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ABSTRACT

At the request of the Chief of Naval Operations, a short-term, in-house Navy Study was made to identify the courses of action that can be taken to improve combat search and rescue capabilities within the next 2 to 3 years. Significant conclusions are presented regarding improvements in aircraft and personal equipment, as well as requirements for the combat SAR mission.

SYNOPSIS

Concern over the recovery of aircrewmen in SEAsia resulted in the Director of Defense Research and Engineering requesting the Navy and Air Force to undertake a coordinated study of means to improve combat SAR capabilities in the next 2 to 3 years. The Chief of Naval Operations, therefore, directed that a short-term, in-house Navy study be made to identify courses of action that will accomplish this objective.

Data on the following incidents are analyzed to determine what factors made rescues successful or unsuccessful:

a. Navy losses of carrier based aircraft in Southeast Asia from 1 April 1966 through 31 March 1967.

b. Air Force tactical aircraft losses in Southeast Asia from 1 July 1966 through 31 March 1967.

c. Marine tactical aircraft losses outside of South Vietnam from 1 April 1966 through 31 March 1967.

<u>Significant findings in the data are:</u>

- The over-land recovery rate was poor. Only 9 percent of the Navy personnel down over land during the day were recovered, and none at night.

- Seventy percent of personnel subsequently captured ejected within 5 miles of where hit and 100 percent ejected within 3 minutes of when hit.

- Fifty percent of the Navy POW's, for whom capture times are known, were captured within 5 minutes of landing on the ground.

- For opposed rescue incidents where suppressive fire was reported, the recovery rates were twice that where no suppressive fire was reported.

- In opposed areas where the general location of a downed pilot was known, the rescue vehicle spent an average of 9 minutes localizing before pickup could be attempted.

- The primary cause of aircraft loss was fire. Ninety percent of the POW's ejected due to fire, the other 10 percent for unknown causes.

Major findings in other areas of the study are:

- In order to make a significant reduction in time late and gain a worthwhile improvement in enroute survivability, a SAR vehicle speed of at least 200 knots is required.

- SAR aircraft operating in conjunction with the Air Strike Group afford the greatest probability of rescue.

- Survival radios, subminiature TACAN beacons, ADF-locators, and air-to-ground markers offer near-term improvements in detection and location.

- In hover pickups, rapid deployment of rescue seats and increased hoist speeds are required.

Conclusions of the study are as follows:

- The area of the SAR process that offers the greatest potential for improvement, and that can be improved in the shortest time, is the detection and localization of the downed aircrewman.

- Two aircraft designs, the tilt wing (CL-84) and compound helicopter (AH-56), meet minimum mission requirements for combat SAR.

- The CL-84 offers the greatest combat rescue flexibility and potential.

- Vulnerability to enemy defenses severely limits the capabilities of current SAR vehicles.

- Air snatch is the only feasible means of rescue in heavily defended areas.

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COMBAT SAR STUDY

INTRODUCTION

Combat search and rescue (SAR) missions are the most important missions undertaken in support of combat air operations in Southeast Asia (SEAsia). The effect on the morale of pilots and aircrewmen of having a reliable, aggressive SAR capability in a limited war environment cannot be quantified. However, the potential savings of valuable military resources (such as combat-experienced air crews) and the deprivation of intelligence sources falling into enemy hands are sufficiently important reasons for maintaining and improving the SAR posture.

Concern over the recovery of aircrewmen in an increasingly hostile environment resulted in a memorandum from the Director of Defense Research and Engineering to the Assistant Secretaries of the Navy and Air Force (R&D). This memorandum, dated 20 March 1967, requested that the Navy and Air Force undertake a coordinated study to effect near-term improvements that can be made in the entire SAR operation. Accordingly, the Chief of Naval Operations directed that a short-term, in-house Navy study be made, the objective being to identify the courses of action that can be taken to improve combat search and rescue capabilities within the next 2 or 3 years.* The CNO memorandum specifically set forth the following tasks:

1. Mission/Threat Analysis - Collate and analyze data from SEAsia SAR operations to determine the critical or controlling factors that made

* CNO Memorandum Op-966D/bl, Ser 093P96, 5 April 1967.

rescues successful or unsuccessful. Define the threat to be encountered by the SAR vehicle.

2. Vehicle Analysis - Identify the important system characteristics that will determine the SAR vehicle requirement.

3. Personnel Survival and Rescue Equipment Analysis - Identify those personnel equipments that will enhance successful survival and rescue.

4. Systems Availability/Effectiveness - Evaluate the vehicles and equipments that can be made available in the specified time frame as to their ability to meet the requirements developed from steps 2 and 3 above.

5. Cost Analysis - Define R&D implications and costs for any of the courses of action defined by the study.

6. Tactics - Consider improvements in tactics and procedures as well as equipment.

In accomplishing these tasks, the study was organized into seven major areas each discussed in detail as an appendix to the basic report:

1. Appendix A - Operations and Tactics
2. Appendix B - SEAsia SAR Data Analysis
3. Appendix C - SAR Parametric Analysis
4. Appendix D - Limited Warfare Environment
5. Appendix E - Aircraft Survivability
6. Appendix F - Aircraft Analysis
7. Appendix G - Search and Rescue Equipment

Search and rescue incidents addressed in the study are primarily those aircraft loss incidents resulting from action over hostile territory, either land or sea. Although several potential environments are considered in establishing mission requirements, North Vietnam (NVN) is the primary scenario considered in the study. Principal conclusions and the rationale identifying potential improvements in the combat SAR mission are discussed in the following paragraphs.

BACKGROUND

Commanders of Naval task forces are charged with the primary responsibility for combat SAR operations for aircraft of the force. Ship-based aircraft and search and rescue forces further support the combat SAR network in the area. Presently in SEAsia, Commander Seventh Air Force has been assigned primary SAR responsibility with the Search and Rescue Center, Saigon, exercising control and coordination of SAR efforts.

Commander Task Force 77 presently deploys in the Gulf of Tonkin four SAR destroyers in two ship elements. The southern SAR destroyer element maintains a UH-2 helicopter on deck alert principally for over-water rescues. The primary combat SAR vehicle is an armed SH-3A on airborne alert during daylight hours in the vicinity of the Northern SAR destroyers. Rescue Combat Air Patrol (RESCAP) are attack aircraft, most frequently A-1's, operating from Yankee Team (TF-77) attack carriers. SH-3A SAR helicopters are based on a CVS, or in its absence, on a Yankee Team CVA.

At present, Navy Combat SAR operations are concentrated in the coastal areas and in the Gulf of Tonkin. This stems from the large percentage of strike missions and predominance of targets in the coastal route packages. Also, probability of rescue is much higher for the pilot who can make it to sea before ejecting from a damaged aircraft. The heavily populated and defended coastal regions are not easily penetrated by present SAR forces. To survive in a heavy antiaircraft artillery (AAA) and surface-to-air missile (SAM) environment, the combat SAR vehicles must characterize attack aircraft in speed and survivability.

UH-2 and SH-3A rescue helicopters are vulnerable to ground fire and SAMs such that operational commanders have established limiting criteria for SAR efforts. In general, the RESCAP must have the downed crewman in sight or maintain contact with him through communications before the helicopter is committed to the effort. The normal procedure is to leave the wingman orbiting the SAR area and have only one RESCAP aircraft return to pick up the helicopter and escort it inland to the rescuee. Vehicle vulnerability necessitating such tactics weighs heavily upon time late at the rescue scene.

SAR force radius of action is largely governed by the unrefueled range of the SH-3A, operating at virtually maximum power during most of the rescue attempts. Although most NVN rescue incidents occur within 50 miles of the coast, the route in is often circuitous to avoid the coastal band of ground defense. Distances from SAR station to penetration points and from carrier to SAR station, as well as the long airborne alert periods, further reduce SAR radius of action. Fuel starvation was the suspected cause of a recent (21 May 1967) loss of an SH-3A on an extended SAR mission across NVN.

The low SAR vehicle speeds (approximately 130 kt) for present helicopters are not entirely compatible with tactical aircraft speeds; they increase vulnerability and extend exposure time of the downed pilot awaiting rescue.

RESCAP aircraft currently are essential members of a team providing suppressive firepower, navigational assistance, search, communications, and on-scene coordination of the rescue. A wider disparity in speeds of the SAR rescue helicopter and the jet RESCAP will be present with the phaseout of the A-1 RESCAP in January 1968. Their future usefulness will be curtailed because of the shorter on-station time and reduced search capability caused by the high speed of the jet RESCAP.

Communications problems impede the rescue effort. Frequently, substantial delays occur in (1) determining the location of downed aircrewmen, (2) rendezvousing with on-scene forces, and (3) coordinating the SAR elements because of interference on guard channel or the primary rescue net.

