USA Space Debris Environment, Operations, and Policy Updates

Presentation to the 48th Session of the Scientific and Technical Subcommittee Committee on the Peaceful Uses of Outer Space United Nations

7-18 February 2011
Presentation Outline

• Earth Satellite Population
• Satellite Reentries in 2010
• Collision Avoidance Maneuvers in 2010
• Satellite Fragmentations
• Disposal of U.S. Spacecraft in 2010
• New U.S. National Space Policy
Growth of the Cataloged Satellite Population

- The number of cataloged objects in Earth orbit by orbit type, as assessed by the U.S. Space Surveillance System.

Graphic compiled from publicly available orbital data at www.space-track.org
Satellite Distribution in Low Earth Orbit

- The highest levels of cataloged object concentration in LEO remain near the sites of the Fengyun-1C, Cosmos 2251, and Iridium 33 breakups.
Satellite Reentries in 2010

- The U.S. Space Surveillance Network recorded 382 reentries during 2010.
  - 369 uncontrolled reentries
  - 13 controlled reentries

- The uncontrolled reentries accounted for a total mass of ~60 metric tons from 22 payloads and 27 rocket bodies.

- No accounts of personal injury or significant property damage were reported.

- The overall rate of uncontrolled reentries is expected to increase during the next several years due to the approach of solar maximum; however, the vast majority of these reentries will represent small debris which do not pose hazards to people and property on Earth.
Controlling the Reentry of Upper Stages

- NASA conducted two new missions to GEO during 2010 and utilized high perigee geosynchronous transfer orbits (1) to avoid leaving stages in low Earth orbit and (2) to prevent the stages from posing reentry risks to people and property on Earth.

- Both stages were left in disposal orbits above LEO and below the GEO operational regime.

<table>
<thead>
<tr>
<th>Spacecraft</th>
<th>Orbital Stage</th>
<th>Stage Perigee</th>
<th>Stage Apogee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Dynamics Observatory</td>
<td>Atlas 5 second stage</td>
<td>2370 km</td>
<td>33515 km</td>
</tr>
<tr>
<td>GOES 15</td>
<td>Delta 4 second stage</td>
<td>6595 km</td>
<td>35165 km</td>
</tr>
</tbody>
</table>
Orbital Debris Collision Avoidance

• Since 2007 NASA has required frequent satellite conjunction assessments for all of its maneuverable spacecraft in LEO or GEO to avoid accidental collisions with resident space objects.

• During 2010 NASA robotic satellites conducted 7 collision avoidance maneuvers.

<table>
<thead>
<tr>
<th>Spacecraft</th>
<th>Maneuver Date</th>
<th>Object Avoided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terra</td>
<td>22 January</td>
<td>Iridium 33 debris</td>
</tr>
<tr>
<td>Cloudsat</td>
<td>17/18 August</td>
<td>Unidentified debris</td>
</tr>
<tr>
<td>Landsat 5</td>
<td>24 August</td>
<td>Cosmos 2251 debris</td>
</tr>
<tr>
<td>Cloudsat</td>
<td>11 October</td>
<td>Zenit rocket body debris</td>
</tr>
<tr>
<td>Cloudsat</td>
<td>13 October</td>
<td>Cosmos 2251 debris</td>
</tr>
<tr>
<td>Aura</td>
<td>22 November</td>
<td>Cosmos 2251 debris</td>
</tr>
<tr>
<td>Landsat 7</td>
<td>21 December</td>
<td>USA 26 debris</td>
</tr>
</tbody>
</table>
ISS Collision Avoidance Maneuver

• After a 14-year mission, NASA’s Upper Atmospheric Research Satellite (UARS) was decommissioned in late 2005 and maneuvered into a lower altitude disposal orbit from which reentry will occur during 2011.

• In September 2010, a small fragment unexpectedly separated from UARS.

• Although the fragment remained in orbit only six weeks, the object was predicted to pass close by the International Space Station on 26 October, posing a collision threat of greater than 1 in 10,000.

• Using the Progress M-07M logistics vehicle, a small collision avoidance maneuver (+0.4 m/s) was conducted a little more than two hours before the predicted time of closest approach.
Satellite Fragmentations in 2010

- Six satellite fragmentations were detected by the U.S. Space Surveillance Network during 2010.

- Fortunately, none of the events have been assessed as contributing large numbers of long-lived debris to the near-Earth environment.

- The causes of four of the events have yet to be determined.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>International Designator</th>
<th>Fragmentation Date</th>
<th>Perigee</th>
<th>Apogee</th>
<th>Cataloged / Assessed Debris</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yaogan 1</td>
<td>2006-015A</td>
<td>4 February</td>
<td>625 km</td>
<td>630 km</td>
<td>8 / 8</td>
<td>Unknown</td>
</tr>
<tr>
<td>Briz-M Tank</td>
<td>2009-042C</td>
<td>21 June</td>
<td>90 km</td>
<td>1490 km</td>
<td>89 / 400⁺</td>
<td>Aerodynamic</td>
</tr>
<tr>
<td>Briz-M Stage</td>
<td>2008-011B</td>
<td>13 October</td>
<td>645 km</td>
<td>26565 km</td>
<td>9 / 30⁺</td>
<td>Propellants</td>
</tr>
<tr>
<td>CZ-3C Third Stage</td>
<td>2010-057B</td>
<td>1 November</td>
<td>160 km</td>
<td>35780 km</td>
<td>1 / 50⁺</td>
<td>Unknown</td>
</tr>
<tr>
<td>NOAA 11</td>
<td>1988-089A</td>
<td>24 November</td>
<td>835 km</td>
<td>850 km</td>
<td>2 / 2</td>
<td>Unknown</td>
</tr>
<tr>
<td>H-2A Debris</td>
<td>2007-005E</td>
<td>23 December</td>
<td>430 km</td>
<td>440 km</td>
<td>3 / 6</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
Status of Fengyun-1C, Cosmos 2251, and Iridium 33 Debris

