Affordable and Lightweight Composite Airdrop Platform

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As the Army transitions to a Future Combat System (FCS)-equipped force, lightweight and durable airdrop platforms will increasingly be needed to sustain operations over an expanded non-linear battlefield. The Army plans to procure the recently developed aluminum Enhanced Container Delivery System (ECDS) airdrop platform to deliver total rig weights up to 10,000 pounds. The ECDS platform has been linked to the Joint Precision Airdrop System-Light (JPADS-L), a high-altitude precision airdrop system, currently under development for the delivery of total rig weights between 2,001 lbs and 10,000 lbs. Application of advanced composite materials will improve the ECDS platform's performance from a strength and stiffness standpoint to allow for high-altitude JPADS missions. In addition to reduced procurement cost, the lightweight composite ECDS platform will be more durable and less prone to galvanic corrosion, thereby decreasing life-cycle cost. Under a Small Business Innovation Research (SBIR) program managed by the U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC), the current aluminum Type V and ECDS platforms were both examined for possible composite replacement. Through a combination of finite element analysis (FEA), testing, and cost-modeling, a composite Type V platform design was developed that would result in weight and procurement cost savings of approximately 30 and 20 percent respectively versus the existing aluminum platform system. Similarly, a composite ECDS platform design was developed that will save greater than 25 percent on weight with no increase in procurement price versus the existing aluminum platform. Composite ECDS platform weight savings would provide an additional 190 to 200 lbs in payload capacity. As part of this research program, four prototype composite ECDS platforms (108” long x 88” wide) are being fabricated using the Vacuum Assisted Resin Transfer Molding (VARTM) method, which is the most cost-effective integral manufacturing process. The first composite ECDS prototype underwent suspension, pull, and roller qualification testing at the US Army NSRDEC’s Roller Test Facility. Subsequent airdrop flight tests will be performed at the U.S. Army Yuma Proving Ground on the four composite ECDS prototypes.

**I. Introduction**

The Army plans to equip its Future Force (FF) with the Future Combat System (FCS); a family of fourteen manned and unmanned ground vehicles, air vehicles, sensors, and munitions linked by an information network. The FCS is expected to greatly improve the Army’s ability to move, shoot and communicate over greater distances. As the Army transitions to a FCS-equipped force, lightweight airdrop equipment will increasingly be needed to deliver the requisite materiel to sustain operations and preserve the system’s overall mission effectiveness over an expanded non-linear battlefield.\(^1,2\) Currently, the Type V aluminum platform is used to deliver Army vehicles and equipment by the single-row, Low Velocity Airdrop (LVAD) method. The reduced-width Dual-Row Airdrop System (DRAS) platform has been introduced into the inventory to support the Army’s Strategic Brigade Airdrop

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(SBA) from the C-17 aircraft, using that aircraft’s logistics rails. The current Type V platform, which is shown in Fig. 1, is a relatively expensive item. It has a high unit cost principally due to its heavy, complex, modular design, which is driven by the reusability requirement, as well as by limits on the width of aluminum components that can be extruded. In addition, the reduced-width DRAS platform has been found to be less durable than the Type V platform due to its reduced footprint. As a result, there is a need for lightweight substitutes for these heavy aluminum airdrop platforms that might also benefit humanitarian relief work involving airdrop of food and other supplies. The army plans to procure the recently developed ECDS platform to deliver 10,000 lb loads. This platform, which is shown in Fig. 2, is similar to the 463L (HCU-6/E) pallet currently in use. The platform, which has a footprint of 108” x 88” (L x W), is compatible with both the C-17 and C-130 aircraft dual rail systems, as well as the C-17 logistic rail system. In addition, the ECDS platform has suspension points for airdrop and helicopter sling load, rail and deck tie-down provisions for restraining the load, and forklift tine entry ports. The ECDS platform has been linked to the Joint Precision Airdrop System-Light (JPADS-L); a high altitude precision airdrop system for the delivery of total rigged weights between 2,001 and 10,000 lbs.

