

The Joint Precision Airdrop System Advanced Concept Technology Demonstration

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The US Army Natick Soldier Center (NSC) is teamed with the Joint Forces Command (JFCOM), US Air Force Air Mobility Command (USAF AMC), the US Army Project Manager Force Sustainment and Support (PM-FSS), and under the oversight of the Office of the Secretary of Defense (OSD) Advance Systems and Concepts (AS&C) office, along with numerous other government agencies and contractors to plan and execute the Joint Precision Airdrop System (JPADS) Advanced Concept Technology Demonstration (ACTD). The JPADS ACTD is integrating a USAF developed laptop-computer-based precision airdrop planning system known as the Joint Precision Airdrop System Mission Planner (JPADS-MP) with the USA Joint Precision Airdrop System (JPADS) in the “light” category of weight (2201-10000lbs rigged weights). The integrated system objectives include the ability to airdrop JPADS systems of up to 10,000 lbs rigged weight, from altitudes of up to 25,000 ft mean sea level (MSL), with up to 30kms of offset (in a zero wind condition), and land precisely within 100 meters circular error probable (CEP) of a preplanned ground impact point. An additional key metric is to have the final system work with the Enhanced Container Delivery System (ECDS) under a gravity drop (ECDS is not extracted), the type V platform, or a 463L pallet (when the payload can be item suspended) and for the entire decelerator/platform system to cost under \$60K (in FY04 \$s and in quantities of 100). This paper will provide an overview of the JPADS program goals, status of the effort with some flight test results to date. The paper will also introduce the reader to the JPADS Concept of Operation (CONOPS), highlight the research, technology and integration challenges associated with precision airdrop systems, and how the JPADS team is overcoming these challenges.

I. Introduction

The purpose of the JPADS ACTD is to meet the Combatant Commander (COCOM) requirement of sustaining combat power using high altitude, precision airdrop as a direct and theater delivery method, into a dynamic, dispersed, and insecure battlespace. This must be done with speed and flexibility to provide an optional capability previously unavailable to the COCOM, and to enable decisive operational superiority. The need for JPADS within the Department of Defense (DoD) is clear from its ranking within the ACTD reviews. JPADS was ranked within the top 5 ACTD FY04 new starts by all COCOM’s, and the Joint Requirements

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Oversight Council (JROC) for FY04 new start ACTDs ranked it the number 2 priority. An image of the JPADS Concept of Operation (CONOPS) is shown in figure 1 on page 6.

This JPADS ACTD is integrating the USAF Joint Precision Airdrop System Mission Planning (JPADS-MP) hardware/software with the US Army Joint Precision Airdrop System-Light (JPADS-L) airdrop systems (10Klb rigged weight capability). The JPADS-MP provides a mission-planning tool with wireless connectivity to the Army JPADS-L airdrop system(s) on-board the aircraft. This integrated technology allows for rapid pre-flight JPADS programming and in-flight mission, threat, and terrain/environment changes, allowing for immediate reaction by the user to real world variations from plan. It is the intent of the JPADS ACTD to demonstrate and assess systems and technologies that can provide a global delivery system capable of 24-hour fort (CONUS) to fighter (unit/teams) distribution. The JPADS-MP system resides in the cockpit via a high altitude compatible laptop computer that is also loaded with Combat Track II (CTII) software and connected to the CTII Hardware. (CT II provide secure satellite communication)

This paper provides the status of the JPADS ACTD program since its start (1QFY04, DoDs FY start on 1Oct), with a focus on the technical aspects of JPADS, an introduction to the CONOPs for JPADS, and the general research, technology and integration challenges associated with precision airdrop. It also briefly outlines the process for accomplishing the ACTD objectives, transitioning residuals for long-term service Operations and Maintenance (O&M) support, and insertion into the formal acquisition process. It should be noted that both the JPADS-MP (USAF) and JPADS (USA) efforts (two are currently competing in the 10,000 lb fully rigged weight (FRW) category, the Dragonfly and the Screamer) are based on prior NSC work sponsored by numerous USAF and US Army sources.

II. The Advanced Concept Technology Demonstration (ACTD) Program

In 1994, the Department of Defense (DoD) initiated the ACTD program to adapt the acquisition process to the changing economic and threat environments. An ACTD program emphasizes the assessment and integration of maturing commercial or government technologies that address critical military needs to expedite transition of those technologies to the warfighters. ACTD's must be Joint and are considered to be the highest priority Office of the Secretary of Defense sponsored science and technology programs within the DoD. The overarching objectives of an ACTD are to conduct meaningful demonstrations of a capability, develop and test concepts of operation to optimize military effectiveness, and prepare (if warranted) to transition the capability into acquisition without loss of momentum. At the conclusion of an ACTD, there are three potential outcomes. 1) Acquisition and fielding of the residual capability that remains at the completion of the demonstration phase of the ACTD to provide an interim and limited operational capability. 2) Fielding of the residual capability without acquiring additional units if the user's need is fully satisfied. 3) Terminating the project or returning it to the technology base if the capability or system does not demonstrate military utility. Instead of testing to requirements as in an operational or developmental test, a Joint Military Utility Assessment (JMUA) is utilized, which identifies "value added" as the overarching assessment metric to determine if the capability (technology and/or procedures) warrants further development or acquisition. In attempting to identify value added, a JMUA must cope successfully with two major challenges: 1) Incorporate the technology into realistic operational scenarios with real users and a realistic range of conditions; and 2) Collect data to measure the impact of the technology on warfighter missions and operations. The ACTD program is managed by the Deputy Under Secretary for Defense, Advanced Systems and Concepts (DUSD, AS&C).

