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LONG LINE LOITER: CONTINUOUS AIR DROP TO SMALL SITES

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Air Force Systems Command
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FOR THE COMMANDER

JULIEN M. CHRISTENSEN, Ph.D.
Director, Human Engineering Division
6570 Aerospace Medical Research Laboratory

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It is envisioned that the Long-Line Loiter concept may be a simple solution to the long-standing problem of precise airborne delivery of personnel and supplies to selected ground locations. Recent studies of continuous resupply from a small aircraft revealed that a line can be accurately dropped to a small precise location on the ground while the aircraft maintains a comfortable altitude above this location, out of range of small arms fire. Once the aircraft is established

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in its orbit, loads of up to at least 200 pounds can be slid down the line to an anchor point, using conventional parachutes to check the rate of descent to approximately 40 feet/second at impact. Current studies provide the system parameters based on line length, parachute size, and matching of payloads and parachute canopies for optimum descent rates These scaled values give the user the flexibility to reduce large loads to appropriate parcel sizes, yet insure no dispersal of the packages, regardless of the number, during delivery.

PREFACE

This report presents research performed by the Flight Environments Branch, Human Engineering Division, Aerospace Medical Research Laboratory, under Project 7184, "Human Performance in Advanced Systems," Task 718405, "Design Criteria for Unusual Flight Environments."

The author acknowledges the contributions of all members of the Flight Environments Branch for their assistance in this research, in particular TSgt R. Fancher and SSgt R. Searle for the enthusiastic support in the design and fabrication of equipment and conduct of testing; B. C. Dixon, Lear-Siegler Incorporated, for his support in conceptual formulation and design criteria as well as fabrication of equipment and conduct of testing; SMSgt B. McMullen and C. W. Sears, for their assistance in the conduct of testing; and to TSgt W. W. Reffner for photographic support. Acknowledgment is also made to Maj C. A. Bell, Aeronautical Systems Division, for his support in field testing and his management of the program; G. Zelinskas, TSgt J. Wheeler, SSgt F. Edwards, SSgt R. Jones, K. Jones, G. Shaw, J. Warner, T. Hulsiger, and F. Diver, of the Experimental Parachute Fabrication Branch, for their assistance in design and fabrication and pegging of various equipment, and, in particular, L. Cole of that Branch for his assistance in range scheduling and general liaison; to L. Riepenhoff, F. Hogue, and O. Fisher, of Zone Shop 6, for assistance in the design and fabrication of machined parts; Maj J. Butler, Air Force Institute of Technology, for ballistics works as well as assistance in conduct of testing; and to R. Lusk, Jr., Data Corporation, for his participation as more than just a contract pilot. The research was performed during the period of July 1971 to December 1972.

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INTRODUCTION

The USAF Tactical Air Warfare Center Quarterly Report, Volume II, No. 6, Autumn 1971, page 32, indicates that one of the major problems of airlift to isolated areas is that of getting supplies to impact in a precise drop zone. A portion of The article states that "The aircrew strives to arrive over an elusive point in space and time and, once there, eject men or objects out of the aircraft and have them land with some precision on a selected point of impact. Compared with the sophisticated systems available to other tactical Air Force missions such as dropping an iron bomb, or taking a picture, or placing a bullet on target, airlift methods are crude and inherently inaccurate. The solution to these two problems, acquiring the drop zone and impacting a load on a desired point, is critical to the future of air drop operations."

The Aerospace Medical Research Laboratory has been working on the Long-Line Loiter concept since December 1968, exploring the feasibility of using the technique for several Air Force missions (ref 1, 2). In particular, work was pursued in the development of two packages, a small aircraft rescue system (ref 3, 4) and a small aircraft Psychological Warfare package (ref 5). Other work in the area include parametric studies on airspeed/line-length versus altitude for several types of line (ref 6), and the upgrading of the small aircraft Psychological Warfare package for use in a C123K aircraft (still active). Based on in-house Long-Line successes and results of a Battelle Memorial Institute project in which a demonstration of a dummy being slid down a circling line was performed, a cargo delivery system was conceptually formulated and presented in a paper at the Air Force Academy, Psychology in the Air Force Symposium, in April 1970 (ref 2). In June 1971, the Aerospace Medical Research Laboratory began development of the circling-line supply system.

DIRECTED DEVELOPMENT CRITERIA

Purpose: To develop an accurate continuous-supply delivery system from a fixed-wing aircraft at from 1,500 to 3,500 feet above a small parametered drop zone in a short period of time.

Specific Criteria:
a. Two Aircraft Altitudes, 1,500 feet above ground level (AGL) and 3,000 feet AGL.
b. Cargo loads to range from 50 to 150 pounds.

LONG-LINE LOITER DELIVERY CONCEPT

As do all of the Long-Line Loiter concepts, the cargo delivery system exploits what is referred to in the literature as the circling-line phenomena. Briefly, the phenomena exhibits itself when an orbiting fixed-wing aircraft is towing a long-line (anywhere from 1,500 feet to thousands of feet, depending on the mission). If the orbit parameters are compatible with the line lengths and configuration, the line will assume a spiraling inverted cone trajectory with the free end at the vertex (figure 1). The system is then capable of two basic modes:

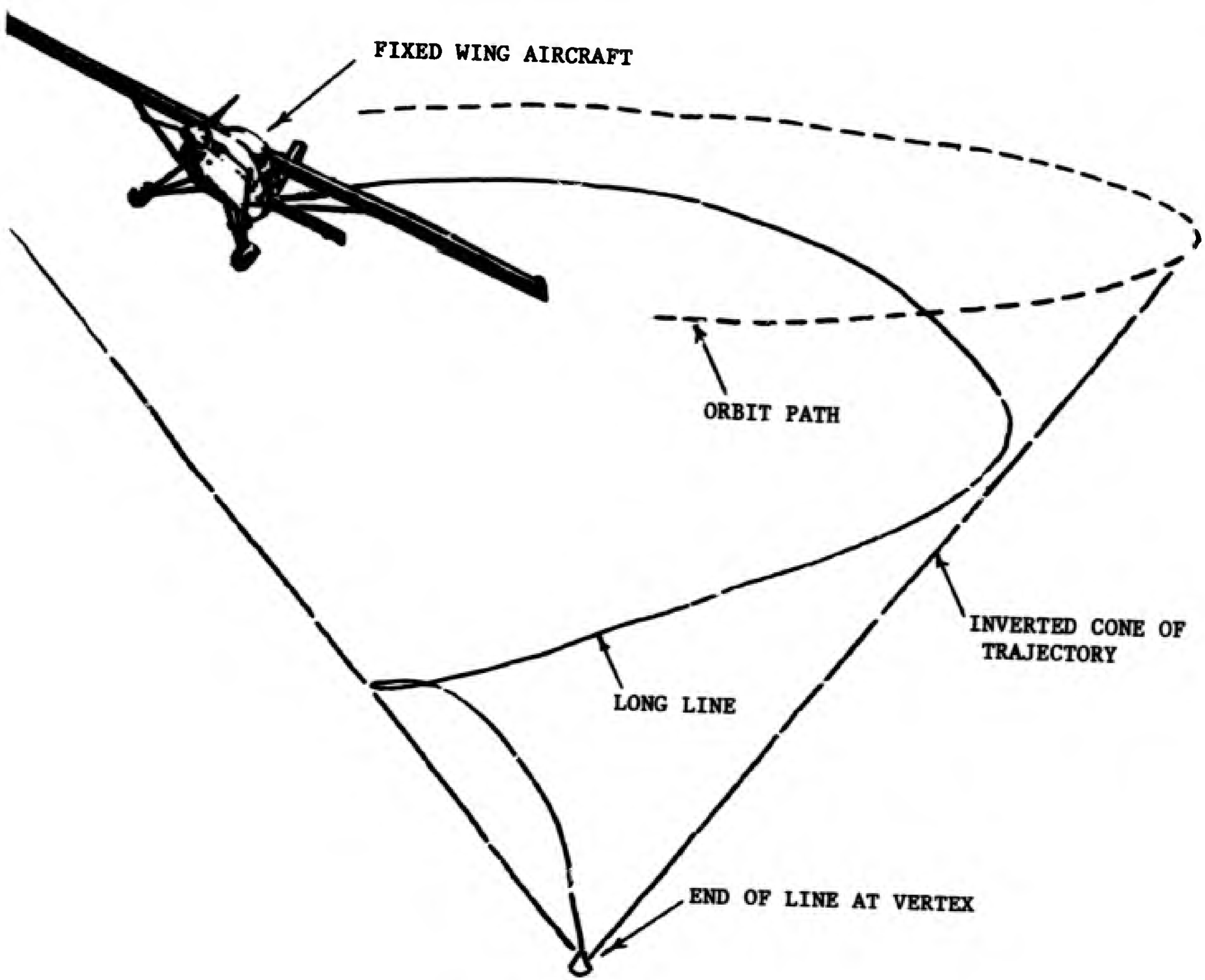

Figure 1. Circling Line Phenomena

(1) the end hovering above ground in the case where the vertex is above the ground, and
(2) a line in contact with the ground point when the vertex is at ground level.

The cargo delivery concept relies on the second mode of the circling-line phenomena, that of the line in contact with the ground. Once the aircraft/ground link is made, the line is used as a guide for cargo which is released from the aircraft and uses a conventional parachute to check the descent rate. The cargo then has no choice but to impact the ground at the anchor point. Once cargo delivery from the aircraft is complete, the same line, when disconnected from the ground, can be used to retrieve and deliver back to home base a limited amount of cargo.

SECTION II

DEVELOPMENT HISTORY

To break down the areas of development, a sequence of events for a Long-Line cargo delivery system had to be analyzed. This sequence of events can be divided into three phases as shown in figure 2. Phase I consisted of course line corrections and the use of a delivery sight to establish a release point for the end of the line. Release point established, the line end is released from the aircraft, the pilot then devotes his attention to initiating the proper orbit. Phase II consists of anchoring the end of the line to the ground while the aircraft orbits overhead, and parasliding the cargo to the anchor point. Phase III is the completion phase and includes anchor disconnect and trailing of any cargo back to home base.

PHASE I

Phase I presented the major portion of the new development work. Prior to this project all accurate deliveries from above 1,000 feet had been made using the double-line delivery method described in previous Long-Line Loiter reports (ref 1, 2, 3, 4, and 6). Because of the necessity for a minimum of complex hardware in the aircraft a bag was designed which would be dropped out of the aircraft deploying the long-line as it fell (ref 7 covers previous work in this area). Using this approach, neither winch, faking barrel, nor other paraphernalia are necessary in the aircraft.

A Long-Line Sight was developed under contract to Kollsman Instrument Corporation to accurately acquire the release point. Parameters for this sight were based on data collected in earlier work (ref 7). Several detents were built into an in-house designed sight-mounting bracket to allow forward tracking of the target as well as release point information.

Release point data was provided by analytic analysis of the ballistics of the deployment bag as well as empirical data gathered during testing.[1]

The initial choice of line type and length was made based upon parametric studies previously done-in-house (ref 6).

PHASE II

Phase II presented a new development area, that of parasliding packages down the line. Previous Long-Line Loiter work had only gone as far as sliding weights up to 20 pounds down the line without a parachute. The only information found from a literature search described work done by Battelle Institute. It stated only that a parachute slide had been made; there was no mention of the delivery method. Our initial effort, however, proved very successful and was integrated into the final system.

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[1] Ballistics analyses was performed by Major J. Butler of the Air Force Institute of Technology, Wright Patterson AFB, Ohio.

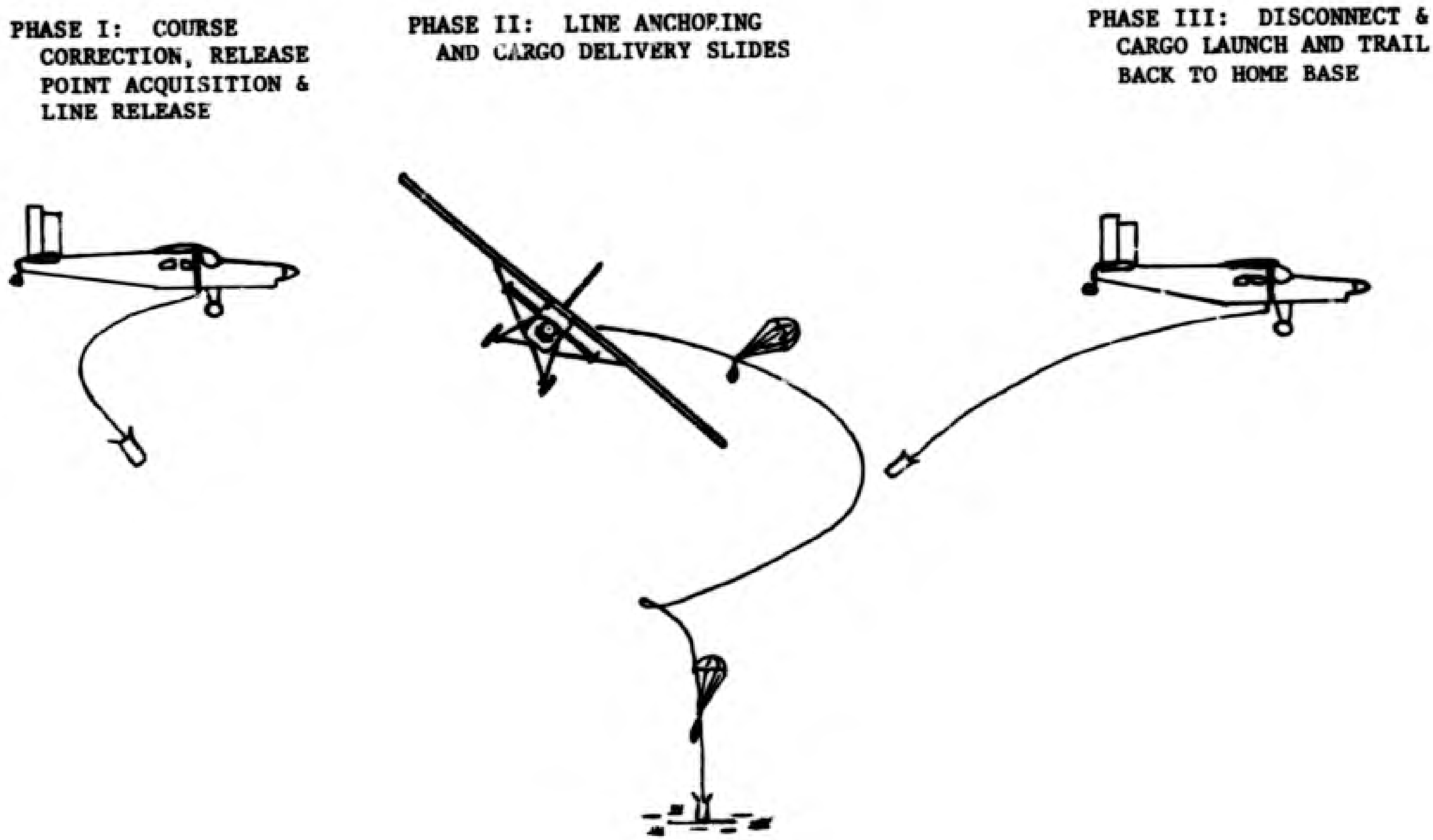


Figure 2. Long-Line Loiter Continuous Air Delivery

In conjunction with this method, we designed and built a boom which allowed cargo to be deployed out of the aircraft and onto the line with a minimum amount of effort by the aircrew members.

Anchoring was accomplished, as in most of our previous efforts, with ground crew assistance. Unassisted anchoring methods were explored and are presented in Future Efforts.

PHASE III

Phase III required no new development efforts. Further discussion of this phase, however, is presented in section V.

SECTION III

EQUIPMENT

This section describes the equipment associated with and fabricated for this development program. Where applicable, limited drawings of the equipment are given in appendix I, for descriptive and dimensional purposes.

AIRCRAFT

Two aircraft were used, a Cessna 206 and a Fairchild-Hiller Heliporter. Descriptions of each are presented below. The Cessna 206 was used as a test bed for early development work and the Heliporter for follow up validation and tactics testing. The final equipment configuration is based on use in the Heliporter.

The Cessna 206 is a high-wing, 6-place airplane with a 285-hp engine, constant-speed propeller and fixed landing gear. The airplane, designed to haul cargo, has removable double-door opening on the right side. Because of the right side opening, right-hand orbits had to be flown, necessitating that the pilot fly from the right seat.

The Fairchild-Hiller Heliporter is a high-wing, eight-place short takeoff and landing (STOL) airplane with a Pratt and Whitney, 550-hp, PT6A-6 turboprop engine, and has fixed landing gear. The aircraft is equipped with a removable floor hatch ideal for a Long-Line exit area. This aircraft, because of its load-carrying ability and STOL characteristics makes it an ideal Long-Line Loiter platform.

