USA Space Debris Environment, Operations, and Measurement Updates

J.-C. Liou, PhD
Chief Scientist for Orbital Debris
NASA Orbital Debris Program Office

52nd Session of the Scientific and Technical Subcommittee
Committee on the Peaceful Uses of Outer Space, United Nations
2-13 February 2015
• Earth Satellite Population

• Space Missions in 2014

• Spacecraft Disposals

• Satellite Fragmentations

• Collision Avoidance Maneuvers

• Satellite Reentries

• DebriSat, MCAT, and DRAGONS
According to the U.S. Satellite Catalog, the number of 10 cm and larger objects in Earth orbit decreased slightly in 2014, driven by the decay of light weight fragmentation debris during high solar activities.

- **Collision of Cosmos 2251 and Iridium 33**
- **Destruction of Fengyun-1C**

### Graph

- **Total Objects**
- **Fragmentation Debris**
- **Spacecraft**
- **Mission-related Debris**
- **Rocket Bodies**

The graph shows the evolution of the cataloged satellite population from 1957 to 2015, with significant events highlighted.
Mass in Near-Earth Space Continued to Increase

- The material mass in Earth orbit continued to increase and reached a total of 6700 metric tons in 2014.
• A total of 90 space launches placed more than 180 spacecraft into Earth orbits during 2014.
Disposal of USA Spacecraft in GEO

Four USA civil spacecraft completed operations in the geosynchronous Earth orbit (GEO) in 2014.

All were moved to disposal orbits above GEO in compliance with UN COPUOS Space Debris Mitigation Guidelines to protect the GEO region.

<table>
<thead>
<tr>
<th>Spacecraft</th>
<th>International Designator</th>
<th>Minimum Height above GEO</th>
<th>Maximum Height above GEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMC-5</td>
<td>1998-063B</td>
<td>241 km</td>
<td>292 km</td>
</tr>
<tr>
<td>Galaxy 26</td>
<td>1999-005A</td>
<td>331 km</td>
<td>392 km</td>
</tr>
<tr>
<td>DIRECTV 1R</td>
<td>1999-056A</td>
<td>355 km</td>
<td>390 km</td>
</tr>
<tr>
<td>XM-2</td>
<td>2001-012A</td>
<td>335 km</td>
<td>341 km</td>
</tr>
</tbody>
</table>
Twelve minor satellite fragmentations were detected by the U.S. Space Surveillance Network during 2014. None of them contributed large numbers of long-lived debris to the near-Earth environment.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>International Designator</th>
<th>Perigee Altitude (km)</th>
<th>Apogee Altitude (km)</th>
<th>Detected Debris</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosmos 1867</td>
<td>1987-060A</td>
<td>775</td>
<td>800</td>
<td>6</td>
<td>Unknown</td>
</tr>
<tr>
<td>Delta II 2(^{nd}) Stage</td>
<td>1999-008D</td>
<td>635</td>
<td>840</td>
<td>6</td>
<td>Unknown</td>
</tr>
<tr>
<td>Cosmos 2428</td>
<td>2007-029A</td>
<td>845</td>
<td>860</td>
<td>17</td>
<td>Unknown</td>
</tr>
<tr>
<td>SOZ Ullage Motor</td>
<td>1994-076G</td>
<td>420</td>
<td>18,990</td>
<td>15</td>
<td>Propulsion</td>
</tr>
<tr>
<td>SOZ Ullage Motor</td>
<td>2008-046H</td>
<td>865</td>
<td>18,720</td>
<td>7</td>
<td>Propulsion</td>
</tr>
<tr>
<td>Cosmos 862 Deb</td>
<td>1976-105F</td>
<td>110</td>
<td>14,990</td>
<td>3</td>
<td>Aerodynamic</td>
</tr>
<tr>
<td>Titan 3C Transtage</td>
<td>1969-013B</td>
<td>35,970</td>
<td>37,130</td>
<td>5</td>
<td>Unknown</td>
</tr>
<tr>
<td>Iridium 47</td>
<td>1997-082C</td>
<td>776</td>
<td>779</td>
<td>10</td>
<td>Unknown</td>
</tr>
<tr>
<td>Haiyang 2A</td>
<td>2011-043A</td>
<td>965</td>
<td>965</td>
<td>4</td>
<td>Unknown</td>
</tr>
<tr>
<td>SOZ Ullage Motor</td>
<td>2010-007G</td>
<td>770</td>
<td>18,750</td>
<td>16</td>
<td>Propulsion</td>
</tr>
<tr>
<td>SOZ Ullage Motor</td>
<td>2007-052F</td>
<td>730</td>
<td>18,790</td>
<td>70</td>
<td>Propulsion</td>
</tr>
<tr>
<td>Iridium 91</td>
<td>2002-005A</td>
<td>776</td>
<td>779</td>
<td>4</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
Since 2007 NASA has required frequent satellite conjunction assessments for all of its maneuverable spacecraft in LEO and GEO to avoid accidental collisions with objects tracked by the U.S. Space Surveillance Network.

