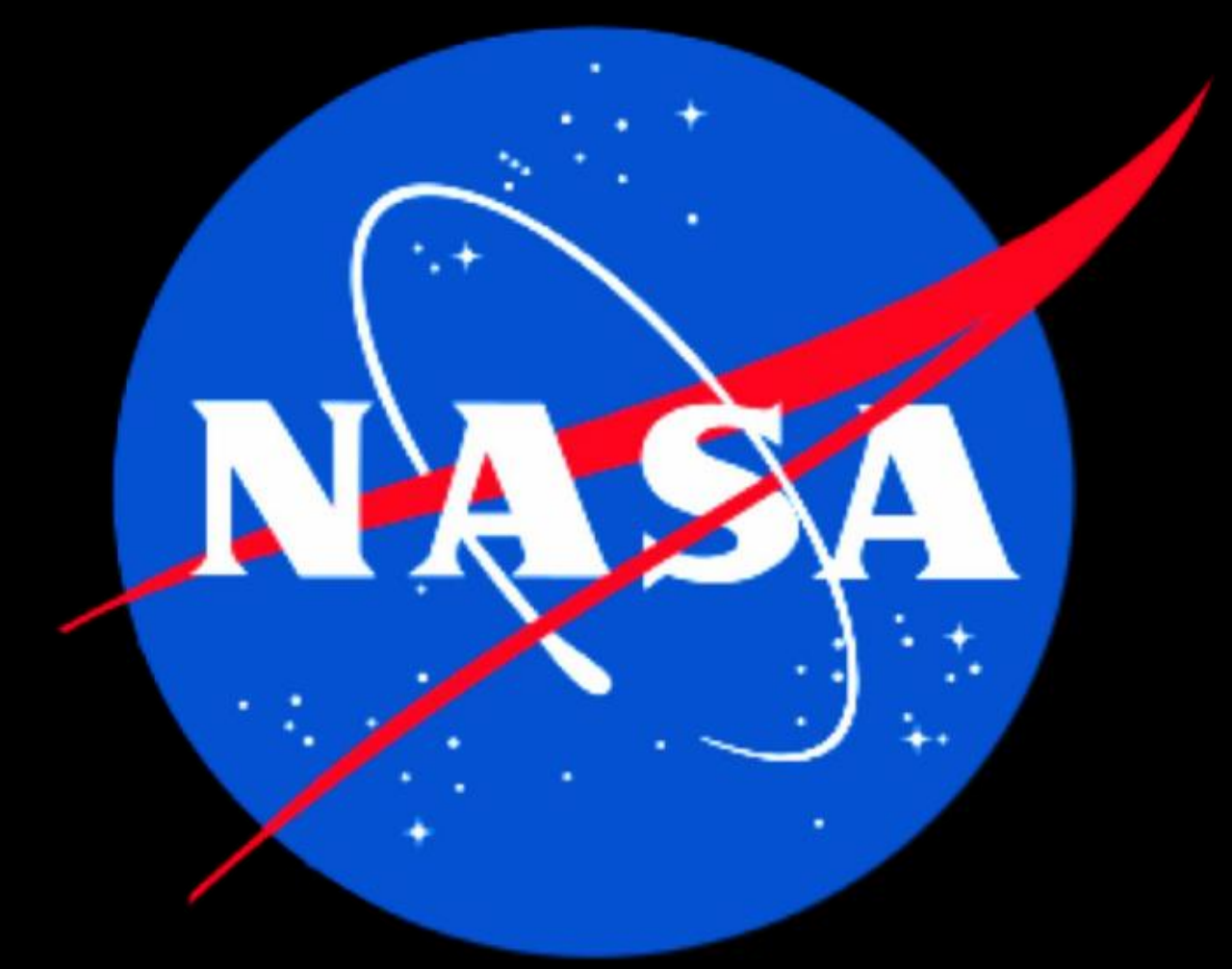


Marshall Space Flight Center Technology Capabilities for use in Space Situational Awareness Activities

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Overview

- Marshall performs research, integrates information, matures technologies, and enhances science to bring together a diverse portfolio of products and services of interest for Space Situational Awareness (SSA) and Space Asset Management (SAM), all of which can be accessed through partnerships with Marshall.
- Integrated Space Situational Awareness and Asset Management (ISSAAM) is an initiative of NASA's Marshall Space Flight Center to improve space situational awareness and space asset management through technical innovation, collaboration, and cooperation with U.S. Government agencies and the global space community.

