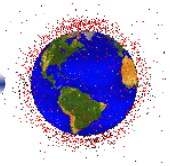
ORBITAL DEBRIS EDUCATION PACKAGE

NASA Johnson Space Center

Orbital Debris Program Office



Overview

- The What, Where, When, and How of Orbital Debris for K-12 Teachers
- Ideas for Making it Simple
- Applications/Activity Ideas for Various Age Groups
- Online Information
- Contact Information

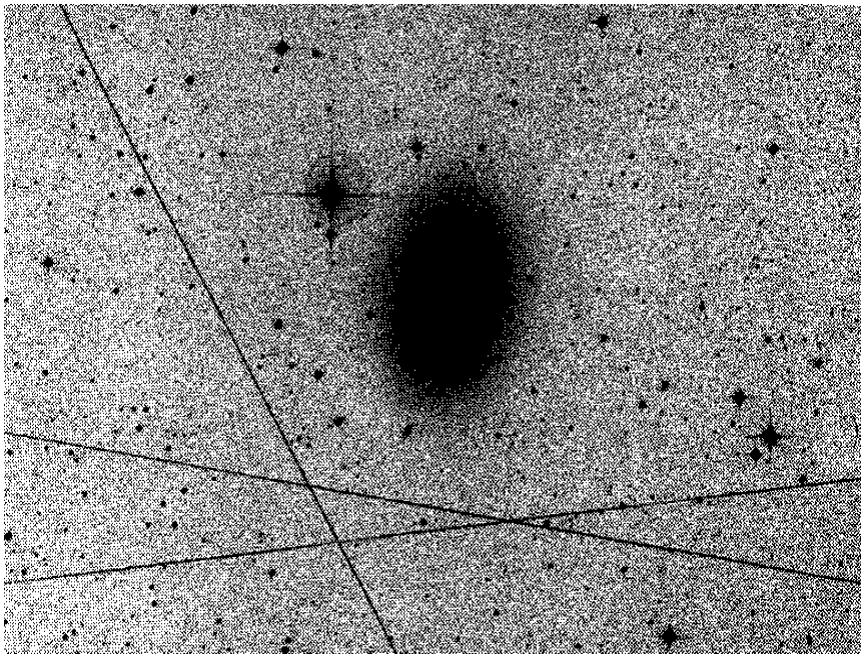


Figure depicts a picture of a star where the streaks are orbital debris crossing the field of view.

General Stats on Orbiting Objects

- Natural Debris
  - **Asteroids, Comets, etc.**
    - Some pass through the near-Earth space
    - Usually smaller than man-made and harder to observe because they are darker
- Artificial Debris (called Orbital Debris)
  - **Sputnik 1 launched October 4th, 1957**
  - **> 28,000 objects created since Sputnik**
    - ~9,000 still in orbit
      - **Only 6% still functional spacecraft**
    - Remaining objects are Space Debris
  - **~ 75 spacecraft launches per year**

