AMCC-AAC

Autonomous Magnetized Cryo-Couplers with Active Alignment Control for Propellant Transfer

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NASA HuLC HUMAN LANDER CHALLENGE

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01. The Cryogenic Bottleneck

Image Credit: NASA (2024)

- Current hardware is gravity-bound and generally not autonomous
- No flight-qualified autonomous, reusable cryo-coupler (TRL 8+)
- Boil-off remains a major issue, allowing cryogenics to only be stored on the order of hours

02. Objectives & Goals

Repeatable Autonomous Docking
Self-aligned mating with a blend of sensors

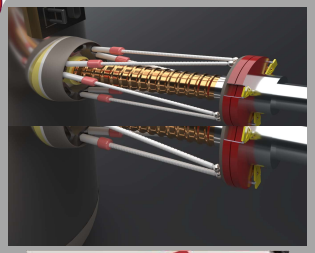
Minimize Propellant Losses
Limit boil off & thermal dissipation for long duration

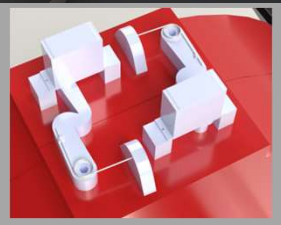
Emergency Disconnect Capability
Execute fail-safe magnetic release in < 150 ms

03. AMCC-AAC Technology Concept

AMCC-AAC features a dual capture system for seamless propellant transfer without manual intervention

1 **Active Alignment System**

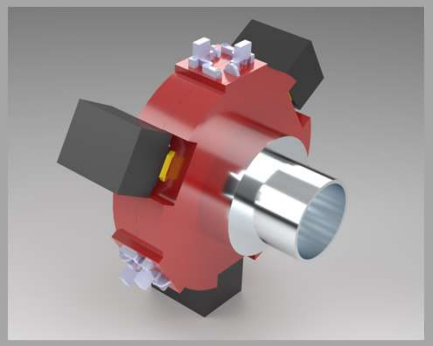




AMCC-AAC is a CV/AI based autonomous coupler utilizing a 6-DOF platform like those used on the ISS

2 **Passive Alignment System**

- Active alignment system uses 3D keypoint data from LiDAR and AprilTags to feed a two-stage Kalman filter
- Once close enough (+/- 5cm) the magnets give the final passive alignment
- 3 pairs of N52 ring magnets supply ~185 N of preload
- Low preload enables rapid disconnect at < 150 ms
- Yellow clamps provide a suctioning grip force that reduces the overall thermal leakage



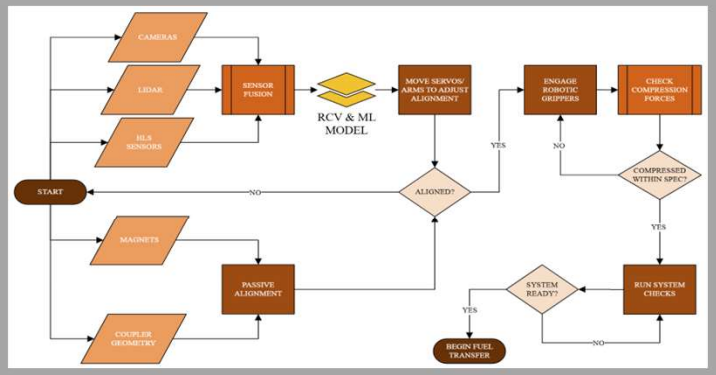
04. Active Alignment Algorithm CONOPS

Sensor Fusion:
CNN heat map + AprilTag + LiDAR

Coarse Approach:
Thrusters bring ports to a 30 cm standoff dist.

Fine Alignment:
Kalman filter drives Stewart actuators

Capture & Seal:
Magnets secure, hooks lock, and clamps compress

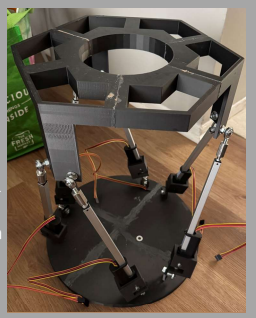


05. Initial Prototype

Scaled prototype printed on Bambu P1S validates fit & O-ring seal

Stewart platform (Actuonix actuators + Arduino Due) does 6-DOF control

Prototype campaign informs machining tolerances and further refinements necessary with CV/AI



Will be used to train AI model

06. Implementation Plan

Timeline

- 3.5 – 4 year to production plan
- Initial prototypes by year 1/2 with functional models EOY 3

Budget

- $6.77 M total program budget
- Includes 3,718 FTE weeks for 23 engineers and 3 support staff
- May need to increase engineer headcount based on demand

	FTE (Weeks)	USD ($)
Total Cost (w/o salaries)	3718.00	$ 710,656.00
	Salaries ($)	**Total ($)**
Total Cost (w/ salaries)	$ 6,058,500.00	$ 6,769,156.00