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スペースデブリ接近評価－衝突リスク低減の経験－

Space Debris Conjunction Assessment -- Collision Risk Mitigation Experience --

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JAXA 統合追跡ネットワーク技術部では、2008 年から JAXA 衛星に接近する可能性のあるスペースデブリ (軌道上の物体) のスクリーニングと接近解析ツール (独自開発) を用いた接近評価作業を開始し、衝突回避の軌道制御要否判定につながる接近評価作業を続けている。

本資料では、JAXA における接近解析や衝突回避プロセスの概要、衝突回避の評価判断に関する知見や課題、各宇宙機関と協調して進めている標準化活動概要を報告する。

In 2008, JAXA Consolidated Space Tracking and Data Acquisition Department (CSTDAD) established the conjunction assessment capability to recognize possible space debris (space objects) approaching to JAXA satellites, when the debris screening engine and conjunction assessment tool became operational, and since then, we have been working on conjunction assessment which leads to judging the necessity for collision avoidance.

This presentation will introduce concept of JAXA conjunction assessment and collision avoidance process, lessons learned and issues for conjunction assessment, and summary of international standardization coordination under way in cooperation with other space agencies.

Space Debris Conjunction Assessment

- Collision Risk Mitigation Experiences -

#5 Space Debris Workshop
January 23, 2013

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Introduction

- **UN COPUOS Space Debris Mitigation Guideline #3 (2007)**

Limit the probability of accidental collision in orbit

- “If available orbital data indicate a potential collision, adjustment of the launch time or an on-orbit avoidance maneuver should be considered.”

- **Capability build**

- In 2008, JAXA established conjunction assessment capability for JAXA satellite in LEO and GEO
- Experienced 1st Collision Avoidance in 2009

- **Space Operation Experiences**

- **Conjunction information sharing standardization**

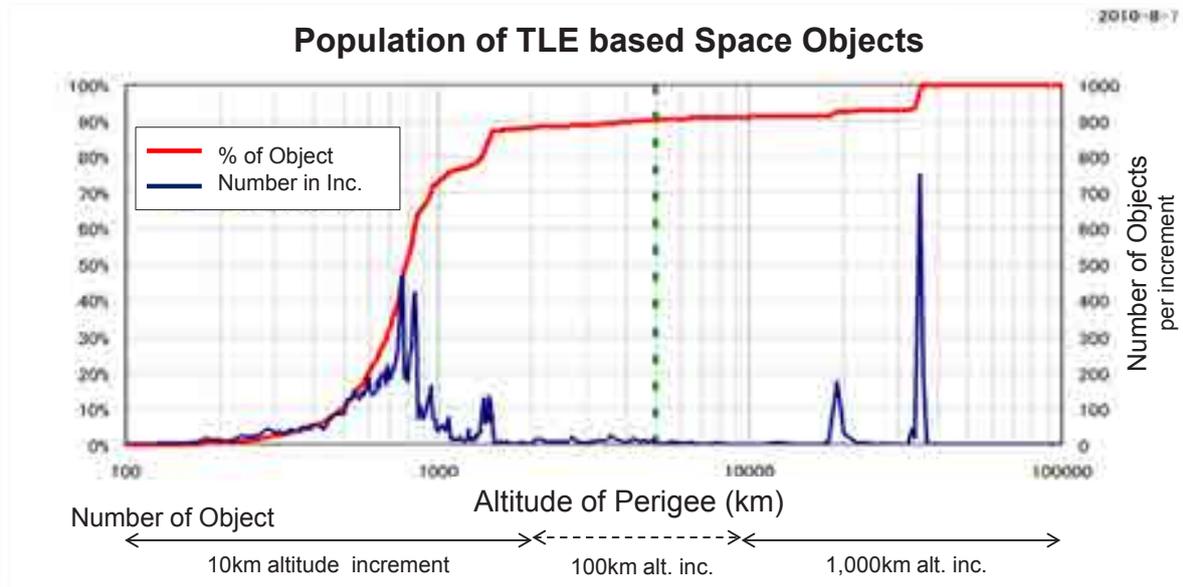
- CCSDS, ISO TC20/SC13
- Conjunction Summary Message (CSM)

