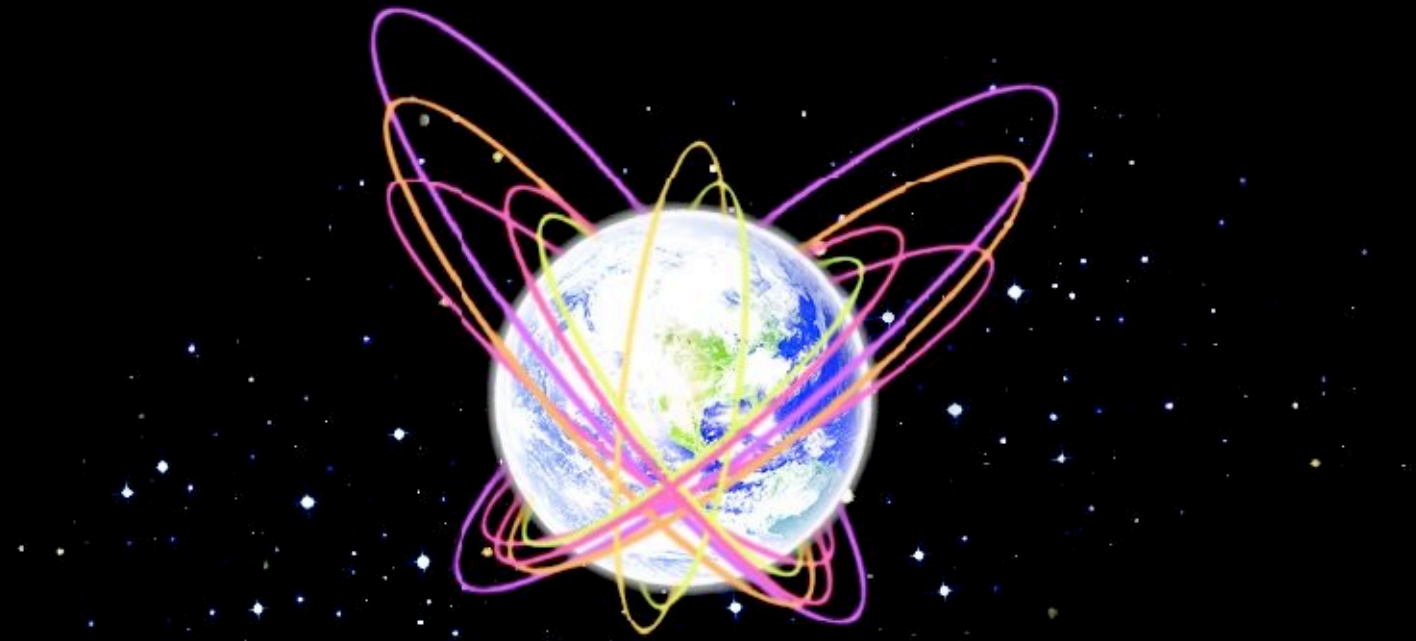
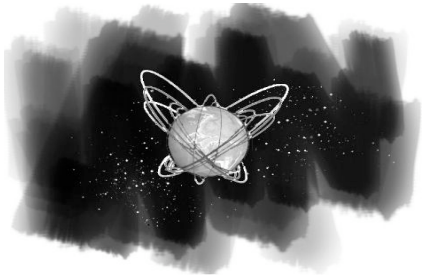
Space Traffic Management



Brian Weeden

Ben-Baseley Walker



Overview

- ISU Report
  - Collision Avoidance
  - Human Zone
  - Sun Synchronous Zoning
  - Geosynchronous Maneuvers
  - Legal / Management / Implementation
- Our Rationale
- Our Next Steps

ISU Report Findings and Recommendations

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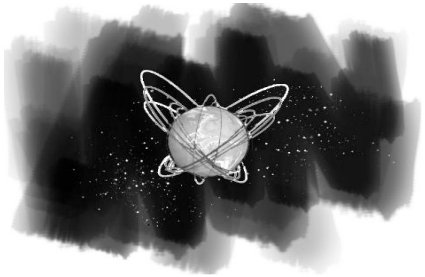
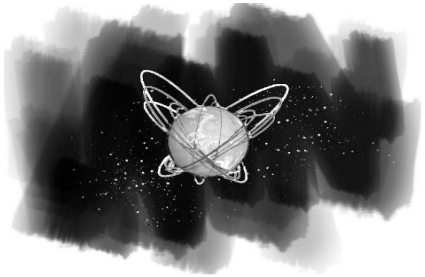


