Unlocking Orbit: Commercializing ISS-Validated Systems

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***Abstract*—The International Space Station (ISS) has long served as the ultimate proving ground for spaceborne innovation by offering a unique environment for testing in microgravity. However, the true potential of emerging space technologies is only realized when they transition from the safety of a crewed testbed to the rigors of an independent, full-scale in-orbit demonstration. In 2025, Kall Morris Inc (KMI) completed International Space Station (ISS) testing of REACCH, the grappling end-effector for KMI's orbital logistics spacecraft, Laelaps. The methodology of the demonstration focused on characterizing adhesion performance and mechanical durability under sustained microgravity, providing the high-fidelity data necessary to transition to a free-flight mission. Through this testing, REACCH became the first commercial technology to successfully and repeatedly capture an unprepared object using the Astrobee free-flying robotic platform as a surrogate chaser. This success was proven in over 170 capture cycles across diverse materials, including aluminum and Multi-Layer Insulation. Our team was able to realize the unique economic and strategic benefits of demonstration aboard the ISS, rather than advancing directly to a free-flying platform in Low Earth Orbit (LEO). Providing this context and lessons learned is intended to assist in the development of, and mission planning for, emerging technologies, as well as limit negative impacts to the LEO environment. The solution KMI is working toward and our path to get there is intended to model resilience, sustainability, and mitigation of debris. This abstract details the strategic evolution of the Laelaps and REACCH technology, moving beyond the ISS to operating in orbit. By analyzing the shift from "validated" to "operational," we outline the critical milestones and lessons learned from the preparation and execution of ISS testing, as well as the development of the full mission demonstration for Laelaps.**

***Index Terms*—Debris Mitigation, Kall Morris Inc (KMI), In-Orbit Demonstration Missions, Orbital Logistics, Space Sustainability**

I. KMI Introduction

Kall Morris Inc (KMI) is an in-space logistics company providing innovative and universal mobility capabilities, leveraging proprietary grappling hardware and exclusive software to provide solutions advanced through strategic partnerships. Working directly with customers, KMI is developing a commercially viable system to extend and enhance vital missions in orbit. Alternative operators offering a similar service in this market require a pre-installed docking solution or intend to build a target-specific or single-use system. These alternatives are limited, potentially burdensome on customers, and focus almost exclusively on next-generation spacecraft.

KMI's solutions, including REACCH[1], are for current, next-generation, and legacy assets and offer a universal system to rendezvous, retrieve, and relocate orbital objects without the need for pre-installed hardware. This method mitigates the drawbacks of traditional self-hosted maneuvering or deorbit, which depletes and disrupts critical mission resources for both industry and defense sectors. By providing a separate spacecraft optimized for in-space maneuvering, KMI ensures efficient and sustainable missions that extend satellite operating life and revenue generation by resolving regulation-required premature disposal.

II. KMI Technology

Laelaps is the KMI rideshare-launchable spacecraft designed to provide a cost-effective, timely, and resource-efficient solution for On-Orbit Servicing (OOS) and Space Servicing, Mobility, and Logistics (SML) operations. This servicing-designed spacecraft is primed to protect space assets for industry, academia, government, and military customers. Built around a 15-inch ESPA-class[2] satellite bus, Laelaps can be launched as a rideshare option on a variety of commercially available launch vehicles. This technology supports a variety of use-cases compatible with numerous Resident Space Objects (RSOs), supporting servicing of up to four RSOs per spacecraft. Fig. 1 shows Laelaps in an operational capacity for anticipated interactions with a satellite.

[1]The technology name "REACCH" is an acronym for "Responsive Engaging Arms for Captive Care and Handling".

[2]"ESPA-class" is an industry phrase derived from the acronyms"EELV Secondary Payload Adapter" where EELV is "Evolved Expendable Launch Vehicle".

