

C04

軌道上デブリデータベースの更新状況 —PMD および異常検知への応用—**Update Status of the On-orbit Objects Database****--Application for Detecting PMDs and Anomalies of Orbit--**

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JAXA 研究開発部門では推移モデルのための軌道上デブリデータベースの更新を継続して行っている。その一環として TLE 軌道履歴をサーベイし、TLE 履歴から A/M の推定を行い、デブリ環境モデルと比較するなどしてサイズや質量を割当てている。また TLE 履歴をサーベイすることで、個々の衛星の運用終了や PMD を行ったことによる軌道変化、および衝突・破砕等による異常な変化やそのタイミングを知ることができる。

そこで TLE 履歴に表れる特徴から、制御を継続している衛星か運用終了やデブリの状態であるか、さらに軌道変化が運用による制御か運用終了や PMD であるか、または衝突・破砕によるイベントかを自動判別、分類する試みを行っている。今後、それらの精度向上のために機械学習を取り入れることも検討している。

JAXA continues to update the on-orbit objects database for the debris evolutionary model. As part of the work, we survey TLE orbit histories, estimate A/M from TLE histories, and compare them to debris environment models to assign sizes and masses. By surveying TLE histories, it is possible to determine orbital changes due to the termination of operations or PMD of individual satellites, as well as anomalous changes due to collisions, etc. and their timing.

We have worked to automatically identify and classify whether a satellite is still under control or out of operation, and whether the orbit change is due to operational control, PMD, or a collision event, based on the characteristics that appear in TLE histories. We are considering incorporating machine learning methods to improve their accuracy.

Update Status of the On-orbit Objects Database --Application for Detecting PMDs and Anomalies of Orbit--

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1

Outline

- JAXA on-orbit objects database
- Updating the database
 - estimate A/M from surveyed TLE orbit histories
 - assign sizes and masses for debris comparing to debris environment models (MASTER)
- Application of TLE orbit history survey
 - identify PMD of satellites
 - detect anomalous orbital changes

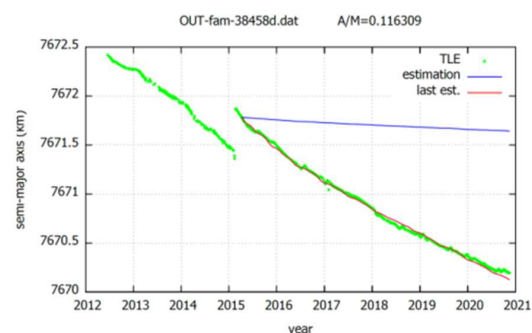
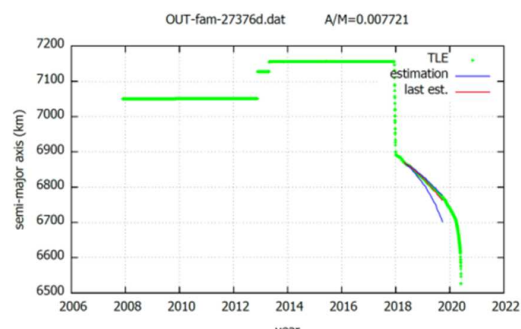
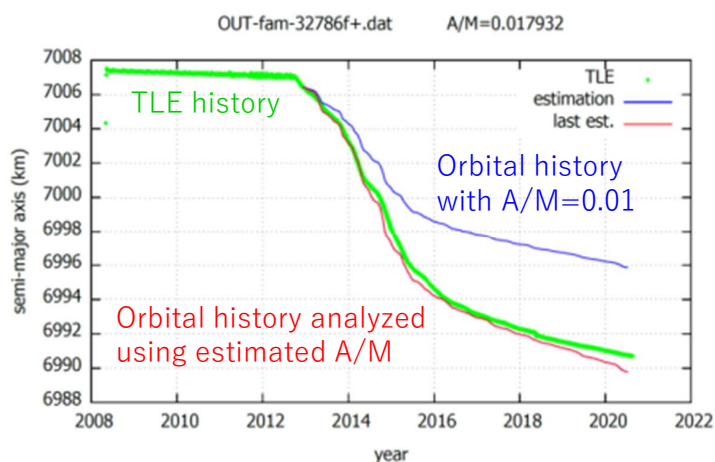
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JAXA On-orbit Objects Database

