RAS 4928

October 7, 2002

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

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

APPLICANT'S REPLY TO THE PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW OF THE STATE OF UTAH AND THE NRC STAFF ON CONTENTION UTAH K/CONFEDERATED TRIBES B

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Pursuant to 10 C.F.R. § 2.754 and the Orders of the Atomic Safety and Licensing Board ("Licensing Board" or "Board") dated September 17, 2001[1] and July 3, 2002,[2] Applicant Private Fuel Storage, L.L.C. ("Applicant" or "PFS") submits its reply to the proposed findings of fact and conclusions of law filed by the State of Utah ("State")[3] and the NRC Staff ("Staff")[4] concerning State of Utah Contention K/Confederated Tribes Contention B – Credible Accidents ("Utah K"). PFS's reply findings on Utah K are submitted separately from the reply findings to be submitted on Contention Utah L/QQ. PFS's reply follows the organization of and responds to the proposed findings of the State, in that the Staff's proposed findings are in general agreement with those of PFS.[5]

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

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

[3] State of Utah's Proposed Fmdings of Fact and Conclusions of Law Regarding Contention Utah K/Confederated Tribes B (Aug. 30, 2002) ("State F.").

[4] NRC Staff's Proposed Findings of Fact and Conclusions of Law Concerning Contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents) (Aug. 30, 2002) ("Staff F.").

[5] Applicant's Proposed Findings Of Fact And Conclusions Of Law on Contention Utah K/Confederated Tribes B (Aug. 30, 2002) ("PFS F.").

I. INTRODUCTION AND OVERVIEW

In its proposed findings, the State presents its view of the hazard to the PFSF posed by potential aircraft accidents. In doing so it relies almost entirely upon the pre-filed testimony of its witnesses and ignores much of the rest of the evidentiary record developed at the hearing sessions on the contention. Where the State does cite the testimony at the hearing, in many instances it mischaracterizes, exaggerates, or takes the testimony out of context. On some issues, the State presents arguments that were never made at the hearing—even by its own witnesses, and arguments that contradict or are inconsistent with its own witnesses' testimony. Instead, it argues that the Licensing Board can "do its own calculations" and then presents new calculations based on assumptions that were never presented at the hearing and are unsupported by any witness and the record as a whole.

One of the State's new arguments is that there is insufficient information in the record for the Board to determine the hazard to the PFSF after 2010, when the F-16 will be replaced by a new fighter aircraft. The State argues that operations conducted by Air Force training flights in Skull Valley are entirely open to change and that the risk posed by potential future operations is unknowable. Contrary to the State's claim, because the aircraft that replaces the F-16 will be a fighter aircraft that will perform similar missions, Air Force flight operations in Skull Valley are not likely to change in the future. Also, the airspace and the terrain in Skull Valley are not suitable for the conduct of combat training operations that could potentially pose an increased risk to a site on the ground like the PFSF.

The State also argues that the Board cannot determine the risk to the PFSF because the operations conducted by the Air Force are not regulated by the NRC. This argument fails because, as was discussed by the NRC Staff at the hearing, the NRC frequently assesses hazards to NRC-licensed facilities posed by external human activities—such as aircraft flights, the transportation of hazardous cargo by road, rail, or ship, and the operation of facilities possessing hazardous materials—that are not regulated in any way by the NRC.

With respect to several issues, in addition to challenging PFS substantively, the State simply argues that the Board should reject PFS's calculations because they were "not conservative," regardless of the support for them in the record. While we deal more specifically with individual conservatisms below, as a general matter, such arguments are meritless, because there is no requirement for calculations to be more conservative simply for the sake of being more conservative. "Conservatisms and margins for error in such calculations are necessary and desirable, but must be footed to some extent in reasonable, scientific ground. Conservatism upon conservatism can distort technical data to the point where it no longer meaningfully describes the mechanism at issue." Philadelphia Electric Co. (Limerick Generating Station, Units 1 and 2), ALAB-819, 22 NRC 681, 736-37 (1985). "To compound conservatisms can be misleading [and] would present a distorted picture . . . ." Public Service Co. of New Hampshire (Seabrook Station, Units 1 and 2), LBP-76-26, 3 NRC 857, 925 (1976). Thus, without sound factual and analytical bases, the State has no grounds for challenging PFS's calculations or assessments as "not conservative."

Furthermore, in this case, an assessment that the aircraft crash hazard to the PFSF satisfies the Commission's 1 E-6 per year ISFSI accident standard is inherently conservative from the perspective of public health and safety in that the standard itself is inherently conservative. The ISFSI standard is the same as the Commission's Part 60 beyond design basis accident standard for above ground facilities at geologic repositories. Private Fuel Storage, L.L.C. (Independent Spent Fuel Storage Installation), CLI-01-22, 54 NRC 255, 264 (2001).[6] In promulgating the Part 60 standard, the Commission concluded that the cancer fatality risk to individuals posed by beyond design basis accidents assumed to have a probability of 1 E-6 per year would be 1 E-8 per year. Id. at 261.[7] As a matter of policy, the Commission has determined that the acceptable cancer risk from exposure to radiation is "in the range of 1 x 10^{-6} to 1 x 10^{-5} per year." 61 Fed. Reg. at 64,265. Thus, the Part 60/Part 72 accident standard could be raised from 1 E-6 per year to 1 E-4 per year and still satisfy the Commission's cancer risk policy. Indeed, the Commission noted that the 1 E-6 standard "is expected to provide conservative estimates of risk" and that "[a] higher screening criterion could probably be justified given the magnitude of the consequences and risks from this facility." Id. Therefore, the 1 E-6 per year aircraft accident standard the Commission established for ISFSIs is inherently conservative and PFS's assessment showing a cumulative accident probability below that means that the actual risk to the public health and safety posed by aircraft accidents at the PFSF would be far below the level of risk the Commission has deemed to be acceptable.

PFS responds below to all of the State's substantive arguments, mostly in the order in which the State made them in its proposed findings. In its proposed findings, PFS previously responded to most of the State's arguments. Therefore, here PFS often briefly summarizes its response to an argument and cites to its proposed findings instead of repeating the details contained there.

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[6] The Commission concluded that the design basis for ISFSIs and repository above ground facilities is the same. Id.; see id. at 265 n.42 (potential accident consequences at ISFSI and repository facilities are similar)

[7] Quoting Disposal of High-Level Radioactive Wastes in Geologic Repositories, Design Basis Events, Final Rule, 61 Fed. Reg. 64,257, 64,265 (1996).

II. LEGAL STANDARDS

The State makes several general legal arguments regarding how the Board should treat the evidence in this proceeding. PFS responds to each of the State's arguments here.

A. Burden of Proof

The State correctly notes that an applicant in an adjudicatory proceeding bears the burden of proving its case by a preponderance of the evidence. See, e.g., Advanced Medical Systems, Inc., CLI-94-06, 39 NRC 285, 302 and n.22 (1994); 10 C.F.R. § 2.732. A preponderance of the evidence requires "only that the record underlying a finding makes it slightly more likely than not." Inquiry into Three Mile Island Unit 2 Leak Rate Data Falsification, LBP-87-15, 25 NRC 671, 690 (1987); Commonwealth Edison Company (Zion Station, Units 1 and 2), ALAB-616, 12 NRC 419 (1980).

The State claims that the NRC Staff shares the burden of proof if it supports the Applicant's position. State F. at 7 (citing Philadelphia Electric Company (Peach Bottom Atomic Power Station, Units 2 & 3), ALAB-566, 10 NRC 527, 529 & n.3 (1979)). However, this is only true with respect to issues falling under the Staff's duty under the National Environmental Policy Act ("NEPA") to prepare an environmental impact statement. See, e.g., Duke Power Co. (Catawba Nuclear Station, Units 1 and 2), LBP-84-24, 19 NRC 1418, 1584 (1984). The Applicant, not the Staff, has the burden of proof with respect to safety issues such as Utah K. Curators of the University of Missouri, CLI-95-1, 41 NRC 71, 121 (1995).

The State states that the Board's factual findings must have a solid foundation and be supported by substantial evidence. State F. at 7-8. We agree, but point out that this requirement is limited to issues in dispute. The role of the Board "is to adjudicate issues in dispute raised in the hearing process," not to address every issue in the license application. Cincinnati Gas and Electric Company (Wm. H. Zimmer Nuclear Power

Station, Unit No. 1), CLI-82-20, 16 NRC 109, 114 (1982). In addition, substantial evidence relates to the amount of evidence required to support an agency decision on judicial review, not the relative amount of evidence required for one party to prevail over another. The fact that one party's witnesses took a position on an issue different from that of the Board does not preclude a finding from being based on substantial evidence. Northern Indiana Public Service Co. (Bailly Generating Station, Nuclear 1), ALAB-303, 2 NRC 858, 866 (1975). "[T]he possibility that inconsistent or even contrary inferences could be drawn if the views of [opposing] experts were accepted does not prevent the trial board's findings from being supported by substantial evidence." Id. (citations omitted).

B. NRC Guidance Documents

The State claims that NRC guidance documents are entitled to "special weight." State F. at 9. Thus, the State implies that PFS cannot modify the four-factor formula presented in the Standard Review Plan for Nuclear Power Plants, NUREG-0800, for calculating aircraft crash hazards to account for the avoidance of sites on the ground by pilots of F-16s transiting Skull Valley. See, e.g., id. ¶ 25.

At the outset, NRC guidance documents, such as standard review plans, are not binding. They serve to help applicants and licensees comply with regulations, but "nonconformance with such guides does not equate to noncompliance with the regulations." University of Missouri, CLI-95-1, 41 NRC at 98. Here, first of all, PFS's modification of the formula in NUREG-0800 does not "violate" the guidance, in that NUREG-0800 itself states that the formula is only "one way" of calculating aircraft crash hazards, and it specifically provides for the use of alternative means of assessment and consideration of factors that may be applicable to particular sites but not others. PFS F. ¶¶ 19-20. One such factor is pilot avoidance. Second, NRC Staff witness Dr. Campe, who was the author of the document, testified that under the circumstances of the PFS site and the aviation activity that takes place around it, PFS's modification of the formula was acceptable. Id. ¶ 18. Thus NUREG-0800 is no obstacle to PFS's assessment.

C. Weight to Accord Expert Testimony

The State argues that the admissibility or weight of expert testimony should be determined under Federal Rule of Evidence 702 and the four factors set forth in Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579 (1993). State F. at 10-11. The Federal Rules of Evidence are not binding on the NRC, but licensing boards and the Commission have relied on them for guidance in admitting expert testimony under 10 C.F.R. section 2.743(c). See e.g., Southern California Edison Co. (San Onofre Nuclear Generating Station, Units 2 and 3), ALAB-717, 17 NRC 346, 365 n.32 (1983).[8] NRC case law, relying on Rule 702 as guidance, holds expert opinion testimony is admissible if it is based on scientific principles, known through the expert's training and experience, and data derived from analyses or by perception. Limerick, ALAB-819, 22 NRC at 720.

The four factors set forth in Daubert are means by which a court can evaluate the reliability of scientific expert testimony, but "Daubert's list of specific factors neither necessarily nor exclusively applies to all experts or in every case." Kumho Tire Co. v. Carmichael, 526 U.S. 137, 141 (1999).[9] "[T]hose factors identified in Daubert may or may not be pertinent in assessing reliability, depending on the nature of the issue, the expert's particular expertise, and the subject of his testimony." Id. at 150. For example, expert testimony concerning handwriting analysis, land valuation, agricultural practices, or railroad procedures may or may not be "scientific" and hence amenable to evaluation

[8] The State's claim that NRC regulations do not address expert testimony, State F. at 10, is wrong. Evidence generally is to be admitted only if it is "relevant, material, and reliable . . . and not unduly repetitious." 10 C.F.R. § 2.743(c).

[9] The Daubert Court focused on scientific testimony because that was the nature of the expertise at issue there. Kumho, 526 U.S. at 147-48.

under the Daubert factors. See id. Thus, a court has broad latitude in deciding how to determine the reliability of expert testimony. Id. at 142; see id. at 152-53. The ultimate goal is to "ensur[e] that an expert's testimony both rests on a reliable foundation and is relevant to the task at hand." Id. at 141.

Therefore, the reliability of PFS's expert testimony (or the testimony of the Staff's or the State's witnesses) does not automatically turn on whether it satisfies any of the Daubert factors. Indeed, the federal standard for evaluating the reliability of expert testimony is in essence no different than the standard articulated by NRC case law. The State is wrong when it asserts that to be reliable "the sponsoring party must demonstrate that the methodology relied upon by expert testimony has been tested and subject to peer review and publication" and must as well demonstrate satisfaction of the other two factors. State F. at 11-12 (emphasis added). Rather, as PFS explained in its proposed findings, the pertinent question is whether the testimony is "supported by appropriate validation – i.e., 'good grounds,' based on what is known." PFS F. at 17 (quoting Daubert; 509 U.S. at 590). In other words, does the testimony constitute knowledge—a body of known facts, or ideas inferred from such facts or accepted as truths on good grounds. Id.[10] On the basis of the substantial evidence in the record, PFS's experts have explained the application of their expertise to the facts and their conclusions are the result of the logical application of their extensive professional experience to the facts. See id. at 17-19. Therefore, their testimony is reliable and entitled to full evidentiary weight.

[10] The State's objection that PFS's testimony has not been published or subjected to peer review is of no consequence where, as here, the subject of the testimony is "too particular, too new, or of too limited interest to be published." Daubert, 590 U.S. at 593; see PFS F. at 17-18. Regarding the fundamental question of whether pilots of crashing aircraft would attempt to avoid sites on the ground, that basic premise was accepted without hesitation by all of the pilots who testified in this case, PFS F. ¶ 22, and thus certainly is "generally accepted" within the meaning of Daubert. 590 U.S. at 596.

The State goes on to argue that where an expert can provide no basis for his conclusions his testimony should be given no weight. State F. at 12-13.[11] The State's argument (with which PFS agrees) in no way undermines PFS's testimony, as PFS's witnesses have amply described the basis for their conclusions on the record of this hearing.

D. Hearsay Evidence

The State argues that hearsay evidence from someone unknown is "most unreliable," State F. at 14 (quoting Tennessee Valley Authority (Hartsville Nuclear Plant, Units 1A, 2A, 1B and 2B), ALAB-367, 5 NRC 92, 121 (1977)), but it does not challenge any specific piece of evidence as being hearsay from unknown persons. PFS responded to the State's general claims regarding hearsay evidence in its response to a State motion in limine to strike the testimony of Gen. Cole, Gen. Jefferson, and Col. Fly. See Applicant's Reply to State of Utah's Motion In Limine to Exclude Applicant's Prefiled Testimony of James L. Cole, Jr., Wayne O. Jefferson, Jr., and Ronald E. Fly (Apr. 1, 2002). At the hearing, the State withdrew its objection to PFS's testimony on the grounds that it was hearsay and the Board admitted the testimony. Tr. at 3010 (Soper); id. at 3011 (Farrar, J.). Therefore, the State should not be allowed its objection again at this point.

The State also argues that "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." State F. at 14. The State cites no

[11] The State cites Public Service Electric & Gas Co. (Hope Creek Generating Station, Units 1 & 2), LBP-78-15, 7 NRC 642, 647 n.8 (1978), for the proposition that the testimony of a witness "who claims no personal knowledge of, or expertise in," a subject will not be accorded the weight given testimony from an expert witness "who has personal knowledge." State F. at 13. Hope Creek states that the opinion of a witness claiming no expertise is not entitled to the same weight as the opinion of a witness with clear expertise. LBP-78-15, 7 NRC at 647 n.8. It says nothing about the relative value to be accorded expertise versus personal knowledge.

authority for this proposition. Nor does it allege that any specific piece of evidence is entitled to no weight on these grounds. It appears as though the State may be trying to lay the groundwork to challenge evidence as hearsay in its reply findings that it should have challenged at the hearing. See State F. at 14 (arguing that the "materiality" of evidence may be determined after it is admitted). Such challenges are impermissible.

Objections to evidence in a party's proposed findings are too late. Louisiana Energy Services, L.P. (Claiborne Enrichment Center), LBP-97-8, 45 NRC 367, 392 n.14 (1997). Delving into new allegations of unreliability regarding hearsay evidence at this stage of the proceeding would essentially require the holding of an evidentiary mini-hearing—up to six months after the evidence was admitted—in which witnesses could answer charges regarding the accuracy and reliability of people to whom they may have spoken. The State had ample opportunity to object to any evidence PFS submitted at the hearing and was able to cross-examine PFS's witnesses on their testimony. Thus, the Board should not entertain further objections at this late date.[12]

E. Licensing Board Calculations

The State argues that the Licensing Board may perform its own calculations. State F. at 14-15. It argues that the Board should do so at several places in its proposed findings where it seeks to introduce calculations that no witnesses presented in their testimony. See Section III.B.4, infra. As discussed below, the State's proposed calculations contain implicit assumptions that are not supported by evidence in the record. Commission case law does not permit the Board to rely on such unsupported

[12] Pending before the Board is the admissibility of PFS Exhs. WWW, XXX, YYY, ZZZ (which are communications to Gen. Cole regarding pilots of crashing aircraft avoiding sites on the ground) to which the State has previously objected. Joint Report on Status of Utah Contention K Exhibits and other Open Items from Hearing Concerning Utah Contention K (Aug. 21, 2002). These exhibits are admissible because expert witnesses may base their opinions on interviews, even under the more strict rules governing the admission of evidence in federal court. See United States v. Gardener, 211 F.3d 1049, 1054 (7th Cir. 2000) (third party interviews reasonably relied upon).

assumptions. Hence, the Board may not perform any calculations that require such reliance. See Vermont Yankee Nuclear Power Corp. (Vermont Yankee Nuclear Power Station), ALAB-229, 8 AEC 425, 437, rev'd on other grounds, CLI-74-40, 8 AEC 809 (1974).

III. DISCUSSION OF STATE OF UTAH'S PROPOSED FINDINGS

The Licensing Board specifically discusses in this Section of the decision the State of Utah's proposed findings.

A. Witnesses

1. State Witness Lt. Col. Horstman

R1. The State claims that Lt. Col. Horstman "has more than 20 years' experience as a pilot in the U.S. Air Force with . . . over 1,800 hours as an F-16 and F-111 fighter pilot." State F. ¶ 1. Lt. Col. Horstman served in the Air Force from 1979 to 1999. He was a B-52 navigator from 1979 to 1983 and then a pilot from 1984 to 1999, i.e., for 15 years. Further, Lt. Col. Horstman spent four of those 15 years in staff positions at Air Combat Command at Langley AFB. Tr. at 4277-82 (Horstman); see State Exh. 38 (Horstman Resume). He has "over 800 hours" as an F-16 pilot. Id. at 2.

R2. The State claims that from October 1997 through June 1999, as "Deputy Commander, 388th Operations Group," Lt. Colonel Horstman "commanded the F-16 Operations Group and 1,500 personnel." State F. ¶ 2. During this period, Lt. Col. Horstman was the deputy operations group commander. As such, he did not command the group—he was the deputy to the commander, Col. Stephen Bozarth, the "Commander of the operations group." Tr. at 4277-78 (Horstman). Col. Bozarth therefore is the one who bore responsibility for any decisions or actions of Operations Group personnel.

2. State Witness Dr. Resnikoff

R3. The State asserts that Dr. Resnikoff is familiar with spent fuel storage systems and "has estimated the probability of accidents regarding air, train and truck accident rates." State F. ¶¶ 7-8. On cross-examination, Dr. Resnikoff stated that he had never previously calculated the probability that an aircraft would crash into a ground facility. Tr. at 8720 (Resnikoff).

3. PFS Witnesses

R4. The State claims that Gen. Jefferson and Gen. Cole have never flown an F-16 and have never flown through Skull Valley. State F. ¶¶ 10, 13. Neither PFS nor these witnesses ever claimed that they had flown an F-16. Col. Fly, however, has approximately 1,200 flight hours in the F-16 (substantially more than Lt. Col. Horstman) and has flown through Skull Valley and on the UTTR. PFS Test. at 6. Gen. Jefferson has also flown on the UTTR. Tr. at 3189 (Jefferson).

R5. The State also claims that none of PFS's witnesses have ever ejected from an aircraft. State F. ¶¶ 10, 13, 16. However, as discussed further below, Section III.B.9(d)(3), infra, all of PFS's witnesses have experience emergencies or combat, in the cases of Gen. Cole and Gen. Jefferson, while flying as Air Force pilots. Thus, PFS's witnesses are well qualified to testify to how Air Force pilots respond to stress under emergency conditions. The State, for its part, presented no evidence that Lt. Col. Horstman, who has also never ejected from an aircraft, had ever experienced any similar emergency situations as an Air Force pilot.

R6. The State claims that General Jefferson has no prior experience using NUREG-0800 or the DOE Standard for aircraft crash analysis. State F. ¶ 11. Gen. Jefferson is qualified to analyze the crash impact hazard to the PFSF. Gen. Jefferson has a master's degree in operations research from Stanford University and completed all of the necessary course work for a Ph.D. from the Stanford School of Business in the area of quantitative decision making. Tr. at 3713 (Jefferson); PFS Test. at 4. He started the first Air Force mission area analysis office (which involved modeling each of the mission areas of the Air Force), has taught courses in risk management, and has performed probabilistic modeling of the effectiveness of Air Force weapons. Tr. at 3713-14 (Jefferson). He currently provides risk management training for General Electric Company personnel. PFS Test at 4. Further, he has reviewed aircraft accidents and accident rates over the course of his career. Tr. at 3714 (Jefferson).

R7. The State claims that "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[e]." State F. ¶ 14 (citing Tr. at 3153, 3157 (Cole)). Gen. Cole testified that as Chief of Safety for the Air Force, he dealt with F-16 crashes, emergencies, and engine failures. Tr. at 3156 (Cole). His duties also included study of factors related to whether a pilot would be able to avoid a site on the ground in the event of a crash. See Tr. at 3157 (Cole). He was concerned with "the whole spectrum of human factors in accident prevention." Id. "[He] dealt intensely with pilots, their training, their proficiency, how they flew, incidents [and] accidents." Id. "[He] was personally responsible for reviewing and approving every accident report the Air Force had in that three-year period." Id.

