C.2

TECHNICAL REPORT
NATICK/TR-90/052

AD A 227 488

PALLETIZED LOADING SYSTEM COMPATIBILITY WITH AMMUNITION AIRDROP RESUPPLY

BY

GLENN DOUCET

SEPTEMBER 1990

FINAL REPORT JANUARY 1987 TO SEPTEMBER 1989

Approved for public release; distribution unlimited.

TECHNICAL LIBRARY
U.S. ARMY NATICK RD&E CENTER
NATICK, MA 01760-5000

UNITED STATES ARMY NATICK
RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK, MASSACHUSETTS 01760-5000

ADVANCED SYSTEMS CONCEPTS DIRECTORATE

DISCLAIMERS

The findings contained in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

DESTRUCTION NOTICE

For Classified Documents:

Follow the procedures in DoD 5200.22-M, Industrial Security Manual, Section II-19 or DoD 5200.1-R, Information Security Program Regulation, Chapter IX.

For Unclassified/Limited Distribution Documents:

Destroy by any method that prevents disclosure of contents or reconstruction of the document.

AD-A227488

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	SEPTEMBER 1990	FINAL REPORT JAN 87 TO SEP 89

4. TITLE AND SUBTITLE

PALLETIZED LOADING SYSTEM COMPATIBILITY WITH AMMUNITION AIRDROP RESUPPLY

5. FUNDING NUMBERS

PE 62786
PR D283
TA AB

6. AUTHOR(S)

GLENN DOUCET

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. ARMY NATICK RD&E CENTER
ATTN: STRNC-AA
NATICK, MA 01760-5015

8. PERFORMING ORGANIZATION REPORT NUMBER

NATICK/TR-90/052

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

OFFICE OF THE PROJECT MANAGER FOR AMMUNITION
LOGISTICS (PM/AMMOLOG)
ATTN: AMCPM-AL
PICATINNY ARSENAL, NJ 07806-5000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The objective of this analysis was to investigate techniques for achieving compatibility between ammunition airdrop resupply and the Palletized Loading System (PLS). The conceptualized PLS, essentially a flatbed truck with a hydraulic lift, is intended to retrieve flatracks that have been airdropped and have them secured and ready to roll in about a minute with minimum time and labor. A maximum payload capacity of 16.5 tons is contemplated.

The results of this analysis indicate that the most practical method of accomplishing this retrievability is by airdropping PLS flatracks on Type V airdrop platforms, with the necessary energy-absorbing honeycomb placed under the flatrack. This configuration allows the airdropping of loads in their overland configuration, saving time at the rigging facility and at the drop zone. This technique has been successfully tested up to a 28,000-lb payload. The PLS could be a great asset for clearing drop zones of heavy resupply loads.

(RH)

14. SUBJECT TERMS			15. NUMBER OF PAGES
Airdrop	Ammunition Resupply	Palletized Loading System	39
Drop Zone	Honeycomb	Type V Platforms	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

TABLE OF CONTENTS

	Page
LIST OF FIGURES	iv
SUMMARY	v
INTRODUCTION	1
Background	1
Objective	1
Approach	2
EQUIPMENT DESCRIPTIONS, CONSTRAINTS, AND ASSUMPTIONS	3
Palletized Loading System	3
Airdrop System	3
Energy Absorption and Tiedown Lashings	3
Equipment Constraints	5
Concept Assumptions	5
ALTERNATIVE AIRDROP CONCEPTS FOR AMMUNITION RESUPPLY	8
Flatrack on Type V Before Airdrop	8
Modification of Type V Platform, Flatrack Modification, and Development of a New Platform	15
PLS Modification	26
Type V Platform on Flatrack After Air Delivery	27
CONCLUSIONS AND RECOMMENDATIONS	28
REFERENCES	29
APPENDIX: Airdrop Certification Requirements for the Palletized Loading System	31

DTIC

Accession For
NTIS GRA&I
DTIC TAB
Unannounced
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A-1

LIST OF FIGURES

Figure		Page
1.	Type V Airdrop Platform.	2
2.	Aircraft and Aircraft Loader Roller Locations.	4
3.	Interoperability Agreement Drawing of Flatrack.	6
4.	Flatrack Guide Rail Locations for C-130, C-141, C-5, and C-17 Aircraft Rollers.	7
5.	Honeycomb Configured on Type V Platform.	9
6.	Flatrack Being Placed on Type V Platform.	10
7.	Flatrack Restrained for Airdrop on Type V Platform.	12
8.	Airdrop of Flatrack on Type V Platform.	13
9.	Static Drop Test Employing Weight Tub.	14
10.	PLS Retrieval of Flatrack From Platform on Drop Zone After Airdrop.	16
11.	PLS Honeycomb Configuration, 8 to 18K.	17
12.	Plan View Showing Location of PLS Honeycomb Stacks, 8 to 18K.	18
13.	Depiction of Individual PLS Honeycomb Stacks, 8 to 18K.	19
14.	PLS Honeycomb Configuration, 18 to 28K.	20
15.	Plan View Showing Location of PLS Honeycomb Stacks, 18 to 28K.	21
16.	Depiction of Individual PLS Honeycomb Stacks, 18 to 28K.	22
17.	Comparison of Present Type V Platform to Platform Modified to Achieve PLS Compatibility.	23
18.	Details of Modified Type V Platform to Maintain PLS and Aircraft Rail System Compatibility.	24

SUMMARY

The purpose of this project was to develop, analyze, and select promising concepts that would create compatibility between airdrop and the Palletized Loading System (PLS). This compatibility could be achieved in a number of ways, and several potential near- and long-term solutions were investigated. Specific system concepts investigated in this analysis were as follows:

(1) rigging flatracks on Type V platforms before airdrop with paper honeycomb placed between the two;

(2) modification of the Type V platform for PLS compatibility;

(3) modification of the flatrack platform for airdrop compatibility;

(4) development of a new platform that would be both airdrop and PLS compatible;

(5) modification of the PLS so that it could retrieve a Type V platform; and

(6) placement of the Type V platform on a flatrack after air delivery so that it could be retrieved by the PLS.

Of particular interest were the following three payload ranges: 8,000 to 18,000 lb, 18,000 to 28,000 lb, and 28,000 to 33,000 lb. These weight ranges were based on loads used at the PLS ammunition distribution system test performed at Fort Hood in 1987. The upper value of each range represents the maximum weight that certain honeycomb configurations can accommodate, given the maximum allowed "g" loading for ammunition.

The concept of rigging PLS flatracks on Type V platforms with energy-absorbing honeycomb placed between the two was considered the most promising because it could be implemented in the near-term. Therefore, this system concept became the object of much of the work under this customer order. This concept is one of the most viable because all necessary components are currently available in the Army logistics system. It is also the most efficient when viewed as part of the total resupply system because it does not require transloading at the rigging facility nor the development of specialized, expensive equipment. The most notable feature of this concept is the placement of the honeycomb. Because it is between the flatrack and the platform, the configuration can be developed independent of the load that will be carried on the flatrack. This feature will allow the delivery of any load, from 8,000 to 32,500 lb, with one of three honeycomb configurations.

Feasibility testing of the PLS flatrack on Type V platform was performed at Yuma Proving Grounds, Arizona. This testing included drops from a static position (12.7 feet to simulate an airdrop impact), airdrops from a C-130, and retrieval by the PLS after impact. These tests proved that the PLS could easily retrieve a load on the drop zone quickly and without interference from the crushed paper honeycomb. Static tests were subsequently conducted at Natick to refine the honeycomb/load spreader cushioning arrangements of the two lower payload ranges in order to further verify the feasibility of the system.

PALLETIZED LOADING SYSTEM COMPATIBILITY WITH AMMUNITION AIRDROP RESUPPLY

INTRODUCTION

Background

Modern weapons can expend ammunition at rates never before achieved, straining the present logistics system. Add to this the current doctrine, which dictates fast moving forces, and the resulting scenario is one that will require airdrop resupply to keep pace with the fighting forces. Presently, the most widely used method of ammunition airdrop resupply is by Containerized Delivery System (CDS). The container is an A-22 rated at 2200 lb. Although a payload of this size can deliver an effective amount of small arms ammunition, its utility as a method of resupply for artillery units is inadequate under scenarios where high rates of fire must be sustained.

Each A-22 container can supply 10 155-mm rounds in a combat configured load, an amount that could be easily expended in less than 10 minutes by 1 gun. Resupply of artillery in substantial amounts would require the use of multiple container drops or platform airdrop. The use of multiple container drop scatters ammunition across the drop zone, complicating the retrieval process. For this reason, artillery ammunition resupply lends itself readily to platform delivery where large quantities can be delivered to a single point on the drop zone.

Platform loads are delivered on Type V platforms (Figure 1), ranging in size from 8 feet to 32 feet in 4-foot increments. The rated capacity of a 12-foot platform is 10,000 pounds. Testing is presently being conducted utilizing six point suspension systems that will allow 42,000 pounds of ammunition on a single platform. Even with a successful 42K system, the problem of removing these large quantities of ammunition from the drop zone will still remain. The drop zone would, in effect, become the ammunition supply point.

Objective

The objective of this project was to investigate methods to integrate the Palletized Loading System (PLS) into the airdrop resupply system. The PLS will be incorporated to achieve a reduction in time required for loading and unloading operations. It can retrieve a 20-foot flatrack with a 16.5-ton payload in 1 minute from the time it hooks up to the load. It can also transport a second flatrack on its accompanying trailer. Utilizing the PLS for drop zone clearing would greatly decrease clearing times, thereby decreasing the drop zone signature and unit vulnerability.

The ultimate goal of the project was to devise an efficient transition from overland travel to air transportation to airdrop and to overland travel again. The ultimate solution being the development of a single pallet that could perform all the above mentioned functions without load manipulation once the pallet is initially loaded.

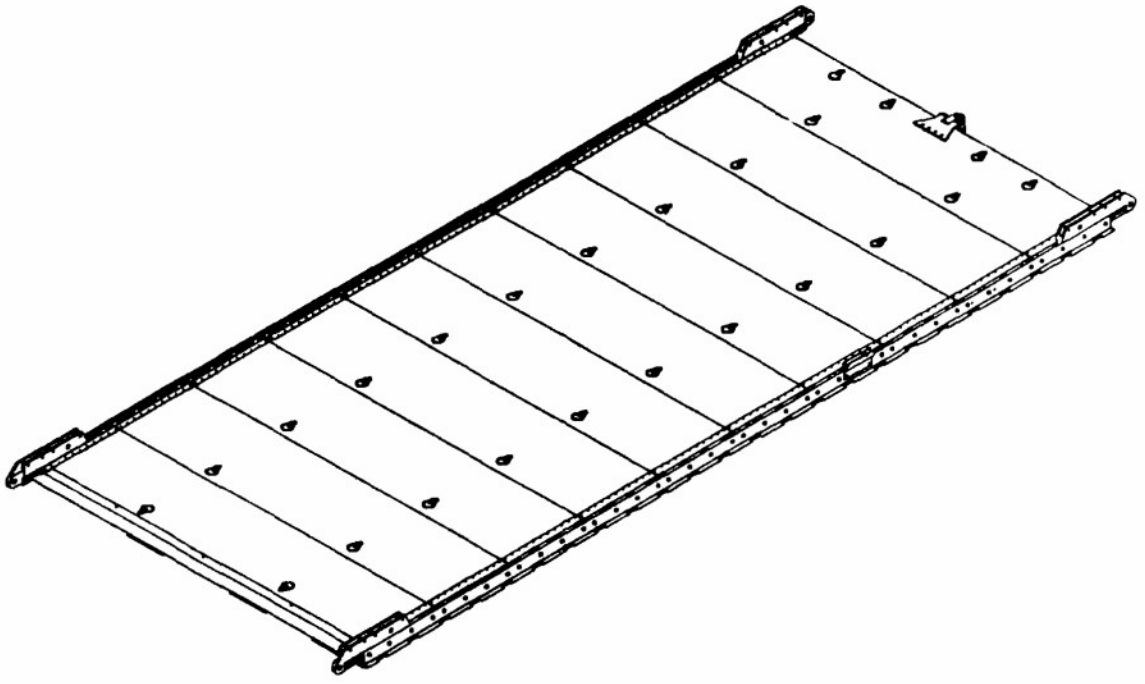


Figure 1. Type V Airdrop Platform.