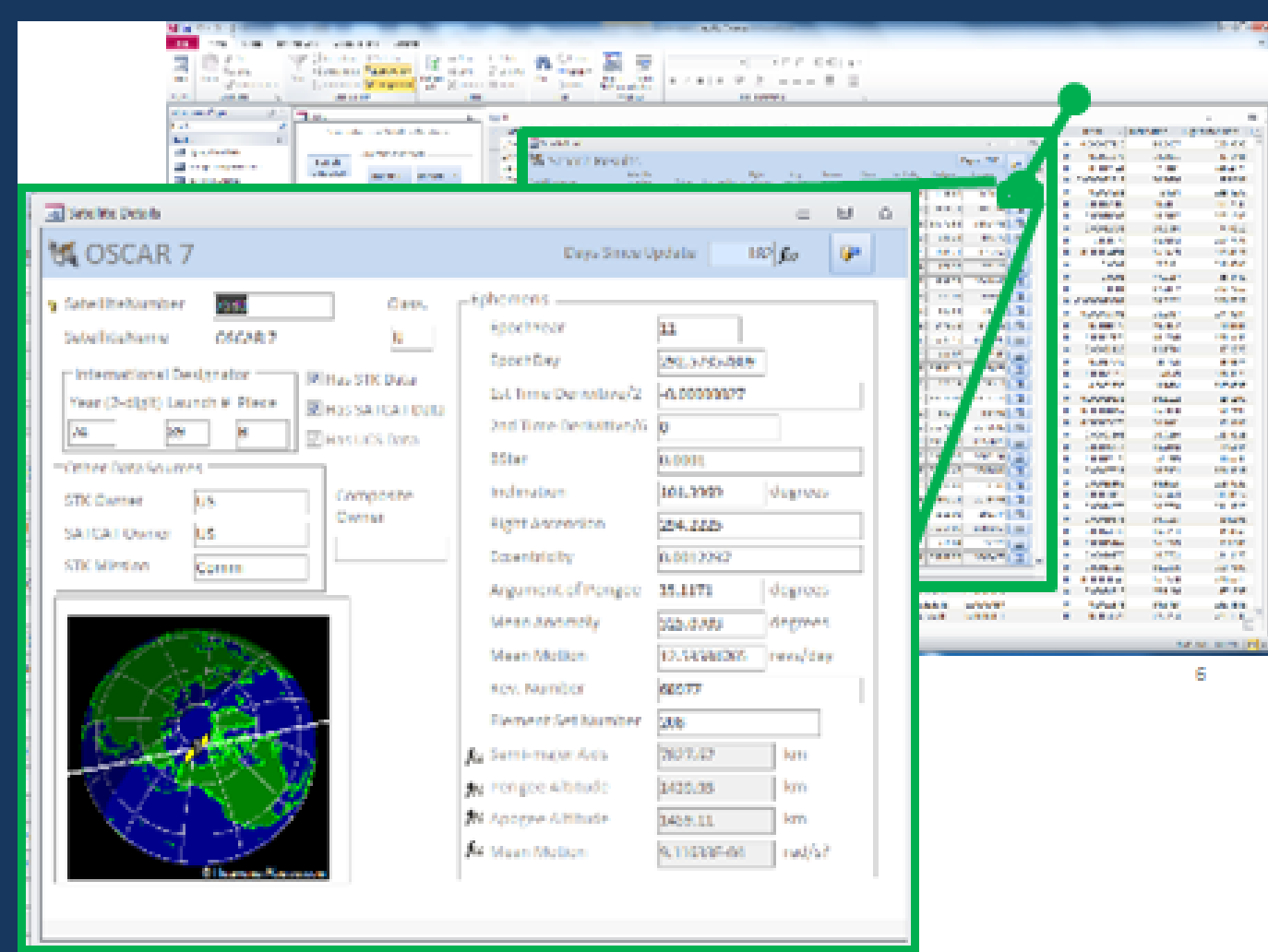
- Marshall Space Flight Center provides solutions for complex issues with in-depth capabilities, a broad range of experience, and expertise unique in the world, and all available in one convenient location.
- NASA has longstanding guidelines that are used to assess space objects. Specifically, Marshall Space Flight Center has the capabilities, facilities and expertise to address these challenges that space objects, such as near-Earth objects (NEO) or Orbital Debris pose.

