



Promoting Cooperative Solutions for Space Sustainability

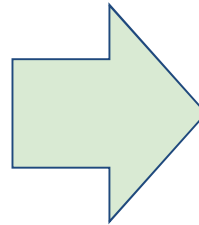
The Evolution of Space Rendezvous and Proximity Operations and Implications for National Security

Dr. Brian Weeden
Director of Program Planning
Secure World Foundation

Trends in the space domain

Old Space Paradigm

- National
- Secret
- Military-led
- Independent
- Strategic



New Space Paradigm

- International
- Transparent
- Commercial-led
- Interdependent
- All levels of war

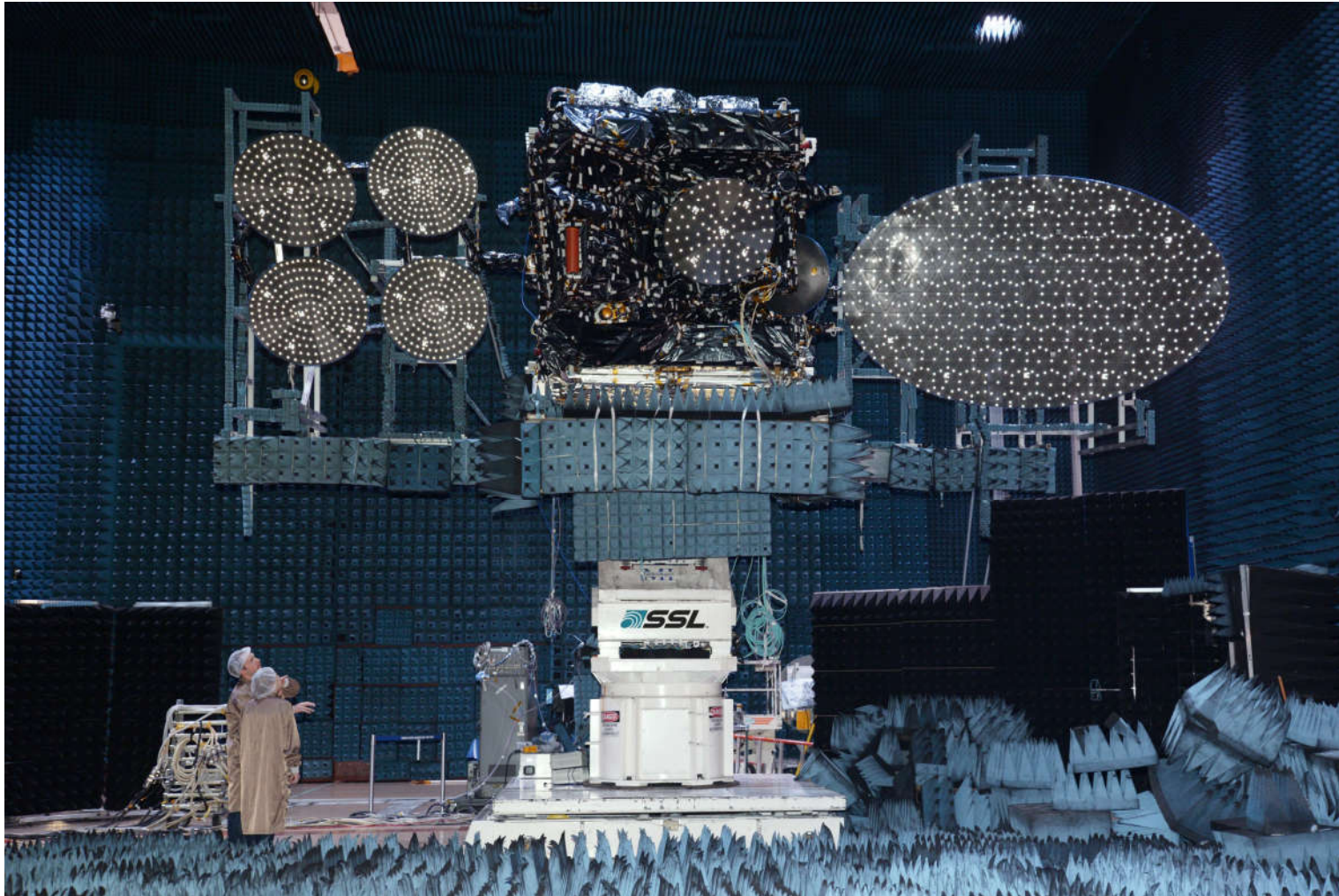
Space is becoming “normalized”



Promoting Cooperative Solutions for Space Sustainability

COMMERCIAL RENDEZVOUS AND PROXIMITY OPERATIONS AND SATELLITE SERVICING

How we do satellites today



Credit: [SSL and SpaceNews](#)