Under SBIR Phase I (Contract number DAAD16-03-C-0006) and Phase II (Contract number W911QY-05-C-0005) contracts managed by the U.S. Army NSRDEC, a lightweight and affordable composite airdrop platform was developed to support the US Army’s JPADS and other military cargo airdrop missions. The goal is to reduce the weight of the platform system for increased payload capacity and/or aircraft range.

This paper chronicles research conducted under both phases of the SBIR program to date. During the Phase I program, research was performed on the
Type V airdrop platform system. During the Phase II program, the developmental effort was aimed at the recently developed ECDS platform. As part of Phase II, four prototype composite ECDS platforms (108” long x 88” wide) are being fabricated using the VARTM process. The VARTM integral fabrication strategy saves cost by integrating foam wrapped with fabric, composite skin and fasteners/attachments in a single step injection process while maintaining fairly close tolerances.

The composite airdrop platform developed will meet the Army’s need for environmentally friendly and durable materials that reduce deployment and life-cycle costs. Composite platforms can offer significant benefits in terms of improved Future Force and Future Combat System (FF/FCS) mission effectiveness. These benefits include reduced weight, reduced initial and life-cycle cost, as well as reduced maintenance and environmental impact, resulting from increased corrosion resistance and damage tolerance. The composite airdrop platforms will outperform, and will have lower life-cycle cost, than aluminum- or steel-based products due to their inherent mechanical properties, superior resistance to environmental deterioration, and low unit production cost.

II. Polymer Matrix Composite Approach

Advanced composite materials were engineered to meet the structural performance requirements of platform systems at reduced weight and cost. Panel designs incorporated hybrid glass/graphite composites resulting in an optimum design that offers weight and cost advantages when compared to current aluminum constructions. Glass fibers provide good impact resistance and strength per pound and graphite fibers provide the best stiffness per pound.

A. Weight

A weight savings of 25 - 35% is attainable in most structures. This is due to the lower density of composites. Depending on material form, composite densities range from 0.045 lb/in$^3$ to 0.065 lb/in$^3$ as compared to 0.10 lb/in$^3$ for aluminum. Thicker composite sections can be considered to meet strength/stiffness requirements while still saving 25-35% of the aluminum weight.

B. Cost

Low cost, high volume composite manufacturing methods are used to make composites cost competitive with metals. VARTM or RTM tooling costs for high volume production of composites parts are similar to metal tooling costs. The production labor time is also similar. The higher cost of composite parts is mostly due to high raw material costs. Selection of the optimal material that provides the maximum cost/performance benefit to the system will be chosen.

C. Part Consolidation

Consolidating many parts in an assembly into one part is a major benefit gained by using composite materials. It enables the designer to go beyond mere material substitution and produce true composite parts. Part consolidation reduces part count, fasteners and assembly time. This reduces weight due to fewer fasteners and thinner parts (fewer point loads). The attachment areas of parts are where the majority of failures occur, due to high point loads and stress concentrations. Elimination of these interfaces improves the reliability of the structure. Integrating the four panels and four roller pads of the current 8 ft. long Type V platform in to a single integrated full-depth composite panel is a good example.

D. Composite Performance

Composites have inherent properties that provide performance benefits over metals. A wide range of fibers and resins are available to select the optimal material combination to meet the structural requirements. The strength-to-weight and stiffness-to-weight ratios are the primary reasons composites are used. The fiber reinforcements provide good damping characteristics and high resistance to fatigue. Most resins provide very good resistance to chemicals and corrosion. The fracture toughness of composites is better than aluminum castings. The fiber reinforcement of composites alters this failure sequence; resulting in an increased resistance to impact. The impact toughness of composites can be maximized by fiber selection, length of fiber and use of tougher resin such as thermoplastics.