III. JPADS Definitions and CONOPS

This section outlines the JPADS components and a potential Concept of Operations (CONOPs) for the Joint Precision Airdrop System (JPADS). It sets the context for the concept of operations by outlining the fundamentals of precision airdrop operations. With this background, it becomes clearer as to not only how to use JPADS, but also when, where, and why JPADS variants should be used and the resources required to integrate the system into a concept of operations and support.

A. Background

Within the US DoD, JPADS is defined as a family of systems within various weight classes defined to support focused logistics. The classes are JPADS Extra-Light (XL) 200-2200 lbs; JPADS Light (L) 2201-10,000 lbs; JPADS Medium (M) 10,001-30,000 lbs; and JPADS Heavy (H) 30,001-60,000 lbs. Each of these weight classes may involve more than one JPADS system with a unique decelerator system, unique Airborne Guidance Unit (AGU), etc. The goal of JPADS is to provide the capability to deliver cargos of varying weight from altitudes up to 25,000 feet mean sea level (MSL) as a threshold (35,000 feet MSL objective) via autonomously guided precision airdrop from C-130, C-17 and other aircraft to multiple impact points on the ground within a 50-100 meter circular error probable. Accuracy requirements will be less strict for the heavier weight variants.

B. Mission and Mission Need

JPADS provides global, high altitude, precision airdrop direct delivery capability for a wide range of cargo weights and cargo types. The United States has staffed an Initial Capabilities Document (ICD) (the new DoD name for a mission needs statement) for the entire family of JPADS weight classes from 200 pounds up to 60,000 pounds. A joint Capabilities Development Document (CDD, which is the new name for an Operational Requirements Documents (ORD)) will be completed during CY05 for at least the JPADS-XL and JPADS-L increments. Therefore, the final approved Key Performance Parameters (KPPs) are not yet available.

C. General Airdrop

Sustainment operations in the Central Command (CENTCOM) Area of Operations (AOR) and potentially most future conflicts encompass expansive, non-contiguous territories that are time/distance sensitive and subject to an asymmetric threat. Employment of forces calls for significant dispersion, extending units from supply bases and extending the Ground Lines of Communication (LOC). The likelihood that these conditions will be replicated in other AORs in which nations find themselves combating terrorism is high given the propensity of terrorist elements to disperse utilizing difficult and compartmentalized terrain to mitigate the informational and maneuver overmatches presented to them by US and Allied Nation forces. Theater re-supply operations can be greatly enhanced with the accelerated development and immediate employment of enablers such as JPADS as a component of the Theater Distribution system.

D. Threat

The proliferation of Man Portable Air Defense Systems (MANPADS) and other non-traditional threats presents a serious risk for airmen and soldiers conducting resupply operations. While LOC security is never guaranteed, insurgent forces are able to continually interdict supply lines and the convoys that utilize them. The result of this action is two fold. Enemy action is targeted at non-armored, combat service support vehicles, often with devastating effects. Mitigation of the enemy's ability to interdict the LOC is met by application of combat power to LOC security; ensuring freedom of movement for supply operations but robbing the fighting force of operational flexibility and resources. Similarly, there are significant risks and shortfalls associated with conducting conventional airdrop operations. For example, US and Allied Nation aircraft cannot meet desired accuracy standards once drop altitudes exceed 2000 feet above ground level (AGL). While drops below this altitude are more accurate, they are subject to small arms, Anti-Aircraft Artillery (AAA) and MANPADS threats. In addition, the time associated with deploying multiple payloads out of an aircraft necessitates a drop zone of substantial length for low altitude drops.

Strategic, operational, and tactical employment of forces in the contemporary operating environment requires a change in the way US and Allied Nations sustain their forces. The time and place of the next battle is unknown. Military planners are no longer able to define the next area of operations with certainty and thus often carefully prepare by strategic forward positioning of forces, equipment, and stocks. This is what we can know longer do because the threat is so dispersed. In the contemporary operating environment, adversaries have the ability to threaten National interests or attack coalition partners with little or no warning. Additionally, our adversaries have changed. They have developed tactics, techniques, and procedures that result in significant disruption of operations. Helicopters are downed by rocket-propelled grenades (RPGs); Vulnerable lines of communications (LOCs) are disrupted by improvised explosive devices (IEDs), and direct action. These two significant changes (strategic warning and asymmetric operations) in the strategic environment are effecting changes in the way US and Allied Nation forces must deploy and employ forces. To provide maximum global agility and flexibility in response to

