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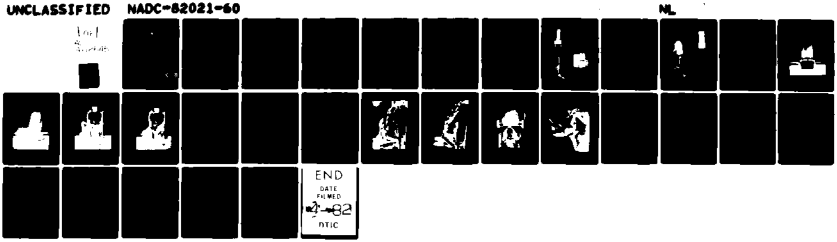

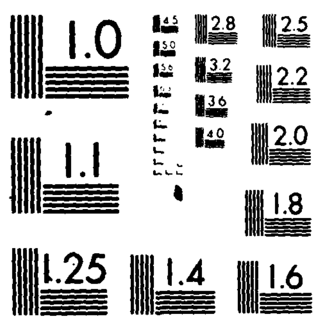

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CURRENT ADM RESTRAINT SYSTEM STATUS TRADE-OFF CONSTRAINTS AND LONG RANGE OBJECTIVES FOR THE MAXIMUM PERFORMANCE EJECTION SYSTEM (MPES)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents the restraint sub-system design options which were investigated for possible incorporation on the Navy Maximum Performance Ejection System (MPES). This study focused mainly on three on-going development items for the advanced development model (ADM), but also considered some longer range objectives whhich address future requirements and anticipated technology developments which are necessary for a more comprehensive restraint package.

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INTRODUCTION

At the present time there are three on-going restraint sub-system elements under development and one existing technology item which combine to meet the requirements of the MPES II ADM. These limited requirements are in accordance with existing and proposed escape system specifications and within the unique operating goals of the MPES seat. This study will focus mainly on the three on-going developmental items for the current ADM; however, the study will itemize some longer range objectives for a more comprehensive restraint package.

CURRENT ADM RESTRAINT SYSTEM REQUIREMENTS

The following is a list of restraint sub-system items and functions which were targeted for incorporation and demonstration on the current ADM system.

- Upper Torso Haulback Upon Ejection Initiation
- Automatic Lap Belt Tightening and Seat Man Separation System
- Seat Mounted Restraint/Parachute Harness
- Single Point Harness Release
- Negative 'G' Provision
- High-Speed Ejection Limb Protection System

When existing technology items and the three developmental items are combined, the following ADM requirements are met:

1. Lap Belt Retraction/Release and Strap Cutter Assembly
2. High Speed Ejection Limb Protection System
3. European Type (Alpha Jet) Seat Mounted Restraint/ Parachute Harness
4. Ballistic Inertia Reel

TRADE-OFF STUDY OBJECTIVES

1. Describe operational requirements and/or deficiencies
2. Determination of options available, if any, and advantages and disadvantages
3. Status of options
4. Technical Risks:
   technological, size, weight and cost etc.

SUBSYSTEM HARDWARE ITEMS

AUTOMATIC LAP BELT RETRACTION/RELEASE AND INERTIA REEL STRAP CUTTER

Operational Requirement/Deficiency

Past and continuous reviews of accident reports has made it clear that there often is insufficient lap belt tension during the flight and during onset of ejecting forces. Crewmembers either do not cinch the lap belt tight enough during ingress or loosen it later for comfort and desired mobility. The following consequences can result when ejecting with a loose lap belt.

1. Submarine effect (pelvis rotates under lap belt) may result which;

   a. compounds existing spinal alignment problems, increasing probability and severity of spinal injury
   b. can lead to foot-cockpit contact
   c. degrades critical seat-man c.g. alignment which then degrades seat performance

2. Can induce limb flail at low speeds

3. The existing slack problem becomes more unfavorable with the MA-2 Harness since crewmembers often are improperly fitted and/or adjusted.

4. May permit hazardous interfacing of the seat survival kit with the harness following ejection, allowing it to hang low and swing uncontrollably beneath the crewmember, striking him behind the legs or in the lower back during seat-man separation and parachute opening.

MIL-S-18471G(AS) states that "the torso restraint shall provide adequate protection for preventing submarining of the lower torso during ejection. Powered lower torso restraint mechanisms may be used to insure adequacy of lower torso restraint during ejection.

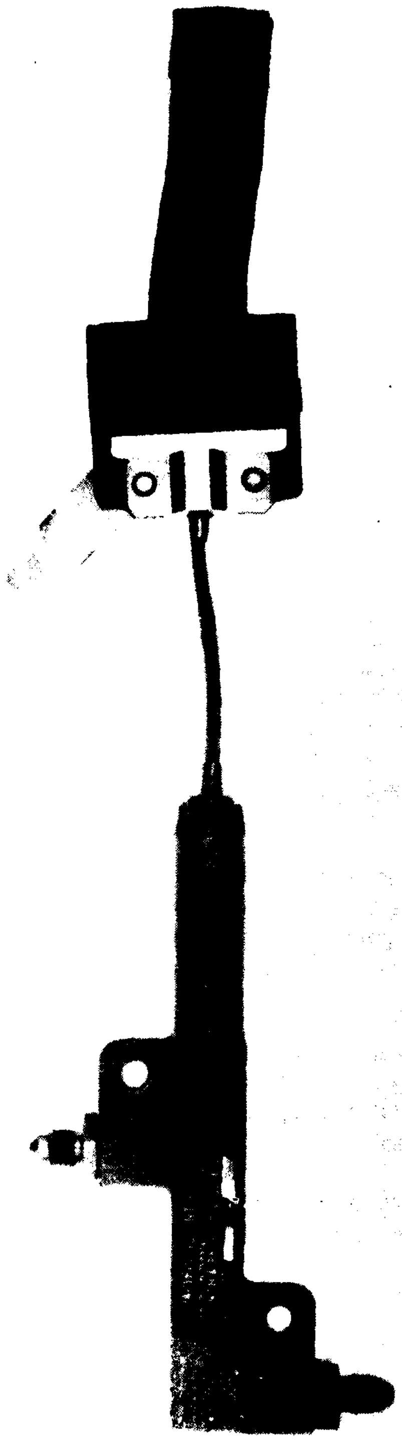
Options

1. NADC initiated cinch and release assembly development (figure 1) constitutes the only known effort to provide an automatic lap belt tensioning and release device mechanism for ejection seat application. Due to past constraints of time and funding, no alternative concepts were investigated. The lap belt end point, which is attached directly into the seat structure rather than the seat kit, is a unique application concept for MPES usage.