Approach

The approach taken to develop concepts for this project was quite straight- forward. Concepts were initiated based on what could be accomplished given unlimited resources and time. This does not mean all concepts would require unlimited resources and time. Next, they were evaluated for feasibility, either as a near- or long-term solution. To properly evaluate concepts, a geometric model of the retrieval process was constructed using CADKEY software. This model can position the PLS retrieval arms and flatrack in any possible position for analysis of concepts for interference, stress points, bending forces, etc. The geometric model was based on the Kenworth prototype PLS.

When an easily implemented concept was found, testing was performed to bring the system as close to fielding as possible given the present state of the requirement for airdrop of PLS flatracks.

EQUIPMENT DESCRIPTIONS, CONSTRAINTS, AND ASSUMPTIONS

Palletized Loading System

Although the PLS has not been procured in its final configuration, its configuration and performance specifications have been well-defined for the purpose of this report. Prototype PLSs have already been produced that, for the purpose of airdrop, perform as the final design will perform.

The PLS consists of three main parts: truck, flatrack, and trailer. The truck refers to the vehicle and the retrieval mechanism with its associated guide system. The retrieval mechanism pulls the flatrack up onto the truck and the guide system keeps it centered on the truck chassis. The flatrack is a specifically designed platform (8 feet by 20 feet) that has guide rails on its underside and an A-frame on the front for PLS retrieval. PLS includes a trailer with the same haul capacity as the truck. To load the trailer, the truck will pick up a flatrack and then push it back onto the trailer.

The PLS will comc in two variants: one with a Material Handling Crane (MHC) and one without. The crane will be rated at 3,900 lb and will be ablc to perform this lift on a standard pallet (48" x 48") from anywhere on a retrieved flatrack and on either side of the truck. Another option available will be a self-recovery winch kit capable of forward or rearward deployment. It will have a minimum tow capacity of 20,000 lb and a minimum line speed of 15 ft/min on an empty spool. The minimum top layer pull will be 10,000 lb, and the cable will be a minimum of 195 feet long.[1]

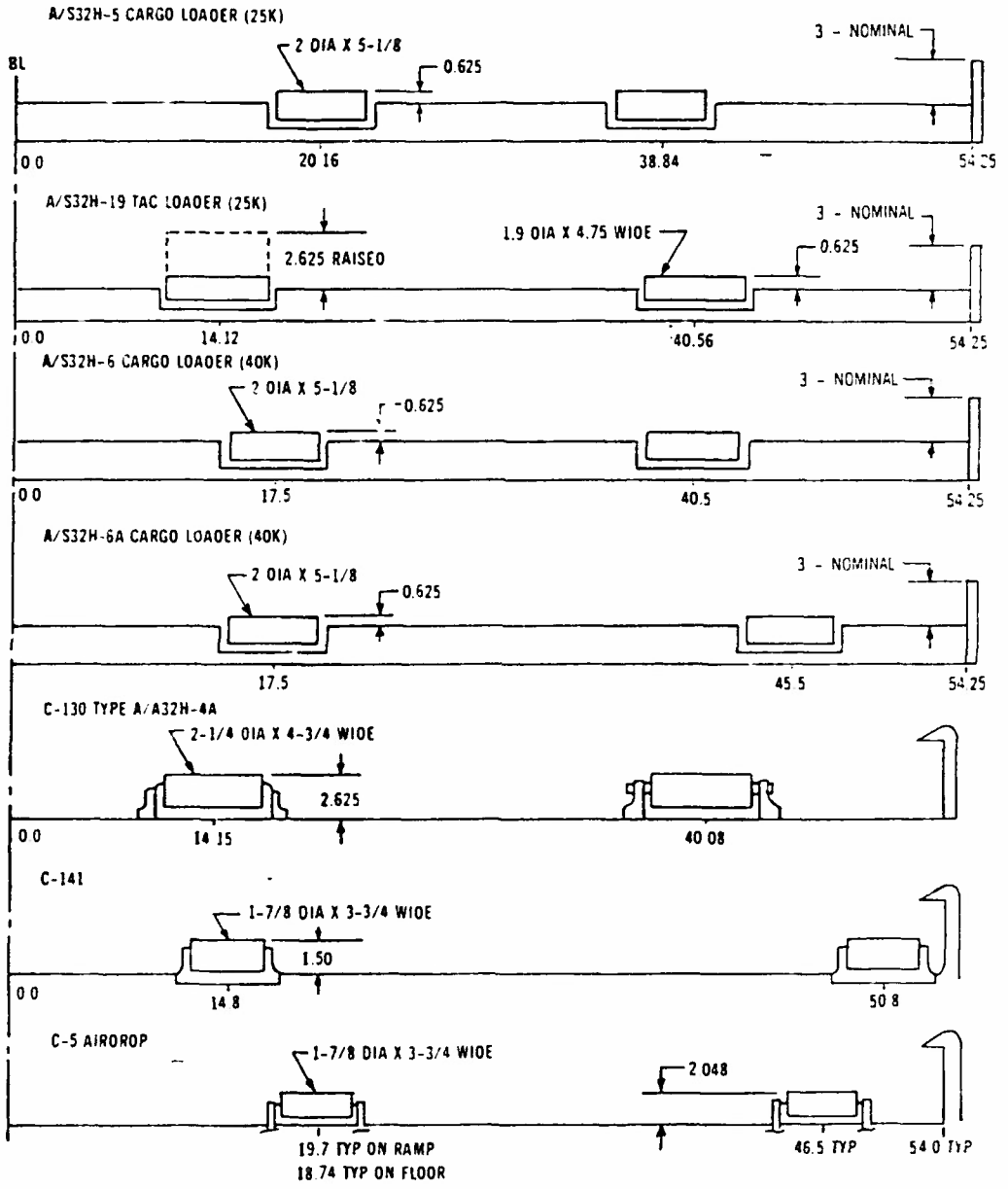
Airdrop System

For the purpose of this discussion, the airdrop system will include the aircraft and the airdrop platform. The part critical to airdrop interface is the aircraft rollers and locking rail system. The rollers run longitudinally along the aircraft floor. Each aircraft (C-130, C-141, C-5, and the C-17), as well as aircraft material loaders, has a different roller spacing as measured laterally from the aircraft centerline (Figure 2). The main work- horse will be the C-130; however, the limiting factor will be the rollers on the C-141. Because of this, all airdrop platforms must be designed to its roller load parameters. The roller system also includes a locking rail system which serves two purposes: (1) it restrains the load in the forward, aft, and vertical up directions; and (2) it holds the load in the craft while the extraction chutes are inflating and until they build enough force to remove the load quickly and safely. The airdrop platform referred to is the Type V airdrop/LAPES (Low Altitude Parachute Extraction System) platform, hereafter referred to as the platform. It has recently entered the system and will replace the Type II airdrop and Metric LAPES platforms.

Energy Absorption and Tiedown Lashings

Presently, the only method available to absorb impact energy in airdrop operations is paper honeycomb. It comes in 3-in thick, 3-ft by 8-ft sheets. The paper honeycomb is placed between a load and the platform and is crushed when its strength of 6,300 lb/ft^2 is exceeded. For many years, Natick has

SUB-NOTE 5.1(2) Aircraft and Loader Roller Locations (Sheet 1 of 2)



BL 0.0 is centerline of aircraft floor or loader. Rollers are on 10-in. centers fore and aft.
Dimensions in inches.

Figure 2. Aircraft and Aircraft Loader Roller Locations.

been trying to find a replacement for paper honeycomb, however, its low cost, uniform crush rate, biodegradability, predictable behavior, and ease of use have made it very difficult to find an economic and/or functional replacement. The tiedown lashing presently certified for airdrop use is a load binder type that has a rated strength of 5000 lb.

Equipment Constraints

There are two constraints that must be adhered to during PLS/airdrop platform concept development. First, the flatrack must be compatible with NATO PLS systems and standard ANSI/ISO containers. This constraint dictates the guide rail geometry on the flatrack which indirectly drives the guide system design on the truck itself. The geometry is given in the interoperability drawing that will be included in the PLS performance specification (Figure 3). The second main constraint is aircraft roller latitudinal spacing. This spacing cannot be modified without redesign and replacement of the aircraft floor, an event not likely to occur. The spacing variation from aircraft to aircraft drives the need for wide roller pads on airdrop platforms. Coincidentally, the roller spacing on the C-5 matches the guide rail spacing on the flatrack. This aircraft however, is not a primary means of airdrop. For this program, the main aircraft of concern are the C-130, C-141, and the C-17. The rollers on these aircraft do not mate with the guide rails on the flatrack (Figure 4).

Concept Assumptions

This investigation covered many concepts. The implementation of each concept involved a modification of a present item or the development of a new item. The items available for modification (in theory) included the PLS truck, PLS flatrack, Type V airdrop platform, and aircraft rollers. The assumption that any item can be developed or modified is much too vague for a realistic approach to this project. Some self-imposed constraints to simplify and produce a more feasible end product follow.

1. If the PLS truck is modified, no other items will be modified. This can be extended to apply to all items. If an item is modified or a new item developed, effort must be made to retain all other items in their present configuration.

2. The aircraft rollers will not be modified; however, they can be removed from the aircraft.

3. The aircraft locking rail system must be used to restrain the load (platform) while in the aircraft and operated as it presently does during platform extraction.

4. Any system developed should also be LAPESable. This constraint requires much more platform strength and load restraint than standard airdrop.

Using the above mentioned guidelines, the concepts that follow in the next section were developed and investigated for feasibility. They are presented in order of priority from the highest to the lowest.

