Space Operations

Risk Mitigation Experience from Collision

Workshop on the Protection of Space Environment
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Agenda

- JAXA Satellite Constellation
- Population of Space Object
- Conjunction Summary
- Conjunction Assessment View
- Conjunction Assessment Experience
- Collision Avoidance View
- Findings
- Conclusion

JAXA Satellite Constellation

■ Earth Observation Satellite

- HEO: EXOS-D, GEOTAIL
- LEO: GOSAT, GCOM-W1, INDEX

■ Communications, Positioning & Engineering Test Satellite

- GEO: DRTS, ETS-VIII, WINDS
- QZO: QZS-1
- LEO: EGS, SDS-4

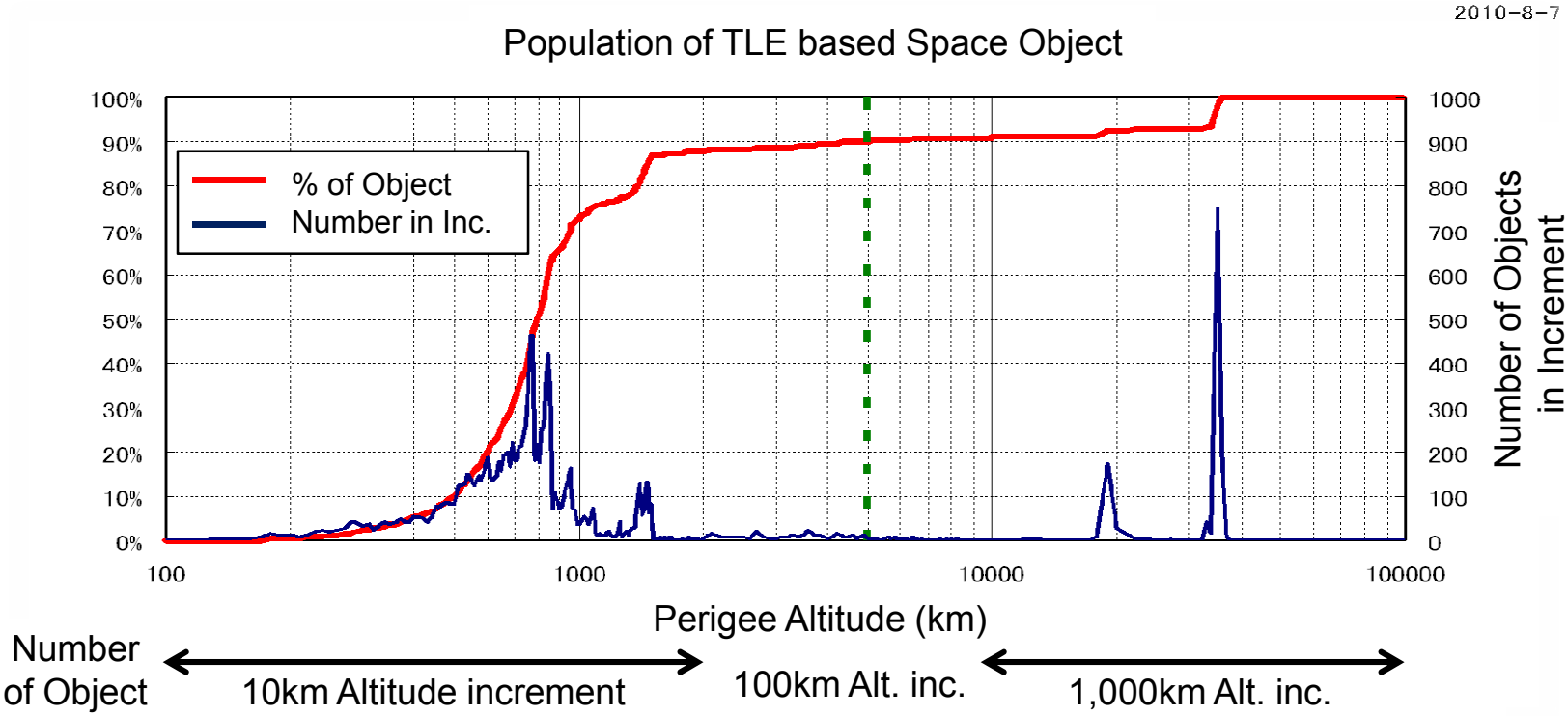
■ Astronomical Observation Satellite

- LEO: ASTRO-E2, SOLAR-B

Population of Space Object

- **Key numbers**
  - Iridium 33/Cosmos 2251 collision: approx. 1,800
  - Cataloged Objects: approx. 16,800

- 90% distribute in LEO region (2,000km altitude below)

