Rhoman Aerospace is developing heavy-lift autonomous flight vehicles for cargo-hauling applications and related hardware and software systems. Our RhomanCraft flight vehicle is an autonomous or remote piloted VTOL multi-rotorcraft flight vehicle that supports independent maneuver to defeat and isolate enemy forces while maximizing human potential. The system is a modular flight platform filling multiple in-field needs, with quadcopter flight dynamics for urban environments, and small dimensions for integration with vehicle transportation infrastructure.

Based on a unique form factor and design, the RhomanCraft can deploy from and land in a truck trailer, and carry non-fixed payloads, including shifting medical supplies and untethered water bottles. Our unique control systems for non-fixed and shifting payloads allows our flight vehicles to fly farther and safer than competitors. Given its key sets of advantages, combined with computer vision, AI for autonomous flight, and the Rhoman team’s engineering experience, the RhomanCraft is the ideal platform to accomplish the US Army’s stated goals in the Near, Mid and Long term.

By combining sustainment, lethality and survivability, the RhomanCraft sustains high tempo operations at the end of extended and contested lines of communication and revolutionizes the Army’s operational frameworks for Multi-Domain Operations.

1. ABOUT RHOMAN AEROSPACE

Rhoman Aerospace is a design, engineering, software, and manufacturing Small Business that is creating autonomous vertical take-off and landing (VTOL) flight vehicles for on-demand supply...
delivery and cargo-hauling. Additionally, Rhoman is developing critical IP-protected software and hardware components to ensure the most efficient and effective control and maneuverability of heavy-lift unmanned aerial systems (UAS), including class 1, 2 and 3 vehicles, and is developing autonomous ground and aerial navigation software in GPS denied and degraded environments.

Rhoman Aerospace’s autonomous vertical take-off and landing (VTOL) flight vehicles have dual-use capabilities for both the agricultural industry as well as for Army resupply operations. Our two flight vehicle options are on-demand, truck-trailer deployable, point-to-point logistics solutions carrying up to 100lbs and up to 500lbs of payload. Our larger flight platform is 1/2 of the cost of a traditional agricultural crop-spraying helicopter and less than 10% of the cost of a U.S. Army Sikorsky UH-60 Black Hawk helicopter. The RhomanCraft flight vehicle is field repairable through its line replaceable units and can immediately deploy and autonomously return to the launch location. The RhomanCraft flight vehicle solution:

- Significantly decreases operational costs of both Army and Agricultural applications
- Autonomous (or remotely piloted) vehicle means one pilot can control multiple flight vehicles, thus increasing operational flexibility
- Rugged vehicle can fly at night, in adverse weather conditions, and around complex obstacles
- Intuitive operation through seamless integration with both existing Army and agricultural navigation and tracking software

From our innovative flight vehicles and control systems to our passion for safety and reliability, Rhoman is delivering the VTOL multi-rotorcraft flight systems of the future.

2. UNIQUE CAPABILITIES FOR THE ADVANCEMENT OF GVS

Rhoman Aerospace’s key technical innovations are two-fold; (1) hardware and software IP that enables optimal control of a UAS vehicles with a large and shifting payload, and (2) autonomous navigation software for both flight and vehicle navigation in GPS denied and degraded environments.

**Optimal Control for UAS vehicles**

Whereas controlling a standard rigid-body multi-rotorcraft is a well-solved problem, controlling a multi-rotorcraft with a shifting payload, human rider, or non-constant center of mass is an entirely different matter. Our control methodology optimally accounts for a changing center of mass and our hardware design enables these control methodologies.
Rhoman designs allow for optimal control of a UAS vehicle is a combination of control algorithms, methodology, and hardware. These unique methods of dealing with any non-fixed payload allows our flight vehicle to fly farther with more payload than competitors. Our payload detection and flight vehicle adjustment system continuously detects the center of mass of our payload and flight vehicle and adjusts the flight vehicle to the most optimal and efficient flight path. This innovative combination of control algorithms, methodology, and hardware creates a VTOL craft that is uniquely capable of carrying any payload or cargo that shifts during flight, such as supplies/provisions and liquids, like Class I (food, water, rations), Class II (Clothing), Class III (Fuel, Oils, etc.), Class V (ammunition), and Class VIII (medical supplies), as well as human riders or pilots in the medium-term.

This innovative combination of our issued and pending IP creates a VTOL craft that can be optimally controlled despite a shifting center of mass and functions with a smaller (and lighter) frame.