Navigation to and maneuvering in the rescue area is usually done at low altitudes - 3,000 to 5,000 feet - to avoid enemy automatic weapons and 37mm AAA fire. Low ceilings and visibility can now result in separation of SAR vehicles and RESCAP or cancellation of the rescue effort. Rescue capability does not now exist at night over land.

Combat SAR operations in SEAsia are being conducted with ASW or utility helicopters adapted and reconfigured for the combat mission. SAR aircraft are relatively slow and vulnerable to the extent that operations over defended portions of NVN are precarious. Increased antiaircraft and SAM defenses would further debilitate tactical capabilities of a force employing current SAR helicopters.

SAR OPERATIONS ANALYSIS

Data from SEAsia SAR operations form the basis of an analysis to determine critical and controlling factors that make rescues successful. A statistical analysis (appendix B) covers a 1-year reference period extending to 1 April 1967. During this period, there were 228 Air Force and 118 Navy incidents directly resulting from combat. Those air combat operations over NVN represent the most difficult SAR conditions and are therefore the area of concentration in this analysis.

The quantitative measure of effectiveness for the SAR process is defined, for the purposes of this study, as recovery rate, that is, the ratio of the number of aircrewmen recovered to the number recoverable, where recoverable is the number downed minus the known killed. Such a definition, by excluding those killed in the aircraft and essentially not recoverable, offers a more precise measure of recovery success. Recovery rate as an effectiveness measure also is conservative, since it groups those missing with those who are potentially recoverable.

Combat rescue success varies appreciably with rescue area. Recovery rates in the less hostile regions (South Vietnam, Laos, and Thailand) are on a par with recoveries over water areas (82% vs 86%). Both categories are representative of "safe havens" or more desirable rescue locations. NVN by contrast represents a hostile environment affording an overall recovery rate of 25 percent.

An evaluation of all NVN over-land rescues further emphasizes the variation in rescue success with locale. Recovery rates for the southern route packages (I and II) vary from 53 to 64 percent. In the densely populated and heavily defended regions adjacent to Hanoi and Haiphong, very few recoveries are performed, as indicated by recovery rates of 4 to 6 percent. The latter represents rescue situations classed as "untenable". In a great number of such cases, rescues were not attempted. SAR aircraft presently are afforded little opportunity for survival in environments challenging attack aircraft survivability.

Rescue success in less hostile regions of NVN averages 20 to 25 percent on the basis of defined recovery rates. The majority of rescues in these regions may be categorized as "hostile" - that is, with opposition from small arms and light AAA, but outside of heavy AAA around major target complexes.

The category of "routine" rescue with little opposition again applies to waters and regions outside NVN control. In such cases, the recovery problem and reported success are comparable to operational rescues.

Navy recoveries during the past year were concentrated in the Gulf of Tonkin. Location of prime targets along the coast permits rapid access to a relatively safe or controlled area for rescue. Relatively few Navy rescues were performed over land. Conversely, a large percentage of Air Force recoveries took place over land but generally in the less hostile regions to the west of NVN targets. This condition of potential rescue areas in relatively close proximity to the target is not considered unique to SEAsia but is representative of most limited warfare scenerios.

Prisoners of war (POW's) represent pilots that an improved SAR system could in many instances pick up. Locations where Navy POW's were downed are generally distributed in a narrow coastal band of NVN extending some 30 miles inland and are usually concentrated adjacent to target complexes. This is further verified by the statistical analysis indicating that 75 percent of the Navy POW's were downed within 5 miles of hit. Examination of the 25 Navy incidents resulting in capture indicates heavy antiaircraft defenses in 16 cases. The coastal plains represent the most highly defended regions and, in turn, those with the highest population densities. Populations reach 1,000 persons per square mile in a number of these regions, further aggravating the rescue problem.

Navy combat SAR incidents analyzed as to land/sea and day/night conditions further delineate and define the problem. Recovery rates established for the 1-year period are listed in table 1.

TABLE 1. NAVY COMBAT SAR INCIDENTS, NVN - 1 APRIL 1966 TO 31 MARCH 1967

	Total Incidents	Recoverable	Recovered	Recovery Rate
Day at sea	59	50	46	92%
Night at sea	4	3	1	33%
Day over land	34	28	3	11%
Night over land	16	13	0	0%

The statistics in table 1 clearly show that the problem is one of a poor recovery rate over land (5 percent day/night overall), with a further degraded capability due to night conditions.

The need for a night recovery capability is clearly evident from the statistics. Despite the fact that the present SAR aircraft do not have a full night over-land capability, the recovery vehicle is not the limiting factor. More often, it is an inability to detect and locate. Of 23 recoverable USN and USAF pilots in night SAR incidents, the vast majority (19) are in the missing category. In only one incident where the pilot was missing was there any sign of survival, and then only a possibility of a flare having been seen. Thus, a major problem in night SAR incidents is the lack of knowledge of the actual location and the recovery potential of the downed aircrewmen.

The low recovery rate for the 34 Navy day over-land incidents during the 1-year period prompted a careful parametric analysis to ascertain problems and areas for potential improvements. The SAR process for purposes of analysis is simplified into a sequence of events and actions that are casually connected. A flow chart of the SAR process is developed in appendix C. The following illustration summarizes the results of this analysis.

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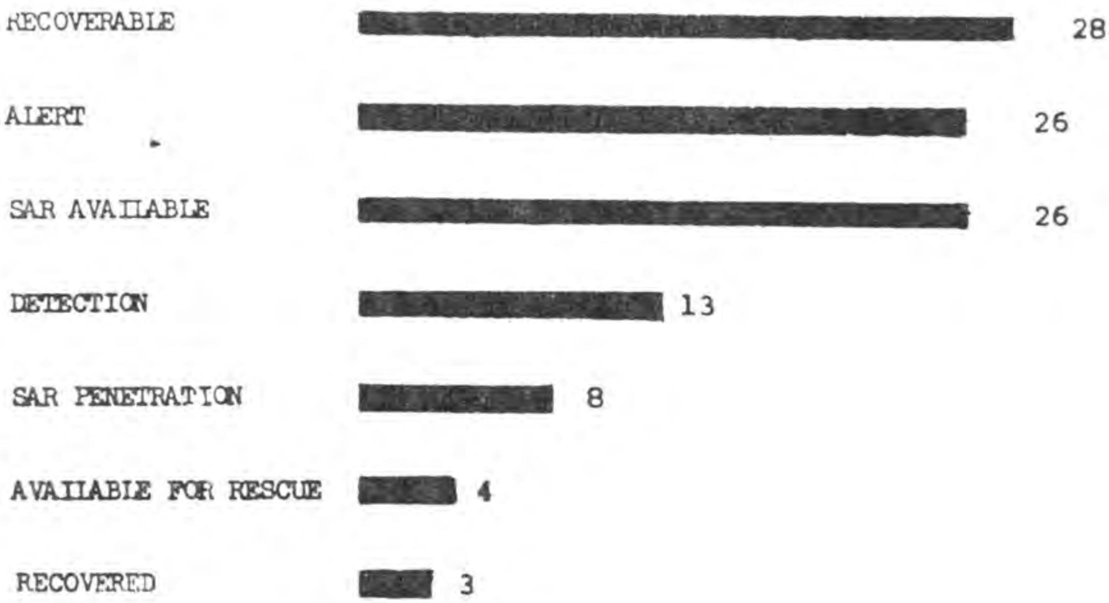

Figure 1. Navy Day Over-Land Recoveries, NVN - 1 Apr 1966 to 31 Mar 1967.

Of the 34 incidents in which pilots were downed over NVN, 6 are known killed, leaving 28 recoverable. Alert was not sounded in two cases due to the mistaken assessment that the pilot was killed. SAR vehicles are indicated to have been available in all instances. Search was reported unsuccessful in 50 percent of the 26 cases.

Of these 13 incidents where the general location of the rescuee was known, the rescue vehicle was able to penetrate to the scene only 8 times. During the time period from initial search until the rescue vehicle arrived, the downed airman was captured in four of these eight incidents before rescue could be effected. Of the four remaining incidents where the rescue vehicle arrived on the scene and the rescuee survived, recovery was unsuccessful in one incident due to the rescuee's difficulty in knowing, without visual sighting, when the helicopter was directly overhead. Thus, rescue was accomplished in only three cases.

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From these data, it can be seen that the SAR process, for day over-land situations, falls short in three areas:

1. Search (13 out of 26 incidents).
2. SAR vehicle penetrability (8 out of 13 incidents).
3. Ability of the downed airman to evade capture on the ground until the SAR vehicle arrives (4 out of 8 incidents).

The qualitative reasons can be deduced in part from the data base case studies. Examination of incidents where search was unsuccessful generally indicates an absence of contact with the downed airmen. In a few instances, momentary beepers were heard but were of insufficient duration for localization. Detection and localization equipment limitations or failures may be inferred, although a number of uncontrollable factors such as capture or injury of the pilot could have precluded a successful search effort.