R8. The State claims that the work that Gen. Cole, Gen. Jefferson, and Col. Fly have done for PFS has been "part time employment." State F. ¶¶ 9, 12, 15 (citing Tr. at 3150-53 (Cole)). Frankly, we fail to see the relevance of this claim. To the extent that it is relevant at all, Lt. Col. Horstman's work for the State was also "part-time employment," in that Lt. Col. Horstman's regular employment is a pilot for

Southwest Airlines. Horstman Test. at 1. Indeed, it was Lt. Col. Horstman who described his work as less than "in-depth" when discussing his initial review of PFS's aircraft crash hazard analysis. See Tr. at 4323 (Horstman).[13]

R9. The State asserts that PFS's witnesses were paid $1,000 per day for their work for PFS. State F. ¶¶ 9, 12, 15 (citing Tr. at 3150-53 (Cole)). However, the State cites no testimony, exhibits, or other representations by PFS's witnesses which it claims are in error owing to their being paid. "It should come as no surprise that most expert witnesses do receive compensation from the parties on whose behalf they testify. But their compensation is for their time and expertise, not for their testimony as such. There is nothing wrong or inherently suspect about that." Louisiana Power & Light Company (Waterford Steam Electric Station, Unit 3), ALAB-732, 17 NRC 1076, 1091 (1983). License applicants and their witnesses are absolutely required to make truthful statements to the NRC. See Virginia Electric and Power Co. (North Anna Power Station, Units 1 and 2), CLI-76-22, 4 NRC 480, 486, 491 (1976), aff'd sub nom. Virginia Electric and Power Co. v. NRC, 571 F.2d 1289 (4th Cir. 1978). The State has provided nothing to show that PFS's witnesses have been anything but truthful here.

R10. The State acknowledges that PFS witness Mr. Vigeant (unlike any of the State's witnesses) is a meteorologist but states that he "has not studied the extent to which a pilot can see under various cloud conditions and altitudes." State F. ¶ 17. Gen. Cole, Gen. Jefferson, and Col. Fly, however, are all aware of the extent to

[13] To the extent that the State implies that Gen. Cole, Gen. Jefferson, and Col. Fly are somehow less qualified than Lt. Col. Horstman because Lt. Cols. Horstman is a full-time pilot for Southwest Airlines, the State is incorrect. Gen. Cole stays abreast of current aviation safety issues in that his full-time position is Senior Director, Safety of the Air Transport Association. PFS Test. at 1. Gen. Jefferson is currently involved in risk assessment and management in that he currently provides risk management training to the General Electric Company. Id at 4. Col. Fly retired from the Air Force in 1998, only one year before he began working on this matter. Id. at 6-7.

which a pilot can see under various weather conditions. See Tr. at 13077-78 (Cole/Jefferson/Fly). Further, Mr. Vigeant presented official weather data collected at Michael Army Air Field ("AAF") for purpose of supporting aviation operations on Dugway Proving Grounds and at Michael AAF. Vigeant Test. at 3-6.

B. Probability of Crashes from Aircraft Transiting Skull Valley

1. The Factual Setting

R11. The State claims that the airspace of the Sevier B MOA lies "directly above the proposed PFS site" and that the MOA is "used for military low altitude training, air-to-air combat training, major exercises, and cruise missile testing." State F. ¶ 21. The State also claims that cruise missile testing is authorized in Sevier D MOA, which lies directly atop the airspace of the Sevier B MOA. Id. ¶ 22. On the contrary, the airspace over Skull Valley is not used for air-to-air or air-to-ground combat training or major exercises and it is not suitable for conducting such training or exercises. Revised Addendum, Tab FF at 15-16; Tr. at 4242-43 (Horstman).

R12. The evidence clearly shows that the airspace over Skull Valley is primarily used as a transition corridor for F-16s en route to the South UTTR. PFS Test. at 10-11, 14, 44; Aircraft Report, Tab E at 2-3; Horstman Test. at 8. The area covered by airspace of the Sevier B and Sevier D MOAs is approximately 145 miles long and extends more than a hundred miles to the south of the proposed PFS site. Private Fuel Storage, L.L.C. (Independent Spent Fuel Storage Installation), LBP-01-19, 53 NRC 416, 432 (2001); PFS Test. at 13; PFS Exh. P. In the vicinity of the proposed site, the MOA airspace is only 12 miles wide and, approximately 10 miles southeast of the PFS site, the MOA airspace narrows to a width of only about 7 miles. PFS Test. at 44; PFS Exh. P. Further, this narrow airspace abuts the Stansbury Mountains to the east with elevations up to 11,000 ft. MSL. PFS Exh P. Therefore, the Air Force does not conduct any air-to-air and air-to-ground combat training in Skull Valley. Such training is conducted in the larger, more suitable areas of the UTTR. Revised Addendum Tab FF at 15-16.

R13. The State's reference to cruise missile testing is irrelevant. Cruise missile testing does not take place within 10 miles of the PFS site. LBP-01-19, 53 NRC at 427. The Board has previously found that cruise missile testing would not pose a significant hazard to the PFSF. LBP-01-19, 53 NRC at 427-28. Therefore, cruise missile testing is not an issue here.

R14. The State claims that most of the F-16 flights through Skull Valley "are concentrated in a narrow corridor of 5 miles or less in width above the proposed PFS site." State F. ¶ 23 (emphasis added). On the contrary, the F-16s typically pass approximately five miles to the east of the PFS site, which is the natural route of transit based on the configuration of the MOA in Skull Valley. PFS Test. at 14, 44 & n.42; Staff Test. at 9; Tr. at 3397-98, 3402-04 (Cole); see Tr. at 3422-24 (Fly). Further, as acknowledged by Lt. Col. Horstman, F-16s following the predominant route of flight down Skull Valley typically fly east of Skull Valley road, which itself is two miles east of the proposed PFS site. See PFS F. at 48.[14]

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[14] The State cites Gen. Jefferson's testimony to support its proposition that the Skull Valley flights are concentrated over the PFSF. State F. ¶ 23 (citing Tr. at 3455). On the contrary Gen. Jefferson only testified that if one assumes that the F-16 traffic is distributed across the entire width of the MOA (see Tr. at 3436, 3440-41 (Jefferson), 3454 (Soper)), because the F-16s fly in formations two miles wide, the F-16 traffic two miles or more inward from each edge of the MOA would be greater than the traffic within two miles of each edge of the MOA. Tr. at 3454-55. Gen. Jefferson testified that in fact the F-16 traffic in Skull Valley is concentrated five miles to the east of the site, but that he had distributed the F-16 traffic across the valley for analyzing the crash hazard at the request of the NRC. Tr. at 3436, 3440-41 (Jefferson). He did not testify that the actual traffic of F-16s transiting Skull was concentrated over the PFSF. Moreover, as discussed below the PFSF is within two miles of the western edge of the MOA and the F-16s fly in formations two or more miles wide. Hence, even if it is assumed that the F-16 traffic is distributed across the entire MOA, the traffic density over the PFSF would be less than the traffic density

R15. The State asserts that "in FY 2000 there were approximately 6,000 [F-16] flights through Skull Valley and additional F-16s have since been stationed at Hill Air Force Base." State F. ¶ 23. In FY00, 5,757 F-16s transited Skull Valley. PFS Test. at 18. In FY99, 4,250 F-16s transited Skull Valley. Id. This is an annual average of approximately 5,000 flights. PFS Test. at 18; Staff Test. at 10. Furthermore, in FY01, 5,046 flights transited Skull Valley. Tr. at 13019 (Cole). If that total were adjusted to account for the effect of the additional F-16s at Hill being there the entire year (as opposed to the half year they were present), the number of flights would have been 5,435. Tr. at 13019-20 (Jefferson). Thus, the State's use of the FY00 sortie count as a projection of the number of flights through Skull Valley in the future is unreasonable.

2. Future Aircraft and Activities in Skull Valley

R16. The State claims that the activity in Sevier B and D MOAs "varies dramatically from year to year" and that "changes in military training in the UTTR and MOAs cannot be anticipated." State F. ¶ 24. First, the State cites no testimony in the record, even from Lt. Col. Horstman, to support that claim and there is none. Skull Valley is a transition corridor for F-16s en route from Hill AFB to the UTTR South Area. PFS Test. at 14; Aircraft Report at 5-6, Tab E at 2-3; Horstman Test. at 8. There is no evidence that it has been or will be used for any other purpose.

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over the center of the MOA. This would be particularly true if one were also to account for the practice of flying some distance away from the restricted area boundary at the western edge of the MOA. See Section III.B 6.(b) (Staff analysis of number of F-16 flights), infra.

R17. Second, the number of F-16 flights through Skull Valley has not "varied dramatically." Based on the Sevier MOA B usage reports,[15] from FY98 to FY01 the following number of F-16 flights transited Skull Valley each year:

Year	Flights
FY98	3,871
FY99	4,250
FY00	5,757
FY01	5,046

Revised Addendum at 4; Tr. at 13019 (Cole). Additionally, over the life of the PFSF, future traffic density of military aircraft operating in the vicinity of the facility will be determined, for the most part, by the future structure of the U.S. Air Force and tempo of U.S. Air Force operations. The long term trend in the USAF structure is to replace aging aircraft with fewer, more capable and more reliable aircraft, which would reduce the number of sorties and the risk of accident per sortie correspondingly. PFS Test. at 22. Based on the evidence, this general trend is expected to continue and to affect Hill AFB equally as the existing USAF aircraft inventory is replaced with fewer, more modern, capable and reliable aircraft over the life span of the proposed PFSF. Id.; see PFS F. ¶¶ 62-63. However, PFS did not take any credit for this trend in its calculation.

R18. Nor will ordnance usage in training "vary dramatically" in the future. Requirements for F-16 ordnance usage in training are established by Air Force regulations and each unit's designated operational capability. Tr. at 13082-84 (Fly). Those requirements do not change frequently. Id. at 13086-87.

[15] The Air Force has stated that the Sevier B MOA usage reports are representative of the number of F-16 flights through Skull Valley. Revised Addendum at 2-5 & n.7; see Tr. at 3355-56 (Jefferson).

Furthermore, the Air Force Safety Agency has stated that ordnance expenditures are not expected to increase in the future. Tr. at 13087-88 (Cole). Thus, there is no reason to credit the State's claim that the military activities in Skull Valley will "vary dramatically" in the future.

R19. The State also claims that the F-16 will be replaced by 2010 and that "[n]o 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." State F. ¶ 24. Thus, the State claims that "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." Id. Contrary to the State's claim, the evidence shows that the F-16s at Hill AFB are likely to be replaced sometime after 2010 by the F-35 Joint Strike Fighter. PFS Test. at 33; Horstman Test. at 13-14. The Air Force has stated that it will employ the Joint Strike Fighter "as a multirole aircraft, primary air-to-ground, which will replace the F-16 and A-10 . . . ." State Exh. 54 at 2. Thus, it is likely to conduct similar missions and similar training. The record establishes that the crash rates for any Joint Strike Fighters based at Hill AFB are likely to be lower than those experienced by the F-16. See PFS F. ¶¶ 31-35.

R20. Furthermore, the activity in Skull Valley is not likely to change significantly in the future because of the configuration of the airspace over Skull Valley and its surrounding terrain. These characteristics of the airspace will as a practical matter greatly limit the types of training activities that may take place in Skull Valley in the future:

> Due to the small size and shape of the airspace over Skull Valley, it is not suitable for the tactical maneuvering typically associated with air-to-air combat training or

> surface attack training, with the exception of low-altitude navigation. In addition, the high terrain on both sides further restricts the utility of the airspace, particularly that below 5,000 ft. AGL (Sevier B MOA), for tactical maneuvers other than low-level navigation. Low level navigation at 1,000 ft. AGL . . . is a low risk event involving monitoring position, maintaining visual contact with your other flight members, and general situational awareness concerning the flight.

Revised Addendum, Tab FF at 15.[16] Therefore, the State's claim that there is "no evidence" in the record regarding the potential future risk to the PFSF is incorrect. To the contrary, the evidence on the record shows that the MOA airspace in Skull Valley over the proposed PFSF is not suitable for training involving high risk tactical maneuvering and that its primary function would continue to be a transition corridor en route to the South UTTR.

R21. Finally, any information relevant to new activities that the State, the Staff, or the Applicant obtained after the facility were licensed would be assessed by the NRC Staff regarding its effect on the risk to the PFSF. See PFS F. ¶ 24.[17] Thus, there is no basis to support the State's claim that future activities or risks to the PFSF "cannot be anticipated."

3. Methodology for Calculating Crash Probability: NUREG-0800

R22. The State asserts that the formula in NUREG-0800 for calculating the crash impact probability at a ground site ($P = N \times C \times A / w$) should be used without modification because NRC Staff witness Dr. Campe had never seen a significant

[16] Air Force instructions also prohibit unrestricted maneuvering associated with "dogfighting" below 5,000 ft. AGL. Id.

[17] Under 10 C.F.R. § 72.11(b), PFS would be obligated to notify the Commission of any information it identified as having a significant implication for public health and safety. In addition, the State would have the right under 10 C.F.R. § 2.206 to request that the NRC take enforcement actions against PFS on the basis of any information the State identified.

departure from that formula in his past reviews of nuclear power plant license applications. State F. ¶ 25. The State is incorrect.

R23. First, the fact that Dr. Campe has not seen a departure from the formula in the past does not mean that PFS's modification of the formula to account for pilot avoidance is invalid. It is valid because unique circumstances regarding F-16 flight down Skull Valley make it reasonable to evaluate an avoidance factor for the PFSF. These include the uniformity of the aircraft and nature of flight, the pilots' training and ability to avoid sites on the ground (particularly for the types of failure expected to occur in Skull Valley), and the well-developed database regarding F-16 in-flight emergencies and the pilots' responses to them. These circumstances do not apply to most other nuclear facilities where the aircraft crash hazard is posed by a wide variety of civilian aircraft flown by pilots with varying skills and backgrounds. See Tr. at 8712-15 (Resnikoff, discussing NRC brief on hazards to Three Mile Island reactor posed by civilian aircraft).

R24. Second, Dr. Campe stated that the use of the avoidance factor, *R*, was an acceptable way to model the fact that military pilots will try to avoid hitting inhabited or built up areas on the ground with their aircraft. See PFS F ¶¶ 17-20. In this respect, NUREG-0800 itself states that its formula is only "one way" of calculating aircraft crash hazard and does not preclude consideration of other factors or using other methods of calculation. Id. Because pilot avoidance is an established fact, id. ¶¶ 21-23, PFS's use of the *R* factor is an acceptable way of modeling the aircraft crash hazard for the PFSF.

4. F-16 Crash Rate Per Mile

R25. PFS's witnesses testified that the appropriate crash rate to use for F-16s transiting Skull Valley was 2.736 E-8 per mile, a 10-year average rate over the period FY89 to FY98 for the normal phase of flight (i.e., flight not involving takeoff or landing or aggressive maneuvering). PFS F. ¶ 25. State witnesses Lt. Col. Horstman and Dr. Resnikoff testified that the appropriate crash rate to use was the lifetime F-16 crash rate for the normal phase of flight, which Dr. Resnikoff calculated to be 3.39 E-8 per mile. Horstman Test. at 14; Resnikoff Test. at 9, 15.[18] This lifetime rate calculated by Dr. Resnikoff was approximately 24% higher than the ten-year crash rate of 2.736 E-8 calculated by PFS's expert panel. In its proposed findings, the State disregards Dr. Resnikoff's crash rate and urges the Board to adopt a crash rate that appears nowhere in the testimony of its witnesses or any other witnesses at the hearing.

R26. PFS's Aircraft Report calculates a crash rate per mile for the F-16 using total mishap data from the period FY89 to FY98. See Aircraft Report at 10-11 and Tab D. In that period, there were 162 total F-16 mishaps (Class A plus Class B) and F-16s accumulated 4,016,311 flight hours. Id. Based on the DOE ACRAM study data,[19] the F-16 flies 471.85 miles per flight hour and 47.18 percent of all flight hours are in the normal phase of flight. Id. Also based on the ACRAM study, 15.09 percent of all mishaps occurred in the normal phase of flight. Id. Thus, the number of mishaps (crashes) per mile in the normal phase of flight for the F-16 is equal to:

> (162 total mishaps x 15.09% in normal flight) / (4,016,311 flight miles x 471.85 flight miles per flight hour) = 2.736 E-8 crashes per mile

[18] Dr. Resnikoff's testimony states that his calculation of the 3.39 E-8/mile rate is shown in State Exh. 76, but State Exh. 76 shows no calculation of an F-16 crash rate for the normal phase of flight—it appears to be a calculation using all mishaps and all flight hours without regard to phase of flight. Thus, State Exh. 76 is not applicable to F-16s transiting Skull Valley. Dr. Resnikoff described his calculation of the 3.39 E-8 crash rate in the text of his testimony, Resnikoff Test. at 14-15, and that is the basis for our review.

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

R27. Dr. Resnikoff assumed in his calculations that the number of mishaps were equal to the total number of F-16 mishaps from 1975 to 2000 and the number of flight hours was the total number of F-16 flight hours from 1975 to 2000. Resnikoff Test. at 15. These assumptions were based on his and Lt. Col. Horstman's view that a lifetime F-16 crash rate was most appropriate to use to assess the risk to the PFSF. Id. at 9. PFS refuted this view in its proposed findings. PFS F. ¶¶ 30-35. Dr. Resnikoff assumed, like PFS, that the number of miles per flight hour was 471.85, that the fraction of total miles flown during the normal phase of flight was 47.18 percent, and that the fraction of all mishaps occurring during the normal phase of flight was 15.09 percent. Resnikoff Test. at 15. Thus, he calculated a crash rate of 3.39 E-8 per mile. Id.[20] Because Dr. Resnikoff's lifetime crash rate includes the early history of the F-16 in which it experienced significantly higher crash rates than now, it would be unreasonable to use his calculated rate to estimate the hazard to the PFSF. PFS F. ¶¶ 30-35.

R28. Now, however, the State urges the Board to adopt a new and even higher lifetime crash rate for the F-16 of 4.10 E-8 per mile. State F. ¶ 38. There is no support in the evidentiary record for use of this new crash rate. Indeed, it is higher than the F-16 lifetime crash rate for normal operations of 3.86 E-8 per mile through 1993 set forth in the DOE ACRAM study, which both PFS's expert panel and Dr. Resnikoff used as the starting point for their calculations. State Exh. 51 Table 4.8; see Aircraft Report at 10-11 and Tab D; Resnikoff Test. at 14-15. Further, both PFS's expert panel and Lt. Col. Horstman testified that the overall crash rate

[20] While the State urges the Board to calculate a new crash rate, it argues in the alternative in favor of Dr. Resnikoff's crash rate, updated to include FY01 data. State F. ¶ 36. Including FY01 (and FY00) data for Class B mishaps, as Dr. Resnikoff did, significantly overstates the risk to the PFSF because the Class B mishap rate for those years increased significantly while the actual F-16 crash rate (destroyed aircraft) did not. Tr. at 8745-50 (Resnikoff).

for the F-16 was higher in its initial years than now, as one would expect, but that the crash rate has been lower and approximately level for the last 15 years or so. PFS Test. at 27-28; PFS Exh. Q; Horstman Test. at 13; Tr. at 4376-77 (Horstman). Therefore, even assuming the use of a lifetime rate were appropriate, the current lifetime rate must be lower than that calculated based on the data through 1993, not higher as the State now argues for the first time.

R29. The State begins by claiming that during the years 1975-1993, the time period of the ACRAM data, a greater percentage of Class B mishaps (which are not actual aircraft crashes) occurred in flight phases other than the normal phase of flight (i.e., takeoff, landing, or special operations). State F. ¶ 30. The State calculates a fraction of destroyed aircraft accidents in the normal phase of flight for the period FY89 to FY98 of 22.3 percent, using PFS's assessment in Tab H of the Aircraft Report of the number of F-16s that were destroyed during the normal phase from FY89 to FY98. Id.;[21] compare Aircraft Report Tab H. The State compares that fraction (22.3%) to the fraction of total F-16 mishaps (Class A and Class B) occurring in the normal phase of flight from 1975 to 1993 as assessed in the ACRAM study (15.09%) and concludes that in the period considered by the ACRAM study a greater fraction of Class B mishaps occurred in phases other than the normal phase of flight. See State F. ¶ 30.

R30. The State's claim regarding the distribution of Class B mishaps is unsupported for two reasons. First, the ACRAM data do not indicate what fractions of Class A mishaps, Class B mishaps, and destroyed aircraft accidents (which are a subset of Class A mishaps) occurred in each phase of flight. The ACRAM study only

[21] The State derived the 22.3% fraction by dividing the number of F-16s PFS had assessed as being destroyed during the normal phase of flight (27) by the total number of F-16s destroyed in the accidents PFS had assessed (121).

provides a breakdown of total mishaps by phase of flight. See Aircraft Report Tab C, Table 4.8. Thus, ACRAM does not state that a higher fraction of Class B mishaps occurred in phases of flight other than the normal phase. Second, the State is comparing ACRAM data for the period 1975 to 1993 to PFS's assessment of destroyed aircraft for the period FY89 to FY98. Since ACRAM looked at Class A mishaps and Class B mishaps together and PFS's assessment only looked at destroyed aircraft,[22] a comparison of ACRAM data to PFS's assessment does not show whether or how the fractions of Class A mishaps, Class B mishaps, and destroyed aircraft accidents occurring in each phase of flight changed between the period ACRAM considered and the period PFS considered.

R31. The State then notes that from 1989 to 1998 there were 139 destroyed F-16s. State F. ¶ 31. It estimates, using its calculated fraction of F-16s destroyed during the normal phase of flight from FY89 to FY98 (22.3%), that there were 30.99 total destroyed F-16s in the normal phase during that period. Id. It argues that because this estimated number of destroyed F-16s is greater than the number of mishaps in the normal phase from FY89 to FY98 PFS had estimated in calculating its crash rate (24.45, Aircraft Report Tab D), PFS should have used this 22.3 percent fraction in its calculations instead of the 15.1 percent that it actually used. State F. ¶¶ 31-32, 37-38.

R32. The State is incorrect. As the State notes, PFS assessed the phase of flight for each of the F-16s destroyed in accidents that occurred from FY89 to FY98 and for which it was able to obtain an accident report from the Air Force. See Aircraft

[22] PFS assessed whether each F-16 accident that was covered in the accident reports and that resulted in a destroyed aircraft occurred in the normal phase of flight for the purpose of determining whether PFS should consider that accident in determining what fraction of accidents in the normal phase would leave the pilot in control of the aircraft with the time to maneuver to avoid the PFSF. Aircraft Report Tab H at 20-21.