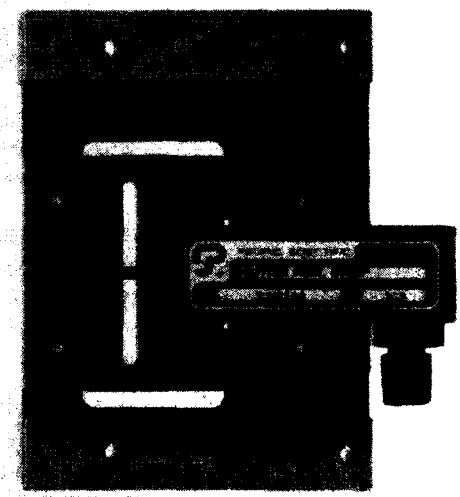
It was proposed in the past, that lap belt shorteners be inserted in the lap belt between the seat kit and the harness attachment fitting. These devices were proposed with the understanding that a separate release mechanism was in existence on the seat. These devices excessively reduced the lap belt adjustment capability, they were bulky and required a protechnic actuation method which also had to be disconnected during seat/man separation.

The current device being developed for the ADM is the only one which provides both the retraction and release function required on the MPES seat.

2. If it was desirable to delete the automatic lap belt cinch capability from the ADM, it would still be necessary to provide a lap belt release mechanism for seat-man separation.



A. Fixed Aluminum Housing - Crash Load Limit - 2,800 lb



B. Inertia Reel Strap Cutter

Figure 1. Lap Belt Retractor and Strap Cutter

3. In addition to the automatic retraction and release of the lap belt, the system also provides a means for severing the inertia reel straps. The same protechnic cartridge simultaneously releases the lap belt and fires the strap cutter. Elimination of the retraction phase would have no effect on the release function.

The mechanism could easily be redesigned to provide for the release function only. This would significantly reduce size, weight, cost and complexity of the unit as well as eliminating one protechnic device and associated plumbing.

Future development efforts with a seat mounted harness incorporating an inflatable bladder may significantly reduce or eliminate the consequences of ejecting with a loose lap belt, thus eliminating the justification for the belt retractor function.

Status of Lap Belt Retractor/Release

The 6.2 Exploratory Development effort consisting of determining functional requirements, building experimental hardware and conducting DT-I-A evaluations have been completed and reported in Report No. NADC-79270-60. Improved feasibility hardware, meeting all the crash load requirements, is currently undergoing additional testing.

Additional investigations are on-going to improve system design features, and to simplify and optimize the mounting configuration and belt adjusters.

The current mounting configurations of the cincher device (figure 2A) has been evaluated and found to be unacceptable. Due to the width of the MPES II seat bucket, the retractors, which are mounted on the outboard side of the seat bucket, are approximately 21 inches between center lines. Previous MPES seat prototypes were approximately 18 inches between center lines, and at best provided marginal lateral restraint. If is necessary that the retractor/release assembly be installed on the inside surface of the seat bucket sides to insure an acceptable degree of restraint. This will also simplify and shorten the routing of the energy transmission lines, reduce the overall width of the seat envelope and improve the seat-man separation function.

This will, however require a redesign (figure 2B) of the system housing but will have no effect on the internal mechanisms and may in fact improve overall system performance since the line of action of the retract/release device will be more in line with the position of the lap belt.

Technical Risks

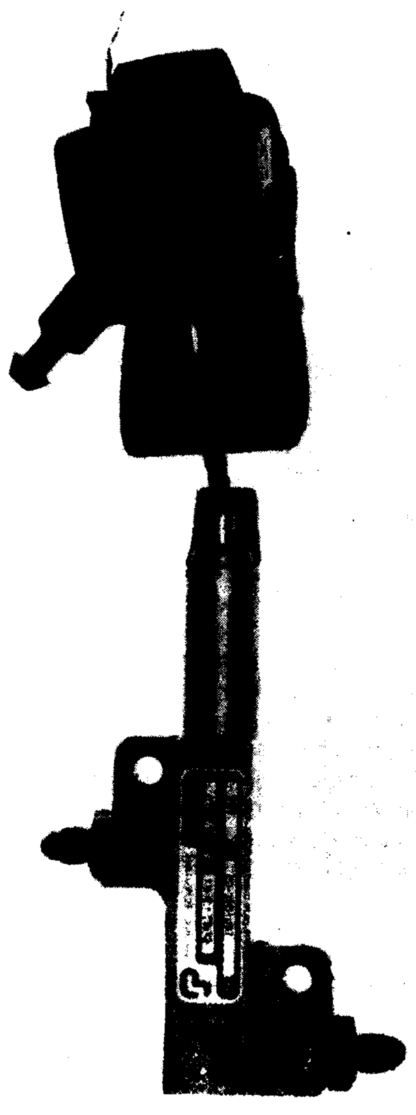
1. The technical risks for successfully developing and demonstrating this device through the 6.4 process with the MPES seat are minimal. Current engineering capabilities and technology can insure a safe and reliable system for use with the MPES seat. Existing problems with the retractor release function have been identified and can be resolved.

The pyrotechnic devices are qualified on other existing inertia reels which are currently operational and the Navy is also currently manufacturing a replacement cartridge for qualification.

2. Unit size, weight and cost

a. Size

The current system size is approaching the most functional design allowable and is considered within practical and reasonable limits. However, the external hardware shape will vary on advanced development models due to changes in the mounting arrangement.



A. Fixed Steel Retractor Housing - Crash Load Limit - 5,000 lb

B. NADC Designed Rotatable Aluminum Housing - Crash Load Limit - 5,000 lb

Figure 2. Fixed and Rotatable Retractors

The length of the retractors will remain essentially the same. The length of the retractor is determined by the desired stroking distance.

b. Cost

One complete ship set of the lap belt retraction/release and strap cutter assembly in 100 lot purchases at current FY money will be approximately $1,500.00

c. Weight (Ship set)

	lb.
2 - Retractors 1.75 each	3.50
1 - Strap	1.00
2 - Pyrotechnics 0.5 each	1.00
Plumbing Fittings	0.50
	6.00 lb.

Considering escape system safety improvements and MPES goals, the size, weight and cost are within acceptable limits.

