



Promoting Cooperative Solutions for Space Sustainability

The Legal, Policy, and Economics Challenges of Space Debris

Brian Weeden

Technical Advisor

Secure World Foundation

bweeden@swfound.org



Promoting Cooperative Solutions for Space Sustainability

My background

- Undergraduate degree in Electrical Engineering
- 9 years in the U.S. Air Force working on space and nuclear operations
 - 3 years I was an Orbital Analyst working in the unit that tracks all the human-generated stuff in Earth orbit
- Master's degree in Space Studies from U. of North Dakota
 - Thesis was on constant thrust techniques to move asteroids
- ISU SSP07 in Beijing
 - Space Traffic Management TP
- Joined SWF as Technical Advisor in 2008
- Currently a PhD Candidate in Public Policy and Public Administration
 - Dissertation topic is the interagency process for making decisions on dual-use space policy

- Dealing with space debris is more than just a technical issue
- Legal, policy, and economic challenges are deeply imbedded in the issue and are likely to be more difficult to overcome than the technical
- Also cannot just look at it in the context of a single country (international problem)

Thinking about space debris from a interdisciplinary and international context from the beginning is essential to success



Promoting Cooperative Solutions for Space Sustainability

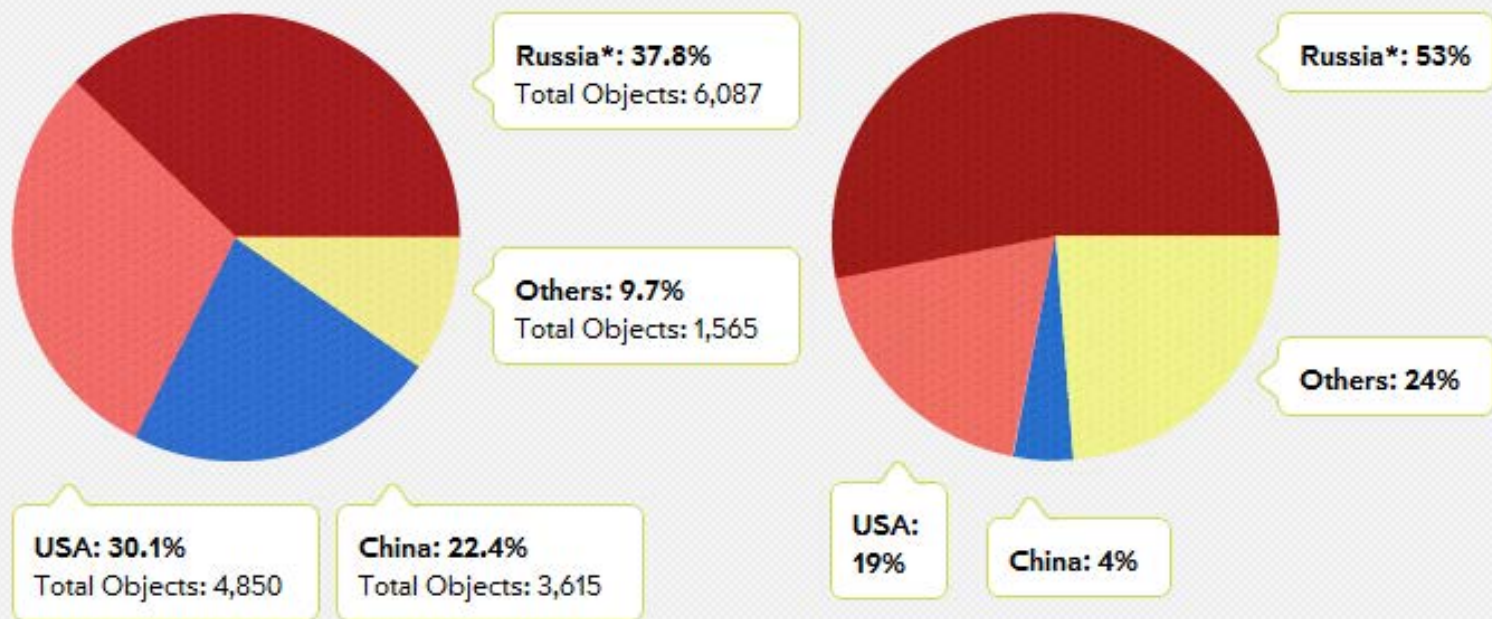
LEGAL PERSPECTIVES

Main legal challenge is uncertainty

- Just about all of the legal challenges can be grouped into two areas:
 1. ***Lack of clarity and consensus on foundational principles***
 2. ***50+ year old legal regime that was intended to stabilize the Cold War relationship between nuclear superpowers (but not do much else)***
- It's a framework that provides broad guidance and direction, but not a lot of specificity
- Nothing explicitly prohibits ADR, but the ***uncertainty creates resistance to action***

Uncertainty #1: Who “owns” the debris?

An interesting way of looking at who owns objects in space is to consider the percentage of ownership by number of objects (left) and by mass of objects (right).



Breakdown of tracked space debris (~22,000 objects)

- OST Article VIII: A State Party to the Treaty *on whose registry an object launched into outer space is carried shall retain jurisdiction and control* over such object
- What do these terms actually mean in a legal context?
 - Jurisdiction: *legal* power (right & ability of a State to make/enforce laws)
 - Control: *operational* power (does this apply for space debris?)
 - This is *not* the same as national sovereignty (ie, flagged ships)
 - The existing space treaties explicitly avoided establishing national sovereignty over space objects

How many “space objects” are there?

Online Index of Objects Launched into Outer Space

