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TECHNICAL REPORT

68-59-AD

A GENERAL ANALYSIS OF THE FACTORS INFLUENCING THE PREPARATION OF LOADS FOR DELIVERY BY AIRDROP

by

James F. Falcone

April 1968

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Airdrop Engineering Laboratory

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James F. Falcone

Project Reference:
1F121401D195

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FOREWORD

Early development of airdrop systems for delivery of military items was principally a trial-and-error type activity conducted by field type military organizations. Most present systems are refinements of the original concepts. The methods and equipment were developed on an individual component basis or as systems for specific, individual items.

The ever increasing use of airpower in military operations has focused attention on all aspects of air delivery including airdrop. It is evident that the Army can only realize the full potential of airdrop by development of systems which will result in reduced cost and complexity, and with reliability comparable to other forms of transporation. A number of specific systems and components are currently under development which will enhance the Army's airdrop capability. This particular study was initiated as Task 08, "System for Rapid Preparation of Airdrop Loads," under Project No. 1F121401D195. The purpose was to evaluate the basic functions and equipment from an overall point of view with particular emphasis on simplification, and time and cost reduction, rather than from the point of view of optimizing specific component or mission requirements. The planned approach was to initially conduct a systems analysis to account for all factors and their inter-relationships and effects on the total system; and to provide a means to compare proposed new components, systems, equipment, or procedures on a cost and effectiveness basis.

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ABSTRACT

A study is being conducted to investigate, in detail, all aspects of the present systems for preparation and retrieval of supplies and equipment delivered by airdrop in an effort to simplify and optimize this phase of an airborne operation. Results of initial general analysis of the problem are presented. The planned approach and definition of the airdrop system models are described. Army requirements for types and quantities of supplies and equipment are evaluated. Time and cost factors are discussed. Problem areas are identified, specific tasks initiated based on findings are described and planned future activities are presented.

A GENERAL ANALYSIS OF THE FACTORS INFLUENCING THE PREPARATION OF LOADS FOR DELIVERY BY AIRDROP

1. Introduction

Dropping of supplies and equipment from aircraft to troops in unaccessible places has its roots traceable back to the early days of aviation. However, it was not until around 1949 prior to the Korean War that airdrop of heavy equipment, including military vehicles, came into being. Development has since progressed to present systems employing the C-130 and C-141 aircraft with a maximum capacity of 35,000 pounds for a single drop load. Current development is also underway to extend this capacity to 50,000 pounds utilizing the C-5A aircraft. Advances also have been made in extending the range of aircraft altitudes useable for airdrop. However, the basic means for preparing loads for airdrop and retrieval after drop has not kept pace with most of the other advances in airborne type operations. Considerable time and expense are involved in the preparation of airdrop loads, and retrieval after drop is not rapid enough to provide the desired fast deployment.

The purpose of this study is to investigate, in detail, all aspects of the present system for preparation and retrieval of supplies and equipment delivered by airdrop in an effort to simplify and optimize this phase of an airborne operation. This report covers the initial general analysis of the problem which was conducted during FY67. As in any data gathering and evaluation activity, the input information was obtained from many varied sources including documents, personal interviews, and personal observations. Since valid data depends upon a good statistical sample, collection of additional data is continuing in order to verify and refine the results currently available.

2. Summary of Work

The planned approach involves the use of a systems analysis to account for all factors and their interrelationships and effects on the total system. Studies up to the present time have been primarily concerned with a literature search and other data gathering and evaluation activities.

The basic system design and operational flow models have been developed. This identified two major areas for study: (1) platform type loads and (2) container type loads. To generate a demand function, studies were conducted to evaluate delivery requirements. Initial studies were also conducted to determine the manpower requirements for rigging platform type loads. A number of problem areas have been identified and provide direction for future detailed investigations.

The present methods and equipment for the preparation of airdrop loads have been developed on an individual component basis or as systems for individual items. Studies have not been conducted to evaluate load preparation from an overall point of view with particular emphasis on simplification and time reduction.

Particular aspects of the present system for preparation of airdrop loads which require extensive study have been identified by the initial study phases conducted and tasks have been initiated in a number of areas to develop improved techniques.

More emphasis must be placed on the development of systems which improve retrieval of loads from the drop zone after landing.

Statistics evaluated indicate the following significant factors:

Preparation of loads for airdrop requires approximately 1 man-hour per ton plus parachute packing time.

Loads prepared on platforms for airdrop using present type equipment have approximately 400-500 lb of airdrop componentry per ton rigged.

Approximately 1.3% of all loads airdropped malfunction because of improper procedures.