LONG-LINE SIGHT

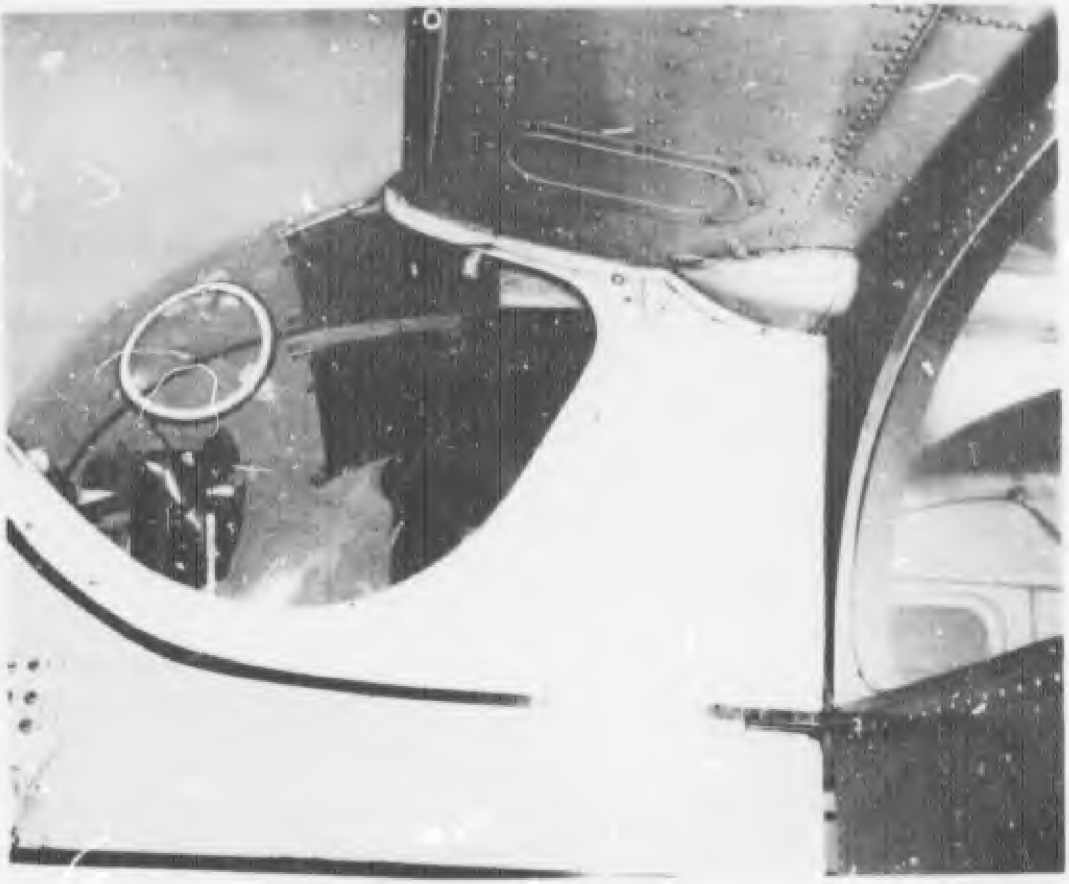
The Long-Line Sight is made up of two parts: a modified periscopic sextant, FSN 6225-1471C-02, modified by Kollsman Instrument Corporation and an in-house designed mounting bracket with fixed position locking detents.

Sextant: The modified instrument is a version of the 1461 periscopic sextant with the following specifications:

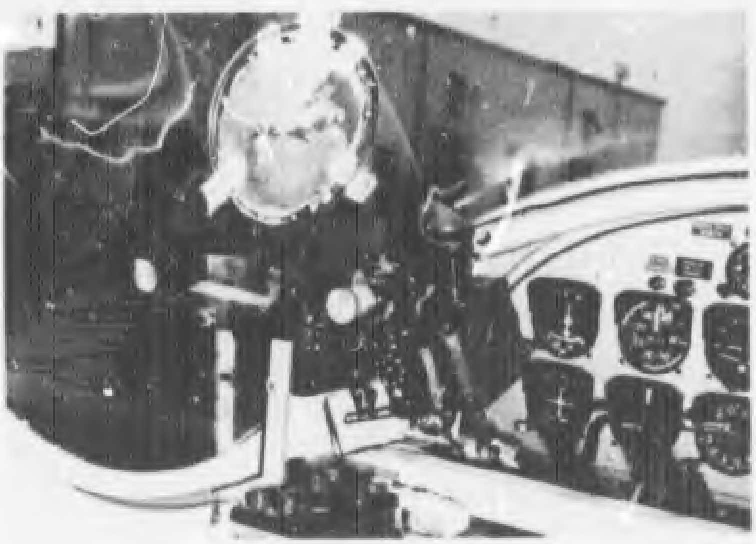
1. 30° Field of View.
2. Unity Power Periscopic System.
3. Reticle Pattern as shown in appendix I.

The modification included the use of an eyepiece in reverse as an objective lens, introducing new erection system, and modifying device to remove excess appendages.

Mounting Bracket: The mounting bracket was made to hold the sextant on the inner portion of the barrel, allowing it to rotate in a teflon bushing. Degree settings lock at 15 , 0°, 15 , 30 , 45 , 60 , 75 , and 90 , with a visual readout of particular locked position. Figures 3(A)



A. Exterior View of Sight Mounted
in Left Side of Wind Screen



B. Sight Mounted in Aircraft

1. Mounting Bracket
2. Modified Sextant

Figure 3. Long-Line Sight

and 3(B) show sight and mounting bracket mounted in the left side of Heliporter windscreen. Limited mount drawings are given in appendix I.

BOOMS

Two different booms were designed and constructed in-house, one for each type of aircraft. Both incorporated the same ideas. The booms are made of galvanized pipe, allowing the line to be attached on the inside of the aircraft and threaded through the pipe to the outside of the aircraft. This design is imperative to the paraslide technique discussed later. Also, both booms have an electrical squib line cutter for emergency jettisoning of the line. Figure 4 (A and B) shows the two booms. Drawings of the Heliporter boom are given in appendix I.

LINE AND LINE DEPLOYMENT BAG

From successes in previous Long-Line Loiter work, a ¼-inch, hollow-woven polypropelene floater rope was chosen for the long line. The line has the following attractive characteristics:

1. Tendency not to kink or knot.
2. 1,250-pound breaking strength.
3. It is very slick.
4. Tendency not to shock load.
5. Very little stretch.
6. Lightweight.

The bag was designed to deploy various lengths of line ranging from 1,500 feet to 4,500 feet (figure 5). Packing instructions are given in appendix II.

PARASLIDE PACKAGES[2]

The paraslide packages are made up of four parts: the parachute, cotton riser extension and package connector, guide ring, and the static line and chute deployment bag.

Parachute: Several size parachutes were used depending on the cargo weight, size/load information is shown below:

1. 30-inch pilot chute, spring removed/25 pounds.
2. 68-inch octagonal extraction chute/50–120 pounds.
3. 8-foot octagonal nylon survival chute/150–200 pounds.
4. 12-foot cargo chute/250 pounds.

The most desirable chute configuration of those tested was the 68-inch octagonal extraction chute.

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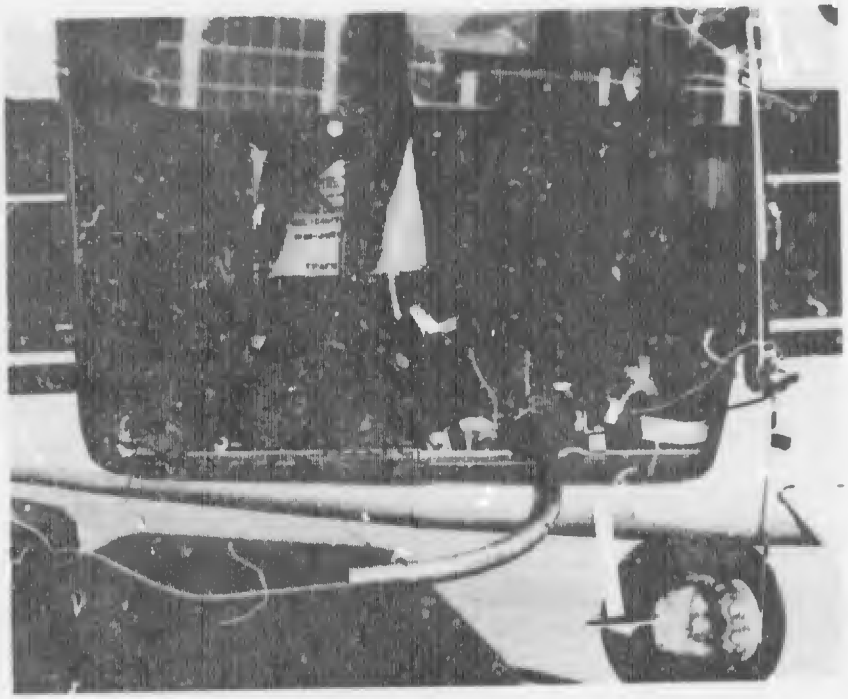
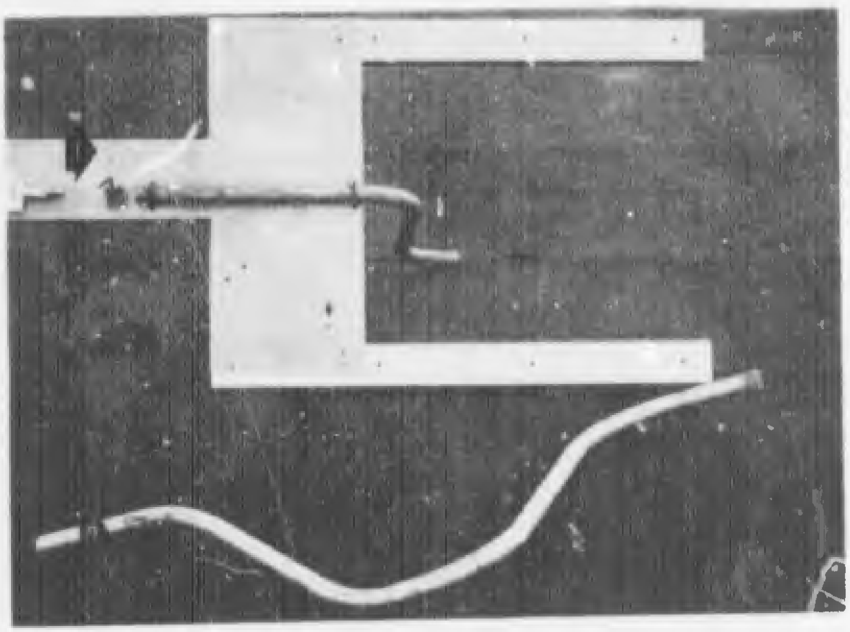
[2] Experimental Parachute Laboratory, Aeronautical Systems Division, Wright Patterson AFB, Ohio



A. Cessna Boom Installed in Cessna 206



B. Porter Boom
   1. Boom Plate with Center-Exit Boom
   2. Optional Left-Side Exit Boom

Figure 4. Cessna and Porter Booms

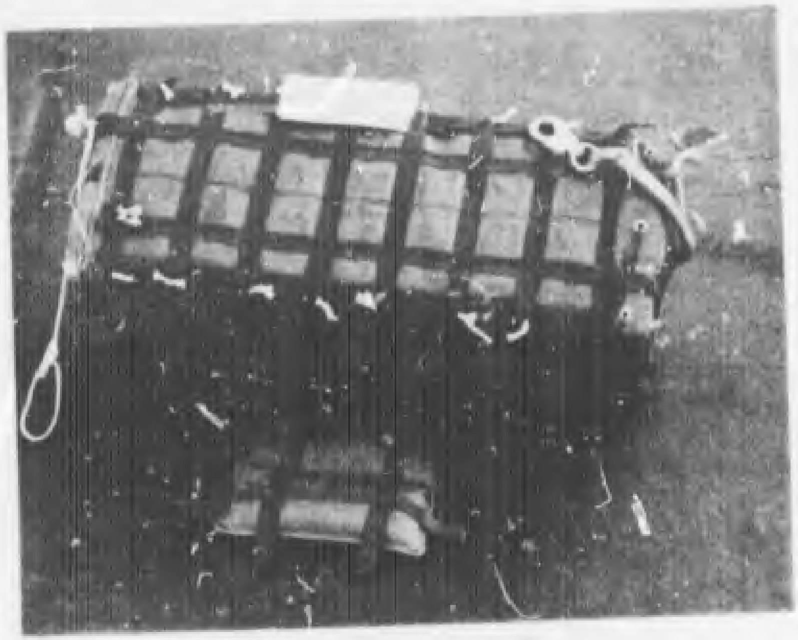


Figure 5. Line Deployment Bag
(Arrow Indicates Extra Strap on 30-Pound Weight)

Cotton Riser Extension and Connector Straps: After a nylon riser extension failed, cotton extensions were used to avoid melting of the material in contact with the long-line. Cotton extensions were also used to fasten cargo packages.

Guide Rings: Guide rings were made to allow the long-line to pass through a large center ring with the chute fastened to a D-ring on one side and the cargo attached to the D-ring on the otherside. Details in appendix I.

Static Line and Chute Deployment Bag: One end of an 18-foot static line was attached to the aircraft; the other end, to a chute deployment bag. The configuration is shown in figure 6.

ANCHORING DEVICES

A "doggy" tiedown ring was used to tie down the line deployment bag after ground impact. The tiedown rings were purchased "off-the-shelf" and modified with a weld (figure 7). Un-assisted anchoring was accomplished using an ADSID-1, Short-Case Penetrator (figure 7). This is discussed further in both the Tactics and the Future Efforts sections of this report.

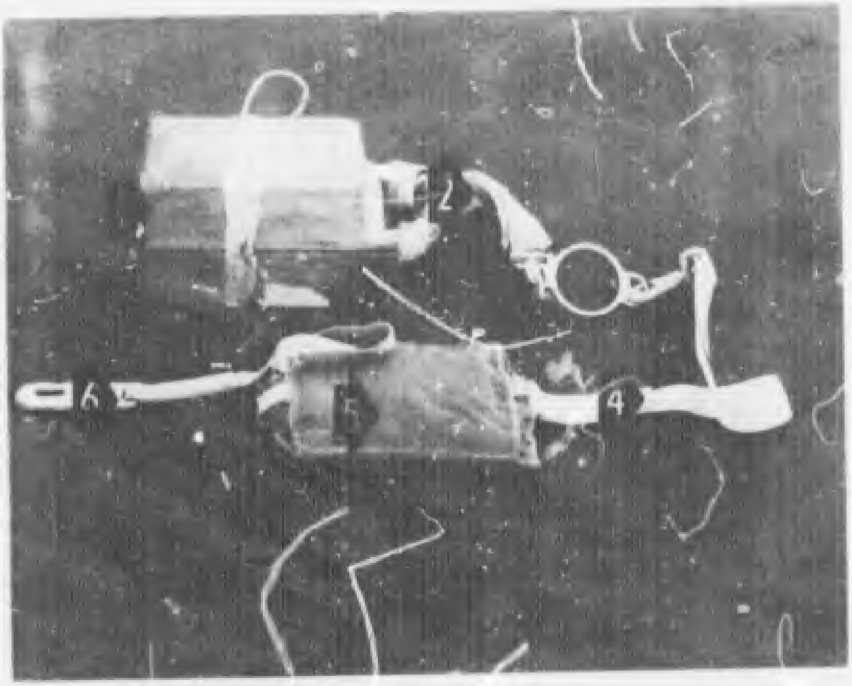


Figure 6: Paraslide Package
1. Dummy Load—100 Pounds
2. Cotton Riser Extension
3. Ring
4. Cotton Riser Extension
5. Static Deployment Bag
6. Static Line

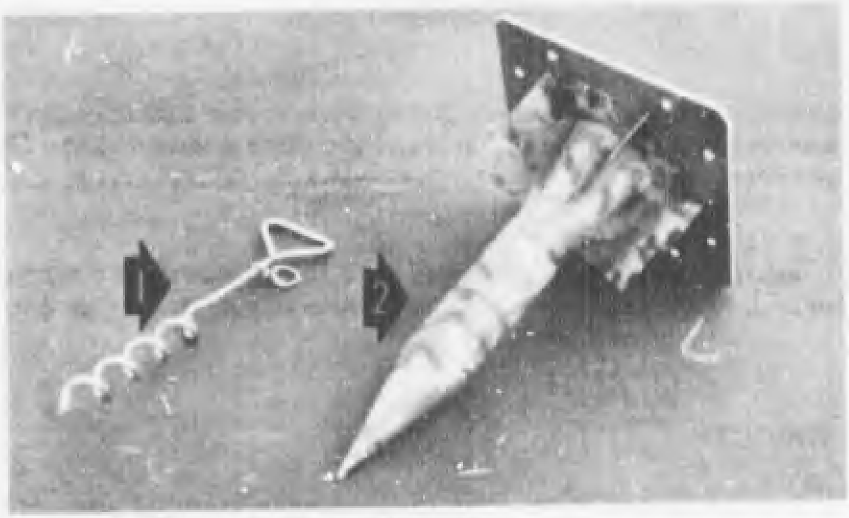


Figure 7: Ground Anchors
1. "Doggie" Ring
2. ADSID–1 Penetrator

SECTION IV

TACTICS

A series of 14 flights was devoted to the development of tactics for various delivery situations. The following tactics were found to yield a high rate of success for the Fairchild-Hiller Heli-porter. A sample calculation for acquiring a drop parameter is given in appendix III.

