Postmission Disposal Options in the 2019 USG Orbital Debris Mitigation Standard Practices (ODMSP)

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U.S. Space Policy Directive-3

- **The U.S. Space Policy Directive-3 (SPD-3), the National Space Traffic Management Policy, was released by the White House in June 2018**
  - The SPD-3 provides guidelines and direction on space traffic management generally, and contains key references and guidelines specific to orbital debris
  - The SPD-3 Goal 2 directs NASA to lead an Interagency Working Group to update the U.S. Government (USG) Orbital Debris Mitigation Standard Practices (ODMSP)

The SPD-3 is available at:

https://www.govinfo.gov/content/pkg/FR-2018-06-21/pdf/2018-13521.pdf

The 2001 USG ODMSP

- **NASA and DOD led the effort to establish the original USG ODMSP in 2001**
  - Based on the NASA Safety Standard (NSS) 1740.14 "Guidelines and Assessment Procedures for Limiting Orbital Debris" (1995)

- **The ODMSP are intended to limit the generation of new, long-lived debris in the future**

Orbital Debris Mitigation = To limit the generation of new orbital debris in the future

Rationale of the 2019 ODMSP Update

SPD-3: Sec. 4, Goals

(b) Mitigate the effect of orbital debris on space activities. The volume and location of orbital debris are growing threats to space activities. It is in the interest of all to minimize new debris and mitigate effects of existing debris. This fact, along with increasing numbers of active satellites, highlights the need to update existing orbital debris mitigation guidelines and practices to enable more efficient and effective compliance, and establish standards that can be adopted internationally. These trends also highlight the need to establish satellite safety design guidelines and best practices.

The U.S. National Space Council announced the completion of the ODMSP update in December 2019. The 2019 ODMSP is available at:

https://orbitaldebris.jsc.nasa.gov/reference-documents/

Objectives of the USG ODMSP

1. **Control of debris released during normal operations**
2. **Minimizing debris generated by accidental explosions**
3. **Selection of safe flight profile and operational configuration**
4. **Postmission disposal of space structures**

- **Per SPD-3, a new section ("Objective 5") was created in the 2019 update for "Clarification and Additional Standard Practices for Certain Classes of Space Operations"**
  – Large constellations, CubeSats, rendezvous, proximity operations, and satellite servicing, *etc*.

Postmission Disposal (PMD) Options (1/8)

***4-1. Disposal for final mission orbits*: A spacecraft or upper stage may be disposed of by one of the following methods:**

a. Direct reentry or heliocentric, Earth-escape

b. Atmospheric reentry

c. Storage between LEO and GEO:

I. Maneuver to an eccentric disposal orbit or

II. Maneuver to a near-circular disposal orbit

d. Storage above GEO

e. Long-term reentry

f. Direct retrieval

4-2. Reliability of disposal

Postmission Disposal (PMD) Options (2/8)

4-1, a. Direct reentry or heliocentric, Earth-escape:

Maneuver to remove the structure from Earth orbit at the end of mission into (1) a reentry trajectory or (2) a heliocentric, Earth-escape orbit. These are the preferred disposal options. For direct reentry, the risk of human casualty from surviving components with impact kinetic energies greater than 15 joules should be less than 0.0001 (1 in 10,000). Design-for-demise and other measures, including reusability and targeted reentry away from landmasses, to further reduce reentry human casualty risk should be considered.

For the first time, the ODMSP establishes "immediate removal from Earth orbit" as the preferred postmission disposal option*!

***This is also the preferred disposal option for Large Constellations in 5-1.**

Postmission Disposal (PMD) Options (3/8)

4-1, b. Atmospheric reentry:

Maneuver Leave the structure in an orbit in which, using conservative projections for solar activity, atmospheric drag will limit the lifetime to as short as practicable but no more than 25 years after completion of mission. If drag enhancement devices are to be used to reduce the orbit lifetime, it should be demonstrated that such devices will significantly reduce the area-time product of the system or will not cause spacecraft or large debris to fragment if a collision occurs while the system is decaying from orbit. The risk of human casualty from surviving components with impact kinetic energies greater than 15 joules should be less than 0.0001 (1 in 10,000).