3. Systems Models

a. Description of Basic System

The basic overall system which encompasses the preparation of airdrop loads can be defined as the outloading phase of an airborne operation. This phase consists of all of the activities associated with placing the required quantities of properly prepared troops, equipment and supplies aboard carrier aircraft. This entails preparation of loads, transportation to aircraft and loading aircraft. The airdrop system is the specific system for analysis under this study. Figure 1 shows the overall system and the items which define the interface areas which must be considered when contemplating any proposed changes to the present airdrop system used for preparation of airdrop loads.

b. Specific Airdrop System Models

The airdrop of supplies and equipment can be broken down into two major classes of loads as defined below:

Container Loads are rigged in standard airdrop containers which consist of slings, (A-7A) cargo bags (A-21, A-22) and flat steel strapping. The containers are packed with supplies, disassembled equipment or small ready-to-use equipment. These loads are normally limited to a maximum weight of 2200 pounds, and are delivered by both high velocity (stabilized descent) and low velocity (retarded descent) airdrop.

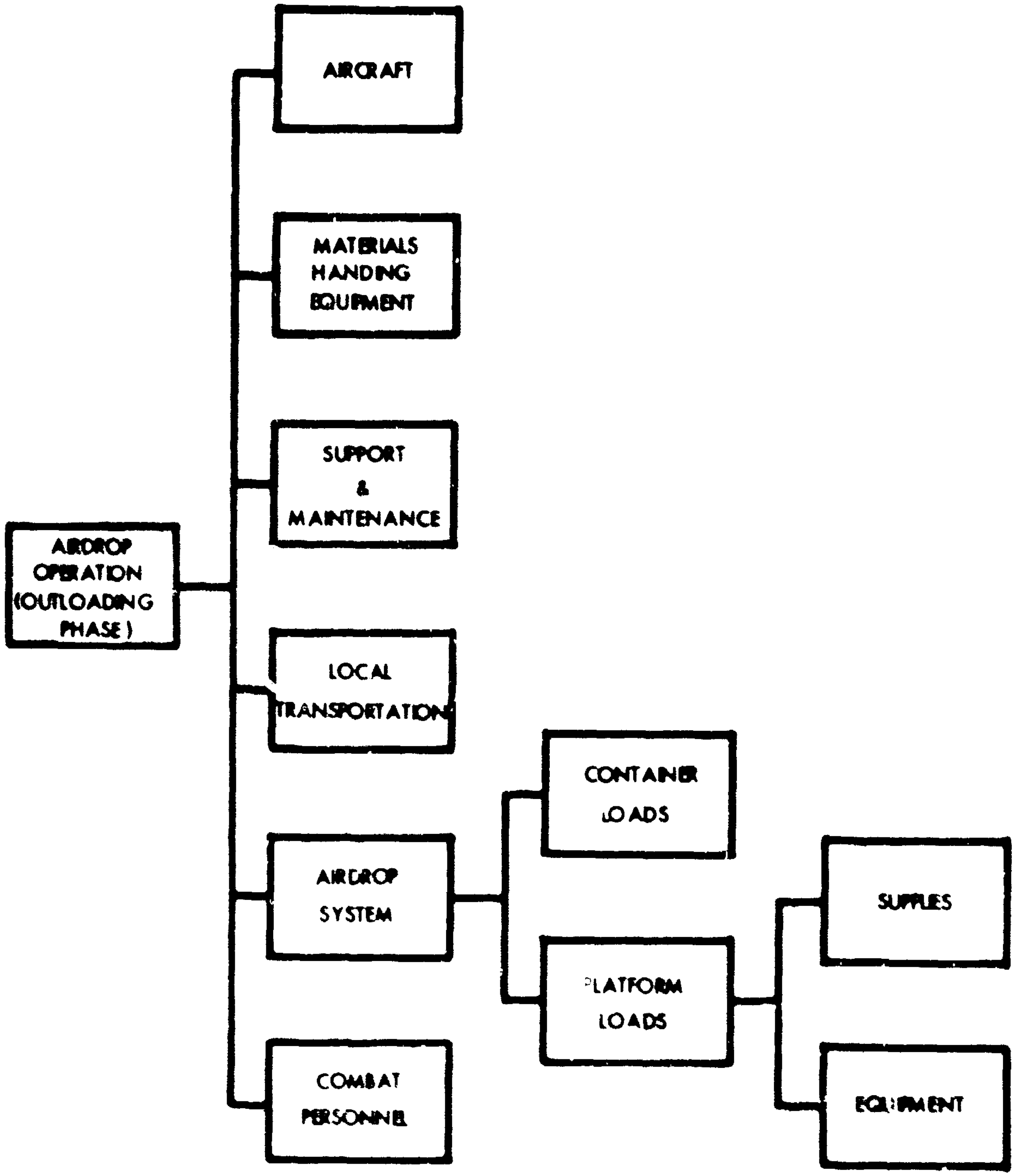

Figure 1. Basic System which Incorporates Airdrop Loads Preparation

Platform Loads

(1) Supply Loads, in addition to being delivered in airdrop containers, are also rigged on aerial delivery platforms. Two distinct rigging procedures are used for this type load; (a) load suspension, and (b) platform suspension. The first system employs four A-22 type containers lashed to an 8-foot modular platform. The parachute suspension lines are attached to the A-22 containers. In the second system, the bulk supplies are lashed to the platform, and the parachute suspension lines are attached to the platform. Bulk supplies of approximately 2200 to 8000 pounds are normally delivered in this manner.

(2) Individual Items too large or too heavy (vehicles, weapons) to be packed into airdrop containers are made up into platform loads. These platform loads require the use of special airdrop equipment to contain the load, extract it from the aircraft, control the descent, and provide a means to dissipate energy at ground impact.

System Design Models

The models which depict the systems for platform loads and container loads are shown in figures 2 and 3. These models indicate all of the major items which compose the airdrop loads and which must be considered in the detailed analysis of load preparation.

