AD NUMBER
AD512210
CLASSIFICATION CHANGES
TO: UNCLASSIFIED
FROM: CONFIDENTIAL
AUTHORITY
30 Jun 1981, DoDD 5200.10

The following notice applies to any unclassified (including originally classified and now declassified) technical reports released to "qualified U.S. contractors" under the provisions of DoD Directive 5230.25, Withholding of Unclassified Technical Data From Public Disclosure.

NOTICE TO ACCOMPANY THE DISSEMINATION OF EXPORT-CONTROLLED TECHNICAL DATA

1. Export of information contained herein, which includes, in some circumstances, release to foreign nationals within the United States, without first obtaining approval or license from the Department of State for items controlled by the International Traffic in Arms Regulations (ITAR), or the Department of Commerce for items controlled by the Export Administration Regulations (EAR), may constitute a violation of law.

2. Under 22 U.S.C. 2778 the penalty for unlawful export of items or information controlled under the ITAR is up to ten years imprisonment, or a fine of $1,000,000, or both. Under 50 U.S.C., Appendix 2410, the penalty for unlawful export of items or information controlled under the EAR is a fine of up to $1,000,000, or five times the value of the exports, whichever is greater; or for an individual, imprisonment of up to 10 years, or a fine of up to $250,000, or both.

3. In accordance with your certification that establishes you as a "qualified U.S. Contractor", unauthorized dissemination of this information is prohibited and may result in disqualification as a qualified U.S. contractor, and may be considered in determining your eligibility for future contracts with the Department of Defense.

4. The U.S. Government assumes no liability for direct patent infringement, or contributory patent infringement or misuse of technical data.

5. The U.S. Government does not warrant the adequacy, accuracy, currency, or completeness of the technical data.

6. The U.S. Government assumes no liability for loss, damage, or injury resulting from manufacture or use for any purpose of any product, article, system, or material involving reliance upon any or all technical data furnished in response to the request for technical data.

7. If the technical data furnished by the Government will be used for commercial manufacturing or other profit potential, a license for such use may be necessary. Any payments made in support of the request for data do not include or involve any license rights.

8. A copy of this notice shall be provided with any partial or complete reproduction of these data that are provided to qualified U.S. contractors.

DESTRUCTION NOTICE

For classified documents, follow the procedure in DoD 5220.22-M, National Industrial Security Program, Operating Manual, Chapter 5, Section 7, or DoD 5200.1-R, Information Security Program Regulation, Chapter 6, Section 7. For unclassified, limited documents, destroy by any method that will prevent disclosure of contents or reconstruction of the document.

SECURITY MARKING

The classified or limited status of this report applies to each page, unless otherwise marked.
Separate page printouts MUST be marked accordingly.

CONFIDENTIAL

AD E122210

(U) Survey of Communication and Navigation Concepts for Space Escape System

DDC FILE COPY

Prepared by T. SHIOKARI, et al.
Vehicle Systems Division

69 JUN 16

Prepared for SPACE AND MISSILE SYSTEMS ORGANIZATION
AIR FORCE SYSTEMS COMMAND
LOS ANGELES AIR FORCE STATION
Los Angeles, California

Contract No. F04701-68-C-0200

Systems Engineering Operations
THE AEROSPACE CORPORATION

AD512210

IN ADDITION TO SECURITY REQUIREMENTS WHICH MUST BE MET, THIS DOCUMENT IS SUBJECT TO SPECIAL EXPORT CONTROLS AND EACH TRANSMITTAL TO FOREIGN GOVERNMENTS OR FOREIGN NATIONALS MAY BE MADE ONLY WITH PRIOR APPROVAL OF SAMSO(S[redacted])
XRLR

CONFIDENTIAL

THE AEROSPACE CORPORATION

DOCUMENT CHANGE NOTICE

TO: Holders of Subject Document

CC:

DATE: 11 July 1969

SUBJECT: Survey of Communication and Navigation Concepts for Space Escape System

TOR-0200(4525-04)-3

FROM: AOCRC

Please note the following correction in Section 5 of the subject document. Frequency [redacted] is mentioned as an SCF ground voice link or backup voice link. This frequency was planned for a specific program which has since been cancelled. Frequency [redacted] should, therefore, be deleted wherever it occurs.

CONFIDENTIAL

Report No.
(14) TOR-0200(4525-04)-3

(16) SURVEY
OF
COMMUNICATION AND NAVIGATION CONCEPTS
FOR
SPACE ESCAPE SYSTEM (U). (U)

(9) Technical operating rept.

Prepared by

(10) T. Shiokari, et al.
Space Vehicles Office
Advanced Vehicle Systems Directorate
Vehicle Systems Division

(11) 16 Jun 64

69 JUN 16

(12) 51p.

Systems Engineering Operations
AEROSPACE CORPORATION
El Segundo, California

Prepared for

SPACE AND MISSILE SYSTEMS ORGANIZATION
AIR FORCE SYSTEMS COMMAND
LOS ANGELES AIR FORCE STATION
Los Angeles, California

(15) Contract No. F04701-68-C-0200

404 237

CONFIDENTIAL
(This page is Unclassified)

Report No.
TOR-0200(4525-04)-3

(U) SURVEY OF COMMUNICATION AND NAVIGATION CONCEPTS FOR SPACE ESCAPE SYSTEM

Prepared by

[redacted]

T. Shiokari
Space Vehicles Office
Advanced Vehicle Systems Directorate

Approved

[redacted]
Space Vehicles Office
Advanced Vehicle Systems Directorate

[redacted] Director
Advanced Vehicle Systems
Directorate
Vehicle Systems Division

The information contained in this Technical Operating Report is developed for a particular program and is therefore not necessarily of broader technical applicability.

ACKNOWLEDGMENT

The work contained in this document was provided by the following Aerospace technical specialists:

Communication

D. H. Martin

W. A. Sandberg

Navigation

A. H. Shapiro

Recovery Operation

R. M. Coulston

Ground Station Coverage

W. A. Sandberg

CONTENTS

TABLES

FIGURES

1. INTRODUCTION

(U) During manned space operations in near earth orbit, an emergency can occur where mission abort or onboard procedure is incapable of resolving the hazard. A space escape system is, therefore, being investigated as a possible solution. Since the escape system is an emergency device, its design is not constrained by purely military consideration. Thus, while military missions require secure communication links and recovery sites, space escape systems are not so constrained. A space emergency situation would have distress assistance available on a worldwide basis as a result of international agreement.

(U) If only military communication resources are considered, the communication coverage will be somewhat limited geographically. By including the domestic and foreign resources, the coverage should approach a global scale. However, this added assistance will not provide the same kind of support that can be achieved from a real-time communication link with mission control. At best, this non-military support could only acknowledge and relay distress messages, assist in the search and rescue operations, and must, therefore, rely on the orbital distress messages and post-splashdown communication and navigation to apprise recovery resources of the landing position. Communications must have a long distance capability to assure voice contact to some recovery source or relay station. Also, post-splashdown onboard navigation to determine position data would be required to provide location information for the search and rescue. This method should result in the minimum orbital wait time but at the expense of long ground wait time and unknown ground conditions.

(U) The alternative is to wait in orbit until coordination with mission control is achieved. This will work if the escape system has enough life support to remain in orbit until the appropriate retrofire time so that the reentry trajectory will impact at the coordinated recovery area. Real-time communications will be needed between the space escape system and mission control where the recovery areas and their weather conditions known. This approach should result in a minimum ground recovery time and a long orbital wait time.

2. OBJECTIVES

(U) The objectives of this study were (1) to survey the communication and navigation systems for possible use in a space escape system, and (2) to assess these systems.

3. STUDY APPROACH

(U) The study determined the available and planned ground- and space-based communication and navigation systems and the phases of a space escape mission which they could support. Following the determination of the applicable systems, an assessment of their capability was conducted.