**Autonomous Navigation in GPS-Denied and Degraded Environments**

Based on patent pending methods, we are merging existing 3D-area map technologies with probabilistic modelling and image recognition software to enable autonomous flight in GPS-denied environments, a method that could also support other autonomous systems.

**3. RHOMAN AEROSPACE IMPACTS ON GVS OTA OBJECTIVE AREAS AND TOPICS**

As it relates to the GVS OTA objective areas, Rhoman Aerospace is well-positioned, well-equipped, and well-suited to directly address the following objective areas for the GVS OTA:

**Architecture, Security, and Modularity (ASM)**

Rhoman Aerospace’s core technological innovation lies in our unique control systems for non-fixed and shifting payloads. This unique allows our flight vehicles to fly farther and safer than others. In addition, Rhoman Aerospace has vast experience, and patented innovations, in creating modular add-ons for flight vehicles that leverage the same base platform vehicle. For example, our RhomanCraft flight vehicle can be easily swapped from a cargo-hauling UAV to a Search & Rescue and/or MEDEVAC UAV with a simple swappable modular device.

**Autonomy (AUT)**

The RhomanCraft leverages powerful AI/ML control and navigation algorithms that guide everything from our autonomous navigation, obstacle avoidance, and payload optimization. Rhoman Aerospace has also taken autonomous navigation to the next level by taking GPS out of the equation. Through SLAM based techniques, Rhoman has developed the next generation of autonomous navigation technology in GPS denied and degraded environments that can be...
leveraged by any autonomous system.

**Collaboration (COL)**

Rhoman Aerospace has made significant advancements in Human Machine Interaction (HMI). Our RhomanCraft flight vehicles require a soldier to enter the GPS coordinates of the drop zone, toss resupply goods into the trailer, and hit launch. The flight vehicle autonomously launches, delivers the goods, and returns to the trailer. It also uses its AI-equipped camera system to avoid soldiers while dropping a resupply push-package. Rhoman has experience designing and planning human-machine teaming for mission execution.

**External Systems (EXT)**

Rhoman Aerospace specializes in dealing with adapting payloads to UAV to maintain optimal flight control and stability with any moving (robotics) or shifting (loose cargo, medical supplies, etc) - so we are experienced with regards to integrating external systems with vehicles.

Rhoman Aerospace’s 4ft x 8ft multi-rotorcraft is designed to fit with existing vehicle infrastructure and be an expeditionary and forward deployable autonomous resupply flight platform. Carrying 50 to 100 pounds of payload, the RhomanCraft 4x8 can autonomously deliver supplies with a combat radius of 15km. This sophisticated flight vehicle leverages Lidar, cameras, laser altimeters, sonar (detecting height above ground), IMUs, GPS, and other sensors in combination with complex autonomous navigation, SLAM, and obstacle avoidance methodologies and algorithms to ensure the most effective and most safe flight vehicle on the market.

**Other Critical Rhoman Aerospace Impact Areas:**

**Autonomous Unmanned Logistics System (ULS-A)**

Rhoman Aerospace’s 4ft x 8ft multi-rotorcraft is designed to fit with existing vehicle infrastructure and be an expeditionary and forward deployable autonomous resupply flight platform. Carrying 50 to 100 pounds of payload, the RhomanCraft 4x8 can autonomously deliver supplies with a combat radius of 15km.

**Human Machine Teaming**

RhomanCraft flight vehicles require a soldier to enter the GPS coordinates of the drop zone, toss resupply goods into the trailer, and hit launch. The flight vehicle autonomously launches, delivers the goods, and returns to the trailer. It also uses its AI-equipped camera system to avoid soldiers while dropping a resupply push-package. Rhoman has experience designing and planning human-machine teaming for mission execution.

**Medium Equipment Trailer**

Future Army trailer and vehicle infrastructure will require charging capabilities for the electronic autonomous ground vehicles and electronic flight vehicles of the future. Rhoman is designing and architecting auto-land and recharge systems for trailers for our electric flight vehicles, so we are in a prime position to support the creation of multi-purpose trailers for the future.

**4. ENGINEERING & DESIGN CAPABILITIES**

Rhoman Aerospace’s team of engineers has experience designing and delivering flight hardware, avionics systems and power systems for space, terrestrial space, and autonomous aquatic systems.
From modeling and simulation through control systems to power systems and structural frames, Rhoman can design and engineer ground and flight vehicle components and complete systems.

