

## Publications

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- Pearson, J., J. Carroll, E. Levin, J. Oldson, and P. Hausgen, "Overview of the ElectroDynamic Delivery Express (EDDE)," AIAA 2003-4790, 39<sup>th</sup> Joint Propulsion Conference, July, 2003.
- Dougal, R., J. A. Carroll, and S. Liu, "High-Voltage Power Switching for a Conducting Tether," AIAA 2004-5716, 2<sup>nd</sup> International Energy Conversion Engineering Conference, Aug. 2004.
- Levin, E. and J. Carroll, "Apparatus for Observing and Stabilizing Electrodynamic Tethers," U.S. Patent 6,755,377, June 2004.
- Levin, E. and J. Carroll, "Method for Observing and Stabilizing Electrodynamic Tethers," U.S. Patent 6,758,433, July 2004.
- Levin, E. and J. Carroll, "Method and Apparatus for Propulsion and Power Generation Using Spinning Electrodynamic Tethers," US Patent 6,942,186, September 2005.
- Pearson, J., J. A. Carroll, E. M. Levin, and J. C. Oldson, *Autonomous Orbit Transfer Vehicle (AOTV)*, AFRL Report AFRL-VS-PS-TR-2005-1216, October 2005.
- Levin, E. M., J. Pearson, and J. C. Oldson, *Dynamics Simulation Model for Space Tethers*, NASA Contractor Report NASA/CR-2006-214432, June 2006.
- Levin, E. M., Dynamic Analysis of Space Tether Missions, Vol. 126 in *Advances in the Astronautical Sciences*, AAS, 2007.
- Pearson, J., E. Levin, J. Carroll, and J. Oldson, "LEO Mobility Vehicle for Space Situational Awareness," AIAA-2008-7689, Space 2008 Conference, San Diego, September 2008.

# EDDE

**ElectroDynamic Debris Eliminator  
For Active Debris Removal**

NASA-DARPA International Conference  
on Orbital Debris Removal  
8-10 December 2009

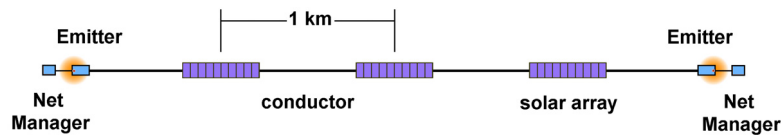
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## Low Earth Orbit Cleanup

- Remove all 2465 objects over 2 kg from LEO
  - Reduce future collision-generated LEO debris by 99%
  - Prevent “debris runaway” from future collisions
- Controlled de-boost
  - Actively avoid all tracked satellites and debris
  - Allow for targeted re-entry if needed
- EDDE vehicles can eliminate almost all future collision-generated debris from LEO in 7 years

## The EDDE Vehicle



- Each vehicle is only 100 kg, and packs into 24”x24”x12”
- Each ESPA secondary payload slot can carry 2 EDDEs

## EDDE Enabling Concepts

- Orbit transfers use solar power & electrodynamic thrust
- Rotation gives stability and high maneuverability
  - 3 patents awarded for vehicle methods & apparatus
- Debris is captured in large lightweight nets
- Supported by data from previous space tether flights
  - SEDS-1, PMG, SEDS-2, and TiPS
  - All tethers and deployers by J. Carroll of TAI

## EDDE Performance

- 100’s of km per day altitude changes
- Over 1 deg per day orbital plane changes
- No propellant required

## Concept of Operations

- EDDE is piggyback launched to LEO and deploys
- Transfers orbit for precise rendezvous with target
- Approaches target from sunlit side using binocular vision and positive control of EDDE position and attitude
- Captures debris with lightweight net, using real-time video under ground control
- Drags object below ISS for quick re-entry, actively avoids other objects, and re-boots to next target

## EDDE Advantage

- The job: remove all 2465 objects over 2 kg from LEO (2166 metric tons total)

Propulsion System	Isp, sec	Typical Number of Vehicles	Estimated Total Mass in Orbit
Bipropellant	300	900	800 tons
NH <sub>3</sub> Arcjet	800	300	250 tons
Ion Thruster	3000	120	65 tons
VASIMR	10000	30	25 tons
<b>EDDE</b>	—	<b>12</b>	<b>1 ton</b>

- 12 EDDEs can do the job in 7 years