(U) The assessment of the communication system (Section 5) primarily evaluated the transmission power and antenna requirements using satellite relay links since these characteristics would influence escape system weight, volume, and operation. In addition to the satellite links, established distress links were evaluated by investigating the available ground coverage and means of alerting the ground rescue resources.

(U) The navigational systems were evaluated (Section 6) to determine their availability, their capability for mission support, and the onboard hardware needs. Navigational aids to determine deorbit time, and retrofire magnitudes and attitude were not included in this study.

(U) Both the Air Force and NASA have established communication and tracking networks to support their space missions. An assessment of these ground networks to determine the coverage they can provide for the space escape system is conducted in Section 4, Ground Station Coverage. The hardware aspects are discussed in Section 5, Communication System.

4. GROUND STATION COVERAGE

4.1 Scope

(U) This section evaluates the coverage provided by existing ground station networks and their ability to provide communication and tracking to assist in the safe recovery of a crew in distress. The networks considered are the Air Force Satellite Control Facility (SCF), NASA Deep Space and Near Space Instrumentation Facility, and SPADATS/Spacetrack Nets.

(U) The communication and tracking coverage analysis was based on the following ground rules:

a. Communications were assumed to be possible down to 0 deg elevation angle. Tracking, however, below local elevation angles of 5 deg would result in severely degraded accuracies.

b. Durations of continuous contact were one minute and four minutes.

c. Coverage considered contact with both a single station and two stations.

d. Orbits considered were 100, 250, and 400 n mi with inclinations of 30 deg, 60 deg, and 90 deg, respectively.

e. Contact can be achieved at any time of the day.

(U) The one and four minute minimum contact durations and one and two station contacts were selected to represent times from alerting ground stations and to coordinating reentry operation. The first one minute contact represents time to send the distress message; verification of message and reentry instruction could be received in the second one minute contact. This, however, is not sufficient for tracking to update the ephemeris in the event that the orbit has been perturbed. The four minute contact is extended for up-down communications to coordinate recovery. The four minute contact could represent tracking capability if sufficient tracking information can be obtained in that length of time.

4.2 Method

(U) The coverage analysis was conducted by determining the number of orbits that are required to make a contact with a ground station. Since an emergency can occur at any time, a probability method was used in the analysis. A computer program developed for a study on orbital return probabilities was used (Ref. 1) and the coverage areas of each ground station were calculated to provide one and four minute minimum contact durations.

4.3 Ground Station Networks

(U) The ground stations consist of the SCF, the Apollo Manned Space Flight Net (MSFN) and the SPADATS/Spacetrack net. The station locations for SCF, MSFN, and Spacetrack are given in Tables 4-1, 4-2, and 4-3. These stations, with coverage circles for one minute and four minutes, are shown in Figs. 4-1 and 4-2 for a 250 n mi circular orbit. If the spacecraft ground trace just touches the outer circle, one minute of contact with the station will be obtained. If the trace cuts across the circle, contact will be longer, reaching a value of four minutes at the inner circle.

(U) The MSFN net includes both the Near Space Instrumentation Facilities (NSIF) and the Deep Space Instrumentation Facilities (DSIF). These stations are listed in Table 4-2 as typical and it is assumed that they have suitable communication facilities. It is also assumed that these stations could assist in an emergency by use of an alarm system although, in reality, the stations may not be operational unless a NASA mission is in progress. It is assumed that suitable communication equipment to support space escape operations can be provided in the Spacetrack ground stations.

(U) To track with the SCF or the MSFN network, a transponder in the escape system is required. The Spacetrack uses skin tracking (which does not require a transponder but both of these networks require pointing data from the scanning radar to acquire the target. Not all stations have scanning radars. Moreover, these radars are limited to an azimuth sector (see

Fig. 4-3) and horizon elevation. If the target should be outside of the azimuth or above the elevation range, or over a station without a scanning radar, then the tracking radar must obtain acquisition data from previous orbital data.

(U) The crew could alert these stations and provide identification information for the tracking station to acquire. All ground tracking methods considered will experience difficulty in the event that an orbital maneuver or emergency has perturbed the nominal orbit. In addition, Spacetrack ground stations will need an alarm and communications link with the space escape system.

4.4 Results

(U) The number of orbits required to contact the different networks for various orbital conditions are summarized in Table 4-4 (Ref. 2). These results are applicable for the communication link; they are representative values for navigation if tracking can be effective to 0 deg elevation and can be acquired for at least four minutes. With a transponder and prior knowledge of the orbit, communication at this low elevation is assumed to be possible for the SCF and MSFN. However, these results are not representative for the Spacetrack network because of the elevation and azimuth limits of the scanning radars.

(U) The results indicate that the NASA network is the most effective for all orbital inclinations and that the SCF net is effective only for the polar inclinations. The NASA network can provide assured contact for the range of altitudes and inclinations within three orbits. The SCF can provide assured contact within three orbits only if the inclination is limited to the polar region.

(C-4) Table 4-1. SCF Ground Stations

Stations		(b)(3), 10 USC 130
IOS	Indian Ocean Station	[redacted]
OL-10	Guam	
HTS	Hawaii	
KTS	Alaska	
VTS	Vandenberg	
NHS	New Hampshire	
OL-5	Thule	

(C-4) Table 4-2. NASA - Manned Space Flight Net (MSFN)

Deep Space Instrumentation Facilities (DSIF)

(b)(3), 10 USC 130

[redacted]

Near Space Instrumentation Facilities (NSIF)

(b)(3), 10 USC 130

[redacted]

(C-4) Table 4-3. SPADATS/Spacetrack Stations

	Station	Latitude (deg)	Longitude (deg)
(b)(3), 10 USC 130 [redacted]		(b)(3), 10 USC 130 [redacted]	(b)(3), 10 USC 130 [redacted]

Notes:

(C-4) (1) (b)(3), 10 USC 130 [redacted]

(C-4) (2) The Eglin radar has an electronically steered beam and can be used for detection and tracking.

(C-4) (3) (b)(3), 10 USC 130 [redacted]

(U) Table 4-4. Number of Orbits for Assured Contact

Network	No. of Sightings	Minimum Contact Time (Min)	Altitude & Inclination								
			100 n mi			250 n mi			400 n mi		
			30°	60°	90°	30°	60°	90°	30°	60°	90°
SCF	1	1	6	4	1	4	3	1	3	2	1
	1	4	6	4	3	4	3	1	3	2	1
	2	1	7	6	3	5	4	2	4	3	1
	2	4	8	7	3	5	5	2	4	3	1
NASA	1	1	2	2	2	1	2	1	1	1	1
	1	4	2	3	2	1	2	1	1	1	1
	2	1	3	3	2	1	2	1	1	1	1
	2	4	3	3	2	1	2	1	1	1	1
Spacetrack	1	1	7	3	1	5	1	1	3	1	1
	1	4	8	3	1	6	1	1	3	1	1
	2	1	8	4	2	6	2	2	4	1	1
	2	4	9	4	2	7	2	2	4	1	1
SCF + NASA	1	1	2	1	1	1	1	1	1	1	1
+ Spacetrack	1	4	2	1	1	1	1	1	1	1	1
	2	1	2	1	1	1	1	1	1	1	1
	2	4	2	1	1	1	1	1	1	1	1

(b)(3), 10 USC 130

[redacted]

(C-4) Fig. 4-1. Net 1, 250 n mi Circular Orbit

(b)(3), 10 USC 130

[redacted]

(C-4) Fig. 4-2. Net 2, 250 n mi Circular Orbit

CONFIDENTIAL

(b)(3), 10 USC 130

[redacted]

(C-4) Fig. 4-3. SPADATS/Spacetrack Stations

CONFIDENTIAL

5. COMMUNICATION SYSTEM

5.1 Scope

(U) Communication with ground stations during the orbital phase was studied, including means of alerting the ground for assistance in the reentry operation. Communication with relay satellites during the post-splashdown phase and by means of established distress radiotelephone links was also investigated.