HI-Q EJECTION LIMB PROTECTION

Operational Requirement/Deficiency

Continuous review of ejection injury data over the past 6 years and the combat injury statistics that have emerged from the Viet Nam conflict, has made it clear that a limb restraint system is necessary. The limb restraint system would provide aircrewmen with a limb protection system which would prevent flail injury (especially above 400 knots where the probability of injury increases rapidly). At lower speeds, limb dislodgement can be induced by other factors in addition to windblast deceleration such as the shock loads of stabilizing drogues.

Also, the unique performance capability of the MPES ejection seat, namely the vertical seeking capability, will result in rotational forces which may induce limb flail at any speed. Once the limbs become dislodged beyond the envelope of the seat restrictions crewmen become susceptible to injury from rearward contact of the seat structure, or from extreme extension of the limb joints themselves. Another consequence of limb flail is the effect on the usual critical seat/man c.g. location during rocket burn, which in turn degrades seat performance. Therefore, the basic requirement is to provide a limb restraint system which will: (1) prevent limb dislodgement during exposure to aerodynamic/deceleration forces especially during high-speed ejection and during periods of seat correction maneuvers; (2) assure that the crewmember will be left in a condition which will allow him to execute proper survival procedures and/or proper escape and evasion tactics following ejection. The official requirement for limb restraint is specified in MIL-S-18471 (AS).

Options

1. The current development of the NADC initiated Hi-'Q' limb protection system (figure 3 to 6) has been directed specifically for incorporation and demonstration on the MPES ejection seat. At the time of program initiation, there were no known systems either available or proposed which met the basic requirement for a totally passive system. As a result NADC prepared the specific MPES seat/hardware integration requirements, the basic system operational/performance requirements and solicited proposals for investigation and feasibility prototyping.

The system that was finally selected for experimental evaluation was based on a careful review of a limited number (3) of acceptable responses which were in accordance with NADC's Statement of Work. Because of usual limited available funding in the 6.2 category, no alternative systems or techniques were concurrently investigated.