▶ FILTER BY ...

Important Note: Information in square brackets ([and]) and highlighted in green has been obtained from other sources and has not been communicated officially to the United Nations. Reference to external views expressed are those of the authors

COUNTRY TOTALS:

Search Object

So there are only 7,162 space objects, right?

found 7162 Objects

International Designator	National Designator	Name Object
[2015-027A]		[COS]
[2015-026B]		[SKY]
[2015-026A]		[DIR]

COUNTRY	IN ORBIT				
	UNASSIGNED	PAYLOAD	ROCKET BODY	DEBRIS	TOTAL
UKRAINE (UKR)	0	1	0	0	1
URUGUAY (URY)	0	1	0	0	1
UNITED STATES OF AMERICA (US)	0	1245	665	3289	5199
UNITED STATES/BRAZIL (USBZ)	0	1	0	0	1
VENEZUELA (VENZ)	0				2
VIETNAM (VTNM)	0	3	0	0	3
ALL (ALL)	0	4047	2024	11083	17154

Not according to USSTRATCOM

Showing 81 to 87 of 87 entries

Various sources on # of space objects

Source	Number	Notes
UN Satellite Registry	7,162*	Compiled from national notifications to the UN
Space-Track.org Catalog	17,154*	Actively tracked and associated with a launch, bigger than 10cm
USSTRATCOM private database	~23,000	Includes catalog plus ~6,000 objects tracked but not associated with a launch
Space debris research community	~500,000	Total objects bigger than 1cm

* As of 23 June 2015

Who has the “authoritative” catalog?



Promoting Cooperative Solutions for Space Sustainability

POLICY PERSPECTIVES

Wicked vs tame public policy problems

- “How, why, and to what effect governments pursue particular courses of action or inaction” (Heidenheimer et al, 1990)
- Tame problems (mathematics, chemistry, chess) have **clear objectives and resolutions**, and can be resolved through application of scientific methods
- Wicked problems are those for which a **purely scientific/rational approach cannot be applied**
 - Cannot explicitly define all the variables
 - Stakeholders have radically different worldviews and timeframes
 - Constraints and resources change over time
 - Problem is never resolved definitively

Characteristics of a wicked policy problem

1. Cannot fully describe the problem without knowing what the solution is (the two are intertwined)
2. No “stopping rule” (no explicitly-defined end state when you know you’re done)
3. Solutions are not right or wrong, but better/worse or good/good enough
4. Each wicked problem is unique and novel
5. Every solution is a “one-shot operation”
6. There is no explicitly defined set of all possible solutions from which the “best possible one” can be chosen

“**Super Wicked Problems**” have all of the characteristics of wicked problems, plus:

- Time is running out
- Those who are causing the problem are also seeking to provide a solution
- Central authority to resolve the problem is weak or non-existent
- Policy responses discount the future irrationally

Sounds a lot like space debris!

