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U.S. Nuclear Regulatory Commission
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November 11, 1999

COMMITMENT RESOLUTION LETTER #21
DOCKET NO. 72-22 / TAC NO. L22462
PRIVATE FUEL STORAGE FACILITY
PRIVATE FUEL STORAGE L.L.C.

References:
1. October 7, 1999 telephone call between NRC/CNWRA, PFS, and S&W
2. PFS letter, Donnell to U.S. NRC, Commitment Resolution Letter #20, dated October 22, 1999

PFS has received additional information from the U.S. Air Force and has been able to supplement our response provided in Reference 2 to NRC/CNWRA questions regarding ordnance carried by F-16s.

The supplemental response regarding ordinance carried by F-16s is enclosed with the U.S. Air Force reference information. If you have any questions regarding this response, please contact me at 303-741-7009.

Sincerely

John L. Donnell

John L. Donnell
Project Director
Private Fuel Storage L.L.C.

Enclosure

NF06

Copy to (with enclosure):

Mark Delligatti
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RESPONSES TO NUCLEAR REGULATORY COMMISSION

POTENTIAL AIRCRAFT CRASHES AT THE PFSF

NOVEMBER 11, 1999

I. THE EFFECT OF ORDNANCE CARRIED BY F-16S

NRC Comment - In light of the NRC questions to which PFS responded on October 22, 1999, the NRC also questioned the overall likelihood of an air craft crash impacting the PFSF, and the NRC requested PFS, should it be unable to show the lack of any credible hazard from aircraft crashes, to identify the type and quantity of live ordnance carried by F-16s flying down Skull Valley and assess the potential consequences of an F-16 carrying live ordnance crashing at or nearby the PFSF. Also, to further support the Air Force's statement of no inadvertent release of ordnance, the NRC requested PFS to show, if possible, how many flights on the UTTR have taken place without an inadvertent release of ordnance.

PFS Response

In its response to the NRC dated October 22, 1999, PFS showed how many flights on the UTTR have taken place without an inadvertent release of ordnance to further support the Air Force's statement that no inadvertent release of ordnance had occurred on the UTTR. (October 22 submission at 23) PFS did not address the potential for other impacts of ordnance to occur at the PFSF because it did not have information from the Air Force regarding the number of aircraft that carry ordnance and the types of ordnance carried while transiting Skull Valley. Since then, however, PFS has received such information (see Tab A) and accordingly provides this additional response to the NRC's comment.

A. Ordnance Carried on Crashing Aircraft

In its response to Comment 2 on October 22 (p. 19), PFS calculated the probability that an F-16 transiting Skull Valley would impact the PFSF to be 4.96×10^{-8} per year (cask storage area plus canister transfer building (CTB)). PFS calculated the cumulative probability that a crashing aircraft would impact the PFSF to be 2.85×10^{-7}, well below the regulatory standard of 1×10^{-6} per year. Therefore, aircraft crashes do not pose a credible hazard to the PFSF whether or not the aircraft are carrying ordnance. Accordingly, PFS

does not need to assess the potential consequences of an F-16 carrying ordnance crashing at or nearby the PFSF.[1]

Ordnance jettisoned by a pilot with engine failure may, however, potentially impact the site apart from the F-16 itself. Accordingly, PFS analyzes the probability of jettisoned ordnance posing a potential hazard to the PFSF separately below.

B. Jettisoned Ordnance from Crashing Aircraft

As discussed in PFS's October 22 response (pp. 9-11), in the event of engine failure, F-16 pilots are trained to climb to gain altitude and reduce airspeed and jettison their external ordnance and fuel tanks, if applicable. Jettisoning ordnance is an intentional procedure undertaken by the pilot to release ordnance and/or other external stores, such as external fuel tanks, in order to lighten the aircraft and to reduce drag.

