A CubeSat Compliant Interface to Enable Spacecraft Docking and Fuel Transfer

2019 CubeSat Developers Workshop
April 23-25, 2019 San Luis Obispo, CA

ORBITFAB
Gas Stations in Space

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The Single Use Paradigm

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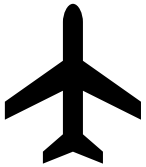
Gas Stations in Space

Rapidly
Attachable
Fuel
Transfer
Interface

750 Refills



40,000 Refills

0 Refills

What We Do

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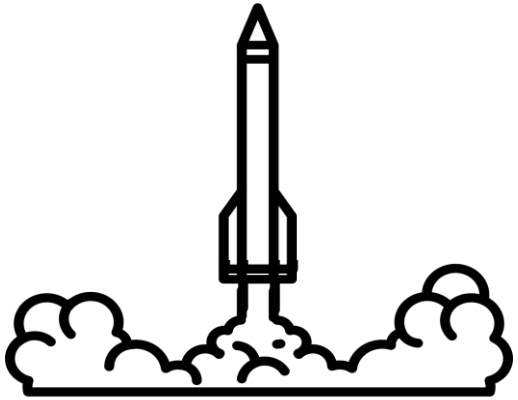

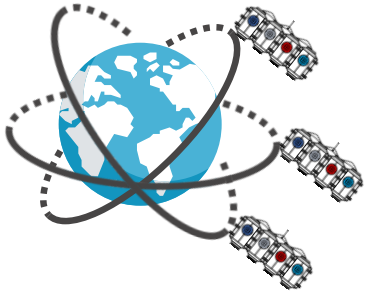

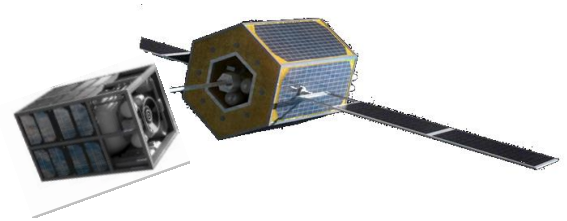

On Orbit Servicing (OOS)

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Gas Stations in Space

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Jetpack

Effective Space solutions

NORTHROP GRUMMAN

INFINITE ORBITS

Tug/ Deorbit

Astroscale

MOMENTUS SPACE

ATOMOS

ALTIUS SPACE MACHINES

ROCKET LAB

FIREFLY AEROSPACE

ULA United Launch Alliance

MOOG

Asset Monitoring

Chandah

HE Robotics

Complex Servicing

SSL

AIRBUS DEFENCE & SPACE

WEINTRAUS

CubeSats in the Quest for OOS

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Benefits

- Small size = Low cost
- Low mass = Less fuel usage
- Rapid development cycles
- Ease of adoption
- Standardized trusted launch
- Ride share
- Disaggregation

Drawbacks

- Small size
- Small fuel quantities
- Complex mechanisms difficult to scale

Timeline of Missions Leading to RAFTI

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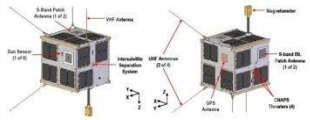
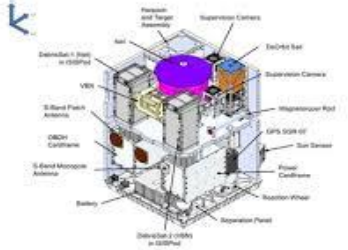
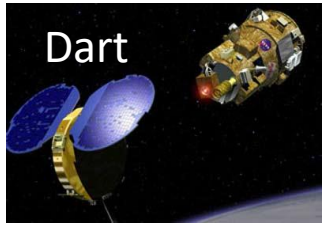
Gas Stations in Space