Promoting Cooperative Solutions for Space Sustainability

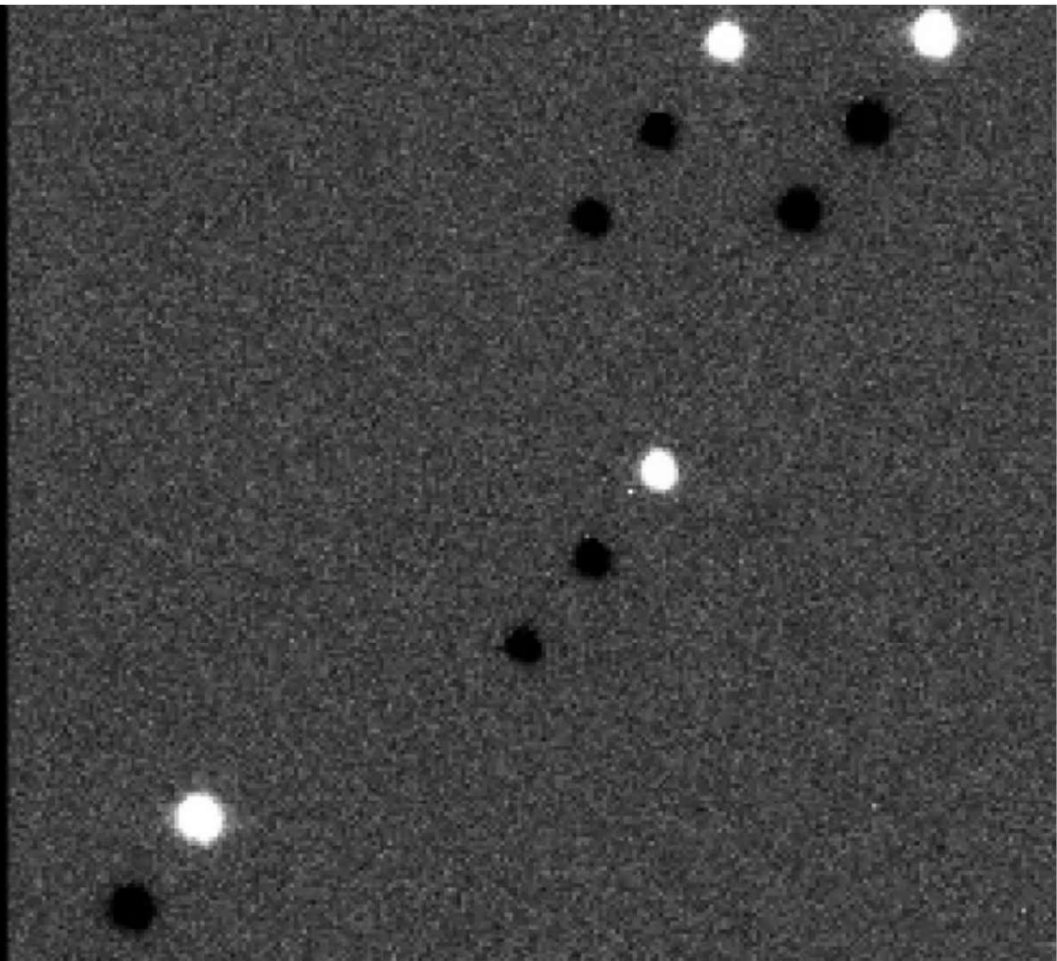
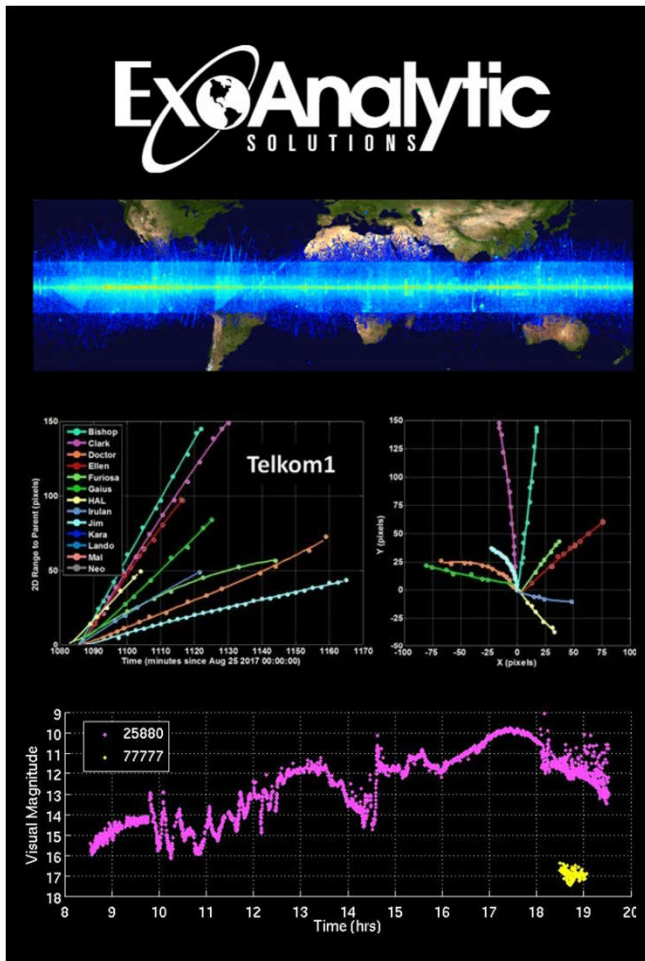
What if cars were like satellites?