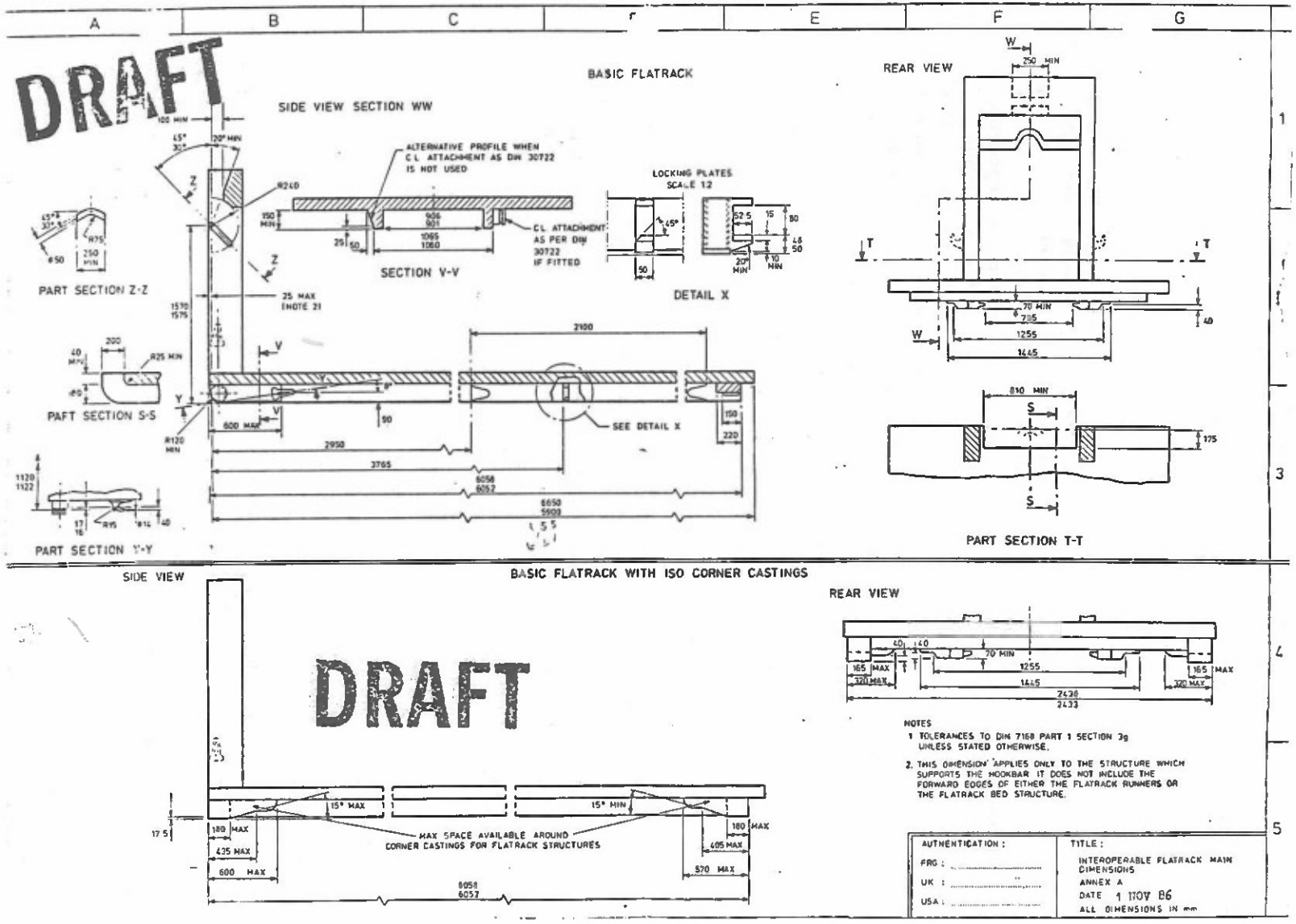


Figure 3. Interoperability Agreement Drawing of Flatrack.

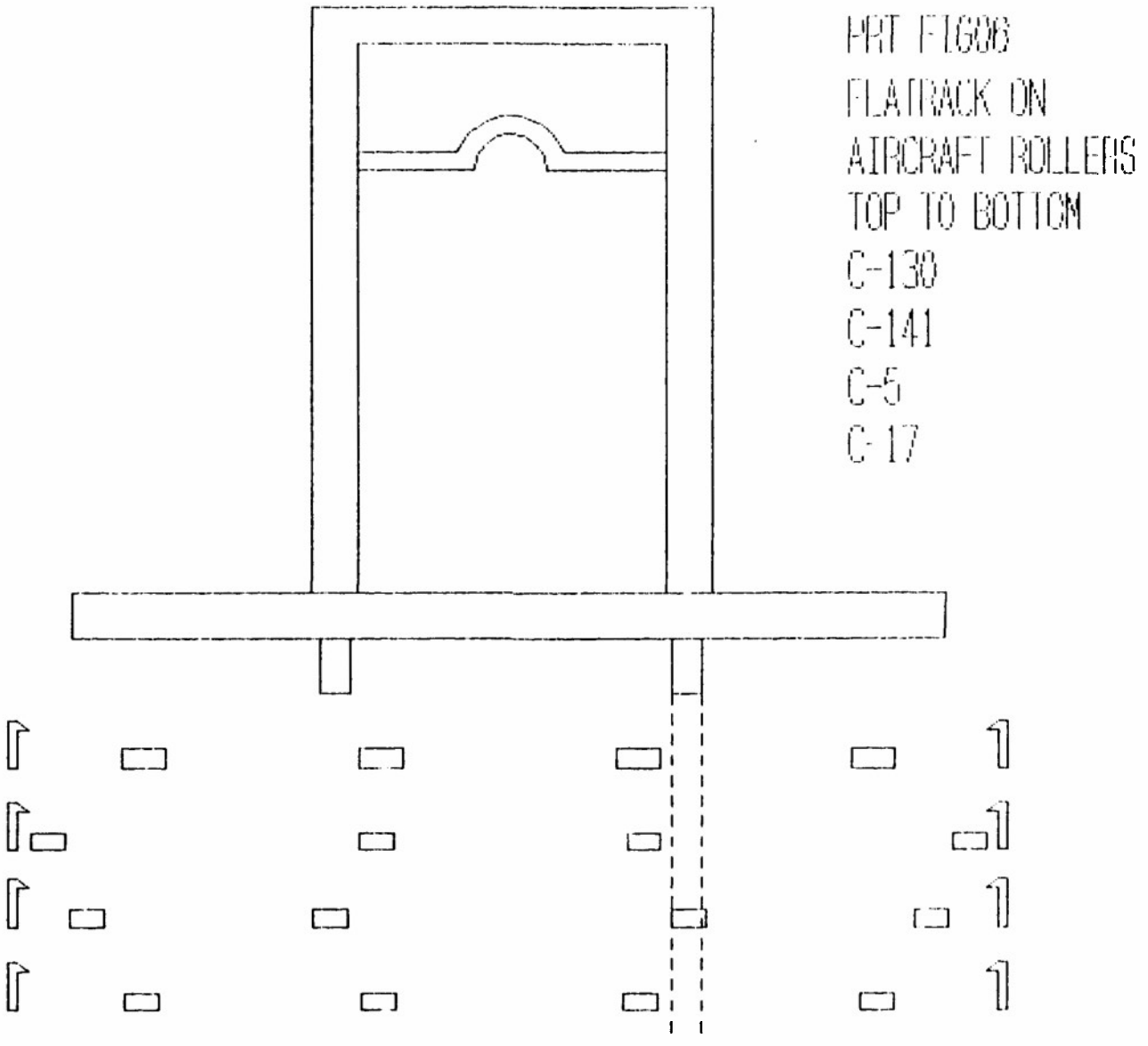


Figure 4. Flatrack Guide Rail Locations for C-130, C-141, C-5, and C-17 Aircraft Rollers.

ALTERNATIVE AIRDROP CONCEPTS FOR AMMUNITION RESUPPLY

As noted in the Summary, a total of six system concepts for achieving PLS airdrop compatibility were investigated. The rigging of flatracks on Type V platforms was considered the best near-term solution because it utilizes presently available equipment and technology. The three functionally similar concepts (i.e., modification of the Type V platform, flatrack modification, and development of a new platform) were considered possible long-term solutions. In order to be effective, all of these concepts would require costly development of new hardware and innovative cushioning technology, such as retrorockets or air bags. The conflicting strength and stiffness requirements of airdrop platforms versus flatracks would also make implementation of any of these concepts a difficult task.

Similar shortcomings were found with modifying the PLS for retrieving Type V platforms and with placing the platform on a flatrack after air delivery for PLS retrieval. Both of these concepts would require new cushioning technology in order to work effectively. With the exception of the rigging a flatrack on a Type V platform concept, all other system concepts would exceed the maximum allowed width of 8 feet specified for road transport when lifted onto the PLS. This issue would have to be addressed before fielding any of these systems. The following is a more detailed discussion of the various concepts investigated.

Flatrack on Type V Before Airdrop

This concept is being pursued as the preferred near-term solution. This method is the most inexpensive and easiest to implement. It is also the most efficient solution if measured by the time a flatrack enters the rigging facility to the time the loaded PLS leaves the drop zone.

A typical scenario is as follows. In the rigging facility, a Type V platform will be configured with the appropriate honeycomb kit (Figure 5). Only three honeycomb kits will be required for the entire weight range of flatracks. The ranges are 8,000 to 18,000 lb, 18,000 to 28,000 lb, and 28,000 to 33,000 lb. The weights are the gross weight of the load and the flatrack. Then, a PLS will arrive at the airdrop rigging facility with a flatrack rigged for overland travel. At the rigging facility, the flatrack will be lifted onto the honey- comb configured Type V platform (Figure 6).

A 24-foot Type V is used instead of a 20-foot platform because of the height of the flatrack A-frame. The A-frame must be placed facing the rear of the aircraft to meet the aircraft tip off curve limitations. A load height exceeding this limitation would endanger the aircraft in the case of an extraction chute malfunction (the load would exit the aircraft slower than normal). The danger comes when the load tips over the edge of the aircraft ramp. If it is too tall, it may contact the ceiling of the aircraft.

With the A-frame facing the rear of the platform, the recovery parachutes will be placed to the rear of the A-frame on the remaining 4 feet of platform. This precaution is necessary to avoid interference between the A-frame and the deployment of the main chutes.

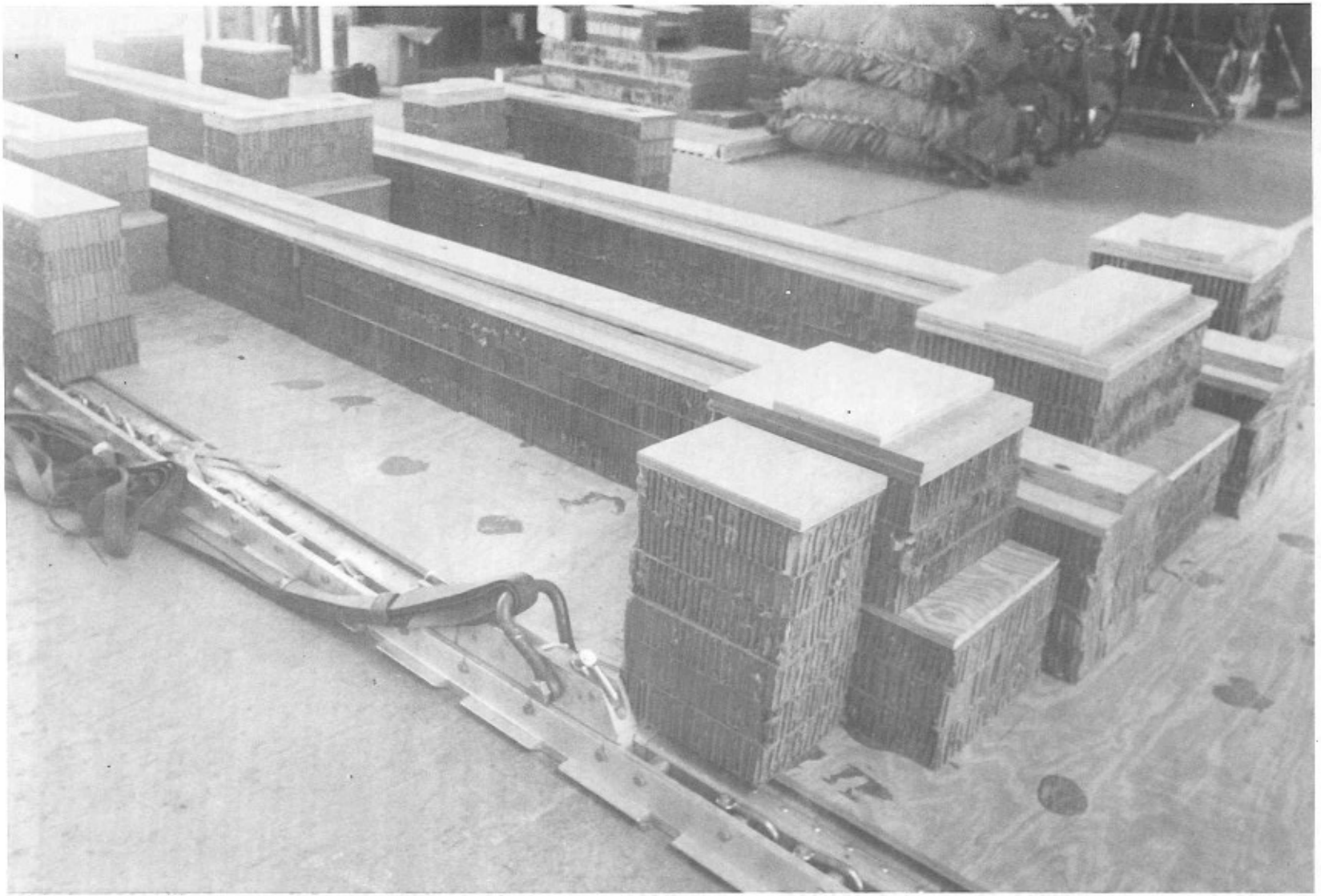


Figure 5. Honeycomb Configured on Type V Platform.