global contingencies, forces will increasingly deploy from a strategic base. Current and emerging US guidance tells us that forces must be able to rapidly deploy, immediately employ upon arrival in the theater of operations and be continuously sustained throughout the operation. New technologies enable US and Allied Nations forces to maneuver against a dispersed enemy in a distributed, non-linear, and non-contiguous fashion. These forces can operate cohesively and maintain situational awareness even while separated by long distances. However, these operations outpace the ability of the logistics tail to keep up. These new methods of maneuver must be matched by new methods of agile sustainment. NATO commanders require sustainment capabilities that can support forces that will be rapidly deployed, immediately employed upon arrival in theater, and conduct widely dispersed operations with lightning agility. The Joint Precision Airdrop System (JPADS) is just such a capability, and receiving increased focus with the DoD and Allied Nations.

E. Characteristics of Precision Airdrop

1.Higher Altitudes

Precision airdrop allows aircraft to release loads at higher altitudes than non-precision airdrop. Non-precision systems are significantly affected by winds both at altitudes and near the ground. The ability of precision airdrop systems to control and/or steer in flight allows them to anticipate and counteract the effects of wind on the airdrop system.

2.Decoupled Aircraft/Load Signature

When guided systems are deployed from altitudes above 20,000 feet AGL, it is difficult to hear or see the aircraft in daylight conditions. In low-visibility conditions, it is not possible to visually acquire the aircraft. Once released, guided systems quickly leave the range of visual identification and/or earshot of the aircraft. This means that even though the aircraft may be seen and/or heard, the exact position of the impact point is unknown to the observer.

3. Flexible Computed Aerial Release Point (CARP)

Because it can steer to the impact point, JPADS can be released from any flight vector and within a relatively large area in the sky dependent on the known accuracy of the winds for the mission and the lift to drag characteristics of the JPADS(s) being airdropped. This also allows for Controlled Dispersion of Loads.

4. Enroute Mission Planning and Satellite Communications

The JPADS-MP system (described below) yields the capability to conduct mission planning and mission changes enroute to the delivery point via non-line-of-sight (NLOS) satellite communications. This is a capability that did not exist prior to JPADS that provides the combatant commanders added flexibility in distribution operations.

F. Uses of Precision Airdrop

Many uses of precision airdrop can be envisioned and some have already been discussed. It is difficult to describe all of the uses of precision airdrop because airdrop is such a flexible tool. It is akin to describing all of the uses of the commercial sector's Federal Express (FEDEX) system. However, the uses of precision airdrop can be conceptually arranged temporally in stages. The stages of precision airdrop are:

- Accompanying equipment and supplies are deployed with the force as equipment essential to the mission at time of arrival into the theater of operations.
- Follow-on equipment and supplies flow into the theater in accordance with a preplanned concept of support.
 - Automatic delivery of equipment and supplies is based on estimates of requirements that are scheduled well ahead of the air tasking order time lines.
 - On-call delivery is the use of carefully planned prepositioned and/or pre-rigged stocks throughout the global distribution system to satisfy emergent requirements.

- o Emergency airdrop occurs when the warfighter discovers a previously unforeseen requirement that cannot be fulfilled by on-call assets.
- Demand supported precision airdrop delivery occurs when theater distribution systems and connectivity are mature enough to deliver supplies through normal requisitioning and issue procedures.

G. Why JPADS

A partial list of Advantages and Disadvantages of Precision Airdrop are provided below

1. Advantages of Precision Airdrop include

- Capitalizes on the capabilities of the strategic base providing direct, global delivery within 24 hours of mission receipt.
- Supports all forces over the entire range of military operations.
- Enables immediate employment by providing a bridge over the gap of time between force entry and mature distribution network capability.
- Unconstrained by theater austerity, maturity, or lack of host nation support.
- Nullifies strategic, operational, and tactical time and distance constraints.
- Provides an option to distribute equipment and supplies when other options are untenable.
- Circumvents remote and compartmentalized terrain.
- Supports multiple entry points into the theater of operations.
- Enables the sustainment of dispersed, non-contiguous, non-linear operations.
- Does not require an extensive logistics footprint in theater
- Reduces risk to aircrews by enabling higher altitudes of flight and flexibility in approach vectors.
- Increases aircraft availability relative to airland operations by decreasing risk to aircraft and aircraft turnaround times.
- Reduces risk to Combat Service Support ground assets by reducing exposure along GLOC.
- Reduces detection of signature (high altitude and some level of standoff).
- Provides greater flexibility to the maneuver commander by allowing changes of delivery point(s) enroute.
- Reduces cross loading, repacking, and intermodal processing times.
- Provides the capability to throughput around the SLOC, ALOC, or GLOC infrastructure.

2. Disadvantages of Precision Airdrop include

- Sustained precision airdrop operations require the capability to recover and retrograde airdrop items (cost factor).
- Precision airdrop net aircraft payload is reduced (slightly) relative to airland operations because of the need for airdrop rigging equipment and the configuration constraints on the load.
- Precision airdrop requires specially trained rigging and mission planning personnel.
- Precision airdrop Points-of-Impact (PI) must be secured to prevent supplies from falling into enemy hands (as must non-precision airdrop payloads).