Encourage "as short as practicable" PMD orbital lifetime limit while maintaining a reasonable cost-benefit balance.

Postmission Disposal (PMD) Options (4/8)

4-1, c. Storage between LEO and GEO:

I. Maneuver to an eccentric disposal orbit (e.g., GEO transfer) where (1) perigee altitude remains above the LEO zone for at least 100 years, (2) apogee altitude remains below the GEO zone for at least 100 years, and (3) the time spent by the structure between 20,182 +/- 300 km is limited to 25 years or less over 200 years; or,

II. Maneuver to a near-circular disposal orbit to (1) avoid crossing 20,182 +/- 300 km, the GEO zone, and the LEO zone for at least 100 years, and (2) limit the risk to other operational constellations, for example, by avoiding crossing the altitudes occupied by known missions of 10 or more spacecraft using near-circular orbits, for 100 years.

The 2001 ODMSP GPS ± 500 km keep-out zone is relaxed to allow other practical, low-risk disposal options.

Postmission Disposal (PMD) Options (5/8)

4-1, d. Storage above GEO:

Maneuver to an orbit with perigee altitude sufficiently above 35,986 km (upper boundary of the GEO zone) to ensure the structure remains outside the GEO zone for at least 100 years.

Adopt a new move-away-and-stay-way principle to better meet the intent of the above-GEO storage option.

Postmission Disposal (PMD) Options (6/8)

4-1, e. Long-term reentry for structures in MEO, Tundra orbits, highly inclined GEO, and other orbits:

Maneuver to a disposal orbit where orbital resonances will increase the eccentricity for long-term reentry of the structure. In developing this disposal plan, the program should (1) limit the postmission orbital lifetime to as short as practicable but no more than 200 years, (2) limit the time spent by the structure in the LEO zone, the GEO zone, and between 20,182 +/- 300 km to 25 years or less per zone; and (3) limit the probability of collisions with debris 10 cm and larger to less than 0.001 (1 in 1,000) during orbital lifetime. To limit human casualty risk from the reentry of the structure, surviving components with impact kinetic energies greater than 15 joules should have less than 7 m^2 total debris casualty area or less than 0.0001 (1 in 10,000) human casualty risk.

Establish a new long-term reentry option while limiting potential risks associated with the new option.

Postmission Disposal (PMD) Options (7/8)

4-1, f. Direct retrieval:

Maneuver Retrieve the structure and remove it from orbit preferably at completion of mission, but no more than 5 years after completion of mission.

Maintain the same retrieval option but adding a time limit to the option.

Postmission Disposal (PMD) Options (8/8)

4-2, Reliability of disposal:

The probability of successful postmission disposal should be no less than 0.9 with a goal of 0.99 or better.

