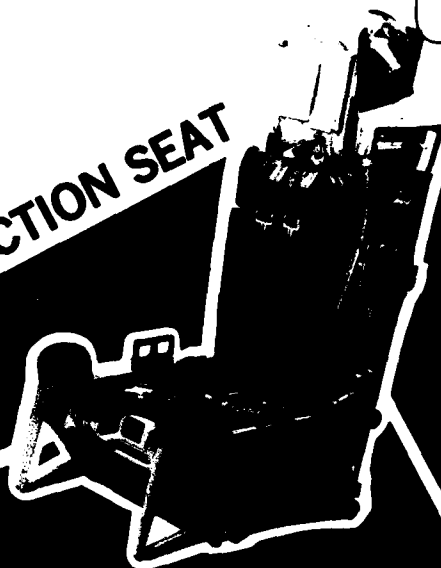


REPORT MDC J4576
REVISION C

ACES II

AD-A133 628
DOUGLAS AIRCRAFT COMPANY
ADVANCED CONCEPT EJECTION SEAT

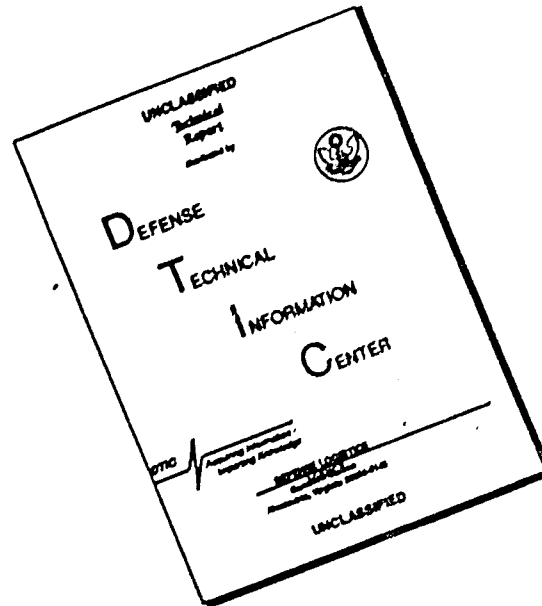


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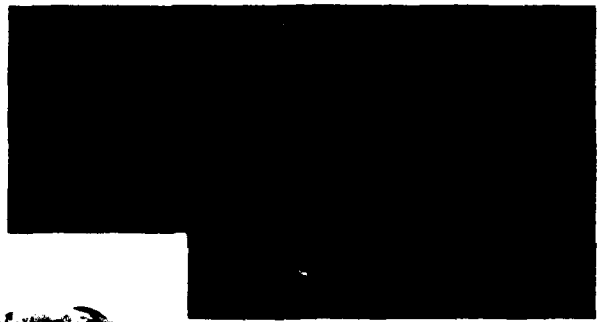
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**DOUGLAS
ACES II
ADVANCED CONCEPT EJECTION SEAT**

1983



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ACES II ADVANCED CONCEPT EJECTION SEAT

ACES II, the Advanced Concept Ejection Seat, is a high-performance escape system developed by Douglas Aircraft Company under contract to the United States Air Force. The increased performance capability greatly improves the survivability of aircrews during escape from aircraft under adverse conditions throughout the flight envelope. The experience gained by Douglas engineers in over 30 years of escape system design, development, and manufacture has been applied to make ACES II, a rugged, lightweight, easy to maintain ejection seat with advanced-technology subsystems. The subsystems were designed, tested, and qualified in the USAF/Douglas ACES I ~~research and development~~ program, and are integral in the all-new seat structure of ACES II. Qualification tests of the ACES II system were completed in June 1973. ACES II seat systems are currently being manufactured by Douglas for installation in F-15A/B, F-16A/B, and A-10 aircraft as the standard USAF Government-furnished aerospace equipment (GFAE) ejection seat. The advanced technology characteristics of the seat and its subsystems are illustrated by the following features:

- Multiple operating modes to optimize performance over the 0 to 600-KEAS escape envelope ;
- Self-contained sensing of escape conditions for recovery mode selection ;
- Electronics for sequencing and precision timing in each mode ;

• Gyro-controlled vernier rocket for positive stabilization at low speeds ;

• Hemisflo drogue parachute for stabilization and deceleration at high speeds and high Mach numbers ; and

• Mortar-deployed recovery parachute for consistent, positive operation ;

- Parachute canopy reefing to optimize recovery performance over the full 0 to 600-KEAS range

The ACES II system was designed to meet the requirements of MIL-S-9479B. Crewmember comfort and rear and upward visibility are salient ACES II design features. The system interfaces with current personal equipment, and the installation requirements are designed to be compatible with present and future aircraft. Canopy breakers are available for applications requiring ejection through the canopy capability.

The ACES II system is configured for optimum performance for a 0 to 600-KEAS escape envelope. However, the design flexibility of the electronic sequencing and timing system will permit changes in the time delays to optimize high-speed performance for aircraft applications where the maximum ejection velocity is less than 600 KEAS.

ESCAPE SYSTEM OPERATION

The automatic escape sequence is initiated by actuation of either or both of the side-mounted ejection control handles. To satisfy special cockpit installation requirements, a center ejection control handle is installed in lieu of the side handles. Operation of either type of control handle actuates an initiator, which energizes the aircraft escape system. The aircraft sequence selector valve directs gas pressure to initiate the power inertia reel and to jettison the canopy. As an option for single place aircraft, the inertia reel may be initiated by the seat-mounted initiator. Pressure from the aircraft sequencing system also ignites the rocket catapult. Catapult pressure activates the recovery sequencer power supply.

As the seat moves up the guide rails, the emergency oxygen system is initiated and the pitots on the parachute container are exposed to the airstream. Pitot and static pressure inputs to the environmental sensing unit act on the speed and altitude transducers to establish switch settings that correspond to the speed and altitude environment. The recovery sequencer monitors the switches and selects the recovery sequence mode appropriate for the environment. Movement of the seat up the guide rails also disconnects the initiation system gas disconnects.

As the seat approaches the top of the guide rails, the recovery sequence is initiated by a switch that is closed by a striker on the guide rails. An electrical signal from the sequencer fires the STAPAC system and on multiple place installations the trajectory divergence rocket. The remainder of the recovery sequence depends upon which of the three recovery modes is in operation. Figure 1 shows the portion of the flight envelope appropriate to each mode. The event-time sequence for each mode is shown in Table 1. The circled numbers in Table 1 relate to the circled numbers in Figures 2, 3, and 4.

In Mode 1, as shown in Figure 2, the recovery parachute mortar is initiated 0.2 second after rocket catapult ignition. As the

TABLE 1
EVENT-TIME SEQUENCE

TYPICAL EVENT TIMING	TIME (SECONDS)			
	MODE 1	MODE 2 (A-10)	MODE 2 (F-15/F-16)	MODE 3
① ROCKET CATAPULT FIRES	0.0	0.0	0.0	0.0
② DROGUE DEPLOYS	NA	0.17	0.17	0.17
③ STAPAC IGNITES	0.18	0.18	0.18	0.18
④ PARACHUTE DEPLOYS	0.20	0.97	1.17	*
⑤ DROGUE RELEASES FROM SEAT	NA	1.12	1.32	*
⑥ SEAT RELEASES FROM CREWMAN	0.46	1.22	1.42	*
⑦ PARACHUTE INFLATES	1.5	2.8	2.8	*
⑧ SURVIVAL EQUIPMENT DEPLOYS	5.5	6.1	6.3	*

*SEQUENCE IS INTERRUPTED UNTIL SEAT CROSSES MODE 3 BOUNDARY, THEN DEPLOYS PARACHUTE AFTER 0.8-SECOND DELAY (A-10) OR 1.0-SECOND DELAY (F-15/F-16)

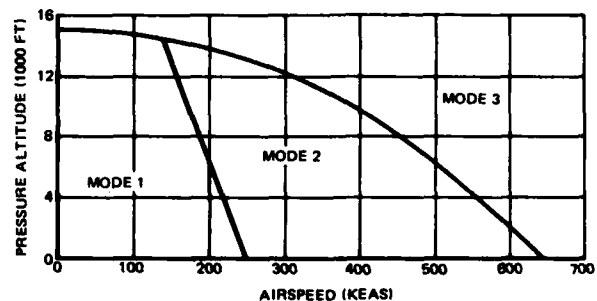


FIGURE 1. MODE ENVELOPES

mortar propels the parachute container away from the seat, the 1.15-second-delay reefing line cutters are initiated and the pilot chute is released. The harness release thruster is actuated 0.25 second later and the deploying parachute separates the crewman from the seat. The parachute inflates to the reefed configuration until the reefing line cutters actuate to permit full inflation.