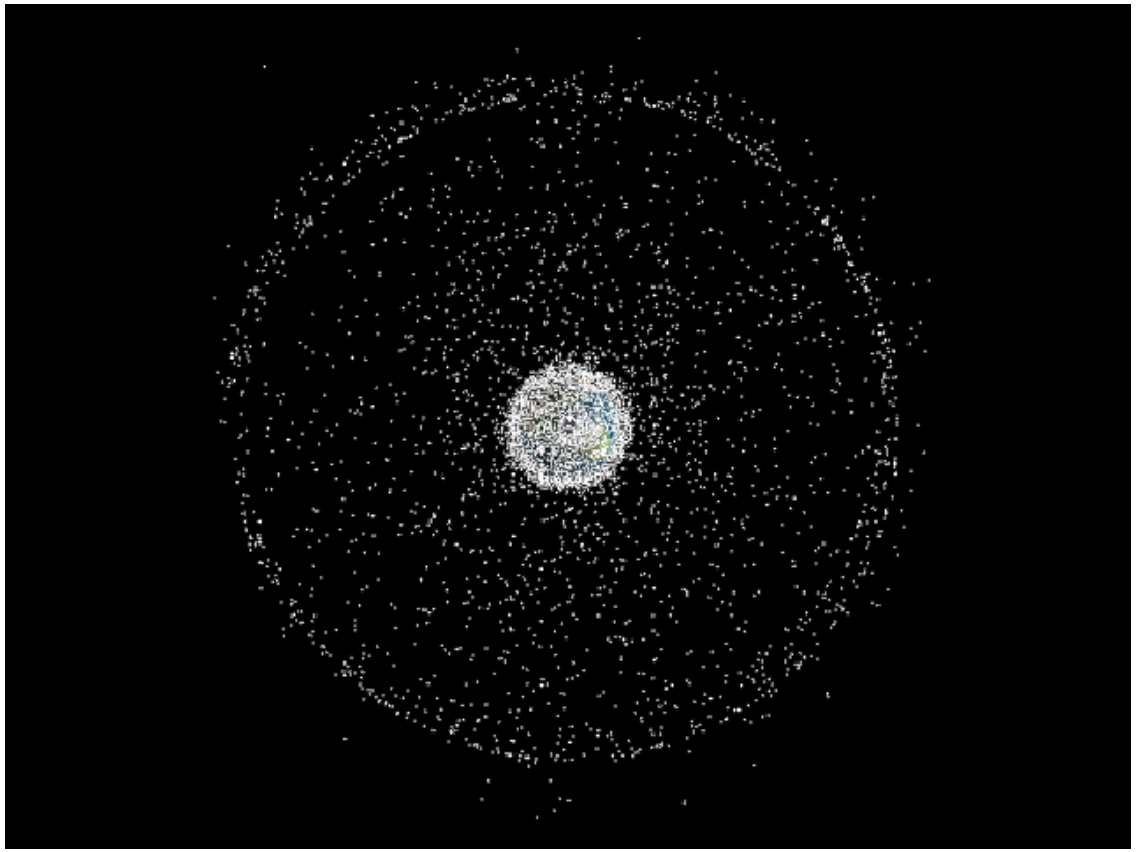
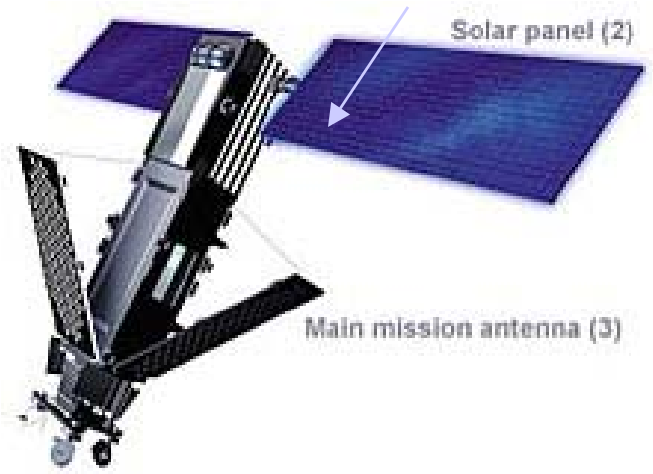


Figure shows the Earth with the dots representing each piece of observable Artificial Debris

What is Orbital Debris?

Orbital Debris = all space objects non-functional and human-made

- Fragmentation Debris (42%)
  - **Break-ups of Satellites**
    - unused fuel, dead batteries, etc.
  - **Productions of deterioration**
    - Paint Flakes, thermal blankets, etc.
- Rocket Bodies (17%)
- Mission-related Debris (19%)
  - **Refuse from Human missions**
  - **Objects released from Spacecraft**
  - **Deployment and operation**
- Non-Functional Spacecraft (22%)



How do we find the Debris?