CANX4/5

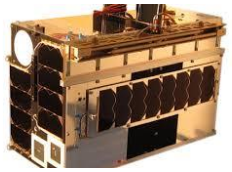
Remove Debris





C-POD

HawkEye360



AAREST

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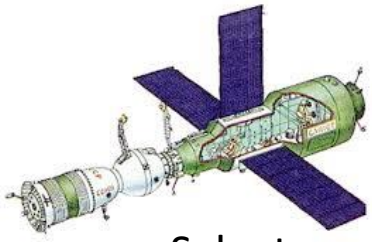
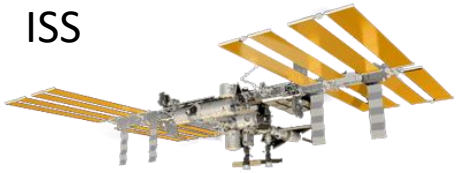
CubeSat/Small Sat Formation Flying and RPOD

Refueling Missions

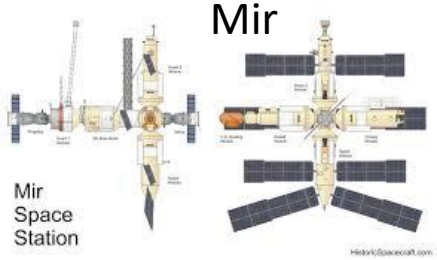


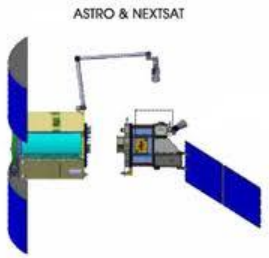
Salyut

ISS

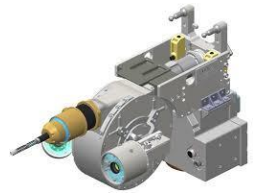


Mir





Orbital Express



RRM

FURPHY (OrbitFab)

Robotics are Complex, Expensive and Heavy

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Solution: Combine Docking and Fueling

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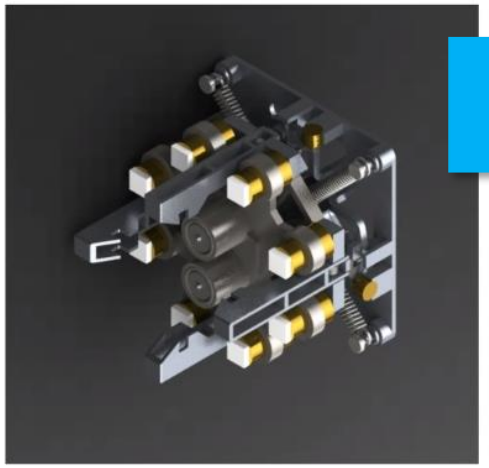

