UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

LBP-03-04

ATOMIC SAFETY AND LICENSING BOARD

RAS 5950 DOCKETED 03/10/03

Before Administrative Judges:
Michael C. Farrar, Chairman
Dr. Jerry R. Kline
Dr. Peter S. Lam

SERVED 03/10/03

In the Matter of	Docket No. 72-22-ISFSI
PRIVATE FUEL STORAGE, LLC	ASLBP No. 97-732-02-ISFSI
(Independent Spent Fuel Storage Installation)	March 10, 2003

PARTIAL INITIAL DECISION
(Regarding "Credible Accidents")

Private Fuel Storage (PFS) is a consortium of electric utility companies that applied for an NRC license to build and to operate, on the reservation of the Skull Valley Band of Goshute Indians some 50 miles southwest of Salt Lake City, an aboveground facility for the temporary storage of spent fuel rods from the nation's nuclear reactors. During a nine-week trial in Salt Lake and at NRC Headquarters ending in mid-2002, the Applicant PFS attempted to demonstrate -- over the opposition of the State of Utah and the Southern Utah Wilderness Alliance (SUWA) -- that its proposal was acceptable in terms of meeting certain safety and environmental regulatory criteria established under federal law, including the Atomic Energy Act and the National Environmental Policy Act (NEPA).

Our decision today deals with just one of the issues considered at that trial, i.e., the chance that military aircraft operations in Utah's West Desert might pose a risk to the facility.[1]

[1] This leaves open two matters tried before this Board: (1) whether PFS has established that its proposed facility satisfies the NRC's seismic safety criteria; and (2) whether the rail spur proposed for transporting spent fuel casks from the main line down Skull Valley is routed as well from an environmental standpoint as the alternatives, including those SUWA suggested, and does not run afoul of wilderness management constraints. We are not yet ready to rule on those two items, having chosen to give priority to completing the matter decided today. Drafting the decisions on those matters is well along, however, and we expect to issue them in the next few weeks. See also fns. 6 & 13, below, to the same effect on matters before another Board.

We find that probability to be too high when measured against the applicable NRC safety criterion governing protection against the risk of accidents at a regulated facility.

Under that criterion (and speaking very generally[2]), an applicant must show either that (1) a postulated accident is so unlikely (i.e., not "credible") that it need not be guarded against, or (2) the facility's design is such that the accident's consequences would be of no real concern. Here, the "credible accidents" issue arises because the proposed facility would sit under the airway that pilots use to fly F-16s (single-engine military jet aircraft) from Hill Air Force Base, located to the north of Salt Lake City, down Skull Valley toward the southern entry to the military's Utah Test and Training Range (UTTR) in the State's West Desert.

The State urged us to find that, under standard NRC calculational protocols, the probability of an F-16 crash into the spent fuel casks is too high to ignore in our safety analysis. The Applicant urged that other factors -- particularly the expectation that pilots would take care to avoid the site before ejecting in an emergency situation -- serve to reduce the calculated accidental crash probability to a level low enough to be disregarded.

On the facts presented, and with the Applicant having the burden of proof, we find that the State's position on accident probabilities prevails: on the key issue, we essentially reject -- as insufficiently proven for nuclear regulatory safety analysis purposes -- the Applicant's "pilot avoidance" theory. Then, applying the probability criterion the Commission established in this very case, we find that there is enough likelihood of an F-16 crash into the proposed facility that such an accident must be deemed "credible." The result is that the PFS facility cannot be licensed without that safety concern being addressed.

As is apparent, there are at least two ways in which that concern might be alleviated. One would be for the Applicant to convince the Air Force to agree to reduce the number, and/or to alter the pattern, of Skull Valley overflights. Although we have no role to play in -- and thus

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[2] We explain this concept in more detail in Subpart E, below.

no views on -- whether the formulation of any such agreement should be entertained, we do note that the emergence of that type of agreement seems relatively unlikely in view of the content of a written "limited appearance" statement (described later herein) filed on behalf of the Secretary of the Air Force early in our 2002 hearings.[3]

A second option for the Applicant would be to attempt to establish that the contemplated (or upgraded) design of the proposed facility's spent fuel storage casks is so robust that an F-16 crash would not have appreciable health and safety consequences. That matter is not now before us, for -- apparently believing that the issue would not need to be reached -- the Applicant shaped the application it submitted to the NRC Staff for review, and the material it submitted to us pre-trial, in a manner that kept evidence on the "consequences" issue from reaching us in a fashion that would have allowed us to address that issue properly.

If the Applicant were to rehabilitate its application by addressing that issue fully, this matter might eventually come before us again, this time with the benefit of Staff analysis. For now, we cannot approve the sought-after PFS license.[4]

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[3] As explained at greater length later (see fn. 11, below), limited appearance statements are not evidence upon which the merits of a decision can be based. Our only purpose in referring to the Air Force filing -- which may be viewed electronically on the NRC ADAMS site (accession # ML021160024) -- is as a possible indicator of the future course of the proceeding.

[4] As the parties are aware, the issue being decided today involves only the risk of accidental aircraft crashes. The risk from intentional aircraft attacks and other potential terrorist activities is not before us in this proceeding, but is being considered by the Commission in a much broader context, not only in this case but across the entire regulatory landscape. See, e.g., CLI-01-26, 54 NRC 376 (2001), and CLI-02-25, 56 NRC __ and related cases (Dec. 18, 2002). In CLI-02-25, the Commission considered, at our request, the question whether NEPA requires the NRC to address in licensing decisions the impact of terrorism as seen in the light of the September 11, 2001 attacks. In ruling that the impacts of a potential terrorism attack need not be considered by Licensing Boards as part of the NRC's environmental review in particular adjudications, the Commission noted that it is itself in the process of more broadly reviewing the potential effects of suicidal aircraft crashes on NRC-regulated facilities. See CLI-02-25, 56 NRC at __ (slip op. at 22). Nothing now before us indicates whether any studies that may have been performed to aid the Commission in evaluating the consequences of aircraft-related terrorism would shed light upon the consequences of the aircraft-related accidents that we have been considering and which could now become the subject of further proceedings herein.

Our decision today, so briefly summarized above, is necessarily a long one. In Part I, we set forth in narrative form the underlying reasoning which led us to that decision:

- In Subpart A, we open by setting the stage in terms of the procedural history of the "credible accidents" contention and by recounting the context in which the matters now being decided arose.
- In the next three portions of the decision, contained in Subparts B through D, we explain our views on certain overarching issues. Specifically, Subpart B deals with the "pilot avoidance" issue, where the Applicant's novel approach is embodied in a so-called "R" factor; Subpart C deals with the four other factors that go into a typical aircraft accident probability calculation; and Subpart D deals with the nature of the safety norm against which that calculation is measured.
- We go on in Subpart E to discuss why questions about the projected consequences of an accident -- including whether a crashing F-16 would penetrate a spent fuel cask -- were not considered at this hearing but may be considered at a later stage.

We then provide, in Part II, a lengthy "Detailed Analysis of Record and Findings of Fact" that reviews the evidence and includes determinations either providing support for, or resulting from, the opinions and holdings expressed in the earlier, narrative portion of this decision. Finally, in Part III, we recite briefly our formal Conclusions of Law and our Order.

An outline of the remainder of this Partial Initial Decision's contents, then, is as follows:

I. NARRATIVE OPINION

A. **Introduction, Background and Summary**

This decision -- by our count the 55th one published in the course of carrying out the Licensing Board's adjudicatory role in this proceeding -- brings to a conclusion at our level (for a time, at least) the legal and factual debate over one issue crucial to the Applicant's plans. The debate on that and other issues has gone on for a long time, most visibly since the Applicant's proposal was noticed for hearing on July 21, 1997.[5] The State of Utah and a number of other parties opposed that proposal, filing some 125 "contentions," or issue statements, challenging the proposal from various safety or environmental standpoints.

Our previous decisions, or voluntary action by the parties, have since resolved -- whether on legal arguments, evidentiary presentations, settlement agreements, or some combination thereof -- most of those matters, leaving pending before this Board but three of those contentions. Those remaining three issues -- aircraft accidents, seismic safety, and rail-line alternatives -- were the subject of full-blown, trial-type evidentiary presentations in various Salt Lake City venues and in our own Washington, DC-area hearing room.

In total, that trial consumed, between April 8 and July 3 of last year, some 45 days of hearing evidence and of conducting related business.[6] The transcript of those proceedings covers some 11,000 pages; during those hearings, the parties presented direct testimony (and usually rebuttal testimony as well) from nearly 40 witnesses, through whom they proffered some 475 exhibits. The parties submitted two sets of post-trial briefs on each of the three issues;

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[5] See 62 Fed. Reg. 41,099 (1997).