The problem of the rescue vehicle not being able to penetrate is attributed simply to the fact that the vehicles in use today cannot exist in the severe defensive environment of NVN. In two cases, MIGs caused a rescue effort to be abandoned. The other cases can be attributed to heavy AAA, SAMs, and in at least one case, heavy small-arms fire that caused a light helicopter to be thwarted in a rescue attempt.

The ability of the downed pilot to survive on the ground and avoid capture until the SAR rescue force arrives is dependent on many factors. Although each case is unique, some statistical factors can be inferred from the data. The location where the aircraft is hit and where the pilot egresses are factors. If the parachute is observed, an immediate search by the enemy is initiated. The heavily defended regions and those of high population density present a very difficult rescue problem.

The record for Navy day over-land rescues during the past year indicates two distinct areas for improvement: (1) search equipments and (2) SAR vehicle survivability. Each will be discussed in greater detail in appendices G and E, respectively. However, <u>time</u> is a factor which influences the success of all phases of the operation.

TIME FACTOR IN COMBAT SAR

The ideal rescue situation involves retrieval of the aircrewman immediately after the incident with essentially zero time late. Time late is defined as the time interval from pilot down to rescue vehicle arrival on the scene. Combat conditions do not necessarily permit the classic zero time-late rescue. The time factor in a hostile environment, however, has been analyzed to establish the effect of speed and tactics as applicable to the ultimate rescue success.

Utilizing SEASIA data as the basis for analysis, varied tactics have been evaluated to establish time late as a function of SAR vehicle speed. Five tactics have been analyzed for varying distances to the rescue scene. Results for a nominal 100 nautical mile radius mission are presented in figure 2. This graph, depicting the five tactics, is annotated to indicate actions of the RESCAP and SAR vehicle during the approach to the rescue scene. Tactics 1 and 2 are representative of present SEAsia operations where the RESCAP first establishes contact with the rescuee, either by radio or visually. The SAR helicopter is then escorted to the scene by the initial RESCAP (Tactic 1) or by a second element of RESCAP aircraft

(Tactic 2). A direct approach to the rescue scene is indicated in Tactics 3 and 4. The wingman departs the scene prior to arrival of the SAR forces in Tactic 3. SAR vehicles in company or trailing the strike group (Tactic 5) represent the least time late.

A wide disparity in time late with varied tactics is apparent from the analysis and graphic representation. A direct approach to the rescue scene generally is more effective than speed in reducing time late. Vulnerability of SAR vehicles presently limits the approaches to that represented by Tactics 1 and 2.

Tactics are important at all speeds, and the effect of increasing SAR vehicle speed is most significant in the range of 100 to 200 knots but diminishes rapidly above 200 knots.

Time late alone does not provide the full criteria in assessing SAR vehicle speed requirements. Survivability of the downed aircrewman, or in more precise terms, his availability for rescue, needs to be determined. A probability-of-survival curve was developed on the basis of known capture times, as indicated in figure 3.

A rapid drop in probability of survival is evident during the first 30 minutes. Individual case studies also indicate that time to capture is often just a few minutes, particularly in the heavily defended areas with high population densities (e.g., 50% of the POW's were captured within 5 minutes).

For time in excess of 30 minutes, the probability-of-survival curve drops less rapidly with time. This segment represents another type of situation in which the pilot egresses in a remote or semiremote region. In such areas, he may be expected to survive for a longer period of time, extending up to many hours.

Since the time to capture was not available for many of the POW's, the survival curve, using only known times, is biased by the fact that the capture times were usually observed by the wingman, who could remain in the area for only a short period of time. A theoretical survival curve, as indicated in figure 3, was derived on the basis of adjusted data and degraded by a factor of 2 so as to be conservative in applying the results to subsequent analysis.

On the basis of the probability of survival-time relationships, some measure of pilot rescue potential can be established for varied tactics and SAR vehicle speeds. Figure 4 depicts these results. Note the distinct knee in the curves at 200 knots for all tactics except that of the Strike Group SAR where effectiveness increases steadily with SAR vehicle speed. From this, it can be concluded that improvements in combat SAR operations can be made by decreasing time late. This can be achieved by (1) decreasing response time, (2) employing a recovery vehicle of at least 200 knots speed, (3) using a survivable SAR vehicle for direct approach to the rescue scene, and (4) operating SAR aircraft with the air strike group.

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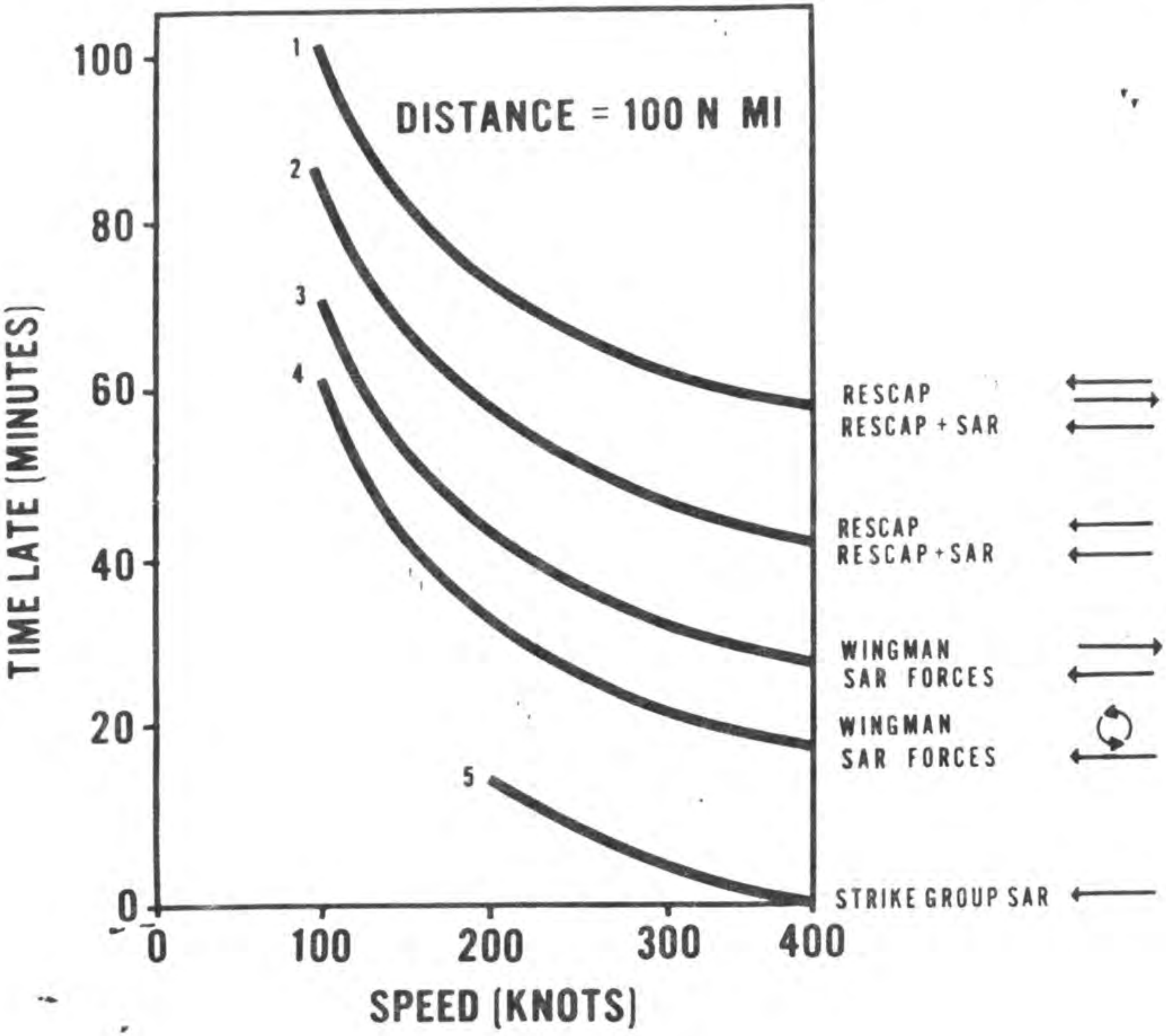

Figure 2. Time Late vs Rescue Vehicle Speed.