III. Composite Type V Platform Design

Three composite Type V platform designs were designed and analyzed as part of the Phase I program. Based on FEA, flexure tests and cost analysis, the best design was down selected. This design is shown in Fig. 3.
IV. Composite ECDS Platform Design

E. Requirement Definition for ECDS Platform

Key Performance Parameters (KPP), used to guide the development of the composite ECDS platform, are listed below. The KPP’s were taken from the Operational Requirements Document (ORD) used during development of the original aluminum ECDS platform.

1. Compatible with current 463L cargo systems as currently equipped on C-130 and C-17 USAF fixed wing aircraft (KPP).
2. Utilize both the 108 inches wide Aerial Delivery System (ADS) and the 88 inches wide Dual Row Logistics System (LS) rails and locks for gravity release airdrop (KPP).
3. Capable of being sling loaded by rotary wing aircrafts (KPP).
4. Capable of being gravity deployed from an altitude of 500 feet AGL, at 140 to 150 knots indicated air speed (KIAS) (KPP). Future product improvement: Capable of parachute extraction airdrops (Interface for Extraction by Parachute, Bracket Assembly).
5. Compatible with Army material handling equipment (MHE) and USAF cargo aircraft and aerial port ground support cargo MHE. Forklift tine pockets that render the platform 2-way forklift capable from the 88-inch sides are required but 4-way capability is preferred (KPP). Future product improvement: Compatible with the Army's Palletized Loading System (PLS).
6. Capable of a rigged weight of 10,000 lbs for single or modular loads.
7. Capable of platform suspended airdrops at maximum rigged weight.
8. Allow for appropriate in-flight load restraint for aerial transport.
9. Reusable 12 times (threshold) and 25 times (objectives).
10. Compatible with standard combat off-load procedures of existing 463L cargo system.
11. Provide cargo tie down provisions (22 total, located on side rails) to allow for efficient load placement and rigging. Tie-down provisions must be compatible with existing 463L cargo nets. Four (4) Heavy Duty D-Rings for sling load by rotary wing aircrafts (KPP) or for platform suspended airdrops at maximum rigged weight. Offer additional inboard tie down provision, (8) each located flush with platform deck.
12. Capable of storage in climate categories (hot, basic, and cold) as current airdrop items as defined in Army Regulation (AR) 70-38.
13. Capable of delivering loads in fully mission capable (FMC) condition with minimal or no modification to standard air drop rigging.
14. Must not degrade the overall performance of the current container delivery system (CDS) airdrop operations.

F. Composite ECDS Design

Six composite ECDS platform designs were investigated as part of the Phase II program. Based on FEA, flexure tests and cost analysis, the best design was down selected. This design is shown in Fig. 4.
V. Mechanical Testing of Composite Laminate Configurations

Composite laminates for structural applications and structural analysis are typically characterized using standard American Society for Testing and Materials (ASTM) tests. Multiple laminates, usually a minimum of 1/8" (3 mm) thick, are used for testing and results are reported as a function of cross-sectional area, i.e. width × thickness. Thus, thickness of the laminate tested is a critical parameter influencing the reported data. The composite panels required for the mechanical coupon testing were fabricated in-house using the VARTM process. The test coupons were machined from the panels using a water jet machine to get accurate coupons according to dimensions specified in the ASTM standards. The machined coupons were tabbed and attached with strain gages where required.

A. Materials for Composite Panel Fabrication

Two different fibers, namely, T700 carbon/graphite fibers and E-glass with stitch bonded lay-up configuration were considered. The stitch-bonded construction maintains the fibers in a straight, unbent mode; thus providing composites with greater modulus and strength than weaves such as woven rovings. It has been found that a composite made of stitch bonded fabric has a 17% greater bending strength than woven fabric with the same parameters. A combination of good mechanical properties and relatively low cost makes glass fibers an attractive choice for the composite platform. Toray’s Torayca T700 carbon fiber was chosen because of its relatively low cost and high strength. This fiber has a 12k carbon fiber tow with a vinyl ester compatible sizing (FOE). This T700 fiber has a tensile strength of 4.9 GPa (711 Ksi), a tensile modulus of 230 GPa (33.4 Msi) and an elongation of 2.1%. The resin system used was epoxy vinylester (VE). Details of the materials selected for the composite ECDS are given below.