[6] That 2002 trial initially included a fourth issue, involving hydrological concerns, that was settled in mid-hearing. A previous trial, conducted some time earlier by our predecessor Board (see fn. 13, below), involved issues relating to the facility's emergency planning arrangements and the Applicant's financial qualifications, matters which that Board has either since resolved and or will resolve shortly (see also fn. 1, above).

those opening and reply "Proposed Findings of Fact and Conclusions of Law" and related materials totaled some 2,200 pages.

The last of those briefs was filed on October 16, 2002, triggering the formal period for preparation of our decision.[7] As a prelude to the substance of today's decision, in Section 1 below we cover in more detail how the proceeding unfolded (and address a misperception about our proceedings), and then in Section 2 explain how the key issues developed.

1. The Procedural Setting

a. The Application Review. All the issues, including the one matter we decide today, had their genesis in an application filed with the Nuclear Regulatory Commission by the Private Fuel Storage, LLC, consortium on June 20, 1997. Triggered by the nuclear power industry's uncertainty about the timely availability of an underground repository for the permanent storage of spent nuclear fuel (as currently contemplated for Yucca Mountain in Nevada), the PFS application sought NRC approval for a facility for temporary aboveground storage of those same fuel rods, now located at various electric-power-generating reactors around the country.

The application envisions as many as 4,000 casks -- each nearly 20 feet high and 11 feet in diameter, made of concrete and stainless steel -- resting on 500 concrete pads arrayed on 99 acres of the Reservation of the Skull Valley Band of Goshute Indians.[8] That

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[7] The Commission urges that, in a typical case, a decision be rendered within 60 days of the filing of the final briefs. Statement of Policy on Conduct of Adjudicatory Proceedings, CLI-98-12, 48 NRC 18, 21 (1998). Just as the trial necessarily took much longer than counsel had predicted (before they each disclosed the large number of witnesses being put forward), the decision-making process has taken longer here, for reasons adverted to in our unpublished Orders of December 11, 2002, and January 23, 2003. In that regard, the lengthy decision-writing process on this issue was aided immeasurably by the extraordinarily thorough and well-crafted papers filed by all three parties.

[8] The Band would derive substantial income from making its Reservation available to the Applicant for the facility. (The disputes among various Band members over the nature of that arrangement, and the distribution of funds thereunder, do not fall within our jurisdiction to resolve. See CLI-02-20, 56 NRC 147 (2002), reversing LBP-02-08, 55 NRC 171 (2002).)

Reservation is located within the borders of -- but is essentially not subject to regulation by -- the State of Utah;[9] it is in Skull Valley (which lies between the Stansbury Mountains to the east and the Cedar Mountains to the west), some 50 miles southwest of Salt Lake City (more locally, it is southwest of the town of Tooele and north of the Dugway Proving Grounds).

The PFS application was duly reviewed by the NRC Staff. In this proceeding, as in others, the role of the Staff at that stage is to scrutinize the application carefully, to seek additional information where it deems it appropriate, and to indicate where it believes improvements in approach or design are necessary. (See also pp. 9-10 and Subpart E, below).

At least partially as a result of that process, PFS filed some 19 amendments to its application before, on September 29, 2000, the NRC Staff indicated it would approve the application. An additional four application amendments were filed thereafter, the last coming on November 21, 2001, some four years after the application was first filed.

b. The Hearing Process. As the Staff review was starting, the NRC published in the Federal Register the July 1997 hearing notice (referred to above) indicating, among other things, that anyone opposed to the issuance of the license could seek to intervene in the proceeding and to request a public hearing before an NRC Atomic Safety and Licensing Board. A number of parties did so, framing their challenges as the "contentions" called for by the NRC's procedural rules.

An NRC Licensing Board was duly appointed to preside over the proceeding in September 1997 (see 62 Fed. Reg. 49,263 (1997)). That initial Board was chaired by Chief Administrative Judge G. Paul Bollwerk, III, and had the same two technical members as this Board (Judges Jerry R. Kline and Peter S. Lam). After that Board devoted enormous effort to resolving a vast number of preliminary matters in the case, responsibilities for the completion of

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[9] See, e.g., Skull Valley Band of Goshute Indians v. Leavitt, 215 F. Supp. 2d 1232 (D. Utah 2002).

the case from that point on were split between that original board, chaired by Chief Judge Bollwerk, and this second board, chaired by Judge Michael C. Farrar, all pursuant to, and as detailed in, a December 19, 2001, Notice of Reconstitution issued by Judge Bollwerk.[10]

As the proceeding before the Licensing Board(s) took shape, the parties intervening in opposition to the project ordinarily found themselves aligned not only against the Applicant PFS but also against the NRC Staff. Aware of that situation, some Salt Lake area residents who made presentations at the "limited appearance" sessions[11] we held last April 8th (at the Salt Palace) and April 26th (at Tooele High School) expressed sentiments seemingly critical of, or reflecting confusion about, the role played by the NRC Staff in proceedings like this.

In view of those sentiments, and the discussion later herein about the role of the NRC Staff (see Subpart E, below, pp. 85-86), it is worth repeating briefly the explanation we attempted at the time, about how the Staff's lengthy pre-hearing review sets the stage for the hearing. Although the public may observe the Staff's seeming to move in concert with an applicant once the hearing begins, the Staff has come to such a position at the hearing only after first satisfying itself -- as it did during the multi-year internal scrutiny described above (see

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[10] See 66 Fed. Reg. 67,335 (2001). For purposes of completeness in this procedural history, we have noted herein how the existence of the two Boards came about. Generally, however, unless the context demands otherwise or we so indicate, references in this decision to "this Board" or "the Licensing Board" are not intended to distinguish between rulings made by the original Board and by this second Board, for there has been no lack of continuity in our respective roles.

[11] "Limited appearance" sessions are conducted in order to allow members of the public who, although unable to undertake the task of becoming a full party to the proceeding and participating in the creation of the evidentiary record, nonetheless would like to make their views known. Those views, which are made part of the agency's official docket, are not evidence upon which a Board decision can be based but, to the extent relevant to the issues being heard, can serve to trigger inquiry by the Board or presentations by the parties. As part of that process, and because of its relevance to an aspect of our decision (see Subpart E, below), we address in the text the concern expressed about the Staff's role.

p. 8) -- that an application passes muster.[12] In other words, that the Staff eventually sides with an applicant at a hearing does not mean that the Staff has not been protecting the public interest.

c. The Opposition Contentions Generally. From the outset of this proceeding, the primary opposition to the facility has come from the State of Utah. The Southern Utah Wilderness Alliance (SUWA) also pressed a number of contentions. (Other entities, including the Skull Valley Band, Ohngo Gaudadeh Devia, Confederated Tribes of the Goshute Reservation, Castle Rock Land and Livestock, Skull Valley Company, and Ensign Ranches of Utah, participated in a more limited fashion or eventually withdrew.)

Several of the State's contentions were the subject of a full evidentiary hearing in front of the Bollwerk Board[13] before we held the lengthy 2002 hearing described above. A number of other contentions had been rejected without a hearing on a variety of grounds. Some were dismissed at the outset for such reasons as not providing necessary supporting documentation,

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[12] In this regard, an applicant is theoretically free during that review process to reject a Staff determination that its presentation is not acceptable and to request a hearing of its own to challenge adverse Staff decisions. See, e.g., Ohio Edison Co. (Perry Nuclear Power Plant, Unit 1), Cleveland Electric Illuminating Co. and Toledo Edison Co. (Perry Nuclear Power Plant, Unit 1; Davis-Besse Nuclear Power Station, Unit 1), LBP-92-32, 36 NRC 269 (1992); Consumers Power Co. (Midland Plant, Units 1 and 2), LBP-85-2, 21 NRC 24, 46 (1985); Kerr-McGee Chemical Corp. (West Chicago Rare Earths Facility), LBP-84-42, 20 NRC 1296, 1306 (1984). Historically, however, applicants have usually elected not to make such challenges on safety matters in original licensing actions, but instead have found it more prudent to accept the Staff's critique and to make the suggested corrections.

[13] Specifically, as noted earlier (see fn. 6), that Board conducted a hearing in mid-2000 on the merits of several contentions involving financial assurance and emergency planning. A partial initial decision was issued on the latter. LBP-00-35, 52 NRC 364 (2000), petition for review denied, CLI-01-09, 53 NRC 232 (2001). The financial assurance matters are still under advisement but will be decided no later than the rest of the matters before this Board.

not raising issues litigable in this forum, and/or not furnishing sufficient justification for being filed outside established time periods.[14]

Other contentions, although initially admitted as appropriate to litigate, were later dismissed by one Board or the other on "summary disposition," a procedure invoked when there are no significant factual disputes about a matter and controlling legal principles warrant resolving it without the formal presentation of evidence at a trial. As to those issues, the Applicant was able to convince us that no evidentiary hearing was necessary to determine that the State's, or other parties', claims lacked merit.[15] In other instances, after discovery of additional facts bearing on particular claims, an intervening party withdrew contentions on the grounds that its concerns had been satisfied.