(U) Real-time up-down communications with the SCF is most desirable to coordinate deorbit parameters for landing at a selected recovery area. However, such capability, as shown in Section 4, requires several orbits to assure a communication link with an SCF ground station for inclinations other than near-polar. Ground networks or resources not directly supporting the mission are assumed to be capable of receiving and relaying messages concerning emergency and planned reentry conditions. This type of support is assumed to be possible provided these facilities can be alerted by the SCF or the spacecraft.

(U) Post-splashdown communication to inform the search and rescue authority of the landing area should be considered. This is to accommodate the eventuality that the distress message will not be received, or that the number of orbits to assure a communication link with the SCF prior to reentry will be excessive. Also, this capability would provide an added backup and an aid in the search and rescue operation. For this mode, both military and civil resources were included as available to assist a military crew in distress. Civil resources consist of domestic and foreign maritime vessels and aircraft.

5.2 Results

(U) The characteristics of the available candidate communication systems for the orbital and post-splashdown phases are summarized in Table 5-1. Within the scope of this investigation, these characteristics indicate that systems exist that can provide global coverage. For the orbital phase, Space-to-Ground Link System (SGLS) would be supporting the mission and would be able to provide the necessary coordination between the escape system and recovery forces. [redacted] The 121.5 MHz is an international aeronautic distress frequency and can provide global coverage. However, at best, it can only relay the message. [redacted] and has coverage over the USA and military installations. [redacted] frequency is a NASA and SCF ground voice link. The NASA stations probably will require an alarm system, since they may not be active when military missions are in progress. Also, some stations may not be manned during periods when NASA missions are not in progress. The SCF stations with [redacted] would only serve as a backup to the SGLS link and would not increase the coverage.

(U) During the post-splashdown phase, TACSAT in the UHF can provide global coverage, and is the only communication satellite that does not place impractical antenna and power requirements on the escape system (see Table 5-2). The TACSAT is being planned for global deployment. Communication link with domestic and foreign ships can be achieved on the distress frequencies of 500 KHz and 2182 KHz. These frequencies appear to provide good coverage if the splashdown area can be targeted to high density shipping lanes and 500 KHz are guarded and monitored on the hour to provide mutual assistance by international agreement. The high density shipping lanes generally occur in the northern latitudes. These medium frequency channels have a long-range capability because of ionospheric propagation but their ability to propagate over long distances is dependent on the atmospheric conditions. During the search and rescue operation, [redacted] since ground coverage and capability is not clear at this time. This frequency range is, however, attractive in that it is possible to conduct both long distance ground-to-ground and space-to-ground communication.

5.3 Satellite Control Facility

(U) Normal on-orbit support of an Air Force manned space station is provided by the SCF. Tracking, communications, and command functions [redacted]

(b)(3), 10 USC 130

(U) The SGLS vehicle equipment for an 0.5 watt transmitter weighs 23.6 lb (Ref. 3). By eliminating only the digital telemetry portion of the SGLS airborne module, the weight can be reduced to 14 lb. The remaining equipment will provide voice pseudorandom noise (PRN) ranging for tracking by the SCF station.

(U) For voice only communications, the implementation in the UHF range can be established much cheaper than by SGLS stations, and it may be possible to augment the SPADATS/Spacetrack net with SCF/UHF communication rather than to add stations with full TT&C capability. This approach, however, will not provide a tracking capability and presumes that this frequency allocation is still available post-1975.

5.4 NASA Communication Network

(U) In an emergency, it is possible to use the NASA networks, but it would probably be necessary to declare that an emergency exists before the NASA network could be requested to commit its ground stations to establish contact with the spacecraft. For such a case, an alarm system is assumed to be necessary in establishing the existence of an emergency. The

NASA station could then relay the alarm and message to the SCF.

[redacted] (b)(3), 10 USC 130

5.5 Distress Notification

(U) Distress notification can be achieved by an automatic alarm system or by using the distress frequencies. By international agreement, the following distress frequencies have been allocated:

Frequencies	Purpose	Remarks
500 KHz	International distress	Coded message used primarily by maritime vessels
2182 KHz	International distress	Voice link used by maritime vessels
121.5 MHz	International aeronautical distress	Continually monitored by all aircraft
[redacted] (b)(3), 10 USC 130		

The 121.5 MHz is the international civil distress frequency that is guarded and monitored by foreign and FAA flight control facilities. The FAA, in addition to the 121.5 MHz, [redacted] (b)(3), 10 USC 130 towers. Distress messages in these aeronautic frequencies will provide a wide air and ground coverage. The medium frequencies, 500 KHz and 2182 KHz, are primarily surface frequencies and are guarded by the Coast Guard and most maritime vessels of all nations; 500 KHz is for transmission of coded messages by radiotelegraphy and 2182 KHz is the voice transmission link.

(U) For ground stations, such as those in the NASA and SPADATS networks, an automatic alarm system will probably be necessary to alert these networks of an emergency. A possible method (Ref. 4 and 5) is for the alarm system to transmit simple tones from the escape system to the ground using non-directional antennas at both the vehicle and ground station. The ground receiver uses a narrow-band phase-lock loop to slowly search the band of frequency uncertainty caused by transmitter frequency drift. It is the narrow band width of the phase-lock loop combined with the low noise figure (NF) parametric amplifier in the ground receiver that permits the use of the non-directional antennas. This signal would be continuously transmitted from the vehicle until voice communication could be established. (b)(3), 10 USC 130 [redacted] watt beacon transmitter is considered adequate.

(U) It is also possible for a short data transmission to time-share the alarm transmission. The most important data for the escape operation are the retrofire time, direction, and magnitude, provided the orbit ephemeris has not been perturbed by the emergency.

(U) The addition of this data transmission complicates the alarm system, in that the receiver must acquire an alarm and be interrupted by data. The receiver must have the capability to record and read out the data. Also, the crew must have some means of entering the data into an automatic keyer in the transmitter.

(U) Another method of alerting the ground (Ref. 7) is to separate a a small telemetry (TLM) satellite from the spacecraft or escape system prior to retrofire. This TLM satellite remains in the same orbit as the space station or escape system. After retrofire, the escape vehicle transmits the time and duration of the retro-impulse to the TLM satellite, which stores the data and transmits it to the ground station on the next contact. The disadvantage with the TLM and data sharing alarm system is that the crew has no assurance of data being received by the ground station.

5.6 Post-Splashdown Communication

(U) Post-splashdown communication is necessary in the event that deorbiting occurs before communication with the ground station can be established, or in the event that the splashdown point is outside of the nominal dispersion area. Also, ground communication equipment is helpful in assisting the recovery operation. The list of equipment for current recovery/survival aids is shown in Appendix 1 (Ref. 8) and is based on present manned spacecraft practice. For the escape system, it is anticipated that it will be modified in accordance with the space escape system concept.

(U) For splashdown cases, where the landing point is uncertain or unconstrained, long range communications would be needed to indicate the approximate position, as determined by surface navigation (see Section 6), to a recovery source. This recovery source is described in the National Search and Rescue Manual (SAR), AFM 64-2. The resources available are the Aerospace Rescue and Recovery Service (ARRS), the Coast Guard, other military aircraft, commercial aircraft, and military and commercial shipping (the Navy rescue capability is not defined here). The resources would not be limited to those of the United States, but would also include those of both friendly and unfriendly nations.

(U) Within the SAR operation, there exists the Automated Merchant Vessel Report (AMVER) system which is operated by the Coast Guard. This system is a maritime mutual assistance program which provides search and rescue in the Atlantic Ocean, Caribbean Sea, Gulf of Mexico, Indian Ocean, and Pacific Ocean.

(U) Merchant vessels of all nations are encouraged to participate voluntarily in providing position reports to the AMVER Center located at Coast Guard New York, via selected coastal, extra-continental, or ocean station vessel radio stations. Information from these reports is entered into an electronic computer which updates vessel positions. Currently, it is estimated that 70, 60, and 10% of all vessels in the Atlantic, Pacific, and Indian Oceans, respectively, participate in this mutual assistance. A typical plot for April 1968 of the average vessels per day in a 300 n mi square area is shown in Fig. 5-1. Plots for other months are available and show similar density. It is of interest to note that if landing is targeted for a latitude with high density (for example, 35 deg N latitude), ship density greater than 2 ships/day in a 300 n mi square area exists. This density can provide good assurance of assistance from commercial vessels.

