The 61st session of the Scientific and Technical Subcommittee (STSC) of the United Nations’ (UN) Committee on the Peaceful Uses of Outer Space (COPUOS) took place at the Vienna International Center in Vienna, Austria, from 28 January to 05 February. Under Agenda Item 6 (“Space Debris”), more than 20 COPUOS STSC Member States delivered statements expressing concerns for the growing threat from orbital debris and emphasizing the need to implement orbital debris mitigation best practices, such as the UN COPUOS Space Debris Mitigation Guidelines and the Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines to address the orbital debris problem. Several technical presentations on orbital debris were provided under the same agenda item, including:

- “2023 Space Debris Activities in France: Highlights”
- “2023 Space Debris Activities and Status in Republic of Korea”
- “An update on UKSA’s Active Debris Removal Activities”
- “ASI activities on Space Debris”
- “ESA’s zero debris approach”
- “IADC activities for 2023”
- “U.S. Space Debris Environment and Activity Updates”

These and other STSC presentations are available on the COPUOS website at https://www.unoosa.org/oosa/en/ourwork/copuos/stsc/technical-presentations.html.

The European Space Policy Institute with co-sponsorship from the United Kingdom Space Agency, also hosted an evening side event during STSC to celebrate the 30th anniversary of the IADC. The event began with an overview of the IADC followed by a panel with representatives from Germany, India, the United Kingdom, and the U.S. Panel discussions focused on promoting the IADC Space Debris Mitigation Guidelines and addressing several key orbital debris challenges facing the international community. Close to 100 participants from STSC Member States attended this very successful side event.
Soon after the direct-ascent antisatellite test (ASAT) against Cosmos 1408 on 15 November 2021 by the Russian Federation, the NASA Orbital Debris Program Office (ODPO) released a new version of the Orbital Debris Engineering Model (ORDEM), version 3.2, using analysis of special radar measurements to incorporate fragments from the breakup (ODQN vol. 26, issue 1, March 2022, pp. 1-5). Data available at that time from the Goldstone Orbital Debris Radar, the Haystack Ultrawideband Satellite Imaging Radar (HUSIR), and the Space Fence indicated the modeled breakup using the NASA Standard Satellite Breakup Model (SSBM) matched radar measurements very well. The subsequent 2 years of statistical radar data collections by HUSIR on sub-centimeter-sized debris, as well as continued cataloging of fragments greater than approximately 10 cm, have allowed regular assessments of the state and evolution of the Cosmos 1408 breakup fragments. In particular, the debris cloud appears to be dragging out faster than originally estimated due to solar flux activity increasing at a faster rate and reaching higher levels than the original Solar Cycle 25 prediction [1]. This project review highlights the latest available data on the Cosmos 1408 breakup cloud from HUSIR and the Space Surveillance Network (SSN), as well as comparisons between the initial predictions used in ORDEM 3.2 development and new analysis using the recorded solar flux values for the 2 years following the breakup.

HUSIR, operated by the Massachusetts Institute of Technology’s Lincoln Laboratory, provides statistical data on orbital debris (OD) down to approximately 5.5 mm up to an altitude of 1000 km and 2 cm to 3 cm throughout low Earth orbit (LEO). The data collected by HUSIR is used to characterize the OD environment in altitude, inclination, and size for a large portion of LEO. Data is collected in a beam park mode, where the antenna is pointed at a fixed azimuth and elevation angle and objects are detected as they pass through the radar beam. Most data are collected using a 75° elevation, due East azimuth (75E) configuration, and data are analyzed on a calendar year (CY) basis. Data from CY 2022 provided the first opportunity for analysis of the Cosmos 1408 breakup fragments over the course of a year. Comparisons of CY 2022 data to previous years show evidence of increased OD flux at altitudes and inclinations corresponding to Cosmos 1408 at the time of its breakup (ODQN vol. 27, issue 4, October 2023, pp. 3-6). Recently analyzed HUSIR CY 2023 data provides new insights into the state of the fragment cloud 2 full years since the event. Figure 1 shows the flux versus orbit altitude for HUSIR CY 2021, CY 2022, and CY 2023 data, limited to objects with sizes 7.2 mm and larger, inclinations from 72° to 94°, and altitudes less than 1000 km. Shaded regions represent the 2σ Poisson confidence intervals.

