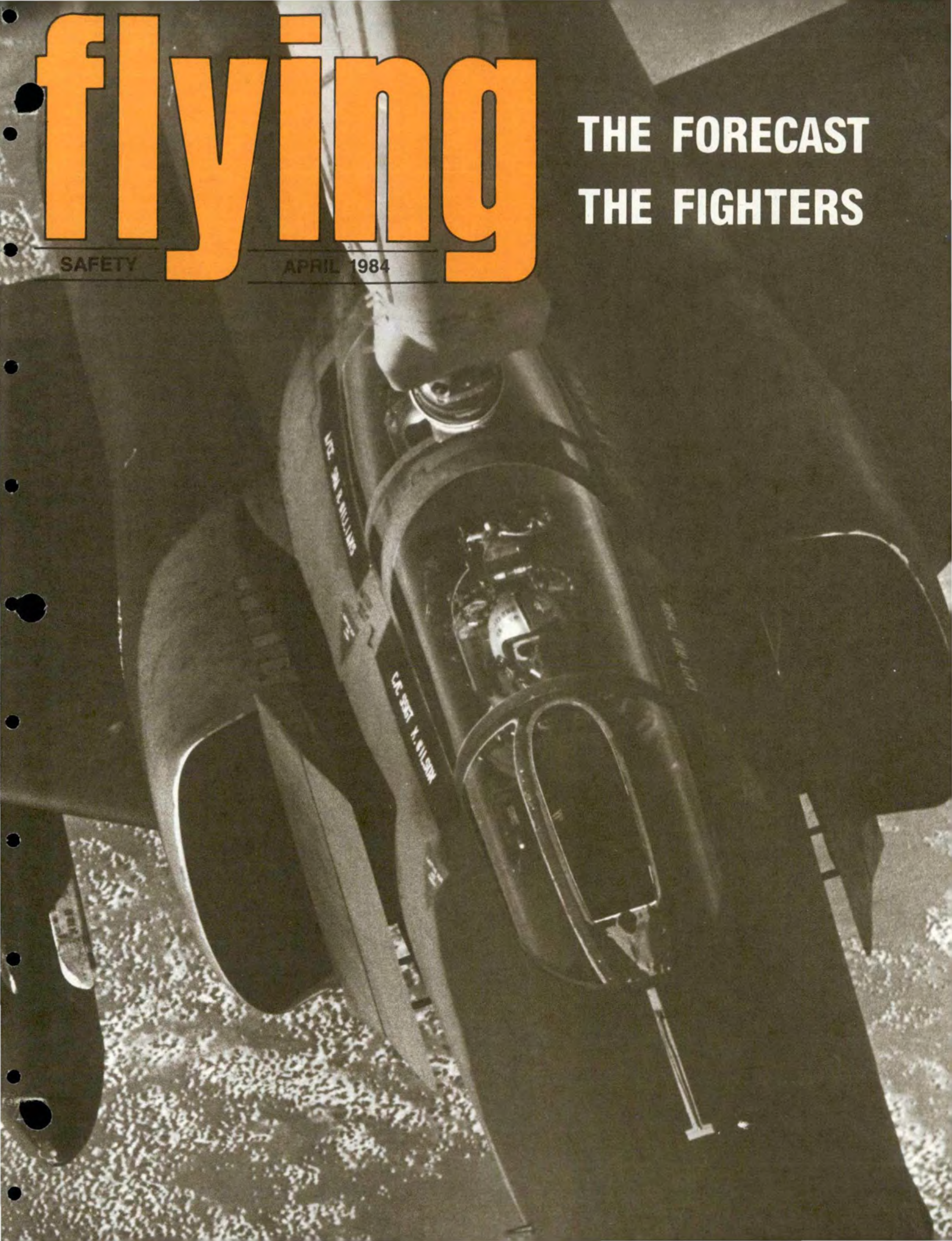
flying SAFETY

APRIL 1984

THE FORECAST

THE FIGHTERS



IFC APPROACH

PROCEDURE TURNS — The Procedures Change

■ The procedure turn maneuver was designed to align an aircraft on an inbound segment of an instrument approach. The maneuver was developed shortly after radio navigation became practical. Early editions of Army Air Corps (and eventually US Air Force) instrument flying directives describe course reversal maneuvers or "procedure turns" that are remarkably similar to the procedures in current use by the USAF, FAA, NATO and the International Civil Aviation Organization (ICAO) (Figure 1). The key word here is similar.

In recent years the ICAO has developed a set of standards for the design of instrument approaches which differ from the DOD and FAA adopted Terminal Instrument Procedures (TERPS) design criteria. ICAO has further developed flight procedures which are related to these design criteria. The flight procedures are contained in ICAO Doc 8168-OPS/611 "Procedures for Air Navigation Services" Volume 1, while the design criteria are in Volume 2. In comparing the areas of "protected airspace" required by ICAO and TERPS we find that the airspace protected for course reversals is significantly different.

A basis for the difference centers on the flight procedures associated with the course reversal maneuver. ICAO member nations which have adopted or will adopt the ICAO approach design criteria make certain assumptions about how pilots will fly a particular maneuver. If those assumed procedures are adhered to, aircraft will remain within the ICAO protected airspace. If, however, standard USAF procedures as described in AFM 51-37 are used, the aircraft can exceed the protected airspace while executing a "procedure turn." This fact was brought to the attention of the USAF when an aircrew, executing an approach, was observed on radar departing the airspace reserved for the approach. Although terrain clearance was not a problem in this case, the investigation of the incident shed new light on how and why the USAF adopted the current procedures for course reversals and more importantly — why they must change for operations worldwide.

Aircrews utilizing published DOD Instrument Approach Procedures, in areas outside FAA control, have no readily available method of determining if an approach was developed using US TERPS, NATO TERPS, ICAO, or host nation design criteria. AFM 51-37, Chapter 6, Paragraphs 6-11, 6-12, and 6-13 describe the three procedures available to USAF pilots for executing course reversals. These procedures, applied to the airspace protected by TERPS, provide course reversal and adherence to the limits of protected airspace. These same procedures may cause an aircraft to exceed the limits of ICAO protected airspace and do not comply with the maneuver upon which the airspace was designed. MAJCOMs have received guidance concerning the authorization for use if ICAO course reversal procedures are to be used by aircrews operating outside of areas under FAA control. The next revision to AFM 51-37 (estimated completion 1 Jan 85) will include ICAO type procedures for course reversal maneuvers.

The bottom line is that we are tasked to develop USAF course reversal procedures which will accommodate both TERPS and ICAO protected airspace. Since ICAO design criteria is the more restrictive, the USAF will adopt the "45°/180°" (Figure 2) procedure turn as the standard for worldwide operations. Other reversal procedures will be published as "procedural tracks" and will be flown exactly as depicted in DOD Instrument Approach Procedures.

Pending issuance of the revised AFM 51-37, aircrews will continue to adhere to the guidance in 51-37 for CONUS operations. (NOTE: MAJCOMS may authorize aircrews to practice ICAO type reversals in CONUS airspace when required.) Aircrews operating outside FAA controlled airspace will comply with interim guidance issued by the MAJCOM.

We encourage your comments and suggestions concerning the development of these and other instrument flying procedures. Send your written inputs to the USAF Instrument Flight Center/FD, Randolph AFB, TX 78150, or give us a call at AUTOVON 487-5071. ■

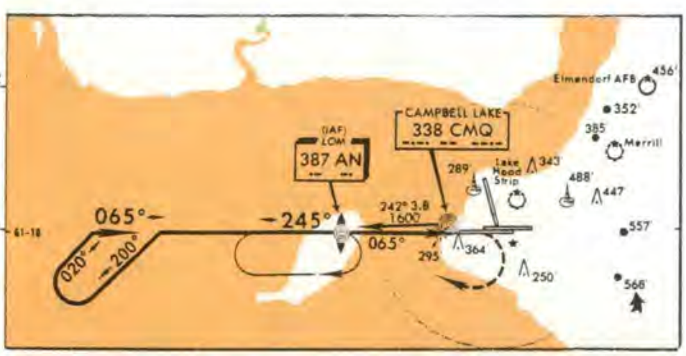


Figure 1

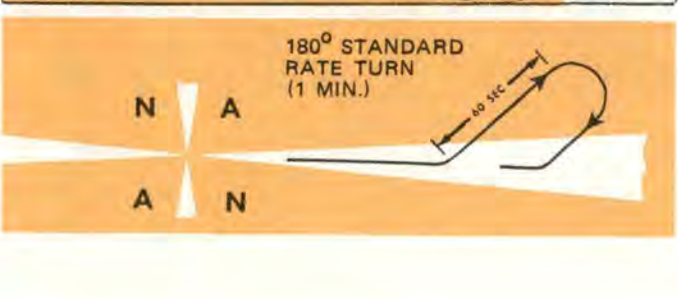


Figure 2

UNITED STATES AIR FORCE

flying

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SPECIAL ISSUE

Last year was the best year in Air Force history in terms of aircraft mishaps. Now it is time to reflect on what the numbers really mean.

In this issue we take a look at how we did in 1983 in our fighter and trainer aircraft. We will cover the heavies in May. This issue also contains the 1984 Aircraft Mishap Forecast. This is not a goal or a preordained chain of circumstance. It is a guide to where our emphasis should be in 1984.

We have decreased our Class A mishap rate every year since 1978. With proper emphasis, we can do it again in 1984.

SPECIAL FEATURES

DEPARTMENT OF THE AIR FORCE • THE INSPECTOR GENERAL, USAF

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1984 MISHAP FORECAST

LT COL JAMES I. MIHOLICK
Directorate of Aerospace Safety

■ The 1984 aircraft mishap forecast predicts that the Air Force will have 70 Class A mishaps, 72 destroyed aircraft, and 12 Class B mishaps this year. Of the 70 Class As, 38 will result from operational factors, 27 from logistics factors (part failures, maintenance, etc.), and 5 from miscellaneous or undetermined factors.

Fighter/attack aircraft will have 27 of the 38 operations Class As, 21 of the 27 logistics Class As, and 4 of the 5 miscellaneous or undetermined Class As. Thirty one of the 52 total fighter/attack Class As will involve F-4s and F-16s. These are some of the events that will happen this year *if* the 1984 aircraft mishap forecast is correct.

The forecast is, as were its predecessors, only a reflection of the mishap potential that currently exists in the way we support, maintain, and operate our aircraft. It is based on three basic assumptions: (1) that we have accurately defined the types of mishaps our aircraft are likely to have, (2) that we have accurately assessed current trends, and (3) that nothing changes in the way we support, maintain, and operate our aircraft in terms of policy, procedures, tactics, etc. It also presupposes that we fly the 3,476,764 flying hours programmed for 1984.

In spite of some past accusations, the mishap forecast is not derived by a room full of fortune tellers with crystal balls, nor is it totally computer generated. It is rather the product of a logical process which begins with a computer generated expression of mishap potential based on the mishap history of each aircraft.

Historical mishap data are biased as a function of recency, i.e., the more recent the data, the more "weight" they are given. The weight given recent history is further biased for the aircraft's age, as newer aircraft are still on the exponential part of their historical mishap rate curve, and do not exhibit the rate "stability" of older aircraft. The weighted projected cumulative rate for each aircraft is next compared to its 1984 programmed flying hours, and the product of these two numbers becomes the initial mishap projection for that aircraft. This is the only purely mathematical part of the process and involves some 8,775 separate calculations (39 aircraft x 25 mishap types x 3 sample time periods x 3 mishap classes).

The next step in the process involves evaluating Class C mishap and Category I materiel deficiency report trends for their reflection of mishap potential. If specific aircraft system trends are increasing or decreasing, the mathematical projection is further biased accordingly. At this point, the last step in the process begins (the "slight-of-hand, mirrors, and body English" step).

AFISC analysts and aircraft project officers get together and "murder" the projection for each aircraft based on their knowlewdge of current or anticipated changes in procedures, tactics, missions, restrictions, training programs, and the impact on mishap potential of any ongoing or anticipated aircraft modifications. Only after all of this is accomplished are the forecasts for each aircraft added to arrive at the Air Force total.

The overriding assumption on which the forecast is based is that nothing unforeseen changes. The inevitability of the forecast is totally dependent on that assumption being correct. If something changes to increase mishap potential, the numbers in that area will increase, and if something changes to decrease potential, they will decrease. We know that something changed last year to decrease mishap potential, and this has been taken into account.

The 1984 aircraft forecast predicts fewer mishaps than any previous forecast. It also represents the largest annual decrease in the numbers predicted. This acknowledgement is still tempered by 1981 and 1982 experience, indicating that the potential for increased mishaps exists until the changes seen in 1983 are firmly established as the new standard for our day-to-day activities.