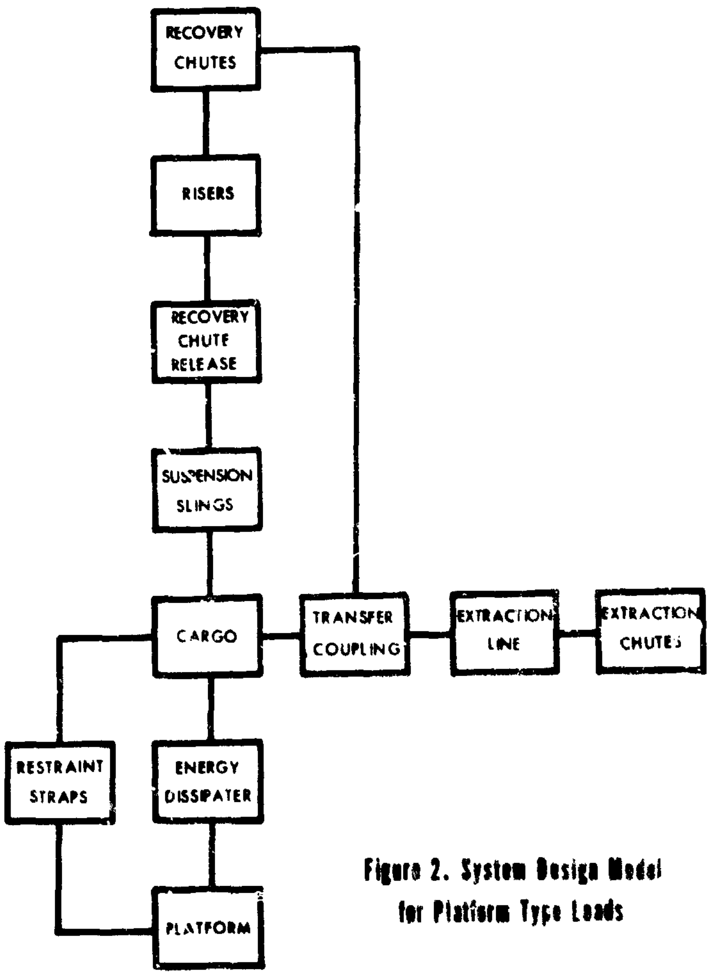

Figure 2. System Design Model for Platform Type Loads

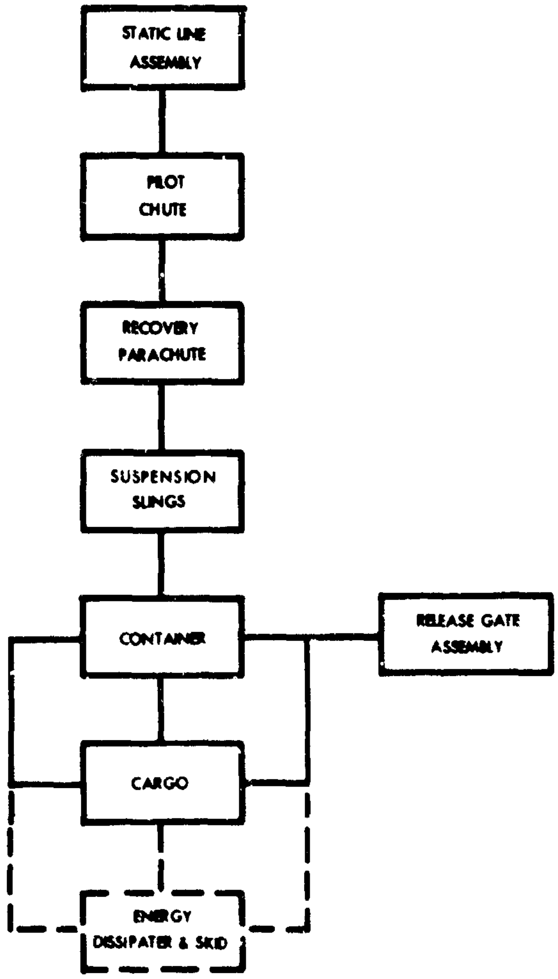

Figure 3. System Design Model for Container Type Loads

4. Delivery Requirements

The types and quantities of equipment and supplies required by the Army varies considerably with the type mission being performed. Even for a given mission, the requirement will vary depending upon the individual in command of the action.

To generate data which would be useful for an overall evaluation of equipment and procedures used to prepare and recover airdrop loads, the available statistics were generalized as follows:

(1) The two major types of airdrop missions can be identified as the deployment of airborne forces, and the daily resupply of Army field forces.

(2) Since most available information relates to a Division size unit, this evaluation, of necessity, is primarily based upon division size delivery requirements. However, to relate the data to mission requirements other than of this magnitude, the equipment requirements were reduced to relative frequency of occurrence, and the supply requirements extrapolated to include requirements per man.

a. <u>Equipment Requirements</u>

Data from a number of sources were evaluated to determine the demand for equipment type platform loads. Both the number and type of loads required varied considerably among the various references. However, from five references examined, there were seven basic items of equipment that comprised better than 85% of all the rigged loads in each of the requirements lists. These items are tabulated in Table I along with the percent of the total requirement that they represent. The last column shows the average frequency of occurrence based upon five different division requirement lists. These data have defined the military items which represent most of the platform loads which currently are rigged for airdrop as well as the relative quantity of each item. The actual number of items dropped depends entirely on the mission performed. However, as a reference, it can be stated that an Air Assault Division requires approximately 1200 equipment type loads (vehicles, weapons).

TABLE I

Division Requirements for Airdrop Items

	PERCENT OF TOTAL REQUIREMENTS					
