RAS 4816

August 30, 2002

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE L.L.C.	)	Docket No. 72-22-ISFSI
	)	
(Private Fuel Storage Facility)	)	ASLBP No. 97-732-02-ISFSI

APPLICANT'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW ON CONTENTION UTAH K/CONFEDERATED TRIBES B

Pursuant to 10 C.F.R. § 2.754 and the Orders of the Atomic Safety and Licensing Board ("Licensing Board" or "Board") dated September 17, 2001[1] and July 3, 2002,[2] Applicant Private Fuel Storage, L.L.C. ("Applicant" or "PFS") submits in the form of a partial initial decision its proposed findings of fact and conclusions of law concerning State of Utah ("State") Contention K/Confederated Tribes Contention B – Credible Accidents ("Utah K"). PFS's proposed findings on Utah K are submitted separately from the proposed findings to be submitted on Contention Utah L/QQ. The proposed partial initial decision is organized as follows. Section I, Background, introduces Contention Utah K and the witnesses for the parties who testified regarding the contention. Section II, Overview and Conclusion, summarizes the testimony on the contention, and presents in narrative form a discussion of the key issues comprising Utah K. Section III, Findings of Fact, presents Applicant's proposed findings of fact on the contention, in sequentially

[1] Order (Revised General Schedule) (September 17, 2001).

[2] Tr. at 13519 (Farrar, J.).

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numbered paragraphs. Section IV, Conclusions of Law, presents Applicant's proposed conclusions of law on the contention, also in sequentially numbered paragraphs.

I. BACKGROUND

A. Contention Utah K

Contention Utah K, which concerns alleged credible accident scenarios that could affect the Private Fuel Storage Facility ("PFSF"), was admitted by the Licensing Board in April 1998. Private Fuel Storage, L.L.C. (Independent Spent Fuel Storage Installation), LBP-01-19, 53 NRC 416, 417-18 (2001). The scope of the contention as admitted was limited to the following issues: (1) the impact upon the facility from (a) accidents involving materials or activities at or emanating from (i) the Tekoi Rocket Engine Test Facility ("Tekoi"), (ii) Salt Lake City International Airport, (iii) Dugway Proving Ground ("Dugway"), including Michael Army Airfield ("Michael AAF"), (iv) Hill Air Force Base ("Hill AFB"), and (v) the Utah Test and Training Range ("UTTR"), and (b) wildfires in Skull Valley; and (2) potential accidents affecting the PFS intermodal transfer point. Id. at 418.

In 1999, pursuant to a PFS summary disposition motion, of the Board dismissed those portions of Utah K relating to hazards posed by Tekoi, wildfires, the testing and storage of biological, chemical and hazardous materials at Dugway, ordnance disposal and unexploded ordnance on Dugway, landings at Michael AAF of aircraft carrying "hung bombs" and the X-33 experimental space plane. Id. at 419; see Private Fuel Storage, L.L.C. (Independent Spent Fuel Storage Installation), LBP-99-35, 50 NRC 180, recons. denied, LBP-99-39, 50 NRC 232 (1999). Pursuant to a second PFS summary disposition motion, the Board dismissed those portions of Utah K relating to the intermodal transfer point. LBP-01-19, 53 NRC at 419; see Private Fuel Storage, L.L.C. (Independent Spent Fuel Storage Installation), LBP-99-34, 50 NRC 168 (1999). In 2001, pursuant to a third PFS summary disposition motion, the Board dismissed issues pertaining to ordnance usage at Dugway and cruise missile testing on the UTTR. LBP-01-19, 53 NRC at 422-29. As discussed further below, in the same order the Board further defined the scope of the issues concerning hazards posed by aviation activities in and around Skull Valley and resolved specific issues concerning the hazards posed by civilian aviation and some military aviation.

In analyzing the aviation-related hazards to the PFSF to support its NRC license application, PFS prepared a comprehensive report on the aviation activities in the vicinity of the site and the specific hazards each activity poses to the facility.[3] The report was prepared principally by Brig. Gen. James L. Cole, Jr., USAF (Ret.), Maj. Gen. Wayne O. Jefferson, Jr., USAF (Ret.), and Col. Ronald E. Fly, USAF (Ret.), who served as expert consultants to PFS on military and civilian aviation and who testified as witnesses for PFS in this proceeding as described below. Their analysis drew upon their broad experience and professional judgment and extensive information obtained from the U.S. Air Force.

The report first assessed the scope of the military and civilian activities in the vicinity of the PFS site. It then assessed the aviation traffic associated with each activity and calculated the crash impact probability at the PFSF for each activity. In calculating the crash impact probabilities, the report determined specific crash rates for each type of aviation activity and accounted for the specific locations and volume of aviation traffic relative to the PFS site. In assessing the hazard posed by potential F-16 crashes, the report assessed in depth the ability of a pilot to direct a crashing aircraft away from the

[3] Aircraft Crash Impact Hazard at the Private Fuel Storage Facility," Revision 4 (August 10, 2000) (PFS Exhibit N) ("Aircraft Report"), and Revised Addendum to Aircraft Crash Impact Hazard at the Private Fuel Storage Facility (July 20, 2001) (PFS Exhibit O) ("Revised Addendum"). Appendix B, which will be filed at a later date, lists all of the parties' exhibits marked and identified for contention Utah K and location in the transcript of the Board's ruling on any offer of an exhibit into evidence.

PFSF before it struck the ground. That assessment was based on Gen. Cole, Gen. Jefferson, and Col. Fly's analysis of all of the available Air Force aircraft accident reports concerning F-16 crashes over the 10-year period from FY1989 to FY1998 and their professional judgment regarding the ability of F-16 pilots to respond to in-flight emergencies. In the end, the report assessed the cumulative hazard to the PFSF and concluded that the crash and jettisoned ordnance impact probability is less than 4.17 E-7 per year.

B. Witnesses

PFS's testimony on aviation hazards was presented by a panel of three highly experienced former Air Force officers, Brig. Gen. James L. Cole, Jr., USAF (Ret.), Maj. Gen. Wayne O. Jefferson, Jr., USAF (Ret.), and Col. Ronald E. Fly, USAF (Ret.). Testimony of James L. Cole, Jr., Wayne O. Jefferson, Jr., and Ronald E. Fly on Aircraft Crash Hazards at the PFSF – Contention Utah K/Confederated Tribes B (Feb. 19, 2002) ("PFS Test.") (admitted after Tr. at 3080).[4]

Gen. Cole is Senior Director, Safety of the Air Transport Association and an associate with Burdeshaw Associates, Ltd., a consulting firm in the Washington, D.C. area that provides services to clients in the areas of aviation, transportation, military operations, and government affairs. In 1994, he retired from the United States Air Force with the rank of Brigadier General. Gen. Cole has extensive experience in and knowledge of aircraft operations and aviation safety. From 1991 to 1994, he served as Chief of Safety of the United States Air Force and directed the entire USAF safety program. In addition, he served as squadron commander of a C-141 heavy jet transport squadron. He was Instructor and Flight Examiner (Check Pilot) qualified and flew

[4] The Board ruled that the testimony be admitted but it has not been actually bound into the transcript. Appendix A, which will be filed at a later date, shows the location in the hearing transcript at which each of the pre-filed testimonies were admitted by the Board.

airdrop, special operations low level, and night vision goggle missions, including clandestine approaches to airfields and blackout landings. He has 6,500 total flying hours in seven different types of aircraft, with 3,000 flying hours in heavy jet aircraft. PFS Test. at 1-2.

Gen. Jefferson is also an associate with Burdeshaw Associates. In addition, he is an associate with Parsons Associates, where he provides risk management training for Gėneral Electric Corp. In 1989, he retired from the United States Air Force with the rank of Major General. Gen. Jefferson has extensive experience in and knowledge of U.S. Air Force aircraft operations and weapons testing and training operations. He served in the Air Force for over 30 years, including service with the Strategic Air Command as a B-52 wing commander. He has 4,450 flying hours in 9 different aircraft types. He has been formally trained by the Air Force at the Air Force Safety Center to serve as an Accident Board President. Since he retired from the Air Force, Gen. Jefferson has been a consultant in management, management training, and quantitative probabilistic analysis. His education includes a master's degree in operations research and a master's degree in business administration. PFS Test. at 4-5.

Col. Fly is also an associate with Burdeshaw Associates. Prior to retiring from the United States Air Force in 1998 after 24 years of service, Col. Fly accumulated extensive experience in and knowledge of U.S. Air Force aircraft operations. He served as an F-16 pilot, instructor, squadron commander, operations group commander and a wing commander. He has approximately 1,200 flying hours in the F-16 as a pilot and instructor. From 1997 to 1998, he served as Commander of the 388th Fighter Wing ("FW") at Hill Air Force Base, Utah, during which time he flew F-16s on the UTTR (including Skull Valley). He was also Commander of the UTTR beginning Oct. 1, 1997 when the range was transferred to the 388th FW. He served as the pilot member for an F-

16 accident investigation board. In addition to his flight operations and training operations experience, Col. Fly also has experience in strategic planning, operational analysis, international affairs, space operations, and logistical support. Furthermore, he is specifically knowledgeable about the operations of military and civilian aircraft that fly in and around Skull Valley, Utah, including the military aircraft that fly from Hill Air Force Base. PFS Test. at 6-7.

PFS testimony on weather in Utah and Skull Valley and on the UTTR as it was pertinent to aviation hazards was presented by meteorologist Stephen A. Vigeant. Testimony of Stephen A. Vigeant on Aircraft Crash Hazards at the PFSF – Contention Utah K/Confederated Tribes B (Feb. 19, 2002) ("Vigeant Test.") (admitted after Tr. at 3090).[5] Mr. Vigeant is a Lead Environmental Scientist for Stone & Webster, Inc. He is a Certified Consulting Meteorologist with more than 25 years of experience in the meteorological aspects of nuclear power plant licensing. He has a bachelor's degree in meteorology from Lowell Technological Institute and a master's degree in meteorology from Pennsylvania State University. He was responsible for preparing sections of PFS's environmental report related to climatology, meteorology, and air quality. Id. at 1-2.

PFS testimony on the hazard to the PFSF posed by potential nearby explosions of ordnance was provided by Jeffrey R. Johns. Testimony of Jeffrey Johns on Aircraft Crash Hazards at the PFSF – Contention Utah K/Confederated Tribes B (Feb. 19, 2002) ("Johns Test.") (admitted after Tr. at 3205).[6] Mr. Johns is a Licensing Engineer for Stone & Webster, Inc. He has 26 years of experience in the nuclear power industry and 10

[5] The Board ruled that the testimony be admitted but it has not been actually bound into the transcript.

[6] In ruling on in limine motions prior to the hearing, the Board excluded the portion of Mr. Johns' testimony on whether the engine of a crashing F-16 would penetrate a spent fuel storage cask as outside the scope of Contention Utah K, which they ruled only concerned the probability of impact, not the consequences. Tr. at 3007-08 (Farrar, J.). The Board ruled that the remainder of Mr. John's testimony be admitted but it has not been actually bound into the transcript.

years of experience with the licensing of independent spent fuel storage installations ("ISFSIs"). He has experience in performing accident analyses for nuclear power plants and ISFSIs. He was responsible for the preparation of portions of the PFSF Safety Analysis Report ("SAR"), including sections dealing with accident analyses and radiation protection for the PFSF. As such, he is familiar with the protection afforded the canister by the HI-STORM 100 storage overpack from postulated events such as tornado-driven missiles and explosions. Id. at 1-2.

The NRC Staff testimony on Utah K was provided by Dr. Kazimieras Campe and Dr. Amitava Ghosh. NRC Staff Testimony of Kazimieras M. Campe and Amitava Ghosh Concerning Contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents) (Feb. 19, 2002) ("Staff Test.") (admitted after Tr. at 4078).[7]

Dr. Campe is a Senior Reactor Engineer in the Probabilistic Safety Assessment Branch, Division of System Safety and Analysis, NRC Office of Nuclear Reactor Regulation, in Rockville, MD. Dr. Campe has had 30 years experience in the NRC (and Atomic Energy Commission) assessing the risk posed by external man-made hazards with respect to nuclear facilities. He prepared Section 3.5.1.6, "Aircraft Hazards," of the NRC's Standard Review Plan, NUREG-0800, which is utilized by the Staff in evaluating aircraft crash hazards at nuclear power reactors and other facilities. Dr. Campe received a doctorate in nuclear engineering from Purdue University. He assisted in the Staff's safety review of the PFSF with respect to aircraft crash hazards, as set forth in Safety Evaluation Report ("SER") Supplement No. 1. Staff Test. at 1; Campe Statement of Professional Qualifications.

Dr. Ghosh is a Principal Engineer at the Center for Nuclear Waste Regulatory Analyses, a division of the Southwest Research Institute, in San Antonio, Texas. Dr.

[7] The Board ruled that the testimony be admitted but it has not been actually bound into the transcript.

Ghosh has experience with respect to probabilistic risk assessments and the design of surface and subsurface facilities. Dr. Ghosh received a doctorate in Mining Engineering from the University of Arizona. He assisted in the Staff's safety review of the PFSF with respect to aircraft crash hazards, as set forth in Supplement No. 1 to the SER for the PFSF. He is also performing pre-licensing activities and reviews of the proposed high-level nuclear waste repository at Yucca Mountain with respect to the design of the facilities, natural and human-induced hazards, and integrated safety analysis. Staff Test. at 1; Ghosh Statement of Professional Qualifications.

Testimony for the State was provided by Lt. Col. Hugh L. Horstman, USAF (Ret.) and Dr. Marvin Resnikoff. State of Utah's Prefiled Testimony of Lieutenant Colonel Hugh Horstman (U.S.A.F. Retired) Regarding Contention Utah K/Confederated Tribes B (Feb. 19, 2002) ("Horstman Test.") (admitted after Tr. at 4216)[8]; State of Utah's Prefiled Testimony of Dr. Marvin Resnikoff Regarding Contention Utah K/Confederated Tribes B (Feb. 19, 2002) ("Resnikoff Test.") (inserted into the record after Tr. at 8698). Lt. Col. Horstman is a commercial pilot with Southwest Airlines and a former F-16 pilot who was deputy commander of the operations group of the 388th Fighter Wing at Hill AFB under Col. Fly. Tr. at 4277-78 (Horstman). Lt. Col. Horstman served in the Air Force for 20 years, with over 800 flight hours in the F-16. Horstman, Resume at 2. Lt. Col. Horstman, however, was not trained to serve on accident investigation boards, having served only once briefly as interim board president. Tr. at 8496-97 (Horstman). Lt. Col. Horstman testified to the alleged hazards posed by military aviation activities in and around Skull Valley.

Dr. Resnikoff is a physicist and a consultant on radioactive waste issues. Resnikoff, Resume (State Exh. 70). He performed numerical calculations and statistical

[8] The Board ruled that the testimony be admitted but it has not been actually bound into the transcript.

analyses concerning the alleged hazards to the PFSF. Dr. Resnikoff stated that he had no independent expertise concerning hazards posed by aviation activities to facilities on the ground. Tr. at 8719 (Resnikoff). He has never served in the military or worked for the Defense Department and has no background in aeronautical engineering or analyzing the performance of military aircraft. Id. at 8717-18. Nor has he ever previously calculated the probability that an aircraft would crash into a ground facility. Id. at 8720.

In addition to the pre-filed testimony presented by the parties, the Board also heard testimony from two Air Force F-16 pilots who had ejected from aircraft that had suffered engine failures. The testimony was not pre-filed and no party had heard the testimony before it was given at the hearing. The Board had desired to hear such testimony after a dispute had arisen over the accuracy of statements made by Lt. Col. Horstman regarding his interviews of F-16 pilots who had ejected from their aircraft. Tr. at 3228-29, 3240-41 (Farrar, J.).

The testimony of Col. Frank Bernard, USAF (Ret.) was sponsored by the State of Utah. Tr. at 3880. Col. Bernard's F-16 suffered an engine failure during a military exercise in Canada in 1986. Tr. at 3888 (Bernard). Col. Bernard had also previously been forced to bail out of an F-105 aircraft that had been damaged in a 1969 mid-air collision in Southeast Asia. Tr. at 3882 (Bernard). The testimony of Col. Michael Cosby, USAF, was sponsored by PFS. Tr. at 3974. Col. Cosby's F-16 suffered an engine failure shortly after takeoff from a Michigan Air National Guard base in 1993. Tr. at 3979 (Cosby). Col. Cosby also testified regarding an accident involving a pilot in his unit who likewise had to eject after an engine failure. Id. at 3999-4000.

II. OVERVIEW AND CONCLUSION

A. Introduction

The remaining issue in this contention is the likelihood that an aircraft would crash and impact the PFSF or that a military aircraft experiencing an in-flight emergency would jettison ordnance that would impact the PFSF.[9] The PFS site is located in Skull Valley, Utah, about 50 miles southwest of Salt Lake City. The aviation activity in the vicinity of the site consists of military operations associated with the UTTR along with some civilian commercial aviation and minimal, if any, general aviation.

The airspace of the UTTR extends somewhat beyond the range's land boundaries and is divided into restricted areas, in which the airspace is limited to military operations, and military operating areas (MOAs), which are located on the edges of the range, adjacent to the restricted areas but which are not restricted to military operations. The PFS site lies beneath the airspace of the Sevier B MOA, two statute miles to the east of the edge of the restricted airspace, and 18 statute miles east of the eastern land boundary of the UTTR South Area. The area under the Sevier B MOA is approximately 145 miles long and is 12 miles wide at the PFS site.[10]

As previously determined by the Board, the specific military air operations of interest in the vicinity of Skull Valley consist of: (1) Air Force F-16 fighter aircraft transiting Skull Valley from Hill AFB to the UTTR; (2) F-16s from Hill and various other military aircraft conducting training exercises on the UTTR; (3) F-16s from Hill returning from the UTTR South Area to the base via the Moser Recovery Route, which

[9] Because the Board excluded evidence on whether a crash impact would actually cause a release of radioactive material, resolution of the contention will not determine the likelihood that an impact at the PFSF would actually cause radiological harm to individuals on or off site.

[10] Sevier D MOA lies directly atop Sevier B MOA, from an altitude of 9,500 ft. above mean sea level ("MSL") to an altitude of approximately 18,000 ft. MSL.

runs to the northeast, 2 to 3 miles north of the PFS site; and (4) military aircraft, mainly large transport aircraft, flying in the direction of military airway IR-420 to and from Michael AAF, which is located about 17 miles southeast of the PFS site, on Dugway Proving Ground ("Dugway").

Specific civilian aviation activities in the vicinity of the PFS site consist of: (1) aircraft flying on federal Airway J-56, which runs east-northeast to west-southwest about 12 miles north of the PFS site; (2) aircraft flying on Airway V-257, which runs north to south approximately 20 miles east of the site; and (3) possibly minimal general aviation activity, although such activity has not been reported in the area. Issues concerning civilian aviation in the vicinity of the PFS site were resolved on summary disposition.[11] The magnitude of potential hazards from civilian aviation activities were also resolved on summary disposition and are addressed in this partial initial decision only for the purpose of determining the cumulative aircraft crash hazard for the PFSF.

PFS has assessed the cumulative hazard from all of these activities and has shown that the probability that an aircraft would crash into the PFSF is less than the 1 E-6 per year standard established by the Commission.[12] The NRC Staff has conducted an extensive review from which it has concluded that "the cumulative probability of a civilian or military aircraft crashing at or affecting the [PFS] Facility is within the acceptance criterion of 10^{-6} per year." Staff Exh. C at 15-99. The State raises various challenges to the PFS and Staff analyses which we discuss below.

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[11] See LBP-01-19, 53 NRC at 451-52.

[12] Private Fuel Storage, L.L.C. (Independent Spent Fuel Storage Installation), CLI-01-22, 54 NRC 255, 265(?)(2001).

B. F-16 Flights Through Skull Valley

1. Nature of F-16 Flights Transiting Skull Valley

The central issue in this contention is the hazard to the PFSF posed by the approximately 5,000 F-16 aircraft sorties that transit Skull Valley each year en route from Hill AFB to the UTTR South Area. The other aviation activity involves many fewer aircraft or occurs significantly farther away, thus having relatively little impact on the accident probability.

An important fact in evaluating the hazard posed to the PFSF from F-16s flying down Skull Valley is that they are in the normal phase of flight. In other words, F-16s transiting Skull Valley are not engaged in aggressive combat maneuvers, such as air-to-air combat training. Rather the Skull Valley corridor is part of the transit route for the F-16s on their way to the restricted area ranges where such aggressive combat maneuvering activities take place.[13]

Typically F-16s transit Skull Valley at 3,000 to 4,000 feet above ground level ("AGL") and 350-425 knots. In Skull Valley, pilots perform operations checks (where the pilot will check and confirm normal operations of the aircraft systems), and fence checks (where the pilot positions certain cockpit switches as if he were preparing to cross into enemy territory.). See PFS Test. at 36. Revised Addendum, Tab FF at 9-10; Aircraft Report at 11-13 and Tab E. Also, pilots may perform G-awareness maneuvers (where the pilot accelerates and then performs two 90° turns to check proper operation of the anti-G suit) and terrain masking (flying below the tops of the mountains to avoid radar detection). Id.

[13] The parties' military experts agree that the aggressive combat maneuvering that takes place on the UTTR occurs too far away from the PFSF to pose a hazard to the facility. See Finding 187, infra.

PFS's expert panel viewed these activities as administrative, routine flight and "low risk." PFS Test. At 15. The State's witness agrees that these activities are of lower risk than the aggressive combat maneuvering that takes place on the restricted ranges but asserts nonetheless that they are "high risk" activities. Horstman Test. at 9. In particular, Lt. Col. Horstman claims that G-awareness turns are not part of the administrative and routine categories of flight. Tr. at 4243 (Horstman) However, the Chief of Safety of Air Combat Command has described G-awareness turns as "a warm up exercise" and "not high risk," Aircraft Report, Tab F (emphasis added). When specifically questioned about this opinion of the Chief of Safety of Air Combat Command, Lt. Col. Horstman acknowledged that G-awareness turns are "normal operations to accomplish before range entry" and that they are "not high risk." Tr. at 4252 (Horstman) (emphasis added). Thus, the weight of the record shows that the F-16 activities undertaken during transit of Skull Valley are not high risk.

2. Crash Impact Hazard Calculation Methodology and the R Factor

PFS's panel of three highly experienced, high-ranking retired U.S. Air Force officers assessed in depth U.S. Air Force statistics and U.S. Air Force accident reports concerning F-16 crashes from 1989 to 1998 to determine the probability of an F-16 crash in Skull Valley. PFS's panel analyzed in detail F-16 in-flight emergencies and evaluated pilot training and experience to determine that a pilot would be able to – and would – point his crashing aircraft away from a structure on the ground, such as the PFSF, in the event of an emergency that left the pilot in control of the F-16. PFS's panel assessed the weather and the sparsely populated nature of Skull Valley and concluded that avoiding the PFSF would be much easier as than the avoidance maneuvers that pilots have successfully taken in the past under conditions more difficult than they would encounter in Skull Valley. Based on their evaluation of Air Force data, their knowledge of F-16 operations, and their understanding of how F-16 pilots respond to emergencies, PFS's expert panel calculated the crash impact probability from the F-16 flights through Skull Valley to be 3.11 E-7 per year.

To calculate this crash probability for the PFSF, PFS's expert panel used the methodology set forth in NUREG-0800, the NRC Staff's Standard Review Plan for Nuclear Power Plants, adapted to fit the circumstances of the Air Force F-16 flights through the Skull Valley and the PFS site. The crash impact probability was calculated as: $N \times C \times A/w \times R$, where N is the annual number of flights through Skull Valley, C is the crash rate per mile of flight, A is the effective area of the PFS site, w is the effective width of the valley, and R is the probability that a pilot of a crashing F-16 would be unable to avoid the PFSF.

We discuss each of the factors below, but we focus first on the "*R*" factor, since that was the focus of much of the testimony in the hearing. The *R* factor consists of two parts: (1) the fraction of accidents leading to a crash that would leave the pilot in control of the aircraft with time to avoid a site on the ground and (2) the fraction of those accidents in which the pilot would actually avoid the PFSF.[14] It was possible for PFS's experts to evaluate an avoidance factor for the PFSF because of the unique circumstances regarding F-16 flight down Skull Valley. These included the uniformity of the aircraft and the pilots' training, the well-developed database regarding F-16 in-flight emergencies, and the pilots' responses to them. These circumstances do not obtain for

[14] Mathematically, since the *R* factor in the equation is the probability that a pilot would fail to avoid the PFSF, *R* is equal to one minus the product of the probability that an accident would leave the pilot in control with time to avoid and the probability that the pilot would actually avoid the site given these conditions.

most other facilities where the aircraft crash hazard is posed by a wide variety of civilian aircraft flown by pilots with varying skills and backgrounds.

To determine the first part of the '*R*' factor, PFS's experts evaluated all F-16 accident reports over a 10-year period that resulted in the aircraft being destroyed. They divided the crash reports into Skull Valley type events (accidents caused by events such as engine failure that could occur in Skull Valley, regardless of the phase of flight in which they actually occurred) and non-Skull Valley type events, and for the former determined the percentage of accidents for which the pilot remained in control and had time to avoid a specific site on the ground. To determine the second part of the '*R*' factor, PFS's expert panel relied upon their expert evaluation of the factors affecting a pilot's ability to avoid the site as well as their examination of the accident reports to determine the probability that pilots in control of a crashing F-16s do in fact act to avoid sites on the ground.

The State argued that PFS should not be allowed to use the *R* factor because it is not part of the NUREG-0800 methodology. However, as articulated at the hearing, under NRC precedent NUREG-0800 constitutes staff guidance and is not a controlling regulation. Tr. at 5549 (Turk). Indeed, NUREG-0800 describes the formula as merely "[o]ne way of calculating" the annual probability for aircraft crash hazards. NUREG-0800 at 3.5.1.6-3. NUREG-0800 does not purport to provide the sole acceptable means for calculating aircraft crash hazard probability, and indeed the NUREG notes that it only constitutes "guidance." Id. at 3.5.1.6-6. Further, NUREG-0800 specifically recognizes that it may be appropriate to take into account other factors and circumstances in determining aircraft crash hazards. In this respect, NRC Staff's witness Dr. Campe, who was one of the authors of the NUREG-0800 methodology, stated that the *R* factor was an acceptable way to model the fact that military pilots will try to avoid hitting inhabited or built up areas on the ground.

Thus, the NUREG-0800 formula does not limit the evaluation of aircraft crash hazard to the factors prescribed in the formula to the exclusion of other factors that may affect the hazard. Rather, such other factors may be considered and utilized as appropriate.

We believe that use of the '*R*' factor is appropriate here. We note that whether a pilot is able to control an aircraft can be reasonably determined from the accident reports which form the basis for PFS's determination of the first part of the *R* factor, as well as from the expert judgment of PFS's well qualified witnesses. In this respect the State's expert, Lt. Col. Horstman, agreed with the large majority of the accident report categorizations by PFS's expert panel on whether a pilot remained in control of the aircraft. See Finding 76 and note 73 infra. To be sure, the State disagrees with some of the determinations, but that is also the case with most of the other factors in the formula as well. The fact that experts may disagree about the correct implementation of a methodology does not invalidate the methodological approach itself.

Regarding whether a pilot in control of an aircraft that had, for example, suffered an engine failure would in fact avoid a site on the ground, all of the pilots who testified in this case – including Lt. Col. Horstman – agreed that, time and circumstances permitting, a pilot of a crashing F-16 would attempt to avoid the PFSF. Moreover, the F-16 accident reports show numerous cases of pilots taking conscious action to avoid sites on the ground. Indeed, PFS presented examples of pilots going so far as to sacrifice their lives to avoid hitting sites on the ground where people could have been injured or killed. Because pilot avoidance is an established fact, it is appropriate for PFS to model pilot avoidance in its crash impact probability calculations. Notwithstanding any dispute as to the precise value to use for this part of the *R* factor, the fact that pilots do and will take steps to avoid sites on the ground cannot be disputed.

In a motion in limine, the State had objected to PFS testimony on the subject of pilot avoidance on the grounds that it was allegedly unreliable, citing Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579 (1993).[15] The State argued that evidence on the *R* factor should have been excluded essentially because PFS's methodology using *R* was new. Id. at 8. We believe that the State's reliance on Daubert is misplaced. In Daubert and Kumho Tire Co. v. Carmichael, 526 U.S. 137 (1999), the Supreme Court assigned to federal district judges a "gatekeeping role," under Federal Rule of Evidence 702, to determine whether expert testimony should be admitted into evidence. Daubert, 509 U.S. at 597; Kumho Tire, 526 U.S. at 141. The crux of Daubert is reliability. Daubert, 509 U.S. at 590. Thus, admissible testimony "must be supported by appropriate validation – i.e., 'good grounds,' based on what is known." Id. The Court defined "knowledge" as "any body of known facts or . . . any body of ideas inferred from such facts or accepted as truths on good grounds." Id. We have heard extensive testimony on pilot avoidance from all parties and the record now includes a large body of facts from which the probability of pilot avoidance – the *R* factor – can be inferred from logical principles. Therefore, we see no reason to exclude PFS's testimony.[16]

Indeed, regarding the State's objection on the grounds of novelty or lack of publication, Daubert itself states that "in some instances well-grounded but innovative theories will not have been published." Daubert, 509 U.S. at 593. "Some propositions . . . are too particular, too new, or of too limited interest to be published." Id.; see Kumho

[15] State of Utah's Motion in Limine to Exclude Applicant's Prefiled Direct Testimony of James L. Cole, Jr., Wayne O. Jefferson, Jr., and Ronald E. Fly (Mar. 25, 2002) ("State Mot.") at 7.

[16] We note that the Court also stated that the subject of admissible scientific testimony need not be "known' to a certainty." Daubert, 509 U.S. at 590.

Tire, 526 U.S. at 151. Furthermore, on a recent ruling, the Federal District Court for the District of Columbia held that testimony by a former Navy pilot on piloting F-14 aircraft was based on "intense practical experience" and thus its admissibility as expert testimony was not undermined by the fact that the pilot had assertedly never been published. Lohrenz v. Donnelly, 2002 U.S. Dist. LEXIS 15261 at *18-*19 (D. D.C. 2002). Therefore, because we focus on the facts and the principles on which the *R* factor is grounded and because its derivation is based on the extensive experience of PFS's three expert witnesses, we will not exclude it because it is arguably new or unpublished.[17]

The State also suggests that PFS's experts' experience-based opinion is unreliable because it is "subjective." See State Mot. at 8. Daubert, however, does not provide a basis for excluding expert testimony simply because it is based on experience or personal knowledge. See Kumho Tire, 526 U.S. at 150.[18] Indeed, Rule 702 was amended in 2000 to reflect Daubert and Kumho Tire and the Advisory Committee Note to the amendment specifically recognizes that "[i]n certain fields, experience is the predominant, if not the sole, basis for a great deal of reliable expert testimony."[19] The note also explains how such experts demonstrate the reliability of their testimony:

> If the witness is relying solely or primarily on experience, then the witness must explain how that experience leads to the conclusion reached, why that experience is a sufficient basis for the opinion, and how that experience is reliably applied to the facts.

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[17] As discussed in Finding 21 below, the theory that military pilots will direct crashing aircraft away from sites on the ground, in particular nuclear power plants, does not appear to be entirely new.

[18] The Daubert factors for evaluating scientific testimony cannot be blindly applied to the testimony of experts that is based primarily on personal knowledge or experience. Kumho Tire, 526 U.S. at 150. Examples of such experts include, "experts in drug terms, handwriting analysis, criminal *modus operandi*, land valuation, agricultural practices, railroad procedures, attorney's fee valuation, and others." Id. (emphasis added).

[19] Accord, United States v. Conn, 2002 U.S. App. LEXIS 14301, at *18 (7th Cir. July 16, 2002).

Following this principle, the lower courts have admitted expert testimony based primarily on the personal knowledge and experience of the expert where reliability was established through logical, clearly explained application of his expertise to the facts at hand.[20] In Daubert, the Court defined "subjective belief" as "unsupported speculation." 509 U.S. at 589-90. Expert opinion that satisfies the rule, however, is clearly more than that. On the basis of the substantial evidence in the record, which we discuss at length in our findings below, we find that PFS's expert panel has explained the application of their expertise to the facts and their conclusions are not unsupported speculation, but the result of the logical application of their extensive professional experience to the facts here.

3. Determination of the Appropriate R Factor for Pilot Avoidance

As stated above, the *R* factor consists of two parts: (1) the fraction of accidents that would leave the pilot in control of the aircraft with time to avoid a site on the ground and (2) the fraction of those accidents in which the pilot would actually avoid the PFSF. We discuss each of these in turn below.

a) Fraction of Accidents Leaving Pilot in Control with Time and Ability to Avoid the PFSF

The first part of the *R* factor involves determining the percentage of potential Skull Valley transit crashes in which an F-16 pilot would remain in control of the aircraft such that the pilot would have the time and ability to avoid the PFSF. PFS's experts calculated this percentage based on their assessment of 10 years of Air Force F-16 accident reports. For each accident, they determined whether the accident would be one that could have occurred in Skull Valley, given the circumstances of the accident and the

[20] See, e g., United States v. Mendoza-Paz, 286 F.3d 1104, 1112-13 (9th Cir. 2002) (valuation of narcotics); First Tennessee Bank Nat'l Ass'n v. Barreto, 268 F.3d 319, 331-35 (6th Cir. 2001) (prudent banking procedures); Maiz v. Virani, 253 F.3d 641, 668-69 (11th Cir. 2001) (Mexican immigration practices).

nature of the F-16 flights through Skull Valley, and whether the pilot had control of the aircraft long enough that he would have been able to avoid the PFSF. After assessing accidents involving 121 destroyed F-16s, they found that 61 of those could have occurred in Skull Valley. The other F-16 accidents were caused by events, such as mishaps related to combat training, takeoff, or landing, that do not occur in Skull Valley. Of the 61 accidents that could have occurred in Skull Valley, PFS's expert panel determined that 58 of those, or 95 percent, left the pilot in control with enough time to avoid a site on the ground. All but four of those 58 accidents were engine failures that left the pilot in control with time to maneuver the aircraft while it glided toward the ground. PFS, however, conservatively used a 90 percent value for this first part of the *R* factor when calculating crash impact probabilities. This evaluation and categorization of the F-16 accident reports by PFS's expert panel is set forth in Tab H of the PFS August 10, 2000 Aircraft Crash Report, Aircraft Report.

The State's expert witness, Lt. Col Horstman, during the course of the proceeding has taken different positions with respect to the expert panel's categorization of the accident reports in Tab H. Initially, Lt. Col Horstman found no fault with the evaluation in Tab H. In his December 11, 2000 deposition, Lt. Col. Horstman generally had high praise for the work of the PFS expert panel, stating that he had initially advised the State that he was in "agreement with all of the expert testimony for the PFS side" and that he "absolutely" was "in general agreement with what Colonel Fly said." Tr. at 4320 (Horstman). He specifically stated that PFS's categorization of the accident reports was not a problem that he had identified in his review of the August 10, 2000 Crash Report, and when asked whether he had identified anything particular in Tab H of the Report concerning the categorization of the F-16 accidents with which he disagreed, he responded, "[n]ot particularly, no." Tr. at 4323, 4325 (Horstman).

Subsequently, however, Lt. Col. Horstman began to take issue with PFS's experts' categorization of the accident reports. Specifically, in his January 30, 2001 Declaration supporting the State's Opposition to PFS's Motion for Summary Disposition, Lt. Col. Horstman challenged the categorization of 12 of the 121 F-16 accident reports evaluated by PFS's expert panel in Tab H. See PFS Exhibit X.[21] PFS moved to strike this part of Lt. Col. Horstman's declaration.[22] The Board declined to strike, but did allow PFS a further deposition regarding Lt. Col. Horstman's analysis of the accident reports. In so doing we stated as follows:

> Relative to [PFS's] motion, the State's explanation regarding Lieutenant Colonel Horstman's position on the aircraft crash analysis reports is troubling, given his clear declaration during the December 11, 2000 deposition that he had reviewed the PFS report discussing F-16 crash analyses and had no particular disagreement with it. On the other hand, we do not believe that the State or Lieutenant Colonel Horstman intentionally withheld information from PFS during his deposition; rather, it seems apparent that Lieutenant Colonel Horstman overstated his familiarity with those analyses. Although any further misstatements of this type by this witness could call into serious question the thoroughness, and thus the viability, of his analysis, the circumstances here do not warrant the action requested by PFS. At the same time, the circumstances do justify providing PFS with an additional opportunity to depose Lieutenant Colonel Horstman on his assessment of the accident analyses. We thus deny the PFS motion to strike with respect to this matter, but allow PFS the option of taking another deposition of Lieutenant Colonel Horstman regarding his analysis of the accident reports.

