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LOADING OF LITTER PATIENTS IN ARMY AIRCRAFT

By

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U. S. ARMY AEROMEDICAL RESEARCH UNIT
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ABSTRACT

Two types of aircraft, the CV-2 "Caribou" and the CH-47 "Chinook", are presently available for medical evacuation of relatively large loads (14 and 24 litters respectively) from minimally prepared landing sites. This report indicates maximum rigging times for conversion of these aircraft to ambulance use, optimal crew sizes for minimum loading times, and some suggestions for loading methods and design of future large medical evacuation aircraft.

APPROVED: Robert W. Bailey

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LTC, MSC
Commanding

LOADING OF LITTER PATIENTS IN ARMY AIRCRAFT

INTRODUCTION

Two types of aircraft are presently available for evacuation of relatively large loads of non-ambulatory wounded from minimally prepared landing sites. These aircraft are the fixed wing CV-2 (Caribou), which can carry 14 litters, and the rotary wing CH-47 (Chinook), which can carry 24 litters.

The purpose of this report is to indicate the expected rigging time necessary to convert these aircraft to air ambulance use and the subsequent loading times under idealized conditions. This information is intended to produce guidelines for management of patient loading of these aircraft and suggest design changes for future aircraft. Variables such as size and experience of loading crews and order of litter placement were evaluated.

RIGGING TIME

Litters are supported in both aircraft by means of a post and strap arrangement similar to that shown in Figure 1. Support on the aisle side of the litters is provided by straps with brackets which can be locked onto the litter poles. These straps are stored in compartments in the cabin ceiling when not in use. Support on the wall side of the litters is provided by lightweight metal posts which are also equipped with brackets for the litter poles. The posts can be left in place for most cargo carrying missions but must be removed and stowed before the troop seats can be used.

Initial installation of the straps (including attachment of the straps to the ceiling support and adjustment of the position of the litter pole brackets on the straps) requires not more than 2.5 minutes per strap. Once this initial installation has been performed in a given aircraft it takes not more than 0.6 minutes to unstow and rig each strap for use. It takes not more than 0.3 minutes to unstow and rig each post for use. Thus, after initial installation, the CH-47 can be rigged for litters by one man in about 11 minutes and the CV-2 can be rigged in about 8 minutes. These estimates assume that troop seats are stowed, that the aircraft is stationary, and that it is cleared of all cargo. The man doing the rigging is assumed to possess no more than average intelligence or manual dexterity and to have no prior training other than a demonstration of the method of rigging one strap and one post.