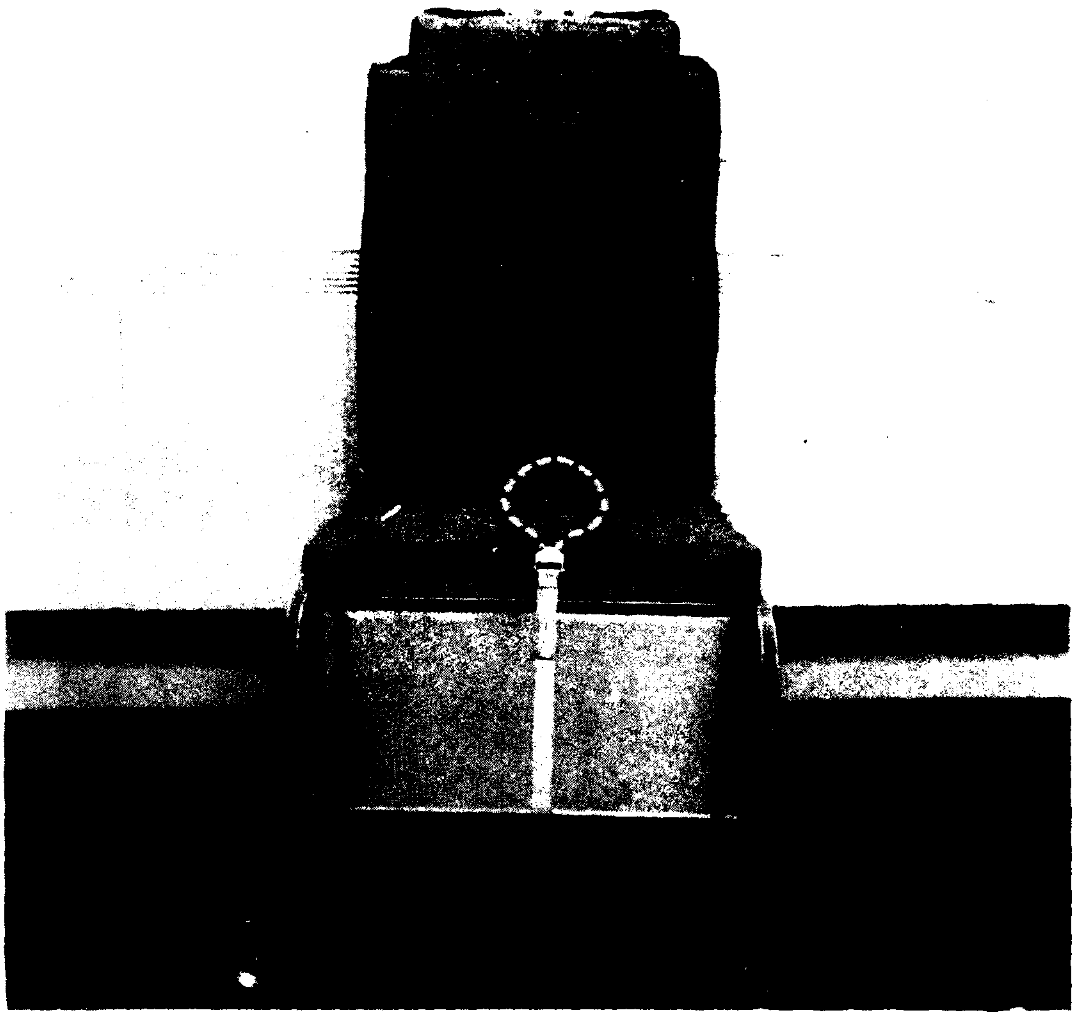


Figure 3. Hi 'Q' Restraint System-Stowed Condition-Front View

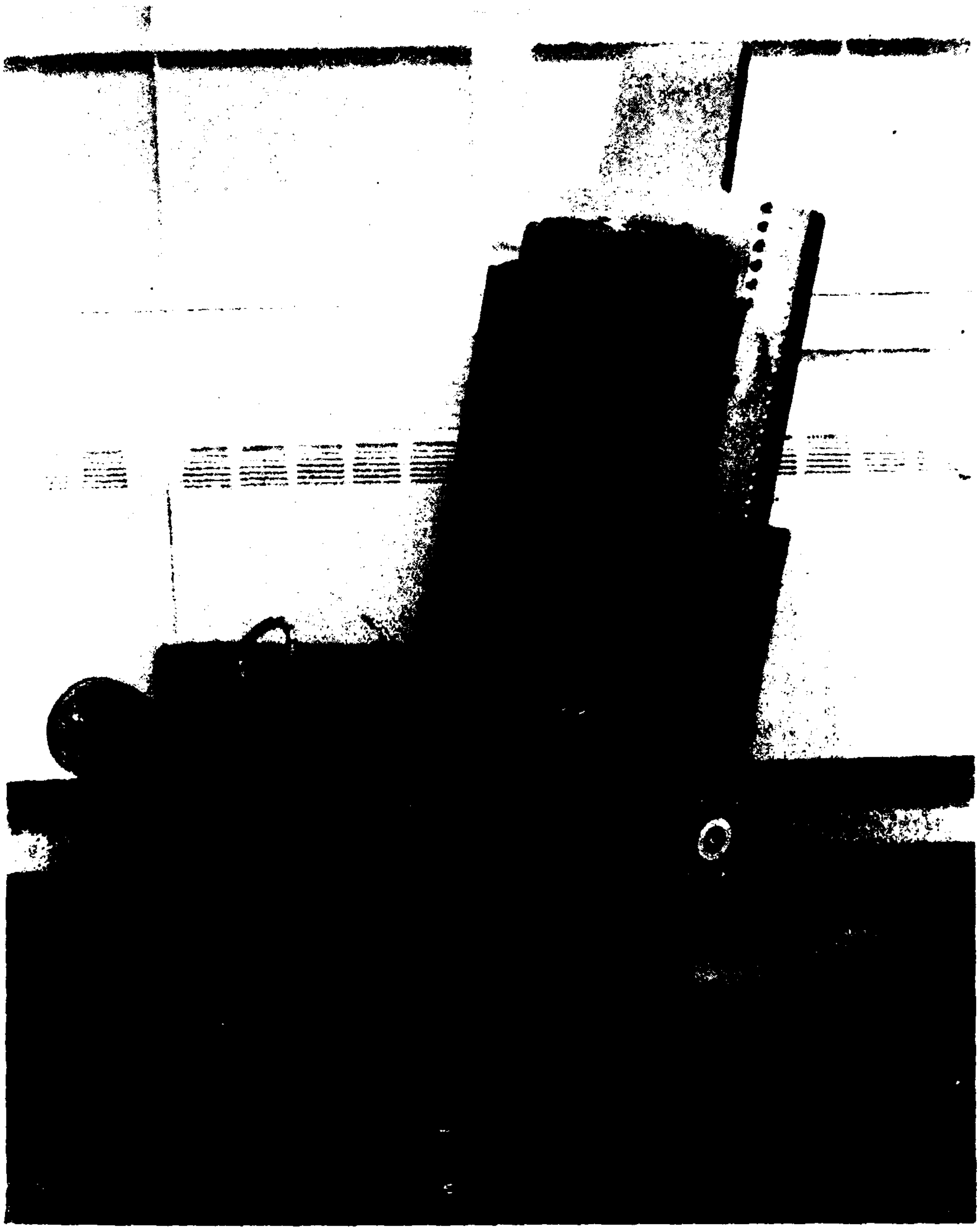


Figure 4. Hi 'Q' Restraint System Stowed – Side View

Figure 5. Hi 'Q' Restraint - Deployed Condition

Figure 6 Hi 'Q' Restraint - After Cinch Up Action

2. There are however other systems, some operational by foreign governments, and some proposed locally, which do provide for arm or leg restraint — but are not passive. They require special garments and/or straps which must be either worn and/or attached upon ingress. The disadvantages of these types of systems are:

Additional preflight preparation
Additional garments must be worn
Added discomfort of bulk and heat
Increased logistic requirements
Susceptible to damage and loss
Possible special sizing requirements
Additional gear for crewmember to carry and stow
Possibility of improper hook-up
Additional ingress attachment requirements
Possibility that the system may purposely not be utilized by the crewmember

3. The requirement for a "passive" system is not prescribed in the general specification for ejection seats. This, however, does not preclude the general recommendation for its incorporation after reviewing the disadvantages of not having this feature. If the requirement for a passive system are proven to be technically unfeasible, other techniques can rapidly be developed which could still meet the general specifications.

Status of Hi-'Q' Ejection Limb Protection System

The Hi-'Q' Ejection Limb Protection System is currently in the 6.2 exploratory development phase which is scheduled for completion at the end of FY-81. At this time, a fully functional feasibility prototype (breadboard) model has been fabricated, delivered and currently undergoing DT-I-A test and evaluation. This will include static deployment testing, windblast testing, and ejection tower testing; also, a safety, compatibility, and user acceptability evaluation. This testing should be completed by the end of FY-81. DT-I-B testing will be conducted during FY-82 and will include in-cockpit turbulence deployment testing and a 250-knot sled test.

Following completion of all the DT-I tesing, sufficient data should be available to fabricate an advanced development model with all the improvements as recommended from the DT-I-A and B evaluation. This will optimize form, fit and function. This advanced system will then initiate DT-II testing, which will primarily consist of full functional testing in the operational environment such as deployment and cinch up in an open cockpit in the 400- to 600-knot speed range. At this stage of development and validation, these tests are considered the most critical and will determine if the system is suitable for Engineering Development.

Technical Risk

1. Current technology in inflatable devices and pyrotechnics are a low risk subelement of the development of the Hi-'Q' limb protection system. The risk is in the implementation of the system to function in the operational environment. The system will be required to deploy and cinch up during periods of adverse attitudes and flight conditions. The effects of in-cockpit turbulence and multidirectional acceleration forces acting on the system during actuation have not yet been assessed, but they are viewed as conditions which will have an effect on system operation. Use of these types of systems in these kinds of applications are new and do generate a moderate risk of meeting prescribed reliability requirements. This aspect will be addressed throughout the advanced development phase.

The fabrication requirements are well within the current state-of-the-art. Inflatable bladders can be built to withstand the expected working pressures of 40 psi and are capable of generating response times well within the 100 milliseconds required to full deployment.

2. Unit Size, Weight and Cost

a. Size

The overall size of the installed configuration of the Hi-'Q' restraint system is entirely within the envelope of the seat structure. The stowed parts of the system are packaged in a way which actually provides back and thigh support for the crewmember. Reducing the size of the current model would be of no benefit regarding system operation or stowage. Space allocations on the seat for this system are also sufficient for all the necessary plumbing and pyrotechnic devices.

b. Weight

One complete installed system including plumbing and gas generators will be 12 pounds.

c. Cost

One complete ship set if purchased in lots of 500 is estimated at $850.00 in FY-81 dollars.