- Baseline file for the debris evolutionary model; NEODEEM
- Over 24000 objects data is maintained, about 20,000 available from TLE data by space-track.org, uncataloged objects from ground observations
- Based on the breakup history, fragment objects supposed to be in the orbit are added
- Orbital elements, mass and the other characteristics of the objects are contained
- Area-to-mass ratios(A/M) of cataloged objects are estimated from TLE orbit histories
- Mass and size of fragments are randomly set to match the A/M with fragments generated by NASA standard breakup model

3

A/M Estimation from Surveyed TLE History

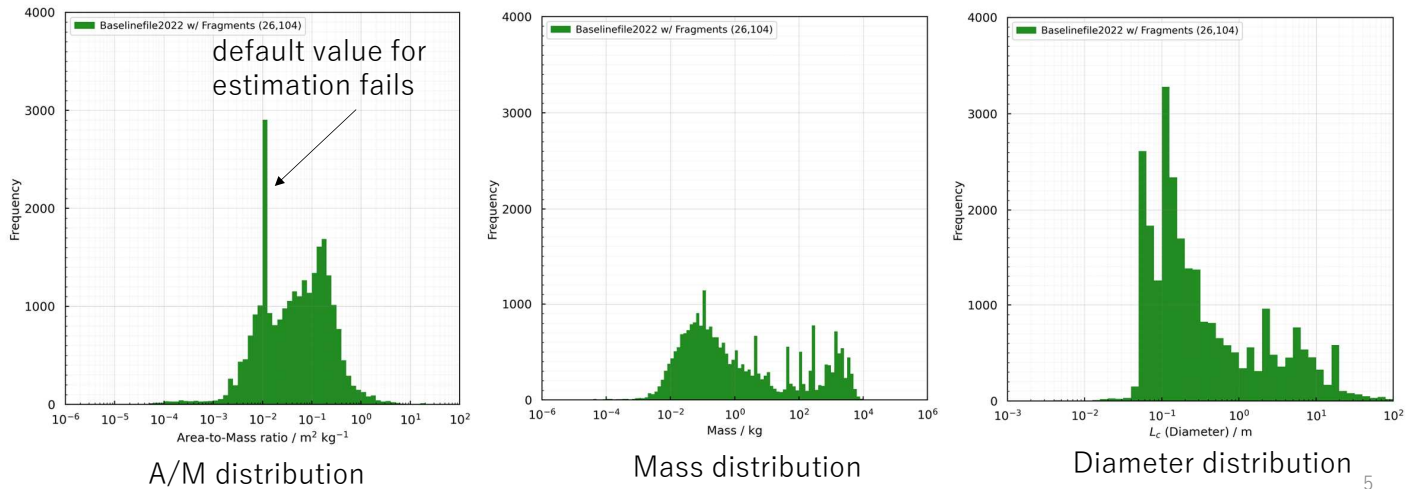


- Daily update TLEs and A/M estimation
- Automatic detection of suitable intervals for analysis