Figure 1. Debris surface area flux as a function of altitude from HUSIR CY 2021, CY 2022, and CY 2023, limited to objects with sizes 7.2 mm and larger, inclinations from 72° to 94°, and altitudes less than 1000 km. Shaded regions represent the 2σ Poisson confidence intervals.

Figure 2. Historical F10.7 solar flux through 20 December 2023 and interpolated NOAA predictions for solar cycle 25 from December 2021.

Comparisons of CY 2022 data to previous years show evidence of increased OD flux at altitudes and inclinations corresponding to Cosmos 1408 at the time of its breakup (ODQN vol. 27, issue 4, October 2023, pp. 3-6). Recently analyzed HUSIR CY 2023 data provides new insights into the state of the fragment cloud 2 full years since the event. Figure 1 shows the flux versus orbit altitude for HUSIR CY 2021, CY 2022, and CY 2023 data, limited to altitudes between 400 km and 1000 km. Detections are limited to Doppler inclinations from 72° to 94°, which showed the highest increase over background levels based on special data collects.
immediately after the breakup, and debris sizes of 7.2 mm and larger, the 99% completeness limit of HUSIR CY 2022 data. The increased flux from 2021 to 2022 over the 400 km to 500 km altitude range, attributable to the Cosmos 1408 breakup, shows a noticeable drop in 2023 back to levels almost equivalent to those of 2021 within uncertainties. This suggests most of the fragments from the Cosmos 1408 breakup at these altitudes and sizes have decayed out of orbit.

Comparing the current distribution of fragments to modeled predictions shows the Cosmos 1408 fragments have decayed faster than originally modeled. This is attributed to increased solar activity over the past few years; the actual solar flux activity of Solar Cycle 25 has been substantially higher than the original NOAA prediction released in December 2019, prompting NOAA to release an update [1]. Figure 2 shows the observed F10.7 solar flux through 20 December 2023 compared to the solar flux prediction for Solar Cycle 25 from December 2021. The ODPO uses monthly predicted fluxes provided by NOAA, interpolated to daily values, and 27-day NOAA forecasts extending from the end of the observed record to propagate objects into the future (see ODQN vol. 24, issue 4, November 2020, pp. 4-6 for more details). The December 2021 prediction was the most recent prediction available after the Cosmos 1408 ASAT and was used to propagate the Cosmos 1408 debris cloud for updating ORDEM 3.2.

Figures 3 and 4 show the percentage of Cosmos 1408 debris greater than 1 mm and 1 cm, respectively, remaining on orbit as a function of time when propagated using the original December 2021 solar flux prediction (presented in ODQN vol. 26, issue 1, March 2022, pp. 1-5) and the observed historical solar flux through 20 December 2023. The sharp decline in the number of fragments still on orbit over the first few years, as compared to the original predictions, is apparent. After the first 2 years, approximately 7% and 9% of modeled fragments greater than 1 mm and 1 cm, respectively, remain on orbit. This contrasts the approximately 22% and 26% originally estimated using the lower predicted solar flux activity.

Figure 5 shows the number of fragments greater than 7 cm remaining on orbit as a function of time under the two propagation scenarios as well as the orbital decay behavior of cataloged fragments; as of 03 February 2024, the SSN has cataloged 1805 Cosmos 1408 fragments. For cataloged fragments, sizes are converted from publicly available radar cross-section (RCS) to size using the NASA Size Estimation Model. The 7 cm-size limit was observed to provide the best overall match between the cataloged fragments and fragments propagated using the historical solar flux values, in terms of both total number of fragments and general decay behavior.

The cataloged fragments exhibit a lower initial number and slower initial decay rate than the modeled fragments. This is likely...
Cosmos 1408
continued from page 3

because fragments that reentered quickly were not adequately tracked and were thus not cataloged – the first Cosmos 1408 breakup debris entered the public catalog approximately 2 weeks after the event. Cataloging fragments from new breakups is generally challenging, and many new fragments may reenter before they can be individually detected, tracked, and cataloged. Had more Cosmos 1408 fragments been cataloged in the first few days, it is expected the early part of the cataloged curve would show more similar behavior to the modeled curves.

To capture trends in the orbital evolution of sub-centimeter-sized debris and to provide timely data for validating and updating models of the OD environment, such as ORDEM, it is critical to regularly monitor the OD populations and the space environment, especially solar activity. Comparisons between the modeled Cosmos 1408 breakup and measurement data is ongoing, and the dynamic behavior of the Cosmos 1408 and other debris clouds, based on updated solar cycle predictions, will be incorporated in upcoming ORDEM releases.