When considering the significant anticipated improvements in crewmember safety, the size, weight and cost are well within the acceptable limits for this subsystem if this system becomes operational. The probability of flail injury at 400 knots is approximately 50 percent. Reduction of that injury rate alone will provide a significant savings in terms of medical expenses and for replacement of disabled aviators.

Ejection at 600 knots and above currently has a 100 percent chance of injury and a high incidence of fatality. Improvement in these statistics will be highly significant with the estimated replacement cost of 1.5 million per aviator fatality.

With an average cost of 40 K. for current technology ejection seats, incorporation of a Hi-'Q' ejection seat constitutes approximately 2 percent of that cost.

Summary

- High speed limb protection is specified in MIL-S-18471(AS) and is identified as a requirement for meeting one of the restraint performance objectives of the MPES program.
- A totally passive restraint system is recommended.
- Inflatable bladders and pyrotechnic devices are considered very low risk technology.
- A moderate risk exists in the implementation of the system to function in the total spectrum of the operational environment, and further evaluation is planned during FY-82 and prior to advanced development.
- Unit size, weight and cost are considered within acceptable limits.

SEAT MOUNTED RESTRAINT/PARACHUTE HARNESS

Operational Requirement/Deficiency

Inadequate aircrew restraint has long been cited as a factor in numerous in-flight emergencies and has also been responsible for resulting in the loss of numerous aircraft, especially under adverse flight conditions. Since the introduction of the MA-2 Integrated Torso Harness in the mid-fifties, it has been used almost exclusively on all Navy ejection seats. It has been reported that the MA-2 harness has been unable to provide adequate restraint against the multidirectional acceleration forces experienced during controlled and uncontrolled flight. The current restraint does not adequately retain the pilot in a position which enables him to reach and maintain sufficient grasp of flight controls duing departures, spins, air combat maneuvers and various aerobatic maneuvers, nor does it allow him to reach and activate emergency devices. The same poor restraint also increases the probability of ejection injury.

Options

There are currently a number of different parachute/restraint harnesses availabe (some operational in foreign aircraft) for evaluation as a candidate replacment for the MA-2 harness. Some of the more obvious disadvantages of the MA-2 harness are as follows:

1. The 15 different sizes require each crewmember to be specially fitted since limited adjustment capability may not provide optimum fit. Also, on oversized MA-2 harnesses there will result excessive slack which contributes to the overall restraint problems during flight ejection.

2. The need to have harnesses for each crewmember instead of each seat is much more costly and requires a larger supply and logistics problem.

3. Physical discomfort due to the need to wear it prior to ingress which contributes to heat problems.

4. Considered bulky, especially in the confines of an aircraft cockpit.

5. The need for stowage when not in use and the potential for damage and wear from the additional handling required.

6. Does not provide for single point release nor is it readily adaptable for such use.

7. Does not provide for a tie-down strap for negative 'g' restraint.

8. In most cases, the summer/winter flight clothing requirements necessitates that each crewmember maintain two different harnesses which adds to the total logistic and supply costs.

One of the available candidate harnesses which meet the requirements specified for the MPES seat is a European type SMR parachute/restraint system (figures 7 to 10) which is currently operational on the Alpha Jet aircraft. This is a seat mounted parachute/restraint harness which incorporates a single point release and a negative 'g' strap. Use of a seat mounted harness will alleviate all eight deficiencies listed above. In addition, the single point release function for normal ingress and egress will also be used for the emergency egress mode and will not be unfamiliar to the crewmember as would an additional emergency handle.