Figure 6. Flatrack Being Placed on Type V Platform.

Once the flatrack is placed on the honeycomb configured platform, additional lashing are used to provide the required airdrop restraint (Figure 7). Requirements, as set forth in the AFSC Design Handbook[2], are as follows: forward - 3 g's, aft - 1.5 g's, lateral - 1.5 g's, up - 2 g's, down 4.5 g's. The flatrack and load must be restrained to the platform at least this well. Because the load is restrained to the flatrack and the platform separately, time on the drop zone is minimized. The crush of the honeycomb due to impact loosens the airdrop lashings, which are then easily removed. The PLS then retrieves the flatrack with the overland lashings intact.

Status. This method has been successfully demonstrated during September to October 1988 (Figure 8). The test included drops from a static height of 12.7 feet to achieve an impact velocity of 28.5 feet/sec and airdrops from a C-130 at an altitude of 1500 feet and 130 knots indicated airspeed. These tests were performed at Yuma Proving Grounds, Arizona. The static drops were performed using weight tubs as loads (Figure 9). The airdrop loads consisted of 210 105-mm ammunition cases filled with sand, each weighing approximately 110 pounds. A summary of the testing is shown in Table 1.

TABLE 1. Flatrack on Type V Platform Test Summary.

Drop No.	Type of Drop	Load (lb)	Date
1	Static	32,000	30 August 1988
2	Static	32,000	1 September 1988
3	Static	32,000	6 September 1988
4	Static	18,000	8 September 1988
5	Airdrop	23,100	14 September 1988
6	Airdrop	23,100	5 October 1988

The purpose of this testing was to determine the proper honeycomb configurations and to test the PLS's ability to retrieve a flatrack after an airdrop. The PLS prototype flatrack used for the test was slightly damaged in drop number 1. The PLS truck was still able to retrieve the flatrack; however, there was slight interference at different times during the retrieval cycle between the guide rollers on the PLS and the guide rails on the flatrack. No damage was caused to the PLS truck during this retrieval. The interference was caused by the center guide rails being twisted outward. The maximum twist resulted in an increased guide rail spacing of 1/2 inch. Another form of damage that did not affect the function of the flatrack was bending of the I-beams. The inner I-beams bowed down in the middle and the outer beams bowed up in the middle in the longitudinal direction.

Four more drops were conducted to test new honeycomb configurations prior to repairing the flatrack. To avoid unnecessary damage to the PLS truck, no attempt was made to retrieve the flatrack with the PLS after any of these drops. The purpose of these tests was to develop a honeycomb arrangement that would provide greater support to the flatrack's longitudinal I-beam members in order to decrease bending of the flatrack and minimize the load carried by the weaker lateral channel sections. The reconfiguration was successful since there was no further apparent damage to the flatrack.

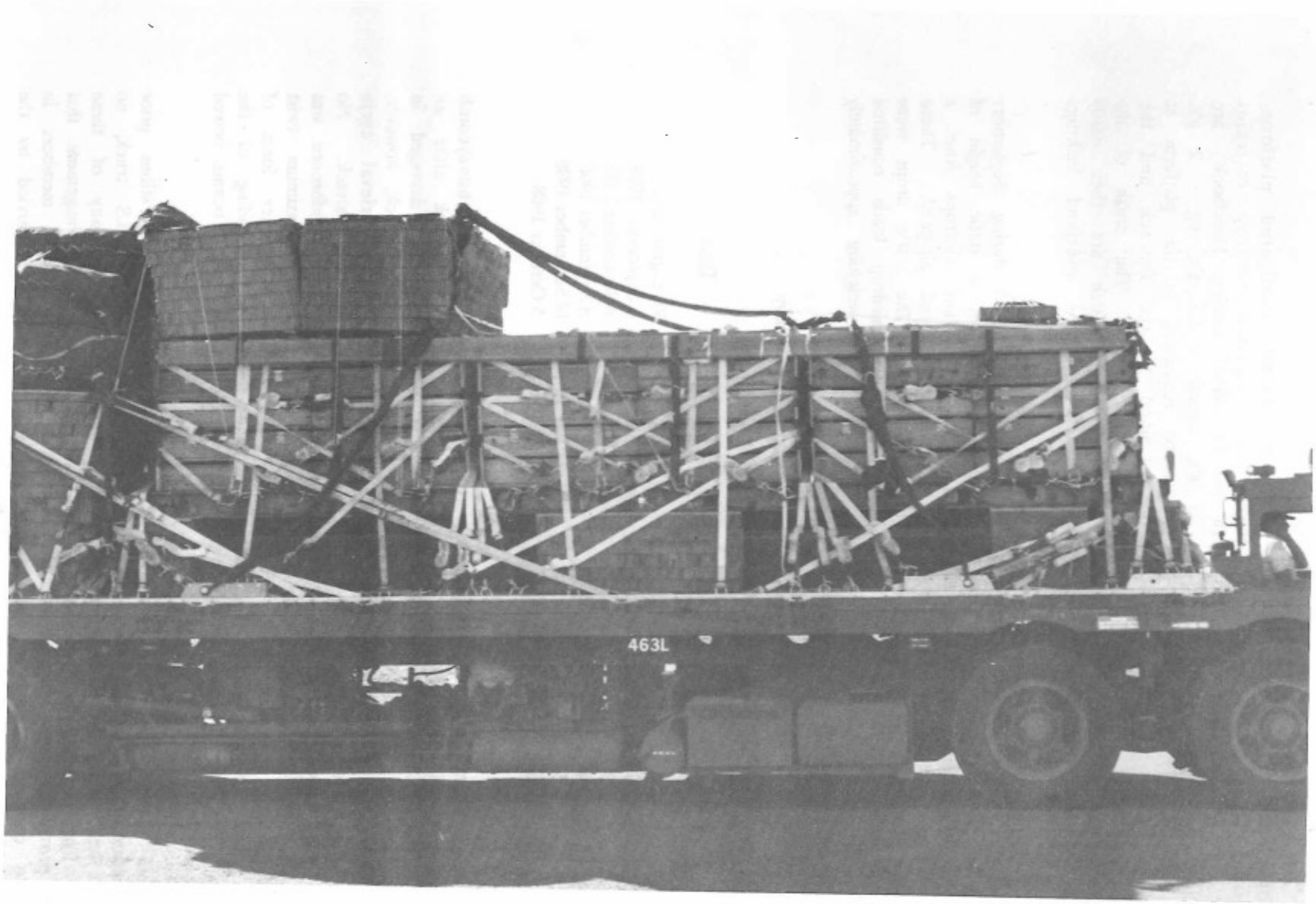


Figure 7. Flatrack Restrained for Airdrop on Type V Platform.

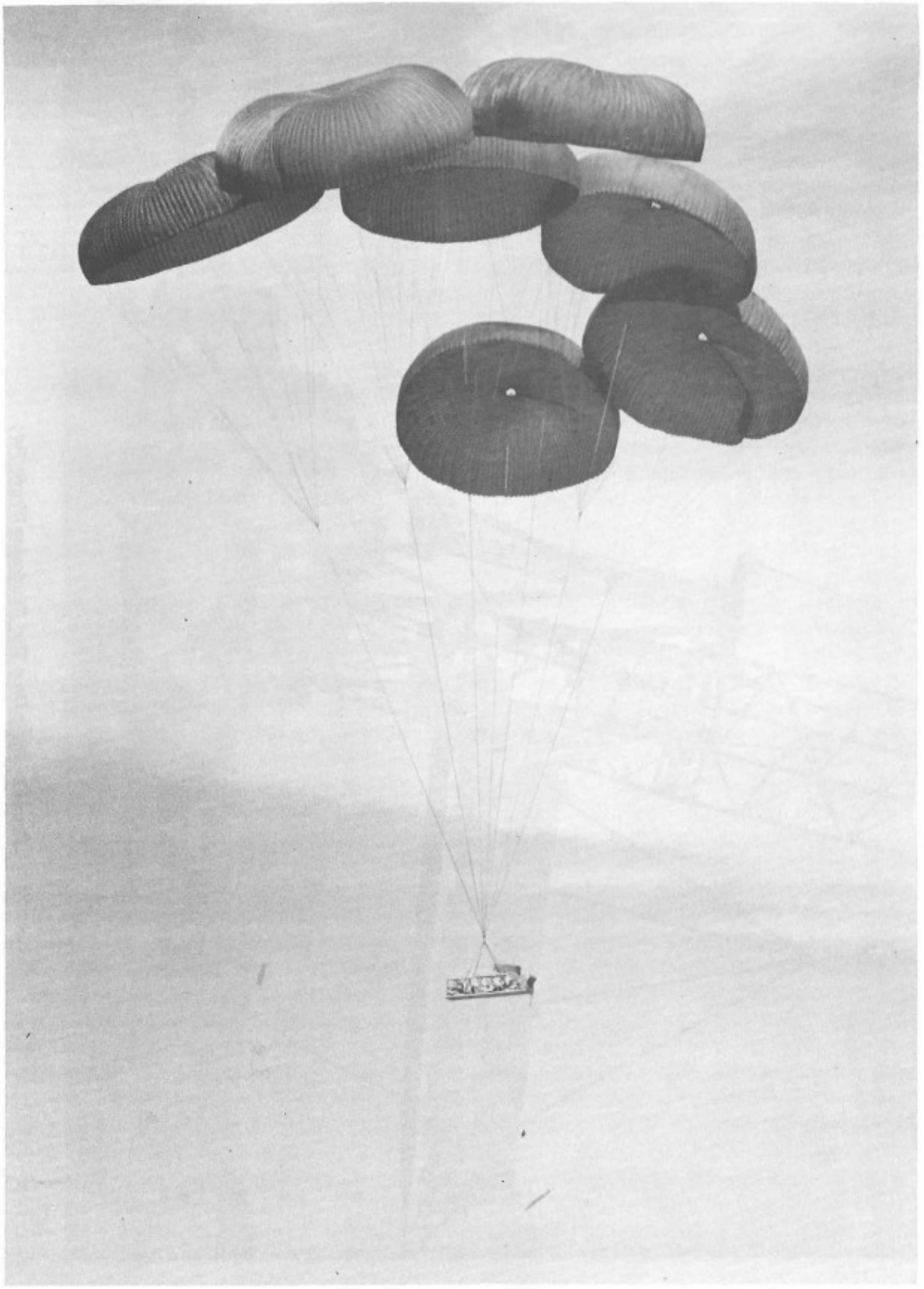


Figure 8. Airdrop of Flatrack on Type V Platform.

