

THE OFFICE OF NAVAL RESEARCH

Autonomous Aerial Cargo/Utility System (AACUS)

Concept of Operations (CONOPs)



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Autonomous Aerial Cargo/Utility System Innovative Naval Prototype Concept of Operations

EXECUTIVE SUMMARY

The primary goal of the Autonomous Aerial Cargo/Utility System (AACUS) Innovative Naval Prototype (INP) program is the development of advanced autonomous capabilities to enable rapid cargo delivery by unmanned and potentially optionally-manned Vertical Take Off and Landing (VTOL) systems. AACUS-enabled vehicles should provide affordable and reliable rapid response cargo delivery to distributed small units in demanding, austere locations and environments. AACUS encompasses the development and implementation of VTOL-based obstacle detection and avoidance, as well as autonomous landings at unprepared off-field non-cooperative landing sites, including dynamic contingency planning to the point of landing with goal-based supervisory control by any field personnel with no special training.

These capabilities are expected to form part of an open architecture framework in order to be used across different VTOL platforms with sufficient reliability to be entrusted with precision cargo delivery and eventually human casualty evacuation from remote sites. The resulting system is expected to be used across a range of VTOL configurations and sizes. Other desired attributes of AACUS include the capability to rapidly respond in all weather conditions (i.e., weather conditions that exceed current manned limitations), be able to be launched from sea and land¹, and to autonomously detect and negotiate precision landing sites in potentially hostile settings, which could require significant obstacle and threat avoidance and evasive maneuvering in the descent-to-land phase.

Core assumptions for AACUS include the existence of a beyond line-of-sight command and control capability (i.e., an air operations center has the ability to task and redirect any Unmanned Aerial Vehicle (UAV) operating in its area), the ability to negotiate with other manned and unmanned aircraft in shared airspace, the presence of advanced weather radars, and other typical technologies found on present-day unmanned systems. While enablers for the AACUS vision, these core assumptions will not be the focus of any major research and development efforts under the current AACUS program.

Navy & Marine Corps Operational Relevance

1) Expected operational outcomes/end state/results

AACUS is an Innovative Naval Prototype (INP) sponsored by the Office of Naval Research (ONR). The goal of the AACUS INP is to develop and demonstrate intelligent autonomous capabilities for a future aerial cargo and utility systems that provides rapid, affordable, reliable,

¹ AACUS is primarily focused on the ground landing phase of operations while a related ONR program, SALT, is focused on shipboard operations.

shipboard-compatible, supply and casualty evacuation. AACUS technology is intended to support and or enhance these missions when other cargo and insertion/extraction options are not available, or when the risk of using manned aircraft is too high.

The core goal of the AACUS effort is the development of technology that affords autonomous obstacle and threat avoidance with autonomous precision landing capabilities including contingency management until the point of landing in unprepared landing sites. This system should include a goal-based supervisory control component such that any field personnel can request and negotiate a desired landing site. Moreover, this system should communicate with ground personnel for seamless and safe loading and unloading. The system should be open architecture framework that allows it to be used across different air vehicle platforms (i.e., VTOL platform agnostic.)

2) Operational capability gaps and payoffs

a) Capability Gaps/ Shortfalls

- i) “Executing resupply is significantly challenging due to primarily to the lack of paved roads coupled with difficult, mountainous terrain which has diminished the effectiveness of traditional means of overland logistics movement using ground transportation. The Joint Force needs an alternate means to provide sustained, time-sensitive, logistics support over widely dispersed locations.” *2011 Joint Cargo Unmanned Aircraft Systems Concept of Operations (22 June 2011)*
- ii) “...combat in urban environments has shown that moving a casualty can be difficult and time consuming. Moving an individual only a few hundred yards can take an hour or more. The extended lines of communication between forces and their FOBs (inclusive of Medical Evacuation (MEDEVAC) by aircraft) are at risk of enemy ambush or improvised explosive device (IED) attack.” *Unmanned Aerial System Casualty Evacuation Concept of Operations and Safe Ride Standards (10 May 2011)*

b) New Capability

There are three different aspects of the AACUS program that make it unique compared to other VTOL (and conventional) cargo Unmanned Aerial System (UAS) programs:

- i) Autonomous detection and negotiation of precision landing sites in potentially hostile settings require significant obstacle and threat avoidance, with potentially evasive maneuvering in the descent-to-land phase.
 - (1) While critical to AACUS, such a capability would substantially improve all unmanned VTOL programs (i.e., those currently focused on Intelligence, Surveillance, and Reconnaissance (ISR) missions). It could also provide additional capability for manned aircraft as a backup mode, and lastly, would have long-term civilian and commercial applications, particularly for first response agencies.
 - (2) This capability is explicitly called out in the *Universal Needs Statement (UNS) For the Cargo UAS, (27 August 2008)* i.e., “Flight controls and navigation systems must support continuous autonomous operations with an ability to redirect resupply missions enroute. Incorporation of autonomous UAS/UAV collision avoidance technology must be considered.”
- ii) While the primary mission of AACUS is resupply/retrograde, there exists a long-term focus on Casualty Evacuation (CASEVAC), and possibly MEDEVAC missions.