For an F-16 flying down Skull Valley, any live ordnance that it was carrying would not be armed when jettisoned because the arming sequence would not have been initiated by the pilot and hence the ordnance could not explode upon impact. Pilots fly with their live weapons unarmed or "safed" until ready to drop for detonation on the range. Arming is normally a two step process involving two different fusing mechanisms that must be intentionally initiated by the pilot. No aircraft over-flying Skull Valley are allowed to have

[1] Further, the probability of an F-16 crashing into the site carrying live ordnance is much less than the above probabilities. As one can see from Table 1 below, fewer than 5 percent of all F-16 sorties carry live bombs or missiles; thus the probability that an F-16 transiting Skull Valley with such live ordnance on board would crash into the PFSF is about 2.5×10^{-9} per year (4.96×10^{-8} multiplied by 0.05). This calculation conservatively assumes that such F-16s would be uniformly distributed across the MOA whereas, not only is their predominant route of choice down the east side of the valley as discussed in previous PFS responses, but planes flying with live ordnance avoid "over-flight of populated areas to the maximum extent possible." Memorandum from Col. Ronald G. Oholendt, USAF (Oct. 26, 1999), provided under the Freedom of Information Act (Tab A).

their armament switches in a release capable mode, and all switches are "safe" until inside DOD land boundaries. (Tab B)

According to the U.S. Air Force, the probability that bombs will explode if they are not armed "is remote." (Tab C) Inert or dummy ordnance does not contain explosives and thus cannot explode under any circumstances. Thus, as a practical matter, the only potential hazard to the PFSF from either live or inert ordnance jettisoned from F-16s suffering engine failure while transiting Skull Valley is from the inertial dead weight impact of the ordnance.

Although it is unlikely that jettisoned ordnance would hit the PFSF, PFS has nevertheless calculated the probability that jettisoned ordnance would impact the PFSF, conservatively assuming that F-16 flights are uniformly distributed across Skull Valley and no steps are taken by the pilot to avoid jettisoned ordnance from striking populated areas and structures, such as the PFSF. Using these conservative assumptions, PFS calculated the probability that such an impact would occur would be no more than 1.04×10^{-7} per year. In its October 22 response, PFS conservatively calculated that the probability of an aircraft impacting the PFSF would be no more than 2.85×10^{-7} per year. (October 22 submission at 19) Thus, the cumulative calculated probability that an aircraft or jettisoned ordnance would impact the PFSF is conservatively no more than 3.89×10^{-7} per year. This is well below the regulatory standard of 1×10^{-6} per year and thus aircraft crashes and ordnance impacts at the PFSF are not credible events.

To calculate the probability of jettisoned ordnance impacting the PFSF, PFS calculated the probability that jettisoned ordnance would impact the cask storage area and the probability that such ordnance would impact the canister transfer building and then added the two probabilities to arrive at the cumulative probability that jettisoned ordnance would impact the PFSF. This method is the same as that used by PFS in its October 22, 1999

response for calculating the probability of an aircraft crash impacting the PFSF. (October 22 submission at 22)

Because the F-16s in Skull Valley fly from north to south, jettisoned ordnance which could potentially impact the PFSF would in all likelihood come from an aircraft directly north of the site.[2] Thus, the probability that jettisoned ordnance would hit the PFSF, P_o, can be calculated as the product of the number of aircraft that would fly directly overhead the PFSF with ordnance (i.e., fly from a point north of the site to a point south of the site) and the number of such aircraft that would jettison their ordnance at points from which the ordnance would strike the PFSF cask storage area or the canister transfer building. If it is assumed that the F-16s in Skull Valley are evenly distributed across the valley (which is conservative, given their predominant route of choice down the east side of the valley and the avoidance of over-flights by aircraft carrying live ordnance of populated areas to the maximum extent practicable), the number of aircraft flying directly over the PFSF cask storage area per year with ordnance is equal to the number of sorties per year, N, times the width of the cask storage area, w_s, divided by the width of the valley, w, times the fraction of aircraft carrying jettisonable ordnance, f_o. The probability that each of those aircraft would jettison their ordnance such that it would hit the cask storage area is equal to the aircraft crash rate per mile, C, times the fraction of crashes precipitated by

[2] F-16s conducting air-to-air combat training on the UTTR (the source of potential UTTR crashes affecting the PFSF) would not be carrying live or inert bombs or missiles and similarly F-16s returning to the Hill AFB via the Moser recovery route would have expended any such ordnance on the range before returning to Hill AFB. Accordingly, these aircraft would not present an ordnance impact hazard to the PFSF.

engine failure, e,[3] times the depth of the cask storage area, d, (i.e., the space in which an aircraft would have to release its ordnance in order for it to impact the area):[4]

$$P_0 = N \cdot w_s / w \cdot f_0 \cdot C \cdot e \cdot d$$

For the CTB, the calculation is the same, except that the width of the portion of the building in which the spent fuel storage casks and transfer cask will be located is substituted for the width of the cask storage area and the length of the building is substituted for the depth of the cask storage area.