ALTITUDES

Tactics were developed for two delivery altitudes, 1,500 feet AGL and 3,000 feet AGL. Altitude must be compatible with the amount of line packed into the deployment bags. A 1,500-foot delivery requires 3,000 feet of line. A 3,000-foot delivery requires 4,000 feet of line.

WIND CALCULATION (AT DROP ALTITUDE)

The Long-Line Sight is placed in the zero-detent position. The aircraft is trimmed and power set to maintain 65 knots indicated. Altitude setting is at that mean sea level (MSL) setting to place the aircraft at 3,000 feet AGL (or 1,500 feet AGL, depending on the drop altitude desired) over the target area. A reference mark is located on the ground which is very nearly the same MSL altitude as the target drop zone (the target can be used, environment permitting). Using the reference point, wind direction is determined by killing the drift and allowing the point to track down the center line of the reticle in the sight. Once the drift is killed, the reference point is timed from +10° forward to −10° back. The ambient temperature is noted.

Using the time from (+) to (−) 10°, true groundspeed is calculated in the usual manner. Table 1 can be used to determine the true groundspeed given altitude (AGL) and time from −10° to +10°. Then using the indicated airspeed, ambient temperature, MSL altitude, and any instrument correction which might be applicable, a true airspeed (TAS) is calculated using a flight computer. Using the true airspeed and the groundspeed and the direction arrived at by killing the drift, the wind velocity can be acquired.

AVERAGE WIND CALCULATION

To enter the drop parameter tables an "average" wind is needed. The average wind is actually a weighted wind. If the wind at the drop zone is known, the average wind is found by:

$$\text{AVERAGE WIND} = \frac{\text{GROUND WIND} + 2 \times (\text{CALCULATED WIND AT ALTITUDE})}{3}$$

DROP PARAMETER

Drop parameters are given in degrees from nadir, (+) positive is forward, (−) negative is back. The drop parameter is read into the Long-Line Sight by combining the visual detent

[1] Ballistics calculations for tables done by Maj. J. Butler, of the Air Force

TABLE I ACTUAL GROUNDSPEED IN KNOTS

TIME	1500 FEET	2000 FEET	2500 FEET	3000 FEET	3500 FEET	4000 FEET
2.00 SEC	156.58	208.78	260.97	313.16	365.36	417.55
2.50 SEC	125.27	167.02	208.78	250.53	292.29	334.04
3.00 SEC	104.39	139.18	173.98	208.78	243.57	278.37
3.50 SEC	89.48	119.30	149.13	178.95	208.78	238.60
4.00 SEC	78.29	104.39	130.49	156.58	182.68	208.78
4.50 SEC	69.59	92.79	115.99	139.18	162.38	185.58
5.00 SEC	62.63	83.51	104.39	125.27	146.14	167.02
5.50 SEC	56.94	75.92	94.90	113.88	132.86	151.84
6.00 SEC	52.19	69.59	86.99	104.39	121.79	139.18
6.50 SEC	48.18	64.24	80.30	96.36	112.42	128.48
7.00 SEC	44.74	[illegible]	74.56	89.48	104.39	119.30
7.50 SEC	41.76	55.67	69.59	83.51	97.43	111.35
8.00 SEC	39.15	52.19	65.24	78.29	91.34	104.39
8.50 SEC	36.84	49.12	61.40	73.69	85.97	98.25
9.00 SEC	34.80	46.39	57.99	69.59	81.19	92.79
9.50 SEC	32.96	43.95	54.94	65.93	76.92	87.91
10.00 SEC	31.32	41.76	52.19	62.63	73.07	83.51
10.50 SEC	29.83	39.77	49.71	59.65	69.59	79.53
11.00 SEC	28.47	37.96	47.45	56.94	66.43	75.92
11.50 SEC	27.23	36.31	45.39	54.46	63.54	72.62
12.00 SEC	26.10	34.80	43.50	52.19	60.89	69.59
12.50 SEC	25.05	33.40	41.76	50.11	58.46	66.81
13.00 SEC	24.09	32.12	40.15	48.18	56.21	64.24
13.50 SEC	23.20	30.93	38.66	46.39	54.13	61.86
14.00 SEC	22.37	29.83	37.28	44.74	52.19	59.65
14.50 SEC	21.60	28.80	36.00	43.20	50.39	57.59
15.00 SEC	20.88	27.84	34.80	41.76	48.71	55.67
15.50 SEC	20.20	26.94	33.67	40.41	47.14	53.88
16.00 SEC	19.57	26.10	32.62	39.15	45.67	52.19

NOTE: THIS TABLE GIVES AIRCRAFT GROUNDSPEED BASED ON THE TIME REQUIRED TO MOVE A POINT ON THE GROUND FROM PLUS 10 DEGREES TO MINUS 10 DEGREES IN THE SIGHT.

readout and the reticle readout; thus if the target appears on the −5° mark on the reticle and the sight is in the +15° readout, combining the two yields at +10° forward of nadir.

A drop parameter can be found using tables II through XI. The tables are entered using altitude (AGL), altitude (MSL), true airspeed (in knots), and average wind velocity.

DELIVERY[4]

Upon arrival in the target area, the pilot should establish a normal rectangular approach pattern with the approach leg into the previously established wind direction. On the downwind leg, configure the aircraft for drop of the line bag, 65 knots indicated, 6 turns of flaps (½ flaps on electric-actuated flaps), ball-centered, Prop 75%, and aircraft trimmed to as near hands-off flight as possible. On the run into the target on the approach leg, check through the sight and determine that there is no discernible drift in advance of 5 seconds from drop

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[4] Taken from appendix IV, Ralph W. Lusk, Jr., Data Corporation.

TABLE II

RECOMMENDED DROP ANGLES FOR MISSION I (1500 FT,AGL)

TOTAL LINE LENGTH = 3000 BAG WT. = 73.5 DRAG COEFFICIENT = 1.00

AIRCRAFT ALTITUDE (FT,MSL) = 1500 TARGET ALT (FT,MSL) = 0

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS 0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	22.00	18.63	15.10	11.28	7.51	3.65	−.26
65.0	23.18	19.87	16.39	12.60	8.87	5.04	1.11
70.0	24.28	21.03	17.60	13.85	10.16	6.35	2.43
75.0	25.39	22.17	18.76	15.02	11.33	7.52	3.57
80.0	26.37	23.20	19.85	16.14	12.49	8.71	4.77
85.0	27.29	24.18	20.88	17.20	13.60	9.35	5.92
90.0	28.23	25.15	21.87	18.21	14.61	10.86	6.91
95.0	29.06	26.02	22.79	19.16	15.61	11.90	7.96
100.0	29.84	26.85	23.67	20.08	16.56	12.88	8.96

AIRCRAFT ALTITUDE (FT,MSL) = 2500 TARGET ALT. (FT,MSL) = 1000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS 0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	22.30	18.97	15.29	11.68	7.95	4.12	.22
65.0	23.49	20.22	16.59	13.03	9.33	5.53	1.63
70.0	24.69	21.45	17.83	14.28	10.59	6.79	2.86
75.0	25.74	22.56	18.99	15.49	11.84	8.07	4.14
80.0	26.74	23.61	20.08	16.63	13.02	9.28	5.37
85.0	27.68	24.61	21.12	17.71	14.15	10.44	6.54
90.0	28.64	25.59	22.12	18.74	15.18	11.48	7.56
95.0	29.47	26.48	23.05	19.71	16.20	12.54	8.63
100.0	30.27	27.32	23.93	20.64	17.17	13.54	9.66

TABLE III

RECOMMENDED DROP ANGLES FOR MISSION I (1500 FT,AGL)

TOTAL LINE LENGTH = 3000 BAG WT. = 73.5 DRAG COEFFICIENT = 1.00

AIRCRAFT ALTITUDE (FT,MSL) = 3500 TARGET ALT. (FT,MSL) = 2000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	22.60	19.08	15.65	12.08	8.38	4.52	.70
65.0	23.88	20.39	16.99	13.44	9.74	5.87	2.03
70.0	25.03	21.59	18.24	14.73	11.08	7.22	3.40
75.0	26.10	22.71	19.42	15.96	12.35	8.51	4.71
80.0	27.11	23.77	20.53	17.12	13.56	9.74	5.96
85.0	28.14	24.82	21.61	18.22	14.67	10.84	7.06
90.0	29.04	25.77	22.61	19.27	15.76	11.96	8.21
95.0	29.90	26.67	23.56	20.26	16.80	13.02	9.30
100.0	30.70	27.52	24.45	21.21	17.79	14.04	10.35

AIRCRAFT ALTITUDE (FT,MSL) = 4500 TARGET ALT. (FT,MSL) = 3000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	22.90	19.41	16.02	12.48	8.70	4.98	1.19
65.0	24.21	20.75	17.38	13.86	10.08	6.35	2.54
70.0	25.37	21.96	18.65	15.18	11.43	7.73	3.95
75.0	26.46	23.10	19.85	16.43	12.71	9.05	5.28
80.0	27.57	24.24	21.01	17.62	13.89	10.24	6.47
85.0	28.54	25.25	22.09	18.74	15.05	11.43	7.69
90.0	29.46	26.22	23.10	19.81	16.15	12.57	8.86
95.0	30.32	27.13	24.06	20.82	17.20	13.65	9.98
100.0	31.22	28.05	25.01	21.79	18.18	14.64	10.96

TABLE IV

RECOMMENDED DROP ANGLES FOR MISSION I (1500 FT,AGL)

TOTAL LINE LENGTH = 3000 BAG WT. = 73.5 DRAG COEFFICIENT = 1.00

AIRCRAFT ALTITUDE (FT,MSL) = 5500 TARGET ALT. (FT,MSL) = 4000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	23.02	19.79	16.41	12.72	9.09	5.36	1.56
65.0	24.26	21.10	17.78	14.12	10.54	6.84	3.06
70.0	25.44	22.34	19.07	15.45	11.91	8.25	4.49
75.0	26.62	23.56	20.32	16.71	13.18	9.53	5.76
80.0	27.66	24.65	21.47	17.90	14.42	10.81	7.07
85.0	28.64	25.69	22.56	19.04	15.60	12.02	8.32
90.0	29.56	26.67	23.59	20.11	16.72	13.18	9.51
95.0	30.52	27.66	24.61	21.14	17.77	14.24	10.57
100.0	31.34	28.53	25.54	22.11	18.79	15.30	11.67

AIRCRAFT ALTITUDE (FT,MSL) = 6500 TARGET ALT. (FT,MSL) = 5000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	23.32	20.13	16.58	13.11	9.52	5.82	2.02
65.0	24.59	21.46	17.95	14.54	10.99	7.33	3.53
70.0	25.86	22.77	19.29	15.96	12.36	8.70	4.88
75.0	26.98	23.96	20.52	17.18	13.69	10.07	6.26
80.0	28.04	25.07	21.68	18.40	14.95	11.37	7.58
85.0	29.03	26.12	22.78	19.55	16.15	12.61	8.83
90.0	30.06	27.19	23.86	20.66	17.28	13.75	9.96
95.0	30.94	28.13	24.85	21.69	18.37	14.88	11.11
100.0	31.78	29.02	25.78	22.68	19.40	15.96	12.22

TABLE V

RECOMMENDED DROP ANGLES FOR MISSION I (1500 FT,AGL)

TOTAL LINE LENGTH = 3000 BAG WT. = 73.5 DRAG COEFFICIENT = 1.00

AIRCRAFT ALTITUDE (FT,MSL) = 7500 TARGET ALT. (FT,MSL) = 6000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	23.63	20.23	16.94	13.51	9.95	6.20	2.49
65.0	25.00	21.63	18.38	14.97	11.42	7.65	3.94
70.0	26.21	22.89	19.70	16.35	12.85	9.10	5.42
75.0	27.35	24.08	20.95	17.65	14.20	10.48	6.82
80.0	28.42	25.21	22.13	18.89	15.49	11.79	8.17
85.0	29.52	26.34	23.29	20.08	16.70	13.00	9.38
90.0	30.47	27.34	24.35	21.19	17.86	14.20	10.61
95.0	31.38	28.29	25.36	22.25	18.97	15.33	11.78
100.0	32.23	29.19	26.31	23.25	20.02	16.42	12.91

AIRCRAFT ALTITUDE (FT,MSL) = 8500 TARGET ALT. (FT,MSL) = 7000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	23.74	20.62	17.34	13.91	10.22	6.59	2.88
65.0	25.04	21.99	18.77	15.39	11.73	8.14	4.45
70.0	26.26	23.27	20.11	16.80	13.16	9.61	5.95
75.0	27.41	24.48	21.38	18.12	14.53	11.01	7.39
80.0	28.58	25.69	22.63	19.40	15.81	12.31	8.69
85.0	29.60	26.77	23.77	20.60	17.04	13.59	10.00
90.0	30.56	27.79	24.85	21.73	18.21	14.80	11.26
95.0	31.57	28.83	25.92	22.83	19.33	15.94	12.40
100.0	32.43	29.75	26.89	23.85	20.39	17.05	13.55

TABLE VI

RECOMMENDED DROP ANGLES FOR MISSION I (1500 FT,AGL)

TOTAL LINE LENGTH = 3000 BAG WT. = 73.5 DRAG COEFFICIENT = 1.00

AIRCRAFT ALTITUDE (FT,MSL) = 9500 TARGET ALT. (FT,MSL) = 8000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	24.05	20.96	17.71	14.13	10.64	7.04	3.31
65.0	25.37	22.35	19.16	15.62	12.18	8.62	4.89
70.0	26.61	23.65	20.53	17.03	13.64	10.12	6.41
75.0	27.87	24.95	21.87	18.39	15.02	11.51	7.78
80.0	28.97	26.12	23.09	19.66	16.34	12.88	9.17
85.0	30.00	27.21	24.25	20.86	17.59	14.18	10.49
90.0	31.08	28.33	25.40	22.03	18.79	15.3[illegible]	11.70
95.0	32.00	29.31	26.44	23.12	19.93	16.57	12.91
100.0	32.88	30.24	27.42	24.14	21.01	17.70	14.06

AIRCRAFT ALTITUDE (FT,MSL) = 10500 TARGET ALT. (FT,MSL) = 9000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	24.36	21.30	17.86	14.53	11.06	7.39	3.78
65.0	25.70	22.71	19.31	16.04	12.63	8.98	5.39
70.0	27.05	24.11	20.74	17.50	14.11	10.45	6.86
75.0	28.24	25.36	22.04	18.86	15.52	11.89	8.34
80.0	29.35	26.54	23.27	20.15	16.87	13.27	9.75
85.0	30.51	27.74	24.50	21.41	18.15	14.55	11.05
90.0	31.50	28.79	25.60	22.57	19.37	15.80	12.34
95.0	32.44	29.79	26.65	23.67	20.52	16.99	13.57
100.0	33.33	30.73	27.64	24.71	21.62	18.13	14.75

TABLE VII

RECOMMENDED DROP ANGLES FOR MISSION II (3000 FT.AGL)

TOTAL LINE LENGTH = 4000 BAG WT. = 86.0 DRAG COEFFICIENT = 1.43

AIRCRAFT ALTITUDE (FT,MSL) = 3000 TARGET ALT. (FT,MSL) = 0

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	14.33	11.37	8.28	5.21	2.09	−1.05	−4.19
65.0	15.17	12.23	9.16	6.10	2.98	−.16	−3.29
70.0	15.98	13.05	9.98	6.91	3.79	.63	−2.52
75.0	16.74	13.83	10.77	7.72	4.61	1.46	−1.69
80.0	17.46	14.57	11.53	8.50	5.40	2.24	−.90
85.0	18.16	15.28	12.24	9.20	6.10	2.93	−.23
90.0	18.82	15.96	12.93	9.91	6.82	3.66	.50
95.0	19.44	16.61	13.60	10.59	7.52	4.36	1.20
100.0	20.05	17.23	14.22	11.21	8.13	4.96	1.80

AIRCRAFT ALTITUDE (FT,MSL) = 4000 TARGET ALT. (FT,MSL) = 1000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	14.56	11.57	8.59	5.55	2.44	−.65	−3.75
65.0	15.43	12.44	9.46	6.42	3.31	.20	−2.92
70.0	16.24	13.27	10.32	7.29	4.18	1.08	−2.04
75.0	17.02	14.07	11.13	8.12	5.01	1.92	−1.20
80.0	17.77	14.82	11.89	8.88	5.77	2.66	−.47
85.0	18.47	15.55	12.63	9.63	6.53	3.44	.31
90.0	19.14	16.23	13.34	10.36	7.27	4.18	1.06
95.0	19.78	16.89	14.02	11.05	7.97	4.89	1.78
100.0	20.41	17.52	14.65	11.69	8.60	5.52	2.39

TABLE VIII

RECOMMENDED DROP ANGLES FOR MISSION II (3000 FT.AGL)