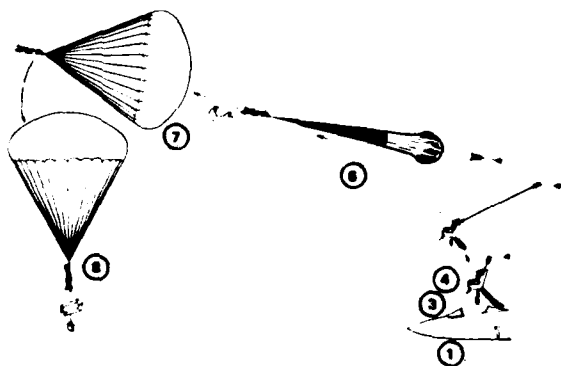


FIGURE 2. MODE 1 OPERATION

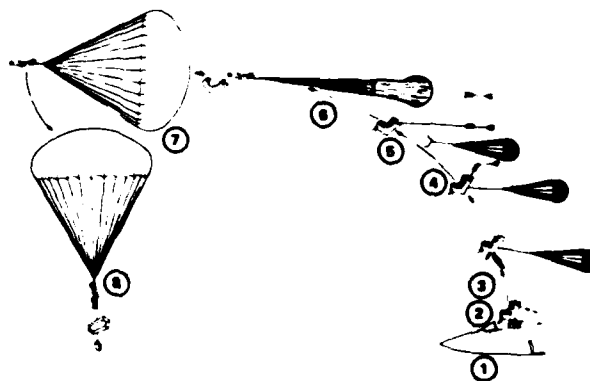


FIGURE 3. MODE 2 OPERATION

In Mode 2, as shown in Figure 3, the drogue gun is initiated as the seat approaches the top of the guide rails. Projection of the drogue gun slug deploys the extraction parachute which, in turn, deploys the drogue parachute. The recovery parachute mortar is initiated 1.0 second after drogue gun initiation and 0.15 second later the drogue bridle is severed from the seat. Parachute operation and seat-man separation then occur as in Mode 1.

In Mode 3, as shown in Figure 4, the sequence is the same as that for Mode 2 except that after deployment of the drogue, initiation of the recovery parachute delay (0.80-second delay for A-10 or 1.0-second delay for F-15/F-16) is inhibited until the seat descends or decelerates to the Mode 3 boundary. When the Mode 3 boundary is reached, the Mode 2 recovery sequence is continued.

In the event of a failure of the recovery system, operation of the emergency release handle mechanically operates the harness release mechanism. This handle also disconnects the parachute container from the seat and releases the pilot chute to deploy it.

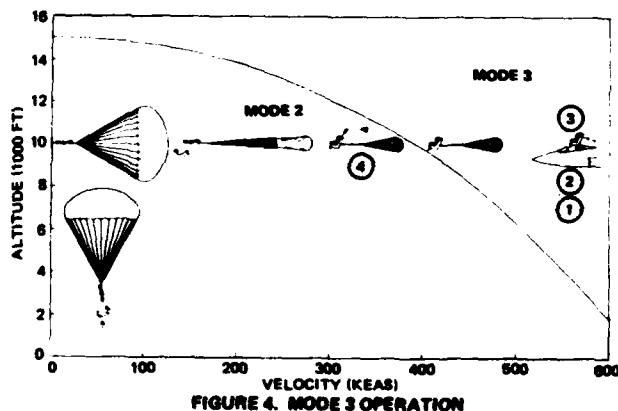


FIGURE 4. MODE 3 OPERATION

Functioning of the Rapid Escape Divestment System (for emergency ground egress) is blocked during ejection by a cam-actuated mechanism which senses the absence of guide rails.

The survival kit system is equipped with an automatic/manual control. Selection of "automatic" will deploy the liferaft and rucksack 4 seconds after seat-man separation. A manual control on the survival kit allows the crewman to deploy the liferaft and rucksack during parachute descent.

Access to the selector switch on the URT-33C radio beacon is provided in the seat pan and, when the switch is selected to "automatic," transmission will commence following seat-man separation.

ESCAPE PERFORMANCE

The zero-zero performance is shown in Figure 5. This figure also illustrates the trajectory deviation due to the extremes in crewman weight and thrust line/cg offset. ACES II performance for bank, dive, and sink conditions is shown in Figures 6 and 7.

Performance for the escape conditions of MIL-S-9479B is shown in Table 2.

TABLE 2
ACES II PERFORMANCE

AIRCRAFT ATTITUDE	VELOCITY (KNOTS)	ALTITUDE REQUIRED (FT)	
		MIL-S-9479B	ACES II
0-DEG PITCH, 60-DEG ROLL*	120	0	0
0-DEG PITCH, 180-DEG ROLL	150	200	150
0-DEG PITCH, 0-DEG ROLL, 10,000-FPM SINK RATE	150	300	116
-60-DEG PITCH, 0-DEG ROLL	200	500	336
-30-DEG PITCH, 0-DEG ROLL	450	500	497
-60-DEG PITCH, 60-DEG ROLL	200	550	361
-45-DEG PITCH, 180-DEG ROLL	250	600	467

*FOR THIS CASE, IMPACT OCCURS AT THE INSTANT THE SEAT AND AIRCRAFT ARE SEPARATED. IN ALL OTHER CASES, CONDITIONS ARE AT INITIATION OF THE CATAPULT ROCKET.