- (1) This also has significant civilian, as well as military, implications.
 - (2) Given that reliability, trust, and cultural acceptance are significant drivers of the success of human payloads, it is recognized that these are longer term goals.
- iii) A focus on developing a user interface that requires little-to-no training for field personnel.
- c) Warfighter payoffs**
- i) AACUS technology for Cargo and CASEVAC UASs will provide increased operational support for deployed units and will provide the payoffs needed by the warfighter previously identified in the Joint Urgent Operational Needs Statement (JUONS) U.S. Marine Corps, Central Command (MARCENT), Cargo UAS Services, 11 Jan 2010 and Universal Needs Statement (UNS) For the Cargo UAS, 27 Aug 2008:
 - (1) "...the CORPS will need an alternate means to provide time-sensitive logistics support to greatly dispersed locations. Cargo UASs can provide a solution to move tailored ammunition, supplies, fuel/water, or weapons packages in adverse weather from the sea or ashore over harsh terrain as required (24/7)." *Universal Needs Statement (UNS) For the Cargo UAS, 27 Aug 2008*
 - (2) "The need is for a "Flying Truck" that can be risked in adverse weather vice manned aircraft." *Universal Needs Statement (UNS) For the Cargo UAS, 27 Aug 2008.*
 - (3) "Incorporation of the Cargo UAS will better enable the Marine Air Ground Task Force (MAGTF) Common Operating Picture by improving visibility over resupply operations, identifying key logistic sites, and maintaining unit mission readiness." *Universal Needs Statement (UNS) For the Cargo UAS, 27 Aug 2008.*
 - ii) As previously mentioned, AACUS technologies could also transition into manned aircraft, and can complement mission planning systems for manned systems, thereby reducing the cost of development for these systems and reducing the operational risks to manned aircraft.
- d) Requirements**
- i) JUONS MARCENT, Cargo UAS Services, 11 Jan 2010. Approved by J8 and assigned to USMC by Joint Rapid Acquisition Cell, (JRAC) for immediate USMC resolution.
 - ii) In general, the basic desired capabilities for an AACUS-enabled system are described below with the understanding that the AACUS program is attempting to advance the state-of-the-art in a high-risk setting; therefore these are guidelines instead of strict specifications. Moreover, this INP is focused on the sensor suite and interface development, so vehicle specifications are not mandatory for AACUS, but are provided for context.
 - The general air vehicle type is expected to operate at high density altitudes (greater than 12,000 ft density altitude), delivering multiple in-stride cargo drops, over round trip distances with a threshold of 150 nautical miles and an objective of 365 nautical miles, therefore reducing the number of ground transport delivered items.

- The air vehicle should be one that can carry a threshold of 1600 lbs and an objective of 5000 lbs of payload internally (with some internal capacity for casualty evacuations).
- The air vehicle is required to travel at speeds of 110 knots threshold and 250 knots objective. Within the terminal area of 5 nautical miles, the air vehicle should be able to descend and land within a threshold of 4 minutes and an objective of 2 minutes and execute an autonomous landing as close to the requested site as possible (<1 m error from computer-designated landing site center point) without over-flight of the landing zone (i.e., the vehicle executes a straight-in approach).
- In addition, the air vehicle shall be able to operate at night (24/7), over harsh terrain, and in all types of environments (weather conditions to exceed manned flight capabilities, satellite-denied).

AACUS Operational and Mission Descriptions

Ultimately, the operating environments for AACUS technology are the same for all Navy and Marine Corps units. Of particular interest to the USMC are operations in high/hot environments with steep terrain. One of the goals of AACUS is to dramatically expand on the operating environments of existing UASs, while also making inroads into operating environments that present significant risks to manned aircraft (i.e., weather, threat, terrain, etc.)

The subset of missions and tasks that will be addressed through the course of the AACUS INP will likely include:

- Logistics (including replenishment, resupply, transport, and equipment retrograde)
 - Including sling-load capabilities.²
- Long-term: CASEVAC and potentially MEDEVAC.

Figures 1 through 3 depicts routine and urgent Cargo UAS logistics missions, as well as a CASEVAC mission. These three figures represent typical missions that AACUS technologies would support, as well as the major functions of such missions with corresponding increasing autonomous capabilities and timelines for achieving these desired goals. The high-level functions (i.e., Mission Request, Mission Planning, Autonomous Flight, etc.) described at each step in the Mission Diagrams are accompanied by increasing potential levels of autonomy with corresponding color-coded boxes. The color of each box reflects the estimated level of maturity for the technologies needed to accomplish each capability.

For example, for the Autonomous Flight function (#3) in Figure 1, the four supporting capabilities are: Planned Route, Obstacle Avoidance, Air Traffic Avoidance, and Weather Avoidance. Both “Planned Route” and “Obstacle Avoidance” are coded as Green because technologies exist and have been previously demonstrated (White Paper, Cargo UAS Tech Roadmap (29 Jun 11)).

² It should be noted that for BAA12-004, sling load designs are specifically not included in order to focus on the autonomous landing aspects of AACUS.