Reference


Modeling the Small Debris Population in ORDEM – Process Overview

A. KING, P. ANZ-MEADOR, D. VAVRIN, AND M. MATNEY

The NASA Orbital Debris Program Office (ODPO) develops and disseminates models, tools, and utilities to the public to provide a standard, validated means of defining the orbital debris (OD) environment, assessing its risks, and ensuring compliance with relevant policies, practices, and procedures. The Orbital Debris Engineering Model (ORDEM) is a data-driven model; measurements of the environment are used to reconcile initial model-based debris populations with the actual population during the build process, and other independent data sets are used to validate the model. In low Earth orbit (LEO), two data sets are used in the build and validation processes. Radar sensors and networks provide statistical or deterministic measurements of the debris environment down to approximately 3 mm interpreted sizes at altitudes below 1000 km, while in situ measurements, via the analysis of returned surfaces, provide data below approximately 1 mm at altitudes below 600 km. This constitutes the small debris population and consists of both degradation by space weathering and ejecta produced by micrometeoroid (MM) and OD impacts.

The small debris population spans the debris size range of 10 μm to approximately 3 mm, and these particles tend to dominate the debris population in this size range. For model building, the lower size is anchored by in situ data collected from the Space Transportation System (STS) window impact data and the upper size by STS radiator perforation data. For model validation, data from the Hubble Space Telescope returned surfaces are used. These measurement data sets provide the means of reconciling a modeled population with the observed population via appropriate scaling of the model population. In situ measurements are transformed from impact feature size to debris size using cratering and perforation damage equations defined by ground-based hypervelocity impact testing and hydrocode simulations—an inverse problem. These selfsame damage equations can be used in the forward problem of simulating damage caused by the model environment during build and validation of the model small particle populations. In situ data and the damage equations are used consistently in both the inverse and forward methods.

This project review focuses on the methodology used to define an initial small debris population via modeling. An continued on page 5
ORDEM Modeling

continued from page 4

essential aspect of modeling this population is characterizing the production of small debris – the phenomenology by which small debris are produced by parent objects in orbit. The ODPO has identified two phenomena capable of producing small debris: impacts and surface degradation. First, impacts from either MM or OD create ejecta or spallation that separate from the parent body. Secondly, surface degradation may include effects due to space weathering attributable to thermal stress, the neutral atmosphere, plasma, or ionizing and non-ionizing radiation in addition to the use of space grade or non-space grade surface materials.

The ODPO examined the types of surfaces commonly found on spacecraft and rocket bodies (R/Bs), including coatings such as paint, solar cells, composite materials, and thermal blankets. Salient findings are that not all surface types are necessarily subject to both specific small debris production phenomena in the size range of interest; a single parent body may feature multiple production surface types; and the long-term influence of production surfaces in near circular and elliptical orbits may differ significantly.

Two distinct methodologies for small particle production modeling have been identified, and these may be termed “first principles modeling” and “statistical modeling.” In the former case parent bodies would be characterized individually or by class according to their surface compositions and composition areas, the sums of which would total the exposed surface area of the object. In the latter case, the known or estimated surface area of these same parent bodies create small debris continuously and are scaled or removed when the model population is reconciled with measurement data. First principles modeling presents multiple technical and non-technical difficulties, for example, determining or defining composition types in the absence of publicly available data; thus, statistical modeling was chosen as offering a tractable path to model the small particle production environment. Once a surface produces small particles, the particles are propagated from their source into the future. In addition to initial orbital parameters, the debris physical parameters of size or characteristic length (L), shape, mass density, and area-to-mass ratio, as well as external factors such as historical and predicted solar activity, all serve to influence their orbital evolution. Hence, small debris orbit parameters are categorized into the ORDEM parameter structure on an annual basis and scaled accordingly to measurements as a function of ORDEM orbital parameters and mass density category [1]. Small debris in LEO, LEO-crossing, and geosynchronous (GEO)-crossing orbits are reconciled with measurement data. Debris smaller than 10 cm are not modeled in GEO because there is no corresponding measurement data in that orbital volume to reconcile against the modeled small debris population.

This general approach was used for the development of the ORDEM 3.X series of models, which incorporated debris mass density as an OD environment parameter. The same approach for ORDEM 4.0, currently in development, has been retained but debris shape is added as an additional population parameter above a threshold size of approximately 316 μm.