1. Uni-directional (0°) Stitch bonded Carbon (FOE sized): The carbon fabric was SAERTEX V97494-00620-01270-00000. The aerial weight of the fabric is 624 g/m² with 598 g/m² in the 0° direction and 12 g/m² of E-glass veil to hold the uni-directional fibers.
2. Bi-directional (0°/90°) Stitch bonded Carbon (FOE sized): The carbon fabric was SAERTEX V93710-00420-01270-00000. The aerial weight of the fabric is 421 g/m² with 205 g/m² being in the 0° direction and 205 g/m² being in the 90° direction.
3. Quasi-isotropic/Quad (0°/-45°/90°/45°) Stitch bonded Carbon (FOE sized): The carbon fabric was SAERTEX V95926-00800. The aerial weight of the fabric is 802 g/m² with 189 g/m² being in the 0° direction, 201 g/m² being in the -45° direction, 205 g/m² being in the 90° direction and 201 g/m² in the 45° direction, tied together with 6 g/m² polyester knitting thread.
4. Bi-directional (0°/90°) Stitch bonded E-glass: The E-glass fabric was VectorPly’s E-LT 2400. The aerial weight of the fabric is 813 g/m² with 408 g/m² being in the 0° direction and 405 g/m² being in the 90° direction.
5. Quasi-isotropic/Quad (0°/-45°/90°/45°) Stitch bonded E-glass: The E-glass fabric was VectorPly’s E-QX 3600. The aerial weight of the fabric is 1212.1 g/m² with 303.8 g/m² being in the 0° direction, 304 g/m² being in the 45° direction, 300.7 g/m² being in the 90° direction and 304 g/m² in the -45° direction tied together with 13 g/m² polyester knitting thread.
The resin/matrix selected was Ashland Speciality Chemical’s Hetron FR998 INF-25 epoxy vinylester (VE) resin, which is a low viscosity, Class I flame spread rated vinyl ester formulated for the VARTM process. The vinyl ester has a viscosity of 250 cps, which is ideal for the VARTM process. It can be catalyzed to give a wide range of pot life and cure time. Hetron FR998 INF has a tensile modulus and strength of about 3.7 GPa and 93 MPa respectively, a respective flexural modulus and strength of about 3.9 GPa and 152 MPa, and heat distortion temperature of 275°F.

B. Mechanical Test Results

All the testing was performed at the Advanced Composite Materials and Textile Research Laboratory (ACMTRL), University of Massachusetts, Lowell. Results of the mechanical testing on selected composite laminate configurations per ASTM standards such as tension (ASTM D3039), compression (ASTM D695), in-plane shear (ASTM D5379), short beam shear (ASTM D2344) and flexure (ASTM D6272) are tabulated in Table 1. Plots comparing strength and modulus of selected composite laminate configurations and baseline aluminum (7000 series) are shown in Fig 5.

Table 1. Composite Laminate Properties per ASTM Testing

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<th>S.No</th>
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<th>ASTM</th>
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Figure 5. Strength Comparison (left) and Modulus (right) Comparison between Composite Laminate Configurations and Baseline Aluminum
VI. Affordable Fabrication Process: VARTM

The integral VARTM fabrication process shown in Fig 6 was used to fabricate the profiles and skins of the composite platform. The dry fabric or preform is laid on a one-sided tooling, with foam core, and with other attachments/fittings. The skin-plus-core lay-up is covered with a reusable silicone bag, and the air is evacuated using vacuum. The liquid resin from an external reservoir is drawn in to the component by vacuum through ports placed at selected locations to provide controlled infusion of the component and good wetting of the perform. Also a high-permeability resin distribution medium placed on top of the preform spreads the resin quickly for good infusion. Geometric complexity does not cause any difficulties with the flow of the resin in the VARTM process as the resin flows around bends and ply drop-offs just as easily as through the flat regions. The manufacturing process can be optimized to minimize void content and maximize strength.