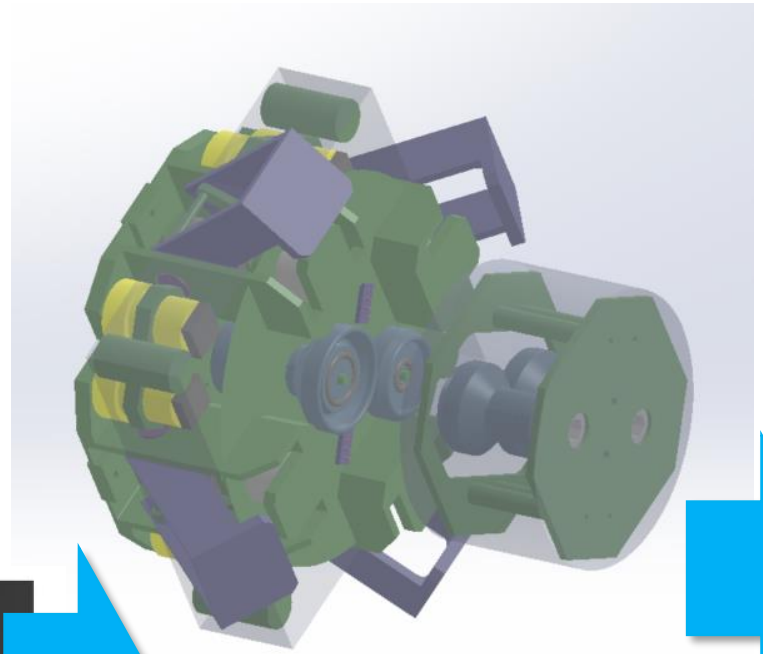

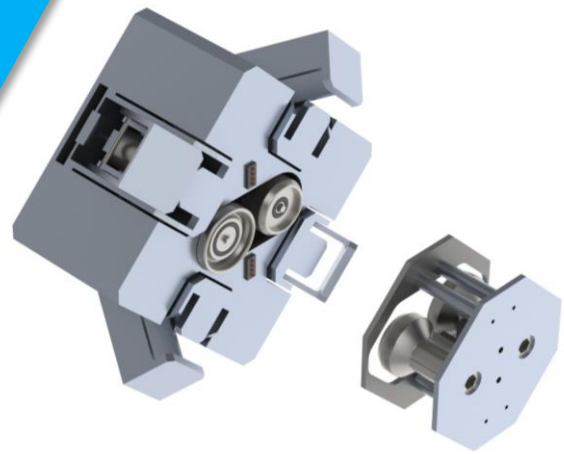

The Development Process at Orbit Fab

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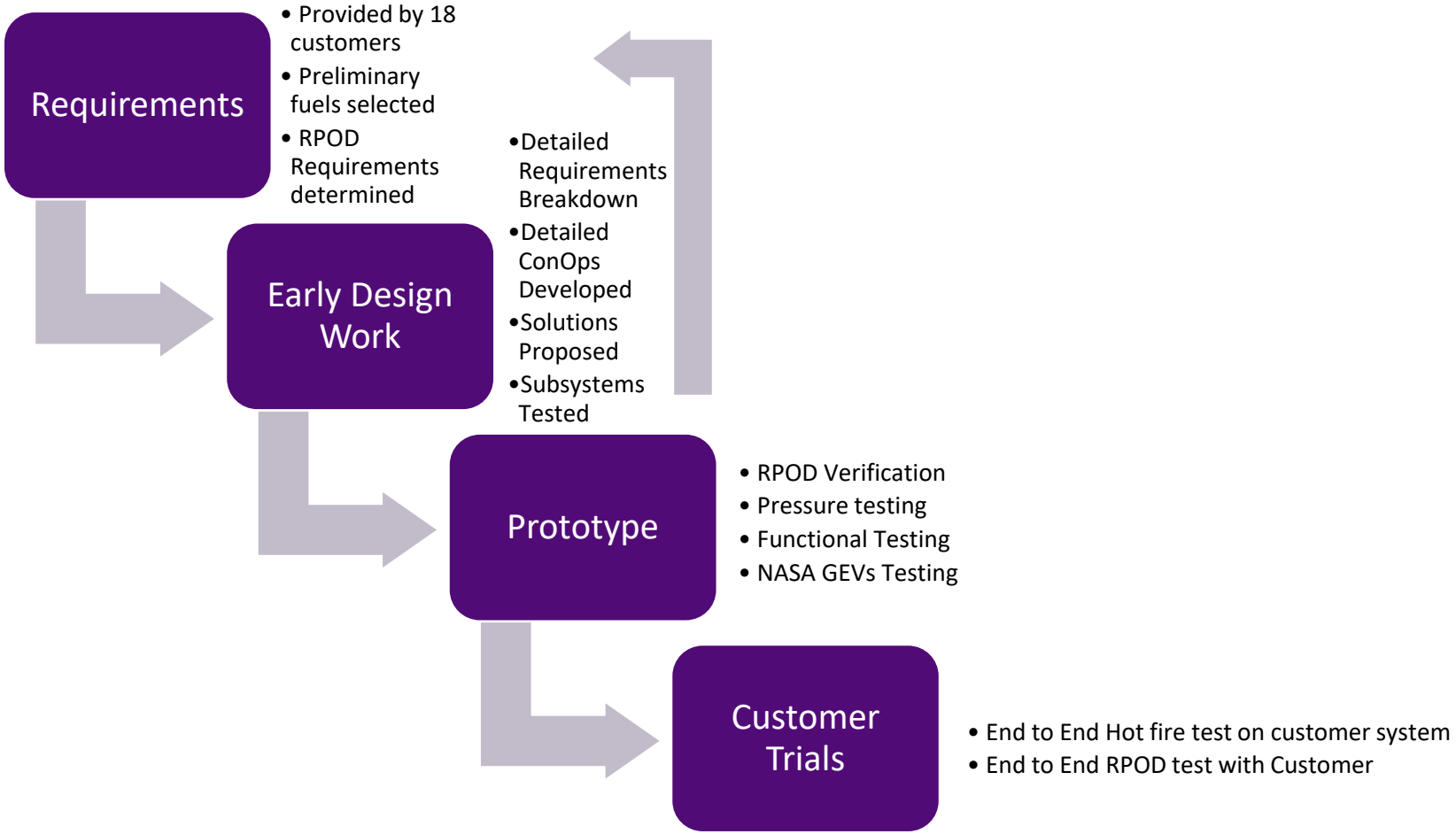