Global Hawk, Predator, and other UASs already perform autonomous flight along planned routes using Commercial off-the-shelf (COTS) GPS/INS systems. Also, there have been several DoD and commercial UASs that perform autonomous detection and avoidance of stationary obstacles. Though these systems are not used by operational UASs at this time, they have been successfully demonstrated and could rapidly be integrated into AACUS technologies.

The technologies for autonomous “Air Traffic Avoidance” are less mature and are coded as Yellow. There have been numerous UAS flights that have demonstrated autonomous air traffic detection and avoidance (White Paper, Cargo UAS Tech Roadmap (29 Jun 11)). While established in the commercial aviation community for collision avoidance (i.e., TCAS II), these systems need maturation for UAS applications, but it is expected that one or more of these technologies will be sufficiently reliable in the near term that they to become AACUS technologies. The final supporting capability under Autonomous Flight is the technology for the “Weather Avoidance” task, which is coded as Red/Yellow due to a lack of a mature and established technology needed for near-term implementation (White Paper, Cargo UAS Tech Roadmap (29 Jun 11)).

It should be noted that re-planning or dynamic re-tasking is an element of all of AACUS mission areas. This reflects the realities of the battlefield, where either the command organization in charge of the UASs determines that an in-flight change in tasking is required, or the UAS automatically determines that it cannot execute the planned mission and must either re-plan or divert to another destination (perhaps because of hostile action, damage, or internal system malfunction). If the command dictates a change of plan, then it is expected that the new mission plan will be generated at the Ground Control System (GCS) and uploaded to the UAS. If the UAS autonomously makes a significant alteration to its mission plan, then it must notify both an operational supervisor and the operator who requested the task, which might result in an override or modification to new plan proposed by the Cargo UAS (CUAS).

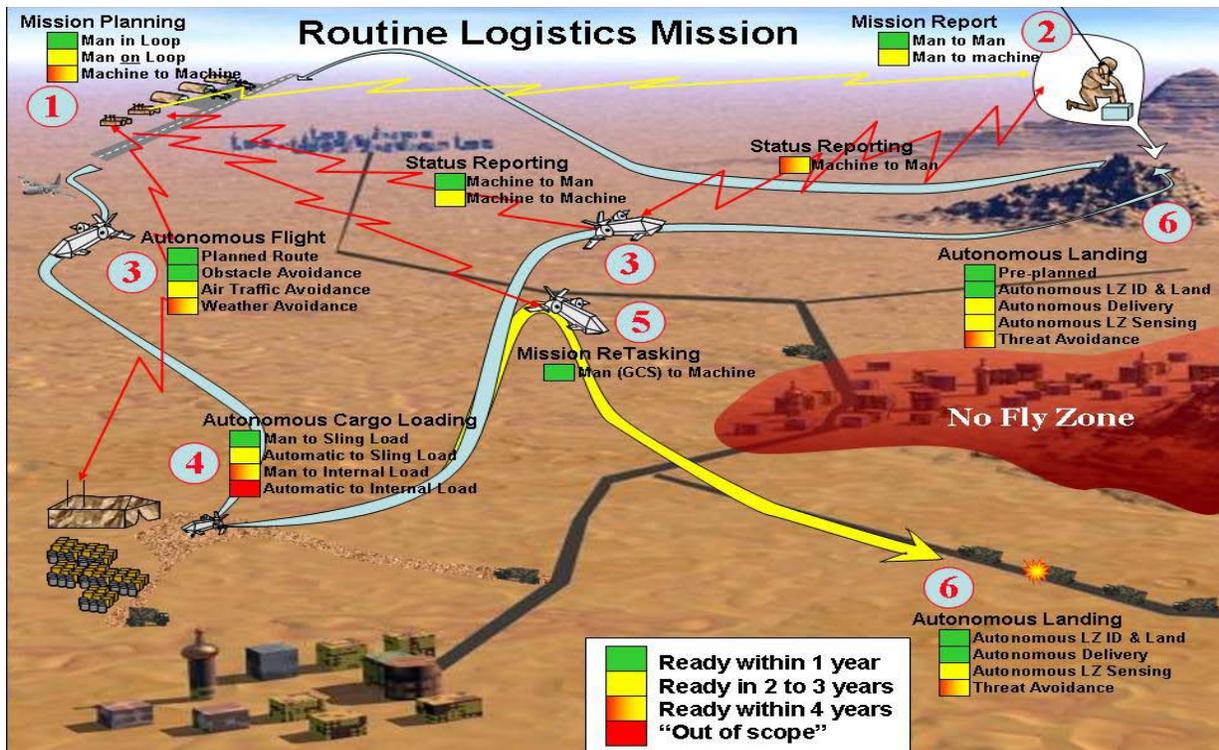


Figure 1 Routine AACUS Logistics Mission with Replanning

The primary focus area for AACUS in Figures 1 through 3 is the Autonomous Landing function, whose sub-functions overlap with many of the other areas. Table 1 lists core capabilities AACUS technologies should support that are above and beyond those supported in current and expected future UAS operations (i.e., terrain and collision avoidance, on-board systems diagnostics, and airspace integration and de-confliction capabilities are systems that either are or will be expected to be on all future UAVs). An example scenario for AACUS is detailed in Appendix A of this report.