Several of the State's contentions survived all this screening and moved into the hearing process before this Board. These State issues included two safety matters -- involving concerns about seismic activity and aircraft accidents -- as well as an environmental issue involving potential water pollution from operations. For its part, SUWA's surviving contention challenged the routing of the proposed rail spur as being inconsistent with environmental and other norms reflected in the National Environmental Policy Act and elsewhere.

Each of the foregoing four issues -- which eventually became the subject of the Salt Lake 2002 hearings -- arose in different fashion, and took different amounts of time to try before either the matter was settled (in the case of the water pollution issue) or the trial was

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[14] We need not recite here the Board's many prior decisions on the initial admissibility of contentions (referred to in the text above) or on summary disposition of previously admitted contentions (<u>see</u> next paragraph of text). We do note that some 120 contentions were covered.

[15] As just noted, we need not detail those here, for each was the subject of a published Board opinion. To the extent that any of the Board's pre-hearing rulings were not ripe for appeal to (or for review by) the Commission at the time, they will become ripe when a Partial Initial Decision to which they relate is issued, or (if unrelated to any earlier decision) when our last Initial Decision is issued. CLI-00-24, 52 NRC 351, 353-54 (2000).

completed. We need not discuss here the background of the other issues that remain pending, for that will be done in due course in the later decisions resolving those issues.

d. The "Credible Accidents" Contention Specifically. We focus instead on how the issue we decide today, involving the likelihood of aircraft accidents, has presented itself. Again speaking generally (see p. 2, above, and Subpart E, below), the Commission requires that any facility it licenses be designed to withstand "credible accidents," that is, any accidents deemed sufficiently likely to occur that they should be guarded against. The probability criterion defining that likelihood is also set by the Commission. Any potential accidents less likely than that criterion are considered "incredible" and are allowed to be disregarded in designing the facility, that is, they do not become part of the facility's "design basis."

Against that background, the State presented a contention -- eventually denominated Utah K / Confederated Tribes B -- arguing that a variety of risks from military and other operations in Utah's West Desert could lead to airborne and other accidents that could threaten the facility.[16] As the State saw it, the cumulative probability of those accidents made them a credible threat to public health and safety, such that they had to be taken into account in some fashion. In contrast, the Applicant, supported by the NRC Staff, saw those accidents as not credible and thus safely disregarded. The subsidiary issues which were the subject of our hearing on the contention are described in the next Section.

2. The Key Issues

a. The Prior Decisions. The "credible accidents" issue presented in this proceeding has had a complicated history, a brief review of which should aid understanding of the action we

[16] A variant of the State's contention was filed by intervenors Confederated Tribes (who opposed the project but did not participate actively at the trial) and Castle Rock Land and Livestock Co. and Skull Valley Co. (representing neighboring landowners who withdrew before trial). The contentions were all consolidated and revised to read as follows: "The Applicant has inadequately considered credible accidents caused by external events and facilities affecting the [proposed facility] and the intermodal transfer site, including the cumulative effects of the nearby hazardous waste and military testing facilities in the vicinity and the effects of wildfires." LBP-98-7, 47 NRC 142, 253, aff'd on other grounds, CLI-98-13, 48 NRC 26 (1998).

take today. A more complete history appears in two prior rulings: (1) this Board's decision granting in part and denying in part the Applicant's motion for summary disposition and referring a key matter to the Commission for its pre-trial resolution (LBP-01-19, 53 NRC 416 (2001)), and (2) the Commission's resolution of that matter (CLI-01-22, 54 NRC 255 (2001)).[17]

In a nutshell, in LBP-01-19 we found there to be no reason to go to trial on a number of concerns the State had attempted to raise about the risk of potential flying or falling objects that might result from certain aspects of military or civilian aircraft operations or airborne testing experiments.[18] But some of those concerns, we held, did justify a trial. As to those, we sought Commission guidance on, and approval of our views about, the appropriate test for "credibility" of an accident -- did that test reach occurrences as unlikely as one in ten million (1×10^{-7}), the

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[17] See also our decisions in LBP-99-34, 50 NRC 168 (1999), LBP-99-35, 50 NRC 180 (1999), and LBP-99-39, 50 NRC 232 (1999), all of which led to the contention's eventually being limited to and reframed as: "The Applicant has inadequately considered credible accidents caused by external events and facilities affecting the [proposed facility], including the cumulative effects of military testing facilities in the vicinity." LBP-99-39, 50 NRC at 240.

[18] In that decision, we ruled on whether or not a genuine dispute of material fact existed regarding several categories of events that the State asserted in its amended contention were "credible accident scenarios." These categories involved assertions that the facility would be at risk from (a) the use of military ordnance at Dugway Proving Grounds; (b) the testing of cruise missiles on the UTTR; and (c) the potential for a variety of aircraft accidents.

In the first two instances, we granted the Applicant's motion to dismiss and thus eliminated the need for further litigation on those issues. With respect to the first, the use of ordnance at Dugway, we found that no genuine dispute of material fact existed because the State no longer contested the Applicant's evaluation of munitions hazards. LBP-01-19, 53 NRC at 424. As to the second, we found that cruise missile testing did not present a genuine dispute of material fact because even in situations where cruise missiles have crashed, the State could not point to any circumstances in which the missiles had strayed more than one mile from the original flight path, a distance which would not bring the proposed site within range. Id. at 427-29.

The third category, aircraft crash hazards, presented several issues about which we found a genuine dispute of material fact to exist; those are the issues on which we went to trial and with which we deal herein. But we also held that other aspects of the State's assertions -- regarding the hazards of commercial aircraft flying to and from Salt Lake City International Airport and of other general aviation activity -- presented no genuine dispute of material fact. Id. at 451, 452. In making that ruling, we found that the State's expert witness had not provided any concrete scientific analysis to controvert the Applicant's submissions, and thus resolved the matter in the Applicant's favor. Id.

criterion applied to nuclear power plants, or for facilities like this[19] need it reach (as we thought) only those occurrences more likely to take place, i.e., with at least a one in a million (1×10^{-6}) likelihood per year?

The Commission adopted the one in a million criterion, for the reasons it explained at some length in CLI-01-22. In essence, the Commission reasoned that, because of the lesser consequences that would attend an accident affecting a spent fuel cask than one affecting a nuclear power plant (see CLI-01-22, 54 NRC at 265),[20] a greater likelihood of an accident (i.e., an accident anticipated to occur more frequently) could be tolerated for spent fuel facilities before requiring that the accident be designed against.[21] Accordingly, the Commission held that for proceedings of this nature, any accident with a likelihood of occurrence of less than one

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[19] In NRC parlance, the proposed interim storage facility is called an Independent Spent Fuel Storage Installation, or ISFSI. See 10 C.F.R. § 72.3.

[20] Given the conclusions we reach later in this opinion (see Subpart E, below), it is important to observe that the Commission's discussion of hypothetical "consequences" -- in the context of setting a probability criterion -- was of a general, comparative character and does not provide any insight into the specific, precise level of consequences that might result if a spent fuel cask accident indeed did take place. See also the notation in CLI-01-22 of the views of Commissioner Dicus, 54 NRC at 265-66.

[21] The pleadings that had been filed when the Commission made the above ruling had placed almost exclusive emphasis, as to F-16s, on the probability, not the consequences, of an aircraft hitting the facility. For example, the Commission's opinion referred to the Applicant's having indicated that "various accident scenarios [were] extremely unlikely" and that "in some cases . . . even if the posited accident did occur, no radioactive materials would be released." CLI-01-22, 54 NRC at 258 (emphasis added). That "in some cases" reference was to general aviation aircraft, not to F-16s, as may be seen by examination of the material cited.

in a million per year could be disregarded.[22] Id. That is, then, the standard we apply to the F-16 overflights and related matters.

b. The Accident Likelihood. Although a number of other accident scenarios were still before us (see Section C.6, below), principal focus as the trial began was on the risk from F-16 flights down Skull Valley on their way to the UTTR. To determine the probability of an F-16 crash into the spent fuel casks, attention turned first to a four-factor formula the NRC Staff had developed long ago -- and embodied in the "Aircraft Hazards" portion of its Standard Review Plan (in a document known as "NUREG-0800," described more precisely below) -- that had regularly been used to calculate the risks of aircraft crashing into NRC-regulated facilities.

Although much argument took place about the values to be given various of the factors in this case, exception was not taken to the underlying legitimacy of the formula itself, i.e.,

$$P = C \times N \times A/w$$

whose factors for calculating yearly accident probability (P) represent, respectively:

- C -- the aircraft's historic accident rate (in accidents per mile flown);
- N -- the number of flights per year;
- A -- the effective area of the facility (in square miles); and
- w -- the width of the airway (in miles).