REFERENCE NO* →	7	10	10	12	14	AVERAGE
1/4-TON TRUCK	37.8	35.5	17.6	22.6	41.0	25.4
M274 (MECH. MULE)	12.1	—	27.7	37.9	24.0	30.9
1/4-TON TRAILER	14.3	17.8	14.9	13.5	12.0	14.5
3/4-TON TRUCK	17.7	15.3	15.6	11.8	12.0	7.0
3/4-TON TRAILER	10.0	5.7	8.7	5.5	5.0	14.5
2 1/2-TON TRUCK	—	8.3	3.0	—	—	4.1
105MM HOWITZER	4.7	6.3	1.1	2.4	6.0	5.7
SUB TOTAL	96.6	88.9	88.5	93.7	100.0	

* REFERENCE NO. IN BIBLIOGRAPHY

b. Bulk Supply Requirements

This analysis was limited to the evaluation of total supply requirements. No attempt was made to establish the actual items and quantities of each type. Since bulk supplies are rigged either in standard containers or on standard modular platforms, it was not considered essential for this study to define the individual items. Rigging 2000 pounds of food in an A-22 container is not significantly different (from the standpoint of airdrop equipment and procedures) than rigging 2000 pounds of any other bulk supplies.

Significant differences exist in the resupply requirements depending upon the type mission which is being performed by the troops being supplied. The values shown in Table II indicate the range of tonnages obtained from various sources of information. To compare these values, it was assummed that a division consists of 15,000 men. This was necessary since most of the data were given as tons per division without defining the division size. The last column in Table II shows the calculated resupply requirements equalized to a 15,000 man division. The values ranged from 400 to 1200 tons per day with the average being 650 tons per day. These values represent the total requirements for support of Army troops. The particular circumstances will determine what portion of the total requirement is airdropped. For an air assault mission, during the first few days, it is expected that 100% of the resupply would be airdropped. On the other hand, for normal resupply of Army field forces, it is anticipated that 10% to 20% of the total requirements will be delivered by air (combination of airland and airdrop). Any amount from 0% to 100% of this could be airdropped. It is significant to note at this point that one Quartermaster Air Delivery Company can prepare approximately 200 tons per day of supplies and equipment for delivery by airdrop.