Promoting Cooperative Solutions for Space Sustainability

The problem of anomaly resolution



Credit: ExoAnalytic Solutions

What's coming

SATELLITE INSPECTION



LIFE EXTENSION



NORTHROP GRUMMAN

SATELLITE REFUELING



MODULAR SATELLITE ASSEMBLY

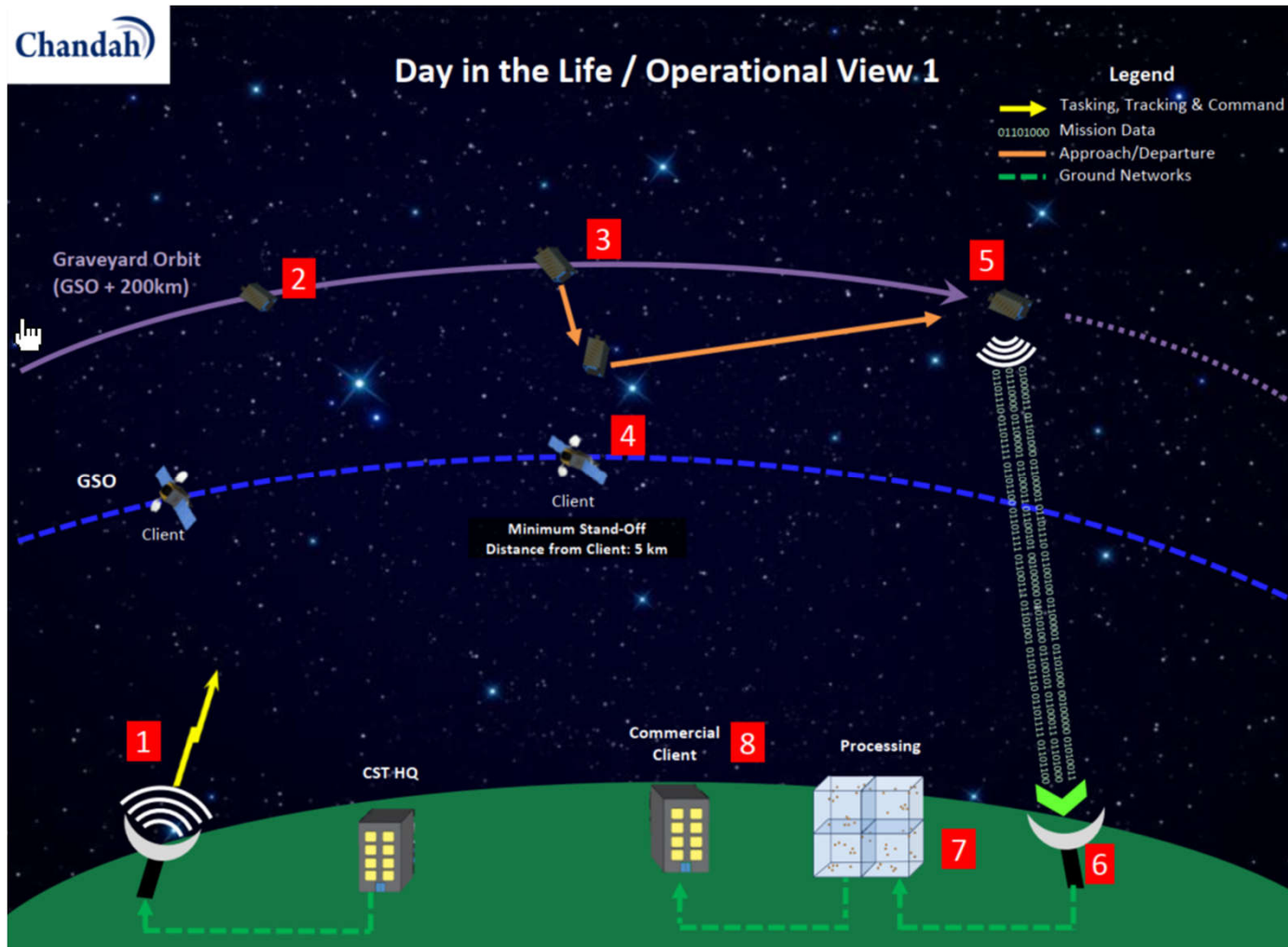


DEORBIT / END OF LIFE SERVICES



**And future
activities and
applications, which
would leverage
technology, norms,
and standards**

Chandah Satellite Inspectors

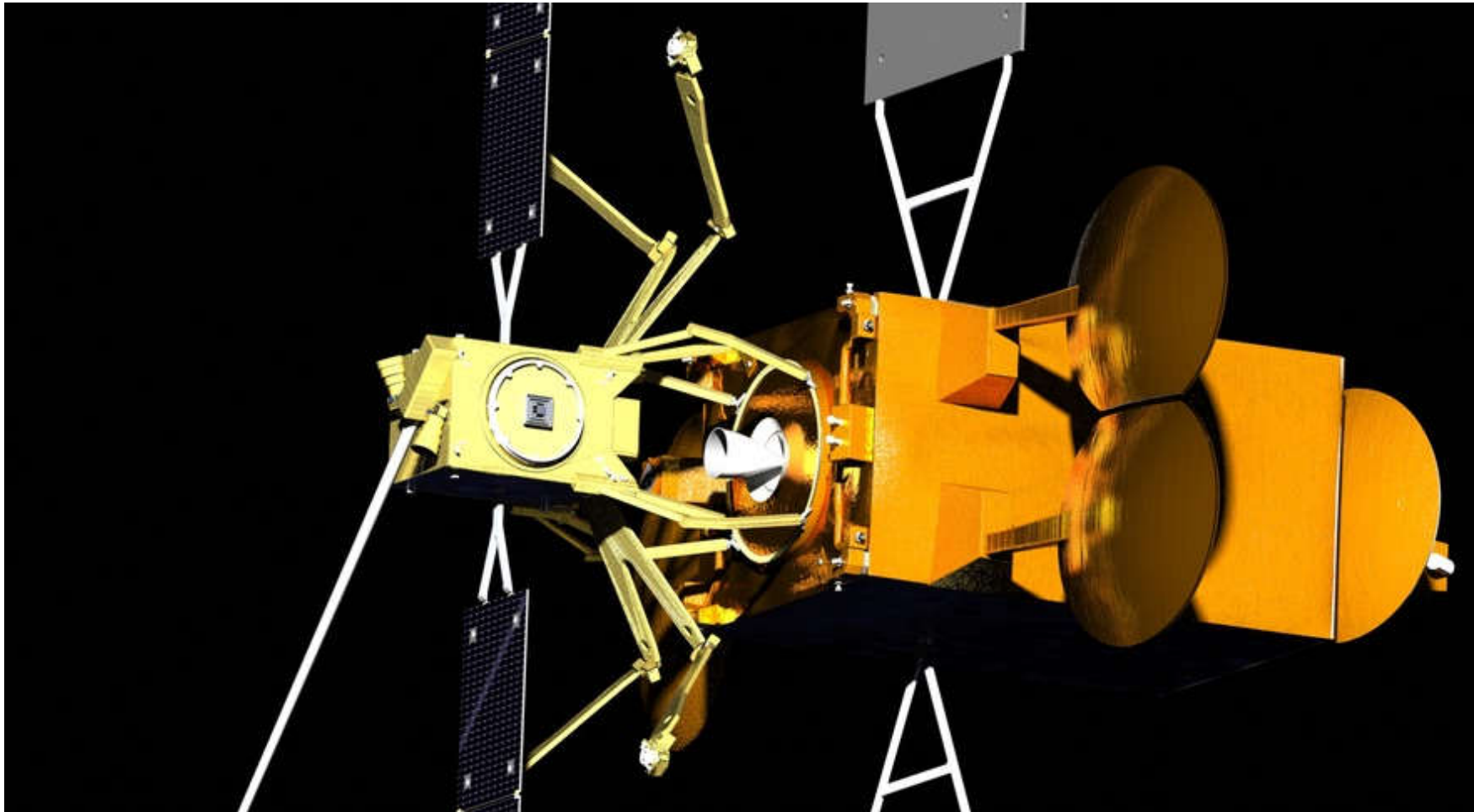


Credit: Chandah Space Technologies