Remember, the forecast is not a goal. The goal is to beat the forecast by additional prevention efforts in those areas it shows as having high mishap potential. The charts show us where we need to concentrate; the challenge now is to prove that we can do as we did in 1983, again in 1984. ■

1984 MISHAP FORECAST

By Aircraft Type and Category of Mishaps

AIRCRAFT		CONT LOSS	COLL GND	RNG	MID AIR	LDG (PLT)	T/O (PLT)	OPS OTH	FLT CONT	GEAR	FUEL SYS	ENG	ENG FOD	HYD/ PNEU	ELEC SYS	STR- UCT	BLD AIR	INST	LOG OTH	BIRD STRK	WX	UND MISC	TOT	FLYING HOURS
USAF	DEST	11	12	3	10	2	0	2	5	0	3	13	0	0	3	0	1	0	2	1	0	4	72	
	CL A	11	12	3	7	3	0	2	5	0	3	13	0	0	3	0	1	0	2	1	0	4	70	3476764
	CL B							1		3		1	2	2						3			12	
A-7	DEST		1									1											2	
	CL A		1									1											2	79408
	CL B																							
A-10	DEST	1		2	2														1				6	
	CL A	1		2	1														1				5	227438
	CL B												1										1	
A-37	DEST																						0	
	CL A																						0	31403
	CL B																						0	
B-52	DEST		1																				1	
	CL A		1																				1	101838
	CL B													1						1			2	
FB-111	DEST											1											1	
	CL A											1											1	19525
	CL B																							
C-5	DEST																							
	CL A					1																	1	58002
	CL B																			1			1	
C-9	DEST																						0	
	CL A																						0	30006
	CL B																						0	
KC-10A	DEST																						0	
	CL A																						0	16299
	CL B																						0	
CT-39	DEST																						0	
	CL A																						0	86351
	CL B																						0	
C-130	DEST	1									1												2	
	CL A	1									1												2	380703
	CL B									1													1	
C-135	DEST					1																	1	
	CL A					1																	1	260334
	CL B																							
C-140	DEST																						0	
	CL A																						0	7000
	CL B																						0	
C-141	DEST		1																				1	
	CL A		1																				1	293366
	CL B									1													1	
E-3	DEST																						0	
	CL A																						0	30540
	CL B																						0	
E-4	DEST																						0	
	CL A																						0	1426
	CL B																						0	
F-4	DEST	3	2		1			1	1		1	1			1		1					1	13	
	CL A	3	2		1			1	1		1	1			1		1					1	13	363469
	CL B							1												1			2	

1984 MISHAP FORECAST
By Aircraft Type and Category of Mishaps

AIRCRAFT		CONT LOSS	COLL GND	RNG	MID AIR	LDG (PLT)	T/O (PLT)	OPS OTH	FLT CONT	GEAR	FUEL SYS	ENG	ENG FOD	HYD/ PNEU	ELEC SYS	STR-UCT	BLD AIR	INST	LOG OTH	BIRD STRK	WX	UND MISC	TOT	FLYING HOURS
F-5	DEST	1			1							1											3	
	CL A	1			1							1											3	30754
	CL B																							
F-15	DEST	1			3				1		1												6	
	CL A	1			2				1		1												5	183433
	CL B									1		1		1									3	
F-16	DEST	1	4	1	1			1	1			6			1					1		1	18	
	CL A	1	4	1	1			1	1			6			1					1		1	18	204049
	CL B																							
F-105	DEST																						0	
	CL A																						0	539
	CL B																						0	
F-106	DEST																					1	1	
	CL A																					1	1	35052
	CL B																							
F-111	DEST	1	1						1			1			1								5	
	CL A	1	1						1			1			1								5	82347
	CL B												1										1	
H-1	DEST																		1				1	
	CL A																		1				1	49393
	CL B																							
H-3	DEST																						0	
	CL A																						0	28581
	CL B																						0	
H-53	DEST		1																				1	
	CL A		1																				1	14404
	CL B																							
H-60	DEST																						0	
	CL A																						0	4320
	CL B																						0	
O-2	DEST											1											1	
	CL A											1											1	28408
	CL B																							
OV-10	DEST				2																		2	
	CL A				1																		1	32154
	CL B																							
T-33	DEST	1																				1	2	
	CL A	1																				1	2	52968
	CL B																							
T-37	DEST	1																					1	
	CL A	1																					1	326262
	CL B																							
T-38	DEST		1			1			1			1											4	
	CL A		1			1			1			1											4	378911
	CL B																							
T-41	DEST																						0	
	CL A																						0	19081
	CL B																						0	
T-43	DEST																						0	
	CL A																						0	19398
	CL B																						0	

Today's Jet Engines Are Better Than Ever

HENRY L. LITTLEJOHN
Directorate of Aerospace Safety

■ The loss of an Air Force first-line fighter always makes the national news. And when the engine is suspected as the cause, there often is an inference that today's jet engines cause a disproportionate percentage of our mishaps.

I'll give you the statistics for both the single-engine and twin-engine mishaps rates for engine-related mishaps and let you judge for yourself. Each aircraft's Class A mishap rate is plotted against its total flying experience.

Figure 1

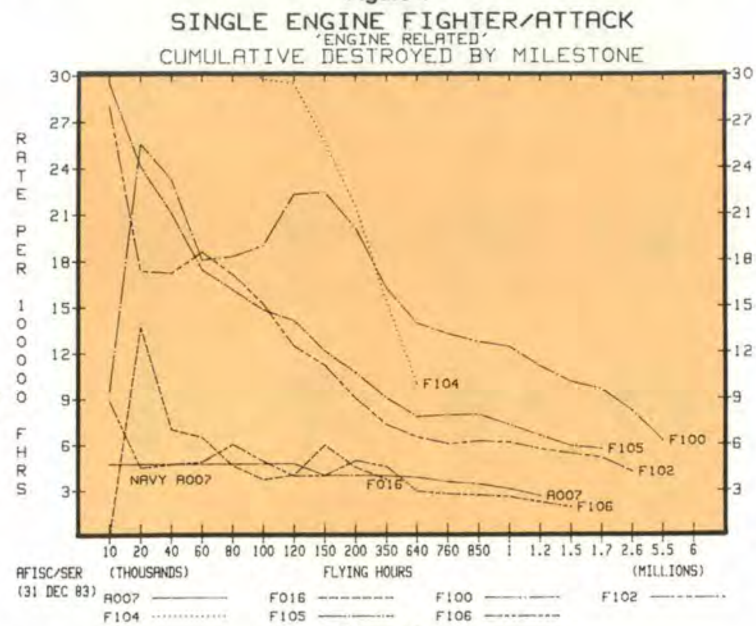
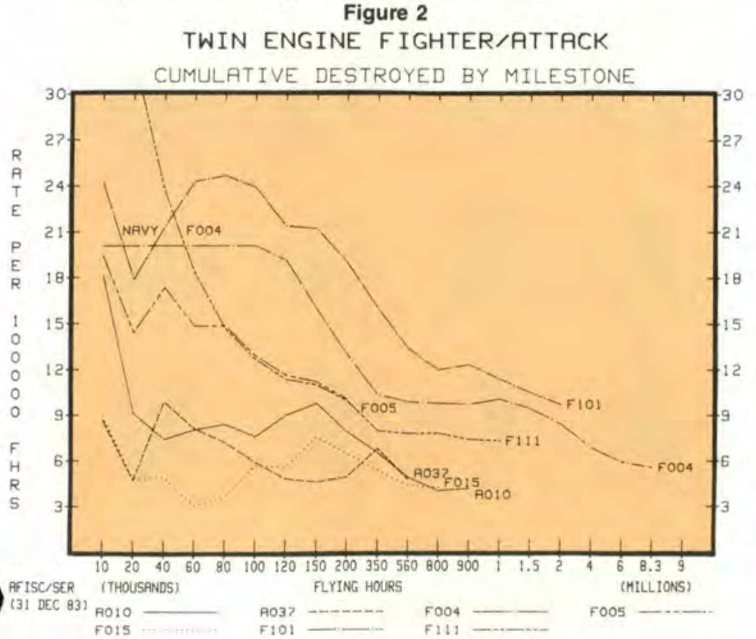


Figure 2



If you look at the three newest USAF aircraft on the above charts (F-16, A-10, and F-15), it's easy to see that their engine-related Class A mishap rates are better than any of the other aircraft. The mishap rates are: F-16, 3.7 per 10^5 flying hours after 349,000 hours; A-10, 0.2 per 10^5 flying hours after 903,000 hours; and F-15, 0.2 per 10^5 flying hours after 795,000 hours; and the trend for all three is still improving.

Of course, there is a reason for these excellent safety records — the overall Air Force and contractor team that developed, procured, manage, support, operate, and maintain these systems. Although I can't cover all of the reasons for the successful programs, some of the reasons are as follows.

During the development of these aircraft (and their engines), inputs from the operational commands and Logistics Command were incorporated into the development contract by Systems Command along with their own requirements. Good communication between the commands, the airframe system program offices (SPOs), the engine SPOs, and the contractors also have identified and solved many potential problems before they happen. Extensive testing under realistic conditions and testing of interfaces between the engine and other aircraft systems have also identified problems that have been solved before causing a mishap. Finally, the service reporting/material deficiency reporting system that has evolved is responsible for early identification of failures that have the potential for catastrophe so that new designs can be developed and implemented before loss of aircraft occurs.

All of you deserve the credit for your continuing efforts and a job well done. ■

A-7

LT COL DOUGLAS M. CARSON
Directorate of Aerospace Safety

■ The A-7 is an all-weather attack aircraft which first entered the USAF inventory in 1968. Approximately 1,000 A-7 aircraft are in service worldwide. Greece has over 50 A-7H models (which are similar to our USAF D models) and Portugal operates about 25 A-7Ps (which are similar to Navy A models). The US Navy has over 500 A-7s. About 75 percent of those are A-7Es which closely resemble our A-7Ds. The USAF has about 400 D and K models in service, mainly with the Air National Guard (ANG). The USAF fleet flies about 80,000 hours per year and should reach 1.2 million hours in 1984. The A-7 has one of the best (some A-7 jocks say the best) air-to-ground capabilities of any aircraft in the inventory, and it will continue to see service with ANG units for several more years.

We have experienced 75 Class A mishaps with the A-7 from the first mishap in 1970 through the end of 1983, which has yielded a cumulative Class A mishap rate of 6.7. These 75 mishaps resulted in the destruction of 75 aircraft and the loss of 31 lives. The mishap rate compares favorably with other USAF fighter/attack aircraft with the A-7 having the fourth lowest destroyed rate out of the following 12 fighter/attack aircraft.

Cumulative Destroyed Rates
(As of 31 Dec 83)

F-104	25.2	F-106	7.3
F-100	16.2	F-111	7.3
F-105	15.6	A-7	6.7
F-16	10.4	F-4	5.4
F-101	9.7	F-15	4.4
F-5	9.7	A-10	4.1

Figure 1

This mishap record is especially significant for two reasons. First, the A-7 is a single-engine aircraft. All of the other fighter/attack aircraft with lower rates are twin-engine aircraft. Secondly, the A-7 is a ground-attack aircraft and continually operates in the low level environment where a high number of mishaps historically occur.

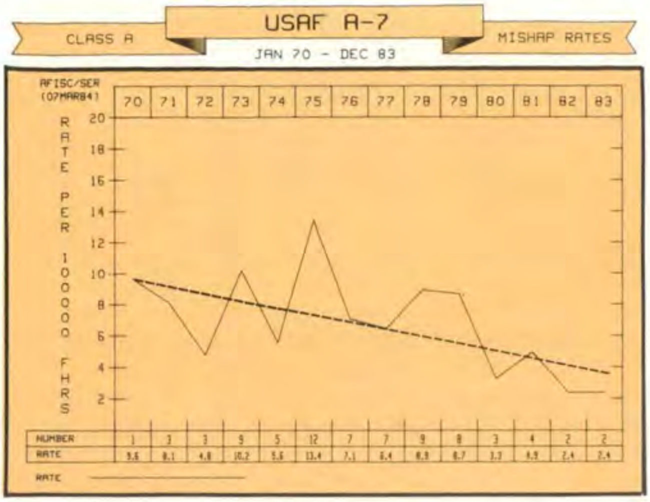


Figure 2

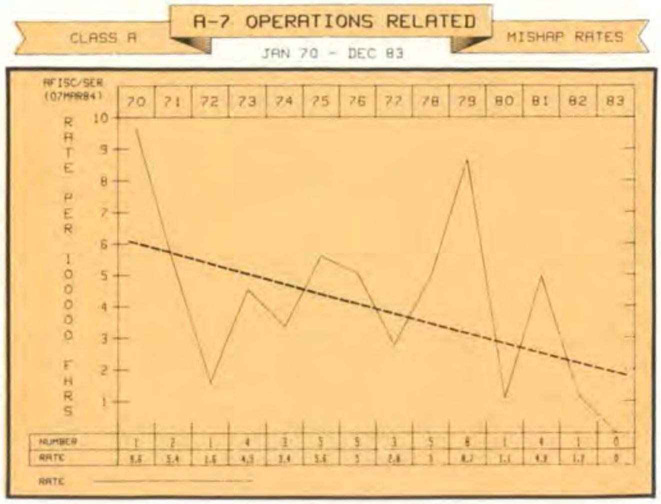


Figure 3

Figure 2 shows the Class A mishap rates and trend for all the A-7 Class A mishaps through the end of 1983. The solid line shows the annual mishap rates, and dashed line indicates the trend. The blocks at the bottom give the actual number of mishaps and rate for each year. This is the "big picture" and the overall trend is very good. To make it more meaningful, let's break it down into operations-related and logistics-related mishaps and then discuss last year's mishaps in more detail.