5. Prototypeing and Production Capabilities

Rhoman Aerospace is focused on delivering key flight vehicle prototypes to uses for product demos and use-case tests, so our manufacturing area and engineering talent is optimized around prototyping capabilities and speed. We have the needed design, engineering and fabrication in-house and through existing previous project collaborators to accomplish component or full system prototyping needs for ground, air, and autonomous vehicles.

6. Personnel with a Relevant Technical Background

Our team includes engineering experts, startup advisors, and advisors in aerospace, military, and defense industries. Specifically, we have expertise in autonomous navigation, collision avoidance, space-flight hardware and anti-ballistic structural design, battery and power and thrust systems, systems integration and verification, and quadcopter design and flight control dynamics (FIGURE/IMAGE). Rhoman’s amazingly talented team consists of engineering experts, including 2 PhD’s in Aerospace, 1 master’s in mechanical engineering, and other former NASA JPL engineers who provide ad-hoc guidance and support.
Founders/Management Team

**Thomas Youmans, Co-Founder & CEO**  
Former Systems Engineer & Data Scientist, NASA JPL  
MS in Mathematics & Statistics from Georgetown University, undergraduate double BA in Physics & Economics  
For the past 4 years, Tom Youmans was a Systems Engineer & Data Scientist at NASA Jet Propulsion Laboratory designing and developing the right hardware solutions to complex aerospace problems and navigating aerospace bureaucracy to advance proposals and projects with private and public partnerships through NASA. More specifically, Tom Youmans worked with SMEs to build spacecrafts for NASA’s Jet Propulsion Laboratory, and planning JPL mission architectures.  
Tom Y has managed, coordinated, and secured labor plans, budgets, and institutional commitment for hardware development and mission operations from industry and academic partners (Lockheed, FFRDCs, Foreign and Domestic Governmental agencies and Universities). Beyond planning missions and synchronizing design requirements from science objectives to spacecraft and subsystem needs, Tom has applied data science techniques to plan testing for the Mars2020 drill ($2B mission launching 2020), and performed machine learning and statistical analysis to determine spacecraft and instrument engineering requirements for operability in high-radiation environments during a Jupiter mission.

**Thomas Callen, Co-Founder & COO**  
Former Sr. Management Consultant in Strategy, Operations, and Technology  
MBA, University of Notre Dame  
For the past 3 years, Tom Callen has been a Senior Consultant at a Management Consulting firm specializing in Strategy, Operations, and Technology. More specifically, Tom Callen specializes in working with startups to launch solutions to market and recruiting and managing operations teams to support product launch efforts. He has extensive experience working with startups to develop and implement its end-to-end market launch strategy in multiple, simultaneous markets, including the management of all pilot and full market launches.  
In addition, Tom Callen has extensive experience in program and project management, with specific focus on high priority, complex operations improvement programs. His experience includes business management, business strategy, product implementation, program and project management, and finance.

**James Croughan, Lead Engineer**  
PhD, University of Southern California, 2020, Aeronautical & Astronautical Engineering, Former Project Manager, Hydrospace Group  
James has 5 years of experience in structural engineering and mechanical engineering with an emphasis in aerodynamics and design. James has designed, engineered, and coordinated production of innovative custom products for the aeronautical, astronomical, and testing-systems industries, including motors for aeronautical and astronomical industries.  
In addition, James has conducted structural and dynamical studies of system designs. He has extensive experience in dynamic feedback loop control systems in high-velocity aeronautical systems. James serves as Rhoman Aerospace’s Structural and Dynamic Control Systems Lead.
Clarence J Henderson, Strategic Military & Defense Advisor
Strategic Military Advisor; Force Development Director of Staff for Combined Security Transition Command-Afghanistan; USAR, Former Infantry Brigade Combat Team Commander, Army Staff, Future Force Modernization DoD Ecosystem Architect
US Army War College, Master of Strategic Studies, MS Agriculture and Statistics

As a former IBCT Commander, Clarence has mastered combined arms maneuver, managed large complex staffs, and thrives in ambiguous conditions. Deployments and missions have included high intensity combat in Iraq and Afghanistan; peacekeeping and security throughout the Sinai, Central and South America, and the Caribbean; bilateral training in South Korea, Japan, Australia, and Germany; and multiple no-notice Defense Support of Civilian Authorities for disaster response in Texas; amongst others.