As will be seen, in this proceeding there was considerable controversy over deriving "C", the appropriate historic or projected accident rate to use; about projecting "N", the number of flights in future years; and about defining "w", the useable width of the airway (but essentially none

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[22] It appeared at that time that, had the Commission ruled that the stricter "one in ten million" criterion should apply, the Applicant would have conceded that the accidents we discuss herein would be deemed credible and thus that they must be designed against. See LBP-01-19, 53 NRC at 431. Instead, the Commission's adoption of the less stringent standard left it open to the Applicant to argue that those accidents were not credible, with the result that their specific consequences would not have to be considered. The impact this had on how the case later developed is reflected in Subpart E, below.

about “A”, the effective area of the facility). But in whatever fashion those disputes were resolved, it appeared early on, from its own calculations, that the Applicant would have some difficulty proving that the accident scenario was “incredible” under the basic four-factor formula.

This led to the most extensive and crucial controversy, involving the Applicant’s attempt to modify the basic four-factor formula by including a fifth factor (denominated “R”*)*. We were told that such a multiplier would reduce the yearly accident probability by accounting for “pilot avoidance,” i.e., the purported action pilots would be expected to take, when able to do so, in guiding their doomed planes away from particular ground locations -- like the PFS facility -- before ejecting.

Pointing to the nature of most inflight emergencies that might be expected over Skull Valley and to the quality of Air Force training to deal with those emergencies, the Applicant proposed to take an approximately 85% reduction in the accident likelihood because of the so-called R factor.[23] To justify that reduction, it analyzed accident causes as reflected in the set of F-16 accident reports prepared by the Air Force, and then relied almost entirely on expert opinion about pilot behavior in emergencies provided by its three-man panel of former high-ranking Air Force officers (whose qualifications, including their familiarity with Skull Valley, we detail later); it also drew upon the accident reports for exemplars of such behavior.

In opposition, the State made two basic arguments: (1) the NUREG-0800 formula is set and will not admit of a fifth factor; and (2) the Air Force’s accident reports and the Applicant’s expert opinions do not support an 85% reduction value for R. In support of the second

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[23] As defined, R represents the probability that a crashing F-16 will hit the site by the pilot’s not avoiding it before ejecting. As will be explained in more detail, R is a function of the product of two components -- which we call R1 and R2 (as they were sometimes referred to during the hearing and in the parties’ proposed findings (see, e.g., Staff Findings ¶ 2.165)) -- that measure conditions leading to accident avoidance. Accordingly, R is best described as follows: R = 1 - (R1 x R2). On occasion at the hearing, however, the product of the two components was itself loosely referred to as “R,” and the Transcript must be read accordingly.

argument, the State -- relying in part on the opinions of its own expert, a former F-16 (and currently Southwest Airlines) pilot who, while serving at Hill Air Force Base, had flown over 150 missions in the UTTR and also served as Deputy Commander of the 388th Operations Wing -- pointed not just to its contrary interpretation of the contents of the reports themselves but also to the purpose for which the reports were prepared and to examples of circumstances in which pilots had erred by ignoring their training.

In essence, we reject the first of the State's arguments (against adding an R-type factor), but accept the second (about the value assigned to R here). We explain why we do so in Subpart B, below.

Having thus not given the Applicant the credit it attempted to assign to the fifth factor, we turn in Subpart C to consideration -- under the classic "four-factor" formula -- of the likelihood of an accident at the PFS site. On the facts presented, we find that probability exceeds the one-in-a-million criterion by over a four-fold margin. We then go on in Subpart D to explain why we cannot accept the Staff's argument that there is so much flexibility in the "one-in-a-million" criterion that the Applicant's proposal should -- notwithstanding the adverse Subpart C result -- be deemed to meet that criterion.

Our ultimate holding, then, is that the accident in question must be deemed "credible," which in turn demands additional analysis from the Applicant if it wishes to pursue its license application, such as by demonstrating that the accident's consequences are not significant. Given the importance that the "consequences" issue could thus well take on as the proceeding goes forward, we set out in Subpart E our understanding of how that matter had come to us only tangentially at the 2002 hearing and thus was -- as the Staff conceded -- not then ready for consideration. We go on to mention briefly how that issue can now become ripe for full consideration, if the Applicant chooses to exercise the option of attempting to demonstrate that there would be no untoward consequences if the "credible accident" indeed did take place.

B. The Proposed Pilot Avoidance ("R") Factor

As has been seen, in order more accurately to reflect its view of reality, the Applicant proposed to add a "pilot avoidance" factor -- called "R" -- to the NUREG-0800[24] formula in an effort to show that the probability of an aircraft crash on the site is much less than the unmodified formula would indicate. As the Applicant sees it, inclusion of the R factor enables it to demonstrate that the facility meets the Commission's licensing requirements.

Underlying the R factor formula modification is the belief of the Applicant's experts that, when possible (which they say is 90% of the time), Air Force pilots would almost invariably (95% of the time) act affirmatively to avoid striking the facility's spent fuel casks in the event of an impending crash. If this predicted "pilot avoidance" behavior could be relied upon, goes the argument, it would reduce substantially -- by some 85% -- the calculated probability of impact on the site and thus permit NRC approval of licensing.

As has been noted (fn. 23, above), the R value the Applicant wishes to add as a factor in the probability formula is a function of two components. The R1 component represents the proportion of times a crashing plane is nonetheless "controllable," said by the Applicant to be 90%; the R2 component represents the proportion of times a pilot in control would avoid the site, said here to be 95%. With R set as equal to 1 - (R1 x R2), the product of the two components is .855 (representing site avoidance), and the value of R to be inserted in the formula is .145 (representing non-avoidance, or the occurrence of the accident).[25]

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[24] PFS Exh. RRR, U.S. Nuclear Regulatory Commission, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, NUREG-0800 (Rev. 2, July 1981).

[25] See fn. 23, above. R1 and R2 as we use them should not be confused with the R_1 and R_2 that were used in earlier documents to represent different concepts that led to the same value for R through a different set of calculations (see, e.g., PFS Exh. N, Aircraft Crash Impact Hazard at the Private Fuel Storage Facility (Rev. 4, Aug. 2000) at 7-8 [hereinafter Aircraft Crash Report]). Although the mathematical calculational process relating to the R factor can be approached in different fashions to reach the same result (compare id. with fn. 23, above), in all such approaches the key issues concern the accuracy of the 90% "in control" and 95% "will avoid" component values upon which the Applicant relies to reach its 85.5% crash reduction rate (and its complement, the 14.5% crash likelihood).

The State makes several arguments against adoption of the R factor. First, it says, the standard NUREG-0800 formula is set with its four factors and does not admit of any alteration. Second, claims the State, the values the Applicant proposes for the components of the R factor do not have sufficient support either in the historic accident reports or in the expert opinion proffered by the Applicant's witness panel.

As to the reports, the State says they do not justify the conclusion the Applicant would draw that 90% of the time a pilot would be in control of the aircraft in an emergency. As to the expert opinion about pilots following their training and taking avoidance action when in control of their planes, the State argues those opinions are undercut by actual experience, including pilot errors that are not only recounted in the very reports which the Applicant presented, but which occur sufficiently frequently to warrant the Air Force's preparing and distributing a re-training video and a written safety reminder. Nor, says the State, can those reports serve as probative exemplars of the Applicant's theories of pilot behavior in issue here, when viewed with an understanding of the limited, very different purposes for which the reports were created.

We discuss the parties' competing arguments in Sections 1 and 2 below.[26] Once again, we do not accept the State's argument that no alterations to the formula are legally or

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[26] At this juncture, we should expand on our previous mention (p. 4, above) of the interrelationship between this Part I Narrative Opinion, explaining our reasoning, and the more detailed supporting material, reviewing and evaluating the evidence, that appears in Part II. In terms of cross-references, particularly with respect to Subparts B and C of both Parts, it is our intention -- whether or not a particular thought in the Narrative is accompanied by a specific reference to the detailed findings -- to place reliance on the portion of the detailed findings that supports the narrative thought.

As a general matter throughout the remainder of this decision, if we cite to a Proposed Finding submitted by one of the parties, rather than to the evidentiary record, it is because (1) we are merely stating that party's position; (2) the matter under discussion is non-controversial; and/or (3) we intend to incorporate by reference the record citations included in the Proposed Finding. On a related topic, if through inadvertence there appears to be a discontinuity between our written text and our record references, the text is to be deemed to reflect our views more accurately.

conceptually permissible. But we reject the value the Applicant proposes for its R factor alteration as not proven by the evidence before us.

1. Amending the Standard Formula

The State asserts that the Applicant's modification of the venerable four-factor NUREG-0800 formula is invalid, almost as a matter of law.[27] It points out that NUREG-0800 makes no reference to any R-type factor in the crash probability formula, and contains no suggestion that the pilot of a crashing aircraft might be able to avoid its impacting the ground site of concern. See State Findings ¶ 57. The State also notes that the key Staff witness -- Dr. Kazimieras Campe, who has for 30 years been evaluating accident hazards, including aircraft crashes (see Tr. at 4080 (Campe)) -- testified that he has never been presented a significant departure from the four-factor formula, and knows of no authoritative sources that recognize a pilot avoidance factor. See Tr. at 4109, 4126 (Campe).

