TAB I

Effective Area Calculations 8-Aug-99
PFSF **F-16** **1000 Casks**

Wing span, WS :	32.7	feet
Cot theta =	8.4	(take off)
Skid distance, S	246	feet (take off)

Effective Area =
Aeff = Af + As
Af = (R + WS)*H*Cot theta + (2*L*W*WS)/R + L*W
As = (WS+R)*S

Cask Storage Facility

Width W =	685	feet
Length L =	690	feet
Height H =	19.6	feet

Diagonal Length R = (L^2 + W^2)^0.5
R = 972.2783

Af =	165459.6 +	31792.66 +	472650	
Af =	669902.3 sq ft	=	0.024029	sq miles
As =	247224.7 sq ft	=	0.008868	sq miles
Aeff =	917126.9 sq ft	=	0.032897	sq miles

Cannister Transfer Building

Width W =	65	feet
Length L =	260	feet
Height H =	90	feet
R =	268.0019	

Af =	227330.6 +	4124.076 +	16900	
Af =	248354.7 sq ft	=	0.008908	sq miles
As =	73972.66 sq ft	=	0.002653	sq miles
Aeff =	322327.3 sq ft	=	0.011562	sq miles

Effective Area Calculations 8-Aug-99
PFSF **F-16** **2000 Casks**

Wing span, WS :	32.7	feet
Cot theta =	8.4	(take off)
Skid distance, S	246	feet (take off)

Effective Area =
Aeff = Af + As
Af = (R + WS)*H*Cot theta + (2*L*W*WS)/R + L*W
As = (WS+R)*S

Cask Storage Facility

Width W = 1520 feet
Length L = 690 feet
Height H = 19.6 feet
Diagonal Length R = (L^2 + W^2)^0.5
R = 1669.281

Af =	280214.2 +	41090.45 +	1048800	
Af =	1370105 sq ft	=	0.049146	sq miles
As =	418687.4 sq ft	=	0.015018	sq miles
Aeff =	1788792 sq ft	=	0.064164	sq miles

Cannister Transfer Building

Width W = 65 feet
Length L = 260 feet
Height H = 90 feet
R = 268.0019

Af =	227330.6 +	4124.076 +	16900	
Af =	248354.7 sq ft	=	0.008908	sq miles
As =	73972.66 sq ft	=	0.002653	sq miles
Aeff =	322327.3 sq ft	=	0.011562	sq miles

Effective Area Calculations		8-Aug-99
PFSF	**F-16**	**3000 Casks**

Wing span, WS : 32.7 feet
Cot theta = 8.4 (take off)
Skid distance, S 246 feet (take off)

Effective Area =
Aeff = Af + As
Af = (R + WS)*H*Cot theta + (2*L*W*WS)/R + L*W
As = (WS+R)*S

Cask Storage Facility

Width W = 1520 feet
Length L = 1170 feet
Height H = 19.6 feet
Diagonal Length R = (L^2 + W^2)^0.5
R = 1918.15

Af =	321188 +	60635.17 +		1778400
Af =	2160223 sq ft	=	0.077487 sq miles	
As =	479909.1 sq ft	=	0.017214 sq miles	
Aeff =	2640132 sq ft	=	0.094702 sq miles	

Cannister Transfer Building

Width W = 65 feet
Length L = 260 feet
Height H = 90 feet
R = 268.0019

Af =	227330.6 +	4124.076 +		16900
Af =	248354.7 sq ft	=	0.008908 sq miles	
As =	73972.66 sq ft	=	0.002653 sq miles	
Aeff =	322327.3 sq ft	=	0.011562 sq miles	

Effective Area Calculations 8-Aug-99
PFSF **F-16** **4000 Casks**

Wing span, WS :	32.7	feet
Cot theta =	8.4	(take off)
Skid distance, S	246	feet (take off)

Effective Area =
Aeff = Af + As
Af = (R + WS)*H*Cot theta + (2*L*W*WS)/R + L*W
As = (WS+R)*S

Cask Storage Facility

Width W =	1520	feet
Length L =	1590	feet
Height H =	19.6	feet

Diagonal Length R = (L^2 + W^2)^0.5
R = 2199.659

Af =	367535.6 +	71856.01 +	2416800	
Af =	2856192 sq ft	=	0.102452	sq miles
As =	549160.3 sq ft	=	0.019698	sq miles
Aeff =	3405352 sq ft	=	0.12215	sq miles

Cannister Transfer Building

Width W =	65	feet
Length L =	260	feet
Height H =	90	feet
R =	268.0019	

Af =	227330.6 +	4124.076 +	16900	
Af =	248354.7 sq ft	=	0.008908	sq miles
As =	73972.68 sq ft	=	0.002653	sq miles
Aeff =	322327.3 sq ft	=	0.011562	sq miles

TAB J

WEAPONS TESTING ON THE UTTR
SOUTH RANGE

<u>1.WEAPONS SYSTEM EVALUATION PROGRAM (WSEP) Nicknamed "Combat Hammer":</u> This program is held annually during a two week period normally in May or June. Combat Hammer is designed to evaluate weapon system combinations from buildup through impact. Aircraft from all United States Air Bases, both continental U.S. and overseas may be involved. Aircraft include F-15E. F-16. F-117. A-10. B-1 and the B-52. The May 1997 WSEP was the largest WSEP effort in history. It involved over 400 people, 226 sorties, 56 aircraft, and 167 weapon employment's.

Weapon Systems Evaluated by type and <u>average</u> number each year:

a. GBU -10/12/24/27	4 - 60 weapons	(inert warhead)
b. GBU-15	6 - 12 weapons	(inert warhead)
c. AGM-142	2 weapons	(inert and live warhead)
d. AGM-65	40 - 60 weapons	(Live warhead)
e. AGM-130	2 - 6 weapons	(inert warhead)
f. AGM-88	2 - 21 weapons	(inert warhead)
g. AGM-86	3 - 4 weapons	(inert warhead)
h. AGM-86C	1 - 2 weapons	(live warhead)
i. AGM-129	3 - 4 weapons	(inert warhead)

<u>NOTE:</u> **Weapon systems indicated in bold have a Flight Termination System (FTS) installed.** Weapon systems that have a capability of exceeding range boundaries are required to have an FTS installed prior to testing on the UTTR. Additional information pertaining to FTS requirements are identified in the 388RANS Supplements 1 & 2 to AFI 13-212. The FTS systems are designed to destruct the weapon and terminate the weapon flight path, on command, in the event of a weapon anomaly from the Mission Control Room at Hill AFB. Averages of three AGM-88s are destructed each year during the WSEP deployment. The UTTR has never experienced a FTS failure.

The normal range ingress is as follows:
a. Aircraft employing AGM-88s depart Hill AFB and proceed direct to the Delta VORTAC and enter the Sevier "B" MOA and then direct to R-6405 and dedicated targets located in R-6407/R-6406.

b. Aircraft employing AGM-65s depart Hill AFB and proceed direct to the Delta VORTAC and enter the Sevier "B" MOA and then enter the range via Sevier MOAs (SKULL VALLEY) to R-6406 and dedicated targets in R-6406 or direct from the Delta VORTAC to R-6405 and dedicated targets located in R-6406. Aircraft transitioning over Skull Valley include F-15, F-16 and A-10. Normal flow is eight aircraft per hour during a two hour period range period Monday-Thursday, WSEP Deployment. Each aircraft will carry a maximum of two live AGM-65 missiles. Altitude is from 5,000 to 10,000 feet above ground level.

c. Aircraft employing GBU-10/12/15/24/27s or AGM-130s depart Hill AFB and proceed direct to the Delta VORTAC and enter the Sevier "B" MOA and then enter the range via Sevier MOAs (SKULL VALLEY) to R-6406 and dedicated targets in R-6407. Aircraft transitioning over Skull Valley include F-15, F-16, F-117 and A-10. Normal flow is eight aircraft per hour during a two-hour period range period, Monday-Thursday WSEP Deployment. Each aircraft will carry a maximum of two inert GBU/AGM-130 weapons. Altitude is from 5,000 to 10,000 feet above ground level.

d. Aircraft (B-52) employing AGM-142 depart their homebase and proceed direct to the UTTR via flight plan routes and enter the range from low level flight routes terminating on entry into the range via R-6405 or R-6406.

The normal range egress is as follows:
All aircraft staging out of Hill AFB depart R-6406 direct to Hill AFB as assigned by Clover Control. Aircraft departing for home base depart R-6406 as assigned by flight plan routing.

5. AGM-86 Air Launched Cruise Missile (ALCM)

The ALCM is an autonomous guided weapon system. Flight profiles vary but generally utilize all restricted areas and MOA's in the south range. Missile profiles that transit from the south range to the north range MOA's (Lucin) exist, but are rarely flown. Flight times vary depending on profile, but generally last 3 to 3.5 hours.

6. AGM-86C Conventional Air Launched Cruise Missile (CALCM)

ALCM variant equipped with a live conventional warhead flight profiles allow it to fly only in restricted airspace and only over DOD withdrawn lands. Flight time is approximately 1.5 hours.

7. AGM-129 Advanced Cruise Missile (ACM)

Improved version of the ALCM Flight profiles vary but generally utilize all restricted areas and MOA's in the south range. Missile profiles that transit from the south range to the north range MOA's (Lucin) exist, but are rarely flown. Flight times vary depending on the profile, but generally last 4 to 5 hours.

8. "Hanging Bombs"

All weapons testing conducted on the UTTR go through a comprehensive safety review and risk anaysis. Footprints are established using guidelines in AFI 13-212, volumes I-III or as provided by the customer. The 388RANS establish Shootcones/Release boxes and all aircraft must adhere to safety parameters established. Currently all non-FTS equipped weapon Shootcones/Release boxes are within restricted airspace over Department of Defense (DOD) owned lands. "HUNG BOMB" procedures are conducted in accordance with aircraft Technical Orders (TOs) and applicable AFIs. Test procedures are contained in the 388RANS supplement to AFI 13-212.

9. Probability of an unintentional release of live ordnance at any given location in Skull Valley and at the Skull Valley Reservation.

No aircraft overflying the Skull Valley are allowed to have their armament switches in a release capable mode. All switches are "Safe" until inside DOD land boundaries. The UTTR has not experienced an unanticipated munitions release outside of designated launch/drop/shoot boxes.

10. Run-in headings for weapons testing.

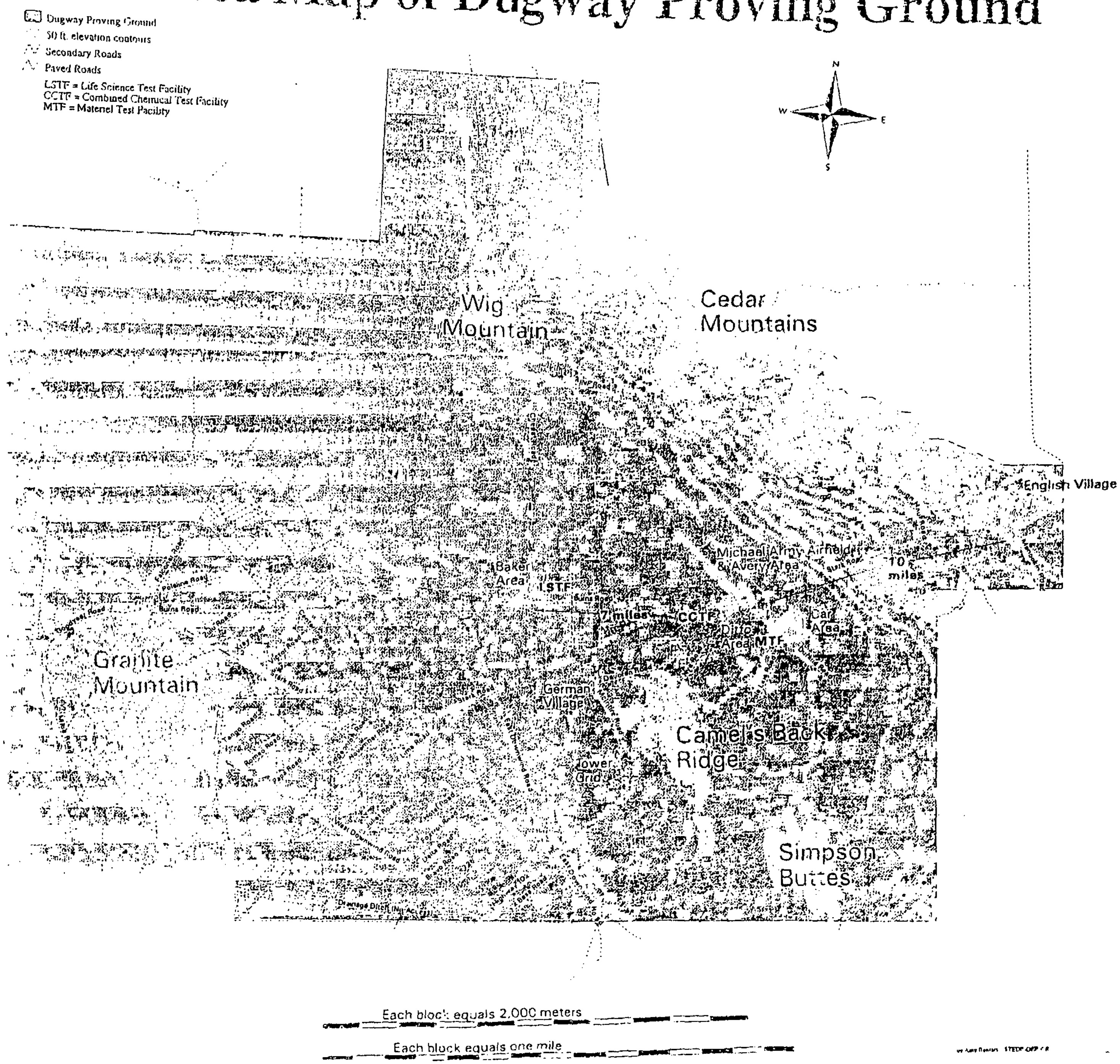
Each weapon tested on the UTTR has a run-in heading established during the safety review process. Footprints, time of fall, altitude at release and release airspeed dictate the headings allowed. No run-in headings are currently over the Skull Valley area.

NOTE.

The information provided is based on our assumption that the main areas of interest would be the Southern UTTR ranges. The southern ranges consist of R-6402, R-6405, R-6406, R-6407 and the Sevier A, B, C, and D MOA's

TAB K

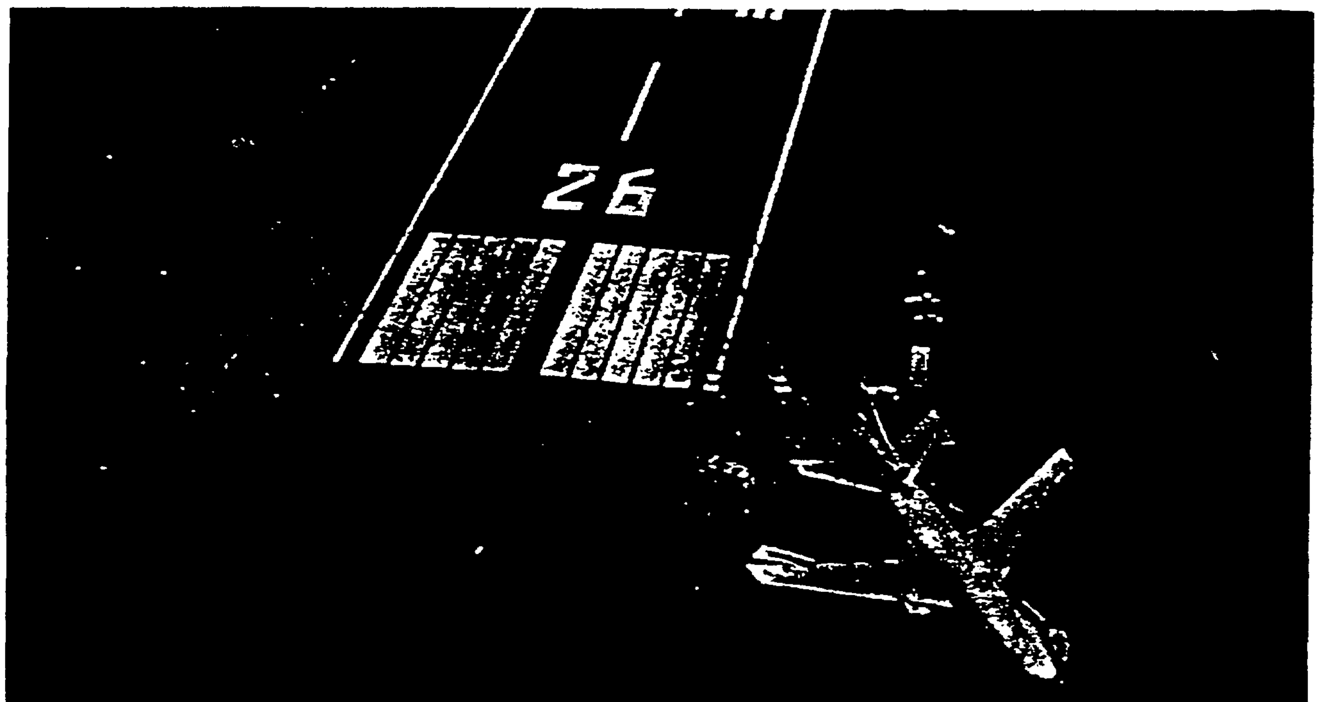
East Area Map of Dugway Proving Ground



TAB L

U.S. Department
of Transportation
Federal Aviation Administration
Office of Safety Oversight

Location of Commercial Aircraft Accidents/Incidents Relative to Runways



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7. Author(s) Robert E. David, P.E.		8. Performing Organization Report No. DOT/FAA/AOV 90-1
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15. Supplementary Notes

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16. Abstract

The location of an aircraft involved in an accident or incident may be documented by the National Transportation Safety Board and the Federal Aviation Administration during the course of their investigation. When available, it will appear in the record of the individual investigation. However, this location information is not available from either of these agencies in a summary form.