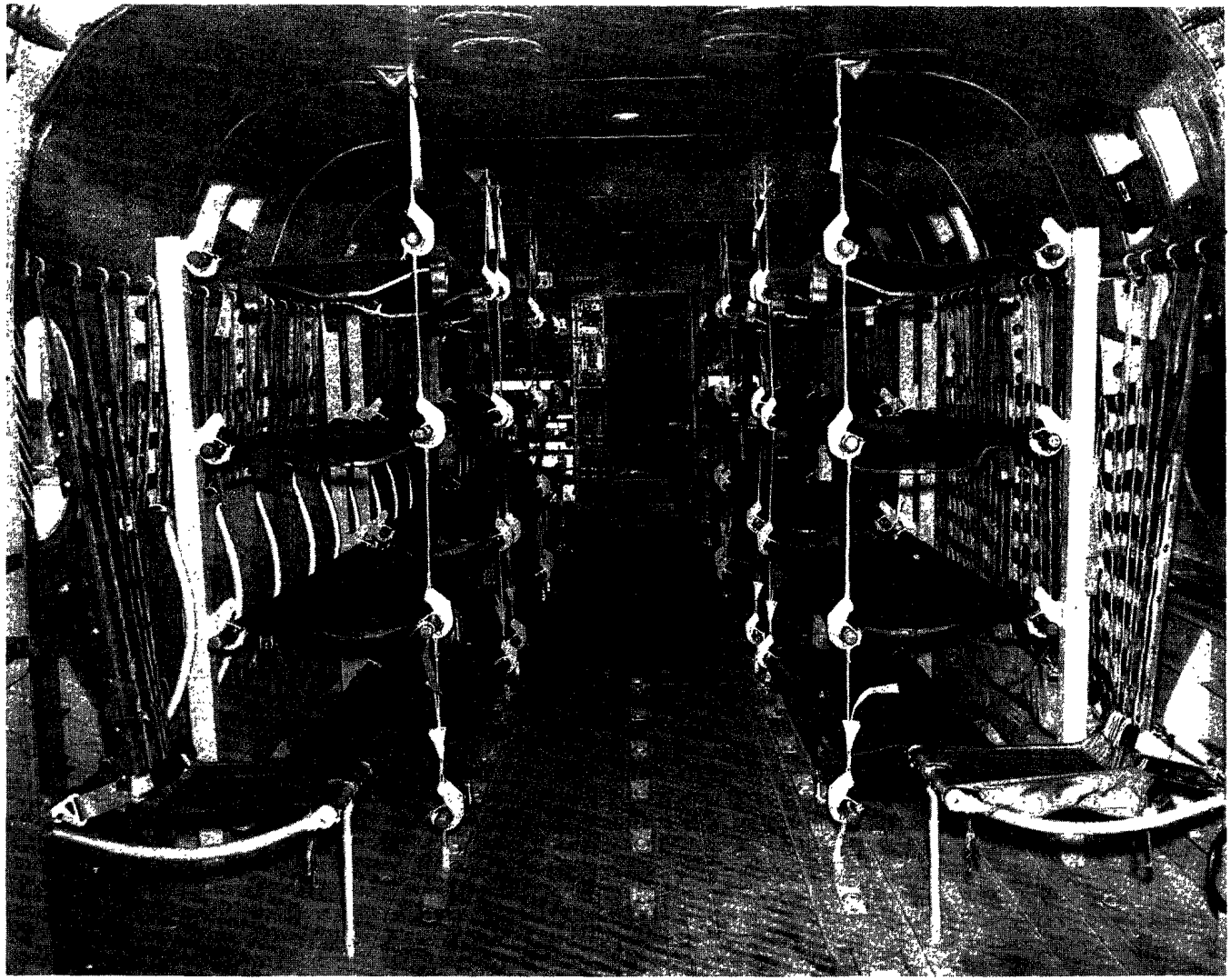

Figure 1
CH-47 "Chinook" with Litters in Place

LITTER PLACEMENT

Standard litter loading procedure calls for brackets on the straps to be placed so that the open side of the bracket faces the litter (See Figure 1). Some experienced medical personnel have advocated reversing the bracket so that the open side (which holds the litter pole) is facing away from the litter. This arrangement is said to make rapid placement of the litters easier. Experimental use of both arrangements indicated that (a) litter support is equally secure in either case, (b) there are moderate-to-strong preference among individuals for both methods, and (c) there is no significant difference in loading speed between the two methods. It was concluded that individual crews may be permitted to use whichever technique they prefer.

Litters are generally installed beginning with the topmost litter with other litters being successively placed in the next lower position. This method reduces the chance that a patient might be injured by an unsecured litter being dropped on him from above. The method also has the advantage that the litter bearers can get directly under the topmost litter while placing it in position. Otherwise, the top litter is at a level which makes manipulation extremely difficult and which might lead to injury of litter bearers from improper load handling techniques. Unfortunately the "top to bottom" method also puts the litter bearers at a disadvantage in installing the fourth litter. This bottom litter must be pushed in under the third litter at near-floor level. A suggested alternative to the "top-to-bottom" method is placement of the bottom litter prior to installation of the third litter. This modified method allows room for the litter bearers to bend down directly over the bottom litter as they install it rather than having to lift it into place at arms length. It was thought that the third litter was at such a level that it could be well controlled by the bearers during installation, minimizing chance of injury of the occupant of the fourth litter. Experimental evaluation of this modification however indicated no significant improvement in time or reported ease in litter placement. It is therefore recommended that the standard procedure be retained.

The outside (strap) support has a tension adjustment near the floor. It is necessary to release tension in the strap in order to disconnect the strap for stowage. It is recommended that these straps be left loose during the rigging and be tightened only after the last litter of each section of four is installed. Straps which are loose during litter installation provide adequate support for litters as long as the aircraft is stationary. At the same time, loose straps greatly simplify the job of installing lower litters since the straps may be easily pushed aside as the litter is placed in position. The straps should be tightened as soon as the fourth and lowest litter is secured.