We reject the State's arguments on this score. As we conclude, the structure and language of the series of Staff documents (like NUREG-0800) that set out the basis for the Staff's "Standard Review Plan" analysis make it clear that they do not establish binding principles that must be followed in all instances. Rather, they are intended as guidance, setting out but one method that the Staff will treat as an acceptable approach to complying with NRC regulations. To that end, NUREG-0800 declares in a standard cover page explanation that "compliance with [this guidance] is not required."

This construction -- that compliance with guidance associated with the Standard Review Plan is not required by the relevant statutes or by NRC regulations -- has long been recognized in NRC practice and jurisprudence. As a general matter, an applicant for a license has the option -- as it sets about to prove to the Staff in the first instance that its proposal meets

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[27] See State of Utah's Proposed Findings of Fact and Conclusions of Law Regarding Contention Utah K/Confederated Tribes B (Aug. 30, 2000) ¶ 57 [hereinafter State Findings].

applicable regulatory requirements -- either (1) to adopt an approach outlined in, and to demonstrate compliance with, the Standard Review Plan (thereby in effect assuring Staff approval) or (2) to present and to justify some alternative approach. See Curators of the University of Missouri, CLI-95-8, 41 NRC 386, 397 (1995). By the same token, an intervenor, though not allowed to challenge duly promulgated Commission regulations in the hearing process (see 10 C.F.R. § 2.758), is free to take issue with the terms of the Standard Review Plan, which represents only Staff guidance and thinking, not official Commission requirements.[28]

That general understanding of the role of the Standard Review Plan is captured in the materials before us. Specifically, with respect to the four-factor formula, NUREG-0800 recognizes at § III.2 (at 3.5.1.6-3) that the formula is just "one way" of calculating the probability of an aircraft crash. Building on that concept, Staff witness Dr. Campe, one of the original authors of the section of NUREG-0800 dealing with aircraft hazards, expressed the view that

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[28] To understand NRC adjudications in terms of matters like that just discussed in the text, it is important to distinguish among the roles, duties and responsibilities of, respectively, the Commission(ers), the Staff, and the Licensing Boards. To that end, we take some care in all our writings to distinguish among those entities; when, instead, the context calls for us to speak of the agency as a whole, we use the term "NRC."

To begin with, it is the five Presidentially-appointed and Senate-confirmed Commissioners who, empowered and directed by the governing statutes (like the Atomic Energy Act and the National Environmental Policy Act), set licensing requirements by issuing regulations on safety and environmental matters. Those regulations are binding on the NRC Staff and on Licensing Boards.

In the course of applying and enforcing agency regulations, the NRC Staff may provide guidance to the regulated community. Boards -- being entirely independent of the Staff -- are not bound, however, to follow such guidance; they are bound only by the Commission's regulations and its adjudicatory precedents (which it issues in the course of conducting judicial-style review of our decisions, much as a higher court reviews a lower court's decisions).

the use of R -- if factually supported -- would be an acceptable way to accommodate the concept that military pilots might avoid a particular ground site.[29] See Tr. at 4098 (Campe).

Accordingly, although NUREG-0800 does not explicitly contemplate the use of an R-type modification factor, we hold that use of such a factor is not prohibited by NRC regulations, Commission precedent, or any other legal principle. Thus, the Board may permit such a modification if it is factually and technically well-founded.

The dispute among the parties as to the use of the R factor, then, comes down to whether the components of the R factor, and the values the Applicant would assign them, are justified by the evidence before us. In the next Section, we address whether those values were proven.

2. Evaluating the Proposed R Factor

a. The Applicant's Position. The overall R factor is a function of the frequency with which pilots undergoing an emergency in which a crash is likely can be expected to take avoidance action before ejecting from the aircraft. The State does not so much challenge the general theories behind the Applicant's promotion of the R factor's two components as it takes issue with the specific values the Applicant would give each of them.

The legitimacy of the R factor thus turns on whether the Applicant has adequately demonstrated (1) how often F-16 pilots are in control of their aircraft while experiencing emergencies; and (2) how often a pilot in such control will, before ejecting, take action to make sure the crashing plane avoids particular ground locations. The Applicant's conceptual basis for developing those two components derives from two beliefs held by its panel of expert witnesses, all retired high-ranking Air Force officers, one with special familiarity with statistical

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[29] We do not find this view to be in any way inconsistent with Dr. Campe's also having indicated that he had not previously been presented with such a concept. See p. 20, above.

analysis, another with significant safety expertise, and a third with extensive flight experience in Skull Valley.[30]

The first belief is that, in an aircraft emergency, a pilot will often have the time and the opportunity to steer the disabled plane away from a ground site before ejecting.[31] The second is that a pilot with the time and opportunity to take such avoidance action will -- to a near certainty -- do so as a consequence of the rigorous training that pilots receive. See PFS Findings at 24-25.

With those assumptions in mind, the Applicant's experts proceeded to estimate the numerical value of R, relying on an analysis of historic F-16 accident reports and on their own expert opinion. See PFS Findings ¶¶ 69, 71. The Applicant determined the values of the R factor's two components through two separate analyses.

The R1 analysis first required an elaborate protocol to screen out inapplicable reports, i.e., reports addressing accidents that occurred under "non-Skull-Valley" conditions. See PFS Findings ¶ 72. In that regard, as will be discussed in more detail in subsection C.4.a, below, the portion of an F-16's training flight that takes place over Skull Valley, while not risk-free, was viewed by the Applicant's experts as akin to "normal flight," in that operations over Skull Valley involve neither takeoff or landing nor (as described in fn. 70, below) the sort of high-risk maneuvers that take place in the UTTR.

From the remaining set of accident reports, the experts determined the frequency (R1) with which pilots who had been operating in "Skull Valley conditions" were presented with the opportunity to steer the aircraft in an emergency situation, which the witnesses set at 90%. See

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[30] Our detailed findings of fact in Part II, below, reflect the witness' qualifications and our findings that they did qualify as experts. See 99-103.

[31] See Applicant's Proposed Findings of Fact and Conclusions of Law on Contention Utah K/Confederated Tribes B (Aug. 30, 2000) at 19-20 [hereinafter PFS Findings].

PFS Findings ¶ 74. Then, the Applicant's panel drew upon their collective expertise to propound the view about R2 that, when encountering an emergency while traversing Skull Valley, a pilot able to control an F-16 about to crash will, before ejecting, guide the aircraft away from the PFS site (or from any site that should be avoided) 95% of the time. See PFS Findings ¶ 91. We delineate below the detailed methodology utilized by the Applicant in determining the values of the two components.

(i) Probability of a Pilot Being in Control of an Aircraft. As was noted above, the R1 component represents the percentage of F-16 crashes that might occur in Skull Valley in which the pilot would be expected to retain control of the aircraft. The Applicant asserts that the most likely cause of an emergency threatening a crash in Skull Valley -- with its "normal flight" conditions -- is engine failure, which leaves the pilot in some degree of "control" (see PFS Findings ¶¶ 68, 73), as that term was employed in the hearing. For all crashes that might occur in Skull Valley, the Applicant assessed at 90% the probability that the pilot would be in such control of the aircraft before ejecting. See PFS Findings ¶ 74.

The Applicant's expert witnesses reached this figure by independently assessing each of the Air Force's available reports (for fiscal years 1989 through 1998) about F-16 accidents (occurring anywhere) that resulted in the aircraft being destroyed. See PFS Findings ¶ 69. Those reports were prepared by Air Force Aircraft Accident Investigation Boards, each of which is typically chaired by a Colonel and includes experts on the relevant subject matter. See PFS Findings ¶ 70.

Initially acting independently of each other, the three members of the Applicant's panel reviewed these accident reports. See PFS Findings ¶ 71. A joint review followed to resolve any discrepancies in their separate professional judgments. See PFS Findings ¶ 71. As a result of this procedure, the experts categorized each accident on two principal counts: (1) could its causes have resulted from the flight conditions experienced during Skull Valley operations; and

(2) did the pilot have enough control over the aircraft prior to ejection to steer the aircraft away from a site such as the PFS facility. See PFS Findings ¶ 72.

