RAS 4831

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	Docket No. 72-22-ISFSI
	)	
PRIVATE FUEL STORAGE, LLC	)	ASLBP No. 97-732-02-ISFSI
(Independent Spent Fuel	)	
Storage Installation)	)	August 30, 2002

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

On April 8, 2002, the Licensing Board convened the Applicant, Private Fuel Storage, LLC ("PFS"), NRC Staff ("Staff"), the State of Utah ("State"), and the Southern Utah Wilderness Alliance ("SUWA") in Salt Lake City, Utah to begin the evidentiary hearings for Contention Utah K/Confederated Tribes B ("Utah K"), Unified Contention Utah LL/QQ, Contention Utah O, and Contention SUWA B. The evidentiary hearings on Contention Utah K continued in Salt Lake City on April 9 through 13, 2002; May 13 through 15, 2002; and in Rockville, Maryland on July 1 through 3, 2002.[1] Following the conclusion of the evidentiary hearing and in accordance with the Licensing Board's announcement at Tr. 12368 (June 25, 2002), the State hereby submits the following proposed findings of fact and conclusions of law with respect to Contention Utah K.

I. PROCEDURAL BACKGROUND

PFS is seeking the first commercial centralized away-from-reactor dry cask storage

[1]Pursuant to 10 CFR § 2.715(a), the Licensing Board also received oral limited appearance statements on April 8 and 26, 2002.

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license to store up to 4,000 concrete storage casks uncovered on concrete pads. The location PFS selected for the nation's largest spent nuclear fuel storage facility is adjacent to an active bombing range and beneath a Military Operating Area ("MOA") airspace used by the U.S. Air Force to conduct low to medium altitude combat training and to enter and exit the bombing range.

The Applicant commenced its plan to obtain a license in June 1997 when it filed a license application for an independent spent fuel storage installation ("ISFSI") under 10 CFR Part 72. The State filed a timely petition to intervene in the PFS licensing proceedings and was subsequently admitted as a party to the proceedings. Private Fuel Storage, LLC (Independent Spent Fuel Storage Installation), LBP-98-7, 47 NRC 142, 157, *reconsideration granted in part and denied in part on other grounds*, LBP-98-10, 47 NRC 288, *aff'd on other grounds*, CLI-98-13, 48 NRC 26 (1998). The Licensing Board also admitted portions of consolidated Contention Utah K and Contention Confederated Tribes B. *Id.* at 190-191, 234-35, 247-48.

As a result of its rulings,[2] the Licensing Board revised Contention Utah K to read:

> 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 232, 240 (1999).

On May 31, 2001, the Licensing Board granted in part and denied in part PFS's motion for summary disposition on remaining Utah K issues, and reserved for hearing

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[2]The Licensing Board denied in part, and granted in part, and deferred in part, PFS's motion for partial summary disposition of Contention Utah K. *See* LBP-99-35, 50 NRC 180, *reconsideration denied*, LBP-99-39, 48 NRC 232 (1999).

portions of Contention Utah K, including the aircraft accident hazards relative to the PFS facility from a) F-16s transiting Skull Valley, including jettisoned ordnance; b) aircraft conducting air-to-air combat training on the Utah Test and Training Range ("UTTR"); c) aircraft flying the Moser Recover Route; d) aircraft flying to and from Michael Army Airfield along IR-420; and e) the cumulative hazard to the PFS facility. LBP-01-19, 53 NRC 416, slip op. at 37, 41-46, 51-52, and 54, (2001), *aff'd on other grounds*, CLI-01-22, 54 NRC 255. Additionally, the Licensing Board established the threshold probability for design basis accidents as 1×10^{-6}. Id., slip op. at 21, 54. The Licensing Board granted summary disposition with respect to the aircraft crash hazard from general aviation aircraft and commercial aircraft flying Airways J-56 and V-257. Id., slip op. at 54.

II. FRAMEWORK OF CONTENTION UTAH K ISSUES.

In Contention Utah K, the State asserts that PFS has failed to design its facility to withstand credible accidents caused by external events affecting the facility such as aircraft crashes. The paramount issue arising before this Licensing Board is whether the cumulative hazard probability from aircraft crashes into the PFS facility during the initial twenty-year licensing period exceeds one in a million.[3]

The Licensing Board must determine a number of subsets of the cumulative hazard probability from various activities near the proposed site, including the hazard probability

[3] At issue in this contention is whether the threshold probability has been exceeded. The potential consequences of the hazard were deemed outside the scope of the hearing issues. *See* Tr. at 3008. The Licensing Board noted that should consequences become relevant to the licensing of the PFS facility, the State could then file a timely contention. *Id.* at 3007-08.

from a) F-16s transiting Skull Valley, including jettisoned ordnance; b) aircraft conducting air-to-air combat training on the UTTR; c) aircraft flying the Moser Recover Route; and d) aircraft flying to and from Michael Army Airfield along IR-420. The Licensing Board previously determined the hazard probabilities from general aircraft and aircraft flying routes J-56 and V-257, which will be factored into the cumulative hazard probability.[4]

The Applicant located its facility site below a U.S. Air Force Military Operating Area ("MOA"), which is a critical low and medium altitude training airspace for combat fighter aircraft en route to the adjacent bombing and training range. Thus, the Licensing Board's decision focuses on the hazards presented by fighter aircraft crashes. During the initial twenty-year licensing period sought by the Applicant, the probability of an aircraft crash from military fighter aircraft will be dependent on the specific type of combat fighter aircraft employed, and the tactics and mission necessary to protect national security as determined by the U.S. Air Force, not by the Applicant or NRC. Consequently, the Licensing Board is cognizant that increases in the probability of a military aircraft crash into the PFS site due to changes in Air Force tactics cannot be controlled by NRC or PFS.

To calculate the aircraft crash probability, the Applicant invoked a hazard probability formula provided in NUREG-0800. Prior to this application, the NUREG-0800 formula, as written, has been relied upon exclusively by NRC and applicants in calculating crash pobability. Following years of reliance on the NUREG-0800 formula as written, and without prior precedent, the Applicant modified the NUREG-0800 formula to essentially

[4]LBP-01-19 at 54.

eliminate the probability of aircraft crashes by claiming that a pilot would not allow a crashing aircraft to impact the PFS facility. The Licensing Board must determine whether the testimony proffered at the hearing supports the unprecedented modification of the NUREG formula and proves a reliable scientific basis for such a modification.

III. RELEVANT LEGAL STANDARD

A. Applicant Has the Burden of Proof Supported by a Preponderance of the Evidence.

First, the Commission may issue an ISFSI license only upon a determination that "the proposed site complies with the criteria in subpart E" (Siting and Evaluation Factors), and "[t]here is reasonable assurance that ... [t]he activities authorized by the license can be conducted without endangering the health and safety of the public ... and [that] issuance of the license will not be inimical to the common defense and security." 10 CFR §§ 72.40(a)(2), (13) and (14).

Next, in a formal adjudicatory proceeding, 10 C.F.R. § 2.732 provides that the applicant has the burden of proof, and "in order for the applicant to prevail on each contested factual issue, the applicant's position must be supported by a preponderance of the evidence." Louisiana Energy Services, L.P. (Claiborne Enrichment Center), LBP-96-7, 43 NRC 142, 144 (1996), *citing* Philadelphia Electric Co. (Limerick Generating Station, Units 1 and 2), ALAB-819, 22 NRC 681, 720 (1985); Pacific Gas and Electric Co. (Diablo Canyon Nuclear Power Plant, Units 1 and 2), ALAB-763, 19 NRC 571, 577 (1984). The staff shares the burden of proof to the extent the staff supports the applicant's position. Philadelphia Electric Company (Peach Bottom Atomic Power Station, Units 2 & 3), ALAB-566, 10 NRC 527, 529 & n.3 (1979). Furthermore, while 10 C.F.R. § 2.714 imposes the burden of going

forward on the intervenor, it does not shift the ultimate burden of proof from the applicant to the intervenor. Yankee Atomic Electric Co. (Yankee Nuclear Power Station), LBP-96-15, 44 NRC 8, 16 (1996).

Additionally, the significance of various facts is for the licensing board to determine, based on the record. The licensing board must satisfy itself that the conclusions reached have a solid foundation. Georgia Institute of Technology (Georgia Tech Research Reactor, Atlanta, Georgia), LBP-97-7, 45 NRC 265, 270 (1997). The licensing board's findings must be supported by reliable, probative, and substantial evidence in the record. Pacific Gas and Electric Co. (Diablo Canyon Nuclear Power Plant, Unit 2), ALAB-254, 8 AEC 1184, 1188 (1975) (*quoting* Wisconsin Electric Power Co. (Point Beach Nuclear Plant, Unit 2), ALAB-78, 5 AEC 319, 322 (1972)). "Substantial evidence" is "more than a mere scintilla," "it means such relevant evidence as a reasonable mind might accept as adequate to support a conclusion." Id. at 1187 (*quoting* Consolidated Edison Co. v. NLRB, 305 U.S. 197, 229 (1938)). Moreover, "[t]he substantiality of the evidence must take into account whatever in the record fairly detracts from its weight." Id. (*quoting* Universal Camera Corp. v. NLRB, 340 U.S. 474, 488 (1951).

Finally, the licensing board "must evaluate the staff's evidence and arguments in the light of the same principles which apply to the presentation of the other parties." Consolidated Edison Company of New York (Indian Point, Units No. 1, 2, and 3), ALAB-304, 3 NRC 1, 6 & n. 14 (1976) (*citing* Vermont Yankee Nuclear Power Corporation (Vermont Yankee Station), ALAB-138, 6 AEC 520, 532 (additional views of Mr. Farrar) (1973); ALAB-229, 8 AEC 425, 440-441, reversed on other grounds, CLI-74-40, 8 AEC 809

(1974). "[S]taff views 'are in no way binding upon' the boards; they cannot be accepted without passing the same scrutiny as those of the other parties." Indian Point, ALAB-304, 3 NRC at 6 (*citing* Southern California Edison Co. (San Onofre Units 2 and 3), ALAB-268, 1 N.R.C. 383, 400 (1975)); *see also*, Texas Utilities Generating Co. (Comanche Peak Steam Electric Station, Units 1 and 2), LBP-82-87, 16 NRC 1195, 1200 (1982), *vacated on other grounds*, CLI-83-30, 18 NRC 1164 (1983).

B. NRC Guidance Documents Bear "Special Weight."

NRC rules mandate that "[d]esign basis external events must be determined for each combination of proposed site and proposed ISFSI . . . design." 10 CFR § 72.90(c). The PFS storage facility must be designed to withstand credible accidents or "design basis events." CLI-01-22, slip op. at 5 & n.10 (*citing* Metropolitan Edison Co. (Three Mile Island Nuclear Station, Unit No. 2), ALAB-692, 16 NRC 921 (1982)). To determine if an accident probability is to be deemed "credible" and, thus, must be reflected in the design, an applicant is aided by guidance documents.

Guidance documents have been described as "evidence of legitimate means for complying with regulation requirements." Louisiana Energy Services (Claiborne Enrichment Center), LBP-91-41, 34 NRC 332, 338 (1991). NRC guidance does not set forth requirements that an applicant must fulfill. *Id.* Rather, NRC's guidance documents "reflect the considered judgment of the staff and offer insight on what is needed to satisfy a regulation." *Id.* If the applicant can meet the guidance standard then the applicant has likely

met the regulatory requirements.[5] Curators of the University of Missouri, CLI-95-1, 41 NRC 71, 98 (1995). Although guidance documents "do not themselves have the force of regulations," guidance documents are "entitled to considerable *prima facie* weight." Vermont Yankee Nuclear Power Corporation (Vermont Yankee Nuclear Power Station), 8 AEC 809, 811, CLI-74-40 (1974).

"[G]uidance consistent with the regulations and at least implicitly endorsed by the Commission is entitled to correspondingly special weight." Long Island Lighting Co. (Shoreham Nuclear Power Station, Unit 1), ALAB-900, 28 NRC 275, 290, *review declined*, CLI-88-11, 28 NRC 603 (1988).

C. Weight to be Given to Expert Witness Testimony.

NRC Rules of Practice do not expressly address expert testimony; hence, the Federal Rules of Evidence provide appropriate guidance.[6] Federal Rule 702, amended in 2000 in response to Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579 (1993), provides:

> If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.

The cornerstones underlying Federal Rule 702 should also bear on the weight given

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[5]However, a failure to meet these standards will not necessarily mean noncompliance. Curators, CLI-95-1, 41 NRC at 98.

[6] *See, e.g.,* Duke Power Company (William B. McGuire Nuclear Station, Units 1 and 2), ALAB-669, 15 N.R.C. 453, 475 (1982).

conflicting expert testimony. In Daubert, the Supreme Court set forth specific factors for use in assessing whether the methodology employed by an expert is reliable: (1) the knowledge or theory can be and has been tested; (2) the knowledge has been subjected to peer review and publication; (3) the potential rate of error has been examined, and (4) the knowledge is generally accepted by the scientific community. Daubert, 509 U.S. at 593-594.

Expert testimony based upon insufficient facts or data should be given little weight. Moreover, testimony not founded on reliable principles and methods should be disregarded or given no weight. To be persuasive, the sponsoring party must demonstrate that the methodology relied upon by expert testimony has been tested and subject to peer review and publication. Additionally, both the potential rate of error must be examined, and the methodology's general acceptance by the scientific community must be shown. The Licensing Board is charged with the responsibility of acting as gatekeeper to exclude unreliable expert testimony and thus, must appropriately accord proper weight to expert testimony. Daubert, 509 US at 592 & n.10; FRE 702 Advisory Comm. Notes, 2000 Amendments.

Furthermore, ultimate conclusions on crucial issues in which an expert cannot or will not detail the basis or foundation for his conclusion should be given no weight. Virginia Electric and Power Co. (North Anna Nuclear Power Station, Units 1 and 2), ALAB-555, 10 NRC 23, 26 (1979) (initially data supporting the basis of the expert's opinion was claimed "confidential and thus immune from disclosure"). "[A] trier of fact would be derelict in the discharge of its responsibilities were it to rest significant findings on expressions of expert opinion not susceptible of being tested on examination of the witness." Id. Similarly, no

weight should be given to testimony of an "asserted expert witness[who] can supply no scientific basis for his statements (other than his 'belief') and disparages his own testimony." Philadelphia Electric Co. (Limeric Generating Stations, Units 1 and 2), ALAB-819, 22 NRC 681, 735 (1985), *review declined*, CLI-86-5, 23 NRC 125 (1986), *aff'd in part, remanded in part, sub nom* Limerick Ecology Action, Inc. v. NRC, 869 F. 2d 719 (3rd Cir.), *rehearing denied* (1989).