(U) The frequencies which all maritime vessels above 1600 gross tons monitor and guard for distress code are 500 KHz and 2182 KHz. The 500 KHz is to transmit coded messages and 2182 KHz is for voice. The 500 KHz frequency is guarded by international agreement for 3 minute periods, 15 minutes before and 15 minutes after the hour; during this 3 minute period, this frequency is silent for distress monitoring by all vessels. The monitoring can be an automatic alarm device. The signal from the distress craft is standardized by international agreement (Ref. 9).

(U) Medium frequencies have, theoretically, long distance transmission capabilities because of the ionospheric propagation. For example, the mean transmission distance with a 10 watt transmitter and a 15.4 ft diameter (1/128 wavelength) antenna is calculated to exceed 1000 n mi (Ref. 10). However, diurnal, seasonal, and meteorological factors can reduce the distance significantly. In general, the influence of these factors is reduced at night, which may permit reliable communication with merchant vessels within 300 n mi radius (see Fig. 5-1).

5.7 Satellite Communication

(U) The two military comsat systems expected to be operational at the time of interest are the Initial Defense Communication Satellite Program (IDCSP-Phase II) and Tactical Communication Satellite (TACSAT) (Ref. 10).

[redacted]

sophisticated modulation techniques that would not be adaptable to the simple equipment on the escape system. These same factors would preclude use of the Intelsats.

(U) The TACSAT is intended for use with small, low power ground stations. It uses both UHF and X-Band transmissions. As shown in Table 5-2, it is possible to achieve an adequate signal-to-noise ratio with a simple antenna. A calculation on the power and antenna requirements using the TACSAT (in the UHF mode) is shown in Table 5-3. At X-Band, a directive antenna (beamwidth < 8 deg) is required, which is contrary to the necessity [redacted] combination.

(U) Although it is technically possible to use TACSAT, there are certain operational problems. Even if the UHF channel is operating, heavy traffic may overpower the weak signal from the escape system. Thus, consideration of TACSAT use is dependent on program plans for the future. In future TACSAT's it would be desirable to reserve a small portion of the UHF band for emergency uses like the space escape system.

5.8 Physical Characteristics of the Communications Equipment

(U) It is not expected that existing Gemini B and Apollo Block II type of equipment will be greatly improved as a result of technological breakthroughs. However, increased transmitter efficiencies will reduce the required input power and improved electronics will allow smaller and lighter packages. For the estimates of the equipment physical characteristics, the 500 KHz transceiver, the VHF transceiver, the the beacon were considered as separate units. Some weight and size reduction is expected from integration of the VHF transceiver and the beacon. No problem is anticipated with environmental or reliability specifications, although the ability to operate after long storage in space (perhaps one year) may have to be proven. The estimated characteristics are listed in Table 5-3.

(U) Table 5-4 gives the estimated total volume and weight, including batteries, for several combinations of equipment and operating times. The batteries are assumed to be silver-zinc, using the present weight and volume data, less 10% for improvements. It is possible that batteries with other chemical combinations could yield a 50% improvement in weight and volume by 1975. Fuel cells are not considered a potential candidate for this low power application.

(U) It is expected that the beacon frequency for direction finding will be [redacted] (b)(3), 10 USC 130 [redacted] scheme will conserve power and identify the beacon. A 3 watt transmitter and a quarter-wave antenna are assumed to be sufficient.

(U) The SGLS equipment is estimated to weigh 14 pounds, occupy 524 cubic inches, and require 14 watts for transmission and 3 watts for reception. The alarm transmitter is assumed to be the same as the beacon transmitter used during search and rescue.

(U) Table 5-1. Summary of Candidate Communication Systems

Candidate System	Status	Frequency (Up/Down) Up & Down	Coverage
Orbit Phase			
[redacted] (b)(3), 10 USC 130			
Post Splashdown Phase			
[redacted] (b)(3), 10 USC 130			
International Distress	Operational	500 KHz 2182 KHz 121.5 MHz	Global Global Line-of-Sight
		[redacted] (b)(3), 10 USC 130	

Note: (1) SGLS
(2) Unified S-Band
(3) Future Planning

(C-4) Table 5-2. Comparison of Satellite Downlink Characteristics

[redacted]

(b)(3), 10 USC 130

CONFIDENTIAL

(U) Table 5-3 Sample TACSAT UHF Uplink Calculation

[redacted] (b)(3), 10 USC 130

Transmitter Power & Antenna Gain, dBm
System Losses, dB
Radiated Power, dBm
[redacted] (b)(3), 10 USC 130
Misc. Losses, dB
Satellite Antenna Gain, dB
Received Signal Power, dBm

Thermal Noise Density, dBm/Hz
Receiver Noise Figure, dB
[redacted] (b)(3), 10 USC 130
Thermal Noise Power, dB