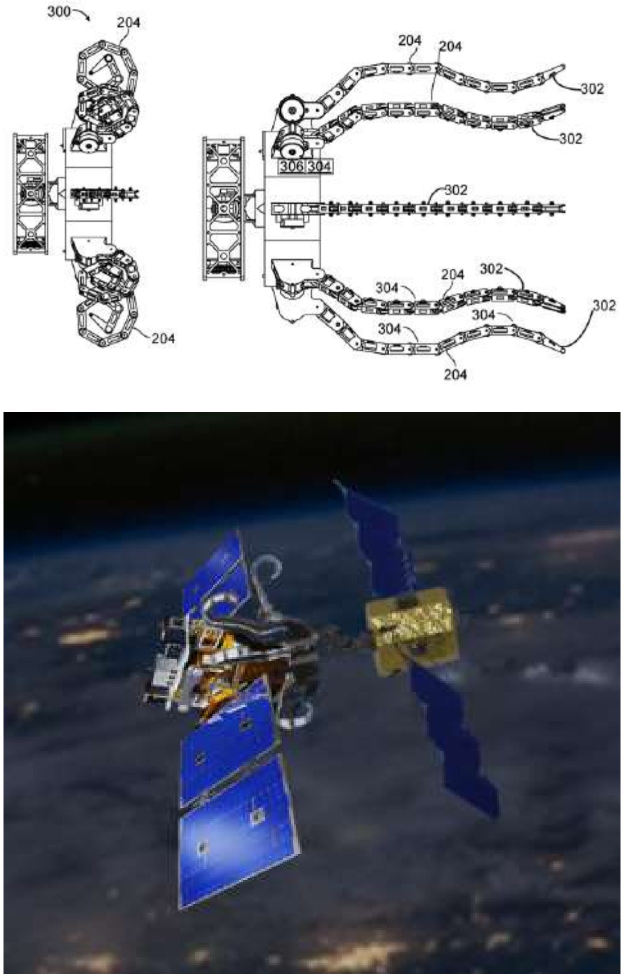

Fig. 1. REACCH US Patent: 11,661,217 (top), Laelaps capturing RSO (bottom)

REACCH is KMI's licensed and patented (US Patent: 11,661,217) grappling end-effector payload that has been internally matured for use on legacy, next-gen, adversarial, or otherwise unprepared objects in Low Earth Orbit (LEO). It uses a combination of segmented, rigid-linked tentacles equipped with mechanical gecko adhesion for a controllable, directional, reversible grip capable of adhering to a target without residue or damage. KMI provides flexible mission design to support the logistics of Relocation as a Service (RaaS) and ensure proper End of Life (EoL) deorbit to maximize potential client operations on-orbit. REACCH has become a key element for Laelaps, the flagship RaaS spacecraft offered by KMI.

III. Preparation for In-Orbit Operations

In preparation for testing aboard the International Space Station (ISS), REACCH underwent many scaling changes to comply with the United States' National Aeronautics and Space Administration (NASA) guidelines and general limitations for operating aboard the station to accomplish science and safety objectives. KMI reduced the REACCH concept down to its basic framework and delivered a scaled-down version of the concept, while maintaining the desired scientific value of the demonstration. Ultimately, the Astrobee-ready REACCH was designed for operating four tentacles with seven segments each, compared to the full-scale eight tentacles with ten segments each. The general mechanics remained consistent to ensure future scalability of the REACCH concept.

The NASA Astrobee free-flyer robot hosted REACCH as a payload, providing power, communication, and mobility, serving as a stand-in for the future Laelaps spacecraft. Astrobee has been on station since 2019, where it has enabled hundreds of science sessions. Adding to the extensive list of achievements attained by KMI, REACCH expanded the envelope for Astrobee hardware testing as it was the largest, heaviest, and most power-intensive payload ever flown by Astrobee. In preparation for the ISS, NASA partners estimated that at least two years would be required to complete all necessary steps for REACCH deployment and in-station testing. Through considerable engagement and dedicated effort, KMI completed all REACCH development, fabrication, testing, and final pre-launch handover in a period of nine months, delivering a quality payload ahead of time that met design, programming, and operational objectives.