TRAFFIC FLOW PATTERN

Comparison of the CV-2 and CH-47 indicates the strong influence that traffic flow has on speed of loading. Both aircraft have rear loading ramps but only the CH-47 has a front exit that is available for normal (nonemergency) use. It is therefore necessary in the CV-2 for unloaded litter bearers to exit by the same way that loaded litter bearers are entering. This two-way traffic in the aisle and entrance severely hinders the loading procedure. It is recommended that future aircraft in which transportation of large numbers of litter-borne patients might be a requirement be provided with an exit at each end of the cargo compartment which would allow easy exit to the ground. Only one of these exits need be of sufficient size for use by loaded litters. The other exit should however be at least large enough to allow rapid exit by a man without recourse to crawling, jumping, or excessive stooping - in short, something far more convenient than an emergency hatch or knock-out panel. It is felt that safety considerations alone should warrant such a requirement.

Crowding in the cabin aisle is a major hindrance to developing a workable loading technique that could be used to minimize loading time by other than trained crews. Untrained crews tend to get in each other's way to such an extent that optimum loading times occur when there are just enough 2-man litter teams to permit one new litter to arrive as each previous litter is secured. Fewer teams than this optimum number result in intervals during which the aircraft has no litters being emplaced, larger numbers result in delays during which litters are kept waiting at the entrance until there is room to move down the aisle. Experienced crews are able to secure individual litters more rapidly and also have worked together enough to develop patterns of movement which permit more than one litter to be emplaced at a time. During the experimental periods litters were loaded "top to bottom" (one section of four at a time) and "front to rear" to maximize aisle room at the entrance (rear) end of the aircraft. In this way the major effect of experience on crew members would show up only in increased facility in handling and securing individual litters. There is no doubt that crews could be trained, through planned simultaneous litter emplacement, to drastically reduce the loading times which will be reported here. The major interest of this report however will be the expected performance of minimally trained crews.

USE OF AIRCRAFT CREW

It is not recommended that members of the aircraft crew be used in the actual loading operation of large numbers of litters. However significant improvements in speed of loading result when litter bearers merely place the loaded litters

in position and immediately leave for another litter. One or (better) two persons who remain in the aircraft at all times are able to adjust and secure one litter while the next litter is being placed in position. This method minimizes interference in traffic flow. More than two individuals used in this task would probably decrease the effectiveness of untrained litter crews as a result of the greater crowding of the aisle. If these two individuals are members of the crew (e.g., crew chief and gunner) the final installation of litters is automatically checked as the installation proceeds and the aircraft can proceed as soon as the final litter is emplaced or at any intermediate point.

DISTANCE OF CARRY

Distance of carry of litters from their ground location to the aircraft should be the minimum compatible with safety. Litters to be loaded were assumed to be placed on the ground along a loading line. It was assumed that the CV-2 could be safely maneuvered to a position such that its rear door was 50 ft from this loading line with the axis of the fuselage of the CV-2 perpendicular to the line. The CH-47 was assumed to be safely maneuverable to a position 75 ft from the loading line with the axis of its fuselage parallel to the loading line. Where the distance of carry is substantially greater or less than these distances greater or fewer litter teams will be required respectively to meet the optimal loading times reported below.

OPTIMAL SIZE OF LOADING CREW

The objective of this segment of the study was to determine the smallest number of two-man litter teams which could load the aircraft to maximum litter capacity in a minimum time under realistic safety precautions but rather idealized conditions. It is recognized that under emergency conditions "floor loading" methods could, for instance, place 19 patients (9 litter borne and 10 ambulatory) in the CH-47 or 12 patients (6 litter borne and 6 ambulatory) in the CV-2 less than one minute after the aircraft had come to a halt with its doors open.

The CV-2 portion of the study used both "experienced" personnel (i.e., persons who had a medical MOS) and "inexperienced" personnel. The time at which each litter was secured was recorded to allow analysis of the round-trip time for each 2-man team and time lag between successive litter placements. In all cases litters were loaded with men who had been instructed to neither aid nor hinder the litter bearers.