Proposed Solution

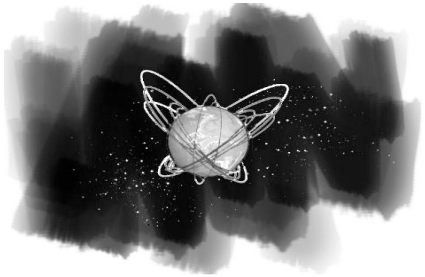
- A set of Space Traffic Management (STM)) rules providing a strong foundation for further research covering four areas of immediate concern.
  - Collision avoidance
  - Sun-synchronous orbit (SSO) congestion
  - Dangers to human-rated craft
  - Improved utility of geo-synchronous orbit

  These rules:
    - Are not focused on debris mitigation
    - Allow more efficient use of crowded orbits
    - Give owner-operators the tools to protect their spacecraft



Areas of Focus

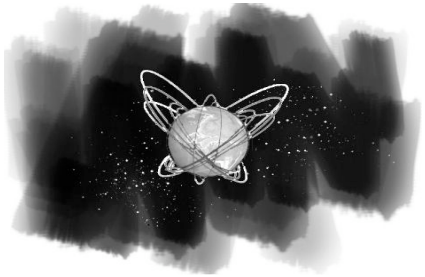
- **Conjunction Assessment / Collision Avoidance**
  - Standardized warnings and maneuver planning to help owner/operators with risk management
- **Human Spaceflight**
  - Created a human-rated zone with more stringent traffic rules
- **Sun-Synchronous Orbit**
  - Developed new slot architecture to eliminate spacecraft-spacecraft conjunctions
- **Geosynchronous Orbit**
  - Proposed voluntary data sharing to enhance maneuver planning



Collision Avoidance

- STM provides standard data set, warnings, and recommendations of avoidance maneuvers to help owner-operators that might not have the tracking or analytical ability in-house
- Gives owner/operator flexibility to maneuver based on internal cost/benefit analysis unless inaction could threaten other spacecrafts

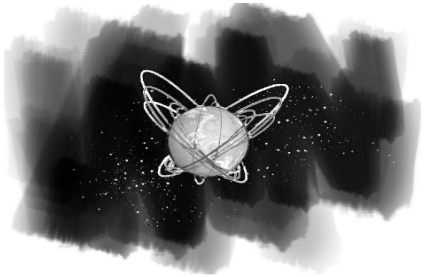
Rules provide the spacecraft owner-operators with the information and tools to help make educated choices and to improve satellite safety



Human Rated Zoning

- Allows for non-human rated spacecraft to co-exist with human-rated in a safe manner
- Improves long-term viability of human orbital zone
- Improves tracking ability for small satellites

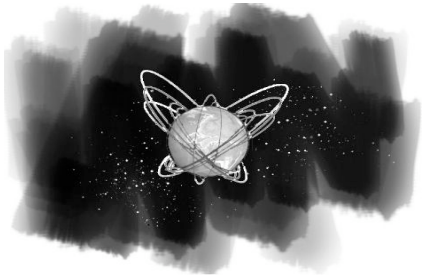
Creates a protected zone for human traffic with minimal impact to current and future non-human rated operators



Sun-Synchronous Zoning

- Designed zoning architecture that creates slots for over 12,000 satellites spaced in altitude, inclination, and true anomaly
- No orbits will cross unless an owner-operator loses station keeping

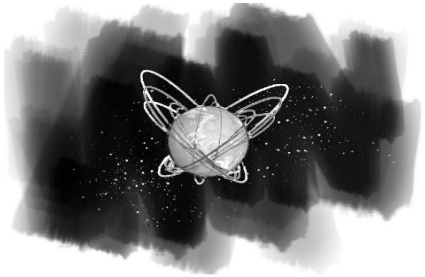
Room for more than an order of magnitude growth over today's SSO population is provided and ensuring minimal collision risk



