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デブリ推移モデルによる将来予測

Prediction of Orbital Debris Population with an Orbital Debris Evolutionary Model

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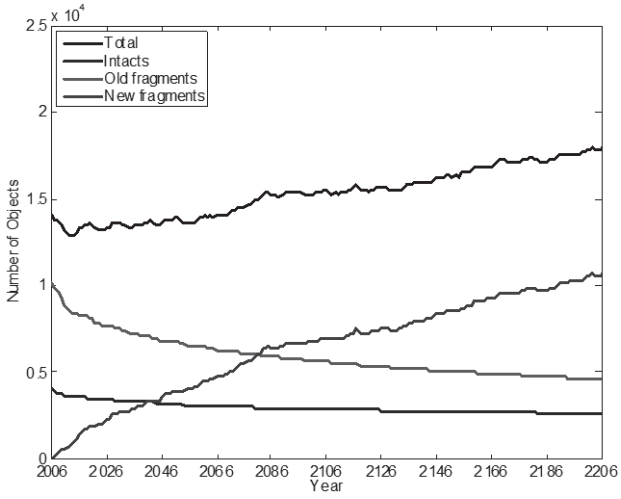
宇宙航空研究開発機構と九州大学は，デブリ推移モデルの開発・維持と推移モデルを用いたデブリ分布の予測を行っている．このデブリ推移モデルは 10 cm 以上の軌道上物体の軌道伝播と衝突率の計算・判定により将来のデブリ分布を予測するものである．これまでに図のような低軌道でのデブリ分布の不安定性の確認やデブリ除去の効果について，推移モデルを用いて予測を行ってきた．本発表では，これらデブリ推移モデルによる結果として，特に種々のデブリ低減対策や除去条件を仮定した場合の将来のデブリ分布の予測結果について紹介する．

Japan Aerospace Exploration Agency (JAXA) and Kyushu University collaborated to develop an orbital debris evolutionary model. Kyushu University has maintained and operated the orbital debris evolutionary model under contract with JAXA. This presentation introduces the outcome of collaborative research with JAXA and Kyushu University. Especially, we introduce result from future projection of debris population under some orbital debris mitigation measures and remediation.



新規打ち上げ・爆発なしを仮定した時の低軌道の物体数の推移

デブリ推移モデルによる将来予測

Prediction of Orbital Debris Population
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Orbital Debris Evolutionary Models in Japan

GEODEEM
- Developed by Kyushu University
- GEO region

LEODEEM
- Developed by JAXA and Kyushu University
- LEO region (< 2000 km)

NEODEEM
- Developed by JAXA and Kyushu University
- LEO-to-GEO region
- One by one collision detection
- Individual orbit propagation

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Collaboration in Debris Modeling Study

- Kyushu University has been conducting orbital debris modeling study under contract with JAXA
  - Updating orbital debris evolutionary model
    - Insertion history
    - Breakup history
  - Operating debris evolutionary model
    - IADC's activities
      - **Action Item (A/I) 27.1**
      - WG 2 Internal Task
    - Future projections based on JAXA's requirements
      - **Effectiveness of active debris removal**

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Effectiveness of post-mission disposal (PMD)

- IADC A/I 27.1
  "Stability of the Future LEO Environment"
  - To assess the stability of the LEO debris population
  - To reach a consensus on the need to use active debris removal
- ASI, ESA, ISRO, NASA, UKSA and JAXA participated
- Kyushu University conducted this study under contract with JAXA
- Scenarios
  - Initial population as of May 1st 2009
  - 8-year cycle launch traffic
  - No new explosion
  - 90% PMD compliance
  - Additional scenarios with 0% and 50% PMD compliance
  - Mean of 100 MC runs is result