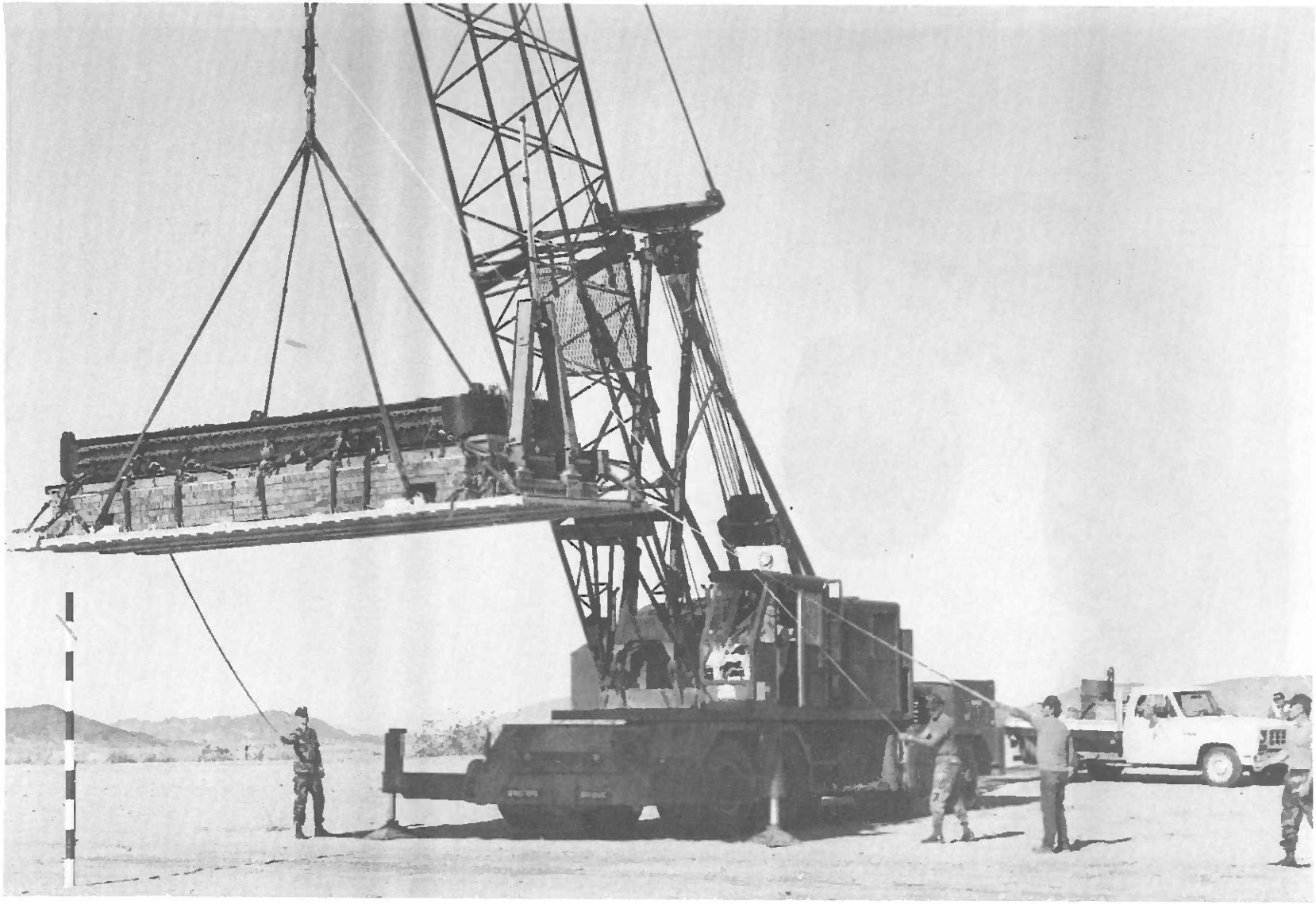


Figure 9. Static Drop Test Employing Weight Tub.

Repairs were made to the flatrack during the time lapse between the fifth and sixth drops. To repair the flatrack, the latitudinal channels were replaced with larger 4-inch channel sections. This repair increased the weight of the flatrack by 600 lb and increased its strength in the lateral direction. Despite this change, however, it was reasoned that use of these larger channel sections in the test flatrack would not affect conclusions about the flatrack's ability, as presently designed, to be retrieved by the PLS after an airdrop. This reasoning was based on the belief that adequate steps had been taken in the arrangement of the honeycomb rigging to eliminate as much direct loading of these members as possible. No damage was sustained during the sixth drop and the flatrack was easily removed from the landing site by the PLS (Figure 10).

To improve the honeycomb configurations still further, subsequent testing of this same flatrack was performed at Natick RD&E Center. This testing was designed to determine the most efficient use of honeycomb and load spreaders. The design of the load spreaders was the major engineering challenge. To date, configurations have been completed for the 8,000 to 18,000-lb range (Figures 11, 12, and 13) and the 18,000 to 28,000-lb range (Figures 14, 15, and 16). The configuration for the 28,000 to 33,000-lb range will be determined at a later date as necessary.

Modification of Type V Platform, Flatrack Modification, and Development of a New Platform

These three concepts will be grouped together since the end product will be very similar in function. That is, they will all be completely compatible with the PLS, aircraft loading equipment, all airdrop certified aircraft, and the actual airdrop. The flatrack would be modified for airdrop, the Type V platform would be modified for PLS compatibility, or a new platform would be a hybrid of the two.

In order of incidence, the first obstacle to overcome is PLS compatibility. This requires center guide rails dimensionally equivalent to the flatrack interoperability agreement drawing (Figure 3). Also required is a hookbar and supporting structure; otherwise it could not be retrieved by the PLS without modification of the truck. A roller pad system would be needed that could support the loaded platform on the aircraft loaders and the aircraft. This problem is exaggerated because the first requirement (PLS guide rails) will, in most cases (C-130, C-141, and C-17), leave no method of support other than the outer rollers and pads unless some other means of support can be devised. The aircraft locking rail system must also be utilized for restraint during flight and proper load extraction during airdrop.

Finally, energy absorption of some sort must be utilized. At this time, placing paper honeycomb under the load is the only method available. This causes a serious problem on the drop zone when it is time to retrieve the load with the PLS. When the honeycomb crushes it relieves all of the tension in the lashings. Depending on the amount of honeycomb used, the slack can be as much as 24 inches. In some cases, the load may also shift when tension is released. Under these circumstances, the PLS truck would be unable to retrieve the load without very time-consuming load adjustments on the drop zone. If an alternative method of energy absorption can be developed (i.e., air bags or retrorockets), this concept group may prove very attractive.

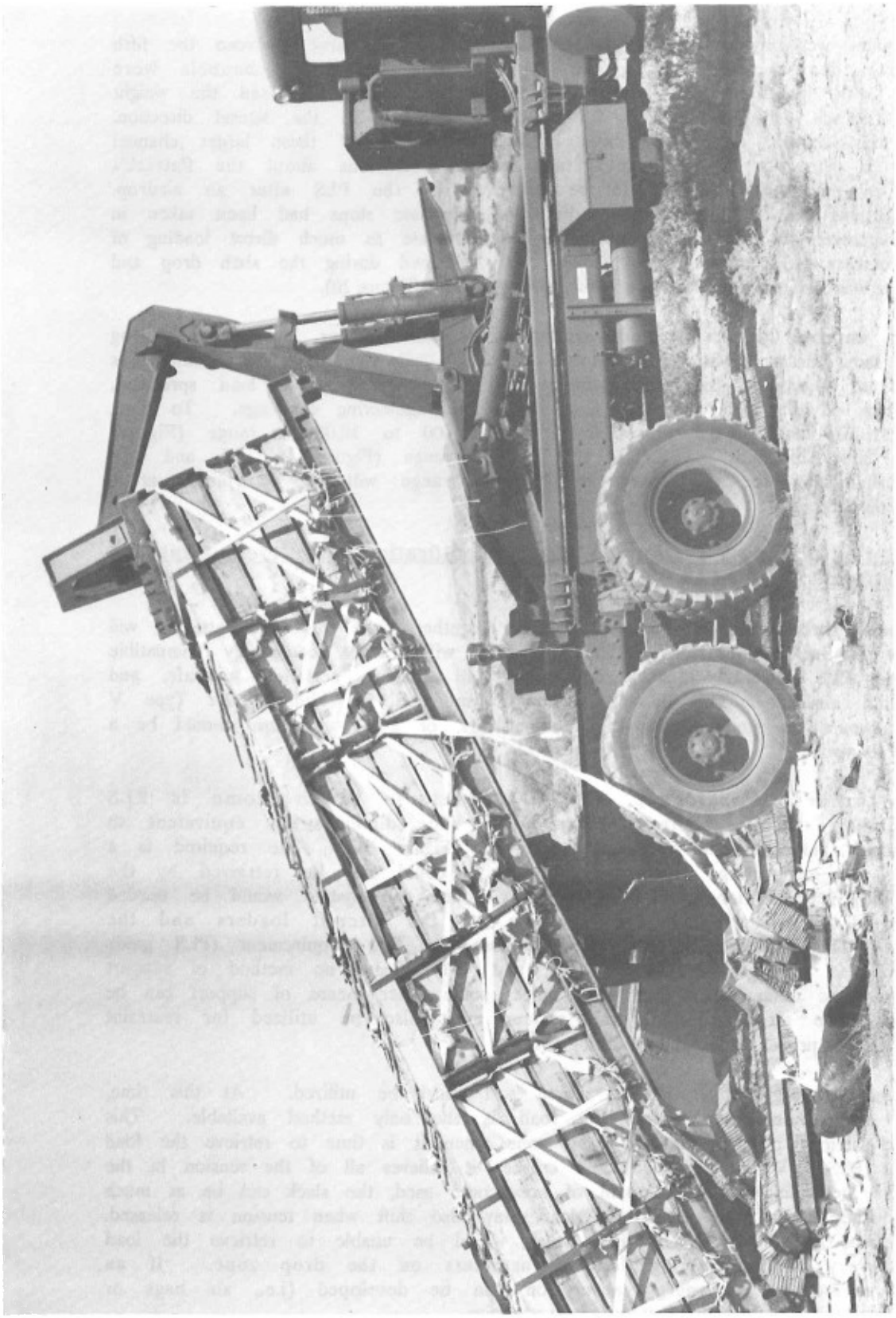


Figure 10. PLS Retrieval of Flatrack From Platform on Drop Zone After Airdrop.