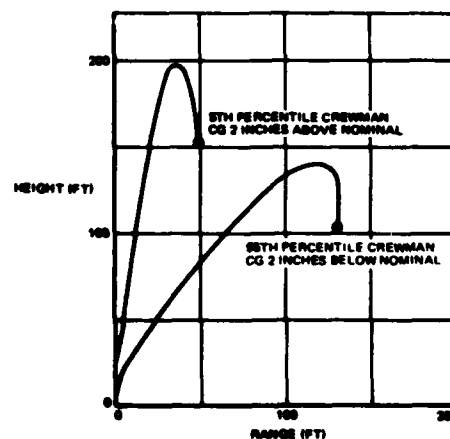
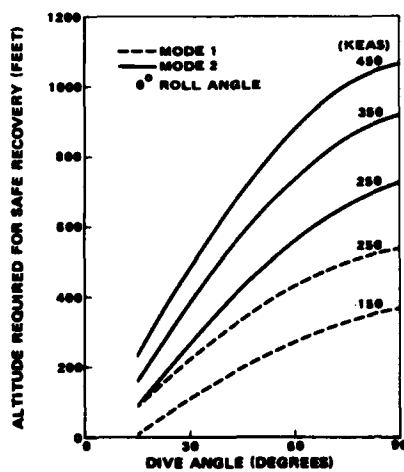
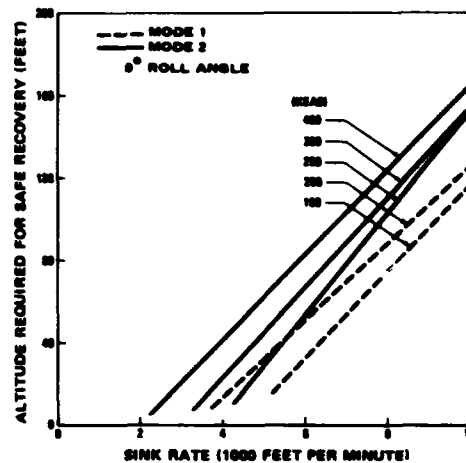
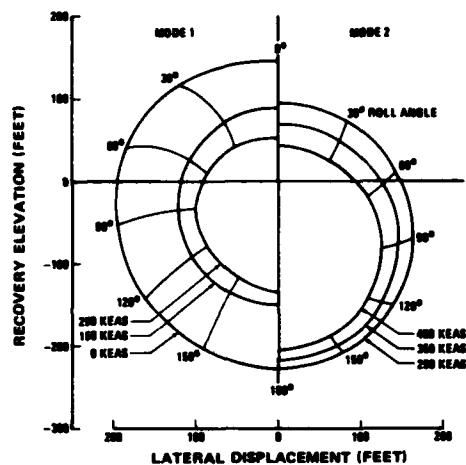


FIGURE 5. ZERO-ZERO TRAJECTORIES



NOTES:

- T = 0 IS CATAPULT IGNITION
- 50TH PERCENTILE CREWMAN
- NOMINAL CG, OCCUPIED SEAT
- AIRCRAFT CONFIGURATION AND SEQUENCING NOT INCLUDED
- REFER TO PILOT'S HANDBOOK FOR SPECIFIC AIRCRAFT ESCAPE ENVELOPE

FIGURE 6. ACES II PERFORMANCE (A-10)

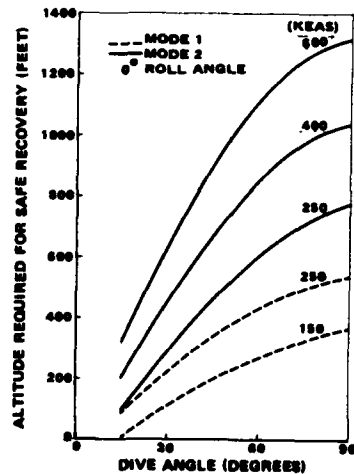
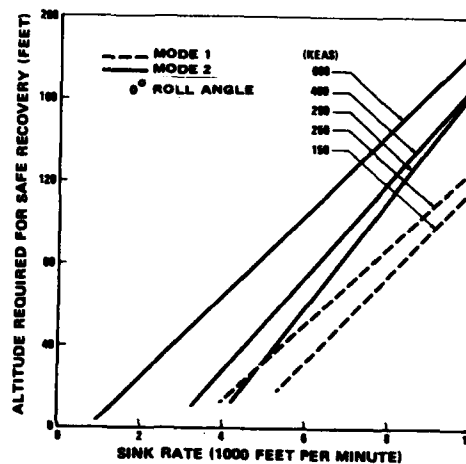
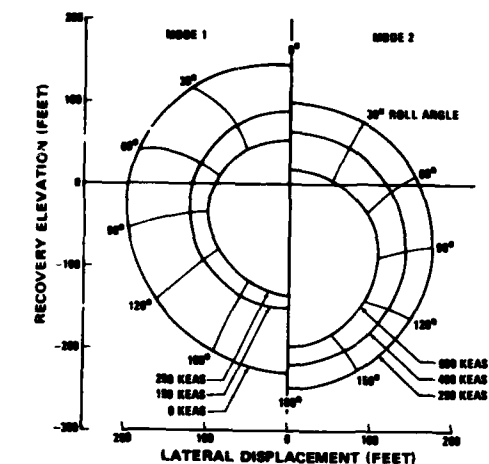


FIGURE 7. ACES II PERFORMANCE (F-15/F-16)

NOTES:

- T = 0 IS CATAPULT IGNITION
- 50TH PERCENTILE CREWMAN
- NOMINAL CG, OCCUPIED SEAT
- AIRCRAFT CONFIGURATION AND SEQUENCING NOT INCLUDED
- REFER TO PILOT'S HANDBOOK FOR SPECIFIC AIRCRAFT ESCAPE ENVELOPE

TECHNICAL DISCUSSION

The ACES II is a lightweight, advanced performance escape system which features a rugged structure and state-of-the-art subsystems. Proven ballistic components and simple mechanisms are used in conjunction with redundant electronic control and timing circuits to achieve inherent reliability and ensure maintenance-free service usage.

The primary ACES II subsystems combine to stabilize the seat and crewman and achieve rapid, minimum-distance recovery. In ejections at low speed, a gyro-controlled vernier rocket provides pitch stabilization and, in high-speed conditions, additional stabilization is provided by a drogue parachute. To achieve minimum-distance recovery in low-speed ejections, the recovery parachute is deployed as the seat leaves the cockpit. At high speeds, the drogue parachute is deployed immediately and the seat and crewman are quickly decelerated to a suitable speed for recovery parachute deployment.

The basis of the recovery performance lies in the multiple recovery subsystem operating modes, the use of electronics for sequencing and time delays, and the efficient use of the recovery and drogue parachutes. The use of multiple recovery modes permits the functions and timing of the recovery subsystem to be selected for each mode to optimize performance throughout the escape envelope. In ACES II the drogue and recovery parachute subsystems are independent; therefore, the drogue need not be deployed in a low-speed, low-altitude ejection where immediate deployment of the recovery parachute is essential. At high speeds the operations of the drogue and recovery parachute are overlapped to increase system deceleration.

An electronic sequencer controls the sequencing, timing, and initiation of the recovery subsystem functions. The electronic time delays are precise (± 3 percent), permitting the recovery

sequence to be programmed so performance penalties due to delay tolerances are almost eliminated. Mode selection is performed by the recovery sequencer in conjunction with an environmental sensing subsystem which determines airspeed and altitude conditions. The environmental subsystem is mounted on the seat and avoids escape system dependence on aircraft systems.

The ACES II drogue and recovery parachute subsystems are configured for the maximum speed conditions where the deceleration forces applied to the crewman approach the limits recommended for escape system design. This is essential to obtain efficient use of the drogue and recovery parachutes under lower speed conditions. The drogue attachments are located so that the forces are applied in the "eye-balls out" direction in which they can best be tolerated by the crewman. The recovery parachute is reefed to permit its deployment at relatively high speeds. The early deceleration due to the reefed parachute contributes to the achievement of minimum-distance recovery.