This study was undertaken to compile in one document the location relative to the runway of these accidents/incidents for aircraft involved in commercial air transportation in the United States. The study examined accidents/incidents that occurred from 1978 to 1987. Since it is intended that this information will be used mainly to make decisions on individual airports, no attempt was made to reach conclusions or make recommendations based on the data.

The accidents/incidents used for this study were categorized as undershoots, landings off the runway, veeroffs, overruns, and other in the vicinity of the airport. The aircraft location was recorded in terms of the distance along the runway centerline or extended centerline (X distance) and the perpendicular distance from the centerline or extended centerline (Y distance).

17. Key Words Accident, Incident, Undershoot, Landing Off, Veeroff Overrun	18. Distribution Statement This document is available to the U.S. public through the National Technical Information Service, Springfield, VA 2216

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EXECUTIVE SUMMARY

Information on the location of aircraft accidents/incidents in the airport vicinity in relation to runways has many applications. It is useful to persons involved in the planning and design of an airport and its surrounding areas, as well as those responsible for day-to-day airport operations.

The location of an aircraft involved in an accident or incident may be documented by the National Transportation Safety Board and the Federal Aviation Administration during the course of their investigation. When available, it will appear in the record of the individual investigation. However, this location information is not available from either of these agencies in a summary form.

This study was undertaken to compile in one document the location relative to the runway of these accidents/incidents for aircraft involved in commercial air transportation in the United States. Since it is intended that this information will be used mainly to make decisions on individual airports, no attempt was made to reach conclusions or make recommendations based on the data.

The National Transportation Safety Board's dockets of commercial aircraft accidents/incidents that occurred from 1978 to 1987 were reviewed to determine the aircraft location. This review was limited to aircraft operating under Part 121, Part 129, and Part 135 of the Federal Aviation Regulations; only scheduled operations were examined under Part 135.

The accidents/incidents used for this study were categorized as undershoots, landings off the runway, veeroffs, overruns, and other in the vicinity of the airport. The aircraft location was recorded in terms of the distance along the runway centerline or extended centerline (X distance) and the perpendicular distance from the centerline or extended centerline (Y distance.)

Appendix 1 provides an explanation of the methodology used to identify applicable accidents/incidents and to determine the aircraft location. Appendix 2 provides a listing of all the accidents/incidents included in this study, while additional appendices list the accidents/incidents in each category.

TAB M

PVP-Vol. 296/SERA-Vol. 3, Risk and Safety Assessment:
Where is the Balance?
ASME 1995

AIRCRAFT ACCIDENT DATA DEVELOPMENT FOR AIRCRAFT RISK EVALUATION TO GROUND FACILITIES THROUGH THE USE OF A G.I.S.*

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ABSTRACT

The close proximity of airports and air navigation facilities to certain ground facilities have been perceived to be a serious hazard to the public because of the activities or the large number of people associated with that facility. Examples of aviation threats to ground facilities are the collocation of several large commercial shopping malls near the approach and departure routes of nearby airports, such as the Eastridge Mall in San Jose, CA, located near the Reid-Hillview general aviation airport, and the Sun Valley Mall in Concord, CA, located near Buchanan Field which serves general and commercial aviation traffic. Although the possibility of an aircraft crashing and hitting a particular building or facility may be quite small, the results are perceived to be serious enough to warrant additional attention.

A previous paper [Ref. 1] described how the risk due to aviation traffic near ground facilities has been determined in the past, and how this risk determination could be improved by focusing on the actual traffic patterns near the facility under scrutiny. This paper will extend the concepts presented in the previous paper by the application of these concepts to a limited example situation. The airport chosen for this example application is the Salt Lake City International Airport located near Salt Lake City, Utah. This situation will be analyzed through the use of a category of computer software called a Geographical Information System or G.I.S.

Among the features of a G.I.S. that lends itself to the evaluation of risks is its ability to manage large amounts of information through the use of its database manager. Because aircraft crashes, even those involving general aviation, are relatively uncommon events, a probabilistic risk analysis must be accomplished in order to develop realistic risk estimates without undue conservatism included. In order to develop the probabilistic distributions that the various models used to estimate the risk of aircraft crashes require, a large amount of data must be gathered, organized, and modified to a form suitable for a G.I.S. This paper will describe the data required to calculate the aircraft risk to ground facilities, where that data can be obtained, and how it can be organized and modified for use by a G.I.S. The description of the G.I.S. and how it manipulates the data to present the results graphically will be presented in another paper [Ref. 3]

INTRODUCTION

The close proximity of airports and air navigation facilities to certain ground facilities have been perceived to be a serious hazard to the public because of the activities or the large number of people associated with that facility. Examples of aviation threats to ground facilities are the collocation of several large commercial shopping malls near the approach and departure routes of nearby airports, such as the Eastridge Mall in San Jose, CA, located near the Reid-Hillview general aviation airport, and the Sun Valley Mall in Concord, CA, located near Buchanan Field which serves general and commercial aviation traffic. Other facilities include the Hollywood Park Racetrack that lies

* Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

Table 6 presents the accidents, aircraft damage, operations and rates for U.S. air carriers operating under 14 CFR 135 [Ref. 14], for the 1978–1993 time period as compiled by the NTSB by Reference 16. The average accident rate for Part 135 Scheduled Air Carriers for 1978–1993 is 1.8 E-5 accidents/aircraft hour, 6.2 E-8 accidents/aircraft mile, and 1.1 E-5 accidents/departure. The average crash rate for Part 135 Scheduled Air Carriers for 1978–1992 is 1.8 E-5 crashes/aircraft hour, 7.0 E-8 crashes/aircraft mile, and 1.2 E-5 crashes/departures. Approximately 97% (399 of 412) of the accidents involving Part 135 aircraft resulted in destruction or major damage to the airframe.

Again, the crash rates presented by Table 6 represent the average crash rates over the entire flight. Assuming that the number of accidents involving scheduled Part 135 aircraft in each flight phase can be approximated by general aviation turboprop aircraft, Reference 18 determines the probability of an air taxi crash during the takeoff and landing flight phases. As for air carriers, excluding accidents that occurred during loading, taxiing, and unloading, and considering the accidents that happened during the takeoff run and initial climb flight phases as takeoff crashes, and accidents that happened during the initial (airport) approach, final (runway) approach, and landing roll flight phases as landing crashes, the takeoff and landing crash percentages are 21.9% and 49.7%, respectively, for scheduled Part 135 aircraft. The combination of the takeoff and landing crashes equals 71.7% of the total number of number of crashes. The probability of an air taxi crash during take is (0.219) * 1.2 E-5 crashes/departure or 2.6 E-6. The probability of an air taxi crash during landing is (0.497) * 1.2 E-5 crashes/departure or 6.0 E-6. The combined probability of an air taxi crash during takeoff or landing is (0.717) * 1.2 E-5 crashes/departure or 8.6 E-6.

While general aviation represents a minority of the total air operations at SLC, its magnitude may be sufficient to cause concern to those facilities that are not built with steal frameworks or with reinforced concrete walls and roofs. Because very few general aviation accidents do not result in destruction or major damage to the airframe (only 216 out of 16,320 or 1.3% for the 1986–1992 time frame as tabulated by Reference 18), the NTSB general aviation accident rate will be applied directly as the general aviation crash rate. Table 7, derived from Ref. 18, gives the average distribution of active aircraft, hours flown, nautical miles flown, landings by general aviation subcategory type averaged over the 1986–1992 time period for the entire U.S. Table 7 also gives the general aviation accidents rates by aircraft subcategory types. The average crash rate for general aviation for 1986–1992 is 6.3 E-5 crashes/aircraft hour, 4.5 E-7 crashes/aircraft miles and 4.2 E-5 crashes/departures. Assuming that the general aviation aircraft population using SLC is similar to the U.S. average general aviation aircraft population, and that the operational characteristics are similar, it is possible to apply the U.S. general aviation crash rate to SLC. The best check of this assumption would be to do a airport specific survey of the general aviation traffic at SLC. This was not done because of the time and expense involved.

Reference 18 adjusts the general aviation crash rates given by Table 7 by the percentage of general aviation crashes for each flight phase. Excluding the crashes that occur during the non-flight phases, and applying the definition of takeoff and landing for air carriers and air taxis to general aviation, the percentage of general aviation crashes that occur during the takeoff flight phase is 25.6%. The percentage of general aviation crashes that occur during the landing flight phase is 44.9%. The combined percentage of general aviation crashes that occur during the takeoff or landing flight phases is 70.5%. The probabilities of a general aviation crash during takeoff, landing and combined takeoff and landing are 1.1 E-5, 1.9 E-5, and 3.0 E-5 , respectively.

As research is still going on in the development of Reference 18, an estimate of the current crash rate for military aviation cannot be provided. Smith in Reference 11 determines a crash probability for takeoff and landing for military aviation for the 1979–1981 time period. These crash probabilities are 1.6 E-6 for the take off phase, and 3.1 E-6 for the landing phase. The combined take off and landing crash probabilities is 2.4 E-6. These values will be used for the military aviation crash probabilities near SLC.

AIRCRAFT CRASH LOCATION DISTRIBUTION

Table 8 developed from Reference 18 presents the crash location distributions of 121 and 135 air carriers as a function of radial distance from the runway threshold and angle to the runway centerline. Both the number of crashes and the percentage relative to the total dataset examined, are presented for each cell grid. For air carriers and air taxis combined, about 65% of all crashes occur within 10° of the runway centerline, and about 50% of all crashes occur within one mile of the runway threshold.

Table 9 developed from Reference 18 presents the crash location distributions of general aviation as function of radial distance from the runway threshold and angle to the runway centerline. Again, both the number of crashes and the percentage relative to the total dataset examined, are presented for each cell grid. For general aviation, about 32% of all crashes occur within 10° of the runway centerline, and about 47% of all crashes occur within one mile of the runway threshold.

TABLE 8. FROM REFERENCE 18

121/135 AIR CARRIER CRASH LOCATION DISTRIBUTIONS (NUMBER)

Angle to Runway Centerline	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Subtotals:
0-9	28	11	2	7	2	1	0	3	1	0	55
10-19	4	0	3	0	0	0	0	1	0	0	8
20-29	3	5	1	0	0	0	0	0	0	0	9
30-39	1	0	0	0	1	0	0	0	0	0	2
40-49	1	0	1	0	0	0	0	0	0	0	2
50-59	0	0	0	0	0	0	0	0	0	0	0
60-69	1	0	0	0	0	0	0	0	0	0	1
70-79	2	0	1	0	0	0	0	0	0	0	3
80-90	2	2	0	0	0	0	0	0	0	0	4
Subtotals:	42	18	8	7	3	1	0	4	1	0	84

Radial Distance to Runway Threshold (miles)

121/135 AIR CARRIER CRASH LOCATION DISTRIBUTIONS (PERCENTAGES)

Angle to Runway Centerline	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Subtotals:
0-9	33.3%	13.1%	2.4%	8.3%	2.4%	1.2%	0.0%	3.6%	1.2%	0.0%	65.5%
10-19	4.8%	0.0%	3.6%	0.0%	0.0%	0.0%	0.0%	1.2%	0.0%	0.0%	9.5%
20-29	3.6%	6.0%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.7%
30-39	1.2%	0.0%	0.0%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%
40-49	1.2%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%
50-59	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
60-69	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%
70-79	2.4%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.6%
80-90	2.4%	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%
Subtotals:	50.0%	21.4%	9.5%	8.3%	3.6%	1.2%	0.0%	4.8%	1.2%	0.0%	

Radial Distance to Runway Threshold (miles)

TABLE 9. FROM REFERENCE 18

GENERAL AVIATION CRASH LOCATION DISTRIBUTION (NUMBER)

Angle to Runway Centerline	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Subtotals:
0-9	365	83	49	26	58	19	10	15	2	22	649
10-19	108	29	23	11	17	9	7	3	2	9	218
20-29	73	25	16	10	14	9	5	8	1	3	164
30-39	73	32	14	8	22	2	7	2	2	6	168
40-49	100	48	30	26	31	14	7	5	2	9	272
50-59	53	23	18	4	14	10	10	6	4	10	152
60-69	38	13	6	7	6	3	6	4	4	8	95
70-79	46	9	8	9	11	0	3	5	3	2	96
80-90	94	25	21	10	33	9	5	12	3	15	228
Subtotals:	950	288	185	111	206	75	60	60	23	84	2042

Radial Distance to Runway Threshold (miles)

GENERAL AVIATION CRASH LOCATION DISTRIBUTION (PERCENTAGES)

Angle to Runway Centerline	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Subtotals:
0-9	17.9%	4.1%	2.4%	1.3%	2.8%	0.9%	0.5%	0.7%	0.1%	1.1%	31.8%
10-19	5.3%	1.4%	1.1%	0.5%	0.8%	0.4%	0.3%	0.1%	0.1%	0.4%	10.7%
20-29	3.6%	1.2%	0.8%	0.5%	0.7%	0.4%	0.2%	0.4%	0.0%	0.1%	8.0%
30-39	3.6%	1.6%	0.7%	0.4%	1.1%	0.1%	0.3%	0.1%	0.1%	0.3%	8.2%
40-49	4.9%	2.4%	1.5%	1.3%	1.5%	0.7%	0.3%	0.2%	0.1%	0.4%	13.3%
50-59	2.6%	1.1%	0.9%	0.2%	0.7%	0.5%	0.5%	0.3%	0.2%	0.5%	7.4%
60-69	1.9%	0.6%	0.3%	0.3%	0.3%	0.1%	0.3%	0.2%	0.2%	0.4%	4.7%
70-79	2.3%	0.4%	0.4%	0.4%	0.5%	0.0%	0.1%	0.2%	0.1%	0.1%	4.7%
80-90	4.6%	1.3%	1.0%	0.5%	1.6%	0.4%	0.2%	0.6%	0.1%	0.7%	11.2%
Subtotals:	46.5%	14.1%	9.1%	5.4%	10.1%	3.7%	2.9%	2.9%	1.1%	4.1%	

Radial Distance to Runway Threshold (miles)

For military aviation, since the resident air unit based at SLC is the 151st Air Refueling Group of the Utah Air National Guard (ANG), the majority of the military operations can be expected to be performed by this unit. This air refueling unit operates the KC-135 Stratotanker, which is approximate in size, weight, and performance to the Boeing 707. Since SLC aviation traffic is controlled by a FAA staffed control tower, and the majority of the military aviation operations can be expected to be performed by KC-135, the military aviation crash location distribution will be modeled by the air carrier crash location distribution.

TARGET EFFECTIVE AREAS

Three facilities, the West Valley Hospital, Granger High School, and the Valley Fair Shopping Mall will be considered as potential targets in a sample calculation in determining the crash frequency for aircraft flights approaching and departing runway 34 at SLC. These facilities only handle modest or insignificant amounts of hazardous or radioactive materials, if any, so the primary risk of an aircraft crash into the facility would be to the occupants of the facility. These three "targets" were chosen because of their proximity to the flight path to SLC runway 34, their large size, and the large number of people that can be expected to be in each facility during certain times of certain days.

The West Valley Hospital is located at approximately 3500 South and 4100 West in West Valley City/Granger area. It is a six story structure with a total floor space of 230,000 ft.^{2} The ground footprint presented by the hospital will be considered to be 230,000/6 or 38,333 ft.^{2} or 0.0014 mi.^{2} The maximum dimensions presented by the structure will be considered to be 200 ft. length and width, and 80 feet height. The hospital is located about 5.4 miles from the threshold of Runway 34 at an angle of 11.5° west of the approach path centerline of Runway 34.

Granger High School is located at approximately 3650 South and 3500 West in Granger. It is a two story structure. However, its has an auditorium that approaches 60 feet in height and a smokestack which approaches 100 feet in height. It has a total floor space of 326,000 ft.^{2} The ground footprint presented by the school will be considered to be 326,000/2 or 163,000 ft.^{2} or 0.0059 mi.^{2} The maximum dimensions presented by the structure will be considered to be 405 ft. length and width, and 60 feet height. The school is located about 5.5 miles from the threshold of Runway 34 at an angle of 7° west of the runway extended centerline.

The Valley Fair Shopping Mall is located at approximately 3650 South and 2500 West in Granger. It is a two story structure which approaches 50 feet in height. It has a total floor space of 608,000 ft.^{2} The ground footprint presented by the mall will be considered to be 608,000 /2 or 304,000 ft.^{2} or 0.0109 mi.^{2} The maximum dimensions presented by the structure will be considered to be 550 ft. length and width, and 50 feet height. The shopping mall is located about 5.6 miles from the threshold of Runway 34 at an angle of 4.5° east of the runway extended centerline.

The target information is summarized below. Also presented are the crash location fractions from Tables 8 and 9 for the facilities located at those specific locations.

	Ground Footprint (mi.^{2})	Max. Dimensions Width/Length (ft.)	Max. Dimensions Height (ft.)	RW34 Threshold Distance (mi.)	RW34 Centerline Angle (°)		p(r,θ) Crash Distribution
West Valley Hospital	0.0014	200	80	5.4	11.5W	AC	0.012
						AT	0.012
						GA	0.004
						MA	0.012
Granger High School	0.0059	405	60	5.5	7W	AC	0.012
						AT	0.012
						GA	0.009
						MA	0.012
Valley Fair Shopping Mall	0.0109	550	50	5.6	4.5E	AC	0.012
						AT	0.012
						GA	0.009
						MA	0.012

AC = Air Carriers, AT = Air Taxis, GA = General Aviation, and MA = Military Aviation

Recall that A_{eff} is equal to the sum of A_{skid}, $A_{structure}$, and A_{shadow}.