The testimony and opinion of a witness who claims no personal knowledge of, or expertise in, particular aspects of the subject matter of his testimony will not be accorded the weight given testimony on that question from an expert witness who has personal knowledge. Public Service Electric & Gas Co. (Hope Creek Generating Station, Units 1 & 2), LBP-78-15, 7 NRC 642, 647 n.8 (1978), *aff'd* ALAB-518, 9 NRC 14 (1979).

D. Weight to be Given to Hearsay Evidence.

Although hearsay may be admitted in NRC adjudicative proceedings, "[o]nly relevant, material, and reliable evidence which is not unduly repetitious will be admitted." 10 CFR § 2.743(c). However, in its quest to be thoroughly informed and obtain all pertinent information, the Licensing Board liberally admitted various forms of hearsay evidence throughout the evidentiary hearing. The Licensing Board is now tasked with determining the weight and persuasiveness afforded hearsay evidence.

Notwithstanding its prior admittance, where no jury is involved, the materiality of evidence may be determined after admittance of the evidence without prejudicing the interests of any party. Public Service Co. of New Hampshire (Seabrook Stations, Units 1 and 2), ALAB-520, 9 NRC 48, 50 n.2 (1979). Thus, the Licensing Board should look towards the standards established to determine relevance, materiality, and reliability when

determining the weight given various forms of hearsay evidence.

"Expert testimony in hearsay form from someone unknown is most unreliable." Tennessee Valley Authority (Hartsville Nuclear Plant Units 1A, 2A, 1B and 2B), ALAB-367, 5 NRC 92, 121 (1977) (testimony was based on an anonymous individual). Thus, hearsay evidence authored by unknown persons should be given no weight. Similarly, where the sponsoring witness cannot testify to an individual's accuracy and reliability, hearsay evidence based on individuals unknown by the sponsoring witness should be given no weight.

E. Licensing Board Independent Calculations.

A licensing board may perform its own, independent calculation. Vermont Yankee Nuclear Power Corp. (Vermont Yankee Nuclear Power Station), ALAB-229, 8 AEC 425, 437 (1974) (conducting independent licensing board calculations to insure "that the basis of each expert's judgment was fully developed in the record, so that the relative weight of those judgments could be evaluated"), *rev on other grounds*, CLI-74-40, 8 AEC 809 (1974). In performing independent calculations, the licensing board should utilize only evidence presented in the record, and analyze such evidence using "universally accepted engineering principles and known facts." Id. A licensing board utilizing its own expertise must provide a basis for its conclusions. Public Service Co. of New Hampshire (Seabrook Station, Units 1 & 2), ALAB-422, 6 NRC 33, 66 (1977).

IV. ISSUES PRESENTED

The issue before the Board on Contention Utah K is limited to the determination of the probability that aircraft or military ordnance would impact the proposed PFS storage facility. Evidence relating to whether such an impact would penetrate a storage cask or cause

a release of radiation was held to be outside the scope of the hearing. Such evidence relating to the consequences of an impact was determined to be inadmissable in this hearing. Tr. at 3008, 3014.

The Board heard evidence on and will determine the probability of an impact to the proposed PFS facility due to the following activities:

1. Aircraft transiting Skull Valley;

2. Jettisoned ordnance;

3. Air to air combat training on the UTTR;

4. Aircraft flying the Moser Recovery Route; and

5. Aircraft flying to and from Michael Army Airfield on IR-420.

In addition to the foregoing activities on which evidence was heard, the cumulative probability of impact to the PFS site includes the probability of impact from general aviation and commercial aircraft flying on Airways J-56 and V-257, which were previously determined on summary disposition.

The probability standard for air crashes has been determined by the NRC to be 10E -6. The ultimate issue is whether the cumulative probability of impact from the various activities exceeds the 10E-6 threshold.

V. FINDINGS OF FACT

A. WITNESSES

(1.) <u>State Witness Lieutenant Colonel Hugh Horstman (USAF, Ret.)</u>

1. Lt. Colonel Horstman has more than 20 years' experience as a pilot in the U.S. Air Force with over 2,500 hours as a pilot and over 1,000 hours as a navigator. He has

flown over 1,800 hours as an F-16 and F-111 fighter pilot. He was also an instructor pilot for both the F-16 and F-111 fighter aircraft as well as an instructor navigator. Horstman Tstmy, Post Tr.___ at 1-2.

2. From October 1977 through June 1999, Lt. Colonel Horstman was the Deputy Commander, 388th Operations Group, Hill Air Force Base, Utah. In this position, he commanded the F-16 Operations Group and 1,500 personnel. The Operations Group was responsible for the administration of all 388th Fighter Wing flying activity, including the sorties flown in the Utah Test and Training Range airspace. The Operations Group was also responsible for managing the UTTR air space and for managing the three fighter squadrons stationed at Hill Air Force Base. In addition, Lt. Colonel Horstman was responsible for the flight line maintenance of all F-16C aircraft assigned to the 388th Fighter Wing. Horstman Tstmy, Post Tr.___, at 1-2.

3. Lt. Colonel Horstman has flown over 150 training missions in the UTTR including air-to-air combat missions, air-to-ground combat missions (e.g., precision ordinance bombing), low level training missions, targeting pod, and night vision goggle missions. While stationed at Hill AFB he was responsible for planning training missions and instructing F-16 pilots. He flew F-16 training missions as an instructor pilot, as a flight lead, and as a mission commander. In those capacities he was responsible for assessing individual pilot performance on various tasks, including emergency procedures. Lt. Colonel Horstman is intimately familiar with the UTTR land and air space, including the military operating areas ("MOAs") over the PFS site. Horstman Tstmy, Post Tr.___, at 1-2.

4. From June 1993 through September 1997, Lt. Colonel Horstman was

stationed at Spangdahlem Air Base, Germany. He served as Deputy Commander of the 52nd Support Group, Chief of the 52nd Fighter Wing Readiness, and Assistant Operations Officer of the 22nd Fighter Squadron. As Assistant Operations Officer, his responsibilities included ensuring that all F-16 pilots in the fighter squadron were combat ready and fully trained. As Chief of Fighter Wing Readiness, his responsibilities included preparing training scenarios for 100 F-16s, F-15s, and A-10s and serving as a flight instructor. Horstman Tstmy, Post Tr.___, at 1-2.

5. Lt. Colonel Horstman retired from the Air Force in 1999. Unlike the PFS witnesses who are retired Air Force pilots, Lt. Colonel Horstman continues to fly as a commercial pilot for Southwest Airlines piloting Boeing 737 jets. He continues his career in aviation as an Adjunct Professor at Embry Riddle Aeronautical University teaching aviation at the masters degree level. Horstman Tstmy, Post Tr._, at 1-2.

(2.) State Witness Dr. Marvin Resnikoff

6. Dr. Marvin Resnikoff is the Senior Associate of Radioactive Waste Management Associates ("RWMA"), a private technical consulting firm based in New York City. He holds a doctorate degree in high-energy theoretical physics from the University of Michigan. Dr. Resnikoff has researched radioactive waste issues for the past 27 years and has extensive experience and training in the field of nuclear waste management, storage, and disposal. Resnikoff Tstmy, Post Tr. 8698 at 2-3.

7. Dr. Resnikoff has researched technical issues related to the storage of radioactive waste, including spent nuclear power plant fuel, and is familiar with spent fuel storage systems that are now in use or proposed for future use in the United States. Dr.

Resnikoff's experience includes technical review and analysis of numerous dry cask storage designs, including proposed independent spent fuel storage installations at the Point Beach, Palisades and Prairie Island reactors, as well as Holtec's HI-STORM and HI-STAR casks for the proposed Private Fuel Storage ("PFS") facility. Resnikoff Tstmy, Post Tr. 8698 at 2-3.

8. Dr. Resnikoff has estimated the probability of accidents regarding air, train and truck accident rates for the States of New York, Nevada and Utah. Resnikoff Tstmy, Post Tr. 8698 at 2-3.

(3.) PFS Witness General Wayne O. Jefferson, Jr. (USAF, Ret.)

9. General Jefferson was retained by PFS through Burdeshaw Associates, a consulting firm which markets the services of retired military officers for a fee. General Jefferson was paid one thousand dollars per day for his participation in the hearing. Tr. (Cole) at 3150-53. General Jefferson's work through Burdeshaw Associates is part time employment. Id.

10. General Jefferson retired from the Air Force in1989. General Jefferson has never flown an F-16 fighter aircraft, has never flown through Skull Valley, and has never ejected from any aircraft. Tr. (Jefferson) at 3126, 3189, 3216.

11. General Jefferson performed all crash probability calculations for PFS. Tr. (Jefferson, Cole) at 3187, 3189. General Jefferson has no prior experience using NRC guidance document NUREG-0800 nor prior experience in using the DOE Standard for aircraft crash analysis DOE-STD-3014-96. Tr. (Jefferson) at 3193, 3699.

(4.) PFS Witness General James L. Cole, Jr. (USAF, Ret.)

12. General Cole was retained by PFS through Burdeshaw Associates, a

consulting firm which markets the services of retired military officers for a fee. General Cole was paid one thousand dollars per day for his participation in the hearing. Tr. (Cole) at 3150-53. General Cole's work through Burdeshaw Associates is part time employment. Id.

13. General Cole retired from the Air Force in 1994. Tr. (Cole) at 3125. General Cole has never flown in an F-16 fighter aircraft, has never flown through Skull Valley, and has never ejected from any aircraft. Tr. (Cole) at 3142, 3158-3160.

14. General Cole has not previously done a crash impact evaluation nor studied the issue of whether a F-16 pilot would be able to avoid a ground sit. Tr. (Cole) at 3153, 3157.

(5.) PFS Witness Colonel Ronald B. Fly (USAF, Ret.)

15. Colonel Fly was retained by PFS through Burdeshaw Associates, a consulting firm which markets the services of retired military officers for a fee. Colonel Fly was paid one thousand dollars per day for his participation in the hearing. Tr. (Cole) at 3150-53. Colonel Fly's work through Burdeshaw Associates is part time employment. Id.

16. Colonel Fly, who has piloted but never ejected from an F-16, retired from the Air Force in 1998. Tr. (Fly) at 3125, 3217. Colonel Fly is not engaged in any business relating to aviation other than his consulting work on this license application for PFS. Id. at 3343-45.

(6.) PFS Witness Stephen Vigeant

17. Stephen Vigeant is a meteorologist. He is not a pilot, has not flown through Skull Valley, and has not studied the extent to which a pilot can see under various cloud conditions and altitudes. He provided meteorological data. Tr. (Vigeant) at 4047-50.

(7.) Staff Witness Dr. Kazimeras Campe

18. 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. He assisted in the Staff's safety review of the PFS facility with respect to aircraft crash hazards. Campe, Ghosh Tstmy, Post Tr. 4078 at 1-3. Dr. Campe has no pilot experience. Tr. (Campe) at 4116.

(8.) Staff Witness Dr. Amitava Ghosh

19. Dr. Ghosh is a Principal Engineer at the Center for Nuclear Waste Regulatory Analyses (CNWRA), a division of the Southwest Research Institute, in San Antonio, Texas. He assisted in the Staff's safety review of the Private Fuel Storage facility with respect to aircraft crash hazards. Campe, Ghosh Tstmy post Tr.4078 at 1-3. Dr Ghosh's employer is a federally funded contractor under the direction of the NRC. Tr. (Ghosh) at 4129-32. Dr. Ghosh has no pilot experience. Tr. (Ghosh) at 4116.

B. PROBABILITY OF CRASHES FROM AIRCRAFT TRANSITING SKULL VALLEY.

(1.) The factual setting.

20. The PFS application proposes to construct an ISFSI to store 40,000 metric tons of spent nuclear fuel in Skull Valley, Utah, two miles east of the largest bombing range operated by the Department of Defense. The Utah Test and Training Range, and the UTTR air space, which is even larger than the ground footprint, are used for aircrew training and weapons testing. Missions on the UTTR include air-to-air and air-to-ground combat training, both day and night as well as low and high altitude. UTTR Capabilities Guide (State

Exh. 41), Horstman Tstmy Post Tr.___ at 4-5.

21. The airspace directly above the proposed PFS site, extending from 100 feet to 5,000 feet above ground level, is within a Military Operating Area ("MOA") known as Sevier B. The location of Sevier B MOA relative to the PFS site is shown on State Exh. 186. Sevier B is part of the UTTR air space and used for military low altitude training, air-to-air combat training, major exercises, and cruise missile testing. Horstman Tstmy, Post Tr.____ at 5.

22. The air space directly above the PFS site, extending from 5,000 feet to13,750 feet above the ground, is also a MOA known as Sevier D. Sevier D is also part of the UTTR air space and major exercises as well as cruise missile testing are authorized in the MOA. Horstman Tstmy, Post Tr.___ at 5.

23. During recent years, F-16 fighter aircraft stationed at Hill Air Force Base have regularly transited Skull Valley in a southerly direction through Sevier B and Sevier D MOAs en route to the UTTR South Area range. Most of the flights through Skull Valley are in Sevier B MOA, and are concentrated in a narrow corridor of 5 miles or less in width above the proposed PFS site. Horstman Tstmy,Post Tr.___ at 6-8; Tr. (Jefferson) at 3455. These F-16s conduct low altitude training, perform G awareness turns, practice terrain masking (radar avoidance) and perform other training while transiting Skull Valley. Horstman Tstmy, Post Tr.___ at 8-9. In FY 2000 there were approximately 6,000 such flights through Skull Valley and additional F-16s have since been stationed at Hill Air Force Base. Horstman Tstmy, Post Tr.___ at 11-12. Using standard NRC methodology, the calculated probability that an F-16 transiting Skull Valley will crash into the proposed PFS

site exceeds the NRC threshold probability of 1 x 10^{-6} for design basis events..