There were 43 operations-related mishaps through the end of 1983. The largest single category, loss of control, was responsible for the loss of 18 aircraft and 11 lives. Not surprisingly, most departures from controlled flight occur in air combat tactics (ACBT). The automatic maneuvering flaps have been instrumental in virtually eliminating this type of mishap. The second largest category involved collision with the ground. Unfortunately, the fatality rate in this type of accident is rather sobering. Fifteen aircraft were destroyed and 14 pilots were killed. Eleven of the mishaps occurred on air-to-ground ranges and four were non-range collisions with the ground. Five midair collisions claimed seven aircraft and two lives. Miscellaneous causes accounted for the five remaining ops-related aircraft losses.

Figure 3 shows the operations-related mishaps and trend from 1970 through 1983. The overall trend was fairly constant through 1981 with ops-related mishaps remaining at a constant four to five mishaps per year. Starting in 1982, there was a dramatic decrease which started to drive the overall trend down. The best news is that last year, for the first time, there were no operations-related A-7 Class A mishaps! Commanders, supervisors, and pilots all deserve a pat on the back for this one. Now it's time for all A-7 drivers to reflect on everything they did right last year and make a resolution to continue to do business that way in the future.

Now, let's take a look at Class A mishaps which were attributed to logistics. Logistics-related mishaps accounted for 32 destroyed aircraft but only three fatalities.

The TF41 engine was the biggest single problem we had with the A-7. Eighteen aircraft were lost and there were many close calls. The major problem areas included turbine (8 mishaps), compressor (5 mishaps), and bearings (5 mishaps). In the mid-seventies, engine modifications (Block 76 mods), which incorporated several fixes in weak areas, were evaluated in a lead-the-force program. The mods proved successful, and a program was started to modify all engines in the fleet. Those engine fixes are

continued

In 1983 the A-7 had the lowest Class A mishap rate of all USAF single-engine aircraft. The record is especially noteworthy considering how many hours this ground attack aircraft logged in the high-risk, low level environment.

about 98 percent complete. Fuel system malfunctions were responsible for eight mishaps. The breakdown is: fuel transfer problems, 2; main fuel control, 2; HP pump, 1; HP filter, 1; and undetermined, 2. There were two oil system mishaps which were the result of oil system FOD.

The actual aircraft structure has presented very few problems with the exception of the canopy. Canopy losses/failures caused three mishaps, one of which was a fatality. Inadvertent ejections resulted when the wind blast pulled out the face curtains. Canopy failures were caused by two separate problems — improperly drilled holes and air bubbles in the lamination of acrylic and fiberglass. The improperly drilled holes were fixed through a one-time inspection, and ultrasonic inspection resolves the lamination problem. Defective canopies were purged from the system. The remaining mishap attributed to the aircraft structure was a wing folding on take off. The pilot ejected successfully, but the aircraft was destroyed. The corrective action was the addition of wingfold mechanism inspection holes.

Figure 4 shows the logistics-related mishaps. The favorable trend is quite probably the result of excellent ANG maintenance, and I expect the number of logistics-related mishaps to stay at a low level. However, it's possible that problems could develop as the aircraft get older.

The USAF A-7 fleet experienced two Class A mishaps in 1983. Both aircraft were destroyed, and one pilot was fatally injured. Both were the result of second-stage high pressure turbine (HPT-2) failures.

The first mishap occurred on the 2V2 ACT mission. The number two aircraft experienced an engine failure. Airstart attempts were unsuccessful. Passing 1,500 feet, the flight lead directed the mishap pilot to eject, which he did immediately. The over-water ejection appeared normal, but, for an unknown reason, post-ejection procedures were not accomplished. When rescue personnel arrived on the scene, they found the pilot had drowned.

The second mishap was similar. The mishap aircraft was number two in a two-ship flight. Five minutes after take off, the aircraft had an engine failure. Airstart attempts were unsuccessful. The flight lead reported the aircraft to be on fire, and the mishap pilot ejected successfully.

As a result of these two mishaps, as well as similar Navy losses, the TF41 hot section extended life program (HELP) was expedited. Under this program, TF41 engines will be retrofitted with totally new design HPT wheel/blade assemblies. Kit delivery is scheduled to start this year, and at a projected rate of 15 kits per month, the retrofit will take about 2½ years to complete.

That's a brief rundown of the mishap experience for the USAF A-7 fleet. The mishap rate has continued to decrease as ANG units have gained experience with the aircraft. At the beginning of 1983, the analysis folks at the Inspection and Safety Center predicted three Class A mishaps for the fleet in 1983. I'm happy to report you proved them wrong! The two mishaps gave us a 1983 A-7 Class A mishap rate of 2.4, which tied 1982 for the lowest rate ever!

Well, what about 1984? I'm not quite as pessimistic as the analysis guys because I know how good the ANG fliers and maintainers really are.

My personal prediction for 1984 is two A-7 Class A mishaps which will result in two destroyed aircraft and one fatality. The breakdown will look like this:

Collision with terrain	1
Logistics-related	1

Remember, this is a prediction — not a goal! I hope I'm wrong — especially about the fatality. ■

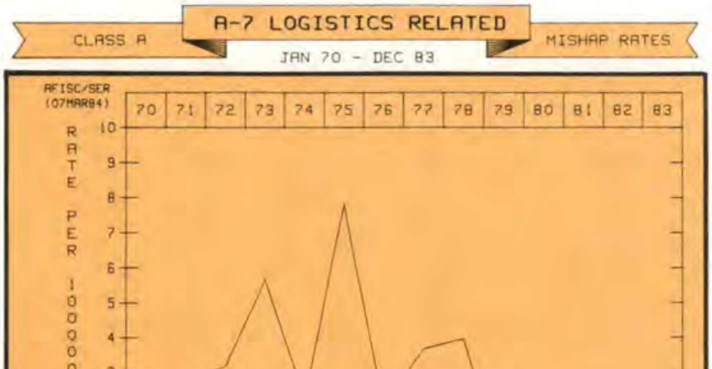


Figure 4

A-10

LT COL JAMES H. GROUND
Directorate of Aerospace Safety

■ The A-10A Thunderbolt II, or "Warthog," to use a more affectionate term, has just completed its 9th year of flying since the first production flight in March 1975. The A-10 is now flown by nine active duty wings, including test wings at Edwards and Eglin, five Air National Guard units, and four Air Force Reserve units. The last production aircraft, which brings the total to 713, will be delivered in March 1984.

This highly maneuverable machine performing close air support for ground troops has the distinction of having the best operational maintainability record in the USAF fighter/attack community. An example is the 73.1 fully mission capable rate for all A-10s in FY 1983. This compares favorably with the F-16 at 65.8, the A-7 at 64.3, and the F-15 at 62.1 during the same time period. You may also be aware that, as of 31 December 1983, A-10 units had accumulated 903,400 hours of flying time with a cumulative Class A rate of 4.2, the best for fighter/attack aircraft in USAF history.

This is a remarkable achievement when one considers the high threat, low altitude tactics that were necessitated after the initial design concept was established during the Vietnam era. This rate, however remarkable, still translates into the loss of 38 aircraft and 19 pilots, a most sobering bottom line when thought of in terms of two squadrons of aircraft and a squadron of fellow pilots. Figure 1 gives a quick overview of all A-10 Class A mishaps.

Comparing annual mishap rates, 1983 was not as successful as 1982 (Figure 2). Seven Class A mishaps resulted in a 3.1 rate including nine

continued

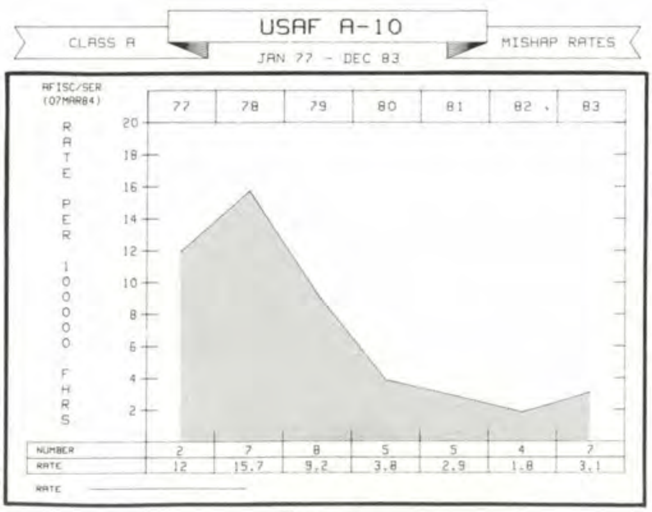


Figure 1

A-10 Class A Mishaps
Operations-Related

CATEGORY	77	78	79	80	81	82	83	CUM.
Control Loss	1	1	1		1	2	1	7
Collision With Ground			2	2	1			5
Range	1	2	1		2		3	9
Midair Collision		1		1			2	4
Landing (pilot)		1				1		2
Flameouts (pilot)						1		1
Ops Other				1				1
LOGISTICS-RELATED								
Flameouts		1	1					2
Flight Controls			1		1			2
Engine Failure		1						1
Fire (hydraulic)			1					1
Log Other							1	1
UNDETERMINED								
			1	1				2
TOTAL	2	7	8	5	5	4	7	38

Figure 2

destroyed aircraft and four fatalities. The following provides a short synopsis of 1983 mishaps.

- Low altitude, hard turn off target, late recovery; ejected out of envelope; fatal.
- False fire warning light on GCA final; shutdown engine; lost control; ejected safely.
- Low altitude turn to conventional range downwind; impacted ground; fatal.
- Low altitude defense maneuvering against attacking aircraft; lost control; ejected safely.
- Low altitude descending turn; late recovery; impacted ground; fatal.
- Midair during BFM; both ejected safely.
- Midair during DACT; one ejected safely, one fatal.

One of the more disturbing aspects of the preliminary analysis of Class A mishaps in 1983 is that 3 of the 7 were loss of control or midair collisions during defensive ACT or BFM. All three were a result of unclear or misunderstood ROE and/or A-10 maneuvering capabilities. More guidance on ACT has been provided to the field and more may be on the way pending final review of the later Class As.

Three others occurred during low altitude, weapons delivery. It appears that all three mishaps may have been the result of channelized attention, distraction, or task saturation coupled with a descent, not perceived until recovery was impossible. Training pilots to maintain situational awareness is one way to fix this problem but a difficult one with which to grapple. There are two potential fixes which may give the pilot some help.

The first is the ground proximity warning system (GPWS) which is presently being flight-tested in the A-10 at Edwards AFB. This system uses a radar altimeter with a wide angle antenna array (over 120° bank) and other inputs to predict ground impact. A voice warning can be provided, even at high bank angles, with sufficient time for the "unaware" pilot to recover.

Other features being tested include take off, landing, and air-to-ground attack modes. This limited discussion is intended only as an introduction to the subject. It is a very complex problem with many obstacles to overcome, not the least of which is being able to provide sufficient warning to the "unaware" pilot while not saturating the situationally aware pilot with nuisance warnings. Even if the concept proves feasible, we will probably not see this modification for many months.

Another potential improvement in terrain avoidance is a new approach to training being developed by Captain Milt Miller of the 162d TFTG (ANG) at Tucson, Arizona. His low altitude awareness training program offers some new ideas that have been well received by many. The program is still being refined, so we'll continue to monitor its progress and report updated status.

Also, if you haven't read "Human Factors Aspects of Selected Class A Mishaps" by Major Jay Stretch, drop by your wing flying safety office. They should be able to get a copy for you. He offers some good ideas for low altitude flying.

The final 1983 Class A is a logistics-related mishap that occurred on GCA final approach. A faulty resistor in the fire detection control box started the sequence of events which led to loss of aircraft control. There are several actions underway which should reduce the potential for a repeat of this type of mishap. A new fire detection system is being tested at Nellis. The test should be completed in early 1985. If this system is procured, approximately 91 percent of the fire warnings, those from chafing or corrosion, could potentially be eliminated. This assumes that we also improve maintenance procedures, and installation instructions so as to minimize false warnings. This will not eliminate the 6 percent from fire detection box malfunctions, the logistic problem in this mishap. These failures have exhibited no pattern. Also, predicting or detecting the potential failure of a resistor has proven impractical. The other 3 percent are the warnings we want — actual fires!

Other actions include changes to the flight manual to improve emergency procedures and more training emphasis on engine fire/flameout procedures when con-

Within the fighter/attack community, by the close of 1983 the A-10 had earned the best cumulative Class A rate — 4.1, and the best operational maintainability record.

A-10 Class B Mishaps

CATEGORY	78	79	80	81	82	83	CUM.
Engine FOD	2		1	4			7
Engine Fire/Overheat	1	1	3	1			6
Engine Failure				1			1
Birdstrike				2			2
Landing				1	1		2
Weapons Malfunction		1					1
TOTAL	**3**	**2**	**4**	**9**	**1**	**0**	**19**

Figure 3

figured for landing. Many of these changes have already occurred.

There were no Class B mishaps in 1983, an improvement over the one hard landing in 1982. Figure 3 gives a summary of all A-10 Class Bs.