Figure 7. Seat Mounted Restraint 3/4 View

Figure 8. Seat Mounted Restraint - Side View

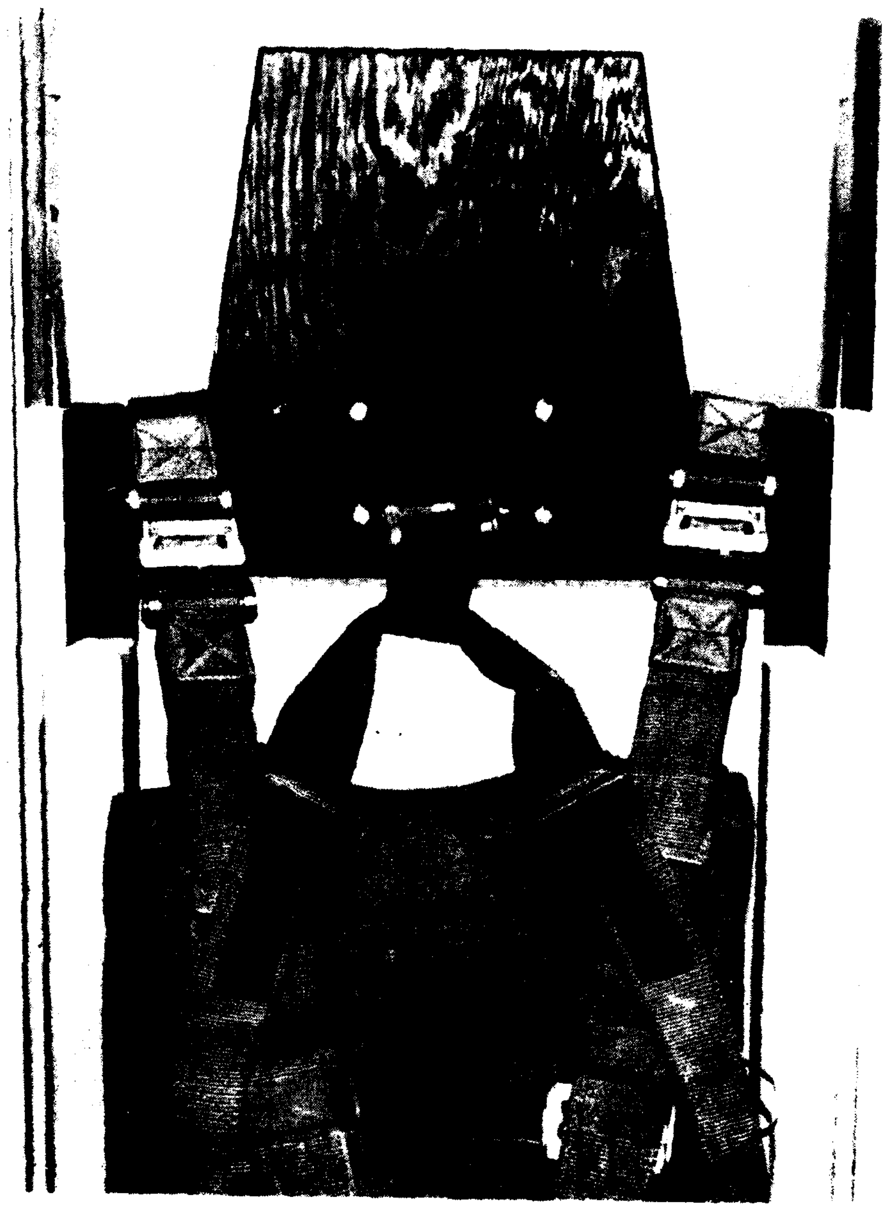


Figure 9. Seat Mounted Restraint -- Upper Connections

Figure 10. Seat Mounted Restraint - Center Buckle Arrangement

The prime consideration for selection of this system in lieu of the MA-2, must be in its performance in the operational environment. If it can be shown that the Seat Mounted Restraint (SMR) system performs better than, or as well as, the MA-2 in the same flight and ejection regimes, then together with the additional advantages listed above this would be sufficient justification for its incorporation as a candidate system for MPES. The final trade-off criteria will then depend on the technical risk, which is addressed below.

Status of Options

Two independent evaluations of the SMR harness are currently in progress. One evaluation is directed towards the modification and integration of the system with the MPES seat and its compatibility with other restraint sub-systems such as the lap belt retractors and the High Speed Ejection Limb Protection (HELP) system. To date, this system appears to be adaptable and compatible with the MPES configuration with some slight modifications to the harness. It also appears to be more compatible for use with the MPES back pack survival kit than the MA-2 harness. This evaluation will also test the seat man separation system function, utilizing the lap belt retractors, inertia reel, Hi-'Q' limb protection system and the backpack survival kit. Finally, these tests will include simulated opening parachute shock load tests which will examine the dynamic effects such as structural integrity of straps and attachment hardware, adjuster slippage, system slack, back pack retention, final location of parachute attach/disconnect fitting, and finally post test actuation of single point release hardware.

The second evaluation is a comparative evaluation with the MA-2 as a base line and will consist of:

Ingress/egress evaluation
Emergency egress evaluation
Aircrew comfort/mobility evaluation
1 'g' pitch evaluation
Life support equipment compatibility evaluation
Centrifuge testing
Flight testing

These studies are scheduled for completion in July, 1982.

System integration requirements are currently being developed and improved prototype for the MPES seat will be fabricated in FY 82 for additional test and evaluation.

In addition to the European type harness, an MA-2 harness is being modified for inclusion in this second evaluation.

Although this modified MA-2 will not address the eight deficiencies listed above, it is anticipated that some improvement will be obtained in the in-flight regimes regarding negative 'g' and off-seat displacement due to multidirectional acceleration forces.

The status of all efforts in parachute/restraint harness will be closely monitored; however, emphasis will be placed on the serviceability of the European type seat mounted harness currently being modified for incorporation with the MPES seat.

Technical Risk

The technical risk for successfully adapting and demonstrating a seat mounted parachute/ restraint harness must be reviewed in relationship to the overall MPES program. In this instance there is an existing operational parachute/restraint available within the Navy. This is not the same for either the lap belt retractor or Hi-'Q' limb restraint requirements.

Despite cited deficiencies, the MA-2 integrated torso harness is available for use with the MPES seat. Therefore, continued development of the seat mounted harness (Alpha Jet Type) for adaptation and demonstration on the MPES seat will not impose a significant penalty to the overall developmental goals of the program if it does not prove to be totally feasible.

The potential for acceptance of a seat mounted harness as an improvement to current operational systems (which is the objective of the MPES technology efforts) will depend upon the results of the comparative test evaluation currently in progress, and also upon additional factors such as cost and weight discussed below.

1. Cost, Weight and Size

a. Cost

The cost comparison listed below is a breakdown of the individual items.

Seat Mounted Restraint	$	MA-2	$
Basic Harness	550.0	Basic Harness	120.0
Release Buckle & Fittings	150.0	2 Male Maxi-Kochs	102.0
2 Male Maxi-Kochs	102.0	2 Female Maxi-Kochs	342.0
2 Female Maxi-Kochs	342.0	2 Male Mini-Kocks	76.0
		2 Female Mini-Kochs	402.0
Total	1,144.0		1,042.0

Although the cost of the seat mounted restraint, as currently configured, is slightly higher per unit cost, it is not significant.

An enormous cost savings will be realized if the system is acquired because only one system will be required for each seat instead of two systems for each pilot. Also, it is anticipated that replacement frequency will be less because it will require less handling and will not be subjected to mistreatment due to stowage or to loss; therefore, the system is economically feasible.

b. Weight and Size

With the seat-mounted restraint in its current configuration, the harness weighs 6 pounds. With anticipated modifications to the harness, the system will be slightly less than 6 pounds.

The MA-2 Harness, without either the female maxi or mini Koch fittings attached, to the harness, they should be included as part of the weight penalty since they are required to complete the restraint system and are supported by the torso during flight. This will add approximately another 1 pound to the system for a total of 5 pounds. The weight difference is therefore insignificant.

When both systems are worn by the crewmember, the total body area encompassed by the MA-2 is greater because of the fabric material supporting the actual restraint. This extra fabric material can and has been removed in some commands. This material does help in making it easier to don the harness, but does increase bulk and heat.

The seat mounted harness does contain a single point attachment buckle which is positioned in the abdominal area and does increase bulk at that point. This configuration has been applied before and is operational on foreign aircraft with no degradation on comfort and mobility. The weight and size comparison of the two systems over-all does appear reasonably similar.

<u>Summary</u>

- A seat mounted restraint is the recommended type for the MPES program.

- Comparative restraint performance between the SMR and MA-2 should justify selection of the SMR.

- Continued development of the SMR for adaption and demonstration on the MPES seat will pose no risk to the overall goals of the program. It is anticipated that the comparative evaluation will show equal or improved performance.

- Cost and weight are comparable on a unit basis, but the SMR will result in large savings as a fleet wide item.

LONG RANGE OBJECTIVES

INTRODUCTION

The projected integrated restraint system for the engineering model of the MPES seat will consider all phases of pilot activity. This includes:

Preflight and Ingress
Inflight
Ejection
Post Ejection
Parachute Deployment and Descent
Emergency Manual Egress

As previously mentioned, some of the technology needed to address the above elements are currently under development and in various stages of investigation. Also, additional perceived deficiencies will be outlined to provide the rationale for the proposed MPES integrated restraint system.