24. The military activity in the Sevier B and Sevier D MOA airspace varies dramatically from year to year. The number and type of missions flown as well as the number and type of bombs and other ordnance carried depend on Air Force tactics and training needs, national policy, budgets and the state of world conflict. Horstman Tstmy, Post Tr.___ at 5; Tr. (Jefferson) at 3352-55, 3494. As opposed to the gradual evolution of commercial air flights, changes in military training in the UTTR and MOAs cannot be anticipated and are completely outside the regulatory loop.[7] The F-16 fighter has been flying for over 27 years and will be replaced by year 2010. Tr. (Cole) at 3372; (Jefferson) at 3367. No evidence is before the Board as to the nature of future training missions or weapon systems that will be active in Skull Valley after the F-16 is retired. Thus, for the majority of the proposed 20 year license period, no evidence is available to calculate the risk to the PFS site from military aircraft crashes and weapons testing.

(2.) Methodology for Calculating Crash Probability: NUREG-0800.

25. The formula for calculating aircraft crash probability for nuclear facilities is set forth in NRC guidance document NUREG-0800 at § 3.5.1.6-3 as: $P_{FA} = C \times N \times A/w$.

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[7] The NRC Staff notified the Board and the parties on August 13, 2002, that the U.S. Air Force had lowered the minimum altitude for flights in Sevier B MOA from 1000 feet to100 feet above ground level ("AGL") at the location of the PFS site. This change, allowing very low altitude flights, represents the continuing change in training activities by the U.S. Air Force. The Applicant's Aircraft Crash Report relies on the previous minimum altitude of 1,000 feet AGL over the PFS site. *Aircraft Crash Impact Hazard at the Private Fuel Storage Facility* (August 10, 2000) ("Crash Report") (Applicant Exh. N) at 6.

Where:

C = inflight crash rate per mile for aircraft using airway

w = width of airway, miles

N = number of flights per year along the airway

A = effective area of plant in square miles

Resnikoff Tstmy, Post Tr. 8698 at 5-7; Applicant Exh. RRR. The above NUREG-0800 formula and methodology have been adopted by the NRC Staff with respect to away-from-reactor ISFSIs. Campe, Ghosh Tstmy, Post Tr. 4078 at 6-7. Staff witness Dr. Kazimieras Campe testified that in his work for the NRC and its predecessor the Atomic Energy Commission, he has been assessing aircraft hazards since the early 1970s. Tr. (Campe) at 4080. In that capacity, Dr. Campe has reviewed applications for "practically every" nuclear power plant with respect to aircraft crashes. Id. at 4122. Dr. Campe has never seen a significant departure from the NUREG-0800 four-factor formula used for aircraft crash assessment in any previous application. Id. at 4122-26. The Board finds that the four-factor formula set forth above and at NUREG-0800 § 3.5.1.6-3 is the appropriate formula to be used for the calculation of aircraft crash probability with respect to the PFS application.

(3.) Input Value C, inflight crash rate per mile for aircraft using airway.

26. The four-factor NUREG-0800 formula for computing aircraft crash probability requires an input value for C, the "inflight crash rate per mile for aircraft using airway." Resnikoff Tstmy, Post Tr. 8698 at 5-6. The U. S. Air Force mishap statistics per 100,000 hours of flight for the F-16, through fiscal year 2001, are shown on the second page of Utah Exh. 154. The Air Force defines a Class A mishap as an accident resulting in loss of

life, a destroyed aircraft, or total cost of property or injury exceeding $1,000,000; a Class B mishap as one resulting in total cost of property or injury of $200,000 or more but less than $1,000,000; and a destroyed aircraft as one which is uneconomical to repair. Applicant Exh. N, Tab C at 4-4.

27. Because the NUREG-0800 formula requires an inflight crash rate per mile and the Air Force mishap data are expressed per 100,000 hours of flight, the Air Force data must be converted to a crash rate per mile to be used in the formula. PFS used the data set forth in the *Data Development Technical Support Document for the Aircraft Crash Risk Analysis Methodology (ACRAM) Standard*, Kimura et al., Aug 1. 1996, to obtain an average flight speed to be used for this conversion. Applicant Exh. N, Tab C, D. The ACRAM document contains mishap data and the estimated milage and number of flight hours for F-16s during years 1975 through1993. Applicant Exh. N at 10 and Tab C, D. Using this ACRAM data, PFS divided the total miles by the total hours to obtain an average flight speed of 471.85 miles per hour flown by F-16s during years 1975 through 1993. Applicant Exh. N, Tab D.

28. The Air Force mishap data are not separated into the various phases of flight, *i.e.* takeoff, landing, special operations and normal flight. The mishaps shown on the Air Force mishap statistics may therefore represent mishaps that occurred in any phase of flight. State Exh. 154. Because PFS used crash rate for "normal flight" to calculate the crash probability, PFS estimated the percentage of all mishaps occurring during "normal flight" and applied that percentage to the Air Force data. Applicant Exh. N at 11-14 and Tab D. PFS based its estimate on the ACRAM data which contain both Class A and Class B mishaps from 1975 through 1993, separated into the four phases of flight: takeoff, landing,

normal flight and special operations. Applicant Exh. N and Tab C, D. PFS divided the number of mishaps shown in the ACRAM data for "normal flight" by the total mishaps for all F-16 flights, obtaining 15.09% as the percentage of F-16 mishaps occurring in "normal flight" during years 1975 through 1993. Id. Similarly, PFS estimated the flight miles occurring during normal flight by dividing the number of "normal flight" F-16 miles shown in the ACRAM data by the total F-16 flight miles, obtaining 47.18% of flight miles occurring during the "normal" phase of flight. Id.

29. PFS used the average speed of 471.85 miles per hour, 15.09 % as the percentage of mishaps occurring during "normal flight," and 47.18% of all flight miles occurring in the "normal" phase to derive a "normal flight" crash rate per mile from the Air Force mishap data.. Applicant Exh. N, Table 1 and Tab C, D. PFS calculated a crash rate using Air Force F-16 mishap data for the 10 year period 1989 through 1998, obtaining a crash rate of 2.736×10^{-8} per mile. Applicant Exh. N at 11 and Tab D.

30. PFS analyzed 121 F-16 crashes during the 10 year period 1989 through 1998 in which the aircraft was destroyed, and determined that 27 of those crashes (22.3%) occurred in the "normal" phase of flight. Applicant Exh. N, Tab H; Resnikoff Tstmy, Post Tr. 8698 at 15. However, in calculating a crash rate, PFS used 15.09%, derived from ACRAM data based on Class A and Class B mishap history to determine the number of mishaps occurring during "normal flight." Applicant Exh. N, Tab D. Destroyed aircraft are defined as Class A mishaps, not Class B mishaps. Applicant Exh. N, Tab C at 4-4. The ACRAM data does not indicate whether mishaps shown for each stage of flight are Class A, Class B or some combination of the two. Id. at table 4.8. The Board finds that during the

years 1975 - 1993 on which the ACRAM data are based, a greater percentage of Class B mishaps have occurred in flight phases[8] other than the "normal" phase of flight, resulting in the lower 15.09% normal flight ratio for Class A and B mishaps and the higher 22.3% normal flight ratio for destroyed aircraft.

31. During the years 1989 through 1998 on which PFS based its crash rate, there were 139 destroyed F-16s. Id., Tab H at 4; State Exh. 154. Using the PFS ratio of 22.3% for destroyed F-16s occurring in "normal" flight, there were an estimated 30.99 destroyed F-16 normal flight mishaps during that 10 year period. However, PFS has used only 24.45 mishaps in calculating the 2.736 x 10^{-8} accident per mile crash rate for normal flight during the period 1989 through 1998. Id., Tab D at 2. The Board finds that the use by PFS of 24.45 mishaps as the number of normal flight mishaps for the period 1989 - 1998 underestimates the normal flight crash rate for that period.

32. Through FY 2001, there have been 272 F-16s destroyed in crashes. State Exh. 154. Using the PFS ratio of 22.3% for destroyed F-16s occurring in the "normal" phase of flight, 60.66 of the 272 crashes were in the "normal" flight phase. The Board finds that it reasonable to estimate that at least 60.66 F-16s have been destroyed during normal flight through FY 2001.

33. Not all F-16 flights through Skull Valley are low risk activities because of the speed, altitude and nature of the missions.[9] Horstman Tstmy, Fost Tr.___ at 9-10. Low

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[8]The four phases of flight are takeoff, landing, normal flight and special operations. Applicant Exh. N, Tab C.

[9] *See* Footnote 7.

level flying, 500 feet AGL and below is very unforgiving due to proximity with the ground, with little margin for pilot error. Applicant Exh. N, Tab E. Low level flights and maneuvering operations in restricted airspace are classified as "special operations" flight phase and have a substantially higher crash rate than "normal flight" ACRAM data. Id., Tab C at 4-5 and Table 4.8. The Board finds that use of only "normal flight" data by PFS to calculate the crash rate of 2.736×10^{-8} per mile is not conservative.

34. PFS used the 10 year period from 1989 through1998 as the basis for calculating a crash rate. Id. at 11. The mishap data for this 10 year period produce the lowest 10 year average crash rate in the history of F-16. Resnikoff Tstmy, Post Tr. 8698 at 15. The years 1995 through 2001 show an increasing trend F-16 crash rates. State Exh. 155. No objective basis is given by PFS as to why the years 1989 to 1998 were chosen as the basis for a crash rate, but rather the decision was admittedly subjective. Applicant Exh. N at 11; Tr. (Jefferson) 3363. NRC Staff witness Dr. Campe testified that the years 1995 through 2001 show an increasing trend and that it would be appropriate for PFS to base its crash rate on additional years. Tr. (Campe) at 8945, 8948. The Board finds that it is neither reasonable nor conservative to base the F-16 crash rate on data from the ten year period 1989 through 1998.

35. The annual crash rate for the F-16 has varied substantially from 1975 through 2001. State Exh. 154. The initial years of service through 1983 show a period of comparatively high accident rates. Id. Every fighter aircraft the Air Force has ever had shows the phenomena of higher crash rates in initial years. Tr. (Jefferson) at 3365. Applicant Exh. N shows higher crash rates for single engine fighter aircraft even after they

have been in service for 100,000 hours. The F-16 is expected to be replaced in 2010, and the replacement aircraft is expected to also have a higher start-up crash rate. Tr. (Cole) at 3372; (Jefferson) at 3367-68. During the most recent seven years for which data are available, there is an increasing trend in F-16 crash rates. State Exh. 155; Tr. (Campe) at 8945; Resnikoff Tstmy, Post Tr. 8698 at 11-12. Crash rates for fighter aircraft are commonly higher at the beginning and at the end of an aircraft's service life. Horstman Tstmy, Post Tr.___ at 13. Using the mishap data for all available years that an aircraft has been in service is the best predictor of the aircraft's future crash rate. Id. at 13-14; Resnikoff Tstmy, Post Tr. 8698 at 9-10. Even in the case of an apparent trend of decreasing crash rates, which is not the case here, it would not be reasonable to limit the database, and all years of data should be used. Resnikoff Tstmy, Post Tr. 8698 at 10. The database used for the ACRAM technical support document used all years of crash history and did not attempt to select or omit certain years of crash history for the F-16 or other aircraft. Id. at 9. The Board finds that the most realistic estimate of future F-16 crash rates is obtained by using the entire F-16 crash history for all years available.

36. Using the average flight speed of 471.85 miles per hour, the ratio of 15.09% mishaps occurring in "normal flight" and the ratio 47.18% of miles flown in "normal" phase of flight, but using the Air Force F-16 Class A and B mishap data for years 1975 through 2000, the crash per mile for normal flight is 3.39×10^{-8}. Resnikoff Tstmy, Post Tr. 8698 at 15; State Exh. 76. Performing the same calculations but adding the F-16 Class A and B mishap data for 2001 shown on State Exh. 154, *i.e.* 22 mishaps and 337,315 flight hours, the crash rate per mile for normal flight becomes 3.44×10^{-8}. The Board finds that using a value

for C, inflight crash rate per mile for aircraft using airway, of less than 3.44×10^{-8} crashes per mile is not realistic.

37. PFS used the ratio of 15.09% of all Class A and B mishaps to determine the number of mishaps occurring in "normal" flight. Applicant Exh. N, Tab C, D. The ratio of 15.09% was derived from ACRAM data which divided mishaps into the four phases of flight without indicating whether a mishap was a Class A or B mishap. Id. The ACRAM data include mishap history for years 1975 through 1993. Id. A second ratio for normal flight mishaps was obtained when PFS analyzed 121 destroyed F-16 crashes during the 10 year period 1989 through 1998, and determined that 27 of those crashes (22.3%) occurred in the "normal" phase of flight. Id., Tab H at 12; Resnikoff Tstmy, Post Tr. 8698 at 15. Because of the unknown distribution of Class A and B mishaps between the various phases of flight in the ACRAM study, and because of its comparatively older data, the Board finds that the ratio indicating that 22.3 % of all destroyed aircraft are destroyed in normal flight phase, when applied to the number of total destroyed F-16s, is the best evidence on which to base an estimate of F-16s mishaps occurring in the "normal" flight phase.

38. Using the average flight speed of 471.85 miles per hour, the ratio of 22.3% for destroyed F-16s occurring in "normal flight" and 47.18% of all flight miles occurring in the "normal"phase of flight, the crash rate per mile for normal flight based on lifetime F-16 mishap data[10] is 4.10×10^{-8}. This figure is obtained as follows:

[10] Mishap data from U.S. Air Force mishap report 1975 - 2001, State Exh. 154, second page.

6,644,260 hours x 471.85 = 3.135×10^{-9} miles.

3.135×10^{-9} miles x 47.18% = 1.479×10^{9} miles in normal flight.

272 destroyed aircraft x 22.3% = 60.66 destroyed F-16 mishaps during normal flight.

60.66 mishaps/1.479×10^{9} "normal" flight miles = 4.10×10^{-8} crashes per mile.

The Board finds that the realistic crash rate for the F-16 to be used as the value for C, the "inflight crash rate per mile for aircraft using airway," is 4.10×10^{-8}.

39. The determination of the crash rate per mile for flights through Skull Valley over or near the PFS site is limited by the fact that the only related evidence presented was based on F-16 fighter aircraft stationed at Hill AFB. General Cole testified that the F-16 would be replaced in 2010. Tr. (Cole) at 3371-72. No studies or estimates of the crash rate for the expected replacement aircraft have been made. Id. at 3372. No evidence was presented as to the type of training missions that will be flown by the replacement aircraft nor whether such missions will be classified as "normal" or "special operations" flights. Therefore, the Board finds that there is insufficient evidence to determine the crash rate per mile for flights transiting Skull Valley above or near the proposed PSF site after 2010.