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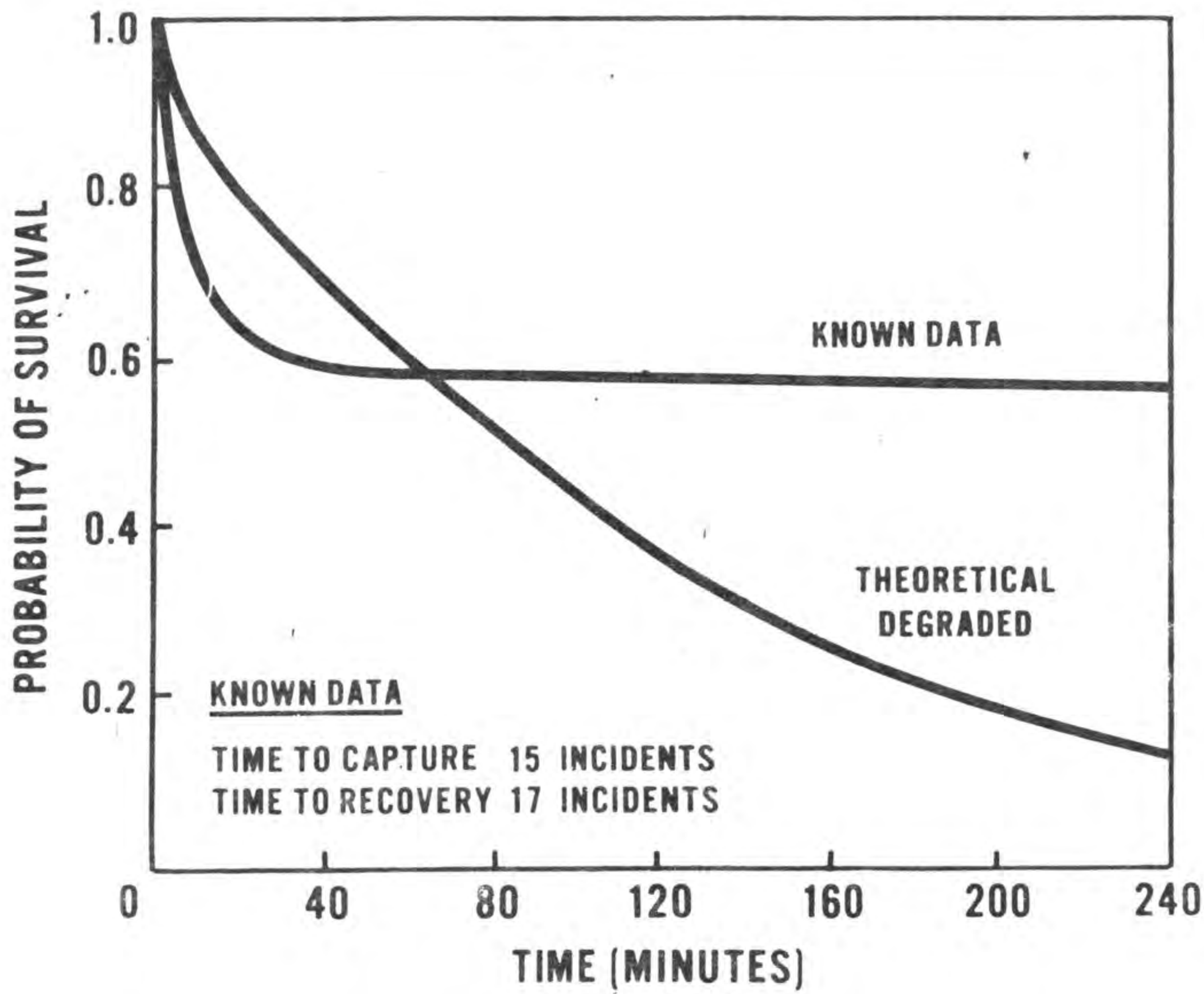

Figure 3. Probability of Survival on the Ground vs Time, Known Data.

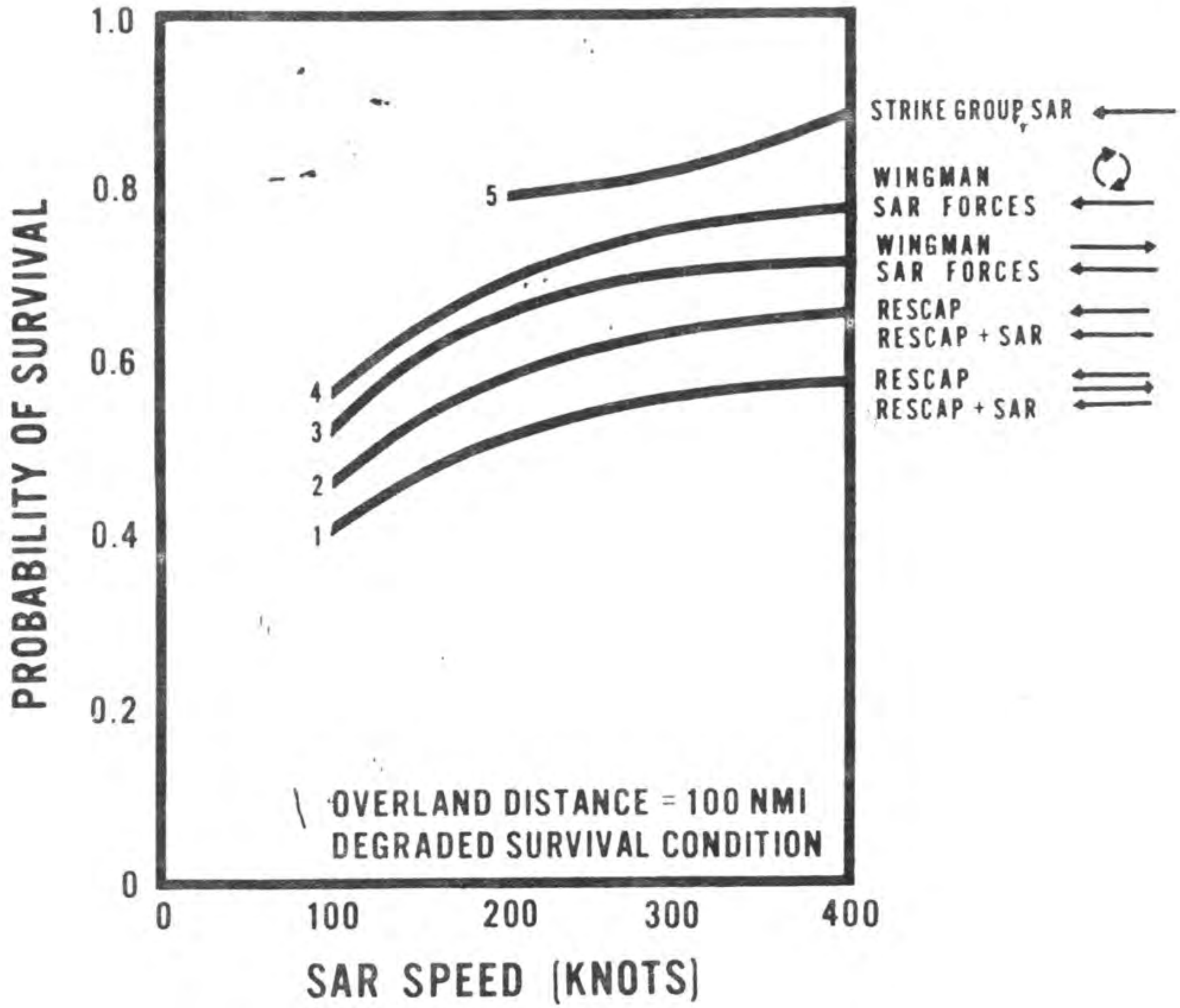

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Figure 4. Probability of Survival on the Ground vs Rescue Vehicle Speed, Five Tactics, Degraded Conditions.

OPERATIONAL CONCEPTS

Several new operational concepts are suggested when considering the potential capabilities of advanced VTOL aircraft and equipments in the SAR role. The analysis indicates that SAR operations, in conjunction with an air attack group, or with the SAR vehicle penetrating directly to the rescue scene, are tactics that effectively increase the probability of rescue. In other circumstances, air-to-air retrieval may be the most feasible means of pilot rescue. Accordingly, the following tactics have been considered:

1. Strike Group SAR
2. SAR Team
3. Air snatch

STRIKE GROUP SAR. A SAR aircraft with speed and range performance compatible with that of attack aircraft could accompany or operate in conjunction with an air strike group. Flying wing on the strike group would be the optimum situation but presently is reserved for the 450-knot, highly survivable aircraft. The same concept, however, also applies to the SAR vehicle, with somewhat less speed, which could penetrate the enroute defense while trailing the strike group or proceeding to a preestablished rescue area outside the target complex (some 10-25 n.mi). Such an area relatively free of AAA could provide a "safe haven" at extended ranges from controlled waters or friendly territories while still allowing a rescue vehicle to be close at hand. The SAR vehicle could be in a position to pick up downed pilots or provide escort during retirement.

The primary advantage of the Strike Group SAR concept is minimization of response time. The rescue vehicle would be afforded the protection umbrella of the strike group, with ECM and fighter protection enroute and attack aircraft available for RESCAP at the rescue scene. Close coordination between the strike group and the rescue force would be automatic since the rescue vehicle would be an integral element of the strike group. The Air Strike Commander maintaining on-scene control of the SAR effort obviates command and control delays.