How we find the Debris directly depends upon the size of the object

- Radar and Optical Measurements

  (for objects 0.5 cm and greater)

  - **Stare at the sky using a telescope and look at what flies through the field of view**
  - **Objects that are bright or big can be observed from the ground**
    - Objects greater than 10 cm are followed (tracked) so that spacecraft can maneuver away from those objects
    - Objects less than 10 cm but greater than 0.2 cm are observable but not tracked (too small to predict object accurately)

- Returned Spacecraft Measurements

  (for objects less than 0.1 cm)

  - **Shuttle, MIR, ISS, HST**
  - **Long Duration Exposure Facility**
    - Launched to measure the material reaction to space environment (included orbital debris)
    - Gathered data on small-sized debris (less than 0.1 cm)

How much Orbital Debris is out there and how do we avoid being hit by it?

- ~ 11,000 objects greater than 10 cm in diameter
  - **These objects are tracked by the United States Space Surveillance Network using radar and optical systems**
  - **~9,000 catalogued objects in both lower Earth orbit (LEO) and geosynchronous (GEO) orbits**
  - **Space objects can maneuver around objects in the catalogue for their orbits are well known**

- ~100,000 objects between 1 and 10 cm
  - **Most are not tracked objects because they are too difficult to observe with ground-based telescopes and radars**
  - **Cannot be shielded against nor maneuvered around debris this size**

- many millions of objects smaller than 1 cm
  - **Are not tracked for same reasons as above -- they are too small**
  - **Many of these debris can still cause significant damage to spacecraft**

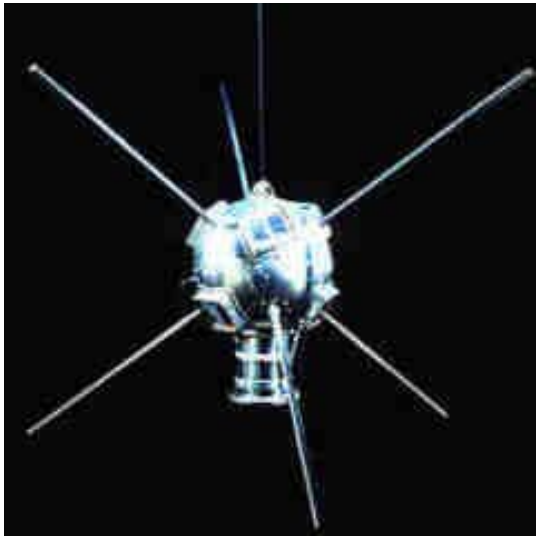
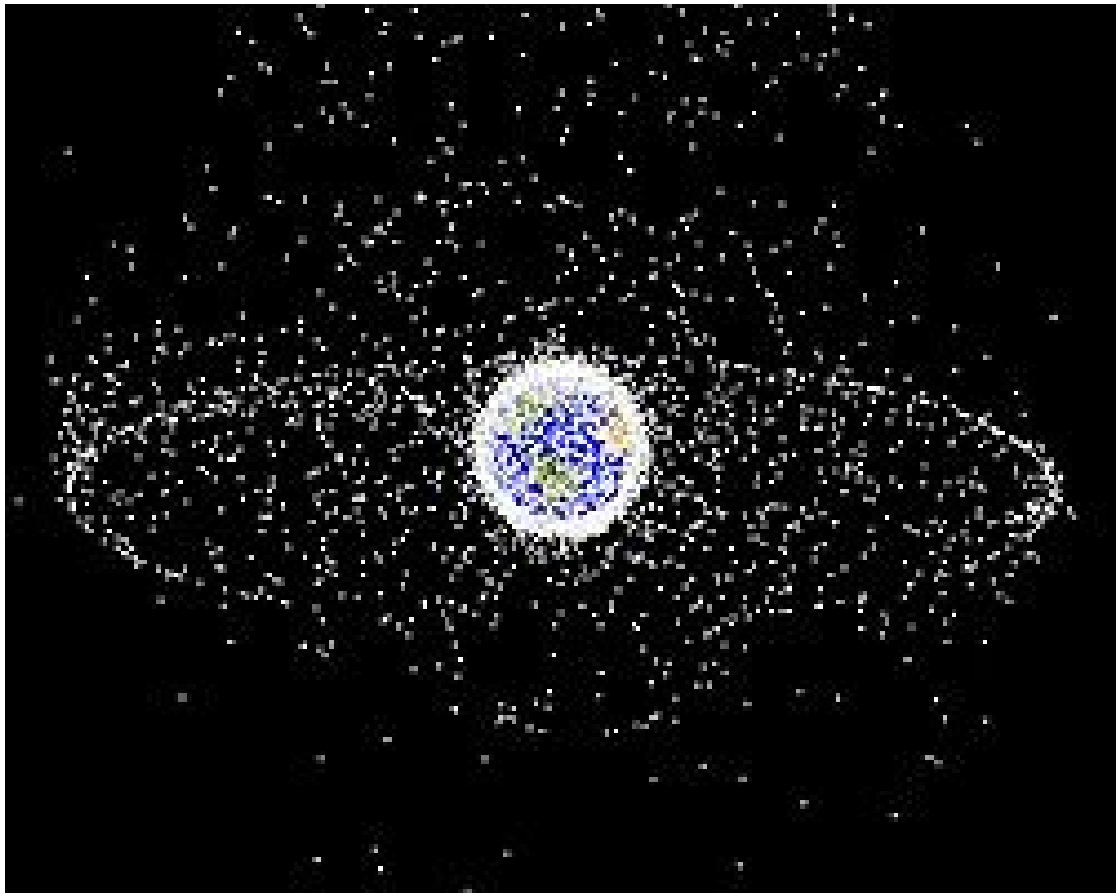