TOTAL LINE LENGTH = 4000 BAG WT. = 86.0 DRAG COEFFICIENT = 1.43

AIRCRAFT ALTITUDE (FT.MSL) = 5000 TARGET ALT. (FT.MSL) = 2000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	14.80	11.84	8.89	5.89	2.82	−.24	−3.32
65.0	15.69	12.73	9.79	6.78	3.70	.63	−2.46
70.0	16.52	13.58	10.66	7.67	4.59	1.53	−1.56
75.0	17.31	14.39	11.49	8.52	5.45	2.39	−.70
80.0	18.08	15.16	12.27	9.30	6.22	3.15	.05
85.0	18.79	15.90	13.03	10.07	7.00	3.94	.85
90.0	19.48	16.60	13.75	10.81	7.75	4.70	1.61
95.0	20.15	17.28	14.43	11.49	8.43	5.37	2.27
100.0	20.77	17.92	15.09	12.17	9.12	6.08	2.98

AIRCRAFT ALTITUDE (FT.MSL) = 6000 TARGET ALT. (FT.MSL) = 3000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	15.04	12.11	9.20	6.23	3.19	.16	−2.88
65.0	15.95	1[illegible].02	10.12	7.15	4.10	1.06	−2.00
70.0	16.79	13.89	11.01	8.05	5.01	1.98	−1.08
75.0	17.60	14.72	11.85	8.92	5.88	2.86	−.20
80.0	18.39	15.51	12.65	9.72	6.67	3.64	.57
85.0	19.12	16.26	13.42	10.51	7.47	4.45	1.39
90.0	19.82	16.98	14.16	11.27	8.24	5.23	2.18
95.0	20.50	17.67	14.86	11.97	8.94	5.92	2.85
100.0	21.14	18.33	15.54	12.66	9.64	6.64	3.58

TABLE IX

RECOMMENDED DROP ANGLES FOR MISSION II (3000 FT,AGL)

TOTAL LINE LENGTH = 4000 BAG WT. = 86.0 DRAG COEFFICIENT = 1.43

AIRCRAFT ALTITUDE (FT,MSL) = 7000 TARGET ALT. (FT,MSL) = 4000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	15.20	12.39	9.50	6.50	3.52	.51	−2.51
65.0	16.11	13.32	10.45	7.47	4.50	1.49	−1.53
70.0	16.97	14.20	11.36	8.38	5.43	2.43	−.60
75.0	17.81	15.05	12.21	9.24	6.28	3.27	.23
80.0	18.59	15.86	13.04	10.08	7.13	4.13	1.09
85.0	19.33	16.62	13.83	10.88	7.95	4.96	1.92
90.0	20.06	17.36	14.57	11.62	8.69	5.70	2.65
95.0	20.74	18.07	15.30	12.36	9.45	6.47	3.42
100.0	21.38	18.74	15.99	13.07	10.17	7.20	4.16

AIRCRAFT ALTITUDE (FT,MSL) = 8000 TARGET ALT. (FT,MSL) = 5000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	15.45	12.67	9.81	6.85	3.90	.92	−2.07
65.0	16.37	13.62	10.79	7.83	4.90	1.92	−1.07
70.0	17.25	14.52	11.71	8.77	5.85	2.88	−.12
75.0	18.10	15.39	12.58	9.64	6.72	3.74	.73
80.0	18.90	16.21	13.43	10.50	7.59	4.63	1.61
85.0	19.66	16.99	14.24	11.32	8.43	5.48	2.47
90.0	20.40	17.75	15.00	12.08	9.19	6.24	3.21
95.0	21.10	18.47	15.74	12.84	9.96	7.02	4.00
100.0	21.76	19.15	16.45	13.56	10.70	7.77	4.76

TABLE X

RECOMMENDED DROP ANGLES FOR MISSION II (3000 FT.AGL)

TOTAL LINE LENGTH = 4000 BAG WT. = 86.0 DRAG COEFFICIENT = 1.43

AIRCRAFT ALTITUDE (FT.MSL) = 9000 TARGET ALT. (FT.MSL) = 6000

DROP TRUE AIRSPEED	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
KTS	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	15.70	12.95	10.06	7.20	4.28	1.32	−1.63
65.0	16.64	13.92	11.05	8.20	5.30	2.34	−.62
70.0	17.56	14.85	11.98	9.13	6.23	3.25	.29
75.0	18.41	15.73	12.87	10.05	7.16	4.19	1.23
80.0	19.22	16.57	13.73	10.93	8.05	5.09	2.14
85.0	20.02	17.37	14.54	11.74	8.87	5.90	2.94
90.0	20.76	18.14	15.33	12.55	9.69	6.73	3.78
95.0	21.46	18.87	16.08	13.32	10.48	7.52	4.59
100.0	22.16	19.58	16.79	14.04	11.20	8.24	5.30

AIRCRAFT ALTITUDE (FT.MSL) = 10000 TARGET ALT. (FT.MSL) = 7000

DROP TRUE AIRSPEED	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
KTS	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	15.95	13.15	10.38	7.55	4.63	1.73	−1.20
65.0	16.93	14.14	11.38	8.55	5.62	2.71	−.23
70.0	17.85	15.07	12.33	9.52	6.61	3.71	.77
75.0	18.72	15.96	13.25	10.46	7.55	4.66	1.74
80.0	19.57	16.83	14.12	11.33	8.42	5.53	2.60
85.0	20.36	17.64	14.96	12.19	9.29	6.41	3.49
90.0	21.11	18.41	15.76	13.01	10.13	7.26	4.35
95.0	21.86	19.17	16.52	13.79	10.89	8.03	5.11
100.0	22.55	19.88	17.26	14.54	11.66	8.81	5.91

TABLE XI

RECOMMENDED DROP ANGLES FOR MISSION II (3000 FT.AGL)

TOTAL LINE LENGTH = 4000 BAG WT. = 86.0 DRAG COEFFICIENT = 1.43

AIRCRAFT ALTITUDE (FT,MSL) = 11000 TARGET ALT. (FT,MSL) = 8000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	16.12	13.44	10.69	7.82	4.97	2.08	−.83
65.0	17.10	14.45	11.72	8.86	6.02	3.14	.23
70.0	18.02	15.40	12.69	9.85	7.03	4.16	1.25
75.0	18.93	16.32	13.63	10.78	7.96	5.09	2.16
80.0	19.77	17.19	14.52	11.69	8.89	6.03	3.10
85.0	20.57	18.02	15.37	12.56	9.78	6.93	4.01
90.0	21.37	18.82	16.19	13.38	10.60	7.75	4.82
95.0	22.10	19.58	16.97	14.18	11.42	8.59	5.66
100.0	22.80	20.31	17.72	14.95	12.20	9.39	6.47

AIRCRAFT ALTITUDE (FT,MSL) = 12000 TARGET ALT. (FT,MSL) = 9000

DROP TRUE AIRSPEED KTS	LEAD ANGLE IN DEGREES FOR AVERAGE HEADWIND COMPONENTS						
	0 KTS.	5 KTS.	10 KTS.	15 KTS.	20 KTS.	25 KTS.	30 KTS.
60.0	16.38	13.74	10.94	8.17	5.35	2.47	−.39
65.0	17.37	14.76	11.98	9.23	6.42	3.55	.69
70.0	18.34	15.74	12.96	10.22	7.42	4.53	1.66
75.0	19.24	16.67	13.91	11.19	8.41	5.53	2.67
80.0	20.10	17.55	14.82	12.12	9.36	6.48	3.63
85.0	20.95	18.42	15.69	13.00	10.23	7.35	4.50
90.0	21.73	19.23	16.52	13.85	11.11	8.24	5.39
95.0	22.48	20.00	17.31	14.67	11.94	9.09	6.25
100.0	23.22	20.76	18.07	15.44	12.72	9.86	7.02

or breakoff approach, and set up approach again at correct heading. It may be necessary to make several runs before wind direction is determined for a no-drift approach to the target.

There may be missions where, due to terrain, meteorological conditions, etc., a cross-wind drop must be made. In this case the headwind component is used for calculating the drop parameter, and the cross-wind component is used to offset the aircraft left or right of the target. No offset factors are presented here because of the difficulty of using the sight in such a case. Target attainment will be marginal and erratic at best under these circumstances.

The actual drop will be accomplished at the predetermined sight setting. The aircraft must be completely stabilized. Yaw, pitch, dive, airspeed deviation, roll, or altitude discrepancy can cause the line bag to miss the target by an unacceptable distance. The mission success is entirely dependent upon the aircraft being stabilized on the prescribed parameters.

The technique for viewing the target through the sight and monitoring the flight instruments at the same time must be worked out by each individual pilot. One technique, however, is to keep both eyes open and switch accepted vision from eye to eye, from sight to instruments. Figure 8 shows the pilot using the Long-Line Sight.

There is also a technique to the release of the line bag from the aircraft. Care must be taken to release the bag into the airstream at exactly the release point, just a second or two error can cause an unacceptable distance error at the target. In addition the aircrew member has a tendency to throw the bag out, giving it an initial downward velocity which, in turn, will change the ballistic trajectory of the bag from that calculated and given in the tables. For this reason, the tendency must be overcome and the bag allowed to *fall* free of the aircraft. It is also preferable that the bag exit bottom-first. One technique found to accomplish all of the foregoing is to place the bag in a vertical position (bottom down) in the floor hole (bottom of the bag even with exterior skin) and releasing the bag on the release signal. With this release technique, the bag was found to have the least amount of tumble before stabilizing itself into the relative wind. This minimum amount of tumble has been programmed into the ballistics and will not effect the impact point. Excessive tumbling, however, will cause impact errors.

BAG IMPACT AND TETHERING

Once released, the bag falls, deploying the line as it goes. From 3,000 feet AGL, the bag takes an average of 20 seconds to impact the ground. At impact not all the line has yet been deployed from the bag and line continues to pay out as the bag sits on the ground. The bag should be tethered to the ground as soon after impact as possible. Two methods of anchoring have been tried successfully, the use of a "doggie" ring and the use of a penetrator. In the case of a penetrator, the bag will automatically be anchored on impact and, for this reason, the penetrator is the most attractive approach. However, the penetrator adds complexity to the overall system; therefore, where a ground team is available, the use of a doggie ring or other such ground anchoring techniques requiring ground crew manipulation is the simplest technique. Also, the bag, not anchoring itself to the ground, can be readily removed by the ground crew if the spot where it lands is not the most ideal tethering point.

Figure 8. Pilot Using Long-Line Sight

The use of the doggie ring is very simple. Because it is light and highly portable, it can be carried to the impact area and screwed into the ground. Generally, two men were used during anchoring, one to hold the bag to keep it from being dragged by the line, and the other to screw in the doggie ring and attach the clip provided on the bag.

In general, anchoring using ground crew manipulation is complete within 20 seconds after impact.

ORBIT

Once the line bag has left the aircraft, it assumes a ballistic trajectory relatively independent of the aircraft (Figure 9 shows bag falling free of aircraft). The use of the sight ends at release. After release, the aircraft is placed into a tight orbit (35°–40° bank). In a no-wind condition the orbit is initiated immediately. As a rule of thumb under headwind conditions, the orbit is initiated 5 seconds past the target for every 15 knots of wind. A pivot point of the orbit should be located upwind of the target so that the downwind side of the orbit is directly above the target.

Once the bag is anchored to the ground, the aircraft assumes a wider orbit (no wind 30° of bank) while maintaining the 65 knots indicated air speed (KIAS) and the drop altitude. If there is ground to air communication the pilot should be advised of the line tension at the ground. Enough tension should be maintained to allow the slides to track down the line to the tether point. If the ground crew advises that the tension is too high, the orbit can be tightened, or altitude can be lost, or airspeed decreased, any of which will relieve the line tension. Note that this is typically a 30-second delay between what the aircraft does and what is exhibited at the tether point; thus, the ground crew should anticipate line conditions so that the situation does not become urgent.

The pilot should also be advised if the line tension becomes too slack, as is usually the case, and if any "line lay" occurs (line laying on the ground). This slack allows the cargo to impact at some distance from the target. Tension can be built up in the line by either increasing the orbit size (less bank angle), increasing the airspeed, or increasing the altitude, all of which will tend to increase the tension. Of these choices, increasing orbit altitude is probably the most desirable. The line should be pretensioned by the aircraft to provide a normal profile, as the cargo is continuously moving down to the impact point.

LARGE IMPACT ERROR-CORRECTING METHODS

If the target is missed by an unacceptable amount, there are two options available: to cut the line or to single-line deploy the same line.

Cutting the Line: When cutting the line, note the initial bag impact point so that a correction may be made for another drop. A knife should be used to cut the line, so that the automatic line-cutter can be used on the following drop if an emergency should occur. After

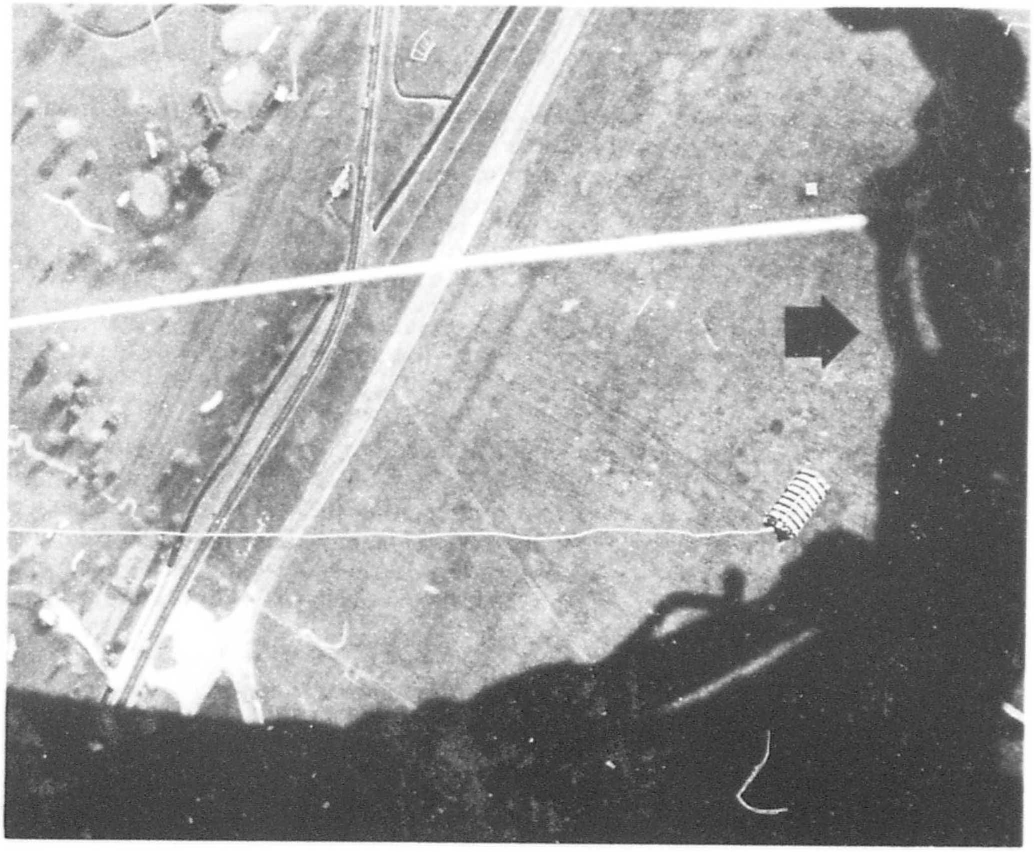

Figure 9. Line Bag as It Exits Aircraft
(Looking Down Through Floor Opening)
*Arrow Indicates Aircraft Direction of Flight

releasing the line, a new line is threaded into the boom in preparation for another try at the target. Before setting up another drop, all possible reasons for missing the target should be considered.

Single-Line Delivery: Although the single-line delivery is much more difficult to perform, it can be used as a back-up line end placement method. The following considerations, however, must be taken into account before attempting this method of delivery: the bag must not have a penetrator, and the end of the line must not be hung up in foliage or other ground obstacles.

Our tests have shown that the most accurate delivery is made by having the aircrew member, other than the pilot, locate the end of the line on the ground, verify that it is not anchored, and direct the pilot as follows:

1. Tell the pilot to fly out of orbit directly toward the target.

2. The aircrew member must keep his eyes on the end of the line at all times (through hole in floor of aircraft), and when he sees the bag is directly over the target, he should tell the pilot to initiate a hard left-hand orbit and to lose approximately 200 feet of altitude. This should allow the bag to fall to the target area. Once the end of the line is back on the ground the pilot should maintain his tight orbit and altitude until the line is anchored.

LINE-CLEARING SLIDE

Because the line is packed into the delivery bag in skeins, occasionally a skein or two will stay intact (approximately 5% of the time). For this reason, a 25-pound dead-weight slide is routinely performed each drop to break out any skeins which might not yet have done so. The slide is performed quite easily by simply connecting the weight to a D-ring on one of the slide rings and dropping it out of the aircraft. This can be done immediately after the pilot has been informed that the bag has been anchored. The weight takes about 35 seconds to impact at the tether point. It is best to hold off starting the paraslides until confirmation of impact although, if time does not permit, chute slides can be initiated 20 seconds after weight release, provided the proper tension exists on the line.