In the legends of each figure, the timeframes associated with the development of the associated technologies should not be interpreted literally; rather they indicate a likely progression in time. The expectation is that the successful development and testing of the related technologies in nominal and off-nominal (i.e., contingency) settings would happen prior to FY17.

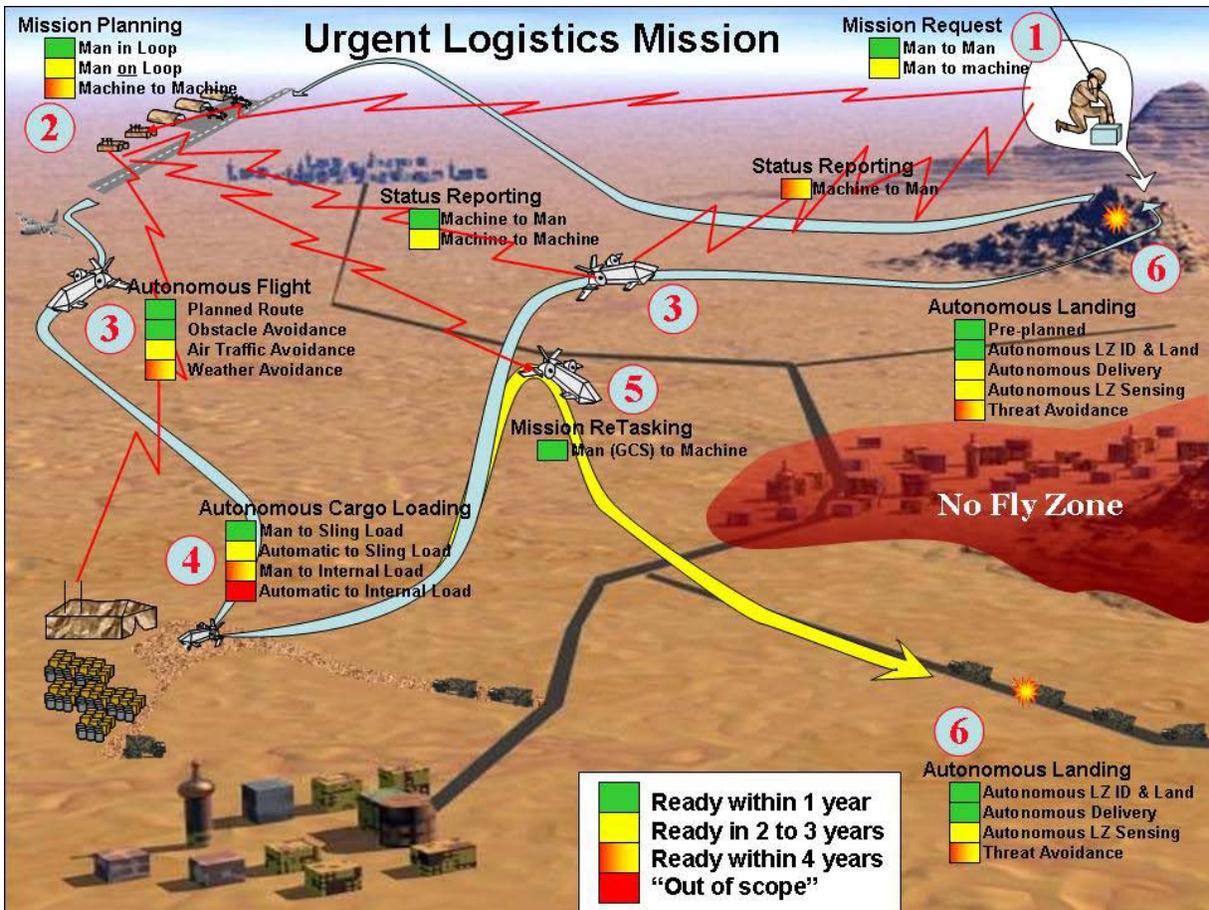


Figure 2 Urgent AACUS Logistics Mission with Replanning

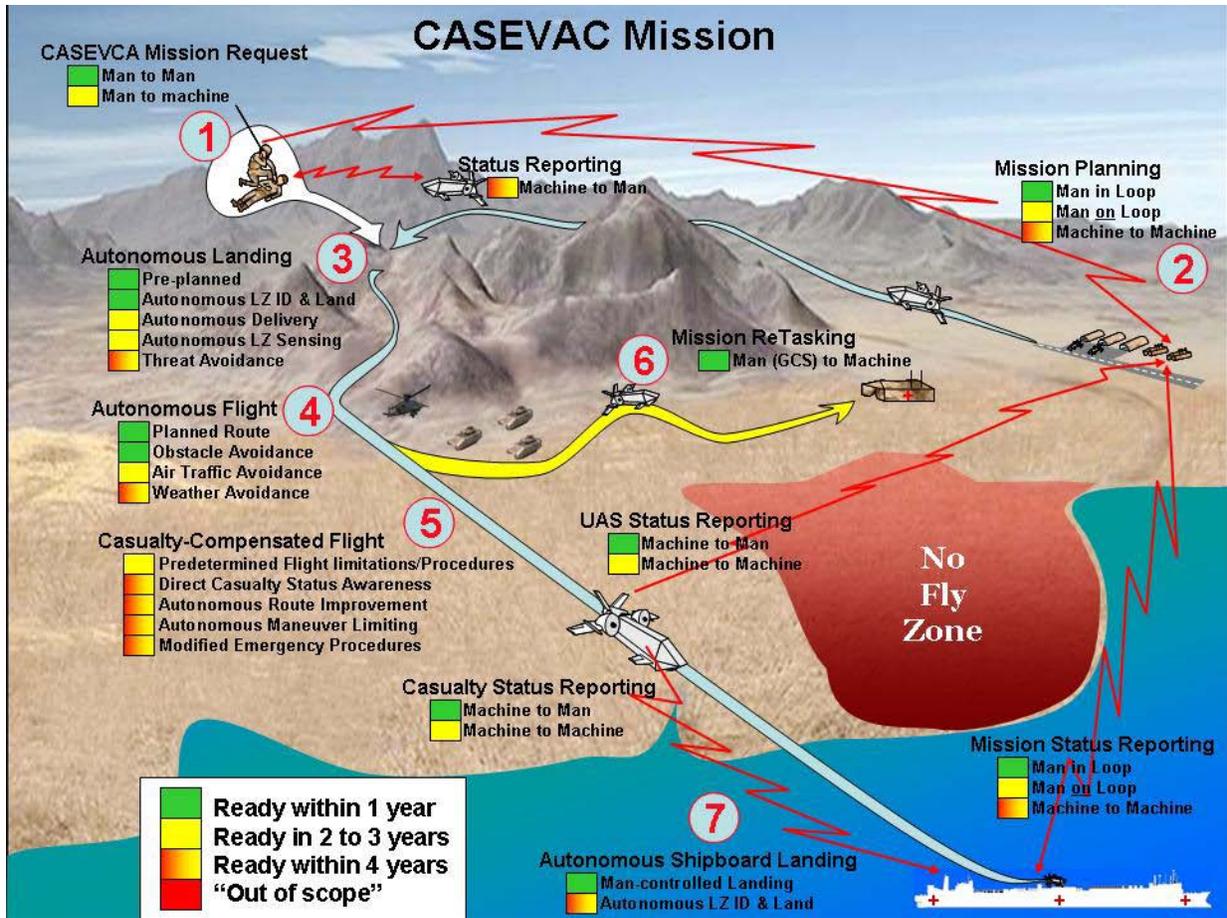


Figure 3 AACUS CASEVAC Mission with Replanning

Table 1: Expected AACUS Capabilities

The AACUS-enabled Cargo UAS (CUAS) should be able to autonomously land and takeoff from unprepared and potentially unmapped sites in Instrument Meteorological Conditions (IMC) and non-icing conditions, in high and hot environments, as well as in dust and sand conditions with minimum visibility.
The AACUS-enabled CUAS should be able to avoid obstacles (both static and dynamic) in flight as well as in the descent-to-during all flight phases.
The AACUS-enabled CUAS shall be capable of autonomously generating complete paths from takeoff to landing, modifiable in real time by a human-on-the-loop or an Operations Center Supervisor (OCS) in real-time. It should autonomously navigate this route and notify the supervisor and requesting task requestor of any substantial significant deviations.
The AACUS-enabled system shall be capable of remote supervisory control at any point in the mission across various agencies (i.e., field personnel, trauma unit, AOC supervisors.)
Field operators must be able to operate both asynchronously as well as beyond line-of-sight. Field operators should not be expected to be co-located with the landing vehicle, nor should they be required to have visual contact with the vehicle during landing.