- ISSAAM's three pronged approach brings together vital information and in-depth tools working simultaneously toward examining the complex problems encountered in space situational awareness.
- Marshall's role in managing, understanding and planning includes many projects grouped under each prong area. These are not limited to those listed below.

Database/Analyses/Visualization

Space Asset Management (SAM) Database

— Is designed to be a comprehensive easy-to-access database of information related to orbital populations and can be used for countless activities in the Space Situational Awareness and Asset Management arena. The database houses two line element (TLE) data and meta-data for space objects in Earth orbit. It incorporates the Joint Space Operations Center (JSpOC) TLE catalog, the Satellite Catalog (SATCAT) Database, the Satellite Database from the Union of Concerned Scientists, and the Systems Tool Kit (STK) Satellite data catalog. Meta-data includes ownership, object status (active, dead, fragment) and mission type. Technical data includes mass, area, orbits, etc.



2001 Leonid Fireball recorded from Hawaii

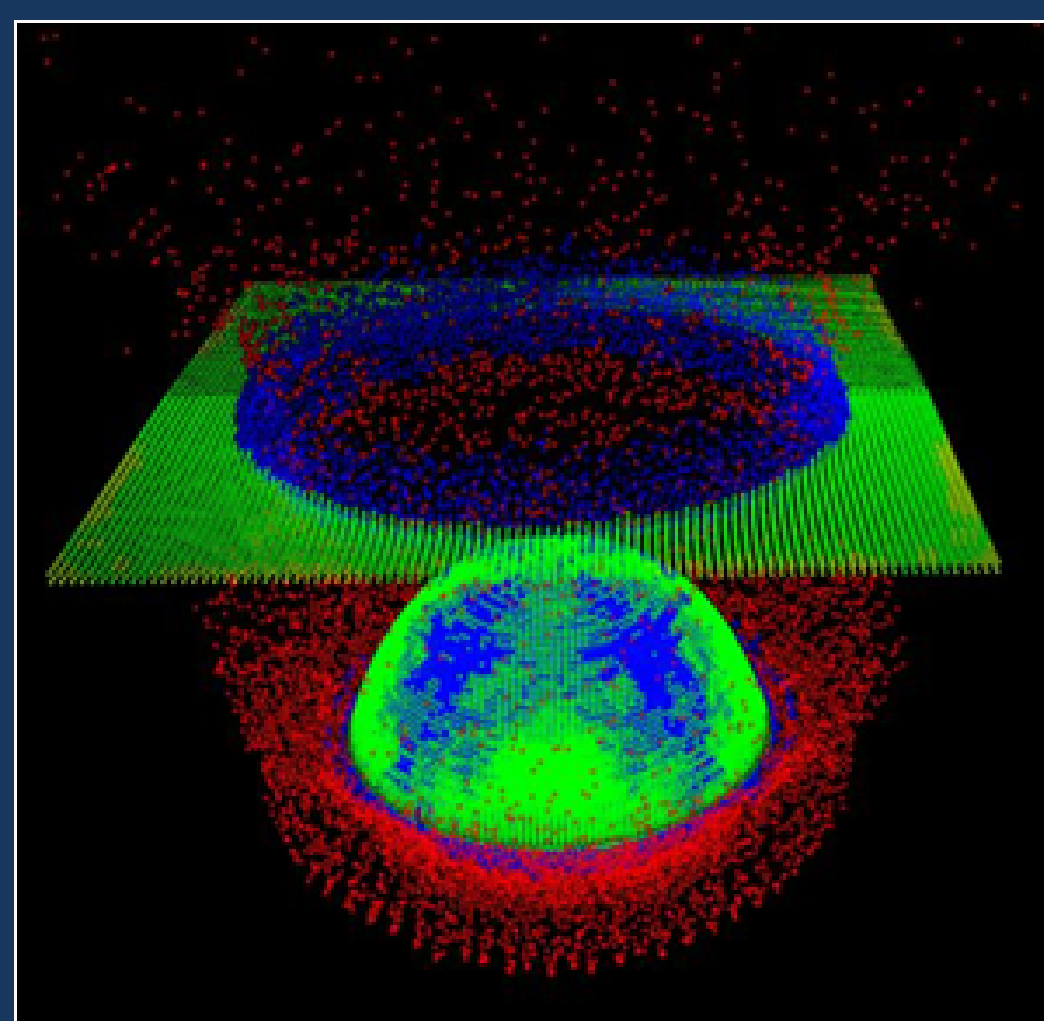
Meteoroid Environment Office (MEO) — MEO, based at Marshall, is the NASA organization responsible for meteoroid environments pertaining to spacecraft engineering and operations. The MEO leads NASA technical work on the meteoroid environment and coordinates the existing meteoroid expertise at NASA centers. The objective of the MEO is to understand the flux and the associated risk of meteoroids impacting spacecraft traveling in and beyond Earth's orbit.