SAR TEAM. The advent of VTOL aircraft designed as fire support aircraft with increased speeds and ordnance-carrying capabilities suggests self- or mutually supporting SAR aircraft. The SAR Team implies a SAR vehicle operating in company with a similar VTOL-type aircraft capable of providing the suppressive fire of a RESCAP aircraft. This team would have the survivability, navigational capability, and suppressive fire necessary to proceed as a group to the rescue scene from a SAR alert without delay.

Two additional advantages of this tactic are:

1. Elimination of the problems of speed incompatibility between the RESCAP aircraft and the SAR rescue vehicle. This incompatibility exists between jet RESCAP and the present (UH-2, SH-3) rescue vehicles.

2. Ability of the rescue vehicle and the RESCAP to share the same base, reducing, if not eliminating, rendezvous and communication difficulties.

AIR SNATCH. Analysis of the SEAsia data indicates that there are certain populous and heavily defended areas - usually associated with strike zones - presently impenetable to search or recovery missions. This has led to a consideration of the possibility of retrieving an ejected airman before he lands to face almost certain capture.

The successes of the USAF in performing air-to-air recoveries of space capsules, and that of both the U.S. Navy and Air Force with air snatches of balloons tethered to a man - such as in the Skyhook ground-to-air recovery system - tend to balance out any initial scepticism of concepts pending thorough investigation.

The basic concept requires an aircraft equipped with a grappling mechanism to fly over a pilot aloft in a parachute device in such a manner that engagement occurs with a portion of the equipment. Following engagement and attachment, the pilot is winched aboard or carried to a safe area where he is released for later recovery.

Air snatch recovery is technically feasible and operationally difficult. The tested parachute method, wherein a close-to-standard chute with snatch drogue is utilized, is closer to operational status than the para-balloon proposal. The para-balloon proposal is an alternative aircraft escape system combining features of parachute and hot-air balloon and providing 30 minutes of controlled altitude hover time.

The technical and operational difficulties foreseen at this time should not be allowed to discourage efforts for a diligent study and pursuit of an operational system of air-to-air recovery. The potential of such a system is best appreciated when considering the possibility of routine, nearly instantaneous recovery and its effect on assets and morale. The capability of a strike-accompanying SAR vehicle would be greatly enhanced if it could be configured for air snatch. Such a configuration and available operational technique is considered the only feasible means of recovery of personnel ejecting in the vicinity of highly defended and populated targets.

DETECTION AND LOCALIZATION

A dramatic improvement in the overall effectiveness of SAR operations may be obtained simply by increasing the probability of successful detection and localization of downed men.

As previously stated, the presence of the downed man in the search area was detected in only 13 of 26 day over-land searches conducted by SAR forces in SEAsia between 1 April 1966 and 31 March 1967. Localization was completed in only three of these instances. The problem is further compounded at night; in 11 of 16 incidents during the same time period, SAR missions were not attempted because of the uncertain location of downed personnel, and lack of knowledge of rescue potential.

The primary improvements to be sought involve:

1. Reducing the time required for localization.
2. Increasing the effective range of detection.

Additionally, improvements should be sought in increasing the reliability of detection equipment, in reducing equipment size, and in reducing the risk of the rescuee's disclosing his position by signalling to the SAR forces.

REDUCING LOCALIZATION TIME. Although it is presently possible to determine the position of a downed man to within a mile by homing on his survival radio, final localization currently depends primarily on a time-consuming visual search of the immediate area by the SAR vehicle. In revealing his position to visual observation by the SAR vehicle, the rescuee frequently risks revealing his position to the enemy. Two or three passes are usually required to "talk-in" the rescue vehicle by voice communications - time enough, in many instances, to permit the enemy to set up an ambush of small-arms fire. A method is needed to permit the recovery vehicle to proceed to a point directly above the downed man on the first pass across the search area.

The DME TACAN Beacon. The first step toward achieving this ability would be to equip aircrewmen with a lightweight DME TACAN beacon. Such a beacon would furnish range information accurate to ±500 feet within a radius of 50 miles radio line-of-sight. Bearing information would be obtained either by using an ADF fix on the survival radio, or by modifying aircraft TACANs to permit Inverse Mode operation. Additionally, the TACAN beacon would have the advantages of (1) alerting the rescuee to the presence of SAR forces in detection range, (2) security, in that transmission would be on interrogation only, thereby preventing detection by enemy forces before SAR arrival, and (3) capacity for multiple-channel operation.

- A program to develop such a beacon should be initiated as soon as possible.

Approach and Hover. Further reduction in localization time can be realized by developing a system to permit approach and hover by the rescue vehicle on the initial pass. Automatic direction finding (ADF) equipments are proposed that permit range and azimuth location accuracy to within a few feet on an approach to a PRC radio.

- A program to develop such a system should be initiated.

INCREASING DETECTING RANGE. The line-of-sight transmission range of UHF radio limits detection range. Use of lower frequencies is precluded by practical antenna size. Therefore, the restriction of line-of-sight range should be acknowledged, and improvements made within the established limitations, both through proper operation of existing equipment and through improved equipment design.

Improvement Through Proper Operation of Equipment. Pointing the antenna of a survival radio toward the receiver decreases the effective range by a factor of 30. Mismatch between ARA-25 receivers and guard receivers sharing the same antenna reduces effective range by a factor of 2.2.

- A program should be initiated to instruct pilots in the most effective way to deploy survival equipment.
- An investigation of possible mismatch problems in ARA-25 and -50 ADF's should be conducted.

Improvement through Equipment Design. Adjusting squelch to eliminate distracting noise on guard channel receivers may reduce sensitivity to the point where a weak signal will not be heard.

- A beeper signal detector should be designed to be installed ahead of audio and squelch controls to give a positive indication of detection regardless of control settings.

Additional Improvements. A program to improve survival radios is currently in progress. Goals include improving reliability, providing multiple channel and IFF capability, and reducing size and weight through use of miniaturization techniques. Unfortunately, one factor limiting reliability and possible reduction of size and weight is beyond the scope of the present program.

- A program should be instituted to develop a new, lightweight, one-shot battery for survival equipment. This development program should also investigate means whereby a positive indication of battery charge-state could be incorporated into future batteries.

VISUAL DEVICES. Visual localization is not as desirable for combat SAR operations as is radio, because of the risk of enemy detection involved. However, localization is presently dependent on use of visual devices, and is likely to remain so for some time to come. Regardless of future radio system developments, visual devices will continue to serve as backup items in the survival kit. Near-infrared (IR) and chemiluminescent devices appear to be promising additions to the signalling devices now used by aircrewmen.

Near IR Devices. IR binoculars and image intensifier scopes are currently being used by the U.S. Army. These could be adapted very easily to SAR uses.

- Aircrewmen should be equipped with near-IR filters for their strobe lights. IR binoculars and image intensifier scopes should be installed aboard SAR rescue vehicles for night operations.

Chemiluminescent Devices. A chemical (TIARA) is available that imparts a chemiluminescent glow to material with which it is inpregnated. A device that fires a TIARA impregnated parachute from an M-8 pistol has been developed.

- Aircrewmen should be equipped with a dispenser of TIARA and colored flare cartridges for purposes of detection and identification.

Air-to-Ground Marker. A device that could be dropped by the wingman to mark the general location of a downed man would aid in directing SAR forces to the proper area to begin search. The device could be a visual marker to color a reference point a brilliant color, or it could be a radar-detectable device such as chaff.

- A program to develop such a marker should be instituted.

LISTING AND ANALYSIS OF SEARCH AND RESCUE EQUIPMENTS. A detailed examination of present and proposed search and rescue equipments is included as Appendix G.

AIRCRAFT SURVIVABILITY

Combat SAR implies an ability to operate and function in a hostile environment. Heavy defenses were noted as a factor in unsuccessful rescue attempts represented by 16 out of 24 Navy POW cases. As previously noted in the analysis, frequently the rescue vehicle was unable to penetrate to the rescue datam.

SAR aircraft survivability is an important measure of effectiveness in the combat SAR role. The analysis in appendix E shows the general effects of speed, altitude, armament, armor, vehicle size, vulnerable area, and maneuverability on aircraft survivability.

Speed was noted to be effective in increasing enroute survivability against small arms. In a basic evaluation of survivability against a 12.7mm weapon, a marked increase in survivability was indicated for speeds in excess of 200 knots. In the enroute condition, increasing aircraft velocity or altitude is generally more effective against small arms than increasing armor protection.

SAR vehicle maneuverability becomes a criterion if operations are to be conducted in heavy AAA or in a SAM environment. A brief evaluation of evasive tactics against SA-2 missiles indicated that at least a 2g maneuver would be required. SAR vehicles under consideration with limit load factors, generally 3.0 or less, would possess marginal evasive capabilities.