Geosynchronous Data Sharing

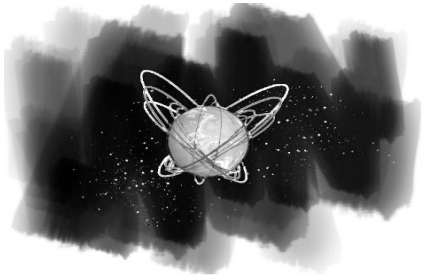
- More accurate conjunction assessment predictions and more efficient collision avoidance maneuver planning
  - Public data error: 20-50 km
  - Owner-Operator data error: 7 km
- Clear separation between station-keeping spacecraft and maneuvering satellites
- Allows for more efficient planning for station-keeping maneuvers

Rules increase efficiency of existing GEO slotting and operations and reduce energy costs



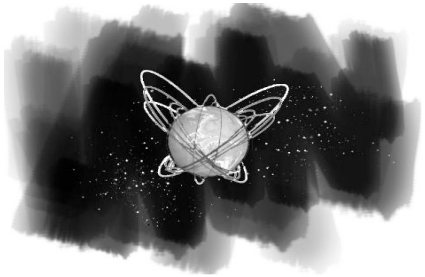
Potential Policy Issues

- Legitimacy of STM organizational body to implement and enforce rules
- Limitations on freedom of action by all actors
- Reluctance to share data due to privacy and competitive advantage concerns
- Arenas for arbitration and legal recourse