PREFLIGHT AND INGRESS

1. The inconvenience of the MA-2 harness and operational problems have previously been pointed out in the section titled "TRADE-OFF STUDY OBJECTIVES" and selection of a seat-mounted type harness has been determinea to be the best alternative.

2. Interface Requirements of SMR

The seat mounted harness must interface with the following:

Inertia reel straps
Lap belt retractors
Parachute attachment
Backpack survival kit
Life preserver
Oxygen hose, if required
Survival vest, if required

3. Areas to be Investigated

a. Investigation and development of how the back pack will interface with the seat mounted harness is currently on-going. Issues to be resolved are:

1. How the pack will be attached to the harness
2. How it will interface with the crewmember, position wise
3. What will be the effect, both structurally and for injury potential during ejection, seat-man separation, parachute opening shock, water entry and accessibility.

b. Investigate the interface of the SMR with the survival equipment.

1. Will a survival vest be required with MPES?
2. Will flotation equipment connect to the main harness?
3. What new developments could impact the restraint configuration?

c. Determine whether or not an oxygen hose connection is required on the SMR.

d. Investigate the requirement for a lift ring on the harness for helicopter rescue.

e. Determine how the inertia reel straps will connect to the harness.

f. Determine maintenance provisions to allow for removal of interfacing hardware such as the back pack survival kit, parachute, inertia reel, etc. without the necessity to disassemble major components or remove them from the seat.

INFLIGHT SITUATION

1. Problem

It has been determined that approximately 50 percent of Navy pilots have been subjected to destabilization and uncontrolled flight. During such conditions, the pilot may be so severly jostled or subjected to an accelerating environment that forces him away from the seat that he will be unable to control the aircraft, and he may be forced to eject (if he can) with his body in an unfavorable position, or he will be carried down to a crash situation. The pilots effort to overcome destabilization with current equipment is likely to be defeated and critical time and altitude is usually wasted before the decision is made to eject.

In addition, it has been reported that crewmembers find themselves subjected to slow build-up of acceleration in the -GX direction (2g) while flying unlocked, which allows forward displacement of the torso away from the seat back. This has resulted in the crewmember being far enough off the seat back during a sudden departure and unable to get back, resulting in an uncontrolled situation. Finally, there have been situations in which the aircraft is experiencing greater than 3 'g's, while the crewmember is "fighting it" but allowing him to move forward at a rate just below where the reel would lock at the rate sensitive limit; once again putting him off the seat back far enough to cause an in-flight emergency.

2. Proposed Solution

The MPES escape system will provide aircrewman with the capability of a manually actuated recyclicable inertia reel which will provide in-flight positioning and restraint of the upper torso which will enhance the pilots ability to control the aircraft during adverse maneuvers, buffering or turbulent conditions or during periods of uncontrolled flight, especially when the pilot is initially unrestrained at the onset of departure.

The system will be capable of fully retracting a 98th percentile torso against a 7 'g' opposing force in 0.7 seconds through the action of a single inertia reel handle mounted on the seat. After stable flight has been obtained, the system can be immediately vented to allow for upper torso mobility, as required. This system will not interface with the normal ejection/retraction function.

Investigations will also be conducted to determine the usefulness of applying cyclic retraction to the lap belt as a means for further optimizing in-flight restraint during adverse flight conditions. The MPES seat currently consists of automatic belt retraction during ejection; therefore, incorporating cyclic retration for in-flight restraint is considered technically feasible.

Prototype hardware of a recyclicable inertia reel designed for incorporation on, and demonstration with the MPES seat, should be available by the end of FY-82.

The problem of negative 'g' will also be alleviated by the use of the recyclicable inertia reel. The currently proposed design of the reel incorporates two different sensors to detect acceleration build-up. The first sensor is sensitive to inertia reel strap motion which locks the reel between 2 and 3 'g'. The second sensor is sensitive to aircraft acceleration (-GX) and also locks the reel between 2 to 3 'g'. It is also feasible to incorporate a multidirectional vehicle sensor in the reel which will automatically lock the reel when some component of Gz is detected. The reel will automatically unlock when the 'g' load falls below a specified level.

In addition, the seat mounted restraint incorporates a front tie-down strap which will further alleviate off seat motion in the -Gz direction.

EJECTION – (CATAPULT PHASE)

The ejection phase is considered the most critical of all the phases associated with crew safety and survival. Many areas still require in-depth research and development. There are three major problem areas that contribute to the growing injury statistics. They are:

- Loose lower restraint
- Spine not properly positioned and immobilized
- Head/neck not properly supported

Loose Lap Belt

The problems and consequences of a loose lap belt during onset of ejection forces has been previously described. This effort has resulted in prototype test hardware currently installed on the MPES seat and will be revised and updated during the 6.3/6.4 development process.

Spine Improperly Immobilized

1. Deficiency – Injury ranging from minor to permanent damage has occurred due to ejection forces transmitted to an improperly positioned spine. These injuries can further contribute to the loss of pilots because of their inability to execute proper survival techniques, especially when ejecting over water. These injuries also hinder escape and evasion attempts in hostile territory.

2. Proposed Technical Improvement

The current MPES II ADM, does not make any provision for immobilizing the spine other than the end point fixity, such as inertia reel straps and the lap belt tensioning device.

Nonejection seat restraint technology is currently being used to develop an inflatable restraint device which incorporates an inflatable bladder system which is packaged within a standard harness arrangement. This system was developed to provide improved crash protection.

In appears feasible to design and develop a version of this inflatable bladder concept for incorporation into the candidate seat mounted harness for the purpose of restraining and positioning the crewmembers spine tightly against a contoured or noncontoured seat back to effectively immobilize the spine. This can also conceivably work in conjunction with an inflatable lumbar support to hyperflex the spine. Hyperflexing the spine is currently being proposed as a means for allowing the spine to more safely withstand the ejection forces. If this concept is proven to be successful and recommended by the medical community within the Navy, it can easily be adapted for use with the MPES restraint configuration. The inflatable bladder for the SMR, however, will continue to be investigated and prototypes will be developed for evaluation and possible incorporation as a future MPES requirement.

In addition to the ability to immobilize the spine, this inflatable concept could also provide head and neck support since ejection statistics continue to document injuries related to head rotation during both the onset of the ejection forces and parachute opening shock forces.