VII. Flexure Testing of Composite Profile

FEA and flexure tests were performed on the selected forklift profile, Profile Fab(6a1), to compare the midspan deflection. The dimensions of the profile were 100” x 11” x 5.44” (L x W x T). The loading consisted of weights of 100 lbs (0.1 psi), 300 lbs (0.3 psi), 500 lbs (0.5 psi), 700 lbs (0.6 psi), 1,000 lbs (0.9 psi), 1,500 lbs (1.4 psi) & 2,000 lbs (1.8 psi) uniformly distributed over the profile’s 80” span. The profile under a UDL of 2000 lbs is shown in Fig 7. Sand bags that weighed 50 lbs each were used to apply the load. The predicted deflection plot of the profile under a UDL of 2000 lbs using FEA software ANSYS is shown in Fig 8 (blue color/negative deflection indicates mid-span deflection). A plot showing a comparison of actual to predicted midspan deflections for the Profile Fab(6a1) over the previously described load range is presented in Fig 9. The plot is almost linear for the considered loads and there is a very close match between the actual deflection and FEA predicted values. Another plot showing actual stress versus deflection for the Profile Fab(6a1) for the tested load range is presented in Fig 10.

Figure 6. Fabric/Core Lay-up (left), Vacuum Bagging (center) and Fabricated Panel (right) using VARTM

Figure 7. Profile Fab(6a1) under a UDL of 2000 lbs (Side View).

Figure 8. Deflection Plot of Profile Fab(6a1) under UDL of 2000 lbs for an 80” Load Span
Mid-span Deflection of Profile Fab(6a1) under UDL

Figure 9. Plot of Actual to Predicted Midspan Deflection for Profile Fab(6a1)

Stress Versus Midspan Deflection for Profile Fab(6a1)

Figure 10. Plot of Actual Stress versus Midspan Deflection for Profile Fab(6a1). Load Corresponding to Stress is Marked on the Plot.
VIII. FEA of Down-selected Composite ECDS Platform

Detailed FEA was performed on the current aluminum ECDS and six different composite ECDS platform concepts. The overall dimensions of the platform designs were 108” long x 88” wide x 5.741” thick. The analysis details of the down-selected composite ECDS design are discussed below.

A. Load Case for Platform Analysis

The FEA was performed on the composite platform for the worst load case which is the sling-loading scenario of 40,500 lbs (10,000 x 3 x 1.35) UDL over the 104"x 84" ECDS area. This UDL translates into a pressure of approximately 4.6 lb/in² (psi). In this scenario, the platform is suspended from the four suspension/lift ring (heavy duty D-rings) provisions. The heavy duty suspension/lift D-rings are located near the corners along the 108” long side rails (two rings per side rail), as shown in Fig 2. The free body diagram of this load case is shown in Fig 11.

B. Geometry/Meshing and Boundary Conditions

A 3-D geometry of the composite ECDS platform was created using ANSYS finite element analysis software. The geometry was meshed and boundary conditions defined based on the load applied. The model was suspended from 4 points and the platform was constrained with the rotating lift rings.

C. Composite Laminate Material Properties for FEA

The tested composite laminate properties (shown in Table 1) were considered for this FEA.

D. FEA Plots

*Composite Stress Distribution: Inverse Strength Ratio (ISR) Plot*

To understand the stress distribution across different layers in a composite laminate under a load, the best approach is to plot the inverse strength ratio (ISR). The ISR is calculated based on the failure strength of the composite material. The ISR represents a failure criterion that is used to determine when a particular laminate configuration has exceeded its failure strength for a certain loading case. The ISR is derived from a quadratic failure criteria that takes into account nine empirically determined (or estimated) failure stresses in tension, compression, and shear as well the coupling effects that occur during certain combined tension and compressive stress states that enhance or degrade strength. The ISR criterion takes into account failure due to a stress state existing in three-dimensional space (X,Y,Z). The development of this quadratic failure theory for composites is attributed to Tsai & Wu. Whenever the ISR exceeds the value of one then the analysis predicts that the failure strength of the laminate in some location has been exceeded. In addition, the “Safety Factor” (SF) is considered to be the inverse of the ISR. In other words, if the ISR = 0.50, then the SF = 2. This is interpreted to mean that all loads can be doubled (but must applied in the identical direction) before the failure strength of the particular laminate configuration is exceeded.