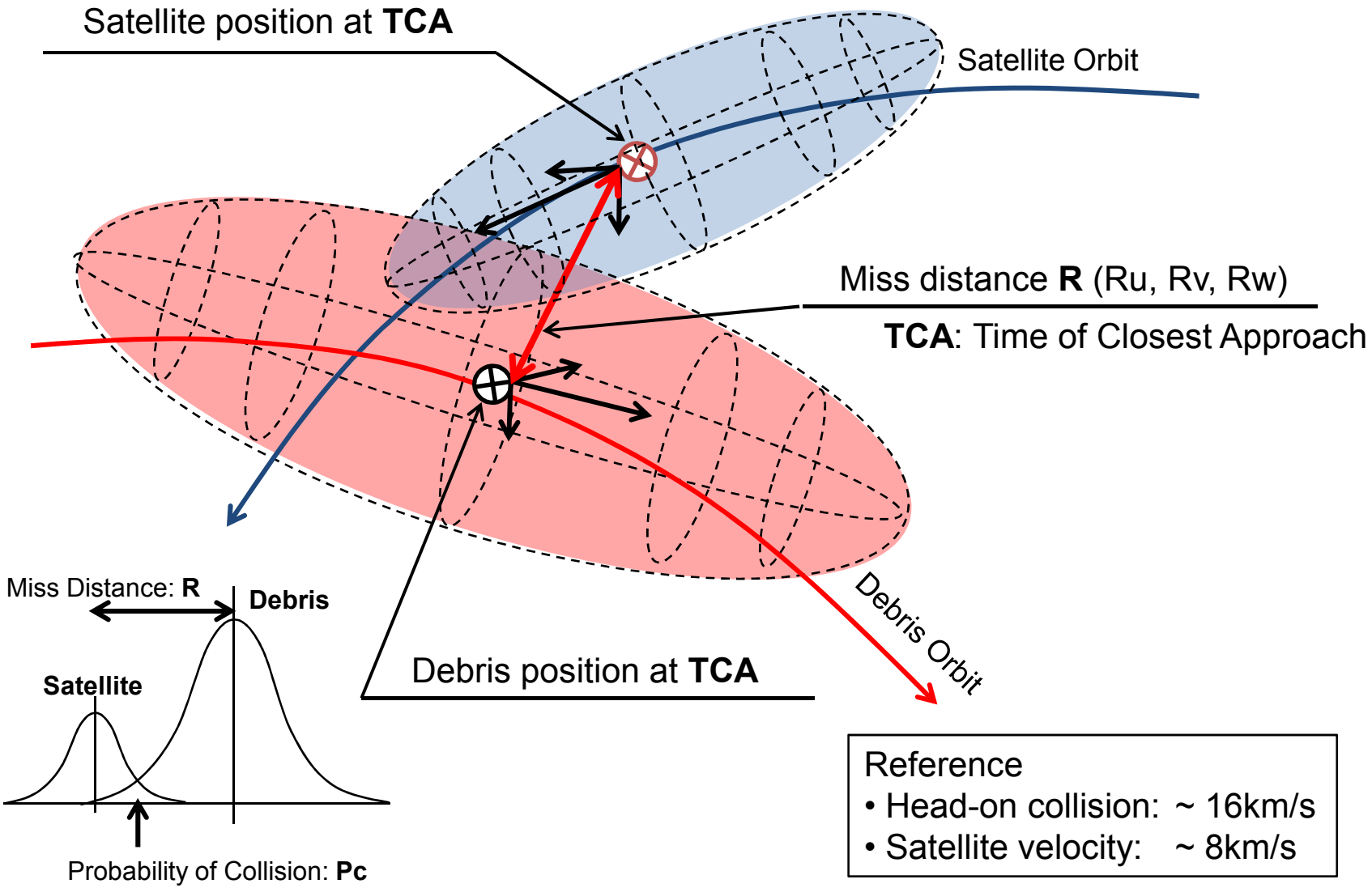


Conjunction Summary

- **Collision Risk Mitigation**
  - Understand conjunction states → Conjunction Assessment
  - Collision avoidance possibility should be evaluated

- **Conjunction Summary Message (CSM)**
  - US provides emergency notice to individual satellite operator with CSM
    - LEO: Overall miss distance < 1km, Radial miss distance < 200m
    - GEO: Overall miss distance < 5km
  - CSM: Time of Closest Approach (TCA), Miss Distance, Relative Position/Velocity, Covariance, etc.
  - International standardization discussion is underway by CCSDS (Consultative Committee for Space Data Systems)
    - CCSDS member agency and organization demonstration in 2013 (CNES, DLR, ESA, JAXA, NASA , etc.)