TAB N INTENTIONALLY REMOVED

TAB O INTENTIONALLY REMOVED

TAB P

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 388TH FIGHTER WING (ACC)
HILL AIR FORCE BASE, UTAH

26 Oct 1999

MEMORANDUM FOR 75 CS/SCSRF (FOIA)

FROM: 388 FW/CV

SUBJECT: Reply to FOIA request by James Cole

1. The wing flew 678 sorties with live and full scale inert ordnance during FY 1998. The number of sorties flown with only training ordnance is not available. Also we do not keep records of the routing where the aircraft actually flew. The details of determining the number of aircraft carrying live ordnance flying specifically though Skull Valley during FY 1998 therefore is not available and the 388 FW would only be speculating in determining this number.

2. The break-down of ordnance by type flown on 388 FW aircraft during FY 1998 is as follows:
   - 156 Live Mk-84 (2000#), normally two per aircraft and includes laser guided bombs of this weight class. 111 sorties.
   - 89 Inert Mk-84 (2000#), normally two per aircraft and includes laser guided bombs of this weight class. 38 sorties.
   - 544 Live Mk-82 (500#), normally four or six per aircraft and includes laser guided bombs of this weight class. 166 sorties.
   - 1029 Inert Mk-82 (500#), normally four or six per aircraft and includes laser guided bombs of this weight class. 355 sorties.
   - 4 AGM-65, normally one per aircraft. 4 sorties.
   - 16 CBU-87 (approx. 1000# cluster bomb), normally 4 per aircraft. 4 sorties.
   - The aircraft flew with no (zero) live air-to-air munitions during FY 1998
   - 7205 BDU-33 (25# training munitions) were expended by the 388 FY during 1998 (normally 9 per aircraft). The wing flies numerous sorties in which the training ordnance is not expended or only partially expended.
   - All 388 FW aircraft carry 510 rounds of 20mm ball ammunition on every sortie

3. The 388 FW does not have records setting forth the likelihood and consequences of ordnance detonation aboard an aircraft which crashes. However, the 388 FW is sensitive to the ramifications of having an aircraft crash while flying with live ordnance and mitigates these consequences by avoiding over-flight of populated areas to the maximum extent possible.

Ronald G Oholendt

RONALD G. OHOLENDT, Colonel, USAF
Vice Commander

Global Power for America

TAB Q

Olson, Eric

From: Olson, Eric
Sent: Wednesday, October 27, 1999 8:14 PM
To: 'Cole, Jack, GEN'
Cc: Zeringue, Cathy; Blount, Wilson; Moran, Paul; Price, Paul
Subject: Ordnance Crash Hazards

Sir,

You asked if we had any data that would shed light on the probability that conventional bombs (Mk 82s, Mk 84s) would function in an F-16 crash scenario. Not having any information that could be used to quantify the likelihood of a crash impact induced detonation, I consulted several persons having significant explosives safety related backgrounds with the Air Force and Navy, with experience in explosives siting, mishap recording, hazard classification and insensitive munitions testing and qualification. None were aware of any historic test programs or analyses that would answer your question. The consensus of this group was that the likelihood of a detonation upon impact is remote, but none of these individuals could offer any assurance that the probability is negligible. Several reasons cited in support of the contention that the probability is remote are:

a. There are procedures for jettisoning unarmed bombs from high altitudes with the expectation that the bombs will not function upon impact with the ground.

b. Multiple fuzing is required to give an acceptable reliability of detonation upon impact.

c. Some fuze designs provide features that allow delayed detonation in order to cause functioning a short time interval after impact on a hard target, for maximum effectiveness. This would not work if impact caused detonation.

d. Other bomb designs having the same explosive fill material as Mk 82s and Mk 84s are effective in penetrating several layers of thick reinforced concrete before the fuze functions the item (bunker busters).

e. The bombs would have had to pass 40-foot drop testing without reaction. Although the impact velocity in this test is much lower that any crash impact velocity, the drop is onto an extremely rigidly supported thick steel plate, resulting in a high-G deceleration.

On the other hand, there is a higher likelihood of bombs exhibiting lower-order but violent reactions when exposed to fuel fires characteristic of aircraft crashes. This is more likely when larger aircraft (bombers, cargo aircraft) are involved because of the larger volume of fuel and the consequent potential for a longer-duration fire. But the possibility of fire induced reactions cannot be ruled out in a fighter aircraft crash.

Please let me know if you need other information from me.

V/R
Eric Olson
(505) 846-5658

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL # of pages ► 1

To GEN JACK COLE	From ERIC OLSON
Dept./Agency	Phone #
Fax # 202-659-3991	Fax #

NSN 7540-01-317-7368 5099-101 GENERAL SERVICES ADMINISTRATION

Tab R

Analysis of the Effective Areas of the Canister Transfer Building and the Cask Storage Area

Because they are the areas within the Private Fuel Storage Facility (PFSF) at which spent fuel will be located, the canister transfer building (CTB) and the cask storage area (SA) must be considered critical areas for effective area calculations for aircraft crash probabilities.

PFS determined the effective area of the PFSF site, where the effective area is defined as the area of the ground in which an aircraft could impact during a crash in which it would strike a critical area within the facility. The effective area includes the skid area and the shadow area. The analysis determined, for the following reasons, that the PFSF should best be considered as two smaller separate critical areas (which areas would simply be summed to yield the PFSF effective area) rather than as one large critical area for the calculation of aircraft crash frequencies.

Ultimately, we are interested in the frequency per year that an aircraft will impact the effective area(s) of the PFSF's critical area(s). At this point in the screening process, in accordance with DOE-STD-3014-96 methodology, no assessment of the severity of the postulated aircraft impact into the facility is being made.[1]

As can be seen from the NUREG-0800 formula for calculating the probability (frequency) of aircraft crashes into a critical area, the probability of such a crash[2] is directly proportional to the size of the effective area.

$$P = N \times C \times A_{eff} / W$$

Where:

[1] DOE-STD-3014-96, paragraph 3.2, page 25.

[2] The probability P in the NUREG formula can be interpreted as the frequency of crashes in a year and this formula is equivalent to the DOE-STD-3014-96 four factor formula. See Attachment 1.

P = Probability that an aircraft will strike a specific critical area
N = Number of aircraft;
C = Crash rate per mile;
A_{eff} = Effective area of that specific facility;
W = Width of the air corridor.

Stated mathematically in terms of probabilities (frequencies), where P(A) is the probability (frequency) of an F-16 striking the SA, and P(B) is the probability (frequency) of an F-16 striking the CTB, the probability (frequency) of striking the total area of A and B (i.e., the probability (frequency) that an F-16 would strike either or both of the areas A and B) is given by the formula $P(A+B) = P(A) + P(B) - P(AB)$.[3] If P(AB), which in mathematical notation is the probability (frequency) of a single aircraft striking both A and B at the same time, = 0, then the probability calculation is reduced to $P(A+B) = P(A) + P(B)$, as has been used by PFS. This is the case when the critical areas are far enough apart to be independent (i.e., one aircraft could not crash into both A and B at the same time). If, on the other hand, P(AB) is >0 (i.e., the effective areas of A and B overlap), then it enters into the equation and, as can be seen from the equation above, makes the probability (frequency) of striking A or B less than the probability of striking A or B when A and B are far enough apart that a crashing aircraft could not strike both A and B (i.e., P(AB) = 0).

Effective area calculations for A_{eff}, which are integral to the above probability equation, are done according to the methodology set forth in DOE-STD-3014 on pages B-26 through B-30.

PFS's analysis follows the important guidance on Pages B-29 and B-30 of the DOE-STD concerning recognition of the specific critical areas within a facility and the need to reduce the unreasonable conservatism which may come by using the gross dimensions of the facility rather than focusing on the critical areas themselves:

[3] Introduction to Probability, John E. Freund. Dover Publications, Inc. New York. 1993 Edition, page 127.

In calculating an effective area. the analyst needs to be cognizant of the "critical areas" of the facility. Critical areas are locations in a facility that contain certain hazardous material and/or locations that. once impacted by a crash. can lead to cascading failures. e.g.. a fire. collapse. and/or explosion that would impact the hazardous material. This knowledge is important for reducing the unnecessary conservatism that is likely to be introduced if the facility's dimensions are used blindly. For example. if the critical area dimensions are small fractions of the overall facility dimensions. this must be reflected in the analysis. In addition. the analyst needs to consider the facility's layout and its location in relation to other facilities when determining the facility input parameters. Information about critical areas and potential aircraft heading angles may eliminate or change the need for further analysis. Otherwise. the conservatism in the analysis might unnecessarily overburden the evaluations.

In addition. there may exist conditions and physical attributes that could affect the evaluation of the effective target areas. For example. there could be nearby barriers that have sufficient structural integrity to resist impact from the categories (or sub categories) of aircraft under investigation. Examples of barriers are robust structures (e.g.. munition storage bunkers and seismically qualified process and storage buildings). extremely rocky terrain. soft soil. dense forests. ravines. and canyons. These special conditions could permit the analyst to reconsider the angle of impact and the skid length for the aircraft of interest. If. for example. the nearby robust structure is tall with respect to the facility. the angle of impact might be considerably larger than the mean value recommended. resulting in a substantially smaller effective target area. The higher angle of impact may result in reduced or negligible skid length. which could also reduce the effective target area. In addition. if the facility is surrounded by other buildings. the skid distance will not be greater that the largest distance between these buildings and the facility.[4]

With the objective to be conservative yet not unnecessarily overburden the evaluations by applying the gross dimensions of the PFSF. PFS has considered the SA and the CTB to have separate effective areas which may be added to arrive at the total effective area of the PFSF. This approach is conservative. in that it does not subtract the overlap of the effective areas of the SA and the CTB (which overlap gives rise to P(AB) in the equation) from the total A_{eff} for the PFSF. This approach also takes into account the vastly different heights of the two areas (90 feet vs. 19.8 feet) and the relatively large distance

[4] DOE-STD-3014-96. pages B-29. B-30.

that separates them (448.5 feet) as well as the large amount of open (non-critical) area that would be included if the facilities were to be considered as only one large area. For the analysis, it may be seen that the SA and the CTB are both rectangles and each has two equal diagonals which each must be analyzed for impact from either direction. By reference to the attached site diagrams (Attachment 2) it may be seen that the effective areas are separate and independent for all approach directions with the exception of an approach from the southeast. Only in this case do the effective areas of the CTB and SA overlap, and then only in a small segment of the southeast corner of the SA.

Additionally, the CTB, which must be struck first on an approach from the southeast, is a tall building with sides constructed of 2 feet of reinforced concrete near the top and more lower down. An aircraft striking the side of the building would have a difficult time penetrating this, and if it did, its fragments would have to fly through an open space and then hit heavily constructed internal structures within the building or at the very least another wall of the same construction. It is thus unlikely that an aircraft striking the side of the building would have enough energy left even if its parts made it through the building to continue on to the SA. Only an aircraft that bounced off the top of the building or just clipped a wing on the side of it as it went by would be able to get to the SA. This shielding or barrier effect of the CTB thus significantly reduces the probability of an aircraft coming from the southeast being able to hit both the CTB and the SA.

Thus, in terms of the probability equation, P(AB) in this case is small and the true probability of hitting the CTB or the SA is nearly (but still less than) P(A) + P(B). Hence, treating the probability of striking the PFSF P(A + B) as equal to P(A) + P(B) is accurate and still conservative.

Attachment 1. DOE-STD-3014-96 four factor formula.
Attachment 2. PFS site diagrams showing effective areas.

Tab R Attachment 1

DOE-STD-3014-96 prescribes "Aircraft crash frequencies are estimated using a "four-factor formula" which considers (1) the number of operations, (2) the probability that an aircraft will crash, (3) given a crash, the probability that the aircraft crashes into a 1-square mile area where the facility is located, and (4) the size of the facility".

Mathematically,

$$F = N \times P \times f \times A_{eff} .$$

Where:

F = Estimated annual aircraft crash impact frequency for the facility of interest;
N = Estimated annual number of site-specific aircraft operations;
P = Aircraft crash rate per mile;
f = Aircraft crash location conditional probability (per square mile) given a crash evaluated at the facility location;
A_{eff} = Site specific effective area for the facility of interest that includes skid and fly-in (shadow) areas.