PARASLIDES

After the line-clearing slide has been made, paraslides may begin. When matching the cargo weight with the chute size, consider the paraslide packages portion (section III) of this report. When using chute sizes other than those tested, reference should be made to figure 10 and descent rates from 60 to 100 feet/second should be selected.

Rings should be threaded onto pipe prior to attachment of the line bag. A sufficient number of rings must be provided to handle all cargo drops to be made with the same long-line.

CHECK:

Assume	ρ = .002308 (H = 1000)
	W = 10,000
	K = 100
Read	V_e = 294
Calc.	V_e = 294.4

$V_e = \sqrt{\frac{2W}{\rho K}}$, Where ρ is a function of H, and is the air density (slufs/ft^3)

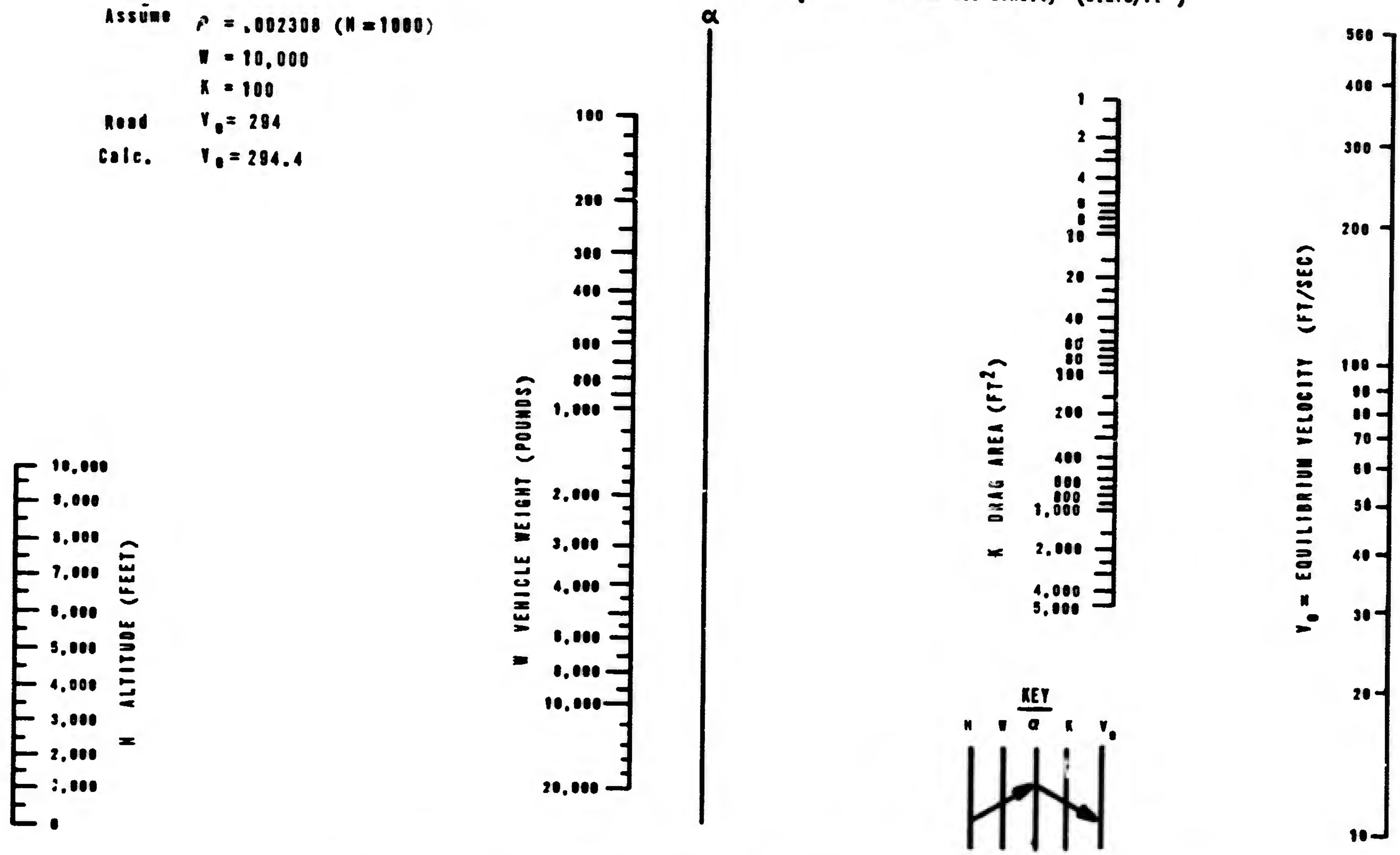

Figure 10. Equilibrium Velocity for Various Parachute Drag and Vehicle Weights

Just prior to the drop, the load is hooked on one side of the ring and the chute on the other (it was found convenient in some instances to attach the loads to the rings prior to the line deployment; however, this was mainly due to the shape and size of the dummy loads used). Figure 11 shows the loads hooked to the ring and the chutes awaiting attachment prior to load exit from aircraft.

When dropping the load out of the aircraft, great care *must* be taken to assure the load exits on the same side of the line that it is attached (i.e., load hooked to ring on the right side of the boom, thus, making it essential that the load falls to the right side of the line). Should the load fall to the wrong side of the line it will cause the ring to rotate 270° thereby looping the parachute riser extension around the line which could result in the package hanging up on the line, breaking the line, or burning the riser extension through and releasing the chute.

When releasing the load out of the aircraft, be sure the tacking on the static line is broken loose prior to drop so that the static line will deploy fully before extracting the chute from the static bag. At the same time be careful not to have the tacking at the connector link break while dropping the load out of the aircraft. Loads can then be dropped at intervals of 15 seconds minimum.

The best part of the orbit to release loads is at the upwind side (see figure 12). This does not limit the drops to the upwind section of the orbit but it does assure better slides and faster impact times since the chute does not have to buck the wind nearly as much as a downwind release. Figure 13 shows a chute and load moving down the line.

TERMINATION AND CARGO RETRIEVAL

Upon ground impact of last paraslide package, the maneuver is ready to be terminated. Depending on time availability, environment, mission, etc, the pilot has the option of either releasing the line at the aircraft or launching the bag from the ground.

Line Release: Releasing the line requires very little effort. Once assured that the line is clear of paraslides, the Long-line is cut loose. The line should be cut with a knife to save the emergency line cutter for actual emergency situations.

If the line is cut while the aircraft is in a fairly tight orbit, it will fall in a relatively small area on the ground. The line is very easy to retrieve by hand on the ground since it doesn't kink or knot very easily. The line should be saved if possible for use at a later time.

Bag Launching and Retrieval: The alternative option is to use the line delivery bag as a cargo retrieval vehicle. The first consideration when using this retrieval method, however, is the availability of ground assistance in removing the anchoring attachment.

Assuming ground assistance, the cargo should be removed from the line, leaving the ring and parachutes still on the line. The chutes should then be slid to the very end of the line if they are not already there and stuffed into the line deployment bag in such a manner that they are

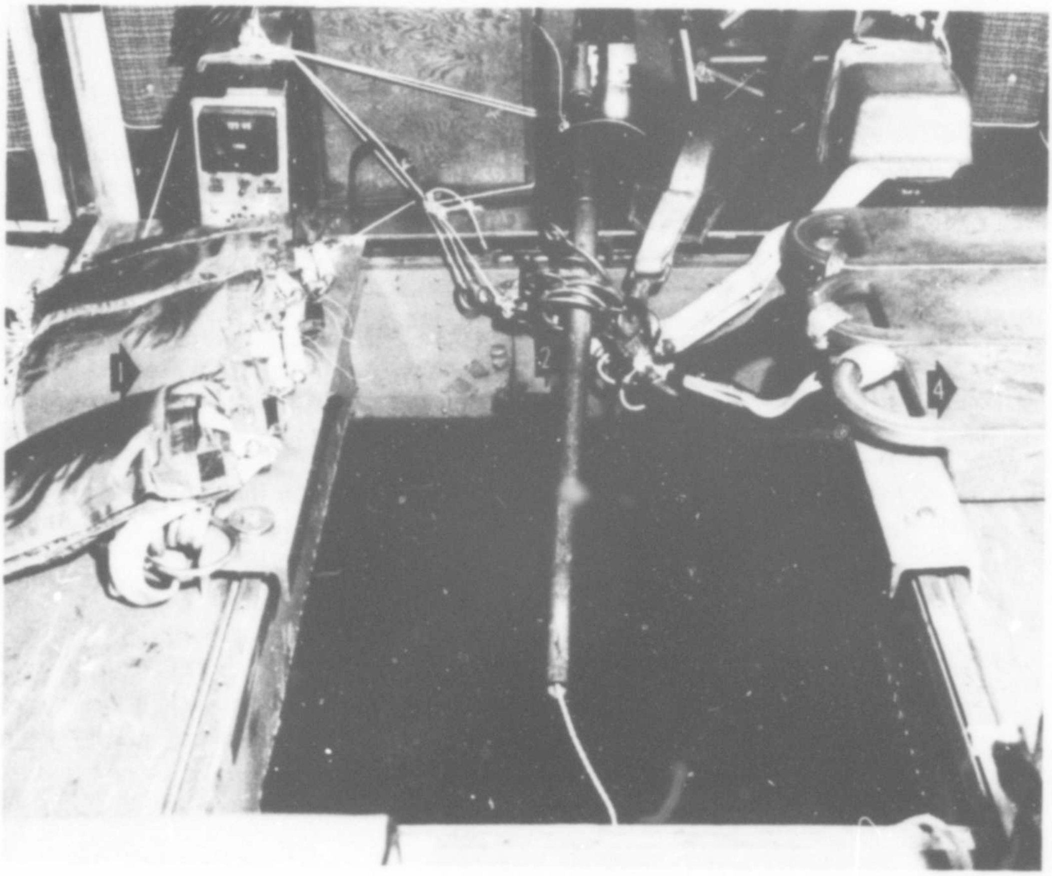

Figure 11: Boom, Ring, Chute, and Dummy Load Arrangement Prior to Take-Off
1. Chutes
2. Boom
3. Rings
4. Dummy Loads

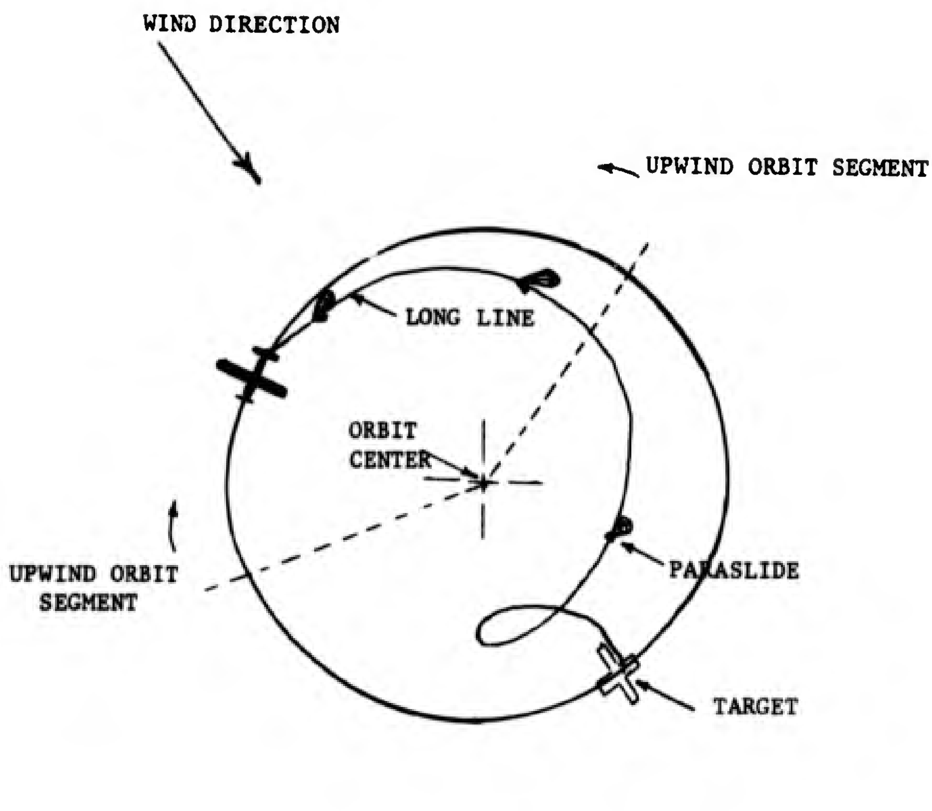

Figure 12. Upwind Paraslides

Figure 13. Paraslide
1. Long-Line
2. Parachute
3. Paraslide Ring
4. Dummy Load

not likely to be inadvertently extracted while the bag is in trail. The remaining room in the bag can be used for miscellaneous cargoes to be delivered back to home base. A limit of approximately 200 pounds of cargo is advised, although the system would probably be unaffected by up to 300 pounds of cargo. There is no need for cargo to be placed into the bag, it may be strapped onto it, but high drag configurations should be avoided and stability in tow cannot be automatically assumed, as in the case of cargo being placed in the bag.

Before disconnecting the bag from the anchor point, be sure the bag is sealed in a fashion sufficient to avoid inadvertent opening while intrail.

The ground crewman, holding the bag so that it does not drag on the ground, should signal the aircraft at this point to begin launch phase.

The ground crewman should be aware that the bag will launch at about 15°–30° from vertical in the *opposite* direction to the aircraft flight direction (figure 14). As line pretension is increased, the launch angle becomes more nearly vertical; therefore, the ground crew should hold the bag back sufficiently to "slingshot" the package clear of existing foliage.

To launch the package, the pilot simply flies out of orbit, straight and level or in a slight climb, and as directly into the wind as possible. Once the bag clears the ground, sharp turns should be avoided to keep the line from stalling. Altitudes should be maintained to assure that no inadvertent ground contact is made with the bag. With aircraft speeds of about 70 knots in level flight, the bag can generally be assumed to be within 500 feet below the aircraft altitude.

When the plane reaches home base, the load can be "self" landed by placing the aircraft in orbit at about 600 feet above the prescribed orbit altitude for the particular bag. Once the line is in a stall condition, the aircraft altitude is slowly decreased until ground contact with the package is made. The line should be released at the aircraft immediately to avoid picking up the package again. It is advisable to use a knife to cut the line and save the emergency line cutter for later use.

Because of yo-yo, visual acuity, and paralax problems as described in earlier reports (reference 1 and 6) a true soft-landing (i.e., less than 40 feet/second) is a very difficult feat. Best results were found when the ground crew advised the pilot as to the package's altitude and notified him when to release the line. Some good soft-landings have been made on sunny days by having the pilot gauge the package's altitude by watching the package and its shadow converge (reference 4).

NIGHT DELIVERIES

A night flight was tried with great success. The tactics were basically the same as those used in daytime visual flight rules (VFR) deliveries with the addition of flashlights and target-marking strobes.

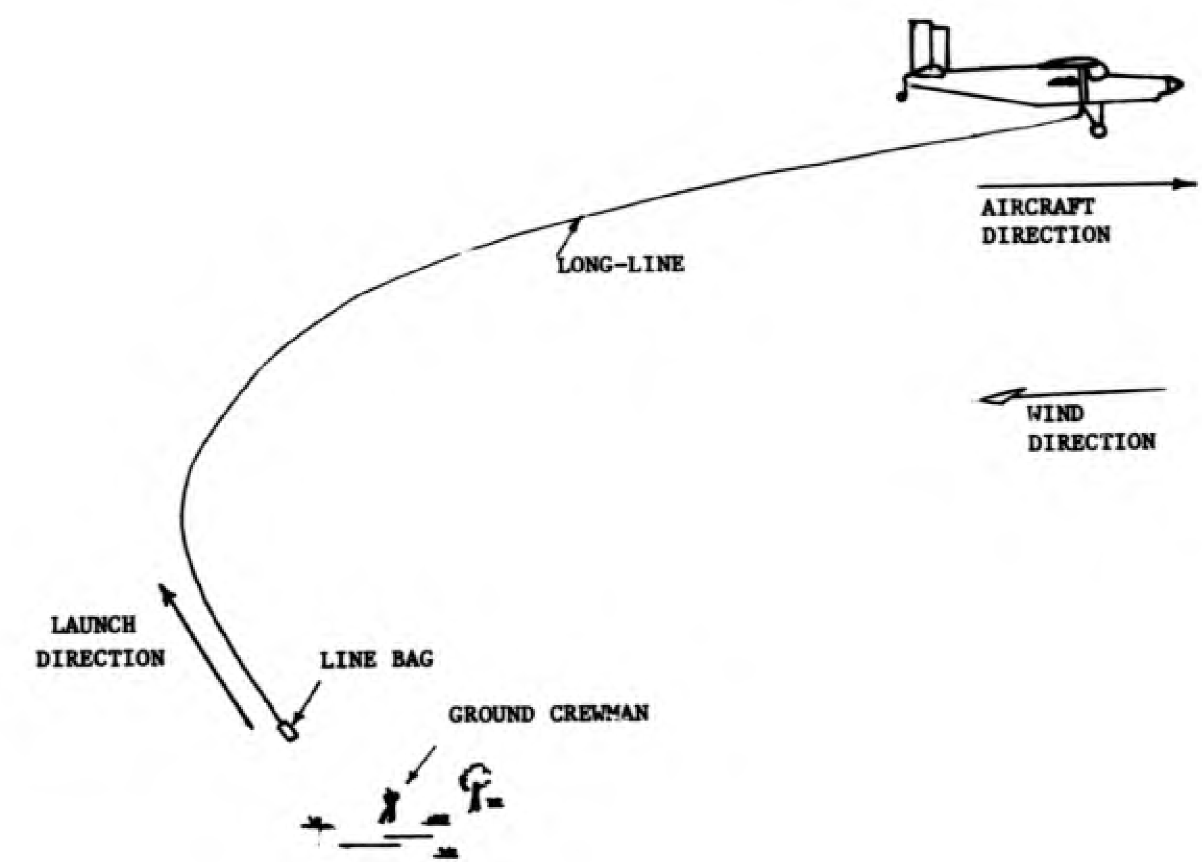

Figure 14. Launch Pattern

Nighttime delivery was made from 3000 feet AGL with the bag impacting within 50 yards of the target as follows. The target was marked by eight rescue strobes (Type: Light Marker, Distress; FSN 62300675209) placed in a cross and a Cessna aircraft landing light was beamed upward at the center of the cross. The target was completely undetectable from the ground since the grass in the field was about 6 inches to 1-foot high. Four flashlights were taped to the side of the line deployment bag facing down. Reflecting tape, 4-inches wide, was placed in several places on the bag in strips approximately 24 inches long. All aircraft lights were turned off with the exception of the beacon, and air/ground communication was maintained.