Hover condition was determined to be especially critical with survivability decreasing rapidly with time in hover. Figure 5 illustrates the effect of opposition by various combinations of small weapons. The requirement for minimum hover time and some means of suppressing the opposing firepower is apparent. Evaluation further indicates that at least 70 percent of the small-arms fire needs to be suppressed in order to appreciably decrease the kill probability in a hover.

Accounts of SEAsia rescues attest to the value of suppressive fire in effecting combat rescues. Table 2 statistically supports a suppressive firepower requirement.

TABLE 2. EFFECT OF SUPPRESSIVE FIRE (OPPOSED PICKUPS ONLY)

	Incidents	Recovered	Percent Recovered
With Suppressive Fire	30	18	60%
No Suppressive Fire Reported	49	15	31%

Recovery success is enhanced with suppressive fire, although data does not differentiate as to suppressive fire from the SAR vehicle or the accompanying RESCAP.

The heavy firepower contribution of the RESCAP aircraft makes it an integral member of the SAR Team. The forthcoming phaseout of the A-1 RESCAP aircraft points to the disparity in speed of the SAR vehicle and the jet RESCAP. Of the available jet attack aircraft for the RESCAP role, the A-7 is best suited for the mission. However, the advent of VTOL types with firepower capabilities approaching those of the A-1 suggests a companion to the SAR type in the RESCAP role.

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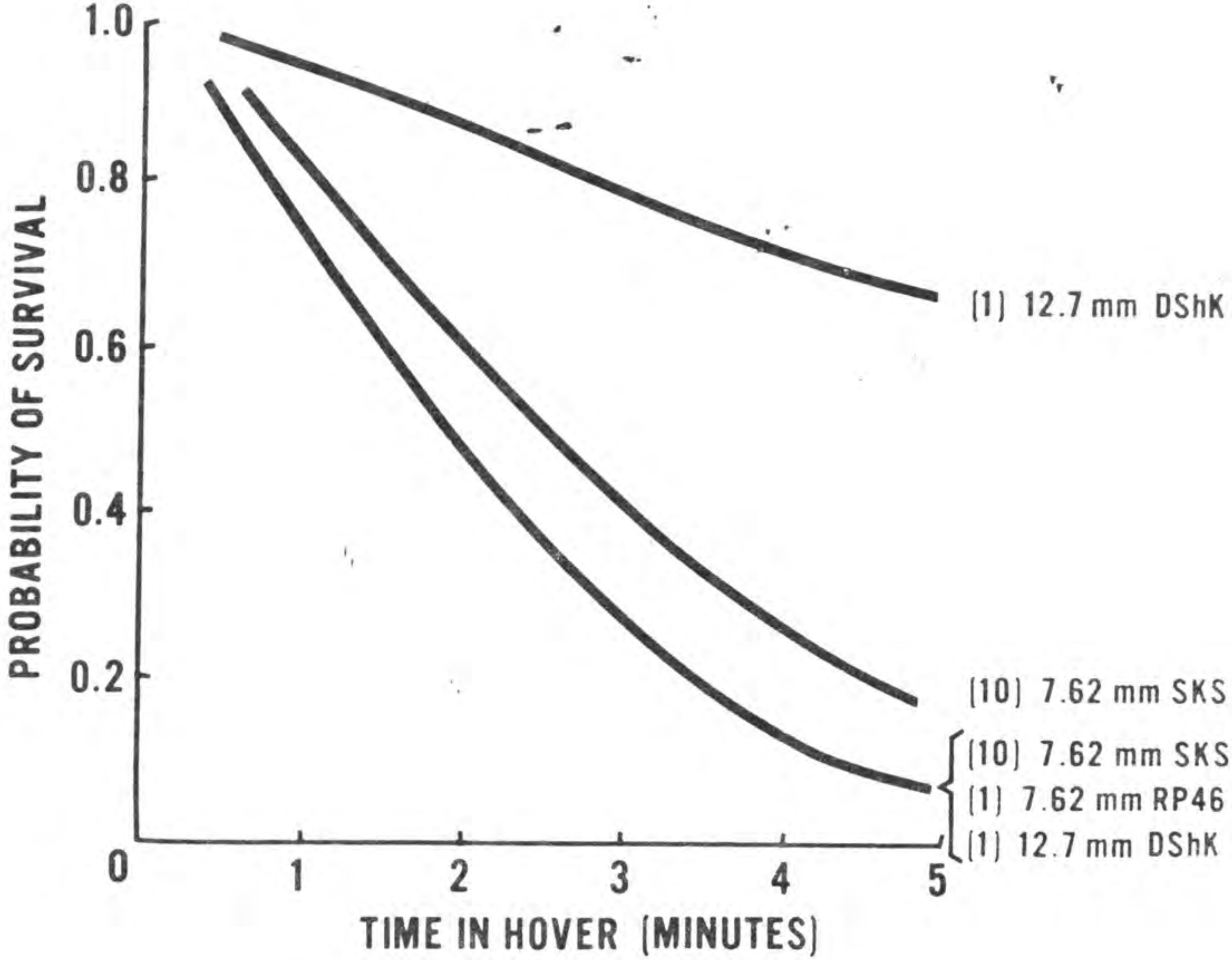

Figure 5. Survival Probability Trend for Time in Hover.

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MISSION REQUIREMENTS

The SAR vehicle, equipment, and command and control requirements are, to a large extent, dependent upon the number and type of combat sorties flown, the loss rates of the aircraft involved, and the SAR tactics employed. However, based upon analysis of SEAsia loss data, certain minimum and desirable requirements become apparent. These are discussed in the following paragraphs.

COMBAT RADIUS. From the analysis of the SEAsia data in appendix B, the combat radius for present Navy SAR operations is about 50 n.mi from the SAR base, with a median of 23 n.mi for land recoveries. However, due to terrain features and the vulnerability of the SAR vehicle to heavy enemy defenses, it must fly a circuitous route to the rescue datum that increases the equivalent combat radius.

In appendix D, SAR operations are analyzed for limited war situations in SEAsia, as well as other areas of the world. Consideration of the entire land mass of North and South Vietnam, for example, indicates that to provide at least 75 percent coverage, a 200-n.mi combat radius (unrefueled) for the SAR vehicle is necessary. In addition to the Vietnam theater, a SAR capability providing 75 percent of the land mass of other selected typical operational theaters requires a 300- to 325-n.mi combat radius.

Appendix A discusses the fighter and attack aircraft that are now being used in SEAsia and will be in the inventory in the next 3 to 5 years. These aircraft are the F-4B, F-8E, A-4C/D/E, A-6, A-7, and RA-5C for the Navy, and the B-57, F-4C, F-100, F-105, RF-4C, and RF-101 for the Air Force. The combat radii of most of these aircraft range from 400 to 500 n.mi when lightly loaded with relatively clean stores. Due to the high drags associated with multiple store loads using MER's and TER's, the practical combat radii obtainable today and for the next 3 years for most attack aircraft are on the order of 200 n.mi (unrefueled).

The A-7 is scheduled to be introduced in 1968. This aircraft offers the promise of an increased combat radius in the high-drag multiple-bomb load configuration. For example, the estimated combat radii of the A-7, carrying 24 Mk 81 Snakeyes and using internal fuel only, are 340 and 455 n.mi for the Close Support and HI-LO-LO-HI missions, respectively. Thus, the desired SAR combat radius should be about 500 n.mi to provide capability for the long-range A-7, with a minimum of 200 n.mi based on the near-term requirement.

Still further in the future is the anticipated development of a VFAX type to replace the F-4, A-4, and A-7 aircraft. Due to improvements now foreseeable in external store carriage, the combat radius of this aircraft should approach 600 n.mi for Close Support and 1,000 n.mi for Deep Strike. Since this aircraft could not be in the fleet in adequate numbers before about 1975, it should not influence the 1970 SAR vehicle requirements. However, for a follow-on SAR vehicle development, a SAR combat radius of 500 to 600 n.mi is indicated if rescue of the crew engaged in long-range Close Support missions with this aircraft is contemplated. Due to the expanse of enemy-held territory which must be traversed for Deep Strike missions at extreme ranges, SAR operations do not appear feasible unless the SAR vehicle is refueled enroute.

SAR VEHICLE SPEED. The SAR vehicle speed requirement is determined on the basis of three considerations:

1. The SAR tactic
2. Time late
3. Aircraft survivability

To be compatible with the Strike Group SAR tactic, the SAR vehicle must be capable of staying with, rendezvousing with, or trailing the strike mission. This places a requirement of 450 knots as the desired speed, with 350 knots as a practical minimum. Time late and vulnerability are correspondingly minimized by the Strike Group SAR tactic.