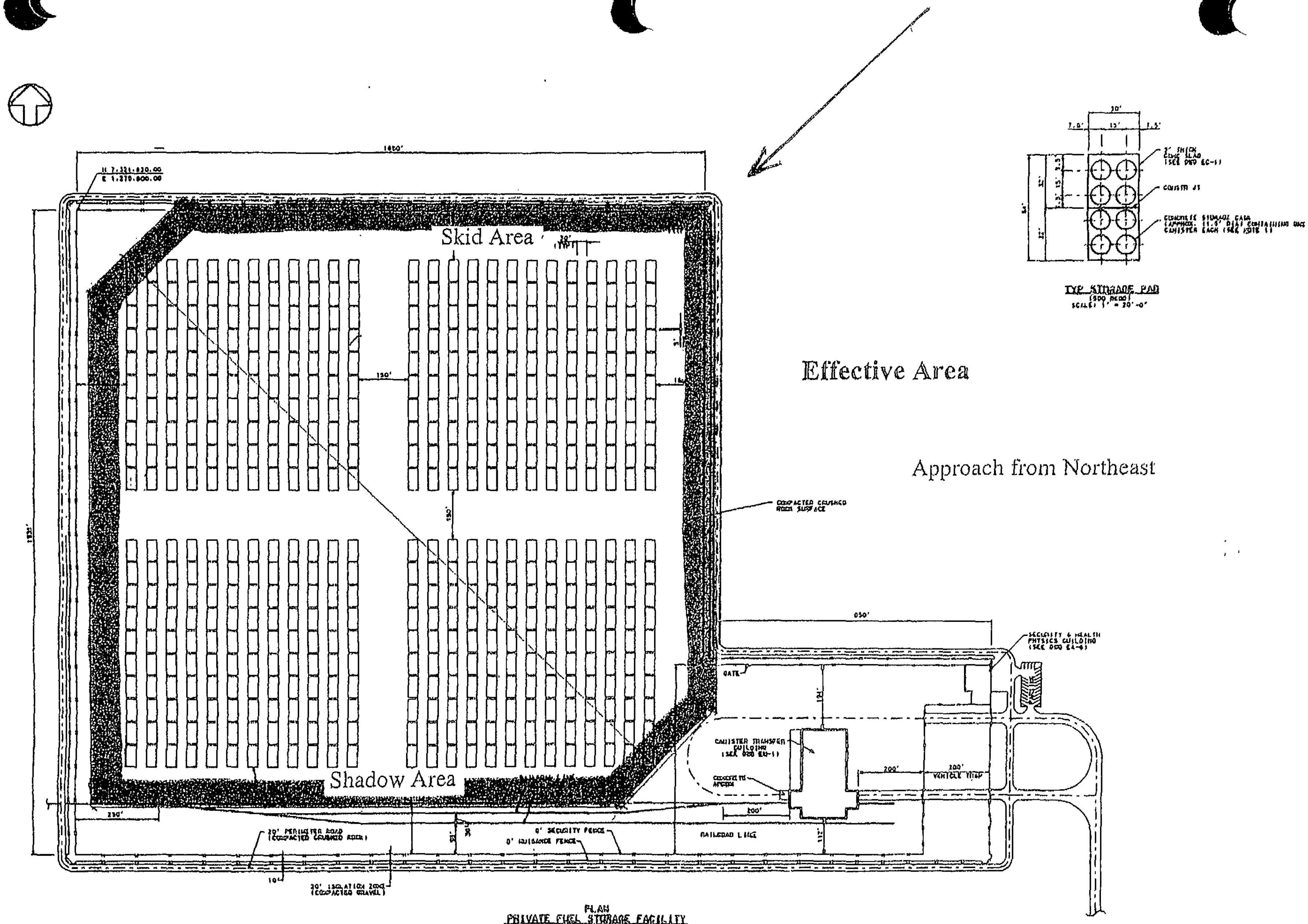


Figure 1.2-1

PFSF GENERAL ARR

PRIVATE FUEL STORAGI
SAFETY ANALYSIS R

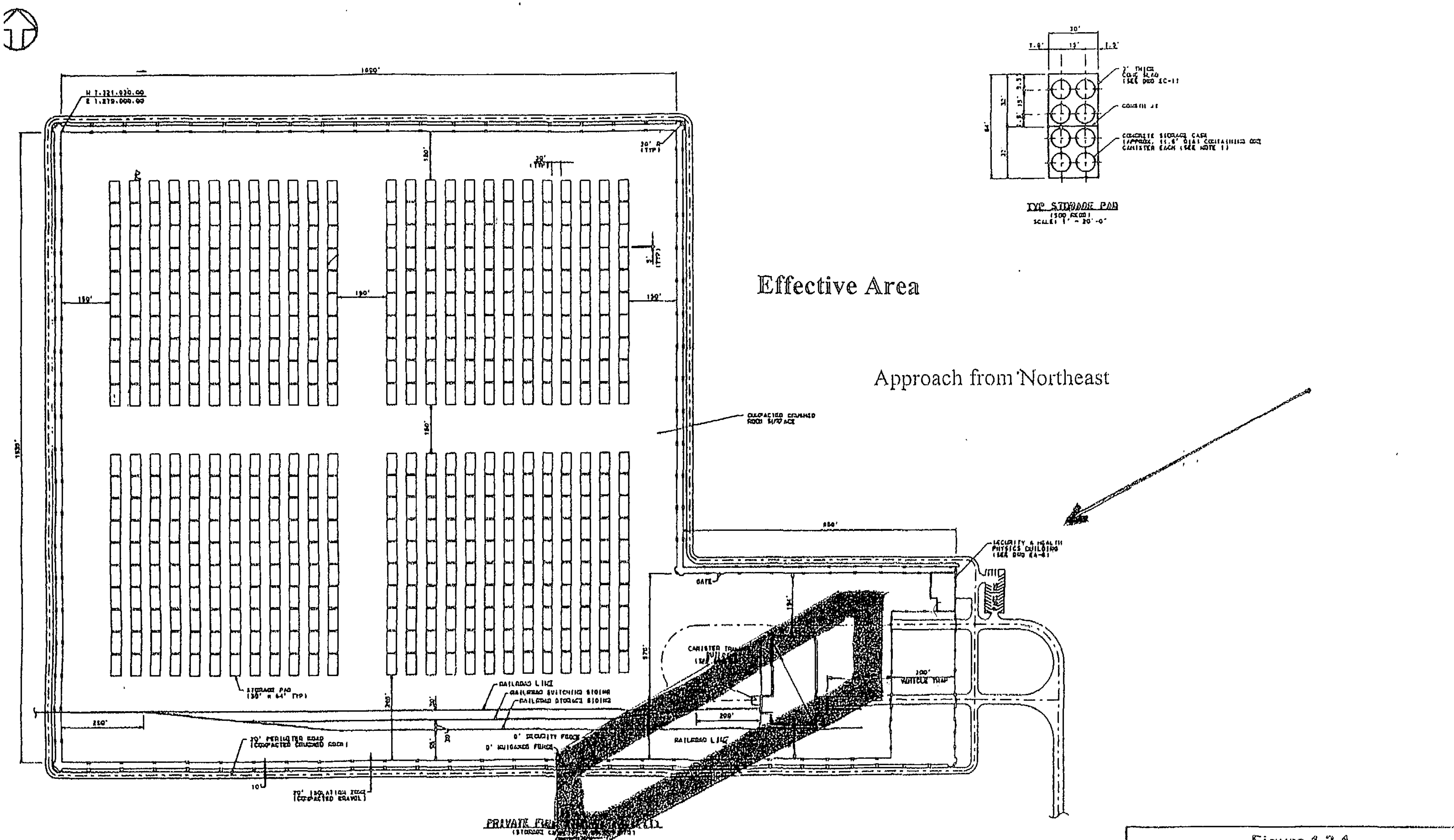


Figure 1.2-1

PFSF GENERAL ARRANGEMENT

PRIVATE FUEL STORAGE FACILITY
SAFETY ANALYSIS REPORT

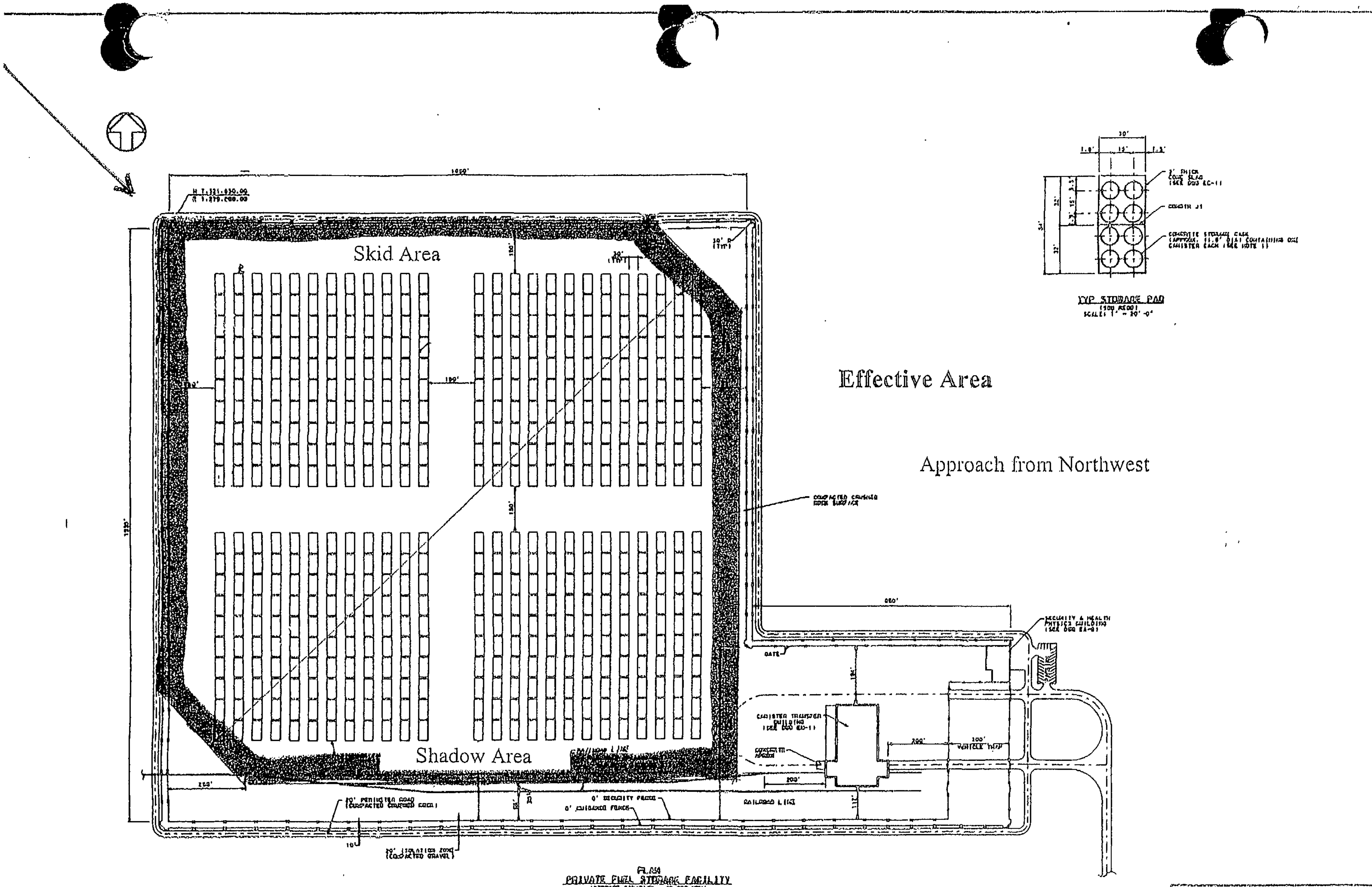


Figure 1.2-1

PFSF GENERAL ARR

PRIVATE FUEL STORAGE
SAFETY ANALYSIS R

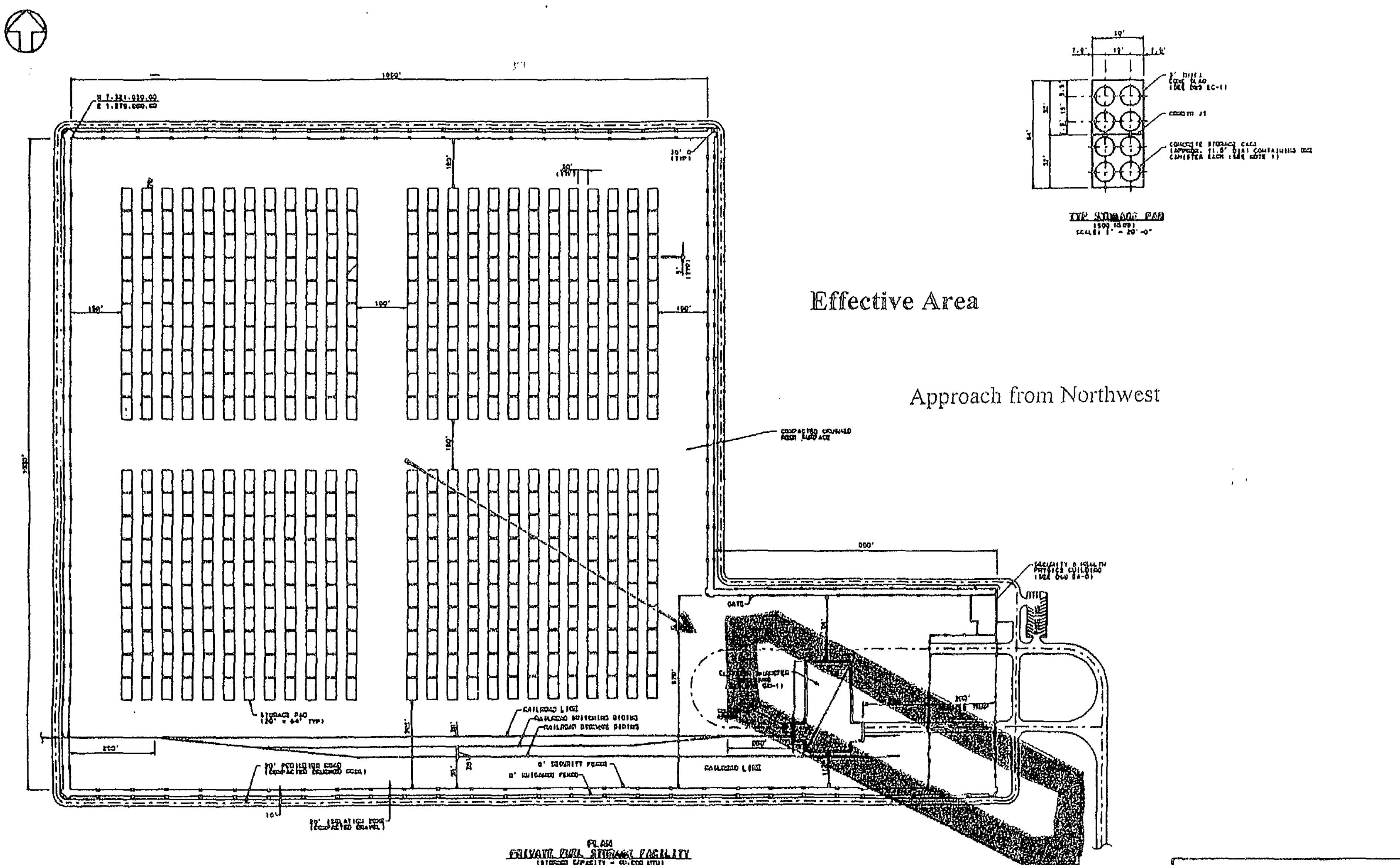


Figure 1.2-1

PFSF GENERAL ARRANGEMENT

PRIVATE FUEL STORAGE FACILITY
SAFETY ANALYSIS REPORT

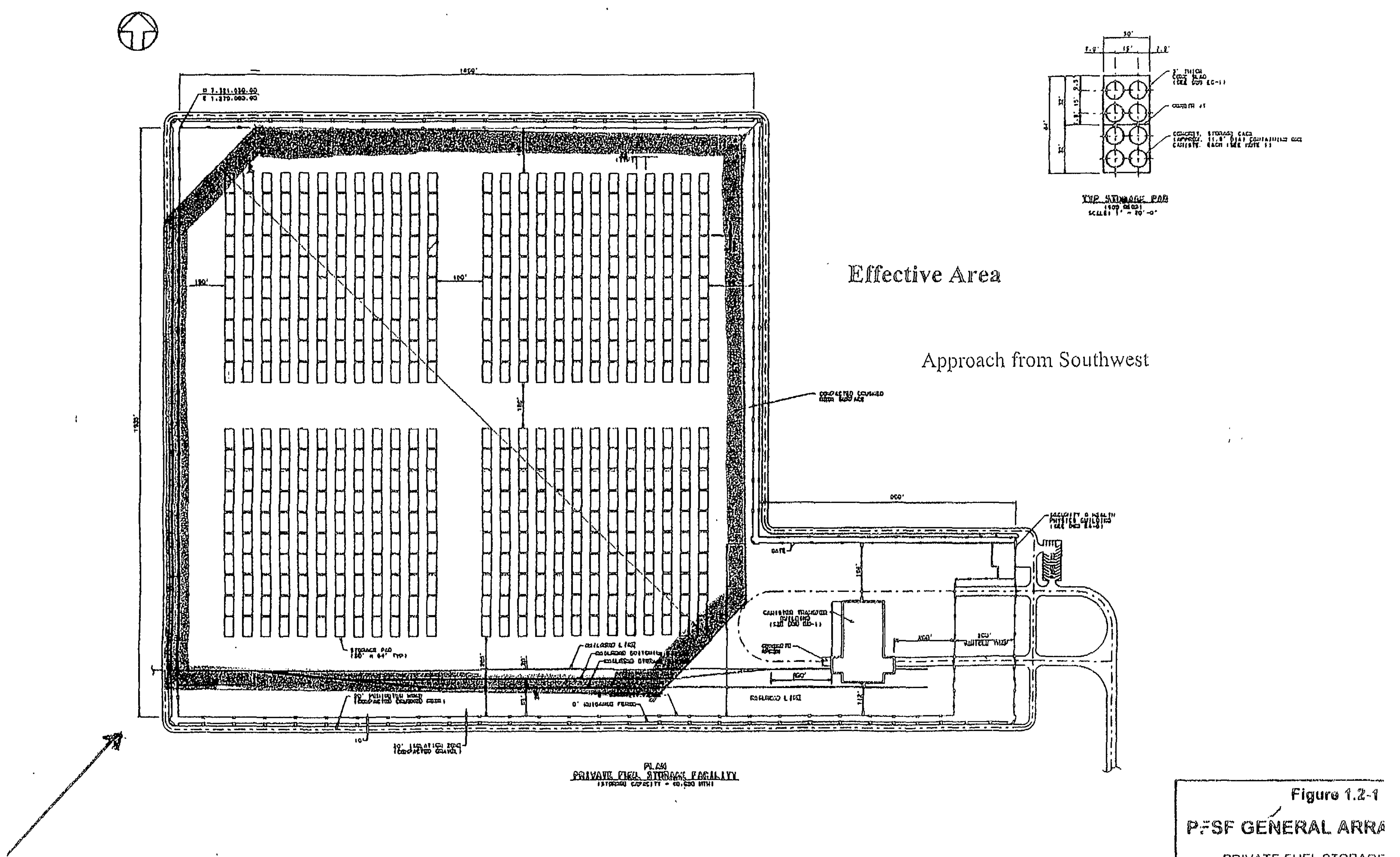


Figure 1.2-1

PFSF GENERAL ARRA

PRIVATE FUEL STORAGE
SAFETY ANALYSIS RE

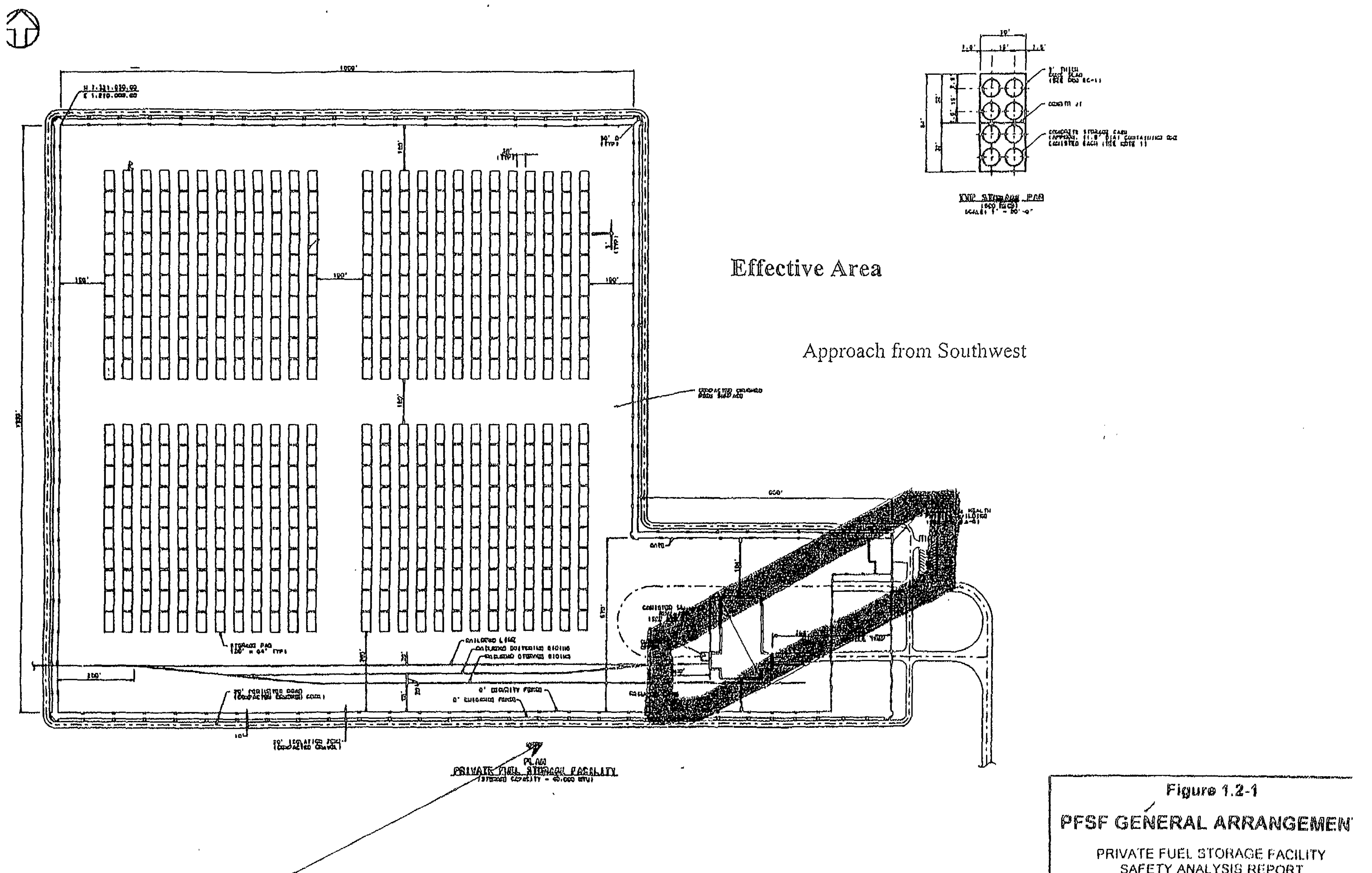


Figure 1.2-1

PFSF GENERAL ARRANGEMEN

PRIVATE FUEL STORAGE FACILITY
SAFETY ANALYSIS REPORT

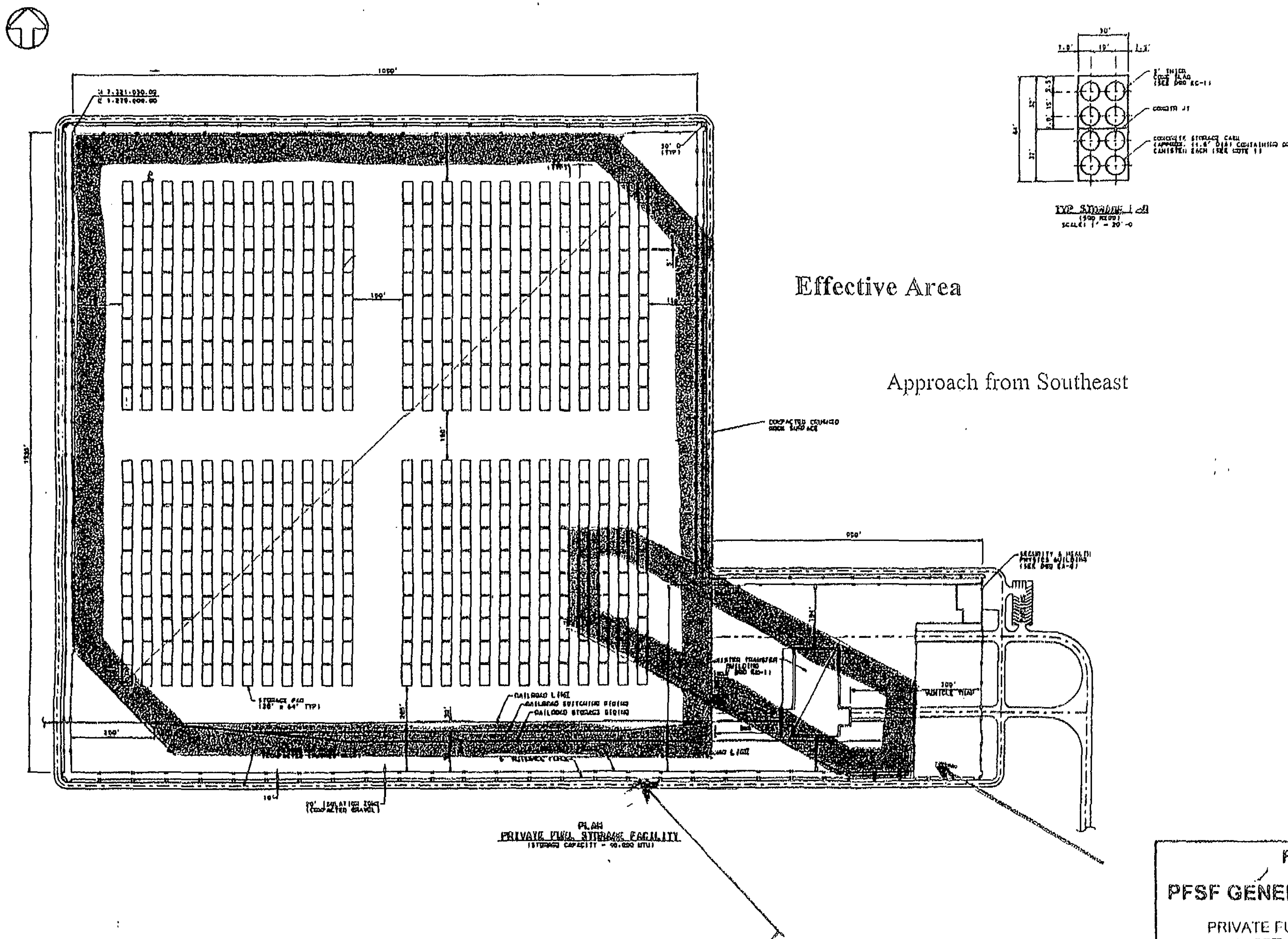


Figure 1.2-1

PFSF GENERAL ARRA

PRIVATE FUEL STORAGE
SAFETY ANALYSIS REI

EJECTION PROCEDURE

BEFORE EJECTION IF TIME AND CONDITIONS PERMIT

1. Turn IFF to EMERGENCY.
2. Notify appropriate ground agency of ejection (include type of aircraft, number of occupants, location and altitude).
3. Stow all loose equipment.
4. Disconnect zero-delay lanyard, lower helmet visor(s) and tighten oxygen mask and chin strap securely.
5. Turn aircraft toward uninhabited area.
6. Actuate emergency oxygen cylinder (high altitude if installed).
7. Attain proper airspeed, altitude and attitude.

Note

If zooming the aircraft, apply trim to prevent pitch down when the control stick is released for ejection.

8. Disconnect oxygen hose and radio cord.

EJECTION

1. HANDGRIPS - RAISE

WARNING

Sit erect, head firmly against headrest, feet back.

2. TRIGGERS - SQUEEZE.

WARNING

Both triggers should be squeezed simultaneously when possible. If only one trigger is squeezed, the fingers of the opposite hand must not be between the handgrip and the trigger as the seat may not fire.

AFTER EJECTION

1. Safety belt - Attempt to open manually.
2. Separate from seat.
A determined effort must be made to separate from seat to obtain full parachute deployment at maximum terrain clearance. This is extremely important for low altitude ejections.
3. If safety belt is opened manually - (Immediately pull parachute arming lanyard (arming ball) if above 14,000 feet or the ripcord handle if below 14,000 feet.

Figure 3-5 (Sheet 1 of 3)

POSTED 30 NOV 99 (CAB)

T.O. 1F-16C-1

FLIGHT MANUAL

NOV 19 1999

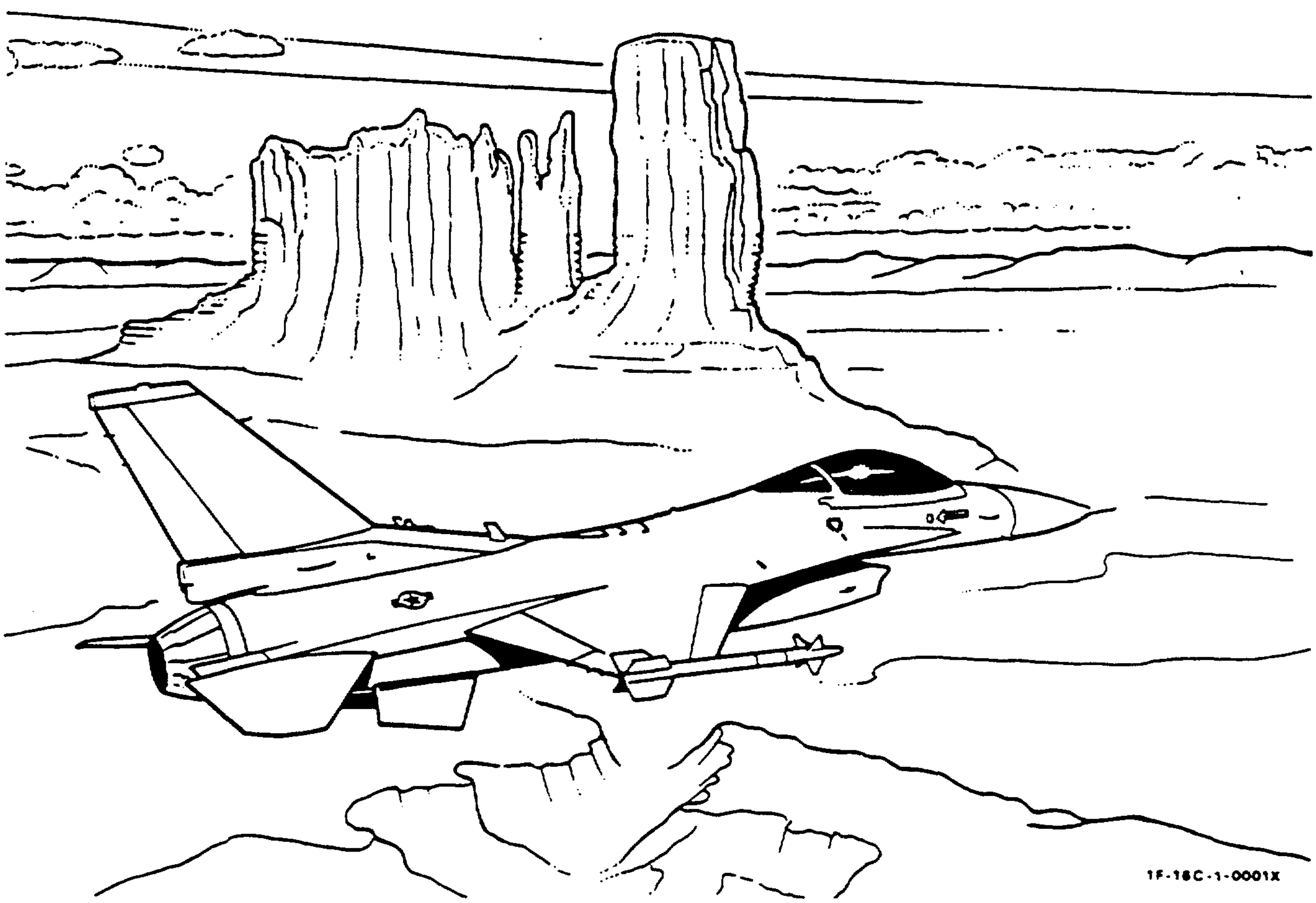
USAF SERIES AIRCRAFT

F-16C/D

BLOCKS 25, 30, AND 32

LOCKHEED MARTIN CORPORATION

F33657-82-C-2034
F42620-97-D-0010



1F-16C-1-0001X

Commanders are responsible for bringing this publication to the attention of all Air Force personnel cleared for operation of subject aircraft.

Published under authority of the Secretary of the Air Force.

4 JANUARY 1999

CHANGE 2 15 SEPTEMBER 1999

If stalls continue:

3. ENG CONT switch - SEC.

If stalls continue:

4. Throttle – OFF for a few seconds, then initiate airstart. Refer to AIRSTART PROCEDURES GE100, this section.

NOTE

For serious hardware problems, the engine may operate normally at idle rpm but exhibit stall/vibration conditions at thrust settings above idle rpm. Attempting additional airstarts will not clear the condition. Use the highest thrust setting below the stall/vibration condition to sustain flight.

If stall(s) clears:

5. Throttle – MIL or below. Minimize throttle movements and make necessary movements slowly.

NOTE

If stall(s) occurred in AB at 30,000 feet MSL or above and while subsonic, the engine is safe to operate in the IDLE to MIL range provided no other abnormal engine indications are observed.

If stall(s) occurred at MIL or below, or in AB below 30,000 feet MSL or while supersonic:

6. Land as soon as possible.

INLET BUZZ GE100

Inlet buzz occurs at supersonic airspeeds if an engine control system failure or a CADC mach signal failure results in insufficient airflow or if the throttle is retarded below MIL while operating in SEC. Inlet buzz causes moderate to severe vibration within the cockpit and may result in multiple engine stalls.

If inlet buzz occurs, the throttle should not be moved until subsonic. Decrease airspeed to subsonic as quickly as possible by opening the speedbrakes and increasing g. If engine stalls occur and persist, the throttle should be retarded to IDLE when subsonic. If the stalls do not clear, retard the throttle to OFF for a few seconds, then advance to midrange. Refer to AIRSTART PROCEDURES GE100, this section.

BIRD STRIKE GE100

In the event of a bird strike or suspected bird strike, AB should be used only if absolutely necessary. It is possible to lodge bird remains in the AB system such that liner damage and subsequent duct burn-through occurs if AB is used. There is no concern of liner damage during any non-AB operation. Refer to ABNORMAL ENGINE RESPONSE GE100, this section, if appropriate.

ENGINE OVERSPEED GE100

An overspeed occurs when rpm exceeds 106 percent. If an overspeed occurs, the 108 DEC, **LESS** 108 AFTC attempts to reduce rpm below maximum limit. However, if the 108 DEC, **LESS** 108 AFTC malfunctions and engine rpm reaches 110 percent, the overspeed protection in the MEC closes the overspeed fuel shutoff valve resulting in a flameout. To restore fuel, retard the throttle to OFF then advance to midrange. Refer to AIRSTART PROCEDURES GE100, this section.