The Long-Line Sight did not have a lighted reticle but the pilot reported that he was able to see the reticle markings with some difficulty (see section V). From 3,000 feet the target was picked up about 3 miles out and the pilot reported no difficulty at all in locating and identifying it as such. The drop was made with the applicable settings. The pilot gave the ground crew a five-count for drop, and the ground crew had no difficulty in identifying the bag with the four flashlights lit as it left the aircraft. The bag was then visually tracked to impact. Upon bag impact, the headlights of one of the ground vehicles were turned on and aimed at the bag; the reflecting tape easily identified the bag's location. The yellow line was also visible. The bag was then anchored to the ground with a doggie ring.

After the aircraft had been notified that the anchoring was accomplished, the paraslides were begun as described under PARASLIDES in this section. The packages were modified with two flashlights. One was taped to the load pointing downward, and one was taped to the cotton riser extension to the chute pointing upward. The packages were easy to track all the way down the line. The upward-facing flashlight illuminated the chute canopy, giving it the appearance of a white bubble. This was the most noticeable of the two lights and was able to be tracked from both air and ground.

Four paraslides were accomplished: two 50-pound, a 100-pound, and a 200-pound. All were successful. One of the slides was made without any flashlights attached and was recovered near the anchor point, as would be expected. However, the flashlight technique should be employed, since the lighted slides are not visible enough to draw attention unless the observer knows what to look for. Also, the lights help the ground crew keep track of the loads. During the orbit maneuver the ground kept the pilot informed of his line tension at the ground.

SECTION V

FUTURE EFFORTS

IMPROVED PORTER CAPABILITIES

There are several areas of improvement to the system presented in this report which constitute minor development efforts and greatly enhance the present capability.

Line Tension Readout: A line tension readout should be incorporated into the boom plate. This could be accomplished by any of a dozen methods and would allow a means of assuring the pilot that excessive line lay or tension is not present. Although the present system doesn't absolutely require air-to-ground communication to monitor line conditions at the ground, it is very advantageous to have it. With the tension readout and correlation testing, this communication link would be far less important.

Long-Line Sight: Several areas of improvement on the long-line sight are recommended to make it easier to use:

1. The reticle should be lighted.

2. Improvement made so that the entire sight need not be rotated to change the detent.

3. The exit pupil angle should be increased.

The most important change listed above is that of a lighted reticle. This change is a very simple one and is recommended before serious night-time use is initiated. Improvements 2 and 3 would make target tracking easier.

The present configuration of the bombsight requires that the pilot move his head to accommodate the changing depression angles as he approaches the target. In those cases where the bag is released near vertical, the pilot is in an awkward position of viewing the target looking straight down. This creates a problem of cross-checking flight instruments during the critical delivery phase.

A suggested remedy to this would be to change the design of the bombsight, allowing for the pilot to maintain a normal sitting position throughout the drop phase. This design could incorporate dove prisms or mirrors to permit the objective lens to be rotated through the changing depression angles with the eyepiece remaining fixed. This design change would permit the pilot to control the aircraft and view the target much better, thus greatly facilitate precise delivery of the line to the ground.

Penetrators: During the test program the ADSID-1 penetrator was used to show feasibility. In this endeavor, the penetrator was successful. Its use in an operational scheme is not recommended. A smaller, less costly and more effective penetrator should be developed if unassisted anchoring techniques are required.

Soft Landing Capability: When using the line bag as a cargo retrieval vehicle, a soft landing of the cargo back at home base is quite difficult under the circling-line method of soft landing. Therefore, a short development program should be undertaken to adapt other Long-Line soft landing techniques into the system. Such techniques as the block line release (reference 3) or the paraloiter technique (references 2 and 6) would be ideally suited for this purpose.

NIGHT DELIVERIES

Night deliveries can be improved greatly by adding a line tension readout, a lighted reticle and a penetrator. The tactics would be much the same as described earlier; however, the ground crew assisted anchoring of the bag, as well as the necessity for air-to-ground communication. could be eliminated.

IFR DELIVERIES

Several schemes have been suggested for making instrument flight rules (IFR) deliveries. The method would be much the same as a night delivery, and similar tactics would probably be used for assuring anchoring and proper line tension. Acquiring the drop point and maintaining the orbit, however, would require additional equipment, such as a mini transponder and lightweight detection and location system or other such acquisition equipment which is currently being upgraded and introduced in the rescue and recovery operational channels.

LARGE AIRCRAFT LONG-LINE LOITER RE-SUPPLY SYSTEM

Future engineering and development could up-grade the current techniques to heavier loads and larger aircraft, such as the C-123 and the C-130. Integrating the line deployment bag to a winching mechanism would improve the system. This could be accomplished by automatic reel-in and reel-out features to maintain preset tension in the line to provide maneuver flexibility. The addition of a winch would provide the resupply point a method of retrieving limited quantities of material or secure any classified objects or material from a location, in addition to personal mail delivery service to those personnel manning remote and isolated locations, and eliminate the present necessity to trail such cargo back to home base. Additionally, work has been done to convert an AWG-13 gunship computer with only minor changes to assist the pilot in flying the orbit maneuver (reference 8). This computer could also be adapted into the system.

Because of its use in another Long-Line Loiter application, the C-123K is judged to be an excellent test bed platform for development of such a system.

SECTION VI

CONCLUSION

The system presented in this report should yield better than a 90% success factor for daytime visual flight rules (VFR) deliveries of cargo to small perimetered drop zones when the tactics are followed as recommended. Feasibility has unquestionably been proved for deliveries of cargo weighing up to 240 pounds to within 50 yards of the target from an aircraft altitude of 3000 AGL in winds up to 30 knots.

Night deliveries are also feasible; improvement of this capability has been suggested. With incorporation of these improvements, night delivery success rates can be expected to be as high as that for daytime VFR deliveries.

An IFR delivery capability is felt to be highly feasible if a development effort is pursued as described in section V.