[redacted] (b)(3), 10 USC 130

S/N, dB

Required S/N, dB

X, dBm

Mean X

---

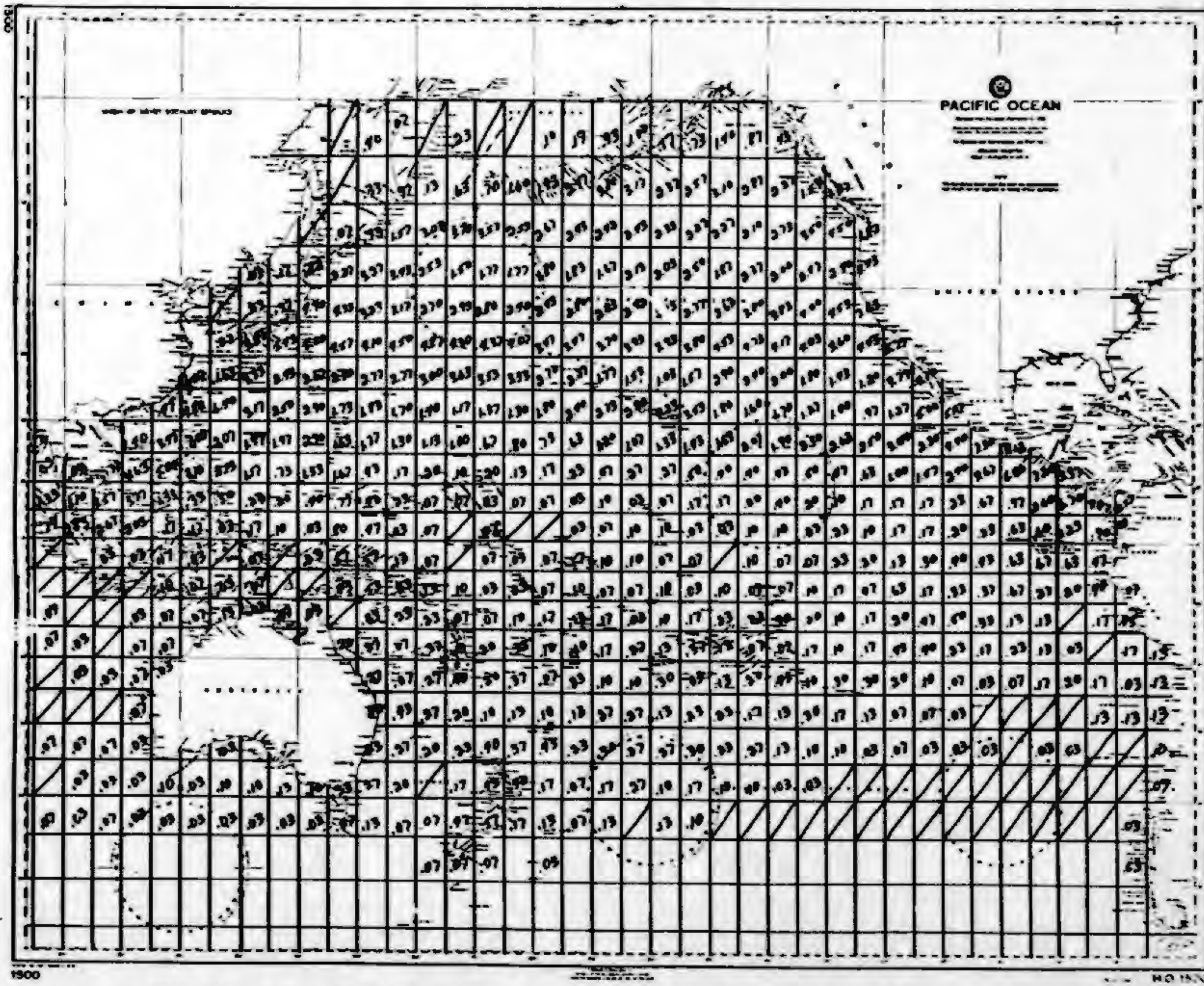
for: [redacted] (b)(3), 10 USC 130

(U)Table 5-4. Typical Communications Equipment Characteristics

Unit	Est. Volume (in. ^{3})	Est. Weight (lb)	Est. Power (watts)
500 KHz Transceiver	80 - 125	5.5	30 (transmitter) 0.5 (receiver)
VHF Transceiver	60 - 80	3	11 (transmitter) 0.5 (receiver)
Beacon	60 - 80	2.5	6(50% duty cycle)
500 KHz Antenna (15 ft)	100 - 150	3	-
Short Range Antenna	10	0.5	-
Beacon Antenna	10	0.5	-
Cabling and Misc.	40 - 50	3	-
Cabling without 500 KHz Equipment	25 - 35	2	-

(U) Table 5-5. Typical Equipment Volume and Weight

Combination	Beacon (hrs)	VHF Rec/Transmit (hrs)	500 KHz Rec/Transmit (hrs)	Est. Total Energy (watt hr)	Est. Total Volume (in. ^{3})	Est. Total Weight (lb)
1	48	48/6	-	378	475-525	27
2	48	48/6	48/3	492	740-885	40
3	48	48/6	48/6	582	805-950	44
4	48	48/6	48/10	702	890-1035	49
5	72	72/6	72/15	1020	1190-1335	72



(U) Fig. 5-1. AMVER Shipping Density Analysis, Unweighted, April 1968

UNCLASSIFIED

6. NAVIGATION SYSTEMS

6.1 Scope

(U) This effort surveyed the available navigational systems and assessed their characteristics (Ref. 11). The systems investigated are those which are considered to be capable of determining either ephemeris data during the orbital phase and/or providing position fix during the post-splashdown phase. Methods of determining deorbit parameters to land at a specified location are not treated in this report.

(U) Navigation satellites, manual navigation, and ground-based hyperbolic grid networks were considered. The ground tracking network is described in Section 4. The candidate satellite navigation systems considered were Transit, Program 621B, and Integrated Communication, Navigation and Identification (ICNI). Omega and Loran C were the ground-based hyperbolic grid network systems considered in the investigation.

6.2 Results

(U) The various navigational systems characteristics and applicability of each system for orbital and post-splashdown phase are summarized in Tables 6-1 and 6.2. In general, the navigational satellites and manual navigation systems can provide position fixes and ephemeris data with a global coverage during post-splashdown and orbital phases with the aid of an onboard computer. The ground-based tracking systems can provide limited coverage during the orbital phase. All ephemeris computations are performed at the ground station. The ground-based hyperbolic grid networks are basically surface navigation aids. A network is planned to provide global surface coverage.

(U) Of the navigational satellites, Transit is presently the only operational system and is used for surface navigation. For a one-position fix, a minimum of six minutes of data is required to accumulate all necessary information; the average interval between fixes is up to two hours.

(U) The 621B and ICNI navigational satellites can obtain all measurements necessary to compute position fixes in seconds. The interval between fixes can be essentially zero. Program 621B is currently in the definition study phase and is potentially the most promising system. ICNI is in a conceptual study phase.

(U) The manual navigation system will support the orbital and post-splash-down phase on a global basis, but requires crew participation in a manner similar to aircraft navigation procedures. The concept is completely autonomous and was demonstrated in part during the Gemini program.

6.3 Transit

(U) Transit accumulates all information necessary to compute a position fix with a method of sequential, time-separated doppler measurements with respect to a single satellite. This results in an ambiguity of predicted coordinates that is symmetrical about the satellite subtrack. The ambiguity is resolvable with any gross knowledge of position except when the fix is obtained from a near overhead pass. Doppler measurements must be obtained by averaging over a finite time interval. Transit navigators operate in a passive, non-transmitting mode. The system is capable of all-weather, 24-hour operation, and is the only navigation satellite system presently in an operational status.

(U) The accuracy of the Transit system for various types of users has been well demonstrated in the course of its operation over the last several years. For example, a navigation receiver in a fixed location on land can be repeatedly located within 100 ft if the antenna height above mean sea level is known and if corrections are provided for all signal propagation anomalies. It must be stressed that this value of 100 ft represents the dispersion of the predicted location with a set of coordinates internal to the Transit system and should be interpreted as an indication of measurement repeatability. It does not necessarily mean the system can locate a fixed receiver to 100 ft relative to the geodetic coordinates of latitude and longitude. Transit accuracy for a ship on the high seas, obtainable on a single satellite pass, has been demonstrated as being typically of the order of 0.25 n mi.

(U) These quoted accuracies will be degraded by approximately 0.25 n mi for every knot of velocity uncertainty. Further degradation will be introduced if the antenna height above mean sea level is not well known. This latter factor is due to the fact that a doppler curve is unique only at a given altitude.

(U) The operational Transit system has four satellites in circular, polar orbits at an altitude of 600 n mi. This type of orbit will inherently provide full global coverage with a single satellite but with far less than continuous availability. Provision of four satellites at the 600 n mi orbital altitude in the operational system results in an average interval between fixes of two hours for a user located near the equator.

(U) The sequential measurement technique requires a minimum of 6 minutes of data to accumulate all information needed for one position fix. However, the obtainable accuracy is enhanced, due to geometrical considerations, if the 6 minutes of data are recorded intermittently over the 20 minutes duration of a typical satellite pass.

(U) Transit is not capable of supporting the orbital and reentry phases in the event of gross uncertainties in escape capsule altitude and velocity. Tumbling of the capsule during reentry will also introduce errors. Furthermore, the probability of getting a fix during these phases is low because of the relatively short duration of these phases and the relatively long measurement intervals required. These limitations also explain why Transit's ability to support aircraft is, for the most part, limited to a slow, straight line, wings-level flight profile.

(U) Transit can definitely support the post-splashdown phase of the escape mission profile. For this case, the escape capsule can be considered to be identical to any ship carrying a Transit receiver. The accuracy of Transit for this case has been stated as being of the order of 0.25 n mi. This accuracy can be degraded due to the motion of the antenna on a capsule that is bobbing in the ocean. Consequently, sea state in the landing area will be a factor that can bear heavily on the obtainable accuracy for this mission phase, although there should be no problem in meeting a 200 n mi accuracy.

(U) The full hardware impact upon the escape capsule peculiar to the Transit navigation system is difficult to define quantitatively. No equipment has been specifically designed for a space vehicle; consequently, none of the present navigator equipment was designed to minimize the volume, weight or prime power requirements. Transit does require a dual frequency receiver

(b)(3), 10 USC 130

[redacted]

mistic, approximation of the Transit requirements. Further details concerning the recent configuration and status of the Transit program are presented in Ref. 12.