Next Legal Steps

- Mandate expansion (ITU or ICAO)
- Amendments and repeals of current laws



Path to Implementation

Key steps for a STM System

Phase 1: Develop Rules

Phase 2: Build Consensus

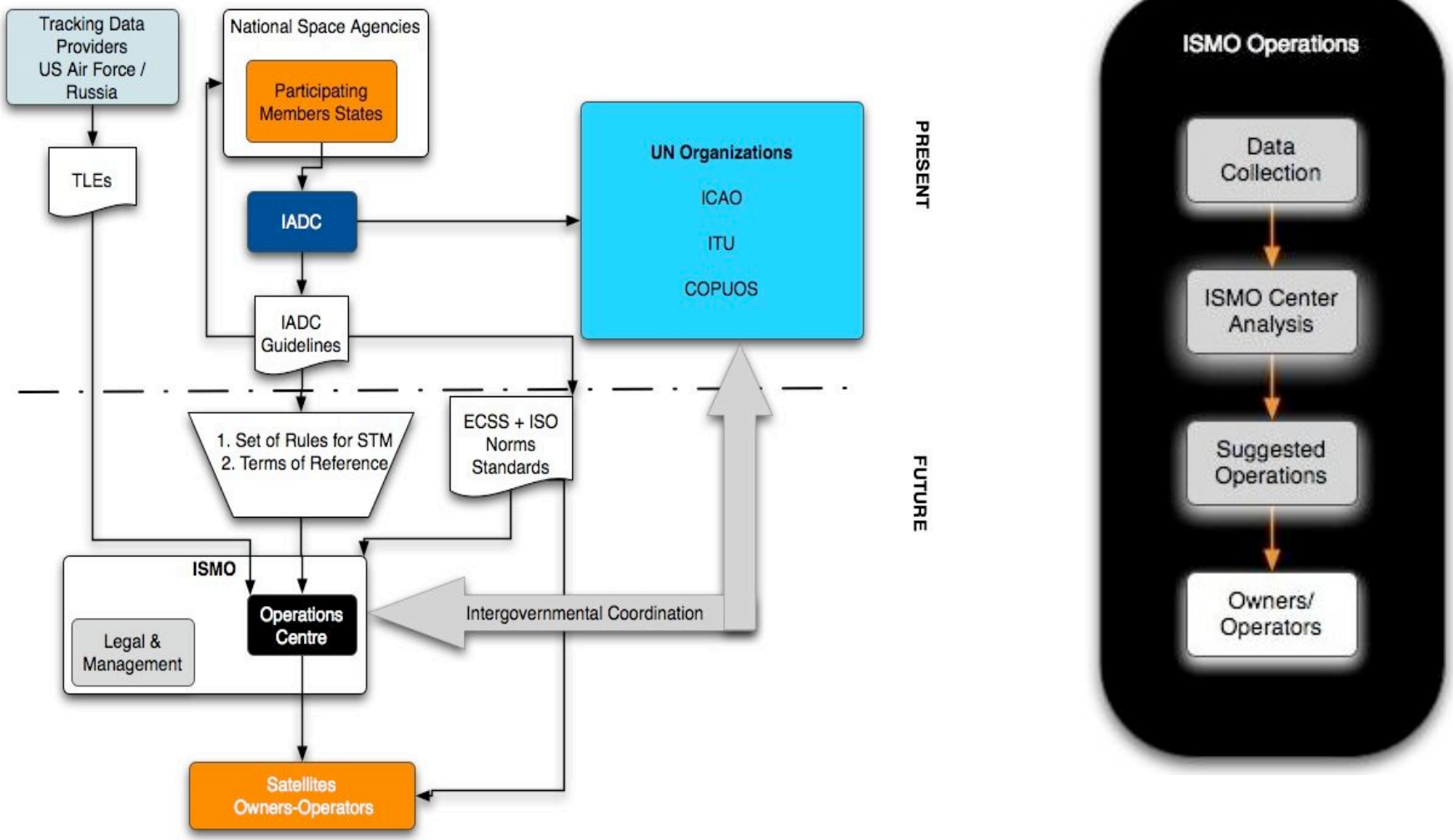
Phase 3: Implement the system

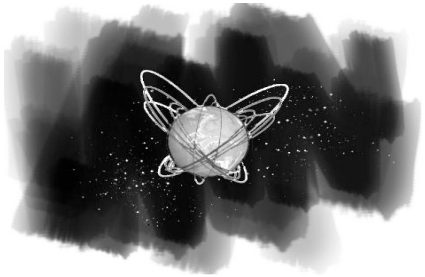
Potential STM Organizations

Managing Body	Phase I: Rule Development	Phase II: Consensus	Phase III: Implementation of the System (1)	Phase III: Arbitration Procedures (2)
UNCOPUOS		✓		✓
ITU		✓		
IADC	✓			
ICAO			✓	✓
New Agency	✓		✓	✓

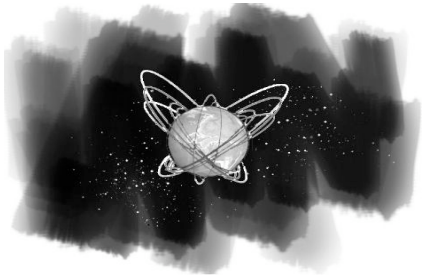
Recommendations

A Road Map to ISMO





Our Rationale and the Way Ahead

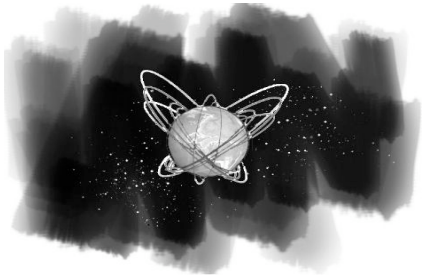


Rationale

- Our approach over the next year is to start assessing in clear practical terms:
  - When STM will be needed,
  - The effects of varying a timescale of implementation
  - Investigating whether it really is beneficial for key actors to engage with STM
  - When is it most beneficial for them to do so.

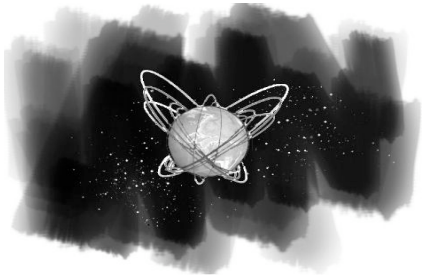
Our Goal: To develop a technically sound and politically viable STM system

- Acceptable to key stakeholders
- Effectively put forward the case for these actors to take part in its implementation