SUBSYSTEM AND COMPONENT DESCRIPTION

The ACES II primary subsystems are depicted in Figure 8 and in the general configuration drawing, Figure 9. These consist of:

- Seat Structure
- Adjustment Actuator
- Guide Rails
- Firing Controls
- Propulsion

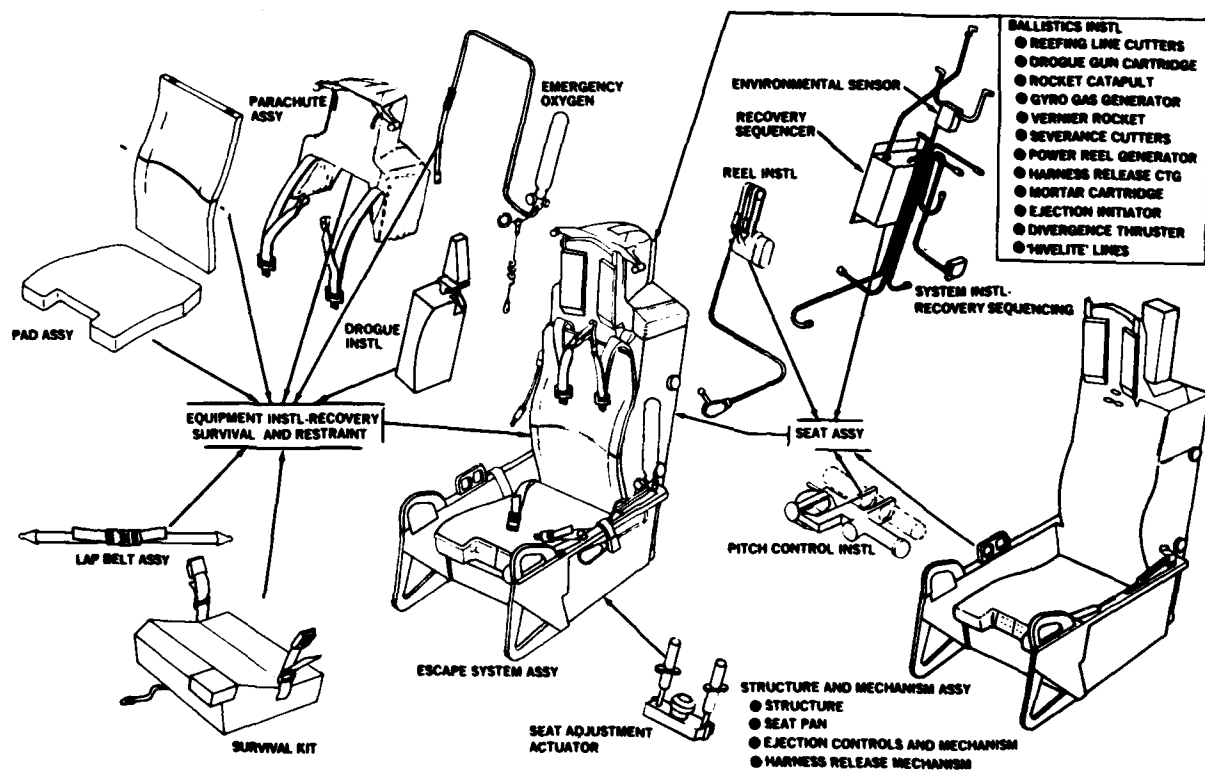


FIGURE 8. ACES II FUNCTIONAL BREAKDOWN

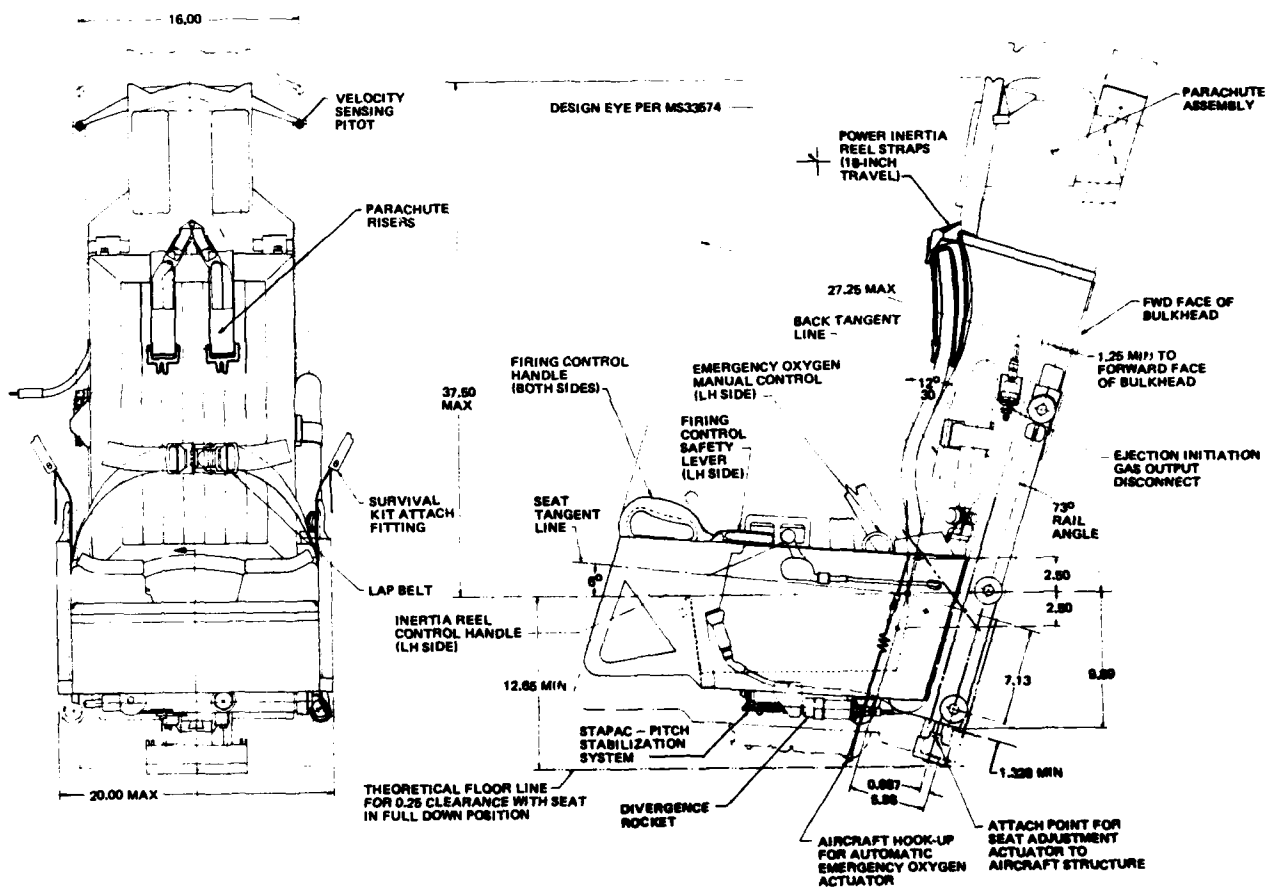


FIGURE 9. ACES II GENERAL CONFIGURATION (A-10/F-15)