The AACUS-enabled CUAS shall be capable of mission re-planning (including path and goal modifications) from a GCS while in flight, both within data link range and Beyond

line-of-sight (BLOS).
All AACUS-enabled CUAS altitudes will be determined by the onboard sensing and flight control system, with the expectation that the vehicle will have knowledge of flight plans filed by other aircraft.
<p>During flight, the AACUS-enabled CUAS shall:</p> <ul style="list-style-type: none"> • Execute preset lost-link procedures to attempt to reacquire the link in the event of data link loss within data link range; • Execute contingency plans in the case of failure of data link reacquisition, a last-minute change in the safety of the landing site, or upon wave-off command by a human in the loop. • Execute an abort if the CUAS detects an unsafe condition.
<p>The AACUS-enabled CUAS shall be able to be terminally guided from a variety of end-users with no specialized training as well as from various locations (field personnel, medical personnel, supply personnel, remote command center); Field users could be BLOS from the launch location and should be able to interact with the CUAS via an unobtrusive device. Terminal guidance shall consist of the following options at the destination location:</p> <ul style="list-style-type: none"> • Update the requested point of landing at any point in the landing sequence • Abort delivery to hold at a remote location. • Abort approach and commence again either to the same or an alternate location. • Abort delivery to return to launch location with original load (or any other location specified by an air operations supervisor at a remote command center.) • Users should be able to specify different flight profiles for supply vs. CASEVAC missions
The AACUS-enabled CUAS should communicate with ground personnel for expeditious and safe loading and unloading. There should be a primary and alternate form of communication in the case of primary system failures.