Meteoroids impacting spacecraft are a quantifiable risk as they can puncture pressurized volumes (i.e. space station modules, propellant tanks) or destroy components (i.e. engines, electronics).

Meteoroid Environment Model (MEM) — Given a state vector, MEM outputs mass-limited or penetrating fluxes and average impact speeds and distributions on the surfaces of a cube-like structure with the ram face oriented along the spacecraft velocity. Some of the revolutionary aspects of MEM are a) identification of the sporadic radiant with real sources of meteoroids, such as comets, b) a physics-based approach which yields accurate fluxes and directionality for interplanetary space-craft anywhere from .2 AU to 2 AU, and c) velocity distributions obtained from theory and validated against observation.

Smooth Particle Hydrodynamic Code (SPHC)

— A software code that can handle one-, two-, or three-dimensional versions of a problem to support high-velocity impact simulation/modeling. It accommodates any material for which a specified set of properties is known, using any of ten equations of state and seven material strength models. SPHC has flexible geometric modeling capabilities, allowing it to simulate a wide range of articles. Impacts can be modeled at any speed below ~50 km/s using initial temperatures, densities, porosities, and user-specified internal pressures. Complex objects can be built up from simple geometric constructs, then duplicated and moved as desired in the simulation space.

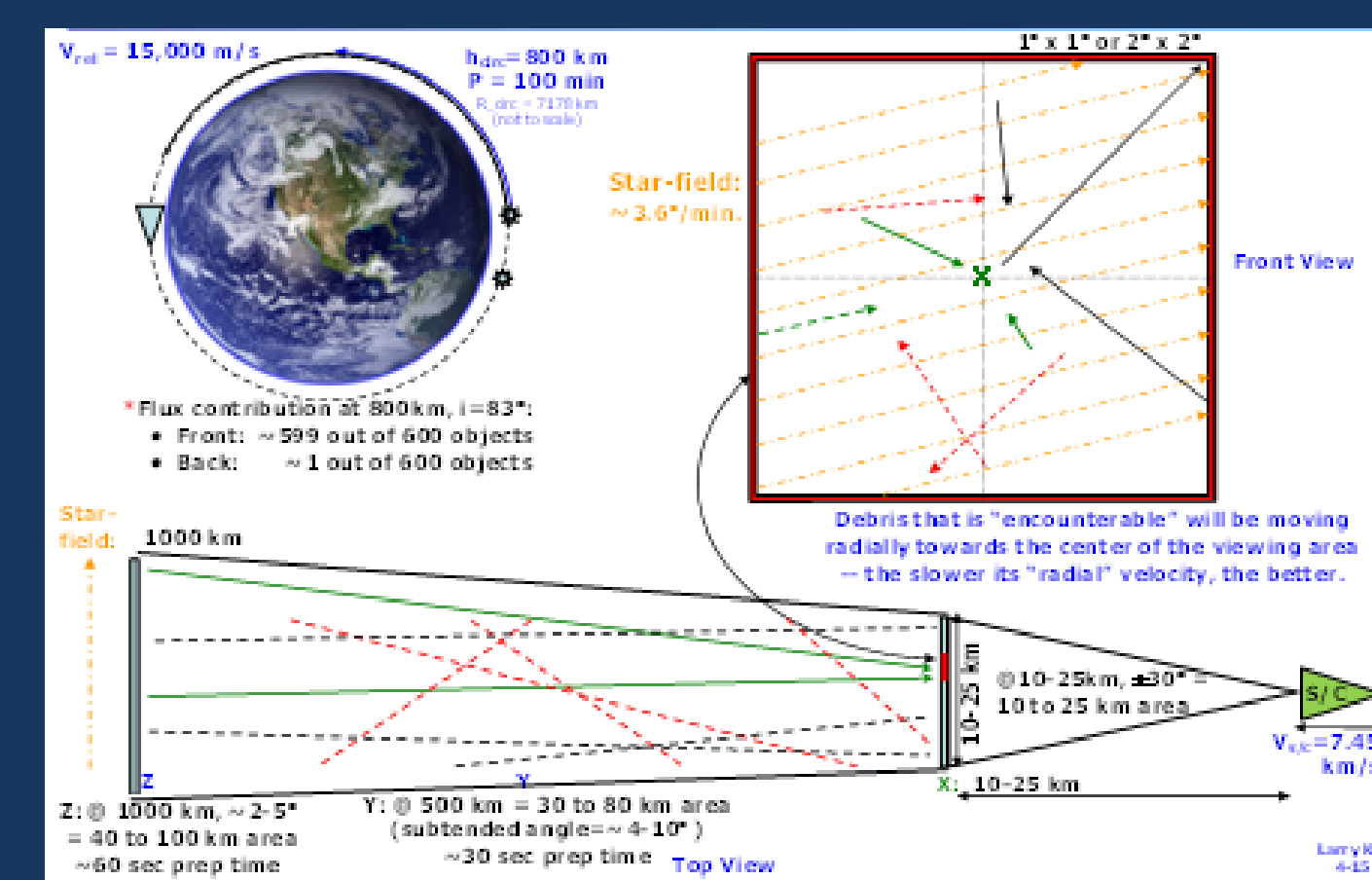


Detection/Tracking

Automated Lunar and Meteor Observatory (ALaMO) — Marshall has two observatory domes, a 15-meter tower with a roll-off roof, and an operations center with laboratory space. The telescopes are equipped with computerized mounts so that observations can be controlled from the operations center.