After completing thorough ground testing to the satisfaction of KMI, NASA, Voyager, and other partners, the next immediate hurdle was surviving launch. SpaceX's Cargo Dragon launched REACCH to the ISS aboard Cargo Resupply Services Mission 31 (CRS-31) on November 4, 2024, docking with the ISS the following day. The prototype was received by the ISS crew without damage or abnormalities, showcasing the result of diligent engineering and testing conducted by KMI and supporting partners. The hardware delivered to the ISS included six REACCH tentacles (four for the mission plus two spares), the hub that holds the tentacles and plugs into Astrobee's payload bay, and two hollow cubes storing six different faceplates of materials and textures commonly flown on satellites.

IV. Testing on Station

Capture testing aboard the ISS was conducted across six testing sessions, each about four hours in length, between November 2024 and April 2025. REACCH was evaluated for its ability to approach, interact with, and securely capture uncontrolled objects of various materials and surface conditions. To represent a variety of rendezvous scenarios, KMI sent an interaction target, the capture cube, to the station. Featuring interchangeable faceplates, shown in Fig. 2, the capture cube, shown with the solar panel simulant (acrylic) in Fig. 3, reflected common cubesat surfaces using 36 faceplates covering six materials and conditions: multi-layer insulation (MLI) simulant, minimal surface texture aluminum, solar panel simulant (acrylic), sheet aluminum, rough textured plastic, and maximal surface texture aluminum.

To conduct the test on station, the crew prepared the REACCH hardware by installing the KMI unit into NASA's Astrobee system to provide power, comms, and mobility. Once installed, KMI and our NASA partners took control of the unit

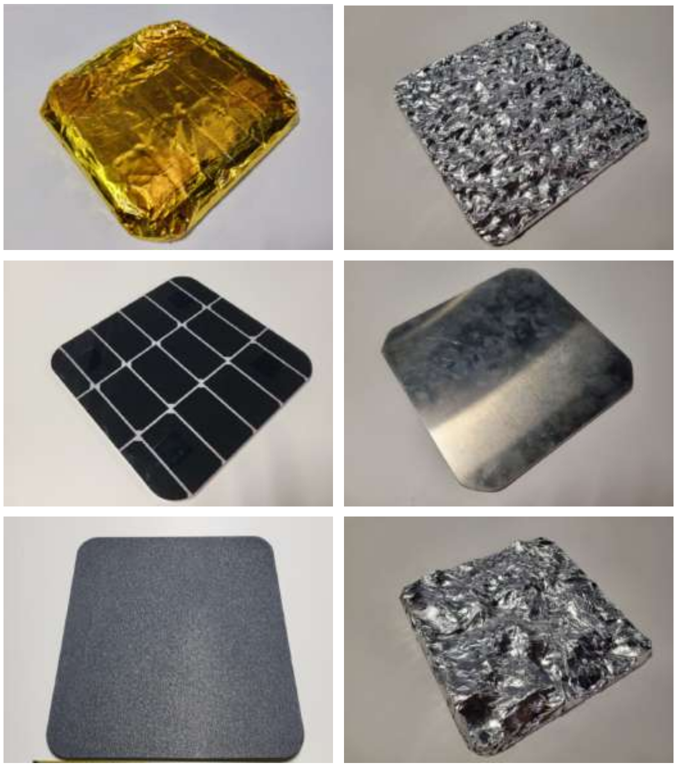

Fig. 2. Faceplate materials of the capture cube.