"Experienced" crews of 1, 2 and 3 teams showed little fatigue effect (defined as systematic increases in round-trip time for a given team) in the time necessary to load the CV-2. Round trip time was relatively stable throughout the study for all experienced crews. Mean time between placements was reduced to a minimum of about .5 min. for the 3 team crew. Further reduction is probably not possible since crowding in the aisle prevents simultaneous placements of litters.

Fatigue effects were more noticeable in the "inexperienced" personnel. Round trip time for one 2-man crew increased from about 1 min. to 3.5 min. on the 12th load at which time one of the litter bearers collapsed. With 2 or more crews fatigue effects were negligible. Typical results are shown in Table 1. With increased

# Teams	Total Time (min)			Lag Time[5] (min)			Round Trip Time[6] (min)		
	[1]CV-2	[2]CV-2*	[3]CH-47	CV-2	CV-2*	CH-47	CV-2	CV-2*	CH-47
1	31.0	12.9	-	2.3	1.0	-	2.3	1.0	-
2	13.1	7.2	8.5	0.8	0.7	0.3	1.9	1.3	0.7
3	9.2	7.8	6.8	0.6	0.5	0.3	1.7	1.7	0.8
4	10.3	-	6.2	0.5	-	0.2	3.0	-	0.9
5	8.2	-	6.8	0.5	-	0.2	3.0	-	1.3

Table 1
Summary of Typical Data

Notes:
1. For 14 litters loaded by inexperienced personnel in the CV-2 with no inside helpers after 50 ft carry.
2. For 14 litters loaded by experienced personnel in the CV-2 with no inside helpers after 50 ft carry.
3. For 24 litters loaded by inexperienced personnel in the CH-47 with 2 inside helpers after 75 ft carry.
4. All aircraft were rigged for litters at start.
5. Average time between successive litter placements, including time for securing.
6. Average time per team from pickup of litter at loading line until return to loading line for the next load.

*CV-2 experienced personnel - no inside helpers

numbers of teams the lag time between completed placements decreases asymptotically to some fixed value determined by the minimum time necessary to fit a litter in place and secure it. The mean round trip time is identical with the mean lag time for a 1 team crew. With increased numbers of teams the mean round trip time may make slight decreases since the fatigue effect (which tends to lengthen the time of the last few trips and hence the average time) is eliminated. Ultimately, however, the round trip time must increase as a result of querying when teams must wait for another team to secure a litter and remove themselves from the aircraft. As mentioned above, there is no point in having more teams than are necessary to insure that another litter will arrive as soon as each litter is secured. Minimum total loading time will occur when each litter team has to wait for a very short period of time prior to emplacing their litter. Nothing is gained by having more litter teams than this minimum as these added teams simply wait longer to get into the aircraft.

It was clear from the CV-2 portion of the study that the major hindrance to minimizing total loading time was the time necessary for the placement and securing of each litter. Therefore an "inside" 2-man team was added for the CH-47 portion of the study. The job of these men was to secure each litter after it was emplaced by an "outside" or carrying team. Since these 2 men did not have to enter or leave the aircraft while they worked, they caused only minor added crowding in the aisle. The addition of these men decreased the asymptotic lag time to about .24 min., a value less than half of that for unaided securing of litters. This reduction in lag time in turn allowed more litter teams to be effectively added and contributed to 24 litters being loaded on the CH-47 in less time than 14 on the CV-2 (see Table 1). The presence of a second exit which allowed a straight-through traffic pattern in the CH-47 also contributed to the decrease in total loading time however.

The use of the securing team is thus not the sole cause of this added efficiency. The crew sizes and times indicated in Table 1 should be considered only as guidelines for local determination of optimal crew sizes and maximum loading times which might be expected for these aircraft under ideal conditions. Notice in Table 1 that addition of the inside team and a "straight-through" traffic flow in the CH-47 results in a continuously increasing round trip time as more teams are added as opposed to the nonlinear change for inexperienced bearers in the CV-2.

The following general rules are suggested for minimizing crew sizes and loading times:

1. Reduce carrying distance to the minimum safe distance.

2. If possible, use one aircraft door for entrance and another for exit of bearers.