H. Execution of Precision Airdrop

As a rule, the execution of precision airdrop is nearly as simple as the execution of any other mode of transportation. Although specially trained personnel are required to actually rig the equipment and supplies and prepare JPADS systems for precision airdrop, the mission is essentially a delivery of supplies and/or equipment. Sources of supply receive requisitions, make shipment mode decisions, and arrange to transport shipments to air terminals. Air terminals route the cargo for loading and movement via air. Airmen prepare, plan and execute the precision airdrop mission in a manner similar to any other contingency mission. Units in the field secure the impact area (i.e., Drop Zone (DZ)) much as they would a logistics release point (LRP). The concepts for delivering equipment and supplies via precision airdrop will be familiar to distribution managers as well as tactical units.

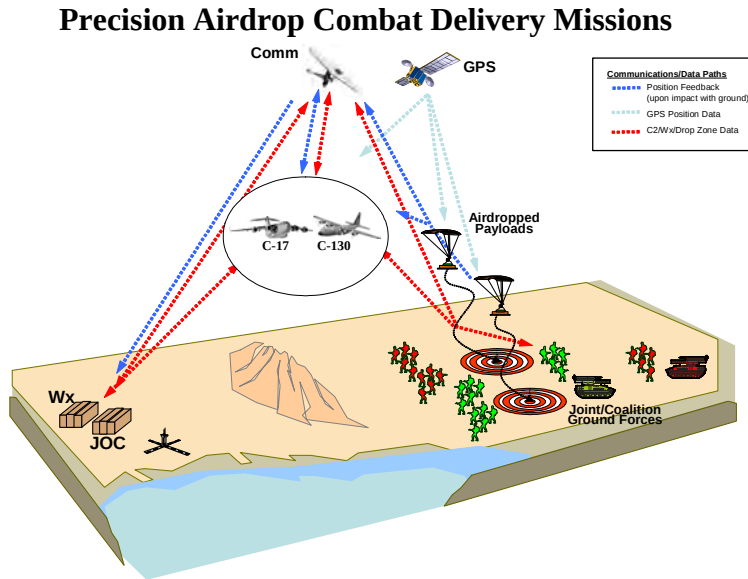


Figure 1. Notional Combat Delivery Operational View with Precision Airdrop System(s)

Figure 1 depicts a notional Combat Delivery scheme with JPADS. The delivery aircraft could be a C-130, C-17 or any aircraft capable of airdrop from high altitudes. The steps involved begin with a “call for resupply” or a planned airborne operation with personnel and equipment. The initial information required for planning such a mission includes: knowledge of what equipment/supplies are needed by the user/caller, when they are needed, and where they are needed. Ground based activities include: Determine which aircraft(s) will be used, preparation of the air droppable bundles/payloads and personnel equipment, preliminary weather information and mission/route planning to meet the missions needed timelines and to minimize detection and known threats. Weather information is provided through the Air Force Weather Agency and provides the initial information used to determine which JPADS system(s) should be used and preliminary drop location options for the planned airdrop time over target (TOT). All JPADS utilize the Global Positioning System (GPS) as the primary navigation sensor and benefit from a GPS re-transmission kit (RTK) mounted inside the aircraft to allow the systems to know where they are just prior to the airdrop. Updated weather or target information can be provided to the aircraft/aircrew while in route via satellite communications (verbal or text). A method of updating precision airdrop system mission plans on-route is also desired to provide the most updated weather estimates and impact coordinates. In route weather updates can be provided by numerous sources (see the JPADS-MP section for more details) such as dropsondes, satellite winds, SATCOM’ed updates (forecasted, pilot reports, and/or ground measurements) and any in route measurements of weather is also desired to be fed back to the Air Force weather Agency for improved future forecasts. The lift to drag ratio of the precision airdrop system(s) chosen and weather conditions at the time of the mission will dictate the level of horizontal offset possible for the mission. After the optimum computed aerial release point (CARP) is chosen, the crew must execute the following: update the precision airdrop systems missions (if required), and run the check list for the airdrop ensuring that the precision airdrop system are on-ready for drop. After the loads are deployed, full visibility of the systems performance will likely be desired and this information should be available to both the aircraft and ground personnel receiving the equipment/supplies. This would likely include at a minimum: the position/location of the payload, the forces/accelerations experienced during the airdrop and upon-landing; the condition of the payload upon landing (i.e. survivability). The Combat Delivery scheme with Precision Airdrop Systems figure shows all of these lines of communication. Some are two-way lines, i.e., weather agencies desire any in-situ weather collected on-route or near the CARP/DZ to update their weather model inputs for the next forecast.

Precision Airdrop CONOP’s are rapidly being developed and early use of systems in real operations is helping ensure that JPADS CONOP’s will be usable and take full advantage of JPADS capabilities.