ENGINE FAILURE OR FLAMEOUT GE100

If the engine flames out, fuel starvation or mechanical failure has occurred.

A flameout is indicated by a decrease in FTIT and engine rpm decaying below in-flight idle (approximately 70 percent rpm). Loss of thrust and lack of response to throttle movement confirm the flameout. The ENGINE warning light illuminates when engine rpm goes below 60 percent. Additionally, the MAIN GEN and STBY GEN lights illuminate below 50 percent rpm and the EPU should start running. Do not mistake a loss of ECS noise as an engine flameout.

A flameout indicates an engine control failure, fuel starvation, fuel system malfunction, or fuel cutoff due to engine overspeed protection. If the engine flames out, two features may instantly restart the engine. There is an autorelight feature and the capability to automatically transfer to SEC if certain faults are detected in PRI. If these features work, the restart may take place instantly and the flameout may not be noticeable (except for the illumination of the SEC caution light). In this situation, remain in SEC. Refer to SEC CAUTION LIGHT GE100, this section.

If the flameout progresses to the point that it is noticeable, retard the throttle to OFF, then advance to midrange. Refer to AIRSTART PROCEDURES GE100, this section.

Tower Shaft Failure GE100

Failure of the engine tower shaft or its associated geartrain results in engine flameout due to fuel starvation. A restart is not possible; primary emphasis should be on a flameout landing. If unable to make a flameout landing, refer to EJECTION (TIME PERMITTING), this section. Because tower shaft failure results in the loss of rotation to the engine-driven gearbox and ADG, the initial symptoms are similar to main fuel pump failure. The primary differences are that the rpm indication drops immediately to zero and ENGINE warning light and the SEC caution light illuminate since the engine alternator is no longer providing power to the 108 DEC, **LESS** 108 AFTC.

The JFS should be started immediately upon entering the JFS envelope to conserve EPU fuel. The JFS drives the ADG and the engine gearbox which restores rotation to both hydraulic pumps and provides a reduced FLCS PMG output. Depending on JFS performance and load, rpm may even be high enough to restore standby generator power; however, main generator power may cycle on and off. Without the load of the engine, the JFS produces a 30-55 percent rpm indication, which is the speed of the engine gearbox and not the actual engine rpm. The true engine rpm is unknown.

Low Altitude Engine Failure or Flameout GE100

Refer to figures 3-10 and 3-11. Initial reaction to any malfunction at low altitude should be to trade excess airspeed for altitude. Higher altitude translates directly to either additional time to achieve an airstart or to additional glide range to reach a suitable landing field. Above 310 knots, more time is available by a zoom climb using a 3g pullup to 30-degree climb angle until approaching the desired airspeed (use approximately 50 knots lead point) and then initiating a zero-g pushover. Below 310 knots, more time is available by performing a constant altitude deceleration to the desired airspeed; if required, climb to achieve minimum recommended ejection altitude.

If the zoom results in an altitude below 4000 feet AGL, there may be insufficient time to achieve an airstart prior to reaching minimum recommended ejection altitude. In that case, primary consideration should be given to preparing for ejection; do not delay ejection below 2000 feet AGL.

If low altitude engine failure or flameout occurs:

1. Zoom.
2. Stores – Jettison (if required).
   If stores jettison is attempted after main and standby generators drop off line but before EPU generator comes on line (up to 2 seconds delay), stores will not jettison.
3. Perform airstart (if altitude permits). Refer to AIRSTART PROCEDURES, this section.

WARNING

Below 4000 feet AGL, there may be insufficient time to perform an airstart prior to minimum recommended ejection altitude.

AIRSTARTS GE100

Refer to figure 3-12. Airstarting the engine does not require exact airspeeds or rpm ranges, but there are key events in the airstart sequence that must be performed in a timely manner in order to have the best chance for an airstart. The key events are initiating the airstart while engine rpm is still high, selecting SEC if there is no light-off prior to rpm decaying below 50 percent in PRI (or immediately when below 10,000 feet AGL), and preserving engine rpm prior to light-off.

Factors such as altitude, airspeed, weather, etc., must be considered in determining whether to try an airstart, to accomplish a flameout landing, or to eject. Jettisoning stores reduces altitude loss during an airstart and improves glide ratio during flameout landing.

If gliding distance is not a factor, maintain 250 knots or more in order to reduce rpm rate of decay until the JFS can be started. The engine can be airstarted with airspeeds from 170-400 knots/0.9 mach; however, 250 knots provides the best tradeoff of altitude loss, range, and airflow for the engine.