Additional documented ejection problems have indicated poor performance of the inertia reel when more than 2 "g" opposing force is applied. Current inertia reels are not adequate in retracting the crewmember under -2Gx which results in him being ejected in a poor position if he is not full back at the time of ejection initiation. One alternative solution to this situation is a prepositioning requirement already being investigated; namely, use of the recyclicable inertia reel. The recyclicable reel would easily retract the crewmember up to 7 'g' as previously described, and could position him full back prior to ejection initiation if sufficient time existed. The design would also have to insure against undue retraction forces when the crewmember is not being subjected to the maximum 'g' the system is designed to overcome.

POST EJECTION

The major problem following separation from the aircraft is the aerodynamic and deceleration forces the crewmember is subjected to, and which was previously described. In addition to the lack of limb protection system, another important factor which contributes to limb dislodgement is an unstable ejection seat. Since the MPES seat will have a stable platform during rocket burn, it will reduce the tendency for limb flail. However, since the MPES seat will also have a vertical seeking capability, it will induce tri-axial rotation and, therefore, require an effective limb protective system. Much emphasis has been placed on a passive limb protection system. However, if an effective restraint configuration is demonstrated, and the passive requirement jeopardize reliability, it may become necessary to adapt the system to the simplest active system possible. It would consist of one simple attachment point, which would be tied in to the manual single point release or ditching handle to simplify the emergency egress situation.

PARACHUTE DEPLOYMENT AND DESCENT

Again, ejection statistics do continue to show injuries during the parachute opening sequence; specifically due to head/neck rotation. Some pilots have also complained of feeling lower back pain during chute opening. The inflatable bladder concept for positioning and immobilizing the spine should ultimately have the capability for preventing excessive head motion by limiting the head displacement and velocity. In the fixed seating area, current efforts are to evaluate various techniques for achieving a controlled deflation of the bladders, some by use of porous materials for the bladders or by various stitching patterns of the bladder edges. Various bladder configurations will be evaluated to determine the most effective and simplest design and packaging requirements.

If it appears feasible to maintain bladder pressure for use as an aid in flotation, it must then be determined what effect the inflated bladder will have on the pilots ability to control his descent and the effects on his visibility, and comfort, etc.

Upon entry in the water, the MPES system will rely on the newest available technology items such as automatic water sensitive parachute release and raft deployment. The back pack survival kit will also allow the raft deployment during descent if sufficient time is available.

EMERGENCY MANUAL EGRESS

The current emergency manual egress procedure for egressing without the seat kit or parachute requires the pilot to release two parachute attachments and two lap belt attachments in addition to the requisite oxygen hose and the leg garters which are disconnected via the ditching handle. The communication connection and the ventilation hose separate when the crewmember stands up. In one aircraft, a front tie down strap is also disconnected by actuation of the ditching handle during an emergency egress. As mentioned previously, the seat mounted restraint will allow the crewmember to divest himself of the restraint harness through the action of a center release buckle which will require a two-motion action. To successfully egress from the aircraft will still require unhooking the O_2 hose and the leg garters.

The MPES configuration offers a second method of emergency ground egress. Instead of removing the harness through the center buckle, the crewmember could elect to pull the ditching handle which would release the lap belt attachment and fire the inertial reel strap cutter simultaneously. The crewmember would then have to disconnect the two parachute attachment fittings and the O_2 hose. He would be free to egress from the aircraft with his harness and back pack survival kit. Emergency ground/water level egress can be made simple by incorporating an automatic O_2 hose disconnect. This would be tied into the actuation of the ditching handle which initiates pyrotechnic release of the lap belt and I.R. straps. A pressure actuated O_2 hose disconnect has been demonstrated previously as a feasible option.

Summary

Ground level emergency manual egress from the MPES seat would provide the crewmember with various options depending on whether he was over land or water. An overwater emergency condition presumably would occur off a carrier during either a take-off or landing with no time to eject. If this occurred during daylight, consensus is that the crewmember does not need his survival kit as urgently as he would if it occurred at night with no visual contact and a much longer and difficult rescue situation. It would also be assumed that the crewmember sustained some injury which would also complicate the situation.

Over Land Emergency Manual Egress

In the overland situation, it is recommended that a "clean" egress be accomplished. This would imply leaving the retraint harness and survival equipment on-board. The rationale being that the crewmember will be completely unencumbered and enable him to conduct a quicker and easier egress. Also, he will have the opportunity to retrieve the equipment, assuming it is not destroyed; finally because it is difficult to establish situations where the survival equipment would be required in this type of egress.

The method of egress then would be:

- disconnect O_2 hose
- release harness through single-point release buckle
- egress aircraft

This would be the same procedure for normal egress and require no unfamiliar functions for the crewmember. There is no need to touch the ditching handle since there are no anticipated leg restraint requirements other than that provided by the limb restraint (HELP) system.

Over Water Emergency Manual Egress

The recommendations for this situation are dependent upon the limited possibilities of being in the aircraft while in the water and the risk attached for a safe recovery.

It would be safe to assume that an in-water manual egress would occur as a result of an accident occurring during a carrier landing or take-off where there was not sufficient time to eject. Assuming the pilot was uninjured, he would be required to effect a rapid manual egress. A number of options are available.

In the case of a daylight operation, the MPES restraint system should provide the crewmember with the single point release center buckle which would free him of all his restraint attachments and enable him to egress with his life preserver, if it was not attached to his harness, and leave the survival kit behind. It the preserver was attached to the harness, the crewmember would then be required to egress via the ditching handle. In this case, pulling the handle would release the lap belt attachment, sever the inertia reel straps and release the front tie-down strap. He would then have to reach back and release his two parachute attachment fittings and finally unhook his oxygen hose. If the preserver was attached to the seat mounted harness, then the pilot would have no option and would be required to egress in all cases with his survival kit, which would make his rapid egress maneuver more cumbersome.

It would seem more reasonable to attach the LPA to the flight suit and give the pilot the option of retaining or leaving the survival kit. Consesus amoung the aircrew developemnt community is in favor of leaving the survival pack and conducting a "clean" egress during a daylight operational emergency. The rationale for this option is based on past experience, which indicates an average recovery time of 15-20 minutes for a daylight accident in close proximity to the carrier with SAR aircraft deployed.

The case for a night time emergency situation does not appear to provide the same consensus. There are equally divided views regarding the need for the survival pack. The MPES configuration will, however, provide the crewmember with the capability of egressing with or without the survival pack.

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