- The intentional destruction of the Fengyun-1C spacecraft in 2007 and the accidental collision of the Cosmos 2251 and the Iridium 33 spacecraft in 2009 remain the worst known debris generation events in Earth orbit.

<table>
<thead>
<tr>
<th>Cataloged Debris</th>
<th>Cataloged Debris in Orbit 1 Jan 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fengyun-1C</td>
<td>3037</td>
</tr>
<tr>
<td></td>
<td>2932 (97%)</td>
</tr>
<tr>
<td>Cosmos 2251</td>
<td>1347</td>
</tr>
<tr>
<td></td>
<td>1273 (94%)</td>
</tr>
<tr>
<td>Iridium 33</td>
<td>528</td>
</tr>
<tr>
<td></td>
<td>492 (93%)</td>
</tr>
</tbody>
</table>

- All together, the two events account for 36% of the total number of cataloged objects residing in or traversing low Earth orbit.

- The rate of reentry of the debris will increase as solar activity increases.
Debris Distribution

- The debris from Fengyun-1C, Cosmos 2251, and Iridium 33 span the entire region of low Earth orbit with the highest concentrations near 750-900 km.
Disposal of ICESAT

- NASA’s Ice, Cloud, and land Elevation Satellite (ICESAT) concluded a highly successful, 7-year environmental monitoring mission in February 2010.

- In compliance with U.S. and UN orbital debris mitigation guidelines, during June and July the 900-kg ICESAT was maneuvered 20 times to bring the spacecraft from an operational altitude of approximately 600 km to a disposal orbit of only 200 km by 580 km. ICESAT was then passivated.

- Reentry occurred without incident six weeks later on 30 August over the Barents Sea.
National Aeronautics and Space Administration

TRACE End of Mission

• NASA’s Transition Region and Coronal Explorer (TRACE) spacecraft completed a successful 12-year, solar observation mission in June 2010 and was passivated in September at a mean altitude of 570 km.

• The spacecraft is expected to reenter the atmosphere within 13 years of decommissioning, in accordance with U.S. and UN guidelines.

TRACE spacecraft

TRACE image of solar eruption
Globalstar communications satellites operate near 1415 km. At mission completion, the objective is to maneuver each satellite to a higher disposal orbit, preferably above LEO, i.e., above 2000 km.
Disposal of TDRS 1

• NASA’s first Tracking and Data Relay Satellite (TDRS) completed more than 26 years of valuable service in October 2009.

• During June 2010 the spacecraft conducted 12 separate maneuvers over an 8-day period to reach a disposal orbit with a perigee more than 300 km above GEO, in accordance with U.S. and UN guidelines.

• After reaching the disposal orbit, TDRS 1 still possessed more than 120 kg of hydrazine. This propellant was expended during 20 more hours of small thruster burns over a period of 10 days.
  - To accomplish the depletion burns, the spacecraft was placed in a special spin-stable attitude, which had never before been used by TDRS 1.

• TDRS 1 completed passivation actions on 27 June in an orbit 345 km by 525 km above GEO.
• Orbital debris mitigation has been addressed in all U.S. National Space Policies since 1988.

• On 28 June 2010, President Barack Obama issued the latest U.S. National Space Policy.

• One of the six principal goals of the new National Space Policy was to strengthen stability in space, including “strengthening measures to mitigate orbital debris”.

• A section of the new National Space Policy was devoted to “Preserving the Space Environment and the Responsible Use of Space”.
“Preserve the Space Environment. For the purposes of minimizing debris and preserving the space environment for the responsible, peaceful, and safe use of all users, the United States shall:

• Lead the continued development and adoption of international and industry standards and policies to minimize debris, such as the United Nations Space Debris Mitigation Guidelines;

• Develop, maintain, and use space situational awareness (SSA) information from commercial, civil, and national security sources to detect, identify, and attribute actions in space that are contrary to responsible use and the long-term sustainability of the space environment;

• Continue to follow the United States Government Orbital Debris Mitigation Standard Practices, consistent with mission requirements and cost effectiveness, in the procurement and operation of spacecraft, launch services, and the conduct of tests and experiments in space;

• Pursue research and development of technologies and techniques, through the Administrator of the National Aeronautics and Space Administration (NASA) and the Secretary of Defense, to mitigate and remove on-orbit debris, reduce hazards, and increase understanding of the current and future debris environment; and

• Require the head of the sponsoring department or agency to approve exceptions to the United States Government Orbital Debris Mitigation Standard Practices and notify the Secretary of State.”