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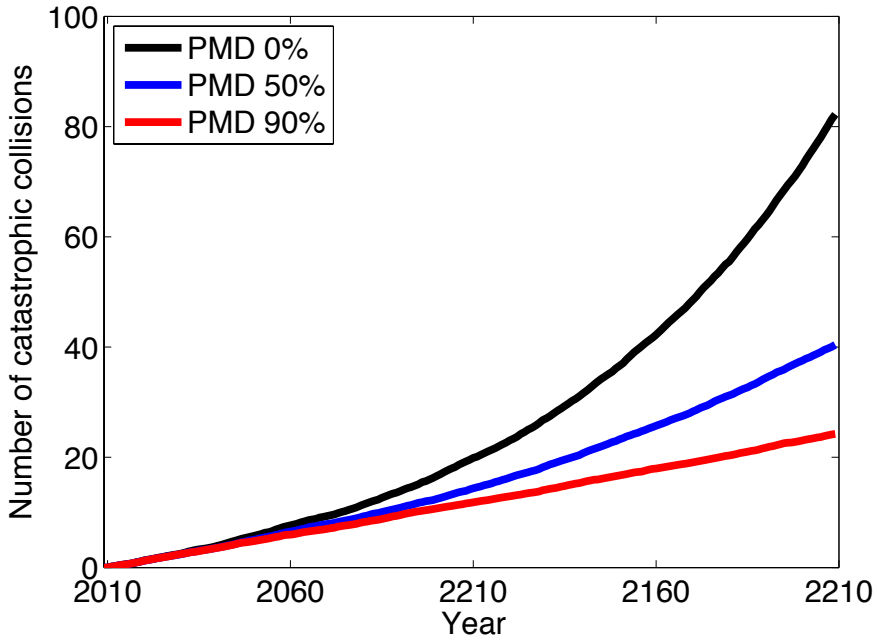
Catastrophic collision



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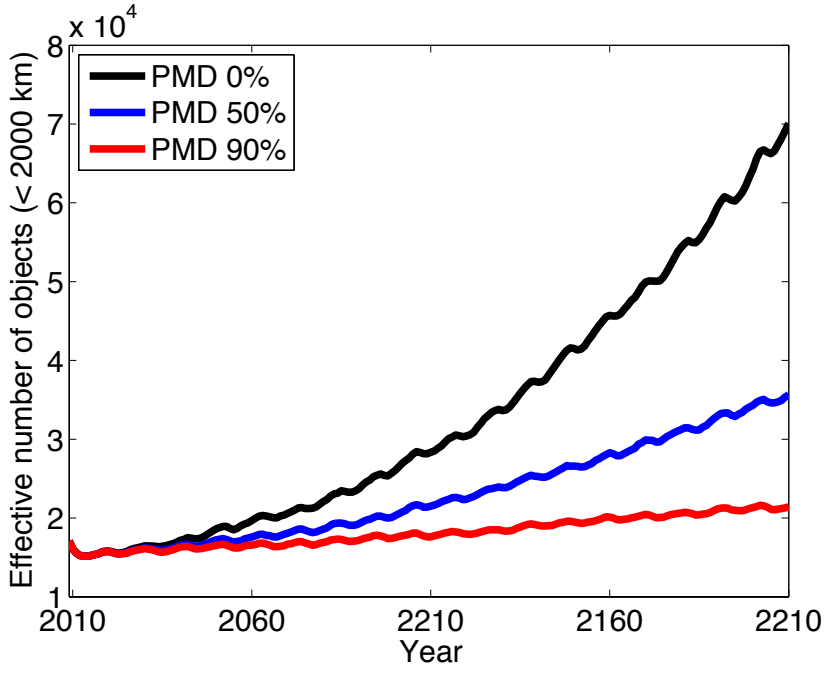
Population growth during next 200 years