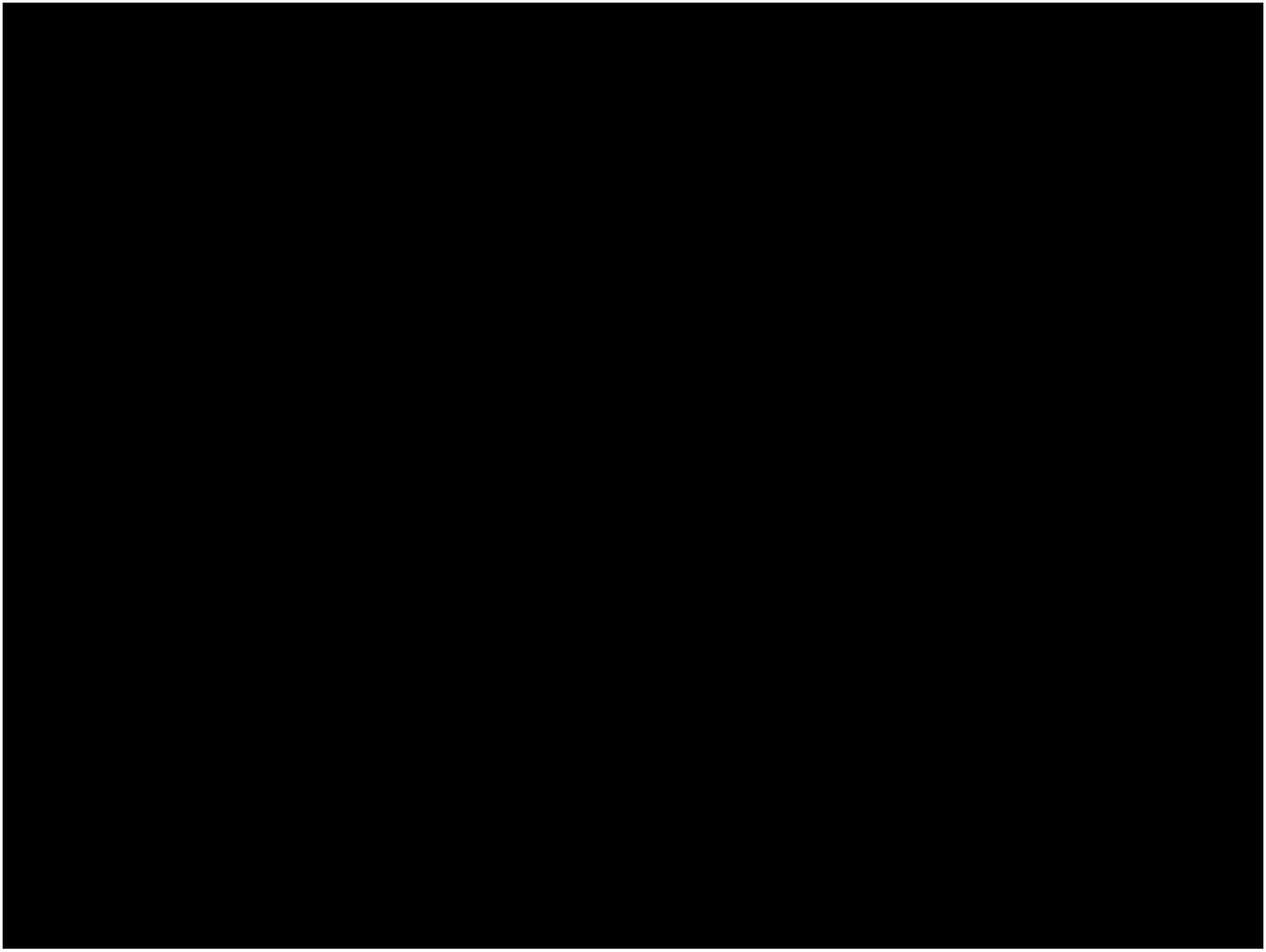


Our Next Steps

- **Secure World Foundation is funding further research and engagement activities with the following goals:**
  - **Rigorous analysis of technical proposals (conjunction assessment, SSO zoning) and legal issues**
  - **Economic analysis and development of policy and industry motivators**
  - **Active engagement with the international community for feedback and involvement in moves towards more effective management of STM**