ALaMO Lunar Telescopes, Huntsville, Alabama

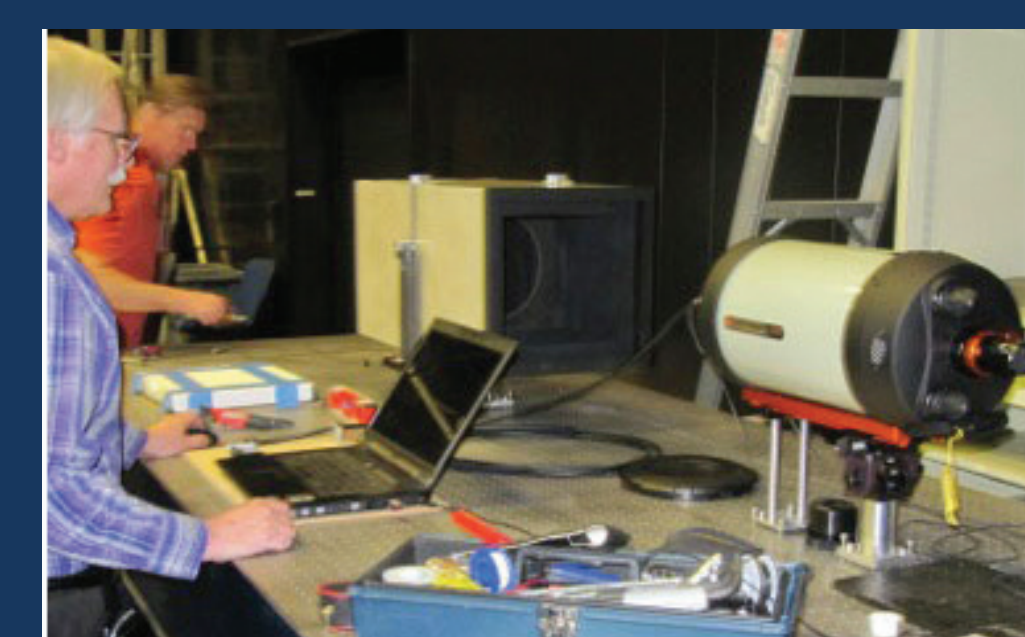


Small Orbital Debris Tracking Camera Development — By combining off-the-shelf digital video technology, telescope lenses, and advanced video image Field Programmable Gate Array processing, Marshall is building a breadboard of a passive orbital tracking camera that can track faint objects (including small debris, satellites, rocket bodies, and NEOs) at ranges of tens to hundreds of kilometers and speeds in excess of 15 km/sec.

Small Orbital Debris Detection, Acquisition and Tracking (SODDAT) — This conceptual technology demonstration spacecraft was developed to address the challenges of in-situ small orbital debris environment classification including debris observability and instrument requirements for small debris observation.



SODDAT — Artist Conceptual Drawing



Dr. Tom Pollock (foreground) from Texas A&M begins checkout of the Star Field Simulator

High-Fidelity Dynamic Star Field Simulator — Is a unique capability developed in conjunction with Texas A&M University that is now in testing. It has a high resolution large monochrome display and a custom collimator capable of projecting realistic star images with simple orbital debris spots (down to star magnitude 11-12) into a passive orbital tracking camera with simulated real-time angular motions of the vehicle mounted sensor. The simulator can be expanded for multiple sensors, real-time vehicle pointing inputs, and more complex orbital debris images and is adaptable to other sensor optics, missions, and installed sensor testing.