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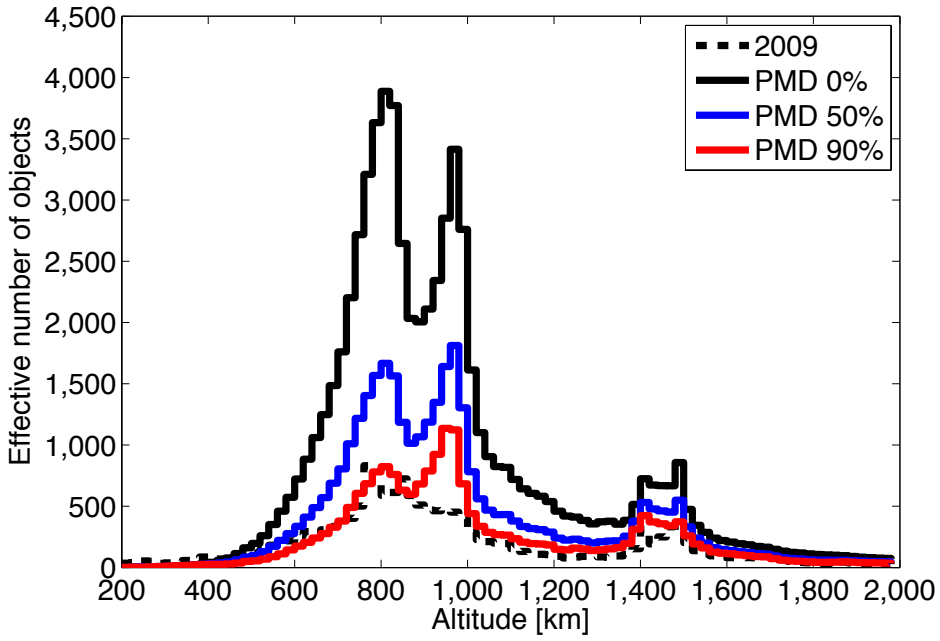
Population snapshot



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Strategies for selecting removal targets

- Orbital debris removal is essential for stabilizing the environment
- Some strategies for selecting removal targets are considered
  - Defining regions for multiple removals
    - Region 1 (R1)
      900 – 1000 km altitudes, 82 – 84 degrees inclination
    - Region 2 (R2)
      700 – 1000 km altitudes, 98 – 100 degrees inclination
  - Considering the influence of accidental collisions
    - Cumulative probability of accidental collisions (PC) during 25 years
    - Expected number of fragments (EN) during 25 years

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Evaluating the proposing strategies

- Projection scenario
  - Initial population as of May 1st 2009
  - No new launch and explosion
  - 100 targets are removed at initial
  - Mass of targets is limited between 500 – 4000 kg
  - Mean of 60 MC runs is result

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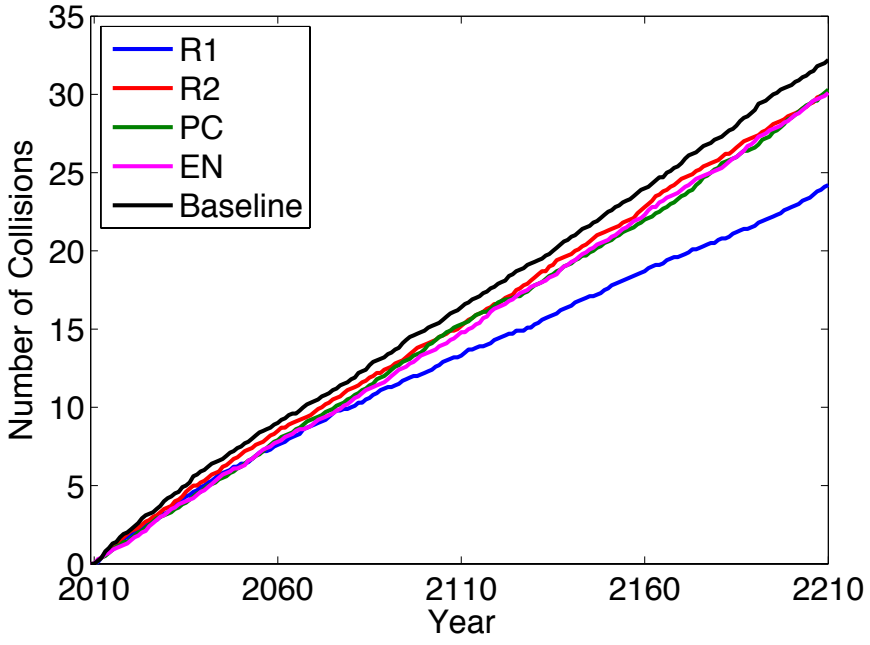
Catastrophic collision