APPENDIX I

EQUIPMENT DRAWINGS

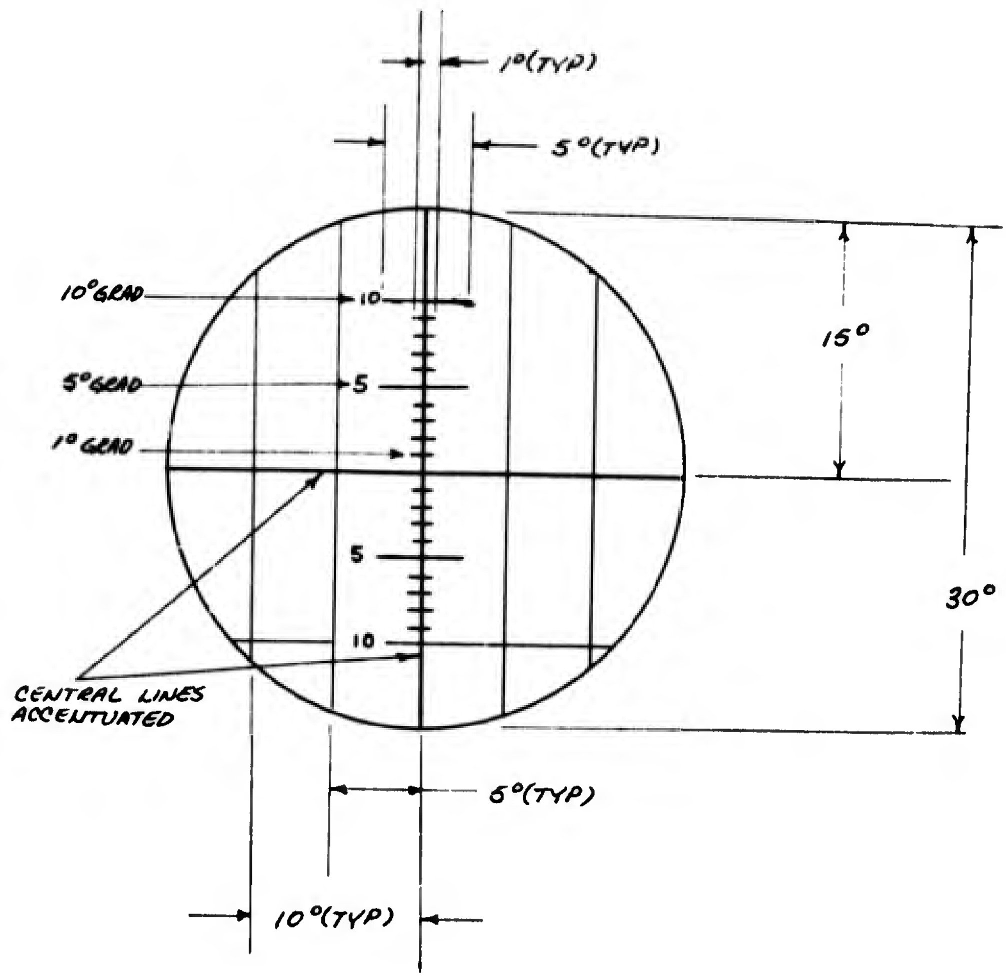

Figure 15. Reticle Pattern

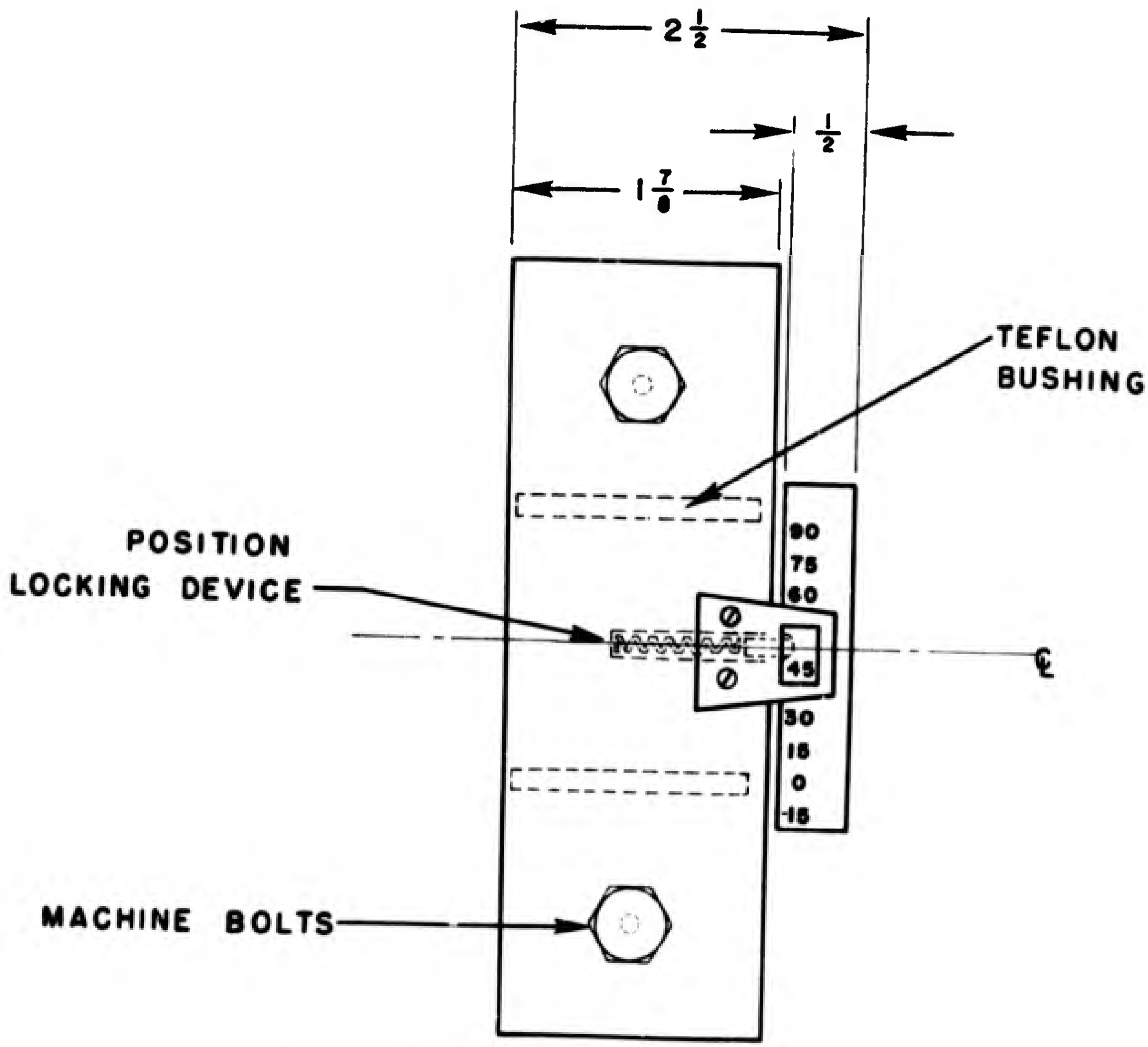

Figure 16. Mounting Bracket

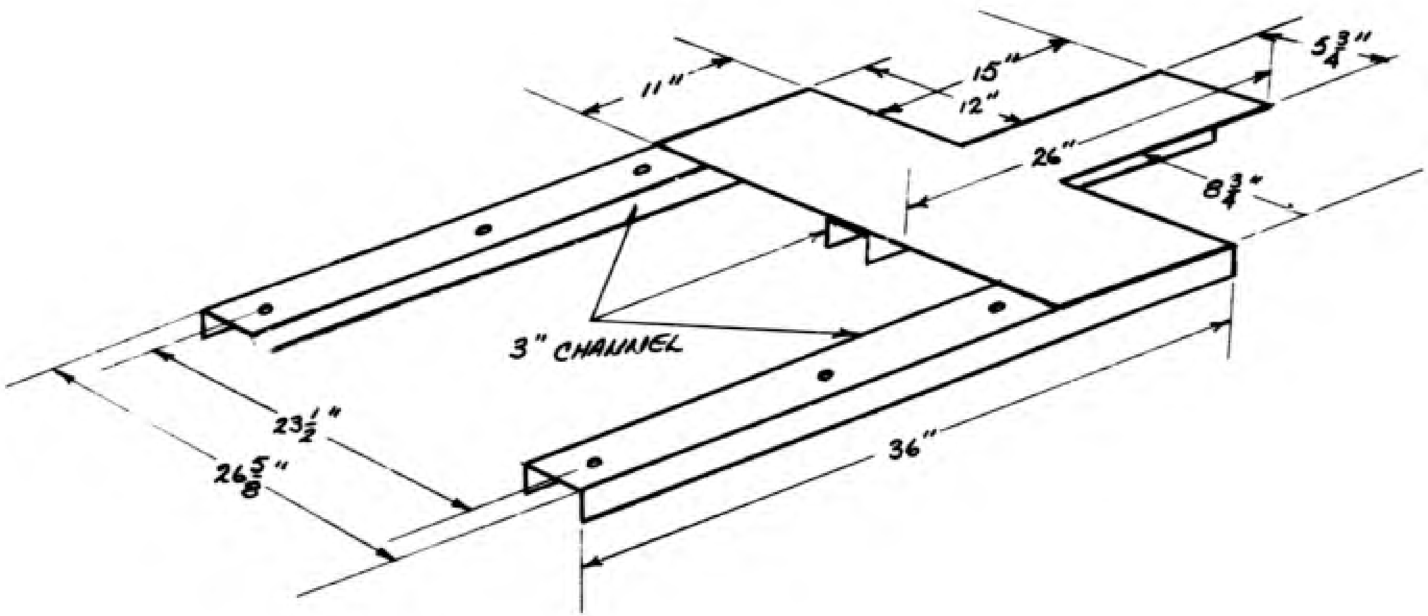

Figure 17. Heliporter Boom Plate

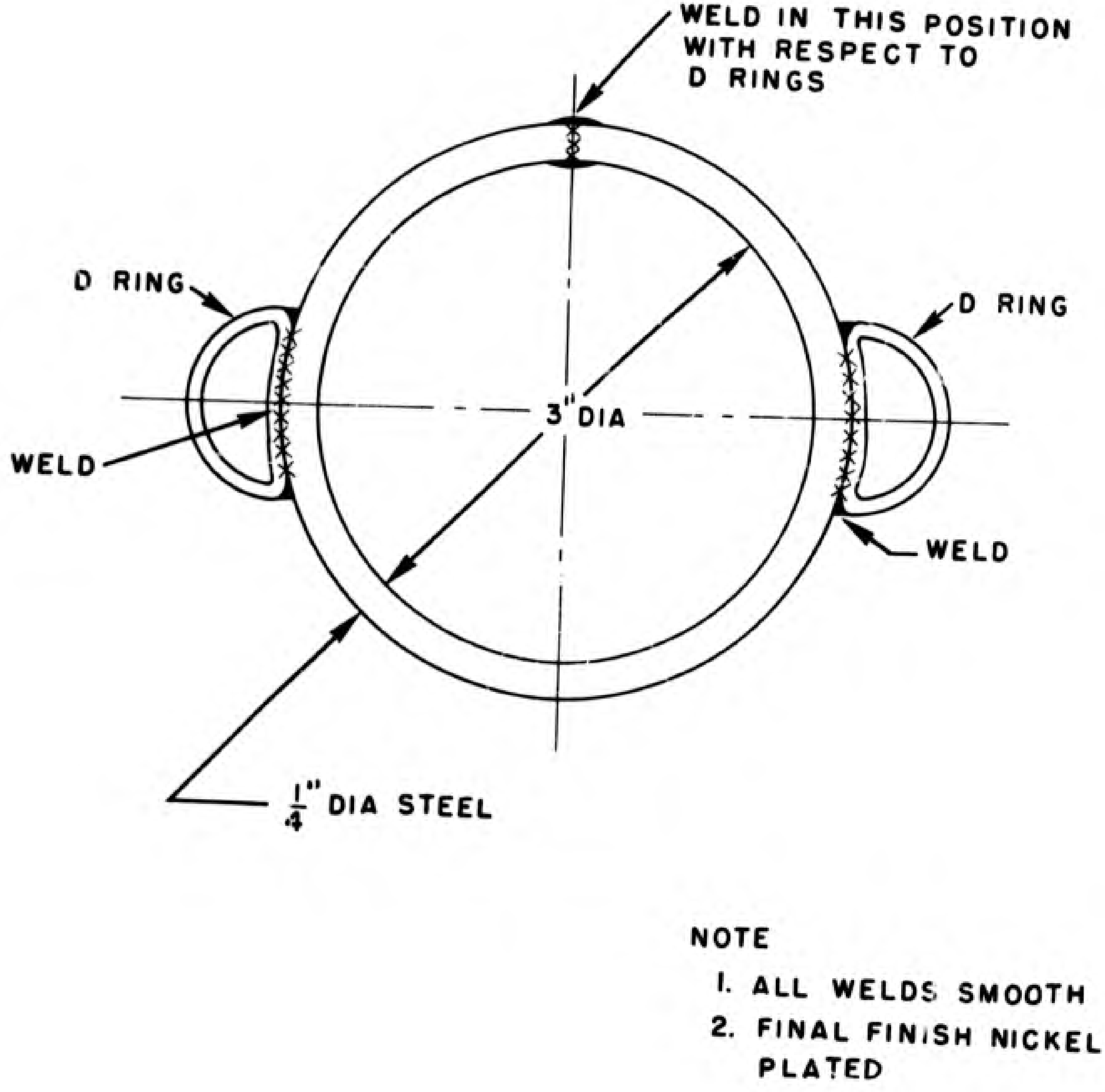

Figure 18. Paraslide Ring

APPENDIX II

PACKING INSTRUCTIONS

PACKING OF THE LINE-DEPLOYMENT BAG

1. Line is *counter* wrapped (one skein right-handed, the next left-handed, etc) on the peg board with 8 wraps to each skein. Number 4 cord (Federal Specification V-T-276; Thread, Cotton) is laid out on the board prior to wrapping (figure 19) to allow easy access for tying skein off. Rubber bands (FSN 1670-568-0323) may be used in place of the cord ties.

2. Skeins are laid out along packing table (figure 20) and bag is broken down to open position with bottom tied in, plywood board in bottom and 30-pound, inside or outside, ballast weight in place (see figure 21).

3. End of line is tied to swivel hook on bag (figure 22) and skeins are laid into bag (figure 23). Layers are stacked in alternating directions, 10 skeins to a layer. A piece of paper is laid between each layer of skeins (the use of paper is optional).

4. Layers are tied down (figure 24) using No. 3 cord.

5. Next layer is started (figure 25). The paper is laid on top of tied-in layer of skeins. The bag is velcro-taped as the layers build. Closure loops on the outside of bag should be tied off as they occur, using the outer jacket of 550-nylon riser line.

6. Upon completion, the top of the bag is tied-off with one strand of No. 5 cord.

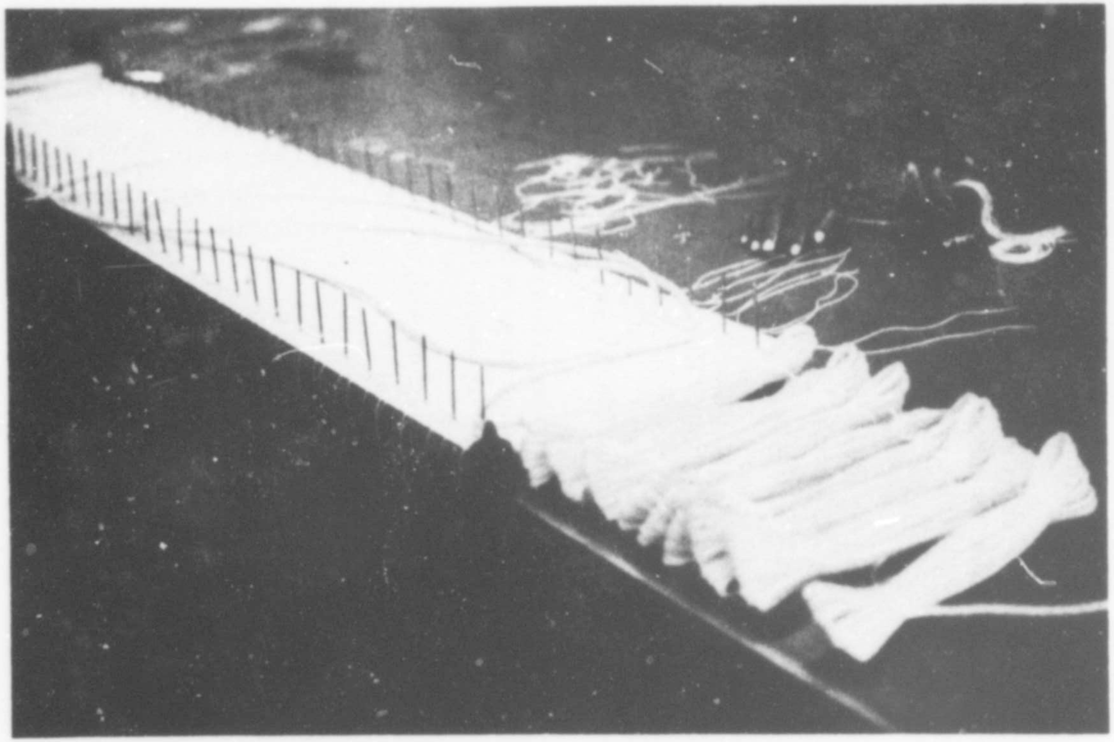

Figure 19. Laying Cord

Figure 20. Skeins Laid Out

Figure 21. Bag in Open Position

Figure 22. Tying Line to Swivel Hook

Figure 23. Placing Skeins in Bag

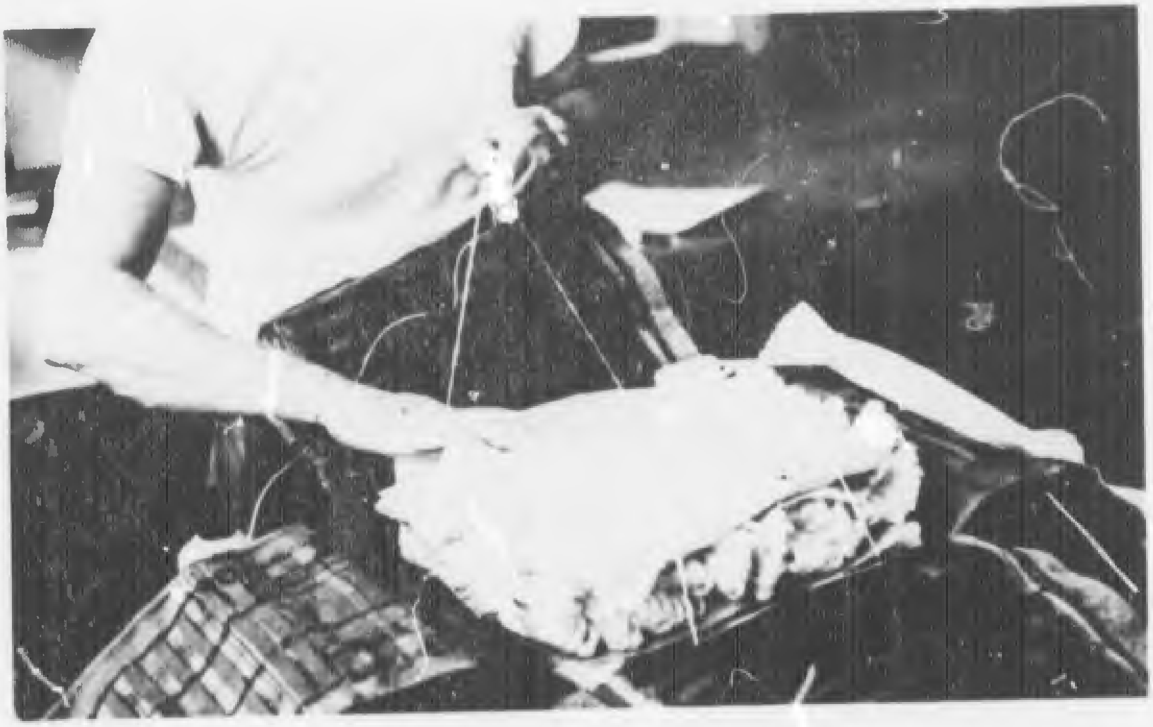

Figure 24. Tying Layer

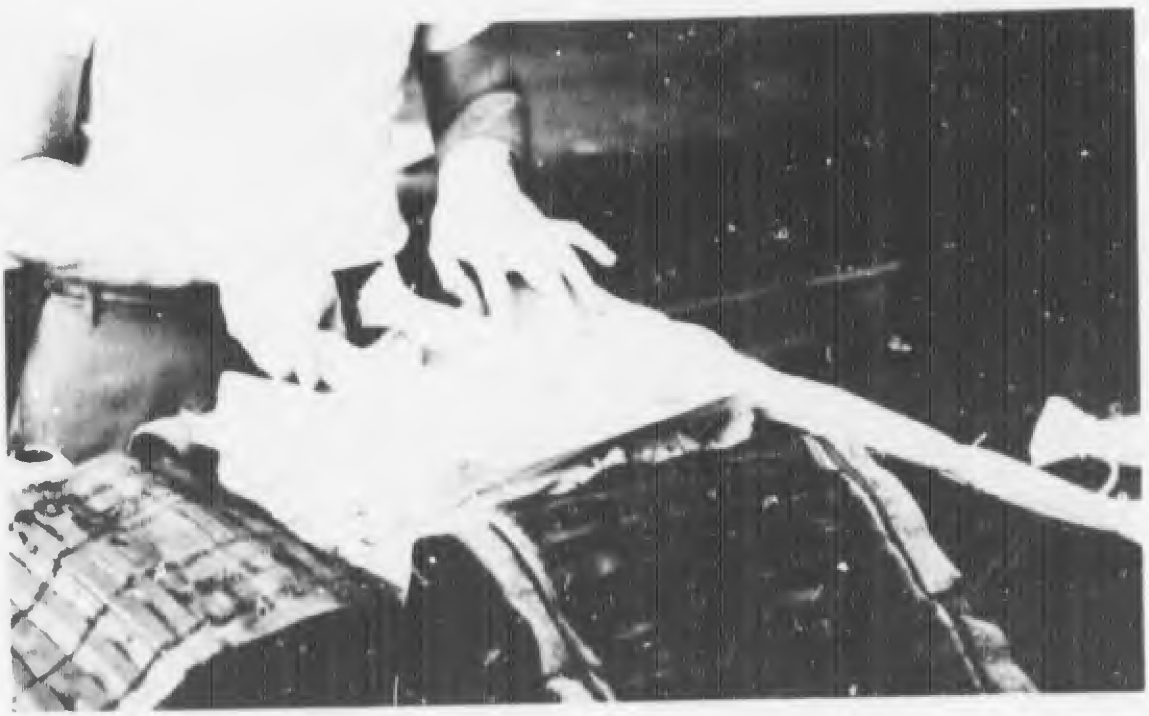

Figure 25. Starting Next Layer

PACKING OF CHUTES

1. Chute is laid out on packing table and bag turned inside-out as shown in figure 26.

2. Apex of chute is tied to inside loop of static bag with No. 3 cotton cord (TYPE I, Specification FED–V–T–276) (see figure 27).

3. Chute is straightened and "S" folded into static bag (figure 28).

4. Risers are skeined and tied with double 16–4 cotton thread (Specification FED–V–T–276) and tucked into bag (figures 29, 30).

5. Bag is closed and tacked with 16–4 cotton thread (Specification FED–V–T–276). The connector link is tied to bag with No. 3 cord (Note: when cotton riser extension is used, the riser connector link is a bag, hook would be at free end of extension).

6. Static line is folded in and cover is velcro-taped shut. A tack is made with 16–4 cotton thread (Specification FED–V–T–276) to avoid inadvertent release of the line (figure 31).