TABLE II

Field Army Bulk Supply Daily Requirements

REF NO*	TONS/DAY	NUMBER OF PERSONNEL	TONS/MAN	LBS./MAN**	TONS/DIV.
11	200	5000	0.04	80	600
11	1000	DIVISION	0.07	134	1000
7	234	8160	0.03	58	435
8	500	DIVISION	0.03	66	500
1	400-1200	DIVISION	0.03-0.08	54-160	400-1200
2	750	AIR ASSAULT DIVISION	0.05	102	750
2	555	ROAD DIVISION	0.04	74	555
3	400	INFANTRY DIVISION	0.03	54	400
			0.04 AVE	86 AVE	650 AVE

*REFERENCE NO. IN BIBLIOGRAPHY

**15,000 MEN PER DIV. ASSUMED IF NOT STATED

5. Time and Cost Considerations

To establish a basis for comparison of various systems or to evaluate proposed changes to the present system for preparation and retrieval of airdrop loads, it was necessary to construct operational flow models. These models identify and relate all of the activities which must be performed. Each activity can then be evaluated as to time, manpower requirements and cost. The overall effect of any particular activity can be evaluated. Also, the events which require greatest time and cost can be identified. Figure 4 shows the basic operational flow model representing the preparation of platform type loads. Figure 5 shows the flow chart for retrieval of loads after drop.