4

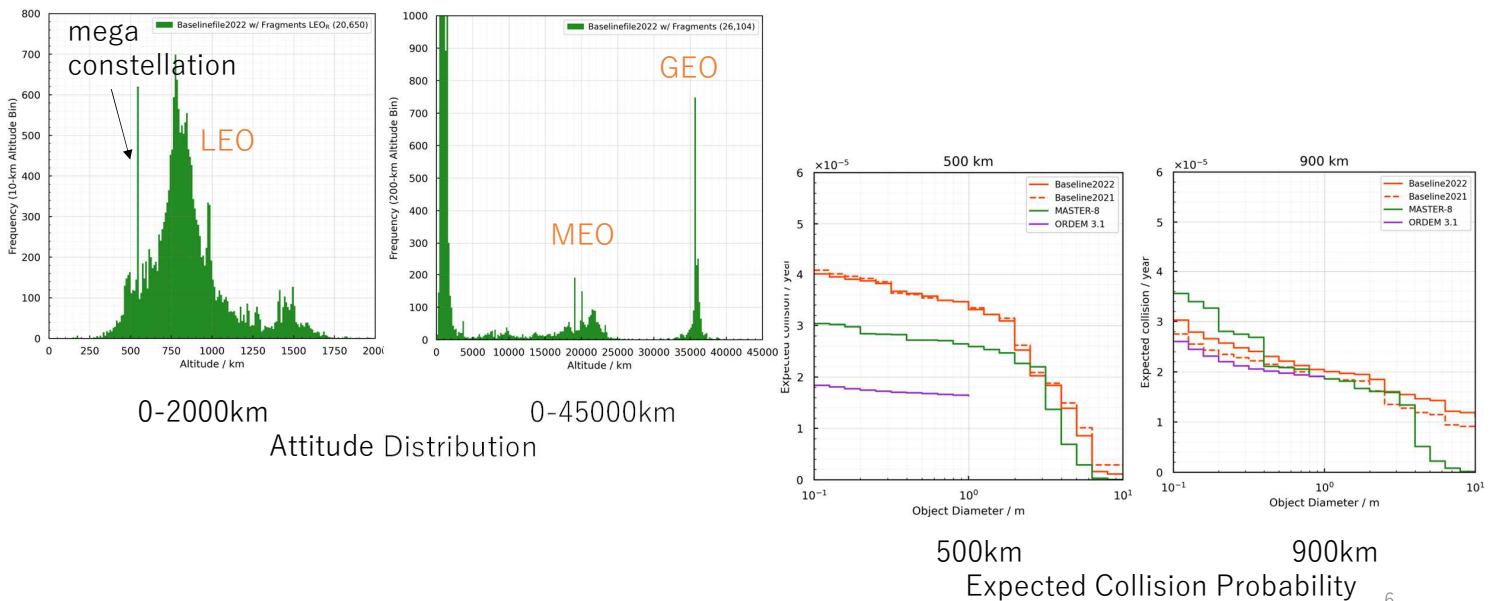
Mass and Size Assignment for Debris

- Masses and sizes of debris are assigned according to that relation between A/M and those of ESA MASTER-8 debris sources
- Explosion fragments generated by NASA standard breakup model are added



5

Characteristics of the Database



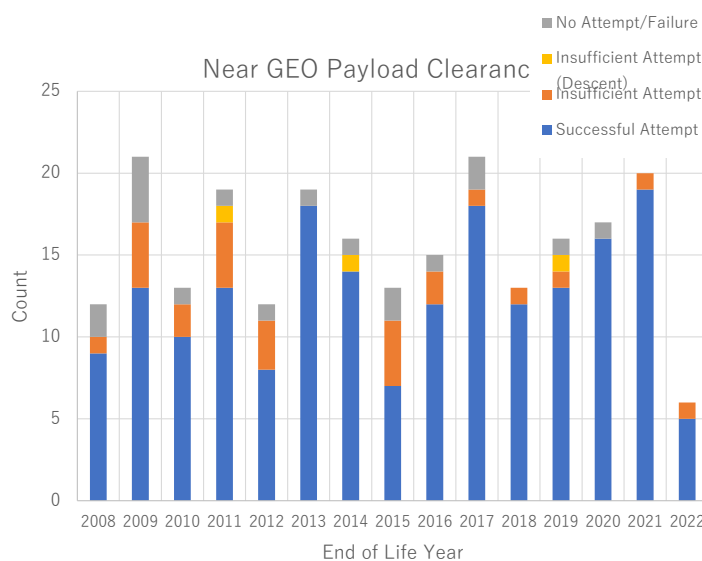
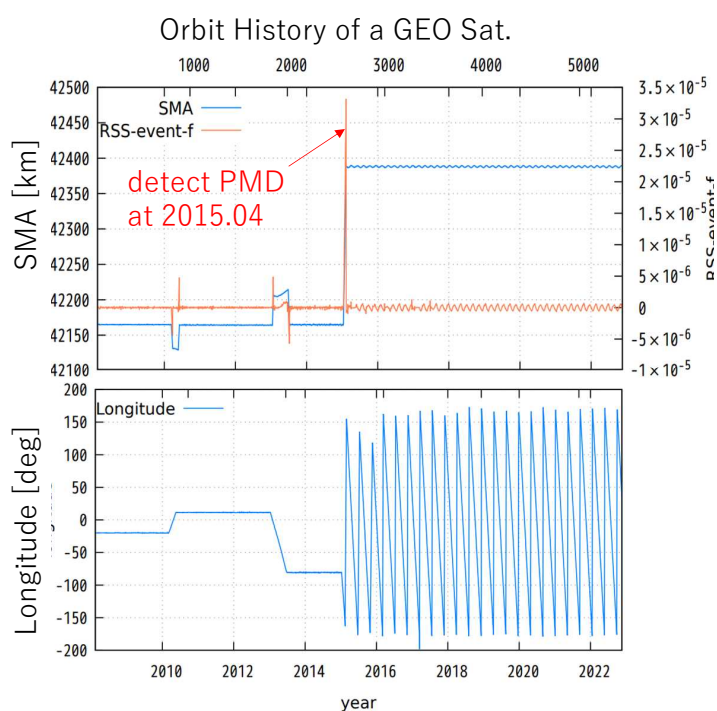
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Application of TLE Orbit History Survey