Report Tab H at 3-4, Table 2. However, PFS also assessed whether each of the accidents could have occurred in Skull Valley (i.e., whether the accidents were "Skull Valley-type events"). See Tab H Table 2. Out of the 27 F-16s that PFS had assessed as destroyed in the normal phase of flight, only 19 were destroyed in Skull Valley-type events. Id. Thus, eight F-16s were destroyed in mishaps that could not have occurred in Skull Valley and hence would not pose a hazard to the PFSF. See id. at 21-25.[23] If the 19 F-16s destroyed during the normal phase of flight in Skull Valley-type events were divided by the total number of destroyed F-16s PFS assessed (121), in the manner the State calculated the fraction of accidents occurring in the normal phase of flight above (note 21, supra), the fraction of accidents occurring in the normal phase of flight that could have occurred in Skull Valley would be 15.7 percent, very close to the 15.1 percent PFS used in its crash rate calculations.[24]

R33. The State's approach is also incorrect because PFS's assessment of the phase of flight of the accidents in Tab H of the Aircraft Report was not intended for the calculation of a crash rate. The Tab H calculations were intended for the specific purpose of assessing pilot avoidance in accidents that could possibly occur in Skull Valley. To be conservative, PFS for this purpose included some borderline accidents as being in the normal phase of flight (e.g., the accident of May 25, 1990),[25] which increased the number of normal phase accidents at the expense of

[23] These eight accidents were caused by things that do not or cannot happen in Skull Valley (e.g., running out of fuel). Aircraft Report Tab H at 23-25 & n.18. Therefore, it is appropriate to exclude them from the calculation of a crash rate applicable to F-16 transits of Skull Valley.

[24] PFS presents this analysis of the F-16 crash rate for the first time only in response to the State's argument, which it made for the first time in its proposed findings. PFS is aware that "[p]roposed findings of fact . . . must be confined to the material issues of fact presented in the record, with exact citations to the transcript of record and exhibits in support of each proposed finding." 10 C.F.R. §2.754(c)

[25] The accident of May 25, 1990 occurred when the pilot was descending to a planned altitude of 300 ft. AGL and this could have been categorized as a special operations accident. PFS Test. at 63.

the other categories. If PFS's assessment were used to calculate a crash rate, this conservatism would cause the normal phase rate to increase and the rates for special operations and takeoff and landing to decrease. The ACRAM study, on the other hand, was focused on accident rates in all phases of flight. It could not skew crash rates toward (or away from) the normal phase because the study results might be used to calculate special operations rates or takeoff and landing rates, depending on the scenario or the facilities for which risk was being calculated. Therefore, the ACRAM fraction of mishaps occurring in the normal phase of flight is appropriate to use here.

R34. The State then goes further and notes that over the lifetime of the F-16 through FY01, 272 aircraft were destroyed in crashes. State F. ¶ 32 (citing State Exh. 154). The State asserts that the Board should multiply those 272 lifetime destroyed aircraft by the State's calculated fraction of destroyed aircraft in the normal phase of flight from FY89 to FY98 of 22.3 percent to conclude that over the F-16's lifetime, 60.66 of the 272 crashes occurred in the normal phase of flight. Id.; see id. ¶ 37. The State used that conclusion to calculate a new lifetime crash rate per mile for the F-16 of 4.10 E-8. See id. ¶ 38.

R35. The State's new crash rate is inappropriate to use for the PFSF. First, none of the State's witnesses testified that this rate should be used. Second, as noted above, this is higher than the lifetime crash rate for the normal phase of flight as of 1993 of 3.86E-8, which is illogical for the reasons explained. Third, as also discussed above, when it calculated the fraction of F-16s destroyed in the normal phase of flight from FY89 to FY98 (22.3%), the State included accidents that could not have occurred in Skull Valley. Thus, it significantly overstated the hazard to the PFSF by including accidents that could not have posed a hazard to the facility.

Fourth, the State argues, with no basis in the record, that one should take the fraction of aircraft destroyed in the normal phase of flight in the period from FY89 to FY98 and apply it to the total number of destroyed aircraft over the lifetime of the aircraft (i.e., from 1975 to 2001) to calculate a crash rate. None of the witnesses in the hearing—not even the State's witnesses—stated that that was a reasonable thing to do. Indeed, the ACRAM fraction of total F-16 mishaps in the normal phase of flight already accounts for all of the F-16 normal mishaps from 1975 to 1993. It is unreasonable, with no basis in the record, to go back and apply the State's calculated fraction of aircraft destroyed in the normal phase from FY89 to FY98 to data from 1975 to 1993. Therefore, the Board will disregard the State's new crash rate calculation.

R36. In addition to arguing for a new crash rate calculation, the State claims that "[n]ot all flights through Skull Valley are low risk activities because of speed, altitude and nature of the missions" and that therefore PFS's use of only normal phase of flight data to calculate the F-16 crash rate is not "conservative," in that "[l]ow level flying, 500 feet AGL and below is very unforgiving due to proximity with the ground, with little margin for pilot error." State F. ¶ 33 & n.9 (citing State F. note 7). This argument, based on a claim that F-16s fly through Skull Valley below 500 ft. AGL, is entirely new, raised by the State for the first time in its findings, and it has no basis in the evidentiary record. The basis for the State's claim is its statement in footnote 7 (¶ 24) that, "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 to 100 feet above ground level ('AGL') at the location of the PFS site." The NRC Staff letter is not part of the evidentiary record in this proceeding and cannot serve as the basis for a

Licensing Board decision.[26] Nor has the State sought to reopen the evidentiary record on the basis of the Staff letter. See 10 C.F.R. § 2.734.

R37. In addition to the above claims raised by the State for the first time in its findings, the State also reiterates themes raised during the course of the hearing concerning the appropriateness of PFS's choice of the time period for its analysis. The State claims that PFS provided "[n]o objective basis" for using the 10-year period from 1989 through 1998 as the basis for calculating a crash rate and, citing the Aircraft Report at 11 and the transcript (Tr. at 3363 (Jefferson)) claims that the "decision was admittedly subjective." State F. ¶ 34 In fact, Gen. Jefferson stated that, "We picked the most recent data that we had, the most recent ten-year period we had at the time." Tr. at 3362-63 (Jefferson). "[W]e selected ten years as a proper rate to use because of recency of the data, as well as being a long enough average not to be unduly influenced by one year's experience." Id. at 3363; see also PFS F. ¶ 25. This rationale testified to by General Jefferson is fully set forth in PFS's Aircraft Report at 10-11. Thus, the State's claim that PFS had no objective basis for the 10-year period that it selected as the basis for calculating the crash rate used in its hazard analysis is clearly erroneous.

[26] Although PFS believes that the appropriate treatment for the State's use of extra-record material would be to exclude it, should the Board not do so, we would call the Board's attention to the complete sequence of extra-record material on this issue. In particular, the NRC Staff letter does not state that flights will occur below 1,000 ft. AGL, or, as the State implies in paragraph 33, below 500 ft. AGL. In a letter to Skull Valley Band of Goshutes Chairman Leon Bear, dated September 10, 2002 (served on the Board and the parties by letter from PFS counsel dated October 2, 2002), the Commander of the 388th FW, Col. Stephen Hoog, USAF, stated that the Air Force had not changed and did not anticipate changing the altitude at which the F-16s fly over the Skull Valley Reservation. In any event, as PFS discussed in its reply to the Staff's letter, the Air Force rarely flies fighters below 500 ft. AGL because the pilots are not trained and qualified to do so. See Letter from John Parkyn, Chairman PFS, to Nuclear Regulatory Commission, dated August 23, 2002 (served on the Board and the parties on August 29, 2002). Finally, as reflected in the evidentiary record, the Commander of Air Combat Command has stated that low-level flying down to altitudes of 500 ft. AGL are not considered high risk by the Air Force. The evidence in the record establishes that flight through Skull Valley is not high risk. PFS F. ¶ 14. Therefore, the State's claim provides no reason for PFS not to use its calculated crash rate.

R38. The State claims that mishap data for this 10-year period used in PFS's analysis produce the lowest 10-year average crash rate in the history of F-16. State F. ¶ 34. In fact, they do not. The 10-year averages for Class A mishap and destroyed aircraft rates were lower for the most recent 10-year period of FY92 to FY01. PFS F. ¶ 26.

R39. The State also claims that it is inappropriate for PFS to use the period from FY89 to FY98 to calculate a crash rate because the years 1995 through 2001 assertedly show an increasing trend in F-16 crash rates. State F. ¶ 34 (citing State Exh. 155; Tr. at 8945, 8948 (Campe)). As was discussed in some detail at the hearing, the period from 1995 to 2001 does not indicate an increasing trend in F-16 crash rates because that period shows generally lower crash rates than occurred in the previous six years, from FY89 to FY94. Staff F. ¶ 2.78. Although the State asserts that Dr. Campe stated that PFS should "base its crash rate on additional years." State F. ¶ 34, Dr. Campe did not testify that the period from FY89 to FY98 was too short to establish a crash rate. Dr. Campe testified that the period from FY95 to FY01 was too short to use to establish a crash rate because looking further back, to approximately 1984, the F-16 crash rate data show no trend with time, only random fluctuation. Tr. at 8946-47, 8949 (Campe). Focusing on the period from 1995 to 2001 to the exclusion of the other data is essentially arbitrary. See Tr. at 8772-77 (Resnikoff). Dr. Resnikoff could offer no basis for using this period other than it showed increasing rates which appeared to be the sole objective of his analysis. Id. at 8772, 8812-13. No other period showed such increasing rates. Tr. at 8888-90 (Ghosh); see Staff Exh. KK.

R40. The State claims 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." State F. ¶

35. Its claim is based on the allegedly higher crash rate that will be exhibited by the replacement aircraft for the F-16, the allegedly increasing crash rate of the F-16, and the fact that other assessments of aircraft crash hazards have used aircraft lifetime history crash rate data. See id. None of these claims has merit. See PFS F. ¶¶ 25-35; see also Staff F. ¶¶ 2.97-2.98 (refuting the State's claim that F-16 crash rates will go up due to the "bathtub effect").

R41. Finally, regarding the F-16 crash rate, the State claims that there is insufficient evidence for the Board to determine the crash rate pertinent to the hazard to the PFSF for the period after 2010 when the F-16 will be replaced. State F. ¶ 39.[27] On the contrary, as discussed in Section III.B.2 above, there is more than adequate evidence for the Board to determine the hazard to the PFSF after the F-16 is replaced, including evidence on the potential crash rate of the Joint Strike Fighter, the F-16's expected replacement.

5. The Effective Width of Skull Valley

R42. In discussing the effective width, *w*, to use in calculating the crash impact hazard to the PFSF, the State claims that "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." State F. ¶ 43. In fact, the Air Force has consistently advised PFS that the predominant or preferred route of flight for F-16s transiting Skull Valley is approximately five miles to the east of the proposed PFSF site, i.e., approximately seven miles east of the restricted airspace. PFS Test. at 16, 44; Staff Test. at 27. The Hill AFB staff has stated that there are no buffer zones inside Sevier B MOA (although there are

[27] PFS's witnesses testified that the replacement for the F-16 would come to Hill AFB sometime after 2010. PFS F. ¶¶ 32, 34.

buffer zones inside the restricted areas on the UTTR). PFSF ¶ 43 n.49. Similarly, the Air Force told PFS twice that because Sevier B is a MOA "you can fly anywhere in it if you wish." Tr. at 3397 (Cole). Therefore, there is no requirement that pilots maintain any given distance from the western edge of the MOA, (although in practice they do not fly anywhere close to the western edge at the latitude of the PFSF).[28]

R43. Next, the State claims that "F-16 formations generally fly down the middle of Skull Valley with part of the formation over or near the PFS site." State F. ¶ 44. The asserted basis for its claim is Lt. Col. Horstman's pre-filed testimony that the F-16 flight leader will select a flight path to keep the easternmost aircraft in the formation 2 miles from the Stansbury Mountains, which would place the easternmost aircraft "5 miles from the eastern border of Sevier B MOA" and his claim that the F-16s would not fly closer than within one mile of the western edge of the MOA. Id.; Horstman Test. at 6-7.[29] However, Lt. Col. Horstman's testimony of the distance that F-16s would maintain from the Stansbury Mountains and the eastern border of the MOA is riddled with inconsistencies, PFS F. ¶ 47 n.51.

R44. PFS fully addressed the issue of how far east the F-16s fly in its proposed findings. PFS F. ¶¶ 42, 47-48. The Air Force has consistently stated that the predominant route of flight for F-16s transiting Skull Valley is approximately five

[28] PFS distributed the F-16 traffic across Skull Valley for analyzing the crash hazard at the request of the NRC. Tr. at 3436, 3440-41; see also note 14, supra. Such an assumption is conservative since it assumes that aircraft would be in a position to potentially hit the PFSF in the event of a crash when in fact they would not. PFS F. ¶ 43.

[29] The State also refers to Gen. Jefferson's testimony that at least half of the flights would be concentrated in a five mile width. As discussed above, this testimony does not support the State's claim that the actual traffic of F-16s flying down Skull Valley is concentrated in the middle of the valley over the PFSF as claimed by the State. See note 14 supra.

miles to the east of the site, which is a natural consequence of the MOA's configuration. Id.; PFS Test. at 16, 44; Staff Test. at 27. Further, the State's witness' testimony contradicts the State's position. In his December 11, 2000 deposition, Lt. Col. Horstman agreed that the predominant route of flight for typical two-aircraft or four-aircraft formations would place all of the aircraft east of Skull Valley Road (which is two miles east of the PFS site) and therefore not over the site as now claimed by the State. Tr. at 4344-45 (Horstman). Lt. Col. Horstman reaffirmed the correctness of this deposition testimony at the hearing. Id.

R45. The State asserts that "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." State F. ¶ 44 n.12. First, F-16 formations are two to three nautical miles nautical wide (approximately 2.3 to 3.45 statute miles). Aircraft Report Tab E at 2 ; see also Revised Addendum Tab FF at 11 & n.22 (9,000 ft. nominal distance between two aircraft). Second, assuming that a formation is four statute miles wide, if the center of the formation were five miles east of the PFSF, the westernmost aircraft would be three miles east of the site and the easternmost aircraft would be seven miles east of the site. At the typical altitude of 3,000 to 4,000 ft. AGL, i.e., near the top of the MOA at that point, the easternmost aircraft would still be able to maintain a safe distance from the Stansbury Mountains. See Staff Exh. D; Tr. at 8648 (Fly). Therefore, there is no inconsistency between the width of the F-16 formations and flying five miles east of the PFS site.

R46. Next, the State claims that the basis for the statement that the predominant route of the F-16s is five miles east of the site "is a casual remark to General Cole of uncertain origin." State F. ¶ 44 n.12. On the contrary, Gen. Cole testified that the statement was made by the Hill AFB staff either on a conference call on November 20, 1998 or at a meeting at Hill on December 15, 1998. Tr. at 3397-98 (Cole). The purpose of both the call and the meeting was to formally discuss Air Force operations in Skull Valley and the UTTR generally so that PFS could obtain information to assess the hazard those operations might pose to the PFSF. See id.; PFS Test. at A7. Thus, the statement by the Hill AFB officials was hardly "casual." Furthermore, that the predominant route of the F-16s transiting Skull Valley is the eastern side of the valley was subsequently reaffirmed by the Vice Commander of the 388th FW. Id; PFS Test. at 44 & n.42; Aircraft Report at 5 n.3. Finally, it is consistent with Col. Fly's experience that he typically flew a south-southeasterly route through Skull Valley that took him about four miles east of the PFS site. Tr. at 3422-24 (Fly).

R47. The State claims that "there is insufficient evidence to determine the width of airway for calculating crash probability after 2010," after which the F-16 would presumably be replaced by the Joint Strike Fighter, because evidence as to the effective width of the valley "was based on the type and flight patterns flown by F-16s stationed at Hill AFB." State F. ¶ 45. On the contrary, evidence as to the effective width of Skull Valley and the route of flight of the aircraft transiting the valley was based not only on current practices, but also on the terrain and the configuration of the airspace. The configuration of the MOA and the restricted airspace to its west serve to naturally funnel traffic transiting the valley away from the PFS site toward the eastern side of the valley and the narrow seven mile wide neck in the MOA southeast of the site. PFS Test. at 44; Aircraft Report, Tab A; PFS Exh. P. PFS F. ¶ 42 & n.48

R48. Thus, PFS's hazard calculation based on the assumption that F-16s are spread over an airway with a width of 10 miles (rather than being predominantly located on the east side of Skull Valley) is inherently conservative because it assumes that more F-16s will fly over the PFS site than actually do.

6. The Number of Flights Through Skull Valley

a. State Assessment

R49. The State notes that F-16s en route from Hill AFB to the UTTR South Area transit Skull Valley and then states that "[o]nly F-16 aircraft are required to transit Skull Valley." State F. ¶ 47. There is no requirement for F-16s or any other aircraft to transit Skull Valley. F-16s commonly use Skull Valley to transit from Hill AFB to the UTTR South Area but there are also other routes by which they can do so without entering the valley. Revised Addendum Tab HH at 10-11.

R50. The State claims that PFS should add Sevier B and Sevier D MOA sortie counts when estimating the sortie count for Skull Valley and further asserts that 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. State F. ¶¶ 47, 50. The Air Force has, however, stated that the Sevier B MOA usage reports are representative of the number of F-16 flights through Skull Valley. While aircraft also transit Sevier D MOA, this number is not large and aircraft only rarely fly above Sevier D. Revised Addendum at 2-5 & n.7; see Tr. at 3355-56 (Jefferson), 8523-24 (Horstman); PFS F. ¶¶ 55, 65. Offsetting this small number is the fact that aircraft may use both Sevier B and D MOAs (and thus be in the MOA sortie counts) but never enter Skull Valley. Id. The Air Force has stated that up to 10 percent of the flights in Sevier B MOA do not transit Skull Valley. Staff Exh. C at 15-19. Accordingly, the Sevier B MOA usage reports are appropriately representative of the number of F-16 flights through Skull Valley.

R51. The State claims that "the best estimate for input value N, number of flights per year along the airway, is 7,040," based on the sum of the Sevier B and Sevier D MOA sortie counts for FY00, increased to account for the additional F-16s stationed at Hill AFB in FY01. State F. ¶ 48. It asserted further that there was "no evidence" that the number of flights in FY00 would never be repeated. Id. ¶ 49. In its proposed findings, PFS discussed in detail why the appropriate number is the average of the sortie counts for Sevier B MOA for FY99 and FY00, increased to account for the additional F-16s at Hill. See PFS F. ¶¶ 54-66.

R52. The State asserts that Gen. Jefferson testified that PFS did not use the higher number of flights in FY00 as a basis for estimating future F-16 Skull Valley flights because of "past history and the current war on terrorism." State F. ¶ 49 (citing PFS Test. at 20-21; Tr. at 3350-51 (Jefferson)). As PFS's experts testified, "past history" also included the fact that the 388^{th} FW achieved the highest sortie rate per aircraft of any F-16 wing in the Air Force in FY00, a rate that would not be sustainable over a long period of time. PFS Test. at 19; see Tr. at 3353-55 (Jefferson); PFS F. ¶¶ 57-58. Furthermore, when the F-16 is replaced by the Joint Strike Fighter, because the planned number of aircraft to be purchased is significantly less than the number of F-16s, the number of sorties flown in the Air Force and at Hill AFB may drop. PFS F. ¶ 62; see also Revised Addendum at 7-12; Staff F. ¶ 2.130 (FAA projects no future increase in military flights).

R53. The State claims that "General Jefferson stated that to his knowledge no F-16 fighter aircraft from Hill AFB were involved in the war on terrorism in Afghanistan." State F. ¶ 49 (citing Tr. at 3351-52 (Jefferson)). Gen. Jefferson stated that he understood that F-16s were involved in the war in Afghanistan though he did not know their home base. Tr. at 3351-52 (Jefferson). Furthermore, in the past, aircraft from Hill AFB have deployed to other bases to fill in for aircraft deployed overseas. Revised Addendum at 7. Even if aircraft from Hill AFB were not deployed overseas for some future crisis, they might well be deployed elsewhere away from the base.

R54. The State claims that Gen. Jefferson stated there was "no statistical basis" for using the average of the FY99 and FY00 Skull Valley sortie counts as a baseline for estimating the number of flights through the valley in the future. State F. ¶ 49 (citing Tr. at 3352-53 (Jefferson)). However, Gen. Jefferson explained that he used the average of the FY99 and FY00 sortie counts because of expected deployments of aircraft away from Hill AFB and, based on his knowledge of practical Air Force wing operation, he did not believe that the 388^{th} FW FY00 sortie rate was sustainable. Tr. at 3350-55 (Jefferson). This was not just the opinion of Gen. Jefferson, who—unlike Lt. Col. Horstman—had served as a wing commander, but also of Gen. Cole and Col. Fly, also both former wing commanders. PFS Test. at 19, 26.

R55. The State asserts that Gen. Jefferson stated "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." State F. ¶ 49. Gen. Jefferson agreed that the number of future sorties were issues of national policy, force structure, and budgets. Tr. at 3352 (Jefferson). However, the evidence is uncontroverted that policy and budgets are driving the number of Air Force aircraft and the number of sorties down over time. Thus, those factors would lead to a reduced future risk to the PFSF, not an increased risk. PFS F. ¶¶

62-63. Moreover, as evidenced over the past four years, the number of flights each year do not fluctuate dramatically. Thus, any policy-driven increase in the number of sorties would be observable in time for the NRC Staff to take appropriate action as part of its enforcement or regular supervisory duties if necessary. See Tr. at 4156-58 (Campe).[30]

b. NRC Staff Assessment

R56. The NRC Staff estimated the number of flights through Skull Valley by using "Air Force upper bound data"—the sum of the FY00 flights in Sevier B and D MOAs, increased by 17.4 percent to account for the additional aircraft assigned to Hill AFB in FY01—to be 7,041 flights per year. Staff F. ¶ 2.117. The State noted, however, that F-16s transit Skull Valley in formations of two or four aircraft, with approximately 9,000 ft. between the aircraft in each pair. Id. ¶ 2.118. Thus, for each pair, one aircraft would be precluded from flying over the facility and hence would not pose a hazard to it. Id. Therefore, for the purpose of calculating the hazard to the PFSF, the Staff divided the upper bound number of flights through Skull Valley by two to yield 3,520 flights per year. Id. ¶ 2.119.

R57. The Staff's approach is an alternative method of estimating the crash impact hazard to the PFSF. At the outset, the Staff's approach is very conservative (wholly apart from the conservatism of using upper bound data for number of flights). It also assumes that the F-16s are distributed across the entire width of the MOA, whereas the predominant route of flight is on the east side of Skull

[30] Finally, the State claims that "there is insufficient evidence to determine the number of flights transiting Skull Valley above or near the proposed PSF site after 2010" after which the F-16 would presumably be replaced by the Joint Strike Fighter. State F. ¶ 51. On the contrary, the record reflects that the Air Force plans to buy fewer Joint Strike Fighters than it bought F-16s and that therefore, it is likely that the number of sorties through Skull Valley will decrease after the F-16 is replaced rather than increase. See PFS F. ¶¶ 62-63. Therefore, PFS's estimates based on current flight operations are likely to be even more conservative compared to the actual hazard to the PFSF after 2010.