Determination of the fraction of F-16s carrying jettisonable ordnance, f_0, depends on the number of sorties carrying ordnance and where they fly. The U.S. Air Force has stated that the F-16s flying on the UTTR dropped the following types and quantities of ordnance in FY1998:[5]

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[3] This assumes, consistent with PFS's assumption underlying its response to Comment 2 (October 22 submission), that crashes not precipitated by engine failures are sudden events in which the pilot does not retain control of the aircraft. It is assumed in such a case that the pilot ejects from the aircraft without maneuvering or jettisoning fuel or ordnance and that the aircraft falls to the ground in a random direction.

[4] The actual dimensions of the cask storage area are used in this calculation (and the CTB dimensions in the CTB calculation) because ordnance jettisoned from an aircraft at a height of 1,000 ft. or more would impact the ground at a steep (i.e., more vertical) angle.

[5] Memorandum from Col. Ronald G. Oholendt, USAF (Oct. 26, 1999), obtained under Freedom of Information Act (Tab A).

Table 1 Ordnance Carried by F-16s on the UTTR in FY98[6]

Ordnance	Sorties	Total Number
Mk 84 2,000 lb. Bomb (live)[7]	111	156
Mk 84 (inert)	38	89
Mk 82 500 lb. Bomb (live)[7]	166	544
Mk 82 (inert)	355	1,029
AGM-65 Maverick	4	4
CBU-87 1,000 lb. Cluster bomb	4	16
Air-to-Air Munitions	0	0
BDU-33 25 lb. Training bomb	/800	7,205

The Air Force has indicated that almost all the above ordnance delivered by F-16s on the UTTR is delivered on the UTTR South Area. Not all F-16s flying from Hill Air Force Base to the South Area to deliver ordnance transit Skull Valley but some instead fly directly into the UTTR restricted areas from the north or northeast. Therefore, the sorties carrying ordnance as shown in the table must be distributed over all the F-16 sorties on the UTTR South Area in order to determine the number of aircraft transiting Skull Valley that will be carrying ordnance.[8]

[6] F-16s also carry 510 rounds of 20 mm ball ammunition on each sortie. The ammunition is carried internally and cannot be jettisoned and hence does not pose a hazard to the PFSF.

[7] The 2,000 lb. bomb and 500 lb. bomb include laser-guided bombs in those weight classes.

[8] Phone conversation between James L. Cole and Colonel Craig Lightfoot, Commander of the UTTR (Nov. 1, 1999).

In response to previous FOIA requests, the Air Force has indicated that there were a total of 5,726 F-16 sorties on the South Area in FY98 and that 3,871 F-16 sorties transited Skull Valley. (August 13 submission at 9 and Table 3) Also, of the munitions in the table above, the BDU-33 training bombs are normally not rigged to be jettisoned from the F-16 when the pilot jettisons stores, so those munitions could not hit the PFSF independent of the F-16 hitting the site.[9] Therefore, if we assume that the 678 F-16 sorties carrying jettisonable ordnance are distributed evenly across all F-16 sorties on the UTTR South Area, the fraction of F-16 sorties carrying jettisonable ordnance, f_o, would be equal to 678/5726 = 0.118.

For the F-16s flying down Skull Valley, the number of sorties is equal to 3,871 (August 13 submission at 9), the width of the PFSF (full cask storage area) is equal to 1,520 ft. (0.2879 mi.) (August 13 submission at 15), the effective width of the valley is equal to 10 mi. (August 13 submission Fig. 1),[10] the fraction of aircraft carrying jettisonable ordnance is equal to 0.118, the crash rate is equal to 2.736×10^{-8} per mile. (August 13 submission at 12), the fraction of crashes precipitated by engine failure is 0.95 (October 22 submission at 12), and the depth of the cask storage area is 1,590 ft. (0.3011 mi) (August 13 submission at 15). Using the foregoing data, the annual probability that jettisoned ordnance would strike the cask storage area, assuming it were fully loaded with 4000 casks, is equal to:

$$P_o = 3{,}871 \times 0.2879/10 \times 0.118 \times 2.736 \times 10^{-8} \times 0.95 \times 0.3011$$

$$= 1.03 \times 10^{-7}$$

[9] Conference with Col. Ron Fly, USAF (Ret.), (Oct. 16, 1999; Memorandum from Col. Ron Fly, USAF (Ret.) (Oct 21, 1999), (October 22 submission, Tab A).