With the statistical production model, a small particle population source object of a given month/year is determined using NASA’s long-term environment model, the LEO-to-GEO Environment Debris model LEGEND [2], which provides updated orbital elements of spacecraft and R/Bs as a function of time. The parameters needed to generate new objects for this small particle population are the perigee/apogee altitude, inclination, and final surface area of the parent body at the given production time in question.

The number of small particles generated per given month for a given spacecraft or R/B (known as that particle’s production rate) is determined using a Poisson distribution based on the generic production rate (PR):

\[ PR = 0.1 \times SA \]

where surface area in square meters (SA) = CSA * 6.0 where CSA represents the cross-sectional area of the parent body if the parent body is a spacecraft. If the parent body is instead a R/B, SA = CSA * 4.5 to account for the unique structures associated with R/Bs. The actual production rate is not critical since each small-particle population will be scaled to fit observations. For each small particle generated in this distribution process, a random generation date is determined for that particle within the production year (i.e., PR for a given month within a given year).

Then, a random \( L \) is chosen for that particle within a uniform logarithmic distribution between 10 μm and approximately 3 mm. The \( L \) determines the shape as well as the length-to-diameter (L:D) ratio – the length \( L \) is defined as being equal to the height of the particle, whereas \( D \) is akin to the square root of the product of the particle’s major and minor diameters \( d_1 \) and \( d_2 \) assuming simple elliptical cylinders [3]. The table contains mass densities of high (HD), medium-high (MDHI), medium-low (MDLO), paint (PNT), and fiber-reinforced plastic (FRP), and shape details for nuggets (N), plates (P), or rods (R).

As shown, nuggets tend to be the most likely shape for HD, MDLO, and MDHI with a L:D ratio for these objects

### Shape for Various Mass Density Categories for \( L \) (≥ 316 μm)

<table>
<thead>
<tr>
<th>Category</th>
<th>Bound (g/cm(^3))</th>
<th>Possible Shape</th>
<th>L:D</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD</td>
<td>&gt; 6</td>
<td>N</td>
<td>0.67 &lt; ( \times ) &lt; 1.5</td>
</tr>
<tr>
<td>FRP</td>
<td>1.5</td>
<td>P, N, R</td>
<td>Depends on shape</td>
</tr>
<tr>
<td>PNT</td>
<td>2.5</td>
<td>P</td>
<td>( \frac{L}{1.502 \times L \times 1.034 \times L} )</td>
</tr>
<tr>
<td>MDLO</td>
<td>2 - 4</td>
<td>N</td>
<td>0.67 &lt; ( \times ) &lt; 1.5</td>
</tr>
<tr>
<td>MDHI</td>
<td>4 - 6</td>
<td>N</td>
<td>0.67 &lt; ( \times ) &lt; 1.5</td>
</tr>
</tbody>
</table>

continued on page 6
between 0.67 and 1.5. Due to the production method for FRP, the small particles may resemble either of the three shape categories and are randomly drawn to be either a plate, rod, or nugget based on specific distributions defined for each shape [4]. Paint particles larger than 316 μm are assumed to be plates with a constant thickness of 150 μm, used as L in the L:D equation. Note for particles with L < 316 μm that these are automatically considered by the model to be nuggets since a concise definition of their exact shape has not been determined.

After this, a volume (V), SA, and CSA are determined for each particle. Given the table, the L:D ratio for each particle is now known, but L and D must also be calculated individually to determine V:

\[ V = \frac{\pi L D^2}{4}, \quad \text{where} \quad D = \frac{2.7 \times L_c}{L + 2} \quad \text{and} \quad L = \left( \frac{L}{D} \right) \times D \]

\[ SA = \pi \left( \frac{L}{D} + 0.5 \right) \left( \frac{L_c^2}{\left( \frac{L}{D} \right)^2 + 1} \right) \]

\[ CSA = \frac{SA}{4} \]

Finally, using the calculated metrics above in tandem with a given particle’s Lc and density ρ, a mass m and area-to-mass A/m for that particle can be determined:

\[ m = \rho V \]

\[ \frac{A}{m} = \frac{CSA}{m} \]

Once all small particle characteristics are determined, the state vectors that define the velocity of these particles being shed from their parent body are calculated based on the state vector of the parent body at the time of the debris objects “creation.” The ODPO propagation tool is used to distribute each of these particles through time in a modeled space environment to the end of a given year/month. Particles that are projected to destructively enter the Earth’s atmosphere are removed from the model population during this process, as shown in the figure. The next step in the build process is to apply fits to the model to reconcile it with in situ measurements.