Appendix A

AACUS Example Scenario Support of forward deployed small unit

A forward forward-deployed unit has established a Combat OutPost (COP) near a mountaintop overlooking a valley. From their vantage point they can call in air strikes on insurgent caravans transporting weapons. The unit was inserted at night by helicopters to a plateau about approximately 500 feet down the backside of the below the ridgeline. This plateau also serves as the supply delivery point for the unit, and the Marines have must carry all supplies over the ridgeline and then down to the COP. The helicopters fly at night, but villagers have heard them, and there are enemy groups searching for the COP. Eventually the unit comes under fire. There are two serious casualties, but they are in stable condition. The unit is also running low on supplies.

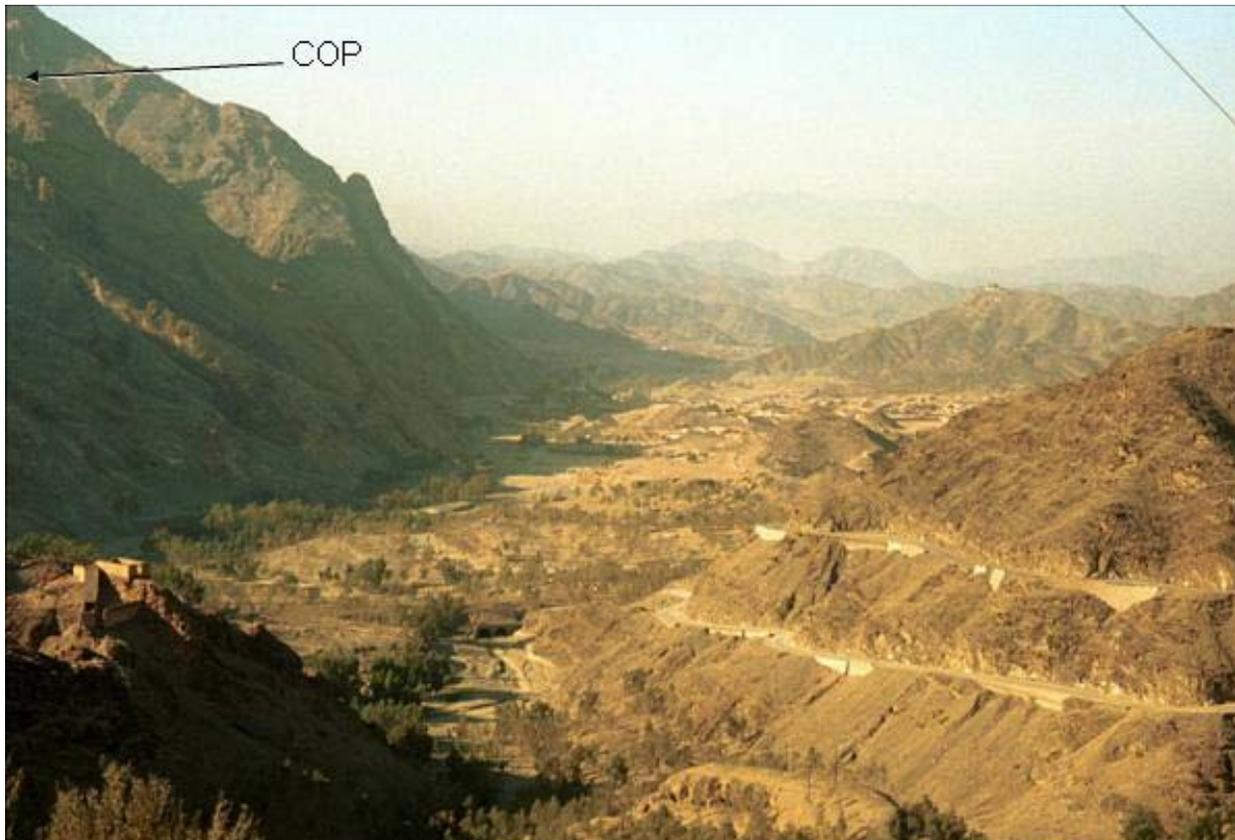


Figure 4 AACUS Scenario 1 depiction

The unit calls the Forward Operating Base (FOB) for air support and supplies but no manned assets are available. They are told that a Cargo UAS mission will be sent in later that night. The unit sends its requested landing coordinates of the supply delivery point, the supplies needed, and any time constraints to the FOB. The FOB forwards the unit position and supply list directly to the logistics support center.