Class C and high accident potential (HAP) mishaps declined slightly for the second consecutive year. Listed below are the major contributors of the 305 that were reported in 1982 and the 291 in 1983 followed by a discussion of a few important areas.

Class C/HAP Mishap Summary

	1982	1983
Close calls	8	2
Engine (w/o FOD)	83	90
Engine FOD	61	43
Birdstrikes (airframe)	29	36
Flight controls	24	14
Landing gear	23	15
Fire warning	16	19
Physiological	15	13
Starter/APU	15	15
Fuel	6	10
All others	25	34
TOTAL	**305**	**291**

Figure 4

The "close call" category is a separate grouping for those that may not quite fit other categories. These fall into two general areas — collision with terrain/terrain features (potential As) and runway departures (As or Bs). Unless a person was on the scene, it's a little difficult to tell whether a runway departure missed a 10-foot ditch by inches and was almost a Class A, or if there was more damage to the pilot's pride than the potential damage to the aircraft. There were four collisions with terrain and four runway departures in 1982 and one of each in 1983.

Engine-related mishaps are another potential "close call" category. We've already noted in figures 1 and 3 that a few have gone beyond "close calls" and become As or Bs. The significant subcategories for 1983 engine shutdowns, failures, and flameouts are as follows: flameouts, 27; oil system, 26; stall/overtemp, 18; other shutdowns/failures, 19. The 19 false fire warnings also resulted in shutdowns but are not categorized as engine-related mishaps. There are some other engine problem areas worth discussing.

In 1983 the A-10 experienced the fourth fan shaft failure in 3 years. The Navy S-3 (TF 34-400) has also experienced this failure, so there is a lot of interest in the proposals to resolve the problem. The failure modes are cracking of the number one bearing housing and bearing failure. An improved carbon bearing seal and a stronger bearing housing with greater clearance have been proposed. A new "Murphy proof" oil filler cap now in the inventory should reduce the number of oil system shutdowns. However, the old cap will be around for awhile, so watch out for "Murphy." Engine stalls during hard maneuvering should be reduced by the addition of TCTO 986, the one-second continuous ignition relay, now completed fleet-wide.

Another important proposal is the hot section improvement, a multi-faceted project that is still about a year and a half from initial installation. Several other engine fixes are on-going, but limited space precludes reporting on all of them. If you want more details, talk to your squadron flying safety officer, the engine shop, or the GE rep. They'll be glad to fill you in on some of the other improvements.

Fuel foam fires in A-10s configured with blue foam have begun to appear again. After the fuel purge system was disconnected, the problem was thought to be solved — at least, the mishaps stopped occurring. One isolated case in 1982 appeared to be caused by lower levels of anti-static additive in the fuel. Incidents in late 1983 apparently occurred in-flight under cold, dry conditions. One theory is that fuel sloshing might be causing the static build-up. The A-10 system manager at Sacramento Air Logistics Center, the Fighter/Attack System Program Office at Aeronautical Systems Division, the manufacturer and others are working together to find a solution. The good news is that the blue foam has managed to suppress all of the fires that its electrostatic characteristics have generated. In the interim, red foam will replace the blue foam in vent tanks and any singed foam found in other tanks.

There were slightly fewer smoke and fume/physiological incidents in 1983. Similarly to fuel foam fires, causes of these problems are not easy to identify. About half were toxic fumes and the other half 0_2/pressurization problems or sinus blocks. The major sources of contaminants appear to have been from leaking carbon seals in the en-

continued

Described by Fairchild as "the answer to the field-telephone prayers of every soldier pinned down in a muddy foxhole," the Warthog has just completed its ninth year of flying.

vironmental control system (ECS) air cycle machine and sticking bleed air valves during water wash. Both of these sources were contaminating the water separator (coalescer) sock. When hot air from the ECS hit the coalescer sock, the contaminants were transformed into toxic fumes. Some excellent investigations and crosstell at safety conferences have helped in the development of local procedures which focused on all facets of the problem. Additionally, Sacramento ALC developed a checklist for investigating A-10 physiological mishaps. AFISC has evaluated this with the thought of developing a generic checklist for all Air Force aircraft. The A-10 checklist should already be distributed to all A-10 units for incorporation into their local procedures.

A major reduction was noted in flight control mishaps. Several modifications have been completed, mainly in the "white area," and another is on-going during depot overhaul. Special flight control maintenance teams, closer attention to tech order instructions, and T.O. improvements made a significant contribution to the downward trend in flight control mishaps. These past and continued efforts should be applauded. Most of the mishaps in 1983 were slat buckling. The A-10 system manager is studying new design proposals, one of which is a unison extension mechanism. It will probably be several months before any new design can be tested. Even though flight control mishaps have decreased, constant attention should be devoted to this area. The potential for a serious problem always exists.

The new designs for A-10 wheels and tires, thorough non-destructive inspections (NDI's) and shot peening of both nose and main wheels, holographic (laser photo) testing of rebuilt tires, and close monitoring of tire condition/pressures, have all greatly contributed to the decrease in wheel and tire mishaps. New wheels and tires have been replacing the old design tires by attrition, but there are still several of the old design wheels and tires in use. Be aware that the new tires can fail, too. A manufacturing defect was identified as the failure mode of one recent tread separation. Again, vigilance is still in order.

This discussion has only skimmed the surface of some of the problems in 1983. If you want more details and the local wizards don't have the answers, give us a call at AUTOVON 876-3886 or write to HQ AFISC/SEFF, Norton AFB, CA 92409. We'll be glad to answer your questions or do our best to find the answer for you. ■

A/T-37

LT COL HORST PONERT, GAF
Directorate of Aerospace Safety

A-37

■ The A-37B Dragonfly fighter bomber was designed as an attack and counter insurgency jet aircraft. From the time it entered the USAF inventory in the early seventies, it became well known for its ruggedness and safety. It is also in use in foreign countries. There are 119 A-37B aircraft in service with TAC, PACAF, the Air National Guard, and the Air Force Flight Test Center.

As of 31 December 1983, the USAF fleet had accumulated 583,909 lifetime flying hours; 28,218 hours were flown in 1983. Through the years, we have experienced a total of 31 Class A mishaps. Due to a mishap-free 1983, the lifetime mishap rate dropped from 5.8 at the end of 1982 to 5.3 at the end of 1983.

A breakdown summary of Ops-related and Log-related mishaps for the last 10 years shows a 5:2 ratio of Ops to Log-related mishaps, while 3 went undetermined (Figure 1). Thus, the crew still plays the key factor in that cruel equation. However, it seems that we have a fairly good handle on the technical aspects. Quality control, troubleshooting procedures, etc., have improved significantly to support a relatively safe flying operation. The last "undetermined" mishap dates back to 1975. Our well trained, dedicated mishap investigation teams and all the technical experts within the various organizations definitely deserve our appreciation for a job well done.

Here are some highlights of 1983's safety "activities" and an outlook for 1984:

■ The HBU series lap belts have been implicated in numerous MDRs. After a newly designed lap belt was developed, the A-37B fleet

modification was completed in September 1983.

■ Most of the Class IVA safety modifications concerning the J85 jet engine (i.e., replacement of compressor blades, turbine rotor wheels, etc.) are 98 percent completed.

■ Kit delivery to standardize instrument locations for the attitude indicator, course indicator, and BDHI will start in March 1984. The modification should be completed this year.

■ The A-37B experienced an increase in engine flameouts with a peak of 12 flameouts last October/November. Five of them occurred during air refueling. Cause is attributed to fuel overspray during/after fuel transfer for various reasons. Air refueling procedures and parameters to fix this problem are presently under review.

For 1984 we do not predict any mishaps. We do need, however, to put all our efforts in striving to make this goal of mishap-free flying really happen. ■

T-37

■ The USAF possesses 649 T-37B trainer aircraft at five UPT bases, one PIT, and one navigator training base. Additionally, there is the ENJJPT (Euro NATO Joint Jet Pilot Training) facility which hosts instructor pilots and trainees from almost all NATO countries.

Total T-37 flying time reached 8,795,049 flying hours by 31 December 1983, and it will climb over the 9 million mark in late summer, 1984. During this time, we experienced only 124 Class A mishaps for an overall rate of 1.4.

For 1983, AFISC predicted 3 Class A flight mishaps, namely two control losses, and one engine problem. But you, the operators, proved us wrong by keeping up your professional work. We experienced only one mishap while accumulating 366,072 flying hours, resulting in a mishap rate of 0.3. The one mishap involved a solo student who broke out of the aux field traffic pattern because of a perceived traffic conflict. While maneuvering for re-entry, he became geographically disoriented in a left turn and crashed. He did not attempt to eject.

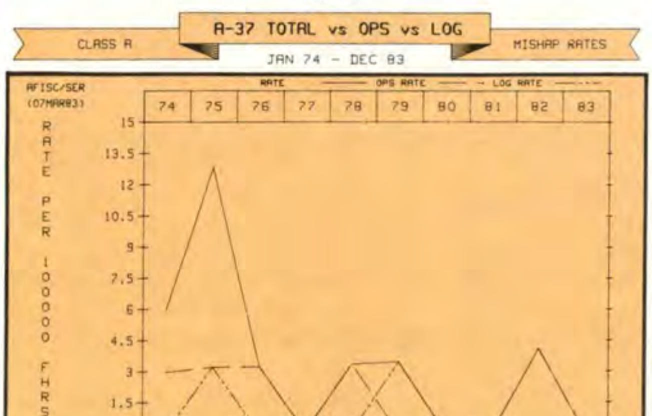
Unfortunately, two T-37B's were destroyed on the ground in 1983 when the aircraft low pressure oxygen systems were serviced with high pressure equipment. These mishaps could have been prevented by following appropriate procedures.

Figure 2 is a summary of the last 10 years' mishap history. We had 18 Class A mishaps, 13 were Ops-related, and 5 were Log-related. As with the A-37 fleet, the pilots account for the majority of mishaps. Solo students seem to be particularly susceptible to control losses. What can we as pilots and supervisors do to preclude recurrence of Ops-related mishaps? Ongoing technical improvements include but are not limited to:

■ HBU-12/A lap belts. Modifica-

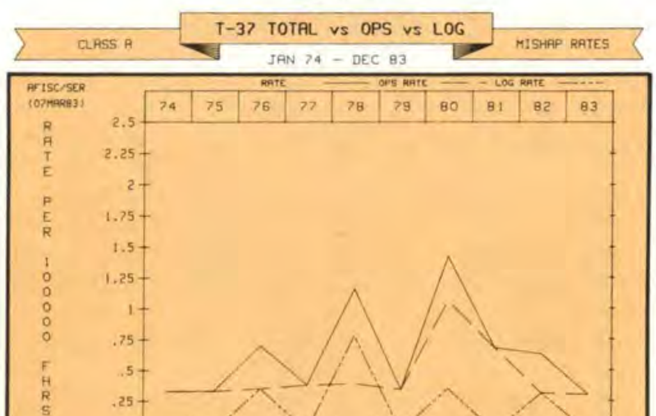
continued

Figure 1



	74	75	76	77	78	79	80	81	82	83
MISHAPS	2	4	1	0	1	1	0	0	1	0
RATE	6	12.8	3.2	0	3.3	3.4	0	0	4.1	0
OPS RATE	3	3.2	3.2	0	3.3	0	0	0	4.1	0
LOG RATE	0	3.2	0	0	0	3.4	0	0	0	0

Figure 2



	74	75	76	77	78	79	80	81	82	83
MISHAPS	1	1	2	1	3	1	4	2	2	1
RATE	.3	.3	.7	.4	1.2	.3	1.4	.7	.6	.3
OPS RATE	.3	.3	.4	.4	.4	.3	1.1	.7	.3	.3
LOG RATE	0	0	.4	0	.8	0	.4	0	.3	0

T-37

continued

tion of the T-37B fleet with newly designed lap belts is more than 90 percent complete.

- ARU-42/A-2 standby attitude indicators. Since primary and secondary attitude indicators operate from the same AC bus, loss of AC power automatically results in loss of all attitude information. The fix is to install a DC powered standby attitude indicator, scheduled to be completed by September 1984. When completed, this hazard will, hopefully, be eliminated.

- Engine flameouts. To minimize the probability of engine flameouts, the following three areas are under evaluation: (1) field-level troubleshooting procedures for main fuel control; (2) the effects of in-flight icing; (3) adequacy of fuel filtration system. Evaluation results are expected soon.

- Fire warning system. There have been over 40 false fire warnings in the last 4 years. After a fatal mishap in 1982, San Antonio ALC was investigating the feasibility of replacing the existing system with improved fire detector loops. Because of a high cost factor and the relatively short time the aircraft will remain in the inventory, the proposed modification was turned down. We need to do a better job in maintenance and inspections of these systems.

In conclusion, the prime area of safety emphasis is *the operator*. Fly smart — fly safe. Make 1984 the safest year yet. ■

F/RF-4

MAJOR GARY R. MORPHEW
Directorate of Aerospace Safety

■ The F/RF-4 is an all-weather, multirole aircraft which remains the backbone of today's fighter force. Although being replaced in the active forces by newer weapon systems, over 1,600 F-4s continue to supply role diversity to the tactical air forces in the active Air Force as well as in the Air National Guard and Reserves. Since 1982, the Guard and Reserve have more of the F-4 fleet than any active command. As of the end of 1983, more than 44 percent of the F-4s belonged to the Guard and Reserve units.