*Deflection and ISR Plot*

The deformed shape and the inverse strength ratio (ISR) plots for composite ECDS Design (half model) under the suspension load case are shown in Fig 12 and Fig 13, respectively. The maximum deflection (center) of the composite ECDS design was around 1.19” (red color does not indicate failure but maximum deflection). The mid-span deflection observed was greater than baseline aluminum ECDS platform, which experienced a deflection of 0.563”. The composite ECDS platform’s greater mid-span deflection is due primarily to the greater unsupported areas between the composite profiles. The maximum ISR observed was around 0.784 (SF = 1.28). However, an ISR of around 0.35 (SF = 2.85) was more representative of typical ISR’s observed. Therefore, even though the deflection of the composite ECDS was higher, the safety factor was similar to that of the aluminum ECDS, which is around 2.7. The composite ECDS would provide >25% weight savings compared to aluminum ECDS.
Figure 12. Deflection of Composite ECDS (Half Model) under Suspension Load Case

Figure 13. ISR Stress Plot for Composite ECDS (Half Model) under Suspension Load Case (Top Skin)
IX. Tooling and Fabrication

The tooling and lay-up process used for the fabrication of the upper section of the composite profile is shown in Fig 14 to Fig 17. The profile sections were fabricated using the VARTM process. The composite skins, profiles and aluminum side rails were bonded together using IPS WeldOn structural adhesive (SS620 and SS340). The final prototype composite ECDS platform is shown in Fig 18.

Figure 14. Split Tooling for Fabrication of Composite Profile (10.71” Wide x 3” High x 108” Long)

Figure 15. Fabric Lay Up

Figure 16. Lay Up Under Vacuum

Figure 17. Fabricated Profile

Figure 18. Photo of Composite ECDS Prototype
X. Composite ECDS Prototype Testing

The composite ECDS will be employed for aerial delivery operations using both the Aerial Delivery System (ADS) rails (108” width) and the dual row Logistics System (LS) rails (88” width). The objective of this testing was to gather required data to evaluate the capability and certify composite ECDS platform and cargo restraint systems for cargo aerial transport and delivery. Results from these tests were used to determine platform structural capability for platform suspended airdrop, fork lifting and sling loading and to interface with aircraft rail and locks to provide adequate vertical, forward and aft restraint. The cargo restraint systems were evaluated for their capability to adequately restrain loads in the vertical up, lateral, forward and aft directions.

The composite ECDS prototype was tested at the U.S. Army NSRDEC’s Roller Test Facility, Natick, MA for roller, lift and suspension load cases. Prior to testing, the composite ECDS platform was weighed, as well as measured to determine compliance with interface requirements. The platform side rail detents, cross section, and platform size were shown to be in agreement with military standard MIL-P-27443E, Fig 4 and Fig 7. The platform’s weight was 574 lbs, which is 25% lighter than the current aluminum ECDS (766 lbs). This weight saving will translate into approximately 192 lbs of additional payload capability.

A. Roller Loads and Rolling Test
This test was performed to determine roller loads resulting from platform loading. Furthermore, this test will serve to determine whether roller contact loads at 4.5G permanently deforms the platform bottom skin. Secondary results from this test include assessment of the force needed to move a loaded platform forward and aft on the rollers.