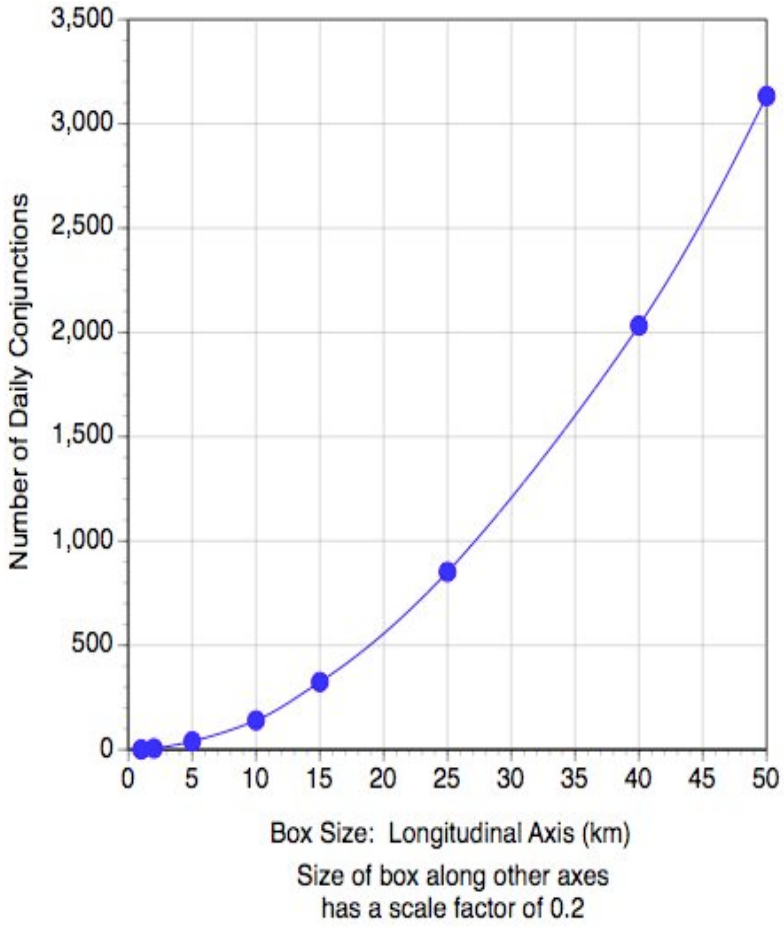


Questions?