Valley, approximately five miles east of the PFSF. PFS F. ¶ 42-43; see Staff F. ¶¶ 2.137-2.140, 2.148.

R58. PFS agrees that because the PFSF is close to the restricted airspace at the western edge of Sevier B MOA, the fact that the F-16s fly in formations of two means that even if it is assumed that the F-16s are distributed across the MOA, the number of flights over or near the PFSF would be less than the number of flights near the center of the MOA and thus the risk to the PFSF would be reduced. See Staff F. ¶ 2.136 (risk is reduced where flights are farther away from the facility). In practice, while there are no official buffer zones in the Sevier B MOA in Skull Valley, pilots maintain some distance away from restricted airspace. Lt. Col. Horstman stated that the distance would be "a mile or two." Tr. at 8572 (Horstman). Col. Bernard stated that it would be "two or three miles . . . a comfortable distance." Tr. at 3924 (Bernard). Col. Fly stated that he flew approximately six miles from the edge of the restricted airspace because of the geometry of the MOA. Tr. at 2422-24 (Fly). Thus, even if it is unrealistically assumed for the purposes of analysis that the F-16s are distributed across the MOA, the westernmost aircraft in each formation would be approximately two miles east of the boundary between the MOA and the restricted airspace.

R59. Given that the PFSF is located only two miles west of the restricted airspace,[31] and that the F-16s fly in two-aircraft formations and would not fly right up to the edge of the restricted airspace, it is reasonable, under this construct, to estimate the number of flights that could possibly pose a hazard to the PFSF by dividing the total number of flights through Skull Valley by two. If the western aircraft in

[31] See Aircraft Report at 6; PFS Exh. P. Indeed, the PFSF is not only within 2 miles of the restricted airspace to the west, it is also approximately the same distance (about 2 miles) north of the restricted airspace. Restricted airspace to both the west and south makes the Staff's construct even more reasonable.

each pair of F-16s flies at least two miles east of the restricted airspace, i.e., at the longitude of the PFS site, and the eastern aircraft flies 1.5 to 2 miles further east still, the number of overflights of the PFS site would be half of what one would calculate if one assumed that the F-16s were evenly distributed across the MOA all the way to its literal western edge. Therefore, the Staff's method of dividing its upper bound number of flights in half is a reasonable alternative method to estimating the number of flights through Skull Valley that could possibly pose a hazard to the PFSF.[32]

7. Site Effective Area

R60. The parties agree that the peak effective area of the PFSF at full capacity (4,000 casks) is 0.13371 square miles. State F. ¶ 52; PFS F. ¶ 38. However, it must be recognized that even if the PFSF ultimately reaches full capacity, the average effective area over the lifetime of the facility is only 55 percent of the peak effective area. See PFS F. ¶¶ 39-41. Using the average effective area instead of the peak area would reduce the overall calculated crash probability by 45 percent.

8. Calculation of Crash Impact Probability Using NUREG-0800

R61. For F-16s transiting Skull Valley, the State calculates a crash impact probability of 7.72 E-6 per year for the PFSF using its input values in the NUREG-0800 formula. State F. ¶ 53. As discussed above, with the exception of the site effective area (where PFS and the State use the same value), the evidentiary record supports the input values used by PFS, not the State. Also, in the face of

[32] The State claims that the Staff's consideration of the formations in which the F-16's fly in assessing the hazard to the PFSF is unreasonable because, the State asserts, an F-16 performing emergency procedures does not stay in formation but "perform various maneuvers and turn toward an emergency landing field." State F. ¶ 48 n. 13. However, the State provides no specific discussion of where the F-16's would fly relative to the PFSF in the event of an emergency. Furthermore, the evidence shows that an F-16 experiencing an emergency in a position where it might hit the PFSF would not necessarily turn toward Michael AAF. PFS F. ¶¶ 50-52. Therefore, the Staff's analysis remains valid.

clear evidence that pilots can and do direct crashing aircraft away from sites on the ground before ejecting, the State fails to account for the pilot's ability to avoid the PFSF in the event of a crash. See PFS F. ¶¶ 21-23, 67 et seq.

R62. The State also reiterates its claim that "there is insufficient evidence to determine the probability of crash impacts to the proposed PFS site after 2010." State F. ¶ 54. This claim is addressed in Section III.B.2, supra.

9. The Applicant's Modification of the NUREG-0800 Formula

a. NUREG-0800

R63. The State claims that PFS lacks the authority to modify the formula in NUREG-0800 to account for pilot avoidance. See State F. ¶¶ 56-59. The State's thesis is essentially that PFS's use of the *R* factor to modify the NUREG formula is invalid because it is new. See id.[33] PFS has addressed these claims in its proposed findings:

- The *R* factor was added to account for pilot avoidance, which is a documented fact. PFS F. ¶ 17;
- Staff witness Dr. Campe, who developed the section of NUREG-0800 containing the formula, found it to be an acceptable way to model pilot avoidance. PFS F. ¶ 18;
- NUREG-0800 itself provides for flexibility in analyzing aircraft crash hazards and in accounting for site-specific effects. The NUREG formula is described as only one way of calculating the hazard and NUREG-0800 specifically refers to the appropriateness of considering other factors not accounted for in the NUREG formula itself. PFS F. ¶ 19;

[33] The State erroneously claims that Dr. Ghosh did not know of any authorities that support calculation of crash probability taking into account the likelihood that a pilot would be able to avoid a ground site in the event of a crash. State F. ¶ 58 (citing Tr. at 4114-15 (Ghosh)). Dr. Ghosh stated that he was aware of the UK Atomic Energy Authority study (see PFS F. ¶ 21), although it was a document he had not relied on. Tr. at 4115 (Ghosh).

- NUREG-0800 is a screening methodology that specifically allows applicants to use alternative methods to show that they satisfy NRC regulations. PFS F. ¶ 20;

- Precedence for accounting for pilot avoidance is provided by an assessment of aircraft crash hazards to nuclear power plants performed for the U.K. Atomic Energy Authority. PFS F. ¶ 21;

- All of the pilots who testified in this case, including State witness Lt. Col. Horstman, agreed that, time and circumstances permitting, a pilot of a crashing F-16 would attempt to avoid a facility like the PFSF. PFS F. ¶ 22.

Therefore, the State's argument that PFS cannot use the *R* factor because it is a new concept is meritless. The record clearly shows that the aircraft crash impact hazard to the PFSF will be reduced because F-16 pilots regularly attempt to guide crashing aircraft away from sites on the ground. There is nothing in NUREG-0800 to prevent the Board from taking that fact into account; indeed, NUREG-0800 specifically provides the flexibility to account for site-specific effects like, in this case, pilot avoidance.

b. F-16 Engine Failures

R64. PFS assessed the F-16 mishaps in the Air Force accident reports and divided them into two categories: 1) those in which the pilot retained control of the aircraft with time to attempt to avoid a site on the ground and 2) those in which the pilot did not retain control and had to eject immediately. PFS F. ¶ 72. The State attacks PFS's assessment in several respects, none of which have merit.

(1) Characterization of F-16 Accident Reports

R65. The State claims that crashes precipitated by engine failure may not leave the pilot in control, "such as where the pilot ejects during an uncontrolled spin." State F. ¶ 60. For support the State references five accident reports and the summary evaluation in State Exhibit 223 of these accident reports prepared by Lt.

Col. Horstman without elaboration. (citing PFS Exhs. 145, 118, 124, 113, 147, Exh. 223 at entries 8, 19, 20, 46, 53.)

R66. As discussed below, the State's characterization of these five accidents as ones in which the pilot was not in control of the aircraft, such that he would not have been able to avoid the PFSF, is wrong. Indeed, with respect to three of the five accidents, Lt. Col. Horstman initially agreed with the conclusion of PFS's expert panel that the pilot was in control of the aircraft. It was not until the afternoon of the next to the last day of the hearing that he changed his position. This change in position occurred after his repeated affirmations on previous cross examination that, but for one exception, PFS Exhibit X captured his disagreements with the review conducted by PFS's expert panel of the accident reports. He provided no justification for this late change of position other than to suggest (as he had earlier in the hearing regarding his assessment of Skull Valley-type events and the phase of flight in which the accidents had occurred) that he had previously believed himself to be bound by PFS's definitions. However, he acknowledged that his claim of being bound by PFS's definitions (which we find to be completely lacking merit in any event) did not apply to his determinations of "Able to Avoid." Tr. at 13593-94 (Horstman); see also PFS F. ¶¶ 170, 172-73.

R67. December 17, 1992 (PFS Exh. 145). This accident involved the pilot turning "20 degrees right to avoid a hunting lodge off his nose."[34] Id. at 2, Further, the accident report clearly indicates the pilot was in control of the airplane when he ejected after having turned to avoid the hunting lodge. The report describes what happened after a bird strike initiated this event:

[34] Id. at 2, ¶2.a (History of Flight).

> Subsequently, a nearly instantaneous and catastrophic engine failure and fire occurred. During this timeframe, the pilot reacted to multiple warning and caution lights in his cockpit as well as directions from his flight leader. He turned 20 degrees right to avoid a hunting lodge off his nose and to head directly toward the nearest landing field, 40 miles east-southeast. Cockpit fire warnings were visually confirmed as [both the pilot and his flight leader] observed smoke and flames coming from the [mishap] aircraft. Following this 30 to 45 second period, which included a climb and several radio calls, [the flight leader] directed "[the pilot of the mishap aircraft], you are still on fire. Recommend you get out [eject]." [The mishap pilot] then ejected.

Id. It was after the pilot ejected that the airplane started a slow roll "further right." Id. As described later in the report: "After ejection, the aircraft turned right, began a slow roll to beyond an inverted attitude, and impacted the ground."[35] The aircraft impacted well clear of the hunting lodge.[36] See also Staff F. ¶¶ 2.272-2.275, 2.333-2.334.

R68. January 13, 1991 (PFS Exh. 118). Contrary to the State's implication, the pilot remained in control of the aircraft after the onset of the emergency. According to the accident report, the pilot noticed smoke and fumes in the cockpit which caused the pilot to undertake a series of steps. These included taking actions to clear smoke and fumes from the cockpit, turning the aircraft toward Al Kharj Airbase, checking the hydraulic and engine pressure oil gauges, and setting the throttle at 80 percent RPM in accordance with emergency action checklist procedures. Some unspecified time later, the engine failed, causing a rapid loss of RPM followed shortly by failure of the main electrical generator Twenty eight seconds after the generator failure, the plane departed controlled flight. Ten

[35] Id. at 5, ¶2.d (Flight Activity).

[36] Id. at 2, ¶2.a (History of Flight).

seconds later the pilot ejected, and the plane crashed in an unpopulated desert area. PFS Exh. 118 at 2-3, ¶ 4 (Flight).

The pilot was clearly in control of the airplane for the time it took to complete the checklist procedures and turn toward Al Kharj airbase, the unspecified amount of time until the engine failure, and the twenty eight seconds after the main generator failure. Had this occurred in Skull Valley in the vicinity of the PFSF, the pilot would have had more than enough time to avoid the facility. The pilot was obviously aware of his location, the nature of his emergency, and took a series of methodical actions in response to the emergency. See also Staff F. ¶¶ 2.276-2.279.

R69. March 19, 1991 (PFS Exh. 124). This accident occurred 7 minutes after takeoff while the aircraft was climbing to flight altitude. At the onset of a problem, the pilot turned toward his departure base with the intention of landing. He flew for 4-5 minutes when the plane started an uncommanded roll and the pilot ejected.[37] Had this occurred near the proposed PFSF the pilot would have had more than adequate time to turn and avoid the facility. In addition, the pilot would have been well clear of the proposed PFSF after the 4-5 minute interval between the initial onset of the problem and the subsequent ejection. See also Staff F. ¶¶ 2.259-2.262.

R70. September 3, 1990 (PFS Exh. 113). As described in paragraph 4 (Flight) on page 2 of the report, the pilot was flying at 500 ft. AGL and 480 knots when he "experienced several warning lights, including the Fire and Overheat lights." At the initial indications of a problem, the pilot initiated a climb. When advised of an actual fire by the flight leader, the pilot initiated a zoom (a more aggressive

[37] PFS Test. at 69-71; PFS Exh. 124 at 3-4, ¶D (Flight).

climb), during which time he initiated the engine airstart procedures. Based upon multiple indications of a fire, the pilot decided to eject 30 seconds after the onset of the initial problem. He then transmitted his intention to eject, and ejected. The plane subsequently pitched forward and impacted the ground.. There is nothing in the report to indicate he rushed his decision or failed to take any appropriate actions due to the fire. He was in control of the plane at the time of ejection and the "flight controls were functioning properly through the pilot's ejection."[38] Therefore, had the accident occurred in Skull Valley, the pilot would have been able to take action to avoid the PFSF. See also Staff F. ¶¶ 2.280-2.281.

R71. February 19, 1993 (PFS Exh. 147). This accident occurred on a bombing range. After the fifth bombing pass, the pilot observed the first indications that an engine problem had occurred. The pilot heard a loud bang and thought he had a compressor stall. He immediately initiated a climb to achieve the maximum altitude below the clouds "simultaneously" complied with the applicable checklist procedures. He subsequently received indications of a fire. Approximately 26 seconds after initiation of the climb to just below the cloud deck, the aircraft began a mild pitch up, entered the clouds and the pilot ejected (estimated time 30-35 seconds from the initiation of the climb) Had this accident occurred in Skull Valley, the pilot would have had adequate time to climb to just below the clouds, comply with the checklist, both of which were done, and make the small turn required to avoid the PFSF. PFS Test. at 81-83; PFS Exh. 147 at 2-3. See also Staff F. ¶¶ 2.199, 2.253-2.256.

R72. Contrary to the State's claims, none of these accidents would have left the pilot unable to avoid the PFSF. Therefore, they do not support the State's assertion

[38] PFS Exh. 113 at 3, ¶12.c (Flight Controls).

that a pilot would not be able to avoid the PFSF if he suffered an engine failure while transiting Skull Valley, and we find that PFS's expert panel has properly classified these accidents as "Able to Avoid."[39].

R73. In addition to arguing that some of the accidents left the pilot unable to control the aircraft, the State claims further that "[c]rashes precipitated by engine failure may result in the aircraft being on fire forcing the pilot to eject." State F. ¶ 60. For support the State refers to 11 accident reports and Lt. Col. Horstman's summary evaluation from State Exh. 223, without elaboration, which include four of the five accidents discussed above. Id. (citing PFS Exhs. 119, 145, 158, 110, 118, 127, 184, 113, 147, 180, 223 at entries 3, 8, 10, 17, 19, 21, 24, 38, 46, 53, 59; Joint Exh. 4).

R74. The State's characterization of those accidents is wrong. Most obviously, two of the accidents they claim were caused by fire were not; they were caused by engine bearing failure, resulting in smoke but not fire. See PFS Exhs. 118, 184. More importantly, neither fire, for those aircraft on fire, nor smoke forced the pilots to eject before they could have or did turn their aircraft away from sites on the ground. In one case the pilot flew for 5½ minutes after initial indications of a problem until ejecting. In another, the pilot flew for over 10 minutes after the fire was confirmed before ejecting. As was noted in the testimony, Tr. at 13023 (Fly), the F-16 does not blow up immediately, if at all, if it is on fire. Therefore, pilots do not have to immediately eject in the event of a fire. In fact, as described in the

[39] We note that PFS's expert panel judged that in 58 of the 61 accidents that were Skull Valley-type events, or 95 percent, the pilot had control and time to avoid the PFSF, but PFS assumed for the purpose of its calculations that the fraction of the "Able to Avoid" accidents was 90 percent. PFSF. ¶ 74. Therefore, even if the State's arguments are accepted with respect to three of these accidents, the fraction of Able to Avoid accidents of 90 percent would remain valid (hypothetical 55/61 = 90.2%).

testimony, there are procedures for certain types of fires that the pilot should be able to extinguish and safely recover the airplane.[40]

R75. Each of the eleven accidents is discussed below. This discussion shows that the pilot was in control such that he could have avoided the PFSF if the accident had occurred in Skull Valley.

R76. January 15, 1991 (PFS Exh. 119). This accident was caused by a lightning strike that resulted in a fuselage fire.[41] The pilot began a descent for an emergency landing at Homestead AFB, Florida.[42] The fire continued to increase in intensity and approximately three minutes after the lightning strike, the pilot "made the decision to abandon the aircraft over an unpopulated area." Id. There is nothing in the report to indicate the pilot rushed his decision to eject or failed to take any appropriate actions during the course of the emergency. Had this occurred in Skull Valley, the three minutes between the lightning strike and the ejection would have provided ample time for the pilot to avoid the PFSF while responding to the emergency. The fact the pilot consciously decided to eject over an unpopulated area implies he had knowledge of the surrounding area as would be expected of pilots flying in Skull Valley. See also Staff F. ¶¶ 2.318-2.320.

R77. December 17, 1992 (PFS Exh. 145). As discussed previously, the pilot of this aircraft turned to avoid a hunting lodge. In addition, he initiated the engine airstart procedures and responded to his flight lead's radio calls. After being

[40] Again, with respect to 10 of these 11 accidents (all but the accident of February 19, 1993, discussed above), Lt. Col. Horstman initially agreed that pilot was in control of the aircraft and would have been able to avoid the PFSF, see PFS Exh. X, and State Exhibit 223 reflects a last-minute change in his position. He provided no justification for this change other than to generally repeat his claim that he had previously been bound by PFS's definitions, but as discussed above we have rejected that claim.

[41] PFS Exh. 119 at 1, ¶1 (History of Flight), at 2, ¶4 (Flight), and at 4, ¶12.g.

[42] Id. at 2, ¶4 (Flight).

advised the aircraft was on fire, the pilot visually confirmed the fire, transmitted his intentions to eject, and then ejected.[43] Since the pilot turned to avoid a hunting lodge (significantly smaller than the PFSF), it is reasonable to assume he would have turned to avoid the PFSF had this occurred in Skull Valley. The pilot actions described in the report all appear reasonable and prudent and there is nothing in the report to indicate the fire caused the pilot to rush his decision to eject or to fail to take appropriate actions. See also Staff F. ¶¶ 2.272-2.275, 2.333-2.334.

R78. September 11, 1993 (PFS Exh. 158). The accident report shows the pilot had ample time from the onset of the emergency to maintain aircraft control, analyze the situation, take appropriate actions,, and that before ejecting he turned the aircraft away from a populated area. The initial indications of the emergency (vibration of the airframe) occurred on the bombing range and the mishap aircraft started back to the airfield from which it had departed.[44] Approximately 5½ minutes later, the mishap aircraft experienced an explosion. The pilot determined that he had an engine failure and began the procedures for initiating an air start, but was advised shortly thereafter by his wingman that the aircraft was on fire. After visually confirming the aircraft was on fire, the pilot turned west away from a populated area and successfully ejected. _PFS Exh. 158 at 3, ¶4 (Flight Activity.)

The 5½ minutes from the onset of the problem until ejection would have provided more than enough time to avoid the PFSF. Moreover, the pilot turned to avoid a populated area just before he ejected and it is reasonable to assume that he would

[43] PFS Exh. 145 at 4-5, ¶d (Flight Activity).

[44] PFS Exh. 158 at 1, ¶1 (History of Flight) and at 2, ¶4 (Flight Activity).

have also turned to avoid the PFSF had it been a consideration. See also Staff F. ¶¶ 2.339-2.347.

R79. April 3, 1990 (PFS Exh. 110). The aircraft was on fire and the pilot flew it for approximately 10½ minutes after the fire was visually confirmed, over 13 minutes from the first indications of a problem, before ejecting.[45] During this time, the pilot turned and flew to the controlled bailout area and subsequently toward Kunsan Air Base.[46] During the approach to the base, the pilot made the decision to eject. PFS Exh. 110 at 56918. Had this occurred near the PFSF he would have had ample opportunity to avoid the PFSF.

R80. January 13, 1991 (PFS Exh. 118). The State incorrectly categorized this airplane as being on fire. As indicated in the accident report, this engine failure was due to a loss of oil and subsequent engine bearing seizure.[47] The smoke and fumes in the cockpit were caused by the leaking oil being ingested into the engine and subsequently into the environmental control system (air conditioning system), and not a fire.[48] As described above, the pilot undertook a series of methodical actions following emergency procedures and turned toward an emergency airfield. The main generator subsequently failed, after which the pilot remained in control of the aircraft for another 28 seconds prior to ejecting. Had he experienced a similar situation in Skull Valley, the pilot would have had ample opportunity to

[45] PFS Exh.. 110 at 56903 (time 17:09.49) first indications of a problem, 56905 (time 17:12.44) fire visually confirmed, and 56918 (time 17:23.12) pilot ejects.

[46] Id. at 56889 (Summary of Accident Board President).

[47] "The oil from within the engine was depleted and the number three bearing quickly deteriorated and seized." PFS Exh. 118 at 6, ¶12.b (Airframe and Aircraft Systems: Engine).

[48] "The leaking oil was drawn into the anti-ice air slots and ingested through the engine inlet cone down into the engine core. As the oil was consumed by the engine it entered the environmental control system (ECS) via the seventh and thirteenth stages of the engine compressor. This accounts for smoke and fumes in the cockpit." Id. (emphasis added).

make the small turn necessary to avoid the PFSF if it were a factor. See also Staff F. ¶¶ 2.276-2.279.

R81. April 18, 1991 (PFS Exh. 127). During the course of this emergency, the pilot zoomed the aircraft approximately 3,000 to level off below a broken deck of clouds, turned toward home base, and initiated the engine airstart procedures. PFS Exh. 127 at 1. After being informed by his wingman that the aircraft was on fire, the pilot visually confirmed the fire and prepared for possible ejection. Id. After being subsequently informed by his wingman the fire was intensifying, the pilot made his decision to eject, and ejected shortly thereafter. Id. at 2. Although the aircraft was on fire, the pilot was clearly maintaining control of the aircraft through out the emergency. Had this occurred in Skull Valley, the pilot would have had the time and ability to avoid the PFSF if it had been a consideration.