IV. JPADS-MP (Joint Precision Airdrop System – Mission Planner)

All precision airdrop systems require some type of laptop-based mission planning system and each requires different input parameters and data prior to being deployed. To avoid significant duplication and multiple laptops in the inventory/aircraft for each type of JPADS utilized, the DoD is currently investing primarily in one mission planner, the JPADS-MP. JPADS-MP is the most sophisticated mission planner for precision airdrop systems being developed at this time. JPADS-MP is under development by a large team for the USAF Air Mobility Command including: Program Management and Execution by the US Army Natick Soldier Center, Planning Systems Inc (lead contractor for hardware, weather, and integration) with Draper Lab (mission planning), the NOAA Forecast Systems Lab (weather assimilation software), and many other supporting services. JPADS-MP (and under other names) has been reported and documented in previous papers. (REFS 1, 2, 3)

The JPADS-MP enables aircrews to plan and initiate load release at a precise Computed Aerial Release Point (or area) through the application of accurate models of the JPADS components and enhanced wind profile/weather knowledge. As the US DoD is investing in a family of JPADS decelerator systems, the requirement has been established to have a single JPADS-MP capable of programming any/all JPADS parachute systems both on the ground and/or while in-route to the Computed Aerial Release Point (CARP).

JPADS-MP provides the capability to model parameters of aircraft position, altitude, airspeed, heading, ground speed, course, onboard load position (station), roll-out/exit time, decelerator opening time and trajectory to stabilization, descent rate due to weight and decelerator drag, and the descent trajectory to the desired point(s) of impact due to the atmospheric three dimensional (3D) wind and density field encountered by the descending load under canopy. Additionally, JPADS-MP provides programming and targeting information to many (eventually all) AGUs to include: drop and target altitudes, steering waypoints (if applicable), and weather/wind magnitude/directions as a function of altitude, opening altitudes, and GPS 'hot start' information. Planning is done preflight and/or on board the airdrop aircraft making use of the aircraft's power, antenna, 1553 data bus when available, and GPS. In addition, the US DoD has linked the Combat Track II (CTII) secure satellite communications transceiver (when installed) to run on the JPADS-MP laptop allowing for small "emails" to be sent to the JPADS-MP (i.e., updated weather information and/or new impact points for any/all of the payloads to be airdropped).

JPADS airdrops are executed using a JPADS-MP derived CARP based on updated, in-situ, and atmospheric information. Weather information can be downloaded via a secure or non-secure US Air Force Weather Agency (AFWA) website known as the Joint Air Force Army Weather Information Network (JAAWIN). Downloaded weather can include a 3-Dimensional cube of data centered over the preliminarily intended impact point, generally a volume of $100 \times 100 \text{ km}^2$ by 40-50Kft in altitude, and in multiple one hour time intervals surrounding the intended drop time. This allows the aircrew maximum flexibility to compute a CARP and re-program JPADS in flight if the mission drop time and or drop locations change while airborne.

The basic JPADS-MP hardware components include a portable, rugged, low- or high-pressure tolerant laptop computer, a JPADS-MP interface processor (PIP), dropsondes, a GPS re-transmission kit, and cabling for C-130, C-17 and other aircraft. When used with JPADS systems, the JPADS-MP also comes with wireless Common Navigation Interface Units (CNIUs, which are under development and will utilize 802.11G wireless technology) which are attached to the AGU's for wireless programming and can either be removed prior to exit from the aircraft or stay with the AGU through flight. The PIP includes an ultra high frequency (UHF) radio receiver and a dropsonde interface processor. JPADS-MP hardware is man-portable (less than 75lb) and installed aboard the selected precision airdrop aircraft in a roll-on/roll-off configuration in less than one hour. The high-pressure tolerant laptop computer and system components enable operation in un-pressurized flight up to 35,000 feet MSL pressure altitude.

JPADS-MP assimilates these high-resolution four-dimensional (4D) forecast weather fields, high-resolution topographic data from the National Imagery and Mapping Agency (NIMA), and wind data measured in near-real-time with dropsondes to produce a three-dimensional (3D) wind, pressure and density field for a given DZ at the planned drop time. JPADS-MP is fully integrated with the FaclonView map overlay program and provides crews the ability to determine safety fans of where ballistic and/or precision airdrop systems could land if they malfunction. The ability to compute safety fans is particularly useful for test considerations. The current JPADS-MP fly-away kit is shown below (figure 2), including its carrying case and an A-sonde (JPADS-MP name for a dropsonde).

Current enhancements include the ability to use JPADS-MP to program a wide range of high-altitude parachute systems by either plugging the JPADS-MP into each AGU respectively or wirelessly programming each system Airborne Guidance Unit (AGU) individually or in combination. The JPADS is being implemented to and will be demonstrated with numerous systems at the next Precision Airdrop technology Conference and Demonstration

(PATCAD-2005, see Reference 4 for details on PATCAD-2003) and include at a minimum the following systems: Affordable Guided Airdrop System (AGAS), 2Klb and 10Klb SCREAMERS, Sherpas, and DRAGONFLY systems. The AGAS and Sherpa systems status are described in Reference 5 and 6 respectively.