The F/RF-4 is programmed to remain in service well into the 1990s. The F-4Es, Gs, and RF-4Cs may be flying into the next century. In order to maintain the combat capability in the future, modifications are under way to improve reliability, increase effectiveness, and provide a safer environment for the crew in an increasingly demanding arena.

When compiling statistics, it is interesting to note that the F-4 community logs nearly 10 percent of the entire Air Force flying time annually; over 346,000 hours in 1983. Even with all the newer weapon systems now fielded, the F-4 logs greater than one-fourth of the total flying time for fighter/attack aircraft. Before you get a swelled head about this, it is sobering to see that the F/RF-4 contributed nearly 24 percent of the Class A flight mishaps during 1983 for all types of aircraft and 30 percent of the fighter/attack Class As.

Even so, 1983 proved to be another good year for the F-4, statistically. While predicted to have 17 Class A mishaps and 16 aircraft destroyed, the F-4 beat the odds for the second year in a row, losing only 13 aircraft in 14 Class A flight mishaps. This is an annual rate of 4.0 per 100,000 flying hours. Thus, historically, we are establishing a good trend (Figure 1). 1980 had 19 Class As for a 5.4 rate; 1981 had 20 Class As for a 5.7 rate; 1982 saw the first trend reversal with 13 Class As and a 3.8 rate; and 1983 continued that lower than predicted rate.

We break the rates down further into three categories: Logistics, Operations, and Miscellaneous/Undetermined. It is here we begin

to find where we are doing things right, and where we must work harder.

Logistically, this was the banner year (Figure 2). Considering that we logged over 346,000 flying hours in 1983, with four significantly different MDSs, and many airframes over 4,000 tactical flying hours, we have had a marvelous logistics year — only 3 Logistics-related mishaps: an electrical failure; a fuel system related double engine flameout; and a fire in flight. This equates to an annual rate of only 0.89! Compared to past years, this rate has been the best since 1963 when we had no logistics-related mishaps (largely due to only a few specially watched aircraft). There were two miscellaneous Class A mishaps in 1983 which involved a failure or suspected failure of a wing surface, but both cases were attributed to a new cause: wingtips vortices/wake turbulence in the ACM/BFM arena. On the operations side of the mishap rate, we have not done so well (Figure 3). While lower than predicted (8 actual vs 10 predicted), some very definite conclusions can be drawn from the mishaps. Second-level cause analysis revealed a more subtle and perhaps even more important factor in Ops mishaps — human factors. In the past, we had labeled tactical employment, the "fly as we are going to fight" missions as being causal or contributory to the mishap rate. In 1983, however, we saw a drastic shift in the "human factor" influence. Over half of the Ops Class A Flight Mishaps involved a breakdown in basic flying skills

- Rejoins, fuel awareness, formation discipline and personal discipline accounted for these losses.
- We need to take a hard look at the man, his environment and the stresses put on him to accomplish the mission and ensure we don't exceed his capabilities.

In the area of Class B Mishaps, 1983 was also a very good year.

- Although there were several mishaps that appeared to run close to the Class B criteria, at year's end we reported only one Class B, the failure of an afterburner fuel pump. Fortunately, the pump modification completed in 1983 should put an end to these mishaps.

Class C and HAP reports for 1983 demonstrated recurring problems: Engine compressor stall/flameouts — 85; afterburner malfunctions —

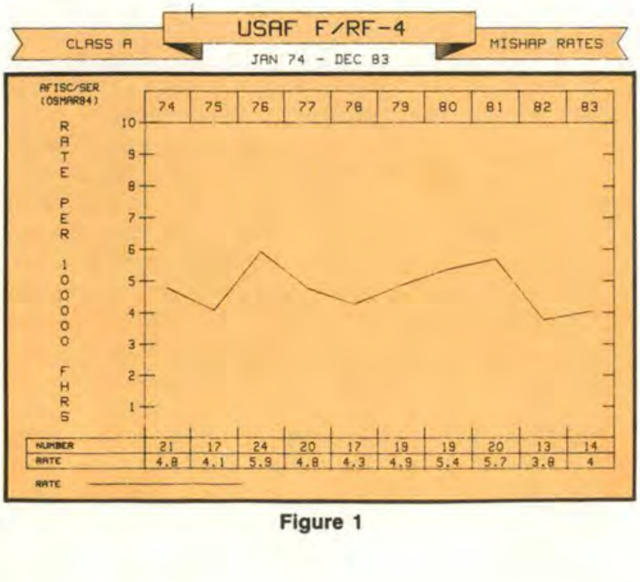


Figure 1

Logistics Factor Mishaps	1981	1982	1983
Engine	1	2	1
Fuel System	2	2	1
Flight Controls	1	1	0
Hydraulics/Pneumatics	2	0	0
Bleed Air	1	1	0
Electrical	1	0	1
Misc/Undet	1	0	0
TOTAL	**9**	**6**	**3**

Figure 2

Operations Factor Mishaps	1981	1982	1983
Pilot Loss Of Control	6	2	4
Collision W/Ground (Non-Range)	2	4	1
Collision W/Ground (Range)	0	1	0
Midair Collision	1	0	2
Fuel Starvation	1	0	1
Ops Other	1	0	0
TOTAL	**11**	**7**	**8**

Figure 3

continued

75; FOD — 91. Class Cs totaled 618 throughout the F-4 fleet in 1983. High Accident Potential (HAP) mishaps numbered 102. Considering the number of aircraft and the total flying time for the year these numbers are not unexpected. Class Cs and HAPs are where we find the Class As and Bs that haven't happened yet. If the F-4 community is to continue its established downward trend, flight safety officers (FSO's) in particular, must be even more diligent in conducting thorough investigations with solid recommendations to those who can work and implement the fixes to the problems.

Your efforts to reduce the overall mishap rate have been successful. We continue to modify the aircraft with safer hardware and learn better ways of accomplishing the mission. In order to improve on the performance of the past 2 years we must pull together to beat the 1983 rate and decrease our losses even further. Updates, modifications and increased awareness on the part of operators, maintainers, and supervisors are essential.

A complete listing of modifications would be excessive for an article of this type, so a summary of the most important ones for 1983 and 1984 is provided.

First, and by far the most significant achievement for the logistics safety efforts, was the complete changeover to the modified afterburner fuel pump. This gargantuan effort was accomplished a full 7 months ahead of schedule! The real payoff will be the decrease in AB pump related fires.

The Engine Bay Integrity program is 92 percent complete and should finish up within the next few months. This program has ferreted out areas of weakness and potential failures and developed inspections to prevent them.

The new pneumatic fire warning system is now installed in over two-thirds of the fleet. While there have been some installation problems and a few surprises, the new system promises to keep the false fire warnings and subsequent engine shutdowns to a minimum.

The long-awaited, Low-Altitude/Canopy Warning modification is in the field. The persistent problem with lost canopies (6 in 1983) should be largely eliminated by this modification.

Although the F-4 logs more than a fourth of the fighter/attack flying time, in 1983 it also contributed almost a third of the fighter/attack Class As. The challenge for '84 is obvious.

A new gas-initiated ejection seat modification has recently been fielded. This modification will do away with the floor-mounted lanyards and replace them with an initiator which will sense the upward motion of the catapult and fire the rocket motor.

A recent decision by the AFLC managers has resulted in a change in the procurement of a new birdstrike resistant windscreen (52 damaging birdstrikes in 1983 for a 15.7 rate). The change involves replacing windscreen quarterpanels with new, stronger panels as a stock supply item rather than as a Class IV modification. This way, F-4s will be getting the new equipment as the panels need replacing instead of awaiting funding and procurement for an eventual fleetwide modification. Phase II of the modification plan, the single wrap around windscreen, is programmed for testing during the summer of 1984 and will continue as a Class IV mod.

Addressing the "human factor" area, we at AFISC are attempting to identify second-level causes of mishaps and to articulate those causes/problems to the field. The past year's mishap investigations have shown an increased awareness of the effects of such factors as stress, inattention, job-related pressures and motivations. There is a long way to go in predictive safety. Until we can get a firm handle on the human element, as we now seem to have on the logistics side, we must all strive to be honest in assessing our own capabilities and performance on a day-to-day basis as well as those for whom we are responsible. Anything less is unacceptable. More importantly, if we fly smart — we'll fly safe. The 1984 mishap forecast predicts 13 F-4 mishaps. That's the actual number experienced in 1983, which was 4 fewer than predicted. With effort we can "beat the system" again this year and prove the forecasters wrong. Let's do it. ■

F-5

MAJOR ERNEST A. BRIGGS, CF
Directorate of Aerospace Safety

■ The USAF operates approximately 100 F-5 aircraft. Tactical Air Command is the primary F-5 user with 70 percent of the fleet. The other main operators of the F-5 tactical fighter are USAFE and PACAF. The main role of the aircraft is in aggressor squadron operations.

The aircraft has been in use by the USAF since 1963, and we have logged a little over 312,000 hours total flying time. We have experienced 30 Class A major mishaps which gives us a lifetime mishap rate of 9.61 for the F-5 weapon system. These Class A mishaps have accounted for the destruction of 30 aircraft and the loss of 11 lives. Operational-related mishaps involved 19 of the 30 total Class A's and the other 11 were logistics-related mishaps.

Of the three 1983 mishaps, two were operational and one logistics-related. This resulted in a 10.1 rate. These mishaps accounted for the destruction of three aircraft and the loss of one life.

Brief descriptions of 1983 mishaps are:

■ In the logistics-related mishap, the aircraft was engaged in the BFM upgrade mission. A helicoil in a fuel flow transmitter was improperly installed during manufacture. The improper seal in the fuel manifold area eventually allowed raw fuel to enter the engine bay area, resulting in an in-flight fire. During the mishap, the wingman confirmed the fire and the pilot successfully ejected at 12,000 feet, sustaining minor injuries. The aircraft impacted the ground and was destroyed.

■ The mission was a 1 V 1 BFM sortie. The mishap F-5 came under attack, and while the pilot attempted to defeat the attack the aircraft departed controlled flight and entered a spin. Recovery attempts were not effective. The pilot ejected and the aircraft was destroyed on ground impact.

■ An F-5 and an F-15 participating in a major exercise had a midair collision. Both aircraft were destroyed by the impact. The F-15 pilot ejected successfully, but the F-5 pilot was fatally injured.

Consistent with the F-5 past history, our 1983 statistics again show the pattern of two operational mishaps for each logistic mishap. Collision with the ground and pilot-induced control loss have accounted for 74 percent of our operational-related mishaps. Only you, the operator, can prevent this type of mishap.

The F-5 weapon system is continually monitored for trends, and many efforts are constantly underway to improve reliability and safety.

■ The egress modification that improves low level ejection to 0 feet and 50 knots was 97 percent complete by the end of 1983.

■ Fuel cell foam has been removed from the USAF F-5 fleet during the past year.

■ Still in progress is the installation of the improved steering actuator. After many problems, this improvement should be completed early in 1984.

Other technical improvements are being investigated and incorporated constantly to improve the safety and dependability of the F-5 weapon system.

Overall, the F-5 is a reliable, safe aircraft. However, human factor mishaps outnumber material failures by nearly two to one. We need everyone involved with the F-5 to resolve to do away with operator-related mishaps in general, but especially in 1984. This goal is achievable and worthy of our effort. ■

F-15

MAJOR MICHAEL J. KAYE
Directorate of Aerospace Safety

". . . an air superiority fighter built for one specific purpose — to clear the skies of enemy aircraft and with all design directed toward that one goal from the beginning . . ."

(from No Guts — No Glory, *by Major Fred Blesse, 1953)*

■ The USAF possesses 665 F-15 aircraft which include 322 A, 54 B, 248 C, and 41 D models. The contracted buy in 1984 is 38 aircraft. F-15s destroyed in flight and ground mishaps since 1974 include 25 A, 3 B, and 9 C models. From 1974 through 1978, logistics accounted for 11 out of 15 Class A flight mishaps. From the beginning of 1979 through 1983, operations accounted for 14 out of 22 Class A flight mishaps, with loss of control the leading problem.

Overall, 1983 was a good year for the Eagle. Six Class A mishaps were forecast for this period, but we experienced only four — three involving loss of control and one a midair.

Two of the loss-of-control mishaps were logistics-related. One involved an aircraft which developed a lateral asymmetry due to an undetermined malfunction in the internal wing fuel transfer system. The pilot was not aware of the lateral asymmetry, exceeded the angle of attack at which the aircraft was controllable, and departed controlled flight. A second mishap occurred when the left stabilator actuator failed allowing the left stabilator to drive to a fully deflected, leading edge up position. The aircraft began a series of continuous rapid right rolls and was not recoverable.

Two operations-related mishaps accounted for three destroyed aircraft. Two aircraft were lost in a midair collision shortly after the mishap element initiated a crossturn to avoid weather. Circumstances indicate a high probability that spatial disorientation contributed to the pilots' failure to see and avoid each other. Another mishap occurred during an attempted negative G rudder roll to defeat a gun attack. The aircraft reacted properly to flight control inputs, but the pilot misinterpreted the resultant roll as an out-of-control condition, became disoriented, and ejected.