Figure above shows the Vanguard 1, the oldest known piece of space debris. It was launched in 1958 to observe the Earth's oblateness, continental drift, and upper atmospheric drag.

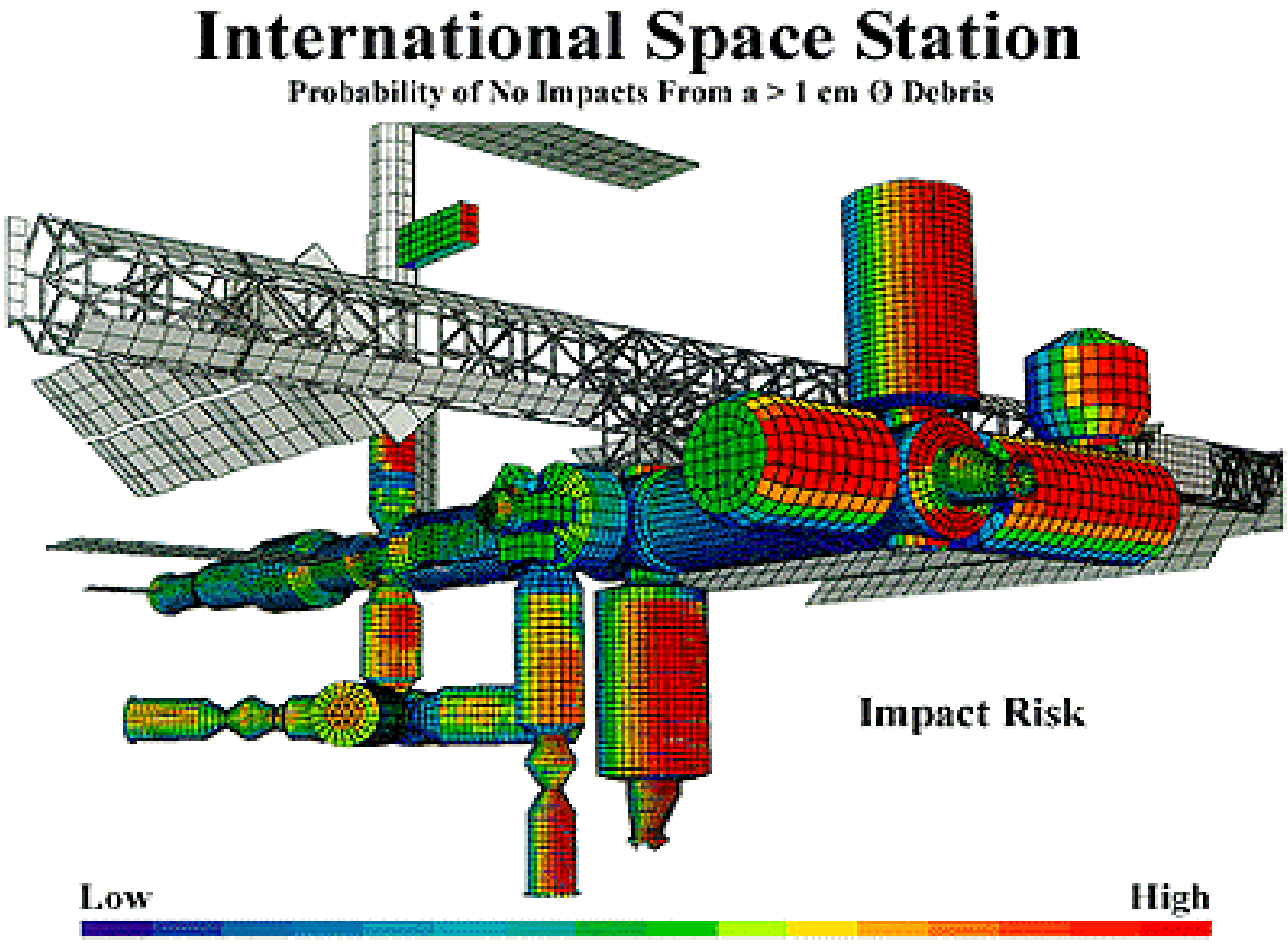
How Long Will Orbital Debris Remain In Earth Orbit?

- **The answer to this question depends upon the altitude of the orbit**
  - **a few days if altitude is less than 200 km**
  - **a few years if altitude is between 200 and 600 km**
  - **decades if altitude is between 600 and 800 km**
  - **centuries if altitude is greater than 800 km**
  - **forever if altitude is 36000 km or greater**



To whom is the Information Important?

- Shielding against debris
  - **Figure at right shows high impact areas for the International Space Station**
  - **Shielding placed in front of the high impact areas**
  - **Shields consist of layers of material with space between in an effort to stop the debris before it hits the station**
- Modeling the future environment
  - **Knowledge of what is up there currently will help asses what will affect the future environment**