(4.) Input Value w, width of airway, miles.

40. The four-factor NUREG-0800 formula for computing aircraft crash probability requires an input value for w, the " width of airway, miles." Resnikoff Tstmy, Post Tr. 8698 at 5-6. Approximately 96% of the F-16 flights through Skull Valley are in

Sevier B MOA. Id. at 15,16; Tr. (Jefferson) at 3396. F-16s may fly through any part[11] of Sevier B MOA but commonly fly at 3,000 to 4,000 feet above ground level. Horstman Tstmy, Post Tr.___ at 9; Applicant Exh. N at 5; Tr. (Cole) at 3396-7. F-16s fly through Skull Valley in 2 ship or 4 ship formations. Horstman Tstmy, Post Tr.___ at 6; Tr. (Jefferson) at 3430, 3455; PSF Exh. N, Tab E. According to the U.S. Air Force, it would be an exception for a solo flight to transit Skull Valley. Campe, Ghosh Tstmy, Post Tr.4078 at 11.

41. In a two ship formation of F-16s, the wingman would fly 1.5 to 2 miles, line abreast, from the flight leader at a position 0 to 10 degrees aft of the leader's flight path. In a four ship formation of F-16s, a wingman would fly 1.5 to 2 miles line abreast from the flight leader. Those two aircraft (lead and wingman) comprise the "lead element." Two additional aircraft with similar line abreast spacing to the lead element will follow 2 to 15 miles behind the lead element. One of the aircraft in the back element will be located between the horizontal spacing of the lead element (2 to 15 miles back). A four ship formation may vary from just over 1.5 to just under 4 miles in horizontal width and over 2 to 15 miles long. Horstman Tstmy, Post Tr.___ at 6.

42. A cross section of Sevier B MOA from a view looking north from the latitude of the proposed PFS site is shown in Applicant Exh. N, Figure 1. Tr. (Jefferson) at 3399-3401. The PFS site is identified as "PFSF" and located at "0" on the "statute miles" scale along the bottom of Figure 1. The PFS site is also located at 4,500 feet mean sea level

[11] *See* Footnote 7.

as indicated by the scale along the right side of Figure 1, which is also ground level or 0 AGL. Id. at 3405. The Sevier B MOA is bounded on the west by a restricted area located two miles to the west of the PFS site. Id. The blacked-out area on Figure 1 labeled "GROUND" represents mountainside terrain of the Stansbury Mountains, which prevents aircraft from flying to the eastern boundary of the MOA. Id at 3401. State Exh. 156B shows Figure 1 with the air space between 3,000 and 4,000 feet AGL shaded in yellow.

43. F-16 flights transiting Skull Valley maintain a "buffer" distance of one mile or more from the western boundary of Sevier B MOA to prevent straying into restricted air space west of the MOA. Horstman Tstmy, Post Tr.___ at 7. Aircraft must avoid flying in this restricted area or the pilot may incur very serious sanctions. Tr. (Jefferson) at 3407. Colonel Cosby, a former F-16 pilot with experience in flying through Skull Valley, a volunteer witness not being paid by any party, testified when flying in Skull Valley he would maintain a comfortable distance of 2 to 3 miles from the restricted airspace at the western boundary of the Sevier B MOA. Tr. (Cosby) at 3924. PFS witness Colonel Fly testified that most flights are down the middle to the eastern side of Skull Valley because of the restricted air space to the west. Tr. (Fly) at 3415. Fly further testified that he generally flew well clear of a one mile buffer zone from the restricted air space west of Sevier B MOA. Id. at 3424. The Board finds that F-16 pilots maintain a distance of at least one mile from the western boundary Sevier B MOA at the latitude of the PFS site to prevent entering restricted airspace.

44. F-16 formations generally fly down the middle of Skull Valley with part of

the formation over or near the PFS site. Horstman Tstmy, Post Tr.___ at 6-7.[12] The formation leader will select a flight path to allow the furthest west aircraft to maintain a distance of at least one mile from the western boundary of Sevier B MOA, beyond which is restricted air space. Id. The flight leader will also select a flight path to allow the furthest east aircraft to maintain a sufficient distance from the Stansbury Mountains, generally 2 miles, placing the furthest east aircraft at least 5 miles from the eastern border of Sevier B MOA. Id.; Tr. (Horstman) at 8593. The width of the Sevier B MOA that is actually used by F-16 formations extends from one mile east of the western MOA boundary to 5 miles west of the eastern MOA boundary, or a width of approximately six miles. Horstman Tstmy, Post Tr. ___ at 6-7. Within this 6 mile width of usable airspace, F-16s fly in two or four ship

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[12]The Board notes the PFS statement "the predominant route" for F-16s is "five statute miles east of the PFSF site" is contrary to the evidence that F-16s fly in formations as wide as 4 miles, and that the basis for the statement is a casual remark to General Cole of uncertain origin:

> Q. But you are not certain of the five miles?
>
> GEN. COLE: It was mentioned either at the conference call or when I was at Hill. I can't specifically recall which time.

Tr. (Cole) at 3398.

> GEN. COLE: The question you asked, and correct me if I'm wrong, was that five miles to the east; five miles to the east of what? I believe it was on the 20 November [1998] conference call. I believe the individual who stated that was Colonel Larry Thompson, who was the chief of safety of the 388th at the time. And the discussion was around the PFS site. So I believe he was talking about five miles east of the site. But it was a notion, an approximate distance. It wasn't a firm thing.

Id. at 3402.

formations which are from 1.5 to just under 4 miles wide. Id. With one ship in the formation flying at either the east or west edge of the usable airspace, the remaining ships in the formation would be inward from the edges. Id. The majority of F-16 flights in Skull Valley would therefore be within a corridor less than five miles wide within the 6 mile width of usable airspace. Id. The usable 6 mile airspace and formations positioned at the outer edges of that airspace are shown on State Exh. 48. Id. PFS witness General Jefferson also testified that because F-16 flights are in formations, at least half of the flights would be concentrated in a five mile width. Tr. (Jefferson) at 3455. No evidence was presented that F-16s transiting Skull Valley in Sevier B MOA fly further west than one mile west of the PFS site nor further east than 5 miles east of the PFS site. The Board finds that the majority of flights through Skull Valley at the latitude of the PFS site are in Sevier B MOA at an altitude of 3,000 to 4,000 feet AGL, and within an airspace five miles or less in width. The Board further finds that a realistic value for w, width of airway, in miles, is 5 miles.

45. The determination of the width of airway to be used in calculating the probability of aircraft crashes at the PFS site is limited by the fact that the only related evidence presented was based on the type and flight patterns flown by F-16s stationed at Hill AFB. General Cole testified that the F-16 would be replaced in 2010. Tr. (Cole) at 3371-72. No evidence was presented as to the type of training missions, flight altitudes or routes that will be flown by the replacement aircraft. Therefore, the Board finds that there is insufficient evidence to determine the width of airway for calculating crash probability after 2010.

(5.) <u>Input Value N, number of flights.</u>

46. The four-factor NUREG-0800 formula for computing aircraft crash probability requires an input value for N, the "number of flights per year along the airway." Resnikoff Tstmy, Post Tr. 8698 at 5-6. In recent years, virtually all aircraft transiting Skull Valley are F-16s flying in a southerly direction from Hill Air Force Base en route to the UTTR South Area range. Applicant Exh. N at 8. The F-16 flights transiting Skull Valley fly through Sevier B and Seveir D MOAs, over or near the PFS site. Horstman Tstmy, Post Tr.___ at 6-10.

47. The U. S. Air Force does not keep records showing specifically the number of F-16 flights in Skull Valley, but does report the usage of Sevier B and Sevier D MOAs for all aircraft in those MOAs, most of which are F-16s transiting Skull Valley. Revised Addendum to Crash Report (Applicant Exh. O) at 3-4 and Tab HH at 2. Only F-16 aircraft are required to transit Skull Valley. Applicant Exh. N at 8, n.7. In addition, some F-16 flights through Skull Valley are not reported on the usage reports for Sevier B and D MOAs because the flights are above both MOAs. Horstman Tstmy, Post Tr.___ at 11-12. The Board finds that the best evidence of the number of F-16 flights transiting Skull Valley in the past is the total number of flights shown on the usage reports for Sevier B and D MOAs as set forth in Applicant Exh. O at 4 and Horstman Tstmy, Post Tr.___ at 12.

48. In FY 2000, the total number of flights reported in the Air Force usage reports for Sevier B and D MOAs was 5,997. Applicant Exh. O at 4; Horstman Tstmy, Post Tr.___ at 11. In addition, 12 additional F-16s were assigned to Hill AFB in April of 2001, raising the total number of F-16s stationed at Hill AFB from 69 to 81, an increase of 17.4%.

It is reasonable to assume that the number of F-16 flights transiting Skull Valley would increase by this same percentage. Cole, Jefferson, Fly Tstmy, Post Tr.___ at 20-21; Horstman Tstmy, Post Tr.___ at 12. The number of flights in Sevier B and D MOAs for FY 2000, 5,997, increased by 17.4% representing the additional F-16s assigned to Hill AFB in 2001, gives a total of 7,040 estimated annual F-16 flights through Skull Valley. Campe, Ghosh Tstmy, Post Tr.4078 at 10; Horstman Tstmy, Post Tr.___ at 12. Both the State and the Staff have in this manner estimated the future number of flights through Skull Valley to be 7,040[13]. Id. The Board finds that the best estimate for input value N, number of flights per year along the airway, is 7,040.

49. PFS used a value for N of 5,870 annual flights based on the average of Sevier B flights for FY1999 and FY 2000, increased by 17.4% representing the additional F-16s assigned to Hill AFB in 2001. Cole, Jefferson, Fly Tstmy, Post Tr.___ at 20-21. General Jefferson testified that the higher number of flights for FY 2000 was not used as a basis for an estimate of future F-16 Skull Valley flights because of "past history and the current war on terrorism." Id.; Tr. (Jefferson) at 3350-51. However, General Jefferson stated that to his knowledge no F-16 fighter aircraft from Hill AFB were involved in the war on terrorism in Afghanistan. Id. at 3351-52. General Jefferson also stated there was no statistical basis for

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[13] The Board notes that the Staff has indicated that the 7,040 flights may be conservative due to the fact that F-16s fly in formations of 2 or 4 ships separated laterally. There the Staff reasons that only one of the ships could fly directly over the PFS site and be in a position to strike the PFS site. Campe, Ghosh Tstmy, Post Tr.4078 at 10-11. In view of the evidence that an F-16 performing emergency procedures no longer stays in a formation but performs various maneuvers and turns toward an emergency landing field, the Board finds the number of flights cannot be reduced on this reasoning. *See* the section on "The factual setting of a pilot during an engine failure emergency," *infra* at 38.

using the average of FY99 and FY00 flights, that the number of future flights would depend on national budgets and policy and that neither he nor the commanders at Hill AFB would know the number of future flights. Id. at 3352-53. The Board finds that it is not realistic nor conservative to base the future estimate of flights in Skull Valley on the average number of flights reported for FY99 and FY00 and further finds that no evidence was presented to show that the higher number of flights in FY00 will not be repeated in the future, as adjusted by the 17.4% increase in F-16s assigned to Hill AFB in 2001.

50. The PFS estimate of 5,870 future flights is based only on Sevier B MOA usage reports. PSF excluded flight counts from Sevier D usage reports on the basis that they may contain flights other than Skull Valley flights and may therefore "overcount" the number of F-16 flights through Skull Valley. Id. at 3356-57. The Air Force has informed PFS that the majority of flights going through Sevier D MOA are F-16s transiting Skull Valley. Applicant Exh. O, Tab HH at 2. General Jefferson testified that there is no way to determine whether all or a portion of the reported flights were in Skull Valley, and it would therefore be more conservative to include the Sevier D flight counts in estimating the number of future Skull Valley flights. Tr. (Jefferson) at 3357. The Board finds that it is not realistic nor conservative to exclude flight counts for Sevier D MOA as a basis in estimating the future number of flights in Skull Valley.

51. The determination of the annual number of flights through Skull Valley over or near the PFS site is limited by the fact that the only related evidence presented was based on the number and type of training flights flown by F-16s stationed at Hill AFB. General Cole testified that the F-16 would be replaced in 2010. Tr. (Cole) at 3372. No evidence was

presented as to the number of aircraft to be stationed at Hill AFB following the retirement of the F-16, nor the type and number of training missions that will be flown by the replacement aircraft. Therefore, the Board finds that there is insufficient evidence to determine the number of flights transiting Skull Valley above or near the proposed PSF site after 2010.

(6.) Input Value A, effective area of plant in square miles

52. The four-factor NUREG-0800 formula for computing aircraft crash probability requires an input value for A, effective area of plant in square miles. Resnikoff Tstmy, Post Tr. 8698 at 5-6. The input value for A, effective area of plant in square miles, is 0.13371. Applicant Exh. N at 15-16.

(7.) Calculation of crash probability using NUREG-0800 formula $P_{FA} = C \times N \times A/w$

53. The probability of an F-16 crash impacting the proposed PFS site is 7.72×10^{-6}, using the NUREG-0800 formula $P_{FA} = C \times N \times A/w$, and the following input values:

C = 4.10×10^{-8}

w = 5 miles

N = 7,040

A = 0.13371 square miles

The Board finds that the realistic probability of aircraft crash impact to the proposed PFS facility is 7.72×10^{-6}.

54. The determination of the crash impact probability to the proposed PFS site is

limited by the fact that the only related evidence presented was based on the number, type of training flights and the crash rates for flown by F-16s stationed at Hill AFB. General Cole testified that the F-16 would be replaced in 2010. Tr. (Cole) at 3372. No evidence was presented as to the number of aircraft to be stationed at Hill AFB following the retirement of the F-16, nor the expected crash rates, number and type of training missions that will be flown by the replacement aircraft. Therefore, the Board finds that there is insufficient evidence to determine the probability of crash impacts to the proposed PSF site after 2010.