1. The Integrated Mission Planning System (IMPS, a futuristic mission planning system) checks the status of all the Cargo UASs in flight, and on the ground and determines that no airborne aircraft can acquire the necessary supplies or has enough fuel onboard to support the unit and therefore should not be re-tasked,
2. IMPS selects a Cargo UAS for the mission (tail # UCV-301) because it has the necessary fuel load and its internal monitors report that all systems are satisfactory.
3. IMPS automatically:
 - a. retrieves data from the Air Operations Center database for existing flight plans for all the manned and unmanned missions planned for the expected duration of the mission (including possible contingencies),
 - b. retrieves data from the Artillery Coordination Center, the Advanced Field Artillery Tactical Data System (AFATDS) database for all the artillery missions planned for the next 45 minutes,
 - c. retrieves data for all the air operations danger/avoid zones, the socio-political no-fly zones, and political/national boundaries from the GIS database,
 - d. retrieves data from the Tactical Ground Reporting System (or some similar distributed information sharing source),
 - e. retrieves the weather data for the area from the Meteorology Operations Center (METOC) database, and
 - f. plans an initial route for the UAS to safely and quickly go to the supply depot, and then to the COP, and then back to base,
4. The FOB Air Operational Command Supervisor (OCS) approves this flight plan.
5. IMPS sends the mission plan data to the Air Operations Center computer and the Artillery Coordination Center computer, and then
6. Sends the mission plan to UCV-301, which verifies all systems are satisfactory including appropriate fuel load and secure doors & access hatches, sounds a warning, turns on its running lights, receives a launch command from ground personnel, turns on its IFF transponder, starts its engine, takes off and begins flying to the supply depot,
7. UCV-301 provides ETA estimates to the supply depot, the OCS and the COP unit leader, and updates these frequently.
8. UCV-301 autonomously detects and avoids any obstacles that were not on the GIS not included in the stored GIS terrain/features database that was uploaded along with the mission plan and returns to its planned route as soon as the obstacle is passed,
 - i. If the deviation from the planned route is greater than $\frac{1}{4}$ mile and/or brings it within close proximity to any another airborne asset, it computes an alternate path and automatically sends the revised path to IMPS, which relays it as a change in flight-plan to the Air & Artillery computers. The OCS is notified of significant path changes and is given the option of modification.
9. UCV-301 also scans for, detects, and autonomously avoids other aircraft, including small UAVs that may not have cooperative sense and avoid avionics (e.g., TCAS, ADS-B, or Mode 5 IFF transponders), as well as birds that could cause damage to the UAS. Since UCV-301 is a VTOL aircraft, it can quickly transition to hover (a mid-air “stop”) if necessary to avoid other air traffic. The OCS is notified of possible unresolved/ambiguous conflicts.
10. UCV-301 also monitors all of its onboard systems while in flight, and reports any anomalies to IMPS so they can be entered into the maintenance schedule.

- a. If UCV-301 experiences a catastrophic system failure, it would report its problem/status immediately to the OCS and IMPS. All procedures and contingency plans for dealing with emergencies should be self-contained inside the UAV. In the case of an emergency landing, the UAS should autonomously look for a safe Landing Zone (LZ), with a high priority for landing in a known secure area, and execute an autonomous autorotation
 - i. The emergency plan should be communicated to the AOC Supervisor in real-time, with possible override capability in terms of landing site approval (management by exception). Once it lands and shuts down, it should notify IMPS and the OCS of its final status.
 - b. If this happens, IMPS would begin scheduling another cargo UAS to take assume the supply mission, and notify the supply system and the OCS of the change in Estimated time of arrival (ETA) and Tail Number for the replacement UAS. The OCS would then notify FOB CC of the situation, and the location of the downed UAS, so that it can be retrieved (or destroyed if necessary).
 - c. One option that could be executed if the UAS had been carrying sensitive supplies, or had been operating in an area where there were no safe/secure emergency LZs, is that the mission plan could have included procedures for a full-speed crash into an open, unoccupied area. The OCS should have input into this decision in real-time, precluding any loss comm scenario (in which event, UCV-301 would execute a known contingency plan.)
11. In the case of normal operations, the supply depot computer identifies the necessary supplies,
 - a. the supply team pulls the supplies,
 - b. brings the load to the Cargo UAS LZ, and
 - c. waits outside the Safe Distance Circle.
 12. UCV-301 lands, and depending on the configuration of the aircraft, may or may not have to shut down the engines. It then communicates to the supply team that it is safe to approach and load.
 13. The supply team confirms that the Tail Number on their supply order matches the Tail Number of the Cargo UAS that has landed.
 - a. The supply team then loads the UAS,
 - b. closes and locks the cargo doors,
 - c. moves to a location outside the Safe Distance Circle,
 - d. releases the UAS.
 - e. At any time, the Supply Team should be able to abort the operation.
 14. UCV-301 sounds a warning, verifies all systems are satisfactory including appropriate fuel load, secures doors and access hatches, sounds a warning, turns on its running lights, turns on its IFF transponder, and starts its engine (if previously shut down). Once the engine is running, the onboard sensors report to the autopilot that all systems are satisfactory.
 15. The UCV-301 notifies IMPS upon completion of loading and takeoff. The OCS should have the ability to select notifications for a CUAS state change.
 16. IMPS then sends data to the Air Operations Center computer and the Artillery Coordination Center computer reporting that UCV-301 is airborne and executing its flight plan to the COP.
 17. During the flight to the COP, the UCV-301 detects that there is a localized snow and an ice storm flowing over the lee of a peak that is on its flight path.
 - a. It automatically determines a path around the bad weather, which may require a new flight plan in the case of large deviations.