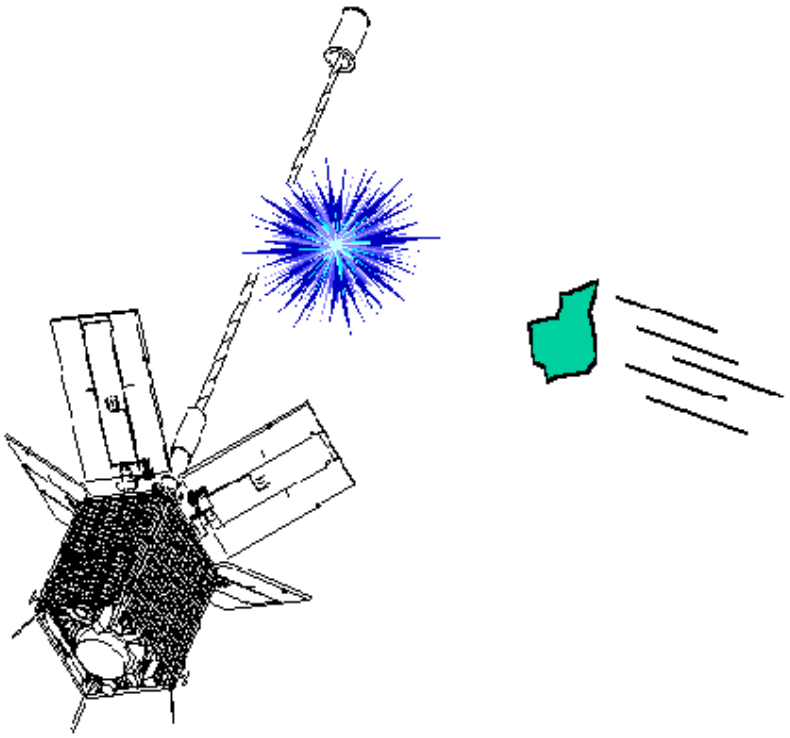
Examples and Results of Impacts

- Shuttle Window Strike - STS-94
  - **image of impact crater found on a Shuttle window**
  - **crater is roughly one millimeter in size**
  - **impacting projectile estimated to be 100 to 150 microns (0.01 cm)**
    - residue indicates the object was aluminum oxide
    - byproduct of a solid rocket motor
  - **impact posed no threat to the crew**
  - **the window was subsequently replaced**

- With respect to other orbiting objects the average relative velocity is nearly 10 km/sec BUT can be as large as 16 km/sec (head-on collision)
  - **debris objects smaller than 0.1 cm generally do not penetrate spacecraft**
  - **0.1 - 10 cm debris penetrate and damage spacecraft**
  - **1 cm debris objects and larger will cause catastrophic failure (loss of functionality of satellite due to the impact)**

CERISE Collision (accidental) 24 July 1996

- **CERISE (communication satellite) collided with a piece of fragmentation debris from an Ariane 1 rocket body**
- **6 meter long stabilization boom was severed**
- **fragment was**
  - **size of a briefcase**
  - **traveling at a relative velocity of 14 km/sec (31,500 miles/hour for a head-on collision)**
- **Following the collision, the satellite's on-board computer was reprogrammed for attitude control.**



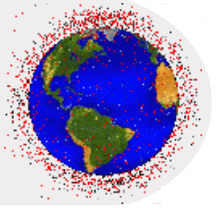
What Is This?

Figure shows a human-made pressurization sphere stemming from a rocket body that fell in Southern Africa

Does Orbital Debris Fall From The Sky?

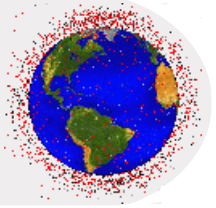
- **About 1 catalogued object decays from orbit per day**
  - **most burn up in the atmosphere**
  - **a few fall to the Earth**
    - **risk is 1 in a trillion of injury from orbital debris**
    - **risk due to lightning strike is 1 in 1.4 million (annual risk in the US)**
    - **one person known to be struck by debris, but not hurt**
- **January 1997**
  - **Texas USA**
    - **Shown here is a 500-pound stainless steel fuel tank, part of a Delta II upper stage rocket but a pressurization sphere and rocket motor chamber were also found**
- **April 2000**
  - **Cape Town South Africa (shown in photo to the right)**
    - **500-pound stainless steel fuel tank, part of a Delta II upper stage rocket (object in the top of the picture to the right)**
    - **pressurization sphere (right object in right photo, man holding the sphere)**
    - **rocket motor chamber (left object in right photo)**

