

IN-SPACE ADVANCED PROPULSION 2030

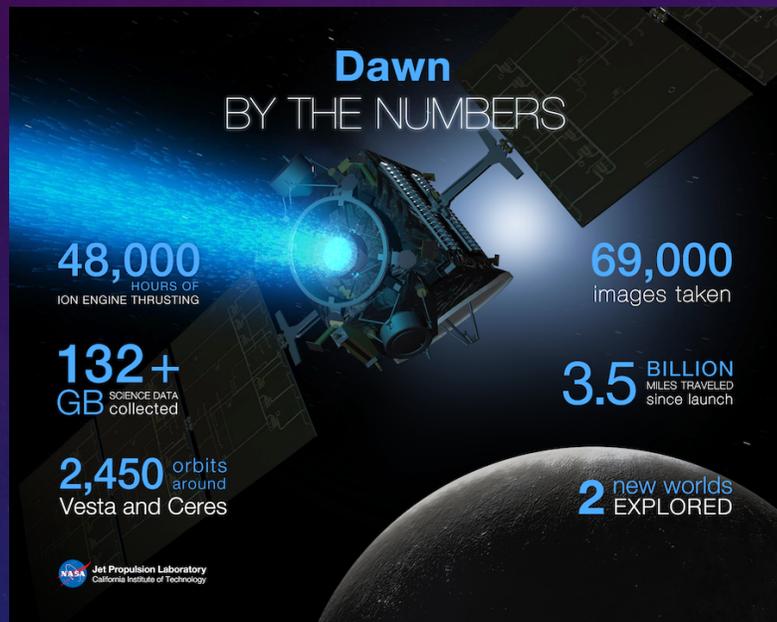
Lee Johnson

Jet Propulsion Laboratory

California Institute of Technology



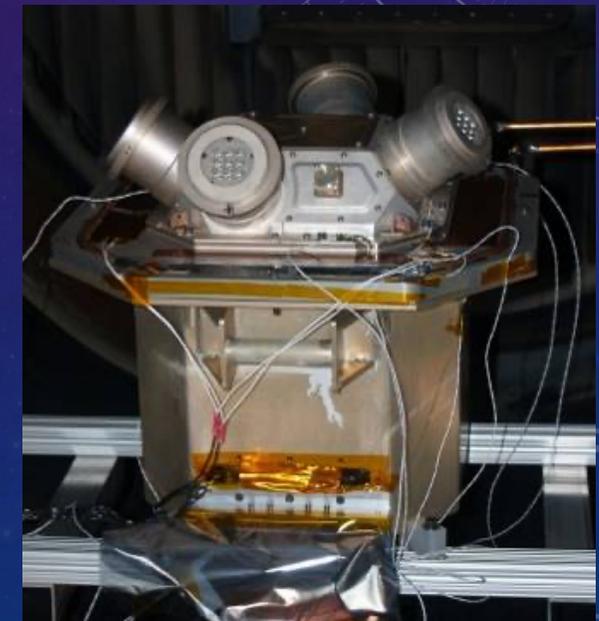
- NASA & JPL experience with electric thrusters DS1, Dawn, JIMO, AEPS/PPE, NEXT, ST-7/LISA mission + considerable research on lab thrusters/systems with associated physics modeling



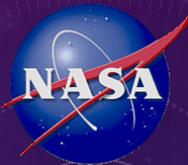
Dawn mission to Vesta and Ceres,
>11.5 km/s delta-V, now >50,000
hours



Hermes long-life 12 kW
thruster in test at GRC



ST-7 microthruster demo for LISA
gravity wave observatory



IN-SPACE PROP CHALLENGE FOR 2030

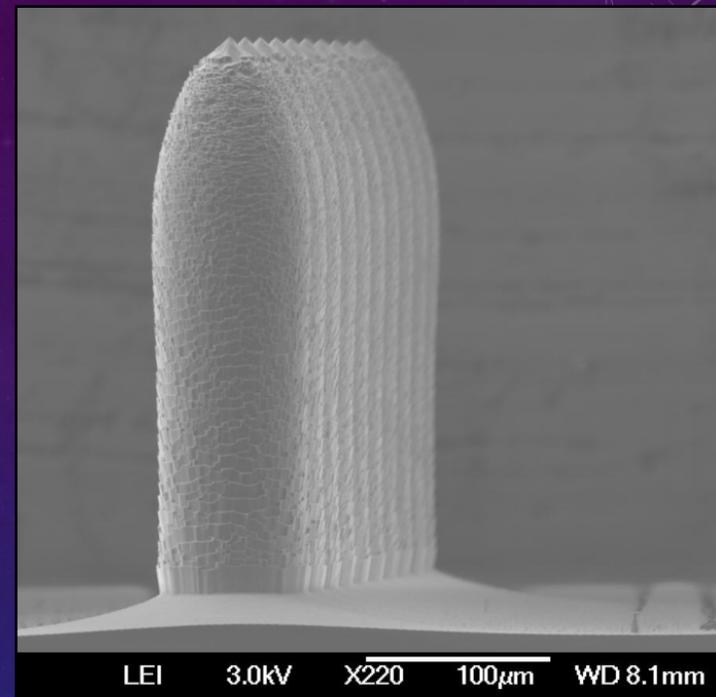
- One perspective: US technology investments have been modest both on AF and NASA sides
- Look back to look forward – typical thruster system dev/qual is a 10 year or more process
 - NSTAR gridded thruster (DS1 '92-'98 + Dawn '02-'07)
 - XR-5 Hall thruster (1998 – 2011)
- What about the private sector – venture capital or commercial *a la* SSL?
- Compare NASA deep space and/or Mars, possibly man-rated and AF GEO, transfer, maneuvering
- Not only are thrusters challenging, but so are system, power supply, interface, heritability
- Promising examples from close to home MASMI 600W long-life Hall and MEP indium micro-thruster
- Interaction with other spacecraft systems – autonomy, commanding, power, thermal
 - Should couple power/prop system optimization (direct drive).
- Challenge to break out of historical processes to enable 2030 vision of routine environment maintenance