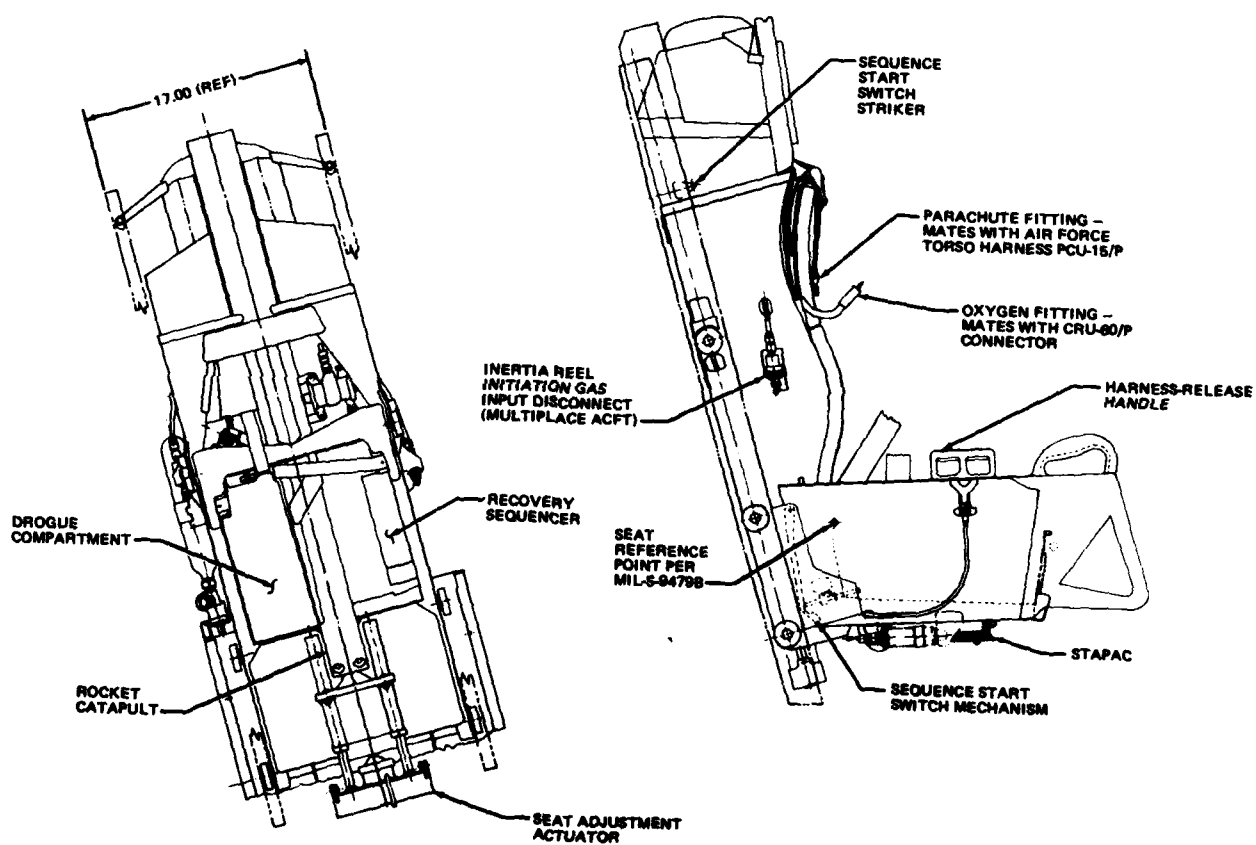


FIGURE 9. ACES II GENERAL CONFIGURATION (A-10/F-15) (CONTINUED)

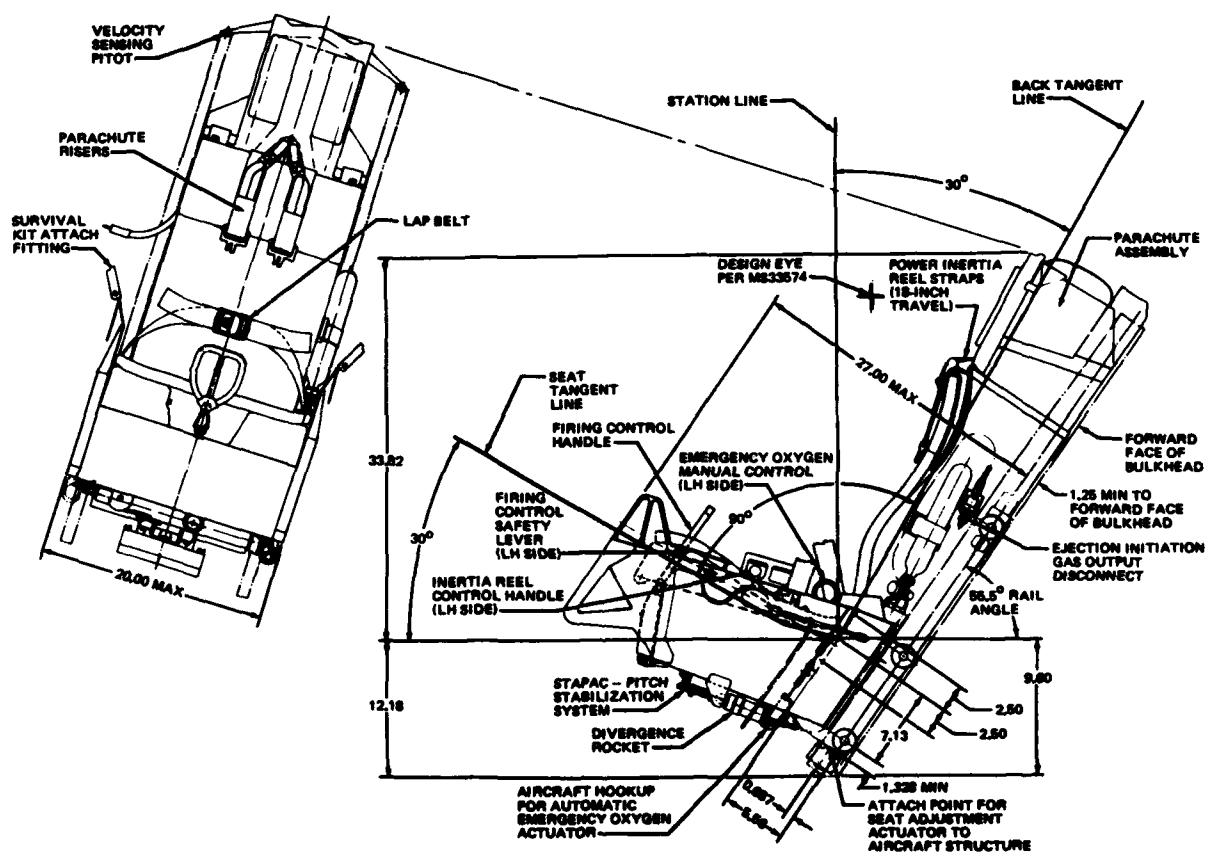


FIGURE 9. ACES II GENERAL CONFIGURATION (F-16)

- Pitch Control Subsystem
- Trajectory Divergence Subsystem (Optional)
- Drogue Parachute
- Recovery Parachute
- Recovery Sequencing Subsystem
- Harness Release Mechanism
- Survival Kit
- Restraint Provisions
- Emergency Oxygen.

Seat Structure

The lightweight seat structure is of monocoque construction and is fabricated primarily of high-strength aluminum alloy. The seat structure consists of the seat back and the bucket. The back has formed, chemically milled aluminum sides, a contoured backrest skin, and sheet metal beams which provide support for the guide rollers. Extensions of the sides support the headrest. The seat bucket has sheet aluminum sides capped by extrusions. The sides attach to the seat back via torque boxes. The bucket enclosure is completed by the sheet metal bottom and front beam. In ACES II the seat-pan is a structural component, and a support shelf on the seat back and hinge pivot points in the forward seat sides carry loads from the fiberglass pan into the seat structure.

Seat Adjustment Actuator

A twin-barrel linear actuator gives the seat a ± 2.5 -inch vertical adjustment (standard). Adjustment ranges of 3.5 to 6.0 are available for specific crew station requirements. A 400-cycle alternating-current, 115/200-volt, four-pole, three-phase induction motor drives two Acme screw barrels through a reduction gear assembly. The actuator is attached to the aircraft structure and the base of the rocket catapult is attached to the actuator barrels. The upper end of the catapult is bolted to the seat structure, permitting up and down adjustment of the seat parallel to the ejection guide rails. This actuator is an off-the-shelf, qualified item. Power requirement is 250 watts.

Ejection Guide Rails

The seat guide rails are made by machining aluminum alloy extrusions. In conjunction with the rollers on the seat, they guide the seat until it has cleared the cockpit region of the aircraft. The guide rails are identical to those for the Douglas ESCAPAC seats. In several aircraft these rails are also used to carry aircraft structural loads and are installed by the aircraft manufacturer as an integral part of the cockpit structure.