1. Roller Testing: UDL of 10,000 lbs.
Roller testing was performed for the following three aircraft roller configurations: C-17, C-17 Logistics, and C-130H/C-130J. For each configuration, there were four roller tracks with rollers spaced 10” apart. To pass this test, the roller loads are not to exceed 2330 lbs/roller for every 10” roller spacing. After the platform has been rolled on top of the roller test bed and a reading of the roller loads has been obtained, a uniformly distributed load of 10,000 lbs was placed on the platform and the roller loads were read again. Altogether 22 sample readings per roller configuration were taken. The test results for all three roller configurations were very good and did not exceed 2,330 lbs/roller requirement. The composite ECDS platform under roller testing (C-130 Configuration, 10,000 lbs. UDL) is shown in Fig 19. The mean roller readings for the three roller configurations C-17, C-17 Logistics and C-130H / C-130J were plotted and are shown in Fig 20, Fig 21 and Fig 22 respectively.

![Figure 19. Roller Test: C-130 Configuration, 10,000 lbs. UDL](image-url)
Figure 20. Mean Roller Readings for C-17 Roller Configuration

Figure 21. Mean Roller Readings for C-17 Logistics Roller Configuration
From the above roller testing, the maximum load observed on the individual rollers was around 1,500 lbs compared to maximum allowable of 2,330 lbs.

2. **Roller Testing: UDL of 45,000 lbs. (4.5G Downward)**

Roller testing was performed with a uniformly distributed load of 45,000 lbs to simulate 4.5G downward loading on the C-130 H/C-130 J roller configuration as shown in Fig 23. This test was performed to determine whether the roller contact loads at 4.5 G permanently deform the platform bottom skin. After testing, all the weights were removed and the composite ECDS platform was visually inspected on the top & bottom surface areas. No damage was observed.

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**Figure 22. Mean Roller Readings for C-130 H/C-130 J Roller Configuration**

From the above roller testing, the maximum load observed on the individual rollers was around 1,500 lbs compared to maximum allowable of 2,330 lbs.

**Figure 23. Roller Test: C-130 H/C-130 J Configuration, 45,000 lbs. UDL**
B. Platform Suspension Test

The objective of this test was to determine sling load and platform suspended airdrop capabilities. A crane was used to lift the test load using the platform suspension/lifting provisions. The platform was suspended using 9 ft slings and, the sling angle was no less than 45º. A uniformly distributed load of 35,000 lbs was placed on the platform. The platform was lifted two feet off the ground and held at this position for no less than 90 seconds, as shown in Fig 24, in order to certify the platform for helicopter sling loading. During this time, the suspension slings, all line attachment points and the overall condition of the load and the platform was inspected for any deformations or interface problems between the slings and the test load or any other anomalies. Deflections of approximately 0.375” and 0.5” were observed along the 108 inch and 88 inch side rails respectively, which was similar to the deflection observed in the aluminum ECDS. The deflection at the center of the composite ECDS platform could not be measured.

![Figure 24. Platform Suspension Test: UDL of 35,000 lbs](image)

The test was repeated for a 14,000 lb concentrated load applied on a 4’ x 4’ footprint placed at the center of the platform as shown in Fig 25. After the load was removed, the platform was inspected and no indication of damage or deformation/wear was found.

![Figure 25. Platform Suspension Test: Concentrated 14,000 lb Load Applied on a 4’ x 4’ Footprint](image)
C. Lift/Suspension Provision Test

The purpose of this test was to determine the strength of the lifting/suspension provisions. The suspension or lift provisions were tested by applying a concentrated load of 18,750 lbs (30,000 lbs x 1.25)/2) around each of two diagonally opposite lift provisions as shown in Fig 26. The force was applied at an angle of approximately 45º up from the horizontal towards the center of the platform. The platform was lifted for approximately six seconds. No visible platform damage/delamination or side rail damage/separation was observed after the load was removed.