Out of the 121 F-16 accidents that destroyed the plane and for which reports were available, the Applicant's experts initially concluded that 61 were Skull-Valley-type events, and that in 58 of those -- or just over 95% -- the pilot retained control of the aircraft. See PFS Findings ¶ 74.[32] For purposes of conservatism, however, for the proportion of accidents that would leave a pilot in control, the Applicant took credit for only 90% rather than the calculated 95%. See PFS Findings ¶ 74. For its part, the Staff concurs with the PFS assessment of the accident reports in this regard.[33]

(ii) Pilot's Acting to Avoid the Site When in Control. As was also noted above, the second component, or R2, in the Applicant's aircraft crash hazard calculation involves the probability that a pilot who is able to control an aircraft experiencing an in-flight emergency would actually take sufficient action before ejecting to avoid a particular ground site. Starting with their strongly held beliefs about pilot training and dedication -- and before examining any of the accident reports and without conducting any statistical analysis -- the Applicant's expert panel assessed the value of this component to be 95%. See PFS Findings ¶ 92.

In reaching this judgment, the Applicant's panel considered a number of factors that they believed were well-founded and would aid a trained, dedicated pilot in accomplishing avoidance: (1) the time the pilot would typically have before ejecting (estimated at one or more minutes, as derived from Air Force data regarding F-16 performance following engine failure);

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[32] Later, the Applicant conceded that one additional accident could have occurred in Skull Valley type conditions. See Cole/Jefferson/Fly Post Tr. 3090, at 78-81. Treating that aircraft as having been in control before the pilot ejected, the proportion of "in control" crashes became 59 of 62, marginally increasing the resulting 95% value.

[33] See 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) ¶ 2.283 [hereinafter Staff Findings].

(2) the pilot's ability to conduct restart operations or otherwise to complete all necessary emergency response actions in timely fashion; (3) the slight turn required to avoid the PFS facility; (4) the training that pilots receive about avoiding inhabited or built up areas on the ground;[34] (5) the familiarity that pilots at Hill AFB would have with the location of the PFS facility; (6) the existence of open spaces around that facility; (7) the excellent weather and clear visibility typical of Skull Valley; and (8) the F-16 flight control computer that keeps the aircraft on a straight flight path after ejection. See PFS Findings ¶ 92.

To corroborate its R2 estimate, the Applicant discussed 15 accident reports as exemplars during the hearing. See Tr. at 3662 (Cole). After the Board repeatedly questioned the statistical legitimacy of such a limited proffer,[35] the Applicant submitted all of the relevant accident reports, which were duly introduced into evidence.[36]

b. The Staff's Position. The Staff asserts that taking credit for a pilot's ability to direct a crashing plane prior to ejecting is a legitimate approach and that the R2 value is not based on

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[34] The relevant F-16 manual urges a pilot preparing to eject to carry out a number of tasks, including -- time permitting -- guiding the plane away from "populated areas." At the hearing, some discussion took place, as a general matter, about what this term means and what type of action is contemplated, as well as how the instruction should be interpreted in the specific circumstance involving spent nuclear fuel casks (and perhaps other areas to avoid). Although those discussions about "populated area" were not entirely illuminating, we explain later (see fn. 67, below), why we do not rest our decision on any interpretation of that concept.

[35] The questions the Board posed to the Applicant sought an explanation as to how the estimated 95% probability of a pilot successfully avoiding a land target was derived from 15 out of 126 accident reports. See Tr. at 3663 (Lam). On its face, 15 successful events out of a total of 126 events yields only a 12% probability of success. See Tr. at 3668 (Lam). The Applicant's position was, however, that it had not placed principal reliance on the accident reports in determining the 95% success probability estimate. See Tr. at 3215-16 (Jefferson).

[36] Following the admission into evidence of the initially proffered 15 accident reports, see Tr. at 3740-45, there was later discussion (recounted at Tr. at 8673-78) about whether all 126 accident reports needed to be before us for a sound decision to be made on the R1 and R2 components. To afford the State an opportunity to analyze and to respond to the additional reports, the hearing was recessed (to consider other issues already scheduled) and reconvened at a later point. See Tr. at 8677-78.

purely subjective opinion.[37] The Staff concurred that a pilot with adequate control of the aircraft and sufficient time to direct it away from a ground site before ejecting would indeed be able to have it avoid the facility at least 95% of the time. See Staff Findings ¶ 2.475.

In support of this position, the Staff joined the Applicant in strongly asserting that Air Force training will prepare a pilot to respond successfully to emergency situations. See Staff Findings ¶ 2.295; Staff Reply ¶ 104. As the Staff would have it, the success of the training programs is evidenced by the accident reports recounting occasions in which pilots have, in ejecting, been successful in causing their crashing planes to avoid objects on the ground. See Staff Reply ¶ 104. In this regard, the Staff points out that "[i]n no report do we find that a pilot with time and opportunity to avoid a ground site failed to do so." See Staff Reply ¶ 89. From this the Staff contends that the Applicant "could have reasonably set the determination at 100%, but, as a measure of conservatism chose to set the value at 95 percent avoidance." See Staff Reply ¶ 89.

The Staff also put forward a sensitivity analysis that it performed as part of its consideration of the 95% value presented by the Applicant. The Staff testimony characterized that sensitivity analysis as evaluating the effect of "increasing by 20 times" the predicted likelihood of a crashing plane hitting the PFS facility. See Campe/Ghosh Post Tr. 4078, at 21. Doing so, the Staff said, increases the overall crash probability by only a factor of 2.5. See id.

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[37] See NRC Staff's Proposed Findings in Reply to the State of Utah's Proposed Findings Concerning Contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents) (Oct. 7, 2002) ¶ 89 [hereinafter Staff Reply].

From that, the Staff urged us to find that the crash probability is thus "not highly sensitive" to variations from the 95% avoidance factor.[38] See id.

c. The State's Position. The State asserts that the Applicant's R1 assertion -- that in 90% of crashes the aircraft is controllable -- is deficient on two grounds. First, although noting that much was made by the Applicant of the evidence that engine failure (see State Findings ¶ 70) -- a circumstance in which the aircraft remains controllable -- is the most likely cause of a crash, the State points out that, according to F-16 manufacturer Lockheed Martin, crashes that occur due to engine failures account for only 36% of Class A mishaps. See State Findings ¶ 67. From this, the State reasons that as a general matter, in a much lesser percentage than the Applicant's postulated 90% would control of the aircraft be retained. Id.

Second, asserting that the accidents that took place in "non-Skull-Valley" flying conditions should not be eliminated from consideration, the State claims that 42% of the 121 crash reports indicate the pilot did not have sufficient control of the aircraft to have avoided the PFS site. See State Reply at 36. Therefore, according to the State, only 58% of those crashes could have resulted in the pilot retaining control of the aircraft, rather than the 90% asserted by the Applicant. See State Reply at 36.

Turning to the R2 component, the State asserts that the value of 95% used by the Applicant "is a purely subjective determination made collectively" by the Applicant's experts, one which "was made without performing any calculation or statistics" and indeed "was made prior to reviewing the F-16 accident reports." State Findings ¶ 69. The State also asserts that the

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[38] More specifically, the Staff examined a "failure to avoid" probability range from 1% to 20%, which it referred to as a "20 times increase." See Staff Exh. C, Consolidated Safety Evaluation Report Concerning the Proposed Private Fuel Storage Facility (Mar. 2002) at 15-58 [hereinafter SER]. Had that range been expressed in terms of the R2 "avoid" component, the range would, of course, have been from 99% to 80%. We discuss later (see fn. 66) the appropriateness of representing that range as a "20 times increase," and then asserting therefrom that the 95% base value is not highly sensitive.

statistical evidence is flawed because it lacks affirmative support; all that is being shown, it says, is the purported absence of negative information, as epitomized by the Applicant's experts testifying that ‘‘we found no case where they tried to avoid something, and they didn't avoid it."[39]

In short, the State vigorously challenges the correctness and reliability of the analytical protocols followed by the Applicant to obtain numerical values for R1 and R2. In addition to these specific challenges to the Applicant's data, the State makes two general arguments in an effort to undercut the Applicant's approach on a broader scale.

First, the State argues that, because of the way the accident reports were compiled, they were never intended to be utilized as the Applicant is doing, and thus cannot validly be used to confirm the Applicant's theories. See State Reply at 35-36. The accident reports were prepared, goes this argument, under Air Force Instruction 51-503, which does not have as one of its intended purposes a determination of whether a pilot was able to control an aircraft during the emergency so as to avoid a ground site.[40]

The State's second argument is that the reports not only are unfit for use as evidence of the pilot avoidance action the Applicant would rely upon, but also that they cut against the Applicant's position. See State Reply at 47. As the State sees it, the reports contain examples of pilot error, and illustrate deviations from pilot training, that -- rather than supporting the Applicant's premise that pilot action is helpful -- demonstrate that pilots cannot always be counted on to perform as trained. See State Reply at 47-50; State Findings ¶¶ 99-102.

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[39] See State of Utah's Reply to the Proposed Findings of Fact and Conclusions of Law of the Applicant and the NRC Staff on Contention Utah K/Confederated Tribes B (Oct. 7, 2002) at 5 (quoting Tr. at 13,103 (Jefferson)) [hereinafter State Reply].