LBP-01-19, 53 NRC 416, 440-41 (2001).

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[21] PFS Exhibit X was Table 1 from Tab H of the Aircraft Report which listed in chronological order each of the F-16 accidents occurring from FY89 to FY98, inclusive. During his July 2001 deposition, Lt. Col. Horstman marked up the table to show each of his disagreements with PFS's categorization of the accidents. Tr. at 4411-12 (Horstman).

[22] Applicant's Motion to Strike Portions of State's Response to Applicants Motion For Summary Disposition on Utah Contention K/Confederated Tribes Contention B, dated Feb. 9, 2001 ("Motion to Strike").

In their pre-filed testimony, PFS's expert panel responded in detail to each of the claims that Lt. Col. Horstman had made in his January 30, 2001 declaration, as subsequently elaborated upon by Lt. Col. Horstman in his July 27, 2001 supplemental deposition. See PFS Test. at 62-88. PFS's expert panel determined that despite Lt. Col. Horstman's claims, a pilot would be "able to avoid" a site on the ground in 95 percent of all of the accidents that could have occurred in Skull Valley in which the pilot has control of the aircraft.

In his pre-filed testimony, Lt. Col. Horstman took yet a different tack. Rather than focusing on the 12 accidents with which he had taken issue in his declaration and subsequent deposition, Lt Col. Horstman broadly attacked the evaluation of PFS's expert panel in Tab H, claiming that PFS's expert panel had improperly "excluded" from its analysis accidents arising from various causes (e.g., lightning). However, his testimony only discussed four of the more than 100 accidents. On cross-examination Lt. Col. Horstman in many instances could point to no specific accidents that were allegedly excluded improperly. Furthermore, he repeatedly confirmed, with one exception, that to the extent that he believed that any such accidents had been improperly excluded, they would be included among the 12 accidents with which he had previously taken issue as identified in PFS Exhibit X. See Finding 79, infra.

At various times, Lt. Col. Horstman claimed that he had believed himself to be bound by PFS's definitions of the categories it used to assess the accident reports and that this somehow prevented him from evaluating the accident reports in the way he believed was relevant. The evidence in the record does not support his claim. In his January 2001 evaluation he created a new category, showing that he did not consider himself bound by the category definitions provided by the PFS expert panel, and he repeatedly acknowledged that he had exercised his professional judgment in his review as to the appropriate category in which an accident should be placed.

In addition, given the definitions of the categories, is difficult to understand Lt. Col. Horstman's claim that those definitions prevented him from assessing the accidents in a relevant way. The categories "Skull Valley-type event" and "able to avoid" are straightforward and binary. Thus, the only question with respect to "Skull Valley-type event" is "could the accident have happened in Skull Valley, yes or no?" If yes, the accident is relevant to the PFSF in Skull Valley. If no, it's not. The only question with respect to "able to avoid" is, "did the pilot have control and time to have been able to avoid a site on the ground, yes or no?" If yes, the accident represents a case where the pilot could have avoided the PFSF. If no, it doesn't. There is no area in between where an accident could fall into neither category. The dividing lines between the categories are defined in terms of their relevance to avoiding the PFSF. There is no basis for Lt. Col. Horstman to claim that the category definitions somehow prevented him from assessing the accidents in a way that is relevant to the hazard to the PFSF.

Moreover, neither in his prefiled testimony nor in the first two phases of the hearing did Lt. Col. Horstman identify, with one exception, any changes that would result if he were no longer bound by PFS's definitions. Only at the very end of the hearing did he identify three accidents for which he would now change his determination of "able to avoid." He suggested that this change had come about because he previously believed himself bound by PFS's category definitions. Tr. at 13593-94. However, on cross-examination he expressly acknowledged that the determination of "able to avoid" was not related to those category definitions and that the category in which an accident was placed (e.g., Skull Valley-type event) would not affect the separate determination of whether a pilot was in control of a crashing aircraft and would be able to avoid a site on the ground. Id. Lt. Col. Horstman gave no other explanation for the change, and being provided no rationale or basis for his change in determination at the eleventh hour, we give them no weight.

We have reviewed the competing claims of the parties of the appropriate percentage to use for whether a pilot remains in control of a crashing F-16. We note that PFS used a value of 90 percent, even though its analysis showed that 95 percent of the time the pilot would remain in control of aircraft. Thus, even doubling the number of accidents in which a pilot did not remain in control, from 3 to 6, the appropriate percentage to use would still be 90 percent (55 in control and of a population of 61, or 55/61 = 90.2%). Based on our detailed evaluation of the record on this issue set forth in Findings of Fact 69-91, infra, we believe that the 90% used by PFS for this first part of the *R* factor is reasonable and supported by the record.

b) Fraction of Accidents in Which Pilots Would Avoid

The second component of the *R* factor is the probability that a pilot with control of his crashing aircraft and time to avoid would actually avoid the PFSF. As stated above, all the pilots who testified in this case, including Lt. Col. Horstman, agreed that, time and circumstances permitting, a pilot of a crashing F-16 would take steps to avoid a site on the ground, such as the PFSF. To assess the probability that a pilot in control of a crashing F-16 would in fact avoid the PFSF, PFS's experts evaluated the available time and the circumstances such a pilot would likely face in Skull Valley. They evaluated and considered: (1) the time the pilot would have based on Air Force data concerning F-16 performance in the event of an engine failure, which would be on the order of one to two minutes; (2) the ability of the pilot to fly the aircraft and simultaneously attempt to restart the engine; (3) the very slight turn required to actually avoid the PFSF if the aircraft were otherwise heading toward it; (4) the training that pilots receive to avoid inhabited or built up areas on the ground; (5) the familiarity of the pilots at Hill AFB with the location of the PFSF, which will be prominently visible and whose location will be published in Defense Department aviation planning guides; (6) the wide open spaces around the PFSF, and in Skull Valley generally, to which a pilot could safely direct his aircraft, especially to the West for a plane headed directly at the PFSF site; (7) the excellent weather and visibility in Skull Valley; and (8) the F-16 flight control computer that will keep the F-16 on basically a straight course after the pilot ejects. Based on their evaluation of all of these factors and their professional judgment and long experience as Air Force pilots, PFS's expert panel assessed that in 95 percent of the cases in which the pilot had control of the aircraft, he would in fact avoid the PFSF.

The panel's expert judgment was corroborated by their examination of the F-16 accident reports (as well as by Air Force experience generally). They found no case, among the accidents that could have occurred in Skull Valley, where a pilot in control of the crashing aircraft failed to take steps to avoid or minimize impact to structures on the ground. In 17 out of 58 Skull Valley – type events, in which the pilot retained control of the aircraft, the reports identified specific pilot actions taken to avoid areas or structures on the ground. In 28 additional cases, the reports showed that the pilot retained situational awareness in that they stated that the pilot maneuvered the aircraft toward an airfield or an area, implying that the pilot was actively directing the aircraft while coping with the emergency. In the 14 remaining cases, the reports did not discuss maneuvering but they stated that there was no damage on the ground. Thus, the State's argument that there are no data on which to base an assessment of the likelihood of a pilot avoiding the PFSF is clearly meritless.

In both its cross-examination of PFS's expert panel and in Lt. Col. Horstman's direct testimony, the State theorizes that it is unlikely that a pilot would avoid the PFSF because the pilot's attention would be riveted solely on his survival. According to the State, because the pilot would be under great stress from the emergency and fearful of suffering serious injury upon ejection, he would not evaluate where his aircraft would impact on the ground and would not take steps to direct it away from the PFSF. The State argues that its theory is supported by its interviews of four pilots who, according to Lt. Col. Horstman, ejected from a crashing aircraft without considering avoidance of people or structures on the ground and also by the fact that the F-16 accident reports (and the video of Col. Bernard's accident) show many cases where pilots have ejected below the recommended minimum safe ejection altitude of 2,000 ft. AGL.

The State's argument is seriously flawed. First, the State ignores that PFS is only accounting for pilot avoidance in those accidents where the pilot has control of the aircraft and time to maneuver. Thus, PFS is not assuming any avoidance in accidents where the aircraft is out of control. In those cases, the pilot is powerless to avoid anything and can only think of getting out of the aircraft as quickly as possible. In cases where the aircraft is out of control, the pilot could suffer potentially severe injuries upon ejecting because of high speed, etc. which would not be avoidable.

The State further ignores that a pilot ejecting from an F-16 in control in Skull Valley would eject at a low airspeed which greatly lessens the potential for serious ejection injuries. Both Col. Fly and Lt. Col. Horstman testified that in the case of an engine failure where the pilot remains in control of the aircraft (the most likely accident scenario for F-16s transiting Skull Valley) ejection would occur at approximately 200 knots. The F-16 pilot's manual notes the increased potential for serious injury when ejecting at speeds above 420 knots, and specifically refers to the potential for flailing injuries (often mentioned by the State) when ejecting at speeds between 450 and 600 knots, and above. Thus, the likely ejection speed in Skull Valley for crashes in which the pilot retains control of the aircraft is well below the 420 to 450 knot floor referenced by the pilot's manual for serious ejection injuries.

Further, the F-16 accident reports confirm that pilots in control of aircraft are unlikely to die or suffer serious injury upon ejecting from an aircraft. The F-16 accident reports showed *no* fatalities and very few serious injuries in ejections where the aircraft was in the pilot's control. Close to 90% of the ejections where the pilot was in control of the aircraft resulted in no injuries or only minor injuries like scratches, bruises, or sprained ankles. The more serious injuries included fractures of the leg and ankle and compression fracture of the spine that occurred upon landing, not ejection. While not insignificant injuries, they are not life threatening.

The State's reliance on Lt. Col. Horstman's interview of four pilots that had ejected from aircraft is generally misplaced for the same reasons. One of the pilots that Lt. Col. Horstman interviewed ejected from an aircraft that had total hydraulic failure and lacked any control of the aircraft. Another pilot ejected because he was blinded by the accident and could not see where the plane was flying. The third pilot never took off. He ejected when the aircraft veered off the runway after an aborted take off. Thus, their accidents and what they were thinking at the time are not relevant to evaluating whether a pilot in control of his aircraft would fail to avoid the PFSF because of stress of the emergency and fear of injury.

With respect to the fourth pilot, who was in control of an aircraft who had suffered engine failure above a deck of low level clouds, there is conflicting evidence in the record. Lt. Col. Horstman testified that the pilot of this aircraft had stated that he was focused solely on survival and that he did not have time even to consider where his aircraft would impact the ground. However, Col. Fly testified that he had subsequently provided the pilot a copy of Lt. Col. Horstman's pre-filed testimony and that upon reviewing it the pilot took "strong objection" to Lt. Col Horstman's statements. Tr. at 3223-24 (Fly). As we discuss in Findings 112-113, approximately more than a minute elapsed between the initiation of this accident and the commencement of the ejection sequence, and for most of the time prior to ejection the aircraft was in a zoom followed by a gradual descent with no apparent unusual or particularly stressful activity occurring.

Based on this sequence of events and the undisputed testimony discussed above that, time and circumstances permitting, pilots will act to avoid structures and populated areas on the ground, it would be unreasonable to conclude that the pilot did not have time even to consider where his aircraft would impact. Rather, in this particular instance the low altitude cloud cover and lack of his familiarity with the area apparently resulted in the pilot not being in a position to take action to avoid a specific site on the ground. As we will discuss below, the circumstances for an aircraft in Skull Valley would be different, in that the pilot would be knowledgeable of the location of the PFSF and the Stansbury and possibly the Cedar mountains would be visible above any low altitude cloud cover to assist the pilot in avoiding the PFSF. Thus, the events of this accident do not support the State's proposition that pilots will fail to avoid sites on the ground because of stress from the emergency and fear of injury upon ejection.

Second, the State ignores that in those cases where the aircraft is in control, while the pilot is responding to the emergency (e.g., attempting to restart his engine) until he ejects, he is continuing to fly the aircraft. Both Lt. Col. Horstman and PFS's expert panel agree that flying or maintaining control of the aircraft is the first step in responding to an emergency. Flying the aircraft includes looking to see where it is going and using the flight controls to control and maneuver it. In the course of flying the aircraft during the emergency, when the pilot looks out the canopy he will see where he is going and what he might hit. The F-16 has a flight path indicator on its "heads up display" ("HUD") that shows where the aircraft is pointed. Thus, because flying the aircraft is part of responding to the emergency, the pilot would not have to artificially pull himself away and think "where am I going and what do I see?" In the course of flying he will also be using the flight controls, so making a small maneuver if necessary to avoid the PFSF would not be a significant burden on him during the emergency.

The State also ignores the extensive training that pilots receive for handling and dealing with stressful situations. All witnesses uniformly agreed that Air Force pilots are highly trained and extremely motivated. Their training and routine retraining includes simulator training on emergency procedures and ejections at least twice a year. It is also uncontested that pilots are trained to handle multiple tasks under stressful conditions. In short, while emergencies and possible ejections are high stress situations, there is no evidence that pilots forget their training for responding to emergencies, including taking steps as necessary to avoid sites on the ground, during accident conditions. The Board heard testimony from Col. Cosby that, while his accident was certainly stressful, the stress did not prevent him from avoiding an apartment complex and an aircraft on the ground before ejecting. Indeed, the State has not identified a single case, in the ten years of F-16 accident data or otherwise, where fear, stress, or distraction caused a pilot in control of the aircraft to fail to avoid something on the ground.

Lt. Col. Horstman also wrongly concluded that because pilots have ejected below 2,000 ft. AGL they would not have avoided the PFSF. The recommended minimum altitude for safe ejection in the F-16 is 2,000 ft. AGL. As documented in the accident reports, pilots have ejected below that altitude. Descending below 2,000 ft. before ejecting did not mean that the pilots were unable to see, were unaware of where they were, or were unable to control their aircraft. Indeed, in a number of cases, the pilot delayed his ejection below 2,000 ft. for the express purpose of avoiding something on the ground.

Neither is the Bernard video relied upon by the State representative of accident situations in Skull Valley. Capt. Bernard was engaged in and focused on highly intensive air-to-air combat training in a large scale "mock war." As such, he did not recognize nor begin responding to the emergency until well after the engine had failed. By the time he began to respond to the emergency, he was already at about 1,000 ft. AGL, well below the recommended minimum ejection altitude of 2,000 ft. AGL. In a Skull Valley event, the pilot would not be distracted by this simulated war and air-to-air combat maneuvering and would immediately respond to the emergency. Typically, a pilot in Skull Valley would be flying at 3,000 to 4,000 ft. AGL at the time of the event and, following the procedures of the F-16 pilot's manual, would "zoom" the aircraft to 5,000 to 7,000 ft. AGL. He would then begin a gradual descent, and if the emergency was not resolved, eject upon reaching 2,000 ft. AGL. There is no reason why the pilot in Skull Valley (unlike Col. Bernard's case) would not immediately respond to the emergency.

Thus, the scenario in the Bernard video is entirely different from that in Skull Valley, and while certainly instructive for training purposes, it is neither instructive nor relevant here. The video's purpose was to reinforce adherence by pilots to the recommended minimum ejection altitude of 2,000 ft. AGL and we do not understand PFS to suggest that pilots would do anything different in Skull Valley. In this respect, all of the analyses in the Crash Report and Revised Addendum assumes that pilots would eject at or before 2,000 ft. AGL.

Lt. Col. Horstman also argues that inexperience would cause a pilot to fail to avoid the PFSF. First, Air Force pilots are well trained before they fly the F-16 and would be even further trained before they were stationed at Hill AFB. While not all F-16 pilots stationed at Hill AFB will have the extensive experience of Col. Fly or Lt. Col. Horstman, we have seen no evidence that USAF pilots generally, and Hill AFB F-16 pilots in particular, are not sufficiently "experienced" to deal with engine failures in non-high risk situations. Second, the F-16 accident reports represent accidents involving pilots with all levels of experience, i.e., they were not filtered or sorted in any way on the basis of pilot experience. Thus, they are representative of pilot performance for all levels of experience. In the 58 relevant accidents (i.e., Skull Valley-type events in which the pilot was in control), there was no case where the pilot failed to take steps to avoid or minimize damage to a site on the ground.

Lt. Col. Horstman also claims that pilots would not be able to avoid the PFSF because they would be unable to see the facility due to weather or the nose of the aircraft obscuring the view of the pilot. First, as to weather, specific cloud cover data for the area shows that 91 percent of the time there is no ceiling and 7 miles visibility at or below 5,000 ft. AGL, i.e., where the F-16s mostly fly, and that 79 percent of the time there would be no clouds whatsoever below 5,000 ft. AGL. Since 5,000 ft. AGL goes to the top of the Sevier B MOA airspace above the PFSF, for the great majority of the time the presence of clouds would not be a factor affecting a pilot's ability to avoid the PFSF site.

Furthermore, the mere presence of clouds would not necessarily obscure the pilot's view of the PFSF – that would depend on the relative positions and altitude of the clouds, the plane, and the facility. More importantly, even clouds that obscured a pilot's direct view of the facility would not deprive him of knowledge of his position relative to the PFSF. He could use landmarks such as Skull Valley Road, the PFS railroad, and the Stansbury and Cedar Mountains to see where he was relative to the PFS site. Even in the rare event of a complete undercast, as the pilot flew down the valley he would be using navigational instruments and position relative to the mountains, where visible, to maintain awareness of his position. The record is well established in this respect that pilots maintain awareness of their location, through familiarity of the area, navigational tools, and maps. Finally, the area around the PFSF is wide open, especially to the west, so the pilot would not have to have a highly precise picture of its location in order to avoid it. Therefore, it is highly unlikely that weather would prevent a pilot from avoiding the facility in the event of an accident.

As for the visibility of the pilot being obstructed by the nose of the aircraft, two points are pertinent. First, the State assumes that a pilot would instantaneously forget the location a facility or structure previously in view once it became obscured by the nose. Such an assumption is illogical. Second, a calculation accounting for the angle of descent of the aircraft, its orientation during a descending glide following an engine failure, and the pilot's field of view over the nose showed that the pilot would be able to see where on the ground the aircraft would impact at the 2,000 ft. AGL ejection point. Indeed, Lt. Col. Horstman acknowledged that, if the nose of the aircraft obstructed the pilot's view of a site on the ground on its glide descent, the aircraft would overfly the site and impact the ground beyond it. Tr. at 8478-79 (Horstman). Thus, the nose of the aircraft will not block visibility of the site and other landmarks not obscured by the aircraft's nose would give the pilot positional awareness.

Finally, Lt. Col. Horstman testified that because the PFSF will be a "facility," as opposed to a "populated area," a pilot would be less likely to avoid the site. This argument is simply a canard. Every F-16 pilot who flies in Skull Valley will know that the PFSF is a nuclear waste storage site, inhabited by operations and security personnel. It is absurd to think that a pilot with the ability to avoid the PFSF would not do so. Indeed Lt. Col. Horstman contradicted his own testimony. On cross-examination he admitted that he or any other pilot would avoid the PFSF if he could. Tr. at 13465 (Horstman).

In sum, the evidence demonstrates that it is very likely that a pilot in control of his aircraft in Skull Valley would avoid the PFSF. PFS's expert's judgment is corroborated by 10 years of information from the Air Force F-16 accident reports. Lt. Col. Horstman's testimony to the contrary is simply factually wrong or it ignores the conditions in which an accident would potentially occur in Skull Valley. It would be wholly unreasonable to conclude that highly trained Air Force pilots familiar with the PFSF, its location and its environs, and who are in control of a crashing F-16, would not undertake the small maneuver necessary to avoid the PFSF site.

4. F-16 Crash Rate

Using Air Force data over the 10-year period from FY89 to FY98, PFS calculated a F-16 crash rate of 2.736 E-8 per mile for normal operations (i.e., flight not involving takeoff or landing or aggressive maneuvering). PFS selected 10-year average to minimize the effect of year-to-year statistical fluctuations in the data and used the most recent 10 years of data, and hence the most relevant at the time, the analysis was initially performed.

The State disputed PFS's estimate of the F-16 crash rate. It claimed that the crash rate relevant to Skull Valley will go up in the future because 1) the F-16 crash rate is allegedly increasing due to the "bathtub effect," and 2) the crash rate for the aircraft that will replace the F-16 in the future will allegedly be higher in the beginning of its lifetime than the F-16 crash rate used by PFS.

The record, however, shows differently. Neither F-16 crash rates over the last 10 years nor the crash rates of recently retired fighter aircraft at the ends of their service lives show any end-of-life bathtub effect. Regarding the potential crash rate of the F-16s possible future replacement, most likely the Joint Strike Fighter, there are several reasons why its crash rate would be lower than the crash rate of the F-16. Foremost, is the fact that Air Force crash rates have steadily decreased over time as a result of better technology, design, maintenance and training. Further, any Joint Strike Fighters based at Hill AFB would not be the first aircraft entering service and thus would likely have even lower crash rates: the Marine Corps will receive the Joint Strike Fighter before the Air Force and the first Joint Strike Fighters that go to the Air Force will be likely deployed at a training base, not Hill AFB.

The State also argues that a lifetime crash rate of the F-16 is required by NRC precedent and that PFS used the lowest 10-year rate ever, notwithstanding an increase in recent years. With respect to the latter point, the Board notes that, contrary to the State's claim, the 10-year period ending in 2001 showed a lower crash rate and over the last several years the rolling 10-year rate has not increased. Further, we disagree with the State's suggestion that a lifetime rate is required by NRC precedent. The fact that a lifetime rate may have been used in some previous NRC aircraft hazard analyses hardly mandates its use everywhere. The question is whether the rate utilized by PFS provides a reasonable basis for future estimates. Here the record shows that military aircraft crash rates have continually decreased since World War II due to better design, maintenance and training, a proposition with which the State's witness, Lt. Col. Horstman agrees. Based on this fact, the lack of any demonstrated end-of-life bathtub curve for fighter aircraft, and the expected improvements and deployment schedule of the Joint Strike Fighter, the 10-year crash rate used by PFS provides a reasonable and conservative basis for estimating the future crash hazard to the PFSF.

5. Number of F-16 Flights

The annual number of flights through Skull Valley, *N*, is another variable in the equation used to calculate the crash impact probability. PFS based its estimate of the annual number of flights through Skull Valley on the Sevier B MOA annual usage reports. The Air Force has stated that the numbers reported for Sevier B were representative of the number of F-16 flights through Skull Valley. PFS used an average of the FY99 and FY00 Sevier B MOA sortie counts which it then increased by 17.4 percent to account for additional aircraft based at Hill AFB in the middle of FY01. Based on this analysis, PFS projected that there would be 5,870 F-16 flights per year in Skull Valley. The reasonableness of PFS's projection is shown by the FY01 Sevier B MOA usage report, which shows that 5,046 sorties were flown that year. If the FY01 sorties were adjusted to account for the additional F-16s at Hill, the total would have been 5,435, several hundred below PFS's estimate.

The State asserts that PFS should have used only the FY00 sortie count as a baseline to estimate the future number of sorties in Skull Valley and that PFS should have added the Sevier B and Sevier D MOA counts together. The State's theory ignores the fact that FY00 was a particularly high sortie year for the 388th FW and the Air Force's opinion that the Sevier B sortie count is representative of the total F-16 traffic through Skull Valley. While the Sevier D MOA airspace lies directly above Sevier B, because the Sevier B and Sevier D MOAs extend to the far southern edge of the UTTR, nearly 100 miles from the PFSF, both MOA sortie counts include aircraft that never enter Skull Valley. The Sevier D counts are small, typically five percent of the Sevier B counts. Thus, treating Sevier B as representative of Skull Valley sorties, while excluding Sevier D sorties, approximately accounts for the aircraft that use the Sevier B and D MOAs but never enter Skull Valley.

Also the State's projection does not account for the Air Force's long term trend of replacing aging aircraft with fewer, more capable and reliable aircraft. By the time the PFSF approaches full capacity total sorties can be expected be decrease as a result.

6. PFSF Effective Area

PFS calculated the effective area of the PFSF, *A*, by taking the area of the entire cask storage area of the facility (i.e., assuming with the presence of 4,000 casks) and the area of the Canister Transfer Building. PFS also included the "skid area" in front of the facility where a crashing aircraft could skid into it and the "shadow area" behind the facility, which effectively accounts for the possibility of an aircraft hitting the casks or the building above the ground level. The State did not take issue with PFS's calculation of the effective area for the facility.

Because the cask storage area makes up nearly 95 percent of the facility's effective area, the effective area is nearly directly proportional to the number of casks on site. Thus, PFS's hazard calculation is conservative, in that it assumes that the facility is at full capacity, a situation that may never be achieved. Even if the facility were ultimately filled, it would be full for only a small fraction of its planned lifetime. Because of the planned loading and unloading schedule for the facility, assuming the facility reaches its maximum 4,000-cask capacity, the time-weighted average effective area for the facility is only about 55 percent of its full effective area. This one factor alone results in PFS's analysis being conservative by a factor of almost two.

7. F-16 Flight Path and Skull Valley Airway Effective Width

The Air Force has stated that the predominate route for F-16's transiting Skull Valley is down the east side of the valley, approximately five miles east of the PFS site at a typical altitude of 3,000 to 4,000 ft. AGL. Pilots perform G-awareness turns to warm up and test their G-suits before entering the range, which could take them further to the west, but those turns can be performed practically anywhere in Skull Valley or south of Skull Valley on the route of flight after the F-16s cross the Great Salt Lake and before they enter the restricted areas on the UTTR. Thus, the great majority of the time the F-16s will predominantly be east of the facility.

Nevertheless, PFS assumed for the purpose of its calculations that the Sevier B MOA could be treated like an airway and that the F-16s were evenly distributed across its width, from the Stansbury Mountains in the east to the edge of restricted airspace in the west. The actual width of the MOA at the latitude of the PFSF is 12 miles but PFS used a width of 10 miles to account for the space lost due to the Stansbury Mountains on the east. However, the MOA expands to a useable width of approximately 11 miles at a latitude three miles north of the PFSF, where, assuming an engine failure, an aircraft would have to be at the recommended ejection altitude of 2,000 ft. in order to crash into the site.

The State advanced a number of evolving theories challenging PFS's use of a 10 mile airway width in its calculations. All of these theories are flawed. The first theory was that pilots would use the PFSF as a turn point and as a reference to update their navigational instruments and hence they would deliberately fly at it while transiting Skull Valley.[23] This theory is flawed mostly because pilots do not do that today – the PFSF does not exist – and there is no need for them to begin to do it if the facility is built. Furthermore, pilots now perform a number of administrative tasks while transiting Skull Valley and it is unreasonable to assume that they would stop doing so in order to use the PFSF as a turn point or to update their instruments. Moreover, contrary to what the

[23] The State fails to recognize that this theory contradicts its claim that pilots would have difficulty locating the PFSF in order to be able to avoid it.

State's position would suggest, there are other features in Skull Valley, most significantly the Stansbury and Cedar Mountain ranges that serve as excellent visual references for navigation. Finally, the presence of restricted airspace nearby to the west and to the south of the PFSF make it unlikely that pilots would change their current flight paths in Skull Valley in order to use the PFSF as a turn point.

The second theory was that there are buffer zones on both sides of the MOA such that aircraft must stay one mile east of the restricted area to the west and one, two, three, or more miles west of the Stansbury Mountains to the east. This theory is flawed because the Air Force has stated that there are no buffer zones inside Sevier B MOA (although there are buffer zones inside the restricted areas on the UTTR). Furthermore, the Air Force has stated that the predominate route of flight down the valley is five miles to the east of the PFS site, not in the center of the valley where the State's purported buffer zones would require the pilots to fly.

The third theory was that pilots would perform G-awareness turns so as to point directly at the site while they were headed to the west, between their first and second turns. This theory is flawed because G-awareness turns could be performed practically anywhere, north or south of the site. Moreover, directly contrary to his hearing testimony (that flights typically would be directly pointed at the PFSF while performing G-awareness turns), Lt. Col. Horstman stated in his December 2000 deposition that G-awareness turns would generally be performed after the F-16s had passed south of the PFS site.

The fourth theory was that pilots would tend to point toward the PFSF because if they suffered an engine failure in Skull Valley they would immediately head for Michael AAF and hence they would fly over the site. This theory is flawed because in order to pose a threat to impact the PFSF, an F-16 would have to suffer its engine failure roughly

15 miles north of the site, at the very north end of Skull Valley. At that point, the aircraft would be about 30-35 miles away from Michael AAF with no way of getting there without restarting its engine. As Col. Fly testified, in that situation he would head for lower terrain down Skull Valley and not attempt to cross the Cedar Mountains so as to maximize the time aloft and the time he would have to remedy his problem.

In short, we believe that 10 miles is a reasonable, conservative width to apply in the equation, particularly given the Air Force's statement that the predominant route of flight is on the east side of Skull Valley approximately five miles to the east of the proposed facility.

8. Conclusion Regarding F-16s Transiting Skull Valley

PFS used a clear and logical methodology to calculate the impact hazard to the PFSF posed by F-16s transiting Skull Valley. PFS's assessments of the number of flights and the F-16 crash rate are based on data published by the Air Force. PFS's assessment of the effective width of the Sevier B MOA in Skull Valley is based on analysis of the terrain in the valley and is very conservative given that the Air Force has stated that the preferred route down Skull Valley is five miles to the east of the site. PFS's assessment of the likelihood that a pilot would be able to direct a crashing F-16 away from the PFSF is based on 10 years of Air Force F-16 accident reports and the professional judgment of three highly experienced former Air Force pilots. The claims made by the State in challenging PFS's analysis are unsupported assertions that have changed over time as the State has sought to create issues where none exists. The State's claims provide no reason to doubt PFS's assessment that the hazard to the PFSF from F-16s transiting Skull Valley is extremely low.

C. Military Ordnance

PFS calculated the probability of jettisoned ordnance impacting the PFSF similar to the way that it calculated the probability of F-16 crashes. Consistent with its approach for calculating the F-16 crash probability, PFS took the number of flights to be the average number of flights carrying jettisonable ordnance through Skull Valley in FY99 and FY00, the same way it used those years' sortie counts as the basis to estimate the future number of Skull Valley transits by F-16s. PFS used the actual area of the site to reflect the steep angle at which jettisoned ordnance would strike the ground, much steeper than the trajectory of a crashing aircraft. Notwithstanding the documented cases where F-16 pilots have checked to see where their ordnance might hit before jettisoning it in an emergency, PFS conservatively took no credit for any such avoidance of the PFSF in its analysis.

The State would assume that the fraction of sorties in Skull Valley carrying jettisonable ordnance would be the same as it was in FY98 rather than the average of FY99 and FY00. The only reason behind the State's claim is that the FY98 fraction was higher than the FY99 and FY00 fractions. The State asserted that ordnance usage was lower in FY00 because some of the F-16s at Hill AFB were deployed to the Caribbean for drug interdiction missions. However, the number of F-16s sent to the Caribbean was small relative to the number remaining at Hill and the training of the F-16s is not based on one particular deployment (or year to year fluctuations in budget). Moreover, the State did not account at all for the FY99 ordnance usage, which was almost identical to the usage in FY00. Requirements for F-16 ordnance usage in training are established by Air Force regulations and each unit's designated operational capability (i.e., assigned mission). Those requirements do not change frequently. Furthermore, the Air Force Safety Center reported that ordnance expenditures are not expected to increase in the future. Thus, the State's claims provide no reason not to accept PFS's assessment of the hazard to the PFSF posed by jettisoned ordnance.

D. Aircraft Conducting Training on the UTTR

F-16s and other fighter aircraft conduct air-to-air combat training in the restricted areas on the UTTR to the west of the PFS site. The closest boundary of the restricted areas to the site is two miles away and aircraft conducting training in the restricted areas observe a roughly three mile buffer zone inside the areas. Thus, the closest approach of any aircraft in the restricted areas to the PFS site is five miles. In addition, aircraft conducting air-to-air combat training perform their aggressive maneuvers toward the center of the range. Based on their analysis of the F-16 accident reports, the PFS experts concluded that an out of control aircraft would fly a maximum of five miles before impacting the ground. Thus, they concluded that air-to-air combat training on the UTTR would pose a negligible hazard to the PFSF. In his December 2000 deposition, Lt. Col. Horstman agreed that any aircraft suffering a mishap on the UTTR would impact the ground before reaching Skull Valley.

Nevertheless, Dr. Resnikoff asserted that aircraft on the UTTR would pose a hazard to the PFSF by assuming that a crashing aircraft could fly 10 miles before impacting the ground. The only support Dr. Resnikoff cited for his assertion was an assessment that PFS had performed prior to analyzing the accident reports, in which PFS had conservatively assumed that a crashing aircraft could fly a maximum of 10 miles before impacting the ground. Since the only basis for Dr. Resnikoff's claim has been superseded, it deserves no credence.

E. Aircraft Flying on the Moser Recovery Route

A small fraction of the F-16s returning from the UTTR to Hill AFB do so via the Moser Recovery Route, which crosses Skull Valley two to three miles north of the PFSF. The Moser route is used under particular weather conditions when the F-16s must land to the north at Hill AFB and cannot use their normal approach route over the Great Salt Lake. PFS evaluated the hazard such aircraft would pose to the PFSF using the same method it used for the F-16s transiting Skull Valley. Based on discussions with the Salt Lake City air traffic control center and the operations group commander of the 388th FW, PFS estimated that the Moser Recovery would be used by no more than five percent of the aircraft returning from the UTTR.

The State asserted that PFS should have assumed that one-third of all flights returned to Hill AFB via the Moser Recovery Route because in the future up to one-third of the flights on the UTTR might be conducted at night. The State's theory was based on an unsupported assumption that flights at night would use the Moser route, especially since the 388th FW was using night vision goggles. On the contrary, the 388th FW operations group commander stated that even at night the Moser Recovery Route was greatly disfavored because of the interference it caused with civilian air traffic over Salt Lake City associated with the Salt Lake City airport. The Hill AFB staff also told the NRC Staff that night vision goggle usage had not led to an increased usage of the Moser Recovery. Therefore, there is no basis for the State's assumption and no basis for its assertion regarding Moser Recovery usage.

F. Aircraft Flying to and from Michael AAF on IR-420

In addition to F-16 traffic in Skull Valley, a relatively small number of flights, mostly large cargo aircraft, fly to and from Michael AAF on military airway IR-420, which begins at the northern boundary of Sevier B MOA in Skull Valley and runs northeast to southwest. PFS accounted for the hazard posed by those aircraft similarly to the way it accounted for the hazard posed by F-16s transiting Skull Valley, although because of the nature of crashes involving large, multi-engine aircraft, it did not include a factor for pilot avoidance. F-16s also fly to and from Michael AAF in the direction of IR-420, but those flights are counted in the Sevier B MOA totals (as they pass through Sevier B MOA) and thus are accounted for in the F-16 hazard calculations above. The State did not contest PFS's calculation of the hazard posed by aircraft flying to and from Michael AAF on IR-420 and we find it to be reasonable and conservative.

G. Conclusion

PFS has assessed the cumulative hazard posed by all of the aviation operations in and around Skull Valley to be less than 4.17 E-7 per year. That total is below the limit of 1 E-6 established by the Commission and hence the PFSF need not be designed to withstand the effects of aircraft crashes. Furthermore, as discussed in the findings of fact below, PFS's assessment is conservative in a number of respects, such that the actual hazard to the facility is less than half of the calculated hazard.