Mitigation/Removal



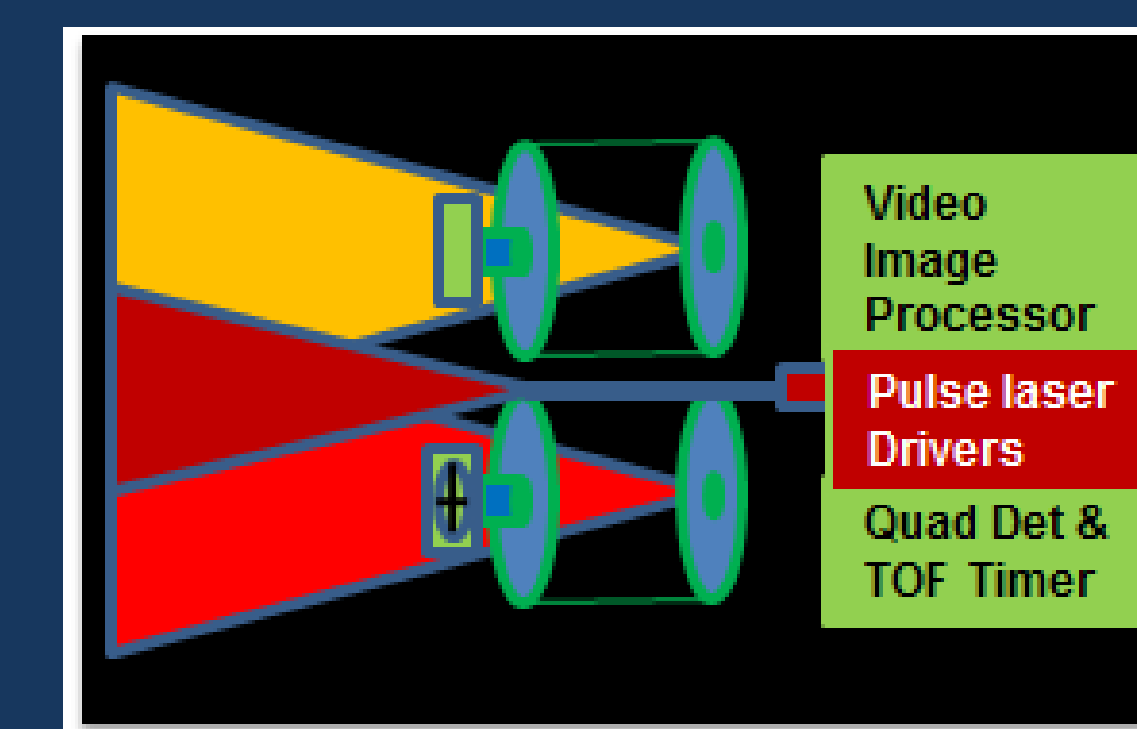
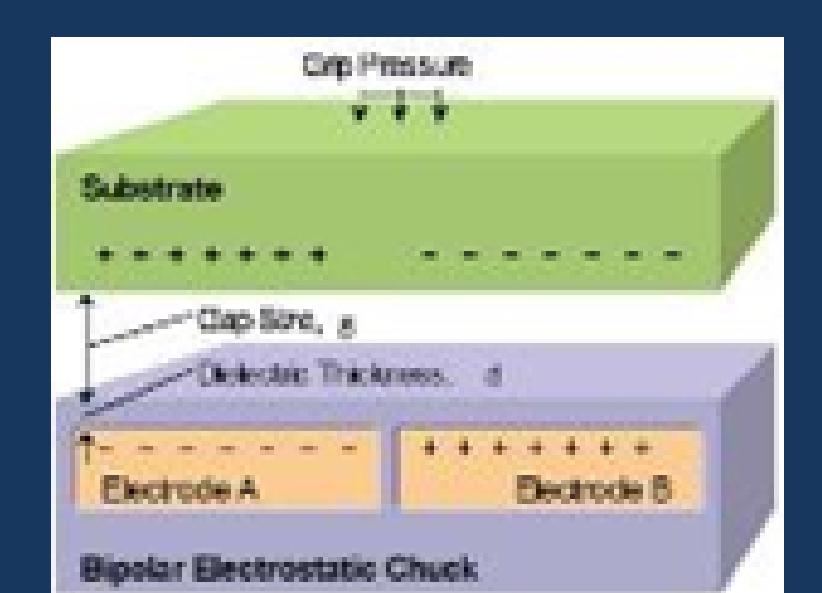
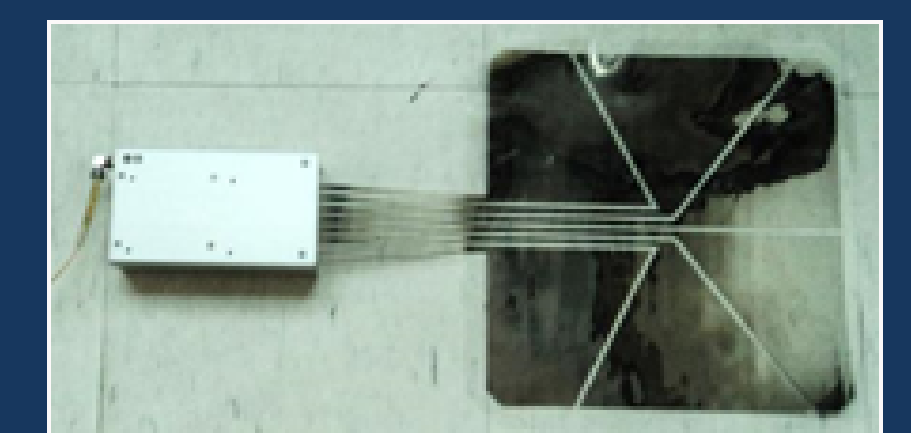
Materials on the International Space Station Experiment (MISSE)

Space Environments Effects (SEE) Testing — This team studies material's behaviors in the space environment. Laboratory capabilities include simulation of orbital atomic oxygen, ultraviolet radiation, electron and proton radiation, plasma, thermal vacuum, and meteoroid and space debris impacts.

Marshall Active Debris Removal — Transportation Architecture Study (MADR-TAS)

— This task is to gather an understanding of large debris/objects and how to most effectively remove them, in the most affordable manner. It will investigate the best transportation methods to reduce the threat of a lower-Earth orbit orbital debris conjunction. In addition the study will help to determine what Resident Space Objects (RSOs) pose to be the largest threat to worsening the lower-Earth orbit orbital debris environment.