Promoting Cooperative Solutions for Space Sustainability

Effective Space Satellite Life Extension

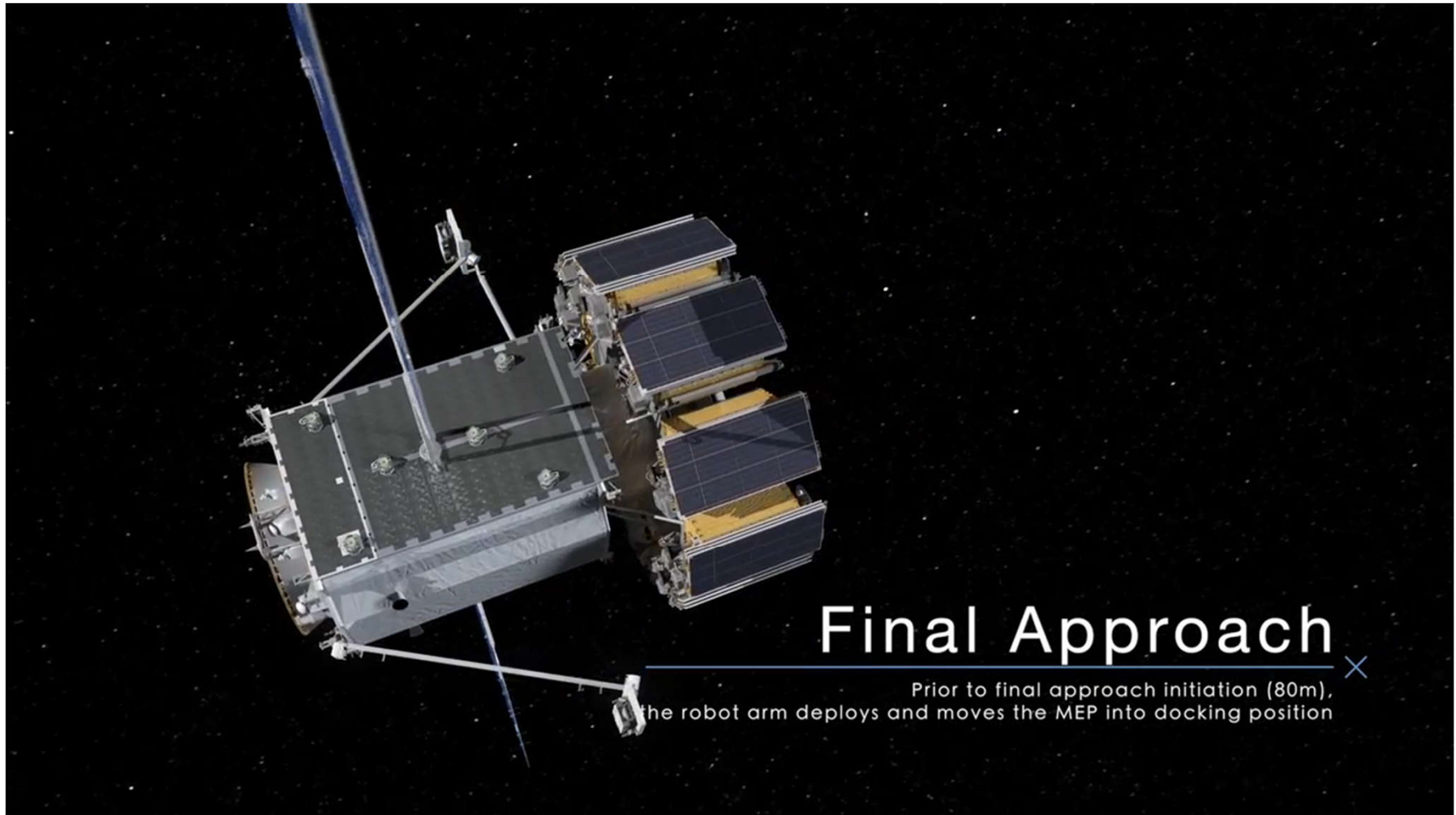


Credit: [Effective Space and SpaceNews](#)



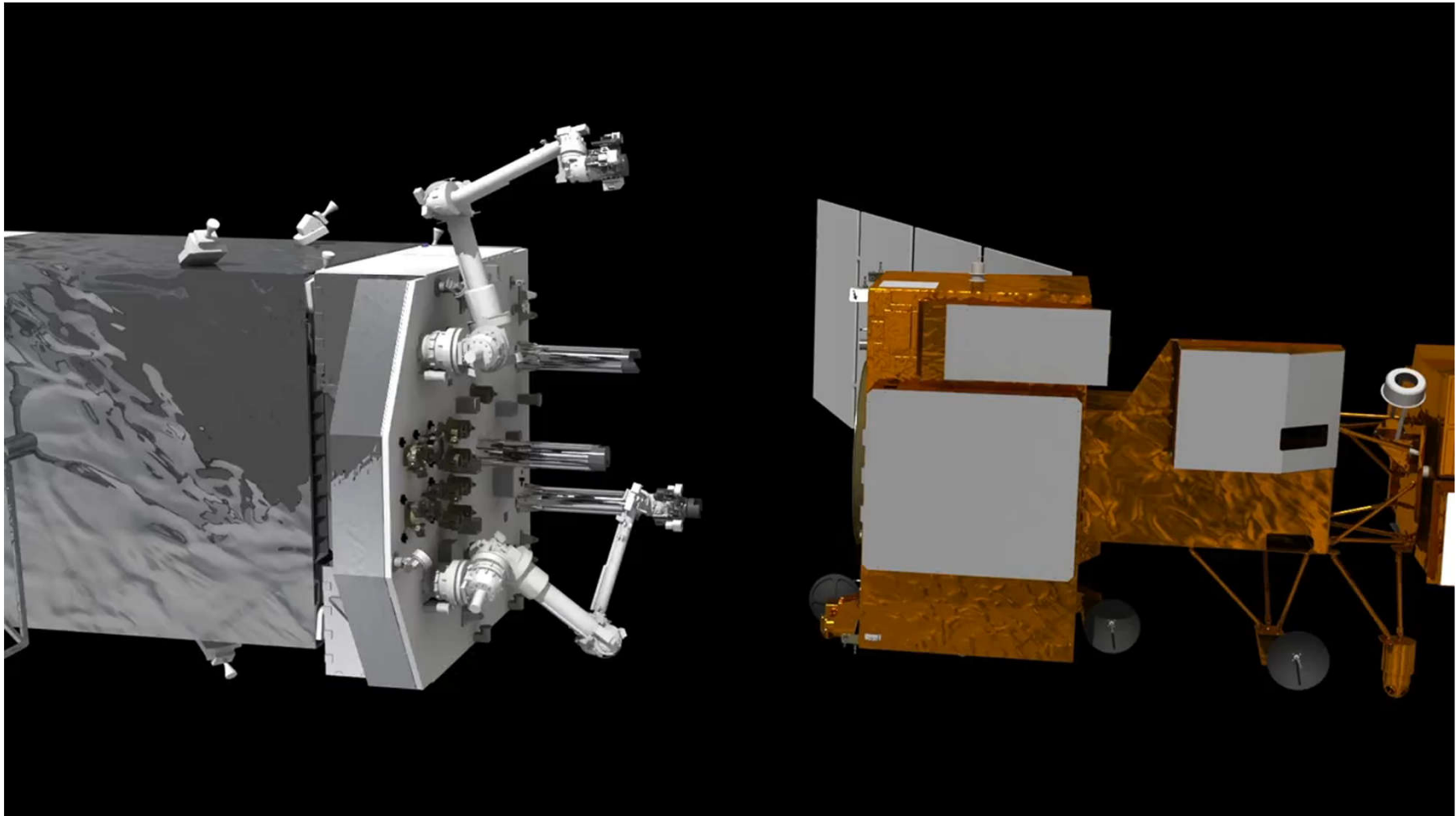
Promoting Cooperative Solutions for Space Sustainability

Northrup Grumman Life Extension Service



Credit: [Northrup Grumman](#)

SSL Satellite Refueling



Credit: [NASA Goddard](#)



Promoting Cooperative Solutions for Space Sustainability

iBoss Modular Satellite Assembly



Modular iBOSS building block (iBLOCK)