PFS used a clear and logical methodology to calculate the cumulative crash impact hazard to the PFSF. PFS's assessments of the hazards posed by each category of operations is soundly based on data published or provided by the Army and the Air Force. PFS's interpretation and use of that data in its assessment is based on the professional judgment of three highly experienced former Air Force pilots. The claims made by the State in challenging PFS's analysis are unsupported and provide no reason to doubt PFS's assessment that the hazard to the PFSF is below the limit established by the Commission.

Based on evaluation of all the evidence in the record, the Licensing Board finds that the cumulative impact hazard to the PFSF from aircraft crashes and jettisoned ordnance is less than 1 E-6 per year. Thus, the PFSF need not be designed to withstand the effects of the impacts of aircraft crashes or jettisoned ordnance. The Board's specific findings on this issue are set forth below.

III. FINDINGS OF FACT

A. Contention Utah K

1. In Contention Utah K, the State alleges that:

> The Applicant has inadequately considered credible accidents caused by external events and facilities affecting the ISFSI, including the cumulative effects of military testing facilities in the vicinity.

LBP-99-39, 50 NRC at 240.[24]

2. On May 31, 2001, the Board granted in part and denied in part a PFS motion for summary disposition of Utah K. LBP-01-19, 53 NRC 416. The decision resolved in favor of PFS the hazards posed by commercial and general aviation.[25] Id. at 451-52; see also Tr. at 3013-14 (Farrar, J., general aviation). The Board left for hearing only the issues of aircraft accident hazards from (a) F-16s transiting Skull Valley, (b) jettisoned military ordnance, (c) air-to-air combat training on the Utah Test and Training Range, (d) military flights on the Moser Recovery Route, and (e) military flights to and from Michael Army Airfield on IR-420. LBP-01-19, 53 NRC at 455-56.

3. In addition, the Board ruled that the PFSF need only be designed to withstand accidents with a probability of at least one-in-a-million (1 E-6) per year and

[24] As discussed above, the portions of Utah K that had concerned wildfires, the Tekoi facility, hazards at Dugway Proving Ground other than the use of military ordnance, and the intermodal transfer point were dismissed by the Board in August and September 1999. LBP-99-35, 50 NRC 180 (wildfires, Tekoi, and Dugway); LBP-99-39, 50 NRC at 236 (intermodal transfer point).

[25] That ruling also resolved in favor of PFS issues regarding the use of military ordnance at Dugway and the testing of cruise missiles on the Utah Test and Training Range. Id. at 424, 427-29.

referred that ruling to the Commission. Id. at 431. On November 14, 2001, the Commission affirmed the Board's ruling that the PFSF need not be designed to withstand aircraft crashes having less than a one-in-a-million annual probability of occurring and stated that the hearing should proceed on the remaining fact issues as specified in the Board order. Private Fuel Storage, L.L.C. (Independent Spent Fuel Storage Installation), CLI-01-22, 54 NRC 255 (2001).

B. Cumulative Hazard From Military Aircraft Crash And Jettisoned Ordnance

4. The sole issue remaining to be decided with respect to this contention is the annual probability that a military aircraft crash or jettisoned military ordnance would impact the PFSF. We have reviewed the information and data concerning the potential hazard to the PFSF from military aircraft crashes and jettisoned military ordnance and have concluded, as set forth below, that they pose no credible or significant hazard to the PFSF. As established by the Commission, the PFSF need not be designed to withstand accidents with a probability of less than 1 E-6 per year. We find that the cumulative probability of impact by a crashing aircraft and jettisoned military ordnance is less than this 1 E-6 per year standard.

5. PFS submitted highly detailed testimony and a comprehensive report on the potential hazards posed to the PFSF by military aircraft and jettisoned ordnance. The report was submitted as PFS Exhibit N, Aircraft Crash Impact Hazard at the Private Fuel Storage Facility," Revision 4 (August 10, 2000) ("Aircraft Report"), and PFS Exhibit O, the Revised Addendum to the Aircraft Report[26] ("Revised Addendum"). The Revised Addendum also contains PFS's responses to a series of Requests for Additional Information ("RAIs") from the NRC Staff regarding

[26] Revised Addendum to Aircraft Crash Impact Hazard at the Private Fuel Storage Facility (July 20, 2001).

aircraft crash hazards.[27] The report and its addendum were principally prepared by PFS's expert witnesses on aviation hazards, Brig. Gen. James L. Cole, Jr., USAF (Ret.), Maj. Gen. Wayne O. Jefferson, Jr., USAF (Ret.), Col. Ronald E. Fly, USAF (Ret.). We find the testimony and the reports credibly describe the hazard to the facility.

6. The Board has previously found that the aviation activity in the vicinity of the PFS site in Skull Valley, Utah (about 50 miles southwest of Salt Lake City) consists of military operations associated with the UTTR along with civilian commercial and general aviation. LBP-01-19, 53 NRC at 432. The airspace over the UTTR extends somewhat beyond the range's land boundaries and is divided into restricted areas, in which the airspace is limited to military operations, and military operating areas (MOAs), which are located on the edges of the range, adjacent to the restricted areas. The PFS site lies within the Sevier B MOA, to two statute miles to the east of the edge of the restricted airspace, and 18 statute miles east of the eastern land boundary of the UTTR South Area. The area covered by airspace of the Sevier B MOA is approximately 145 miles long and is 12 miles wide in the vicinity of the PFS site. Id.

7. Military air operations in the vicinity of Skull Valley include (1) Air Force F-16 fighter aircraft transiting Skull Valley from Hill Air Force Base to the UTTR South Area; (2) F-16s from Hill and various other military aircraft conducting training exercises on the UTTR; (3) F-16s from Hill AFB returning from the UTTR South Area to the base via the Moser Recovery Route, which runs to the

[27] Request for Additional Information on Aircraft Hazards—Partial Response (Mar. 30, 2001) ("March 30 Response"), contained in Revised Addendum Tab FF; Request for Additional Information on Aircraft Hazards—Clarification (May 15, 2001) ("May 15 Clarification"), contained in Revised Addendum Tab GG; Request for Additional Information on Aircraft Hazards—Remaining Response and Clarification (May 31, 2001) ("May 31 Response"), contained in Revised Addendum Tab HH.

northeast, 2 to 3 miles north of the PFS site; and (4) military aircraft, comprised mainly of large transport aircraft, flying on military airway IR-420 to and from Michael AAF, which is located on Dugway about 17 miles southeast of the PFS site. LBP-01-19, 53 NRC at 432.

8. Civilian aircraft also will be flying in the general area of the PFS site, including: (1) aircraft flying on Federal Airway J-56, which runs east-northeast to west-southwest about 12 miles north of the PFS site; (2) aircraft flying on Airway V-257, which runs north to south approximately 20 miles east of the site; and (3) other minimal general aviation activity, which has not been reported but nonetheless could occur in the area. LBP-01-19, 53 NRC at 432. As noted above, the Board has also previously ruled on the hazard to the PFSF posed by commercial and general aviation. Id. at 449-52.

9. PFS calculated the crash impact probabilities for each of the aviation activities conducted in the vicinity of the PFSF site by using the methodologies of the DOE standard, Accident Analysis for Aircraft Crash into Hazardous Facilities, DOE STD 3014-96 (Oct. 1996), and the NRC Standard Review Plan for Nuclear Power Plants, NUREG-0800, as modified to reflect the particular circumstances at the PFS site. The calculations were based on: the number of aircraft flights, aircraft crash rates, the effective area of the PFSF from the perspective of a crashing aircraft, the space over which the flights are distributed, the distance between the flights and the PFSF, and, for military fighter aircraft, the likelihood that a pilot of an aircraft experiencing an in-flight emergency would be able to direct the aircraft away from the PFSF before the pilot ejected and the aircraft impacted the ground. PFS Test. at 8-9; Staff Test. at 6-7. Based on this information, the impact hazards

posed by the individual aviation activities conducted in the vicinity of the PFSF site are conservatively estimated as follows:

Table 1 Calculated Aircraft Crash Impact Probabilities	
Aircraft	**Annual Probability**
F-16s Transiting Skull Valley	3.11×10^{-7}
Aircraft on the UTTR	$< 1 \times 10^{-8}$
Aircraft Using the Moser Recovery	2.00×10^{-8}
Aircraft on Airway IR-420	3.0×10^{-9}
Aircraft on Airway J-56[28]	1.9×10^{-8}
Aircraft on Airway V-257[28]	1.2×10^{-8}
General Aviation Aircraft[28]	$< 1 \times 10^{-8}$
Cumulative Crash Probability	$<3.85 \times 10^{-7}$
Jettisoned Military Ordnance	3.2×10^{-8}
Cumulative Hazard	$<4.17 \times 10^{-7}$

10. For the purpose of assessment, we have grouped the aircraft flying in and around Skull Valley that could potentially pose a hazard to the PFSF in the event of an accident as above. Based on the testimony and the other evidence in the record, we have assessed the annual crash impact probabilities for the PFSF for each group of aircraft and the probability that ordnance jettisoned from a military aircraft (separate from the aircraft itself) would impact the PFSF. We find that the annual crash impact probability for all aircraft (military and civilian) and jettisoned ordnance combined is less than 4.17 E-7/year. Each of the military operations that contribute to this cumulative hazard estimate is further discussed separately below.

[28] As stated above, the appropriate estimates for the hazards from commercial and general aviation aircraft were resolved on summary disposition. We present the calculated hazard here solely for the purpose of determining the cumulative hazard to the PFSF.

C. F-16 Aircraft Transiting Skull Valley

1. Introduction

11. Based on information PFS received from Hill AFB, F-16 fighter aircraft transiting Skull Valley en route from Hill AFB to the UTTR South Area typically pass approximately five miles to the east of the PFSF site. PFS Test. at 14; Staff Test. at 9; Tr. at 3397-98, 3402-04 (Cole); see Tr. at 3422-24 (Fly). The F-16s typically fly through the Sevier B MOA, between 3,000 and 4,000 ft. above ground level (AGL),[29] with a minimum altitude of 1,000 ft AGL.[30] PFS Test at 14; Staff Test. at 9; Tr. at 3396-97, 3404 (Cole), 4356-57, 4369 (Horstman). A few aircraft fly higher, through Sevier D MOA, between approximately 5,000 ft. AGL and 14,000 ft. AGL. PFS Test. at 14..[31] It is unusual for aircraft to fly through Skull Valley at altitudes above 14,000 ft. AGL (18,000 ft. MSL). Tr. at 4372-73 (Horstman). Aircraft fly through Skull Valley at approximately 350 to 400 knots[32] indicated airspeed (KIAS). PFS Test. at 14.

12. In fiscal years (FY) 1999 and 2000, an average of approximately 5,000 F-16 flights transited Skull Valley per year. PFS Test. at 14 & n.10; Staff Test. at 10. Because 12 F-16s were added to the 69 aircraft stationed at Hill AFB in the middle of FY2001, PFS estimated that approximately 5,870 flights per year will

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[29] The ground elevation at the PFS site is approximately 4,500 ft. above mean sea level (MSL). Tr. at 8609.

[30] The NRC Staff has advised the Board that the Air Force has lifted the instruction limiting flight to a minimum altitude of 1,000 ft. AGL in Skull Valley. See Letter from Mark Delligatti, NRC to John Parkyn, Chairman PFS, dated August 12, 2002. PFS does not believe that such a change would have any impact on its assessment of the hazard to the PFSF. See Letter from John Parkyn, Chairman PFS, to Nuclear Regulatory Commission, dated August 23, 2002.

[31] Sevier D MOA lies directly atop Sevier B MOA and extends from an altitude of 9,500 ft. MSL to an altitude of approximately 18,000 ft. MSL. Tr. at 4369 (Horstman).

[32] One knot is one nautical mile per hour.

transit Skull Valley during the life of the PFSF. This estimate was made by increasing the 5,000 annual flights by 17.4 percent to account for the additional F-16s. PFS Test. at 16, 20-21. PFS's witnesses testified that the estimated number of F-16 transits will likely prove conservative in the future in that, as discussed below, the continuing modernization and increased technological capability of newer military aircraft will likely result in fewer aircraft and a reduction in annual sorties over the life of the PFSF. PFS Test. at 22-23.

13. It is highly unlikely that a crashing F-16 would impact the PFSF. F-16s use the airspace above Skull Valley primarily as a transition corridor to the UTTR. Typically F-16s will start a descent after turning south from over the Great Salt Lake and descend below 5,000 ft. AGL before entering the Sevier B MOA. They typically fly in pairs that spread out in a tactical formation which may be 1-2 nautical miles across. Staff Test. at 11. The typical maneuvers that F-16s may undertake while transiting Skull Valley are part of the administrative and routine categories of flight, or normal phase of flight, which are low risk (compared to aggressive combat training maneuvers in restricted areas, which is higher risk). PFS Test. at 15; Staff Test. at 12. Col. Fly testified based on his personal knowledge that the administrative and routine activities in Skull Valley consist of operations checks, to see if the aircraft is functioning properly, G-awareness turns, and "fence checks," to simulate flying from friendly airspace into enemy airspace. Tr. at 3522-24 (Fly) Aircraft Report, Tab E at 3. "G-awareness" turns, are performed to ensure that the pilots' flight suits are functioning properly and to prepare the pilots to take higher G-forces in more aggressive maneuvering on the range. Revised Addendum, Tab FF at 16-17; Tr. at 3523-24, 13030 (Fly), 13032

(Cole). Air-to-air and air-to-ground combat training does not take place in Skull Valley. Tr. at 4242-43 (Horstman).

14. Lt. Col. Horstman asserted that the activities in Skull Valley were "high risk." Horstman Test. at 9. The Chief of Safety for Air Combat Command has stated, however, that the activities that the F-16s conduct in Skull Valley (G-awareness turns and low-level flight) are not high risk. Aircraft Report Tab F; see Tr. at 8469, 13031 (Cole). On the stand, Lt. Col. Horstman initially asserted, contrary to Colonel Fly's testimony, that G-awareness turns were not administrative and routine. Tr. at 4243 (Horstman). But in his December 2000 deposition he had stated that they were. Tr. at 4250 (Horstman). Upon further cross-examination, he agreed with the Chief of Safety's statement that G-awareness turns "are not high risk" and are part of "normal operations." Tr. at 4252 (Horstman). Therefore, Lt. Col. Horstman's assertion regarding the "high risk" of the activities in Skull Valley is unsupported.

15. By far the most likely cause of an accident in Skull Valley would be an engine failure. PFS Test. at 17; see Tr. at 4250, 4501 (Horstman). Based on PFS's assessment of Air Force F-16 accident reports for each of the accidents in the period from FY1989 to FY1998 for which reports were available, in 100% of the accidents of this type, the pilot retained control of the aircraft. PFS Test. at 15; Staff Test. at 18. Air Force pilots are trained and instructed to avoid ground facilities in the event of a mishap in which the pilot can control the direction of the aircraft. PFS Test. at 15; Tr. at 3898 (Bernard). Thus, it would be highly likely that the pilot of an F-16 that had suffered an engine failure would be able to take steps, if necessary, to avoid a facility on the ground, such as the PFSF, before ejecting. Id.; Staff Test. at 20.

2. Crash Impact Hazard Calculation Method

16. Considering this flight profile, the annual probability that an F-16 transiting Skull Valley would crash and impact the PFSF can be conservatively estimated as 3.11 E-7, using the following equation based on the Standard Review Plan for Nuclear Power Plants, NUREG-0800 (PFS Exh. RRR):

$P = C \times N \times A / w \times R$, where

P = probability per year of an aircraft crashing into the PFSF

C = in-flight crash rate per statute mile

N = number of flights per year along the airway

A = effective area of the PFSF in square miles

w = width of airway in statute miles

R = a factor that accounts for the reduction in crash hazard resulting from the pilot's ability to avoid impacting the PFSF site

PFS Test. at 15; Staff Test. at 7, 16.

17. The NUREG-0800 equation does not expressly include the factor *R*. See NUREG-0800 at 3.5.1.6-3. Nor, however, does NUREG-0800 prohibit the use of such a factor, as discussed below. Here, the *R* factor was included in the formula by PFS's expert witnesses to account for pilot avoidance. PFS Test. at 15, 17-18; Tr. at 3192 (Jefferson). The addition of the R factor was based on the fact that most mishaps would leave a pilot in Skull Valley in control of his aircraft with the ability to avoid the PFSF and historically many Air Force pilots have directed their aircraft away from areas on the ground before ejecting from their crashing aircraft. PFS Test. at 17.

18. The State argued that PFS should not be allowed to use the *R* factor to account for a pilot's ability to avoid the PFSF in the event of a crash because it is not contained in NUREG-0800. E.g., Resnikoff Test. at 7-8. However, NRC Staff

witness Dr. Campe, who was one of the authors of the section of NUREG-0800 dealing with aircraft hazards, stated that the use of *R* was an acceptable way to model the fact that military pilots will try to avoid hitting inhabited or built up areas on the ground with their aircraft. Tr. at 4098 (Campe). Dr. Resnikoff acknowledged that Dr. Campe was more familiar with NUREG-0800 than he was. Tr. at 8721 (Resnikoff).

19. NUREG-0800 itself states that the formula is only "[o]ne way of calculating" the probability per year of an aircraft crashing into a facility. NUREG-0800 at 3.5.1.6-3; Tr. at 3208, 3687 (Jefferson), 4125-26 (Campe). The methodology provides for flexibility in the analysis. See Tr. at 4107-09 (Campe). For example, it allows for the consideration of factors, such as altitude and the distribution of past accidents, that are not represented by variables in the formula. NUREG-0800 at 3.5.1.6-3; Tr. at 3687-88 (Jefferson). It provides explicitly for case-by-case analysis depending on site-specific or aircraft-specific conditions. NUREG-0800 at 3.5.1.6-4; Tr. at 3688-89 (Jefferson); see Tr. at 8911-12 (Campe).

20. Furthermore, NUREG-0800 states explicitly that an applicant may propose an alternative method of analysis in lieu of NUREG-0800 if the alternative is acceptable under the Commission's regulations. NUREG-0800 at 3.5.1.6-6 to -7; Tr. at 3688-89 (Jefferson), 4105-06, 4179 (Campe).[33] Dr. Campe also testified that NUREG-0800 was largely a screening methodology, and when an applicant needed to perform more detailed analyses to demonstrate compliance with an NRC requirement, it was free to do so even though the detailed analytical methodology was not set forth in NUREG-0800. Tr. at 4126-28 (Campe).

[33] As a legal matter, NUREG-0800, an NRC standard review plan, is a guidance document that does not constitute a binding Commission regulation. E.g., Curators of the University of Missouri, CLI-95-8, 41 NRC 386, 397-98 (1995).

21. Precedence for application of an *R* factor for pilot avoidance can found in an assessment of aircraft crash hazards to nuclear power plants performed for the U.K. Atomic Energy Authority. The study stated that military aircraft crashes in which the pilot is in control of the aircraft just before impact may be excluded from the hazard to the facility based on "observed" pilot avoidance. PFS Exh. TTT (T.M. Roberts, U.K. Atomic Energy Authority, Safety and Reliability Directorate, "A Method for the Site-Specific Assessment of Aircraft Crash Hazards," (July 1987)) at 3; Tr. at 3716-17 (Jefferson); see Tr. at 3212 (Jefferson). The study judged that, for controlled crashes in which the pilots "retained enough control of the aircraft to have some influence" over the point of crash impact, only a "very small percentage" of the crashes would result in the impact of a structure. PFS Exh. TTT at 7-8; Tr. at 3717-19 (Jefferson).

22. Furthermore, all of the pilots who testified in this case, including State witness Lt. Col. Horstman, agreed that, time and circumstances permitting, a pilot of a crashing F-16 would attempt to avoid a facility like the PFSF. PFS Test. at 17; Tr. at 3194 (Jefferson), 3774-77 (Cole), 3777, 13111-12, 13127 (Fly), 3989, 3904-07 (Bernard), 3992-93, 3998-4001 (Cosby), 4229, 4512-14, 8432, 8441-42, 8502-03, 8546, 13465, 13562 (Horstman). Col. Cosby described two accidents, one his own, in which the pilots deliberately guided their crashing aircraft away from things on the ground. Tr. at 3980-81, 3999-4000 (Cosby). As discussed below, Air Force pilots are trained to direct their aircraft away from populated areas before ejecting. Furthermore, as set forth in Findings 147-148 below, the F-16 accident reports show many cases of pilots acting to avoid sites populated or built-up areas on the ground and PFS presented examples of pilots going so far as to sacrifice their lives to avoid hitting sites on the ground where people could

have been injured or killed, see Tr. at 3763-66 (Cole). While Lt. Col. Horstman asserted that PFS's assumptions regarding pilot avoidance were "unrealistic and unconservative," Horstman Test. at 15, he later admitted that that was a broad overstatement of PFS's position, Tr. at 8439 (Horstman), and that a pilot would avoid the site in a "large body" of accidents, id. at 8503. See also id. at 8432 ("[t]here are many pilots who would have an opportunity to avoid [even flying under a deck of clouds] and would avoid").

23. Therefore, pilot avoidance is an established fact. Every pilot who testified was unshakeable in his conviction that any pilot would avoid a site if time and circumstances permitted. Further, the record is clear that pilots are successful in doing so. Because pilot avoidance is an established fact, it is appropriate for PFS to model it in its crash impact probability calculations. NUREG-0800 does not bar the addition of the *R* factor to the formula therein.[34] The determination of the appropriate value of *R* is a separate question, which was the subject of much testimony at the hearing and which is the subject of a substantial portion of this decision.

24. The question also arose of how the NRC could know the value of the *R* factor in the future. Tr. at 4148-49 (Kline, J.). Dr. Campe testified that the *R* factor, along with other variables related to the crash hazard such as the aircraft crash rate, is based on historical or actuarial data and thus its value is based on what actually

[34] The question arose of whether it was appropriate to apply the *R* factor to the NUREG-0800 crash impact probability formula since most of the aircraft transiting Skull Valley would be on the east side of the valley and would never be pointed at the PFS site; thus, if one of them suffered an accident, pilot avoidance would never be an issue. Tr. at 4140-41 (Kline, J.). It was explained that the *R* factor is effectively applied only to those aircraft pointed at the site at the time of their mishaps. Tr. at 4142 (Campe, Ghosh), 4199-200 (Ghosh). For the other aircraft that were not pointed at the site and thus would not hit it, *R* was effectively taken to be zero. Id. Alternatively, the *R* factor could be seen as a modification to the crash rate, *C*, so that the crash rate would be site specific and would recognize that most of the aircraft that would otherwise hit the site would in fact avoid it. Tr. at 4183-85, 8905-07 (Campe).

happened in the past. Tr. at 4150-52 (Campe). Projection of a future value for *R* depends on correct interpretation of historical data. Id. at 4152-53. Any new information relevant to R that came to light after the facility were licensed could also be assessed by the NRC Staff as well. Id. at 4156-58. In addition, the licensee could be obligated to monitor and report crash rate and pilot performance information from the Air Force. Id. at 4159-61, 4163. Thus, the NRC Staff would become aware of any changes that occurred that would increase the risk to the facility and take appropriate action if necessary. And since the crash hazard would be much lower in the early years of PFSF operation (i.e., when only a fraction of the cask storage area was filled), the NRC Staff would have ample time to determine whether any changes were occurring that would cause the predicted crash hazard to increase.

3. F-16 Crash Rate

25. The crash rate per mile for the F-16 flight, *C*, was calculated from Air Force data to be 2.736 E-8 per mile. PFS Test. at 16; Staff Test. at 13. This represents an average of the Class A and Class B mishap rates[35] over the 10-year period from FY 89 to FY 98 for the F-16 in normal flight operations, i.e., flight not involving takeoff or landing or aggressive maneuvering on a training range. Aircraft Report at 10-11, Tab D; PFS Test. at 16; Staff Test. at 12-13. PFS selected the 10-year average to minimize the effect of statistical fluctuations from year to year and to capture the most recent, and thus most relevant, period at the time the analysis was first conducted. Aircraft Report at 11; Tr. at 3362-63 (Jefferson), 3372-73

[35] The Air Force defines a Class A mishap as one in which the aircraft was destroyed or suffered more than $1 million in damage or there was a fatality. Aircraft Report at 9. A Class B mishap involves damage to the aircraft between $200,000 and $1 million. Tr. at 8862 (Cole).

(Cole); see Tr. at 3807 (Jefferson), 8894-95 (Campe).[36] Although the State's counsel suggested that PFS had chosen the "lowest" 10-year crash rate ever for the F-16, e.g., Tr. at 8843-44 (Soper), PFS chose the 10 most recent years, and hence the most relevant, at the time it did its analysis. Aircraft Report at 11; Tr. at 3362-63 (Jefferson); 3372-73 (Cole).

26. Moreover, inclusion of the crash rate data for subsequent years (FY99 to FY01) would have practically no effect on the crash rate calculated by PFS. Tr. at 3375-76, 3726-33 (Jefferson); PFS Exh. UUU; PFS Test. at 27. Focusing just on Class A mishaps, as of FY98, the 10-year average crash rate was 3.54 mishaps per 100,000 flight hours. The 10-year Class A mishap rate went up slightly to 3.67 and 3.64 for the ten years ending with FY99 and FY00, respectively. However for FY 2001, the 10-year Class A mishap rate fell to 3.53, slightly below that for the 10 year period used by PFS. PFS Test at 27. Similarly, the most recent 10 year crash rate for destroyed aircraft (3.37 per 100,000 flight hours) is slightly below that for the 10-year period used by PFS (3.46 per 100,000 flight hours). PFS Exh. UUU. Taking an average for the last 13 years, the rates for both Class A mishaps and destroyed aircraft are within two percent of the rates for the 10-year period used by PFS. Id. Thus, the inclusion of recent data since PFS computed its crash rate would have little or no impact on the analysis.[37]

27. The State claimed that the crash rate relevant to Skull Valley will go up in the future because the F-16 crash rate is going up due to the "bathtub effect" related

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[36] As of FY98, the 10-year average crash rate for the F-16 was 3.54 Class A mishaps per 100,000 flight hours; the 5-year average was 3.08 per 100,000 hours; and the lifetime rate was 4.38 per 100,000 hours. Aircraft Report Table 1.

[37] Further, the crash rate used by PFS is significantly conservative because it is based on Class A and Class B mishaps, and not destroyed aircraft. See Finding 36, infra.

to the aging of the aircraft. See Resnikoff Test. at 9.[38] While State witness Dr. Resnikoff claimed that the F-16 was exhibiting the "bathtub effect" and that its crash rates were going up, it was shown on cross-examination and in the NRC Staff's rebuttal testimony that Dr. Resnikoff had selected his period of analysis in a biased manner so as to manufacture an upward trend in rates. See Tr. at 8750-77, 8782-88, 8806-13, 8817-18 (Resnikoff), 8886-92, 8899-8903 (Campe/Ghosh); see also Tr. at 3392-93, 3735-38 (Jefferson).[39] Furthermore, even Lt. Col. Horstman admitted that accident rates appeared to have been level over time since the mid-1980s and that the F-16 was not currently exhibiting an end of life bathtub effect. Tr. at 4376-77 (Horstman); see State Exh. 52.

28. In fact, careful examination of F-16 crash rates, in particular that of the F-16A which is the first of the F-16 models to be retired from service, as well as the crash rates of other recently retired fighter aircraft at the ends of their service lives shows no end-of-life bathtub effect. The crash rates have remained the same near end of life or decreased with time. Tr. at 3376-77 (Jefferson); PFS Test. at 28-31; PFS Exhs. Q, R, S, T, U, V. State witnesses Dr. Resnikoff and Lt. Col. Horstman did not examine the crash rate trends exhibited by other fighter aircraft, nor challenge in rebuttal the analysis of PFS's experts. Tr. at 8754-55 (Resnikoff), 4381 (Horstman).

29. Particularly instructive is the end of life crash rate for the F-16A. Lt. Col. Horstman stated in his December 11, 2000 deposition that he believed the F-16A would illustrate the bathtub effect that he expected the subsequent models of the

[38] The basis for Dr. Resnikoff's claim that the bathtub effect existed with respect to the F-16 was the testimony of Lt. Col. Horstman. Tr. at 8725-26 (Resnikoff).

[39] Dr. Resnikoff also misstated the trend in accident rates by using Class B mishaps, which do not result in an aircraft crashing into the ground. See Tr. at 8733, 8744, 8747-50 (Resnikoff).

F-16 to exhibit. See Tr. at 4378-80, 4383 (Horstman). The F-16A was the first model of the F-16. Most of them have now been retired. PFS Test. at 28-29. Over the past five years, the five-year and 10-year average accident rates for the F-16A have remained flat. Id. at 29; PFS Exh. R. Thus, the F-16A is not exhibiting a bathtub effect and there is no reason to believe that other models of the F-16 will exhibit a bathtub effect. PFS Test. at 29.[40]

30. The State claimed further that the crash rate for the aircraft that will replace the F-16 in the future, most likely the F-35 Joint Strike Fighter ("JSF"), will be higher in the beginning of its lifetime. Horstman Test at 14. Thus, Lt. Col. Horstman argued for the use of the lifetime crash rate of the F-16 as an average for the PFSF, including the early years when the crash rate was very high, as a surrogate for the presumed high early crash rate for the JSF. Id.[41] However, PFS's expert panel convincingly explained why the JSF's crash rate, assuming it were to come to Hill AFB, would be significantly lower than the crash rate of the F-16 early in its lifetime.

31. First, over the history of the Air Force, the aggregate crash rate has steadily decreased over time. Tr. at 8656 (Fly); PFS Exh. 82. For example, Air Force-wide destroyed aircraft rates in 1998 were approximately four times lower than they were 35 years ago. See PFS Exh. 82. Lt. Col. Horstman acknowledged in this respect that "typically every few years" the Air Force crash rate goes down

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[40] Lt. Col. Horstman never examined the crash rate data for the F-16A to see whether it would support his theory, though he had stated his intent to do so in his December 11, 2000 deposition. Tr. at 4381-82, 4383-85 (Horstman).

[41] Dr. Resnikoff argued for the use of a lifetime crash rate based on analysis of crash rates of a variety of civilian aircraft for the Three Mile Island nuclear power plant, Tr. at 8710-12 (Resnikoff); see Resnikoff Test. at 10, but that analysis was not relevant to the crash rate or the crash rate trend exhibited by Air Force F-16s. See Tr. at 8714-15 (Resnikoff); see also Tr. at 8813-17 (Resnikoff).

because "they build better planes." Tr. at 4398-99 (Horstman).[42] In addition, better pilot selection and training, better maintenance practices and procedures, and better analytical tools and better technology are further factors that have resulted in the continual reduction of military aircraft crash rates over time. PFS Test. at 32; Tr. at 3370-71 (Cole), 4398-99 (Horstman).

32. Second, approximately 35 years will elapse from the introduction of the F-16 in 1975 to the planned introduction of the JSF in 2010.[43] The increased skill and technology in designing better aircraft, the improved maintenance practices and procedures, and the better pilot selection and training over these 35 years will result in a lower crash rate for the JSF than for the F-16. Tr. at 3369 (Jefferson), 3370-71, 3377-78 (Cole); Tr. at 4398-4401 (Horstman). This expectation is strongly supported by the history of single engine jet fighter aircraft, which shows that initial crash rates for single engine jet fighters have steadily decreased over time. Tr. at 3370-71 (Cole); see also Aircraft Report, Figure 2.

33. Third, it would be particularly inappropriate to use the lifetime crash rate average for the F-16, including the early years when the crash rate was very high, as a surrogate for the presumed high early crash rate for the JSF, as suggested by the State, because the F-16 was originally a technology demonstration program. The origination of the F-16 as a technology demonstration program led it to have

[42] Lt. Col. Horstman attempted to dismiss this trend by saying that, "if you predict in 10 years in the future, they'll have minus 200 crashes." Tr. at 4403 (Horstman). No one, however, had suggested attempting to fit a straight line to the trend in Air Force crash rates from 1947 to the present.

[43] The F-16 was introduced in 1975. See Aircraft Report, Table 1. It is anticipated that the JSF will be introduced with the Marine Corps in 2010. PFS Test. at 33.

higher initial crash rates than one would expect from a more traditionally managed program like the JSF.[44] Tr. at 8657 (Fly).

34. Fourth, Hill AFB would not receive the first JSF aircraft, which would be expected to experience the somewhat higher initial crash rates of a new aircraft. The Marine Corps will receive the JSF before the Air Force and the first Air Force JSFs will likely be deployed at a training base, not Hill AFB. Tr. at 8656-57 (Fly); see Tr. at 3372 (Cole).[45] Furthermore, initial crash rates are based on fewer accidents and lower numbers of flying hours, both of which would translate into lower numbers of flights through Skull Valley. PFS Test. at 32.

35. For all of these reasons, we believe that use of the lifetime crash rate average for the F-16, including the early years when the crash rate was very high, as a surrogate for the presumed high early crash rate for the JSF would be inappropriate. The current F-16 crash rate more accurately represents the future crash rate for the JSF as it might replace the F-16 at Hill AFB.

36. Additionally, PFS's estimate of the crash rate for the F-16 is conservative, in that it used a crash rate that included not only destroyed aircraft, but also Class A and B mishaps in which no aircraft was destroyed. PFS Test. at 111; Aircraft Report at 25; id. Tab H at 4 n.8.[46] If an aircraft was not destroyed in a mishap, the mishap does not represent an event that could have posed a hazard to the PFSF, which consists of hardened concrete and steel structures. Tr. at 3731

[44] Lt. Col. Horstman attempted to compare the JSF with the V-22 Osprey tilt-rotor aircraft which has experienced a number of crashes in its development. Tr. at 4389 (Horstman). The crashes of the V-22, however, are related to its tilt-rotors, which are new technology and which will not be present on the JSF, the Air Force version of which will be a conventional jet-powered fighter aircraft. Tr. at 8657-58 (Fly); see Tr. at 4393-94 (Horstman).

[45] Dr. Resnikoff agreed that the crash rate relevant to the PFSF is that exhibited when the aircraft would be at Hill AFB, not earlier. Tr. at 8730 (Resnikoff).

[46] See note 38, supra.

(Jefferson).[47] Indeed, Class B mishaps do not represent instances where the F-16 struck the ground. Tr. at 8733-34 (Resnikoff), 8862-63 (Cole). Since, in the 10 years from FY 89 to FY 98 there were 162 Class A and Class B mishaps but only 139 destroyed aircraft, the crash rate is overstated by 16.5 percent. PFS Test. at 111. In other terms, the crash rate based on destroyed aircraft is about 14 percent lower than PFS's calculated rate. Thus, the Skull Valley F-16 crash rate would be reduced from 2.736 E-8 per mile to 2.35 E-8 per mile.

37. Therefore, for the foregoing reasons, we find that PFS has used a reasonable conservative crash rate for the F-16 and its potential future replacement that may transit Skull Valley.

4. PFSF Effective Area

38. Given the flight characteristics and dimensions of the F-16, the effective area of the PFSF where the storage casks are located (including the Canister Transfer Building) is 0.1337 sq. mi.. This assumes a facility at full capacity with 4,000 spent fuel storage casks on site. PFS Test. at 16; Staff Test. at 27-28. This effective area accounts for the possibility that an aircraft impacting in front of the facility could skid into it and the possibility that an aircraft that would otherwise impact just beyond the facility would hit an elevated structure at the facility.

39. PFS's hazard calculation is conservative in that it assumes that the facility is at full capacity, a status that may never be reached. According to the crash impact probability equation above, the crash impact probability is directly proportional to the site effective area. Since the cask storage area makes up nearly 95 percent of the facility's effective area, Aircraft Report at 16, the effective area and the

[47] Chris Y. Kimura et al., Data Development Technical Support Document for the Aircraft Crash Risk Analysis Methodology (ACRAM) Standard (Aug. 1, 1996) (State Exh. 51) at 4-5.

impact probability are nearly directly proportional to the number of casks on site. Because of the planned loading and unloading schedule for the facility, its time-weighted average effective area is only about 55 percent of its full effective area. PFS Test. at 113; Aircraft Report at 25-27. Thus, the time-weighted average crash impact probability would also be 55 percent of its peak value. PFS Test. at 113.