- TLE of satellite shows each condition such as under operation, end of operation, deployment of deorbit devices, control for PMD.
- TLE of the others may show anomalies such as collisions, explosions, generation of new debris, disappearance from TLEs, etc.
- Objective is to detect those by surveying

7

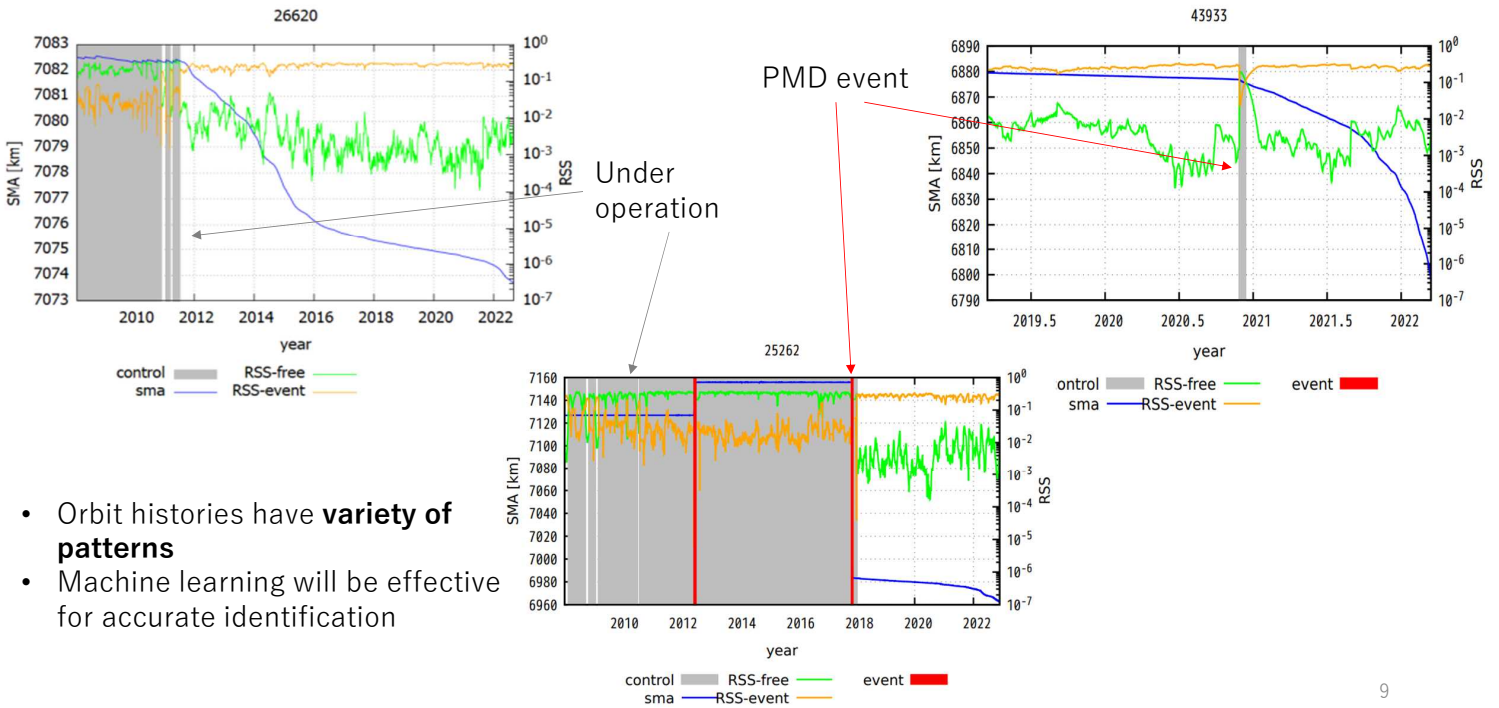
PMD Identification from TLE History : GEO