**References**


MEETING REPORT

The NASA-DOD Orbital Debris Working Group Meeting, 28 November 2023, Virtual

The 26th annual NASA-DOD Orbital Debris Working Group meeting was held virtually on 28 November 2023. This annual, one-day meeting provides a framework for cooperation and collaboration between NASA and the DOD on orbital debris-related activities, such as measurements, modeling, mitigation, and policy development. NASA and the DOD have benefited significantly from this group, and many collaborations directly result from this working group. This year’s meeting was co-chaired by the NASA Orbital Debris Program Office (ODPO) and by the Operational Assessments Division, HQ Space Operations Command, U.S. Space Force (USSF).

After opening remarks, NASA began with a presentation on the U.S. Government Orbital Debris Mitigation Standard Practices, followed by an update on the next-generation Orbital Debris Engineering Model, ORDEM 4.0. The ODPO then gave an update on the DebiSat project and the fusion of measurements and analysis from the project into ORDEM 4.0 and the NASA Standard Satellite Breakup Model.

Two ODPO presentations on radar and optical measurement activities were presented: first, the low Earth orbit debris environment as revealed by recent measurements from the Haystack Ultrawideband Satellite Imaging Radar (HUSIR) and the Goldstone Orbital Debris Radar; then, an update on the Eugene Stansbery - Meter Class Autonomous Telescope (ES-MCAT). The ES-MCAT recently completed a re-coating of the primary mirror and began its second survey of the geosynchronous region in January 2023 (ODQN, vol. 27, issue 1, March 2023, pp. 4-5). The final ODPO presentation included updates on reentry analysis activities, including inspection of a recovered fragment of the Dragon 2 trunk that reentered over Australia in July 2022.

The DOD personnel with the 18th Space Defense Squadron at Vandenberg Space Force Base presented an overview of the on-orbit breakup detection and analysis process. This was followed by an update on the Space Surveillance Telescope as it proceeded through initial operating capability to operational acceptance into the Space Surveillance Network in September 2022. Next, the USSF summarized the flow of observation data for uncorrelated tracks for the Space Fence. The final DOD presentation discussed research and other efforts toward debris mitigation in cis-lunar space.

UPCOMING MEETINGS

13-21 July 2024: Committee on Space Research (COSPAR) 2024, BEXCO, Busan, Korea

The 45th Assembly of the Committee on Space Research (COSPAR) Scientific Assembly will convene in the Busan Exhibition and Convention Center, BEXCO. The COSPAR panel on Potentially Environmentally Detrimental Activities in Space (PEDAS) will conduct a program entitled “A Sustainable Space Exploration: from the Mitigation of Space Debris in Earth’s Orbit to the Safeguard of Planetary Environments.” The main topics to be discussed in the PEDAS.1 sessions will include orbital debris observations and measurements; environmental models and databases; modeling and risk analysis; mitigation and remediation; sustainable space activities; national and international standards and guidelines; mega-constellation impact on astronomy; pollution of the Earth’s atmosphere by rocket launches and re-entries; cis-lunar space; and Lunar and Martian environments. The abstract submission period closed on 09 February 2024. Please see the PEDAS.1 session website at https://www.cospar-assembly.org/admin/session_cospar.php?session=1295 and the Assembly website at: https://www.cospar2024.org/.

14-18 October 2024: 74th International Astronautical Congress (IAC), Milan, Italy

The IAC will convene in 2024 with a theme of “Responsible Space for Sustainability.” The IAC’s 22nd IAA Symposium on Space Debris will cover space debris detection, tracking and characterization; modeling; risk analysis; hypervelocity impact and risk assessments; mitigation; post-mission disposal and space debris removal; operations in the space debris environment; political, legal, institutional, and economics aspects of mitigation and removal; and orbit determination and propagation. Interactive presentations on space debris topics will also be provided to allow more digital display capabilities for attendees. The abstract submission period closed on 28 February 2024. Additional information for the 2024 IAC is available at https://www.iaafasto.org/events/iac/international-astronautical-congress-2024/ and https://www.iac2024.org/.