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Population of Space Objects

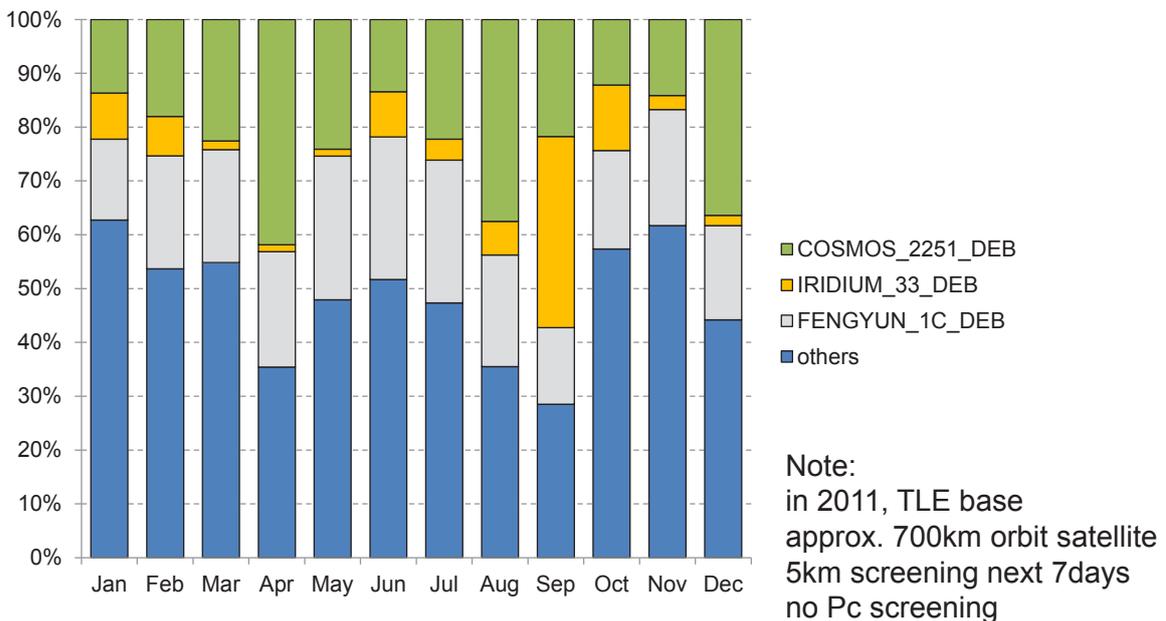
- U.S. cataloged objects in Earth orbit: approx. 16,000
- 90% distributed in LEO region (2,000km alt. below)



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Congested Orbital Environment

- Approaching space objects to LEO satellite



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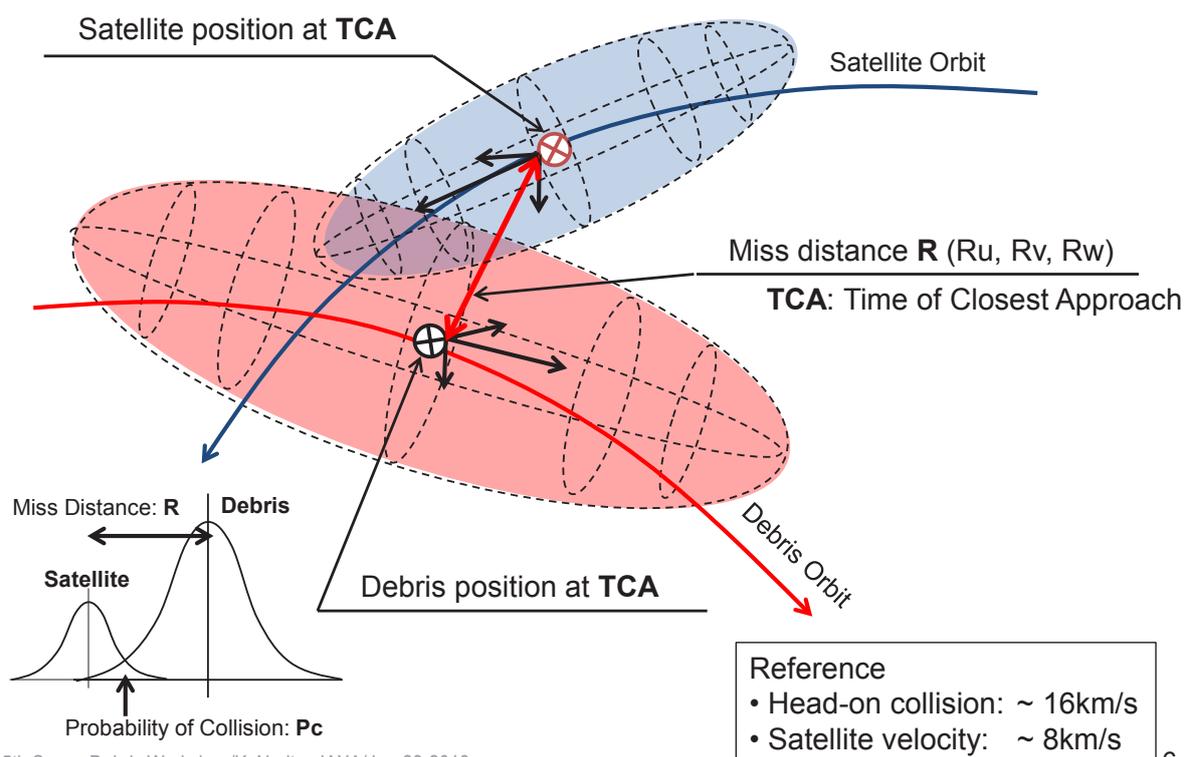
Conjunction Assessment