NASA also assists other U.S. government and foreign spacecraft owners with conjunction assessments and subsequent maneuvers.

During 2014 NASA executed or assisted in the execution of 21 collision avoidance maneuvers by robotic spacecraft.

- 2 maneuvers were needed to avoid debris from Fengyun-1C
- 4 maneuvers were needed to avoid debris from the collision of Cosmos 2251 and Iridium 33
The International Space Station (ISS) has conducted 21 debris collision avoidance maneuvers since 1999.

During 2014, a record five debris avoidance maneuvers were executed.
Satellite Reentries in 2014

- More than 600 reentries of spacecraft, launch vehicle upper stages, and other debris were recorded by the U.S. Space Surveillance Network during 2014.
  - Spacecraft: 86; upper stages: 49; debris: 467 (including 243 reentries of the Fengyun 1C, Iridium 33, and Cosmos 2251 fragmentation debris).
  - The high reentry rate was due to the peak of solar maximum in 2014.
  - The oldest spacecraft that reentered was NASA’s weather satellite TIROS-2, which was launched into a 619 km × 732 km orbit for a one-year mission in 1960.

- The total mass of the 2014 reentries was more than 100 metric tons.
- No accounts of personal injury or significant property damage were reported.
The “DebriSat” project is a collaboration among NASA, the U.S. Air Force, The Aerospace Corporation, and the University of Florida for laboratory-based hypervelocity impact experiments on a representative, modern LEO satellite and an upper stage mockup.

The objective is to characterize the physical properties of impact fragments to improve satellite breakup models and space situational awareness.
Hypervelocity Impact Sequences

- Hypervelocity impacts of the two targets were successfully carried out at the Arnold Engineering Development Complex in April 2014.
- Fragment processing and measurements are currently underway.
NASA, the U.S. Air Force, and the Air Force Research Laboratory are building a new 1.3-m debris telescope to be deployed on Ascension Island.

- Groundbreaking for the observatory occurred in October 2014.
- Operations will start in late 2015.
- The telescope will be operated remotely from NASA JSC.

The low latitude of the site will permit observations of low inclination debris at all altitudes.

- Debris as small as 10 cm in GEO should be detectable.
In-Situ Measurements of Small Debris

- NASA, the U.S. Naval Academy, the U.S. Naval Research Laboratory, Virginia Tech, and the University of Kent (Great Britain) are developing new technologies for in-situ measurements of small debris from space.

- A new system, Debris Resistive/Acoustic Grid Orbital Navy-NASA Sensor (DRAGONS), has been approved by the International Space Station (ISS) Program for a 2017 deployment on the ISS.

- DRAGONS combines several particle impact detection principles to measure time, location, speed, direction, energy, and the size of each impacting particle to improve the environment definition for the millimeter and smaller debris population.