Electrostatic Gripper Tech Dev — specialized Electro-Static grippers will allow gentle and secure Capture, Soft Docking, and Handling of a wide variety of materials and shapes (such as upper-stages, satellites, arrays, asteroids) without requiring physical features or cavities for a pincher or probe or using harpoons or nets. Combined with new rigid boom mechanisms or small agile chaser vehicles, flexible, high speed Electro-Static Grippers can enable compliant capture of spinning objects starting from a safe stand-off distance.

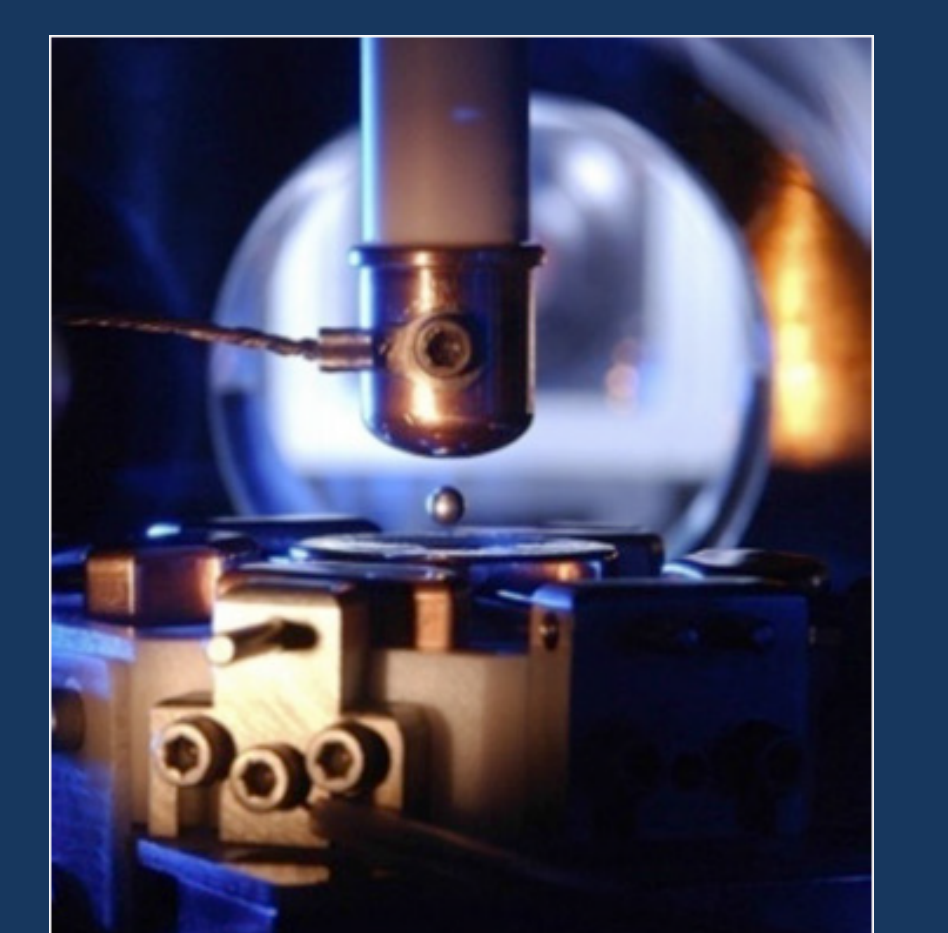


Small Orbital Debris Active Removal (SODAR)

— The architectural study investigated the overall effectiveness of removing small orbital debris from low-Earth orbit using a satellite-based non-weapons class, low power laser. The results found that a spacecraft with an integrated forward-firing laser is capable of reducing the small orbital debris flux within a 60 to 100 km orbital shell by a significant amount within the one spacecraft's operational lifetime.

Material Ablation Deorbit Study/Experiments

— Marshall is working with industry and academia to study the use of laser ablation to deorbit small debris. This concept is being considered for addition to the SODDAT in conjunction with the SSASSE. It would detect, track, and then heat debris with a laser, changing its trajectory to lead to deorbit.



Levitated sample in Marshall's Electrostatic Levitation Laboratory