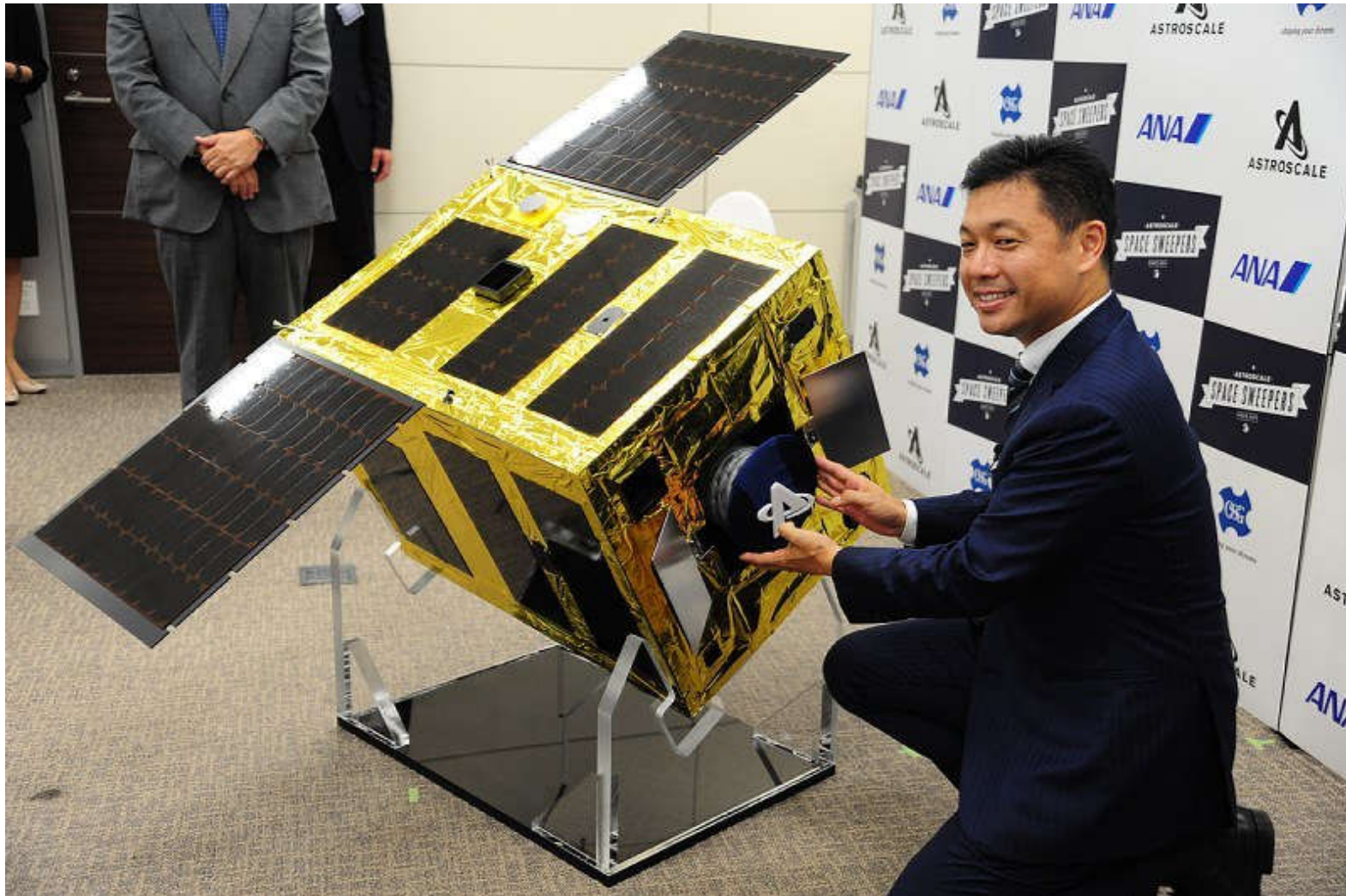


Multifunctional intelligent Space System Interface (iSSI)



Credit: iBOSS GmbH

Astroscale Debris Removal



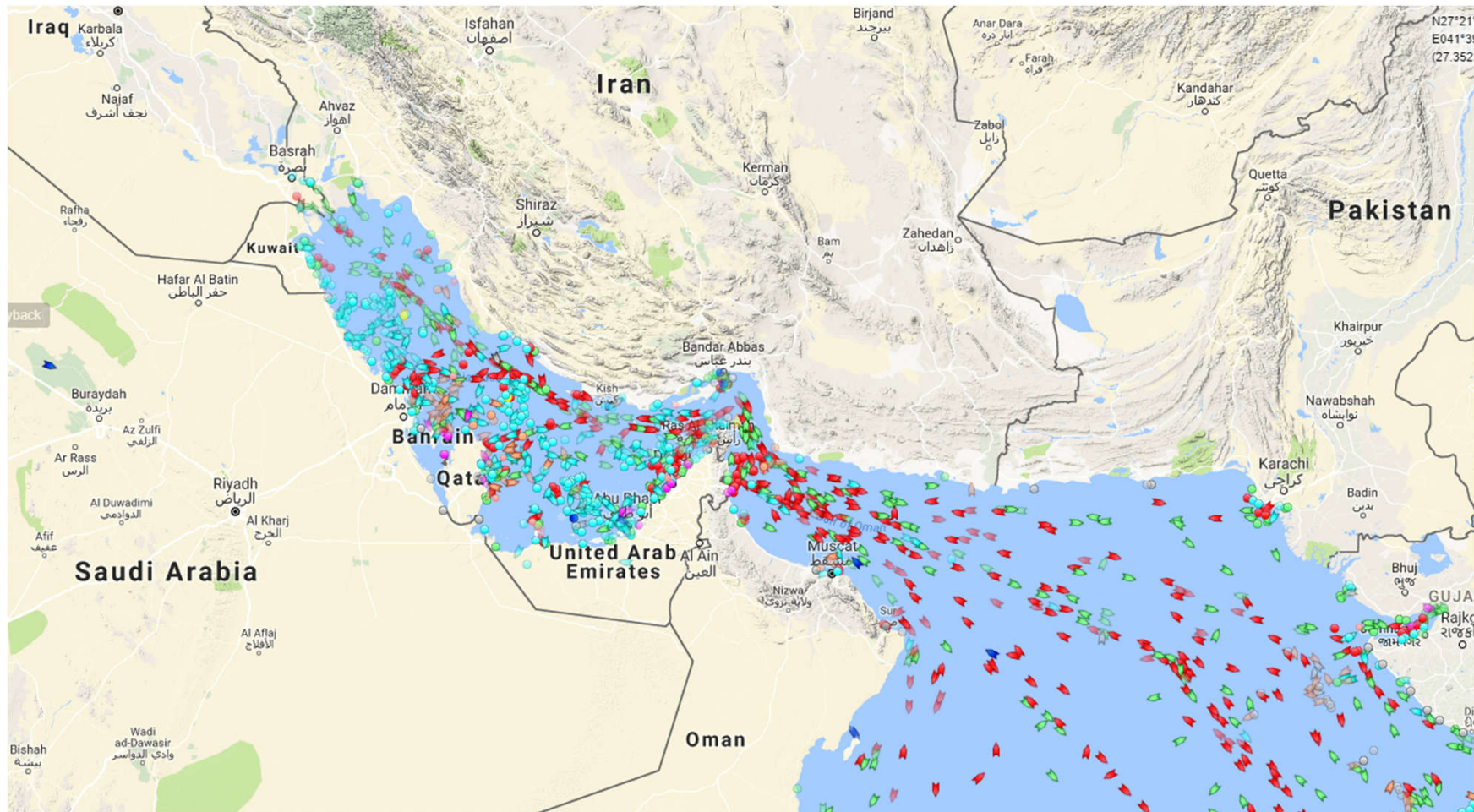
Credit: [Mainichi](#)