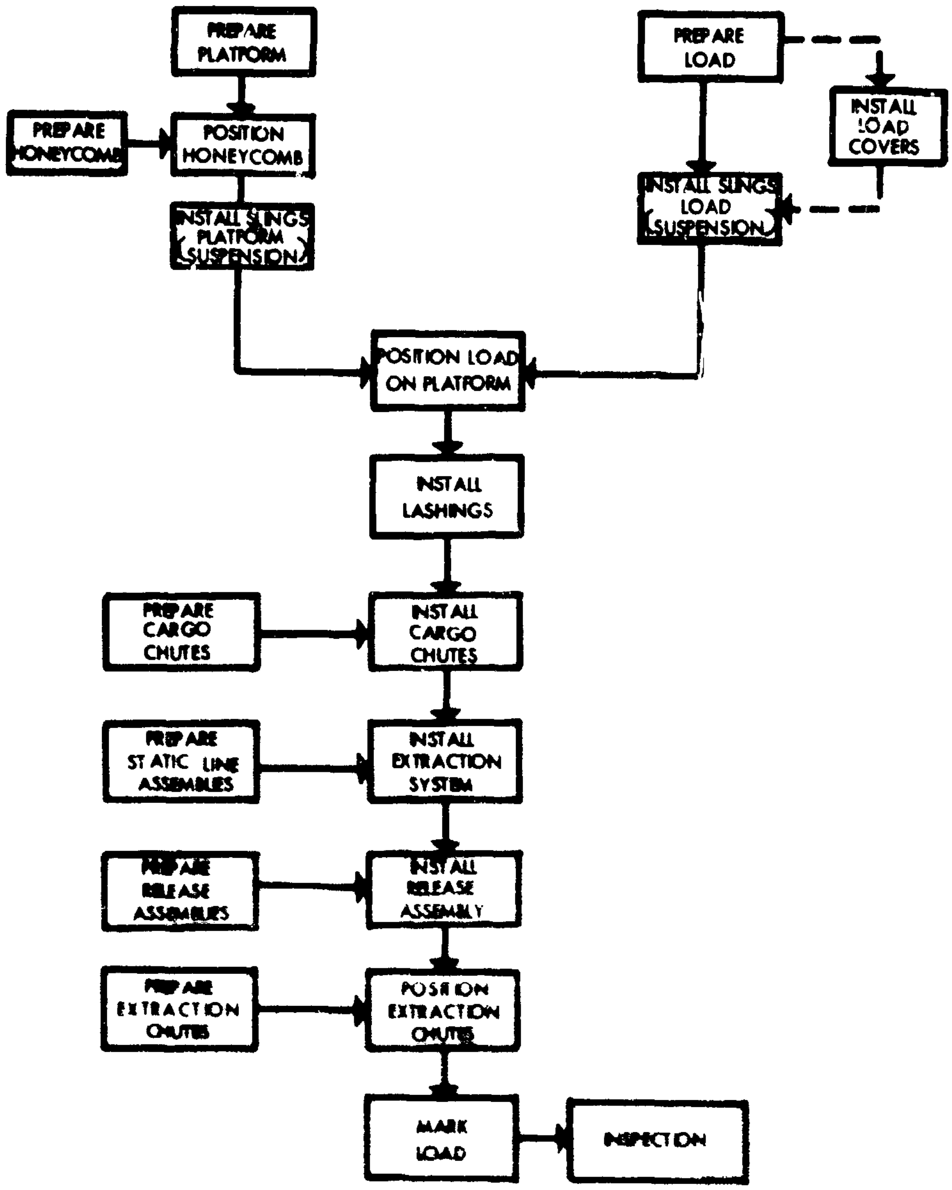

Figure 4 Typical Flow Model for Assembly Line of Platform Loads

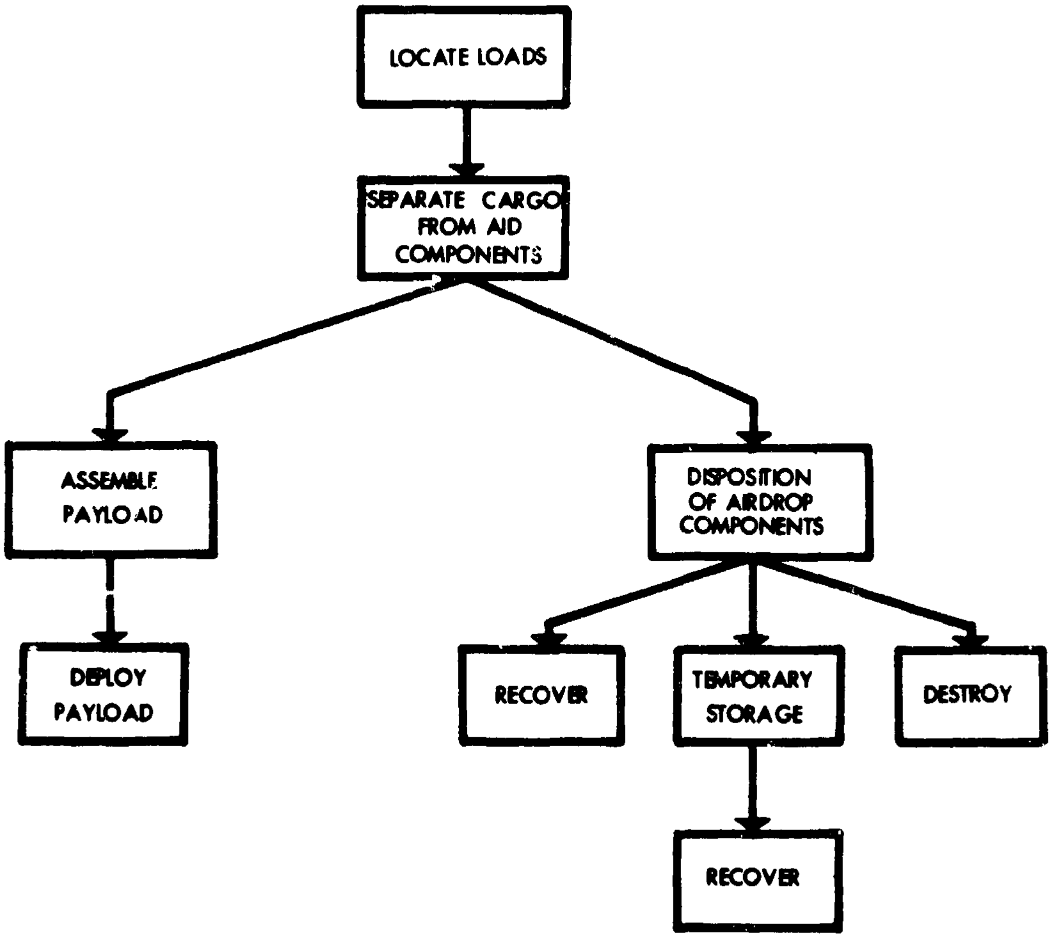

Figure 5. Operational Flow Model for Retrieval of Airdrop Loads after Drop

At the present time, only limited information has been obtained relative to manpower and time requirements for rigging airdrop loads. Table III shows one set of data obtained from the QM school at Ft. Lee. These data are representative of assembly line rigging procedures. As can be seen, the time to accomplish each activity has been equalized by providing the required number of personnel at each station. This is to insure that the assembly line keeps moving. To evaluate these data, the man-hours were used as a basis for comparison.