RAFTI System Boundaries

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Inside the System

- User Documentation (ICD, CAD, Specifications, App Notes, White-papers, Materials list)
- Assembly & testing procedures
- Marketing Materials
- Technician Training
- Storage
- Ground Support Equip
- Assembly & testing jigs
- Qualification & Acceptance Testing
- Shipping & Packaging
- Customer Support

Coupling

- Mounting
- Heater
- Handshake
- Self-test
- Kinetic Energy Absorption
- Valve Control
- Electrostatic dissipation

Outside the System

- Power conditioning
- Pump/Blow-down
- Flow Meter
- Thermal Blanket
- Alignment Indicators
- Thruster
- Boom Deploy
- Piping
- Launch Adapter
- Redundant Valve(s)
- Vent Valve(s)
- Disposal

Misalignment of Docking Spacecraft

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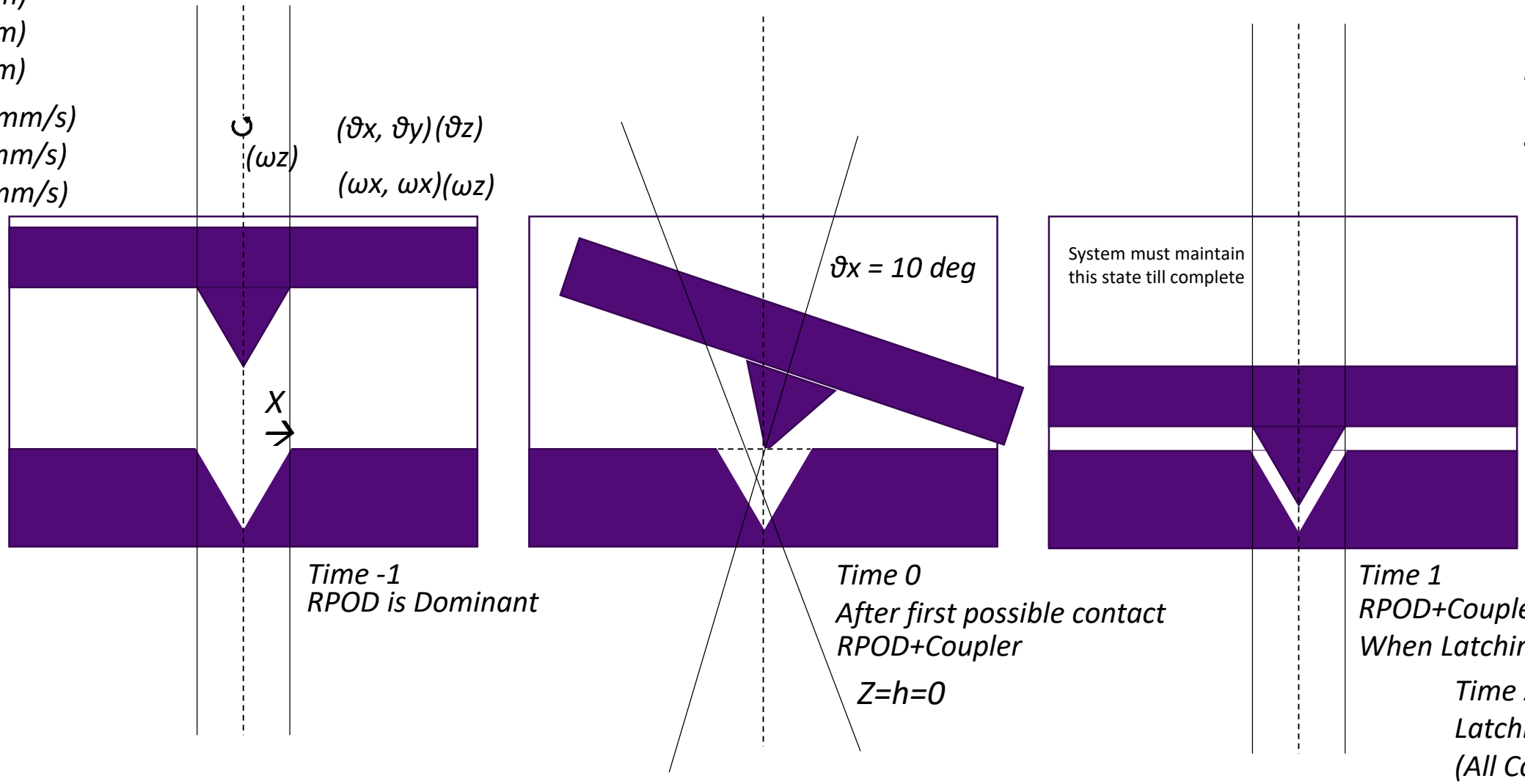
X (+_10 mm)
Y (+_10 mm)
Z (+_10 mm)