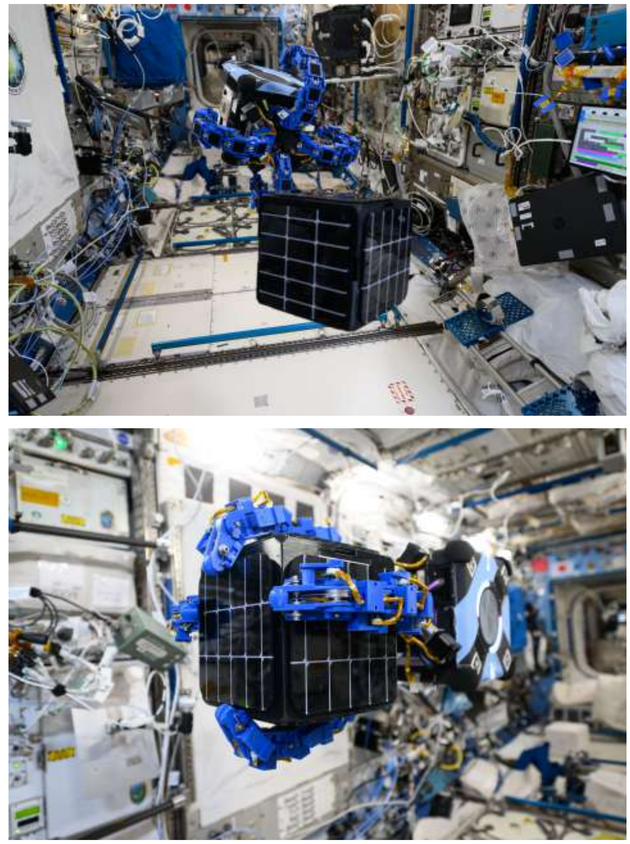

Fig. 3. REACCH capturing the capture cube with solar panel simulant panels.

to initialize the experiment and fine-tune various parameters. Once ready, the crew passed the capture cube to the ground-controlled Astrobee, where it measured its approach position in order to activate its autonomous capture cycle. This cycle ran the tentacles until they were in appropriate contact with the client object, in this case, the capture cube. Once the experiment was run, operations were momentarily paused to evaluate the quality of capture and adjust as needed for the next capture cycle. Images of REACCH before and after capture can be seen in Fig. 3.

At the conclusion of operations, REACCH was cycled more than 170 times, producing the first capture of an uncontrolled object by a commercial company. Through development, demonstration, and debriefs, numerous insights and advantages of REACCH were identified. These further refinements, ongoing innovations, and continued terrestrial testing validate that REACCH will meet and exceed customer requirements for space object docking, regardless of the state of the hardware, whether it be prepared or unprepared. With captures completed on various materials, material surface conditions, and approach parameters, coupled with the informative data from sensor inputs, video logs, static images, post-mission hardware inspection, and first-person accounts from crew, KMI can uniquely compare mission planning simulations for future captures against the large data set of on-station captures.

V. REACCH RETURNS TO KMI

Following the return of hardware from the ISS aboard SpaceX CRS-32, REACCH went through a comprehensive evaluation process with NASA and Voyager Technologies. The spaceflown materials were released to KMI and returned on the 4th of July, 2025. Function checks were conducted upon receipt, and all systems met and exceeded wear and degradation resistance requirements. Future REACCH utilization is expected to involve tentacle actuation fewer than ten times over the lifetime of an early, non-refuelable Laelaps spacecraft. With the Astrobee-REACCH exceeding that by an order of magnitude through more than 170 capture cycles, REACCH carries a significant factor of safety on the functional design, validated by the positive results of post-mission evaluation.

There was a tremendous benefit gained from completing the ISS/Astrobee demonstration prior to the launch of a fully integrated satellite mission in LEO. By prioritizing the demonstration aboard the ISS, KMI was able to return all materials for evaluation of damage and wear endured by both the capture surfaces on the REACCH tentacles and client surfaces. Had the materials not been returned, there would've been a very limited capability for post-mission evaluation in a LEO environment. Additionally, this in-station testing allowed for the ability to rapidly reset and re-run the demonstrations with parameters that would be unsafe in the LEO environment. If the full scope of the ISS demonstration were to be attempted with free-flying satellites in LEO, it is estimated that nearly 300 satellites (Laelaps and client assets combined) would have been required.

Lastly, all demonstrations were conducted under the supervision of NASA and Japan Aerospace Exploration Agency (JAXA) astronauts, with Commander Sunita Williams coordinating the majority of the work on-station. After the ISS mission, KMI was able to host Commander Sunita Williams for a full debriefing and critical review of the operations she was involved in. In addition to direct feedback and commentary, demonstration aboard the ISS allowed for the capture of a myriad of pictures and videos of operations. Several of those images cleared for release have been included in this paper. The volume and detail of images would not have been possible from a free-flying LEO mission, and gave the technical team precious, real-time data to analyze in prototype performance.