For the SAR Team tactic, speed is important but not a critical factor. Appendix C, figures C-8 and C-9 show that the largest gain occurs by increasing the SAR vehicle speed to about 200 knots. After this point, the curves bend over, decreasing in slope and minimizing gain due to speed. Likewise, appendix E, figure E-2 shows that enroute vehicle survivability is dependent on speed. These curves show that most of the gain in survivability is achieved by increasing vehicle speed to at least 200 knots. Thus, the minimum SAR vehicle speed required to accomplish mission objectives is 200 knots. At this speed, there is some incompatibility with present jet RESCAP. However, for the SAR Team tactic, it is considered that the team will consist of two similar vehicles, one configured as the rescue aircraft and the other as the RESCAP with the necessary firepower support.

HOVER. The analysis of aircraft survivability in the hover condition (appendix E) shows that it is imperative that hover time be kept to a minimum - about 2 minutes per rescue (desired). However, vehicle hover requirements are based upon the assumption that the SAR vehicle be capable of making two sequential rescues, allowing for the capability of fine positioning over each rescue datum and for crewman assist with the injured cases as required. Since the median localization time at the SAR scene is 6 minutes, a 15-minute hover time has been set as a minimum reasonable design requirement. Furthermore, analysis of the SEAsia environment (appendix D) shows that about 99 percent of the operating environment is under 89.6°F at 3,000 feet altitude. It seems reasonable, then, that for Navy SAR operation, the hover requirement for the SAR vehicle should be 15 minutes at an altitude of 3,000 feet OGE on an 89.6°F day.

SAR VEHICLE SURVIVABILITY. It is important to improve the capability of the SAR vehicle to penetrate to the rescue datum (enroute requirement) and survive during the actual recovery operation (hover survivability requirement). The enemy threat consists of: (1) small-arms fire plus optically aimed AAA up to 37mm; (2) radar-directed 57mm, 85mm, or larger AAA; (3) SAMs - SA-2 or SA-3 missiles; and (4) MIGs.

The analysis in appendix E shows the effects of speed, altitude, armament, armor, vehicle size, vulnerable area, and maneuverability on overall vehicle survivability.

In terms of the mission requirements for survivability, enroute speed must be greater than 200 knots. An enroute altitude of 4,000 to 5,000 feet is [redacted]

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However, against improved FANSONG radars or against advanced missiles such as the SA-3, the SAR survivability could be marginal if it must depend upon such maneuvers. A more detailed analysis is required if SA-3's are introduced into the environment.

It is recognized that avoidance is not the only means of surviving the fire from radar-directed guns and SAMs. In addition to speed and maneuverability, ECM and passive radar detection equipment are essential for survival in the SAM and radar-directed gun environment.

Vehicle size and armor are also factors in determining survivability. The combined measure of size and armor is vulnerable area, which should be kept to a minimum. The essential areas requiring armor protection are fuel tanks and system, flight control systems, engines, transmission, and aircrew.

In hover, an important element to survivability is the use of suppressive fire. The SAR vehicle and the RESCAP should be capable of providing adequate suppressive fire during rescue; 20mm turrets are desired in this regard.

BASING. As discussed in appendices A and F, current SAR operations utilize the UH-2 and the SH-3A helicopters. Normally, the UH-2 is based on and operates from a DLG. The SH-3A operates from either a CVA or CVS, depending upon the availability, with the CVS preferred.

In any analysis of follow-on SAR vehicles, ship capability to serve as an operating base has to be considered. The analysis of basing (appendix F) shows that strength of the landing platforms generally limits the size of vehicle that can be operated from them. Aircraft weight limitations of the ship platforms and decks are:

Ship Class	Max. Operable Aircraft Gross Weight (lb)
DLG	12,000
LPD	31,000
LPH	30,000
CVS	46,000
CVA	70,000

In addition to gross weight limitations, other factors must be considered, such as elevator clearances, maintenance and repair facilities, berthing facilities, etc.

The location of the landing platform is also important. In some ships, the platforms are located at a level such that basing and operation of the SAR vehicle would require removal of some of the ship superstructure. This is necessary to maintain an adequate margin between the ship center of gravity and center of buoyancy.

From an analysis of projected SAR vehicle size and weight, their preferred basing is on an LPD or CVS. However, as discussed in appendix F, there are a number of other possibilities, each with advantages and disadvantages. Also, it might be necessary to base Strike Group SAR vehicles on the CVA.

NIGHT/ALL-WEATHER. The SAR vehicle must be capable of night and all-weather operations from a ship under the same conditions as all-weather attack aircraft. It should be capable of proceeding to the rescue datum without visual reference to landmarks or use of extensive location aids such as TACAN. In localizing at datum, the SAR vehicle should be capable of descending and operating at 500 feet above the ground with a visibility of 1 mile. All-weather requirements can be met by the IHAS system with the additional incorporation of a terrain-avoidance radar, which is required for night operations. An automatic system for transition to hover is desirable when the rescue vehicle approaches within the ARA-50 or ARA-25 range. The SAR rescue vehicle should be configured for slow flight to allow fine adjustment of position over the rescue scene; it should be capable of automatic hover without drift in winds up to 45 knots.

SEARCH AND LOCALIZATION EQUIPMENT. Search and rescue equipments are surveyed in appendix G. Figure 1 illustrated the fact that search was successful in only 13 of 26 Navy NVN over-land incidents for which the SAR forces were alerted. Thus, the need for an improved search capability is apparent.

It is essential that the wingman or the pilot have the ability to mark the downed pilot's location. It is also essential that RESCAP aircraft and the SAR rescue vehicle be capable of finding the marker.

Radio reliability must be improved such that an availability of 99 percent is achieved, assuming redundant multichannel radios. This requirement includes the battery as an integral part of the radio.

In lieu of visual contact, an improved aircraft ADF and PRC size personal DME transponder are required for precise localization. The DME transponder indicates range to the man through the standard aircraft TACAN. The addition to the aircraft of inverse mode TACAN would provide TACAN bearing information as a backup to the UHF bearing and would be particularly valuable if the downed crewman's UHF radio were inoperative. The desired accuracy of the localization devices is ±20 feet, with ±50 feet being acceptable.

For night search, an IR filter should be supplied for the crewman's strobe light in order to provide a relatively secure means of marking the man's position.

It should be noted that these search and localization requirements can all be fulfilled in a relatively short period of time and, once fulfilled, will improve any SAR vehicle system.

RECOVERY EQUIPMENT. Due to the extreme vulnerability of the SAR rescue vehicle when it is in hover, there is a need for a high-speed hoist. The hoist should be capable of controlled empty cable drop at speeds approaching free-fall and, in the event of poor positioning of the first drop, a controlled high-speed empty retrieval. A variable speed retrieval of up to 400 feet per minute is desirable if safety stops and g-loading limit devices can be added.

In addition to the hoist improvements, there is a requirement for a seat or capsule that can be lowered in folded position through a jungle canopy. The device should then be capable of being unfolded to provide a seat and protection against branch snagging and collision during retrieval.

COMMAND AND CONTROL. As discussed in appendix D, the present SAR alerting process usually starts with the pilot of the stricken aircraft or his wingman transmitting a MAYDAY directly to the RESCAP aircraft or SAR DD. A backup link exists through the E-1A or E-2A, C-130, or PIRAZ. Automatic middleman relay aircraft are used when ranges become extended.

A primary requirement for improvement of the command and control of SAR missions is the reduction of radio traffic on guard channel by the addition or more radio channels to the pilot's personal radios.

A further improvement could be realized by having the senior RESCAP pilot be the SAR Commander rather than someone who is not as close to the actual SAR scene.

All of the foregoing mission requirements are summarized in table 3.

TABLE 3. MISSION REQUIREMENTS SUMMARY

Vehicle		
Speed	200-450 kt	
Radius	200-500 n.mi	
Survivability	Small Arms to SAM	
Crew	3-4 persons	
Rescue	2 persons, space for 4	
Hover	15 min, 3,000 ft OGE/89.6°F.	
Basing	DLG (desired)	
	LPD, LPH, LSD, LST	
	CVS, CVA	
Avionics	**Strike Group SAR, SAR Team**	**Escorted SAR**
TACAN	X	X
IHAS	X	
Terrain-Avoidance Radar	X	
Active ECM	X	
Passive ECM	X	X
UHF	X	X
VHF	X	X
HF	X	
Loud Hailer	X	X
UHF/ADF	X	X
SAR/ADF	X	X
Ground Fire Detector	X	X

TABLE 3. MISSION REQUIREMENTS SUMMARY (Continued)

Armament	Strike Group SAR, SAR Team	Escorted SAR
IR Gunsight	X	X
Twin Turret	X	X
Miscellaneous Search Equipment		
IR Binoculars		
Image Intensifier Scope		
Improved GHD Marker		
Recovery Equipments		
High-Speed Hoist (drop and lift)		
Improved Jungle Penetrator & Protective Pickup Device		
Personal Equipment		
Add TIARA Marker Chutes		
Add IR Shield to Strobe		
Add DME TACAN Beacon		
Improve PRC Radios (quantity 2 per pilot) as to:		
1. Reliability (Availability to 0.99, including battery)		
2. Coded		
3. Multichannel		
4. Size		
5. Battery life		

AIRCRAFT ANALYSIS

A performance analysis of candidate SAR aircraft capable of an operational status within a 3-year period was performed by the Naval Air Systems Command. The time frame essentially restricts the vehicles considered to (1) those presently in a flight status, (2) experimental prototypes, or (3) modifications thereto. SAR adaptations of vehicles listed in table 4 were evaluated on the basis of data informally submitted by airframe contractors. The vehicles may be categorized as pure helicopters, compound helicopters,* tilt-wing, ducted fan, and fan-in-wing types.