Collective action problems

- Problems where the group would benefit from everyone taking a particular action, but the cost of doing so makes it implausible for any one individual to do so
- Categorical example: Prisoner's Dilemma
- Many real world examples
 - Pollution
 - Cyber security
 - Management of natural resources (fisheries, forests)
 - Voting



Promoting Cooperative Solutions for Space Sustainability

ECONOMIC PERSPECTIVES

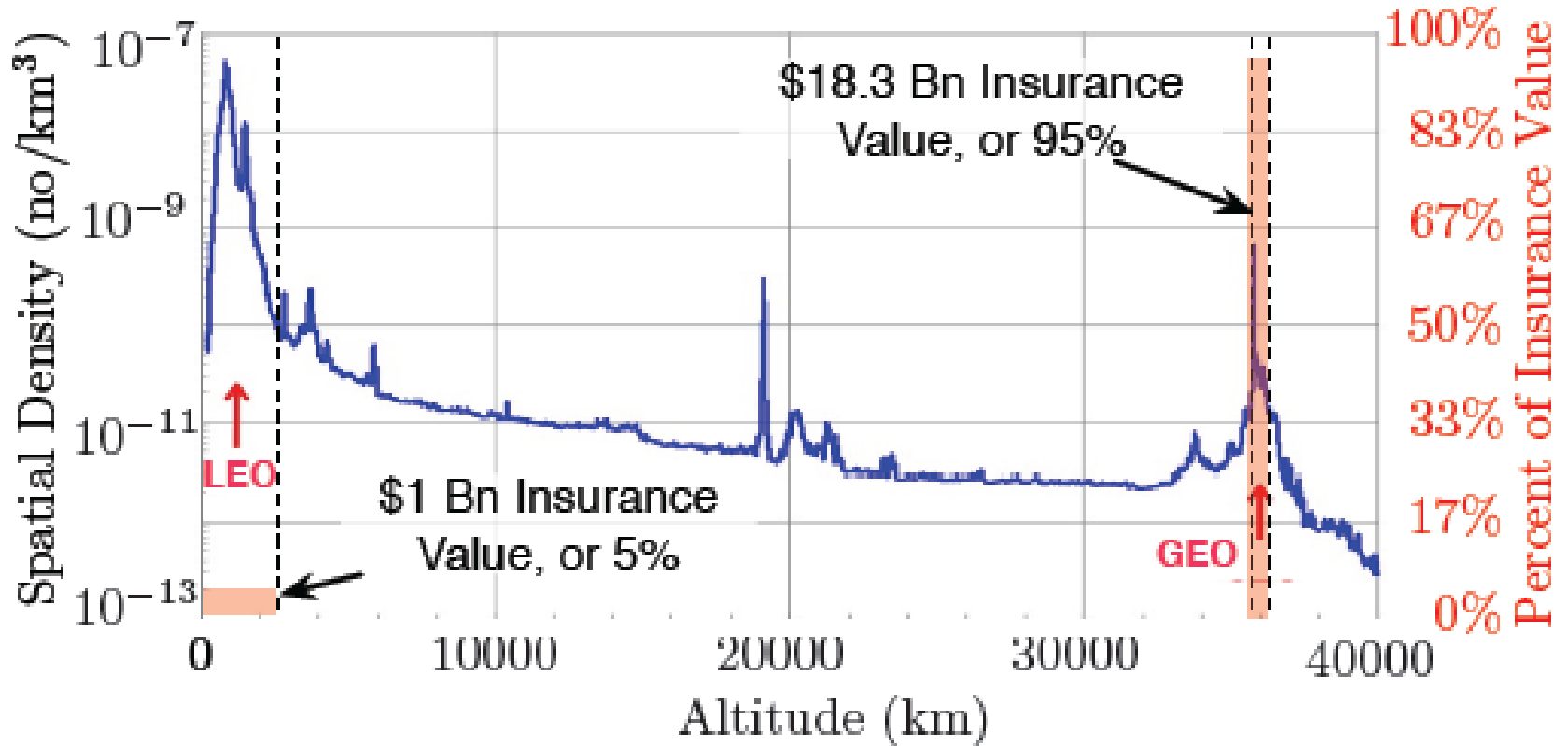
Actual costs from space debris

- Annual risk of collision in the worst region is about 0.8% per year
- **Worst-case analysis:** Cost to maintain a satellite constellation at 850 km for 20 years