[10] The actual width is 12 miles, but the easternmost two miles would not usable by many aircraft because the altitude of the ground there begins to approach the ceiling of the Military Operating Area.

For the CTB, the values of the variables are the same except that the width of the portion of the CTB where the storage casks and transfer casks will be located (100 ft. or 0.0189 mi.) and the length of the CTB (260 ft. or 0.0492 mi.) (SAR Fig. 4.7-1) are substituted for the width and depth of the cask storage area thus:

$P_o = 3{,}871 \times 0.0189/10 \times 0.118 \times 2.736 \times 10^{-8} \times 0.95 \times 0.0492$

$= 1.1 \times 10^{-9}$

Therefore, the cumulative probability that jettisoned ordnance from an F-16 transiting Skull Valley would hit the PFSF is equal to $1.03 \times 10^{-7} + 1.1 \times 10^{-9}$, or 1.04×10^{-7}. The cumulative annual probability that an aircraft or jettisoned ordnance from an aircraft would hit the PFSF is 2.85×10^{-7} (October 22 submission at 19) + 1.04×10^{-7}, or 3.89×10^{-7}. This remains well below the regulatory standard of 1×10^{-6} per year and thus air crashes and ordnance impacts do not pose a credible hazard to the PFSF.

PFS showed in its October 22 submission that its calculation of an air crash impact probability of 2.85×10^{-7} per year for the PFSF was conservative. The above calculation showing that the probability that jettisoned ordnance would impact the PFSF is 1.04×10^{-7} per year is also highly conservative for the following reasons:

- First, the calculation assumes that the F-16 flights are distributed evenly across Skull Valley, when in fact their predominant route of choice is down the east side of the valley and aircraft carrying live ordnance avoid flying over inhabited areas to the maximum extent practicable.

- Second, the calculation assumes that the entire area within the cask storage area contains spent fuel storage casks, when in fact it contains a significant amount of open space. The cask storage pads are 30 ft. wide and are spaced 30 ft. apart and moreover there is 150 ft. between each of the four quadrants of storage pads as

well as space between each cask on a pad. (PFSF SAR Fig. 1.2-1). Thus, from the perspective of a piece of ordnance falling north to south, parallel to the rows of storage pads, over half of the cask storage area is open space in which falling ordnance would not hit a cask.

- Third, the calculated annual probability of 1.04×10^{-7} is for a fully loaded facility, which would be the situation for only a short period of time. The annual calculated risk would be less for virtually the entire life of the facility, even assuming full use of its licensed capacity. On average, over the expected 40 year life of the facility, the annual calculated risk for ordnance impacting the PFSF would be approximately half of the 1.04×10^{-7} probability calculated above, or about 5.2×10^{-8}.

Therefore, the true probability that jettisoned ordnance would impact the PFSF is much less than 1.04×10^{-7} per year and the true cumulative risk from air crashes and ordnance impacts is much less than 3.89×10^{-7}. Thus, these events are truly non-credible and need not be considered further in the licensing of the PFSF.

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

WEAPONS TESTING ON THE UTTR
SOUTH RANGE

1. WEAPONS SYSTEM EVALUATION PROGRAM (WSEP) Nicknamed "Combat Hammer": 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 average 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)

NOTE: 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

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

RESPONSES TO NUCLEAR REGULATORY COMMISSION

POTENTIAL AIRCRAFT CRASHES AT THE PFSF

NOVEMBER 11, 1999

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does not need to assess the potential consequences of an F-16 carrying ordnance crashing at or nearby the PFSF.[1]

Ordnance jettisoned by a pilot with engine failure may, however, potentially impact the site apart from the F-16 itself. Accordingly, PFS analyzes the probability of jettisoned ordnance posing a potential hazard to the PFSF separately below.

B. Jettisoned Ordnance from Crashing Aircraft

As discussed in PFS's October 22 response (pp. 9-11), in the event of engine failure, F-16 pilots are trained to climb to gain altitude and reduce airspeed and jettison their external ordnance and fuel tanks, if applicable. Jettisoning ordnance is an intentional procedure undertaken by the pilot to release ordnance and/or other external stores, such as external fuel tanks, in order to lighten the aircraft and to reduce drag.