(8.) <u>The Applicant's modification of the NRC NUREG-0800 formula.</u>

(a) <u>The nature and effect of the PFS modification.</u>

55. PFS acknowledges that if the four factor NUREG-0800 formula is used to calculate crash probability to the proposed PFS site, the probability of impact from F-16s transiting Skull Valley alone would exceed the standard set by the Commission of 1×10^{-6}. Tr. (Jefferson) at 3197-99. PFS has calculated the impact probability using a modification of the NUREG-0800 formula shown below with the NUREG-0800 formula for comparison:

$P = C \times N \times A/w \times R$ Formula used by PFS.

$P = C \times N \times A/w$ Formula given in NUREG-0800

Applicant Exh. N at 6; Cole, Jefferson, Fly Tstmy, Post Tr.___ at 15; Tr. (Cole) at 3185-86.

The additional formula component "R" added by PFS reduces the crash probability on the theory that the pilot of an F-16 about to crash will guide the aircraft away from the PFS site before ejecting. Applicant Exh. N at 16. PSF has estimated the value of R to be 14.5%, thereby obtaining an 85.5% reduction in the probability that would otherwise by obtained using the four factor NUREG-0800 formula. Cole, Jefferson, Fly Tstmy, Post

Tr.___ at 17-18; Resnikoff Tstmy, Post Tr. 8698 at 8.

(b) Lack of authority to modify the NUREG-0800 formula.

56. The decision to modify the NUREG-0800 formula by adding the "R" factor was made was by the three PFS retired Air Force witnesses, General Cole, General Jefferson, and Colonel Fly. Tr. (Cole, Fly) at 3186-89. None of these PFS witnesses testified to having any previous experience using NUREG-0800. Tr. (Jefferson) at 3193; (Cole) at 3184; (Fly) at 3344. The "R" factor formula devised by the PFS witnesses has never been used prior to the PFS application. Tr. (Jefferson) at 3193, 3211; (Cole) at 3186. All calculations with the modified "R" factor formula were done by General Jefferson. Tr. (Jefferson) at 3189; Tr. (Cole) at 3187.

57. The NRC guidance document NUREG-0800 makes no reference to a crash probability formula using an "R" factor and makes no reference to the concept that the pilot of a crashing aircraft will be able to avoid impacting a site on the ground. Tr. Jefferson at 3207-08. Neither DOE Standard 3014-96 (October 1996) *Accident Analysis For Aircraft Crash Into Hazardous Facilities* (Applicant Exh. SSS) nor *Data Development Technical Support Document for the Aircraft Crash Risk Analysis Methodology (ACRAM) Standard* (UCRL-ID-124837, August 1996) (State Exh. 51) make reference to a crash probability formula using the "R" factor nor make reference to the concept that the pilot of a crashing aircraft will be able to avoid impacting a site on the ground. Tr. (Jefferson) at 3209-11.

58. Staff witness Dr. Kazimieras Campe testified that in his work for the NRC and its predecessor the Atomic Energy Commission, he has been assessing aircraft hazards since the early 1970s. Tr. (Campe) at 4080. In that capacity, Dr. Campe has reviewed

applications for "practically every" nuclear power plant with respect to aircraft crashes. Tr. (Campe) at 4122. Dr. Campe has never seen a significant departure from the NUREG-0800 four-factor formula used for aircraft crash assessment in any previous application. Tr. (Campe) at 4122-26. Dr. Campe, a contributing author of the NRC guidance document NUREG-0800, testified that neither NUREG-0800 nor any DOE document dealing with aircraft crash probability makes reference to a pilot's ability to avoid a ground site. Id. at 4101-03. Dr. Campe further testified that he knows of no authorities that have recognized a pilot's ability to avoid a ground site in crash probability calculations. Id. at 4109. Dr. Campe knows of no studies relating to a pilot's ability to avoid a ground site. Id.

59. Staff witness Dr. Ghosh is employed by a contractor or the NRC, the Center for Nuclear Waste Regulatory Analysis. Tr. (Ghosh) at 4111-13. Dr. Ghosh did the calculations for the NRC staff review of the PFS application. Tr. (Campe) at 4099. Dr. Ghosh also was the principal author of an aircraft crash analysis for Yucca Mountain. Tr. (Ghosh) at 4111; State Exh. 157. Dr Ghosh did not use a factor based on a pilot's ability to avoid a ground site in the Yucca Mountain study, nor does he know of any authorities that support calculation of crash probability using the theory that a pilot would be able to avoid a ground site in the event of a crash. Id. at 4114-15.

(c) The factual setting of a pilot during an engine failure emergency.

60. PFS has separated F-16 crashes into two categories: 1) crashes precipitated by engine failure or other malfunction where the pilot will retain some control of the F-16; and 2) all other crashes where the aircraft is not controllable and the pilot immediately ejects. Applicant Exh. N. at 16. Crashes precipitated by engine failure may not leave the F-16

controllable by the pilot, such as where the pilot ejects during an uncontrolled spin. Applicant Exh. 145, 118, 124, 113, 147; State Exh. 223 at entries 8, 19, 20, 46, 53. Crashes precipitated by engine failure may result in the aircraft being on fire forcing the pilot to eject. Applicant Exh.119, 145, 158, 110, 118, 127, 184, 113, 147, 180; Joint Exh. 4; State Exh. 223 at entries 3, 8, 10, 17, 19, 21, 24, 38, 46, 53, 59.

61. In an emergency caused by engine failure leaving the F-16 controllable, the pilot will "zoom" the aircraft, which is a climb to trade speed for altitude, and will discard all fuel tanks, bombs and other weapons, known as jettison of stores. Horstman Tstmy, Post Tr.___ at 15-16. Zooming the aircraft provides the pilot with additional time aloft to attempt to restart the engine before the aircraft crashes. Id. The zoom is accomplished by raising the nose to establish a 30 degree climb. Tr. (Fly) at 13080-81. During the zoom maneuverer, the nose of the F-16 will block the pilot's view and he will not be able to see what is in front of him. Id. If the pilot had been flying at an altitude of 4,000 feet AGL, the zoom would take the F-16 to approximately 7,000 or 8,000 feet AGL. Tr. (Horstman) at 13453. In accordance with the F-16 flight manual, upon reaching the airspeed of 250 knots the pilot will end the zoom by "pushing the plane over" and start a descent. Id. at 13299-300. The maneuver of pushing the plane over uses some of the F-16's energy and the aircraft slows to approximately 200 knots. Id. at 13300-01.

62. The F-16 will then begin a glide at the speed of 200 knots with approximately a 6 degree angle of descent. Id. at 13300-02; Tr. (Fly) at 13641-42. If the emergency occurred in the general area of Skull Valley, the pilot would then turn the aircraft toward Michael Army Air Field, the designated emergency air field and attempt to restart the engine

during the glide. Tr. (Horstman) at 8576-79; 8601-05; 8625-27; 13366-70; State Exh. 186; Tr. (Bernard) at 3921-23; Applicant Exh. N, Tab E; Tr. (Fly) at 3334. During the glide descending at 6 degrees, the pilot's view will be obscured in front of the aircraft for a distance of approximately 5,500 feet for every 1,000 feet of altitude. Tr. (Fly) at 13639-42. As the aircraft continues on this glide path the pilot will not be able to see ground terrain closer than 22,000 ft. in front of the aircraft at the altitude of 4,000 AGL, nor closer than 13,750 feet in front of the aircraft at an altitude 2,500 ft AGL. Id. Upon reaching the altitude of 2,500 feet AGL, the pilot will slow the F-16 to the slowest possible speed in preparation for ejection. Tr. (Horstman) at 13302-07. Slowing the F-16 for ejection is done by raising the nose of the aircraft to at 20 degrees above the horizon, at which point the nose of the aircraft will block the pilot's view of the ground in front of the aircraft for 10 miles. Id. The F-16 will remain at 20 degrees nose high until the pilot ejects. Id. at 13303; 13305-06. The pilot will eject at or before reaching the minimum altitude of 2,000 feet AGL in accordance with published directives. Applicant Exh. N at19c and Tab E. Horstman Tstmy, Post Tr.___ at 16; Tr. part two (Jefferson) at 19-20.[14] At the minimum ejection altitude of 2,000 AGL, the F-16 will be 3.22 miles from the crash impact site. Tr. part two (Fly, Jefferson) at 20-21. The F-16 flight manual shows additional ejection checklist steps to be performed, including "If time permits, . . . direct the aircraft away from populated areas." Applicant Exh. PPP; State Exh. 224[15] at pages corresponding to Applicant Exh. PPP.

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[14]Also see relevant F-16 flight manual pages. Applicant Exh.PPP; State Exh. 224 at pages corresponding to Applicant Exh. PPP.

[15]State Exh. 224 was filed August 16, 2002 per the Board direction at Tr. 13718.

63. The crash probability reduction factor "R" added to the NUREG-0800 formula by PFS is based on the theory that the pilot of an F-16 about to crash will guide the aircraft away from the PFS site before ejecting. Applicant Exh. N at 16.

(d) The determination of "R" by PFS

64. PFS used a value of 14.5% for "R" in the five factor formula devised by PFS. Cole, Jefferson, Fly Tstmy, Post Tr.___ at 17-18. This value for "R" is based on two underlying component values used by PFS:

90% Used by PFS to represent the percentage of F-16 crashes that could occur in Skull Valley in which the pilot retained control of the aircraft, and

95% Used by PFS to represent the percentage of times that a pilot in a controllable aircraft would direct the crashing aircraft away from the PFS site.

Id. PFS used these values to arrive at a value for "R" in the following manner:

90% x 95% = 85.5%

100% - 85.5% = 14.5%

Id.

(e) The 90 % component, percentage of crashes where pilot retains control of aircraft.

65. PFS witnesses Cole, Jefferson and Fly testified that the determination that 90% of crashes would leave the pilot in control was based on a review of accident reports over a ten year period. Id. at 17. The ten year period used by PFS for this review is 1989 through 1998, and the reports reviewed are identified in Applicant Exh. X and Applicant

Exh. N at Tab H[16]. Even though PFS reviewed 126 class A mishap reports, five reports were eliminated from consideration on the basis that only crashes involving destroyed aircraft would be considered, a total of 121. Applicant Exh. N, Tab H at 3-4. One of the crash reports eliminated was the F-16 flight of December 19, 1991 that disappeared after take off and was never heard from. Tr. part two (Fly) at 27-28. PSF witness Fly testified that the F-16 was "probably" destroyed but nevertheless was not considered in the 121 crashes reviewed. Id.

66. General Jefferson testified that in 42% of the 121 crashes reviewed, the pilot did not have control of the aircraft such that the pilot could avoid the PFS site even if he so desired. Tr. (Jefferson) at 3817; Applicant Exh. X. Therefore only 58% of crashes could have resulted in the pilot retaining control of the aircraft. The higher percentage (90%) of controllable aircraft used by PFS is based on further eliminating 60 of the 121 destroyed aircraft reports which PFS "found not to be relevant to Skull Valley." Applicant Exh. N, Tab H at 15. Of the remaining 61 crash reports considered, PFS determined that 59 represented crashes where the aircraft remained controllable with sufficient time to avoid a fixed site on the ground. Id. at 20 and Table 4. In that group of 59 crash reports, 5 reports show the pilot ejected during an uncontrolled spin or the aircraft was otherwise uncontrollable. Applicant Exh. 145, 118, 124, 113, 147; State Exh. 223 at entries 8, 19, 20, 46, 53. Also within that group of 59 crash reports are 11 reports that show the F-16 was on fire when the pilot ejected. Applicant Exh.119, 145, 158, 110, 118, 127, 184, 113, 147, 180;

[16] The full mishap reports are shown in Joint Exh. 1 - 12; Applicant Exh. 80, 103-218.

Joint Exh. 4; State Exh. 223 at entries 3, 8, 10, 17, 19, 21, 24, 38, 46, 53, 59.

67. The determination of 90% for crashes in which the aircraft is controllable is inconsistent with the evidence that engine failure is the most likely cause of a crash where the pilot retains control and the evidence that only 36% of F-16 Class A accidents are engine failures according to the manufacturer, Lockheed Martin. PFS Exhibit N at 17b; State Exh.56.

68. The Board finds that the component value of 90% used by PFS to represent the percentage of F-16 crashes that could occur in Skull Valley in which the pilot retained control of the aircraft with sufficient time to avoid the PFS site, is neither realistic nor conservative and was determined by selecting data in a subjective manner.

(f) The 95 % component, percentage of times a pilot in a controllable F-16 would direct the crashing aircraft away from the PFS site.

69. The component value of 95% used by PFS is a purely subjective determination made collectively by PFS witnesses General Jefferson, General Cole, and Colonel Fly. Tr. (Jefferson) at 8882. The determination of 95% was made without performing any calculation or statistics, and was made prior to reviewing the F-16 accident reports. Tr. (Jefferson) at 3215-16; 3966-67; 3972-73; 13118-13122.

70. Engine failure is the most likely cause of an F-16 crash where the pilot retains some control of the aircraft. Applicant Exh. N at 17b. This 95 % component represents the percentage of time that a pilot will be successful, during an engine failure emergency, in performing emergency procedures including attempting to restart the engine, in specifically locating the PFS site which will be 3.22 miles or more away at the time of ejection, in

directing the aircraft away from the PFS site while also directing the aircraft way from any populated areas, and in ejecting at or above the minimum altitude of 2,000 feet AGL.[17]

71. None of the PFS witnesses who determined the component value of 95% have ever ejected from an F-16. Id. at 3216-17. Neither General Cole nor General Jefferson have ever piloted an F-16. Tr. (Cole) at 3142; Tr. (Jefferson) at 3189. The 95% value is the collective opinion of PFS witnesses Cole, Jefferson and Fly based on U.S. Air Force training, the visibility of the PFS site, and the time available. Tr. (Jefferson) at 8882.

(i) *U. S. Air Force Training*

72. The F-16 fight manual provides the following reference:

> Ejection (time permitting)
> If time permits, descend to avoid the hazards of high altitude ejection. Stow all loose equipment and direct the aircraft away from populated areas. Sit with head against headrest, buttocks against back of seat, and feet on redder pedals.
>
> 1. IFF MASTER knob - EMER.
> 2. MASTER ZEROIZE switch (combat status) - ZEROIZE.
> 3. Loose equipment and checklist - Stow.
> 4. Lapbelt and helmet chin strap - Tighten.
> 5. Night vision devices - Remove (if appropriate).
> 6. Visor - Down.
> 7. Throttle - IDLE.
>   Slow to lowest practical airspeed.

