National Aeronautics and Space Administration



# SMALL SPACECRAFT PROPULSION & INSPECTION CAPABILITY (SSPICY)

Elwood F. Agasid Deputy Program Manager Small Spacecraft & Distributed Systems

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www.nasa.gov

# AGENDA

- Global Increase in the Use of Space
- Orbital Debris Remediation & NASA
- SSPICY Mission Concept & Demonstration
- Development & Mission Timelines





# CONGESTED SPACE

U.S. Space Surveillance Network currently tracks about 44,000 objects in space.

- Active satellites and space debris 10 cm in diameter or larger are tracked.
- A large portion of the objects are considered space debris, e.g., spent rocket bodies and collision fragments.
- Some research cites that in 2018 there were ~ 170 million space objects considered space junk.
- Conjunction risks are increasing.





# KESSLER SYNDROME

Spent rockets, satellites and other space trash have accumulated in orbit increasing the likelihood of collision with other debris. Unfortunately, collisions create more debris creating a runaway chain reaction of collisions and more debris known as the Kessler Syndrome after the man who first proposed the issue, Donald Kessler. It is also known as collisional cascading.







## Space is Getting Crowded!

# Contributing Factors

- Increased number of countries and businesses interested in space
- Space-as-a-Service businesses communication and other services, Earth observation, weather, etc. – such services are estimated at 10,000+ companies
- Increased number of space launch providers and increased frequency of launches
  - ~ 258 launches in 2024
    - SpaceX 138
    - Launches from KSC & Cape Canaveral 93

# Access to Space Has Improved

- Based on current trends, there are expected to be over 480 orbital launches and 43,000 active satellites by 2032.
- NASA's VADR (Venture-Class Acquisition of Dedicated and Rideshare) contract utilizes the following launch providers.



- ABL Space Systems of El Segundo, California
- Arrow Science and Technology LLC of Webster, Texas
- Astra Space Inc. of Alameda, California
- Blue Origin Florida, LLC of Merritt Island, Florida
- Firefly Aerospace, Inc. of Cedar Park, Texas
- Impulse Space Inc. of Redondo Beach, California
- L2 Solutions DBA SEOPS, LLC of Houston, Texas
- Momentus Space LLC of San Jose, California
- Northrop Grumman Systems Corporation of Chandler, Arizona
- Phantom Space Corporation of Tucson, Arizona
- Relativity Space Inc. of Long Beach, California
- Rocket Lab USA Inc. of Long Beach, California
- SpaceX (Space Exploration Technologies Corp.) of Hawthorne, California
- United Launch Services LLC of Centennial, Colorado





### RECENT LAUNCH STATISTICS

In 2023, 2938 spacecraft launched. Of these:

68% had mass less than 600 kg

27% had mass less than 200 kg

#### Small Spacecraft systems virtual institute (\$3VI) Small Spacecraft Technology State-of-the-Art Report

2024 Edition



Much of SmallSat and CubeSat constellation expansion is attributable to operators such as SpaceX, OneWeb, and Planet.

Approximately 660 CubeSats in LEO represent about 30% of operational objects in space.



Statistics Credit:

### SATELLITE & DEBRIS BOX SCORE



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# **Orbital Debris**

The U.S. Space Forces - Space (S4S)

maneuvered to a medium Earth orbit (MEO)

disposal orbit. At the time of the breakup, the

apogee and perigee altitudes of this Centaur

were approximately 34,949 km and 7622 km,

respectively, with an inclination of 9.3 degrees.

Although more than 10 fragments were initial-

ly identified, none had been cataloged by the

S4S as of 13 January 2025. The breakups of two

website over the past quarter.

**Quarterly News** 

Volume 29, Issue 1 February 2025

#### **Two New On-orbit Fragmentations**

Inside...

**Radar Measurements** of the Orbital Debris Environment from HUSIR and Goldstone: 2023 Meeting Reports Monthly Number of **Objects in Earth Orbit by Object Type** Upcoming Meetings Space Missions and Satellite Box Score

identified two new on-orbit fragmentations and bits were reported by the S4S in August 2018 made the announcements via the space-track (2014-055B, 109 cataloged fragments, see ODQN vol. 22, issue 4, November 2018, p. 2 The first breakup was an Atlas V Centaur and ODQN vol. 23, issues 1&2, May 2019, p. 2) (International Designator 2018-022B, U.S. Sat- and April 2019 (2018-079B, 214 cataloged fragellite Catalog Number 43227) on 6 September ments, see ODQN vol. 23, issue 3, August 2019, 2024. The 2.2-metric-ton upper stage was asso- pp. 1-2). It is likely that the cause of the breakciated with the deployment of National Oceanic ups was related to passivation. and Atmospheric Administration (NOAA) Geo-The second breakup was associated stationary Operational Environmental Satellite with Intelsat 33E (International Designator (GOES) 17 on 1 March 2018. After releasing the 2016-053B, U.S. Satellite Catalog Number GOES-17 spacecraft, the Centaur successfully 41748) in geosynchronous orbit (GEO) at

approximately 04:30 UTC on 19 October 2024. At the time of the breakup, the apogee and perigee altitudes of Intelsat 33E were 35,797 km and 35,773 km, respectively, with an inclination of 0.037 degree. Intelsat 33E was launched in 2016 and was still operational when the breakup occurred. The S4S had cataloged 18 fragments from the breakup as of 13 January 2025.