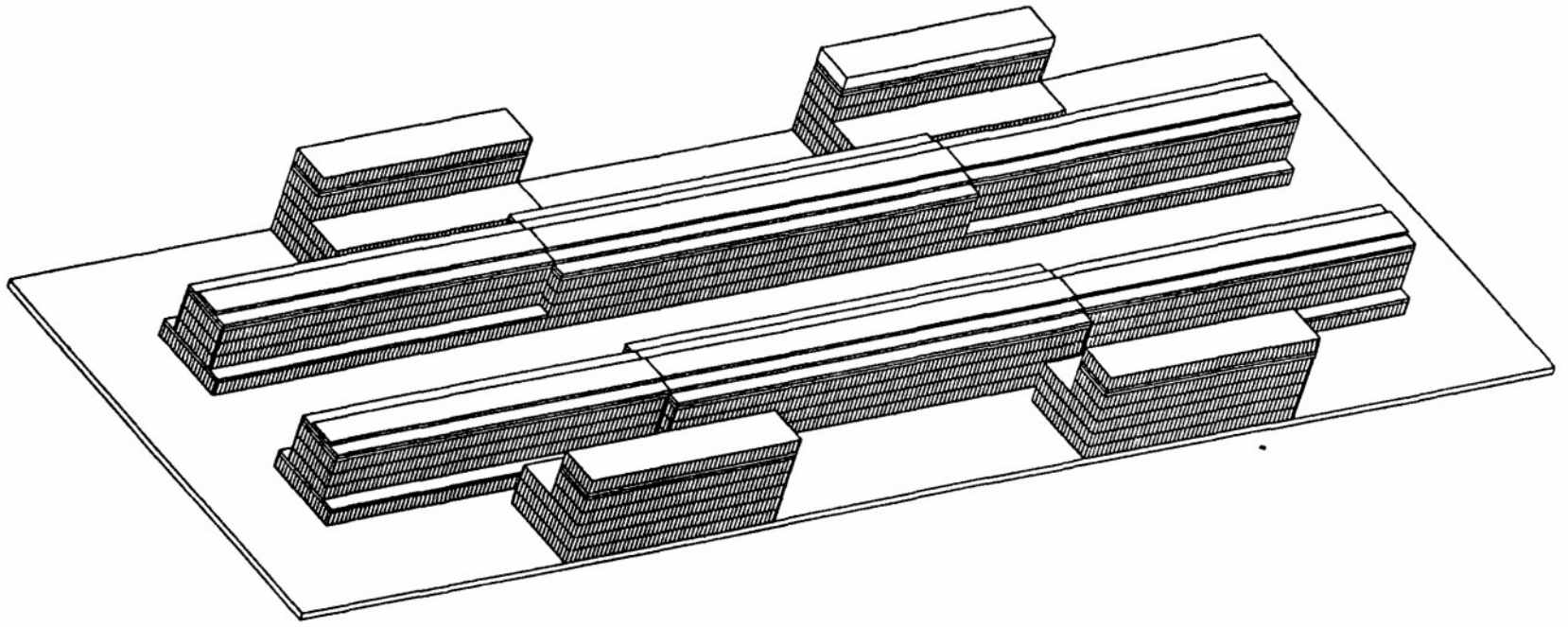


Figure 11. PLS Honeycomb Configuration, 8 to 18K.

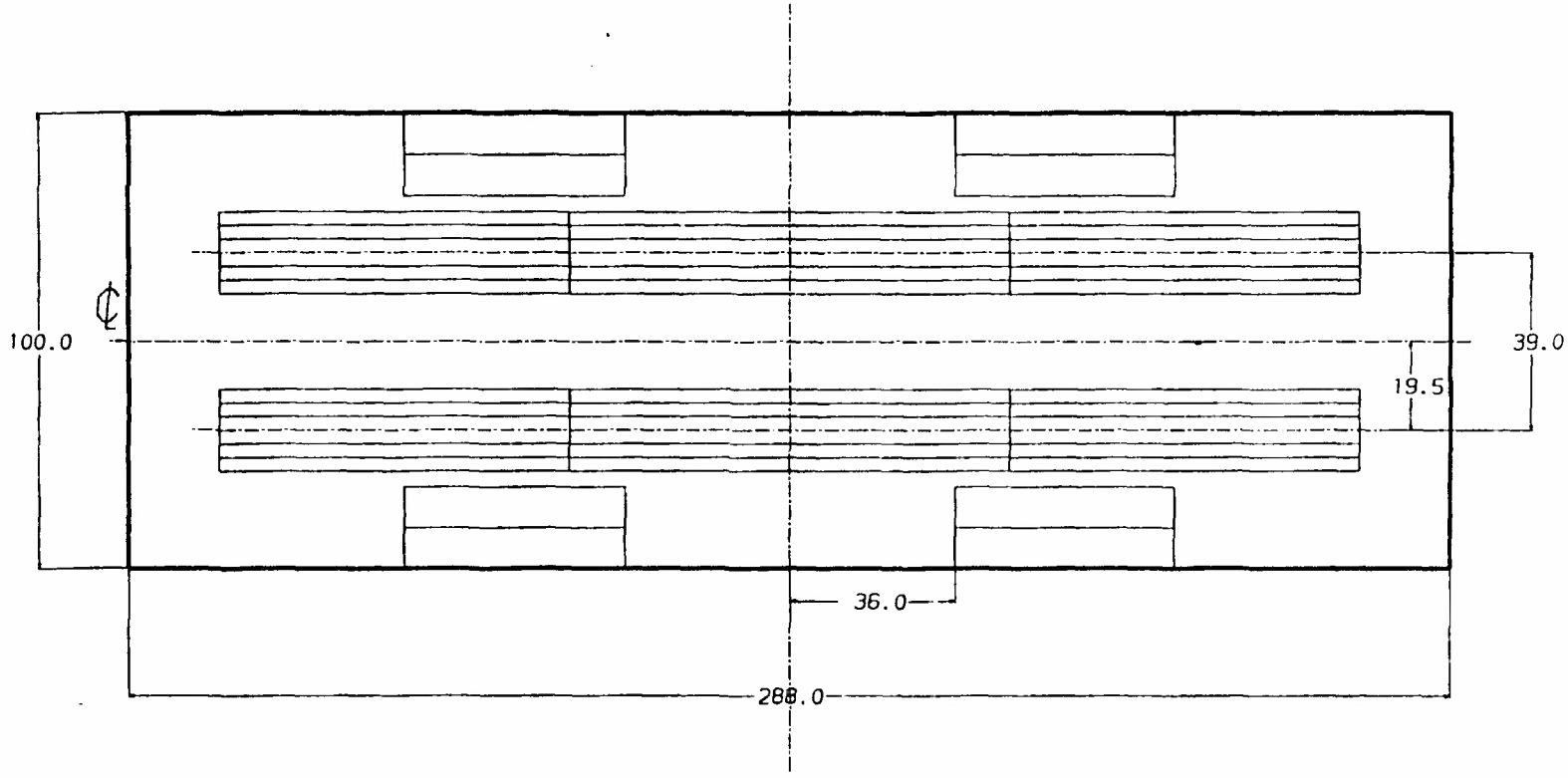


Figure 12. Plan View Showing Location of PLS Honeycomb Stacks, 8 to 18K

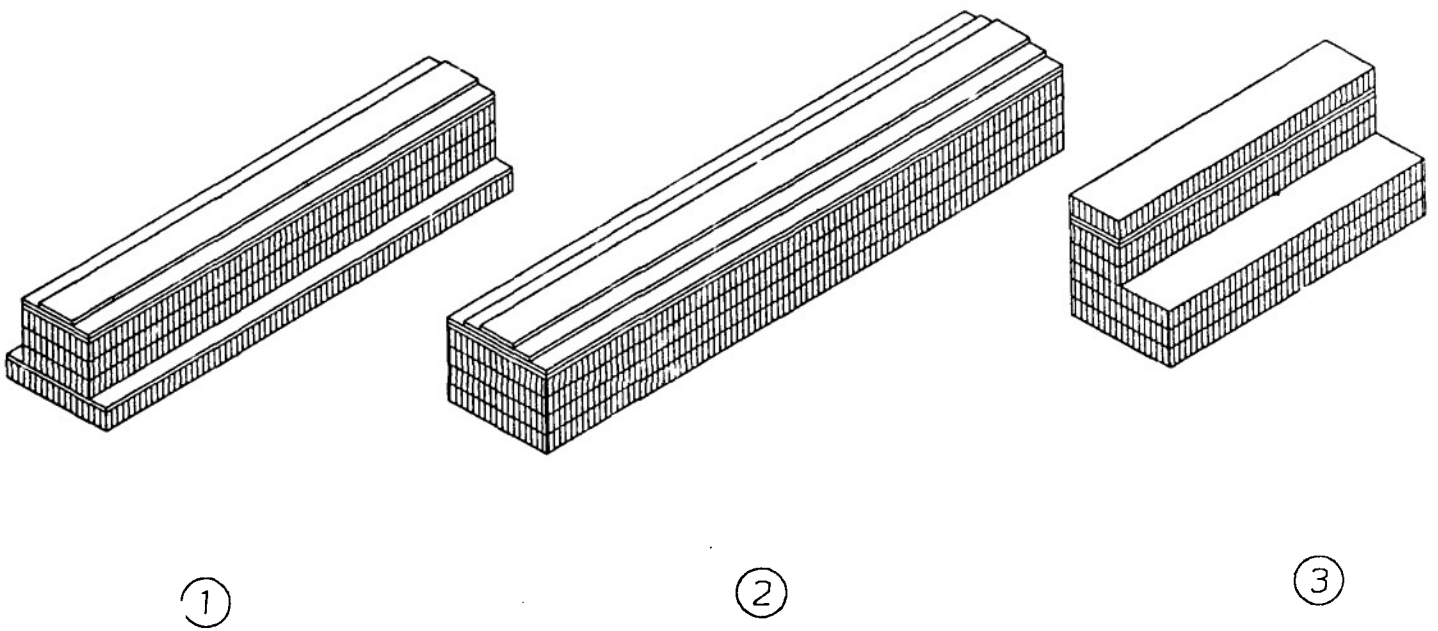


Figure 13. Depiction of Individual PLS Honeycomb Stacks, 8 to 18K.

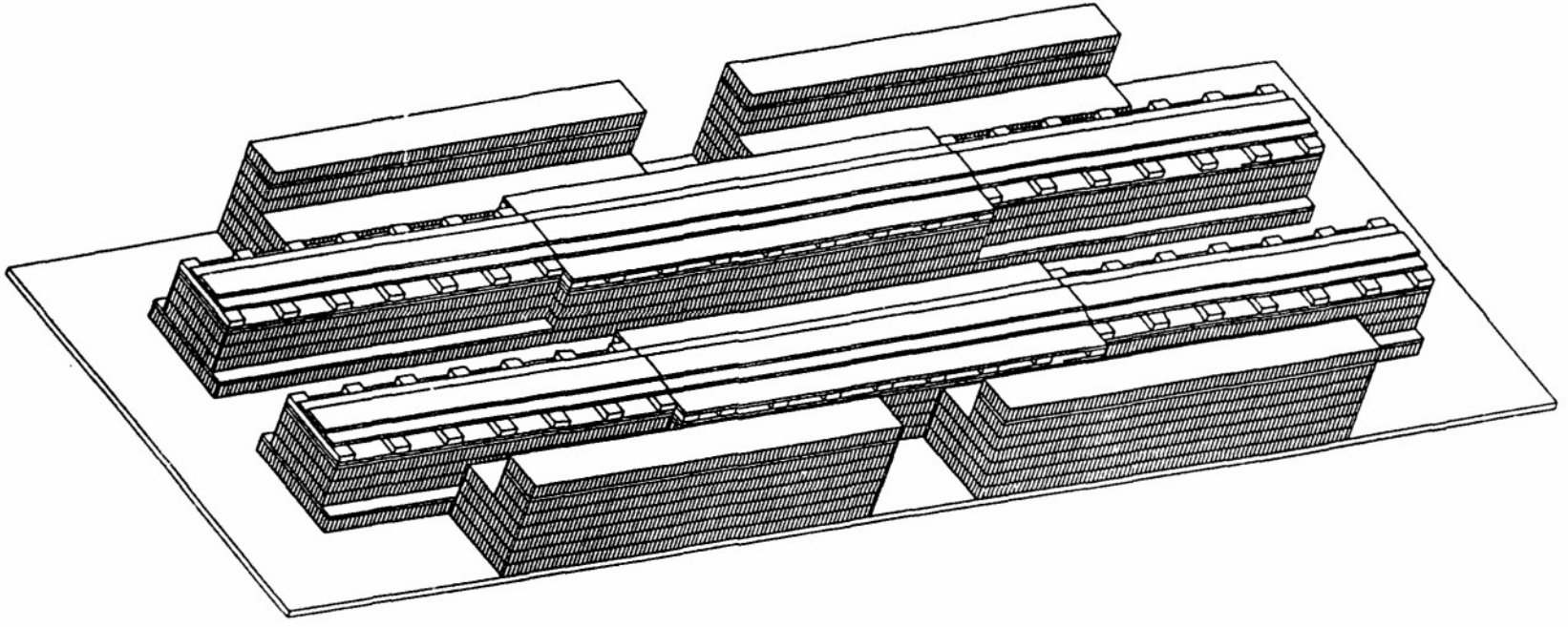


Figure 14. PLS Honeycomb Configuration, 18 to 28K.