For an F-16 flying down Skull Valley, any live ordnance that it was carrying would <u>not</u> be armed when jettisoned because the arming sequence would not have been initiated by the pilot and hence the ordnance could not explode upon impact. Pilots fly with their live weapons unarmed or "safed" until ready to drop for detonation on the range. Arming is normally a two step process involving two different fusing mechanisms that must be intentionally initiated by the pilot. No aircraft over-flying Skull Valley are allowed to have

[1] Further, the probability of an F-16 crashing into the site carrying live ordnance is much less than the above probabilities. As one can see from Table 1 below, fewer than 5 percent of all F-16 sorties carry live bombs or missiles; thus the probability that an F-16 transiting Skull Valley with such live ordnance on board would crash into the PFSF is about 2.5×10^{-9} per year (4.96×10^{-8} multiplied by 0.05). This calculation conservatively assumes that such F-16s would be uniformly distributed across the MOA whereas, not only is their predominant route of choice down the east side of the valley as discussed in previous PFS responses, but planes flying with live ordnance avoid "over-flight of populated areas to the maximum extent possible." Memorandum from Col. Ronald G. Oholendt, USAF (Oct. 26, 1999), provided under the Freedom of Information Act (Tab A).

their armament switches in a release capable mode, and all switches are "safe" until inside DOD land boundaries. (Tab B)

According to the U.S. Air Force, the probability that bombs will explode if they are not armed "is remote." (Tab C) Inert or dummy ordnance does not contain explosives and thus cannot explode under any circumstances. Thus, as a practical matter, the only potential hazard to the PFSF from either live or inert ordnance jettisoned from F-16s suffering engine failure while transiting Skull Valley is from the inertial dead weight impact of the ordnance.

Although it is unlikely that jettisoned ordnance would hit the PFSF, PFS has nevertheless calculated the probability that jettisoned ordnance would impact the PFSF, conservatively assuming that F-16 flights are uniformly distributed across Skull Valley and no steps are taken by the pilot to avoid jettisoned ordnance from striking populated areas and structures, such as the PFSF. Using these conservative assumptions, PFS calculated the probability that such an impact would occur would be no more than 1.04×10^{-7} per year. In its October 22 response, PFS conservatively calculated that the probability of an aircraft impacting the PFSF would be no more than 2.85×10^{-7} per year. (October 22 submission at 19) Thus, the cumulative calculated probability that an aircraft or jettisoned ordnance would impact the PFSF is conservatively no more than 3.89×10^{-7} per year. This is well below the regulatory standard of 1×10^{-6} per year and thus aircraft crashes and ordnance impacts at the PFSF are not credible events.

To calculate the probability of jettisoned ordnance impacting the PFSF, PFS calculated the probability that jettisoned ordnance would impact the cask storage area and the probability that such ordnance would impact the canister transfer building and then added the two probabilities to arrive at the cumulative probability that jettisoned ordnance would impact the PFSF. This method is the same as that used by PFS in its October 22, 1999

response for calculating the probability of an aircraft crash impacting the PFSF. (October 22 submission at 22)

Because the F-16s in Skull Valley fly from north to south, jettisoned ordnance which could potentially impact the PFSF would in all likelihood come from an aircraft directly north of the site.[2] Thus, the probability that jettisoned ordnance would hit the PFSF, P_o, can be calculated as the product of the number of aircraft that would fly directly overhead the PFSF with ordnance (i.e., fly from a point north of the site to a point south of the site) and the number of such aircraft that would jettison their ordnance at points from which the ordnance would strike the PFSF cask storage area or the canister transfer building. If it is assumed that the F-16s in Skull Valley are evenly distributed across the valley (which is conservative, given their predominant route of choice down the east side of the valley and the avoidance of over-flights by aircraft carrying live ordnance of populated areas to the maximum extent practicable), the number of aircraft flying directly over the PFSF cask storage area per year with ordnance is equal to the number of sorties per year, N, times the width of the cask storage area, w_s, divided by the width of the valley, w, times the fraction of aircraft carrying jettisonable ordnance, f_o. The probability that each of those aircraft would jettison their ordnance such that it would hit the cask storage area is equal to the aircraft crash rate per mile, C, times the fraction of crashes precipitated by