R82. March 19, 1996 (PFS Exh. 184). This accident was an engine failure that occurred while undertaking training maneuvers on the range.[49] After the initial indications of a problem, which included a "loud bang, heavy aircraft vibrations, caution lights and trailing smoke, the pilot "immediately" proceeded with the critical action procedures and attempted an airstart. He also requested a snap vector to Alpena Airbase, Michigan, responded to input from his flight lead, and subsequently began a descent to maintain an airspeed of approximately 200 knots. Id. at 2. As the situation continued to deteriorate and with no indications of a

[49] PFS Exh. 184 at 1, ¶A (History of Flight), at 6 (Opinion as to the Cause of the Accident), and at 2, ¶d(Flight). The State incorrectly categorized this aircraft as being on fire, although the aircraft "appeared to be on fire" at the time. Id at 2, ¶d (Flight). The accident was caused by a loss of oil which in turn caused the engine to seize. The investigator stated in his Opinion as to the Cause of the Accident: "Based upon the evidence which I found to be clear and convincing, the mishap aircraft engine failed and seized due to catastrophic failure of the number one engine bearing." Id. at 6. Thus, this accident was caused by a mechanical failure similar to that which caused the January 13, 1991 accident in which a seized engine bearing caused smoke but not fire.

engine airstart, the pilot informed his flight members he would have to eject. He subsequently ejected and the aircraft impacted on range property. Id. at 2-3. There is no indication that the aircraft was out of control and had this occurred in Skull Valley the pilot would have had the time and opportunity to avoid the PFSF if it were a consideration.

R83. September 3, 1990 (PFS Exh. 113). This accident was discussed above. The pilot flew for approximately 30 seconds from the time of the initial indications of a problem until ejecting. After being advised of the fire, the pilot initiated a zoom in accordance with emergency procedures. After making the decision to eject, the pilot radioed his intentions to other flight members and then ejected.[50] There is nothing in the report to indicate the pilot rushed his decision to eject because of the fire or failed to take any appropriate actions prior to ejecting. Since the pilot zoomed in accordance with emergency procedures, took the time to inform other flight members of his intention to eject, and there was no damage done to civilian property,[51] it is reasonable to assume the pilot would have made the small turn necessary to avoid the PFSF or other facility on the ground, if it were a factor. See also Staff F. ¶¶ 2.280-2.281.

R84. February 19, 1993 (PFS Exh. 147). This accident was discussed above. As noted above, the pilot terminated the air-to-ground bombing passes and climbed to an altitude just below the clouds prior to ejecting. The pilot had adequate time to turn and avoid a facility such as the PFSF if it had been a factor. See also Staff F. ¶¶ 2.199, 2.253-2.256.

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[50] PFS Exh. 113 at 2, ¶4 (Flight).

[51] Id. at 2, ¶5 (Impact).

R85. June 25, 1995 (PFS Exh. 180). In this accident the aircraft experienced an engine fire and the pilot ejected while in control of the aircraft. The report states: "Hosea 43 reported Hosea 42 was on fire. The engine never recovered and with a confirmed fire the MP [mishap pilot] safely ejected approximately two minutes into the emergency."[52] The aircraft impacted on a wooded hill.[53] During the two minutes from the onset of the emergency until the pilot ejected, he executed the critical action procedures for low altitude engine failure/airstart. This included zooming the aircraft from 2,000 ft AGL, at which it had been flying, and establishing a 200-220 knot glide, attempting to restart the engine, jettisoning external stores, and starting the Jet Fuel Starter. With a confirmed fire and the engine producing no thrust, the pilot prepared to eject and ejected at 2,000 ft. AGL. [54] Thus, the accident report shows that the pilot clearly had time and the ability to make the small turn that would have been necessary to avoid the PFSF or a similar facility if it would have been necessary.

R86. December 16, 1991 (Joint Exh. 4). This accident occurred after leveling off at approximately 16,300 ft. MSL following a take-off and climb. After the initial indications of an engine malfunction, the pilot followed the critical action procedures for initiating an engine airstart, requested a vector to an emergency airfield and turned toward the airfield. During this time, he was informed by his wingman that he was on fire. Based upon a second confirmation that the aircraft was on fire and an unsuccessful airstart attempt, the pilot initiated "a controlled ejection in accordance with Dash-One emergency procedures."[55] He had

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[52] PFS Exh. 180 at 1, ¶A (History of Flight); see also Id. at 3, Para D (Flight Activity).

[53] Id. at 3, ¶E (Impact).

[54] Id. at 3, ¶D (Flight Activity).

[55] Joint Exh. 4 at 3-4, ¶2.d.(2) (Flight Operations).

descended approximately 5,300 feet during this time and the "controlled ejection" was initiated at approximately 11,000 Ft. MSL.[56] The report shows no indication that the pilot had rushed anything even though the aircraft had been reported on fire. In fact, the pilot confirmed the fire prior to making his decision to eject.[57] Had this have happened in Skull Valley, the pilot would have had ample opportunity and the capability to avoid a ground facility such as the PFSF.

R87. As shown by the accident reports, the State's characterization of these 11 accidents as ones in which fire caused the pilot to have to eject such that he could not have avoided the PFSF was incorrect. First, the accident reports show that in two of the accidents, contrary to the State's claims, the aircraft was not on fire. Second, and more importantly, in no case did fire or smoke require the pilot to eject immediately and before he could have maneuvered, if necessary, in order to avoid the PFSF if the mishap had occurred in Skull Valley.

(2) State Presumption Regarding Pilot Maneuvers in an Emergency

R88. The State correctly observes that in the event of an engine failure, the pilot will execute a "zoom" maneuver to gain altitude and time to respond to the emergency. State F. ¶ 61; see also PFS F. ¶ 68. After climbing and thereby decelerating to approximately 250 knots, the pilot will push the nose of the aircraft over and begin a gliding descent at a speed of approximately 200 knots. State F. ¶ 62; see also PFS F. ¶ 68. The State then claims that "the pilot would then turn the aircraft toward Michael Army Air Field . . . ." State F. ¶ 62. The pilot, however, would not automatically head toward Michael AAF. See PFS F. ¶¶ 50-51. In fact, Col. Bernard testified that would not be his initial inclination:

[56] Id. at 4 ¶3.a (Ejection Seat).

[57] Id. at 4, ¶2.d.(2) (Flight Operations).

Q. Would you -- if there's an emergency like a failed engine, would you point towards Michael Army Airfield? Would that be the inclination?
A. No.
Q. No, you wouldn't head --
A. No, you'd point the airplane towards some unpopulated area.

Tr. at 3922 (Bernard)[58]

R89. For an engine failure to ultimately cause the aircraft to impact at the latitude of the PFSF, the aircraft would have to suffer the failure roughly 17 miles north of the site. PFS F. ¶ 50. That would put the aircraft approximately 35 miles from Michael AAF with no way of getting there without restarting the engine. Id. Thus, it is more reasonable to conclude that the pilot would head toward lower terrain, e.g., in the middle of Skull Valley, to maximize his time aloft and to provide him with a more suitable place to eject. Id.

(3) Visibility of the PFSF

R90. The State then claims that during the 200-knot gliding descent, the pilot would not be able to see at various distances in front of the aircraft depending on his altitude. See State F. ¶ 62. However, regardless of the pilot's altitude, he will be able to see the flight path marker of the aircraft, which indicates where the aircraft would impact the ground if the aircraft continued on its glide path. Tr. at 13643 (Fly). Thus, the pilot would be able to see where the aircraft would or would not hit before he ejected. Id.; see also PFS F. ¶¶ 135-137. In fact, Col. Cosby

[58] Counsel for the State then asked him, "Well, I mean assuming that you're trying on engine restart and you were going to recover and land it somewhere." Tr. at 3922 (Soper) (emphasis added). To which Col. Bernard responded, "Well, Michael Army Airfield is a primary . . . , if you have an engine failure, it's a place you can glide into and land the airplane, so you might try and head for that initially, to decide whether or not you've got enough altitude and airspeed to put the airplane safely on the ground without having to bail out of it." Tr. at 3922-23 (Bernard). At the point where an aircraft engine failure would potentially put the PFSF at risk, i.e., the northern end of Skull Valley the aircraft would not have enough altitude and airspeed to glide to Michael AAF. PFS F. ¶50.

specifically refers to use of the flight path marker as a reference for where his airplane was headed while describing his maneuvering during the accident. Tr. at 4014, 4022 (Cosby). Lt. Col. Horstman expressly conceded that if the nose of the aircraft obstructed the view of a site on the ground while the aircraft was in a "glide descent" (after zooming subsequent to an engine failure), the aircraft "would overfly" the site before ground impact would occurred. Tr. at 8478-79 (Horstman).

R91. The State also claims that the pilot will slow the aircraft down before ejecting by "raising the nose of the aircraft to at 20 degrees above the horizon," which will block the view of the pilot. State F. ¶ 62. On the contrary, there is no requirement for a pilot to raise the nose of the aircraft 20 degrees above the horizon prior to ejecting. See Section III.B.9(d)(4), infra. The prescribed emergency procedure in the pilot's manual only tells the pilot to eject at the "lowest practical airspeed," not to raise the nose 20 degrees. PFS Exh. PPP at 3-42, 3-43 ¶ 7; see Tr. at 3604-05 (Fly). Finally, a pilot would turn to avoid the PFSF before he ejected, so even if he were to raise the nose of the aircraft, by the time he was doing so he would no longer be pointed at the PFSF. See, e.g., Tr. at 4512 (Horstman, pilot would decide to turn away from the PFSF while in gliding descent).

c. Fraction of Accidents Leaving Pilot in Control of Aircraft

R92. The *R* factor as calculated by PFS has two components: 1) the probability that an accident would leave the pilot in control of the aircraft with time to avoid a site on the ground, and 2) the probability that, given these conditions, a pilot would actually avoid the PFSF. State F. ¶ 64; PFS F. ¶ 67. PFS determined that the probability that an accident would leave the pilot in control was 90 percent, based on its review of 10 years of F-16 accident reports. State F. ¶ 65;[59] PFS F. ¶ 69.

R93. The State states that PFS excluded from its database the accident of December 19, 1991 in which the aircraft disappeared after take off and was never heard from again. State F. ¶ 65. Col. Fly testified that the accident was excluded from the database because PFS had no way to consider it, in that PFS had no information about the accident other than that it did not occur on takeoff. Tr. at 13113-27 to –29 (Fly); see PFS Exh. 210. Therefore, it was reasonable for PFS not to include the accident in its analysis, and the State has not identified any error introduced into PFS's analysis as a result of its exclusion.

R94. The State notes that PFS found that in 42 percent of all of the F-16 accidents the pilot did not have control of the aircraft and asserts that PFS arrived at a probability that 90 percent of the accidents in Skull Valley would leave the pilot in control by "eliminating" accident reports that PFS found not to be relevant to Skull Valley. State F. ¶ 66. It later asserts that PFS selected the data for its assessment of the accident reports "in a subjective manner." State F. ¶ 68. As described in great detail in the record, for each accident, PFS's experts independently assessed whether it would have left the pilot in control with time to avoid a site on the ground and it assessed whether the accident could have happened in Skull Valley. PFS F. ¶¶ 71-74. PFS did not select data in a subjective or biased manner. Tr. at 8875-78 (Jefferson). The accidents that PFS "excluded" were those that could not have happened in Skull Valley (e.g.,

[59] The State states that PFS reviewed 121 accident reports in which the aircraft was destroyed. See State F. ¶ 65. In fact, PFS reviewed 117 accident reports in which 121 aircraft were destroyed (some accidents were mid-air collisions in which both aircraft were destroyed). See Aircraft Report Tab H at 3-4; Tr. at 13008 (Jefferson).

accidents caused by mid-air collisions during air-to-air combat training) and hence could not have posed a hazard to the PFSF. PFS F. ¶ 72.

R95. In this respect, Lt. Col. Horstman fully agreed that this 42 percent included accidents involving activities that would only take place on the restricted ranges – e.g., air-to-air combat – and that it would be improper to include such accidents as Skull Valley-type events in evaluating a pilot's ability to avoid a site on the ground. Tr. at 8370-71 (Horstman). Tab Y to the Aircraft Report sets forth 35 such accidents that occurred during aggressive combat maneuvers that do not take place in Skull Valley. By the same rationale, it would inappropriate to include as Skull Valley-type events accidents initiated by the special circumstances involving take-offs and landings, or other activities that would not occur in Skull Valley. See Aircraft Report, Tab H.

R96. The State claims that in the accidents PFS assessed as leaving the pilot in control with time to avoid a site on the ground that "5 reports show the pilot ejected during an uncontrolled spin or the aircraft was otherwise uncontrollable." State F. ¶ 66 (citing PFS Exhs. 145, 118, 124, 113, 147). As discussed above with respect to each accident, the State is wrong. None of those accidents, had they occurred in Skull Valley, would have left the pilot unable to avoid the PFSF. Indeed, Lt. Col. Horstman agreed that three of these accidents would have left the pilot in control of the aircraft and able to avoid the PFSF. See PFS Exh. X (accidents of Sept. 3, 1990 (PFS Exh. 113), Jan. 13, 1991 (PFS Exh. 118), and Dec. 17, 1992 (PFS Exh. 145)).

R97. The State also claims that "11 reports . . . show the F-16 was on fire when the pilot ejected." State F. ¶ 66 (citing PFS Exhs. 119, 145, 158, 110, 118, 127, 184, 113, 147, 180; Joint Exh. 4). The State implies that the fact that the aircraft was on fire means that the pilot would not have been able to avoid a site on the ground. But as discussed above, that is not the case.

R98. The State claims that PFS's assessment that 90 percent of the accidents would leave the pilot in control is inconsistent with a statement by F-16 manufacturer, Lockheed Martin, that 36 percent of the Class A mishaps involving the F-16 are caused by engine failure. State F. ¶ 67 (citing State Exh. 56). First, PFS's conclusion was soundly based on its expert witnesses' specific evaluation of each of the F-16 accident reports over the 10-year period from FY89 to FY98. Second, considering the whole database, PFS assessed that 57 out of 121 accidents in which the aircraft was destroyed – 47 percent – were caused by engine failure. See Aircraft Report Tab H, Table 4; Tr. at 13007 (removing entry of Feb. 24, 1994, Jefferson).[60] Thus, there is not a great difference between the PFS and Lockheed Martin assessments when one considers that the Lockheed Martin statement covers accidents over an unknown period of time and includes Class A mishaps in which the aircraft was not destroyed. See State Exh. 56. Third, PFS assessed that 54 out of the 61 accidents that could have happened in Skull Valley – 89 percent – were caused by engine failure. See Aircraft Report Tab H, Table 4; Tr. at 13007 (Jefferson). PFS assessed that all of those left the pilot in control with time to avoid a site on the ground. See Aircraft Report Tab H, Table 4. Therefore, the difference between PFS's assessment and the Lockheed Martin statement arises because PFS's expert panel was considering an applicable subset of F-16 Class A mishaps (destroyed aircraft), while the Lockheed Martin statement apparently applies to all F-16 Class A mishaps. In addition, the State

[60] At the hearing PFS added one accident to its database that was not listed in Tab H of the Aircraft Report. Tr. at 13004-06 (Cole). It was an accident for which the Air Force had not provided the report at the time it had provided to PFS all of the other F-16 accident reports. Id at 13005. That accident did not involve an engine failure. Id.

expert witness agreed with the PFS analysis of which accidents were caused by engine failures.[61] Thus, there is no inconsistency.

d. Fraction of Accidents in Control in Which the Pilot Would Avoid the PFSF

R99. PFS's panel of expert witnesses assessed the probability that a pilot in control of his aircraft following an in-flight emergency would actually avoid the PFSF to be 95 percent, based on their professional judgment as experienced Air Force pilots. PFS F. ¶ 92. The assessment was based on: (1) the time the pilot would typically have based on Air Force data concerning F-16 performance in the event of an engine failure; (2) the pilot's ability to fly the aircraft and attempt to restart the engine or otherwise respond to the emergency; (3) the very slight turn required to actually avoid the PFSF; (4) the training that pilots receive to avoid inhabited or built up areas on the ground; (5) the familiarity of the pilots at Hill AFB with the location of the PFSF; (6) the wide open spaces around the PFSF, to which a pilot could safely direct his aircraft; (7) the excellent weather and visibility in Skull Valley; and (8) the F-16 flight control computer that will keep the F-16 on a straight course after the pilot ejects. PFS F. ¶¶ 92 et seq.

R100. The State attacks PFS's assessment on the grounds that: 1) the assessment is "subjective," 2) pilots will be distracted by the need to perform emergency procedures, 3) PFS's expert witnesses are unqualified to assess pilots' responses to stressful situations, 4) the Air Force does not train pilots to avoid specific sites on the ground, 5) pilots will be unable to see the PFSF, 6) pilots will be unable to avoid the PFSF and the other structures in Skull Valley, 7) Air Force training on emergency procedures is inadequate, 8) pilots will be distracted by stress, 9)

[61] See PFS Exh. X; Tr. at 4411-12 (Horstman). Lt. Col. Horstman did not mark up or disagree with any accident with respect to whether it was an engine failure.

weather will obstruct the pilots' view of the PFSF, 10) the nose of the aircraft will obstruct the pilots' view, 11) the F-16 accident reports allegedly do not support PFS's conclusions, and 12) PFS's analysis requires impermissible dependence upon a third party "outside the regulatory loop" for the safety of the PFSF. Most of the State's claims have already been addressed. See PFSF ¶¶ 92 et seq. Nevertheless, we respond to each of them in order here, noting our earlier reasoning in our findings, and we show that none of the State's claims have merit.

(1) Objectivity of PFS Determination of Likelihood of Pilot Avoidance

R101. The State alleges that PFS's assessment of the likelihood of pilot avoidance was "a purely subjective determination." State F. ¶ 69 (citing Tr. at 8882 (Jefferson)). On the contrary, as described above, PFS's determination was based on its experts using their judgment and experience to evaluate objective facts and reach a reasoned conclusion. Nowhere on Tr. 8882 or elsewhere in the record did Gen. Jefferson describe PFS's determination as subjective. Rather, General Jefferson states his agreement there with Judge Lam that the 95% determination is the collective "expert opinion" of the PFS expert panel of the likelihood that pilots would be able to avoid the PFSF based on (1) the excellent training received by U.S. Air Force pilots, (2) the prominence of the facility compared to its surrounding landscape, and (3) the sufficient time available for pilots to take action to avoid the facility. This testimony parallels General Jefferson's testimony earlier in the hearing. When counsel for the State asked Gen. Jefferson whether the determination was "a subjective determination based on your collective opinions," Tr. at 3215 (Soper), Gen. Jefferson replied, "No, . . . it's our expert opinion based on data that we gathered as to the amount of time a pilot would have in a controlled situation and his ability to do things like start the engine, see what's outside, what to avoid." Tr. at 3215 (Jefferson).

R102. The Aircraft Report, where this determination was first presented, describes the evaluation undertaken by Gen. Cole, Gen. Jefferson, and Col. Fly of the time a pilot would have to direct the aircraft away from the site, the pilot actions required to avoid the site, and other factors affecting a pilot's ability to avoid the site. From this evaluation, they concluded based on their combined professional judgment derived from their extensive cumulative Air Force experience that pilots in control of the aircraft and capable of avoiding the PFSF would invariably do so. Aircraft Report at 18-19.

R103. The State claims that PFS made its evaluation without performing a calculation and before it assessed the accident reports with respect to pilot avoidance. State F. ¶ 69. There is, however, no requirement for expert opinion to be based on formal calculation or statistical analysis. Moreover, the State ignores that PFS's expert panel did calculate the time that a pilot would have available following a typical engine failure to avoid the PFSF (with which the State has not taken issue). Aircraft Report, Tab U. Further, although PFS made its determination before reviewing the accident reports, it found upon reviewing the reports a significant number of cases in which pilots took steps to avoid sites on the ground and <u>no</u> cases in which a pilot could have avoided a site on the ground but did not. Aircraft Report at 19. Thus, PFS concluded that:

> Based on the data from the accident reports, the probability that a pilot with the time and opportunity to direct a crashing F-16 away from the PFSF would <u>fail</u> to do so could reasonably be set at zero. Nevertheless, although the percentage could reasonably be set at zero based on the factors described . . . and the supporting data from the accident investigation reports, PFS has chosen to set the percentage, as a conservative upper bound, at 5%.

Id. (emphasis in original). Thus, the final numerical value for the probability that a pilot in control of the aircraft would avoid the PFSF was shown to be conservative from the available data and hence the fact that it was not the product of a calculation does not undermine PFS's assessment or impugn its conclusion.

(2) Pilot Distraction During Emergencies

R104. The State states that the 95 percent probability that a pilot in control would avoid the PFSF "represents the percentage of time that a pilot will be successful . . . 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, [and] in directing the aircraft away from the PFS site while also directing the aircraft way from any populated areas . . . ." State F. ¶ 70. The State's argument, however, completely ignores the general situational awareness that pilots are trained to maintain; the specific awareness that they would have of the PFSF based on its visual prominence, its identification in DoD and UTTR instructions, and briefings before flying on the UTTR; and uncontradicted testimony that an Air Force pilot's basic flying skills includes the capability to simultaneously accomplish multiple tasks. In its proposed findings, PFS described in detail the actions a pilot would take in avoiding the PFSF in the event of an accident and showed that avoiding the facility would not be difficult for an Air Force pilot to accomplish, even while the pilot was performing the other actions he normally would in response to an engine failure. PFS F. ¶¶ 93-98; see also Tr. at 3607-08 (ejection checklist, Fly).

(3) PFS Witnesses' Experience

R105. The State criticizes PFS's witnesses for never having ejected from an F-16 and criticizes Gen. Cole and Gen. Jefferson for never having flown an F-16. State F. ¶

71. First, State witness Lt. Col. Horstman never ejected from an F-16 either. Horstman Test. at 15. On the other hand, the Board heard testimony regarding pilots' responses to emergencies from Col. Bernard and Col. Cosby, both of whom have ejected from F-16s.

R106. Second, PFS's witnesses have extensive professional experience that allows them to accurately assess what a pilot would be able to do in an emergency situation. Gen. Cole served in the Air Force for 30 years. Tr. at 3147 (Cole). As Chief of Safety of Air Force he directed the entire USAF safety program. PFS F. at 1. He also served as a wing commander. PFS Test. at 2. As a pilot, he was Instructor and Flight Examiner (Check Pilot) qualified and flew airdrop, special operations low level, and night vision goggle missions, including clandestine approaches to airfields and blackout landings. PFS F. at 4-5. He has 6,500 total flying hours in seven different types of aircraft. Id. at 5.

R107. Gen. Jefferson served in the Air Force for over 30 years. PFS F. at 5. He served with the Strategic Air Command as a B-52 wing commander and has 4,450 flying hours in 9 different aircraft types. Id. He was formally trained by the Air Force at the Air Force Safety Center to serve as an Accident Board President. Id.