TABLE III

Man-hour Requirements for Assembly Line Rigging of Platform Loads

	M151 1/4 TON			M37 3/4 TON			2 1/2 TON TRUCK			105MM HOWITZER			1 1/2 TON TRAILER			AVERAGE
	MEN	MIN	MAN-HRS	MEN	MIN	MAN-HRS	MEN	MIN	MAN-HRS	MEN	MIN	MAN-HR	MEN	MIN	MAN HR	MAN-HR
PLATFORM FAB. & PREP.	5	6	0.5	5	6	0.5	6	12	1.2	5	6	0.5	5	6	0.5	0.65
HONEYCOMB PREP.& POSITIONING	5	6	0.5	7	6	0.7	9	12	1.8	4	6	0.4	6	6	0.6	0.80
PREPARE & POSITION LOAD	13	6	1.3	7	6	0.7	9	12	1.8	5	6	0.5	7	6	0.7	1.00
LASHING	3	6	0.3	7	6	0.7	5	12	1.0	5	6	0.5	4	6	0.4	0.58
ATTACH RECOVERY CHUTES & EXTRACTION SYS.	3	6	0.3	4	6	0.4	12	12	2.4	4	6	0.4	4	6	0.4	0.78
RELEASE ASSY.	2	6	0.2	2	6	0.2	3	12	0.6	2	6	0.2	2	6	0.2	0.28
INSPECTION	1	6	0.1	1	6	0.1	1	12	0.2	1	6	0.1	1	6	0.1	0.12
TOTALS HOURS	0.7			0.7			1.4			0.7			0.7			0.84
TOTALS MAN-HR	3.2			3.3			9.0			2.6			2.9			4.21

SOURCE OF DATA REF. NO. 13

The last column in Table III shows the average values for the manpower requirements. The manpower requirements for the same items were compared to the rigged weights as shown in Table IV. Again, the last column shows average values for the 5 items. As can be seen, on the average it takes approximately 0.9 man-hours per ton for rigging platform loads. The variation is from approximately 0.6 to 1.7 man-hours per ton. This does not include time required to pack parachutes.

TABLE IV

Manpower Requirements for Common Airdrop Loads

	M151 1/4 TON	M37 3/4 TON	2 1/2 TON TRUCK	105MM HOWITZER	1 1/2 TON TRAILER	AVE.
RIGGED WT. (TONS)	1.9	3.8	9.5	4.5	3.5	4.6
RIGGING MAN-HRS.	3.2	3.3	9.0	2.6	2.9	4.2
MAN-HRS. PER TON	1.68	0.87	0.95	0.58	0.83	0.91

Only one other set of data was obtained and is summarised in Table V. The average preparation requirement from these data indicates approximately 1.2 man-hours per ton. This set of values was not specifically indicated as being related to an assembly-line type of operation which may account for the increased value. However, this is not stated as a valid conclusion at this time and additional data must be obtained and evaluated to refine the statistics.

TABLE V

Manpower Requirements for Rigging Airdrop Loads

	PAYLOAD (TONS)	RIGGING MAN-HRS	PLATFORM [illegible] (MAN-HRS)	MAN-HRS PER TON
A-22 CONTAINER	1	1 1/2	[illegible]	[illegible]
[illegible] PLATFORM LOADS	4	4	[illegible]	[illegible]
[illegible]	3	[illegible]	[illegible]	[illegible]
A-21 CONTAINER	[illegible]	[illegible]	—	[illegible]
A-7A CONTAINER	[illegible]	[illegible]	—	[illegible]
			AVE - 1.23	

SOURCE OF DATA [illegible]

6. Definition of Problem Areas

Analysis of data obtained and observation of rigging operations have identified a number of areas where efforts should be expended to achieve improvements in preparation of airdrop loads. Following is a brief discussion of the major problem areas.

a. Energy Dissipater

The present standard cushioning system which uses paper honeycomb, provides a functionally acceptable energy dissipater. However, there are a number of problems associated with its fabrication and use. Quality Control of paper products is such that large tolerances on crushing stress must be accepted. Expanding of honeycomb is still not adaptable to field type environments, and storage presents many problems. Also, there have been instances where removal of vehicles from honeycomb stacks involved considerable time and labor.

b. Level of Skill & Training Requirements

Previous discussion of manpower requirements indicated that on the average it takes approximately 1 man-hour per ton plus the time for packing the chutes to prepare loads for airdrop. In addition to the manpower requirements, the level of skill requires specialized training and the use of rigging manuals for each type load prepared. Considerable efforts must be expended to simplify the equipment and procedures presently being utilized.

Further evidence of the level of complexity and skill requirements is apparent from an analysis of reported malfunctions. Table VI shows a summary of reported malfunctions for a 21-month period. The bottom row indicates the percent of the total malfunctions which were diagnosed as being incorrect procedures.