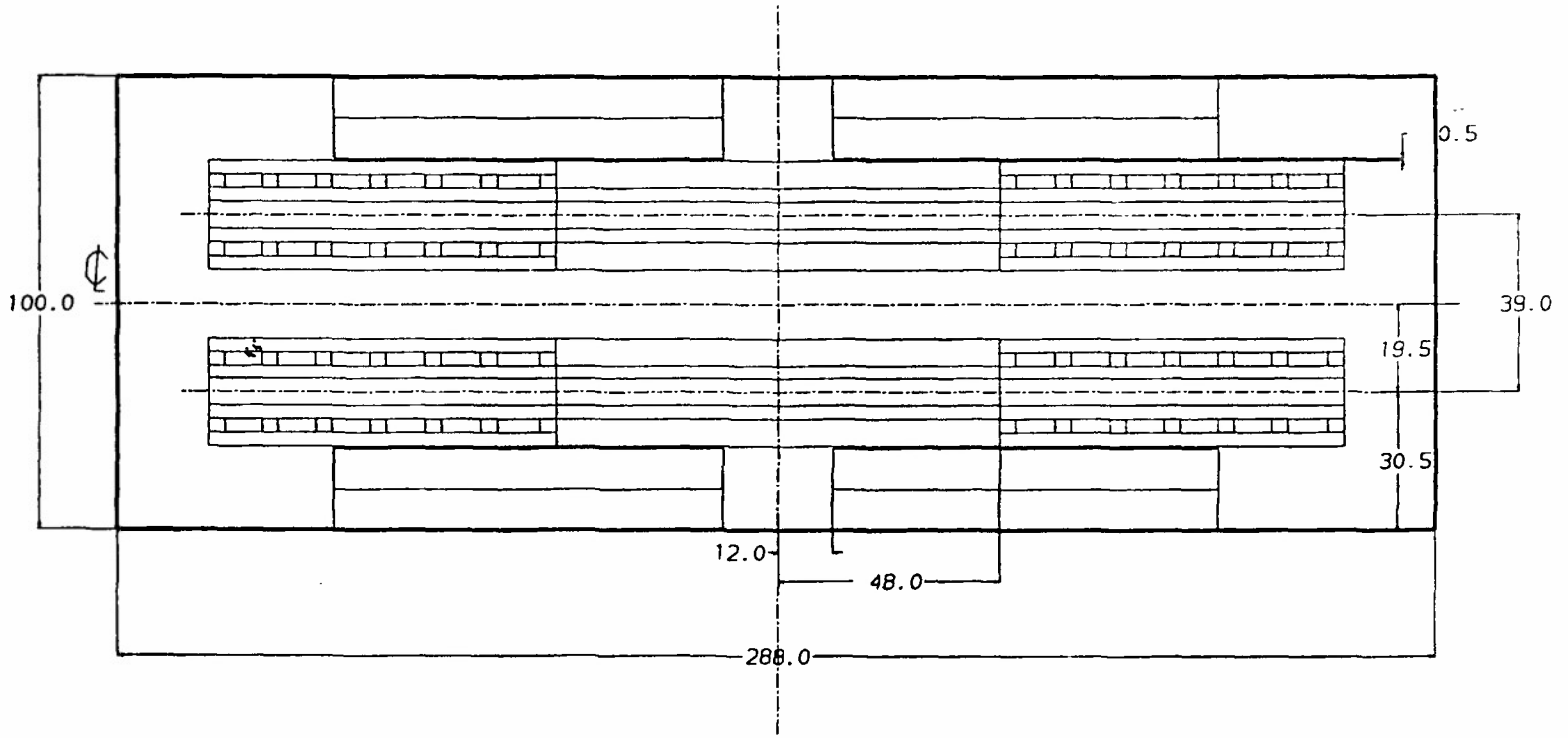


Figure 15. Plan View Showing Location of PLS Honeycomb Stacks, 18 to 28K.

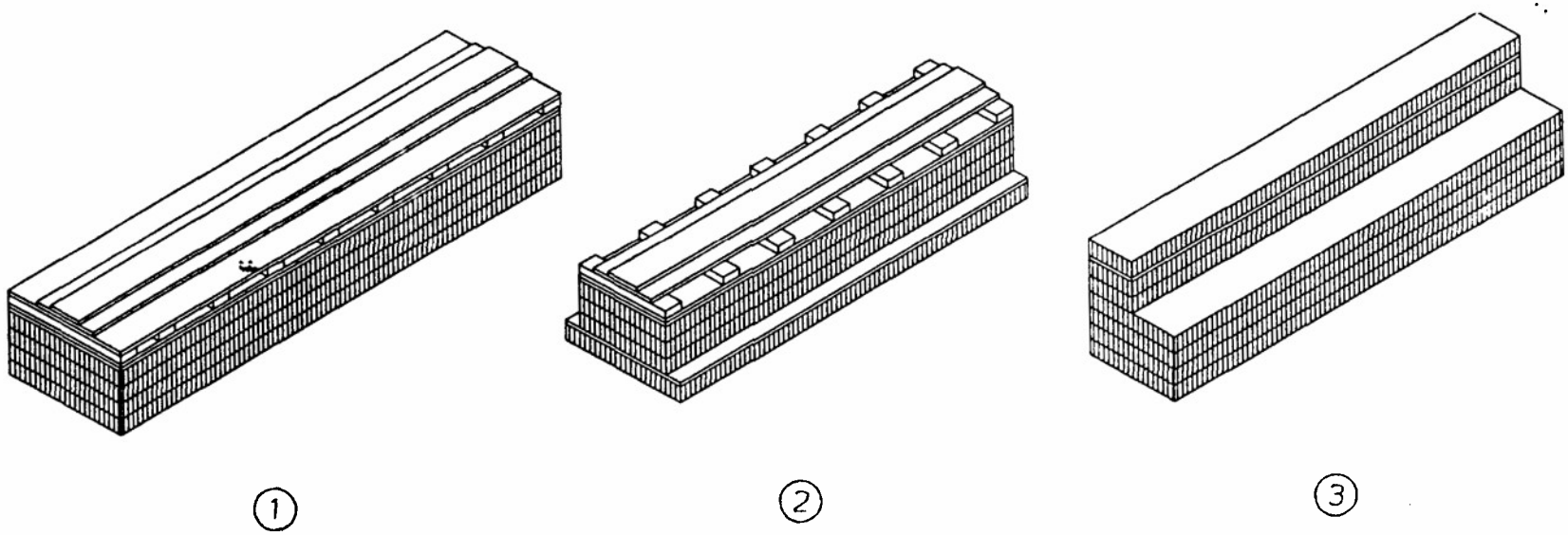


Figure 16. Depiction of Individual PLS Honeycomb Stacks, 18 to 28K.

Although each of these concepts would ultimately produce functionally similar platforms, the difficulties associated with implementing each of the three concepts are quite different. The following will explain each individual concept.

Modification of the Type V Platform for PLS Compatibility. This concept involves modifying certain components presently used on the Type V platform. These modified components would be functionally similar to the original components; therefore, many of the rigging methods and air items presently in use could be easily transitioned. To achieve compatibility between aircraft and PLS, a retrieval link must be fitted to the platform. This link will be an A-frame structure that attaches to the tandem link/suspension bracket. Another bracket would be placed a few feet inward on the rail for suspension of the load during airdrop. The A-frame position during retrieval could be maintained by a cable attached to a clevis at some point along the side of the platform. Another change necessary for PLS compatibility would be the addition of guide rails similar in geometry to the guide rails on the flatrack. These rails would replace the inboard roller pads presently on the platform (Figure 17).

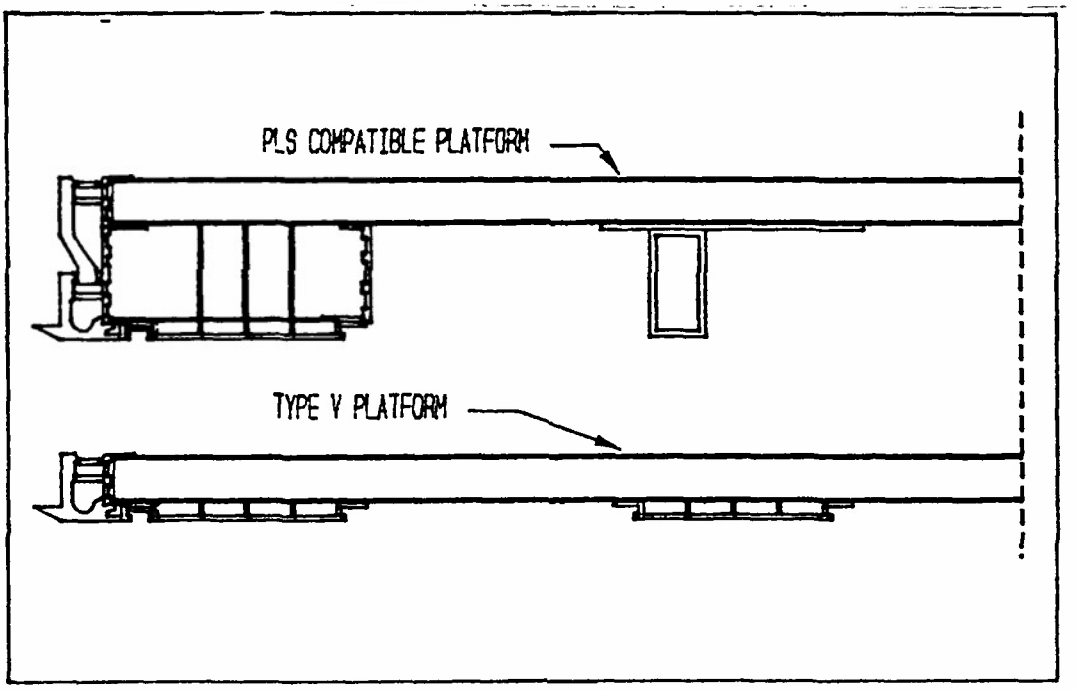


Figure 17. *Comparison of Present Type V Platform to Platform Modified to Achieve PLS Compatibility.*

With the guide rail modification, the outside roller pads and the end rail will no longer mate with the aircraft rollers and locking rail. To maintain compatibility, spacers must be placed between the outboard roller pad and the platform panels and an extension will be needed for the end rail (Figure 18). In this configuration, rigging procedures will be completely transferrable from the present system because the platform deck will not be altered in any way other than being 4.5 inches higher.