R108. Col. Fly served in the Air Force for 24 years. Id. at 6. He served as an F-16 pilot, instructor, squadron commander, operations group commander and wing commander. Id. Two of these assignments were as a formal training course instructor pilot where he taught pilots how to fly the F-16, employ the weapons, and academic subjects such as air-to-air combat and the physiological effects of high G maneuvering, to include G-induced Loss of Consciousness (GLOC). See Tr. at 13027-29 (Fly). He has approximately 1,200 flying hours in the F-16. PFS

Test. at 6. Id. He served as Commander of the 388th FW at Hill AFB, during which time he flew F-16s on the UTTR and through Skull Valley. Id.

R109. Third, all of PFS's expert witnesses testified regarding experience they had dealing with emergencies or serving in combat in which pilots must fly their aircraft in difficult situations under great stress. Gen. Cole served in Vietnam and flew 1,000 hours in combat in the AC-47 aircraft. Tr. at 3160-61, 3608-10 (Cole). Gen. Jefferson served in Vietnam flying defoliation missions at very low level, in formation, under enemy fire. Tr. at 3624-25 (Jefferson). He also experienced an in-flight emergency early in his career in which his aircraft was in apparent danger of exploding due to a fuel tank fire, yet he landed the aircraft successfully. Tr. at 3622-24 (Jefferson). Col. Fly experienced a number of in-flight emergencies during his career that required him to respond under stress. Tr. at 3615 (Fly). He described one example in which he landed an F-4 aircraft that had suffered a flight control malfunction that was not covered in the aircraft emergency procedures. Id. at 3615-18. Therefore, for the foregoing reasons, PFS's witnesses are well-qualified to assess a pilot's ability to respond to an in-flight emergency under stressful conditions and to avoid the PFSF in the event of a crash in Skull Valley. By contrast, Lt. Col. Horstman's testimony reflects no experiences he had in dealing with emergencies.

(4) U.S. Air Force Training

R110. The State asserts that there is only one line in the pilot's manual for the F-16 that instructs pilots to direct their aircraft away from populated areas before ejecting, State F. ¶ 73, and claims that the Air Force only intends for pilots to avoid "a large geographical area, not a specific site or targets on the ground," State F. ¶ 74. The State's insinuation that Air Force pilots would not even try to avoid the PFSF is clearly incorrect and at odds with the evidentiary record. The State ignores the testimony of every pilot that appeared before the Board, including that of its own expert witness, Lt. Col. Horstman. All the pilots appearing before the Board, including Lt. Col. Horstman, testified that they would certainly attempt to avoid the PFSF, knowing that it was a nuclear waste storage site, or any sort of industrial facility with nothing else around it, if they could. PFS F. ¶ 141.[62] This claim is refuted in further detail in PFS's proposed findings. See PFS F. ¶¶ 140-142.

(5) **Visibility of the PFSF**

R111. The State asserts that the PFSF will be difficult for a pilot to identify because it will be too small and too far away. State F. ¶ 74. However, the State ignores both the prominence of the facility in the otherwise sparse landscape and the knowledge that the pilot would have of the terrain and the location of the PFSF even absent visual sight of the facility. It will have a 90 ft. tall canister transfer building, PFS F. ¶ 159, and comprise a large fenced area surrounded by 130 ft. lamp poles, id. ¶ 97. Lt. Col. Horstman agreed that the PFSF would be one of the largest built-up areas and would have perhaps the tallest structure in Skull Valley and would be of "fairly unique" appearance. PFS F. ¶ 138. Col. Fly testified that he could see ranch houses from the air at a distance of five miles. Id. Observing their surroundings is something pilots constantly do while they are flying their aircraft. Tr. at 3551-53 (Fly), 3599 (Cole), 4019 (Cosby); see Tr. at 3989-91 (Cosby). Thus, if a pilot were pointed at the PFSF in the event of a mishap in Skull Valley, he would very likely be able to see and identify the facility.

[62] The State cites the PFS Aircraft Report Tab R to support its claim that the PFSF itself would look like an unpopulated area. See State F. ¶ 74. Tab R makes no such statement.

R112. Further, as PFS discussed in its proposed findings, in addition to its visibility, because of the nature of the facility, the location of PFSF within the middle of the valley will be well known to the pilots who fly through Skull Valley. PFS F. ¶ 97. From the time the pilot enters Skull Valley about 25 miles to the north of the PFSF he will have mountains on both sides, a road down the center of the valley and a railroad to the west side of the valley. He will also have a flight plan developed, a flight map of the area, and will know his course of flight in relation to these prominent landmarks, including the PFSF facility. See PFS F. ¶¶ 132-33 (discussing pilots' use of landmarks and instruments in the event of reduced visibility due to weather). These factors, which the State does not dispute, would provide the pilot with the knowledge of where he was in comparison to these prominent landmarks as well as the PFSF, well before he actually saw the facility.

R113. Thus, the State's postulated scenario, in which the pilot would suddenly have to look for the facility 3.22 miles in front of him before he could avoid it (State F. ¶ 74) is simply inaccurate. He would see the facility long before that point. Furthermore, a pilot flying generally down the middle of the valley would know that the facility was ahead of him and would be aware of the wide open areas to the west to which he could easily divert and avoid the PFSF, and all other structures in Skull Valley, even if he did not see the facility. Similarly, a pilot following the predominant route of choice through Skull Valley five miles to the east of the site could simply continue in the same general direction and for further assurance could make a simple turn to the left towards the Stansbury Mountains just before ejecting to ensure avoidance of the PFSF and other inhabited structures in the general environs. PFS F. ¶98. Thus, the premise of the State's postulated scenario is faulty. The pilot would see the PFS site. Even if he did not, it would remain relatively easy for him to avoid it.

(6) Pilot Avoidance of Other Populated Areas in Skull Valley

R114. The State then implies that a pilot would have difficulty avoiding the PFSF because he would also wish to avoid other populated areas in Skull Valley. State F. ¶ 75. The State's premise of its postulated dilemma is faulty. As PFS discussed in its proposed findings, the PFSF is surrounded by wide open spaces. There are no structures at all within two miles of the facility. To the west of the facility there is nothing but flat, open ground for a distance of 10 miles. PFS F. ¶ 98; see also Staff F. ¶ 2.299. Thus, there is a large expanse into which a pilot suffering a mishap while flying in the general direction of the PFSF and the other structures in the general environs could direct his aircraft without hitting anything.

R115. The State claims that two F-16 accident reports show that a pilot would have difficulty avoiding the PFSF. See State F. ¶ 75 (citing accidents of July 11, 1996 and August 31, 1992). The July 11, 1996 accident (in which the aircraft struck a house) occurred after an engine failure during an attempted emergency landing at the Pensacola Regional Airport. See PFS F. ¶ 150. At the point the pilot realized he could not make it to the runway, "[t]here were houses everywhere he looked below him." Id. The pilot nonetheless continued maneuvering the airplane to avoid structures on the ground up to the very last moments possible. In contrast to that accident, with "houses everywhere," the PFSF will be an isolated facility with a miles of open space around it where a crashing aircraft pointed at the PFSF could easily be directed to impact the ground without hitting anything that could be damaged. See id. ¶ 151.

R116. In the August 31, 1992 accident, the pilot did not hit anything. Id. ¶ 169. The accident report stated that the aircraft impacted approximately 150 yards from two inhabited dwelling structures. PFS Exh. 140 at 4. The land on which the aircraft impacted was a "wooded area," id. at 2, that "contained primarily trees and underbrush," id. at 4. By contrast, the PFSF will be obviously visible in the middle of Skull Valley and would not be difficult for a pilot to see in the event of an accident. See PFS F. ¶ 138.

(7) Air Force Training On Emergency Procedures

R117. Next, the State criticizes Air Force training because responding to engine failures is practiced only on simulators. See State F. ¶ 76. Simulator training, however, is thorough and realistic. The simulator looks like an F-16 cockpit and contains the same instruments. Tr. at 3333-34 (Fly).[63] It enables a pilot to practice navigation, flying in bad weather, air-to-air combat, and some bombing missions. Id. at 3334. The simulator can also simulate the failure of any of the aircraft's systems. Id. "There are literally hundreds of emergencies that the F-16 simulator simulates, and they put the pilot through real-time stresses and radio calls . . . , those kinds of extraneous and external inputs to the pilot, so that the pilot can focus on the task at hand and solve whatever he is presented with . . . ." Tr. at 13260 (Horstman).

R118. Thus, a pilot can practice responding to an engine flameout by going through all of the emergency procedures up to and including pulling the ejection handles if the engine fails to restart. Tr. at 3334 (Fly); see also id. at 3810. Pilots rehearse emergency procedures extensively and are regularly tested on them, both on the ground and in the simulator. Tr. at 3330-31 (Cole), 3811 (Fly), 13260

[63] The transcript erroneously indicates the testimony as having been presented by Gen. Cole.

(Horstman). They practice simulated ejections twice per year. Tr. at 4015 (Cosby). Col. Cosby testified that this thorough training enables a pilot to respond automatically or instinctively to emergency situations and that part of the pilot's instinctive response includes the pilot knowing where he is and what he might wish to avoid hitting on the ground. Tr. at 3988-90 (Cosby). Lt. Col. Horstman testified that his F-16 training was "magnificent"—"the finest flight training, beyond a shadow of a doubt." Tr. at 8548-49 (Horstman). Thus, there is no basis to support the State's claim that Air Force emergency procedure training is insufficient to enable a pilot to avoid the PFSF if he were to suffer an engine failure in Skull Valley.

R119. Next, the State criticizes Air Force training for not including practicing ejections from an aircraft. See State F. ¶ 76. It argues that the simulator does not produce the sensation of ejection. Id. It claims that until a pilot actually ejects, "the pilot has never fully experienced that sensation nor made decisions relating to where the aircraft will impact." Id. (citing Tr. at 3333-37 (Cole/Fly)). However, Air Force training provides pilots with a sense of what ejection feels like by putting them through a simulated ejection in an ejection seat that actually shoots them into the air. Tr. at 3335-37 (Fly). Col. Fly testified that with the combination of training and the simulated ejection, "the Air Force does everything they can to make you as prepared as you can possibly be so that when you're faced with that decision [to eject], you will make the correct one." Tr. at 3338 (Fly). The avoidance of areas on the ground, is discussed during emergency procedures training. Tr. at 3810. As noted above, Col. Cosby testified that being aware of his surroundings and what he might wish to avoid on the ground is part of the pilot's instinctive response to emergencies that is developed by rigorous training.

Tr. at 3989-90 (Cosby). This instinctive response by pilots to avoid structures on the ground is borne out by the accident reports. Thus, there is no merit to the State's argument that Air Force training is inadequate to prepare pilots to be able to the avoid the PFSF in the event of an accident in Skull Valley.

(8) Emergency Stress and Pilot Error

R120. The State claims that the stress of the in-flight emergency would impair a pilot's ability to avoid the PFSF in the event of a mishap in Skull Valley. See State F. ¶¶ 77-79. PFS showed in detail in its proposed findings that this claim was unsupported. PFS F. ¶¶ 105-09, 115, 117-24. Specifically, the State first claims that a pilot would be under great stress due to fear of injury during ejection. State F. ¶ 77.[64] Contrary to the State's claim, while ejecting at high speed or while out of control can be dangerous, ejecting in the controlled situation that a pilot in Skull Valley would face after an engine failure is much safer. PFS F. ¶ 118. In fact, the F-16 accident reports showed no fatalities or life-threatening injuries resulting from controlled ejections after the kinds of mishaps that could occur in Skull Valley. Id. ¶ 119. Thus a pilot in Skull Valley would be much less likely to suffer the fear and distraction alleged by the State.

R121. The State also distorts Col. Bernard's testimony in claiming that it supports the State's position. The State asserts that "Colonel Bernard . . . testified that the greatest stress levels 'by a significant measure' faced by a pilot occur during the moments before ejection." State F. ¶ 77 (citing Tr. at 3901-02 (Bernard)). On the contrary, he only agreed that the preceding seconds before ejection was "one of the greater stress situations" compared to "other military operations, like training

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[64] The State cites Col. Bernard in support of its assertion that, "Ejection from an F-16 is a violent and dangerous procedure which can cause severe injury or death." State F. ¶ 77 (citing Tr. at 3900 (Bernard)). Col. Bernard, however, only stated that ejection was "violent" in that the pilot is ejected by a rocket; he did not state that ejection could cause severe injury or death. See Tr. at 3900-01 (Bernard).

and so forth." Tr. at 3901-02 (Bernard). He did not testify or agree that the stress would prevent him from performing applicable emergency procedures. See id. The State claims that Col. Bernard testified that "you have a period of divided attention during an emergency that 'completely becomes focused on what you need for your survival.'" State F. ¶ 77 (citing Tr. at 3898 (Bernard)). Col. Bernard, however, was describing the shift in focus of the pilot's attention from the mission to the emergency in the case where he has a problem that is not immediately obvious. Tr. at 3897-98 (Bernard). Moreover, he testified, regarding his "ability prior to ejection to focus on matters other than [his] survival," Tr. at 3896 (Soper), that "in a controllable airplane and in an area that's heavily settled, I think you would spend a substantial amount more time directing the plane away from populated areas and/or things that you wanted to avoid on the ground," id. at 3896-3897 (Bernard) (emphasis added). Thus, Col. Bernard's testimony simply does not support the State's claims.

R122. Next, the State cites a 1996 message from the Air Force Chief of Safety to support its assertion that pilots will make errors in emergency situations, focusing on past ejections below the minimum recommended safe altitude of 2,000 ft. AGL. State F. ¶ 78 (citing State Exh. 57). However, the document concerned ejecting below 2,000 ft. AGL, not controlling the aircraft or directing it. Tr. at 3318-19 (Jefferson). Furthermore, the message was sent out to address a problem six years ago and thus it is no longer current. Id. at 3319. Gen. Cole, who was the predecessor to the Chief of Safety who sent the message, stated that the message was a management and leadership tool intended to get aircrews to refocus on what was important to flight safety. Tr. at 3323-25 (Cole).

R123. Regarding ejecting below the recommended altitude of 2,000 ft. AGL, while PFS assumed for its analysis that pilots would eject at 2,000 ft., ejecting below that altitude would not mean that the pilot would be unable to avoid the PFSF. PFS F. ¶¶ 123-24. This is self evident from the accident reports in which pilots continued to fly the aircraft below 2,000 ft, including taking steps to avoid sites on the ground. In the context of the Chief of Safety message, Gen. Cole testified that depending on the circumstances of the mishap it may be easy for a pilot to make a controlled ejection below 2,000 ft. AGL. Tr. at 3321 (Cole). The 2,000 ft. level is not an absolute limit; pilots may use judgment to go somewhat below it if, for example, they believe they can save their aircraft by doing so. Id. at 3321-22; see also PFS F. ¶ 124. Therefore, the message provides little support to the State's claim that stress would prevent a pilot from avoiding the PFSF in the event of an accident.

R124. The State cites a statement by Lockheed Martin that 52 percent of F-16 Class A mishaps "have been caused by pilot error." State F. ¶ 78. That statement is entitled to little if any weight in this proceeding in that it pertains to many mishaps that are unrelated to pilot avoidance of the PFSF in Skull Valley. As discussed in Section III.B.9.c, supra, that statement concerns all F-16 mishaps, including those occurring during takeoff and landing and aggressive maneuvering in simulated combat training, not just those in which the pilot is in control of the aircraft with the time to avoid a site on the ground like the PFSF.

R125. The State then asserts that "[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." State F. ¶ 79 (citing Horstman Test. at 18-19). Lt. Col. Horstman stated on cross-examination, however, that his claim was an overgeneralization and that the focus of a pilot would depend on the circumstances of the accident. Tr. at 8445-46 (Horstman). He later stated that in the event of an engine failure, a pilot would have time and "he would avoid the [PFS] site." Tr. at 8502 (Horstman); see also PFS F. ¶ 105. While the pilot is responding to an engine failure he is flying the aircraft and maintaining awareness of his location and the location of anything on the ground he would not wish to hit. Id. ¶¶ 107-09. Finally, the State identified no actual F-16 accident in which a pilot had the opportunity to avoid a site on the ground but failed to do so because his attention was diverted by stress. See PFS F. ¶ 126. Thus, the State's assertion is simply unsupported by the large record that has been assembled on this issue.

R126. The State cites Col. Cosby's testimony for the proposition that a pilot would spend his time attempting to restart his engine to the exclusion of other emergency procedures or avoiding a site on the ground. State F. ¶ 79 (citing Tr. at 4030 (Cosby)). The State takes one answer to a hypothetical question out of context and ignores the rest of Col. Cosby's testimony. First, Col. Cosby only agreed that there were "some circumstances"—never defined—in which a pilot's attention may be diverted from trying to avoid the PFSF. Tr. at 4030 (Cosby). He never stated that he had focused on his engine failure to the exclusion of performing any emergency procedure. Second, regarding whether stress would impact a pilot's ability to respond to an emergency, Col. Cosby testified that rigorous Air Force training makes responding to an emergency a mechanical and instinctive process, even under stress, including the pilot's maintaining awareness of his location and the location of things on the ground that he would not want to hit. Tr. at 3987-91 (Cosby). Regarding whether a pilot could respond to an emergency and avoid a site on the ground simultaneously, Col. Cosby stated that pilots are good at "multitasking," i.e., performing different tasks simultaneously. Id. at 3994-95. Regarding whether stress would impair a pilot's ability to avoid the PFSF while completing his emergency procedures, Col. Cosby stated that as long as the stress was psychological and not physical the pilot would follow the critical action procedures he had been regularly trained to employ in response to an emergency and he would still be able to avoid the site. Tr. at 4027-28 (Cosby). Therefore, Col. Cosby's testimony supports PFS's position regarding a pilot's ability to avoid and does not support to the State's proposition that stress would distract the pilot from avoiding the PFSF.

R127. Regarding Col. Cosby's accident itself, the State claims that Col. Cosby testified that he spent too much time and attention trying to restart the failed engine. State F. ¶ 80 (citing Tr. at 3978-80 (Cosby)).[65] However, despite his attempts to restart the engine, Col. Cosby twice turned to avoid things on the ground he did not want to hit with his aircraft—first an apartment complex and then another airplane on the taxiway of the airport at which Col. Cosby was trying to land. Tr. at 3980-81 (Cosby).[66] Therefore, contrary to the State's claims, Col. Cosby's experience strongly support's PFS's conclusion that there is a very high probability that a pilot suffering an engine failure in Skull Valley would be able to avoid the PFSF.

[65] Col. Cosby stated that he "probably spent too much time or attention trying to get the engine restarted." Tr. at 3980 (Cosby) (emphasis added).

[66] The State asserts that the board that investigated Col. 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. (citing Tr. at 4008 (Cosby)). In fact, the board determined after a series of simulator tests that only two out of ten pilots who tried were able to land the aircraft under Col. Cosby's circumstances, notwithstanding their awareness of the flight profile and where the engine failure would happen. Tr. at 4008-09 (Cosby). In any event, potentially landing an aircraft is not an issue in Skull Valley.

R128. The State also claims that Col. Bernard's accident supports its notion that a pilot who suffered an engine failure in Skull Valley would be too distracted to avoid the PFSF. See State F. ¶ 81. Col. Bernard's accident did not occur under conditions that pilots would experience in Skull Valley, in that he was participating in a large mock battle in which he was actively engaged in combat training activities, which he continued even after his engine had failed. PFS F. ¶ 116. Thus, his attention was consumed by significant distractions that pilots in Skull Valley would not face. Id.

R129. The State claims that, "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." State F. ¶ 81 (citing Tr. at 13690-91 (Fly)). However, as Col. Fly explained, "If you had taken Colonel Bernard and put him in a typical Skull Valley position and he had the same engine problem, he would have wound up with much more time to analyze the situation and to act accordingly." Tr. at 13692 (Fly); see also Tr. at 13645-46 (Fly); PFS F. ¶ 116. If Col. Bernard's engine had failed while he was flying in Skull Valley, he would have had control of the aircraft and sufficient time, in the range of a minute or two, to avoid a site on the ground. Tr. at 13648-50, 13692 (Fly); see State Exh. 220 (engine failed while aircraft was at 480 knots and 5,900 ft. MSL/3,700 AGL); compare Aircraft Report Tab U at 4. In contrast, Col. Bernard did not pull himself away from his combat training mission and began to focus on his emergency until he was somewhere below 2000 feet AGL and 200 knots airspeed. See State Exh. 220. In Skull Valley, a pilot would be at approximately 3,000 to 4,000 ft. AGL and 350 to 400 knots. PFS F. ¶ 11. Thus, "the 'post strike' portion of the training mission" is not "generally representative of flying conditions that normally occur in Skull Valley," as claimed by the State. State F. ¶81.[67]

R130. Finally, the State claims that the F-16 accident was Col. Bernard's second ejection, implying that somehow his first accident should have prepared him to respond to the second and that pilots experiencing their first engine failure in Skull Valley could not respond to it any faster than Col. Bernard responded to his engine failure. State F. ¶ 81.[68] In fact, in Col. Bernard's first accident, he did not eject. Tr. at 3884, 3886 (Bernard). He had a mid-air collision during aerial refueling, in which his F-105 aircraft was severely damaged, with the canopy knocked off, and after which it was tumbling through the air out of control. Id. at 3884-86. After regaining consciousness, Col. Bernard loosened his straps and was thrown from the aircraft by G-forces. Id. at 3886. This accident was nothing like his later F-16 accident and there is no reason to believe that it prepared him better to respond to the F-16 mishap or that pilots who experience their first engine failure in Skull Valley would not avoid the PFSF.

R131. Next, the State claims that in half of the F-16 accident reports reviewed by PFS where the aircraft remained controllable with sufficient time to avoid a specific ground site, the pilot ejected below recommended minimum safe altitude of 2,000 ft. AGL. State F. ¶ 82. However, merely because the pilot ejected below 2,000 ft. does not mean that he would not have been able to avoid the PFSF. PFS F. ¶¶

[67] The State refers to PFS's classification of engine failures generally as Skull Valley-type events as support for its position. That classification however appropriately reflects that an engine failure, such as Col. Bernard's, could occur in aggressive maneuvering on the range, or in Skull Valley flight at 3,000 to 4,000 ft. It does not mean that the pilot's perceptions of what is happening or his actions during the emergency would be the same while participating in a mock battle as they would be while transiting Skull Valley.

[68] The State also asserts that Col. Bernard is "one of the most experienced fighter pilots in the world," State F. ¶ 81. This statement may or may not be correct, but there is nothing in the record to support it and the State cites nothing.

123-24; see id. ¶ 162. In fact, as discussed in Section III.B.9(d)(11), infra, in a number of cases, the pilots specifically delayed their ejection below 2,000 ft. in order to take additional actions for the express purpose of avoiding sites on the ground and were commended for doing so. Further, the accident reports make clear that descending below 2,000 ft. did not mean that the pilots were unaware of where they were or were unable to control their aircraft; rather they were actively controlling and flying the aircraft. PFS F. ¶123.