Xdot (+_5 mm/s)
Ydot(+_5 mm/s)
Zdot(+_5 mm/s)



Time -1
RPOD is Dominant

Time 0
After first possible contact
RPOD+Coupler
Z=h=0

Time 1
RPOD+Coupler
When Latching possible

Time 2 (Not Shown)
Latching Complete
(All Coupler)

X →
Y OOP
Z ^

Misalignment - Z Axis View

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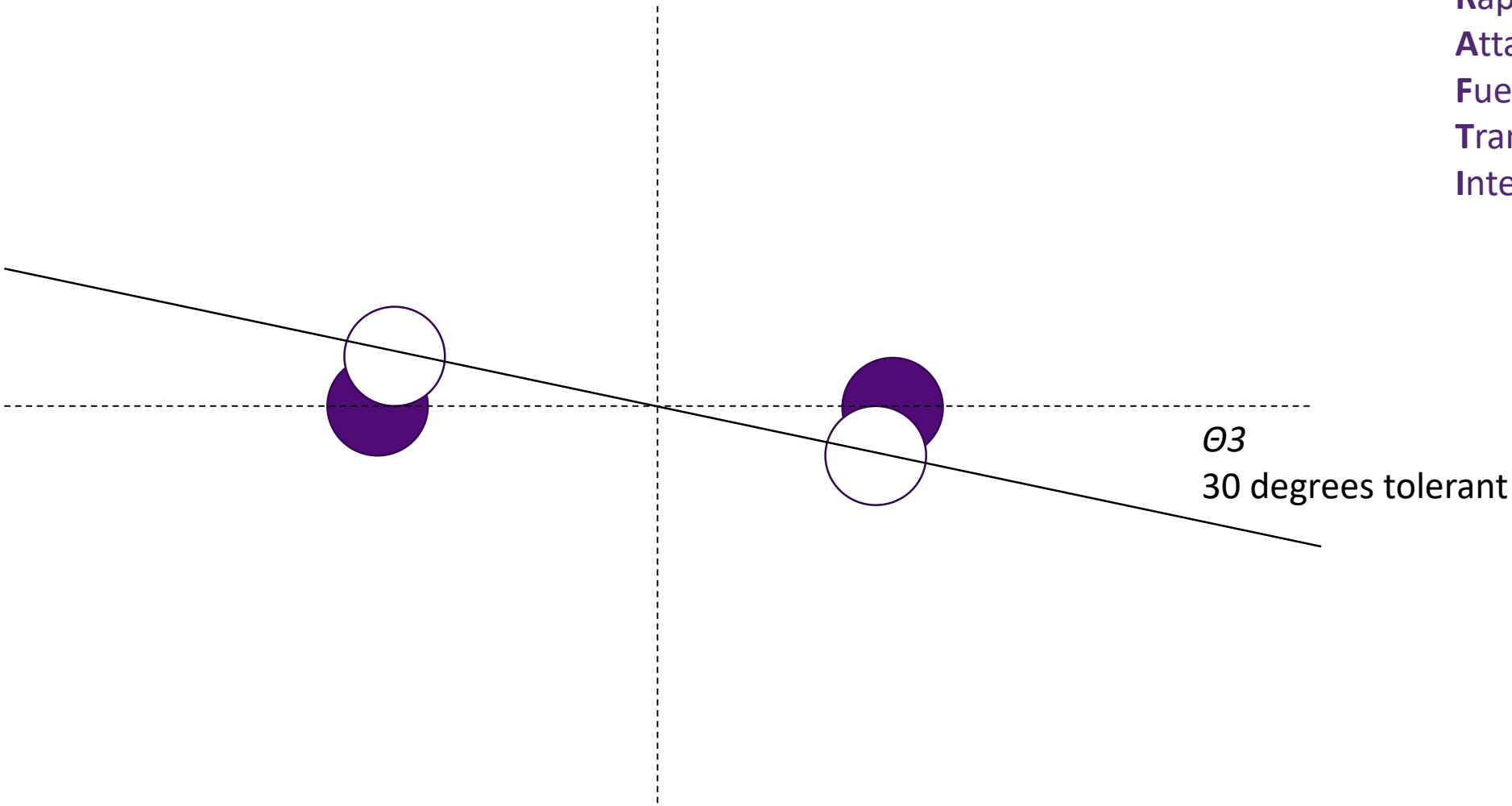