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[2] F-16s conducting air-to-air combat training on the UTTR (the source of potential UTTR crashes affecting the PFSF) would not be carrying live or inert bombs or missiles and similarly F-16s returning to the Hill AFB via the Moser recovery route would have expended any such ordnance on the range before returning to Hill AFB. Accordingly, these aircraft would not present an ordnance impact hazard to the PFSF.

engine failure, e,[3] times the depth of the cask storage area, d, (i.e., the space in which an aircraft would have to release its ordnance in order for it to impact the area):[4]

$$P_o = N \cdot w_s / w \cdot f_o \cdot C \cdot e \cdot d$$

For the CTB, the calculation is the same, except that the width of the portion of the building in which the spent fuel storage casks and transfer cask will be located is substituted for the width of the cask storage area and the length of the building is substituted for the depth of the cask storage area.

Determination of the fraction of F-16s carrying jettisonable ordnance, f_o, depends on the number of sorties carrying ordnance and where they fly. The U.S. Air Force has stated that the F-16s flying on the UTTR dropped the following types and quantities of ordnance in FY1998:[5]

[3] This assumes, consistent with PFS's assumption underlying its response to Comment 2 (October 22 submission), that crashes not precipitated by engine failures are sudden events in which the pilot does not retain control of the aircraft. It is assumed in such a case that the pilot ejects from the aircraft without maneuvering or jettisoning fuel or ordnance and that the aircraft falls to the ground in a random direction.

[4] The actual dimensions of the cask storage area are used in this calculation (and the CTB dimensions in the CTB calculation) because ordnance jettisoned from an aircraft at a height of 1,000 ft. or more would impact the ground at a steep (i.e., more vertical) angle.

[5] Memorandum from Col. Ronald G. Oholendt, USAF (Oct. 26, 1999), obtained under Freedom of Information Act (Tab A).

Table 1 Ordnance Carried by F-16s on the UTTR in FY98[6]

Ordnance	Sorties	Total Number
Mk 84 2,000 lb. Bomb (live)[7]	111	156
Mk 84 (inert)	38	89
Mk 82 500 lb. Bomb (live)[7]	166	544
Mk 82 (inert)	355	1,029
AGM-65 Maverick	4	4
CBU-87 1,000 lb. Cluster bomb	4	16
Air-to-Air Munitions	0	0
BDU-33 25 lb. Training bomb	/800	7,205

The Air Force has indicated that almost all the above ordnance delivered by F-16s on the UTTR is delivered on the UTTR South Area. Not all F-16s flying from Hill Air Force Base to the South Area to deliver ordnance transit Skull Valley but some instead fly directly into the UTTR restricted areas from the north or northeast. Therefore, the sorties carrying ordnance as shown in the table must be distributed over all the F-16 sorties on the UTTR South Area in order to determine the number of aircraft transiting Skull Valley that will be carrying ordnance.[8]

[6] F-16s also carry 510 rounds of 20 mm ball ammunition on each sortie. The ammunition is carried internally and cannot be jettisoned and hence does not pose a hazard to the PFSF.

[7] The 2,000 lb. bomb and 500 lb. bomb include laser-guided bombs in those weight classes.

[8] Phone conversation between James L. Cole and Colonel Craig Lightfoot, Commander of the UTTR (Nov. 1, 1999).

In response to previous FOIA requests, the Air Force has indicated that there were a total of 5,726 F-16 sorties on the South Area in FY98 and that 3,871 F-16 sorties transited Skull Valley. (August 13 submission at 9 and Table 3) Also, of the munitions in the table above, the BDU-33 training bombs are normally not rigged to be jettisoned from the F-16 when the pilot jettisons stores, so those munitions could not hit the PFSF independent of the F-16 hitting the site.[9] Therefore, if we assume that the 678 F-16 sorties carrying jettisonable ordnance are distributed evenly across all F-16 sorties on the UTTR South Area, the fraction of F-16 sorties carrying jettisonable ordnance, f_o, would be equal to 678/5726 = 0.118.