Five Class B flight mishaps occurred in 1983. Two resulted when one of the main landing gear failed to extend, one from an AIM 9 hangfire, one from an augmentor burnthrough, and one when an aircraft departed the runway during landing roll because of a situation involving a low runway coefficient of friction and an antiskid malfunction.

The following were primary F-15 safety concerns in 1983.

■ Stabilator servocyclinder input shaft failures. Two failures occurred in 1983, one resulting in the loss of an aircraft. Two ECPs provide fixes for this problem. ECP 1751 is nearing completion and involves the installation of a new actuator clevis and the removal of actuator summing lever balance weights. Retrofit for ECP 1757 will begin this summer and involves an input shaft manufactured from an improved metal and a centering device that will drive the stabilator to neutral should the input shaft ever fail.

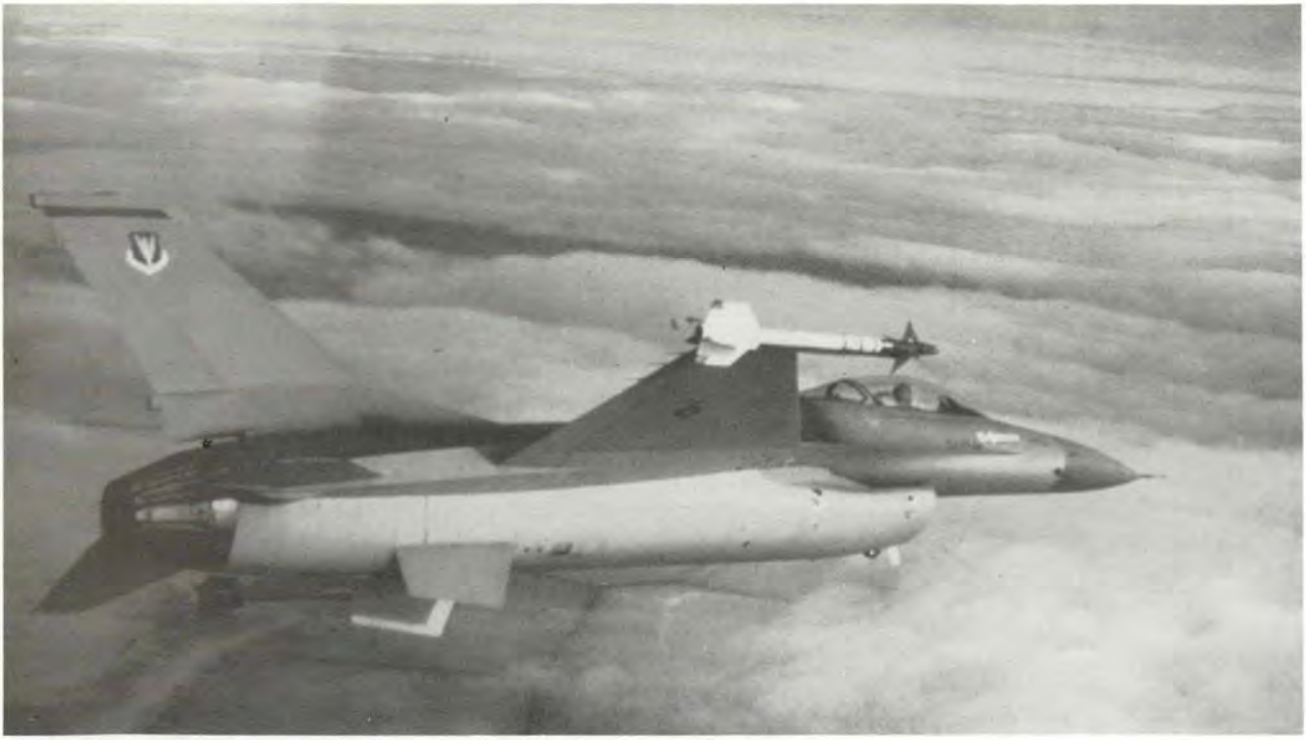
■ Afterburner burnthroughs. The fleet has experienced 25 incidents since the beginning of 1982 with over half of these occurring in 1983. Corrective actions are underway which will improve the augmentor liner and nozzle connecting hardware. These fixes should significantly reduce this type of mishap in 1984.

■ Landing gear emergency extension system failure. Failure of a main landing gear to extend resulted in two Class B mishaps in 1983. Although in both cases the malfunction could not be duplicated, it appears the landing gear door unlock actuator failed to function properly. Beginning in February, all uplock actuator slipper seals will be replaced with new notched seals. This action, in conjunction with revised door torque specifications, should correct the problem.

■ Red foam engine contamination. Deteriorating red wing tank foam created significant problems in 1983. A series of problems were encountered including several dual-engine anomalies. Project Foam Express was developed to accelerate red foam changeout in problem aircraft. The effort has been highly successful and will be completed by the end of 1984.

The F-15 Class A mishap rate in 1983 was 2.4 compared to a total fighter attack rate of 3.9. Although 1982's F-15 rate of 2.0 was slightly better than 1983, last year's rate represents an excellent achievement in which we can take pride. According to the AFISC forecasters our biggest challenge in the Eagle fleet in 1984 will be midairs. They predict three — that's half the total mishaps forecast. We can beat that. Let's continue working to reduce the mishap rate even further and strive for zero in 1984. ■

The first F-15 became operational in November 1974 at Luke AFB, Arizona. By the end of 1983, the 665 USAF Eagles earned a low 2.4 Class A mishap rate.



F-16

COLONEL PAUL ROST
Directorate of Aerospace Safety

■ Last year was a milestone year for the F-16. Despite a very poor start in January, we finished the year with the best overall mishap rate yet — a 7.4 Class A rate (Figure 1). For those of you who remember, we predicted 21 F-16s would be lost in 1983 and challenged you to bring that number to less than 13. Your hard work really paid off, as we finished the year with 11 Class As, a significant improvement over the 17 lost in 1982. This is particularly noteworthy since last year's hours alone accounted for 43 percent of the total hours flown since the first F-16 flight in 1975. Here are some of the significant milestones you achieved in 1983.

- 1,000th F-16 delivered worldwide (Jul 83).
- Lowest F-16 mishap rate ever (Class A rate — 7.4).
- Entered the "mature phase" by passing the 300,000 system hour point.
- Thunderbirds completed a

Figure 1

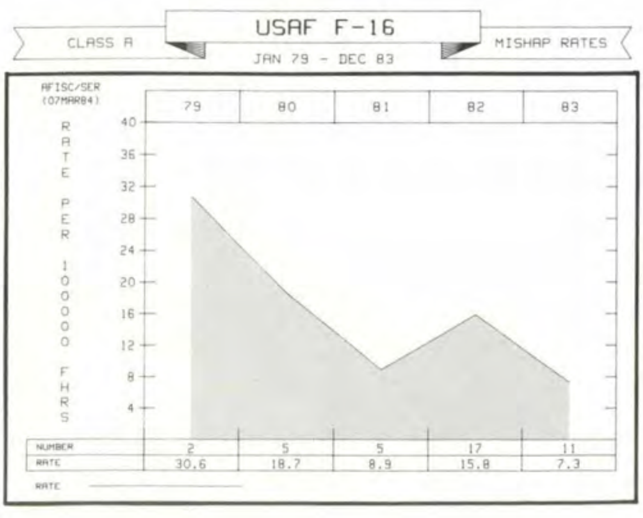
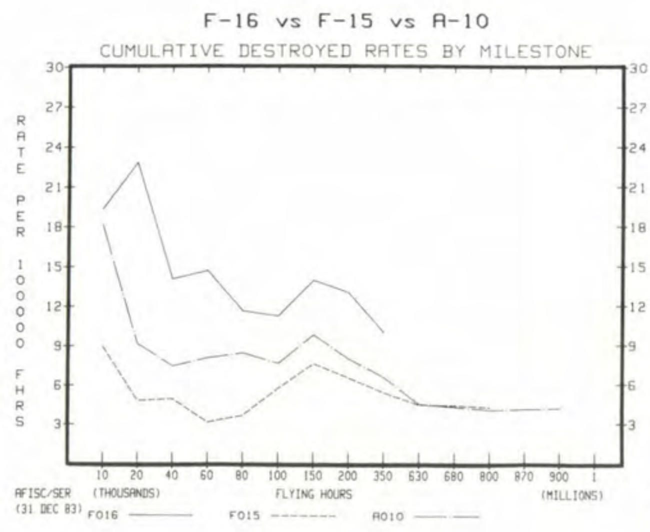


Figure 2



highly successful season in the Air Force's newest fighter.

How do we know we have entered the "mature phase" in F-16 ops? If you look at the chart in Figure 2, you will see a comparison between the F-16 and the F-15/A-10 over their lifetimes. The curves generally match, and show us to be on the downhill slope — a match with the other two aircraft curves leads us to believe the rates will continue to decline, which is a sign of system maturity. However, your hard work is still going to be needed to do this, so there can be no resting on our laurels. The rest of this article will be devoted to reviewing last year's history so we can learn from it to make this year better.

Let's look at the breakdown of last year's mishaps. It shows:

- 21 Class As forecast, 11 Class As actual.
- None lost to flight controls.
- 5 log mishaps (4 engine, 1 landing gear).
- 5 ops mishaps (all collision with ground).
- 1 other (ground crew ingestion).

The last one was particularly unfortunate in that we lost a maintenance troop who was sucked down the intake while trying to go from the left to the right side by crawling under the intake in front of the nose gear. It is a very tragic way to learn a lesson we should all know so well.

However, months later, a gear pin was sucked out of a firefighter's pocket as he tried to do virtually the same thing. For both ops and maintenance, it is imperative that we respect the F-100 engine's power. Even at idle, it has a voracious appetite.

Here is a historical comparison of log mishaps:

Historical Comparison
F-16 Class A Log Mishaps

CAUSE	'79-'82	'83
Engine	9	4
Flight controls	2	0
Landing gear	1	1
Electrical	3	0
Total	15	5

As you can see, in the log category, four of the five mishaps last year were engines. The engine malfunctions broke down as follows:

- Compressor knife edge seal failed.
- Incorrect procedures used.
- Main fuel pump incorrectly installed.
- Turbine blade incorrectly machined.
- PFCB line failed.

Fixes are being worked on all of these problems, but it is significant to note that human error was a definite factor in two of these, and may have been a factor in all four. For the maintenance troops, the obvious answer is to follow the technical order procedures precisely — without shortcuts. Here are some of the fixes:

- Stronger compressor knife edge seals started in production in December 1982. Older engines are being retrofited at a rate of approximately 15 a month as they come through the depot.
- New procedures have been designed to "Murphy-proof" turbine wheel assembly. In addition, TCTO 2J F-100-723 has checked our turbine wheels in the field to purge any remaining faulty blades from the system.
- TCTO 1F-16-695/735 has been completed. As a result, all our engines have a bracket on the PFCB which should prevent further fatigue failures.

There are other log fixes on the way for 1984. Prime among these are the effects of Falcon Rally II, a depot mod, which is installing a number of engineering fixes — most significant is the Quad PMG for the flight control system which will provide all our F-16s with two on line sources of electrical power. This will finally provide true dual redundancy in the flight control system and will cure our reliance on batteries as backups (a use they were never designed to fulfill). All of our airplanes won't be modified until 1986-87, but you'll be flying this system, soon if not already.

The other major modification program for the F-16 will be Falcon Sweep I which will be done by contractor field teams at your bases. It will start in July 1984 and run for a year. There are 11 engineering changes being installed this way — the major ones are replacement of the landing gear selector valve (so you won't have to pin the gear prior to shutdown), installation of the WOW fader on the older birds, and installation of leading edge asymmetry brakes. Also, the power

continued

As the F-16 entered the mature phase in 1983, it also achieved its lowest mishap rate ever — a 7.4 Class A rate.

approach handling package will be installed in the older birds. This will make it easier to fly a precise AOA on final, with all the benefits in touchdown control this can provide.

In addition to these, 1984 will also bring us a new gear driven main fuel pump for the engine. This should provide a more reliable and durable pump, eliminating most of the catastrophic failures common to the current vane pump.

The problem with the landing gear/tail hook circuitry going through the same connector is still being worked. Until a redundant capability can be developed, our only protection is via manpower — the maintainers have to keep a handle on this through close inspections of the connectors.

Overall, for the pilots, the obvious lesson learned here is that you cannot be too critical about your engine. When it's the only one you have, it's got to be 100 percent all the time. Throughout the history of the airplane, roughly 35 percent of the mishaps have been engine related, so if there is anything you know well in Section III, your odds are that it will need to be the engine. One of the things we should be thinking about the engine is timely use of BUC. Follow the flight manual guidance — and when turning off the EEC has not helped, and the manual calls for BUC, do not delay in getting there. If the engine rpm is still above BUC idle, it may be possible to catch/preserve rpm by transferring to BUC first, rather than shutting down and doing an airstart. However, if a BUC airstart is made, it is important to give the rpm a chance to "catch up" to the fuel schedule before you try and accelerate out of BUC start. A recent stall/stag at low altitude was safely recovered through a successful BUC start done this way.