R132. The State asserts that the F-16 accident involving Maj. Tom Smith, whom Lt. Col. Horstman interviewed, represents an example of an F-16 engine failure mishap where the pilot would not have been able to avoid the PFSF. State F. ¶ 83. The accident involved an engine failure while the pilot was flying above a low undercast. See PFS Exh. 175. First, overcast conditions in Skull Valley are uncommon. PFS F. ¶ 130. However, if that accident had happened in Skull Valley, the pilot would have been able to rely on his situational awareness drawn from sighting the mountains on either side of the valley and awareness of the location of the PFSF to direct his aircraft away from it before ejecting. PFS F. ¶¶ 112-14; see id. ¶ 133. Furthermore, the record does not support Lt. Col. Horstman's characterization of the time available to Maj. Smith. Col. Fly spoke to Maj. Smith and he told Col. Fly that he had time to consider where he was and that he knew that he was over a rural area in Belgium. He stated he was concerned where the aircraft would impact the ground but was not familiar enough with the area to know of any specific sites below him. Tr. at 3223-24 (Fly); see also PFS F. ¶¶ 112-13.

R133. Lt. Col. Horstman also interviewed three other pilots who had ejected from aircraft and who assertedly stated that their thoughts were focused on their own survival and that they did not consider where their aircraft would impact. State F. ¶ 84. However, these three accidents are not relevant to whether a pilot in control of a crashing aircraft would avoid the PFSF because they were not cases in which the pilots had control of their aircraft, in the air, with time to avoid a site on the ground. PFS F. ¶¶ 110-11.

(9) **Weather Effects**

R134. The State claims that "weather conditions limiting visibility will prevent the pilot from being able to avoid the PFS site." State F. ¶ 85. The State is wrong. A pilot in Skull Valley would be aware of the location of the PFSF and would be able to avoid it even if he could not see it. PFS F. ¶¶ 131-34; see also id. ¶¶ 112-14 (discussing accident). Moreover, weather that merely "limited" visibility may not prevent a pilot from seeing the PFSF at all. See id. ¶¶ 127-31.

R135. The State claims that, "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." State F. ¶ 85. In fact, pilots flying in Skull Valley will be fully aware of the location of the PFSF, what it is, and that it is a site that they would wish to avoid in the event of a crash. PFS F. ¶¶ 97, 140-41. If the pilot knows where the PFSF is, he does not need to see the place to which he would direct his aircraft, because the PFSF is surrounded by wide open spaces with nothing to hit. PFS F. ¶¶ 98, 134.

R136. The State claims that, "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." State F. ¶ 85. It is not necessary for a pilot to literally see the PFSF in order to avoid it. Pilots will be aware of their location relative to the PFSF—through the use of situational awareness and navigational instruments—even if they were flying over a complete undercast. PFS F. ¶ 133. In addition, the evidence in fact shows where pilots have descended through clouds in order to see and avoid things on the ground before ejecting from their aircraft. See Tr. at 13579-80 (Horstman); Joint Exh. 9 at 13-14. Other accident reports show pilots above clouds taking measures to avoid populated areas as well. See Joint Exh. 11 (receiving instructions from air traffic control); see also PFS Exh. 189 (pilot in contact with air traffic control albeit over uninhabited area).

R137. The State claims that, "No evidence suggests that a pilot would turn away from the PFS site at the risk of impacting a populated area hidden by clouds." State F. ¶ 85. Again, if a pilot believed that he was in danger of hitting the PFS site, he could safely direct his aircraft away from it in the knowledge the PFSF is surrounded by wide open spaces. PFS F. ¶¶ 98, 134. An aircraft flying down the middle of the valley in the general direction of the site could easily divert to the west in the event of an accident. Id. ¶ 98. A pilot following the predominant route of flight five miles to the east of the PFSF could continue in the same direction or make a slight turn towards the Stansbury Mountains before ejecting to ensure avoidance of the PFSF and the few structures in the valley to the east of the facility. Id.

R138. The State claims that "navigation instruments cannot be relied upon to locate the PFS facility." State F. ¶ 85. On the contrary, a pilot would be able to use his instruments to maintain awareness of his location relative to the PFSF. Col. Fly discussed how a pilot would plan his route of flight through the valley before the mission and would mark the route on his map. Tr. at 13049-50 (Fly). As the pilot flew along his route, he could use his horizontal situation indicator to see his position relative to his planned course. Tr. at 13050-51 (Fly). He will be able to use his inertial navigation system, coupled with his global positioning system, to determine his location and the relative bearing and distance to the navigational turn point he has selected at the time. Tr. at 13049, 13053-54 (Fly); Revised Addendum Tab FF at 7; see id. at 27-28. He will also be able to use his Tactical Air Navigation System (TACAN) to determine his bearing and distance to the ground station he has selected at the time. Id. at 28. See also Revised Addendum Tab GG, Question 4. Furthermore, if the pilot has the PFSF itself selected as a turn point, it would put a symbol on the aircraft HUD indicating its location. Tr. at 8418-20, 13451-52, 13473 (Horstman). Therefore, instruments could be quite useful in helping a pilot to avoid the PFSF.[69]

R139. The State asserts that, "If the PFS site were programmed as a navigation or turn point, the disabled aircraft would be pointed directly at the PFS facility." State F. ¶ 85. First, that is not necessarily the case, in that F-16s fly in formation such that at least half of the aircraft in the formation would not be pointed directly at the site. Revised Addendum Tab FF at 11. It is also possible that while both aircraft were pointed in the general direction of the site, neither would be pointed directly at it. Id. Finally, if a pilot were using the PFSF as a turn point he would have very good knowledge of the location of the facility and could easily turn away from it. Id. The State also asserts that whatever navigation point the pilot had been using prior to the emergency, he would switch his navigation system to select Michael AAF as an emergency airfield. State F. ¶ 85. However, that is not necessarily the case, PFS F. ¶¶ 50-51, and the pilot would retain his knowledge of where he was and where the PFSF was immediately prior to the switch. Tr. at 13053, 13656 (Fly).

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

R140. The State asserts that a pilot's view of the PFS site will be obstructed when cloud cover is at least 50 percent and that there is a high probability it will be obstructed when cloud cover is at least 25 percent. State F. ¶ 86. It then claims that because of cloud cover at 5,000 ft. AGL or below, "[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. (citing PFS. Exh. 245). First, the presence of clouds would not necessarily obstruct the pilot's view of the PFSF. That would depend on the relative positions and altitudes of the clouds, the pilot, and the facility. PFS F. ¶ 131. Ceilings occur at or below 5,000 ft. AGL in Skull Valley only 8.5% of the time. PFS F. ¶130.[70] A pilot flying above 25 percent and 50 percent cloud cover would frequently be able to see the PFSF. Tr. at 13034-41 (Fly). In addition, with clouds at 5,000 ft. AGL, a pilot could still fly through Skull Valley at 4,000 ft. AGL and remain below them. See Revised Addendum Tab FF at 23. Second, even if clouds momentarily obstructed his view of the PFSF landmarks such as Skull Valley Road, the PFS railroad, and the Stansbury and Cedar Mountains would tell the pilot where he was relative to the PFS site. PFS F. ¶ 132. Furthermore, sometimes the weather would be bad enough that pilots would not fly in Skull Valley. PFS F. ¶ 133 n.104. Therefore, the pilot's view will not be obstructed as often as asserted by the State and in any event he would still have knowledge of his position relative to that of the PFSF and would be able to take action to avoid the facility if necessary.

[70] Cloud coverage data from Michael AAF, which is closely representative of the conditions in Skull Valley, show there is no ceiling at or below 5,000 ft. AGL and more than 7 miles visibility 91.5 percent of the time. PFS F. ¶¶ 129-130. PFS obtained the specific layered cloud coverage data cited by the State from Salt Lake City (PFS Exh. 245) because it was the closest station to the PFS site with layered cloud coverage data. Tr. at 13058 (Vigeant); see Tr. at 13061 (Fly). Nevertheless, conditions at Michael AAF are generally better than those at Salt Lake City. Tr. at 13058 (Vigeant); PFS Exh. 245 at 2.

R141. The State asserts that "[b]ecause 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." State F. ¶ 87. While a cloud that is a part of 25 percent sky cover may obstruct a pilot's view of the ground if he is just above the cloud, as a matter of simple geometry the obstruction would only be momentary, as the movement of the aircraft would change the pilot's perspective so that his view was no longer blocked. See Tr. at 13035-36, 13041-43 (Fly). Furthermore, Lt. Col. Horstman testified that a pilot's ability to maintain sight of a specific point on the ground for a sufficient length of time to land an aircraft depended on whether there was a cloud ceiling, as defined by the FAA, below him. Tr. at 13458-59 (Horstman). The FAA defines a cloud ceiling as cumulative sky coverage of five-eighths (62.5 %) or greater. Vigeant Test. at 4-5. Thus, 25 percent cloud coverage would not have the effect asserted by the State.[71]

R142. The State claims that clouds above a pilot would prevent him from "zooming" the aircraft in an emergency and thus reduce the time available to him to respond to it. State F. ¶ 88. However, as PFS noted, if the cloud layer were not solid, the mere presence of the layer above the pilot, as opposed to an actual cloud, would not prevent him from performing his normal zoom maneuver. PFS F. ¶ 130 n.101. Furthermore, on cross-examination Lt. Col. Horstman acknowledged that even if a pilot were flying just below a cloud layer he would have time to avoid the PFSF before ejecting in that he would allow his aircraft to decelerate to recommended ejection speeds before ejecting. PFS F. ¶ 134 n.105. He agreed that "most of the

[71] The State asserts that pilots cannot see through transparent clouds if they are looking through them at an angle. State F. ¶ 87. On the contrary, Col. Fly, Gen. Jefferson, and Gen. Cole all testified that although looking at an angle may be somewhat more difficult that looking straight down, a pilot could see through transparent clouds. Tr. at 13077-78 (Cole/Jefferson/Fly).

time" a pilot would have sufficient time to avoid the PFSF if he were flying as low as 2,500 ft. with a cloud layer at 3,500 ft. and many pilots would in fact do so. Id.

R143. The State concludes that, "weather conditions adversely impact a pilot's ability to see Skull Valley ground sites 50% of the time." State F. ¶ 90. On the contrary, the great majority of the F-16 flights transit Skull Valley at 3,000 to 4,000 ft. AGL. PFS F. ¶ 11. In Skull Valley there is no ceiling below 5,000 ft. AGL 91.5 percent of the time and there are no clouds at all below 5,000 ft. AGL 79 percent of the time. PFS F. ¶ 130.[72] Thus, over 91.5 percent of the time weather would have no significant impact on a pilot's ability to see the PFSF and over 79 percent of the time it would have no impact whatsoever. And as discussed above, a pilot could maintain his awareness of his location relative to that of the PFSF without having to see the site. Therefore, weather in Skull Valley would not have a significant impact on a pilot's ability to avoid the site in the event of an accident.

(10) Pilot's View During Emergency Procedures

R144. The State claims that during the zoom and glide maneuver that a pilot would execute in response to an engine failure in Skull Valley, his view of the ground in front of his aircraft would be "substantially impaired." State F. ¶ 96; see id. ¶¶ 91-95.[73] In particular, it claims that during the glide descent, the pilot's view will be obscured for a distance of approximately 5,500 feet in front of the aircraft for every 1,000 feet of altitude. Id. ¶ 94. First, the pilot would know where he was

[72] The State notes that Skull Valley experiences ground fog 2.5 percent of the time. State F. ¶ 89. The occurrence of ground fog is included in PFS's cloud coverage data. See PFS Exh. 245 (e.g., 15 Dec 01, 2100 hrs); Tr. at 13057 (Vigeant).

[73] The State claims that in response to an engine failure the pilot would turn toward Michael Army Airfield. State F. ¶ 94. That is not necessarily the case given the distance from northern Skull Valley to the airfield. PFS F. ¶¶ 50-51.

relative to the PFSF immediately prior to suffering the engine failure. Tr. at 13053 (Fly). Second, what the State fails to point out is that during the entire glide descent, the pilot will be able to see the ground in front of the aircraft sufficiently far ahead to see where the aircraft would hit if the pilot did not turn it. See PFS F. ¶¶ 135-37. Furthermore, the pilot has a larger field of view just to each side of the nose of the aircraft. Tr. at 13640-41 (Fly); see Staff Exh. 65 at 171. Thus, the pilot's view of sites on the ground that the aircraft might hit would not be obstructed.

R145. The State claims that just prior to ejecting, the pilot would "rais[e] 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." State F. ¶ 95. On the contrary, there is no requirement for a pilot to raise the nose of the aircraft 20 degrees above the horizon prior to ejecting. The ejection procedures in the pilots' operation manual make no mention of raising the nose above the horizon. The prescribed emergency procedure tells the pilot to eject at the "lowest practical airspeed." PFS Exh. PPP at 3-42, 3-43 ¶ 7. Finally, a pilot would turn to avoid the PFSF before he ejected, so even if he were to raise the nose of the aircraft, by the time he was doing so he would no longer be pointed at the PFSF. In the words of Lt. Col. Horstman, "So your decision process for where the aircraft impacts has to be made during your descent." Tr. at 4512 (Horstman); see also id. (pulling the nose up is the last action before the pilot ejects). "And if the weather was clear, I would look out and find the best place for me to land and the aircraft to land, and I would try to avoid any possible damage to anything but dirt in the desert for both me and the aircraft." Id. at 4513.

(11) Evidence from F-16 Accident Reports

R146. The State claims that before reviewing the accident reports, PFS had already concluded that 95% of the pilots would be able to avoid the site and that PFS Exh. 100A was prepared to justify the 95% component of the "R" factor. State F. ¶ 97. As discussed at the beginning of Section III.B.9(d) above, PFS's expert witnesses first assessed the probability that a pilot in control of his aircraft following an in-flight emergency would actually avoid the PFSF to be 95 percent based on their professional judgment as experienced Air Force pilots and their consideration of the factors relevant to pilot avoidance of the PFSF. They subsequently reviewed the accident reports and found the reports fully supportive of their professional judgments. As reported in the August 2000 Aircraft Report, they found no cases where a pilot had the ability to avoid a site on the ground but failed to do so. Aircraft Report at 19; see also PFS F. ¶ 143. In response to a question from Judge Lam, PFS's expert panel undertook a more formal evaluation of the accident reports documenting the information contained in the reports concerning pilot avoidance. PFS F. ¶ 144.

R147. The State implies that PFS's analysis of the accident reports is somehow weakened by the fact that the accident 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." State F. ¶ 97 (emphasis added). First, the accident reports may "comment on what a pilot's action or reaction may or should have been under the circumstances."[74] Second, the purpose of the preparation of the reports is not relevant; rather, it is the information they contain regarding what the pilots did. PFS's analysis focused on what the reports stated regarding pilot avoidance

[74] Air Force Instruction 51-503, Chap. 5, § 5.6.5. (State Exh. 60). A report may also contain a Statement of Opinion regarding the cause or causes of the accident which could discuss the cause of damage or injuries on the ground, if any. See id. at 46.

actions and maneuvering and whether the accidents caused any damage on the ground (which the reports are required to document). See PFS F. ¶¶ 143-146; see also Tr. at 13118-20 (Jefferson).

R148. The State claims that "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." State F. ¶ 98 (citing Tr. at 13109 (Jefferson)). Gen. Jefferson explained at the hearing that PFS's evaluation of the accident reports with respect to pilot avoidance was not a statistical evaluation. Rather, it was a qualitative evaluation "to give the best look that we could find as to what supporting evidence there might be." Tr. at 13110 (Jefferson); see PFS F. ¶ 145. That finding would support assigning a value of 100 percent to pilot avoidance where the aircraft was in control rather than the 95 percent value that PFS used. See Tr. at 13126 (Jefferson); Aircraft Report at 19. It should also be pointed out that neither the PFS witnesses nor Lt. Col. Horstman found any reports where the pilot had the opportunity to avoid a site or populated area on the ground or at least to minimize damage but failed to do so. PFS F. ¶¶ 145-46; see also PFS F. ¶ 156 (Lt. Col. Horstman similarly found no such reports).

R149. The State claims that, "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 F. ¶ 99. Initially, it must be observed that, as discussed above, ejecting below 2,000 ft. would not mean that the pilot would be unable to avoid the PFSF. Further, review of the reports showed 17 instances where specific actions were taken by the pilot to avoid areas or structures on the ground after an accident-initiating event. PFS F. ¶ 146. The clearest example was Col. Cosby's accident, in which he maneuvered first to avoid an apartment complex and then again to avoid an aircraft on the airport taxiway on which he was attempting to land. Id. ¶ 147; see also id. ¶ 148, (other examples). Contrary to the State's claim, the accident reports clearly show pilots avoiding areas on the ground and ejecting at or above 2,000 ft. AGL. See PFS Exh. 140 at 4; PFS Exh. 145 at 5; PFS Exh. 158 at 3; PFS Exh. 182 at 58240; PFS Exh. 179 at 3. In three additional cases the pilots deliberately delayed ejection below 2,000 ft. to avoid identified populated areas. See PFS Exh. 205 at 2, 7; Joint Exh. 1 at 2; Joint Exh. 9 at 2, 16. As discussed in Section III.B.9(d)(5), supra, the State's assumption that the PFSF would be too far away for a pilot to see before he ejected is wrong.

R150. The State claims that "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 [of turning the aircraft toward an uninhabited area]." State F. ¶ 100 (citing State Exh. 223). The claim that the pilots would not have had time to avoid the PFSF simply is not supported by the record. State Exh. 223 does not discuss what the pilots were doing before they ejected and it does not discuss the time available to the pilots. In a number of cases the pilot specifically delayed his ejection below 2,000 ft. in order to take additional actions for the express purpose of avoiding sites on the ground. PFS F. ¶ 123; see PFS Exh. 205 at 2, 7; Joint Exh. 1 at 2; Joint Exh. 9 at 2, 16.

R151. Further, the accident reports make clear that descending below 2,000 ft. did not mean that the pilots were unaware of where they were or were unable to control their aircraft; rather they were actively controlling and flying the aircraft. PFS F. ¶ 123. Some of the aircraft in the reports had taken off but had never reached

2,000 ft. See PFS Exh. 128 at 7,9; PFS Exh. 134 at 3; Joint Exh. 6 at 2, 4. PFS also noted that the 2,000 ft. altitude is a recommended minimum, not an absolute requirement; pilots are permitted to exercise judgment in responding to emergencies and have been commended for delaying their ejection to avoid populated areas. PFS F. ¶ 124; Joint Exh. 9 at 16; PFS Exh. 205 at 17. Moreover, in some cases the pilots had committed to attempting to land and the 2,000 ft. AGL minimum was not applicable. See PFS Exh. 79 at 2; PFS Exh. 110 at A-1, N-9; PFS Exh. 111 at 1-2; PFS Exh. 174 at 3; Joint Exh. 3 at 3; Joint Exh. 10 at 2-3. Thus, the State's claim has no basis.

R152. The State asserts that, "In 5 of the 58 crashes the pilot ejected during an uncontrolled spin or the aircraft was otherwise uncontrollable." State F. ¶ 100 (citing PFS Exhs. 145, 118, 124, 113, 147). The State made the same argument, citing the same accidents, with respect to PFS's determination of the probability that a mishap in Skull Valley would leave the pilot in control of the aircraft. See State F. ¶ 66. As discussed above, Section III.B.9(b)(1), supra, the State's assertions are incorrect. Those accidents did not represent instances where the aircraft were out of control such that the pilot could not have avoided the PFSF.

R153. The State claims that, "In 11 of the 58 crashes, the F-16 was on fire when the pilot ejected." State F. ¶ 100 (citing PFS Exhs. 119, 145, 158, 110, 118, 127, 184, 113, 147, 180; Joint Exh. 4). The State made the same argument, citing the same accidents, with respect to PFS's determination of the probability that a mishap in Skull Valley would leave the pilot in control of the aircraft. See State F. ¶ 66. As discussed above, the State's assertions are incorrect. Section III.B.9(b)(1), supra. While most, but not all, of those accidents were cases in which the aircraft was on fire, they did not represent instances where the aircraft were out of control such that the pilot could not have avoided the PFSF.

R154. The State claims that, "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." State F. ¶ 101. There is no basis to the State's theory that Air Force pilots would avoid a large populated area on the ground but would not avoid the PFSF. PFS F. ¶¶ 139-42; see also PFS F. ¶¶ 158-60. Indeed, one accident report describes a pilot descending through clouds and then maneuvering to avoid a farm before ejecting. Joint Exh. 9 at 13-14. Pilots in Skull Valley would be aware of the PFSF and its location and would clearly attempt to avoid it if they could in the event of an accident.

R155. The State cites two accidents, one where the pilot hit a structure on the ground while trying to avoid others (July 11, 1996), and one where the pilot missed a structure on the ground by 150 yards (August 31, 1992), as examples allegedly supporting its theory. See State F. ¶ 101. In the July 11, 1996 accident, the pilot clearly maneuvered to avoid or minimize damage to sites on the ground. In contrast to that accident, with "houses everywhere," the PFSF will be an isolated facility with a large area around it, where a crashing aircraft could easily be directed to impact without hitting anything that could be damaged. PFS F. ¶ 151. In the August 31, 1992 accident, the report stated that the pilot deliberately turned to avoid a populated area and did not hit any structures on the ground. PFS F. ¶ 169. Thus, it was simply a case of successful avoidance.

R156. Next, the State claims that "[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," State F. ¶ 102. To the contrary, those cases show that the pilots knew where they were and acted accordingly in the event of an emergency, whether turning toward an emergency airfield, away from a populated area, or both. PFS F. ¶ 152; see also id. ¶ 165.

(12) Dependency on an Agency Outside the Regulatory Loop

R157. The State argues again that there is insufficient information to determine the future hazard to the PFSF, in that military needs may cause changes in use of the airspace above the PFS site, a new aircraft will replace the F-16, and the capabilities of the pilots and equipment will turn on decisions made by the Air Force. State F. ¶¶ 103-04.[75] PFS addressed these claims in its discussion of the evidence regarding the future hazard to the PFSF, and showed that there is more than adequate evidence for the Board to find that the PFS site satisfies NRC requirements. See Section III.B.2, supra.