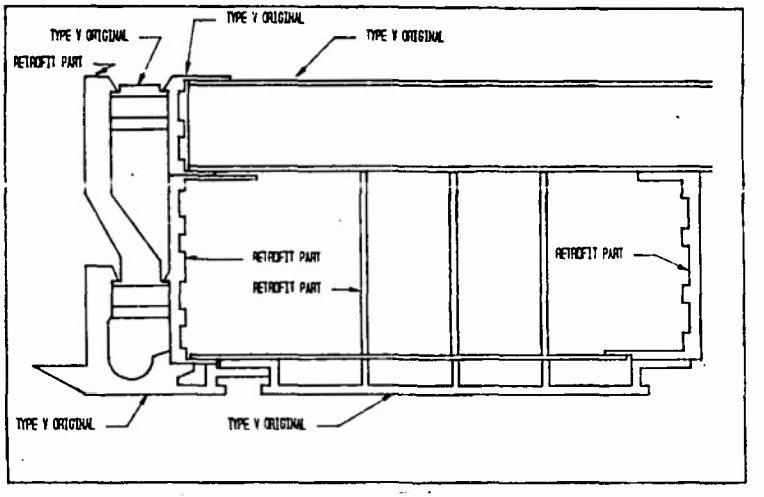


Figure 18. *Details of Modified Type V Platform to Maintain PLS and Aircraft Rail System Compatibility.*

With these modifications come an increase in weight and cost. These increases are estimated as 1000 lb and $2050, bringing the total weight of a 20-ft platform to 2830 lb and the total cost to approximately $7,000. This weight estimation was based on *preliminary* design modifications to mate with the aircraft roller system. The cost estimation was based on the cost per pound of similar aluminum extrusions presently being procured for the Type V platform.

Due to these modifications, the inner roller pads (now thinner guide rails for PLS retrieval) will no longer match the roller spacing on the C-130, C-141, and C-17 (the center roller on the C-5 configured for airdrop is coincidentally the same as the guide rail spacing on the PLS flatrack), as mentioned earlier (Figure 4). This mismatch leaves the outboard rollers to support the entire load. Assuming uniform distribution, the outer roller pads could support a 30,000-lb, 20-foot platform. In actual practice, however, this is not the case because of slight variations in the heights of the rollers. This theory was tested at Natick to determine the maximum load of a Type V platform modified for PLS compatibility.

The roller test was conducted at the Natick C-141 mock-up roller test facility. In order for a load to meet certification requirements, roller loading must not exceed 1580 lb on any single roller. To simulate a Type V platform modified for PLS compatibility, the center rollers were removed from the roller test device. This supported the entire load by the outside rollers, as would be the case for a fully compatible platform. The test consisted of six load weights on a 20-ft Type V platform. Each load was moved on the test bed to various locations, then roller loading data were recorded. This procedure compensates for variations in the platforms and rollers.

The first trial was the empty platform to achieve a baseline. The weight of the unladen platform was 1,830 lb. Deflections were measured laterally

across the front of the platform and the roller loads recorded. The rounded average gross weights of the succeeding loads were 12,200 lb, 18,000 lb, 23,200 lb, 28,600 lb, and 34,000 lb. The following table is a condensation of the test data.

TABLE 2. Composite of Roller Test Data.

Weight (lb)	Maximum Deflection at 1 g (in)	Deflection at PLS Guide Rails (in)	Maximum Deflection at 4.5 g's (in)
12,200	0.213	0.185	1.66
18,000	0.288	0.231	2.08
23,200	0.354	0.287	2.58
28,600	0.362	0.295	2.65
34,000	0.482	0.367	3.30

The maximum deflection was at the center of the platform. The deflection at the PLS guide rails is the deflection measured at the point where PLS guide rails would be if the platform were PLS compatible. This is the point where interference with the aircraft floor would occur during flight. As can be seen from Table 2, the deflections are not large enough to cause a problem at normal gravitational force (1 g). The clearance on aircraft loaders is 0.625 in and the clearance on the C-141 aircraft is 1.5 in. The interference occurs when the in-flight requirement of 4.5 g is encountered. Since this force would be applied dynamically, it would cause a deflection equal to twice the static equilibrium deflection of the same force.

For example, a 34,000-lb platform would deflect 0.367 inches at the guide rails under 1 g. At 4.5 g, the static equilibrium deflection would be 4.5 x 0.367 = 1.65 inches; however, the maximum dynamic deflection would be 2 x 1.65 = 3.3 inches. This will impact the floor of any aircraft. To alleviate this problem, the product EI (the modulus of elasticity times the moment of inertia) must be increased to decrease the spring constant of the platform in the lateral direction, or support must be given to the platform under the center guide rails. It may be possible to place shoring under the platform on the aircraft floor. A space would be left so the platform could roll in without interference. When deflections occur during flight, they would be limited to the distance between the guide rails and the shoring.

Modifications of the Flatrack for Airdrop Compatibility. There are a number of modifications that must be made to the PLS flatrack before it would be compatible with the airdrop system. These modifications are based on the prototype flatrack used in the Fort Hood test (procured by Natick for the purposes of this project) and the interoperability agreement drawing. A major modification is required to mate the flatrack with the aircraft roller and locking rail system. This system is crucial for in-flight restraint as well as holding the load in the craft until the extraction chutes can build enough

force to extract the load quickly and safely. Because of the spacing of the center guide rails, they cannot be utilized for support. The prototype PLS flatrack is made of steel for both strength and anticorrosion purposes. Therefore, any modifications or additions to the PLS flatrack would also have to be made of steel. Steel, however, is three times stiffer than aluminum on a per volume basis. Hence, the longitudinal stiffness of an airdrop compatible flatrack made of steel will be much greater than that of the present extruded aluminum Type V platform. As stated earlier, the present Type V platform is already too stiff (it does not flex enough to conform to the slight irregularities in the roller heights) to pass a roller loading test at gross weight when supported by the outer rollers only. Consequently, the load capacity of this concept, due to the maximum roller load restriction, can be expected to be lower than that of a Type V platform modified for PLS compatibility.

Development of a New Platform. Designing a completely new platform may be the only feasible way to produce a completely compatible platform/flatrack due to the balance that must be maintained between strength and stiffness. The Type V platform and the PLS flatrack modification concepts are very risky, taking into account the presently available test data on roller loading and lateral deflections. A new platform could have traits not possible with a modified platform or flatrack.

Because achieving compatibility with the PLS is a relatively straightforward task, the major hurdles come about when air transport and airdrop compatibility is attempted. For this reason, a new platform would be easier to design if it more closely resembled a Type V airdrop platform rather than the PLS flatrack. The Type V platform was designed with a modular configuration since it sometimes becomes damaged upon impact. This possibility cannot be overlooked if a new platform could be developed. This fact becomes relevant when designs are considered which employ sliding or movable parts that rely on tolerances being maintained to function properly. This would also be the case with a modified flatrack, unless it was permanently converted to a 9-ft width, which would cause a problem on the roadways. This roadability problem is one shared with all three completely compatible concepts.

As stated earlier, the main stumbling block of a compatible platform is the method of impact energy absorption. A new platform could be designed to accept new methods of energy absorption and be concurrently developed with the flatrack on Type V concept. This, however, would be a long-term project as we are still facing major difficulties in developing a fieldable alternative energy absorber.

PLS Modification

This concept would entail retrieving a Type V platform from the drop zone with a PLS that has been modified in some way to make it compatible with the Type V platform. The same problem that plagues many other concepts also affects this one.

After airdrop, the honeycomb will crush and cause the tiedown lashings to loosen. There may also be a load shift. These factors make it necessary to modify the airdrop procedures or equipment in some way to eliminate the loosening of the lashings. Until a new method of energy absorption is devised

and the configuration of the new pallet that would mate with this new energy absorber is defined, any modification to the PLS or development of an interfacing system would be premature given the present airdrop system.

Type V Platform on Flatrack After Air Delivery

This concept involves dragging or placing an airdropped platform on a flatrack so it could be retrieved by the PLS. Barring development of an airdrop platform incorporating a new form of energy dissipater, this concept will be even more difficult to implement than the modified PLS or interfacing system.

Once again, crushing of the honeycomb at impact will cause loosening of the tiedown lashings and possible shifting of the load. These lashings will first have to be tightened before the platform can be dragged or placed on the flatrack. In addition, however, one is confronted by the problem of having to secure the platform to the flatrack before the flatrack can be retrieved by the PLS.

CONCLUSIONS AND RECOMMENDATIONS

At this time, rigging flatracks on Type V platforms is the best solution for PLS airdrop compatible systems. It utilizes presently available procedures and equipment and has been successfully demonstrated without major difficulties. Other concepts examined were not as effective as rigging flatracks on Type V platforms, and they will remain so until a different method of energy absorption can be developed.

Therefore, it is recommended that the concept of rigging flatracks on Type V platforms be adopted as a near-term solution. In order to implement this concept, the PLS configuration would have to be finalized and user requirements for specific ammunition loads would have to be identified. Once these steps are taken, airdrop certification of the various PLS flatrack ammunition loads can be carried out by the Airdrop Systems Division of Natick's Aero-Mechanical Engineering Directorate. Load certification for airdrop would follow the procedures outlined in the memorandum shown in the appendix of this report.

REFERENCES

1. Purchase Description: Palletized Load System (PLS), ATPD-2141 (Draft Copy) U.S. Tank-Automotive Command, ATTN: AMCPM-TVMP, Warren, MI 48397-5000.

2. AFSC Design Handbook (DH) 1-11, Air Transportability, Design Note 2B2, 20 February 1980, p. 1.

APPENDIX:

Airdrop Certification Requirements for the Palletized Loading System

STRNC-UAS 26 June 1989

MEMORANDUM FOR RECORD

SUBJECT: Airdrop Certification Requirements for the Palletized Loading System (PLS)

1. The rigging procedures have been developed and tested for the low velocity airdrop of the PLS flatrack for up to 28,000 lbs. of payload. These procedures include the honeycomb configuration, the placement, and the restraint for the flatrack to the platform. The restraint of the ammunition stowed on the flatrack has not been established for the various types of munition loads.

2. In order to certify the PLS for airdrop, all munitions that will be rigged on the PLS must be identified. Only munitions that are certified for airdrop can be airdropped on the PLS.

3. Once the munitions have been identified, rigging procedures can be developed by Natick. The restraint of the ammunition for airdrop will be based on the existing ground transportability restraint and the additional restraint required for airdrop. The rigging procedures will be designed such that many different load configurations can utilize the same rigging procedures. Limitations will be set which will include; maximum height, weight, tip-off profile, and center of gravity location.

4. Airdrop Certification Testing will be conducted in order to test the developed procedures. The rigging procedures will be incorporated in a Proposed Test Plan (PTP) which will be sent to the Air Force for their approval.

5. Upon the Air Force approval, the PLS can be airdrop tested. The required number of airdrop tests will be determined by Natick and stated in the PTP.

6. Natick will provide a statement of certification upon satisfactory evaluation of the airdrop test report.

7. The final rigging procedures will be sent to the QM School for publication in the appropriate rigging manual.

for George Chakonian
WARREN CAMPBELL
Mechanical Engineer
Systems Integration Branch
Aero-Mechanical Engineering Directorate

CF:
Glenn Doucette, ASCD
Actg C, MEB, AMED