17-20 September 2024: 25th Advanced Maui Optical and Space Surveillance Technologies Conference (AMOS), Maui, Hawaii, USA

The technical program of the 25th Advanced Maui Optical and Space Surveillance Technologies Conference (AMOS) will focus on subjects that are mission critical to space situational awareness. The technical sessions include papers and posters on space debris; space situational/space domain awareness (SDA); SDA systems and instrumentation; astrodynamics; satellite characterization; space weather; and related topics. The abstract submission deadline was 01 March 2024. Registration for this hybrid conference opens in April 2024 for in-person and virtual attendees. Additional information about the conference is available at https://amostech.com.
Monthly Effective Mass of Objects in Earth Orbit by Orbital Regime cataloged by the U.S. Space Surveillance Network. This chart displays the mass of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. Low Earth orbit (LEO) includes resident space objects (RSOs) with altitudes within or crossing below 2000 km; medium Earth orbit (MEO) RSOs with altitudes within or crossing the range from 2000 km to 35,586 km; geosynchronous orbit (GEO) RSOs with altitudes within or crossing the range from 35,586 km to 35,986 km; and the remainder with altitudes within or crossing the range from 35,986 km to 600,000 km, referred to as Super-GEO. "Effective" mass scales the mass of each object by the fraction of its orbit that falls within the specified altitude ranges. Cataloged objects without available orbital elements are excluded.
Debris Assessment Software 3.2.6 Release

The NASA Orbital Debris Program Office has released version 3.2.6 of the Debris Assessment Software (DAS), replacing the prior June 2023 release of DAS 3.2.5. The updated version provides data that can verify compliance of a spacecraft, upper stage, and/or payload with NASA’s requirements for limiting debris generation, spacecraft vulnerability, post-mission disposal, and reentry safety.

This release incorporates a fix to the cross-sectional area tool, where some shapes were not correctly read in before processing. The apogee-perigee history tool also received a fix for apparent fast reentries from high altitudes; this issue was localized to the science utility and did not affect requirement verification. Finally, a fix was implemented for Requirement 4.5-2, small particle penetration assessment, where some layers were not read in correctly before processing.

Users who have already completed the software request process for earlier versions of DAS 3.x do not need to reapply for DAS 3.2.6. Simply go to your existing account on the NASA Software portal and download the latest installer. Due to file size limits, the installer has been split into several .zip archive files: the main installer and five separate files containing debris environment data. Users must download the main installer (which includes the debris environment for years 2016 to 2030) and additional environment files required to assess mission years beyond 2030.

Approval for DAS is on a per project basis; approval encompasses activities and personnel working within the project scope identified in the application. For new users, DAS is available for download, pending an approved application submission, via the NASA Software Catalog. To begin the process, click on the Request Software button at https://software.nasa.gov/software/MSC-26690-1.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1998-067</td>
<td>ISS dispensed objects</td>
<td>Various</td>
<td>415</td>
<td>423</td>
<td>51.6</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2023-169A</td>
<td>TJS-10</td>
<td>PRC</td>
<td>35757</td>
<td>35818</td>
<td>0.4</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2023-170A</td>
<td>STARLINK-30800</td>
<td>US</td>
<td>558</td>
<td>560</td>
<td>43.0</td>
<td>22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2023-171A</td>
<td>STARLINK-3086I</td>
<td>US</td>
<td>553</td>
<td>554</td>
<td>43.0</td>
<td>22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2023-172A</td>
<td>CHINASAT-6E</td>
<td>PRC</td>
<td>35783</td>
<td>35789</td>
<td>0.0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2023-173A</td>
<td>DRAGON CRS-29</td>
<td>US</td>
<td>232</td>
<td>401</td>
<td>51.6</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2023-174A</td>
<td>CONNECTA T3.1</td>
<td>TURK</td>
<td>513</td>
<td>525</td>
<td>97.5</td>
<td>104</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2023-175A</td>
<td>O3B MPOWER F05</td>
<td>SES</td>
<td>6186</td>
<td>8230</td>
<td>2.1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2023-178</td>
<td>O3B MPOWER F06</td>
<td>SES</td>
<td>6328</td>
<td>8248</td>
<td>3.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2023-176A</td>
<td>HAYANG 3A</td>
<td>PRC</td>
<td>767</td>
<td>789</td>
<td>98.6</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2023-177A</td>
<td>STARLINK-30901</td>
<td>US</td>
<td>299</td>
<td>305</td>
<td>43.0</td>
<td>22</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

continued on page 10