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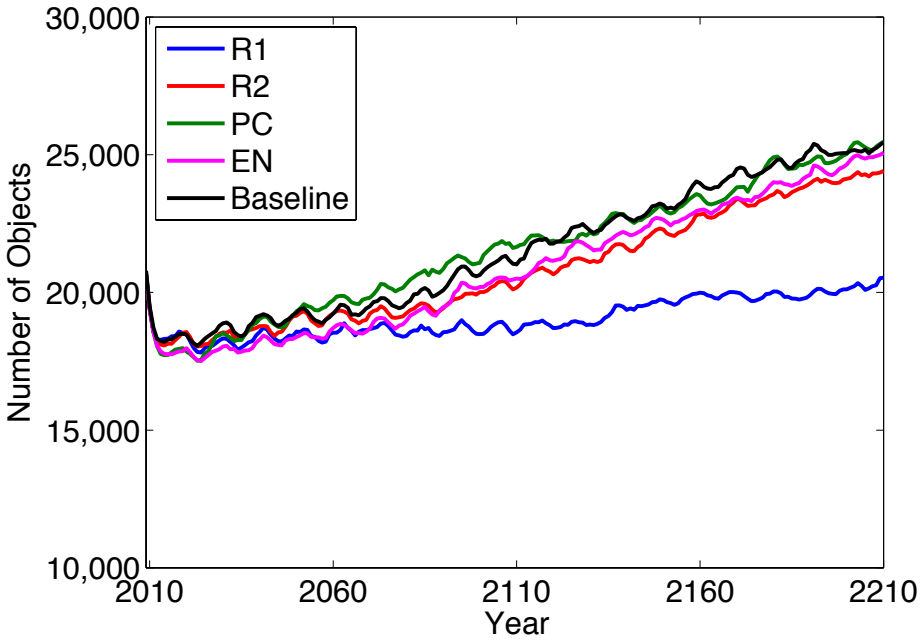
Population prediction during next 200 years



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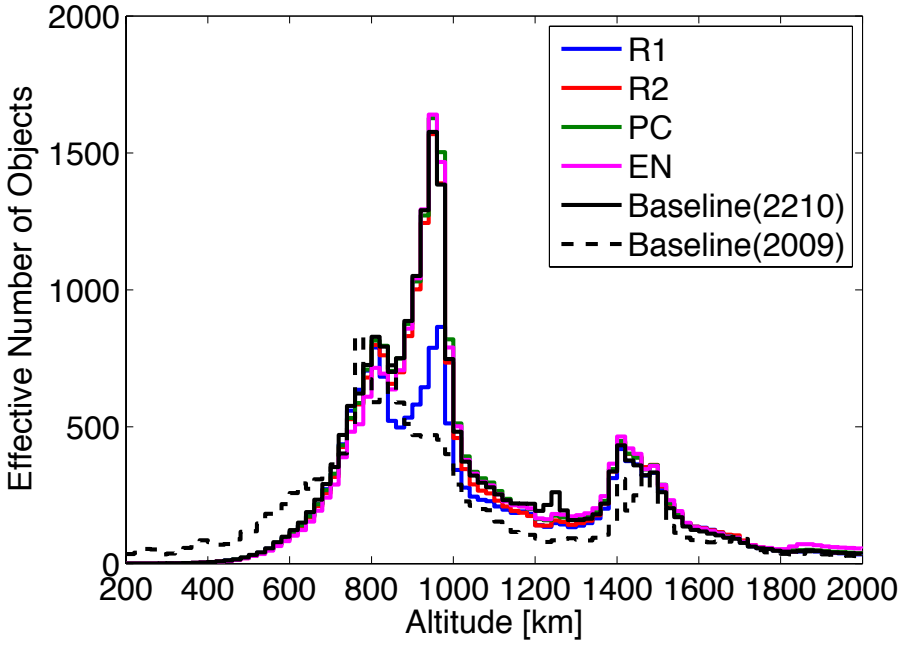
Population snapshot



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Summary

- This presentation introduced the future projection using NEODEEM, which is developed by JAXA and Kyushu University

- IADC A/I 27.1
  - Some scenario which the different PMD compliance
  - PMD compliance effects the growth of future debris population
  - PMD cannot stabilizes the future debris population
- Effectiveness of active debris removal
  - Four strategies for selecting targets is evaluated