Reducing Threat Of Orbital Debris



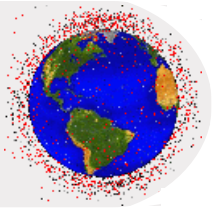
- **Limit the creation of orbital debris**
- **Prevent satellite explosions**
  - **vent or burn remaining fuel in rockets**
  - **better battery designs to prevent explosions**
- **At end of life remove satellite from popular orbit**
  - **“graveyard” orbits**
    - 300 km above geosynchronous orbit (GEO)
  - **maneuver to lower the altitude**
    - lower altitude such that the object naturally decays within 25 years due to the drag of the atmosphere
- **Collision Avoidance**
  - **requires precision tracking**
- **NASA Safety Standard 1740.14**
  - **Now, all NASA flight projects are required to provide debris assessments as a normal part of the project development. (Wasn’t in place for early launches.)**
- **Cleaning Up the Debris**
  - **Clean up would only concern the larger pieces since they make the smaller pieces**
  - **Isn’t cost effective because it would include rendezvous w/ objects which is very difficult**

Ideas for Making It Simple



- Describe sizes/speeds/distances of Debris on a level your student will understand
  - **Size of Debris**
    - 0.1 cm object ~ the diameter of pencil lead
    - 1 cm object ~ the diameter of your first fingernail or a nickel
    - 10 cm object ~ diameter of a grapefruit
  - **In low Earth orbit debris is moving at ~ 7 km per sec (25,200 km/hour or 18,000 miles/hour) which compares to:**
    - An airplane at cruise altitude traveling 600 miles/hr
    - Pro baseball player pitching from the mound to home plate going 70 –100 miles/hr
    - An automobile traveling on the highway at 50 – 70 miles/hr
    - Roller coaster racing 50 – 60 miles/hr
  - **1cm aluminum sphere (similar to a nickel in size) @ 10km/sec (36,000 km/hr or 22,320 miles/hr) = Energy which compares to:**
    - a Ford Escort traveling 55 miles/hour
    - bowling ball hitting you at 520 km/hr (~300 miles/hr)
    - 60 lb safe hitting you at 60 miles/hr
  - **Distances to Satellites (sample distance: Los Angeles to New York City = 2790 miles) which compares to:**
    - 250-600 km = 150-375 miles (lower Earth orbit where the shuttle and space station are located)
    - 20,000 km = 12,500 miles (distance to Global Positioning Satellites (GPS))
    - 36,000 km = 22,500 miles (distance to Geosynchronous Satellites which are used for communication and television broadcasts)

Activities for the Students



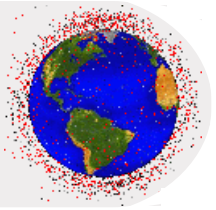
- Make a Satellite out of Everyday Materials
  - **Material Suggestions:**
    - toilet paper and paper towel holders, egg cartons, cloth, toothpicks, q-tips, Styrofoam balls, construction paper, etc
  - **Include debris shields**
  - **Include purpose for Satellite**
- Discuss options for increasing awareness about debris
- Discuss options to reduce orbital debris
  - **See prior slide for reduction of threat from orbital debris**
- Track satellites and the International Space Station
  - **Look for satellites in the night sky (see links on next slide)**

Other Documentation

- Internet Information
  - **NASA JSC Orbital Debris Website**
    - www.orbitaldebris.jsc.nasa.gov
  - **Amateur Tracking of Satellites**
    - www.heavens-above.com
  - **Hypervelocity Impact of Orbital Debris**
    - http://hitf.jsc.nasa.gov/hitfpub/main/index.html
    - http://www.wstf.nasa.gov/Hazard/Hyper/debris.htm
  - **United States Space Command Tracking Objects for the Catalogue**
    - http://www.spacecom.mil/
  - **General Information**
    - http://see.msfc.nasa.gov/see/mod/modtech.html
  - **Inter-Agency Debris Committee**
    - http://www.iadc-online.org

- Books for the Younger Audience
  - **Junk in Space, by Richard Maurer**
  - **Space Junk, by Jo Windsor**

Contact Information



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