Figure 2. JPADS-MP Fly-Away Kit
From Right to Left: Dropsonde, JPADS-MP HW & Laptop & Carrying Case

JPADS MP recently passed two Operational Utility Evaluations (OUEs) for ballistic system airdrops. One was for use on the C-17 and one for the C-130 Aircraft. Both were executed by the USAF Air Mobility Commands Test and Evaluation Squadron for high altitude high-speed CDS systems using a 26-foot Ring Slot (ballistic) Parachute system. The results of these two OUE's were impressive. JPADS-MP demonstrated a 70% improvement in accuracy over current C-17 MP methods and a 56% improvement over current C-130s MP methods. Many JPADS-MP enhancements are on-going at the time of this paper submission and as noted, many other MP systems exist of varying levels of maturity for programming (in most cases) a specific JPADS. JPADS has also been utilized with great success by Special Operations Forces in current operations.

V. DRAGONFLY

The DRAGONFLY system is being developed by the US Army NSC JPADS ACTD Team and is a collaborative effort between Para-Flite Inc. developer of the decelerator system, Wamore Inc. as the developer of the AGU, Robotek Engineering, providing the avionics suite, and Charles Stark Draper Laboratory leading the GN&C software development. The program began in fiscal year 2003 and fully integrated system flight tests commenced in the first quarter of fiscal year 2004.

The primary decelerator for the DRAGONFLY System is a 3,470-ft² high performance parafoil. The canopy is a true advancement in the state of the art of large parafoil system design and construction with an emphasis on low cost and ease of use/simplicity. Para-Flite has implemented advanced manufacturing techniques, such as the use of laser cutting of the rib sections, to achieve system cost goals without sacrificing performance goals. The high aspect ratio (3.2:1) semi-elliptical planform uses an advanced airfoil section and a "multi-grommited" slider to control the deployment of the canopy. The elimination of a multi-stage pyrotechnic deployment system permits dramatic reductions in canopy design complexity, further reducing the production cost. Packing and rigging time of the system is also greatly reduced. The canopy, with a wingspan slightly in excess of 100-ft, can be easily repacked by two persons in less than 3 hours.

Effective application of advanced wing design features such as taper, twist, and variable anhedral has resulted in a parafoil with flight performance parameters substantially in excess of what has been previously demonstrated by

other large parafoil designs. Wind corrected glide ratios in excess of 3.5:1, at flight speeds better than 40 knots, have been recorded at fully rigged weights of 10Klbs. Only one-sixth of the outboard trailing edge of the canopy is deflected on each wingtip to affect directional control and braking (flare) for landing. As such, control line loads and total stroke are much lower than comparable systems and the canopy is exceptionally responsive to control input. This has permitted substantial reduction in the power requirements and total weight of the Airborne Guidance Unit (AGU) used to control the parachute. (Reference 7)

The AGU connects to the parafoil risers and is suspended between the parafoil and the payload. The AGU currently weights approximately 175-lb. The design has proven itself extremely rugged and robust through flight test. As with the parafoil design, great attention has been paid to minimization of unit cost. The AGU and its avionics suite rely heavily on the effective integration of commercial-off-the-shelf components. Primary system electromechanical subcomponents include: a pair of 1.5 hp brushed servomotors, motor controller, 54:1 gear reducers, 900Mhz RF modem, microprocessor, dual GPS, and three 12VDC sealed lead acid batteries. Two batteries provide 24VDC to the actuators, while the third battery provides power to the avionics.



Figure 3. DRAGONFLY system just prior to ground impact in Kingman Arizona

A key element of Dragonfly is the development of Guidance, Navigation and Control (GN&C) software to autonomously fly the 10,000-pound capable parafoil. This software must guide the parafoil from deployment altitudes up to 25,000 feet above Mean Sea Level (MSL) to landings within a 100-meter Circular Error Probable (CEP) of the target. Other key goals include robustness to a variety of failure modes, algorithms that are sufficiently generic to facilitate adaptation to both smaller and larger decelerators, efficient enough to perform well on a very modest microprocessor, and capable of meeting system performance requirements with a navigation sensor suite limited by recurring system costs.

Dragonfly flight testing commenced in March, 2004 at Red Lake in Kingman, Arizona. Initial flights were remote controlled, executing planned maneuvers to establish the flight characteristics of the Dragonfly system; these occurred in March and April. The results of these flight tests were used to conduct system identification and establish GN&C parameters as described elsewhere in this paper. (Reference 8) First flight of the autonomous flight software occurred in May 2004. Testing has continued since then at approximately six-week intervals, with flights starting in October occurring at the Corral Drop Zone (DZ) at Yuma Proving Ground (YPG), Yuma, Arizona. During this time, the GN&C software was matured in parallel with evolution of the canopy, rigging, and airborne hardware, including a major upgrade to the AGU involving new actuation motors, necessitating revised flight software motor interfacing. The move to YPG was a milestone as this was the first time the system flew from a C-

130 airplane, deploying at 130 Knots Indicated Air Speed (KIAS), considerably faster than the C-123 used in Kingman. Flights from military aircraft commenced in February 2005. As the flight test program proceeded, system weights were gradually increased up to the Dragonfly maximum of 10,000 pounds (fully rigged weight), as were drop altitudes, heading toward a goal of flights from 18,000 feet Mean Sea Level (MSL) by spring 2005. Initial autonomous flights were deployed directly over the targeted impact point, and then gradually more offset from the target was introduced. GN&C software was initialized in early tests assuming no winds, then forecast winds were used, and eventually flight tests will include updates of the GN&C mission file while enroute to the DZ with current winds estimates based on an assimilation of forecast and dropsonde wind and density data from JPADS-MP (planned for Jun05).