[17] The emergency procedures for an F-16 engine failure are more fully described in foregoing section "The factual setting of a pilot during an engine failure emergency," *supra* at 38.

8. Assume ejection position.

9. Ejection handle - Pull.

Applicant Exh. N at 19a; and PPP; State Exh. 224, at page (3-39) corresponding to Applicant Exh. PPP (3-43).

73. Of the approximately 10,000 pages of directives and procedures for the F-16, the only reference to directing the aircraft before ejecting is found embedded in the above provision: *If time permits. . . direct the aircraft away from populated areas.* Tr. (Horstman) at 8551. Except for a similar one sentence reference in flight manuals for other aircraft, there are no other Air Force documents that refer to training a pilot to avoid populated areas. Tr. (Jefferson) at 3251, 52; (Horstman) at 13532.

74. The Air Force does not teach pilots to look for specific sites on the ground in an emergency. Tr. (Horstman) at 8550-51. There is no Air Force training or guidance to avoid a house, a facility, or other specific ground site and pilots do not have the tools for such a task. Id. at 13464-65. Directing the aircraft away from a populated area refers to a large geographical area, not a specific site or targets on the ground. Id. at 13531-32. An F-16 pilot will eject at a distance of at least 3.22 miles and possibly as far away as five miles from where the F-16 will impact. Id. at 13612-13; Tr. part two (Fly, Jefferson) at 20-21. The task of directing an F-16 away from a populated area before ejecting requires the pilot to determine if the impact area 3.22 or more miles in front of the aircraft is a populated area. Tr. (Horstman) at 13612-13; 13624. It is relatively easy to determine if a city is within the crash impact area because its size makes it easy to locate and the pilot may know its approximate location from general situational awareness. Tr. (Horstman) at 13470-71; (Fly)

at 3290. Conversely, a pilot may not be able to see smaller specific ground sites from 3.22 miles or further, nor be able to recognize such sites as populated areas. Tr.(Horstman) at 13470-71. The PFS site covers only 0.13 square miles and consists mostly of open space and concrete casks and does not appear to be a populated area. Applicant Exh. N at Tab R; Horstman Tstmy, Post Tr.___ at 17-18.

75. The notion of directing the aircraft away from a populated area also includes the notion that a pilot would not direct the aircraft away from one area at the risk of impacting a more populated area. Tr. (Horstman) at 13612-13; 13624. The decision to turn away from a populated area requires the pilot to assess the impact area of where the F-16 is pointed and alternative impact areas to turn towards. Id. A pilot in Skull Valley would not direct an F-16 toward the Goshute Indian Village in an effort of avoid the PFS facility. Id.; State Exh. 222. The mishap report for the F-16 crash of 11 July 1996 shows the pilot turned "towards what he perceived to be a less congested area" yet the impact destroyed two houses killing a child and injuring her mother. Joint Exh. 10; State Exh. 223 no.14. The mishap report for the F-16 crash of 31 August 1992 shows the pilot ejected at 2,000 feet AGL after the pilot turned toward "what appeared to be an uninhabited area" yet impacted 150 yards from two inhabited dwellings. Applicant Exh.140; State Exh. 223 no. 7. These mishap reports demonstrate the level of a pilot's ability to turn away from large populated areas, and the inability to locate and avoid specific ground sites.

76. Air Force training does not include practicing engine failure emergencies where the F-16 engine is failed for training purposes. Tr. (Fly) at 3555-56. If an engine fails, the pilot will for the first time be in that emergency situation. Id. Engine failures are

practiced only on flight simulators. Tr. (Cole, Fly) at 3333-37. Neither does Air Force training include practicing ejections from an aircraft. Id. Pulling the ejection handle in a flight simulator merely causes the simulator to go blank and stop. Id. Until a pilot actually ejects from an aircraft during an emergency, the pilot has never fully experienced that sensation nor made decisions relating to where the aircraft will impact. Id.

(ii) *Emergency stress and Pilot Error*

77. Pilots are under great physical and emotional stress during inflight emergencies, which causes their performance to deteriorate. Horstman Tstmy, Post Tr.___ at 20; Tr. (Jefferson) at 3252-54. A pilot's primary concern upon realizing the aircraft is about to crash is for the pilot's survival, which is dependant on ejection. Horstman Tstmy, Post Tr.___ at 17-21; Tr. (Bernard) at 3898-99. Ejection from an F-16 is a violent and dangerous procedure which can cause severe injury or death. Horstman Tstmy, Post Tr.___ at 17; Tr. (Bernard) at 3900; (Cole) at 3145; (Jefferson) at 3274, 3304. U.S. Air Force publication *Flying Safety* reports that through September 2000, 6.8% of F-16 ejections have resulted in fatal injuries. State Exh. 151 at 11-13; Tr. (Jefferson) 3255, 3270-71. Colonel Bernard, who ejected from an F-16 during a training mission, testified that the greatest stress levels "by a significant measure" faced by a pilot occur during the moments before ejection. Tr. (Bernard) at 3901-02. Colonel Bernard testified that you have a period of divided attention during an emergency that "completely becomes focused on what you need for your survival." Id. at 3898.

78. The U. S. Air Force Chief of Safety sends out messages known as ALSAFECOMSs to distribute critical safety information to Air Force commands.

Horstman Tstmy, Post Tr.___ at 20-21. During 1996, the Air Force Chief of Safety sent out ALSAFECOM 02-1996, one of only four ALSAFECONs sent out that year. Id.; State Exh. 57. It advised of significant pilot errors in emergency situations, including 73% of ejections in the previous six months occurring below the published minimum altitude of 2,000 feet due to futile attempts to restart failed engines. Id. It further advised that incorrect assessment of airborne situations and timely ejections had become a problem, and that erroneous assumptions and poor airmanship flourished in emergency situations. Id. It concluded that crew members confronted with inflight emergency induced stress may need external intervention to alter inappropriate actions. Id. F-16 manufacturer Lockheed Martin has determined that 52% of Class A F-16 accidents have been caused by pilot error. Horstman Tstmy, Post Tr.___ at 20; State Exh. 56.

79. Restarting a failed engine, like ejection, would save a pilot's life and avoid the dangers associated with ejection. Horstman Tstmy, Post Tr.___ at 19. Thus there is an incentive for a pilot to restart the engine an avoid ejection. Tr. (Cosby) at 4010. The cost of an F-16 is approximately $40 million. Tr. (Fly) at 3339. Pilots will take every opportunity to save the aircraft by restarting the engine before ejecting. Tr. (Cosby) at 4010-11. A pilot in an emergency commonly focuses on the task of restarting a failed engine to the exclusion of performing other emergency procedures, including assessing where the aircraft will impact. Horstman Tstmy, Post Tr.___ at 18-19; Tr. (Cosby) at 4030.

80. Volunteer witness Colonel Michael Cosby ejected from an F-16 after the engine failed during a 1993 training mission. Tr. (Cosby) at 3978-80. Colonel Cosby testified that he spent too much time and attention trying to restart the failed engine. Id.

The board that investigated Colonel Cosby's accident determined that if he had spent less time focusing on restarting the engine, he would probably have avoided the crash and been able to successfully land. Id. at 4008.

81. Volunteer witness Colonel Frank Bernard ejected from an F-16 after the engine failed during a 1986 training mission. Tr. (Bernard) at 3888-89. Colonel Bernard testified that it was error on his part to use all his time trying to solve his failed engine problem, which drove him to eject at only 170 feet AGL. Id. at 3895-96. Video recordings are routinely made during F-16 flights. Tr. (Horstman) at 13133-36. The U.S. Air Force used the actual video recording taken from Colonel Bernard's F-16 during his ejection emergency to produce a safety training video for F-16 pilots. Tr. (Horstman) at 13135-37; State Exh. 220. The video shows the "post strike" portion of the training mission which is generally representative of flying conditions that normally occur in Skull Valley. Tr. (Horstman) at 13435-38; 13448-51; State Exh. 220. Following disengagement from the mock battle training, the circumstances represented in the Bernard training video are representative of any F-16 with a failed engine. Tr. (Fly) 13690-91; State Exh. 220. According to the classifications used by PFS to access mishap reports, the Colonel Bernard engine failure emergency would be considered a Skull Valley event in which the pilot had the time and circumstances to avoid the PFS site. Tr. (Horstman) at 13435-38. Colonel Bernard, one of the most experienced fighter pilots in the world, ejected only four seconds prior to the aircraft impacting the ground. Id.; State Exh. 220. This was Colonel Bernard's second ejection. Id.

82. From reviewing F-16 crash reports for the ten year period 1989 through

1998, PFS determined that 58 reports represented crashes where the aircraft remained controllable with sufficient time to avoid a specific ground site. Applicant Exh. 100A. In that group of 58 crash reports, 29 reports (50%) show the pilot ejected below the published minimum altitude of 2,000 feet AGL. State Exh. 223.

83. Lt. Colonel Horstman interviewed active duty Air Force pilot Major Tom Smith, who ejected from an F-16 on January 13, 1995. Tr. (Horstman) at 8585-86. Lt. Colonel Horstman and Major Smith were both flying when Major Smith ejected. Id. Lt. Colonel Horstman was Major Smith's supervisor at the time and had several conversations with Major (then Captain) Smith concerning his emergency and ejection. Id. Following an engine failure, Major Smith zoomed the aircraft, jettisoned stores, attempted to restart the engine and ejected. Horstman Tstmy, Post Tr.___ at 19; Applicant Exh. 175. Major Smith said he did not have time to think about where his jettisoned stores would impact or where the F-16 would impact. Horstman Tstmy, Post Tr.___ at 18-19. Major Smith also said his thoughts were focused on his survival, and if he were to again be required to eject given the same circumstances, he would again not consider where the stores or aircraft would impact. Id. at 18-19. PFS reviewed the accident report of Major Smith's crash and determined it represented a situation where a pilot would have time to avoid a specific site. Applicant Exh. 100A.

84. Lt. Colonel Horstman contacted the deputy commander of the 388th flight wing at Hill AFB and asked for permission to interview a fighter pilot who had previously ejected. Tr. (Horstman) at 8586-87. In response to that request, the 388th deputy commander selected three fighter pilots stationed at Hill AFB who had ejected and invited

Lt. Colonel Horstman to Hill AFB for the purpose of interviewing the pilots. Id. Colonel Horstman interviewed the three pilots, Captain Pietrykowski, Lt. Tidgewell, and Colonel Coots. Horstman Tstmy, Post Tr.___ at 18-19. Each of the pilots said their thoughts were focused on their own survival and did not consider where the aircraft would impact. Id. Each of the pilots said that if they were required to eject under the same circumstances, they would again not consider where the aircraft would impact. Id.

(iii) *Inability to see the PSF site due to weather conditions.*

85. The ability to direct an aircraft away from the PFS site assumes the pilot will recognize the PFS site as a populated area and can see a more desirable crash site to turn towards. Tr. (Horstman) at 13612-13; 13624. The Board notes that the necessity of being able to see the PFS site is not lessened even if the pilot could otherwise locate the PFS site. No evidence suggests that a pilot unable to see the ground will be motivated or trained to search for the PFS site in an emergency. No evidence suggests that a pilot would turn away from the PFS site at the risk of impacting a populated area hidden by clouds. In any event, navigation instruments cannot be relied upon to locate the PFS facility. Id. at 8481-87; Horstman Tstmy, Post Tr.___ at 24. The "heads up display" ("HUD") of an F-16 would do nothing to facilitate locating the PFS site unless the location were specifically programmed as a navigation point. Tr. (Fly) at 3142-43. If the PFS site were programmed as a navigation or turn point, the disabled aircraft would be pointed directly at the PFS facility. Horstman Tstmy, Post Tr.___ at 8. After an emergency occurs in Skull Valley, regardless of what navigation point had been used up to that time, the pilot would switch to the preprogramed navigation point for the designated emergency air field, Michael Army Airfield. Tr.

(Horstman) at 13365-67. Simply put, weather conditions limiting visibility will prevent the pilot from being able to avoid the PFS site. Horstman Tstmy, Post Tr.___ at 21-24; Tr. (Cosby) at 4025.

86. Historical weather data representative of Skull Valley shows that at 5,000 feet or less the sky has the following cloud coverage:

Overcast (100% cloud covered)	9% of the time
Broken (5/8 to 7/8 cloud covered)	3 % of the time
Scattered (3/8 to 4/8 cloud covered)	6% of the time
Few (2/8 or less cloud covered)	4% of the time

Applicant Exh. 245; Tr (Vigeant) at 13058. The cloud coverage for Skull Valley represents a ceiling at 5,000 feet 12 % of the time. Id.; Applicant Exh. O at 22. A pilot's view of the PFS facility will be obstructed when cloud coverage is 50% or greater and there is a high probability it will be obstructed when the sky is 25% cloud covered. Horstman Tstmy, Post Tr.___ at 21-24; Tr. (Horstman) at 8377-84. A pilot will not be able to see the PFS facility at least 12% of the time and may not be able to see the PFS facility up to 21% of the time. Id.

87. Because clouds have vertical development and because a pilot's view of the ground is at an angle, a sky that is 25% cloud covered may completely block the pilot's view of the ground. Tr. (Horstman) at 8377-84. Clouds are generally dense enough that they cannot be seen through. Applicant Exh. O at 24. Even clouds referred to as "transparent" cannot be seen through by a pilot viewing the ground at an angle. Tr. (Horstman) at 8575-76; (Jefferson, Cole) at 13078. A single cloud may be positioned at any given time to preclude a view of the PFS site. Applicant Exh. O at 24; Tr. part two (Fly) at 8.

88. Clouds above the pilot will prevent the pilot from "zooming" the aircraft in an emergency. Horstman Tstmy, Post Tr.___ at 21. This inability to zoom the aircraft will require the pilot to stay at a lower attitude with less time for emergency procedures including avoiding populated areas. Id. Sky conditions above 5,000 feet through 14,000 feet in Skull Valley are overcast or broken (5/8 to 100% cloud covered) 23 % of the time. Applicant Exh. 245.

89. In addition to cloud coverage, Skull Valley has ground fog 2.5% of the time which cannot be seen through. Tr. part two (Vigeant) at 5-7; (Fly) at 13077-84.

90. Overall, weather conditions adversely impact a pilot's ability to see Skull Valley ground sites 50% of the time. Tr. (Horstman) at 13416-13424. Similarly, PFS gives only the faint assurance that "pilots should be able to visually locate the site the majority of the time." PFS Ex. O, Tab FF at 24.