Promoting Cooperative Solutions for Space Sustainability

NATIONAL SECURITY IMPLICATIONS

The future of space...



Credit: MaritimeTraffic.com



Promoting Cooperative Solutions for Space Sustainability

... and the fog of war

THE USS VINCENNES AND A DEADLY MISTAKE

By **Molly Moore**

July 4, 1988

A \$1 billion Aegis guided-missile cruiser, considered the most sophisticated combat ship in the world, yesterday shot down a large Iranian passenger airplane that was apparently mistaken for a small F14 fighter jet.

The apparent mistake cost an estimated 290 civilian lives, according to the Iranian government, and has raised questions about the capabilities of the high-technology combat ship that was intended to revolutionize the Navy's ability to protect its fleet.

In the heat of a skirmish with Iranian gunboats, the sophisticated radar system that is supposed to be able to identify hundreds of potential targets simultaneously indicated to the ship's operators that the approaching Iran Air A300 Airbus was an attacking F14 fighter, U.S. officials said.

Minutes later, with the airliner nine miles from the ship and closing, the USS Vincennes fired two Standard surface-to-air missiles. The Vincennes crew, hampered by the gulf's hazy summer skies, did not see the commercial plane until it exploded, officials said.

Credit: [The Washington Post](#)



Promoting Cooperative Solutions for Space Sustainability

Luch/Olymp-K

From Russia, Unofficial Assurance about Intent of Lurking Luch Satellite

by Mike Gruss — October 20, 2015

The Russian satellite, alternatively known as Luch or Olymp, launched in September 2014 and seven months later moved to a position directly between the Intelsat 7 and Intelsat 901 satellites, which are located within half a degree of one another in geostationary orbit 36,000 kilometers above the equator.

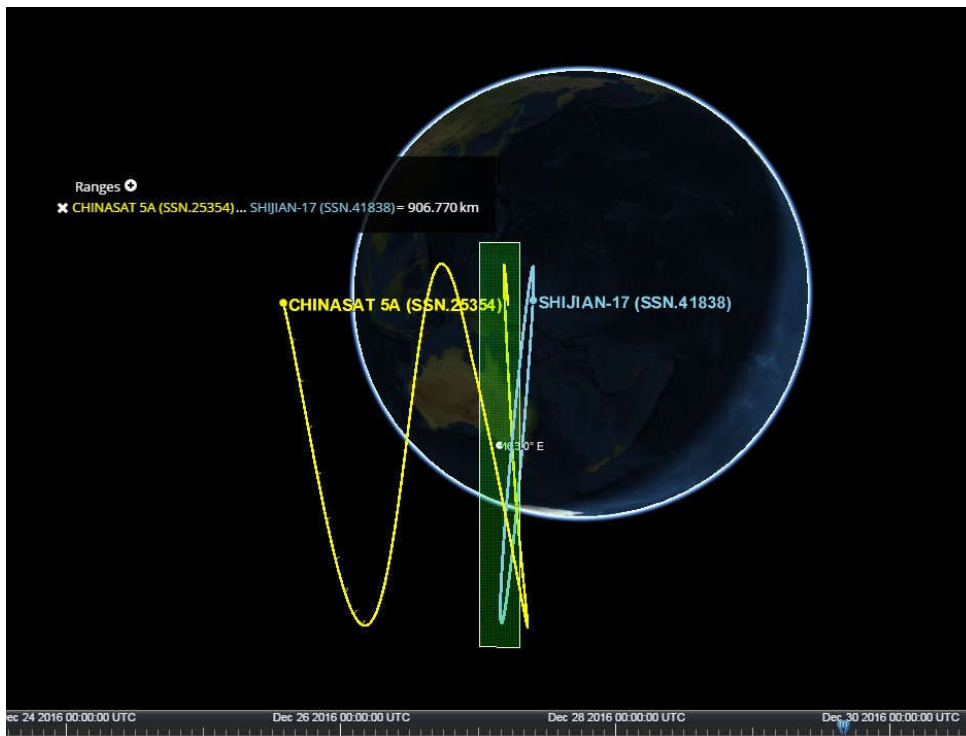
In late September, the satellite moved again, according to an analysis published Oct. 5 by Brian Weeden, technical adviser at the Secure World Foundation.

The satellite has now settled at 24.4 degrees west longitude, right next to the Intelsat 905 satellite at 24.5 degrees west, according to information available on the space tracking website n2yo.com, which republishes U.S. Defense Department data.

Moiseyev said the Luch “is simply a relay satellite, sending signals from spacecraft to Earth, for example from the International Space Station — we have communications problems there — and from one satellite to another.”

“In no way can it be an ‘aggressor,’” he told the state news agency. “Any satellite can make some clumsy maneuvers, but collisions are extremely rare.”

Credit: [SpaceNews](#)



Date(s)	Event
3 -11 Nov 2016	Launch, initial GEO drift
12 Nov 2016	Rendezvous with Chinasat 5A (163 deg E)
13 Nov – 28 Dec 2016	Proximity Operations with Chinasat 5A
25 Apr – 19 June 2017	Relocated to 125 deg E
20 June – 29 Sep 2017	Parked next to Chinasat 6A
29 Sep – 8 Oct 2017	Relocated to 118 deg E
11 Jan 2018	Initiated Eastward drift
10 Feb	Rendezvous with Chinasat-20
11 Feb – 16 Mar	Proximity operations with Chinasat-20. Distance between objects generally under 10 km, several times within 1 km
17 Mar – 14 April	Relocated to 115 deg E

Credit: [AGI, Breaking Defense](#)



Credit: [The Associated Press](#)

RULES OF ENGAGEMENT

ALL ENEMY MILITARY PERSONNEL AND VEHICLES TRANSPORTING THE ENEMY OR THEIR SUPPLIES MAY BE ENGAGED SUBJECT TO THE FOLLOWING RESTRICTIONS:

- A. WHEN POSSIBLE, THE ENEMY WILL BE WARNED FIRST AND ASKED TO SURRENDER.
- B. ARMED FORCE IS THE LAST RESORT.
- C. ARMED CIVILIANS WILL BE ENGAGED ONLY IN SELF-DEFENSE.
- D. CIVILIAN AIRCRAFT WILL NOT BE ENGAGED WITHOUT APPROVAL FROM DIVISION LEVEL EXCEPT IN SELF-DEFENSE.
- E. CIVILIANS SHOULD NOT BE HARMED UNLESS DOING SO IS NECESSARY TO SAVE U.S. LIVES, IF POSSIBLE, CIVILIANS SHOULD BE EVACUATED BEFORE ANY U.S. ATTACK.
- F. IF CIVILIANS ARE IN THE AREA, ARTILLERY, MORTARS, ARMED HELICOPTERS, AC-130S, TUBE-LAUNCHED OR ROCKET-LAUNCHED WEAPONS, AND TANK MAIN GUNS SHOULD NOT BE USED AGAINST KNOWN OR SUSPECTED TARGETS WITHOUT THE PERMISSION OF A GROUND MANEUVER COMMANDER, LTC OR HIGHER.
- G. IF CIVILIANS ARE IN THE AREA, ALL AIR ATTACKS MUST BE CONTROLLED BY A FAC OR FO.
- H. IF CIVILIANS ARE IN THE AREA, CLOSE AIR SUPPORT, WHITE PHOSPHORUS WEAPONS AND INCENDIARY WEAPONS ARE PROHIBITED WITHOUT APPROVAL FROM DIVISION LEVEL.
- I. IF CIVILIANS ARE IN THE AREA, INFANTRY SHOOTS ONLY AT KNOWN ENEMY LOCATIONS.
- J. PUBLIC WORKS SUCH AS POWER STATIONS, WATER TREATMENT PLANTS, DAMS, AND OTHER UTILITIES MAY NOT BE ENGAGED WITHOUT APPROVAL FROM DIVISION LEVEL.
- K. HOSPITALS, CHURCHES, SHRINES, SCHOOLS, MUSEUMS, AND OTHER HISTORICAL OR CULTURAL SITES WILL BE ENGAGED ONLY IN SELF-DEFENSE AGAINST FIRE FROM THESE LOCATIONS.
- L. ALL INDIRECT FIRE AND AIR ATTACKS MUST BE OBSERVED.
- M. PILOTS MUST BE BRIEFED FOR EACH MISSION AS TO THE LOCATION OF CIVILIANS AND FRIENDLY FORCES.

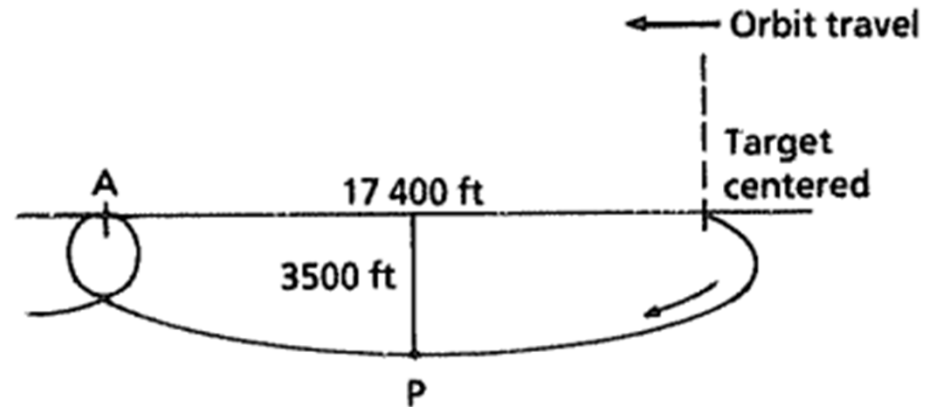
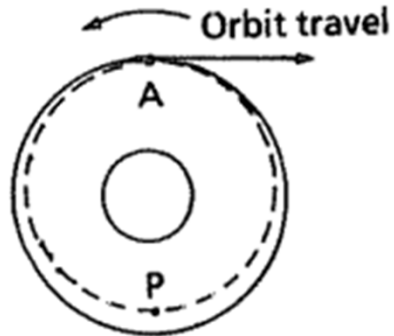
Figure C-1. Example of rules of engagement.

Credit: [GlobalSecurity.org](#)

But remember space is different

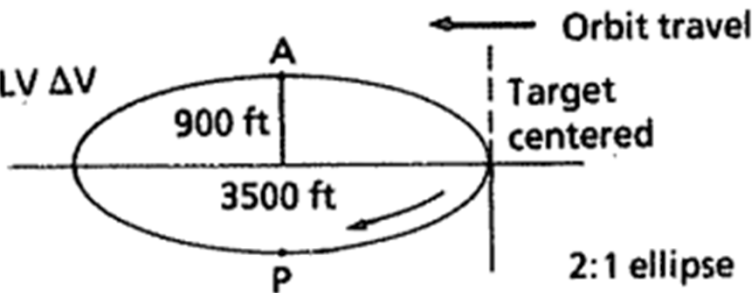
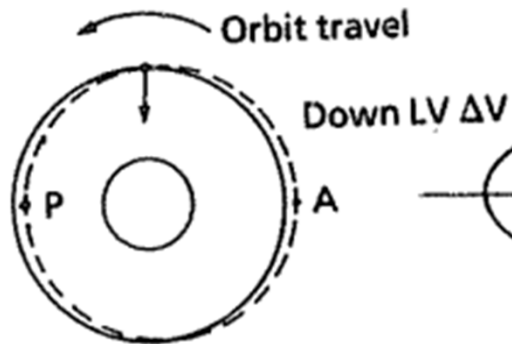
II.

Retrograde
 $\Delta V = -1.0 \text{ ft/s}$



III.