40. By the same token, because the hazard is proportional to the number of casks, the crash impact hazard to a facility that contained fewer than 4,000 casks would be reduced proportionally. Tr. at 4084-85 (Campe); see Tr. at 8788-90 (Resnikoff). Thus, for example, the crash impact probability for a facility storing only 2,000 casks would be approximately half of the probability for the facility with 4,000. Tr. at 4085-87 (Campe).

41. The relationship between the crash impact hazard and the number of casks makes this approach to calculating the hazard conservative in another respect as well. By the time the PFSF is full, the USAF should be well into delivery of the Joint Strike Fighter, the replacement for the F-16 as discussed below. PFS Test. at 23. Because the Air Force will replace the F-16 on a less than one for one basis, the new aircraft will likely result in fewer sorties through Skull Valley and hence, by the time the PFSF is full, a lower hazard than what is calculated here. Id.

5. Skull Valley Effective Airway Width

42. The Air Force has consistently advised PFS that the predominant or preferred route of flight for F-16s transiting Skull Valley is approximately five miles to the east of the proposed PFSF site. PFS Test. at 16, 44; Staff Test. at 27; Tr. at 3397 (Cole). This stated preference is consistent with Col. Fly's testimony that he typically flew about four miles east of the site in a south-southeasterly direction.

Tr. at 3422-24 (Fly). Further, this preferred route is a logical result of the natural configuration of the MOA and the restricted airspace to its west which serve to naturally funnel the F-16 traffic in Skull Valley away from the PFSF toward the eastern side of the valley and the narrow seven mile wide neck in the MOA southeast of the PFSF site. PFS Test. at 44; Aircraft Report, Tab A; PFS Exh. P.[48]

43. Nevertheless, PFS conservatively assumed for purpose of its calculations that the Sevier B MOA could be treated like an airway and that the F-16s were evenly distributed across the width of the Sevier B MOA, from the Stansbury Mountains in the east to the edge of restricted airspace in the west. The width, *w*, of this hypothetical airway was chosen to be 10 statute miles based on the useable airspace in the Sevier B MOA through which the F-16s could fly at the latitude of the PFSF.[49] PFS Test. at 16, 43; Staff Test. at 27. For F-16s flying above the Sevier B MOA (i.e., above 9,000 ft. MSL/4,400 ft. AGL), the width of the useable airspace would the full 12 miles. See Tr. at 3795 (Jefferson). Using an airway width of 10 miles for the purpose of analysis is conservative, in that it assumes overflights of the PFSF site that in fact would not occur. Therefore, it assumes that aircraft would be in a position to potentially hit the PFSF in the event of a crash when in fact they would not. Tr. at 3443-52 (Jefferson), 4207 (Campe); see PFS Test. at 16; Staff Test. at 26.[50]

[48] At the northernmost end of the MOA, approximately 10 miles to the north of the PFSF, the MOA is 17.0 miles wide. Ten miles to the south of the PFSF the MOA narrows to its narrowest width, 7.1 miles wide. PFS Test. at 44; see PFS Exh. KKK (map). The terrain within the MOA at its narrowest width ten miles south of the PFSF is basically flat and the entire width of the MOA at this latitude is usable airspace. Hence, within a north-south distance of 20 statute miles, the MOA has narrowed to the east by almost 10 statute miles. This configuration serves to naturally funnel F-16 traffic in Skull Valley toward the eastern side of the valley. PFS Test. at 44.

[49] The Hill AFB staff made clear in an October 2001 memo to the NRC Staff that there are no buffer zones inside the Sevier B MOA. Tr. at 3427-28 (Jefferson).

[50] The NRC Staff had requested that PFS spread the aircraft across the width of the valley and the height of the Sevier B MOA for the purpose of analysis. Tr. at 3792-94 (Jefferson), 4107 (Campe).

44. Further, if one treats the MOA as an airway, the most relevant width of the MOA is actually north of the site, in that an aircraft that suffered an engine failure and was pointed at the site would have to glide some distance before impacting it. Tr. at 8645-46 (Jefferson). North of the site the MOA is wider, expanding to a useable width of 11 miles at a point three miles north, where an aircraft would have to be at the recommended ejection altitude of 2,000 ft. if it were to glide into the site. Id.

45. The State advanced a number of evolving theories as to why PFS should have used a smaller effective airway width in its calculations. The first theory was that pilots would use the PFSF as a turn point and as a reference to update their navigational instruments and hence they would deliberately fly at the PFSF while transiting Skull Valley. Horstman Test. at 8. Nevertheless, pilots do not do that today – the PFSF does not exist – and there is no need for them to do it if the facility is built. PFS Test. at 37-39. Using the PFSF as a turn point would merely be a matter of convenience. Tr. at 8565-66 (Horstman). Thus, given the sensitivity of the PFS facility, it is difficult to accept that Air Force pilots would deliberately change their current practice so as to fly over the PFSF more frequently. See Tr. at 3906-08, 3928-30 (Bernard).

46. Moreover, pilots routinely perform administrative tasks while transiting Skull Valley and the construction of the PFSF would provide no reason for them to change their routine. PFS Test. at 36-38. In addition, the Stansbury and Cedar Mountain ranges on either side of Skull Valley now provide excellent visual references for maintaining positional awareness and other cultural, man-made features in Skull Valley can be use for navigational turn points or sensor alignment if desired. Id. at 37-39. Furthermore, the configuration of the Sevier B

MOA tends to funnel the F-16s' flight paths in a southeasterly direction, away from the PFSF toward the narrow neck of the MOA east of English Village. Id. at 36, 38-39. Finally, if a pilot did use the PFSF as a steer point, its location would be programmed into the aircraft's avionics, which could project an image representing the facility on the aircraft HUD and make it easier to locate in the event of an emergency. Tr. at 8418-20 (Horstman).

47. The State's second theory was that F-16s transiting Skull Valley observe buffer zones on both sides of the MOA such that aircraft would stay one mile east of the restricted area to the west of the PFSF and one, two, three, or five miles west of the Stansbury Mountains or the MOA's boundary to the east. Horstman Test. at 6-7; Tr. at 8571, 8613-14 (Horstman).[51] However, the Hill AFB staff has stated that there are no buffer zones inside Sevier B MOA (although there are buffer zones inside the restricted areas on the UTTR). Note 66, supra. There are also no written instructions or guidelines to maintain the distance from the mountains asserted by Lt. Col. Horstman. Tr. at 4343 (Horstman). Indeed, Lt. Col. Horstman testified that not all flights maintained the same distances from the

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[51] The testimony of Lt. Col. Horstman on the distance that he would maintain from the eastern edge of the MOA was riddled with inconsistencies. At one point in his cross-examination he was asked whether he "always kept the furthest eastern ship no closer than five miles from the eastern boundary of the MOA" (as he had stated in his pre-filed testimony at 6), to which he replied:

> No. I allowed my wingman to go over to – and there's no real definition. I didn't want him to go to the top of the mountains. A mile or two from the eastern edge, I would let my wingman go that far.

Tr. at 8571 (Horstman) (emphasis added). Upon redirect by State counsel, Lt. Col. Horstman suggested that this mile or two guidance was meant to be from the Stansbury Mountains and not the "eastern edge" of the MOA as he had stated in his previous answer. Tr. at 8593-95 (Horstman). Upon further cross-examination, he then opined that the distance from the eastern boundary of the MOA that he would observe varied from approximately three miles at the 11,031 ft peak of the Stansbury somewhat to the north of the PFSF (see PFS Exh. P) to about two miles at the 6,515 ft peak to the south of the PFSF (see PFS Exh. P). Tr. at 8613-14 (Horstman). He confirmed that both these distances were from the MOA boundary. Id. Regardless of whether Lt. Col. Horstman's first answer of a "mile or two from the eastern edge" of the MOA or his second answer of two to three miles from the MOA boundary is correct, both are less than the "5 miles from the eastern boundary of the Sevier B MOA" claimed in his pre-filed testimony.

edges of the MOA. Tr. at 8571-73 (Horstman). Col. Fly testified that his experience while flying in Skull Valley was that the aircraft closest to the Stansbury Mountains would fly within a couple thousand feet of mountains, which he stated "was fairly standard" practice for other mountainous terrain in which he had flown. Tr. at 8648 (Fly).

48. Further, Lt. Col. Horstman's pre-filed testimony is inconsistent with his hearing and deposition testimony regarding the flight path of the F-16s. His pre-filed testimony states that "the natural and typical flight path of an F-16 formation is essentially down the middle of Skull Valley with part of the formation flying over or near the proposed PFSF site." Horstman Test. at 6. Indeed, the airway width of six miles at the latitude of the PFSF claimed in Lt. Col. Horstman's pre-filed testimony would be centered on Skull Valley road.[52] In his December 11, 2000 deposition, however, Lt. Col. Horstman testified that the predominant route of flight for typical two-aircraft or four-aircraft formations would place all of the aircraft east of Skull Valley Road. Tr. at 4344-45 (Horstman).[53] Lt. Col. Horstman reaffirmed his deposition testimony at the hearing. Id. His hearing and deposition testimony is in general accordance with the Air Force's statements that the predominate route of flight down the valley is about five miles to the east of the PFS site, rather than the center of the valley. PFS Test. at 14; Tr. at 3397,

[52] The western edge of the MOA is approximately two miles to the west of the PFSF which is approximately two miles west of Skull Valley road. PFS Test. at 43; see Aircraft Report Tab A (map). Therefore, at the latitude of the PFSF, an airway of six miles width that is one mile from western boundary of the MOA and five miles from the MOA's eastern boundary would be centered on Skull Valley Road. See Figure 1 after page 6 of Aircraft Report.

[53] F-16s typically fly in Skull Valley in formations of two, with both aircraft abreast of each other and about 1.5 to two miles apart. Tr. at 4351 (Horstman); see Tr. at 4344-46, 4353-54 (Horstman). Formations of four would consist of two formations of two, with the second formation some distance behind and perhaps some distance laterally offset from the first group. See Tr. at 4344-46 (Horstman); see also Revised Addendum, Tab GG, Question 7.

3402-04 (Cole); see Tr. at 3422-24 (Fly). Lt. Col. Horstman's pre-filed testimony is not.

49. The State's third theory was that pilots would perform G-awareness turns so as to point directly at the site while they were headed to the west, between their first and second turns. See Tr. at 4359-66 (Horstman). However, G-awareness turns could be and are performed at a number of different places in Sevier B MOA. Lt. Col. Horstman himself stated that he had performed such maneuvers from the point at which he entered Sevier B MOA to a point 40 miles to the south. Tr. at 4362-63 (Horstman).[54] Moreover, Lt. Col. Horstman's hearing testimony that based on his "experience, . . .generally speaking" G-awareness turns would occur such that aircraft would be pointed "directly towards the PFS site" and fly "right over the site" (id. at 4361-63) is directly contradicted by Lt. Col. Horstman's December 2000 deposition. There, Lt. Col. Horstman stated: "Generally, the G-awareness maneuver would come after you pass south of the proposed site." Tr. at 8542 (Horstman); see PFS Exh. 99 at 105.[55] Thus, we do not find that G-awareness turns would draw a significant fraction of the F-16s over the PFSF site.[56]

[54] Lt. Col. Horstman also stated that the second turn in the G-awareness maneuver could be performed within 10 seconds of the first, which would not put the aircraft over the PFS site, even if the pilots commenced the turn at the point he described. Compare Tr. at 4361-63 (Horstman, 60 second delay puts wingman over PFS site) with Tr. at 4366 (Horstman, 10 second delay).

[55] On redirect, Lt. Col. Horstman sought to justify the differences between his deposition testimony and his hearing testimony by saying his hearing testimony was based on subsequent conversations with Hill AFB F-16 pilots who stated that "they do [G-awareness maneuvers] before [south of the proposed site] now." Tr. at 8591-92 (Horstman). However, contrary to his explanation on redirect, Lt. Col. Horstman stated during his hearing testimony that the location of the g-awareness turns as he had described them to the Board was based on his personal experience of "my hundred or so flights down Skull Valley in an F-16," not on subsequent discussions with Hill AFB pilots following his December 2000 deposition. Tr. at 4362 (Horstman).

[56] We note, as discussed above, that PFS's and the Staff's calculations assume that the aircraft are evenly distributed across the MOA, rather than located predominantly on the east side of Skull Valley, and hence more overflights of the PFSF site are analytically predicted than actually occur.

50. The fourth theory advanced by the State at the hearing was that pilots would tend to point toward the PFSF because if they suffered an engine failure in Skull Valley they would immediately head for Michael AAF and hence they would fly over the site. E.g., Tr. at 13369 (Horstman). However, in order to pose a threat to impact the PFSF, an F-16 would have to suffer its engine failure roughly 17 miles north of the site, at the very north end of Skull Valley. See Tr. at 4511 (Horstman, discussing hypothetical F-16 engine failure at Timpie Springs at 425 knots and 3,000 ft. AGL). At that point, the aircraft would be about 30-35 miles away from Michael AAF with no way of getting there without restarting its engine,[57] and would need to fly over the Cedar Mountains to reach Michael AAF. Thus, Col. Fly testified that in such a situation he probably would head for lower terrain so as to maximize the time aloft and the time he would have to remedy his problem. Tr. at 3552-53, 13656-57 (Fly). This would not involve heading for the higher terrain of the Cedar Mountains as suggested by Lt. Col. Horstman. Indeed, since the PFSF is approximately 17 miles from Michael AAF, a pilot would have to be directly over or beyond the PFSF, at which point it would not be an hazard to the PFSF, before a pilot could reasonably contemplate reaching Michael AAF with an engine failure.

51. Lt. Col. Horstman's testimony that pilots would invariably turn toward Michael AAF upon the first hint of trouble is also inconsistent with much of his other testimony on the record. In discussing one of the F-16 accident reports in which a pilot suffered an engine failure and spent some time attempting to restart his engine, Lt. Col. Horstman stated that because the aircraft was 20 miles from where it would impact, he would expect the pilot to be focused on solving his

[57] Michael AAF is located 17 miles south-southwest of the PFSF. PFS Test. at 98.

engine problem at that point. Tr. at 13384 (Horstman). "We're nowhere near the thinking about ejecting, or thinking about emergency airfields . . . ." Id. In discussing another report, he criticized a pilot for making an "egregious . . . error" by attempting to reach an emergency airfield without having an engine functioning well enough to do so. Tr. at 13385-87, 13460-61 (Horstman). Lt. Col. Horstman stated that the pilot should have ejected over the Gulf of Mexico instead of trying to reach the airfield. Tr. at 13385-86 (Horstman).[58]

52. Finally, even if the State's premise about immediately turning toward Michael AAF were accepted, it would not affect the width of the airway for those flights experiencing mishaps that did not leave the pilot in control of the aircraft. In those cases, the pilot would not be able to maneuver, either toward Michael or away from the PFSF. See Aircraft Report at 7-8 (out of control accidents require pilot to eject quickly). Under PFS's analysis, potential crashes in which the aircraft would not be under the pilot's control account for more than two-thirds of the hazard to the PFSF for F-16s transiting Skull Valley.[59]

53. As discussed above, PFS's assumption that the F-16s are spread out across the Sevier B MOA (rather than located predominantly on the east side of Skull Valley) is conservative because it assumes that more F-16s will fly over the PFS site than actually do. The State's claims regarding the effective width of the valley are undermined by information provided by the Air Force which

[58] We also note that Lt. Col. Horstman's January 2001 Declaration states that in the event of an emergency the pilot would look for a place to safely eject and, "[g]iven sufficient time . . . would aim for a flat spot such as the center of Skull Valley." Declaration of Lt. Col. Hugh L. Horstman, Air Force (Retired) in support of State of Utah's Response to PFS's Motion for Summary Disposition of Contention Utah K and Confederated Tribes B (January 30, 2001) at ¶83.

[59] The value of R attributable to aircraft under control after their mishaps is 0.045, while the value of R attributable to aircraft out of control is 0.1. Therefore, the fraction of the total Skull Valley F-16 hazard posed by aircraft out of control is 69 percent, while the fraction posed by aircraft under control is 31 percent. Aircraft Report at 23-25.

contradicts the State's claims, as well as significant inconsistencies in the State's testimony. Even if the State's testimony were not contradicted, we find that it does not overcome the inherent conservatism in PFS's analysis. Therefore, we find that 10 miles is a reasonable value to use for the effective airway width of Skull Valley.

6. Number of F-16 Flights

54. PFS projected the number of flights per year along the airway, *N*, to be 5,870 flights for future years. That number is based on an average of the annual number of F-16 sorties through Skull Valley for FY99 and FY00, increased proportionately for additional aircraft stationed at Hill AFB beginning in FY01. We find this number is a conservative projection of future traffic density particularly when the PFSF would be approaching its maximum capacity.

55. The Air Force had stated to PFS that the Sevier B MOA usage reports are representative of the number of F-16 flights through Skull Valley. Revised Addendum at 2-5 & n.7; see Tr. at 3355-56 (Jefferson). Based on the Sevier B MOA usage reports provided by the Air Force to the Federal Aviation Administration ("FAA"), in FY99, 4,250 F-16s transited Skull Valley and in FY00, 5,757 F-16s transited Skull Valley. PFS Test. at 18. This is an annual average of approximately 5,000 flights. PFS Test. at 18; Staff Test. at 10.

56. The number of F-16 flights through Skull Valley in FY99 and FY00 reflects current Air Force operations and the normal fluctuations in the number of sorties flown annually. PFS Test. at 18. There are several reasons for the higher number of Skull Valley sorties in FY00. First, the Air Force experienced fewer overseas deployments of aircraft (which take them away from their home bases) in FY00. The Air Force formally adopted the Air Expeditionary Force ("AEF") concept,

which began a new policy for overseas and other deployments of Air Force units away from their home bases, and initially implemented it in October 1999 (FY00). PFS Test. at 18-19. The AEF's purpose is to make more equal and regular the on-going deployment of Air Force units from their home bases of operations which reduces the amount of time spent away from the home base of operations. Id. The net effect relevant here was to generally increase the amount of training time available for units at their home bases when they are not deployed relative to what they had prior to FY00.

57. Another reason that fewer aircraft were deployed overseas in FY00 was that deployments to areas like Bosnia, Kosovo, and the Persian Gulf tapered off toward the end of FY99. Id. During FY00, United States military forces were not involved in a major international crisis. Id. During such a crisis the F-16s based at Hill would be expected to be deployed and in such instances the number of UTTR sorties in future years would likely be lower than those in FY00. Based on past history and the current war on terrorism, it is reasonable to expect periodic unscheduled future deployments and an associated lower sortie count at Hill.

58. In addition to overseas deployments tapering off during FY00, another reason for the higher number of Skull Valley sorties in FY00 was that the 388th Fighter Wing significantly increased its sortie count from its available aircraft, and achieved the highest sortie rate per aircraft of any F-16 wing. Id. Since the 388th Fighter Wing was doing what it could to maximize its sortie rate in FY00, it has little leeway to increase the rate even more. Id. The historic trend of fluctuations in sortie rates makes it unreasonable to expect the number of sorties to continue indefinitely at the maximum or near-maximum rate achieved by the 388th Fighter Wing in FY00. The substantial decrease in sorties in FY01, discussed below,

confirms that it would be unreasonable to project future flights based on a single year of high sortie rates. Thus, we find that the average sortie counts for FY99 and FY00 provide a reasonable baseline for estimating future sortie counts in Skull Valley.

59. To project the future number of annual flights, the average of the FY99 and FY00 sortie counts of 5,000 is increased proportionately to 5,870 flights to reflect the authorized increase in the number of F-16s at Hill AFB in FY01. The combined number of F-16 aircraft (active plus reserve) assigned to the 388th Fighter Wing and 419th Reserve Wing at Hill AFB has increased in FY 01 from 69 (54 for the 388th + 15 for the 419th) to 81 (66 for the 388th + 15 for the 419th), for an increase of 17.4%. PFS Test. at 20; Staff Test. at 10. Assuming the same Skull Valley sortie rates per F-16 as determined above, the 12 additional F-16s would also increase the number of F-16 sorties through Skull Valley by 17.4%. Id. at 20-21.[60]

60. It is reasonable to assume that the number of F-16 sorties transiting Skull Valley would increase in proportion to the number of F-16s based at Hill AFB. As the number of F-16 aircraft assigned to the 388th FW increases, the number of pilots, maintenance personnel, flying hours and support funding will also increase proportionally. PFS Test. at 21. These are determining factors in the number of sorties flown and a change in them will result in a corresponding change in sorties flown. Id. Since the squadrons at Hill AFB all have similar training requirements, they tend to fly similar schedules in terms of airspace usage and mission types (simulated air-to-air combat, medium altitude surface attack, low

[60] The average number of reserve aircraft in recent years is closer to 17 than the 15 assumed above. PFS Test. at 21. Therefore, the relative increase in the number of F-16s at Hill resulting from the addition of 12 active aircraft is lower, closer to 16.8%. Id.

altitude navigation and bombing, etc.). Id. As a result, total flights through Skull Valley will tend to change with changes in the total number of F-16s at Hill AFB.

61. Fiscal year 2001 data on the number of flights through Skull Valley support the foregoing approach for projecting future sortie counts. According to the Sevier B MOA usage report for FY01, 5,046 flights transited Skull Valley. Tr. at 13019 (Cole). If that total were adjusted to account for the effect of the additional F-16s at Hill being there the entire year (as opposed to the half year they were present), the total would have been 5,435. Tr. at 13019-20 (Jefferson). This is well below the PFS projection of 5,870. Id. at 13017, 13020.

62. Additionally, over the life of the PFSF, future traffic density of military aircraft operating in the vicinity of the PFSF will be determined, for the most part, by the future structure of the U.S. Air Force and tempo of U.S. Air Force operations. The long term trend in the USAF force structure is to replace aging aircraft with fewer, more capable and more reliable aircraft, which would reduce the number of sorties and the risk of accident per sortie correspondingly. PFS Test. at 22. PFS's experts expect this general trend to continue and to affect Hill AFB equally as the existing USAF aircraft inventory is replaced with fewer, more modern, capable and reliable aircraft over the life span of the proposed PFSF. Id.

63. In this respect, the JSF, a stealth-type aircraft currently in research and development, is the planned replacement for the F-16. PFS Test. at 22-23. The total planned USAF buy over the life of the airplane is 1,763 aircraft, which is only 78% of the 2,230 F-16s ordered by the USAF. Id. The PFSF would not approach full capacity until close to 20 years into its operational life at which time the Air Force should be well into delivery of the JSF. See Finding 43, supra. However, the calculated aircraft crash probability for the PFSF using the average

of the FY 99 and FY 00 sortie counts is based upon the Facility being at full capacity and does not assume any Air Force downsizing or modernization. Thus, the Air Force's long-term modernization program that would, following current trends and expectations, result in a significant downsizing and a likely reduction in total annual sorties will in all likelihood result in PFS's calculated hazard for the PFSF being even more conservative.

64. Lt. Col. Horstman asserted that PFS should have used only the FY00 sortie count as a baseline to estimate the future number of sorties in Skull Valley and that PFS should have added the Sevier B and Sevier D MOA counts together. Horstman Test. at 12.[61] Increasing this sum by 17.4% to account for the additional F-16s deployed at Hill would result in a sortie count projection of 7,040. Id. This testimony is, however, inconsistent with Lt. Col. Horstman's July 2001 deposition where he stated that taking an average of the FY99 and FY00 sortie counts appeared to be a "logical, sound way" of estimating sortie counts for the future. Tr. at 8521-22 (Horstman).[62] Lt. Col. Horstman also does not account for the absence of large overseas deployments in FY00,[63] the 388th FW's maximizing its sortie rate for FY00, which would not be sustainable indefinitely, and the smaller number of aircraft projected for the Air Force in the future. See PFS Test. at 26. The unreasonableness of using the atypically high sortie rate of FY00 as

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[61] State witness Dr. Resnikoff made the same assertions, but the bases for them were the testimony of Lt. Col. Horstman. Tr. at 8722, 8726 (Resnikoff).

[62] Lt. Col. Horstman acknowledged that he knew of no plans to expand Hill AFB, add further F-16s to the base, or increase the number of sorties flown through Skull Valley. Tr. at 8566-67 (Horstman).

[63] Lt. Col. Horstman asserts that the Air Force AEF concept was implemented in FY97, Horstman Test. at 11-12, but those early AEF deployments were experimental and the first Air Force-wide implementation of the AEF concept did not begin until FY00. Tr. at 8652-55 (Fly).

the basis for future projections is demonstrated by the FY01 sortie count which was somewhat below the average of the FY99 and FY00 sortie counts.[64]

65. Further, it would be unreasonable to use the combined Sevier B and Sevier D sortie counts as the basis for future projections as argued by Lt. Col. Horstman. As discussed above, the Air Force has stated that the Sevier B sortie count is representative of the traffic through Skull Valley. The Sevier D MOA airspace does lie directly above Sevier B. However, because the Sevier B and Sevier D MOAs extend to the far southern edge of the UTTR, nearly 100 miles from the PFSF, both Sevier B and D MOA sortie counts include aircraft entering the UTTR from the south, such as bombers and aircraft conducting cruise missile tests, that never enter Skull Valley. Revised Addendum at 4; Tr. at 3355-56 (Jefferson); see Tr. at 8523-24 (Horstman). The Sevier D counts are small, approximately five percent of the Sevier B counts. Revised Addendum at 4. Thus, taking Sevier B to be representative of Skull Valley accounts for the small number of aircraft that use the Sevier MOAs but never enter Skull Valley.

66. Based on the foregoing findings, we conclude that PFS's projection of the annual number of F-16 sorties through Skull Valley of 5,870 is a conservative basis on which to project the aircraft hazard to the PFSF.

7. The Ability of a Pilot to Avoid the PFSF in the Event of a Crash

67. PFS's expert panel of retired Air Force officers determined that a pilot's potential ability to avoid hitting the PFSF site in the event of a crash reduced the crash

[64] The FY01 count for Sevier B MOA was about 24 percent below the FY00 count for Sevier B MOA. Tr. at 13020-21 (Jefferson). The FY01 count for Sevier B plus Sevier D MOAs was about 21 percent below the FY00 count for Sevier B plus Sevier D MOAs. Id. at 13021.

impact probability by 85.5%. PFS Test. at 17-18. The probability that a pilot would avoid the PFSF in the event of a crash is equal to the product of 1) the probability that a pilot would be in control of his aircraft with time to maneuver it away and 2) the probability that the pilot would actually direct the aircraft away from the PFSF, given those conditions, before ejecting. Id. at 17; see Tr. at 3769-70 (Cole).

68. As discussed further below, the most likely cause of an accident in Skull Valley is an engine failure. Tr. at 3603 (Fly). At the altitudes and airspeeds at which F-16s fly through Skull Valley, approximately 3,000 to 4,000 ft. AGL and 400 knots, the pilot would respond to the engine failure by jettisoning ordnance and external fuel tanks, climbing roughly 2,000 to 3,000 ft., and then gliding back toward the ground at a speed of roughly 200 knots to maximize the time available to restart the engine. Tr. at 3546-55 (Fly); Aircraft Report at 18, 19b-19e, Tab U; see Tr. at 3559-69 (Fly), 4227, 4511, 13299-301 (Horstman). During that time, which would be roughly one to two minutes, the pilot would be attempting to restart his engine and would also be aware of his surroundings in the course of flying the aircraft and looking for an emergency airfield or a place to eject. Tr. at 3546-55 (Fly), 4512-14 (Horstman); Aircraft Report at 19c-19d, Tab T.[65] Over the course of the emergency, assuming the pilot did not restart the engine, the aircraft would travel roughly 17 miles. Tr. at 4511, 8473 (Horstman). At any time during that process, if the pilot saw a built up area or structure on the ground, he could direct his aircraft away from it while continuing to respond to the emergency. Tr. at 3553-55 (Fly), 4512-13 (Horstman); Aircraft Report at 19d, 20. Responding to

[65] As discussed below, the procedures for restarting the engine are relatively simple and take only a fraction of this one to two minutes. About 45 seconds would be spent waiting for the engine to spool up and attain useable thrust. See Finding 97, infra.

engine failures is something that Air Force pilots train on regularly in simulators. Tr. at 3810-11 (Fly); see also Tr. at 3812-13 (Fly, early pilot training). As Colonel Cosby testified, and as exemplified by his first-hand experience, as a result of such routine training, a pilot's actions in the event of an such emergency become virtually automatic. Tr. at 3988-89 (Cosby).

a) Fraction of Accidents Leaving Pilot in Control

69. PFS assessed the probability that a pilot would be in control of his aircraft following an in-flight emergency at 90 percent. PFS Test. at 17. PFS's panel of experienced aviators arrived at this probability by independently assessing the Air Force's FY89-FY98 F-16 accident report for each F-16 accident for which a report was available that resulted in the aircraft being destroyed. PFS Test. at 17; Aircraft Report at 16-18, Tab H. These reports covered accidents in which 121 aircraft were destroyed, out of the 139 actually destroyed in that period. Aircraft Report, Tab H at 4; Tr. at 13004-05 (Cole), 13006-08 (Jefferson).[66]

70. These accident reports were prepared under Air Force Instruction 51-503 after each aircraft mishap to determine the cause of the accident, to preserve all available evidence, to provide a complete factual summary for use in claims, litigation, disciplinary actions, adverse administrative proceedings, and for other purposes in accordance with AFI 51-503. PFS Test. at 10. The reports follow a set format which describes the circumstances surrounding the accident, including: a summary of the history of the flight, the flight mission, preflight activities and planning, the actual flight activity, crash impact information, the functioning of the emergency escape mechanism, rescue activity, maintenance and mechanical

[66] The other reports were essentially removed from the database at random, in that the Air Force stated that they were lost or never prepared. Thus the large set of reports that PFS used provides a robust statistical basis for its analysis. PFS Test. at 89-90.

factors, supervisory factors, pilot qualifications and performance, navigational aids and facilities, weather, and pertinent directives and publications. The flight activity section provides relevant information as to pilot actions after the emergency begins. Id. Each report may conclude with a statement of opinion by the investigating officer as to the cause of the accident. Id. The reports are prepared by an accident board typically chaired by a Colonel and comprised of subject matter experts, including pilots of the relevant aircraft type. Tr. at 3659-60 (Cole); see Tr. at 4033-38, 4041-42 (Cole), 4038-40 (Fly), 4040 (Jefferson). We find these reports a credible source of data to evaluate the causes of, and the pilot and aircraft responses in, F-16 accidents relevant to Skull Valley.

71. Each of the three PFS experts independently assessed each accident report in accordance with established evaluation parameters. This individual review was followed by a joint review that resolved the few differences that resulted from their individual assessments based on their combined professional judgment. PFS Test. at 58-59; Aircraft Report, Tab H at 6-7.[67]

72. Following this process, PFS's expert panel categorized each accident as (a) one that could or could not have occurred in Skull Valley (i.e., "Skull Valley-type events") and (b) one in which the pilot did or did not have control of his aircraft and time to direct it away from a site on the ground (i.e., "able to avoid"). PFS Test. at 58. PFS's assessment of whether the accident could have occurred in Skull Valley was based on whether the initiating accident event could have occurred in Skull Valley. Aircraft Report, Tab H at 11-12; see id. at 14-16; Tr. at 3957 (Fly). Thus, for example, engine failures, in almost all cases, would be

[67] The independent assessment by the three experts and the explicit assessment instructions reduces the likelihood that the analysis suffers from any statistical bias. Tr. at 8875-78 (Jefferson).

Skull Valley type events. On the other hand, mid-air collisions during mock dogfighting would not (since such dogfighting does not take place in Skull Valley). Aircraft Report, Tab H at 8; Tr. at 3856-60 (Fly).

73. PFS's assessment of whether the pilot was in control and would have time to direct his aircraft away from the PFSF was based on the specific information in the F-16 accident reports regarding each accident. PFS Test. at 59-60; Aircraft Report, Tab H at 11. An engine failure is by far the most likely cause of an accident in Skull Valley and, in every case of engine failure, PFS assessed that the pilot would have control and time to avoid a site on the ground. PFS Test. at 17; Tr. at 3770 (Cole).[68]

74. PFS ultimately found that 61 accidents during the 10-year period were Skull Valley-type events and in 58 of them, or 95 percent, the pilot retained control of the aircraft with time to direct it away from a site on the ground. Tr. at 13007 (Jefferson); see PFS Test. at 81, 88; Aircraft Report, Tab H at 14-20. Nevertheless, PFS assumed that the fraction of accidents that would leave a pilot in control of the aircraft and able to avoid a site on the ground was 90 percent. PFS Test. at 17; Tr. at 3214, 13007 (Jefferson), 3770 (Cole).[69] This assumption

[68] On the stand, Lt. Col. Horstman disagreed that engine failure would be the typical cause of an accident in Skull Valley, Tr. at 4227 (Horstman), but in his December 2000 deposition he conceded that, with the possible exception of a bird strike, engine failure would be virtually the only reason an F-16 would crash in Skull Valley. Tr. at 4250, 4501 (Horstman).

[69] PFS performed a second assessment where it evaluated only those accidents that occurred under parameters, such as speed and altitude, at which pilots fly in the Sevier B MOA ("Sevier B MOA flight conditions"). Those accidents made up a subset of the Skull Valley-type events. PFS performed the assessment to evaluate if anything peculiar to the Sevier B MOA flight environment would change its conclusion regarding the fraction of accidents that would leave the pilot in control with the time to attempt to avoid a site on the ground. Nothing did. Tr. at 3959 (Fly); PFS Test. at 58-60. PFS performed a third assessment in which it assessed all of those accidents that occurred in the "normal" phase of flight (as opposed to special operations, takeoff, and landing), which was also a subset of the Skull Valley-type events, to evaluate whether consideration of the phase of flight would change its conclusion regarding the fraction of accidents that would leave the pilot in control with the time to attempt to avoid a site on the ground. It did not. Tr. at 3860-64 (Fly/Jefferson), 3958-59 (Fly); PFS Test. at 58-60.

conservatively doubles the number of Skull Valley-type events in which a pilot would not be in control from three to six.

75. Lt. Col Horstman, took various inconsistent positions with respect to this evaluation by PFS's expert panel. In his December 11, 2000 deposition, Lt. Col. Horstman generally had high praise for the work of the PFS expert panel, stating that he had initially advised the State that he was in "agreement with all of the expert testimony for the PFS side" and that he "absolutely" was "in general agreement with what Colonel Fly said." Tr. at 4320-21 (Horstman). He further stated that he had reviewed the accident reports and that PFS's categorization of the accident reports in Tab H was not one of the issues that he had identified in his review of the PFS Aircraft Report. Id. at 4323-25. When asked specifically whether he had identified anything particular in Tab H of the Aircraft Report (in which PFS categorized the accident reports) with which he disagreed, he responded: "Not particularly, no." Id. at 4324-25. Indeed, even near the end of the hearing, he acknowledged that "Ninety-three percent of the time" a pilot is going to be in control of a crashing aircraft. Tr. at 13471 (Horstman).

76. After his December 2000 deposition, however, Lt. Col. Horstman did take issue with the categorization by PFS's expert panel of the accident reports in Tab H of the Aircraft Report and the panel's assessment there that a pilot would retain control of the aircraft 90% of the time. Thus, in his January 30, 2001 Declaration supporting the State's Opposition to PFS's Motion for Summary Disposition, he objected to various aspects of the categorization of 12 of the 121 F-16 accident reports evaluated by PFS's expert panel in Tab H. See PFS Exhibit X;[70]

[70] PFS Exhibit X was Table 1 from Tab H of the Aircraft Report which listed in chronological order each of the F-16 accidents occurring from FY89 to FY98, inclusive. During his July 2001 deposition, Lt. Col. Horstman marked the table identifying those accidents on which he disagreed with PFS's categorization of the accident. Tr. at 4411-12 (Horstman); see also PFS Exh. Y.

Horstman Test. at 30-31; State Exh. 65; Tr. at 4411, 4414-15 (Horstman).[71] In its pre-filed testimony, PFS responded in detail to Lt. Col. Horstman's claims regarding each of the 12 accidents. PFS Test. at 62-88. PFS showed that despite the State's arguments, a pilot would be "able to avoid" a site on the ground in 95 percent of all of the accidents that could have occurred in Skull Valley, albeit PFS continued to conservatively assume only a 90% probability for the "able to avoid" factor used in its hazard analysis.[72] Id. at 88; Tr. at 3214, 13007 (Jefferson), 3770 (Cole).[73] Lt. Col. Horstman did not address or respond on rebuttal to the analysis of PFS's experts evaluation of his criticisms.