Firing Controls

The ejection control handles, mounted on the seat bucket sides, are interconnected by a torque tube so that actuation of either or both handles initiates the ejection sequence. The controls are connected by a mechanical linkage to a JAU8 initiator which sends a pressure signal, through a hose and disconnect, to initiate the aircraft escape system. Dual initiators can be provided, if required, to interface with the aircraft system.

The control handles are actuated by an upward and aft pull and lock in the extended position. The hand opening in each handle is covered on the inboard side by a flexible safety guard for protection against inadvertent actuation.

A ground safety lever is located adjacent to the left side control handle. When the lever is in the "safe" position the ejection controls are locked. The initiator and firing control mechanism are fully enclosed. A safety pin is inserted to lock the controls prior to maintenance operations.

For special cockpit applications, a center ejection control handle can be supplied in lieu of the side firing controls. The ground safety lever is located on the left side of the seat.

Propulsion

A CKU-5/A rocket catapult is used to eject the seat from the cockpit and propel it away from the aircraft. The unit consists of a solid-propellant rocket motor integrated with a catapult which is powered by a solid-propellant cartridge.

The rocket motor, or sustainer, is ignited at the end of the catapult stroke. A typical plot of catapult acceleration and sustainer thrust is shown in Figure 10. The peak catapult

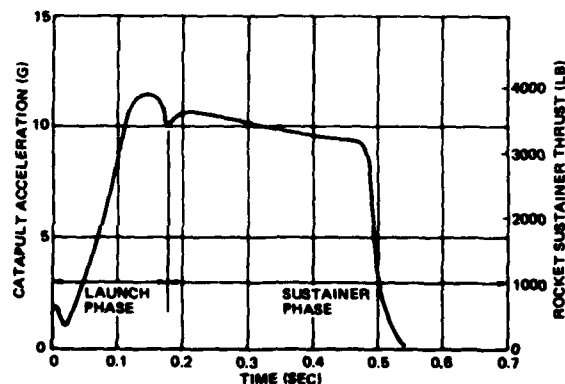


FIGURE 10. TYPICAL ROCKET CATAPULT ACCELERATION AND ROCKET MOTOR THRUST VERSUS TIME CURVE

acceleration is approximately 12g and the seat velocity at the end of the catapult stroke will average 43 feet per second. The sustainer has a nominal impulse of 1150 pound-seconds.

Catapult pressure is tapped from the upper casing of the catapult to initiate the recovery sequencer power supply.

Pitch Control Subsystem

A unique but simple system is used to stabilize the seat if any pitching is produced by cg/rocket catapult thrust misalignment or aerodynamic forces. It is operative from the time the seat leaves the guide rails until after rocket catapult burnout. This system, known as "STAPAC," comprises a vernier rocket motor located under the seat bucket, and a simple pitch-rate gyro located just forward of the rocket motor, as shown in Figure 11. As the seat approaches the top of the guide rails, the gyro is brought up to operating speed by a gear rack driven by a gas generator. The gas generator is initiated electrically by the recovery sequencer. As the rack reaches full travel it uncages the gyro and fires the vernier rocket mechanically. The rocket burns for approximately 0.3 second. In the caged position the vernier rocket nozzle thrust vector is directed up through the nominal dynamic cg of the occupied seat. If the seat starts to pitch from adverse moments of any origin, the gyro precesses and rotates the rocket around its lateral axis, thus applying a correcting moment, as shown in Figure 12.

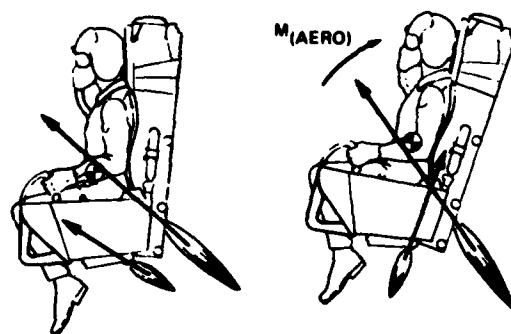
The additional 235-pound-second near-vertical impulse of the vernier rocket adds to trajectory height and improves sink rate capability. The additional two g's of spinal acceleration are acceptable because of the low spinal g's produced by the main rocket catapult. A typical thrust-time curve for the rocket is shown in Figure 13. The STAPAC unit is designed to stabilize and control the seat trajectory for dynamic cg/rocket thrust line misalignments about the pitch axis of ± 2 inches from nominal.



FIGURE 11. STAPAC ASSEMBLY

Trajectory Divergence Subsystem

A trajectory divergence subsystem is available as an option for multiple ejection requirements. In tandem or side-by-side ejections, the divergence system ensures that there is no interference between the two crewmen or their escape system components.



CORRECTING FOR LOW CG

CORRECTING FOR HIGH CG
OR AERO FORCES

FIGURE 12. STAPAC OPERATION

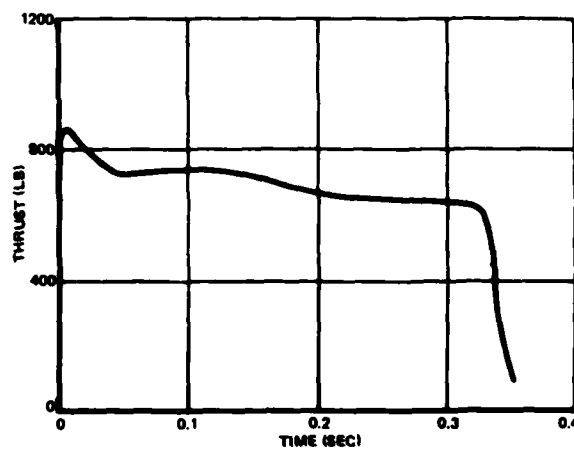


FIGURE 13. TYPICAL VERNIER ROCKET PERFORMANCE

Trajectory divergence is achieved by a small rocket which is initiated by the recovery sequencer as the seat leaves the guide rails. The rocket is oriented to cause the seat to roll and the redirection of the main rocket thrust results in lateral motion and trajectory displacement. The rockets are installed on opposite sides of the two seats causing them to roll in opposing directions. Trajectory divergence at zero speed is illustrated in Figure 14.

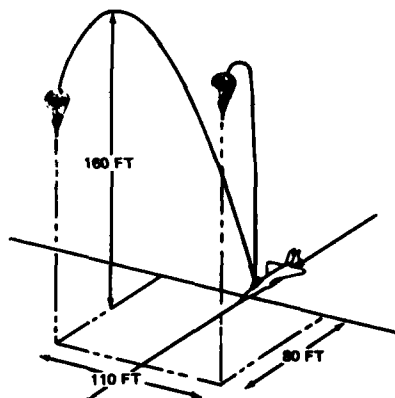


FIGURE 14. DIVERGENT TRAJECTORIES - ZERO SPEED (F-15A/B)

Drogue Parachute Subsystem

The primary functions of the drogue parachute are stabilization and deceleration under high-speed escape conditions and stabilization during descent from high altitude. Reliable drogue operation is essential for safe recovery in a high-speed escape. A Hemisflo drogue parachute is used because of its ability to operate satisfactorily under transonic and supersonic conditions. These conditions apply to the Modes 2 and 3 recovery sequences as the drogue is not used in the low-speed, low-altitude, Mode 1 recovery sequence.

The drogue is a 5.0-foot Hemisflo parachute. The deployment system includes a drogue gun and a 2.0-foot Hemisflo extraction parachute. The parachutes are stowed in a metal compartment in the seat back. Packing does not require any special tools or fixtures.