6.4 Navigation Satellite System (621B)

(U) This navigation satellite system is an Air Force development, formalized as Program 621B, but its present status is strictly conceptual. The probability of its achieving operational status is undefined. However, conceptual studies (Refs. 13 and 14) have indicated what the hardware impact would be upon the escape capsule. These values have been tabulated in Table 6-3.

(U) This system accumulates all information necessary to compute a position fix by measuring the range difference between the navigator and pairs of synchronous altitude satellites. Triple satellite coverage to provide two range differences plus independently derived altitude information or quadruple satellite coverage to provide three range differences, is required. If pure range measurements are obtained, then double and triple satellite coverage, respectively, would suffice. As in any ranging technique, the measurements are inherently instantaneous and can be performed simultaneously. The navigator operates in a passive non-transmitting mode similar to Transit.

(U) The accuracy of this approach has been theoretically established as being of the order of 0.1 n mi. Coverage and availability characteristics of this system are typical of any system whose orbital configuration is implemented at synchronous altitude. The coverage provided by any single constellation of satellites will be approximately 1/3 of the earth's surface and this area will be serviced with continuous availability. Provision of three constellations of satellites will provide full global coverage as presented in Figure 6-1. The measurement time has been established as being less than 10 seconds to record all measurements necessary for computing a fix in a sequential format. Because of the continuous availability of this system, the interval between fixes is essentially zero. Unlike the Transit system, there is no ambiguity of measurement intrinsic to this ranging approach provided the ranging code is long enough for a sufficiently great ambiguity interval. For the post-splashdown phase, a range-code length approaching one earth radius (approximately 3000 n mi) would be adequate to ensure the absence of ambiguities.

(U) Because of the instantaneous measurements and continuous availability inherent in the design of this system, it would be capable of providing support for all phases of the escape mission profile.

6.5 Integrated Communication Navigation and Identification (ICNI)

(U) The ICNI concept, also an Air Force satellite system, is in a conceptual status. The navigation portion of ICNI, as presently envisioned, is virtually identical to that postulated for Program 621B. The major advantage of ICNI is that it would provide not only a navigation aid for the escape mission but would also provide communications channels to inform a ground control center of the escape capsule status and projected or actual splashdown coordinates. Such an integration of function would be expected to result in a significant reduction of hardware required by any user. However, it is difficult to imagine this concept being available as an operational system any earlier than the late 1970's. The 621B program is much further along in achieving a firm design configuration.

6.6 Omega

(U) Omega (Ref. 15) is a ground-based navigation aid that has been designed and developed by the Navy. These ground stations are operated in the Omega mode, which is a method whereby each station is independently controlled by

(b)(3), 10 USC 130

[redacted]

This capability of the Omega system makes it economically feasible to deploy

(b)(3), 10 USC 130

[redacted]

semi-operational status which means that down times are allowed for necessary maintenance only and are kept as short as possible.

(U) The VLF signals are propagated in a mode where the lower edge of the ionosphere and the earth's surface constitute a waveguide. The VLF signals will not propagate through the ionospheric blanket. Therefore, utility of this system is constrained to the on-ground phase.

(U) The system accumulates the information necessary to compute a navigation fix by measuring the relative phase difference between signals received from two Omega transmitters. These measurements are performed sequentially and over some small but finite time interval. This time interval is approximately 10 seconds and, since the grid is continuously available, the interval between fixes is essentially zero. The Omega receiver does not directly compare the signals received from two transmitters but measures the phase difference of each signal relative to an onboard oscillator. The navigator operates in a passive, non-transmitting mode.

(U) The accuracy that has been demonstrated by Omega is better than 2 n mi in all cases. There is an ambiguity interval intrinsic to the Omega format that at present will occur every 72 n mi. However, present pla: s already are firm to extend this interval up to 7,200 n mi.

(U) The use of the Omega system as a navigation aid has bee: proposed to the United States Weather Bureau as a position location device for free floating weather balloons (Ref. 16). The Weather Bureau has acted positively upon this recommendation, originally proposed by the Aerospace Corporation, and has designated this system as OPLE, Omega Position Location Equipment. It was demonstrated in the course of the prior Aerospace study that the necessary electronics could be effectively fabricated from the latest integrated circuit and thin film techniques. Partly as a result of the possibility, the hardware penalty upon the escape capsule necessitated by Omega can be less than that resulting from any of the alternate navigation aids being discussed in this report.

(U) In summary, Omega would definitely be useful for the post-splashdown phase. Demonstration of compatibility between Omega receivers and aircraft navigators has been accomplished. Under no circumstances will this approach be able to support the orbital and reentry phases of the mission profile.

6.7 Loran C

(U) Loran C is included in this study primarily because it is a more familiar system than Omega. Both systems are ground-based navigation aids which generate a hyperbolic grid. Furthermore, since Loran C and Omega have in common all characteristics of any such hyperbolic ground-based navigation aid, only the differences between Loran C and Omega need be explored.

(b)(3), 10 USC 130

[redacted]

take significantly more ground stations to provide global coverage with Loran C than with Omega. Moreover, there are no plans, at present, for extending the Loran C coverage to anything approaching a truly global network. The existing Loran C stations are in a fully operational status and the coverage provided by them is presented in Figure 6-2. It can be seen that present coverage is wholly inadequate for the application of interest and further consideration of this alternative is not warranted. Details concerning Loran C, including recent status, are provided in Ref. 17.

6.8 Manual Space Navigation

(U) The Manual Space Navigation system (Ref. 18) is carried in the capsule and can determine the orbit characteristics without satellite or ground support. The system consists of a handheld space sextant, stadimeter, and look-up graphs. Using these tools, the crewman can establish the six independent parameters describing the orbit. The handheld space sextant was flown on Gemini VII and was demonstrated to be operationally feasible.

(U) The crewman obtains the navigational data by taking earth curvature measurements with the stadimeter and angular measurements between two reference stars with the sextant. The earth curvature measurement is directly related to orbital altitude. These measurements with time references, taken at several intervals along the orbit, are sufficient to establish the orbital characteristics. The computation cycle has been reduced to graphical look-up charts and a worksheet which permit the crewman to determine his orbit independent of ground assistance. This graphical cycle is similar to aircraft navigational procedures. The accuracy of this method has been determined by taking the measured sextant data from the Gemini VII flight and comparing them with ground tracking data. This comparison indicates that the in-position error was 6. 3 n mi cross-track and 10. 1 n mi along-track.

(U) The development of the manual space navigation system did not include the ground navigation phase, but its concept during this phase should be possible with some modification. The use of the sextant during floatation may, however, pose problems in providing a relatively stable platform while making measurements.

(U) The procedure of using graphical look-up tables and sightings in space requires the crewman to be experienced in navigational procedures. It is estimated that this procedure will require in the order of 45 minutes. By use of onboard computers, the manual computation will require only the transferral of sighting data to the computer. This approach will reduce his direct involvement and reduce the computation cycle time. However, the accuracy of this concept is, in general, related to the time between sightings. Therefore, the computer will not appreciably reduce the time period for establishing the orbit but will reduce operational complexity.

(U) Manual navigation is attractive since it is completely independent of ground support, satellites, or parent spacecraft inputs. Such capability would be desirable in the event that ground communication is lost and the orbit has been perturbed from the emergency situation. However, other factors that should be considered are the time required to compute the orbit and the crew's ability to perform the navigation following an emergency.