Conjunction Assessment View



Reference
- Head-on collision: ~ 16km/s
- Satellite velocity: ~ 8km/s

Conjunction Assessment Experience

- Probability of collision (Pc) will be calculated by the satellite operator using CSM data with some assumptions

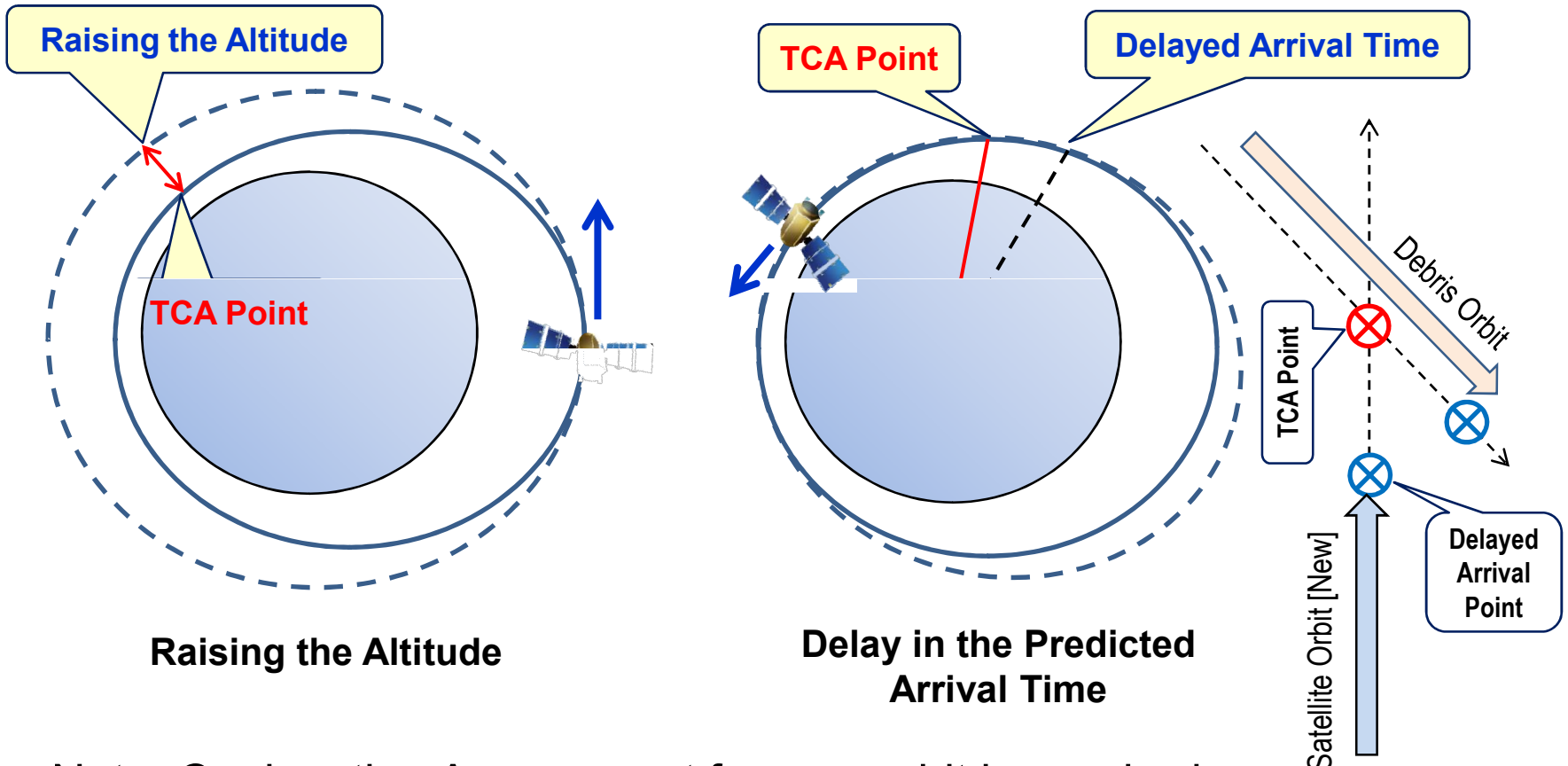
- "Pc" is not a single evaluation source, but leads this assessment task. Other useful information will be
  - Satellite Maneuver Plan
  - Miss Distance
  - Days since Epoch
  - Covariance
  - Prediction/Propagation condition
    → Space Weather (Solar Flares, etc.) information is essential

- 1 to 2 days "concentrate" work before TCA
  - CSM will be noticed TCA-72H or later
  - Simulation and/or Drill is needed

- Minimize satellite fuel consuming is important

Collision Avoidance View

- No specific Collision Avoidance method is existing
  - Satellite orbit control maneuver method is applied



Raising the Altitude

Delay in the Predicted Arrival Time

Note: Conjunction Assessment for new orbit is required

Findings

- UN COPUOS Space Debris Mitigation Guideline 3:
  Limit the probability of accidental collision in orbit

  In developing the design and mission profile of spacecraft and launch vehicle stages, the probability of accidental collision with known objects during the system's launch phase and orbital lifetime should be estimated and limited. If available orbital data indicate a potential collision, adjustment of the launch time or an on-orbit avoidance maneuver should be considered.

- Information Sharing (possibility)
  - Generic satellite information such as (1) in-operation or not, (2) maneuver capability (Y/N), (3) rough dimension
  - Point of contact
  - Ephemeris
  - Information sharing should be limited

Conclusion

- Collision Risk Mitigation: Conjunction Assessment
- International Standardization for CSM
- Conjunction Assessment Experience, and
- Findings:
  - UN COPUOS Space Debris Mitigation Guideline 3
  - Information Sharing

Thank you for your attention!