- b. Then UCV-301 notifies IMPS and the OCS of the route change, and no potential conflicts are detected.
 - c. The OCS can override the system and modify the planned route.
18. When UCV-301 is nearing the COP, it provides the unit leader with an estimate of how close and when it can get to the requested coordinates, as well as a set of alternatives if it cannot land at the requested site (as well as why it cannot land at the selected site). In this scenario, UCV-301 determines initially that the requested site is acceptable and generates an Estimated Time of Arrival (ETA).
 19. As it approaches the site in the last 25 ft to descent, UCV-301 detects an obstacle that makes it unsafe to land. It automatically executes a wave-off, contacts the unit leader to negotiate an alternate landing site.
 20. The unit leader, also equipped with data from a distributed information sharing source, approves an alternate landing site, and UCV updates its expected time to land.
 21. Once UCV-301 lands, it communicates to the unit leader and others in the COP that it is safe to approach for unloading/loading.
 22. Two Marines were wounded and are in need of immediate attention, so the unit leader contacts the OCS to request two casualties for evacuation on the UAS (this was not part of the original plan).
 23. Once approved by the OCS, IMPS generates a new return path for the UAS so that it goes directly to the nearest Trauma Unit, and transmits the new instructions to UCV-301.
 24. The two casualties are placed in the cargo compartment of UCV-301 along with their gear.
 25. The cargo doors on UCV-301 are closed, and the unit leader gives the launch order once all personnel are clear.
 26. UCV-301:
 - a. Verifies all systems are satisfactory including appropriate fuel load, secure doors and access hatches, and the landing site is clear of personnel.
 - b. Evaluates the terrain and obstacle data that it collected during its approach and descent, and computes a departure path.
 - c. It would normally execute a takeoff with rapid transition to high-speed forward flight to minimize threat risk and maximize stealth, but given the casualties on board, it executes a takeoff to minimize G-loads, rapid altitude changes, and maintains constant air pressure in the cargo compartment that matches the estimated air pressure for the altitude at the Trauma Unit which is at a lower altitude. Such a different takeoff/flight/landing profile should be selectable by a ground user.
 - d. Periodically updates the Trauma Unit on the ETA.
 27. UCV-301 communicates to the Trauma Unit that it is on final approach and then executes an autonomous patient condition-specific onboard landing at the designated UAV LZ. Once it lands, it shuts down its engine, and communicates to medical personnel that it is safe to approach.

Appendix B

Acronym List

AACUS	Autonomous Aerial Cargo/Utility System
AFATDS	Advanced Field Artillery Tactical Data System
AOC	Air Operations Center
API	Advanced Programmer Interface
Arty	Artillery
ASL	Above sea level
ASuW	Anti-surface warfare
ASW	Anti-submarine warfare
BLOS	Beyond line-of-sight
C2	Command and control
CASEVAC	Casualty Evacuation
CC	Company Commander
CG	Center of gravity
CM	Configuration management
COIN	Counter Insurgency Operations
CONOP	Concept of Operation
COP	Combat outpost
COTS	Commercial off-the-shelf
CUAS	Cargo Unmanned Aerial System
CVBG	Aircraft-carrier battle group
DA	Density altitude
DoD	Department of Defense
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities
EGF	Elite Guard Force
ETA	Estimated time of arrival
FAA	Federal Aviation Administration
FOB	Forward Operating Base
G	Gravity or gravitational acceleration
GCS	Ground control system
GIS	Geographic information system
Govt	Government
GPS	Global Positioning System
helo	Helicopter
HOGE	Hover out of ground-effect
HW/SW	Hardware/software
ID	Identify or identification
IFF	Identification friend-or-foe transponder
IMPS	Integrated Mission Planning System
INP	Innovative Naval Prototype
INS	Inertial navigation system
ISR	Intelligence, surveillance and reconnaissance
JFACC	Joint Forces Air Component Commander

JRAC	Joint Rapid Acquisition Cell
JUONS	Joint Urgent Operational Needs Statement
K	Thousand
KM	Kilometer
kts	Knots (nautical miles per hour)
LOS	Line of sight
LZ	Landing zone
MAGTF	Marine Air Ground Task Force
MARCENT	U.S. Marine Corps, Central Command
MEDEVAC	Medical Evacuation
METOC	Meteorology operations center
mi	Mile (statute mile)
MOE	Measure of Effectiveness
MOP	Measure of Performance
MPS	Mission Planning System
Nm	nautical mile
OCS	Operational Command Supervisor
ONR	Office of Naval Research
Ops	Operations
OR	Operating room
Plt	Platoon
PoR	Program of Record
RCS	radar cross-section
RF	Radio Frequency
RPG	Rocket propelled grenade
RTB	Return to base
SATCOM	Satellite communication
SUW	Surface warfare
T&E	Test and evaluation
TBD	To be determined
U.S.	Unites States
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UCV	Unmanned Cargo Vehicle
UGS	Unattended ground sensor
US	Unites States
USMC	United States Marine Corps
USN	United States Navy
USS	Unites States Ship
USW	Submarine warfare
VTOL	Vertical take-off and landing