Simplified Con Ops

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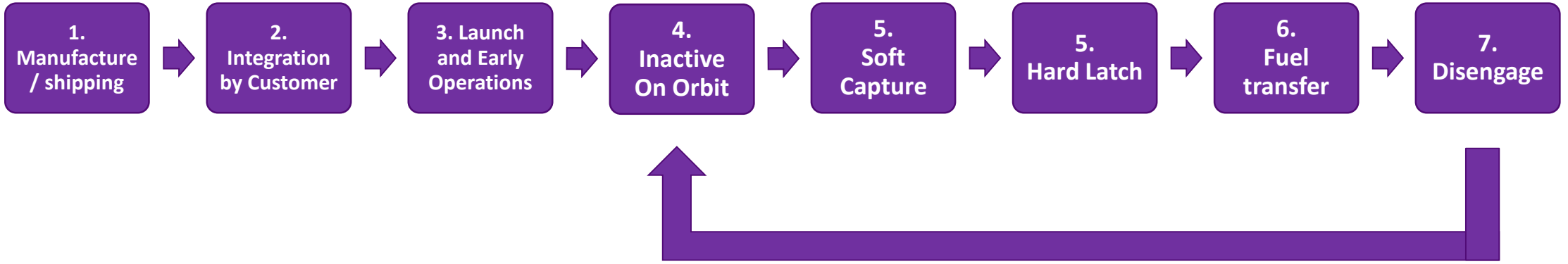

Primary Latch (Soft)

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- Makes the first docking contact.
- Needed to capture the two S/Craft together.
- Shouldn't open the face valves.
- Allows the hard latch to be slower.
- Must ensure no bounce out.

MUST BE FAIL SAFE IN COMBINATION WITH SECONDARY LATCH.

Secondary Latch (Hard)

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- Provides the force needed to hold the s/c together and allow for fluid flow at 500 psi (low pressure) or 3,000+ psi (high pressure).
- Must make the final alignment of any valves/connectors.
- Must be minimum power over attached time.
- Reconfigurability to change from Normally Open to Normally Closed desired.

MUST BE FAIL SAFE IN COMBINATION WITH PRIMARY LATCH.