77. Lt. Col. Horstman's explanation for the change in his position was that prior to preparing his January 2001 declaration, he "hadn't been asked to go do a much more in-depth analysis." Tr. at 4323 (Horstman). However, he also testified unequivocally that he had reviewed the F-16 accident reports prior to his December 2000 deposition.[74] He gave the same answer in response to the same

[71] Lt. Col. Horstman also argued that PFS should have looked at the accident reports over the entire history of the F-16 to determine the fraction of accidents that would be classified "able to avoid," Horstman Test. at 30-31, but he could point to no substantive or statistical basis for his belief that the fraction would have been different had PFS done so. See Tr. at 8504-06 (Horstman).

[72] PFS changed the categorization of one of the accidents (16-Sep-97), leaving 62 Skull Valley type events in the database of which 59 (or 95 percent) were "able to avoid." PFS Test. at 80-81.

[73] Of the 12 accidents on which Lt. Col. Horstman disagreed with PFS's categorizations, he would change four of PFS's categorizations from non-Skull Valley events to Skull Valley-type events, all four which he would also classify as "unable to avoid." See Accidents for 19-Sept-90, 31-Jul-92, 16-Sep-97, and 13-May-98 on PFS Exh. X. Lt. Col. Horstman would also change PFS's categorization of "able to avoid" to "unable to avoid" for four additional accidents which both he and PFS would classify as Skull Valley-type events. See Accidents for 19-Mar-91, 8-Jun-91, 19-Feb-93, and 13-Jan-95 on PFS Exh. X. If Lt. Col. Horstman's categorizations were accepted, there would be 64 Skull Valley type events in the database of which 54 (or 84 percent) would be "able to avoid." Thus, the difference between what Lt. Col. Horstman concluded from his review in terms of whether a pilot retained control after the accident is not greatly different from the fraction of 90% that PFS used in its probability hazard calculation.

[74] The applicable question and answer is as follows:

> Q: Let me be clear about this. You reviewed the accident investigation reports prior to the preparation of this supplemental [discovery] response and prior to your December 11, [2000] deposition?

question in his July 2001 deposition. Id. at 4329-30, 4478-80. Furthermore, when asked to describe his review of the accident reports at that time he stated:

> I read all the accident reports and looked at how they were portrayed or categorized, what type of incident, whether it was inflight or on the ground. Those are the kinds of things for the categories of all the reports.

Tr. at 4330 (Horstman, quoting July 2001 deposition at 10) (emphasis added); see also id. at 4480 (same).[75] Yet later in the hearing he retracted these unequivocal statements and stated that, "I had not reviewed all the accident reports prior to the December deposition." Id. at 4480, 13593.

78. These contradictory statements can only cast doubt upon Lt. Col. Horstman's credibility. In denying PFS's Motion to Strike Lt. Col. Horstman's declaration in opposition to PFS's Motion for Summary Disposition, the Licensing Board specifically stated "any future misstatements of this type by this witness could call into serious question the thoroughness and the thus the viability of his analysis . . ." LBP-01-19, 53 NRC at 441. PFS concludes that the contradictory statements above and other inconsistencies that we have noted throughout these findings do call into serious question the thoroughness and viability of Lt. Col. Horstman's analysis.

79. In his pre-filed testimony discussing PFS's analysis in Tab H, Lt. Col. Horstman did not specifically address the 12 accidents discussed in his declaration that he had identified on PFS Exhibit X. In total, he discussed only four of the accidents.

> A: Yes, sir, that's correct.

Id. at 4324

[75] He went on to describe in the July 2001 deposition the review that he had undertaken leading up to his analysis in his January 2001 declaration in which he challenged PFS analysis in Tab H as a "second" review of the accident reports. Id. at 4330.

Horstman Test. at 30-33. He also made numerous broad claims about PFS having improperly "excluded" from its analysis accidents arising from various causes (e.g., lightning) or occurring under various conditions (e.g., under instrument flight rules), but the only specific accidents he discussed were the four he had previously identified in PFS Exhibit X. Id. Further, on cross-examination, but for one exception, he could point to no specific accidents other than the four discussed in his testimony, and he repeatedly referred to PFS Exhibit X as containing any accidents that he claimed had been improperly excluded by PFS. Tr. at 4422-24, 8507-15, 8519 (Horstman); see also Tr. at 13091-92 (Jefferson).[76]

80. At the hearing in April, however, Lt. Col. Horstman claimed that he believed he was bound by PFS's category definitions in his evaluation of the accident reports, reflected in PFS Exhibit X, and suggested that, but for believing himself bound, he would have categorized the accidents differently. Tr. at 4441-42, 4444, 4447-51, 4481-82, 4485 (Horstman); see also id. at 8350.[77] Lt. Col. Horstman could not, however, identify anything in PFS's definition of Skull Valley-type events appearing in the Section of Tab H entitled "Evaluation Parameters or Data Categories" that would prevent him from exercising his professional judgment as to whether an accident could have occurred in Skull Valley. Tr. at 8364-65

[76] The one exception that Lt. Col. Horstman referred to on cross-examination that was not discussed in his testimony nor previously identified on PFS Exhibit X was the March 16, 1990 accident that he claimed for the first time at the hearing (discussed below) had been improperly excluded because of a presumed altitude limit on the Skull Valley-type event category. Tr. at 8508-09 (Horstman); see also id. at 8369. This accident was extensively discussed at the hearing. Tr. at 4446-51 (Horstman) As discussed below, we find that PFS properly excluded that accident, and moreover, had it been included it would have increased the percentage of "Able to Avoid" accidents computed by PFS.

[77] Lt. Col. Horstman's made this claim for the first time in response to questions from the Board after he had previously confirmed that "any disagreement . . . expressed" in his pre-filed testimony concerning PFS's analysis of the accident reports was "limited to the 12 accidents that [he had] marked up . . .in PFS Exhibit X." Tr. at 4415 (Horstman) (emphasis added).

(Horstman); see also Aircraft Report, Tab H at 9, 11-12.[78] The only words in the report that he could point to that he claimed restricted his professional judgment as to whether an accident was a Skull Valley-type event was a single phrase concerning "engine failure caused by flight in a high altitude, low speed condition" in the third paragraph on page 15 of Tab H describing the expert panels results of their statistical evaluation of Skull Valley-type events. Id. at 8368-69; see also Aircraft Report, Tab H at 13, 15; Tr. at 4445-49, 4456-57. Based on this phrase, Lt. Col. Horstman testified that PFS's definition of a Skull Valley-type event contained a "high altitude" restriction, Tr. at 8369, 8508-09 (Horstman), but for which he claimed he would have categorized the March 16, 1990 accident as a Skull Valley-type event. Id. at 4446-51, 4481-83.[79] He also acknowledged, however, that this phrase only concerned "Able to Avoid" accidents (which Lt. Col. Horstman agreed was a proper determination for the March 16, 1990 accident) that PFS's experts had concluded were not Skull Valley-type events. Tr. at 8369, 4484 (Horstman); see also Aircraft Report, Tab H at 15.[80]

81. Finally, there is nothing in the record that suggests that Lt. Col. Horstman believed himself to be bound by PFS's category definitions when he reviewed the

[78] Indeed, Lt. Col. Horstman stated that the definition of Skull Valley-type events on page 11-12 of Tab H "is really generic in nature," Tr. at 8368, which confirms that the definition set forth there would not operate to constrain his professional judgment.

[79] This testimony is inconsistent with Lt. Col. Horstman's earlier testimony that Skull Valley-type events "were not altitude restricted, to [his] knowledge." Id. at 4446-51.

[80] In this respect, Col. Fly clearly explained why the PFS expert panel did not consider the March 16, 1990 accident a Skull Valley-type event. Tr. at 13093-95 (Fly). First, the engine failure that initiated the accident was caused by an extremely abnormal combination of high altitude and low speed flight (flying at 27,000 ft at 90 knots) that does not place in Skull Valley. Id. Second, only the Pratt & Whitney F-16 engine, not flown out of Hill AFB, is susceptible to engine failure at such high altitude, low speed combinations. The 388th and Reserve Wing at Hill fly F-16s that have the General Electric engine which is not susceptible to failure under such conditions. Id. Thus, at best, this suggests that Lt. Col. Horstman failed to understand PFS's analytical methodology.

accident reports prior to his July 2001 declaration at which he marked up PFS's categorization on what became PFS Exhibit X. Indeed, he in conjunction with his review he created a new accident category for assessing accidents in which expressly modified PFS's definition for Sevier B flights. Id. at 8352-55. He also clearly applied his judgment in interpreting the definitions of the categories and placing accidents in them. Id. at 4454-56, 4485-87, 4491-94, 4497-99, 8357-59. Thus, it appears that at the time of his earlier review he did not perceive himself bound by PFS's category definitions.[81] In addition, as discussed above, after extensive cross-examination on this topic in the April and May hearing sessions, Lt. Col. Horstman repeatedly reaffirmed that the 12 accidents marked on PFS exhibit X were the limit of his disagreement with respect to PFS's analysis in Tab H.(except for the March 16, 1990 accident discussed above). Tr. at 4411-12, 4414-15, 8506-13, 8519-20 (Horstman).

82. However notwithstanding the above testimony, by the end of the hearing, Lt. Col. Horstman claimed that he had yet a different position from those he had at his July 2001 deposition, when he had marked up PFS Exhibit X, and even from his testimony in April and May 2002. Tr. at 13593-94 (Horstman). By the end of the evidentiary hearing, Lt. Col. Horstman claimed that he now believed that 113 accidents out of 129 that he reviewed occurred under "Skull Valley conditions" and should be classified as Skull Valley-type events. Id. This he claims was based on his further review of the accident reports since his July 2001 deposition. Id. at 13593. Further, in response to a question from the Board, he testified that this subsequent analysis that he performed had been discussed in the May hearing session. Id. at 13594. However, it is clear from the record of the May session

[81] Indeed, as we set forth in the summary we do not see how the definitions of "Skull Valley-type events" and "able to avoid" could operate to confine Lt. Col. Horstman's professional judgment

that Lt. Col. Horstman never testified about performing an additional review of the accident reports from which he concluded that 113 accidents (as opposed to the 61 identified by PFS's expert panel) should be classified as Skull Valley-type events. Nor is such a review referenced and discussed anywhere else in the record. To the contrary, when asked at the May session to identify those accidents that he believed PFS had improperly excluded from its analysis of Skull Valley-type events, he repeatedly referred (with the sole exception of the March 16, 1990 accident) to PFS Exhibit X that he had marked up at his July 2001 deposition. See Tr. at 8506-07, 8519-20 (Horstman).

83. Lt. Col. Horstman discussed two accidents he alleged were indicative of PFS improperly excluding types of accidents from its Skull Valley event database. First, Lt. Col. Horstman discussed the accident of May 13, 1998 in claiming that PFS improperly excluded from its database accidents caused by bird strikes. Horstman Test. at 32-33.[82] He claimed that large birds have been identified at Timpie Springs Waterfowl Management Area, located 25 miles north of the PFS site. Id. at 32; Tr. at 4507 (Horstman). In the May 13, 1998 accident, however, the pilot ejected immediately and the aircraft crashed out of control, PFS Test. at 86, and thus, the aircraft would have traveled nowhere near the 25 miles or more necessary to strike the PFSF site from the Timpie Springs area.

84. In addition, according to Air Force data on bird strikes, in the last 15 years for which data is available, no bird strikes have occurred within 25 miles of the PFS site. Id. at 87. The closest one occurred 25 miles away, across the Cedar

[82] Lt. Col. Horstman cites a July 6, 1998 accident in his pre-filed testimony (at 32), but there is no accident report in the record for a July 6, 1998 accident. At the hearing he cited the May 13, 1998 accident, Tr. at 4531 (Horstman) which does concern an accident caused by a flock of pelicans. See PFS Exh. 201. The May 13, 1998 accident is identified in PFS Exh. X as one of the accidents that Lt. Col. Horstman took issue with PFS's classification.

Mountains in the UTTR; the next closest on record was 37 statute miles away. Id. Further, the Hill AFB informs the NRC that the likelihood of a bird strike in Skull Valley was so low that it normally was not a part of mission planning. Id.[83] In addition, even if an F-16 were to experience a bird strike at Timpie Springs that left the pilot in control (e.g., a strike that caused an engine failure), Lt. Col. Horstman testified the aircraft could not reach the PFS site. See Tr. at 4511-14 (Horstman, aircraft travels 17 miles); id. at 4536-37.[84] Therefore, we concur with PFS's assessment that the May 13, 1998 accident was not a Skull Valley-type event and bird strikes would not affect the likelihood that a pilot would be able to avoid the PFSF in the event of an emergency.[85]

85. Second, Lt. Col. Horstman discussed the accident of May 25, 1990, which he asserted was caused by GLOC, in claiming that accidents arising from GLOC could occur in Skull Valley. Horstman Test. at 32. He pointed to no F-16 accidents caused by GLOC, however, that PFS improperly excluded from its analysis. Tr. at 4297-99 (Horstman).[86] Neither the evidence in the record nor the official Air Force records supports Lt. Col. Horstman's claim that the May 25, 1990 accident was caused by GLOC. Furthermore, Col. Fly, who has significant experience instructing pilots on the effects of G-forces, testified that he knew of no one who had suffered GLOC in a G-awareness turn like those performed in

[83] The fact that F-16s typically transit Skull Valley at altitudes of 3,000 ft. to 4,000 ft. AGL also seems to greatly reduce the risk of bird strikes. The same database referred to in the text above shows that 83.1% of all bird strikes occur below 1,000 ft. AGL and that all 7 of the bird strikes within 50 miles of the site occurred at or below 800 ft AGL. PFS Test. at 87.

[84] Of curse, if the pilot were in control of the aircraft he could act to direct the aircraft away from the PFSF.

[85] We note that crashes caused by bird strikes (e.g., by ingestion of the bird into the engine) would be accounted for in the accident rate so the only question here is whether those crashes would be ones in which a pilot would have the ability to avoid the PFSF.

[86] In this respect, PFS included the May 25, 1990 accident in its analysis as a Skull Valley-type event on a different rationale. PFS assessed the accident as having been caused by the pilot's loss of situational awareness while at low altitude. Aircraft Report Tab H at 18.

Skull Valley. Tr. at 13026-31 (Fly). Nor did the Chief of Safety of Air Combat Command. Tr. at 13031-32 (Cole).

86. Lt. Col. Horstman based his claim about the cause of the May 25, 1990 accident on an off-the-record conversation he allegedly had with an officer he identified at various times as a four-star general, a two-star general, the commander and the director of operations of U.S. Air Force Air Combat Command, and the director of plans of Tactical Air Command (which subsequently became Air Combat Command). Tr. at 4261, 4265-66, 4283-85, 4291-92, 8599 (Horstman); see id. at 8532-33. According to Lt. Col. Horstman, this officer told him either immediately or shortly after the Accident Board investigation had been completed that the pilot had been killed due to GLOC. Tr. at 4261, 4284, 4291-92. Contrary to this assertion, however, the accident report did not identify GLOC as the cause of the crash or even mention GLOC. Indeed, the report stated that the pilot was conscious at the time the aircraft impacted the ground. PFS Exh. 80 at 3.[87] Moreover, the Air Force in response to a Freedom of Information Act ("FOIA") request and in its regularly compiled statistics on GLOC accidents did not identify this accident as being caused by GLOC. PFS Exh. 81; State Exh. 50; Tr. at 4285-89, 4318-19 (Horstman).

87. Further, the May 25, 1990 accident was discussed by Lt. Col. Horstman in both his January 2001 declaration and in his July 2001 deposition. In neither did he

[87] Lt. Col. Horstman speculated that accident reports might not identify the cause of an accident as GLOC because it can be difficult to determine when GLOC happens, but he could recall no examples of such accident reports. Tr. at 4295 (Horstman). Contrary to Lt. Col. Horstman's speculation, examples of other accident reports involving GLOC in which GLOC was referred to and discussed in the reports were pointed out to him. Tr. at 4293-94 (Horstman). Further, Lt. Col. Horstman acknowledged under cross-examination that if it was the official opinion of the Accident Board that the accident had been caused by GLOC, as opposed to the belief of one of the individual Board members, he "would expect it to be reflected in the report." Id. at 4240-41.

identify the accident as having been caused by GLOC. Tr. at 4299-4301, 4314-15 (Horstman); see also PFS Exh. Y at 131. The first time that he identified this accident as being a GLOC accident was in his pre-filed testimony in February 2002, more than a year after he had initially reviewed the accident.

88. Most troubling, however is the fact that Lt. Col. Krebbs, the pilot that Lt. Col. Horstman stated was killed in the accident and to whom the commander of Air Combat Command supposedly referred by name, was not flying the aircraft that crashed and had no involvement in the accident.[88] The accident report states that Maj. Archie E. Stuart was the pilot flying the aircraft that crashed and who was killed in the accident, not Lt. Col. Krebbs. PFS Exh. 80 at 1-2. Lt. Col. Krebbs was in another flight of F-16s that had previously been scheduled to fly with the aircraft that crashed but did not due to a schedule change. Id. at 1.

89. The inconsistencies in Lt. Col. Horstman's testimony lead us to give no credence to his assertion as to the cause of the May 25, 1990 accident. In any event, regardless of the accuracy of Lt. Col Horstman's claims, PFS included the May 25, 1990 accident in its assessment as one of the accidents that could have occurred in Skull Valley. Aircraft Report Tab H at 18. Thus, the State's claim with respect to this accident would not affect PFS's calculations even if it were accepted.

90. In sum, we find that PFS's assessment that 90 percent of the accidents in Skull Valley would leave the pilot in control of the aircraft is soundly based on a rigorous analytical approach. While Lt. Col. Horstman cited 12 instances in

[88]Lt. Col. Horstman confidently asserted that "[t]he commander of Air Combat Command . . . told me the day after the accident board conclusion was over, that Colonel Krebbs was killed due to G-induced loss of consciousness," Tr. at 4261 (Horstman) and he claimed further personal familiarity with the accident by stating that, "[the accident report] doesn't say that Colonel Krebbs was on vacation for two weeks before the accident," Tr. at 4259-60 (Horstman).

which he disagreed with PFS's categorizations of the accidents in the database, he failed to rebut PFS's detailed responses to his claims. Furthermore, his testimony with respect to when and to what extent he reviewed the F-16 accident reports was strikingly inconsistent and his testimony regarding the asserted cause of one of the accidents was incredible. Therefore, we find that Lt. Col. Horstman's testimony with respect to the fraction of the accidents that would leave the pilot in control of the aircraft with time to avoid a site on the ground provides no basis to doubt PFS's analysis.

91. Therefore, in accordance with the foregoing, the Board finds that at least 90 percent of the accidents in Skull Valley would leave the pilot in control of his aircraft with the time to attempt to avoid the PFSF.

b) Fraction of Accidents in Control in Which Pilot Would Avoid

(1) PFS Panel Assessment

92. Based on their professional judgment as experienced Air Force pilots, PFS's panel assessed the probability that a pilot in control of his aircraft following an in-flight emergency would actually avoid the PFSF to be 95 percent. PFS Test. at 17; Aircraft Report at 18-23; Tr. at 3215-16 (Jefferson). The assessment was based on: (1) the time the pilot would typically have based on Air Force data concerning F-16 performance in the event of an engine failure, i.e., one minute or more, Tr. at 3559-69 (Fly), 3915-16 (Bernard), 8662 (Jefferson); Aircraft Report at 19c-19e, Tab U; (2) the pilot's ability to fly the aircraft and attempt to restart the engine or otherwise respond to the emergency, Tr. at 3546-55, 13704-05 (Fly); see Tr. at 3994-96, 4006-07 (Cosby); (3) the very slight turn required to actually avoid the PFSF, Aircraft Report at 22-23; Tr. at 3094-96, 13702 (Fly),

3910 (Bernard), 4023-25 (Cosby); see Tr. at 4188 (Campe), 8527 (Horstman); (4) the training that pilots receive to avoid inhabited or built up areas on the ground, Aircraft Report at 19-19a; Tr. at 3898, 3920 (Bernard), 3989-91 (Cosby), 4188-89 (Campe); (5) the familiarity of the pilots at Hill AFB with the location of the PFSF, which will be prominently visible and whose location will be noted, along with other nuclear facilities, in Defense Department aviation planning guides, see Tr. at 3921 (Bernard), 13114 (Fly); (6) the wide open spaces around the PFSF, to which a pilot could safely direct his aircraft, Aircraft Report at 21-22; Tr. at 13116, 13703-04, 13709-11 (Jefferson), 13706-07 (Fly); see, 4023-27 (Cosby); (7) the excellent weather and visibility in Skull Valley, see Findings 129-130, infra; and (8) the F-16 flight control computer that will keep the F-16 on a straight course after the pilot ejects, Aircraft Report at 21; Tr. at 3096-99, 3505-06, 3525-27 (Fly), 3507, 3510-11 (Jefferson), 3996-98, 4016-17, 4019-20, 4025-26, 4029-30 (Cosby); see Tr. at 3248 (Jefferson). See also Tr. at 8661 (Jefferson).[89]

93. PFS assessed that in the event of an engine failure, which would be by far the most likely accident leaving the pilot in control of the aircraft, an F-16 pilot transiting Skull Valley would have approximately one minute or more to respond to the emergency and potentially avoid a site on the ground before having to eject at the recommended altitude of 2,000 ft. AGL. Aircraft Report at 19c-19e, Tab U. As discussed in Finding 68 above, in response to an engine failure at low altitude, the pilot would climb ("zoom") to gain altitude and reduce speed and then glide back toward the ground at a speed that would maximize the time available to respond to the emergency (e.g., by restarting the engine). Based on data from the F-16 pilot's manual, PFS calculated, for example, that a pilot transiting Skull

[89] The NRC Staff's review of PFS's analysis assessed in detail the process PFS followed as well as PFS's data. Tr. at 8910, 8912, 8917-23 (Campe).

Valley at 350 knots at 3,000 ft. AGL would have 1 minute and 16 seconds to perform the zoom and glide maneuver before ejecting at 2,000 ft. AGL and would have over 2 minutes at 400 knots and 4,000 ft. AGL. Aircraft Report Tab U at 3-4. Col. Bernard confirmed that at 400 knots and 4,000 ft. AGL, the pilot would have on the order of two to three minutes to respond to the emergency. Tr. at 3915-16 (Bernard). Graphs from the F-16-1 pilot's manual show that in the range of speeds and altitudes at which F-16s fly in Skull Valley the pilot would always have over 45 seconds to perform the maneuver. Tr. at 3559-69 (Fly), 8662 (Jefferson); see Aircraft Report Fig. 3 following page 19c.

94. Based on the activities that the pilot would have to perform to respond to an engine failure, the pilot would have adequate time during the zoom and glide maneuver to avoid the PFSF. Aircraft Report at 19c-19d; Tr. at 3546-55 (Fly). The actions required to restart the F-16 engine would take only a fraction of the time available to the pilot before he reached the 2,000 ft. AGL recommended minimum ejection altitude. Id. at 19d; see Tr. at 3549-51 (Fly). Moreover, pilots are trained at multitasking, so that they are able to perform emergency procedures while simultaneously flying their aircraft. Tr. at 3994-96 (Cosby); see id. at 4006-07. Furthermore, it would take 45 seconds after the pilot restarted the engine for it to develop usable thrust. Aircraft Report at 19c, Fig. 3; see Tr. at 3550-51, 13705 (Fly). Thus, at some point in the aircraft's glide before the pilot either resumed flying or ejected there would be a 45 second period in which the pilot would easily be able to turn to avoid the PFSF without the turn interfering with the restarting of the engine. Aircraft Report at 19c; Tr. at 13704 (Fly).

95. The turn the pilot would have to make to avoid the PFSF would be slight, on the order of four degrees (assuming that the pilot turned just before he ejected at

2,000 ft. AGL), and easily made in the time available to him while he was gliding toward the ground. Aircraft Report at 22-23; Tr. at 3094-96 (Fly), 3910 (Bernard), 4023-25 (Cosby); see Tr. at 8527 (Horstman);13702 (Fly). The Hill AFB staff corroborated in its meeting with the NRC Staff that turning to avoid the facility would not be difficult. See Tr. at 4188 (Campe). In his accident, Col. Cosby turned 180 degrees to avoid an apartment complex and then maneuvered his aircraft further to avoid another aircraft on the ground. Tr. at 3980-81 (Cosby).

96. Pilots would turn to avoid the PFSF because they are trained to avoid inhabited or built up areas on the ground. Aircraft Report at 19-19a; Tr. at 3898 (Bernard), 3989-91 (Cosby), The instruction manual for the first aircraft on which Air Force pilots are trained states, "turn aircraft toward uninhabited area."[90] The F-16 pilot's manual states, "direct the aircraft away from populated areas."[91] Col. Bernard and Col. Cosby both stated that the objective is to minimize damage and risk to people or property on the ground by, for example, directing the aircraft into a river or a lake. Tr. at 3920 (Bernard), 3990-91 (Cosby). Dr. Campe testified that based on the NRC Staff's meeting with the Hill AFB staff, avoidance of built-up areas on the ground if the aircraft was in control was "something that is . . . in every pilot's mind, attitude [and] training to consider that." Tr. at 4188 (Campe); see id. at 8932. Moreover, the fact that the PFSF will be a storage

[90] T.O. 1-T37B-1 at 3-14 (Aircraft Report Tab S), quoted in Aircraft Report at 19a.

[91] T.O. 1F-16C-1 at 3-43 (State Exh. 150), quoted in Aircraft Report at 19a n.16A. Lt. Col. Horstman suggested that the manual cited by PFS was different with respect to emergency procedures than the manual for the F-16s currently flown at Hill AFB because the manual cited by PFS was for a block of aircraft that assertedly had different engines. Tr. at 13628-29 (Horstman). In fact, the Block 30 and the Block 40 F-16 have the same engines, Tr. at 13632 (Fly) and the manuals have identical language regarding the direction of the aircraft away from populated areas, Tr. at 13637 (Farrar, J.).

facility for nuclear material would also likely reinforce the pilot's desire to avoid it. Tr. at 3921 (Bernard).

97. Pilots flying in Skull Valley will know where the PFSF is. The site will be prominently visible. Lt. Col. Horstman agreed that it would be one of the largest built up areas and would have perhaps the tallest structure in Skull Valley and would be of "fairly unique" appearance. Tr. at 13510-11 (Horstman). The restricted area will have 130 ft. light poles around its boundary to provide illumination 24 hours a day. PFS Test. at 66 note 80; Aircraft Report at 22. Pilots will see the site as they fly over it from week to week, even as it is being constructed. Tr. at 3600-01 (Fly); see also id. at 13051-52. Its location will be noted, along with other nuclear facilities, in Defense Department aviation planning guides. Aircraft Report at 90-91; see also Tr. at 3519-20 (Cole), 13114 (Fly). Along with other sensitive areas beneath the airspace of the UTTR, such as the chemical and biological laboratories on Dugway Proving Ground, the PFSF would be depicted on aviation maps and its location published in Air Force instructions for the UTTR. Tr. at 13114 (Fly). Pilots also receive orientation with respect to safety hazards when they come to a new base which would make them further aware of the facility. Tr. at 3781-82 (Cole), 3783 (Fly); see Tr. at 8932 (Campe).

98. Avoiding the PFSF would also not be difficult because of the wide open spaces around the facility to which a pilot could safely direct his aircraft. Aircraft Report at 21-22; see Tr. at 4023-27 (Cosby), 13116, 13709-11 (Jefferson). Skull Valley is a sparsely populated region. In the area near the PFSF, the only other buildings present are the small number of residences (housing 30 people) in the Skull Valley Band of Goshutes Village, located about 3.75 miles east of the PFSF, on

the east side of Skull Valley Road, and two ranches, located along Skull Valley Road 2.75 and 4.0 miles northeast of the PFSF. Id.[92] Thus, there are no residences or structures of any kind to the west of the PFSF. Aircraft Report at 21-22. Accordingly a plane flying down the middle of the Valley in the general direction of the site could easily divert to the west in the event of an accident. Tr. at 13703-04 (Jefferson). Likewise, the distances between the PFSF and the other buildings to the east are large enough not to affect a pilot's ability to avoid the PFSF. Tr. at 13706-07 (Fly). An F-16 following the predominant route five miles to the east of the PFSF would be to the east of the PFSF and the other structures in the general vicinity of the PFSF as well and could continue the same direction, or make a slight turn towards the Stansbury upon ejection to ensure avoidance. Tr. 13700-01 (Fly).

99. As discussed in Findings 129-130, infra, the weather in Skull Valley is generally excellent and would be unlikely to prevent a pilot from avoiding the PFSF in the event of an accident. There is no cloud ceiling below 5,000 ft. AGL and seven or more miles of visibility 91 percent of the time. Seventy-nine percent of the time there are no clouds (or fog) at all below 5,000 ft. AGL.

100. Avoidance of the PFSF will also be facilitated by the F-16 flight control computer, which will keep the F-16 on a straight course after the pilot ejects.[93] Aircraft Report at 21; Tr. at 3505-06 (Fly), 3996-98, 4016-17 (Cosby). The computer will attempt to keep the aircraft flying at a constant altitude by increasing the angle of attack of the aircraft as it decelerates. Once the aircraft reaches a programmed angle of attack, the computer will hold that attitude and

[92] The Tekoi Rocket Engine Test Facility which is located approximately 2 miles southeast of the PFSF (State Exh. 222), is no longer in operation. See Staff Exh. C at 15-36.

[93] The computer operates on backup power sources after an engine failure. Tr. at 3525-26 (Fly).

heading as the aircraft descends while maintaining that angle of attack. The aircraft will most likely impact the ground at a velocity between 170 and 210 knots at a point along the straight-ahead flight path from the point of pilot ejection. Aircraft Report at 21; Tr. at 3096-99 (Fly). The aircraft may roll slightly about its longitudinal axis after the pilot ejects but the flight path along the ground would remain basically unchanged. Tr. at 4019-20, 4025-26, 4029-30 (Cosby). This would be the case even with the aircraft canopy gone after the pilot ejects. Tr. at 3527 (Fly).

101. Based on these factors, PFS's expert panel concluded that "a pilot who remained in control [of the aircraft[after the event precipitating the crash would invariably take action to have the crashing F-16 miss the site." Aircraft Report at 23; PFS Test at 17. They found further support for this conclusion in the "F-16 accident investigation reports, which show that pilots do, when relevant, maneuver [the] aircraft to avoid sites on the ground." Id. Nevertheless, to account for possible unforeseen circumstances they determined that a pilot in control of a crashing aircraft would be able to direct the aircraft away from the PFSF at least 95% of the time. Id.

102. We find that PFS's experts provided a factual basis and an explanation of their reasoning with respect to each factor supporting their judgment that a pilot in control of a crashing aircraft would avoid the PFSF 95 percent of the time.

(2) State Challenges to PFS Assessment

103. Lt. Col. Horstman claims that PFS's assumptions regarding pilot avoidance were "unrealistic and unconservative," Horstman Test. at 15, for a number of reasons. Yet, as noted above, he acknowledged that this was a "broad overstatement" and stated many times his agreement that under the right set of circumstances pilots

would avoid the PFSF, and that many of them would in fact do so. See Finding 22, supra. Indeed, Lt. Col. Horstman's inconsistencies on this subject are perhaps best demonstrated by his answer to a single question in which he first testified that under the right set of circumstances "every Air Force pilot and every Navy pilot and every Marine Corps pilot would in fact attempt to avoid the site," but then stated that he thought the probability of a pilot avoiding the PFSF was "zero percent." Tr. at 13446 (Horstman).

104. We address below each of Lt. Col. Horstman's objections to PFS's assessment that a pilot in control of a crashing aircraft would avoid the PFSF 95 percent of the time on a number of grounds. These are (1) the pilot's focus on his survival will preclude him from taking action to avoid the PFSF; (2) the nose of the F-16 will obstruct the pilot's view of the PFSF; (3) weather will obstruct the pilot's ability to see the site; and (4) the PFSF is not a "populated area" for which the F-16-1 guidance would apply.

(a) The Pilot's Focus on His Survival

105. In his prefiled testimony, Lt. Col. Horstman claimed that the attention of pilots of crashing aircraft are "riveted on their survival" and thus they would be unable to avoid a site on the ground. Horstman Test. at 18; see also id. at 30 ("available . . . time would most likely be used on tasks related to the pilot's survival, not on attempting to locate and avoid the PFS facility site"). We find this claim unsupported by the evidence. First, Lt. Col. Horstman admitted that his statement was an overgeneralization and that the focus of a pilot would depend on the circumstances of the accident. Tr. at 8445-46 (Horstman). He agreed that a mishap leaving the pilot in control of the aircraft, such as an engine failure, is very different from one that does not. Id. Lt. Col. Horstman further

acknowledged that his statement did not concern engine failures, which would be by far the likeliest cause of an accident in Skull Valley and which would leave the pilot in control of the aircraft. See Tr. at 8502-04 (Horstman). Because here we are concerned only with accidents in which the pilot remains in control, of which the vast majority are caused by engine failure, Lt. Col. Horstman's prefiled testimony on this point is unsupported and we give it no weight.

106. Second, Air Force pilots train regularly on responding to in-flight emergencies. See, e.g., Tr. at 13260 (Horstman); Tr. at 3325, 3329-31 (Cole), 3332-34, 3338, 3556 (Fly), 3988-89, 4015 (Cosby, emergencies and ejection). 3591-93, 3598-99 (Cole, situational awareness), 3595-96 (Fly, same), 3596-98 (Jefferson, same) As discussed in Finding 96, supra, they are also trained in cases of controlled ejection to avoid areas on the ground that could result in harm to people if the areas were hit by the crashing aircraft. In this respect, it's undisputed that the Air Force provides excellent training for its pilots. Tr. at 3529, 3767 (Cole), 3548 (Horstman).

107. Third, in those cases where the aircraft is in control and PFS has assessed avoidance to be possible, while the pilot is responding to the emergency (e.g., by attempting to restart his engine), the pilot is continuing to fly the aircraft until he ejects. Tr. at 3546-55 (Fly), 3598-99 (Cole), 3989-91, 3994-95, 3998-4001 (Cosby), 13696-700 (Cole/Jefferson/Fly). Lt. Col. Horstman, PFS's panel, and Col. Cosby all testified that flying or maintaining control of the aircraft is the first step in responding to an emergency. Aircraft Report at 19; Tr. at 3321, 3593 (Cole), 3275 (Jefferson), 8550 (Horstman), 3989 (Cosby); see Horstman Test. at 15; Tr. at 3546-55 (Fly). Flying the aircraft includes looking out the canopy to see where it is going and using the flight controls to control and maneuver it. Tr.

at 3275 (Jefferson), 3551-53 (Fly), 3599 (Cole), 4019 (Cosby); see Tr. at 3989-91, 4006-07 (Cosby). Simultaneously flying the aircraft, responding to the emergency, and being aware of his surroundings is part of the pilot's maintaining his situational awareness, which all Air Force pilots are trained to do. Tr. at 3591-93, 3598-99 (Cole), 3593-96 (Fly), 3596-98 (Jefferson). As explained by Colonel Cosby, as a result of their training and experience, pilots are very good at accomplishing many different tasks simultaneously, i.e., "multitasking," which is part of every pilot's "basic flying skills." Tr. at 3994-95, 4001 (Cosby).

108. In the course of flying the aircraft during the emergency, when the pilot looks out the canopy he will see where he is going and what he might hit, including things on the ground he would not want to hit. Tr. at 3553-55, 13081-82, 13641-44, 13673-75, 13684 (Fly), 3896-97 (Bernard), 3989-91 (Cosby), 4514 (Horstman).[94] The F-16 has a flight path indicator on its heads up display ("HUD") that accurately shows where the aircraft is pointed. Tr. at 3102-03, 13643 (Fly); see Tr. at 4012-15, 4021-22 (Cosby). As discussed below, the HUD and other means of maintaining situational awareness would enable a pilot to maintain his awareness of the PFSF's location even in the event of cloud cover.