![Image of Lift Provision Test](image)

**Figure 26. Lift Provision Test: Concentrated Load of 18,750 lbs on two Diagonally Opposite Lift Rings**

D. Side Rail Test:

The purpose of these tests was to determine if the platform’s side rails have adequate strength to meet the in-flight requirements for restraint in the forward (3G) and upward (2G) directions. To test the side rails, the platform was rolled on to the test rail bed and locked in place. Both tests were performed using the 108” wide ADS roller configuration, with the platform locked in place along its 88” long sides. This configuration was deemed more critical than the 88”-wide C-17 LS roller arrangement. For the 3G forward test, an in-plane load of 30,000 lbs. (3G) was applied for 1.5 minutes to the platform using the Roller Test facility’s hydraulic ram. For the 2G upward test, an upward load of 20,000 lbs. (2G) was applied for 1.5 minutes to the platform using the Roller Test Facility’s two overhead cranes.

1. 3G Forward Side Rail Test

   For the 3G forward side rail test, the composite ECDS platform was wrapped with two built up nylon webbings. A wood block was placed under the webbings on the back of the composite ECDS platform to provide a bearing surface to protect the side rail. The webbings were attached to chains wrapped around a Type V platform that had been placed in front of the composite ECDS platform. The extraction point on the Type V platform was, in turn, connected to the hydraulic ram. With the composite ECDS platform locked in the rails, the hydraulic ram then pulled on the Type V platform, which was free to move in the rails, transferring the force applied by the hydraulic ram to the ECDS platform. The 3G forward rail test set up is shown in Fig 27. No platform or side rail damage or delaminations were observed upon inspection after the load had been removed.

2. 2G Upward Side Rail Test

   For the 2G upward side rail test, the composite ECDS platform was locked in position and a 20,000 lb upward load was applied, spread over eight of the tiedown provisions along the two 108” long sides. This is much more severe than anticipated in a real scenario, in which the tiedown rings along the 88” sides would also be used to further spread the load. The 2G upward rail test set up is shown in Fig 28. The upward deflection of the platform during the test was very small and no damage or delamination was observed after the test.
Figure 27. Side Rail Test: 30,000 lbs Forward (3G)

Figure 28. Side Rail Test: 20,000 lbs Upward (2G)
E. Rail Tiedown Provision Test

The purpose of this test was to determine the strength of the tie down provisions/rings. The tiedown provisions were tested by applying a load of 7,500 lbs for no less than 6 seconds. This load was applied once vertically up, and then at 45° from vertical and along the transverse direction of the platform.

1. Rail Tiedown Ring Test: Vertical

The rail tiedown ring vertical load test set up is shown in Fig 29. The 7,500 lb. load was held for a minimum of 6 seconds and no damage was observed.

![Figure 29. Rail Tiedown Test: 7,500 lbs, Vertical](image)

2. Rail Tiedown Ring: 45°Test

The rail tiedown ring 45° load test set up is shown in Fig 30. The 7,500 lb. load was held for a minimum of 6 seconds and no damage was observed. The test was also performed at 10,000 lbs and held for the minimum 6 seconds. No side rail/composite structural damage/delamination was observed, validating the adequacy of the metal/composite interface design.

![Figure 30. Rail Tiedown Ring Test: 7,500 lbs, 45 Degrees from Vertical](image)
F. Deck Tiedown Ring Test

One of the deck tiedown rings was tested up to the required 4,500 lb. load and held for the minimum 6 seconds. No damage was observed after the test. The deck tiedown ring test set up is shown in Fig 31.

![Deck Tiedown Ring Test: 4,500 Lbs Load](image)

**Figure 31. Deck Tiedown Ring Test: 4,500 Lbs Load**

XI. Conclusion

Engineered advanced polymer matrix composite materials were used in the development of a lightweight and affordable composite ECDS platform. Altogether four prototype composite ECDS platforms are being fabricated using the VARTM integral fabrication process. The first composite ECDS prototype platform has successfully passed all the ground qualification tests necessary to permit airdrop testing of the platform from U.S. Air Force cargo aircraft. Airdrop testing of the composite ECDS prototype platforms at the U.S. Army Yuma Proving Ground is scheduled to begin during the summer of 2007. The composite ECDS platform is >25% lighter compared to the current aluminum ECDS, which will provide about 200 lbs of additional payload capacity.

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