For the F-16s flying down Skull Valley, the number of sorties is equal to 3,871 (August 13 submission at 9), the width of the PFSF (full cask storage area) is equal to 1,520 ft. (0.2879 mi.) (August 13 submission at 15), the effective width of the valley is equal to 10 mi. (August 13 submission Fig. 1),[10] the fraction of aircraft carrying jettisonable ordnance is equal to 0.118, the crash rate is equal to 2.736×10^{-8} per mile. (August 13 submission at 12), the fraction of crashes precipitated by engine failure is 0.95 (October 22 submission at 12), and the depth of the cask storage area is 1,590 ft. (0.3011 mi) (August 13 submission at 15). Using the foregoing data, the annual probability that jettisoned ordnance would strike the cask storage area, assuming it were fully loaded with 4000 casks, is equal to:

$$P_o = 3{,}871 \times 0.2879/10 \times 0.118 \times 2.736 \times 10^{-8} \times 0.95 \times 0.3011$$

$$= 1.03 \times 10^{-7}$$

[9] Conference with Col. Ron Fly, USAF (Ret.), (Oct. 16, 1999; Memorandum from Col. Ron Fly, USAF (Ret.) (Oct 21, 1999), (October 22 submission, Tab A).

[10] The actual width is 12 miles, but the easternmost two miles would not usable by many aircraft because the altitude of the ground there begins to approach the ceiling of the Military Operating Area.

For the CTB, the values of the variables are the same except that the width of the portion of the CTB where the storage casks and transfer casks will be located (100 ft. or 0.0189 mi.) and the length of the CTB (260 ft. or 0.0492 mi.) (SAR Fig. 4.7-1) are substituted for the width and depth of the cask storage area thus:

$$P_o = 3{,}871 \times 0.0189/10 \times 0.118 \times 2.736 \times 10^{-8} \times 0.95 \times 0.0492$$

$$= 1.1 \times 10^{-9}$$

Therefore, the cumulative probability that jettisoned ordnance from an F-16 transiting Skull Valley would hit the PFSF is equal to $1.03 \times 10^{-7} + 1.1 \times 10^{-9}$, or 1.04×10^{-7}. The cumulative annual probability that an aircraft or jettisoned ordnance from an aircraft would hit the PFSF is 2.85×10^{-7} (October 22 submission at 19) + 1.04×10^{-7}, or 3.89×10^{-7}. This remains well below the regulatory standard of 1×10^{-6} per year and thus air crashes and ordnance impacts do not pose a credible hazard to the PFSF.

PFS showed in its October 22 submission that its calculation of an air crash impact probability of 2.85×10^{-7} per year for the PFSF was conservative. The above calculation showing that the probability that jettisoned ordnance would impact the PFSF is 1.04×10^{-7} per year is also highly conservative for the following reasons:

- First, the calculation assumes that the F-16 flights are distributed evenly across Skull Valley, when in fact their predominant route of choice is down the east side of the valley and aircraft carrying live ordnance avoid flying over inhabited areas to the maximum extent practicable.

- Second, the calculation assumes that the entire area within the cask storage area contains spent fuel storage casks, when in fact it contains a significant amount of open space. The cask storage pads are 30 ft. wide and are spaced 30 ft. apart and moreover there is 150 ft. between each of the four quadrants of storage pads as

well as space between each cask on a pad. (PFSF SAR Fig. 1.2-1). Thus, from the perspective of a piece of ordnance falling north to south, parallel to the rows of storage pads, over half of the cask storage area is open space in which falling ordnance would not hit a cask.

- Third, the calculated annual probability of 1.04×10^{-7} is for a fully loaded facility, which would be the situation for only a short period of time. The annual calculated risk would be less for virtually the entire life of the facility, even assuming full use of its licensed capacity. On average, over the expected 40 year life of the facility, the annual calculated risk for ordnance impacting the PFSF would be approximately half of the 1.04×10^{-7} probability calculated above, or about 5.2×10^{-8}.

Therefore, the true probability that jettisoned ordnance would impact the PFSF is much less than 1.04×10^{-7} per year and the true cumulative risk from air crashes and ordnance impacts is much less than 3.89×10^{-7}. Thus, these events are truly non-credible and need not be considered further in the licensing of the PFSF.

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

WEAPONS TESTING ON THE UTTR
SOUTH RANGE

1. WEAPONS SYSTEM EVALUATION PROGRAM (WSEP) Nicknamed "Combat Hammer": 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 average 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)

NOTE: 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.

[illegible]rcraft 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

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 #
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