(U) Table 6-1. Summary of Candidate Navigation Systems

Candidate System	Status	Type	Mission Phase	Coverage
SCF	Operational	Ground Based	Orbit	Polar Orbit
Spacetrack	Operational	Ground Based	Orbit	Polar Orbit
Transit	Operational	Satellite	Post-Splashdown	Global
621B	Conceptual Design	Satellite	Orbit and Post-Splashdown	Planned Global
Omega	Semi-Oper.	Ground Based	Post-Splashdown	Planned Global
Loran C	Operational	Ground Based	Post-Splashdown	Regional
Manual Navigation	Development	Visual Sighting	Orbit and Post-Splashdown	Global

(U) Table 6-2. Summary of System Characteristics of Candidate Navigation Systems

Pertinent Characteristics	[redacted] (b)(3), 10 USC 130
Type	
Status	
Measurement Technique	
Navigator Operating Mode	
Position Accuracy in n mi	
Measurement Time For One Navigation Fix	
Interval Between Navigation Fixes (Availability)	
Measurement Ambiguity	

(U) Table 6-3. Summary of Hardware Impact on Escape Capsule Imposed by the Candidate Navigation Systems

Pertinent Characteristics	Candidate Systems (Assumes No On-Board Computer)					
	Transit	621B	ICNI	Omega	Loran C	Manual Space
Receiver Weight	None designed for space vehicle.	9.7 lb	9.7 lb	0.24 lb	None designed for space vehicle.	11 lb
Receiver Volume	Assume 621B values	350 cu in.	350 cu in.	234 cu in.	Assume Omega values	460 cu in.
Receiver Prime Power	are typical.	48.5 W	48.5 W	4.6 W	are typical.	0

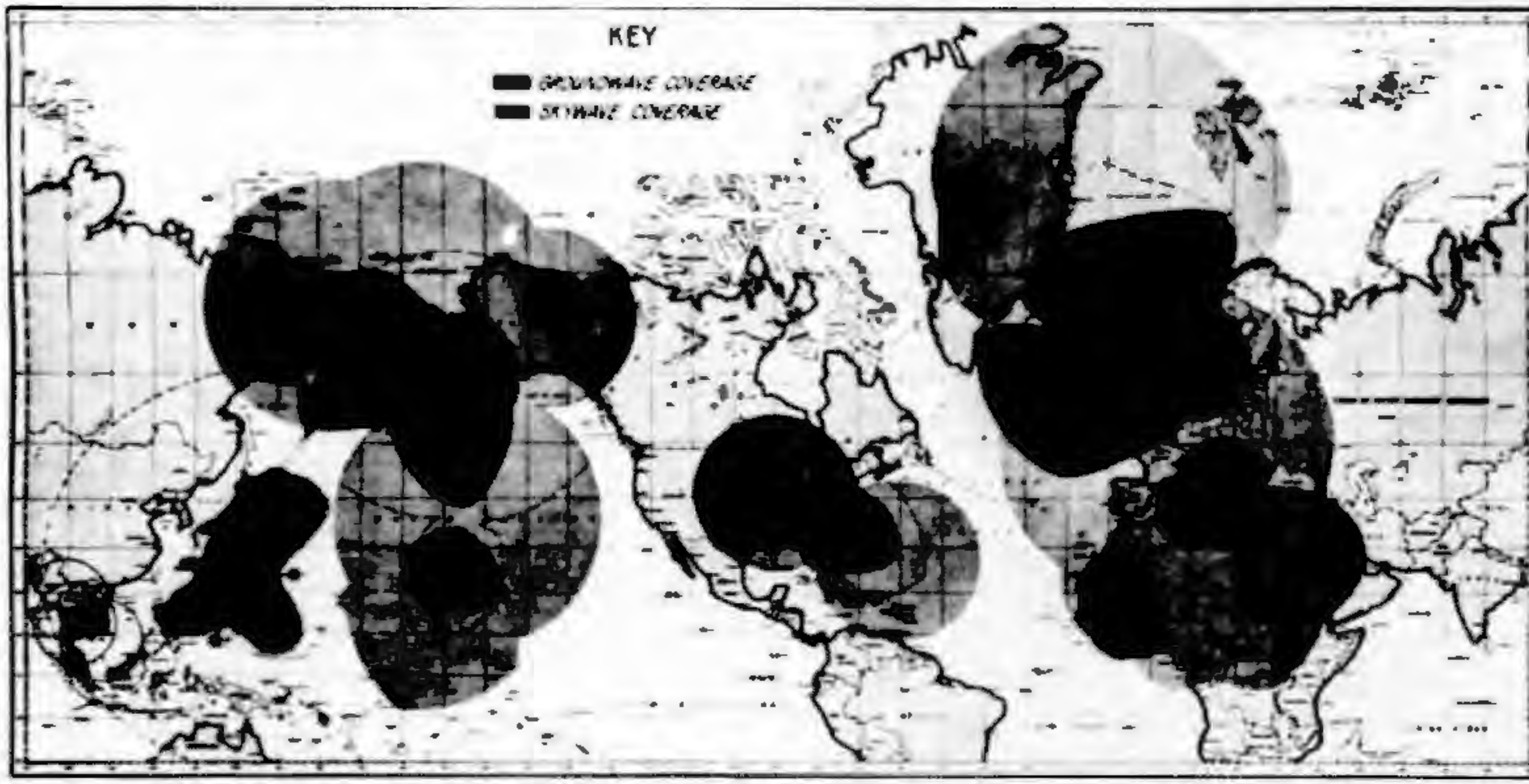
UNCLASSIFIED

(b)(3), 10 USC 130

[redacted]

(U) Fig. 6-1. 621B Coverage for Fifteen Satellites Deployed

UNCLASSIFIED



(U) Fig. 6-2. Coverage Areas LORAN-C System

7. CONCLUDING REMARKS

(U) The investigation indicates that many possible communications and navigation systems exist on a global basis and are available during the orbital and post-splashdown phases of space escape. In general, the systems requiring large power and antennas should be eliminated as candidates because space escape systems must be lightweight, low volume, and functionally simple. For communication, it was assumed that links which do not normally support the missions can be made available by a distress alarm, with the provision that support is limited to acknowledgment and relay of messages. The promising communication links are summarized below:

Orbit Phase	AF/SCF	1. Polar orbit coverage 2. Real time up-down communication link
	NASA/MSFN	1. Global coverage 2. Must be alerted to provide assistance
	International Distress	1. Global coverage 2. Transmission limited to acknowledgement and relay of message
	Military Distress	1. Coverage limited to USA & military bases 2. Real time up-down communication link possible
Post-Splashdown Phase	TACSAT	1. Global coverage 2. Future planning uncertain
	International Distress	1. Global coverage 2. Possible to contact rescue sources in the area.

(U) The navigational aids during the orbital phase are ground-based tracking and satellite systems. The ground-based tracking networks, SCF and Spacetrack, are most effective for near polar orbits. Ephemeris data are determined at the ground stations and must then be transmitted to the escape system. The promising navigational satellite systems for the orbital phase consist of 621B and ICNI. These satellites are both in conceptual design phase but could provide global coverage if they are operationally deployed. The user of these systems operates in a passive mode and will require a receiver and an onboard computer to determine ephemeris data. The manual navigation concept obtains position data by visual sighting and computes the ephemeris.

(U) During the post-splashdown phase, two navigational aids are promising: the Omega ground-based hyperbolic grid network and the Transit satellites. Of these, Omega has a lower potential hardware impact upon the escape system than Transit and has comparable accuracies, but no global coverage capability at present. Transit is a proven operational surface navigational aid with global coverage.

8. REFERENCES

1. "Return Probabilities for Redundant Access to Multiple Recovery Sites with Local Time Constraints", Aerospace ATM 68(3520-82)-13, S. T. Chu and A. R. Nagy, 13 March 1968

2. "Space Rescue Communication Coverage Study", Aerospace ATM, W. Sandberg.

3. "Final Design Report, Space Ground Link Subsystem, Vol 1," 4300-7500-002, TRW Systems, 1 February 1967.

4. "Space Escape Systems; On Orbit Communication", Aerospace Corporation, ATM 69(4525-04)-11, D. H. Martin, 3 April 1969.

5. "Space Escape System Communication and Tracking Study", Aerospace Corporation, ATM-68(3520-82), W. A. Sandberg, 18 January 1968.

6. "Apollo Ground Systems", NASA/MSC, 1 November 1966.

7. "Communication for Apollo Emergency Deorbit System", ATM-67(7080-33)-9, R. Stang, 7 June 1967,

8. "Recommended Recovery and Survival Aid Equipment, Escape from Spacecraft Study", IOC 69-5111.14-5, R. Coulston, 28 February 1969.