VI. SCREAMER

The “SCREAMER” (Reference 9) consists of a Ram Air Drogue (RAD) parafoil and a recovery chute all integrated into the platform/payload by Strong Enterprises and a single actuator AGU produced by RoboTeK Engineering, Inc. This system is deployed via a gravity drop and the static line deploys the RAD. The RAD is controlled by the AGUs as the system flies at very high speeds and deploys two standard US Army G-11 round cargo parachutes at a preprogrammed target point, which is set above and slightly offset, from the desired ground impact point based on anticipated ground winds. This system is not controlled in the final stage of descent. The SCREAMER AGU has been used to fly systems close to 500lbs all the way up to 10Klbs. At the time of this submission, the 10Klb SCREAMER system has been flown autonomously on numerous occasions from deployment altitudes of up to 18Kft MSL and air speeds of 140KIAS from a C-130 aircraft. The SCREAMER is shown in figure 4 below under its final recovery parachutes. SCREAMER is composed of modular man-portable components. It flies fast and is designed penetrate 60- to 70- knot winds.

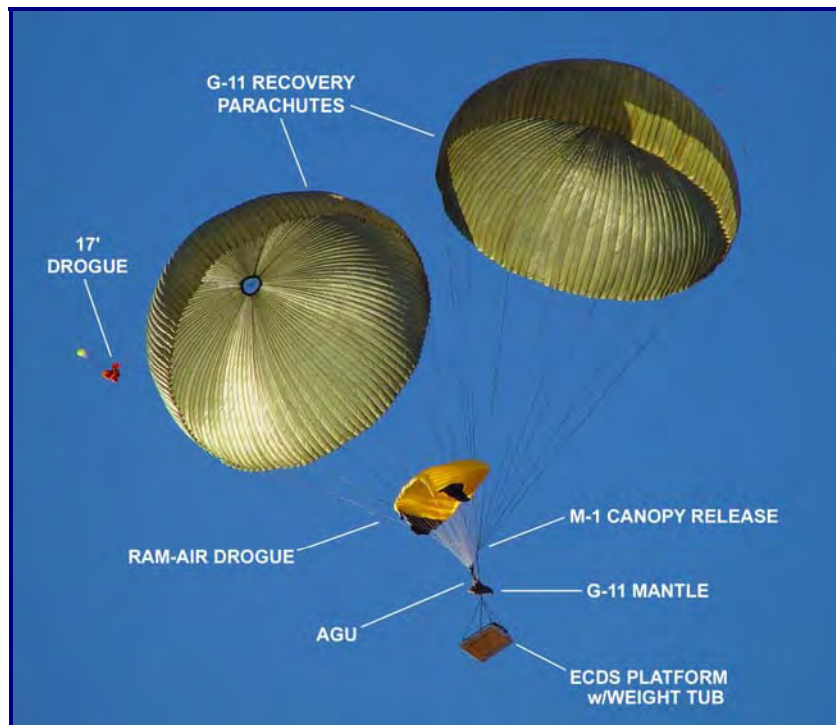


Figure 4. Screamer systems near ground impact

The SCREAMER is a modified High Altitude Low Opening aerial delivery system, which autonomously navigates during drogue parafoil flight to a programmed target point. After descending in a circular pattern above the target to a preset mission recovery altitude, two G-11 cargo parachutes are deployed to arrest forward glide and affect a standard ballistic recovery descent of approximately 24 feet per second. The major components of the SCREAMER include a 650-feet squared parafoil ram-air drogue (RAD) main canopy, an AGU, a pair of G-11 recovery parachutes and a small platform or Recovery Mantle on which the parachutes and AGU are rigged. An Enhanced Container Delivery System platform-based payload (or Type V or 463L pallets) is slung beneath the SCREAMER and decoupled through a single point swivel.

The RAD deploys immediately on exit from the aircraft. The 650-feet squared ram-air main parachute applies a classic 2:1 aspect ratio parafoil platform with a cord dimension of 209 inches and a span of 423 inches. The recovery parachutes affect an approximately 24 feet per second vertical recovery in the terminal flight phase and are currently deployed at approximately 1100 feet above ground level. The G-11s deploy simultaneously by a 17-foot drogue parachute initiated by a software command from the onboard AGU.

The AGU is situated in the risers directly beneath the RAD out of the structural load path. AGU navigational and control instrumentation consists of a global positioning system (GPS) and turn-rate sensor gyros. The AGU is 18 inches squared by 4.5 inches and weighs 45 pounds. Two 1000-pound Spectra steering control lines cascade to the three outer trailing edge suspension lines on each side of the parafoil.