In flight, the throttle must be retarded to OFF and then advanced back to the operating range for only four reasons: to reset the overspeed protection logic, to clear a stall, to begin the airstart procedure, or to terminate a hot/hung start. Exact throttle position is not important for an airstart in either PRI or SEC, so any position between IDLE and MAX AB is acceptable; however, the midrange position is preferred because of possible throttle misrigging at IDLE or possible engine overspeed shutdown at MIL or above.

Low Altitude Zoom Capability

DATA BASIS ESTIMATED **ENGINE F110-GE-100**

CONFIGURATION:

- GW = 23,000-25,000 LB
- DI = 0-50
- LG - UP

CONDITIONS:

- WINDMILLING OR SEIZED ENGINE
- 30-DEGREE CLIMB MAINTAINED TO 170/250 KIAS

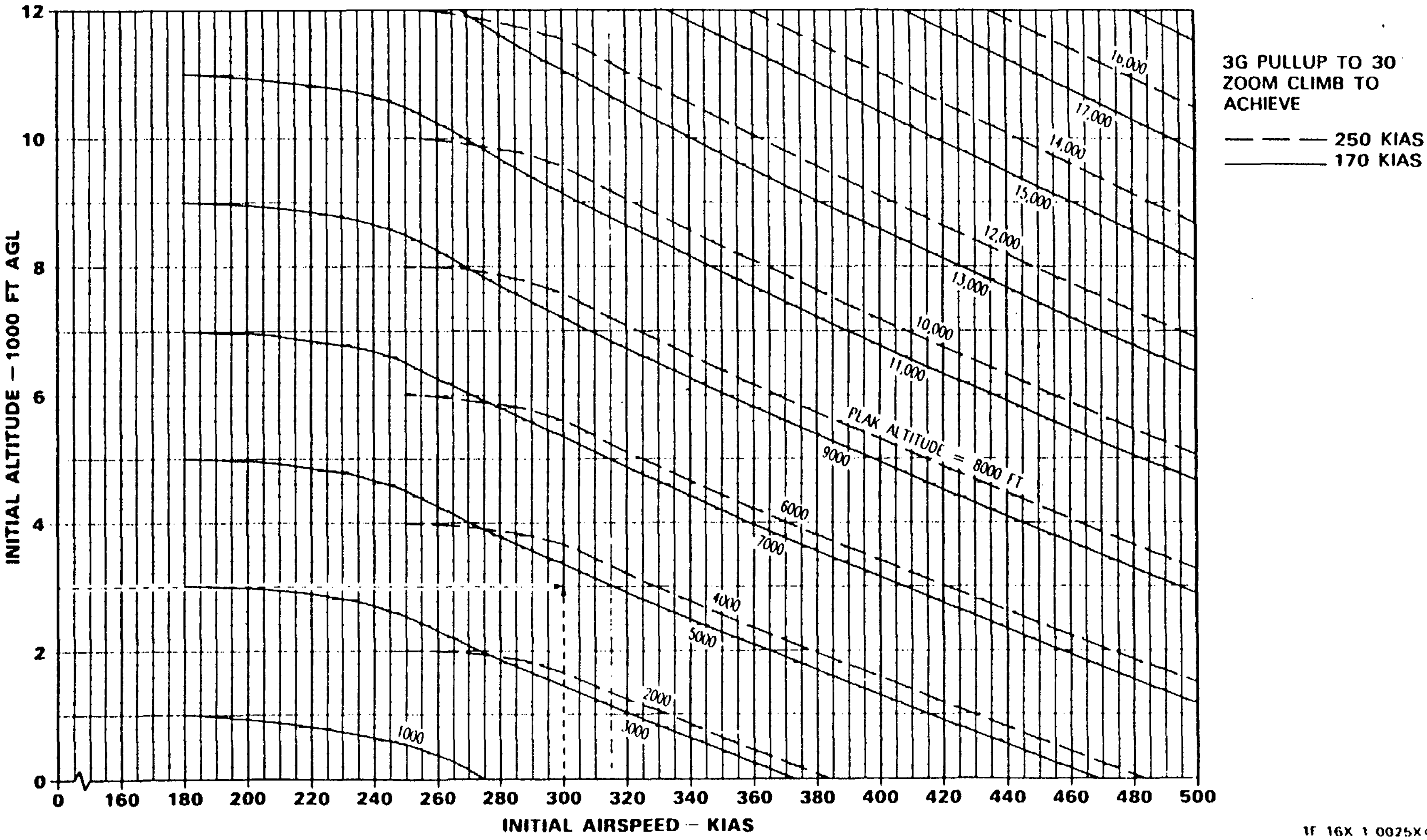


Figure 3-10.

Low Altitude Airstart Capability

DATA BASIS ESTIMATED

ENGINE F110-GE-100

CONFIGURATION:

- GW = 23,000-25,000 LB
- DI = 0-50
- LG — UP

CONDITIONS:

- 30° DIVE TO DESCENT KIAS OR 3G PULLUP TO 30° ZOOM CLIMB INITIATED FROM THE AIRSPEED/ALTITUDE EXISTING AT FIRST RECOGNITION OF ENGINE FAILURE
- AIRSTART INITIATED AT START OF DIVE OR ZOOM BY CYCLING THROTTLE TO OFF AND THEN MIDRANGE
- 45 SECONDS ASSUMED AFTER THROTTLE ADVANCE TO ACHIEVE USABLE THRUST (ASSUMES AIRSTART INITIATION AT 25 PERCENT RPM)
- DESCENT AIRSPEED IS 170 KIAS (SEC) (JFS RUN LIGHT ON)

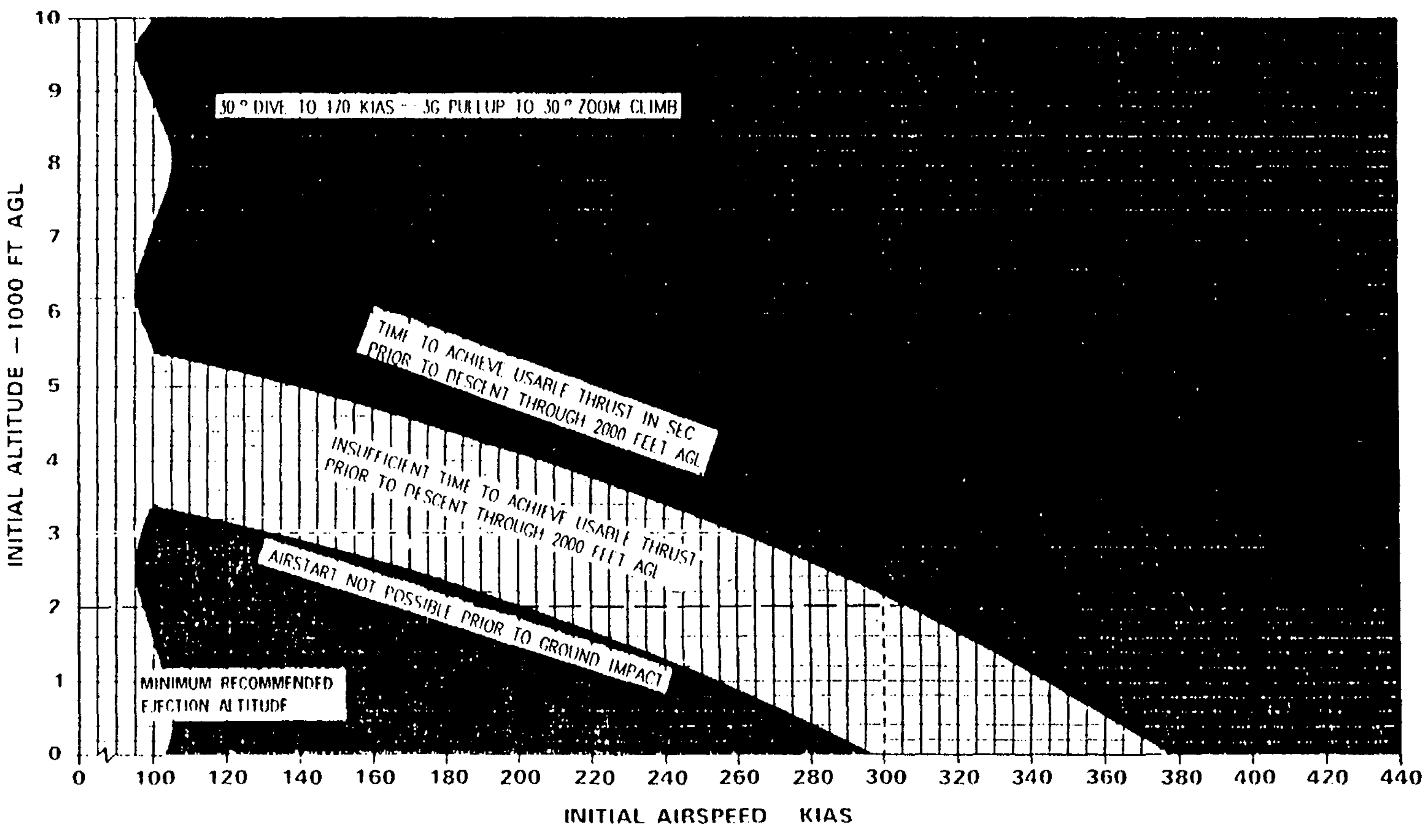


Figure 3-11

Once the throttle is retarded to OFF and then advanced back to the normal operating range, do not retard the throttle to OFF again during the airstart unless a hot/hung start occurs. Unnecessarily retarding the throttle to OFF terminates any start attempt which may be in progress.

A successful restart depends on many variables: cause of flameout, type of fuel, altitude, airspeed, and engine rpm when the airstart is attempted. High engine rpm is the most important variable and provides the best chance of a successful restart. Therefore, do not delay the initiation of an airstart in an attempt to reach a particular flight condition. Initiate the airstart as soon as it becomes apparent that engine rpm has decayed below in-flight idle (approximately 70 percent rpm) or illumination of the ENGINE warning light, engine instrument indications, and no response to throttle movement confirm a flameout. The best conditions for either a PRI or SEC airstart are below 30,000 feet MSL, at 250 knots or more, and with high engine rpm.

At medium and high altitudes, the airstart attempt should be started in the engine control mode selected by the 108 DEC, **LESS** 108 AFTC (either PRI or SEC). The 108 DEC, **LESS** 108 AFTC contains diagnostic logic designed to identify PRI engine control failures and may automatically transfer to SEC. If there is no indication of a light-off before rpm decays below 50 percent, place ENG CONT switch to SEC (even if the SEC caution light is on) and continue the airstart attempt. At low altitude (below 10,000 feet AGL), SEC should be selected as soon as possible after initiating the airstart.

Of equal importance to selecting SEC when required is preserving engine rpm. The JFS should be started as soon as the aircraft is in the JFS envelope. The advantage of using the JFS to assist the airstart is that once the JFS RUN light is on, airspeed can be reduced. Under normal conditions the JFS will motor the engine at a minimum of 25 percent.

An airstart can be rapid if light-off occurs above 60 percent rpm. Airstarts initiated between 50-25 percent engine rpm are slow to lightoff and may take up to 90 seconds to regain usable thrust. If altitude is available, increasing airspeed can assist engine acceleration and decrease the time to regain usable thrust once a light-off is achieved. As long as engine rpm continues to increase, this condition should not be considered as a hung/no start. Spooldown airstarts initiated below 25 percent rpm have been successful during flight tests, but spoolup to usable thrust may take more time than is available. Keep engine rpm at 25 percent or above during spooldown airstarts, if possible. Following the rapid FTIT increase and peak of a light-off, FTIT slowly decreases approximately 50°C. Therefore, do not confuse a drop in FTIT as an unsuccessful airstart unless accompanied by decreasing rpm as well.

High Altitude Airstart Considerations GE100

As altitude is increased above 30,000 feet MSL, the probability of a successful airstart can be improved by attempting the airstart as soon as possible (before rpm decays below approximately 50 percent) and by quickly descending to altitudes below 30,000 feet MSL after the airstart is initiated. Airspeeds above 250 knots (400 knots/0.9 mach maximum) should be considered as a means to reduce altitude and increase the probability of a successful airstart. Spooldown airstarts can be achieved with rpm as low as 25 percent, but not at all airspeeds and altitudes.

At high altitudes, dive as required to maintain speed in the 250-400 knot/0.9 mach range. Unless an airstart is obviously impossible (total lack of fuel, tower shaft failure, engine seizure, etc.), do not become tempted to establish a maximum range or maximum endurance glide. The first consideration should be an immediate spooldown airstart attempt even if the engine fails for no apparent reason. If a spooldown airstart is not successful before reaching 20,000 feet MSL, a JFS-assisted airstart should be attempted. When below 20,000 feet MSL, turn JFS on. Activating the JFS above 20,000 feet MSL is prohibited since successful JFS start/motoring of engine is unlikely and the brake/JFS accumulators will be depleted. If the JFS RUN light is on, airspeed may be reduced to achieve maximum range or maximum endurance (200 or 170 knots, respectively, plus 5 knots per 1000 pounds of fuel/store weights over C 2000, D 1000 pounds). Time constraints due to EPU fuel consumption must also be considered. A maximum range or maximum endurance glide from above approximately 35,000 feet MSL may exhaust EPU fuel prior to landing. (Refer to T.O. 1F-16C-1-1, figure B6-3 or D6-3.) With the JFS running, EPU fuel consumption is also reduced.

Low Altitude Airstart Considerations GE100

Initiate the airstart as soon as possible. After initiating a zoom climb and jettisoning stores (if required), retard the throttle to OFF then advance the throttle to the normal operating range. Place the ENG CONT switch to SEC and turn on the JFS (START 2) to assist the airstart.

Following a zoom climb, plan to arrive at 250 knots until the JFS RUN light is on; airspeed may then be reduced to achieve maximum range or maximum endurance (200 or 170 knots, respectively, plus 5 knots per 1000 pounds of fuel/store weights over C 2000, D 1000 pounds). If a higher airspeed is maintained or an attempt is made to gain airspeed to delay the rpm decay, available time may be reduced to the point that an airstart is not possible.

During any low altitude airstart attempt, constantly evaluate altitude above the ground relative to airstart success. Do not delay ejection below 2000 feet AGL unless the engine is producing thrust capable of maintaining level flight or safely controlling the sink rate or unless a flameout landing can be accomplished.

Airstart Procedures GE100

To begin the airstart sequence, retard the throttle to OFF; then immediately advance the throttle back into the normal operating range, preferably midrange.

NOTE

> If the throttle is retarded to OFF to clear a stall, it should be maintained in OFF for a few seconds to allow the stall to clear.

After throttle advance, monitor for signs of a light-off before rpm decays below 50 percent (characterized by a rapid increase in FTIT accompanied by a slow increase in rpm). If rpm and FTIT continue to decay after rpm drops below 50 percent, place the ENG CONT switch to SEC (even if the SEC caution light is illuminated).

If a hot/hung start occurs, retard the throttle to OFF and allow the FTIT to drop to below 700°C before advancing the throttle. Increasing the airspeed (maximum of 400 knots/0.9 mach) should help the next airstart to be cooler. If the condition persists, retard the throttle to OFF, place the ENG CONT switch to SEC, and allow the FTIT to decrease below 700°C before advancing the throttle.

After entering the JFS envelope, start the JFS to assist in preserving rpm. With the JFS RUN light on, airspeed may be reduced to achieve maximum range/endurance.

If the JFS stops running or fails to run within 30 seconds, do not reattempt a JFS start until the brake/JFS accumulators have time to recharge. Allow 1 minute of engine rotation (either windmilling or JFS assisted) at 12 percent rpm or above to insure that the brake/JFS accumulators are fully recharged. Recharging begins 3-4 seconds before the JFS RUN light illuminates or 30 seconds after selecting a start position (in the event of a JFS failure to run). Recharging occurs regardless of JFS switch position.

In the event of a JFS shutdown, the JFS switch does not relatch in either start position while the JFS is spooling down. Spooldown from full governed speed takes approximately 17 seconds. The JFS switch must be cycled to OFF and then START 2 to reinitiate a JFS start. It is possible to complete the spooldown before the brake/JFS accumulators are recharged if the JFS ran for only a short time.

It is possible the engine may not respond properly to throttle movement following an otherwise successful airstart. If this occurs or if thrust is insufficient to ensure a safe landing, refer to ABNORMAL ENGINE RESPONSE, this section.

When the airstart is completed and usable thrust is regained, turn the JFS off. Reset the main generator using the ELEC CAUTION RESET button and verify MAIN GEN and STBY GEN lights are off. Cycle the EPU switch to OFF and then back to NORM.

To accomplish an airstart:

1. Throttle – OFF, then midrange.

CAUTION

- FTIT should decrease rapidly when throttle is OFF. If FTIT does not decrease rapidly, verify that the throttle is OFF.
- Do not mistake a rapid initial FTIT increase during an airstart as an indication of a hot start. Typically, airstarts are characterized by rapidly increasing FTIT with a slow increase in rpm.

If a relight does not occur before rpm decays below 50 percent, or if below 10,000 feet AGL:

2. ENG CONT switch – SEC (even if SEC caution light is on).

3. Airspeed – Attain approximately 250 knots or establish maximum range or endurance airspeed (200 or 170 knots, respectively, plus 5 knots per 1000 pounds of fuel/store weights over Ⓒ 2000, Ⓓ 1000 pounds) with JFS RUN light on.
   Above 30,000 feet MSL, airspeeds in the 250-400 knot/0.9 mach range should be considered to reduce altitude and increase the probability of a successful airstart.

NOTE

If maximum gliding range is not a factor, consider maintaining 250 knots or more above 10,000 feet AGL to provide best restart conditions (in case of JFS failure). Below 10,000 feet AGL with the JFS RUN light on, maintain maximum range or maximum endurance airspeed.