Retrospect on Ops

Let's turn now to ops. We lost 5 F-16s because of ops factors in 1983. A historical comparison of last year to our experience from 1979 to date

The Quad PMG will provide all F-16s with two on line sources of electrical power. The result will be true dual redundancy in the flight control system.

shows improvements in several areas.

Historical Comparison
F-16 Class A Ops Mishaps

CAUSE	'79-'82	'83
Pilot induced control loss	5	0
Collision with ground	1	5
Range	1	0
Midair	1	0
Landing/T.O.	2	0
Pilot induced flameout	2	0
TOTAL	12	5

It should not take a mental wizard to see that our problems in 1983 were with collision with the ground. It is easy to sit here and simply call them pilot error, but as is usually the case, there is a lot more to it. Let's look at the underlying causes of these mishaps — the secondary causes.

Pilot induced loss of consciousness (LOC) showed up in two of our mishaps. While we have not traditionally carried this as a secondary cause, we'll put it in this category for our purposes here. The G-suit connectors have been replaced and hopefully, this will no longer be a contributory cause of LOCs.

However, it appears two of our mishaps last year were due to pilot induced LOCs — either because the G-suit became disconnected without them knowing it, or because they exceeded their personal G tolerance for that flight. The F-16 is the first operational aircraft which makes the pilot's limits the limiting factor. There are many things we can do to influence this — the proper conditioning is one of the most important. Responses to an LOC survey conducted by AFISC were enlightening. We found that the number of LOCs in the F-16 were more than we had anticipated, and that despite all the publicity, LOCs are still occurring. Several survey participants provided strong evidence that G tolerance is a volatile trait. Layoffs for sickness or leave do affect your tolerance, and you should take this into account during your first several missions after you return to duty. If you are not a believer that pilot induced LOC is a problem, you need to reassess your thinking — we have approximately 250 survey answers that testify to the fact that it is a problem — and occurs on all of our fighter aircraft.

The remaining three mishaps all have three common secondary causes:

- Task saturation.
- Channelized attention.
- Chronic fatigue.

My premise is that the last of these makes you more susceptible to the first two. Chronic fatigue can be induced by the job, or self-induced through your personal life style. In any case, it is imperative that you consider it in your planning process. If you think you can "play it by ear" when things start to happen in-flight, or that your "experience" will pull you through, you may be in for a rude awakening when you suddenly find your "inner reserves" have been depleted through fatigue. This is why good flight planning is so critical to safe operation of a single-seat fighter.

Do you have a plan to handle task saturation? How do you intend to prioritize your needs when it happens? What will it take to cause you to implement that plan? If you do not have that answer now, it is unlikely your implementation will be timely in the real time scenario. This will lead you to channelized attention, and that means excluding things from your crosscheck. That exclusion may even be intentional. In fact, several of our 1983 mishaps suggest this. Pilots, in their desire to cut down on the work load (reduce task saturation), deliberately excluded the altimeter or day VMC altitude references from their crosschecks because they believed it was not a factor. Had they implemented their task saturation plans? And was dropping the altimeter a valid prioritization? It appears the lesson learned is that the altimeter is one instrument you may temporarily drop from the crosscheck only at great risk.

There are several similar mishaps in the F-16 history (at least 3) and I know of some from other aircraft in the "old days," so it is not a new problem — unfortunately, it is one we haven't fixed.

There is a lesson here for all of us, and it is that your self-discipline is the key. When you're out there single-ship solo, all the supervision in the world won't keep you from busting your tail. It comes down to you and you alone. There are no shortcuts in a basic crosscheck.

Prognosis For 1984

The AFISC analysis, and General Dynamics statisticians all say that 1984 won't be as good as 1983. Those are statistics only. I think we'll do even better. Here are what I think are the high threat areas for 1984 that you should be looking at:

Log

- Engines (engine reliability drives the overall log rate).
- Leading edge flap system.
- Landing gear, to include brakes and tailhook system.
- Chafing.

Ops

- Midair collisions (we are overdue if non-USAF F-16 and other fighter/attack experience is an indicator).
- Human factors (task saturation, channelized attention, fatigue, HUD/Instrument crosscheck, spatial disorientation).
- Mission planning.
- Heavyweight landings.
- Judgment.

Summary

Despite some lessons learned the hard way, 1983 was a turning point for the F-16. I believe an achievable goal for 1984 is an overall rate of 6.0 per 100,000 flight hours. This would equate to 10-11 aircraft lost. Pure statistics forecast 21, and AFISC forecasts 18, so this will be a challenge to you. However, last year, the Air Force forecast 81 Class A mishaps and had 59 (Our best record ever — by far). Of the 22 "saves" you troops in the field made, 10 or 45 percent were due to the F-16's excellent performance in 1983. The challenge is to do it again in 1984. ■

If you think you can "play it by ear" when things start to happen in flight, or that your experience will pull you through, you may be in for a rude awakening.

F-106

MAJOR JAMES M. TOTHACER
Directorate of Aerospace Safety

The F-106 has been a front-line interceptor through three decades. This distinguished service should continue through 1987.

■ Our longest string of consecutive months without an F-106 Class A mishap came to an end in June of 1983, just 3 days short of 23 months. In fact, both of the year's Class A mishaps occurred in June. These two Class As fulfilled the AFISC forecast for the F-106 in 1983.

The first mishap occurred during two-ship maneuvering at low altitude over water. Radar and radio contact were lost with the mishap aircraft which was in a fighting wing position. This turned out to be one of those tragic, frustrating mishaps because the pilot was killed and no trace could be found of the wreckage, making determination of cause impossible. Any one or a combination of the factors of spatial disorientation, loss of control, physical incapacitation, or catastrophic aircraft failure could have caused this mishap.

Our second F-106 loss was not as serious since there was no pilot fatality. The mishap occurred during a front cutoff simulated radar missile attack. Moments after the pilot started a turn to steer a radar lead collision solution, an undefined maneuver of unknown origin occurred resulting in a G-induced loss of consciousness (LOC). Following the LOC, the mishap pilot regained consciousness, but was disoriented. He perceived a lack of aircraft response to his control inputs and ejected after descending through the recommended out-of-control ejection altitude. The pilot sustained major injuries upon ground impact because of his excessive descent rate caused by chute/seat entanglement. It is important to note the mishap pilot was not wearing an anti-G suit on this mission.

There were no Class B mishaps in 1983, and the total Class C count was 59. Engines accounted for the largest category of reports with 15 but only one FOD mishap caused reportable damage this year. This year's total amounted to 4 fewer FOD mishaps than in 1982.

It goes without saying the Dart isn't getting any younger, but work is still ongoing to keep the F-106 safe for you to fly. The negative G restraint system should be installed in late spring or early summer — just another feature to ensure you "seat of the pants" flyers don't get disconnected.

Remember, we already have another streak started without a Class A. So, let's be careful out there, and we'll break that 23-month string. ■

F/FB-111

MAJOR MICHAEL J. KAYE
Directorate of Aerospace Safety

This vintage fighter bomber was designed for all-weather, supersonic operation at both low and high altitudes. The modernization program underway should enhance the F/FB-111's safety record.

■ The F/FB-111 aircraft are all-weather, supersonic fighter bombers which reflect early 1960s state-of-the-art technology. A total of 562 of these aircraft were produced for the USAF. The USAF F/FB-111 fleet flies about 100,000 hours per year and reached the 1.25-million-hour point late in 1983. In the F/FB-111's history there have been 108 Class A mishaps which resulted in 87 destroyed aircraft.

Overall, 1983 was a good year for the F/FB-111. Seven Class A mishaps were forecast for this period, but the fleet experienced only four — two being operations-related and two logistics-related. One FB-111 and three F-111s were lost resulting in Class A rates of 5.6 and 3.8 respectively. Although only one FB-111 was lost, that rate was higher because of the lower numbers of aircraft and annual flying time.

Aggressive initiatives for improvements in system safety are being actively pursued by users and supporting agencies. The following is a list of primary F/FB-111 safety concerns and the modifications which should result in increased effectiveness and aircrew safety.

TFR

Numerous incidents have occurred in which the TFR systems have penetrated below 68 percent (83 percent FB-111A) of the set clearance plane without a fail/flyup being generated. Because of the critical nature and complexity of this problem a Blue Ribbon Panel was formed to focus on the solutions to these discrepancies. This effort is ongoing and presently the panel has 51 action items encompassing all aspects of the system improvement program.

Uncommanded Flight Maneuvers

Uncommanded flight maneuvers (UFMs) are a critical safety issue. In-depth analysis has revealed no single trend. Predominant failures are connector-related, but they are spread throughout the flight control system. Special corrective actions have been established to deal with the wiring problems in addition to a Blue Ribbon Panel action item which has resulted in depot teams performing field investigations and repairing of connector/wire problems. The second most predominant failures are the A4 circuit boards in the FB-111 computers. Sacramento ALC has established a program to replace the boards. Installation is scheduled to start in March 1984 and be completed in December 1984. The third most frequent failure is damper-related. The primary problems are clogged filters and leaking seals. New procedures have helped to isolate damper problems, and organizations have negotiated to have the damper filters cleaned/replaced during depot maintenance.

continued

The USAF F/FB-111 fleet flies about 100,000 hours each year and reached the 1.25-million-hour point late in 1983.

F/FB-111 continued

pack into the existing crew module parachute compartment. The reduced descent rate provided by the higher drag parachute will require modification of the capsule impact attenuation bag. The second improvement involves a seat incorporating energy attenuators and optimized aircrew positioning. Both these improvements are presently in the test and evaluation stage.

Engines

TF30 engines have experienced three major problems. These include: fan disk and hub rupture causing uncontained fan failure, primary fuel manifold cracking resulting in engine flameout, and short engine life. The Pacer 30 (3, 7, 9) program was developed to address these problems and improve TF30 reliability. Pacer 30 (3, 7, 9) modifications should improve the engine substantially. It incorporates 40 changes to the engine during a depot overhaul and is forecast to be completed in 4 years.

P-100 engines are installed in all F-111F aircraft and have also experienced three major problems. These include: high pressure turbine blade fatigue, compressor stator vane failure, and shorter than desired engine life. A Pacer 30 (100) upgrade program has been developed consisting of 50 individual efforts which address durability and reliability improvements for all P-100 engine sections.

Parachute Entanglement

Crew module stabilization brake parachute (SBP) and recovery parachute (RP) entanglement caused by yaw and lateral CG eccentricity was identified as a problem in a past mishap. An extensive effort has resulted in the development of a system which severs the SBP upon deployment of the RP in the low-speed mode. The SBP modification was approved in April 1983, and a contract awarded in September 1983 for engineering data, prototype and production kits. Estimated start of installation is May 1985.

Ejection Injuries

Approximately 30 percent of crew module ejections have resulted in aircrew back injuries. These injuries have occurred during both the ejection and landing phases. Two improvements are being pursued. A new higher drag recovery parachute system is being evaluated that will

Horizontal Tail Servo Actuator (HTSA) FOD

A foreign object in the HTSA mechanical stop area was identified as the cause of an F-111 mishap. An interim fix is complete which involves a split collar that eliminates the possibility of foreign objects entering the mechanical stop area and preventing the valve from returning to neutral. Two additional TCTOs provide a permanent fix, and both should be complete by the end of the year.

The F/FB-111 is an important weapons system with unique capabilities. Extensive programs are underway to further enhance the aircraft and the future looks encouraging.

The Class A mishap rate in 1983 was considerably better than in 1982, and represents an achievement in which we can take pride. Let's strive in 1984 to reduce the mishap rate even further. Your continued help in highlighting areas needing improvement is a critical key to success if we are to achieve this goal. ■

The unique capabilities of this aircraft will become even more obvious as current initiatives enhance its already good record.

T-38

MAJOR ERNEST A. BRIGGS, CF
Directorate of Aerospace Safety

■ Air Training Command is the primary USAF user of the the T-38 Talon and the aircraft's principal role is undergraduate pilot training. Tactical Air Command, Systems Command, and Strategic Air Command also operate T-38s.

The T-38 first began logging flying time with the USAF 24 years ago (1960). Since its introduction into service, the T-38 system has experienced a total of 165 Class A mishaps to the end of 1983. These mishaps have resulted in the destruction of 156 aircraft and the loss of 64 lives.

Operations-related mishaps still outnumber logistics-related mishaps by nearly two to one. Of the 165 total Class A mishaps, 99 qualify as operations-related compared to 54 classified as logistic-related. The remaining mishaps qualify under undetermined and miscellaneous categories.

In 1983 we experienced five Class A mishaps with the T-38. Two were operations-related. These mishaps caused the destruction of five aircraft and the loss of three aircrews. A brief review of our 1983 Class A mishaps follows.