R158. The State concludes 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." State F. ¶ 104 (citing Tr. at 4151-52 (Campe)). On the contrary, the *R* factor is based on historical or actuarial data. PFS F. ¶ 24; Tr. at 4150-52 (Campe). Given that data, this is not a case of delegation to a third party. Id. at 4151-52. Projection of a future value for *R* depends on interpretation of the historical data. Id. at 4152-53. If any new information relevant to *R* came to light after the facility were licensed, it could be assessed by the NRC Staff as well. Id. at 4156-

[75] The State also claims that PFS's assessment that a pilot in control of a crashing aircraft would avoid the PFSF 95 percent of the time was "subjective." State F. ¶ 103. PFS responds to that claim in Section III.B.9(d)(1), supra.

58. In addition, the licensee could be obligated to monitor and report data from the Air Force. Id. at 4159-61, 4163.[76] Furthermore, other interested persons (including the State) could bring any new information to the attention of the Commission pursuant to 10 C.F.R. § 2.206. Thus, the NRC Staff would become aware of any changes in the risk to the facility and could take appropriate action if necessary. Since the crash hazard would be much lower in the early years of PFSF operation, due to the smaller number of casks and therefore the smaller site effective area, the NRC Staff would have ample time to determine whether any changes were occurring that would cause the hazard to increase. PFS F. ¶ 24.

(13) Conclusion Regarding PFS's Modification of NUREG-0800

R159. The State claims that PFS's modification of the NUREG-0800 formula for calculating the hazard to the PFSF is neither realistic nor conservative because there are no authorities recognizing a modification to the formula based on a pilot's ability to avoid a ground site and PFS has shown no data or reliable basis on which to conclude that Air Force pilots have or in the future will have a measurable ability to reduce the risk of aircraft crashes impacting the PFSF. State F. ¶ 105. On the contrary, PFS's modification of the NUREG-0800 formula logically follows from the documented fact that pilots in control of crashing F-16s will avoid areas on the ground if possible.[77] PFS's assessment of the likelihood that a pilot would be able to direct a crashing F-16 away from the PFSF is based

[76] Under 10 C.F.R. § 72.11(b), PFS would be required to report to the Commission any information that it identifies as having a significant implication for the public health and safety.

[77] A U.K. Atomic Energy Authority study also recognizes that military aircraft crashes in which the pilot is in control of the aircraft just before impact may be excluded as hazards to nuclear power plants based on observed pilot avoidance. PFS F. ¶ 21.

on 10 years of Air Force F-16 accident reports and the professional judgment of three highly experienced former Air Force pilots.

C. Aircraft Using the Moser Recovery Route

R160. The State challenges PFS's assessment of the hazard to the PFSF posed by F-16s returning to Hill AFB via the Moser Recovery Route, claiming that the number of flights on the route will increase in the future because of an increase in night missions and night vision goggle training by the Air Force. State F. ¶¶ 107, 109-10, 113. These claims are not supported by the record. PFS F. ¶¶ 191-93.

R161. The State attacks Gen. Cole's discussions with a local air traffic controller as the basis for PFS's assessment of the traffic on the Moser Recovery because Gen. Cole did not know the basis for the controller's estimate. State F. ¶ 108. However, the State completely ignores the information PFS received from the operations group commander of the 388th FW that corroborates the air traffic controller's estimate that fewer than five percent of the F-16 flights returning to Hill AFB use the route. See Tr. at 3799-802 (Fly). The operations group commander reiterated that the Air Force "has a strong preference not to use [the Moser route]," day or night. Id. at 3800. Even at night, the F-16s will land to the south with a significant tail wind to avoid using the Moser route and, furthermore, even if they wish to land to the north, there are procedures that enable them to do that without using the Moser route. Id. at 3800-01. The State also ignored the fact that the Hill AFB staff told the NRC Staff that night vision goggle usage had not led to an increased usage of the Moser Recovery. Staff Test. at 39; PFS Test. at 98 & n.168.

R162. The State also overestimates the number of F-16 sorties on the UTTR South Area which serves as a baseline for calculating the traffic on the Moser Recovery. The

State estimated that there would be 10,413 flights on the UTTR South Area in 2001. State F. ¶ 110. On the contrary, even if the FY99 UTTR South Area F-16 sortie count, which was the highest of the years for which there is data in the record, is increased to account for the additional F-16s based at Hill AFB in FY01, the estimated number of sorties would be 8,461. Tr. at 8866 (Jefferson); see Revised Addendum Tab HH at 4. Therefore, there is simply no basis to support the State's assertions regarding the traffic on the Moser Recovery Route.

R163. The State challenges PFS's accounting for pilot avoidance in the event of an accident on the Moser Recovery on the same grounds that it challenges PFS's accounting for pilot avoidance for the F-16s transiting Skull Valley. State F. ¶ 112. PFS responded to the State's claims in Section III.B.9, supra, and showed that they have no merit.

D. Hazard Posed by Jettisoned Ordnance

R164. PFS estimated the hazard to the PFSF from jettisoned ordnance on data from Hill AFB regarding ordnance usage by F-16s in FY99 and FY00, when approximately two percent of the F-16s transiting Skull Valley carried jettisonable ordnance. See PFS F. ¶¶ 196-98. The State challenged PFS's assessment in various respects as discussed below, most of which PFS responded to in its proposed findings. See id. ¶ 199.

R165. The State assumes that the number of F-16 sorties carrying ordnance will be the same as it was in FY98, the year which the greatest number of F-16 sorties carried ordnance. State F. ¶ 116. There is no basis to the State's use of FY98 data to the exclusion of all other data regarding F-16 ordnance usage. See PFS F. ¶ 199. The State asserts that in early 2001, the 388th FW Operations Group Commander "advised that current training needs require more sorties to carry ordnance than the training conducted in FY 2000." State F. ¶ 116 (citing Horstman Test. at 29). Lt. Col. Horstman claimed in his testimony that the 388th FW operations group commander told him that the usage of ordnance in FY00 was lower than normal because of the deployment of some Hill AFB F-16s to the Caribbean for drug interdiction missions. Horstman Test. at 29. However, 1) based on Col. Fly's conversation with a former deputy operations group commander of the 388th FW, the Hill AFB deployments to the Caribbean were very small relative to other overseas deployments the 388th FW had made in the past, Tr. at 13090-91 (Fly); 2) fighter wing ordnance training requirements are not based on one particular deployment (or year to year fluctuations in budget), PFS F. ¶ 199; and 3) ordnance usage by the 388th FW in FY00 was almost the same as it was in FY99, id. Thus, the State's argument for using FY98 data while completely ignoring the other data in the record is simply arbitrary.[78]

R166. The State also assumes that all F-16 sorties carrying ordnance from Hill AFB to the UTTR will transit Skull Valley. State F. ¶ 117. The State cites to no basis in the record other than the fact that the Air Force does not track the flight paths of the aircraft. Id. PFS's expert panel assumed that the fraction of F-16s carrying ordnance while transiting Skull Valley was the same as the fraction of all F-16s transiting Skull Valley (some aircraft enter the UTTR directly from the north or northeast rather than transiting Skull Valley) on the basis of a conversation between Gen. Cole and Col. Craig Lightfoot, USAF, UTTR Commander.

[78] The State claims that, "PFS does not know the reason for the decline in the number of sorties carrying ordnance from FY98 to FY00." State F. ¶ 116 (citing Tr. at 3500 (Jefferson)). Col. Fly testified that requirement to drop live or heavy weight ordnance was small relative to the usage of light weight practice ordnance and avionics for training and that at times the depot at Hill AFB would give the 388th FW live ordnance that was approaching the end of its service life to drop in training. Tr. at 3501-02 (Fly).

Aircraft Report at 81-82 & n.86. Thus, there is simply no support for the State's assumption, which again is completely arbitrary.

R167. The State calculates a probability of ordnance impact at the PFSF by assuming that the total number of F-16 flights transiting Skull Valley per year will be 7,040, which is the sum of the Sevier B and Sevier D MOA sortie counts for FY00, increased by 17.4 percent to account for the additional F-16s added to Hill AFB in FY01. State F. ¶ 119; see id. ¶¶ 47-48. The State, however, overestimates the annual sortie count. See Section III.B.6 above.

R168. The State also uses its assessments of the F-16 crash rate and the effective width of Skull Valley in its calculation. See State F. ¶ 120. These assessments are erroneous. See Sections III.B.4 and III.B.5, supra.

R169. The State uses a PFSF effective area estimated by Dr. Resnikoff with a presumed "skid area" for jettisoned ordnance to strike the ground in front of the PFSF and slide into it. State F. ¶ 120 & n.32. However, Dr. Resnikoff had no basis for his assumption. PFS F. ¶ 197 n.141. Gen. Jefferson, on the other hand, testified that the ordnance would not skid because it would impact the ground at a steep angle. Tr. at 8868-69 (Jefferson); PFS Test. at 107; see Revised Addendum Tab FF at 18-19 (ordnance impact angle much greater than F-16 impact angle).

R170. The State assumes that all pilots suffering mishaps in Skull Valley would jettison ordnance, see State F. ¶ 122, claiming that "[n]o evidence is offered in support of [PFS's] assumption [that in 10 percent of the accidents the aircraft would be out of control and the pilot would eject quickly without jettisoning ordnance]." On the contrary, PFS's expert panel analyzed the F-16 accident reports and found that 10 percent of the accidents that could have occurred in Skull Valley left the aircraft out of control without time to avoid the PFSF. PFS F. ¶¶ 69-74. The entire purpose of jettisoning ordnance is to provide more time while the aircraft is under control to respond to the emergency. Aircraft Report at 19b-19c. Thus, there would be no reason to jettison ordnance if the aircraft was out of control.

R171. PFS's panel discussed two of the out of control accidents in its Aircraft Report and showed that in those cases the pilots flew into the ground without ejecting at all (or jettisoning ordnance). Aircraft Report Tab H at 18-19; see PFS Exhs. 80, 125. Furthermore, Col. Bernard testified that in his first accident, which was a mid-air collision that left his aircraft out of control, he bailed out without jettisoning ordnance because there was no time to do so. Tr. at 3887-88 (Bernard). Thus, there is clear evidence in the record that, contrary to the State's claim, in some cases, in which the aircraft are out of control, pilots will not jettison ordnance.

R172. Finally, the State asserts that pilots might jettison ordnance without crashing and hence the ordnance jettison rate could be higher than the crash rate. State F. ¶ 122. First, in calculating the ordnance jettison rate, PFS used Class A and Class B mishaps, which include mishaps in which the aircraft never crashes. PFS F. ¶ 36. Second, the possibility of ordnance being jettisoned without the aircraft suffering a mishap at all is very remote. PFS Test. at 108. The most likely case would be a controlled jettison of hung ordnance in a specifically approved area, which would not threaten the PFSF. Id. If ordnance was jettisoned without the aircraft itself suffering a mishap and the ordnance caused significant damage on the ground, it would be reflected at least in the Class B mishaps. Id. Therefore, the scenario postulated by the State would not have a significant effect on the calculated jettisoned ordnance hazard.

R173. Therefore, as shown above, the State's assessment of the hazard posed to the PFSF by potentially jettisoned ordnance is severely flawed. Each of the State's assumptions regarding the input variables for the State's calculation is erroneous and hence the Board should disregard the State's assessment.

E. Air-to-Air Combat Training on the UTTR

R174. The State asserts that PFS's assessment of the hazard posed by air-to-air combat training on the UTTR is invalid because it accounts for pilot avoidance in cases in which an aircraft suffering an in-flight mishap were to remain in control of the pilot. See State F. ¶ 123. The State argues that rather than PFS's assessment, the Board should adopt Dr. Resnikoff's assessment as a minimum value for the annual hazard. Id. ¶ 124.

R175. As discussed above and as discussed in PFS's proposed findings, pilot avoidance is a fact to which all of the pilots who testified in this proceeding agreed. See, e.g., PFS F. ¶ 22. Furthermore, in the case of a mishap on the UTTR, the UTTR would present a large safe area for a crashing aircraft and Michael AAF, on the east side of the UTTR but west of the Cedar Mountains, would be available for the pilot to make an emergency landing if possible. Therefore, it would be unreasonable to postulate that a pilot in control of a crashing aircraft in such circumstances would glide over the Cedar Mountains, and off the restricted range towards Skull Valley, the PFSF and other inhabited structures located there. PFS F. ¶ 189.

R176. Regarding Dr. Resnikoff's assessment, PFS showed in its proposed findings that its assumptions could not be supported and that hence it is not valid. PFS F. ¶ 190. Therefore, the State's claims regarding the hazard posed by training on the UTTR are unsupported and the Board adopts PFS's assessment.

F. Cumulative Hazard to the PFSF

R177. The State claims that the Board should find that the cumulative hazard to the PFSF is the sum of the hazards posed by the individual aviation activities that the State has calculated (or that the Board has previously determined). See State F. ¶¶ 125-26. As shown above, the State's assessments of the hazards posed by the individual aviation activities in and around Skull Valley are erroneous. Therefore, the Board finds that the cumulative hazard to the PFSF is that calculated by PFS, i.e., less than 4.17 E-7 per year. PFS F. ¶ 206.

R178. The State also asserts that PFS's assessment of the cumulative hazard is not conservative in that its crash rate calculation is not conservative. See State F. ¶¶ 128-32. The State claims that the fraction of all mishaps occurring in the normal phase of flight (i.e., not special operations, takeoff, or landing), cannot be assumed to apply to destroyed aircraft. The State argues that because destroyed aircraft are a subset of all Class A and Class B mishaps, the fraction of aircraft destroyed in the normal phase of flight could be higher than the fraction of all Class A and Class B mishaps occurring in the normal phase of flight (and correspondingly, the fraction of non-destroyed aircraft mishaps occurring in the normal phase could be lower than the fraction of all mishaps occurring in the normal phase). See State F. ¶¶ 129-30.

R179. The State's mathematical construct is correct but it does not invalidate PFS's assessment. First, it is also possible that the fraction of aircraft destroyed in the normal phase of flight could be lower than the fraction of all mishaps occurring in the normal phase of flight. Second, even if the fraction of aircraft destroyed in the normal phase of flight is higher than the fraction of total mishaps in the normal phase, it is impossible (because destroyed aircraft are a subset of all mishaps) for the number of destroyed aircraft in the normal phase to be higher than the number of total mishaps. PFS assumed for the purpose of its assessment that all mishaps (i.e., Class A plus Class B mishaps) were crashes in which the aircraft struck the ground. See Aircraft Report at 10; id. Tab D. To calculate its crash rate, PFS applied the fraction of mishaps occurring in the normal phase of flight to all mishaps, not just destroyed aircraft. See Aircraft Report Tab D. Thus, PFS does not make the error postulated by the State.[79]

G. Conservatism of PFS's Aircraft Hazard Assessment

R180. The State's findings have totally ignored significant conservatisms incorporated in the hazard calculated for the PFSF. These may be thought of as falling within three general categories – quantifiable, non-quantifiable and procedural.

R181. The quantifiable conservatisms include the following. First, PFS's estimate of the F-16 crash rate included not only destroyed aircraft, but also Class A and B mishaps in which no aircraft was destroyed. PFS F. ¶ 36. A crash rate based on destroyed aircraft would be about 14 percent lower than PFS's calculated rate. Id. ¶ 36.

R182. Second, PFS's calculation assumes that the facility is at maximum capacity of 4,000 casks. This assumption is conservative in two respects. One, the facility may never become full. PFS F. ¶ 39. If the facility never becomes more than half

[79] The State uses a hypothetical example of five aircraft destroyed in the normal phase of flight plus five aircraft suffering Class B mishaps on the runway. State F. ¶¶ 129-30. In that hypothetical, 50 percent of all mishaps occurred in the normal phase (5 out of 10). One hundred percent of the aircraft destroyed were destroyed in the normal phase (5 out of 5). (No Class B mishaps occurred in the normal phase.) Using PFS's approach of basing a crash rate on all mishaps, 50 percent of the assumed crashes (i.e., 5) occurred in the normal phase. That would not underestimate the number of aircraft actually crashing (i.e., destroyed in the normal phase) (also 5), in that destroyed aircraft are a subset of all mishaps. The only case for which PFS's approach would not be conservative would be if all destroyed aircraft were destroyed in the normal phase and no non-destroyed mishaps occurred in the normal phase. In that instance (for which there is no actual evidence in the F-16 database), PFS's assessment would be accurate, in that the number of assumed crashes in the normal phase would be exactly equal to the actual number of destroyed aircraft in the normal phase.

full, the crash probability will be reduced by about fifty percent, i.e., the crash impact probability for a facility storing only 2,000 casks would be approximately half of the probability for the facility with 4,000. Id. ¶ 40. Two, even if the facility becomes full, the time-weighted average effective area of the facility would only be 55 percent of the peak area; thus the average aircraft hazard would only be 55 percent of the peak hazard. PFS F. ¶ 39. For example, at the maximum cask loading rates of 200 casks per year on which the facility design is based, see Aircraft Report at 26, at the end of one year's operation the effective area would be 0.0220 sq. mi. and the crash probability less than 6.79 E-8 per year; after five years, with 1000 casks on site, the effective area would be 0.0445 sq. mi. and the crash probability less than 1.379 E-7 per year; after ten years of operation, with 2000 casks, the effective area would be 0.0757 sq. mi. and the crash probability less than 2.356 E-7 per year. See Aircraft Report at 26 (crash impact probability is directly proportional to effective site area); id. Tab I.[80]

R183. Third, PFS's estimate of the hazard posed by jettisoned ordnance is conservative in that 1) about half of the cask storage area at the PFSF, even when full, will consist of empty space rather than storage casks, PFS F. ¶ 198 and 2) none of the inert munitions carried through Skull Valley would penetrate the lid of a cask and the great majority of them would not penetrate the side of the cask, id. If all of these conservative factors are accounted for, the hazard to the PFSF, assuming it reached full capacity during its lifetime, would drop from the calculated value of less than 4.17 E-7 per year to roughly 1.9 E-7 per year. PFS F. ¶ 207.[81]

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[80] The effective site area after one year of operation (200 casks) was calculated the same way as the effective areas for the site with 1,000 and 2,000 casks. See Aircraft Report Tab I.

[81] Assuming that one does not take into account the conservatism in the crash rate due to the inclusion of Class A and Class B mishaps, which conservatism the State has challenged, the calculated hazard to the

R184. The State has also ignored the unquantified conservatisms in PFS's assessment. First, PFS uniformly distributed the aircraft across the valley when it performed its calculations even though the predominant route of flight is approximately five miles to the east of the site. PFS F. ¶¶ 42-43. Thus, PFS's calculations presume that aircraft and jettisoned ordnance would be in a position to potentially hit the PFSF when they typically would not be.

R185. Second, as described by the NRC Staff, the approach of calculating an impact probability to determine whether the threshold for further analysis is met is inherently conservative because it assumes every impact would result in an off-site radiation dose in excess of the limits in 10 C.F.R. § 72.106(b). Staff Test. at 6; Tr. at 2997-98 (Turk); see Tr. at 2986-88, 2996 (Barnett).[82]

R186. Third, the regulatory standard of 1 E-6 per year, itself, established by the Commission as defining a credible accident event for an ISFSI, CLI-01-22, 54 NRC 255, is conservative because the cancer risk arising from beyond design basis accidents at ISFSIs is two or more orders of magnitude less than what the Commission has determined to be acceptable due to exposure to radiation. See Section I, supra.

R187. Finally, any uncertainty regarding the assessment of the hazard posed by aircraft accidents at the PFSF is mitigated by the existing procedural regulatory mechanisms in place to ensure that any new information relevant to the hazard that came to light after the facility were licensed would be assessed by the NRC

PFSF taking into account quantified conservatisms would still drop from less than 4.17 E-7 per year to less than 2.16 E.7 per year. See PFS Test. at 113 & n. 179.

[82] As the Staff noted, the NRC's approach to assessing aircraft crash hazards to licensed facilities generally, not just the PFSF, is conservative in that the Staff performs a calculation of the impact probability and then generally assumes without assessment that the impact would result in a radiation dose exceeding 10 C.F.R. Part 100 limits. Staff Test. at 6 (citing NUREG-0800 § 3.5.1.6); see Tr. at 2997-98 (Turk).

Staff. First, the NRC Staff could assess any information of which it became aware that indicated that the aircraft hazard to the PFSF had changed. See PFS F. ¶ 24. PFS is obligated to report to the Staff any information that came to PFS's attention that was significant to public health and safety. 10 C.F.R. § 72.11(b). Moreover, PFS could be obligated to specifically monitor and report data relevant to the hazard assessment. PFS F. ¶ 24. In addition, third parties such as the State could file petitions with the Commission for enforcement action against PFS on the basis of any information they identified. See 10 C.F.R. § 2.206. Thus, the NRC Staff would become aware of any changes that occurred that would increase the risk to the facility and it could take appropriate action if necessary. Since the aircraft hazard would be much lower in the early years of PFSF operation (i.e., when only a fraction of the cask storage area was filled), the NRC Staff would have ample time to determine whether any changes were occurring that would cause the predicted aircraft hazard to increase. All of these would serve to mitigate any uncertainty regarding the risk to public health and safety posed by the PFSF.

IV. CONCLUSIONS OF LAW

The State sets forth a series of conclusions of laws that are based on its proposed findings. Having rejected the State's proposed findings, we also reject its proposed conclusions of law and adopt the proposed conclusions of law set forth in PFS's Proposed Findings.[83]

[83] One point not addressed above, the State argues that, "Evidence relating to the penetration of a storage cask is not relevant and is inadmissible in this proceeding." State Conclusion of Law F. ¶ 1. The fact that most ordnance carried by F-16s (e.g., 500 lb. bombs) would not penetrate a spent fuel storage cask is relevant, in that ordnance that could not penetrate a cask would not contribute to the hazard to the facility, even if it were jettisoned and struck the facility. Evidence concerning ordnance penetration of casks was contained in State Exhibits 62 and 63 (and Lt. Col. Horstman's testimony, Question and Answer 74), which the Board admitted at the hearing. See Tr. at 4221-25. Substantively, State Exhibits 62 and 63 establish

V. CONCLUSION

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

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that 500 pound MK-82 bombs are the equivalent of "BB pellets" that will not penetrate the casks, analogous to determinations that have been made with respect to general aviation aircraft in other settings, referred to by the NRC Staff in argument on motions in limine at the hearing. See Tr. at 3006. Therefore, PFS should be permitted to rely on State Exhibits 62 and 63 to show that its assessment of the hazard to the PFSF posed by jettisoned ordnance is conservative.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

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

CERTIFICATE OF SERVICE

I hereby certify that copies of the Applicant's Reply to the Proposed Findings Of Fact And Conclusions Of Law of the State of Utah and the NRC Staff on Contention Utah K/Confederated Tribes B were served on the persons listed below (unless otherwise noted) by e-mail with conforming copies by U.S. Mail, first class, postage prepaid, this 7th day of October, 2002.

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