109. Thus, because flying the aircraft is part of responding to the emergency, the pilot would not have to artificially pull himself away and think "where am I going and what do I see?" Tr. at 3551-52, 8648-49, 13102, 13685 (Fly), 3141-42 (Cole), 3276-77, 13697 (Jefferson), 8606 (Horstman). Maintaining situational awareness of his surroundings is something that all Air Force pilots are taught to do. Tr. at

[94] "And as I'm glid[ing] down I'm going to look at everything out there. I'm going to look at a mountain top, I'm going to try to locate the PFS site, I'm going to look at roads, I'm going to try to locate houses and farms and anything else. So that as you heard in the previous testimony, if given the opportunity, I would put the aircraft in the position where it damaged the least – with no damage." Tr. at 4514 (Horstman).

3103-05 (Cole), 13334-35 (Horstman). In the course of flying he will also be using the flight controls, so making the small maneuver that might be necessary to avoid the PFSF would not be a departure from his train of thought or actions during the emergency. Tr. at 3552-55 (Fly). Indeed, while the State argues its case forcefully, it has identified no case, in ten years of F-16 accident data or otherwise, in which a pilot failed to avoid something on the ground because of fear, stress, or distraction.

110. Lt. Col. Horstman claimed that his position is supported by his interviews of four pilots who ejected from aircraft without considering whether to avoid anything on the ground. Horstman Test. at 18-19 & n.2. We find that Lt. Col. Horstman's pilot interviews are largely irrelevant to this determination because for three of the accidents the pilot was not in control of the aircraft (and thus the accidents were not ones that would have been classified as "able to avoid" in the first place). The circumstances of the fourth accident do not suggest that fear, stress or distraction played any role in the pilot's actions.

111. With respect to the first three accidents, one involved a plane that had suffered a total hydraulic failure immediately prior to landing. Thus, the pilot had lost any ability to control the plane and had no choice but to eject. Tr. at 3787; (Fly); Tr. at 4235, 8446 (Horstman).[95] The second accident involved a situation in which the aircraft suffered a tire blowout on the runway during take-off. The pilot aborted the take-off and could not prevent the aircraft from veering off the

[95] Lt. Col. Horstman maintained that this accident was "perfectly relevant" because the pilot was focused on his survival. Tr. at 8447 (Horstman). Lt. Col. Horstman's rationale, however, ignores the uncontroverted fact that the aircraft was out of control and that the pilot could not have avoided anything on the ground irrespective of the focus of his attention. Col. Fly testified that the pilot of the aircraft, Col. Coots, stated to him that if he had a mishap in which he retained control of the aircraft that of course he would consider what his aircraft might hit. Tr. at 3787 (Fly).

runway and had no choice at that point but to eject. The airplane never got airborne. Tr. at 4235 (Horstman); see PFS Exh. 98.[96] The third accident involved a pilot who ejected after he was blinded when the canopy of his plane was struck by an American White Pelican (average weight over 12 pounds[97]) while flying at approximately 500 knots. Tr. at 4237, 8451-54 (Horstman); see PFS Exh. 97.[98] Thus, these three accidents do not concern accidents in which the pilot was in control of the aircraft and could have avoided a site on the ground. Accordingly, what these pilots were thinking at the time is not relevant to evaluating whether a pilot in control of his aircraft would avoid the PFSF.

112. The fourth pilot experienced an engine failure while flying 4,000 ft. AGL over a cloud layer in Belgium. PFS Test. at 83-84; PFS Exh. 175; Tr. at 3222 (Jefferson). Lt. Col. Horstman testified that the pilot of this aircraft had stated that he was focused solely on survival and that "he did not have time to think" where his aircraft or jettisoned stores would impact the ground. Horstman Test. at 47. However, Col. Fly testified that he had subsequently provided the pilot a copy of Lt. Col. Horstman's pre-filed testimony and that upon reviewing it the pilot took "strong objection" to Lt. Col Horstman's characterization of the circumstances involving the accident. Tr. at 3223 (Fly). He told Colonel Fly that he had time to consider where he was and that he knew that he was over a rural

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[96] Lt. Col. Horstman maintained that the aircraft was in control because the pilot had "flyable airspeed." Tr. at 4235 (Horstman). The accident report, however, indicated that the pilot did not decide to eject until after the aircraft had gone out of control on the ground following the tire blowout. PFS Exh. 98 at 20; Tr. at 8462 (Horstman).

[97] See PFS Exh. 201 at 3.

[98] Lt. Col. Horstman acknowledged that the pilot could not see and thus could not have avoided a site on the ground regardless of his state of mind. Tr. at 8454 (Horstman). Yet he maintained that the aircraft was "perfectly flyable [and] controllable" and that the pilot was capable of flying it. Id. at 8455-56. Nonetheless, Lt. Col. Horstman agreed that he would have ejected immediately if the same thing had happened to him. Id. at 8458. Lt. Col. Horstman's emphasis on the "flyability" of the airplane regardless of the state of the pilot appears to be an attempt to create a substantive point out of semantics.

area in Belgium. He stated he was concerned where the aircraft would impact the ground but was not familiar enough with the area to know of any specific sites below him. Id. at 3223-24.

113. The accident report shows that more than a minute elapsed from the time of the initiating event of the accident to the commencement of the ejection sequence. PFS Exh. 175 at 3-4. For the last 40 seconds prior to ejection, the aircraft was completing its zoom followed by a gradual descent with no apparent unusual or particularly stressful activity occurring. Id. Based on this sequence of events and the undisputed testimony discussed above that, time and circumstances permitting, pilots will act to avoid structures and populated areas on the ground, it would be unreasonable to conclude that the pilot did not have time even to consider where his aircraft would impact. Rather, in this particular instance the low altitude cloud cover and lack of familiarity of the area apparently resulted in the pilot not being in a position to take action to avoid a specific site on the ground.

114. We will address weather issues in Skull Valley below, but we note at this point that PFS's witnesses testified that given the same weather in Skull Valley, the pilot would have been able to avoid the PFSF because of his awareness of his position relative to the PFSF, which would be enhanced by his ability to refer to the Stansbury Mountains (and possibly the Cedar Mountains) which would have been visible above the clouds. PFS Test. at 83-84. The layer of clouds at the time of the accident was at 3,000 ft. AGL and thus the Stansbury mountains would have been clearly visible above the clouds to assist the pilot with his navigation and general situation awareness that typically would not be available under similar weather conditions in Belgium. Id. Furthermore, avoiding the PFSF in

Skull Valley would be easier than avoiding structures in Belgium because the PFSF will be generally an isolated facility in the middle of the valley whereas the Belgian countryside typically has villages and farms distributed throughout. Id. Finally, the location of the PFSF will be well known to pilots transiting Skull Valley, id., unlike the situation described by the pilot in the January 13, 1995 accident. Therefore, PFS's expert panel concluded that it was reasonable to conclude that a pilot who experiences an engine problem above a low overcast in Skull Valley would be cognizant of the approximate position of the PFSF and would be able to take reasonable measures to avoid it, if necessary. Id. We agree with this assessment by PFS's expert panel.

115. Lt. Col. Horstman also asserted that the pilot would be unlikely to avoid the PFSF because he would be under stress from the emergency and would fear suffering serious injury upon ejecting from the aircraft. Horstman Test. at 17, 20. However, dealing with emergency situations is an integral and necessary part of pilot training. A pilot undergoes repeated training on a regular basis to respond to emergency situations, such as engine failure, so that the response in an actual emergency situation becomes instinctive. Tr. at 3987-89, 4015, 4027 (Cosby). Both Col. Bernard and Col. Cosby testified that the stress they felt before they ejected did not interfere with their taking action to respond to the emergencies. Tr. at 3894-97 (Bernard), 3987-89, 4027-28 (Cosby). In the case of Col. Cosby, responding involved considerable maneuvering of the aircraft to avoid apartment buildings and an aircraft on the ground. Tr. at 4009, 4014-15, 4027-28 (Cosby).

116. In Col. Bernard's case, his primary distraction was that he was engaged in a large mock battle at the time his engine failed, a situation that would not occur in Skull

Valley. See State Exh. 220 (video); Tr. at 13645-48 (Fly).[99] Col. Bernard failed to notice his engine problem and continued to attack one aircraft and subsequently react defensively to another. If Col. Bernard's engine had failed while he was flying in Skull Valley, he would have had control of the aircraft and sufficient time, in the range of a minute or two, to avoid a site on the ground. Tr. at 13648-50, 13692 (Fly); see State Exh. 220 (engine failed while aircraft was at 480 knots and 5,900 ft. MSL/3,700 AGL); compare Aircraft Report Tab U at 4.

117. The accident reports PFS evaluated (see Findings 143-155, infra) in which pilots avoided things on the ground were real accidents in which pilots experienced stress. Tr. at 3658 (Fly); see also Tr. at 8873-75 (Fly, considering pilot stress). Yet they steered their aircraft away from things on the ground or alternatively determined that nothing was in their path. Air Force pilots are trained and retrained to deal with deciding to eject and ejecting from aircraft. Tr. at 3145-46 (Cole), 3337-38 (Fly), 4015 (Cosby), 13132-33 (Horstman). Preparing and deciding to eject is something the pilots will do in the course of responding to the emergency while at the same time directing their aircraft away from things on the ground. Tr. at 3277-78 (Jefferson), 3282, 3606-08 (Fly), 3606 (Cole); 4015 (Cosby).

118. The State has suggested that severe injuries, such as flailing or the ripping of limbs from the pilot's body, could occur upon ejection from the aircraft. See, e.g., Tr. at 3271-74 (Soper). However, the potential for such severe injuries is associated with ejecting from an aircraft out of control or at very high speed. For

[99] Lt. Col. Horstman testified that "[T]here clearly is chaos that wouldn't happen in Skull Valley." Tr. at 13436 (Horstman). The radio calls and the "focus of [Col. Bernard's] attention" are not normal for Skull Valley. Id. at 13437. Col. Bernard was "responding to other flight members as opposed to solving his emergency" and was "task saturated." Id. at 13438. See also id. at 13449-51 (Horstman, acknowledging that Col. Bernard was engaged in stressful mock combat activities).

example, the F-16-1 pilot's manual states "severe forces" can cause "flailing and skin injuries between 450-600 knots." PFS Exh. PP. Ejecting from an aircraft that is in control where the pilot would have the opportunity to avoid the PFSF is much less dangerous than ejecting from an aircraft out of control or at very high speed. Tr. at 3258, 3268-70, 3302, 13015-017 (Jefferson), 3273-74, 3280-81 (Fly). For a plane in control, the pilot can reduce the speed of the aircraft to avoid the potential for flailing and other potential serious ejection injuries accordance with the provision of F-16 –1 Manual that "[e]jection should be accomplished at the lowest practical speed." PFS Exh. PPP. In this respect, after an engine failure, the pilot will typically eject from the aircraft at an airspeed of about 200 knots. Tr. at 3604 (Fly); see Tr. at 4231 (Horstman). The F-16 –1 Manual states that injuries caused by wind blast and flailing do not occur at those speeds. Tr. at 3604-05 (Fly); PFS Exh. PPP. If the aircraft is in control, injuries caused by ejecting at a high rate of speed or rate of descent at low altitude would not occur. Tr. at 13015-17 (Jefferson).

119. The F-16 accident reports specifically address the question of pilot injuries, Tr. at 13012 (Jefferson), and independently confirm that for situations in which the pilot is in control of the aircraft the potential for serious injuries upon ejection is greatly reduced. In those 58 accidents classified as "Skull Valley-type events," in which the pilot remained in control of the aircraft, there were no fatalities. Id. at 13012-13. In 89 percent of the ejections, the pilots suffered no injuries or only minor injuries such as scratches and bruises. Id. at 13012-13. In the remaining 11 percent, there was one case in which an airman in the rear seat of a two-seat F-16 was burned by the ejection rockets of the front seat, but in all other cases the injuries suffered occurred during the parachute landing. Id. at 13013. The few

parachute landing injuries consisted mostly of fractures to the extremities and compression fractures of the spine, but they were not life-threatening. Id. at 13013-14. Thus, we find the claim that fear of ejecting would cause pilots not to avoid the PFSF not to be persuasive, especially considering that the pilot's alternative to ejecting is to crash with the aircraft, which would leave little doubt of the consequences.

120. Lt. Col. Horstman also claimed that pilots would not attempt to avoid a site on the ground because of the danger of avoidance, stating that, "So now you're asking these young men and women, who are very well trained, to take that training one step further and die for the cause. Because, as you have seen in many cases, in order to avoid something, they're [the pilots] going to have to die." Tr. at 13560 (Horstman). Lt. Col. Horstman's claim is inconsistent with his previous testimony, is unsupported by the evidence, and is not credible. Lt. Col. Horstman testified earlier in the proceeding that banking the aircraft before ejecting to avoid the PFSF would have an "absolutely miniscule" impact on the pilot's safety because of the 2,000 ft. AGL ejection altitude. Tr. at 8528-29 (Horstman). He added that, "It would be slightly different but fundamentally, even at 1,000 feet you are pretty comfortable with your ejection seat and your ability to survive." Id. at 8530. He stated further that "whether you are in truly level flight or ten degrees of bank, it is not relevant toward your safety." Id. at 8529.

121. Further, as discussed, in the accident reports for Skull Valley-type events in which the pilot had control of the aircraft (and thus would be able to avoid the PFSF), there were no fatalities or life threatening injuries. This was true for situations in which the pilot banked to avoid something on the ground or generally directed the

plane away from populated areas.[100] Further, PFS's assessment of the time a pilot would have to respond to an emergency and guide his aircraft away from the PFSF was based on the assumption that pilots would eject at the minimum recommended altitude of 2,000 ft. AGL, Aircraft Report at 19c-19e; see id. Figs. 3, 3-A, Tab T, even though the accident reports show many examples where pilots ejected at lower altitudes but nonetheless survived without severe injury, compare State Exh. 223 (ejection altitudes) with Tr. at 13012-13 (Jefferson) (no severe injuries). As PFS's witnesses have consistently testified, given the circumstances of the PFSF in Skull Valley and the accident scenarios that would leave the pilot in control of the aircraft, avoiding the PFSF would not put the pilot's life at risk. Tr. at 3772, 3778-79 (Cole), 3772-73 (Jefferson), 3784-85 (Fly). As stated above, Lt. Col. Horstman himself essentially agreed that taking steps to avoid the site in which a pilot was in control of the aircraft would not cause the pilot to risk his life.

122. It is important to distinguish accidents that leave the pilot in control of his aircraft from those that do not. PFS's assessment of the ability to avoid and its assessment of whether pilots had suffered injuries upon ejecting from aircraft only considered accidents where the aircraft was in control. Tr. at 3669 (Jefferson), 8440, 8445 (Horstman). PFS assumed that pilots of aircraft that are out of control would not be able to avoid the PFSF. Id.; Aircraft Report at 7. Those pilots could suffer injury upon ejecting from their aircraft. E.g., Tr. at 13016-17 (Jefferson). Nevertheless, those accidents involving aircraft that are out of control are not germane to determining the probability that a pilot in control of his aircraft would

[100] See, e.g., Joint Exh. 1 at 3 (26 Dec 89); PFS Exh. 115 at 13 (20 Sep 90); PFS Exh. 119 at 4 (15 Jan 91); Joint Exh. 3 at 5 (unmarked) (20 Feb 91) (no indication of injury); PFS Exh. 128 at 15 (7 May 91); PFS Exh. 134 at 8 (13 Jan 92); PFS Exh. 140 at 7 (31 Aug 92); PFS Exh. 145 at 9 (17 Dec 92); compare PFS Exh. 100A (designating accidents in which pilots maneuvered to avoid areas on the ground).

avoid the PFSF. See Aircraft Report at 7; Tr. at 8370-71 (Horstman). PFS witnesses consistently maintained this distinction throughout the different phases of the hearing.

123. Lt. Col. Horstman asserted that because in some cases pilots ejected below the minimum recommended safe ejection altitude of 2,000 ft. AGL, ipso facto they would be unable to avoid anything on the ground. Tr. at 13371, 13604-05 (Horstman); State Exh. 223. Lt. Col. Horstman provided no evidence to support this claim. In fact, in a number of cases, the pilot specifically delayed his ejection below 2,000 ft. in order to take additional actions for the express purpose of avoiding sites on the ground. Tr. at 13108 (Jefferson), 13702 (Fly). Further, the accident reports make clear that descending below 2,000 ft. did not mean that the pilots were unaware of where they were or were unable to control their aircraft; rather they were actively controlling and flying the aircraft. See, e.g., Joint Exh. 1 (26 Dec 89); Joint Exh. 3 (20 Feb 91); Joint Exh. 7 (2 Feb 94); Joint Exh. 9 (7 Jun 96); PFS Exh. 205 (24 Aug 98); Tr. at 3318-19 (Jefferson), 3321 (Cole). One salient example was Col. Cosby's accident, where he avoided an apartment complex and then an aircraft on the taxiway on which he was trying to land, before ejecting at less than 50 feet above the ground. Tr. at 3980-82 (Cosby).

124. In this respect, the 2,000 ft. altitude is a recommended minimum, not an absolute requirement. Tr. at 3321-22, 3764, 13659-60, 13666-70 (Cole), 3095, 3100-01, 3560, 13670-72 (Fly). Pilots are permitted to exercise judgment in responding to emergencies. Tr. at 3321-22 (Cole), 13671-72 ("[W]e train pilots. We don't train robots") (Fly). The F-16-1 flight manual states that "[m]ultiple emergencies, adverse weather and terrain etc. may require modification of these procedures," Tr. at 13664 (Cole), and the charts in the F-16-1 flight manual that depict the time

available at different speed and altitude combinations before reaching 2,000 ft. AGL describe this 2,000 ft AGL as the "Minimum Recommended Ejection Altitude." Aircraft Report, Figures 3 and 3A following page 19c. See also Aircraft Report at 19e, 38 (referring to 2,000 ft. AGL as the "minimum recommended ejection altitude"). In fact, pilots have been officially commended by Accident Boards for delaying their ejections in order to avoid sites on the ground, Tr. at 13581-82, 13597-98 (Horstman); Joint Exh. 9; PFS Exh. 205.

125. Lt. Col. Horstman also argues that inexperience would cause a pilot to fail to avoid the PFSF. Horstman Test. At 19-20. We find no factual basis for this claim. First, Air Force pilots are well trained before they fly the F-16, would be even further trained before they were stationed at Hill AFB, and would further train upon arrival at Hill. Tr. at 3811-12 (Fly); PFS Test. at 47. This training takes approximately two years and is designed to provide a sufficient level of experience to proficiently operate the F-16 under both routine and emergency conditions at home base and to successfully conduct combat sorties when deployed in actual military operations. PFS Test. at 47. Second, the F-16 accident reports represent accidents involving pilots with all levels of experience, i.e., they were not filtered or sorted in any way on the basis of pilot experience. PFS Test. at 48-49. In none of the 58 relevant accidents (i.e., Skull Valley events in which the pilot was in control) did the pilot fail to avoid a site or take action to minimize damage on the ground. Finally, Col. Cosby testified that even "very average" pilots would be able to simultaneously respond to an emergency and direct the airplane away from a site on the ground. Tr. at 4000-01 (Cosby).

126. In sum, the record does not support Lt. Col. Horstman's claims that pilots would not be able to avoid the PFSF because of distraction due to focus on their survival,

fear of ejection injury, general stress during emergencies, the purported danger of avoidance itself, or inexperience. Nor does the mere fact that pilots have ejected below 2,000 ft. AGL mean that they would be unable to avoid the PFSF. The F-16 accident reports describe many cases of avoidance where several of these factors are present, yet none of them show a case where a pilot could have but failed to avoid a site on the ground. Col. Bernard's and Col. Cosby's testimony about their experiences ejecting from F-16s further show that it is highly likely that pilots in control of their aircraft after an in-flight mishap would be able to avoid the PFSF.

(b) Weather Effects

127. Lt. Col. Horstman also claims that pilots would not be able to avoid the PFSF because they would be unable to see it due to weather or the nose of the aircraft obscuring the view of the pilot. Horstman Test. at 21, 24. First, as to weather, Lt. Co. Horstman claimed that a pilot would not be able to see the PFSF 46 percent of the time because 46 percent of the time there is a cloud ceiling at or below 12,000 ft. AGL. Horstman Test. at 22; Tr. at 8372-74 (Horstman). On cross-examination, however, Lt. Col. Horstman had to admit that his data and represented all cloud cover at all altitudes, not just opaque cloud cover at or below 12,000 ft. Tr. at 8390-92, 8394-95 (Horstman). Furthermore, a ceiling as currently defined by the FAA indicates only that the cumulative cloud cover, from the ground up to the altitude at which the ceiling is measured, covers five-eighths of the sky or more. Vigeant Test. at 4-5. It does not indicate total sky coverage at all altitudes.

128. Moreover, Lt. Col. Horstman also misinterpreted his data in that it does not represent a ceiling at any altitude. At the time the data was taken, a ceiling was

defined as opaque cloud cover over more than five tenths of the sky. Tr. at 4053 (Vigeant); Vigeant Test. at 3; see id. at 4-5 (definition changed with introduction of automated weather observation stations). Thus, the level of the ceiling was the altitude at which the cumulative opaque sky cover (beginning at ground level and going up) exceeded 50 percent. Tr. at 4068-69 (Vigeant); Vigeant Test. at 8 & n.8. The sky cover observations that constituted the basis for Lt. Col. Horstman's data were made on the basis of total sky coverage, not just opaque cloud coverage that would obscure visibility, and thus they are not relevant to determining whether a pilot in Skull Valley could see the PFSF. Id. at 7-9.

129. Actual ceiling data based on 30 years of climatological data from Michael AAF shows no ceiling at any altitude combined with a visibility greater than or equal to seven statute miles 70.5 percent of the time. Vigeant Test. at 4. Because Michael AAF is close to the proposed PFSF site in Skull Valley and because the data was specifically collected by the Air Weather Service to support aviation operations at Dugway Proving Grounds, the ceiling and visibility data would be closely representative of that for the PFSF site. Id. at 6.

130. Cloud cover in Skull Valley that would affect a pilot's ability to see the PFSF at the altitudes flown by the F-16s would be very uncommon. The same 30 years of climatological data from Michael AAF shows there is no ceiling below 5,000 ft. AGL (where the F-16s mostly fly) and seven or more miles of visibility 91.5 percent of the time. PFS Test. at 53; Vigeant Test. at 4; Tr. at 4071-72 (Vigeant); see Tr. at 4048-49 (Vigeant). Because a ceiling as defined by the FAA is indicative of a pilot's ability to maintain sight of a point on the ground for a sufficient length of time to land an aircraft without using instrument procedures, Tr. at 13458-59 (Horstman), this data shows that more than 90% of the time

clouds would not impair a pilot's ability to see and avoid the PFSF while flying through Skull Valley. Further, specific cloud cover data from Salt Lake City shows that 79 percent of the time there would be no clouds (or fog) below 5,000 ft. AGL whatsoever. Tr. at 13061 (Fly); PFS Exh. 245; see Tr. at 13055-59 (Vigeant), 13059-64(Fly).[101]

131. Further, the presence of clouds, whether they constituted a ceiling or not, would not necessarily obstruct the pilot's view of the PFSF. That would depend on the relative positions and altitudes of the clouds, the pilot, and the facility. PFS Test. at 52-55; Tr. at 13032-36, 13038-42, 13095-96 (Fly), 8422 (Horstman).[102] PFS's testimony showed in graphic form that where there is a ceiling, a pilot below the ceiling (and in some cases a pilot above) could see the PFSF with no difficulty. PFS Test. at 53-55; Revised Addendum, Tab FF, Figs. 9-1 to 9-12. Lt. Col. Horstman acknowledged that cloud cover above the pilot would not affect his ability to see the PFSF. Tr. at 8374-75, 8377, 13456 (Horstman). In fact one of the accident reports describes how the pilot purposefully glided down through an overcast cloud layer, spotted farms on the ground, avoided them, and then ejected.

[101] Clouds above a pilot could affect his response to an engine failure in that he would not climb into a cloud, but if the cloud layer were not solid, the mere presence of the layer above the pilot, as opposed to an actual cloud, would not prevent him from performing his normal climb and glide maneuver. See Revised Addendum, Tab FF at 26; Tr. at 13454-56 (Horstman). Using the same cloud data as above, there would be no clouds below 4,000 ft. AGL 83 percent of the time and no clouds below 8,000 ft. AGL 65 percent of the time. Tr. at 13676 (Fly).

[102] Lt. Col. Horstman performed a demonstration in which he purported to model cloud cover in Skull Valley by placing Scrabble tiles on a note pad. See Tr. at 8378-84 (Horstman). Because the tiles were laid directly upon the note pad, the demonstration did not reflect the height of the clouds above the ground nor the height of the aircraft attempting to observe the PFSF. See Tr. at 13041-43 (Fly). Also, because the note pad was blank, the demonstration did not capture the landmarks on the ground that a pilot could use to orient himself with respect to the PFSF even if he could not observe it directly. See Finding 132. We find this demonstration to be of no use in either visualizing the effect of cloud cover nor of relevance to the ability of a pilot in Skull Valley to avoid the PFSF site. Furthermore, Lt. Col. Horstman's testimony concerning his demonstration involving 25% cloud cover is inconsistent with his testimony that a ceiling as defined by the FAA is indicative of a pilot's ability to maintain sight of a specific point on the ground for a sufficient length of time to land the aircraft. Tr. at 13458-59 (Horstman).

See Tr. at 13579-80 (Horstman); Joint Exh. 9 at 13-14. Thus, even total cloud cover below a pilot might not prevent him from ultimately seeing the PFSF before he ejected.

132. In addition, even clouds that obstructed a pilot's view of the facility would not deprive him of knowledge of his position relative to the PFSF. Tr. at 3288-90 (Fly). That knowledge is what the pilot needs to avoid the site. Tr. at 13711 (Jefferson). He could use landmarks such as Skull Valley Road, the PFS railroad, and the Stansbury and Cedar Mountains to see where he was relative to the PFS site. Tr. at 13038-41, 13044-52 (Fly), 8417-18, 8420-21 (Horstman). Col. Fly performed a demonstration at the hearing in which he showed that even with as much as 75 percent cloud cover, a pilot could see landmarks that would enable him to determine his position relative to the location of the PFSF. Tr. at 13044-48 (Fly). In addition to landmarks, the pilot would have available as well his navigational instruments, map, and flight plan to assist in determining his position relative to the location of the PFSF. Tr. at 13049-52 (Fly).[103]

133. Even above a complete undercast, as he flew down the valley the pilot would be using instruments and his map and could refer to features like the mountain ranges, if visible, to maintain awareness of his position. Tr. at 3288-90, 3601-02, 13052-53, 13079-80, 13096 (Fly), 8479-80 (Horstman), 13098-99 (Jefferson); see Tr. at 8921 (Campe), 13457 (Horstman); PFS Test at 51-53.[104] He might also have the PFSF programmed into his avionics as a steer point, which would put a symbol on the aircraft HUD indicating its location. Tr. at 8418-20, 13451-52,

[103] The relevant navigational instruments continue to function after an engine failure. Tr. at 13053-54 (Fly).

[104] In some cases where the weather was bad enough, the F-16s would not fly in Skull Valley. Tr. at 13098 (Jefferson); see, e.g., Tr. at 4538, 4541 (Horstman, thunderstorms are dangerous and with clouds "from the ground to the moon" many activities would be cancelled).

13473 (Horstman). In any event, the route of flight would be thoroughly planned beforehand with turn points along the way that the pilot could use as a reference to determine his position. Tr. at 13049-51 (Fly).

134. Finally, the area around the PFSF is wide open so the pilot would not have to have a highly precise picture of its location in order to avoid it. Tr. at 13711 (Jefferson) As discussed above, the only other buildings present near the PFSF are the Goshute village, about 3.75 miles east of the site, and two ranches, located 2.75 and 4.0 miles northeast of the site, and Tekoi (no longer in operation) two miles to the southeast. There are no structures of any kind to the west of the site, Aircraft Report at 21-22, and a plane that happened to be directed at the PFSF could easily divert to the west even in the event of total cloud cover over the site. Therefore, it is highly unlikely that weather would prevent a pilot from avoiding the facility in the event of an accident. [105]

(c) Visibility of PFSF

135. Equally unavailing is Lt. Col. Horstman's suggestion that the nose of the aircraft would obscure a pilot's ability to see and avoid the site. See, e.g., Horstman Test. at 24; Tr. at 8477 (Horstman). Consideration of the angle of descent of the aircraft, its orientation during a glide, and the pilot's field of view over the nose, shows that in fact the pilot would easily be able to see the point on the ground

[105] Lt. Col. Horstman also claimed that clouds above the pilot could cause him to have to eject from his aircraft immediately upon suffering an engine failure, in that he would have no space available to climb and then glide his aircraft toward the ground. Horstman Test. at 21-23. On cross-examination, however, Lt. Col. Horstman acknowledged that even if a pilot were flying just below a cloud layer he would have time before ejecting in that he would allow his aircraft to decelerate to recommended ejection speeds before ejecting. See Tr. at 8406 (Horstman). Lt. Col. Horstman acknowledged that at a speed of 425 knots and an altitude of 3,000 or 4,000 ft. AGL, a pilot would have time to avoid the PFSF if he suffered an engine failure while flying just below a cloud layer. Id. at 8422-23; see id. at 8441-42. He also agreed that "most of the time" a pilot would have sufficient time to avoid the PFSF if he were flying as low as 2,500 ft. with a cloud layer at 3,500 ft. and many pilots would in fact do so. Id. at 8423-26. UTTR weather data show that if there is a ceiling on the UTTR, 96 percent of the time it is at an altitude of 3,000 ft. or above. Tr. at 8429-30 (Horstman).

where it would impact. Tr. at 13642-44, (Fly); see Tr. at 3095, 3098-99 (Fly, F-16 glide path), 3569-85 (Fly, describing F-16 instruments and pilot's view); PFS Exhs. MMM (diagrams of F-16), NNN (F-16 HUD diagram); see also Tr. at 4511, 13168 (Horstman, confirming visibility below nose of aircraft). Indeed, on cross-examination Lt. Col. Horstman readily concurred that if the nose of the aircraft obstructed the view of a site on the ground while the aircraft was in a "glide descent" the aircraft "would overfly" the site before ground impact would occurred. Tr. at 8478-79 (Horstman). Furthermore, the pilot would have better visibility just off to either side of the nose of the aircraft. Tr. at 13640-41 (Fly); see Staff Exh. 65 at 171.

136. The State presented a video of a simulator that purported to show the visibility of the ground the pilot would have after an engine failure. See State Exh. 221 (video). However, the simulation was not representative because the conditions in the simulator were not those that would exist during an engine failure and the pilot's response to it. The simulator had the F-16 flying in powered, level flight at 200 knots at 2,000 ft. AGL, which put the nose of the aircraft approximately seven to 11 degrees above the horizon. Tr. at 13208-10 (Horstman). In the case of engine failure, when the pilot is descending in a 200-knot glide after his zoom maneuver, the aircraft flight path will not be level as in the simulation, but rather approximately 6 degrees below the horizon. Tr. at 3095, 3098-99, 13642 (Fly), 13258 (Horstman). According to the F-16-1 Flight Manual, the angle of attack (i.e., the angle between the flight path of the plane and where the nose of the aircraft is pointing) will be 7 degrees. Tr. at 13642 (Fly).[106] Thus, the nose will

[106] This testimony was given after the discussion of the different F-16-1 Flight Manuals for the Block 30 and the Block 40 both flown at Hill AFB (see Tr. at 13627-33) and Col. Fly was able to confirm that "both version" of the F-16-1 flight manuals provided the same 7 degree angle of attack for flight at 200 knots.

be approximately 1 degree above the horizon in contrast with the 7 to 11 degrees shown in the simulator video. Tr. at 13642, 13644 (Fly). In such a glide descent the pilot will have sufficient visibility to see the point on the ground at which the aircraft would impact. Id. at 13642-44.[107] Indeed, as stated above, Lt. Col. Horstman agrees that an aircraft in a glide descent following engine failure will overfly any point obstructed from the pilot's view by the nose of the aircraft. Tr. at 8478-79 (Horstman).

137. In addition to the pilot being able to see the ground, the F-16 flight path marker (which shows on the HUD where the aircraft is headed) will provide an accurate indication of where the aircraft will hit the ground and will assist the pilot in avoiding a structure on the ground. Tr. at 3102, 13643-44 (Fly), 4012-15, 4022 (Cosby). In addition, if the pilot has programmed the PFSF as a steer point in his aircraft avionics, the aircraft HUD would place a marker over the facility that would help the pilot see where it was. Tr. at 3111-17 (Fly).

138. Regarding the site's visibility, Lt. Col. Horstman agreed that it would be one of the largest built-up areas and would have perhaps the tallest structure in Skull Valley and would be of "fairly unique" appearance. Tr. at 13510-11 (Horstman). The site will also be illuminated at night for security reasons. Aircraft Report at 22. The visibility in Skull Valley is excellent; 96.3 percent of the time it is greater than or equal to seven miles. Revised Addendum Tab FF at 32. Col. Fly stated

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Tr. at 13642 (Fly). Lt. Col. Horstman incorrectly identified the angle of attack as 11 degrees. E.g., Tr. at 13255, 13280, 13304 (Horstman).

[107] In the descending glide, the F-16's flight path marker would be approximately 6 degrees below the horizon. The aircraft will impact the ground at the point where the flight path marker intersects the ground. The pilot can see an additional, approximate 5 degrees below the flight path marker before the nose of the aircraft starts to obstruct his visibility. Therefore, the pilot will be able to clear his flight path of any buildings, facilities, etc. Conversely, anything that is obscured under the nose of the aircraft is too close to the airplane to be hit and will be overflown. See Tr. at 13642-44 (Fly).

that he could see ranch houses from the air at a range of five miles and he believed that pilots would not have difficulty seeing the PFSF in excess of that distance. Tr. at 13674-75 (Fly). Lt. Col. Horstman did not express disagreement. Therefore, we find that the visibility of the site would not adversely affect a pilot's ability to avoid it in the event of an accident. Further, pilots regularly flying through Skull Valley would know where the facility was located, and new pilots would be briefed and have a flight orientation of the area before hand. See Finding 98, supra.

(d) The PFSF as a Populated Area

139. Finally, Lt. Col. Horstman testified that the fact that the PFSF will be a "facility," as opposed to a "populated area," would make it less likely that a pilot would avoid the site, in that the pilot's manual for the F-16 instructs pilots to turning the aircraft away from "populated areas" before ejecting. Horstman Test. at 18; Tr. at 13532, 13465 (Horstman); see Tr. at 13557-61 (Horstman). He claimed that a pilot whose crashing aircraft was going to hit the Hoover Dam might not try to avoid it because the dam was not, strictly speaking, a "populated area," despite the fact that damaging the dam could potentially cause great harm to many people. Tr. at 13559-60 (Horstman).

140. This argument, however, was not supported by the evidence and flies in the face of common sense and humanity. See Tr. at 3989-93 (Cosby). It will be well known to F-16 pilots flying in Skull Valley that the PFSF is a nuclear waste storage site. Wholly aside from the pilot's general knowledge, see Tr. at 3780-81 (Fly), the locations of nuclear power plants and nuclear waste sites are published in Defense Department route planning guides, Aircraft Report at 90-91, and sensitive areas, such as the chemical and biological laboratories on Dugway

Proving Ground beneath the airspace of the UTTR, are depicted on aviation maps and their locations are published in Air Force instructions. Tr. at 3519-20 (Cole), 3780, 13114 (Fly); see Tr. at 3929-30 (Bernard), 13472 (Horstman, pilots will have general awareness of the site). Pilots receive orientation with respect to safety hazards when they come to a new base. Tr. at 3781-82 (Cole), 3783 (Fly); see Tr. at 8932 (Campe). Moreover, pilots will see the site as they fly over it from week to week, even as it is being constructed. Tr. at 3600-01 (Fly); see also id. at 13051-52. Thus, they would be conscious of the site and can readily be presumed to know to divert their aircraft to the left or the right in the event of an emergency while transiting Skull Valley.