213 PMDs identified automatically

8

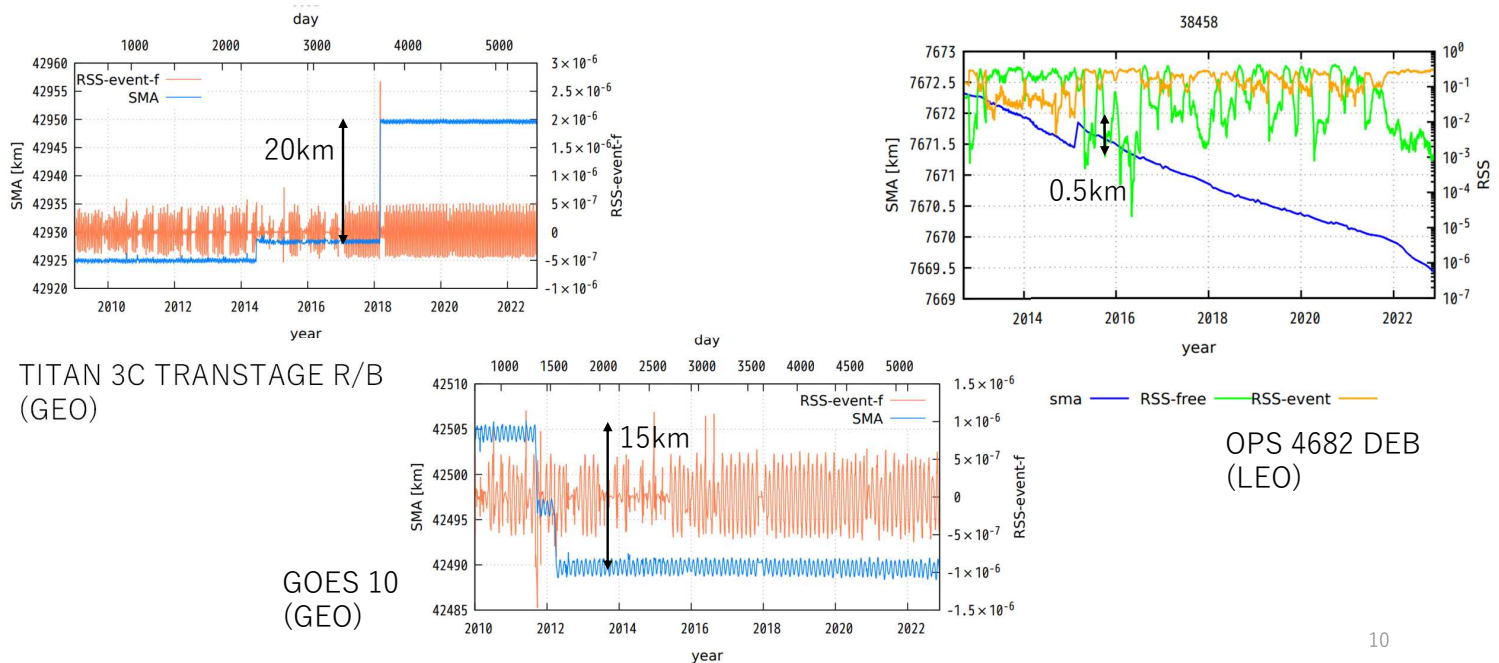
PMD Identification from TLE History : LEO



9

Future Work

Detection of **anomalous** orbital changes by TLEs daily check



10

Summary

- JAXA's original database for debris evolutionary model have been developed
- We have updated it by analyzing TLEs and add observation data to improve the completeness
- An application of TLE survey, we identified PMD of GEO satellites with sufficient accuracy, and work on using machine learning to improve accuracy for LEO satellites
- Detecting anomalous orbital changes is another objective