- The mishap sortie was a cross-country proficiency flight. Shortly after take off, the crew experienced engine problems. Crack propagations led to an uncontained stage two turbine wheel failure. The aircraft became uncontrollable and the crew ejected without sustaining injury. The aircraft impacted the ground and was destroyed.
- The mission was a solo contact student training sortie. After work in the training area, the pilot returned to the traffic pattern. He reported initial, pitched-out and reported gear down. The aircraft was allowed to develop an excessive rate of descent during the final turn, descended into a forested area, and was destroyed on impact with the trees. The pilot did not eject and was fatally injured.
- The mishap aircraft was Number Two in a two-ship flight scheduled for a night formation training mission. The flight progressed normally through entry into the training area. During a left descending turn, the wingman broke out of formation and was observed to continue a descending turn using afterburners. Flight lead's attempts to contact the aircraft were unsuccessful. The mishap aircraft continued the descent through an undercast and was destroyed on ground impact. Both crewmembers were fatally injured.
- The aircraft was on a functional test flight. The pilot had just leveled off at approximately 12,000 feet MSL and accelerated to 500 KIAS for a rudder trim check. The aircraft experienced a sudden violent buffeting and yawing and very rapidly pitched down. The pilot ejected, sustaining several injuries from windblast. The horizontal tail had failed and departed the aircraft. The aircraft was destroyed on impact.
- The aircraft was lead for an initial formation solo. The student reported control problems shortly after take off. The formation proceeded to the area to burn down fuel. During a controllability check the student lost control of the aircraft and ejected successfully. The aircraft was destroyed on ground impact.

Much work is done to improve the safety and reliability of our equipment; we must all work hard to ensure that the human factors in aircraft mishaps are reduced.

Some examples of the ongoing efforts to improve the T-38 system are:

- The cockpit upper longeron modification started in 1981 when cracks were discovered during routine inspection. Over 800 aircraft have been completed and the program should finish this year.
- In 1979, durability and damage tolerance assessments revealed a fatigue problem in the dorsal longeron of the T-38 aircraft in severe usage roles. A modification to incorporate a 14-foot external steel doubler adjacent to the existing longeron has been completed on the 151 severe usage aircraft scheduled for modification.
- The single-motion/sequenced ejection modification has been divided in two. The single-motion and ballistic inertial reel are continuing but the sequenced ejection modification has been delayed by an ATC requirement to have the sequence selectable by the instructor pilot.

The T-38 is continually monitored for trends and efforts at every level to help ensure the development and improvement in safety and reliability.

The human element in flight mishaps is a factor that deserves constant consideration in any mishap prevention program. Know your limitations and don't exceed them. Our continuing task is to learn from previous mistakes. The lessons of our aviation history are well documented — let's learn from them. ■

Say goodbye to false alarms and hello to . . . **THE**

The new fire warning system has been installed to provide warning if, and only if, there's an actual fire or overheat condition.

■ Now that a majority of the F-4 fleet has been modified with the new fire warning system, it has become necessary to explain some of the features of the TCTOs. As with all modifications, the new system has some peculiarities that can make the aircrew unsure of what the real situation is. The warning of a fire somewhere in the aircraft requires immediate action. False indications in the old system were a major decision factor in acquiring the new warning equipment. While there have been a few false lights with the new system, nearly all have been attributed to installation errors. The aim, of course, is to provide warning if, and only if, an actual fire or overheat condition exists.

TCTOs 1235 to 1237 are designed to meet that objective. They involve a departure from the traditional fire/overheat warning system in that they use a pneumatic principle to trigger the warning rather than electrical resistance or capacitance.

The problem with the old system was that any sort of damage or corrosion to the loops often triggered a fire/overheat light when no source of hot air existed. The primary cause was the design of the aircraft itself. That is, the access doors to the engine and the locations of the loops did not lend themselves to mutual compatibility. The amount of maintenance requiring dropping the doors induced shorts and breaks in the loops.

The pneumatic system now being installed does not reduce the number of door openings or corrosive elements, but since there is no electrical circuit to be completed within the bay, no short circuit can develop.

The design of the new system is relatively simple. Each loop, whether in the engine bay or around the engine nozzle flaps, consists of a hollow stainless steel tube with a central core (Figure 1). The core itself is gas-charged with hydrogen. An inert gas, helium, acts as an averaging medium. The helium is precharged within the tube to a low grade pressure which keeps an integrity switch inside the detector closed (Figure 2). As long as the pressure is maintained, the continuity of the system is assured. Should a fire develop, the hydrogen within the core escapes, raises the pressure within the tube, closes the alarm switch inside the detector, and illuminates the appropriate light in the cockpit (Figure 3). Also, should the temperature in the entire engine bay rise, the helium pressure increases and similary closes the warning switch.

The tube and core are resistant to twists, crushing, dents, kinks and vibration which eventually might pinch off the gas route to the detector by a coil of inert metal wrapped

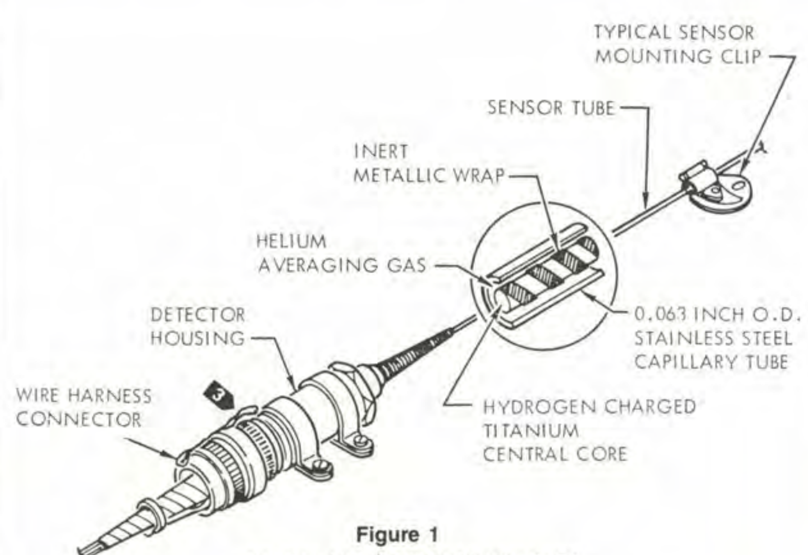


Figure 1
TYPICAL FIRE/OVERHEAT DETECTOR

NEW FIRE LOOPS

MAJOR GARY R. MORPHEW
Directorate of Aerospace Safety

around the core. The gaps between the coils serve as open avenues for gas pressure downstream of the deformation.

So, what can go wrong?

As stated above, as long as the helium pressure is maintained as a predetermined level, the system integrity is assured. Should the fire/overheat loop be severed, however, the helium would escape as well as any hydrogen that may be present as a result of a fire. Once the loop is open-ended, the pressure will not rise sufficiently to illuminate the fire/overheat warning light. Loop severing may occur due to repeated bending of the loop until fatigue and fracture of the stainless steel occurs, or by a localized high intensity torch effect which simply melts/burns through the loop. In either case, warning by that loop is lost.

Fortunately, there are a few items which may clue the pilot to a degraded system. If the break in the loop occurs prior to flight, the preflight fire warning tests will reveal the loss of system integrity. If the cause of the open loop is a fire burn-through, momentary illumination of the fire/overheat light may occur. If the pilot sees the fire/overheat light flash, normal procedures require a continuity check on the system where again, the loss of integrity will be found. In the engine bay, no one loop is completely isolated. Four separate detection loops overlap somewhat to provide a certain amount of redundancy. If one loop becomes disabled, another loop may activate a warning light as soon as the temperature/pressure requirements are met. The overheat loop exterior to the engine, however, is a single loop source of warning.

What can the crew do to maximize warning? First, and foremost, a complete warning system check must be performed prior to each flight. This is a two-phase check. The continuity and pressure of each loop is checked by pressing the Fire Warning Test button. As long as the lights light up, all five loops associated with each engine are capable of sending pressure increases to the detector.

Next, the circuit box where all the wires meet must be checked by using the Warning Lights Test switch in conjunction with the Fire Warning Test button. The Warning Lights Test switch is activated illuminating all cockpit warning lights, including the fire/overheat lights. Once illuminated, the Fire Warning Test button is depressed and all four fire/overheat lights should go out. This compares the voltages to cancel the signals, assuring that the circuit box recognizes all detector inputs. The Fire Warning Test button is then released to reset the circuit box to the ready mode. Finally, the Warning Lights Test switch is released.

Should the need arise to check the system airborne, whether as a result of a momentary fire/overheat indication or other indications which lead the crew to suspect a fire/overheat condition, only the Fire Warning Test button need be depressed. Since the warning control circuit box is outside the engine bays, there is normally no requirement to check it.

The fire and overheat warning provided by the TCTO 1238 to 1237 modification goes a long way toward providing accurate assessment of fire conditions. The loss of warning caused by gas escape is currently being worked by the engineers. Until they can resolve the shortfall, awareness by the aircrew and a good understanding of how the system works provides the best defensive action. If anything raises your suspicions about engine performance or instrument indications, perform a Fire Warning Test. If you do not get an assurance of loop integrity, proceed as if the light did illuminate. ■

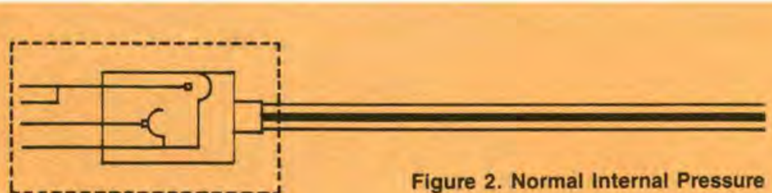


Figure 2. Normal Internal Pressure

Figure 3. Fire Warning Pressure

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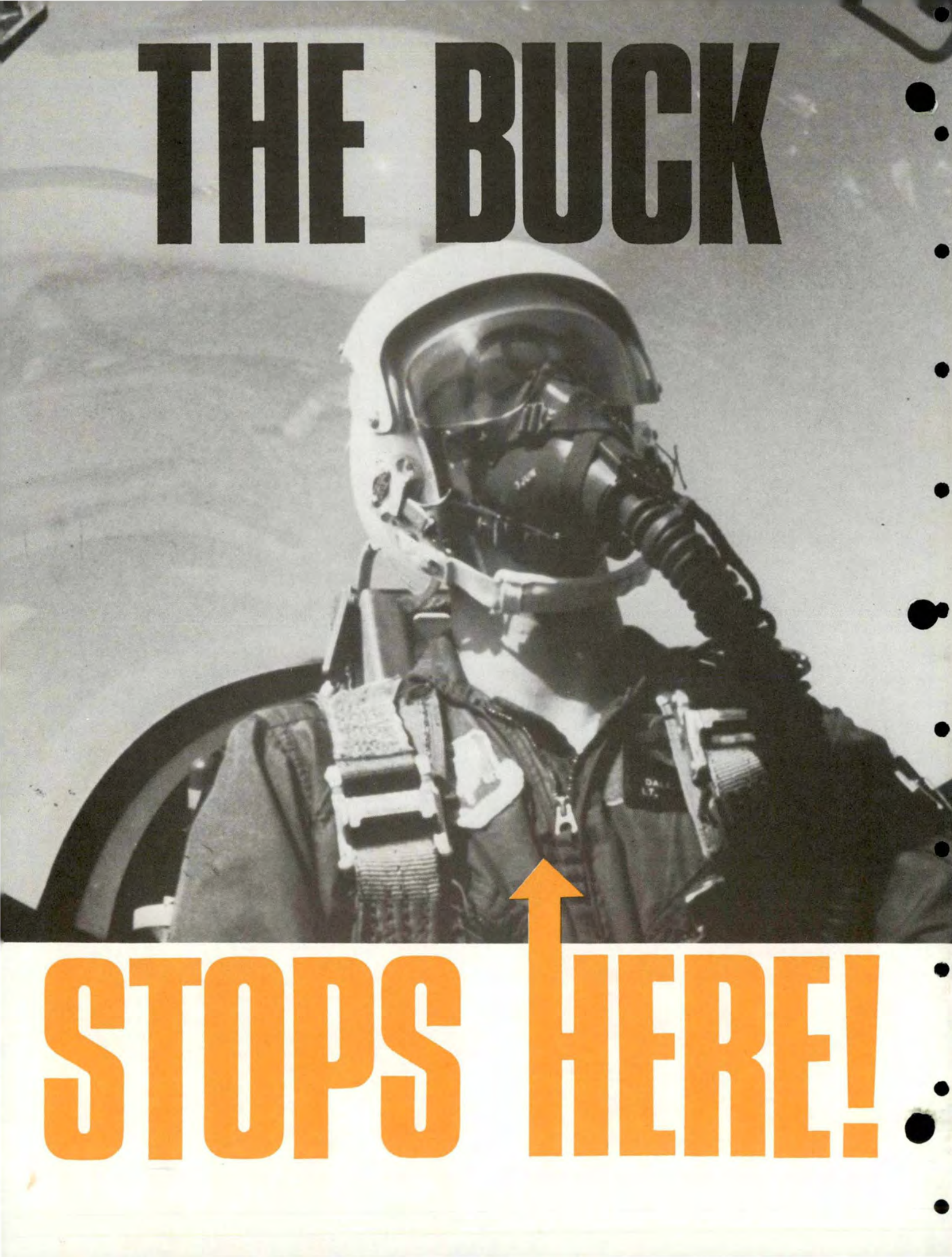
THE BUCK
STOPS HERE!