TABLE 4. SAR VEHICLE ANALYSIS

Pure Helicopters	Compounds	Tilt-Wings	Others
AH-1G	UH-2	CL-84	X-22
CH-46	AH-56	XC-142	XV-5A
	16H		
	SH-3D		
	NH-3		
	CH-53		

SAR equipment loading for the combat SAR aircraft established in appendix F provides for day/night operations with nominal firepower. Avionics and armament weights set stringent performance requirements on the smaller aircraft configurations.

The doppler navigation equipment, IHAS, is sufficiently developed to provide the navigation accuracy required for the mission within 3 years. IHAS has the potential for integrating terrain-avoidance radar and automatic approach and hover equipment, without which the over-land night/all-weather SAR mission becomes extremely hazardous.

Developmental work is necessary to refine automatic approach to and hover over a specific spot. As noted in appendix G, approaches to this problem could include specialized beacons on the ground or development of equipment to maintain hover over a light source. Research should be initiated to provide a capability without delay.

*Modified to compound SAR versions from existing configurations indicated in table 4.

Appendix E concludes that suppressive fire is the most effective protection for the rescue vehicle while in a hover mode. Both 20mm and 30mm aircraft turrets are under development by industry for the Marines and Army for various helicopters. These weapons provide the maximum "standoff" capability with greatest projectile kill potential. Furthermore, 7.62mm MINIGUNS, firing up to 4,000 rounds per minute, are considered acceptable for the rescue mission, particularly for the rescue vehicle in the SAR Team concept. In conjunction with the aircraft turrets, ground fire detection equipment has been proposed that will automatically train the turret to oppose the greatest detectable threat to the vehicle. This lightweight equipment, coupled with an infrared fine-sighting device, provides a rapid response to hostile small-arms fire.

The performance analysis was conducted with a baseline mission of 200 n. mi. radius and 5,000 feet enroute altitude, and a 15 minute hover at 3,000 feet/89.6°F to pick up two rescuees.

The mission requirements as derived in the study establish a 200-knot speed and a minimum radius of 200 nautical miles.

Appendix F, figure F-1b presents the radius of action of those aircraft that can sustain at least 200 knots. Of these, only the CL-84, AH-56, and XC-142 reach and exceed the 200-n. mi. radius of action when configured with the desired avionics and armament (1,962 lb).

The XC-142, as noted in appendix F, is approximately double the size and weight of the CL-84 but with less speed and little gain in radius.

The AH-56 and the CL-84 meet the minimum mission requirements and provide the maximum gain in combat SAR capability within the next 3 years. A comparative appraisal of these vehicles as combat SAR aircraft is outlined in table 5. The performance reflects best estimates, subject to further verification and analysis.

TABLE 5. APPRAISAL OF COMBAT SAR VEHICLES

	Tilt Wing (CL-84)	Compound (AH-56)
Systems Requirements		
Detection/Location	=	=
Survivability:		
Enroute	x	
Hover	=	=
Time Late	x	
Firepower		x
Mission Adaptability		
Strike Group SAR	x	
SAR Team		x
Operational Factors		
Rescue Capability:		
Hover/Pickup		x
Air Snatch	x	
Shipboard Basing:		
Weight	=	=
Size	x	
Night Capability		x
Cost		x

The aircraft analysis represents a broad assessment of the performance and characteristics of VTOL designs in meeting combat SAR mission requirements in the next 3 years.

The CL-84 and the AH-56 versions in particular offer improvements in combat SAR. A competition evaluation of these types is recommended, including detailed appraisal of survivability, firepower capabilities, and maintainability.

CONCLUSIONS AND RECOMMENDATIONS

The most important conclusions of the combat SAR study are as follows:

1. Significant improvements in combat SAR can be attained in a 3-year period. The potential for improvement has been shown to exist in the day over-land and night rescue missions. The improvement can be accomplished by:

a. Increasing the success factor for search and localization by modification and addition of special avionic equipments.

b. Using a faster and less vulnerable rescue vehicle.

c. Improving SAR tactics to take advantage of vehicle improvements.

d. Improving rescue equipments.

e. Providing MIGCAP.

f. Increasing suppressive fire support capability.

2. Reliable detection and localization offer the greatest gains. An analysis of the Navy over-land incidents has shown that lack of search success is the principal contributor to rescue mission failure. A high

probability of detection and localization is essential for successful SAR. Improvements or additions are required in three areas:

a. Procedures and devices for marking the rescue datum.

b. Aircraft avionics and night equipments.

c. Increased reliability of radios and other personal survival equipments.

3. Two aircraft designs - tilt-wing (CL-84) and compound helicopter (AH-56) - meet minimum mission requirements for combat SAR. The study considers these aircraft as the ones that can best meet the following mission requirements within the 3-year time frame:

a. 200-n.mi range at greater than 200 knots.

b. 15-minute hover time with an avionics/armament payload of appromately 2,000 pounds.

c. Recovery of two aircrewmen.

d. Adequate armor and armament for survivability in the environment.

4. The CL-84 tilt-wing aircraft offers the greatest combat rescue flexibility and potential. Furthermore, it comes closest to achieving a Strike Force SAR capability and is compatible with the "air snatch" technique. The CL-84, operating with the SAR Team, has the advantage of higher speeds (350 kt) and is thus more compatible with MIGCAP and additional jet RESCAP aircraft. The compound (AH-56) is well suited for the SAR Team by virtue of its 215-knot speed and firepower, but it cannot function with the Strike Group SAR due to the difference in speed.

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5. Air snatch is the only feasible rescue method in heavily defended areas. Although the technique has been demonstrated under ideal conditions, considerable development and operational evaluation are required.

6. Recovery success relates directly to the amount of time the pilot can remain with his aircraft after it is hit. This time has a high correlation with whether or not the hit caused an aircraft fire. If the aircraft is on fire, the pilot frequently must egress near the area where he was hit and therefore is usually captured. If the aircraft is not on fire, the pilot generally heads his aircraft toward a safe area such as the Gulf of Tonkin. If he makes it to a safe haven, the statistics show that the pilot has a high probability of recovery.

7. Vulnerability limits capabilities of current SAR vehicles such as the SH-3. This is readily shown by the large number of times that the rescue vehicle cannot or does not penetrate to make a rescue. Slow speeds, lack of adequate navigation and avionics equipments, and lack of sufficient suppressive firepower limit their ability to penetrate the heavy enemy defenses.

8. Preferred SAR basing would be a DLG or landing-type ship. Addition of the combat SAR splinter group to CVA/CVS deck loads will correspondingly reduce the strike aircraft loading and should be considered as desirable only for the Strike Group SAR concept. Assignment of landing ships to the combat SAR support mission requires the minimum ship modifications.

9. A night over-land SAR capability does not exist at present. To provide such capability, the SAR vehicle needs the ability to avoid terrain while navigating accurately without external reference, and to hover over jungle canopy without the use of visible light.

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On the basis of the previously established conclusions, the following recommendations are made.

1. Develop and improve the following detection and localization equipments:

   a. TACAN beacon

   b. ADF

   c. Markers

   d. Radios

   e. Night viewing and signaling devices

2. Conduct a competitive evaluation of CL-84 and AH-56 combat SAR aircraft designs. This evaluation should include performance, maintainability, survivability, armament, and program costs.

3. Continue air snatch developments and methods for extending air chute time to improve SAR capability over heavily defended areas.

4. Develop SAR aircraft navigation, approach, and hover equipments for night over-land rescue to permit automatic transition-to-hover over a rescue beacon or rescuee.

5. The following suppressive fire capability should be provided as a minimum:

   a. 20mm turrets to provide the maximum suppressive fire for the escort vehicles.

   b. 7.62mm MINIGUN turrets for maximum volume of fire on the rescue vehicle.

6. Develop a ground fire (small arms) detection system.

7. Finally, continue analysis of SEAsia combat SAR data to ascertain new trends or problem areas and provide a means of evaluating SAR improvements.

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