RAFTI Current Config

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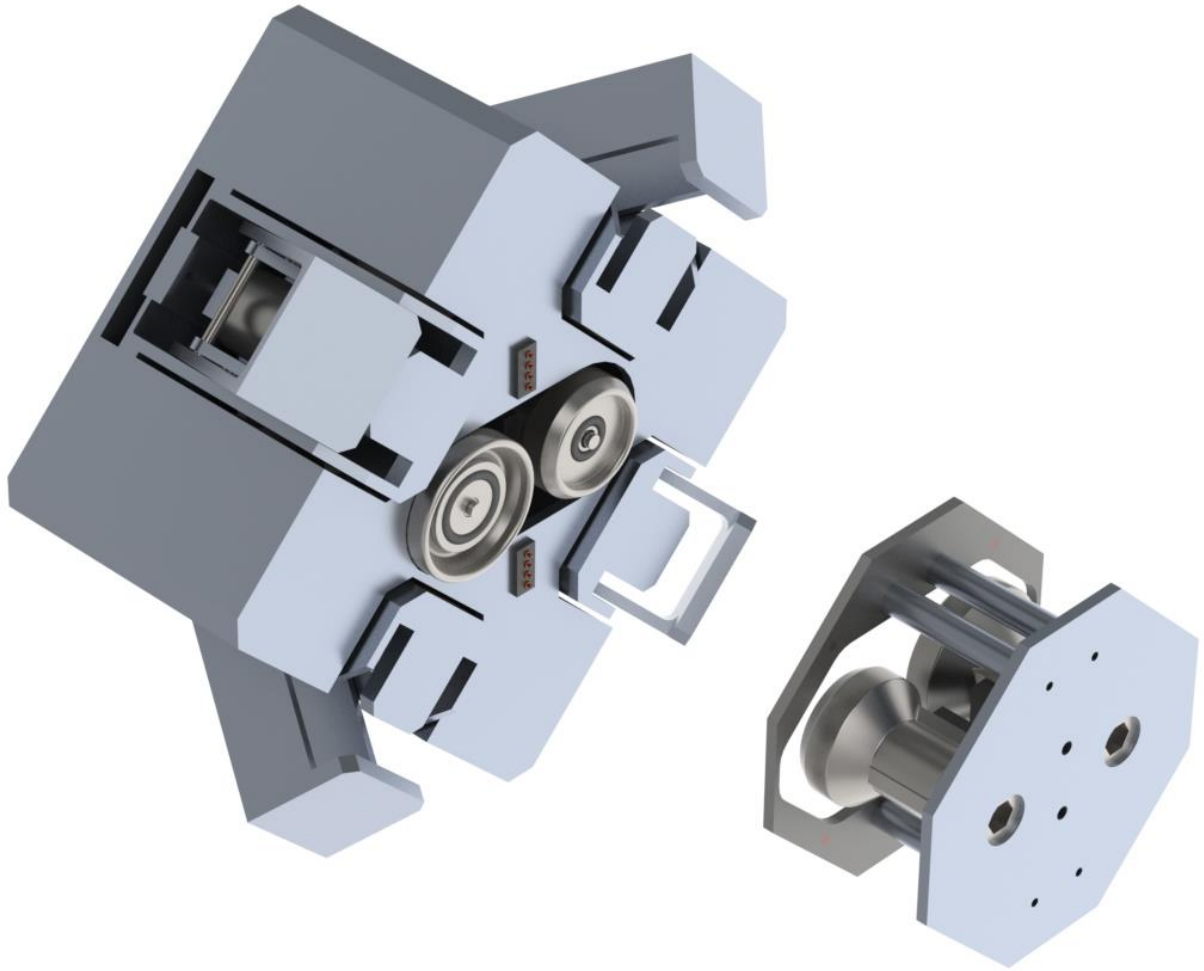

Expected Performance

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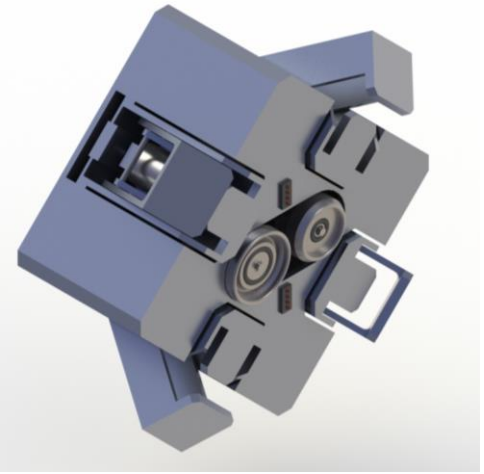
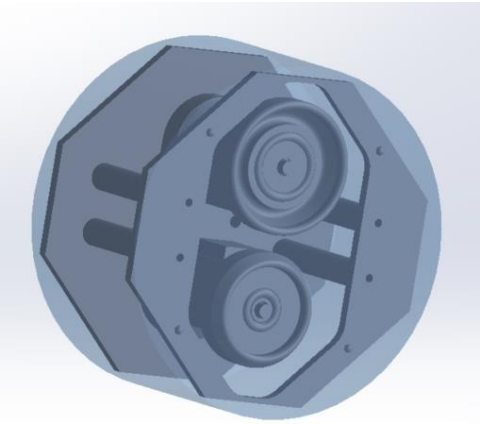
Gas Stations in Space