The drogue gun is initiated by the recovery sequencer as the seat nears the top of the guide rails. The drogue-gun slug deploys the extraction chute and is then detached from the chute by means of a release lanyard. The extraction chute deploys the drogue chute with a dual strap arrangement which prevents squidding and ensures rapid inflation. The drogue parachute bridle has a two-point attachment to the seat structure.

When deployment of the recovery parachute has commenced, the drogue parachute is detached from the seat. This is achieved by shaped-charge cutters which sever the bridle at the two attach points. The cutters are initiated by the recovery sequencer 0.15 second after the parachute mortar has been fired. A typical plot of deceleration during drogue operation is shown in Figure 15.

Recovery Parachute Subsystem

A reefed, mortar-deployed parachute is used to obtain a good balance between low-speed and high-speed performance. The mortar assures positive, consistent deployment, while reefing permits the parachute to be deployed at relatively high speeds without excessive onset of forces during alignment of the crewman for recovery. Line first deployment assures low snatch forces at line stretch.

A reinforced 28-foot C-9 canopy is used with the reefing line and dual 1.15-second delay cutters installed on the skirt. The canopy is hand packed in a metal container and the suspension lines are stowed in tunnels on either side. A spring-powered pilot chute is stored in an enclosure on top of the container. The mortar

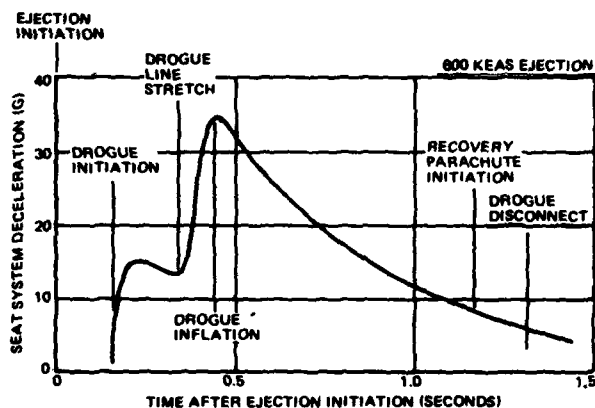


FIGURE 15. TYPICAL SEAT SYSTEM DECELERATION DURING DROGUE OPERATION

attaches to a breech-disconnect assembly on the seat. The parachute assembly is located behind the headrest and the risers pass forward to connect to the fittings on the torso harness. The risers are looped down behind the upper portion of the back cushion to permit the crewmember full freedom of movement.

When the mortar is initiated by the recovery sequencer, it accelerates the container to a velocity of approximately 60 feet per second. During the mortar stroke, the reefing line cutters are initiated and the pilot chute is released. The suspension lines deploy first and then the canopy deploys skirt-first as the container strips off. Deployment time varies with airspeed, so that at high speed the parachute inflation is delayed by the reefing line until the cutters actuate. At low speed the cutters actuate before the canopy has commenced to inflate and inflation is not delayed.

Figure 16 shows a typical plot of deceleration during operation of the reefed parachute system under high-speed conditions. The reefing effectively controls the level of deceleration during the critical initial phase of parachute opening.

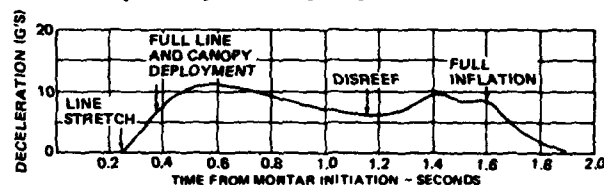


FIGURE 16. RECOVERY PARACHUTE DECELERATION (95TH PERCENTILE)

Recovery Sequencing Subsystem

The recovery sequencing subsystem selects the operational mode appropriate to the escape environment and executes the recovery sequence. The subsystem consists primarily of an environmental sensing unit and a recovery sequencing unit, Figure 17.

The environmental sensing unit contains two altitude compensated dynamic pressure transducers and two static pressure transducers. Pressure inputs are obtained via two pitots mounted on the parachute container and from a static port which is open to the ambient (base) pressure behind the seat. The dynamic pressure transducers are set to switch from a low-speed to a high-speed position at a nominal velocity of 250 knots at sea level. The altitude compensation decreases the crossover speed as altitude increases.

The static pressure transducer is set to switch from a high-altitude to a low-altitude position at 15,000 feet. At high speeds the reduced ambient pressure behind the seat causes a Mode 3 switch indication until speed is reduced. This results in short periods of Mode 3 operation during high-speed ejections at altitudes under 15,000 feet.

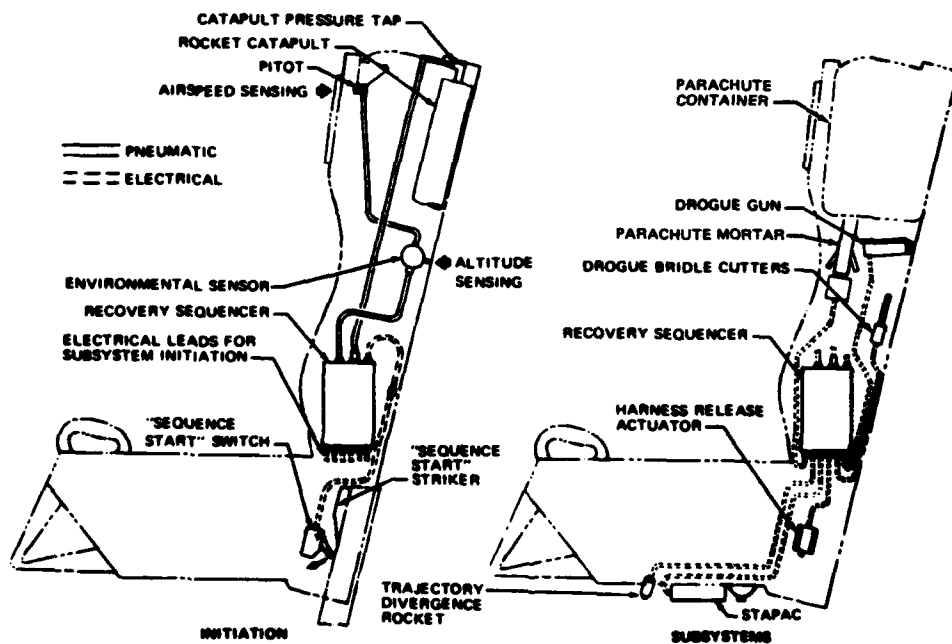


FIGURE 17. RECOVERY SEQUENCING SYSTEM

The recovery sequencing unit contains electronic logic circuits to interrogate and interpret the speed and altitude transducers in the environmental sensing unit, and electronic time delays to establish the correct event-time sequence in each recovery mode. Electrical power is supplied by thermal batteries which are initiated by gas pressure tapped from the catapult. The recovery sequence timing is initiated by dual "sequence-start" switches which are closed by contact with a striker plate mounted on the guide rails.

The recovery sequencer is fully redundant in that there are two identical, independent electronic systems (including batteries) to execute the recovery sequence. Each redundant system fires one of two bridge wires in each of the squibs used to initiate the ballistic components.

Harness Release Mechanism

The harness release mechanism releases the crewman from the seat during the automatic recovery sequence. The mechanism is powered by a thruster which is electrically initiated by the recovery sequencer 0.25 second after the recovery parachute mortar is fired. The drag of the deploying parachute effects positive seat-man separation. The harness release mechanism can also be operated manually by a control handle located on the right side of the seat bucket.

Initiation of the thruster or operation of the manual control rotates a bellcrank which, by means of rods and cables, mechanically withdraws the following:

- Lap belt lock pins
- Inertia reel strap lock pin
- Seat pan latch

- Parachute mortar disconnect pin
- Pilot chute lock pin.