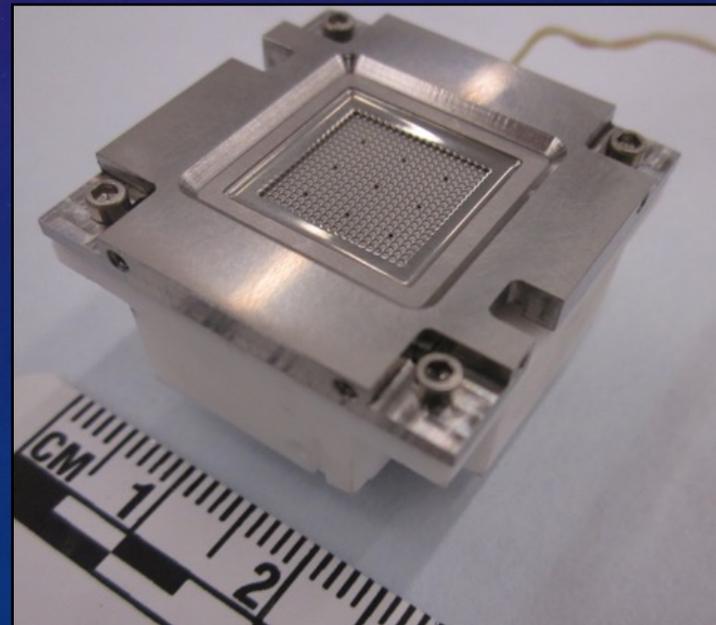
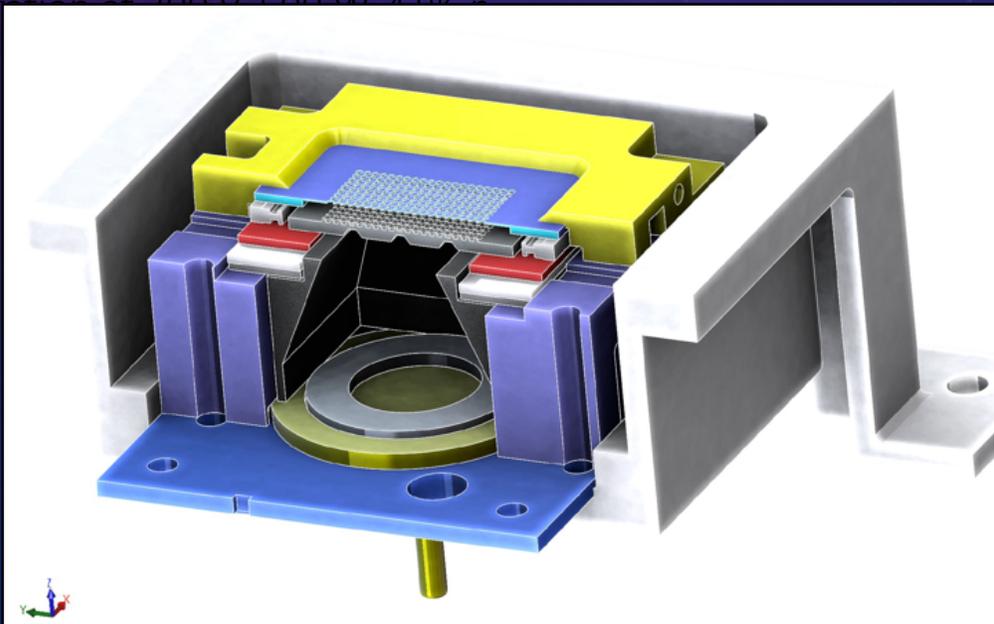
”...not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills...”

INDIUM MEP MICRO-THRUSTER

- Based on field emission ionization/accel from semiconductor-process emitter array
 - external flow driven by capillary forces
- 100 micro-newton for cubesat, moving towards 1 mN for smallsat
- 1 km/s velocity change for 3u cubesat at 100 μ N



Operation at 200 V, 500 W, 41%



MASMI HALL THRUSTER



- Magnetically Shielded Miniature (MaSMi) Hall Thruster
- Power Range: 150 – 900 W
- 40-50% total efficiency, 30-40 mN, >1,400 s
- >100 kg Xe throughput (>10 kh lifetime)
- Internally-mounted hollow cathode