The recovery mantle (RM) is a tubular steel frame that is located directly in the load path below the main canopy riser extension and above the payload swivel, which serves as the load sling confluence point. The RM also serves as a location for the transfer link (RAD flight-to-recovery phase), which is integral with the platform and the payload swivel.

VII. JMUA Objectives

The current sustainment distribution system is incapable of responding globally or within theater to a dynamic tactical environment from operational and strategic distances. Supplies and equipment generally reach users in days or weeks rather than in hours. It is the intent of the JPADS ACTD to demonstrate and assess the systems described above that can provide a global and in theatre delivery capability within 24 hours of request the warfighter (unit/teams) worldwide. The JMUA itself does not focus on the “24 hour” timeline, but rather the capability and military utility of JPADS to deliver supplies to the warfighter in field conditions. To assess the JMUA objectives and report on the JPADS military utility, the assessment team developed three critical operational issues (COI, see table 1) and many supporting objectives. In addition to the formal assessment, significant data on the decelerator systems is being collected through technical testing with US Army developed instrumentation packages

Table 1. JMUA COIs: Three COIs support the JMUA of the JPADS.

COIs/Objectives
COI 1. Does the JPADS system-of-systems successfully support payload delivery at the target weights and standoff distances in its intended operational environment?
COI 2. Does the JPADS system-of-systems provide the Joint Task Force (JTF) Commander with an enhanced operational capability?
COI 3. Is the JPADS system-of-systems suitable for employment in its intended environments?

To formulate these COIs and objectives, the assessment team combined the operational capabilities required by users with ACTD objectives and information gathered during integration process, team meetings, and technology demonstrations. Test measures supporting the COIs and objectives were developed with the extraction of tasks from the Universal Joint Task List and Service task lists from the participating military services task lists. The UJTL

serves as a common language and reference system for joint commanders, combat support agencies, operational planners, combat developers, and trainers to communicate mission requirements. It is the basic language for development of a joint mission essential task list that identifies required capabilities for mission success. The three levels of war organize the UJTL: strategic, operational, and tactical—the JMUA execution is at the tactical level of war.

Doctrine, Organization, Training, Material, Leadership, People, facilities (DOTMLPF)

The JMUA will address DOTMLPF impacts. DOTMLPF will be a critical piece of the methodology, and the JMUA IPT (integrated process team) will be cognizant of this throughout assessment (e.g., via observation, warfighter interviews, etc.). Reporting DOTMLPF findings will be within appropriate the JMUA objectives. DOTMLPF specific issues include:

- Doctrine: Will introduction of the technology necessitate changes to current doctrine (e.g., new procedures or changes to concepts of operation and tactics, techniques, and procedures)?
- Organization: Will the technology enhance mission responsiveness?
- Training: Will fielding of the technology require additional training? What type, how much, when? Will periodic refresher courses be required?
- Materiel: What additional equipment will be required to support use of the technology?
- Leadership: How will introduction of the technology affect leadership? How will it combat the "fog of war?"
- People: Will warfighters with a specific skill set be required to operate the technology?
- Facilities: Will fielding of the technology require certain facilities for storage or setup?

VIII. Conclusions

Planned airdrops for the JPADS ACTD continue with the JPADS-MP linked to both of the 10Klb JPADS-L decelerator systems with emphasis on locking down on configurations, increasing reliability, and pushing for higher altitudes (up to 25KftMSL). A planned Early User Training (EUT) for the JPADS ACTD systems is planned for Sept05. Three JMUA's are planned starting in Dec05 and concluding with the 3rd during the summer of CY07. The JPADS-L technologies are then expected to transition into PM-FSS under a formal program of record at the Milestone B level. A two year residual phase with remaining JPADS ACTD assets will be executed with support from DUSD AS&C during FY07 and FY08. Low Rate Initial production will start in FY10 if the Systems Design and Development program is successful and meets all Key Performance Parameters during Operational Testing (OT).

At the time of this submission, two 10Klb JPADS-L decelerator systems are being developed with a "user prioritization" decision being scheduled during the summer of CY05 to determine which system will continue throughout the JPADS ACTD program.

Numerous weeks of integrated testing are still planned and the status of the JPADS ACTD program has been provided. JPADS-MP is being matured and linked to many JPADS-XL systems and other airdrop applications concurrently. The paper provided a short overview of what an ACTD is and how they are assessed. It also provided the reader a draft CONOPs outlining the need and anticipated use of JPADS. In addition, the paper outlined the JPADS ACTD systems being matured and tested.

The JPADS ACTD is the largest and highest priority US airdrop program supported by the Department of Defense to date. JPADS investments are rapidly increasing within the US and Allied Nations. JPADS is analogous to what JDAMs are for smart munitions. Numerous JPADS systems are in the process of being fielded under Urgent Operational Need Statements for current operations as concurrently, the JPADS-XL program prepared to begin a formal program of record the in early 2006.

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