141. Further, all the pilots that appeared before the Board, including Lt. Col. Horstman, testified that they would certainly attempt to avoid the PFSF, knowing that it was a nuclear waste storage site, or any sort of industrial facility with nothing else around it, if they could. Tr. at 3921 (Bernard), 3776-77 (Cole), 3777, 3784 (Fly), 3777-78 (Jefferson), 4026-27 (Cosby). On cross-examination Lt. Col. Horstman testified that, "I'm in complete agreement that, given the right set of circumstances, the pilot would intentionally avoid the PFS site." Tr. at 4229 (Horstman); accord id. at 4512-14. "Now everyone in here and Colonel Fly would agree with me more than anyone if they knew about it they would try." Id. at 13465. He stated in his declaration supporting the State's opposition to PFS's motion for summary disposition of Utah K that, "I agree that any pilot, given adequate time and circumstances, would steer his or her aircraft away from a built up or population area." Tr. at 4226 (Horstman) (emphasis added). [108]

[108] Indeed, Col. Bernard stated that "most pilots are going to take fairly extraordinary efforts to save other lives." Tr. at 3914 (Bernard). As noted above, PFS presented examples of pilots going so far as to sacrifice their lives to avoid hitting sites on the ground where people there could have been injured or killed. See Tr. at 3763-66 (Cole) . Lt. Col. Horstman appeared to retract his claim when he stated late in

142. Thus, we find that Lt. Col. Horstman's argument that pilots would not avoid an industrial facility such as the PFSF is simply not credible. It is clear from the testimony on the record, including Lt. Col. Horstman's admissions, that the intent of the Air Force instruction to "avoid populated areas" or "turn aircraft toward uninhabited area" before ejecting is to avoid harm to human beings on the ground and that pilots would attempt to avoid the PFSF if they could for that reason alone. Tr. at 3286-88, 13633-34 (Fly).

(3) F-16 Accident Reports

(a) PFS's Evaluation of the Accident Reports for Pilot Avoidance

143. As stated above, based upon its evaluation of the time and circumstances involving likely emergencies that might occur while transiting Skull Valley, PFS's expert panel determined that a pilot in control of a crashing aircraft would be able to direct the aircraft away from the PFSF at least 95 percent of the time. PFS Test. at 17; Findings 93-102, supra. In addition, PFS's expert panel relied upon the accident reports for confirmation of their professional assessment that at least 95% of the time that a pilot in control would direct a crashing aircraft away from the PFSF. PFS Test. at 17. The accident reports showed that pilots in control of a crashing aircraft do in fact take necessary action to avoid sites on the ground after an accident-initiating event. In addition, the accident reports showed no cases in which a pilot failed to take steps to avoid or minimize damage to facilities or populated areas on the ground. Aircraft Report at 19, 23, Tab H at 28

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the hearing that, "I think just due to their humanity the pilots would do what we've seen and go below 2,000 feet to avoid any populated areas and they miss houses and they kill themselves trying as we've seen in other things." Tr. at 13463 (Horstman). There will be persons at the PFSF 24 hours a day and there is no reason that pilots would view the lives of the operations and security personnel at the PFSF any differently.

n.22. Based on their review of the accident reports, the panel believed that the percentage of pilots in control who would avoid the PFSF could reasonably be set at 100%, but chose to keep it at 95%. Id.

144. In response to questions from the Board, PFS's expert panel undertook a more formal evaluation of the accident reports for information concerning pilot avoidance. Tr. at 8662-63 (Jefferson). The evaluation focused on the F-16 accident reports for the 58 accidents that the expert panel determined were Skull Valley-type events in which the pilot retained control of the aircraft. See PFS Exh. 100A. Because many of the accidents occurred in military training areas with little or no civilian population, many of the accident reports do not contain any discussion of pilot avoidance because of the lack of populated or built-up areas that would require avoidance. Tr. at 13107 (Jefferson). Therefore, in addition to direct evidence of steps a pilot may have taken or not taken to avoid populated or built-up areas, PFS's expert panel also looked at a pilot's maneuvering of the aircraft as indicating that he had situational awareness and knew where he needed to go, as well as the absence of actual damage on the ground caused by the impact as indicating that the pilot did not fail to take action to avoid a site or structure on the ground. E.g., Tr. at 8678-80, 13106-07, 13110-11, 13117 (Jefferson), 13099-103 (Jefferson/Fly).

145. This evaluation by PFS's expert panel of the accident reports was not a statistically based evaluation. Tr. at 13121-22 (Jefferson). Rather, it is a qualitative evaluation of information in the reports relevant to the issue of pilot avoidance. Tr. at 13118-23 (Jefferson/Cole). Highly significant in this respect is that the reports show no instance in which a pilot failed to take steps to avoid or

minimize damage to facilities or populated areas on the ground.[109] The professional judgment of the expert panel was that a pilot in control of a crashing aircraft "would invariably take action to have the crashing F-16 miss the site" and this fact confirmed using an avoidance percentage of 100 percent instead of only 95% would be appropriate. Aircraft Report at 23; PFS Test. at 17j; Tr. At 13121-22, 1324-26 (Jefferson 13124-25 (Cole). However, to accounting for "unforeseen circumstances," the avoidance factor was kept at 95%. Id. See also Aircraft Report at 19, 23, Tab H at 28 n.22.

146. The expert panel's evaluation of the 58 Skull Valley events in which the pilot retained control of the aircraft showed 17 instances where specific actions were taken by the pilot to avoid areas or structures on the ground after an accident-initiating event. Tr. at 8662-66, 8678-80, 13100, 13108-09 (Jefferson); PFS Exh. 100A; see also Tr. at 3746-56 (describing examples).[110] The accident reports showed 28 cases in which the pilot turned toward an emergency airfield or took some other action indicating that he had situational awareness and knew where he needed to go. Tr. at 8662-66, 8678-80, 13106, 13108-09, 13119-20 (Jefferson); PFS Exh. 100A; see also Tr. at 13099-103 (Jefferson/Fly). Finally, the remaining 13 accident reports showed no cases where the pilot had the opportunity to avoid a facility or populated area on the ground but failed to do so; in other words those reports showed no harm to people or structures on the ground. Tr. at 3672, 3808-

[109] As discussed below, Lt. Col. Horstman agrees that there is no instance identified in the accident reports in which a pilot in control of a crashing aircraft failed to take action to avoid or minimize or damage to facilities or populated areas on the ground. Tr. at 8516-17 (Horstman).

[110] In two cases the reports indicate that the some damage was caused on the ground, but those were cases in which the pilot was attempting to avoid some other larger or more important populated area or structure on the ground. Tr. at 3959-60 (Cole), 13103, 13113/25-/26, 13124 (Jefferson); e.g., Tr. at 3750-52 (Fly).

09, 13122-23 (Cole), 3809 (Fly), 8662-66, 8678-80, 13103, 13108-09, 13117, 13123-24 (Jefferson); PFS Exh. 100A.[111]

147. We find the evaluation presented by PFS's expert panel of the accident reports to be highly persuasive. The accident reports clearly confirm a key fact that all pilots have testified to in this proceeding – that time and circumstances permitting a pilot will avoid populated and built-up areas. For example, a significant number of the reports clearly show that the mishap pilot maneuvered the aircraft in order to avoid populated areas or particular structures and built up areas that were directly in their flight path. The clearest example of this is the accident report involving Colonel Cosby as amplified by his personal testimony. The accident report succinctly states that: "Noticing a residential area in [his] flight path, [Colonel Cosby] made a 2-G left turn . . . ." PFS Exh. 79 at Bates No. 57619. The Board heard Col. Cosby's testimony in particular that he saw an apartment complex in front of him and made a hard 180-degree turn to the left in order to avoid it. Tr. at 3980-81, 3993-94, 4021 (Cosby). A 180-degree turn reversing direction is clearly much more than would be required for a pilot to turn and avoid the PFSF. In addition, as Col. Cosby was attempting to land he saw another plane on the taxiway on which he was trying to land and again maneuvered his aircraft ("put[ting] the airplane off in the infield") to avoid the plane. Tr. At 3980-81 (Cosby).

148. Other accident reports, though lacking the dramatic first hand account of Col. Cosby's accident, clearly reflect a pilot maneuvering the aircraft to avoid, or to

[111] While the reports are required to indicate any damage or injuries on the ground, they are not required to report pilot avoidance actions. Tr. at 3661 (Cole). Thus, a case with no damage but no mention of pilot avoidance might or might not have been a case in which the pilot avoided something; the only thing such a case indicates is that the pilot did not fail to avoid something. Tr. at 3661, 3664, 13122-23 (Cole), 3665, 3670, 13117 (Jefferson).

ensure avoidance of, populated areas or sites or structures in their flight paths. Accident reports that fall into this category include:

- The December 26, 1989 accident report[112] states: "During his zoom and resulting glide, the pilot made frequent corrections to his flight path to avoid populated areas while [his wingman] provided assistance with checklist support and addition clearing of the projected impact area of the jet. Early in the zoom, the pilot made a right hand turn to a northwesterly hearing to a relatively unoccupied area on the ground. The pilot intentionally delayed ejection below minimums recommended in T.O. 1F-16C-1. to further avoid populated areas in his flight path." Joint Exh. 1 at 2 (emphasis added); see also PFS Exh. 100A, Item 1.

- The September 20, 1990 accident report[113] states that one of the wingman informed the emergency aircraft that "there was a highway off his nose," after which the pilot made a "check turn to the northwest prior to ejection." After the turn another of the wingman "confirmed that there was no obstructions off [the] nose" of the crashing aircraft. PFS Exh. 115 at 4; see also PFS Exh. 100A, Item 2.

- The May 31,1992, accident report states that "[a]fter turning the aircraft toward an uninhabited area, the pilot ejected safely and the aircraft crashed and was destroyed." The report further states that "[r]ealizing the engine had seized, [the pilot] made the decision to abandon the aircraft over an unpopulated area." Joint Exh. 5 at 2 (emphasis added); see also PFS Exh. 100A, Item 49.

- The August 31, 1992 accident report[114] states that the "mishap pilot calculated that he could not reach [the nearest emergency airfield] by

[112] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

[113] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

[114] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

using an engine-out gliding procedure," and [p]assing approximately 5,000 feet MSL, [the pilot] abandoned further attempts to start the engine and seeing a populated area dead ahead and what appeared to be an uninhabited area to [his] left, turned the aircraft left onto a westerly heading, stowed [his] loose items, and at about 1,900 feet MSL, zoomed the aircraft and ejected at the apex of his zoom." PFS Exh. 140 at 4 (emphasis added); see also PFS Exh. 100A, Item 7.

- The December 17, 1992 accident report[115] states that "[the pilot] turned 20 degrees right to avoid a hunting lodge off his nose and to head towards the nearest landing field." PFS Exh. 145 at 2 (emphasis added); see also PFS Exh. 100A, Item 8.
- The September 11, 1993 accident report[116] states that "[t]he [mishap pilot] turned west" based on advise of his wingman to "turn west away from populated areas." PFS Exh. 158 at --- (emphasis added); see also PFS Exh. 100A, Item 10.
- The February 2, 1994 accident report[117] states: "After several unsuccessful airstart attempts, Captain MacWilliam directed the aircraft toward an uninhabited wooded area and safely ejected." Joint Exh. 7 at 1 (emphasis added); see also PFS Exh. 100A, Item 11.
- The May 15,1995 accident report,[118] which involved engine failure that "occurred at about 1200 feet AGL and about 430 knots," states that the pilot "turned slightly to point toward unpopulated terrain, and began to climb." The "aircraft impacted in privately owned desert ranch land."

[115] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

[116] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

[117] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

[118] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

"No structures were nearby." PFS Exh. 179 at 2 (emphasis added); see also PFS Exh. 100A, Item 15.

- The June 7, 1996 accident report[119] states that the pilot was flying above the clouds at about 10,000 feet MSL when his engine failed. Determining that he could not glide back to the home base, he "dropped below" the cloud deck at about 2,900 ft. AGL. "He visually cleared his aircraft away from inhabited farm sites, correcting slightly to the right towards a clear field area." He ejected at approximately 1,600 feet AGL, and the aircraft "impacted the ground . . . in a cornfield." Joint Exh. 9 at 1-2, 4, 13-14, 16 (emphasis added); see also PFS Exh. 100A, Item 13.

- The August 24, 1998 accident report[120] states that the "pilot delayed action jettisoning his external fuel tanks . . . due to his proximity to populated areas." "As it became apparent" he did not have enough altitude to reach the nearest emergency airfield, "he turned his aircraft toward the ocean and successfully ejected once the aircraft was clear of any populated areas." PFS Exh. 205 at 1 (emphasis added); see also PFS Exh. 100A, Item 16.

Thus, these accident reports clearly show the pilot the maneuvering a crashing aircraft to direct it away from populated areas and facilities on the ground.[121]

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[119] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

[120] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

[121] The accident reports set forth above are all Skull Valley-type events from the 10 year data set used for the evaluation, FY89-FY98 in which it was determined that the pilot had control of the aircraft. In addition, other accident reports are part of the record that do not fall within this definition, either because they were determined not to be Skull Valley-type events or fell outside of the applicable time period for the data set, but similarly show actions by a pilot to maneuver an aircraft to direct it away from populated areas or facilities on the ground. See, e.g., Joint Exh. 2 at 1 ("After at least two unsuccessful attempts to restart the engine, Captain West determined that he could not make a landing at Wendover, pointed the aircraft toward an uninhabited area of the desert and successfully ejected.") (emphasis added); Joint Exh. 8 at 3 (the pilot "directed the aircraft away from inhabited areas and ejected"); Joint Exh. 14 at 1 ("pilot turned aircraft towards an uninhabited area").

149. In addition, other accident reports show that while the pilot may not have maneuvered the aircraft away from populated areas or facilities on the ground, the pilot took steps to determine that his flight path was directed at an uninhabited area before ejecting. Accident reports that fall under this category include:

- The February 20, 1991 accident report[122] states that after descending "through the [scattered to broken] clouds," the pilot determined that he could not glide to the nearby airfield. "He checked his flight path and determined there was nothing to harm, no inhabited areas or buildings" before successfully ejecting. Joint Exh. 3 at 4 (unmarked) (emphasis added); see also PFS Exh. 100A, Item 4.

- The May 7,1991 accident report states[123] that the "Capt. Norris purposefully stayed with the jet a little while longer while its expected flight vector arced through the elephant cage or AN-FLR radar." He decided to eject when "he could visually confirm that the jet appeared to gliding toward [a] picnic area and away from inhabited areas." PFS Exh. 128 at 8 (emphasis added) [124]; see also PFS Exh. 100A, Item 5.

- The January 15, 1991 accident report states that the pilot "made a decision to abandon the aircraft over an unpopulated area." PFS Exh. 119 at 2; see also PFS Exh. 100A, Item 3.

- The August 21, 1995 accident report states that mishap aircraft "cleared his flight path" and that "[n]o structures were nearby" the point of impact. PFS Exh. 182 at 4-5 (unmarked); see also PFS Exh. 100A, Item 12.

[122] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

[123] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

[124] The accident occurred approximately two hours after sunset, see PFS Exh. 128 at 2, 15, making it unlikely that the picnic area would be in use.

150. In two of the accident reports, the crashing aircraft did hit structures on the ground, but both these accidents occurred near cites and the pilot clearly maneuvered the aircraft to avoid and minimize impact on the ground. See PFS Exh. 100A. Pilots transiting Skull Valley with the wide open spaces around the PFSF would not face such a choice of avoiding densely populated areas and impacting in more sparsely populated areas

- The January 13, 1992 accident report[125] states that after missing an attempted landing the pilot took-off again and "turned East (away from the city)." The pilot "realized [he] was going to have to eject so [he] attempted to point the aircraft away from populations centers and . . . ejected." PFS Exh. 134 at 3 (emphasis added). The report states that the "aircraft hit a house in a sparsely populated area approximately one mile east of McConnell AFB, KS, destroying the house and the aircraft, " but injuring no one. Id. at 1; see also PFS Exh. 100A, Item 6.
- The July 11, 1996 accident report[126] concerns an attempted emergency landing at the Pensacola Regional Airport. At the point the pilot realized he could not make it to the runway, "[t]here were houses everywhere he looked below him." It looked less dense to his right so "he started a right hand turn trying to aim the [aircraft] at an area where 'there were few, if any, houses.'" The pilot "continued to try and guide the aircraft into an open area" until the aircraft became so low and slow that his control inputs weren't affecting its flight path. The pilot ejected and the aircraft landed in a residential area 1.5 miles northwest of Pensacola Regional Airport, destroying a house, severely damaging another and killing a resident. Joint Exh. 10 at 5-6, 10; see also PFS Exh. 100A, Item 14.

[125] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

[126] This accident involved an engine failure. See Aircraft Report, Tab H, Table 1.

151. These two accidents thus clearly reflect the pilots maneuvering this aircraft to avoid or minimize damage to sites on the ground. In contrast to the accident that occurred in Pensecola with "houses everywhere," the PFSF will be an isolated facility with a large area around it, especially to the west, where a crashing aircraft that may be pointed at the PFSF could easily be directed to impact without hitting specific ground features, populated areas, or anything that could be damaged. Tr. at 13703-04 (Jefferson); Aircraft Report at 21-22. Lt. Col. Horstman testified that, "It is without a doubt easier to avoid a point target than it is an area target when you are talking about a city versus 50 acres as an example regardless of how big the city is. It would clearly take less maneuvering to avoid a smaller area." Tr. at 13471 (Horstman).

152. In addition to the reports stating explicitly that the pilot avoided an area on the ground, 27 other reports showed cases in which the pilot turned toward an emergency airfield or took some other action indicating that he had situational awareness and knew where he needed to go. E.g., Tr. at 8663 (Jefferson); see PFS Exh. 100A. Those cases show that the pilots knew where they were and acted accordingly in the event of an emergency, whether turning toward an emergency airfield, away from a populated area, or both. Tr. at 13102 (Fly). For example, in the second accident that Col. Cosby described, the pilot first turned toward his base but when he determined that the weather was not good enough for him to land he turned away from populated areas and ejected. Id. at 13103. In the June 7, 1996 accident, the report specifically states that the pilot made an "instinctive" turn back towards his home base when the incident began. In the April 18, 1991 accident, "The mishap pilot immediately zoomed the aircraft, turned toward home base and initiated engine airstart procedures." PFS Exh. 127

at 2. In the September 11, 1993 accident, "During a pull up after the third bombing pass, Bronco 3 experienced a momentary airframe vibration which stopped, then reappeared moments later on the base turn. [He] terminated the bomb pass and began a climb towards the emergency divert field." PFS Exh. 158 at 1. These are just a few examples in the reports which clearly show that the pilots have an awareness of where they are and what needs to be done in the event of an emergency.

153. Finally, the remaining 14 accident reports did not state whether the pilot maneuvered, but they reported no harm to people or structures on the ground, i.e., they showed no cases where the pilot had the opportunity to avoid a facility or populated area on the ground but failed to do so. E.g., Tr. at 8663, 8665-66, 13103 (Jefferson); see PFS Exh. 100A.[127] While this last group of reports contains less explicit information than the first two groups, the point they stand for is important. If the probability of success is defined as one minus the probability of failure, then because the reports in total show no cases of failure to avoid, they support a finding that the probability of successful avoidance is 100 percent. Tr. at 13117 (Jefferson); Aircraft Report Tab H at 28 n.22.

154. Another interesting fact that the accident reports highlight is the assistance provided the accident pilot by his wingman (or in one case air traffic control) in terms of directing the aircraft away from structures and facilities on the ground and other aspects of responding to the emergency. Col. Fly testified that he would expect other flight members to alert a pilot of an aircraft with a problem to the location of the PFSF or any other area to avoid. Tr. at 13658-59 (Fly). His testimony is supported by the accident reports describing flight members (and in

[127] Accident reports are required to report damage or injuries on the ground. See note 111, supra.

one case an air traffic control) helping pilots respond to their emergencies and avoid areas on the ground.[128] Therefore, because F-16s typically transit Skull Valley in flights of two or four aircraft, there is additional reason to believe that a pilot would be able to avoid the PFSF in the event of an accident.

155. Thus, the accident reports clearly show that pilots will take actions, time and circumstances permitting, to avoid populated areas and structures on the ground. While not a formal statistical analysis, the accident reports fully support the collective professional judgment of PFS's expert panel[129] that pilots in control of a crashing aircraft would be able to direct the aircraft away from the PFSF at least 95 percent of the time. In this respect it is highly significant that the accident reports do not record a single instance where a pilot in control of a crashing aircraft failed to avoid an isolated facility or structure, such as the PFSF, given the time and opportunity to do so.

156. Indeed, Lt. Col. Horstman himself acknowledged that he could not find any accident report that indicated that a pilot in control of an aircraft did not take steps to attempt to minimize damage on the ground when he could have. Tr. at 8516-17 (Horstman). While he has raised various interpretations and explanations of why the accident reports do not establish that a pilot would avoid the PFSF, as discussed next we find his interpretations and explanations unpersuasive. Therefore, we find that the accident reports fully support the collective

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[128] See, e.g., Joint Exh. 1 at 2 (assistance with checklist and clearing of projected impact area); Joint Exh. 3 at 3-4 (unmarked) (assistance with location of emergency airfield); Joint Exh. 5 at 2 (assistance with location of airfield); Joint Exh. 10 at 3-4 (location of airfield, safe location to jettison fuel tanks); Joint Exh. 11 at 3 (vector to clear area from air traffic control); Joint Exh. 14 at 3 (altitude and navigation assistance); Joint Exh. 15 at 3 (assistance clearing impact area of boats).

[129] The cumulative professional experience of PFS's expert panel is impressive. Collectively, it includes two retired generals and a retired colonel, the former Chief of Safety of the U.S. Air Force, three former Wing Commanders, and more than 12,000 hours of experience flying military aircraft. PFS Test. at 1-6.

professional judgment of PFS's expert panel and that of every pilot that has testified before the Board, that given the time and opportunity, pilots will avoid or minimize impact on populated areas and structures on the ground.

(b) State Challenges to PFS Evaluation

157. Lt. Col. Horstman has raised a host of interpretations and explanations to argue that the accident reports provide no basis "to predict that pilots would in the future, locate and avoid the PFS facility." Horstman Test. at 27. We find for the reasons below, however, that his arguments are not supported by the record. Indeed, Lt. Col. Horstman appears to misread or ignore pertinent information in the accident reports in order to make his arguments.

158. For example, in his pre-filed testimony (as well as on rebuttal), Lt. Col. Horstman claimed that none of the accident reports showed a pilot avoiding a site on the ground. Horstman Test. at 27; Tr. at 8497 (Horstman); State Exh. 223. One thrust of his argument was that, although pilots avoided things, one could not tell whether the pilot was avoiding an "area" or a "specific ground feature," such as the PFSF facility. See Horstman Test. at 27; Tr. at 8499-8500 (Cosby accident), 13381-82 (September 11, 1993 accident), 13408-09, 13459-60, 13531-32 (Horstman); see also id. at 13462-63 ("highly populated area" vs. "sparsely populated area"). Thus, he argued that in Col. Cosby's accident one could not tell whether the apartments that Col. Cosby avoided were an "area" or a "feature" and hence the report on Col. Cosby's accident (PFS Exh. 79) did not show that a pilot would have been able to avoid the PFSF. Id. at 8499-8500.

159. We do not find this argument to be credible. Col. Cosby stated that he avoided a complex of eight to twelve buildings. Tr. at 4012 (Cosby). The restricted area at the PFSF will contain 4,000 casks on concrete pads and will cover approximately

99 acres, roughly 1/3 of a mile by 1/3 of a mile when full. Aircraft Report at 15. It will be surrounded by a security fence and 130 ft. light poles which will illuminate the restricted area 24 hours a day. PFS Test. at 66, note 80. Further, the restricted area will contain a large Canister Transfer Building 260 ft. long and 90 ft. high. Id. Thus, if the buildings in Col. Cosby's accident constituted an "area," so would the PFSF.

160. Furthermore, the PFSF will be an isolated facility with a large open areas surrounding it. Tr. at 13703-04 (Jefferson); Aircraft Report at 21-22. As noted earlier, all of the pilots who testified in this hearing stated that they would avoid the PFSF if they could and, as noted above, if a pilot were heading towards a built-up area it would be easier to avoid a smaller area of acres as opposed to a much larger area of square miles, particularly here where there is nothing to the west of the PFSF. Therefore, we can find no support for Lt. Col. Horstman's claim that a case in which a pilot avoided a populated area would not support PFS's claim that the pilot could have avoided the PFSF.

161. In a similar vein, Lt. Col. Horstman also claimed that Col. Cosby's accident represented "only [a] close range landing type maneuver" and thus does not show that Col. Cosby could have avoided the PFSF. State Exh. 223 at 2 (item 9). The Board heard Col. Cosby testify that he saw an apartment complex in front of him and made a hard 180 degrees to the left in order to avoid it. Tr. at 3980-81, 4021 (Cosby). Lt. Col. Horstman testified on rebuttal that Col. Cosby had done "a magnificent job of avoiding things." Tr. at 13379 (Horstman). Yet when asked about it on cross-examination, he maintained that Col. Cosby was not avoiding the apartments, that the purpose of the turn was only to land the aircraft. Tr. at

13569, 13571 (Horstman). The evidence simply does not support Lt. Col. Horstman's characterization of the facts.

162. Lt. Col. Horstman argued that because the pilots in some of the reports ejected below the 2,000 ft. minimum recommended ejection altitude for the F-16, their training had failed and they had "broken the rules," or they had violated an "Air Force regulation." Hence they would not avoid a site on the ground. Tr. at 13219, 13370-71 (December 26, 1989 accident), 13378-79 (Cosby accident), 13385 (July 11, 1996 accident) (Horstman). Lt. Col. Horstman's theory is disproven, however, by the fact that pilots in the reports, including Col. Cosby, did in fact avoid sites or areas on the ground even though they ejected below 2,000 ft. See Finding 123, supra. According to the evidence in the record, ejection at below 2,000 ft. is not related to pilot's ability to avoid a site on the ground. Id. Further, the accident reports refer to the 2,000 ft. limit as "minimum recommended ejection altitude" and not as "rule" or "regulation." See, e.g., Joint Exh. 1 at 2; Joint Exh. 6 at 4; Joint Exh. 9 at 16; PFS Exh. 205 at 17. Indeed, some pilots have been specifically commended for delaying their ejection below 2,000 ft. AGL in order to avoid something on the ground. See Joint Exh. 9 at 16; PFS Exh. 2052 at 17. Thus, the asserted link between "violating" the minimum recommended ejection altitude and the hypothetical failure to avoid a site on the ground is conjecture and is not supported by the record.[130]

[130] The video of Col. Bernard's accident was created to reinforce the pilot's training to eject at 2,000 ft. AGL, but the fact of his accident does not mean that a pilot would fail to avoid the PFSF. See Tr. at 13698 (Cole), 13699-700 (Fly). The situation surrounding Col. Bernard's accident is very different from the situation pilots encounter in Skull Valley. Tr. at 13650-52, 13705-06, 13708-09 (Fly), 13652-55 (Cole). Indeed, the video reflects that at 1,000 ft. AGL, because of his involvement in the mock battle, he had not yet considered ejection. State Exh. 220.

163. Lt. Col. Horstman also argued that reports showing pilots maneuvering their aircraft did not show that pilots would be able to avoid a site on the ground since the reports did not state why the pilots made the maneuver. Tr. at 13371-72 (September 20, 1990 accident), 13393-94 (April 18, 1991 accident), 13396-400 (accidents of December 16, 1991, April 24, 1992, May 5, 1992, September 1, 1992), 13410 (Horstman). First, some of his claims were simply incorrect – the reports stated what the pilot was avoiding. For example, in the September 20,1990 accident, the pilot turned to avoid a highway, then his wingman cleared his path again before the pilot ejected. See PFS Exh. 115 at 4; Tr. at 13538-40 (Horstman) (September 20, 1990). Second, an indication that the pilot was maneuvering the aircraft shows that the pilot knew where he was, that he had the presence of mind to respond to the emergency, and that he was flying the aircraft. See Finding 152, supra. As discussed in Finding 107-109, supra, part of flying the aircraft is seeing where it is going and, if necessary, making a small course adjustment in order to avoid a site on the ground. Therefore, as discussed in Finding 11 above, we find the reports that the pilots maneuvered their aircraft and responded to the emergencies as indicative that they would also steer the aircraft as necessary to avoid a site on the ground before ejecting.

164. Referencing the February 20, 1990 accident report, Joint Exh. 3, Lt. Col. Horstman argued at one point that a pilot "clearing his flight path" before ejecting did not demonstrate that the pilot was trying to avoid anything on the ground. Tr. at 13373-74 (Horstman). In fact, the accident report showed that the pilot was looking to ensure that his aircraft would not hit anything before ejecting. Tr. at 13540-42 (Horstman); see Joint Exh. 3 at 4 (pilot "checked his flight path and determined that there was nothing to harm, no inhabited areas or buildings").

Inconsistently, in discussing the accident of June 7, 1996, Lt. Col. Horstman agreed that "clearing his flight path" meant that the pilot was checking to see whether his flight path was clear of things on the ground either before ejecting or before jettisoning stores. Tr. at 13384 (Horstman); Joint Exh. 9 at 2. As a practical matter, therefore, a pilot checking his flight path is looking to make sure his flight path is clear, whether it be a structure or another plane, and it shows the awareness to check and ensure that his aircraft or its stores would not hit anything.

165. Lt. Col. Horstman similarly claimed that reports stating that pilots directed their aircraft toward a particular area before ejecting do not demonstrate that they are directing them away from anything. Tr. at 13382 (February 2, 1994), 13387-89 (May 15, 1995, August 24, 1998, and April 3, 1990), 13394-95 (July 17, 1991, November 27, 1991, and December 16, 1991), 13408-09 (Horstman). Lt. Col. Horstman's argument is unconvincing. The February 2, 1994 accident report specifically stated that the area to which the pilot directed the aircraft was uninhabited. Tr. at 13578 (Horstman); Joint Exh. 7 at 1. The May 15, 1995 accident report described the area toward which the plan was being directed as "unpopulated terrain." Tr. at 13584 (Horstman); PFS Exh. 179 at 2 and 205.[131] In the August 24, 1998 accident, the report states that when it became apparent that the pilot did not have sufficient altitude to reach the airfield, "he turned the aircraft toward the ocean and successfully ejected once the aircraft was clear of any populated areas." Tr. at 13586 (Horstman); PFS Exh. 205 at 2. Indeed, that pilot was specifically commended for delaying the jettison of his fuel tanks and

[131] Lt. Col. Horstman claimed that the aircraft in the May 15, 1995 accident hit a ranch, Tr. at 13388 (Horstman), but he admitted later that the report states that the plane hit "ranch land" and did not hit any structures on the ranch, Tr. at 13583 (Horstman).

his ejection and pointing the aircraft toward the water. PFS Exh. 205 at 17. Yet Lt. Col. Horstman refused to draw the inference that the pilot turned toward the ocean in order to avoid populated areas. Tr. at 13586 (Horstman). It is clear in these cases that the pilots were steering the aircraft in order to control where the aircraft impacted and hence avoid damage, in the same manner as if they were attempting to avoid a specific area or facility. Therefore, we find that Lt. Col. Horstman's argument has no support.

166. Lt. Col. Horstman similarly argued that the pilots intentionally delaying ejection or delaying the jettison of aircraft stores to avoid something on the ground were not avoiding anything on the ground. E.g., Tr. at 13374-75 (Horstman, May 7, 1991 accident). This argument flies in the face of the accident report in question which states that, "Since he [the pilot] could visually confirm that the jet appeared to be gliding toward the picnic area and away from inhabited areas he then decided to eject." PFS Exh. 128 at 8 and 205; see Tr. at 13542-45. Lt. Col. Horstman's argument similarly ignores other accident reports which specifically commended pilots for delaying the jettison of stores or their ejection in order to prevent harm on the ground. E.g., PFS Exh. 205 at 17. While delaying ejection or the jettison of stores may not involve maneuvering the aircraft, it still causes the aircraft not to hit the objects or areas observed by the pilot and hence it is avoidance in fact. Therefore, we find that Lt. Col. Horstman's argument is similarly unsupported here.

167. Lt. Col. Horstman argued that reports showing that the pilot did not hit anything did not show that he avoided something. E.g., Tr. at 13372 (Horstman, January 15, 1991). That is correct as to any one report. However, as we discuss in Finding 153, supra, taken in their totality, it is quite significant that none of the

accident reports show that the pilot hit something he could have avoided. This absence of failures to avoid in a large database that also showed a significant number of cases of avoidance (thereby indicating the frequent presence of things to avoid) strongly suggests that pilots are very successful in avoiding areas on the ground.

168. Lt. Col. Horstman claimed that pilots could never rely on third parties, such as other flight members, to help them avoid the PFSF in Skull Valley. Tr. at 13402 (November 21, 1996) (Horstman); see also id. at 13380-81 (September 11, 1993). However, this claim is disproven by the fact that, as discussed in Finding 154, supra, many of the reports reflect that the pilots did rely on flight members or air traffic controllers to give them guidance to enable the pilots to avoid a site on the ground.

169. Lt. Col. Horstman argued that cases in which the pilot avoided one area but hit something else or where the pilot closely avoided something on the ground represented failures of avoidance. Tr. at 13375-76 (August 31, 1992), 13385-86 (July 11, 1996) (Horstman). First, avoidance is avoidance, whether by 100 ft. or 1,000 ft. Further, the August 31, 1992 report stated, contrary to Lt. Col. Horstman's claim, that the pilot deliberately turned to avoid a populated area and did not hit any structures on the ground. PFS Exh. 140 at 4; see Tr. at 13556-57 (Horstman). Second, as discussed in Findings 150-151, supra, while in two cases a pilot avoiding a densely populated area may have hit a lesser populated area, in Skull Valley, the PFSF is essentially an isolated facility. Aircraft Report at 21-22. Depending upon the route of flight, a modest turn by the pilot to the west or the east would ensure avoidance of the PFSF as well as other structures in the general vicinity. See Finding 98, supra.

170. Lt. Col. Horstman claimed that in some of the accidents that PFS assessed as "able to avoid" the aircraft was in fact not controllable and therefore the pilot was not in a position to avoid a facility on the ground, such as the PFSF. See Tr. at 13378 (accident of December 17, 1992), 13390-93 (accidents of January 13, 1991 and March 19, 1991), and 13403-05 (accidents of September 3, 1990 and February 19, 1993) (Horstman); see also State Exh. 223, Items 8, 19, 20, 46, and 53. Of these five accidents, Lt. Col. Horstman had identified his disagreement with PFS' classification only for two of them (the March 19, 1991 and February 19, 1993 accidents) until the very end of the evidentiary hearings. See PFS Exh. X. PFS addressed both of those accidents in its pre-filed testimony and showed that pilot would have had the ability to avoid a site on the ground.[132]

171. For the two accidents for which Lt. Col. Horstman previously identified his disagreement with PFS's expert panel, he merely restates his earlier disagreement and does not address PFS's response set forth in their pre-filed testimony. We find the evaluation of PFS's expert panel persuasive. In the March 19, 1991 accident (PFS Exh. 124), the pilot turned back towards the base that he had departed from after the first indications of an oil/hydraulic malfunction and flew the aircraft for 4-5 minutes before it began an uncommanded barrel role. Thus, had the event occurred in Skull Valley he would have had more than enough time to fly the aircraft away from built-up structures on the ground, such as the PFSF. PFS Test. at 69-71. In the February 19, 1993 accident (PFS Exh. 147) the aircraft suffered an engine failure, the pilot zoomed to just below the cloud deck, and he maintained control of the aircraft for about 26 seconds prior to the plane beginning an uncontrolled climb into the clouds. Lt. Col. Horstman claims that

[132] PFS Test. at 69-71 (March 19, 1991), 81-83 (February 19, 1993).

the pilot took no action to avoid any site on the ground, but ignores the fact that the accident occurred in the middle of a bombing range and in such a setting there was no need to take avoidance. In Skull Valley, the pilot would have had sufficient time to direct the aircraft away from built-up areas, and remaining below the cloud deck, would have been able to see the PFSF and avoid. PFS Test. at 81-83.

