Autonomous Aerial Cargo System
The Sea Land Air Military Research initiative (SLAMR)
Naval Postgraduate School (NPS)
FY21 Joint Distribution Deployment Enterprise
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Fiscal Year	Estimated Investment
2023	[redacted]
2024	[redacted]
2025	[redacted]
Total	[redacted]

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Introduction

Expanded use of unmanned aerial systems (UAS) represents a paradigm shift for the battlefield, enabling frequent, flexible, long range, tactical resupply in support of expeditionary maneuver teams and Ship-to-Shore lines of support and logistics as well as flexible options for airborne Intelligence, Surveillance & Reconnaissance (ISR). Concepts such as EABO will require new and less expensive means of aerial resupply, to include into contested environments.

The NPS will lead this RDT&E project to deliver a militarized variant of an autonomous VTOL cargo aircraft developed primarily to serve the commercial logistics/parcel market. This variant will be capable of operating from maritime platforms.

Need Being Addressed

Unmanned Aerial Resupply: Today, small payload aerial resupply missions expose aircrews to unnecessary risk, consume limited aircraft time, and are less frequent or flexible than ground / expeditionary forces would prefer. The current bulk cargo delivery model using manned air assets has multiple problems:

1. The air assets present large signatures and represent targets of opportunity for any opposition forces, and
2. Once delivered in bulk, supplies are largely immobile and require ground forces to receive and secure them, or small ground vehicles and forces for last-mile delivery to their destination.

A Vertical Take-Off and Landing (VTOL) aerial ULS able to carry 300-500lbs of payload that can be operated and maintained by a small team having minimal training would transform aerial resupply and give US forces a valuable advantage.

Maturity of the Technology

The maturity of the technology at the time of project startup is expected to be 6. At conclusion, the maturity of the technology is expected to be 7. The first commercial prototype was first flown at the NPS Field Laboratory demonstrating the viability of the proposed approach.

The scope of the proposed research effort is to develop and validate a variant of a commercial VTOL UAS suitable for autonomous operations to include operations from ships. The capabilities to be developed include:

- Shipboard on-deck CONOPS (stowage, positioning, fueling, marinization)
- Shipboard flight operations (takeoff / landing flight controls)
- Integration with a Defense operating environment (mission control, secure communications)

Anticipated Benefit/ROI for Implementing the Proposed Capability

The anticipated benefit/ROI of the proposed capability is a transformational ability to execute safe, on-demand aerial resupply over-the-horizon to expeditionary troops via the VTOL aerial platform. No autonomous VTOL platform today exists to transport 300-500 lbs payload across 300 mi at an acquisition and operational cost substantially lower than traditional helicopters and airplanes.

Specifically: the key benefits of the proposed capability are:

- **Safety:** Eliminates risk to pilot/crew, and lower signature than manned aerial assets.
- **Resupply tempo:** Enables on-demand resupply and other movement of materiel.
- **Lowered costs:** Expected lower acquisition and operational costs vs manned assets.

Technical Merit

Recent maturation of key enabling technologies allows for integration of many existing, off-the-shelf systems, permitting rapid overall system and capability development. These maturing areas of technology include sensors and computation, electric and hybrid-electric powertrain elements, and software / robotics / flight control development tools.

Following are technical elements specific to the proposed system.

Hybrid-Electric Powertrain: The proposed system's hybrid-electric powertrain offers the best of both worlds for ULS: reduced-complexity energy transmission and rotor drive mechanism for the propulsors (electric), coupled with the high power-density storage inherent in liquid fuel. The system can be refueled in austere conditions where battery charge infrastructure is not available.

Autonomous Payload Pickup / Dropoff: The proposed system's design features a unique automated payload-handling system enabling the aircraft to self-taxi and to pick up / drop off loaded cargo pods. This automation system will enable the aircraft to reach a high level of utilization and accomplish unattended loading/unloading. This system has been demonstrated and refined, and it combines innovative software, sensing, and mechanical design.

Modular Payload to Expand Capabilities: A modular payload capability enables a range of battlefield duties, including cargo flexibility (varying size, shape, materials), extra fuel tank (for longer range / high endurance), and custom ISR / EW / other mission-specific payloads.

Rapid Deploy: The proposed system has a capability for transport and rapid deployment of the Chaparral from a C-130 and standard shipping containers. This enables flexible deployment to austere environments, and compact shipboard stowage.

Performance Metrics

Proposed metrics by which the RDT&E effort will be measured include:

- *At conclusion of Design phase:* Stakeholder review and approval of shipboard on-deck CONOPS, Defense operating environment integration plan, marinization plan.
- *At conclusion of Build/integration phase:* Stakeholder review and approval of physical systems and software interfaces and integrations.