4. JFS switch – START 2 below 20,000 feet MSL and below 400 knots.

NOTE

- If the JFS switch is erroneously placed to START 1, leave it there.
- If the JFS RUN light does not illuminate or goes off once illuminated, place the JFS switch to OFF and reattempt START 2 when the brake/JFS accumulators are recharged. The JFS switch does not relatch in either start position while the JFS is spooling down.

If engine rpm rolls back or hangs below in-flight idle (approximately 70 percent) and FTIT exceeds 935°C:

5. Throttle – OFF, then midrange.
   Allow FTIT to drop below 700°C before advancing the throttle.

6. Airspeed – Increase (400 knots/0.9 mach maximum).

If hung start/hot start persists:

7. Throttle – OFF.

8. ENG CONT switch – SEC.

NOTE

The proximity of the ENG CONT switch to the JFS switch makes the JFS switch susceptible to being bumped to OFF when selecting SEC.

9. Throttle – Midrange.
   Allow FTIT to drop below 700°C before advancing throttle.

If engine does not respond normally after airstart is completed:

10. Refer to ABNORMAL ENGINE RESPONSE, this section.

If engine responds normally:

10. JFS switch – OFF.

11. ELEC CAUTION RESET button – Depress.
    Verify MAIN GEN and STBY GEN lights are off.

12. EPU switch – OFF, then NORM.

13. ADI – Check for presence of OFF and/or AUX warning flags.
    If warning flag(s) is in view, refer to TOTAL INS FAILURE, this section.

WARNING

Ⓔ If only AUX flag is in view, pitch and roll attitude information is likely to be erroneous due to INS autorestart in the attitude mode when other than straight and level, unaccelerated flight conditions existed.

14. Land as soon as possible.

15. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

FLAMEOUT LANDING

The decision to eject or make a flameout landing rests with the pilot. Considerations for attempting a flameout landing must include:

- Nature of the emergency.
- Weather conditions.
- Day or night.
- Proximity of a suitable landing runway.
- Proficiency in performing simulated flameout (SFO) landings.

The above data is for a descent to sea level. If the descent was stopped at 5000 feet:

- Range = 20.8 – 3.0 = 17.8 nm
- Fuel consumed = 55 – 10 = 45 pounds
- Time = 3.4 – 0.6 = 2.8 minutes

DESCENT WITH INOPERATIVE ENGINE

Figure B6-3 contains time and distance data for a descent with an inoperative engine. The data is presented as a function of descent airspeed for descents from various initial altitudes to sea level. Minimum EPU operating time is shown.

The chart is intended to be used to estimate the time available for engine airstart attempts once the aircraft has been maneuvered into the airstart envelope and may also be used to obtain glide distance with the engine inoperative.

REFER TO FIGURE B6-3.

Enter the chart with airspeed (A); proceed upward to the appropriate GW/altitude line (B) and then to the left to read time (C) and distance (D). To determine time and distance available to descend to another altitude, repeat the above steps for the final altitude and take the difference between the sets of data.

SAMPLE PROBLEM

A.	Descent airspeed	= 250 KIAS
B.	GW/altitude	= 20,000 pounds/ 30,000 feet
C.	Time (to sea level)	= 7.8 minutes
D.	Distance (to sea level)	= 40.0 nm

If the descent was stopped at 5000 feet:

- Time = 7.8 – 1.5 = 6.3 minutes
- Distance = 40.0 – 6.2 = 33.8 nm

Descent With Inoperative Engine

DATA BASIS FLIGHT TEST

ENGINE F110-GE-100/SMALL INLET

CONFIGURATION:

- DRAG INDEX = 0

CONDITIONS:

- STANDARD DAY
- WINDMILLING ENGINE OR LOCKED ROTOR
- NO WIND

NOTE: REDUCE TIME AND DISTANCE 1% FOR EACH 10-UNIT INCREASE IN DRAG INDEX.

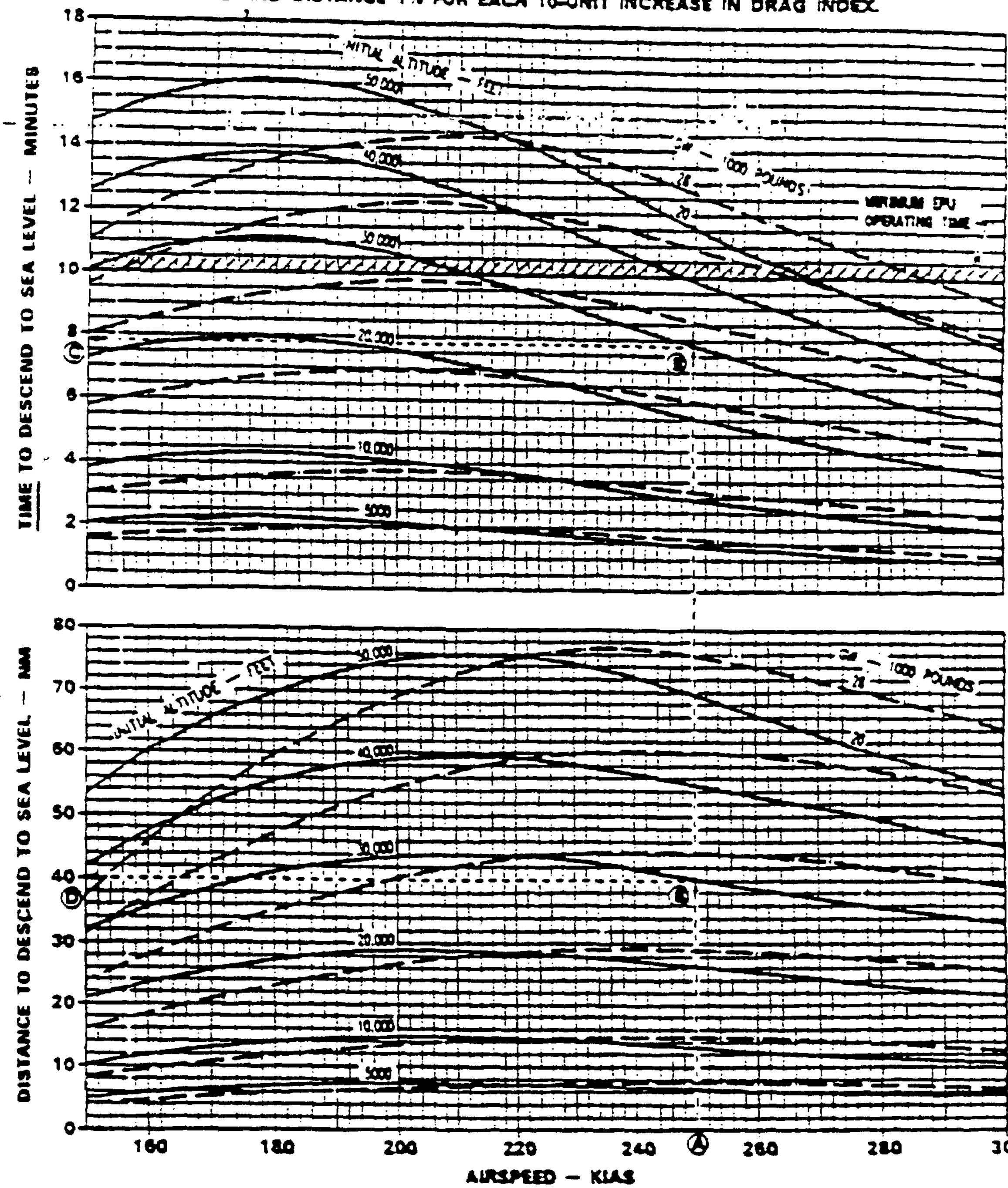


Figure B6-3.

Tab U

Corroborating Calculations Confirming Available Time for F-16 Pilot Experiencing Engine Failure or other Controllable Emergency in Skull Valley to Avoid the Private Fuel Storage Facility

As set forth in Section III.A.5.b of the text, Figure 3-11, T.O. 1F-16C-1, entitled Low Altitude Airstart Capability, shows that an F-16 in the green area of that chart will have enough time to zoom from a low altitude and achieve an airstart (assuming 45 seconds from the time of throttle advance until attaining usable thrust) before descending to the recommended ejection altitude of 2,000 ft. As discussed in the text, this is more than adequate time for the pilot to accomplish the largely automatic airstart procedures and prepare for ejection, including finding a safe place for the airplane to crash after ejection.

PFS has also performed calculations, set forth in this appendix, as it did in Revision 0 of this Report, based on Figure 3-10 , Low Altitude Zoom Capability,[1] Air Force Manual T.O. 1F-16C-1, and the Descent with Inoperative Engine Chart, Figure B6-3, Air Force Manual T.O. 1F-16C-1-1.[2] As in Revision 0 of this Report, these calculations are based on the zoom scenario described in the October 21, 1999 memorandum of Col. Ronald Fly, USAF (Ret.) (Tab E).[3] PFS has revised its calculation of the zoom capability from Revision 0 of this Report to take a more detailed look at the combination of speeds and

[1] This Figure is the zoom chart for F-16s with General Electric (as opposed to Pratt & Whitney) engines, which are the type of F-16s flown out of Hill AFB and on the UTTR. See note 19A in Report.

[2] Figures 3-10 and B6-3 are at the end of this Tab.

[3] Under this scenario, the pilot will initiate a climb in a 30-degree nose-high attitude until he reaches a speed of 250 knots. At 250 knots, the pilot will initiate a push over after which the plane would glide at approximately 210 knots. This scenario has been changed slightly in the current version of the Air Force T.O. 1F-16C-1, p. 3-98, which now provides for the pilot to level off and decelerate at a speed of 250 knots until the jet fuel starter comes on, at which point the pilot may slow further to descend at the maximum range or maximum endurance speed of the F-16 (Tab T). (The jet fuel starter is used to start the engine at takeoff and it can also assist and facilitate mid-air restarts and is highly likely to come on.) PFS does not have the information necessary to directly calculate the time aloft under the scenario set forth in the current version of Air Force T.O. 1F-16C-1. However, the time would be the same general range as that which PFS has calculated assuming a climb until the aircraft would reach 210 knots followed by an immediate descent, and it would not alter the conclusion that the pilot would have sufficient time to avoid the PFSF (as is shown and confirmed by the Low Altitude Airstart Capability, Figure 3-11 of the current version of T.O. discussed in the text of this Report).

altitudes at which F-16s transit Skull Valley (and to apply a more conservative interpretation of Figure 3-10 than it did in Revision 0).[4]

These calculations, detailed below, corroborate the conclusions in the text of the Report based on Figure 3-11. They show that, at the speeds and altitudes at which F-16s normally transit Skull Valley, a pilot would have somewhere in the range of 1 to 2 minutes between the initial sign of trouble and the point at which the pilot would reach the minimum recommended ejection altitude of 2,000 ft. AGL.

F-16 at 350 knots and 3,000 feet

Because F-16s normally transit Skull Valley on a southerly heading at 3,000 to 4,000 feet AGL and 350 to 400 knots, PFS conservatively uses an altitude of 3,000 feet and a speed of 350 knots as entering factors to determine a Low Altitude Zoom Capability from Figure 3-10, Air Force T.O. 1F-16C-1. This chart is used to find the height to which an F-16 will zoom under various speed and altitude conditions. Using the factors of 350 knots and 3,000 feet, a point is defined on the chart by reading the initial altitude of the aircraft from the Y axis and the initial speed of the aircraft from the X axis. By interpolating vertically between the 250 knots (dashed) lines labeled 4,000 and 6,000 feet above and below that point, it may be determined that an aircraft would zoom to a peak altitude of 4480 feet when reaching 250 knots. Using the 170 knot (solid) lines labeled 5,000 and 7,000 feet, by similar interpolation it may be seen that the aircraft would reach 5,735 feet when achieving 170 knots. Since it is assumed that the pilot is striving to achieve a glide speed of 210 knots,[5] by another interpolation between these two derived altitudes, it may be determined that the aircraft would zoom to 5,107 feet (a gain of 2,107 feet).[6]

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[4] In Revision 0, PFS assumed that the altitude on the Figure 3-10 was reached at the point at which the pilot starts to lower the nose of the aircraft and that the aircraft would continue to gain altitude as the plane nosed over to its gliding attitude. This was in accordance with the note at the upper right corner of the chart which says that the 30 degree climb in maintained until the relevant airspeed is reached. In these calculations, PFS conservatively interprets the altitude on Figure 3-10 as the peak altitude reached after the aircraft has nosed over and reached its gliding attitude.

[5] See Tab E.

[6] This calculation, as well as the other calculations in this Tab, assume that external ordnance and other stores are jettisoned at the time ascent is initiated, which Col. Ronald Fly, USAF (Ret.) indicates is the procedure, as opposed to waiting until the F-16 levels out upon reaching its gliding speed, as had been

As an estimate of the time taken for the zoom in this case, the aircraft begins the zoom at 350 knots and ends at 210 knots, for an average airspeed of 280 knots indicated airspeed (326 knots true airspeed)[7] or 550 feet per second. The aircraft achieves 30 degrees in the zoom. Allowing for time to establish the climb and to push over (lower the nose) to level out at the top, a 20 degree average climb is assumed. To gain 2,107 feet of altitude in a 20 degree climb, by geometry an aircraft must travel a distance of at least 6,160 feet. At 550 feet per second, this will take 11.2 seconds.

By reference to the Descent with Inoperative Engine Chart, Figure B6-3, Air Force T.O. 1F-16C-1-1, a glide time from 5,107 feet AGL to 2,000 feet AGL (the recommended ejection altitude) can be determined. Using a glide speed of 210 knots and a Gross Weight of 26,000 pounds (dashed lines) and referencing the top part of the Figure labeled Time to Descend, it may be seen that an aircraft at 5,000 feet AGL in Skull Valley (10,000 feet MSL) could glide for 1.75 minutes before reaching ground level (5,000 feet MSL). The glide rate is thus 21 seconds per 1,000 feet of altitude lost.[8] Therefore, gliding from the peak altitude of 5,107 feet to the 2,000 foot ejection altitude (i.e., 3,107 feet) would take 65.2 seconds.

The total climb and glide time back to the recommended ejection altitude is then 11.2 + 65.2 = 76.4 seconds, or 1 minute 16.4 seconds, which is well above the minimum of 45 seconds shown in Figure 3-11. As discussed in the text of the Report, the pilot steps required to attempt restart of the engine are relatively simple since the airstart sequence is largely automatic and would take only a fraction of the available time, leaving the pilot with more than sufficient time to survey the terrain and avoid populated areas and structures, as he is trained to do, before he reaches the 2,000 ft. ejection altitude.

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assumed in PFS's August 13, 1999 submission. Without the drag of ordnance and external stores, the F-16 is capable of zooming to a higher altitude.

[7] True airspeed is Indicated Airspeed adjusted for the effects of pressure altitude and temperature. True airspeed is the actual airspeed through the air mass; indicated airspeed is what the pilot sees on his instruments.

[8] PFS had previously calculated in Revision 0 of this Report a descent ratio of 24 seconds per 1,000 feet on the basis of its previous estimate of the weight of the F-16s in Skull Valley. PFS has adopted the more conservative (and accurate) weight here in that F-16s transiting Skull Valley (with full internal fuel tanks) would weigh somewhere in the range of 25,000 pounds.

F-16 at 400 knots and 4,000 feet

Since as stated above, F-16s routinely transit Skull Valley at 3,000 to 4,000 feet AGL and 350 knots to 400 knots, to examine the other end of the normal range, calculations were made with an airspeed of 400 knots at 4,000 feet AGL. In this case, assuming again that the pilot would zoom to level at 210 knots, the aircraft would reach a peak altitude of 7,281 feet and this zoom would take 15.9 seconds. From this altitude, the aircraft would glide back down to the 2,000 foot ejection altitude, losing 5,281 feet and taking 110.9 seconds. Thus, the total time for an aircraft at 400 knots and 4,000 feet to zoom and then glide back down to ejection altitude of 2,000 ft. AGL is 15.9 + 110.9 = 126.8 seconds, or 2 minutes 6.8 seconds.

F-16 at 420 knots and 1,000 feet

Although the lowest altitude in Skull Valley (north of English Village on Dugway) at which planes can fly is 1,000 feet, pilots do not routinely descend to 1,000 feet AGL while transiting Skull Valley. Further, as discussed in the text of the Report, any F-16 flying at 1,000 feet AGL would be flying at a faster speed, for operational considerations, at a minimum speed of 420 knots. The higher airspeeds pilots normally fly at the 1,000 feet AGL altitude coincidentally increase the aircraft's zoom capability and resultant time. Using 420 knots and 1,000 feet AGL in parallel calculations to those above, it may be determined that an F-16 would zoom to a peak altitude of 4,448 feet when achieving 210 knots, and this zoom would take 16.3 seconds. The gliding descent to 2,000 feet would take 51.4 seconds. Thus, the total climb and glide time would be 16.3 + 51.4 = 67.7 seconds or 1 minute 7.7 seconds, or in the same range as for a plane flying at 350 knots at 3,000 feet AGL.

F-16 at 350 knots and 1,000 ft.

In the remote event that a pilot were to be at 1,000 feet and only 350 knots, which is very unlikely given that pilots flying at this altitude are normally flying faster (420 to 480 kts) for operational reasons, the pilot would jettison stores and zoom as in other cases. In this case, however, the pilot would aim for a speed of about 190 to give maximum endurance (time to assess and correct the problem) in this low altitude situation. Assuming he is aiming for 190 knots, he could achieve a peak altitude of 3,335 ft. To do this, he would travel at least 6,827 feet at an average speed of 270 knots indicated airspeed (313 knots true airspeed or 529 ft./sec.) and take 12.9 seconds.