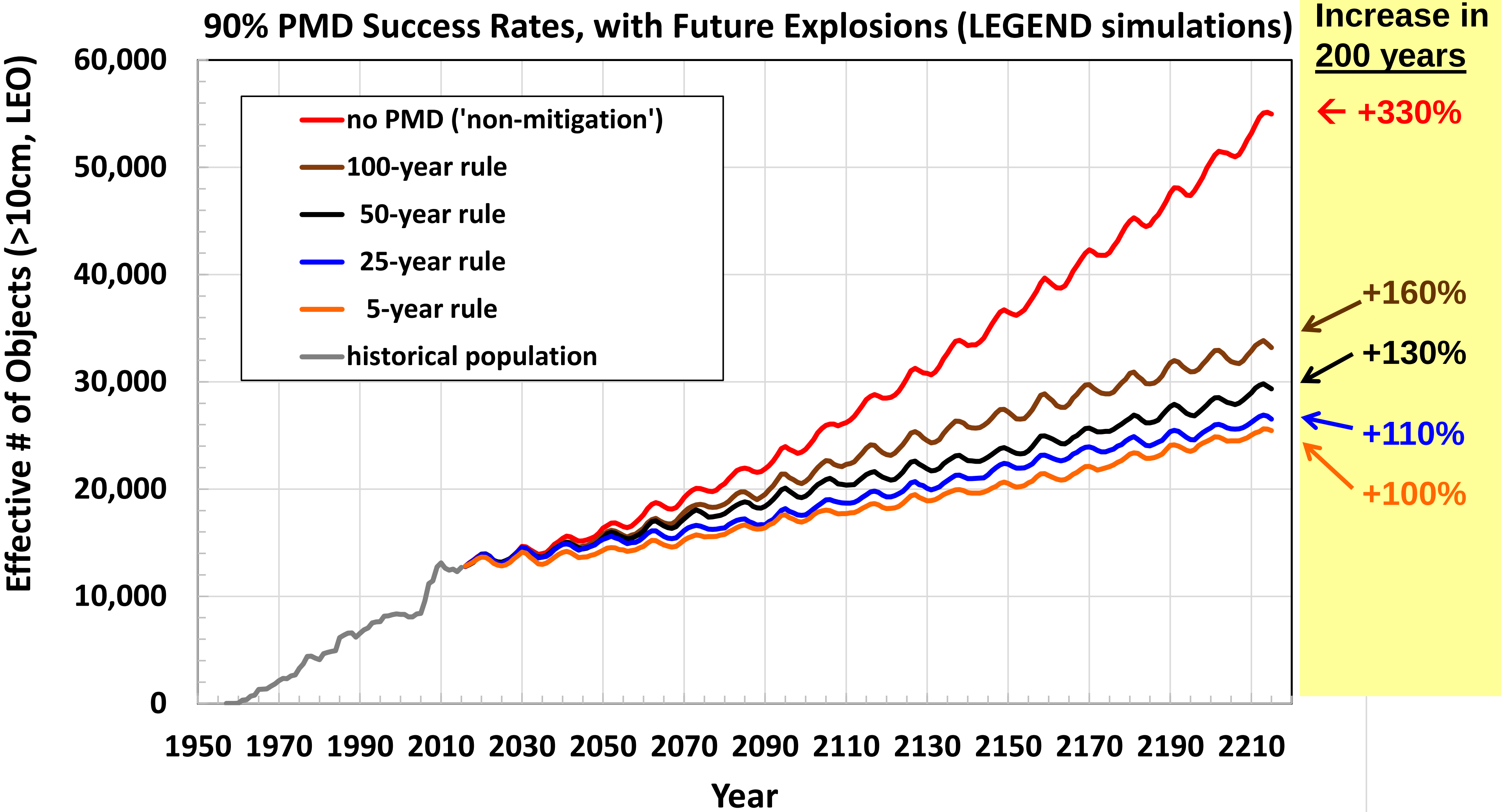
Establish a new reliability threshold for postmission disposal.