- *Demonstrations:* Demonstrations of stowage, positioning, fueling, and shipboard takeoff & landing.
- *Documentation:* Stakeholder review and approval of generated documentation for operations and maintenance.

Instances of Use
While the specific proposed system has not yet been deployed in industry, the major elements are drawn from maturing fields of technology.

- *Hybrid-electric powertrain:* Widely deployed in automotive, growing in aerospace.
- *VTOL flight systems:* Multiple air-taxi systems have demonstrated successful flights.
- *Delivery Drones:* Multi-national shippers running trials, startups scaling operations.
- *Ground delivery robots:* Scaled deployments in selected cities and campuses.
- *Self-driving cars:* Deployments operating in specific communities.

The proposed system currently has strong demand signal from multiple promising commercial markets, including express logistics, e-commerce, oil & gas logistics, mining logistics, pharmaceutical & medical (healthcare) logistics, humanitarian aid / disaster relief.

Integration Potential

US Air Force - Agility Prime has become a center of acceleration for electric VTOL and hybrid-electric VTOL aircraft systems for both troop transport and logistics. Agility Prime is working with several platform partners now, it has a dedicated budget to field an initial operational capability (IOC) in FY23, and intends to request POM funds for acquisition of these aircraft systems beginning in the FY24 defense budget and continuing onward.

JTAARS: The Army Futures Command's Sustainment Capabilities Development and Integration Directorate as well as the Marine Corps' Capabilities Development and Integration office are seeking autonomous aerial resupply systems for operational test and evaluation, heading toward acquisitions in subsequent years.

Team and Previous Projects

[redacted]

Appendix A

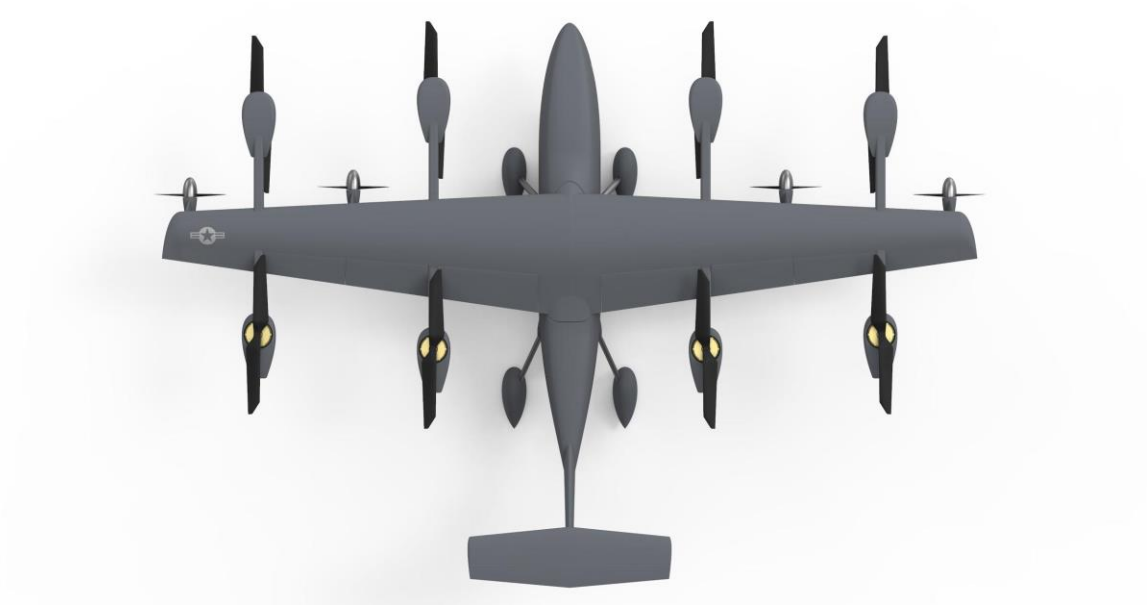
Major deliverables for the proposed effort include:

- *Shipboard CONOPS definition:* Demonstration of key shipboard operations and the development and delivery of written instructions for stowage, positioning, fueling.
- *Shipboard operations demonstration:* Documentation and rationale of system marinization approach, demonstration of shipboard takeoff & landing in a variety of environmental conditions.
- *Integration with Defense operating environment:* Integration of system into a realistic operating exercise, with mission planning, communications and control.

Year 1	Requirements-gathering and design (on-deck CONOPS, weather/conditions ops plan)	[redacted]
Year 2	Integration (1x aircraft with appropriate features for shipboard operation) and capabilities development (control laws, CONOPS items)	[redacted]
Year 3	Demonstrations and documentation delivery (shipboard operations, manuals/guides)	[redacted]

Appendix B

Autonomous Aerial Cargo System (render) - front view



Autonomous Aerial Cargo System (render) - top view

Full-scale demonstrator flight (prototype aircraft) at Camp Roberts - October 2019.