TABLE VI

Reported Malfunctions for Supply Equipment Airdrops

	OCT DEC [illegible]	JAN MAR [illegible]	APR JUN [illegible]	JUL SEP [illegible]	OCT DEC [illegible]	JAN MAR 1967	APR JUN 1967
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
INCORRECT PROCEDURES AS % OF TOTAL MALFUNCTIONS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

For 5 of the 7 quarters reported (Table VI) the incorrect procedures accounted for more than 50% of the reported malfunctions. Although the actual malfunction rate is only approximately 1.8%, the high percentage of human errors clearly shows the need for better equipment and procedures.

c. Weight of Airdrop Components

The weight of components required to rig airdrop loads represents a large percentage of the total weight of the load. This is particularly true for loads under 10,000 pounds. Figure 6 indicates the airdrop componentry weight as a percentage of the total weight. loads under 10,000 pounds, the required equipment for airdrop approximates 1/5 to 1/4 of the total weight.

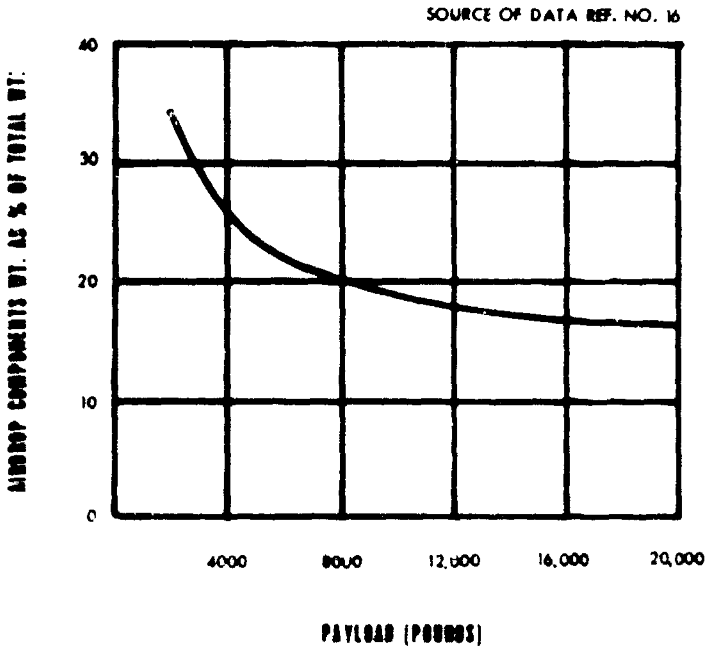

Figure 6. Airdrop Componentry Weight

The philosophy of using universal components and one basic system to cover the entire weight range apparently has a bearing on this problem. A thorough analysis of the weight problem including a study of the validity of a universal system is definitely warranted.

d. Retrieval of Loads after drop

No statistical data have been obtained at this time to quantify the exact magnitude of the problems involved in retrieving supplies and equipment airdropped, and then putting them into use. However, considerable comments have been received from a number of sources which indicates that this aspect of airdrop needs to be investigated in considerable detail.

7. Current Programs

A number of tasks have been initiated based upon the results of the FY67 studies, and are currently being investigated in detail. Following is a brief discussion of some of these studies.

a. Modular Honeycomb Concept

An initial statistical analysis was conducted to evaluate the sizes of honeycomb energy dissipater material used to rig the seven most common heavy drop items. Currently there are 26 distinct sizes required for these airdropped items.

Using smaller unit sizes to build stacks in a manner similar to laying bricks, it is entirely feasible to rig the common vehicles with as few as 5 different standard sizes of precut honeycomb.

Limited laboratory testing of this concept has been completed, and additional analyses and testing have been planned.

b. Analysis of Individual Components

A study has been initiated to evaluate all airdrop components to reduce rigging time and simplify usage. As part of this study the feasibility of eliminating screwthread type connectors is being determined. Also, a study has been started to simplify or eliminate platform tiedown clevices. Additionally, all other hardware items will be studied in detail with an aim of simplification.

c. Higher Velocity Impact

A study is in progress to determine the feasibility of increasing impact velocity which will enable a reduction in parachute requirements and in rigged weight.

8. Future Plans

In addition to tasks already initiated, the following activities are contemplated:

As an interim improvement, each phase of the rigging operation will be evaluated with the specific goal of reducing time requirements by approximately 10% to 20%. This seemingly small achievement will reduce the manpower requirements for an average heavy drop load by approximately 1/2 to 1 man-hour. For a division size airdrop (approximately 1200 loads), this would be a reduction of 500 - 1000 man hours.

As a more long range approach, new concepts for completely different systems are being formulated. This includes load bearing platforms with integral energy dissipaters and multiple systems for various weight ranges and/or type loads in place of universal systems.

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13. ABSTRACT

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Recovering	[illegible]					
Retrieval	8					
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Armed Forces supplies	9				9	
Air-drop operations	4		9		4	
Analysis			8		8	
Cost			8,9			
Time			[illegible],9			
Amount					8,9	
Projection			[illegible]		8	
Planning			[illegible]		8	