172. With respect to the other three accidents, Lt. Col. Horstman had not expressed any disagreement whatsoever when he previously reviewed PFS's classification of the accidents as "Able to Avoid." See PFS Exh. X. Neither did he identify any disagreement with PFS's categorization of these accidents in his February pre-filed testimony or in the April and May 2002 sessions of the hearing. To the contrary, he repeatedly reaffirmed, with one exception,[133] that the extent of his disagreement with PFS's categorization of the accident reports was limited to those set forth in PFS Exh. X. Tr. at 4411-12, 4414-15, 8506-13, 8519-20 (Horstman).

173. Thus, it was not until the next to the last day of the hearing that Lt. Col. Horstman identified these accidents for which he would now change his determination of "able to avoid." He suggested that this change had come about due to his having previously believed himself bound by PFS's category definitions. Tr. at 13593-54 (Horstman). As we have already held above, however, we find this claim of Lt. Col. Horstman to be lacking in any merit whatsoever.[134] Lt. Col. Horstman gave

[133] That exception was the March 16, 1990 accident discussed above.

[134] Moreover, on cross-examination he expressly acknowledged that the determination of "able to avoid" was not related to those category definitions and that the category in which an accident was placed (e.g., Skull Valley-type event) would not affect the separate determination of whether a pilot was in control of a crashing aircraft and would be able to avoid a site on the ground. Id. at 13593-94.

no other explanation for the change, and being provided no rationale or basis for his change in determination at this late date, we give them no weight.

174. Moreover, the flaws in Lt. Col. Horstman's new determinations are readily evident. As discussed above, the December 17, 1992 accident (PFS Exh. 145) involved the pilot turning to avoid a hunting lodge after which he ejected from the aircraft. Lt. Col. Horstman testified regarding this accident that, "you can't even stretch your imagination far enough to think that the pilot was in control of the airplane." Tr. at 13378 (Horstman). If so, he never explained how he could have concluded in his initial review that the pilot was in control of the aircraft. The answer is quite simple. The accident report shows that the pilot in fact maneuvered the plane to avoid hitting a hunting lodge and was indeed in control of the aircraft at the time he ejected. Tr. at 13565-67 (Horstman); PFS Exh. 145 at 2. Thus, we find no merit to Lt. Col. Horstman's newly minted claim; the accident report clearly shows that the pilot avoided a specific site in that accident.

175. Similarly, a brief review of the reports concerning the other two accidents do not appear to support his claim either. The report for the September 3, 1990 (PFS Exh. 113) accident shows that the pilot was operating at low altitude when he got several warning lights, initiated a climb and subsequently zoomed the aircraft as would be expected for a pilot in control and flying at low altitude. Thirty seconds after initial indications of the problem and indications of a fire, the pilot made the decision to eject. Shortly after the ejection, the aircraft pitched down and impacted the ground in the open desert. The pilot clearly was in control of the situation and took appropriate actions before he ejected. Had he been in Skull Valley, it is reasonable to assume he would have pointed the aircraft away from

any facility prior to ejecting, and the aircraft would have impacted the ground shortly after ejection without hitting the PFSF.

176. The January 13, 1991 accident (PFS Exh. 118) appears similar to the March 19, 1991 and the February 4, 1997 accidents. After the accident initiating event, the pilot turned toward an airfield and followed parts of two different emergency checklists. The main generator then failed and twenty-eight seconds later the airplane went out of control. Had this accident occurred in Skull Valley instead of the middle of the Saudi desert, he clearly would have had time to turn and avoid the PFSF.

177. Lt. Col. Horstman also claims with respect to several accidents that clouds would have precluded a pilot from taking actions to avoid a site on the ground. For example, he claims that with respect to the January 13, 1995 accident (PFS Exh. 175)that weather would have prevented the pilot from avoiding anything on the ground. Tr. at 13405. As discussed in Finding 114, supra, we do not find Lt. Col. Horstman's claims with respect to this accident persuasive. The cloud cover was at 3,000 ft. AGL and had the accident occurred in Skull Valley the pilot could have easily used the mountains and his navigation instruments to know his position relative to that of the PFSF and steer his aircraft to the wide open area around the facility. Id.

178. The other two accidents involving weather both involved situations in which the pilot was in contact with air traffic control, and would have been in a position to be directed by air traffic control to an uninhibited area. Indeed, that is what occurred in the November 21, 1996 accident (Joint Exh. 11). As reflected in PFS Exh. 100A, Item 40 states for this accident: "the recommended heading provided by ATC (Air Traffic Control) to uninhabited area." This is stated in the accident

report as well. Joint Exh. 11 at 1 ("pilot received directional heading from radar facility toward unpopulated area"). Indeed, this accident explicitly shows the pilot avoiding populated and built-up areas on the ground. Also, the cloud cover in this instance was only approximately 3,000 AGL. Id. at 3. Therefore, without assistance from radar control the pilot again could have easily used the mountains and his navigational instruments to avoid the PFSF. Similarly the pilot of the February 4, 1997 accident (PFS Exh. 189) was in contact with air traffic control above a cloud deck and could have been directed to an uninhabited area if need be. In that case the aircraft impacted in federal land 11 number miles from Wendover, in an unpopulated area.

179. Lt. Col. Horstman claimed that PFS mischaracterized the April 3, 1990 accident by incorrectly stating that the pilot turned toward a controlled bailout area. Tr. at 13389 (Horstman). The accident report stated, however, that the pilot did in fact make the turn. PFS Exh. 110 at A1; see Tr. at 13588 (Horstman).

180. In conclusion, Lt. Col. Horstman's claim that none of the F-16 accident reports support a finding that a pilot would in fact avoid the PFSF in the event of a mishap in Skull Valley that left him in control of the aircraft is profoundly wrong. Lt. Col. Horstman ignores many instances where the reports stated explicitly that pilots maneuvered specifically to avoid hitting populated areas. His claim that reports that discuss the pilot maneuvering and responding to the emergency are irrelevant to pilot avoidance is also contradicted by the record. As PFS's witnesses stated, maneuvering and responding to an emergency indicates that the pilot is aware of his situation and is actively dealing with it. Since all of the pilots who testified in this proceeding stated that pilots would try to avoid the PFSF if they could, we believe that dealing with an in-flight emergency would include

maneuvering to avoid areas on the ground before ejecting. Hence the accident reports that discuss maneuvering are probative of pilot avoidance. Finally, Lt. Col. Horstman's claims about aircraft being out of control in several accidents are unconvincing, in that his claims are not supported by the rest of the evidentiary record. Furthermore, despite his statement that he reviewed the accident reports in detail as far back as one year ago, in three cases he identified the accidents only on the last day of the hearing, suggesting that his beliefs are less than heartfelt.

c) **Conclusion**

181. In accordance with the foregoing, PFS' crash impact hazard analysis established that 85.5 percent (90% x 95%) of the crashing F-16s would be able to avoid the PFSF. Hence the calculated crash impact hazard to the PFSF would be reduced by this fraction. Thus, the factor *R* in the equation above is equal to 100% - 85.5%, or 14.5%.

182. PFS's crash impact probability calculations are not highly sensitive to changes in the fraction of accidents that would leave a pilot in control of his aircraft after an in-flight emergency with time to avoid a site on the ground. We note that PFS used 90% when its analysis showed that 95% of the time the pilot would remain in control of aircraft. PFS Test. at 17, 62. Thus, even doubling its number of accidents in which a pilot did not remain in control from 3 to 6, the appropriate percentage would still be 90% (55 in control out of a population of 61, or 55/61 = 90.2%). Even assuming that Lt. Col. Horstman were correct that some additional accidents should have been classified as not able to avoid, it would not change the results of the analysis.

183. The results of the crash impact probability calculation using the equation in finding 14 above are also not highly sensitive to changes in the probability that a

pilot in control of his aircraft after an in-flight emergency would fail to avoid a site on the ground. The NRC Staff performed a sensitivity analysis in which it varied the probability of failure to avoid from one percent to 20 percent. Tr. at 4081-82 (Ghosh). It found that the crash impact probability changed by a factor of approximately 2.5. Id. PFS assumed a probability of failure to avoid of 5 percent. See PFS Test. at 17. According to the Staff's analysis, if the probability of failure to avoid is increased by a factor of four, from 5 percent to 20 percent, the crash impact probability increases only by a factor of 1.86. Tr. at 4084 (Ghosh). This would change PFS's calculated hazard for F-16s transiting Skull Valley from 3.11 E-7 to 5.78 E-7. The cumulative hazard probability would increase from <4.17 E-7 to <6.84 E-7, which would remain well within the 1 x E-6 criterion.

8. Conclusion

184. PFS used a clear and logical methodology to calculate the impact hazard to the PFSF posed by F-16s transiting Skull Valley. PFS's assessments of the number of flights and the F-16 crash rate are based on data published by the Air Force. PFS's assessment of the effective width of Skull Valley is based on an analysis of the physical dimensions of Skull Valley and on information regarding where the F-16s fly that was provided to PFS by the Air Force. PFS's assessment of the likelihood that a pilot would be able to direct a crashing F-16 away from the PFSF is based on 10 years of Air Force F-16 accident reports and the professional judgment of three highly experienced former Air Force pilots. The claims made by the State in challenging PFS's analysis are unsupported assertions that have changed over time as the State has sought to create issues where none exist. The State's claims provide no reason to doubt PFS's assessment that the hazard to the

PFSF from F-16s transiting Skull Valley is extremely low, well below the Commission's IE-6 Standard. PFS's analysis also includes significant conservatisms that give added confidence to the crash probability calculated by PFS. In particular, the calculated probability is essentially proportional to the number of casks stored at PFSF, so that during the facility's initial years, the risk to PFSF for F-16 crashes would be a small percentage of the risk already calculated as less than the NRC standard.

D. Aircraft Conducting Training on the UTTR

185. Aircraft on the UTTR South Area perform a variety of activities, including air-to-air combat training, air-to-ground attack training, air-refueling training, and transportation to and from Michael AAF (which is located beneath UTTR airspace). PFS Test. at 90; Staff Test. at 36. We determined on summary disposition that aircraft conducting air-to-ground attack training and weapons testing using air-delivered ordnance and aircraft conducting air refueling training would pose no significant hazard to the PFSF. See LBP-01-19, 53 NRC at 446. The hazards posed by aircraft flying to and from Michael Army Airfield on Dugway are discussed below, separate from the hazards posed by UTTR operations. Thus, the only activity we assess here is air-to-air combat training on the UTTR.

186. We find that aircraft conducting air-to-air combat training on the UTTR pose a negligible hazard to the PFSF, i.e., less than 1 E-8. This is primarily because the activity on the UTTR occurs too far away from the PFSF to pose a hazard to the facility. The PFSF is located 2 miles east of the eastern boundary of the UTTR restricted airspace. PFS Test. at 91. The aggressive maneuvering that takes place in air-to-air combat training occurs toward the center of the restricted area range,

typically more than 10 miles from range boundaries. Id. at 92. On the basis of where F-16s fly on the UTTR, PFS assumed a 3-mile buffer zone just inside the UTTR restricted areas as a practical limit in defining where aircraft do not fly while conducting aggressive maneuvering flight operations in UTTR restricted areas. Id. at 91; Staff Test. at 36. Thus, the PFSF is located 5 miles east of the closest point at which an event leading to a crash would be expected to occur. PFS Test. at 92. Hence, a crashing aircraft on the UTTR either would not be able to reach the facility before impacting the ground (if it were out of control) or would be steered away from the facility (if it were in control). Id.

187. The assumed three mile buffer is reasonable because it reflects what actually takes place on the range and corresponds to the practical limit that pilots observe while flying training exercises on the UTTR. Aggressive maneuvering during simulated air-to-air engagements at visual or beyond visual ranges, tends to take place toward the center of the restricted areas. PFS Test. at 91; Staff Test. at 37. Furthermore, the Cedar Mountains provide a clear visual indication to pilots of the eastern edge of the restricted area and Clover Control provides warnings to pilots as they approach within 5 miles of the edge of the restricted area to prevent them from straying outside. PFS Test. at 91; see also Aircraft Report at 37c.

188. Accidents on the UTTR that did not leave the pilot in control of the aircraft would not pose a hazard to the PFSF. Review of the F-16 crash reports for accidents occurring during special in-flight operations (i.e., operations involving aggressive maneuvers on a training range) in which the pilot does not maintain control of the aircraft (e.g., a mid-air collision or G-induced loss of consciousness) indicates that most such accidents would occur toward the center of the restricted ranges. PFS Test. at 92; Staff Test. at 37. It is most likely such crashing aircraft would travel

less than 5 miles horizontally before impacting the ground. Even in the event of G-induced loss of consciousness, which is the type of accident that would not leave the pilot in control but would cause the aircraft to travel the greatest distance before hitting the ground, the aircraft would travel no more than about five miles. PFS Test. at 92; Staff Test. at 37; see also Aircraft Report, Tab Y.

189. For accidents in which a pilot does maintain control, the aircraft would be five or more miles from the PFSF site when the accident occurred by virtue of the 2 miles that the PFSF is from the eastern boundary of the UTTR airspace and the three mile buffer observed while operating in restricted airspace. The UTTR is a large safe area to receive a crashing aircraft in an emergency. PFS Test. at 93-94: PFS Exh. P (map). As discussed above, pilot training instills a responsibility to avoid populated areas in the event of an emergency if possible, PFS Test. at 93, and the accident reports clearly show that in emergencies pilots do direct their aircraft away from populated areas. Moreover, Michael AAF, on the east side of the UTTR, would be available for the pilot to make an emergency landing if possible. Id. at 94. Therefore, it would be unreasonable to postulate that a pilot in control of a crashing aircraft in such circumstances would glide over the Cedar Mountains, and off the restricted range towards Skull Valley, the PFSF and other inhabited structures located there. Id. at 93. Indeed, in his December 2000 deposition, Lt. Col. Horstman agreed that an aircraft crashing on the UTTR would not fly into Skull Valley and reach the PFSF. Id. at 94.

190. State witness Dr. Resnikoff asserted that aircraft on the UTTR would pose a hazard to the PFSF by assuming that a crashing aircraft could fly 10 miles before impacting the ground. Resnikoff Test. at 17-19; Tr. at 8792-94. The only support for Dr. Resnikoff's assertion was an previous assessment PFS had performed,

before it had obtained the information from the accident reports, in which PFS had conservatively assumed that a crashing aircraft could fly a maximum of 10 miles before impacting the ground. Tr. at 8798-99 (Resnikoff); see PFS Test at 94-95. Thus, the only basis for Dr. Resnikoff's assumption has been superseded and there is no reason to credit Dr. Resnikoff's claim. Therefore, we find that aircraft conducting air-to-air combat training on the UTTR would not pose a significant hazard to the PFSF.

E. Aircraft Flying on the Moser Recovery Route

191. Most of the F-16s returning to Hill AFB from the UTTR South Area exit the northern edge of the range (away from Skull Valley and the PFSF) in coordination with air traffic control. PFS Test. at 96; Staff Test. at 38. However, some aircraft returning to Hill AFB from the UTTR South Area may use the Moser Recovery Route, which runs from the southwest to the northeast, with the centerline of the route approximately two miles from the PFSF site at its closest approach. PFS Test. at 96. The Moser route is only used during marginal weather conditions or at night under specific wind conditions which require the use of Runway 32 at Hill AFB. Id.; Tr. at 3462-64, 3799-3802 (Fly); see also Tr. at 3466-70 (Fly). PFS calculated the average annual crash impact probability for aircraft flying the Moser recovery route using the same method used for calculating the hazard from F-16 flights through Skull Valley. PFS Test. at 97.

192. PFS estimates that approximately five percent of the F-16 flights on the UTTR return to Hill AFB via the Moser Recovery. PFS Test. at 97; Tr. at 3456-58 (Cole), 3799-3802 (Fly). This estimate is supported by conversations with the Vice Commander of the 388th FW at Hill AFB, the operations group commander of the 388th FW, and an air traffic controller in the Salt Lake City Air Traffic

Control Center. Id. Thus, based on FY98 UTTR sortie data, an estimated 286 flights used the Moser Recovery in FY98. PFS Test. at 97. PFS defined the Moser Recovery as an airway with a width, *w*, of 10 nautical miles (11.5 statute miles) (equal to the width of military airway IR-420). PFS Test. at 97; Staff Test. at 40. The other factors PFS used in its calculation were the same as those used to calculate the hazard to the PFSF from F-16s transiting Skull Valley: the crash rate, *C*, was equal to 2.736 E-8 per mile; the effective area of the site, *A*, was 0.1337 mi^2; and 14.5 percent of all crashes would be attributable to events in which the pilot could not direct the aircraft away from the PFSF (the *R* factor). PFS Test. at 97. PFS assumed that the sortie rates on the UTTR, and thus the number of flights on the Moser Recovery Route increased proportionally to the number of F-16 sorties through Skull Valley. Id. It then increased the number of FY98 Moser flights proportionally to account for the higher Skull Valley sortie counts in FY 99 and FY 00 and the sorties that would be flown in the future by the 12 additional F-16s assigned to Hill AFB in FY 01., Thus, PFS calculated a crash impact hazard from the Moser Recovery of 2.0 E-8 per year. Id.[135]

193. The State asserted that PFS should have assumed that one-third of all flights on the UTTR returned to Hill AFB via the Moser Recovery because in the future, up to one-third of the flights on the UTTR may be conducted at night. Resnikoff Test. at 16; Horstman Test. at 30; see Tr. at 8833-34 (Resnikoff). The State's theory was based on an unsupported assumption that all flights at night would use the Moser route, purportedly because the 388th FW was using night vision goggles in training. See id. On the contrary, the 388th FW operations group commander

[135] The NRC Staff calculated the hazard from the Moser Recovery using the actual 2000 UTTR sortie data and arrived at a similar number of flights using the route. See Staff Test. at 39-40 (the Staff also assumed a different probability of pilot avoidance than PFS did).

stated that even at night the Moser Recovery was greatly disfavored because of interference with civilian traffic at Salt Lake City Airport. Tr. at 3800-01 (Fly). The Hill AFB staff told the NRC Staff that night vision goggle usage had not led to an increased usage of the Moser Recovery. Staff Test. at 39; PFS Test. at 98 & n.168. Therefore, there is no basis for the State's assumption and no basis for its assertion regarding Moser Recovery usage.[136] Thus, we find that the crash impact probability at the PFSF arising from flights on the Moser Recovery Route is equal to 2.0 E-8 per year.

F. Aircraft Flying to and from Michael AAF on IR-420

194. Michael Army Airfield is located on Dugway Proving Ground, 17 statute miles south-southwest of the PFSF. PFS Test. at 98; Staff Test. at 41. IR-420 is a military airway that runs from northeast to southwest and ends about 7 miles north of the PFSF site, at the northern edge of the Sevier B MOA (i.e., IR-420 runs from the edge of Sevier B to the northeast). Id. Aircraft flying to and from Michael AAF from the northeast, including aircraft flying to and from Hill AFB, may fly in the direction of IR-420 and pass within a few miles of the PFSF site. Id. The majority of the flights to and from Michael AAF are F-16s from Hill AFB conducting training. Id. Those aircraft using IR-420 are accounted for in PFS's Skull Valley-transiting F-16 calculation.[137] Most of the remainder of the aircraft flying to and from Michael AAF are cargo aircraft such as the C-5, C-17, C-141, C-130 and the smaller C-21 and C-12. Id. We find that these aircraft contribute no significant risk to the PFSF.

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[136] The State also assumed that there would be more F-16 flights on the South UTTR than were actually flown in FY99 and FY00. See Tr. at 8864-66 (Jefferson).

[137] Any F-16 using IR-420 would necessarily fall into the Sevier MOA traffic count as IR-420 ends where the Sevier MOAs begin at the north end of Skull Valley. Any F-16s that went to Michael AAF without transiting Skull Valley would not be relevant to the hazard to the PFSF.

195. The same method PFS used to calculate the hazard to the PFSF from F-16s transiting Skull Valley was used to estimate the probability of an aircraft impacting the PFSF from aircraft flying to and from Michael AAF (i.e., $P = C \times N \times A / w$). The State did not submit testimony on the hazard posed by aircraft flying to and from Michael AAF in the direction of IR-420. See Horstman Test.; Resnikoff Test. NUREG-0800 provides an in-flight crash rate of 4 E-10 per mile for large commercial aircraft, which is appropriate to apply to the types of large cargo aircraft flying to and from Michael AAF. PFS Test. at 99; Staff Test. at 42. PFS estimated a maximum of approximately 414 annual flights by aircraft other than F-16s at this airfield. PFS Test. at 99; Staff Test. at 43-44.[138] The effective area of the PFSF is 0.2116 mi^2, calculated for the types of aircraft flying to and from Michael AAF, using the same method as was used to calculate the effective area of the PFSF for an F-16. PFS Test. at 99; Staff Test. at 43. The width of the airway is 10 nautical miles, or 11.5 statute miles. Id. Therefore, an upper bound on the probability of an aircraft impacting the PFSF, is 3.0 E-9 per year.

G. Military Ordnance Hazard

1. Hazard from Direct Impact

196. Based on data from Hill AFB regarding ordnance usage by F-16s in FY99 and FY00, approximately two percent of the F-16s transiting Skull Valley carry jettisonable ordnance.[139] PFS Test. at 12; Staff Test. at 32. In the event of an

[138] The 414 flight estimate was based on FY97 data from Michael AAF. Based on the total number of takeoffs and landings at Michael AAF each year from FY98 to FY00, excluding those conducted by F-16s, a maximum of 212 flights per year during that period were conducted by aircraft other than F-16s. PFS Test. at 99-100. If it is taken into account that the aircraft fly to and from airfields in all directions from Michael AAF, the estimated number of flights in the direction of the PFSF would be even lower. Id. at 100.

[139] Because of the other ways available to Air Force pilots to train to deliver the newer, laser directed or self-guided ordnance, there is very little requirement for pilots to train by dropping live or heavy weight ordnance on the UTTR. Tr. at 3501-03, 13084-85 (Fly).

incident leading to a crash in which the pilot would have time to respond before ejecting from the aircraft (e.g., an engine failure), one of the pilot's first actions would be to jettison any ordnance carried by the aircraft. PFS Test. at 102. The potential hazard posed to the PFSF by jettisoned military ordnance is very small due to the small number of aircraft carrying ordnance, the rarity of aircraft jettisoning ordnance, and the small probability that ordnance jettisoned somewhere along the route would hit the PFSF. PFS estimated this probability as 3.2 E-8, based on the NUREG-0800 formula to calculate the probability, *P*, that the ordnance would impact the PFSF using the equation $P = N \times C \times e \times A/w$.

197. PFS generally followed the same approach that it used in calculating the hazard to the PFSF for F-16s transiting Skull Valley as follows:

- The number of aircraft carrying live or inert ordnance through Skull Valley per year, *N* in the equation above, would be 150. This is based on the average number of F-16s carrying ordnance through Skull Valley for FY 99 and FY 00 (2.556 percent of the total number of Skull Valley sorties), increased by 17.4 percent to account for the additional aircraft based at Hill AFB in FY 01. PFS Test. at 102. PFS based its estimate on the two most recent years, the same years it used to estimate the Skull Valley sortie count. Id.

- The crash rate for the F-16s, *C*, was taken to be 2.736 E-8 per mile. PFS Test. at 103; Staff Test. at 34.

- The pilot was assumed to jettison ordnance in 90 percent of all crashes, the fraction of the crashes, *e*, assumed to be attributable to engine failure or some other event leaving him in control of the aircraft (in crashes attributable to other causes it was assumed that the pilot would eject quickly and would not jettison ordnance). PFS Test. at 103; Staff Test. at 31. Even though the accident reports reflect that pilots will take steps to avoid jettisoned ordnance impacting built-up or populated areas, PFS conservatively assumed no "R" factor to account for such avoidance. Revised Addendum at 30-31.[140]

- Skull Valley was treated as an airway with a width, *w*, of 10 statute miles. PFS Test. at 103; Staff Test. at 33.
- The area of the PFSF, from the perspective of ordnance jettisoned from an aircraft flying from north to south over the site, *A*, was taken to be the product of the width and the depth of the cask storage area (assuming a full facility with 4,000 casks) plus the product of the width and depth of the canister transfer building, in that pieces of ordnance are small relative to an aircraft and impact the ground at a steep angle. PFS Test. at 103.[141] Thus, the area of the PFSF was calculated to be 0.08763 sq. mi. Id.

Based on these input values, PFS calculated the hazard to the PFSF from jettisoned ordnance to be 3.2 E-8.

198. PFS's estimate of the hazard posed by jettisoned ordnance is conservative in two respects. First, it does not take into account that about half of the cask storage area at the PFSF, even when full, will consist of empty space rather than storage casks. PFS Test. at 112; Aircraft Report at 83. Second, it also does not take into account the fact that according to the Air Force none of the inert munitions carried through Skull Valley would penetrate the lid of a cask and the great majority of

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[140] Pilots are also trained to steer their aircraft away from populated areas before ejecting if possible, but they are trained to jettison ordnance quickly upon suffering an engine failure at low altitude. See Tr. at 3557-58 (Fly) (jettison ordnance); Finding 96; supra (avoid populated areas).

[141] Dr. Resnikoff asserted that PFS should have used a "skid area" in front of the PFSF to account for jettisoned ordnance potentially skidding into the PFSF. Resnikoff Test. at 20. The only basis for his assertion was an undocumented conversation between Dr. Resnikoff and Lt. Col. Horstman. Tr. at 8801-05 (Resnikoff). Gen. Jefferson, on the other hand, testified that the ordnance would not skid because it would impact the ground at a steep angle. Tr. at 8868-69 (Jefferson).

them would not penetrate the side of the cask. Id.[142] The net effect is that the hazard from jettisoned ordnance is on the order of 7 E-9 per year rather than the calculated figure of 3.2 E-8 per year. Id.

199. The State claimed that PFS should have assumed that the fraction of sorties in Skull Valley carrying jettisonable ordnance would be the same as it was in FY98 rather than what it was in FY99 and FY00. Horstman Test. at 29. The only reason behind the State's claim is that the FY98 fraction was higher than the FY99 and FY00 fractions.[143] Lt. Col. Horstman asserted that lower ordnance usage in FY00 was due to some of the F-16s at Hill AFB having been deployed to the Caribbean for drug interdiction missions. Horstman Test. at 29. However, the deployment to the Caribbean was much smaller than other past deployments and the training of the F-16s is not based on one particular deployment (or year to year fluctuations in budget). Tr. at 13090-91 (Fly). Moreover, the State did not account at all for the FY99 ordnance usage, which was almost identical to the usage in FY00. Revised Addendum, Tab GG at 14. Requirements for F-16 ordnance usage in training are established by Air Force regulations and each unit's designated operational capability. Tr. at 13082-84 (Fly). Those requirements do not change frequently. Id. at 13086-87. Furthermore, the Air Force Safety Agency has stated that ordnance expenditures are not expected to increase in the future. Tr. at 13087-88 (Cole). Thus, the State's claims provide

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[142] See Letter from Col. Lee Bauer, USAF, Deputy Associate Director for Ranges and Airspace, to Connie Nakahara, Utah Department of Environmental Quality (Dec. 28, 2000) (State Exh. 62); Letter from Denise L. King, Freedom of Information Act Manager, 96th Communications Squadron (AFMC), Eglin Air Force Base, Florida, to Connie Nakahara, Utah Department of Environmental Quality (Jan. 18, 2001) (State Exh. 63).

[143] Notably the State did not claim that PFS should have used FY98 as the baseline for estimating the sortie count for Skull Valley. See Horstman Test at 12. Had the State done so, its estimated sortie count would have been approximately 4,500 (increasing the FY98 Sevier B MOA count by 17.4 percent to account for the additional F-16s added to Hill AFB in FY01). See id. at 11.

no reason to doubt PFS's assessment of the hazard to the PFSF posed by jettisoned ordnance.

2. Potential Hazard from Nearby Explosion

200. PFS also addressed the potential hazard to the PFSF posed by jettisoned live ordnance that might land near the facility (without hitting it) and explode on impact, as well as the hazard posed by a potential explosion of live ordnance carried aboard a crashing aircraft that might impact the ground near the PFSF (also without hitting it) and found both to be insignificant. See PFS Test. at 104-06. The State submitted no testimony on these potential hazards.

201. The U.S. Air Force has specifically stated that "[n]o aircraft flying over Skull Valley are allowed to have their armament switches in a release capable mode. All switches are 'SAFE' until inside DOD land boundaries." PFS Test. at 101-102. The Air Force has also stated that "[t]he UTTR has not experienced an unanticipated munitions release outside of designated launch/drop/shoot boxes" PFS Test. at 102; Staff Test. at 34. Consequently, the likelihood or probability of an inadvertent weapons release from F-16s flying over Skull Valley impacting or affecting the PFSF is as a practical matter zero.

202. As stated above, Air Force pilots do not arm the live ordnance they are carrying while transiting Skull Valley near the PFSF. Furthermore, the likelihood that unarmed live ordnance would explode when impacting the ground after being jettisoned is "remote" and the Air Force has no records of such incidents in the last 10 years. PFS Test. at 104; see also Tr. at 8444, 8470-71 (Horstman). Thus, it is highly unlikely that jettisoned live ordnance or live ordnance carried aboard a crashing aircraft that did not directly impact the PFSF would damage the facility.

203. Nevertheless, PFS conservatively assumed that ordnance jettisoned from or carried aboard a crashing aircraft would have a 1 percent chance of exploding and calculated the hazard that potentially exploding ordnance landing nearby the PFSF would pose to the facility. PFS Test. at 105-06. PFS assumed that a storage cask or the Canister Transfer Building could be damaged if a bomb exploded close enough to exceed their explosive overpressure limits. Johns Test. at 5-6; Aircraft Report at 83b. PFS conservatively assumed that each F-16 carrying ordnance through Skull Valley was carrying a 2,000 lb. bomb, the largest piece of ordnance they carry. PFS Test. at 105. PFS then calculated the probability that the ordnance would land close enough to explode and damage the PFSF, using a method similar to what it used to calculated the probability that jettisoned ordnance would hit the PFSF. See id. PFS concluded that there would be an annual probability of less than 1 E-10 that the PFSF would be damaged by a nearby explosion of ordnance. Id. at 105-06. Thus we find that potentially exploding ordnance poses a negligible hazard to the facility.

3. Conclusion Regarding Ordnance Hazards

204. PFS used a clear and logical methodology to calculate the hazard to the PFSF posed by ordnance. As noted above, PFS's assessment of the crash impact hazard posed by F-16 transits of Skull Valley is based on sound data and analysis. PFS obtained the further information needed to assess the hazard posed by ordnance from the Air Force and from its analysis of the physical characteristics of the PFSF. The claims made by the State in challenging PFS's analysis are generally unsupported and the State did not challenge PFS's assessment of the hazard posed by potential nearby explosions of ordnance. Therefore, the State's claims provide

no reason to doubt PFS's assessment of the hazard to the PFSF posed by ordnance.

205. As with the calculation for F-16s transiting Skull Valley, PFS's calculations of the hazards posed by ordnance include an unquantifiable conservatism in the assumption that the F-16s are uniformly distributed across the width of the valley. The predominant route of flight actually is down the eastern side of the valley. See Finding 42, supra. Thus, PFS's assumption that F-16s would be flying over or near the site and could have emergencies that would require them to jettison ordnance that could land near the site is highly conservative. In addition, as noted below, PFS's hazard calculations for the PFSF generally are conservative because of assumptions made regarding the F-16 crash rate and the effective area of the facility.

H. Conclusion

206. The Licensing Board concludes that PFS has assessed the cumulative hazard posed by all of the aviation operations in and around Skull Valley to be less than 4.17 E-7 per year. That total is below the limit of 1 E-6 established by the Commission and hence the PFSF need not be designed to withstand the effects of aircraft crashes.

207. As noted above, the impact hazard that PFS calculated for the PFSF is conservative in a number of respects (F-16 crash rate, site effective area, jettisoned ordnance hazard). See Findings 36, 39, 198, supra. If these conservative factors are accounted for, the hazard to the PFSF would drop from the calculated value of less than 4.17 E-7 per year to roughly 1.9 E-7 per year. PFS Test. at 113.

208. PFS used a clear and logical methodology to calculate the cumulative crash impact hazard to the PFSF. PFS's assessments of the hazards posed by each category of operations is soundly based on data published or provided by the Army and the Air Force. PFS's interpretation and use of that data in its assessment is based on the professional judgment of three highly experienced former Air Force pilots. The claims made by the State in challenging PFS's analysis are unsupported and provide no reason to doubt PFS's assessment that the hazard to the PFSF is below the limit established by the Commission.

IV. CONCLUSIONS OF LAW

1. Under the Commission order that ISFSIs do not need to be designed to withstand the effects of accidents with probabilities less than 1 E-6 per year, CLI-01-22, 54 NRC 255, because the cumulative annual probability of an aircraft crash or jettisoned ordnance impact is less than 1 E-6, we find that the PFSF need not be designed to withstand the effects of those events.

V. CONCLUSION

The Applicant respectfully requests that the Board rule in its favor on Contention Utah K.

Respectfully submitted,

Jay E. Silberg
Ernest L. Blake, Jr.
Paul A. Gaukler
D. Sean Barnett
SHAW PITTMAN, LLP
2300 N Street, N.W.
Washington, DC 20037
(202) 663-8000
Counsel for Private Fuel Storage L.L.C.

August 30, 2002

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE L.L.C.	)	Docket No. 72-22
	)	
(Private Fuel Storage Facility)	)	ASLBP No. 97-732-02-ISFSI

CERTIFICATE OF SERVICE

I hereby certify that copies of the Applicant's Proposed Findings Of Fact And Conclusions Of Law on Contention Utah K/Confederated Tribes B were served on the persons listed below (unless otherwise noted) by e-mail with conforming copies by U.S. Mail, first class, postage prepaid, this 30th day of August, 2002.

Michael C. Farrar, Esq., Chairman
Administrative Judge
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
e-mail: MCF@nrc.gov

Dr. Jerry R. Kline
Administrative Judge
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
e-mail: JRK2@nrc.gov; kjerry@erols.com

Dr. Peter S. Lam
Administrative Judge
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
e-mail: PSL@nrc.gov

*Office of Commission Appellate
Adjudication
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Office of the Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Attention: Rulemakings and Adjudications
Staff
e-mail: hearingdocket@nrc.gov
(Original and two copies)

* Adjudicatory File
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Catherine L. Marco, Esq.
Sherwin E. Turk, Esq.
Office of the General Counsel
Mail Stop O-15 B18
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
e-mail: pfscase@nrc.gov

Denise Chancellor, Esq.
Assistant Attorney General
Utah Attorney General's Office
160 East 300 South, 5th Floor
P.O. Box 140873
Salt Lake City, Utah 84114-0873
e-mail: dchancellor@utah.gov

John Paul Kennedy, Sr., Esq.
David W. Tufts, Esq.
Confederated Tribes of the Goshute
Reservation and David Pete
Durham Jones & Pinegar
111 East Broadway, Suite 900
Salt Lake City, Utah 84105
e-mail: dtufts@djplaw.com

Joro Walker, Esq.
Land and Water Fund of the Rockies
1473 South 1100 East
Suite F
Salt Lake City, UT 84105
e-mail: lawfund@inconnect.com

Diane Curran, Esq.
Harmon, Curran, Spielberg &
Eisenberg, L.L.P.
1726 M Street, N.W., Suite 600
Washington, D.C. 20036
e-mail: dcurran@harmoncurran.com

Tim Vollmann, Esq.
Skull Valley Band of Goshute Indians
3301-R Coors Road, N.W.
Suite 302
Albuquerque, NM 87120
e-mail: tvollmann@hotmail.com

Paul EchoHawk, Esq.
Larry EchoHawk, Esq.
Mark EchoHawk, Esq.
EchoHawk PLLC
P.O. Box 6119
Pocatello, ID 83205-6119
e-mail: paul@echohawk.com

* By U.S. mail only

Paul A. Gaukler