VI. Commercializing REACCH

REACCH's first use in the commercial landscape will be aboard the Laelaps spacecraft in its inaugural mission, led by KMI. Using the lessons learned on station, REACCH will continue maturing in its design as it prepares for operations in the space environment. KMI is iterating the design throughout 2026 and early 2027, where REACCH will expand from four shorter arms, rated for the ISS, to eight longer arms, rated for the space environment. REACCH will maintain its course of design to be rated for a variety of client objects, regardless of their shape or size.

As the core technologies of REACCH are developed further, the universal capture system will be integrated into the full Laelaps servicing satellite. Because REACCH is capable of rendezvous, proximity operations, and docking (RPOD) and attaching to any space object without causing damage, it represents a transformative leap beyond the current state of the art in space robotics. This system design will be iteratively improved in parallel, toward the goal of providing an optimized product for grappling RSOs.

Traditional end-effectors are typically designed for specific targets, requiring predefined interfaces, grappling fixtures, or cooperative features on the object to enable secure capture. This limits their flexibility and utility in dynamic, unstructured environments such as satellite servicing, debris removal, or orbit change maneuvers. In contrast, a client-agnostic, non-damaging end-effector eliminates the need for prior modifications or cooperative design, enabling interaction with a wide range of legacy and future spacecraft, regardless of shape, material, or surface condition. The goal of this system is to provide an optimized product for grappling RSOs for In-Space Servicing, Assembly, and Manufacturing/Space Access, Mobility, and Logistics (ISAM/SAML) objectives, including RaaS, Active Debris Removal (ADR) services, non-destructive repositioning, and protection for critical in-space assets.

This capability is revolutionary because it unlocks true operational versatility and responsiveness in space, allowing for EoL servicing of aging or damaged satellites, safe capture of uncooperative or tumbling debris, and orbital relocation maneuvers without requiring invasive or destructive contact. By preserving the structural and functional integrity of target objects, this end-effector not only extends the lifespan of space assets but also adheres to growing industry priorities around sustainability and responsible space operations. It sets a new benchmark for universal, reusable, and non-invasive robotic interfaces in orbit, paving the way for a more resilient and serviceable space infrastructure.

Laelaps and its mission parameters are being managed and created by KMI and its partners, who will be integrating REACCH into their vehicle designs. KMI will be purchasing many components from flight-proven providers, where KMI will serve as the technical integrator to ensure mission success. In-orbit operations are anticipated to take place in 2028, with follow-on operations expected from future Laelaps space vehicles. A rendering of Laelaps can be seen in Fig. 4, featuring REACCH on the forward face. These efforts advance the availability of delivering the technology as a specific product or operating as a service for commercial and government customers.

KMI, alongside our partners, will continue to advance our solutions, including REACCH and Laelaps, for current, next-generation, and legacy assets. Offering a universal system to rendezvous, retrieve, and relocate orbital objects without the need for pre-installed hardware is a critical need for both industry and defense sectors. Commercializing a secure and safe relocation method of uncontrolled and uncooperative RSOs will unlock the full potential of operating in orbit.

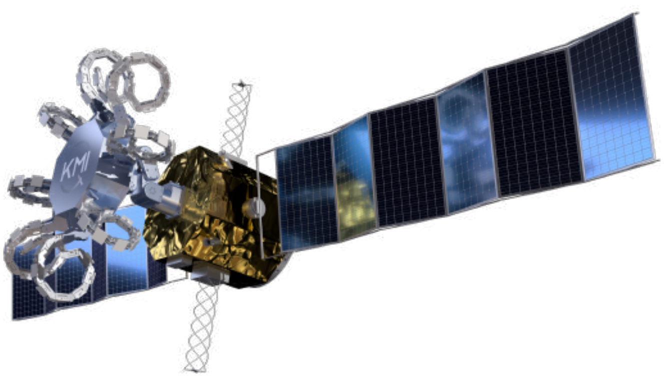

Fig. 4. Laelaps with integrated 8-tentacle REACCH universal capture system.