Summary

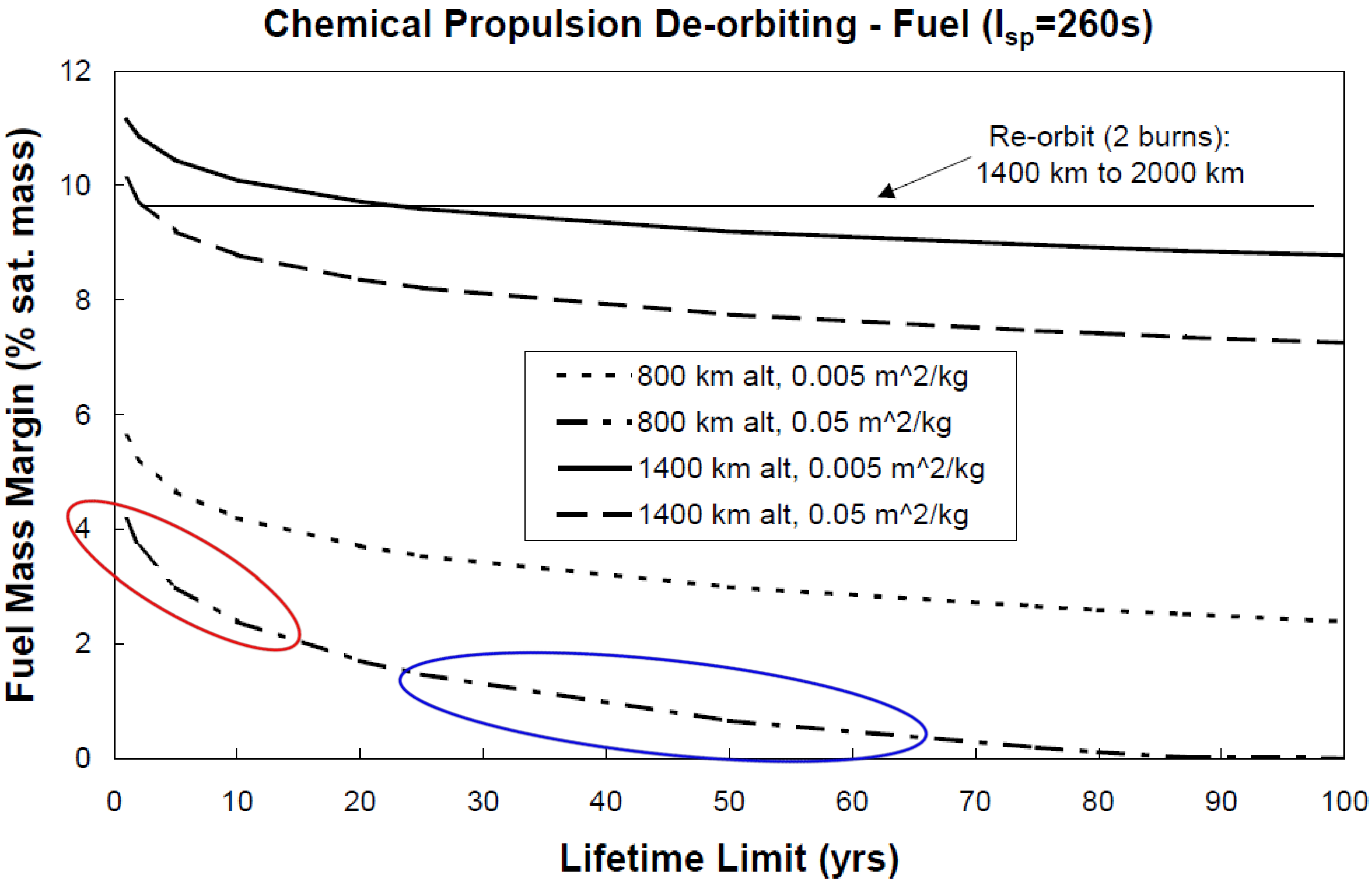
- **This 2019 ODMSP update includes improvements to the original objectives as well as clarification and additional standard practices for certain classes of space operations**
- **The updated standard practices are significant, meaningful, and achievable**
  - Disposal options: immediate removal, long-term reentry, PMD reliability, *etc*.
- **The 2019 ODMSP, by establishing guidelines for USG activities, provides a reference to promote efficient and effective space safety practices for domestic and international operators**