(iv) *Inability to see the PFS site due to limited visibility during emergency procedures.*

91. A pilot flying straight and level in an F-16 can see only 11 degrees below the horizon before the nose of the aircraft obstructs the pilot's view. Tr. (Fly) at 13080. A pilot flying through Skull Valley at 425 knots and 4,000 feet AGL would not be able to see the ground for a distance of over four miles in front of the aircraft. Id. at 13639-40.

92. In an emergency caused by engine failure leaving the F-16 controllable, the pilot will "zoom" the aircraft, which is a climb to trade speed for altitude giving the pilot additional time aloft. Horstman Tstmy, Post Tr.___ at 15. The zoom is accomplished by raising the nose to establish a 30 degree climb. Tr. (Fly) at 13080-81. During the zoom maneuverer, the nose of the F-16 will completely block the pilot's view of the ground in

front of him. Id.

93. If the pilot had been flying at an altitude of 4,000 feet AGL, the zoom would take the F-16 to approximately 7,000 or 8,000 feet AGL. Tr. (Horstman) at 13453. In accordance with the F-16 flight manual, upon reaching the airspeed of 250 knots the pilot will end the zoom by "pushing the plane over" and start a descent. Id. at 13299-300. The maneuver of pushing the plane over uses some of the F-16's energy and the aircraft slows to approximately 200 knots. Id. at 13300-01.

94. The F-16 will then begin a glide at the speed of 200 knots with approximately a 6 degree angle of descent. Id. at 13300-02; Tr. (Fly) at 13641-42. If the emergency occurred in the general area of Skull Valley, the pilot would then turn the aircraft toward Michael Army Air Field, the designated emergency air field and attempt to restart the engine during the glide. Tr. (Horstman) at 8576-79; 8601-05; 8625-27; 13366-70; State Exh. 186; Tr. (Bernard) at 3921-23; Applicant Exh. N, Tab E; Tr. (Fly) at 3334. During the glide descending at 6 degrees, the pilot's view will be obscured in front of the aircraft for a distance of approximately 5,500 feet for every 1,000 feet of altitude. Tr. (Fly) at 13639-42. As the aircraft continues on this glide path the pilot will not be able to see ground terrain closer than 22,000 ft.(4.16 miles), in front of the aircraft at the altitude of 4,000 AGL, nor closer than 13,750 feet in front of the aircraft at an altitude 2,500 ft AGL. Id.

95. Upon reaching the altitude of 2,500 feet AGL, the pilot will slow the F-16 to the slowest possible speed in preparation for ejection. Tr. (Horstman) at 13302-07. Slowing the F-16 for ejection is done by raising the nose of the aircraft to 20 degrees above the horizon, at which point the nose of the aircraft will block the pilot's view of the ground in

front of the aircraft for 10 miles. Id. The F-16 will remain at 20 degrees nose high until the pilot ejects. Id. at 13303; 13305-06. At the minimum ejection altitude of 2,000 AGL, the F-16 will be 3.22 miles from the crash impact site. Tr. part two (Fly, Jefferson) at 20-21.

96. The Board finds that during failed engine emergency procedures, an F-16 pilot's ability to see ground sites in the path of the aircraft is substantially impaired. The Board further finds that the pilot would not be able to see the ground during the zoom portion of the procedure and would not be able to see the impact location at the time of ejection.

(v) *Lack of supporting evidence from mishap reports.*

97. PFS reviewed 126 U.S. Air Force F-16 mishap reports for the ten year period 1989 through 1998 and determined that the 58 reports identified in Applicant Exh.100A are "all accidents relevant to Skull Valley transit in which the pilot retained control and had enough time to avoid a specific site. Tr. (Cole) 3660; Applicant Exh. 100A. Before reviewing the reports, PFS had already concluded that 95% of pilots would be able to avoid the PFS site. Tr. (Jefferson) at 3967; 13118-22. The reports were reviewed and PSF Exh. 100A was prepared to justify the 95% component of the "R" factor. Tr. (Jefferson)13100-01; 13118-22. PFS acknowledges that U.S. Air Force mishap reports are not prepared for the purpose of determining if the pilot avoided a ground site or could be counted on to avoid a ground site. Tr. (Jefferson) at 8880-81; 13118-22. U. S. Air Force regulations requiring when and how mishap reports are prepared do not include guidance on the subject of the pilot's avoidance of a ground site. Tr. (Jefferson) at 13118-22; State Exh. 60, 66.

98. PFS admits that mishaps shown in Applicant Exh. 100A do not statistically

support a 95% success rate for a pilot to avoid a ground site. Tr. (Jefferson) at 13109.

99. The same 58 crashes shown in Applicant Exh. 100A as examples of where "the pilot retained control and had enough time to avoid a specific site" were reviewed extensively by Lt. Colonel Horstman . Tr. (Horstman) at 13362-70. A review of the 58 crashes shown in Applicant Exh. 100A shows that in no case did a pilot identify a specific ground site from the minimum ejection altitude of 2,000 ft. and take some maneuver to avoid it. State Exh. 223[18]; Tr. (Horstman) at 13370-92; 13407-10; 13445-47. The pilot task contemplated by the PFS avoidance factor, the identification of a ground site from a distance of 3.22 miles or more, and turning away from that sight did not happen a single time during the ten year period reviewed by PFS. Id.; State Exh. 223.

100. In 29 of the 58 crashes (50%), the pilot ejected below the published minimum altitude of 2,000 feet AGL, indicating that the pilot did not have time to perform emergency procedures including the contingent procedure, *If time permits. . . direct the aircraft away from populated areas.*[19] State Exh. 223. In 5 of the 58 crashes the pilot ejected during an uncontrolled spin or the aircraft was otherwise uncontrollable. Applicant Exh. 145, 118, 124, 113, 147; State Exh. 223 at entries 8, 19, 20, 46, 53. In 11 of the 58 crashes, the F-16 was on fire when the pilot ejected. Applicant Exh.119, 145, 158, 110, 118, 127, 184, 113, 147, 180; Joint Exh. 4; State Exh. 223 at entries 3, 8, 10, 17, 19, 21, 24, 38, 46, 53, 59.

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[18]Entries no. 11 and no. 31 are the same mishap, making a total of 58 mishaps shown on State Exh. 223.

[19]*See Emergency stress and Pilot Error* and *U. S. Air Force Training* sections, *supra* at 47 and 44 respectively.

101. A reference to a pilot turning away from a populated area or towards a sparsely populated area is consistent with Air Force training but represents a pilot avoiding a large area such as a city not a specific ground site. Tr. (Horstman) at 13530-32. The crash report of 11 July 1996 shows the pilot turned "towards what he perceived to be a less congested area" yet the impact destroyed two houses killing a child and injuring her mother. Joint Exh. 10; State Exh. 223 no.14. The crash report of 31 August 1992 shows the pilot turned toward "what appeared to be an uninhabited area" yet impacted 150 yards from two inhabited dwellings. Applicant Exh.140; State Exh. 223 no. 7.

102. In Applicant Exh. 100A, PFS notes that in several crashes the pilot turned toward an emergency air field and suggests that it represents evidence of a pilot avoiding a ground site. Tr. (Jefferson) at 13100-01. A turn towards an emergency air field is not an effort to avoid a ground site but rather a standard emergency procedure that indicates the pilot intends to fly the aircraft and land it. Tr. (Horstman) at 13368-69.

(vi) *Dependency on agency outside the regulatory loop.*

103. The determination that 95% of pilots during an emergency will recognize the PFS site as a populated area and direct the F-16 away is the subjective opinion of PFS witnesses Cole, Jefferson and Fly based on the current U.S. Air Force training, current missions, current Air Force equipment and policies. Tr. (Jefferson) at 8882. The air space above the PFS site is a military operating area used by aircraft in route to the nations largest bombing range two miles from the PFS site. Tr. (Horstman) at 4-5; State Exh. 41. The training conducted in Skull Valley is therefore dependent on the combat needs of the nation and world conflict. Horstman Tstmy, Post Tr.___ at 4-5; Tr.(Jefferson) at 3352-55; 3494.

As opposed to the gradual evolution of air commerce, military needs may dictate change in use of the airspace above the PFS site at any time[20].

104. The evidence presented to the Board is based on Air Force training and emergency procedures specifically for the F-16, a fighter aircraft that has flown for twenty-seven years and will be replaced in 2010. Tr. (Cole) at 3372. It is not known what aircraft will replace the F-16. Tr. (Jefferson) at 3374. The capabilities of the pilots and equipment will turn on decisions made by the U.S. Air Force. Id. The Board finds that lack of actuarial data and total reliance on human factors under the control of the U.S. Air Force for the safety of the PFS site, amounts to delegating an essential element of safety outside the regulatory loop.v Tr. (Campe) at 4151-52.

(vii) *Conclusion regarding the Applicant's modification of the NRC NUREG 0800 formula.*

105. The Board finds that there are no authorities or published guidelines recognizing a modification to the NUREG-0800 crash probability formula based on a pilot's ability to avoid a ground site. The Board further finds that PFS has shown no data or reliable basis on which to conclude that U. S. Air Force pilots have or in the future will have a measurable ability to reduce the risk of aircraft crashes impacting the PFS facility. The Board concludes that it is not realistic nor conservative to modify the four factor NUREG-0800 formula to allow a reduction in crash probability based on a pilot's ability to avoid the PFS site.

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[20] *See* footnote 7.

C. PROBABILITY OF CRASHES FROM FLIGHTS ON THE MOSER RECOVERY ROUTE.

106. The Moser Recovery Route ("MRR") is a flight route from the UTTR South Area to Hill AFB. The center of the route is approximately two miles from the PFS site. Cole, Jefferson, Fly Tstmy, Post Tr.___ at 96; PFS Ex. N. at Tab W. The width of the MRR airway is 11.5 miles and the PFS site is therefore directly below the MRR flight path. PFS Ex N at 49.

107. The MRR is used at night, during marginal weather conditions, and when runway 32 at Hill AFB is the active runway. PFS Ex N at 48-48a; Horstman Tstmy, Post Tr.___ at 30. The PFS Crash Report states that "Because pilots train on the UTTR mostly during the daytime and in good weather and because aircraft landing at Hill usually use runway 14 . . . due to the wind patterns at Hill[ ], the Moser recovery is seldom used." PFS Ex.N at 48a (footnote omitted). Subsequent to preparation of the PFS crash report, the U. S. Air Force announced on July 18, 2001 that night vision goggle training would increase and stated that of the total training flights in MOAs, "approximately one third will be night sorties." State Ex. 64 at 4; Horstman Tstmy, Post Tr.___ at 30. A realistic number of flights using the MMR is therefore 33% of the flights returning to Hill AFB from the UTTR South Area. Horstman Tstmy, Post Tr.___ at 30.

108. The Board notes that PFS has estimated that less than 5% of flights return to Hill AFB on the MMR based on information from "local air traffic controllers." Cole, Jefferson, Fly Tstmy, Post Tr.___ at 97; PFS Ex. N at 48a-49. That information was obtained for PFS by General Cole. Tr. (Jefferson, Cole) at 3455-62. General Cole was not

able to obtain any records from Hill AFB or the FAA on the use of the MRR. Id. General Cole therefore telephoned the vice commander at Hill AFB in August of 1999 and asked what percentage of the 5,726 flights flown in 1998 used the MRR, and was then given an estimate of "less than 15%." Id. General Cole also telephoned the union representative for Salt Lake City air traffic controllers, Doug Scaddon, who estimated that less than 5% of aircraft returned to Hill on the MRR. Id. General Cole does not know the basis for Mr. Scaddon's estimate nor the period of time to which it relates. Id. General Cole believes that Mr. Scadden does not control flights on the MRR and did not know the specific number of flights involved but rather gave a "macro estimate." Id. The Board finds that the basis for the conclusion that less that 5% of flights returning to Hill AFB use the MRR is faint and unconvincing.

109. PFS has concluded that the MRR is seldom used based in part on the fact that pilots train "mostly during daytime." PFS Ex. N at 48a. Accordingly, the Board finds that an increase in night training is likely to increase flights on the MRR. The Board further finds that the official Air Force statement that one third of training flights in MOAs will be at night provides a more realistic basis to estimate the number of future flights on the MRR than the estimate of "less than 5%," the basis of which is unknown.

110. The number of flights using the MRR should be estimated at 33% of the flights returning to Hill AFB from the UTTR South area. Horstman Tstmy, Post Tr.___ at 30. In 1998 there were 5,726 sorties flown in the UTTR South range. Cole, Jefferson, Fly Tstmy, Post Tr.___ at 97. To account for the increase in sorties and aircraft assigned since 1998, the 5,726 flights in 1998 should be increased by the ratio of Skull Valley sorties in 1998

(3,871) to those in 2001 (7,040), resulting in 10,413 flights on the UTTR South Area for 2001. Resnikoff Tstmy, Post Tr. 8698 at 16. Thirty three percent of these flights or 3,436 flights will or are likely to return to Hill AFB on the MRR. Id.

111. The NUREG-0800 formula $P_{FA} = C \times N \times A/w$ is also used for calculating the crash probability for F-16s on the MRR.[21] Using the crash rate C for F-16s of 4.10×10^{-8} determined supra[22], the number of flights N of 3,436, the area A of 0.1337 square miles[23], and the width W as 11.5 miles[24], the calculated annual probability of crash impact is 1.64×10^{-6}.

112. The Board notes that PFS has reduced the crash probability for MRR flights by 85.5% by using an "R" factor of 14.5% determined by PFS as described above.[25] Cole, Jefferson, Fly Tstmy, Post Tr.___ at 97. For reasons previously given above, the Board concludes that it is not realistic nor conservative to modify the four factor NUREG-0800 formula to allow a reduction in crash probability based on a pilot's ability to avoid the PFS site.[26]

113. The Board finds that it is neither realistic nor conservative to use an annual probability of aircraft crashes from aircraft flying on the MRR of less than 1.64×10^{-6}.

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[21] *See* "Methodology for Calculating Crash Probability: NUREG-0800," *supra* at 19.

[22] *See* "Input Value C, inflight crash rate per mile for aircraft using airway," *supra* at 20.

[23] Cole, Jefferson, Fly Tstmy, Post Tr.___ at 97; Applicant Exh. N at 15, 16.