other Centaurs with similar MEO disposal or-

#### SATELLITE BOX SCORE (as of 4 December 2024, cataloged by the

U.S. SPACE SURVEILLANCE NETWORK)

Country/ Organization	Spacecraft*	Spent Rocket Bodies & Other Cataloged Debris	Total
PRC	737	4810	5547
CIS	1558	5321	6879
ESA	101	27	128
FRANCE	100	531	631
INDIA	106	85	191
JAPAN	206	100	306
υκ	717	1	718
USA	8709	4883	13592
OTHER	1139	97	1236
Total	13373	15855	29228

PROJECT REVIEW

Resource: https://orbitaldebris.jsc.nasa.gov/quarterly-news/



### NASA Solicitation for Advanced Propulsion Demonstration and Inspection Services

- NASA received a congressional mandate to investigate technologies and services to address the need for orbital debris assessment and removal, in addition to demonstrating advanced propulsion. In response, NASA issued a solicitation to companies developing technologies and services that address these areas of interest.
- Four companies responded to the solicitation and upon assessment, a contract was awarded to Starfish Space, LLC of Seattle, Washington to demonstrate the desired capabilities and services.

**Credit: Starfish Space** 



# NASA SSPICY Mission SPACE SPACE

By 2026, Starfish Space will build and launch an Otter vehicle that will inspect up to four US-originated, uncontrolled RSOs in LEO.

- → Inspection: spend 30 days per RSO gathering spin rate, spin axes, orbital elements, surface condition, and satellite geometry which will be sufficient for a subsequent Starfish Space active debris removal (ADR) missions
- → Schedule and Cost: the mission will cost NASA under \$15M over a performance period of 34 months, starting in August 2024. Launch on SpaceX's Transporter mission in Q4 2026. All RSOs inspected within 20 months of launch.
- → Technology: Starfish Space will perform the mission with highly efficient electric propulsion, utilize its autonomous navigation systems, advance three systems to TRL 9, specifically Navigation (CETACEAN), Guidance and Control (CEPHALOPOD), and robotic boom (Manta).

# Mission Specifications: Starfish Payloads





**CEPHALOPOD** 



Autonomous **Guidance Software** 

Enables trusted. fuel-efficient RPOD and vehicle





**Autonomous Navigation** Software

Using computer vision to understand other satellites



Nautilus



Satellite Docking Mechanism

**Can dock with** satellites already in space

Completed CDR on November 22nd, 2024



Manta



**Articulating Boom for** Thrust

**Allows Otter to service 10x larger satellites** 

**Completed CDR on** November 12, 2024

### **Otter Overview**





### Spacecraft Overview

- Small, **ESPA-class vehicle** capable of missions in both **LEO** and **GEO**
- Cutting-edge, modular flight software for **autonomous RPOD**
- **Capture** mechanism capable of docking with unconfigured, **unprepared surfaces**
- Large servicing capacity with 5,000+ m/s of ΔV

#### **Services in LEO**

- Debris Inspection
- Debris Disposal
- Altitude Boost
- Orbital Adjustment

### **SSPICY Otter: Technical Specifications**



<b>Otter Characteristics</b>	Appx. Specification			
Fully Loaded Mass	330 kg			
Delta-V (undocked)	5450 m/s			
Power Generation (EOL)	1240 W			
Thrust (EP via Safran's PPS X00)	60 mN			
Dimensions	See diagram			
Docking Space	<20 cm			
Docking Time	~1 day			
Servicing Design Life (LEO)	5+ years			
GNC Sensors: Inertial	IMU, star tracker, GPS			
GNC Sensors: Relative	4 cameras, including stereo pair and MAC			
Starfish Payload	Manta robotic boom, Nautilus capture			
Communication	S-band uplink, X-band downlink			



#### **Courtesy of Starfish Space**

7.77 m

### **Otter Mission ConOps**



After inspection of first object, repeat steps 3 - 5 for each subsequent object





### Small Spacecraft Propulsion and Inspection Capability (SSPICY)

Demonstration of electric propulsion and other advanced capabilities to perform rendezvous, proximity operations, inspection, and characterization of US-owned non-operational spacecraft and debris in low-Earth orbit.

The SSPICY demonstration mission is funded and managed by NASA's Small Spacecraft Technology program. The award is enabled by NASA's Small Business Innovation Research program. Both programs are part of NASA's Space Technology Mission Directorate. Starfish Space of Tukwila, Washington, leads the design, development, and operation of the SSPICY technology demonstration.

Animation Credit: NASA and Starfish Space

### SSPICY DEVELOPMENT TIMELINE



	118	<b>2025</b> 239	421	428 20	<mark>)26</mark> 573	695	819 865 2027	1061
20/24	12/16/24	4/16/2025	10/2025	12/2025	3/2026	7/2026	11/16/2026 Q4/2026	6/16/2027
ЛР	MCR	MDR	Delivered	Deliv.	Deliv.	Complete	FRR Launch	Complete
			Payloads	Payloads	Payloads	Testing		Inspection
KO 9/20/2	) 24		PIL	EM	FM	Satellite		First
Proje	ect							

#### **Acronym Definitions**

- ATP Authority to Proceed
- EM Engineering Model
- FM Flight Model
- FRR Flight Readiness Review
- KO Kick Off
- MCR Mission Concept Review
- MDR Mission Design Review
- PIL Processor-in-the-Loop



### SSPICY MISSION TIMELINE MONTHS FROM LAUNCH