Backup Charts

Effectiveness of the 25-year Rule

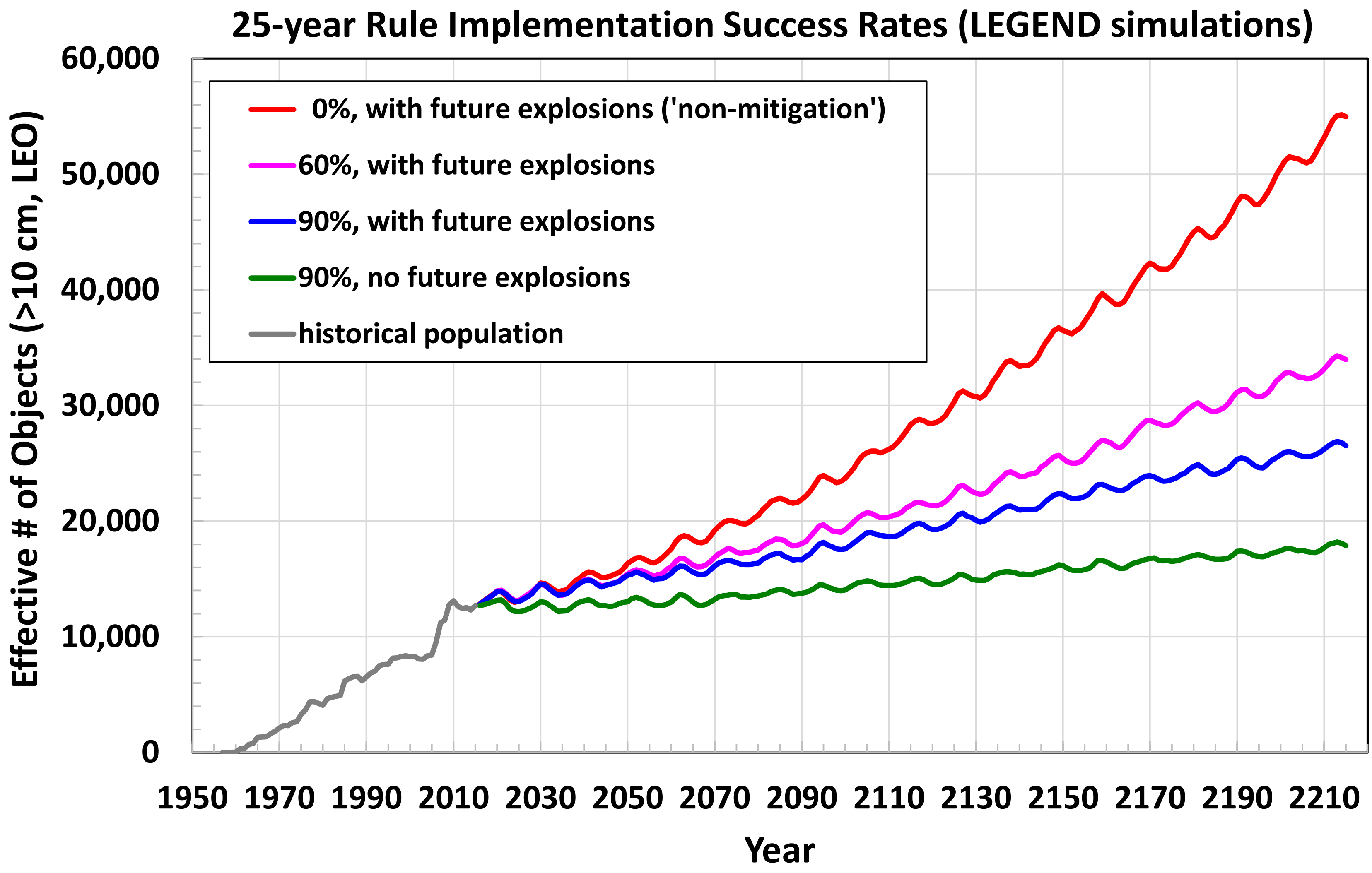


Post-Mission Deorbit Fuel Requirements



(IADC Debris Mitigation Guidelines Support Document, 2004)

PMD Success Rates



Increase in 200 years

← +330%

← +170%

← +110%

← +40%

Orbital Debris Environment Management

- **“Prevention is better than cure”**
  - (*Prov*.) It is better to try to keep a bad thing from happening than it is to fix the bad thing once it has happened.
- **“An ounce of prevention is worth a pound of cure”**
  - (*Prov*.) It is better/<u>cheaper</u> to stop something bad from happening than it is to deal with it after it has happened.

- **Orbital Debris <u>Mitigation</u> = Prevention**
- **Orbital Debris <u>Remediation</u> = Cure**

Active Debris Removal

<u>SPD-3, Sec. 5. Guidelines</u>

The United States should pursue active debris removal as a necessary long-term approach to ensure the safety of flight operations in key orbital regimes. This effort should not detract from continuing to advance international protocols for debris mitigation associated with current programs.