At an altitude of 3,335 feet and 190 knots with an estimated gross weight of 26,000 pounds, the aircraft will glide back to 2,000 feet in 28.0 seconds. Thus, the total time from initiation of the zoom to peak altitude and back down to the 2,000 foot recommended ejection altitude would be 40.9 seconds. This calculation is close to but slightly less than the minimum 45 plus seconds for the initial condition of 350 knots at 1,000 ft. AGL derived from Figure 3-11, Low Altitude Airstart Capability, set out in the current version of the Air Force T.O. 1F-16C-1.

Thus, even in this unlikely scenario of being at 1,000 feet and only 350 knots, the pilot would have sufficient time to assess the geographic area and find a safe place to abandon the aircraft if an airstart is unsuccessful.[9]

Conclusions

The above calculations show that at the speeds at which the F-16s normally transit Skull Valley, a pilot would have more than a minute in which to react and take action to avoid the PFSF. These calculations are in accordance with Figure 3-11, Low Altitude Airstart Capability, which as discussed in the text of the Report, shows that the initial condition combinations of 350 knots at 3,000 ft AGL, 400 knots at 4,000 ft. AGL, and 420 knots at 1,000 ft AGL are all substantially in the green area, showing that the pilot has sufficient time to zoom, start his engine and achieve usable thrust before reaching the minimum recommended ejection altitude, therefore indicating that he would also have time to assess the geographic situation and turn to avoid the PFSF or other inhabited areas in the

[9] This calculation differs somewhat from what PFS had previously calculated for an aircraft at 350 knots and 1,000 feet in Revision 0 of this report because of PFS's use of a more conservative interpretation of Figure 3-10, Low Altitude Zoom Capability. Furthermore in this regard, as discussed above, PFS's calculated time aloft for 1000 ft. AGL at 350 knots in the text of this appendix is somewhat less than that shown on the Low Altitude Airstart Capability, Figure 3-11 of the current version of T.O., which reflects the conservatism of PFS's calculations.

event the engine were not starting. Indeed, as noted above, even assuming the unlikely scenario of traveling at 350 knots at 1,000 feet AGL within Skull Valley, both Figure 3-11 and the calculation above show that the pilot will have sufficient time to assess the geographic situation and turn to avoid the PFSF or other inhabited area.

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND
LANGLEY AIR FORCE BASE, VIRGINIA

15 Jan 2000

MEMORANDUM FOR JACK COLE, JR., BGEN, USAF, (Ret.)

FROM: HQ ACC/SE
175 Sweeney Blvd.
Langley AFB VA 23665-2700

SUBJECT: Immediate Ejection History for F-16 Aircraft

1. I am unable to locate quantifiable data regarding the need for immediate ejections for F-16 aircraft. However, it seems occasions for immediate ejections are rare in the F-16. According to your definition, an immediate ejection would be defined as the pilot having no time to point the aircraft away from populated areas. As far as I can tell, in most cases, a pilot will normally have enough time in the F-16 to turn the aircraft away from populated areas prior to ejection, but again, I have no direct data to bear that out.

2. It is possible that a catastrophic situation could arise that may require an immediate ejection, such as a midair collision where flight controls are damaged and the pilot is unable to control the aircraft. While it is difficult to predict such an occurrence, these situations are considered rare, and military operating areas are normally over sparsely populated regions to help mitigate associated risks.

3. If more information is required, please let me know.

Greg Alston

GREG ALSTON, Colonel, USAF
Chief of Safety


MOSER RECOVERY
HIF
HIF 30 DME ARC
14°30
HIF 186/30
HIF 180/30
HIF 152/24
051°
PFSF
SEVIER B
MIJ 350/12
MIJ
MICHAEL AAF
SALT
LAKE
PROMONTORY POINT
FREMONT
CARRINGTON ISLAND
STANSBURY ISLAND
ANTELOPE ISLAND
OGDEN Chan 104
SALT LAKE CITY Chan 115
FAIRFIELD Chan 113
BOLINDER-TOOELE VALLEY
Grantsville
BINGHAM CANYON MINE
CAMP WILLIAMS
CEDAR VALLEY
Cedar Fort
Fairfield
Riverton
STATE PRISON
NDB DUGWAY
Dugway
Clearfield
Sunset
Hooper
DAVIS MOSQUITO ABATEMENT
Farmington Bay
Stansbury
Smokestack 5540 (1207)

TAB X INTENTIONALLY REMOVED

TAB Y

CRASH IMPACT RISK POSED BY OPERATIONS ON THE UTTR

A. Introduction

PFS has reviewed the likelihood that crashes involving aircraft conducting air-to-air combat training on the UTTR, in which the pilot does not maintain control of the aircraft, would result in an impact at the PFSF. As previously set forth in Section IV of the Report, the aggressive maneuvering on the UTTR most likely to result in an accident in which a pilot does not maintain control of the aircraft occurs toward the center of the restricted area ranges, not near the edges. This was stated as a qualitative conservatism in PFS's February 2, 2000 Revision 1 of the Report, but PFS did not attempt at that time to quantify this conservatism.

As indicated in Tab H, however, Brig. Gen. James L. Cole, USAF (Ret.), Maj. Gen. Wayne O. Jefferson, USAF (Ret.), and Col. Ronald E. Fly, USAF (Ret.) have reviewed for PFS the recently obtained AFI 51-503 Aircraft Accident Investigation Reports for F-16s that were destroyed in special inflight operations from fiscal year 1989 to fiscal year 1998. Their assessment confirms that accidents occurring during special inflight operations in which a pilot does not maintain control of the aircraft are those involving aggressive maneuvering. According to Col. Fly, such maneuvering occurs toward the center of the restricted area on the UTTR. Based on this additional pertinent information and the fact that aggressive maneuvering does not take place near the boundary of the restricted area on the UTTR (which PFS describes in Section IV of the Report), PFS is now able to revise its calculation to quantify in part the qualitative conservatism in its previously calculated probability that a crash during aircraft operations on the UTTR would impact the PFSF. Although quantified in part, PFS's calculated probability still remains highly conservative. As a practical matter, the probability of an aircraft on the UTTR impacting the PFSF in the event of a crash is virtually zero for the reasons set forth below and in the Report.

B. Aircraft With the Potential to Strike the PFSF from the UTTR

The following analysis shows that the virtually all of the accidents on the UTTR in which a pilot would not maintain control of the aircraft would occur during high-stress, aggressive maneuvering which takes place towards the center of the restricted area ranges, as opposed to near the edge of the ranges near the PFSF. Between FY89 and FY98, 35 aircraft were destroyed in Special Inflight Operations accidents in which the pilot was assessed as not able to avoid a fixed ground site. See Table 2 at the end of Tab H. The analysis broke down these 35 losses by cause and the results are tabulated below. Explanations of each category follow the table.

Special Inflight Operations Accidents in Which A Pilot Could Not Have Avoided A Ground Facility FY89 to FY98	
Cause	**Number of F-16s Destroyed**
Midair Collision	12
G-induced Loss of Consciousness (GLOC)	6
Departed Controlled flight	4
Spatial Disorientation/Loss of Situational Awareness	5
Collision with the ground	8
Total	35

Midair Collision When aircraft are engaged in aggressive combat maneuver training, such as air-to-air intercept or close-in dogfighting, the risk of a collision is greatly increased. Since, as a matter of safety, these activities take place near the center of the restricted area ranges, these accidents are unlikely to occur near the edge of a restricted area. When a collision occurs, both of the aircraft involved are damaged and one or both may be destroyed. In the accident reports PFS reviewed, there were 5 accidents in which

2 aircraft each were destroyed[1] and 3 where only one aircraft was destroyed. In the latter 3 cases, the remaining aircraft was able to be flown back to a base for landing. In each case, the mid-air occurred during the aggressive combat maneuver training phase of the flights. Such maneuvering occurs toward the center of the restricted area ranges or well out over water. Moreover, in none of the Special Inflight Operations accident cases reviewed was the destroyed aircraft able to fly or glide any appreciable distance before impacting the ground or water. In the only accident report presenting quantitative data (because the accident happened on an instrumented range), the crashing aircraft fell laterally a measured distance of about two miles after a midair collision at approximately 19,000 ft. AGL. The seven other midair reports are not as specific, but use similar language in describing how the aircraft fell to the ground (e.g., nose-low spiral, flat spin, inverted with low forward velocity, etc.).

GLOC (G-induced Loss of Consciousness) GLOC occurs when the pilot pulls so many G forces (1 G is equal to 1 times the force of normal gravity) while maneuvering that, even with his protective devices and good physical condition, he no longer retains consciousness, and in his blacked out state, cannot control the aircraft or recognize his danger. Based on Col. Fly's experience as an F-16 flight instructor and an academic instructor responsible for teaching the physiological impacts of flying a high-performance jet fighter, it typically takes 20 to 30 seconds from the time a pilot becomes unconscious until he has regained consciousness and completed his mental reorganization to where he is fully cognizant of where he is and what is happening.[2] This 20 to 30 second time interval is based on the testing of pilots under GLOC conditions using a centrifuge and is the time frame on which pilots are instructed to expect to be incapacitated by GLOC.[3] The aircraft flight parameters (climbing, diving, airspeed, bank angle, altitude, etc.) will

[1] Nine F-16s were destroyed. In one of the mid-air collisions, one of airplanes destroyed was a F-15, which went into a flat, level spin after the collision.

[2] Upon the pilot becoming unconscious, the pilot will cease acting on the controls of the plane and the G forces on the plane will return to 1.

[3] The accident report for the February 28, 1994 accident states that 24 seconds is the "average time of total GLOC incapacitation," which is in the middle of the 20 to 30 second time frame taught by Col. Fly as an instructor.

determine whether the pilot will have time to regain consciousness and resume flying the aircraft or else impact the ground prior to his regaining consciousness. The six accident reports reflect that all of the GLOC-induced accidents occurred during stressful maneuvering during air-to-air combat training. Because that kind of training and maneuvering takes place near the center of the restricted area ranges on the UTTR while practicing air-to-air engagements, GLOC-induced accidents would occur there rather than near the edge of the ranges. In addition, since GLOC is a temporary condition, even an aircraft going the speed of sound in level flight (approximately 10 miles per minute) would only travel about 5 miles in the 20-30 seconds the pilot was incapacitated, which is not far enough to reach the PFSF from near the center of the restricted area ranges where GLOC-induced accidents would occur. Moreover, for an aircraft that impacted the ground, part of the distance traveled would be in the vertical rather than the horizontal direction, thereby shortening the horizontal distance traveled.

Further, the six GLOC-induced accident reports reflect that five of the accidents occurred while the plane was in a high speed, steep angle dive[4] and one occurred during a high G descending turn at low altitude. Therefore, the reported GLOC accidents crashed in near proximity to the onset of GLOC and would not have threatened the PFSF from near the center of the range where the GLOC-induced accidents would occur.

Departed Controlled Flight In these accidents the pilot simply loses control of the aircraft while maneuvering near the edge of the plane's aerodynamic flight envelope or practicing familiarization and recovery procedures, such as in Horn Awareness Recovery Training Series (HARTS), where the pilot is taught to recognize and recover from these borderline flight conditions after being warned of the conditions by a horn. Departure from controlled flight can also result from aggressive maneuvering during combat training. By definition, the aircraft is no longer in control and falls steeply to the ground. All four reports for this type of accident indicated that they either involved HARTS training or aggressive combat training. Because such activities are normally planned to occur at the

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[4] Of these five accidents, the terminal flight conditions for four of the accidents were described by the pilot or witnessed by other pilots. With respect to the fifth accident, there were no eye witnesses, but the impact angle estimated in the report from the circumstances of the accident was 60° or more.

center of the range area, this category of accident poses no threat to facilities off the range, such as the PFSF.

Spatial Disorientation/Loss of Situational Awareness These accidents occur basically when the pilot cannot tell which way is up, usually because of loss of outside references to the horizon. It normally happens in conjunction with cloud cover or other poor visibility but also occurs in maneuvering flight because the pilot has focused on another aircraft or a ground target to the exclusion of an awareness of the airspace around him. When this happens, the pilot is at risk of losing control of the aircraft. The reports confirm that all five of this type of accident occurred during practice air-to-air engagements (3) or near a ground target (2). Hence, this condition is not likely to happen on the UTTR in the vicinity of the PFSF since pilots fly under visual flight rules (clear of clouds) on the UTTR while practicing air-to-air combat and because the high demand activities like air-to-air training and ground attack training that might result in a pilot focusing on one or two factors at the expense of his overall situational awareness do not take place near the edge of the range.

Collision with the Ground This category of accident occurs when aircraft are training in air-to-air low level intercepts, air-to-ground attack, or other low level maneuvering and the pilot makes a mistake and hits the ground. The accident reports confirm that all accidents of this type occurred during aggressive or stressful maneuvering. In such an accident, the aircraft obviously will not glide further. Since low level maneuvering and air-to-ground attack are not practiced near the edges of the restricted area ranges on the UTTR near the PFSF, this category of accident is unlikely to pose a hazard to the PFSF.

Thus, analysis of the types of accidents which occur in Special Inflight Operations in which the pilot does not retain control of the aircraft shows that few to none of them would pose a significant hazard to a facility, such as the PFSF, located outside the edges of the restricted areas. The accident reports show that virtually all the accidents occurred during aggressive maneuvering. On the UTTR, such maneuvering occurs towards the center of the restricted areas, not near the edges. This, coupled with the observation that when the pilot does retain control of his aircraft after an incident leading to a crash, he invariably steers the aircraft away from ground structures and populated areas, means that F-16 operations on the UTTR pose very little, if any, risk to the PFSF.

Tab Z

CRASH RATE FOR LARGE CARGO AIRCRAFT ON IR-420

To calculate the crash rate per mile of the large military cargo aircraft that fly on military airway IR-420, PFS has reviewed and evaluated U.S. Air Force Aircraft Accident Investigation Reports for destroyed large military cargo aircraft for FY89 to FY98. PFS elected to use destroyed aircraft rather than Class A or Class B mishaps as the basis for this calculation because it was the most relevant data for the calculation of crash rates for large, multi-engine cargo aircraft. Data over the last 10 years indicate that the crash rate for large cargo aircraft flying on IR-420 should be zero, in that no large cargo aircraft were destroyed in that period in conditions under which large cargo aircraft on IR-420 fly. To account for the hypothetical possibility that an aircraft on IR-420 could crash, however, PFS has used for IR-420 the large commercial aircraft crash rate from NUREG-0800 of 4×10^{-10} crashes per mile.

There were 13 Class A and 15 Class B mishaps involving large cargo aircraft (C-5, C-10 (and KC-10), C-17 and C-141) from FY89 to FY98, for a total of 28 mishaps. In the 13 Class A mishaps, however, only 6 aircraft were destroyed. (No aircraft were destroyed in the Class B mishaps.) Class A or a Class B mishap can easily occur in a large multi-engine cargo aircraft without a consequent crash due to the redundancies in the aircraft systems, most particularly extra engines to power the aircraft to a landing field in the event of a problem. Such mishaps where no aircraft is destroyed pose no threat to a facility on the ground because the pilot necessarily retains control of the aircraft such that it did not crash. [1] Even in a rare circumstance in which a pilot could avoid a crash because of proximity to an airport at which he could make an emergency landing, the pilot would necessarily maintain control of the aircraft such that he could direct it away from a large lighted facility on the ground, such as the PFSF, even at night.

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[1] For example, on 5 April 1991, a KC-10 experienced a catastrophic failure of its number 2 engine at 22,000 ft. MSL on departure from Moron Air Base, Spain. The airplane experienced violent to severe airframe buffet. The pilot declared an emergency and returned to land at Moron with a total flight time of 41 minutes. The amount of time shows that the pilot could have avoided a specific ground site even if he had not been able to reach an airport.

PFS obtained the Air Force Aircraft Accident Investigation Reports for each of the mishaps in which large cargo aircraft were destroyed as a result of flight operations over the period from FY89 to FY98 (10 years). There were 6 aircraft destroyed during this period. As shown below, however, none of the aircraft were destroyed under conditions that would exist on IR-420 and hence none of the accidents are applicable in deriving a crash rate for aircraft flying on IR-420.

Of the 6 aircraft destroyed, 1 was a C-5 aircraft:

29 Aug 90:	Destroyed on Takeoff. The aircraft crashed approximately 7-10 seconds after lift-off from the runway.

There were 5 C-141 aircraft destroyed as a result of flight operations during this same period, as listed below:

21 Feb 89:	Crashed 2.6 miles from the runway during landing approach in a thunderstorm.
30 Nov 92:	Midair collision (2-C141s destroyed) during formation air refueling operations on a moonless night.
23 Mar 94:	A parked C-141 was destroyed when it was hit by another aircraft which crashed during landing.
13 Sept 97:	A C-141 was destroyed in a midair collision with a German cargo plane over the South Atlantic Ocean well off the coast of Africa. There was no radar coverage or control in the area and flight services from air traffic controllers from several nearby African nations were poor to non-existent. (For flights on IR-420, the aircraft would be under radar control from either Salt Lake Air Traffic Control Center or Clover Control).

There were no C-10s (or KC-10s) nor C-17s destroyed during this time frame.

It is the considered judgment of Maj. Gen. Wayne O. Jefferson, USAF (Ret.), a former B-52 wing commander, that none of these aircraft were destroyed under conditions that would in any way be consistent with conditions encountered by flights on IR-420 to and from Michael Army Airfield.

Hence, the 10 year empirical crash rate for such aircraft under the flight conditions encountered on IR-420 is zero.

Because there were no relevant destroyed aircraft during the period, even with a very large number of flying hours, PFS finds it conservative to use the previously established NUREG-0800 crash rate for large commercial aircraft of 4.0×10^{-10}.