Radially inward
 $\Delta V = 1.0 \text{ ft/s}$



Credit: NASA Rendezvous and Proximity Operations Handbook (1985)



Promoting Cooperative Solutions for Space Sustainability

WAY FORWARD

The Woomera Manual



A Manual on the International Law of Military Space Operations



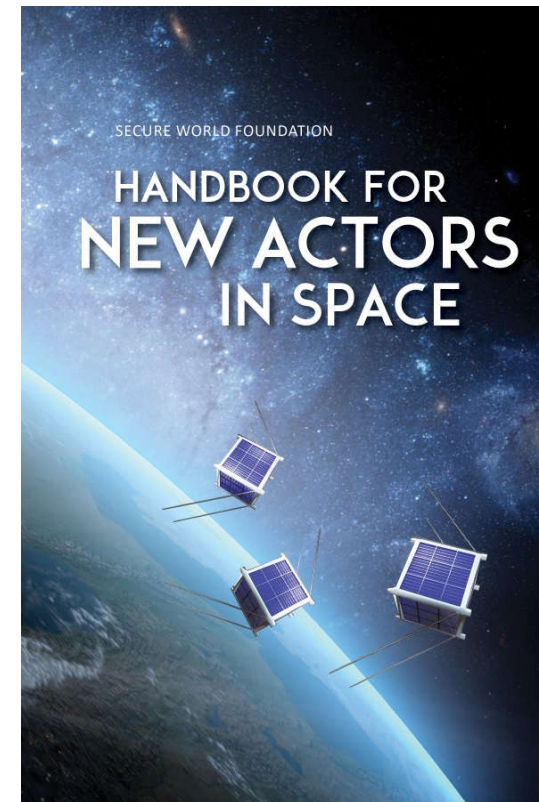
Manual on International
Law Applicable to Military
Uses of Outer Space



Promoting Cooperative Solutions for Space Sustainability

SWF Handbook for New Actors in Space

- **Goal:** Create a publication that provides an overview fundamental principles, laws, norms, and best practices for safe, predictable, and responsible activities in space
- **Two specific audiences:**
 - Countries developing space programs and/or having to oversee and regulate their first satellites
 - Universities and start-up companies that are developing/operating satellites



www.swfound.org/handbook



Promoting Cooperative Solutions for Space Sustainability



CONFERS

*Fostering Standards
to Enable Commercial
Satellite Servicing*

Satelliteconfers.org

Incidents in Space Agreement?



Credit: [Wikimedia Foundation](#)

Agreement Between the Government of The United States of America and the Government of The Union of Soviet Socialist Republics on the Prevention of Incidents On and Over the High Seas

BUREAU OF INTERNATIONAL SECURITY AND NONPROLIFERATION

Signed at Moscow May 25, 1972
Entered into force May 25, 1972

[Narrative](#)
[Treaty Text](#)
[Protocol](#)

Space arms control?



Credit: [United States Mission to Geneva](#)



Promoting Cooperative Solutions for Space Sustainability

U.S. Leadership?

“As with past frontiers, it is those who show up, not those who stay home, who create the rules and establish the norms in new areas of human activity.”

Dr. Scott Pace, Executive Secretary, National Space Council
Keynote [speech](#) to the 2017 Galloway Space Law Symposium



Promoting Cooperative Solutions for Space Sustainability

THANK YOU

QUESTIONS?

bweeden@swfound.org



Promoting Cooperative Solutions for Space Sustainability

Human-generated space objects

Active Satellites

Total number of operating satellites: 1,886			
United States: 859	Russia: 146	China: 250	Other: 631
LEO: 1,186	MEO: 112	Elliptical: 40	GEO: 548

Current through 4/30/2018
Data from the [Union of Concerned Scientists](#)

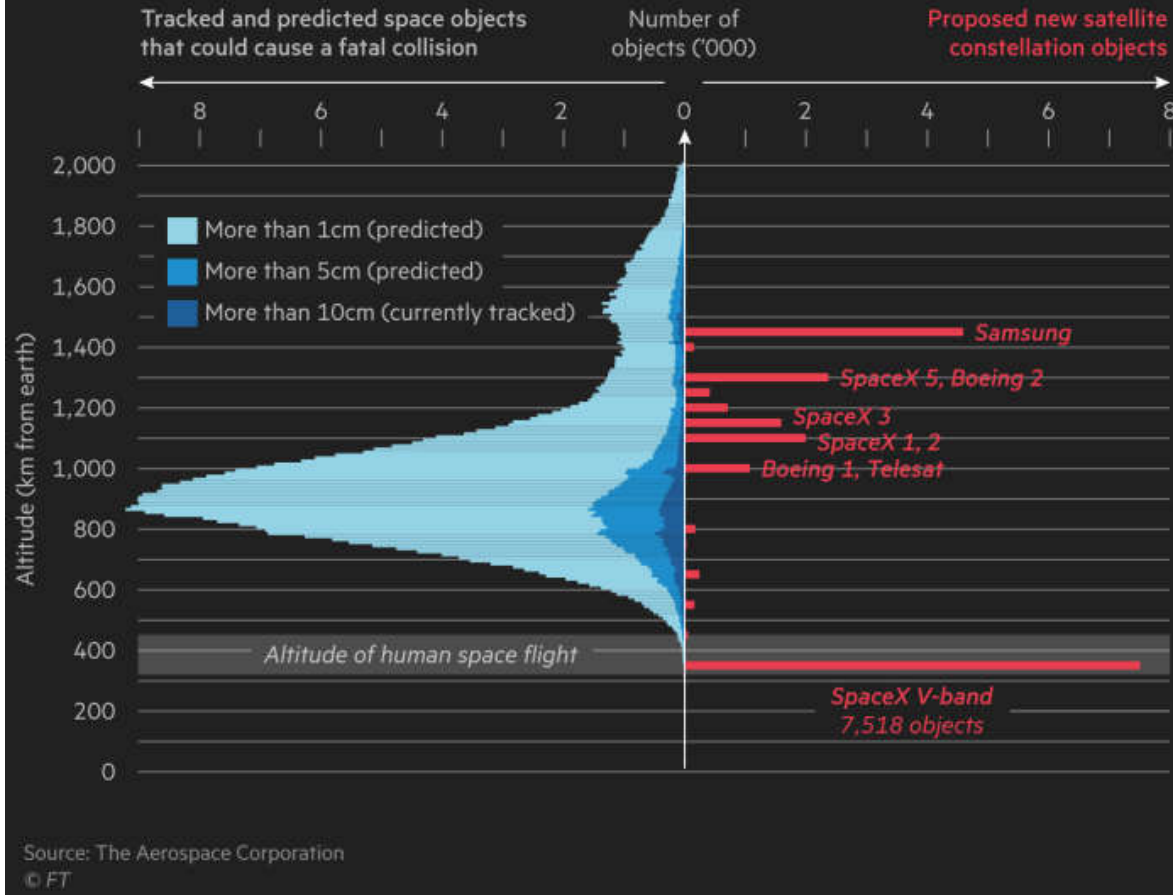
Space Debris

Larger than 10 cm	~20,000	Sources of new debris
Between 1 and 10 cm	~500,000	Can cause major damage
Smaller than 1 cm	Many millions	Can cause minor damage

Data compiled from U.S. Strategic Command, NASA, and ESA.

Current and future of space debris?

Proposed satellite constellations will add thousands of new objects to low earth orbit



Credit: [The Aerospace Corporation and The Financial Times](#)