- **Orbit Determination (OD) and conditions**
 - Covariance (radial, in-track, cross-track)
 - Days since Epoch, Number of available data, etc.
 - Space Environment (short-term) concerning OD and Orbit Prediction
 - **Atmospheric drag, Solar radiation pressure**
- **Conjunction Assessment**
 - Probability of collision (P_c) will be calculated under some assumptions such as “dimensions (RCS)”
 - “ P_c ” is not a single evaluation source
 - **Miss distance**
 - **Credibility of OD and Orbit Prediction**
 - Satellite condition
 - **Regular maneuver plan**
 - **Fuel consumption, Recovery maneuver to mission orbit, etc.**
 - Concentrated work in a limited time is required (i.e. TCA-72h to -12h)

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Conjunction Assessment View

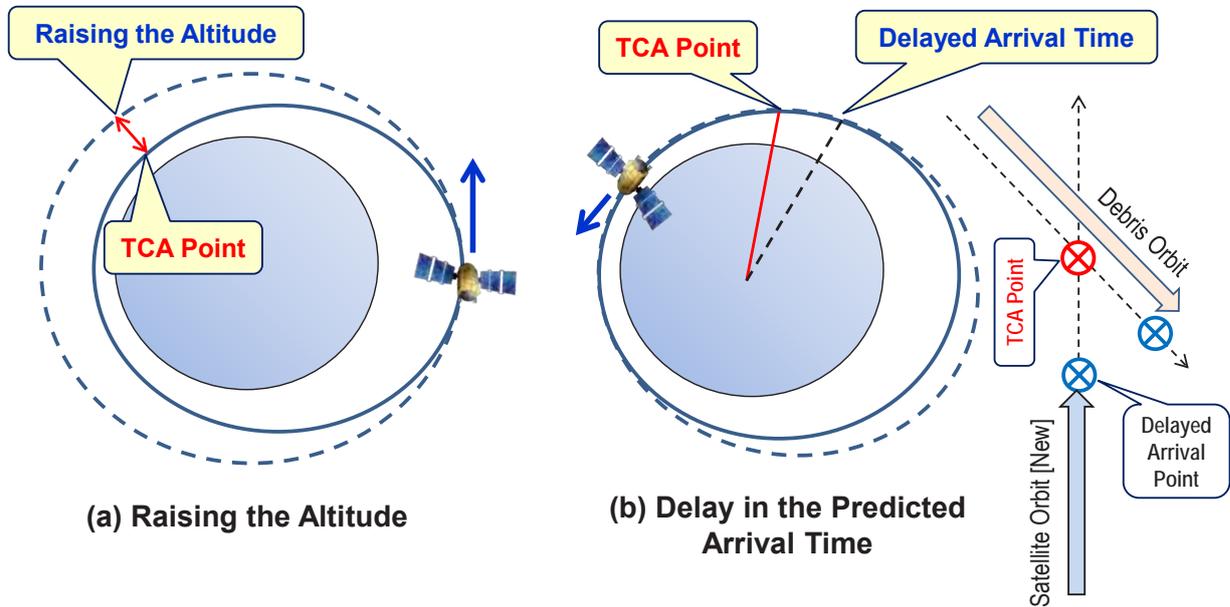


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Collision Avoidance View

● Useful regular satellite maneuver theory



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Space Operation Experiences

● Characteristics of Orbital Flight Dynamics

- Space Environment (short-term) concerning OD and Orbit Prediction

● Information sharing

- Direct communications with approaching satellite operator should be prepared, assuming s/c to s/c collision
- Registration of Space object information
 - State should provide registration information as soon as practicable to the Secretary-General to UN.
- Use a standard format when sharing orbital information on space objects
 - Operators should use a common, internationally recognized standard formats to enable collaboration and information exchange.

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Standardization

● **Conjunction Summary Message (CSM)**

- Standard message format for spacecraft conjunction information
- Facilitate interoperability and enable warning and mitigation
- CCSDS member agency demonstration will be in 2013 (CNES, DLR, ESA, JAXA, NASA, etc.)
- CSM Example
 - **TCA (Time of Closest Approach), Miss distance, Relative position/velocity, and**
 - **State Vector, Covariance Matrix, etc.**

Conclusion

● **Conjunction Assessment**

- Orbit Determination (OD) and conditions
- “Pc” is not a single evaluation source

● **Collision Avoidance**

- Useful regular satellite maneuver theory
- (1) Rising the altitude, (2) Delay in the predicted arrival time

● **Space Operation Experiences**

- Space Environment (short-term) concerning OD and Orbit Prediction
- Information Sharing

● **Standardization**

- Conjunction Summary Message (CSM)