[40] See State Reply at 35; State Exh. 60, U.S. Air Force, AF Instruction 51-503, Aircraft, Missile, Nuclear, and Space Accident Investigations (Apr. 5, 2000) [hereinafter AFI 51-503].

d. The Board's Decision.

R1. We find that the 90% controllability value the Applicant would assign to R1 is supported by sufficient evidence to justify our adopting it. The central issue on this point is whether it is legitimate to distinguish flight conditions in Skull Valley from those over the UTTR for purposes of distinguishing among the types of emergencies likely to be triggered in each. On that score, while certain maneuvers have to be conducted on the way down Skull Valley, and those maneuvers are not risk-free, they are significantly less intense than the mock combat and similar exercises that take place over the UTTR. See Aircraft Crash Report, Tab H at 8. We find it was appropriate, therefore, for the Applicant to limit its R1 analysis to the subset of F-16 crashes consisting of those that occurred in "Skull-Valley conditions."[41]

But this alone does not establish that the 90% controllability value is a permissible one. The State saw, in a number of the accident reports, facts that led it to argue that particular aircraft that the Applicant said were controllable, indeed were not. See State Reply at 37-38. We discuss those disputed reports in our Detailed Findings (B-14 to B-39) in Part II, below. As we find there, the Applicant has the better of that evidence, albeit just barely.

R2. In contrast, we find that the proposed 95% value for the R2 factor was unproven. In essence, the Applicant's experts believed that in an emergency situation, there was effectively a near certainty that a combination of factors -- primarily visibility, time, and training -- would lead ejecting pilots to send their crashing planes away from the PFS site.[42] See Tr. at

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[41] The above analysis also explains the difference between the Applicant's R1 evaluation and the apparently significantly different evaluation by the F-16 manufacturer. Lockheed Martin's 36% engine-failure analysis covered all accidents, regardless of where they occurred, while the Applicant's 90% focused only on accidents occurring in normal flight, thereby eliminating from consideration those occurring on takeoff or landing or in special flight conditions, each of which implicates many other types of crash causes.

[42] As has been seen (pp. 25-26, above), the Applicant put forward eight factors to support its pilot avoidance claim. But upon inquiry from the Board, the Applicant's witness agreed that the three factors just mentioned in the text were the primary ones.

8882 (Jefferson). But when the subject is the prediction of human behavior under stress, the successful establishment of an assertion of near certainty inherently calls for a highly probative showing.

To be sure, the Board has no quarrel with the general value system held by the Applicant's experts, to the extent that they strongly believe that Air Force pilots are well trained, that they will in good faith attempt to act to the best of their ability and training in an emergency situation, and that as pilots they are committed to high standards of human behavior. In that regard, we note the existence, in more than one official or unofficial accident report in the record, of heroic action whereby a pilot -- at the cost of his life -- stayed with his plane, rather than ejected safely, so as to be sure to avoid people in harm's way on the ground.[43]

The question is not, however, whether some pilots will perform heroic deeds, even at enormous personal risk, when called upon to do so. The question is, instead, whether the preponderance of the credible evidence supports the notion that, for nuclear safety regulatory purposes, pilots under the special stress of an ejection-type situation can be counted on almost invariably to perform exactly as their training has prepared them to do, or whether, in contrast, their performance is likely to be affected by such things as lack of time or visibility or by what amounts to, in the State's words,[44] "human factors" sources of errors.

We accept that in the event of aircraft failure, in the vicinity of the PFS site or elsewhere, pilots would generally do what they could, consistent with their other responsibilities, to guide

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[43] See PFS Exh. YYY (pilot died avoiding a school); PFS Exh. ZZZ (pilot intending emergency landing on parade ground died avoiding marchers); Tr. at 3763-65.

[44] See State Findings ¶ 104; see also individual accident reports which mention this concept: PFS Exhs. 187, 193, 197, and 200.

their aircraft away from vulnerable ground areas[45] before ejecting. But the 95% value of R2 propounded by the Applicant -- which has the burden of proof -- is far from sufficiently well-founded.[46] We are forced to conclude, for the reasons set out below, that the evidence supporting a high value for the R2 factor is too uncertain to be relied upon to make safety-related decisions for nuclear facility licensing purposes.

In short, probative contrary evidence undercut each of the three central factual premises -- visibility, time, and training -- underlying the Applicant's expert beliefs. When the concept being advanced is "near certainty," the proof necessarily must be solid. We find that in the face of the powerful evidence the State submitted to support its challenge, the Applicant has not met that burden -- to the contrary, the State's evidence predominates.[47]

Detailed analysis exposes the weaknesses in the Applicant's three basic reasons supporting its claim of 95% "pilot avoidance" success, which we first paraphrase. See Tr. at 8882 (Jefferson). First, because the weather in the areas surrounding the PFS site is almost always clear, pilots can almost always see problematic ground areas. See PFS Findings ¶¶ 99, 129-30. Second, there is almost always sufficient time before ejecting for the pilots to take action to steer the crashing planes away from those ground areas. See PFS Findings ¶ 94.

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[45] As indicated earlier (see fn. 34), because it is not necessary to our decision, we do not decide some key questions about the intent and scope of the F-16 Training Manual's instruction to "avoid populated areas." Thus, although we lay out some of the questions below (see fn. 67), we assume for purposes of this decision that pilots would for one reason or another treat the spent fuel casks the same as "populated areas."

[46] In this regard, none of the Applicant's expert panel, well-qualified though they might be in other respects, had ever ejected from a plane. See Tr. at 3216-17 (Jefferson/Cole/Fly). Faced with conflicting hearsay testimony about the thoughts of pilots who had ejected, the Board suggested obtaining direct, live testimony from pilots who had undergone that testing experience. See Horstman Post Tr. 4214, at 18-19; Tr. at 3222-24 (Jefferson/Fly). As will be seen, evidence provided by one -- Colonel Frank Bernard -- was particularly instructive on the key question underlined in the preceding paragraph.

[47] We provide, in the opening and closing paragraphs of Subpart B of Part II, below, additional thinking on the way in which the State's evidence predominates.

Third, the exceptional training Air Force pilots receive will almost always cause them, prior to ejecting, to attempt to guide their aircraft to avoid those areas. See PFS Findings ¶ 96. The State has vigorously challenged each of these asserted reasons.

To put our evaluation of the State's challenge in perspective, the Applicant's asserted R2 value essentially predicts almost certain success in human performance during emergency, stress-filled conditions.[48] Prevailing on such a claim is difficult, precisely because it takes very little in terms of examples of failure to defeat such a high success claim. Moreover, any prediction of human performance that claims there will be, particularly during emergency, stressful conditions, 95% success -- which the Applicant asserts to be conservative compared to the 100% theoretically supportable by its approach -- could benefit from a rigorous, in-depth evaluation and analysis of reliable operational data, which is lacking here.

The State has mounted a frontal challenge to the Applicant's evaluation and analysis. As to the visibility factor, the State's expert witness pointed out a variety of reasons why an F-16 pilot might be precluded from seeing a land feature. Those reasons included line of sight problems because of the configuration of the cockpit and the attitude of the aircraft[49] and the ways scattered cloud formations or fog can obstruct a pilot's sights.[50] For the pilot deliberately to avoid a land feature 95% of the time, the pilot must either be able to see the site, or have situational awareness of its existence, that same 95% of the time.[51] The State's expert

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[48] Colonel Bernard, who ejected from an F-16 during a training mission and whose testimony we draw upon in other respects below, testified that the greatest stress levels by a "significant measure" faced by a pilot occur during the moments before ejection. Tr. at 3897-98 (Bernard). He pointed out that there is a period of divided attention during an emergency that "completely becomes focused on what you need for your survival." Id.

[49] See Tr. at 13,302-07 (Horstman); Horstman Post Tr. at 4214, at 24.

[50] See Horstman Post Tr. 4214, at 21-24; Tr. at 8377-84, 13,416-24 (Horstman).

[51] The Applicant's witnesses stressed throughout the hearing the importance they placed on Air Force pilots developing and maintaining constant situational and positional awareness, so that regardless of where they are flying and where they are headed, they are

testimony cast significant doubt on whether the conditions necessary for visibility -- line of sight and meteorological conditions -- are present 95% of the time.

Secondly, the State offered evidence that there are instances where sufficient time is not available for pilot actions to avoid problematic land features. In this regard, a major concern is that because a successful restart is the most desirable outcome in engine failure emergencies, pilots are trained -- and perhaps more importantly, strongly motivated -- to attempt repeatedly to restart the engine.[52] The motivation is obvious: a successful restart of the engine means the incident is over, the plane is saved, the pilot is no longer in jeopardy, and the pilot need not eject.[53] This may lead to too many (in terms of lost altitude) attempted unsuccessful restarts, resulting in too little time for taking all the other steps called for in the situation before ejecting. See Horstman Post Tr. 4214, at 18-19; State Exh. 57, U.S. Air Force, ALSAFECOM 002/1996 (1996) at 3 [hereinafter ALSAFECOM 002/1996].