[24] Applicant Exh. N at 49.

[25] *See* "The Applicant's modification of the NRC NUREG-0800 formula," *supra* at 36.

[26] Id.

D. PROBABILITY OF IMPACTS DUE TO JETTISONED ORDNANCE

114. F-16s transiting Skull Valley may carry up to six ordnance per flight. Horstman Tstmy, Post Tr.___ at 27. An F-16 may carry two MK-84 2,000 lb. bombs per flight. Id. After a pilot zooms the aircraft in an emergency, the pilot will release the bombs and fuel tanks from the aircraft, a procedure known as "jettison all stores." Id. at 28. Typically, a pilot will take no action to select where the ordnance will impact. This is because the immediate jettison of all stores may be necessary to control the aircraft, and also because the pilot's attention may be focused on tasks relating to the pilot's survival, such as restarting a failed engine or ejecting. Id.

115. In FY1998, the 388th fighter wing carried ordnance on 678 sorties. Applicant Exh. O, Tab HH at 13. That number was reduced to 151 sorties with ordnance in FY1999 and 128 sorties with ordnance in FY 2000. Id. at 13-14. The 419th fighter wing at Hill AFB also carries ordnance but no records showing ordnance carried by the 419th are available. Id. at 12, n. 27. According to the Vice Commander of the 388th fighter wing, it is reasonable to assume the 419th FW carries ordnance of the same type and at the same rate as the 388th FW. Id. PFS has used the ratio of aircraft assigned to the 388th and 419th fighter wings to determine that by multiplying the number of 388th sorties by 1.278 the total 388th and 419th fighter wing sorties is obtained[27]. Id. The total number of 388th FW and 419th FW sorties carrying ordnance is therefore:

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[27]The Board notes that PSF did not account for 419th FW ordnance in its Crash Report shown in Applicant Exh. N, but based all calculations and discussion on 388th FW data only.

Total Sorties Carrying Ordnance

FY98 678 x 1.278 = 866

FY99 151 x 1.278 = 193

FY00 128 x 1.278 = 164

116. The number of sorties that carry ordnance varies dramatically and is dependent on training tactics, national policy and world conflict. Horstman Tstmy, Post Tr.___ at 28-29; Tr.(Jefferson) at 3494. On February 1, 2001, 388th FW Operations Group Commander Colonel Coots advised that current training needs require more sorties to carry ordnance than the training conducted in FY 2000. Horstman Tstmy, Post Tr.___ at 29. PFS does not know the reason for the decline in the number of sorties carrying ordnance from FY98 to FY00. Tr. (Jefferson) at 3500. Hill AFB is capable of flying 678 sorties with ordnance through Skull Valley in a single year. Id. at 3499. The Board finds that the evidence of the number of sorties carrying ordnance has been presented for only the years FY98, FY99 and FY00, with FY 98 having the most sorties with ordnance. The Board finds that it is neither realistic nor conservative to assume that future flights will carry less ordnance than flights in FY98.

117. The Air Force does not keep records of the routing where aircraft with ordnance actually flew. Applicant Exh.N, Tab P. The Board finds that it would be conservative and appropriate to assume that all sorties with ordnance transit Skull Valley. In FY98 there were 866 sorties carrying ordnance and a total of 4,086[28] flights through Skull

[28]Horstman Tstmy, Post Tr.___, at 11; Applicant Exh. O at 4.

Valley. Therefore, assuming all flights with ordnance transited Skull Valley, 21.2 % (866/4,086) of Skull Valley flights carried ordnance in 1998.

118. PFS reasons that most of the ordnance is delivered to the UTTR South Area, and not all flights to the UTTR South Area will transit Skull Valley. Applicant Exh. N at 81. PFS therefore determines the percentage of all flights carrying ordnance by dividing the number of sorties carrying ordnance by the number of UTTR South Area sorties, rather than Skull Valley sorties. Id. at 81-82. There were 5,726 F-16 sorties in the UTTR South Area in FY 1998. Id. at 82. Using the reasoning adopted by PFS, 15.1% (866/5726) of all flights, including those through Skull Valley, carried ordnance in 1998.

119. The number of flights estimated for Skull Valley is 7,040[29]. The Board finds that the number of flights per year carrying ordnance is conservatively estimated to be 7,040 x 21.2% =1,492. The Board further finds that it is neither realistic nor conservative to use a number lower than 1,063 (7,040 x 15.1%) as the annual number of sorties carrying ordnance.

120. The NUREG-0800 formula $P_{FA} = C \times N \times A/w$ is also used for calculating the crash probability for jettisoned ordnance.[30] Using the crash rate C for F-16s of 4.10×10^{-8} determined above[31], the number of flights N of 1,492, the area A of 0.12519

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[29]*See* "Input Value N, number of flights," *supra* at 31.

[30] Resnikoff Tstmy, Post Tr. 8698 at 19; *see also* "Methodology for Calculating Crash Probability: NUREG-0800," *supra* at 19.

[31]*See* Input Value C, inflight crash rate per mile for aircraft using airway *supra* at 20.

square miles[32], and the width W of 5 miles[33], the calculated annual probability of impact from jettisoned ordnance is 1.53×10^{-6}. The Board finds that the annual probability of impacts from jettisoned ordnance is conservatively calculated to be 1.53×10^{-6}.

121. Using the above input values but substituting the number 1,063 as the number of flights N, the calculated annual probability of impact from jettisoned ordnance is 1.09×10^{-6}. The Board finds that it is not realistic to use an annual probability of impacts from jettisoned ordnance of less than 1.09×10^{-6}.

122. The Board notes that PFS did not use the NUREG-0800 formula to calculate impacts from ordnance but used a modified formula:

$P_{FA} = C \times N \times A/w$ NUREG-0800 formula

$P = N \times C \times e \times A/w$ Formula used by PFS

Cole, Jefferson, Fly Tstmy, Post Tr.___ at 102. PFS has included an additional factor "*e*" which reduces the probability of ordnance impacts by assuming that the pilot would jettison ordnance in only 90% of crashes. Id. at 102-3. PFS assumed the pilot would eject quickly in the other 10% of crashes without time to jettison ordnance. Id. No evidence is offered in support of that assumption. The Board notes that emergency procedures indicate that jettison of stores precedes attempts to restart the engine and thus a pilot may jettison stores, successfully restart the engine and avoid crashing.[34] Thus, jettisoned ordnance may occur

[32] Resnikoff Tstmy, Post Tr. 8698 at 20; State Exh.79 and 80.

[33] Resnikoff Tstmy, Post Tr. 8698 at 20; *see also* "Input Value w, width of airway, miles," *supra* at 27.

[34] *See* "The factual setting of a pilot during an engine failure emergency," *supra* at 38.

more frequently than F-16 crashes. The Board finds that it is neither realistic nor conservative to reduce impact probability for jettisoned ordnance on the assumption ordnance will be jettisoned less frequently than the F-16 crash rate.

E. PROBABILITY OF CRASHES FROM AIR-TO-AIR COMBAT TRAINING OVER THE UTTR

123. The Board notes that PFS has used an "R" factor to reduce the probability of crashes from combat training on the reasoning that "invariably the pilot would steer the aircraft away" from the PFS facility. Cole, Jefferson, Fly Tstmy, Post Tr.___ at 91, 94. For the reasons previously discussed, the Board finds that it is not realistic nor conservative to allow a reduction in crash probability based on a pilot's ability to avoid the PFS site.[35]

124. The Board finds that an annual probability for crashes from air-to-air combat training over the UTTR of less than 2.74×10^{-7} is not realistic. Resnikoff Tstmy, Post Tr. 8698 at 17-19; State Exh. 78.

F. CUMULATIVE PROBABILITY OF AIRCRAFT AND ORDNANCE STRIKING THE PFS FACILITY.

125. The total hazard probability to the PFS site is the sum of all individual hazard probabilities. Resnikoff Tstmy, Post Tr. 8698 at 20. Values for aircraft flying routes J-56 and V-257 and for general aviation aircraft have been determined by pervious order.[36] The value for aircraft flying route IR-420 is taken from the PFS Crash Report. PFS Exh. N at 55; Cole, Jefferson, Fly Tstmy, Post Tr.___ at 99.

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[35]*See* "The Applicant's modification of the NRC NUREG-0800 formula," *supra* at 36.

[36]*See* CLI-01-22, 54 NRC 255 (November 14, 2001).

IMPACT HAZARD	CALCULATED ANNUAL CRASH PROBABILITY
F-16 aircraft transiting Skull Valley	7.72×10^{-6}
Aircraft flying Moser Recovery Route	1.64×10^{-6}
Jettisoned ordnance	1.53×10^{-6}
Air-to-air combat training over the UTTR South Area range	2.74×10^{-7}
Aircraft flying route J -56	1.90×10^{-8}
Aircraft flying route V-257	1.20×10^{-8}
General aviation aircraft	1.00×10^{-8} *
Aircraft flying route IR -420	3.00×10^{-9}
Cumulative Hazard	1.12×10^{-5}

* PFS has used $< 1 \times 10^{-8}$ for this value, which is rounded here to 1×10^{-8} for convenience.

Cole, Jefferson, Fly Tstmy, Post Tr.___ at 110.

126. The Board finds that a cumulative annual impact probability for crash hazards to the PFS site from aircraft and ordnance is equal to or greater than to 1.12×10^{-5}.

127. The Board finds that a cumulative annual impact probability for crash hazards to the PFS site from aircraft and ordnance of less than 1.12×10^{-5} is neither realistic nor conservative.

Conservatism claimed by PFS

128. The Board notes that PFS claims its crash rate is conservative because it is based on total Class A and Class B mishaps, which were higher in number than the number of destroyed F-16s during the ten year period 1989 - 1998. Cole, Jefferson, Fly Tstmy, Post

Tr.___ at 111. This is not correct, however. PFS has based its crash rate on ACRAM data which provide only total mishap data without indicating whether a mishap is a Class A or Class B.[37] By definition, destroyed aircraft are Class A mishaps. PFS used the ratio from the ACRAM data showing 15.09% of all mishaps (including those in other flight phases such as takeoff, landing, etc.) occurred in "normal flight." The 15.09% ratio used by PFS is applicable only to all mishaps, not the subset of destroyed aircraft.[38] (Using other data specifically for destroyed aircraft, the ratio is higher (23.3%) for the percentage of destroyed aircraft occurring in the normal flight phase. PFS Exh. N, Tab H; Resnikoff Tstmy, Post post Tr. 8698 at 15.)

129. To illustrate: Assume 10 mishaps in year *X*; 5 were Class A mishaps where the aircraft was destroyed during flight, and 5 were Class B mishaps occurring on the runway. The resulting ratio, 50% of all mishaps occur during flight, is not conservative by the fact that there were more total mishaps than destroyed aircraft.

130. Further, the year *X* ratio of 50% of all mishaps occurring during flight cannot be applied to the subset of all destroyed aircraft. Doing so would result in the false conclusion that 50% of all destroyed aircraft, or only 2.5 aircraft, were destroyed during flight.

131. Similarly, PFS used data for all Class A and B mishaps occurring in takeoff, landing, normal flight and special operations, and assumed that 15.09 % of all such mishaps

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[37] *See* "Input Value C, inflight crash rate per mile for aircraft using airway," *supra* at 20.

[38] *Id.*

occurred during normal flight. No basis exists to conclude that the PFS crash rate is conservative by the fact that there were more total mishaps than destroyed aircraft during 1989 through 1998. The PFS ratio of 15.09% is based on 1975 through 1993 ACRAM data.[39]

132. The Board finds the conservatism claimed by PFS is not a conservatism and that the proper consideration of destroyed aircraft rates shows that PFS has underestimated the crash rate used by PFS.

VI. CONCLUSIONS OF LAW

1. Evidence relating to the penetration of a storage cask is not relevant and is inadmissible in this proceeding. Tr. at 3008, 3014.

2. No evidence was produced to estimate the probability of hazards from aircraft training in the UTTR and MOA airspace above the PFS site, or from ordnance jettisoned from such aircraft, after the year 2010. The hazards from crash and ordnance impacts after 2010 are dependent on decisions to be made by the U. S. Air Force. The Board concludes that to assume that the probability of hazards after 2010 will be below the threshold probability of 1×10^{-6} constitutes the delegation of an essential element of safety to an unlicensed and uncontrolled third party outside the regulatory loop.

3. The Board concludes that reducing the probability of aircraft crashes on the expectation that a U.S. Air Force pilot will not allow a crashing aircraft to impact the PFS facility constitutes the delegation of an essential element of safety to an unlicensed and

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[39] *Id.*

uncontrolled third party outside the regulatory loop.

4. PFS has made a subjective determination that the probability of aircraft crashes can be reduced by 85.5% based on the expectation that a U.S. Air Force pilot will not allow a crashing aircraft to impact the PFS facility. The Board concludes that the methodology used by PFS to make such a determination has not been tested, has not been subjected to peer review and publication, the potential error rate has not been examined, and the methodology has not been generally accepted in the scientific or other authoritative community. The Board concludes that such determination by PFS is unreliable and should be stricken as inadmissible under 10 CFR § 2.743. *See* Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579 (1993).

5. The Board concludes that the correct formula for calculating probability of aircraft crashes is the four factor formula shown in NUREG-0800 at 3.5.1.6-3, and that PFS has not produced sufficient evidence to support using a modification of that formula to reduce the probability based on the expectation that a U.S. Air Force pilot will not allow a crashing aircraft to impact the PFS facility.

6. The Board concludes that the annual probability of impacts to the PFS facility from aircraft and jettisoned ordnance is not less than 1.12×10^{-5}.

7. The Board concludes that the annual probability of impacts to the PFS facility from aircraft and jettisoned ordnance exceeds the 1×10^{-6} threshold probability for design basis accidents applicable to ISFISIs. *See* CLI-01-22, 54 NRC 255 (November 14,

2001). Accordingly, PFS does not meet the requirements of 10 CFR §§ 72.90, 72.94, 72.98 or 72.122(b)(1).

DATED this 30th day of August, 2002.

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CERTIFICATE OF SERVICE

I hereby certify that a copy of STATE OF UTAH'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW REGARDING CONTENTION UTAH K/CONFEDERATED TRIBES B was served on the persons listed below by electronic mail (unless otherwise noted) with conforming copies by United States mail first class, this 30th day of August, 2002:

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