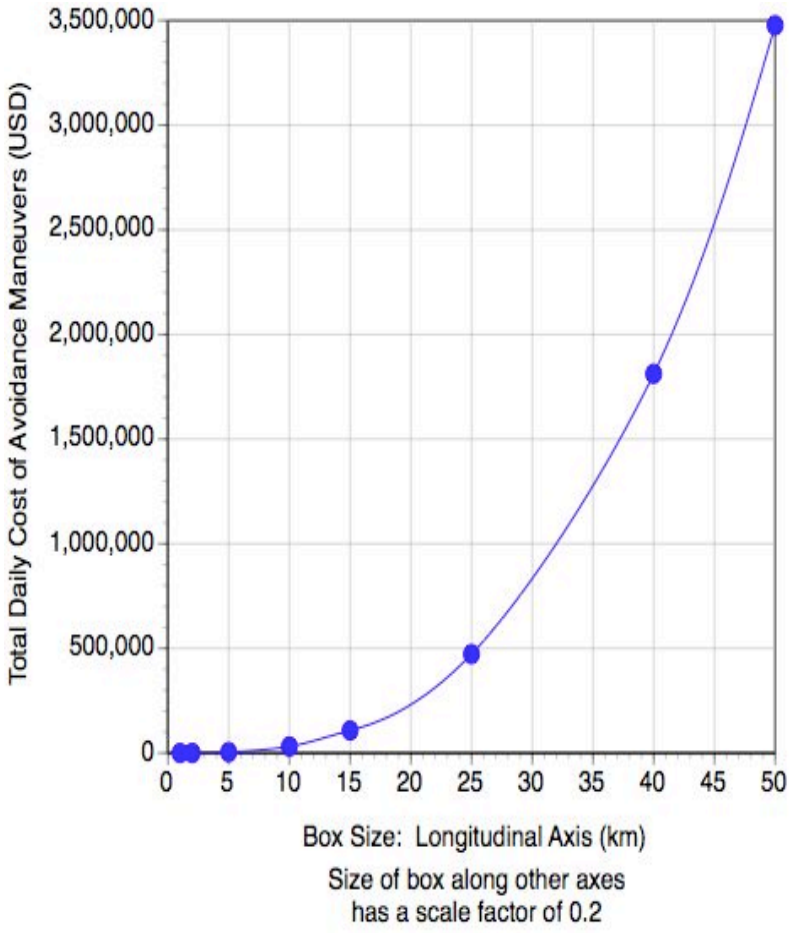


The Effect of Data Accuracy

Number of Conjunctions



Daily Cost of Maneuvers



Orbital Lifetime vs Altitude

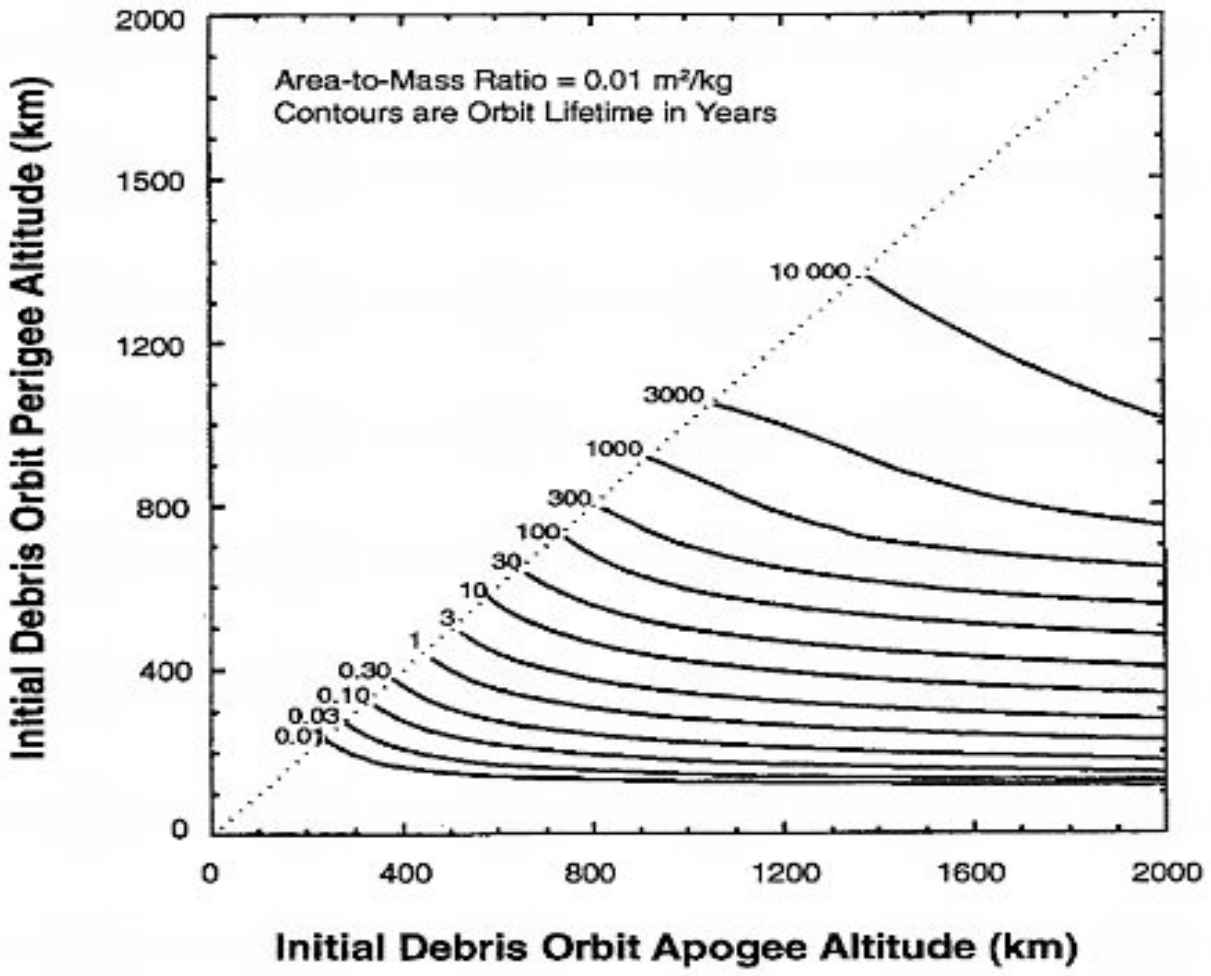
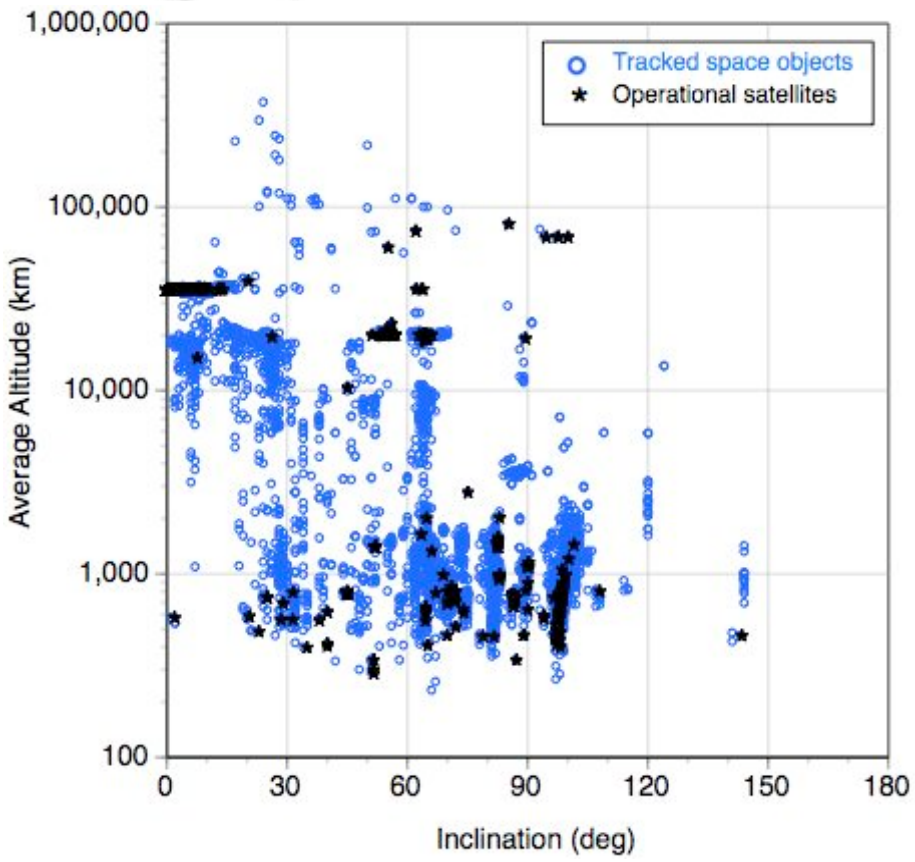
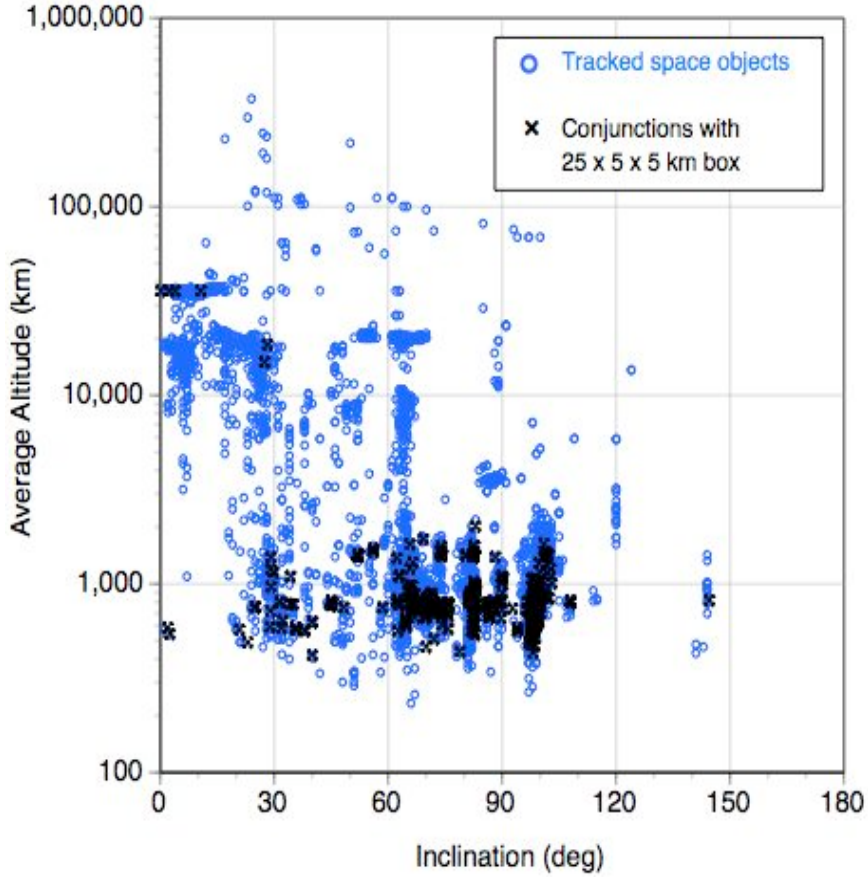


Figure 1-1: Orbital Lifetime as a Function of Altitude (Jehn 2007)

Current On-Orbit Trackable Population (~12,00 Objects)





Key question: at what number of collisions do critical orbits become unusable?

Relative Velocity of Conjunctions