9. "Radio Regulation", General Secretariat of the International Telecommunication Union, Geneva, 1959

10. "Space Escape System: Post-Splashdown Communication", ATM 69(4525-04)-44, Aerospace Corporation, D. H. Martin, 7 March 1969.

11. "Utility of Navigation Systems as Tracking Aids During Emergency Escape from Spacecraft", Aerospace Corporation, ATM-69(4525-04)-12, A. H. Shapiro, 22 April 1969.

8. REFERENCES (Cont.)

12. "The Navy Navigation Satellite System: Description and Status", by Thomas A. Stensell, Jr., Presented in "Navigation", Volume 15, No. 3, dated Fall 1968.

13. "System 621B Satellite System for Precise Navigation: Final Report", SAMSO TR-69-4, January 1969 (Hughes Analysis).

14. "Satellite System for Precise Navigation; Program 621B", SAMSO TR-69-2, January 1969 (TRW Analysis).

15. "Omega - A Worldwide Navigational System", AD-630 900, by J. A. Pierce, et. al., 1 May 1966.

16. "GHOST and SCOMO Preliminary System Definition Phase", Aerospace Corporation Report No. ATR-65(7060)-3, by Lowell Greenberg, 14 April 1965.

17. "Time Synchronization from Loran C", by L. Dennis Shapiro, IEEE Spectrum, August 1968.

18. "Analytic Development of Optimum Astronaut Procedure for Use of Air Force Space Navigation System in the Manual Mode", Universal Technology Corporation, AFAL-TR-69-14, R. M. Silva, March 1969.

19. "SGLS, Space-Ground Link Subsystem, Ground Station System Analysis Report", WDL-TR3227-1, Vol. I, 15 November 1968.

APPENDIX

DESCRIPTION OF RECOVERY/SURVIVAL AIDS

1. VHF Recovery Beacon

Characteristics: [redacted] (b)(3), 10 USC 130

modulated signal [redacted]

of 3 W. Transmi[redacted]

period. The signal is essentially line-of-sight and is readable for direction finding (DF) purposes to a distance of 70 - 90 n mi by AN/ARA-25 DF equipment and 122 n mi by AN/ARD-17 equipment in aircraft flying at 10,000 feet altitude.

Dimensions: The current Gemini-B beacon weighs 3.0 lb. Its size is 6.75 x 4.03 x 4.0 in. Input power of 22 watts is drawn from the re-entry module power supply.

Applicability: The beacon is the primary electronic DF device for locating the descending or landed escape device.

NOTE: Modification to include 121.5 MHz is recommended to provide alternate transmission on the commercial aircraft distress frequency.

2. VHF Survival Transceiver

Characteristics: The survival transceiver transmits/receives

[redacted] (b)(3), 10 USC 130

beacon. The unit is included in each crewman's survival kit.

Dimensions: 6.3 x 4.6 x 2.07, 4 lb.

Applicability: This unit provides backup to the recovery beacon and would be used in case of egress or after the expiration of the recovery beacon's 24 hour transmission capability.

3. (b)(3), 10 USC 130 [redacted]

Applicability: This unit is recommended for inclusion, as the primary (clear) command channel is at this frequency.

4. (b)(3), 10 USC 130 [redacted]

plus 10 minutes per hour for 36 hour duration. It receives during the remainder of the period

Dimensions: 8.537 x 3.437 x 3.093 in., 4.22 lb.

Applicability: The unit provides communications capability beyond line-of-sight for both DF and voice. Location can be determined to within 50 miles when used in the DF mode. However, its inclusion should receive lowest priority due to the general unreliability of HF reception and the absence of HF/DF net stations in the southern hemisphere.

5. Flashing Light

Characteristics: Dual flash rate at 10 and 60 flashes/minute at 1.2 and 1.0 candle power/flash, respectively. Duration is 24 hours total out of a 36 hour period with the high flash rate not to exceed 2 hours.

Dimensions: 1.38 dia. x 3.5 in., .19 lb.

5. Flashing Light (continued)

Applicability: The unit provides a high intensity night-time visual aid for close-in location of the escape device.

6. Sea Dye Marker

Characteristics: Activation by immersion results in a yellow-green fluorescent streak in the water. Operating time is 2 hours.

Dimensions: (See MIL-P-17980).

Applicability: The dye provides a highly visible water coloration which enhances location of the escape device during day-time search.

7. Survival Kit (per crewman)

Characteristics: The kit contains a variety of personal survival items for all climates and terrains. Included are a one-man life raft, sea anchor, cold weather gear with sleeping bag, medical kit, water purification kit, survival light and the above-noted survival radio.

Dimensions: (Approximate) 8 x 10 x 15 and 4 x 6 x 15 in.; 22 lb total

Applicability: One kit (or equivalent if single multiman package provided) should be installed for each crewman to assure extended survival in all climates in the event it becomes necessary to abandon the escape device.

8. Personal Parachute

Characteristics: The parachute should be standard military type of either seat, back or chest pack configuration.

Dimensions: (Approximate) 8 x 10 x 24 in; 18 lb.

8. Personal Parachute (continued)

Applicability: Each crew-man should be provided with a parachute to use in the event the primary terminal descent system fails. It additionally provides an environmental shelter capability.

NOTES: 1. If the escape device is installed in the reentry module and lands with it, only one complement of the above equipment need be carried. If the escape device is installed elsewhere in the orbiting vehicle, then two installations may be required - one in the reentry module and one in the escape device, unless the escape device installations can be readily transferred to the reentry module prior to normal reentry.

2. The above items are recommended as baseline for near-term application. It is recognized that volume and weight economies may be effected through combined packaging of the several discrete items into fewer units. This approach should be particularly applicable to the electronics items.

AEROSPACE CORPORATION

INTERNAL DISTRIBUTION LIST

(REFERENCE: COMPANY PRACTICE 7-21-1)

REPORT TITLE		
SURVEY OF COMMUNICATION AND NAVIGATION CONCEPTS FOR SPACE ESCAPE SYSTEM		
REPORT NO. TOR-0200(4525-04)-3	PUBLICATION DATE 16 June 1969	SECURITY CLASSIFICATION C-4

(NOTE: FOR OFF-SITE PERSONNEL, SHOW LOCATION SYMBOL, e.g. JOHN Q. PUBLIC/VAFB)

(b) (6)

[redacted] (4)

(b) (6)

APPROVED BY [redacted] DATE 13 June 69

SHEET ______ OF ______

AEROSPACE FORM 2394 REV 7-66

AEROSPACE CORPORATION [redacted]

EXTERNAL DISTRIBUTION LIST

(REFERENCE: COMPANY PRACTICE 7-21-1)

REPORT TITLE

SURVEY OF COMMUNICATION AND NAVIGATION CONCEPTS FOR SPACE ESCAPE SYSTEM

REPORT NO.	PUBLICATION DATE	SECURITY CLASSIFICATION
TOR-0200(4525-04)-3	16 June 1969	C-4

MILITARY AND GOVERNMENT OFFICES	ASSOCIATE CONTRACTORS AND OTHERS
[redacted] (SMAOR) (3)	

(NOTE: SHOW FULL MAILING ADDRESS; INCLUDE ZIP CODE, MILITARY OFFICE SYMBOL, AND "ATTENTION" LINE.)

[redacted]

AFR 310-2 DISTRIBUTION STATEMENTS X'd BELOW APPLY

1. 2. 3. 4. 5.

IF LIST COMPRISES TWO OR MORE SHEETS, COMPLETE THIS SIGNATURE BLOCK ON LAST SHEET ONLY

APPROVED BY [redacted] (FOR AEROSPACE CORPORATION) DATE 13 June 69

APPROVED BY Lt. [redacted] (AF OFFICE) SMAOR (SYMBOL) DATE 13 June 69

SHEET ____ OF ____

AEROSPACE FORM 2980 REV 11-66