Parameter	Low Pressure	High Pressure
Max. Operating Pressure	500 psig	3,000 psig
Proof Pressure	1,000 psig	4,500 psig
Internal Leakage (GHe)	< 1 x10^{-6} scc/s	< 1 x10^{-6} scc/s
External Leakage	< 1 x10^{-6} scc/s	< 1 x10^{-6} scc/s
Cycle Life	>1,000 cycles	>1,000 cycles
Operating Temp Range	-40 to 120 ℃	-40 to 120 ℃
Weight (grams)	• 150 g (Service Valve) • 250 g (Coupling Half)	• 200 g (Service Valve) • 400 g (Coupling Half)
Size	• 0.25 U (Service Valve) • 0.5 U (Coupling Half)	• 0.25 U (Service Valve) • 0.5 U (Coupling Half)
Random Vibration	NASA GEVs	NASA GEVs
Pyro-shock	NASA GEVs	NASA GEVs
Media	MMH, UDMH, Water, H2O2, Methanol	Nitrogen, Helium, Xenon, Krypton



Active Side 0.5 U



Dual Service Valve and Passive Docking side fits inside 'Tuna Can' Volume

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Fuel Sale Trials

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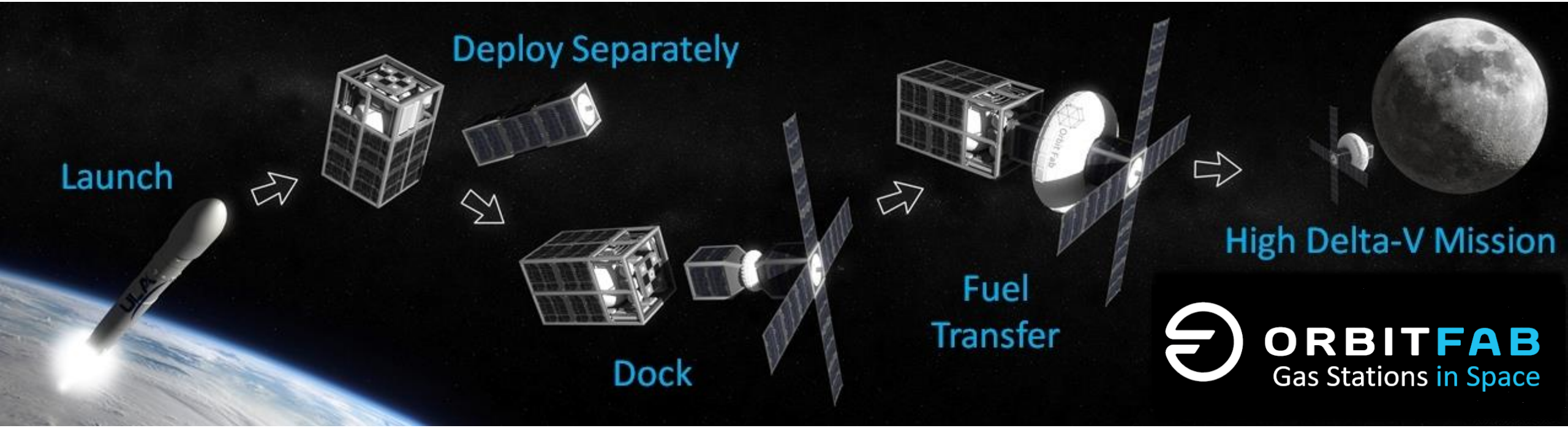

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