Clarence matches existing defense requirements to technological solutions by navigating the complex DoD innovation ecosystem. Specifically, he designs solutions to existing defense problems and then recruits entrepreneurs who possess unique technologies that match the solution.

Engineering & Design Team
Our amazingly talented Rhoman Aerospace team includes engineering and business experts, and advisors in aerospace, military, and defense. Our engineering team of PhDs, Mechanical Engineers, and former NASA engineers was uniquely selected to ensure that all skill gaps are competently covered:

- PhD, Autonomous Systems
- PhD, Flight Dynamics
- MS, Mechanical Engineering
- VTOL design, constructing and coding experience
- 3D area map design and programming

Our team of Advisors brings a wide array of skills and experience, including military and defense contracting experience, engineering experience, and aerospace startup experience.

Management & Advisors

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomas Youmans</td>
<td>CEO</td>
<td>Systems Engineer, NASA JPL</td>
</tr>
<tr>
<td>Thomas Callen</td>
<td>COO, Management Consultant</td>
<td>MBA, Management Consultant</td>
</tr>
<tr>
<td>James Henderson</td>
<td>DoD Advisor, IBCT Commander</td>
<td>Former IBCT Commander</td>
</tr>
<tr>
<td>Bjorn Cole</td>
<td>Tech Advisor, Research Engineer</td>
<td>GTRI/LM</td>
</tr>
</tbody>
</table>

Dynamics Engineer, NASA JPL, Design and guidance, Dynamic structural review, verification
Structural Engineer, NASA JPL, Structural design and planning, Structural/functional review

Fig. 6: The Rhoman Aerospace Leadership and Advisory Team

Engineering Team

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Specializations</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD Aerospace, Dynamic Controls</td>
<td>Hardware and Power system design, construction &amp; delivery for autonomous flight and marine systems, dynamic flight control research and programming</td>
</tr>
<tr>
<td>MS Aerospace Engineering</td>
<td>CAD flight vehicle design and modeling, electric human payload helicopter power systems and design, battery testing, structures</td>
</tr>
<tr>
<td>BS Aerospace Engineering</td>
<td>Quadcopter design, build, code and fly, powertrains</td>
</tr>
<tr>
<td>BS Computer Science</td>
<td>Embedded programming, robotics, sensor fusion, hardware testing and integration</td>
</tr>
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Fig. 7: Our experienced team provides a unique approach to the center-of-mass research proposition
7. **Government Contracts & Past Performance**

Rhoman Aerospace currently has a contract with the Federal Aviation Administration (FAA). Entitled ‘Regulations to Ensure eVTOL Control with Potential Shifting Payload,’ the proposed research will provide data to address the safety implications of control systems for multi-rotorcraft control and stability with potentially shifting payloads, as necessary for the multitude of eVTOL vehicles currently being developed for anticipated widespread use in and above dense urban areas. Specifically, this data will lead to industry standards to set safety expectations, yielding recommendations for certification, and validation tests for eVTOL craft.

Rhoman also has a Research Grant from the National Science Foundation into the technical applicability and customer requirement needs for 50-500lb payload vertical take-off and landing flight vehicles. The grant was initiated in October 2019.

8. **Previous Technical Accomplishments**

Rhoman Aerospace is currently building and testing a 4ft by 8ft vertical take-off and landing flight vehicle for the Federal Aviation Administration and testing unique hardware and software solutions to address shifting payloads on a UAV. Supported by 7 issued and pending non-provisional patents, Rhoman Aerospace is a unique leader in autonomous flight vehicles, payload adaption for moving vehicles, and autonomous robotic system & human teaming.

9. **Applicable Equipment and Facilities**

Rhoman Aerospace rents both warehouse and manufacturing equipment from our warehouse location in Van Nuys, CA. Our facility provides access to a warehouse space, as well as all the equipment, tools, CNC machines, and welding machines that is more than sufficient to complete all required projects and work related to the advancement of our flight vehicle and logistics solutions and GVS OTA initiatives. More specifically, the warehouse space includes equipment such as welding equipment, 3D printing, laser-cutting, textiles fabrication, soldering equipment, etc., which is more than enough work space and room for the entire Rhoman Aerospace team to work simultaneously on FAA related contract, GVS OTA initiatives, as well as other ongoing product development, research, and ongoing product development and other business initiatives.

*Rhoman Aerospace has the right team in place to perform the required prototyping, research, and development to support the warfighter from flight platforms to autonomous vehicle systems.*