Figure 26. Chute and Bag

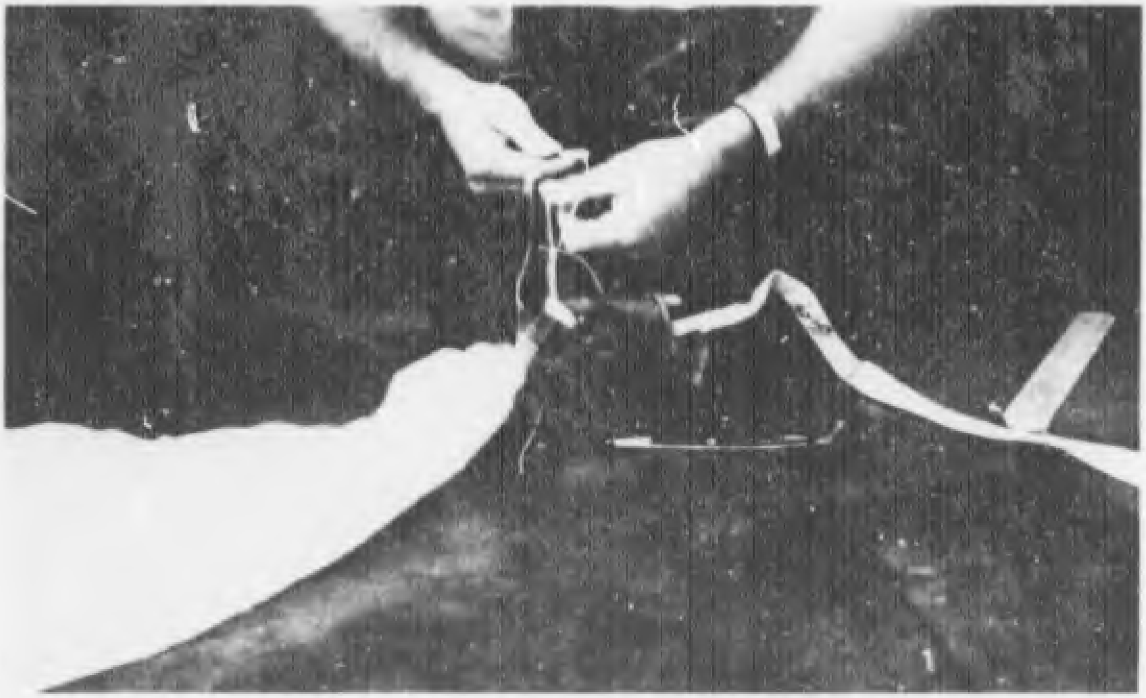

Figure 27. Tying Chute to Bag

Figure 28. Folding Chute into Bag

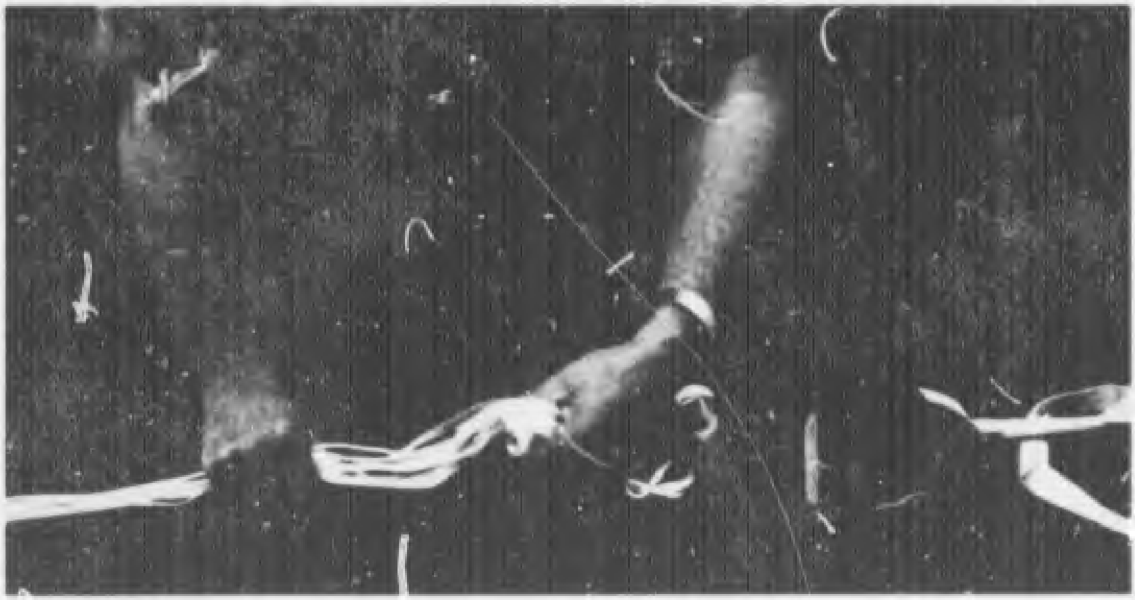

Figure 29. Risers Being Skeined and Tied

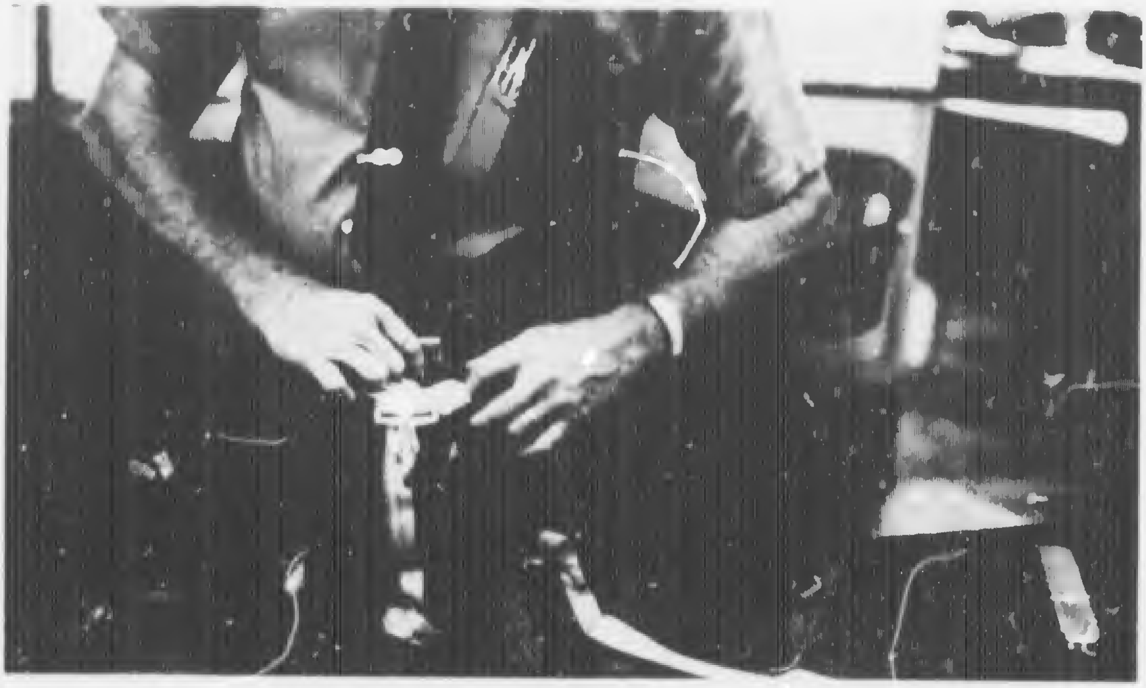

Figure 30. Tucking Risers into Bag

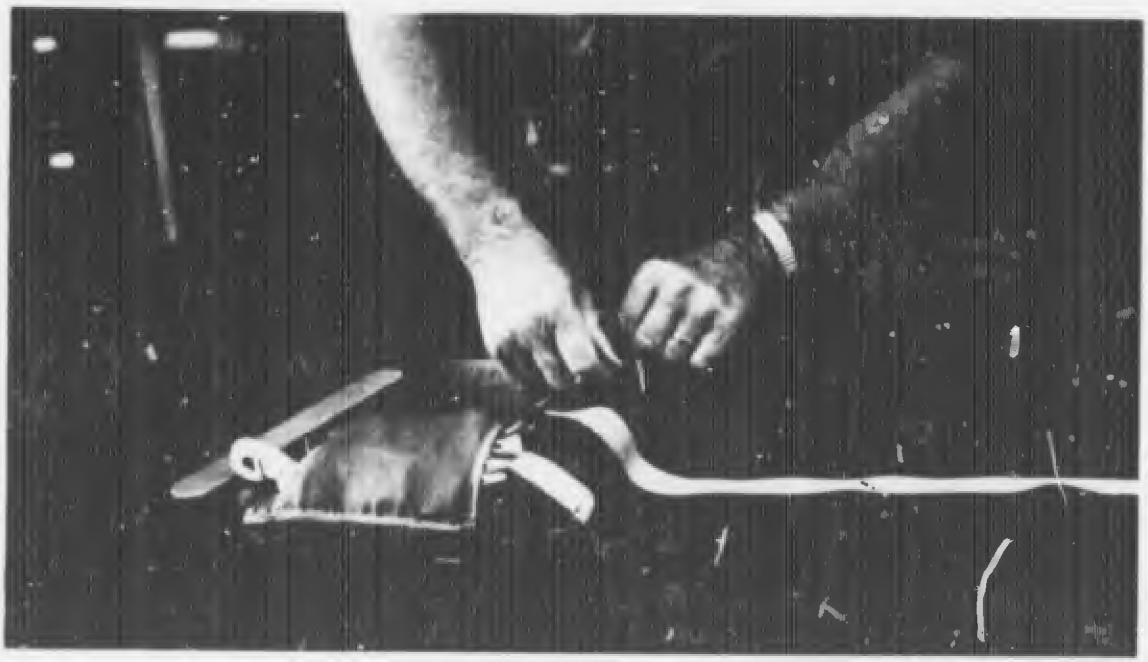

Figure 31. Tacking Line in Bag

APPENDIX III

SAMPLE PROBLEM

ACQUIRING A DROP PARAMETER

MISSION:

1. 3,000 AGL Drop
2. Target Altitude, 1180 Feet MSL
3. Indicated Airspeed 65 Knots

Wind Calculation

1. Drift is killed at heading 215°.
2. Time from +10° to —10° is 11 seconds at 3000 AGL.
3. MSL altitude is 4180 feet.
4. True Airspeed is figured at 70 knots.

Using table I, page 14, true ground speed is figured to be 56.94 knots.

The wind velocity at 3000 feet AGL is then equal to:

$$W = 70 - 59.94$$
$$= 10.06 \text{ knots at } 215^\circ$$

Average Wind Calculation

The winds at target location are reported to be 5 knots at 210°. The average wind is then equal to:

$$W_{AV} = \frac{(5) + 2 \times (10)}{3}$$
$$= \frac{25}{3}$$
$$= 8.33 \text{ Knots}$$

DROP PARAMETER

USING:

1. 3000 feet AGL drop.
2. 4180 feet MSL delivery altitude.
3. 70 Knot true airspeed (TAS).
4. 8.33 knots average wind velocity.

The drop parameter is found in table VII, page 20, for MSL altitude of 4,000 feet to be approximately +12.1° by averaging the setting for 70 knots TAS at 5 knots of wind and 70 knots TAS at 10 knots of wind for 8.33 knots of wind.

APPENDIX IV

COMMENTS

ASD TECHNICAL MANAGER COMMENTS

1. The long line loiter continuous resupply concept was evaluated from two different altitudes from the porter aircraft. The earlier flights were conducted at 1500 feet AGL, at 65KIAS. At this altitude the line length used was 3000 feet. This length provides adequate line length to perform the maneuver without over burdening the pilot with precise aircraft control. If the line length is increased appreciably above this amount the aircraft must increase altitude, airspeed, or decrease the bank angle to prevent the line from sagging too much at the tether point (ground lay). If the bank angle is made too shallow (below 30° bank angle average) the inclination of the line from the tether point becomes too shallow. This causes the mass to bow the line as it slides. This is undesirable for two reasons. First, the weight will make contact prior to reaching the tethered point, usually on the downwind side. Secondly, the pilot is more prone to stay farther away from his orbit point which results in unacceptable changes in line tension. A second altitude of 3000 feet AGL was used with the bank angle and airspeed being retained at 30° (average) and 65KIAS respectively. For this altitude, airspeed combination it was found that 4000 feet of line was optimum.

2. The long line bag delivery made under VFR conditions with ground team assistance is the easiest type to perform. In this case, the pilot utilizes two people on the ground to assist in the delivery of the line and obtain instruction on orbit corrections. When the bag makes contact with the ground, one member of the ground team secures it to a "doggie" ring to provide sufficient anchor strength to prevent the ground end from being moved during the para slide. The second ground team member keeps the pilot informed of the line condition and elevation of the descending para slide cargo. Frequently, the ground member advises the pilot to correct his altitude or orbit position to satisfy the existing wind conditions in order to maintain a more uniform line tension and normal line profile for those existing conditions. There is approximately a 30-second delay involved in making an aircraft correction until it is felt on the ground end, for the 4000-foot line. The ground team is in a position to better observe the need for a correction and to advise the pilot to make timely corrections. The ground team sets up the drop zone with drop point markers to facilitate acquisition and improve drop accuracy. Once the line has been secured to the ground the wind is the only variable the pilot does not have directly under his control. He is required to compensate for it by changing turn rates, increasing bank angles downwind, shallow turns into the wind. This induces variations in the line tension and inclination of the line under strong wind conditions. In addition to this perturbation being induced in the line under wind conditions, there is another factor to contend with during the paraslide. The descent is affected by a combination of the relative line segment inclination and what position the mass is with respect to the wind and tether point. Generally, the mass arrives at a downwind position on the line and the descent rate becomes very slow. The limiting factor is being able to maintain the line with a steep enough incline to keep the mass descending at a desirable rate. There have been cases in which the mass stopped due to wind loading of the parachute on the downwind side of the orbit. For this reason, it is essential that the payload and

parachute canopy be mated to the conditions. The preliminary operational observations indicates that the long line loiter continuous resupply system should be restricted to winds of less than 25–30 knots at the orbit altitude and a surface wind of 15 knots or less. Our testing involved mating the parachute canopy to a payload that would provide descent rates in the 60 feet per second to 100 feet per second range.

3. The release point of the paraslide and the aircrafts orbit position relationship is critical. Generally, for our case of 3000-ft altitudes AGL, 4000 feet of line and 65KIAS the transient time of the mass was approximately 65 seconds. For this reason the release point of the mass was usually going in the upwind turn. This placed the aircraft back at that position for the terminal descent phase of the mass. This is important because that is the time at which the line has gone back to its maximum tension cycle, hence it is more vertical at that time interval. This timing of slide gives good assurance of having the mass make contact at the tether point. In case of moderate wind conditions it is desirable for the pilot to continue past the drop point a given time—based upon ground speed check—to establish himself at the optimum point past the drop point. The pilot maintains this position with respect to tether point to provide an optimum line profile for the para slide. This reduces the chances of the paraslide mass from getting too far downwind from the tie point and loading the line. The compensation of the bank angles to hold the ground point under a wind condition induces variations in the line tension. This can be readily understood if one visualizes that the line segment nearest the aircraft is flying at the same speed as the aircraft and develops lift over this portion. However, the lower line segment is affected very little by the aircraft movement, but is under loading caused by the wind. For this reason, as the aircraft approaches the downwind the lower portion of the line has reached a very low angle. Conversely as the aircraft approaches upwind side of the orbit tension is at a maximum. This phenomenon is acceptable up to the limits discussed in the preceding paragraph.

4. The ASSISTED NIGHT DELIVERY requires that the ground team set up the area to receive the end of the line. This involves securing the drop zone for safety, providing a tie-point for the end of the line, and outlining the drop point with lights or flares to give the pilot a sighting aid for releasing the end of the line. Two-way radio contact is recommended to verify that the approach to the drop point appears satisfactory from the ground. The pilot gives a 5-second count down prior to release to alert the ground team that the line bag is being released. To facilitate the location of the line and bag, it is suggested that lights be attached to the bag and the end of the line have strips of reflective tape wrapped at 5-foot intervals to reduce hazards to ground personnel in locating the bag and line for the tie down. The drop point must be clearly defined by illuminating markers to aid the pilot in maintaining his desired position with respect to the anchor point.

5. For unassisted deliveries, it will be necessary that the drop zone must be precisely identified by some type of cuing device to the aircraft. Additionally, the aircraft will require a precise method of ground-positioning about the drop point. This could most easily be accomplished by directional illuminators on the ground which radiate a rather narrow beam of light up toward the aircraft. The bag containing the line will require an attached penetrator to inbed in the ground on impact. The penetrator anchors the line. This is necessary in order to pretension the line to assure clear passage of the para-slide cargo to the desired landing point.

A simple block latch release mechanism would allow for separation of the payload and parachute near the tether point. This would allow for retrieval of the bag and line back into the aircraft. The unassisted night delivery drop zone acquisition at forward locations may be extremely difficult. A method of providing a covert drop-zone-location finder would have to be devised to insure that the pilot acquires the target and drops at the proper location.

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PILOT TECHNIQUES FOR LONG LINE LOITER

Prior to take-off for a Long Line Loiter mission, it is advisable to acquire the winds for the target area at the altitude from which the mission is to be accomplished. Upon arrival in the target area, establish a normal rectangular approach pattern with the approach leg into the forecasted winds. On the downwind leg configure the aircraft for drop, 65 knots airspeed, 6 turns of flaps (½ flaps on electric actuated flaps) ball centered, prop 75%, and aircraft trimmed to as near hands off flight as possible. On the run into the target on the approach leg, check through the sight and determine that there is no discernible drift of the aircraft. Should there be drift, make another dry run with a heading correction which the pilot believes will kill the drift. Check again on approach leg for continued drift. It may be necessary to make several runs before wind direction is determined and a no-drift approach to the target can be made.

There may be missions where, due to terrain, meteorological conditions, etc., a crosswind drop must be made. Should this be the requirement, offset the aircraft 5 degrees (sight markings) into the wind for each 10 knots of crosswind at the mission altitude. Under these circumstances, target attainment will be marginal and erratic at best.

The actual drop will be accomplished at a predetermined sight setting. The aircraft must be completely stabilized. Yaw, pitch, dive, airspeed deviation, roll, or altitude discrepancy can cause the line container to miss the target by an unacceptable distance. The mission success is entirely dependent upon the aircraft being stabilized on the prescribed parameters.

The technique, for viewing the target through the sight and monitoring the flight instruments at the same time, must be worked out by each individual pilot. During the test program, the undersigned kept both eyes open and switched accepted vision from eye to eye, i.e., from sight to instruments.

When the line drop is made in a no-wind condition, the aircraft will immediately go into a tight orbit. This tight orbit will be continued until the line has been secured to the ground. Following the line being secured, the aircraft will assume a wider orbit. For each 15 knots of wind at mission altitude, the aircraft will be flown 5 seconds past the release point before turning into the tight orbit maneuver. While the actual slides of the packages down the line are in progress, the orbit should be held up-wind of the impact area. Package slides should be initiated while the aircraft is near the point in its orbit of heading into the wind.

An increase in airspeed of the aircraft will create additional tension on the line; this increase of tension can also be attained by an increase in altitude. Following line container drop that an increase in power is necessary to hold the airspeed and altitude. This increase is approximately two to three inches of engine torque pressure.

Should this system be used by aircraft equipped with three-axis auto pilot, the degree of successful drops would increase appreciably.

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