Constellation Size	Replenishment Cost (\$B, No debris)	Replenishment Cost (\$B, Fatal only)	Replenishment Cost (\$B, All impacts)
Small (5 sats)	\$19.1	\$20 (+5%)	\$20 (+5%)
Medium (20 sats)	\$15.5	\$16.5 (+6.5%)	\$17.16 (+11%)
Large (70 sats)	\$7.6	\$8.68 (+13%)	\$9.57 (+26%)

Ailor, Womack, Peterson, and Murrell (2010)

Insurance is not going to help (much)



Schaub, Jasper, Anderson, and McKnight (2014)

The stark reality of economics

- The odds of developing an economic incentive mechanism for removing space debris in LEO are ***extremely small*** because there's ***little direct economic value in LEO***
 - Nearly all the economic activity in space takes place in GEO
 - Total value of global space activities: \$280 billion
 - Total private benefits from LEO: ~\$3 billion
 - Almost all users of LEO are public entities deriving social benefits
- The ***debris problem was almost entirely created by governments*** using public money (legacy debt that needs to be dealt with)
- Any ***funding of ADR activities is likely to come from public money***
 - Either as governments conducting missions themselves or purchasing services from private sector

Space as a Common Pool Resource (CPR)

- **Excludable:** can prevent others from using the resource
- **Rivalrous:** someone else's use of the resource precludes your own use of it

	Excludable	Non-excludable
Rivalrous	Private goods food, clothing, cars, personal electronics	Common goods (Common-pool resources) fish stocks, timber, coal
Non-rivalrous	Club goods cinemas, private parks, satellite television	Public goods free-to-air television, air, national defense

Outer space as whole is a public good, but heavily used regions of Earth orbit (LEO, GEO) are Common-Pool Resources (CPRs)

- Won 2008 Nobel Prize in economics for her work on common-pool resources (CPRs)
- Discovered that there are many cases where the tragedy of the commons is false
 - Resources can be managed sustainably without either Leviathan or privatization
 - Resource appropriators self-organize to develop governance model that is suited to local conditions
- Distilled 8 principles which were common to all cases of successfully managed CPRs



Ostrom's Principles

1. Clearly-defined ***boundaries of the CPR*** (effective exclusion of external unentitled parties)
2. ***Congruence*** between governance structure or rules and the resource context
3. Collective-choice arrangements that ***allow most resource appropriators to participate in the decision-making process***
4. ***Effective monitoring*** by monitors who are part of or accountable to the appropriators
5. ***Graduated sanctions (penalties)*** for resource appropriators who violate community rules
6. Low-cost and easy-to-access ***conflict resolution mechanisms***
7. Self-determination of the community is recognized by higher-level authorities
8. In the case of larger common-pool resources: organization in the form of ***multiple layers of nested enterprises***



Promoting Cooperative Solutions for Space Sustainability

MOVING FORWARD

Lessons going forward (1)

- Learn from other domains, but don't copy/paste ideas
 - Air Traffic Management \neq Space Traffic Management, but there are some useful concepts that might help
- Technical definitions/approaches are good places to start, but don't ignore politics
 - Wicked problems by definition cannot be solved through purely scientific/rational means
 - Need to have a cultural/behavioral/political dimension as well
- Push for a collaborative solution, but don't be surprised if it's the last thing that gets tried
- Recognize that not all stakeholders have the same perspective/priorities
 - Developed spacefaring countries have a different perspective from developing countries

Lessons going forward (2)

- Focus on developing policy interventions at multiple levels
 - International, national, and individual actor
- Don't discount value of incremental policies, or starting from coalitions of the willing
 - Start with a core constituency, and increase it over time
- Pay attention to the process & actors involved as much as the actual “solution”



Promoting Cooperative Solutions for Space Sustainability

Thank you for your time. Questions?

bweeden@swfound.org