The crewman is released by withdrawal of the lap belt and inertia reel pins, and release of the seat pan latch allows the pan to rotate. The survival kit is withdrawn from the seat bucket when the crewman is pulled away from the seat by the recovery parachute. Release of the parachute mortar and pilot chute by the harness release mechanism is required only in the event of a failure of the automatic recovery sequence. In this case, operation of the manual control handle will not only release the crewman from the seat but will also allow the pilot chute to deploy. The pilot chute is designed to extract the parachute container from the seat and deploy it.

During a ground emergency in which the crewman must leave the aircraft as quickly as possible, the restraint release handle performs another important function. In the first part of its travel, the handle actuates the Rapid Escape Divestment System, which separates the survival kit attach fittings via a series of Rapid Deflagration Cord (RDC) lines.

A separate manual control located on the seat back behind the cushion serves as a means of withdrawing the various locking pins for the installation and removal of equipment during servicing. Actuation of this control does not initiate the Rapid Escape Divestment System. When the mechanism is actuated it locks in the release configuration until the reset plunger is depressed.

Survival Kit

ACES II has a nonrigid survival kit which stows in the seat bucket beneath a rigid seat pan. Ejection and crash loads imposed on the seat pan are distributed directly into the seat structure. The volume of the bucket enclosure is 1800 cubic inches.

The kit consists of a fabric outer case which houses the liferaft, a rucksack, and a small auxiliary container for the stowage of survival equipment. A URT-33C beacon is installed on the outside of the kit. Two adjustable straps secure the kit to the crewman's torso harness by means of quick-release connectors.

A control, located in the right-side forward edge of the seat pan, allows the crewman to preselect automatic or manual deployment of the rucksack and liferaft. When automatic deployment is selected the kit closures are released by a 4-second delay cutter which is armed at seat-man separation. This allows the rucksack and liferaft to drop on a 25-foot lanyard. When manual operation is selected, the crewman can deploy the rucksack and liferaft during descent by pulling the manual release ring. The auxiliary container is secured to the outer case and does not deploy.

The URT-33 beacon is activated and the antenna is deployed automatically at seat/man separation. Access to the beacon on-off switch is provided at the forward edge of the seat pan.

Restraint Provisions

A lap belt and powered inertia reel restrain the crewman during ejection or crash conditions. The hardware is compatible with the Air Force torso harness. The inertia reel is installed in the upper portion of the seat structure. The dual inertia reel straps pass around roller fittings on the parachute risers and are secured to the seat structure by a locking pin. With this arrangement of the inertia reel straps there is no tendency for the risers to slip off the crewman's shoulders during rapid twisting movements. The inertia reel control is located on the left side of the seat bucket.

EMERGENCY GROUND EGRESS

The ACES II seat is fitted with a Rapid Escape Divestment System that permits the crewman to leave the cockpit in a

ground emergency by actuation of a handle on the seat and by manually disconnecting his parachute risers/shoulder harness. The system comprises quick-release mechanisms on the survival kit retention straps, RDC energy transfer lines, and an initiation device.

The initiation device includes an interdiction function which is connected to a guide-rail-sensing striker. Initiation of the system, which is possible only when the seat is in the aircraft, is accomplished by actuation of the emergency harness release control. This actuates the survival kit quick-releases and at the same time releases the lap belt from the seat. As the crewman stands to leave the seat, the hoses for oxygen and other services are automatically disconnected.

Actuation of the emergency release control after the seat has left the aircraft will not initiate the divestment system.

EMERGENCY OXYGEN

A 22-cubic-inch emergency oxygen supply is contained in a modified MS 22069-3 cylinder assembly. The cylinder assembly is on the left side of the seat back where it is visible for inspection and can be readily removed. The oxygen supply hose is routed to the CRU-60/P connector mounted on the torso harness. The system is actuated automatically in an ejection by a lanyard anchored to the cockpit structure; however, a manual control is located on the left side of the seat bucket if the need arises for emergency oxygen during flight.

SYSTEM WEIGHT

A weight summary for the ACES II is shown in Table 3.

TABLE 3
WEIGHT SUMMARY

	AIRCRAFT SEAT WEIGHTS (POUNDS)		
	A-10	F-15	F-16
SEAT ASSEMBLY	127	127	131
ROCKET CATAPULT	21	21	21
SEAT ADJUSTMENT ACTUATOR	5	5	5
*TOTAL	153	153	157

*DOES NOT INCLUDE SURVIVAL KIT CONTENTS, GUIDE RAILS, SEAT ADJUSTMENT ACTUATOR MOUNTING BRACKETS, GUIDE RAIL-MOUNTED STRIKER, OR LIMB RESTRAINT OPTIONS.

ESCAPE SYSTEM TEST CAPABILITY

Diversified test capabilities include Douglas-owned environmental laboratories and support facilities, a surveyed-in camera range located at the Long Beach Municipal Airport adjacent to Douglas, and engineering personnel and technicians well experienced in planning and conducting tests. Fifty-nine static ejection tests have been conducted at the Long Beach facility alone. In addition, Douglas has conducted over 130 complete systems tests at Government-owned high-speed track facilities.



An ejection tower test facility capable of providing development and dynamic evaluation of crew escape/restraint systems is at the Douglas Aircraft Company facility in Long Beach, California. The test facility will allow the repeated nondestructive use of a single seat for dynamic tests of crew escape/restraint systems during the catapult launch phase. The 64-foot-long tower, with a pneumatic-powered, track-guided movable carriage, has three operating positions – horizontal or inclined 17 or 35 degrees from the vertical. The 4-foot-long movable carriage contains provisions for mounting various ejection seats or test articles weighing up to 425 pounds.

MANUFACTURING CAPABILITY

The Douglas Aircraft Company has demonstrated the capability to manufacture a wide range of sophisticated aerospace military vehicles. This expertise in manufacturing and production is part of the team effort that has produced more than 10,000 ejection seats.

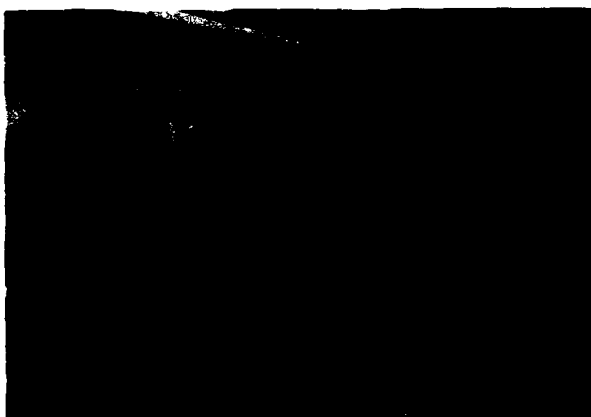
Utilization of the latest manufacturing techniques and processes, coupled with the advantage of experienced manufacturing per-



sonnel and management, provides an unsurpassed combination for design and production of high-performance escape systems.

Douglas is currently under contract to the United States Air Force to produce the ACES II Advanced Concept Ejection Seat as the standard USAF ejection seat for installation in the F-15, F-16, and A-10 aircraft.

Douglas manufactures ACES II ejection seats in a newly equipped, completely modern production center which is set aside and dedicated to the manufacture of aircraft escape systems. Douglas has the capability and flexibility to meet all requirements for the manufacture and mass production of ACES II escape systems.



ACES II SYSTEMS HAVING VARIATIONS IN SEAT HEIGHT,
WIDTH, VERTICAL ADJUSTMENT RANGE, EMERGENCY OXYGEN
SUPPLY, LIMB RESTRAINT AND MODE 2 EVENT TIMING
CAN BE FURNISHED FOR SPECIFIC AIRCRAFT CONFIGURATIONS.

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