Moreover, the time pressure increases as the plane's altitude diminishes for, as the Air Force Manual provision on ejection procedures stresses, minimum ejection altitude should be

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cognizant of their surrounding environment. See Part II, below, pp. 140-41.

[52] See Horstman Post Tr. 4214, at 15-16, 18-19; see also Tr. at 3979-80, 4007-11, 4010-11 (Cosby), 3338-40 (Cole/Fly). In this regard, although pilots practice starting a failed engine on a simulator, an engine is never deliberately failed in flight as a training maneuver (unlike the training given to civilian pilots of small aircraft). See Tr. at 3333-37 (Cole/Fly).

[53] See Horstman Post Tr. 4214, at 19. Although ejection has saved many pilots' lives, it is far from a risk-free maneuver -- for there is significant threat of various injuries, including life-threatening ones, from ejecting from an aircraft even during ideal conditions (on this score, the State offered evidence concerning pilot fatalities and significant injuries from F-16 ejections). See State Exh. 151, Lt. Col. George D'Amore & Lt. Col. Tom Luna, USAF II Ejections and You, the Aircrew, U.S. AIR FORCE FLYING SAFETY, Sept. 2001, at 11-13; Tr. at 3901 (Bernard); see also Tr. at 3145 (Cole), 3270-71, 3303-04 (Jefferson), 3273-74 (Fly/Cole). Of course, actual ejection is never practiced (simulators can allow a pilot to practice all the steps preceding ejection and to experience being shot 12 to 15 feet up a set of anchored rails). See Tr. at 3335-36 (Cole/Fly). Accordingly, there is no way -- other than through an actual previous ejection -- to experience the full stress of the ejection phenomenon before it takes place in an actual emergency situation that is already stress-filled. See Tr. at 3333-37 (Cole/Fly).

no less than 2,000 feet above the ground to provide the pilot the best survival opportunity.[54] Indeed, to promote pilot safety, Air Force training emphasizes that pilots should not eject too low. See Manual at 3-42. But the desire to avoid ejection (with its potential for personal injury and its certainty of aircraft loss) by re-starting the plane sometimes leads to ejecting below the desired altitude. See ALSAFECOM 002/1996 at 3. In that situation, the pressure of belatedly carrying out other responsibilities can take away from the time needed to guide the plane away from the "populated areas" referred to in the Manual (see related discussion, fn. 67, below).

Regarding the third asserted reason, the State introduced evidence that despite the extensive training provided to Air Force pilots, and notwithstanding their dedication, they commit human errors -- and such errors would be expected to occur -- particularly in instances where very high stress exists. The State demonstrated convincingly that four interrelated factors contribute to these pilot errors:

- Pilots are trained to focus on attempts to save the aircraft by constantly trying to restart its single engine. This can leave very little time for a safe ejection when the pilot eventually realizes that restarting the engine is futile. See Horstman Post Tr. 4214, at 15-16, 18-19; ALSAFECOM 002/1996 at 3. See also Tr. at 3979-80, 4008, 4010-11 (Cosby).

- Preparation for ejection from the aircraft -- which poses a significant threat to the pilot -- takes much of the pilot's attention, competing with trying to avoid a given land area, which the Manual says to do "if time permits" after attending to other matters. See Horstman Post Tr. 4214, at 15-16, 18-19; Manual at 3-42; see also Tr. at 4030 (Cosby) (pilot might be pressured by restart or other concerns that may direct his attention away from trying to avoid the facility), 3896-99 (Bernard).

- Ensuring the plane's altitude is not too low to avoid major injury or fatality upon ejection from the aircraft also competes for the pilot's attention. See Horstman Post Tr. 4214, at 17.

- The stress level involved is expected to be extreme, in that a pilot is put in the situation where saving the plane, saving his own life, and saving lives on the ground create conflicting priorities. See Horstman Post Tr. 4214 at 20; ALSAFECOM 002/1996 at 3.

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[54] See PFS Exh. PPP, U.S. Air Force, Technical Order 1F-16C-1 at 3-42 [hereinafter Manual].

These factors, obviously interrelated with the time factor, effectively counter the notion that pilot training eliminates pilot error.[55]

Specifically in this regard, we find compelling the purpose of the Air Force training video the State introduced late in the hearing.[56] This training video incorporates a cockpit video recording made on board Colonel Frank Bernard's F-16 aircraft during a 1986 training mission

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[55] The Applicant's reliance on pilot training and commitment to carry the day is perhaps facially analogous to the rationale underlying the Commission's "realism rule," which presumes that in an emergency, trained professionals -- state and local emergency response officials -- will act as they are expected to do by responding with their "best effort" in the event of a nuclear power plant accident. Long Island Lighting Company (Shoreham Nuclear Power Station, Unit 1), CLI-86-13, 24 NRC 22, 31 (1986); see also 10 C.F.R. § 50.47(c)(1)((iii)(B). The Applicant here did not expressly rely on that rule and in any event, as we explain below, it cannot be used to bolster predictions about the future behavior of Air Force pilots flying through Skull Valley, whose commitment is not in doubt.

Consistent with the analyses of the former NRC Appeal Board and the United States Court of Appeals for the First Circuit regarding the realism presumption, it is apparent this precept applies only to the macro-level policy decision made by an official about whether governmental agencies will respond at all to an emergency, rather than to the countless micro-level, action-oriented decisions made by individual actors on how to carry out their specific tasks as the actual crisis unfolds. See Massachusetts v. United States, 856 F.2d 378, 383 (1st Cir. 1988) (recognizing that realism rule is directed toward response on the state and local government level, rather than responses on an individual actor level); Public Service Co. of New Hampshire (Seabrook Station, Units 1 and 2), ALAB-937, 32 NRC 135, 148-49 (1990) (realism rule is directed solely toward "those persons in leadership positions (such as governors, mayors, civil defense directors, and state police superintendents) whose regular duties include the initiation of measures to protect the public health and safety in the event of an emergency that puts the populace at risk"); see also Public Service Company of New Hampshire (Seabrook Station, Units 1 and 2), LBP-89-32, 30 NRC 375, 600 (1989) (calling a municipality's declaration that it would not be able to implement an emergency plan a "political decision").

In our view, these cases establish that the critical factor in determining whether the realism presumption applies is the nature of the decisions in question. For policy decisions, the realism rule in effect says the relevant official will respond regardless of any prior stated lack of commitment to do so. For military pilots, in contrast, there is no doubt as to their commitment. Instead, the types of choices they make in attempting to address an emergency (e.g., changing direction, adjusting altitude) are very action-specific decisions not at all akin to the broad policy decisions -- such as those made by a mayor to dispatch police and fire departments to the scene of an emergency -- to which the realism rule is applicable.

[56] See State Exh. 220, Videotape: Late Decision to Eject (U.S. Air Force 1986) [hereinafter Bernard Video].

in which he ejected after he had engine trouble. The Air Force used the video -- which features not only the cockpit video but a recounting by Colonel Bernard both of how the situation and the belated ejection unfolded, and of the lessons he learned and wanted to pass on -- to provide safety training for F-16 pilots.

The central message of the Bernard Video can be taken as reinforcing the need in emergencies to follow training instructions, from someone whose failure to do so almost cost him his life when he ejected at only 170 feet above the ground. On the video, Colonel Bernard says it was an error on his part to have utilized all his time focusing on trying to solve his engine problem rather than to eject earlier, when he reached the minimum safe altitude prescribed by the Manual. See also Tr. at 3896 (Bernard).

This video demonstrates, the State suggests, that even though Air Force pilots are well trained, they still make critical mistakes; mistakes so important and so frequent that the Air Force believed a “reminder video” was warranted. See State Findings ¶ 81. We agree that this dramatic evidence -- that pilots ignore their training often enough to warrant vivid reminders -- is highly probative of the issue before us. The Air Force’s decision to produce and disseminate the training video featuring Colonel Bernard provides additional evidence countering the Applicant’s assertion that pilots nearly always do what they are trained to do.[57] That his experience was incorporated into a safety video to remind pilots of the need to follow their training is all to the good -- but it demonstrates the fallacy in any holding that would rely on pilots almost always doing what their training (superb though it may be) told them to do.

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[57] The Applicant would have us disregard Colonel Bernard’s experience because the problem took place in, and was caused by, conditions not akin to those encountered in Skull Valley. See Tr. at 13,692 (Fly). That premise is true, but does not take away from the lesson we draw from his experience -- pilots make mistakes, and the Air Force recognizes it. See, e.g., ALSAFECOM 002/1996. There is no basis for us to find that -- although they make mistakes in other phases of flight, in other locations -- they would almost never make a mistake while having the opportunity, under the stress of impending ejection, to avoid the PFS site.

With similar import to its production and dissemination of the Bernard Video, the Air Force published in 1996 the written document entitled ALSAFECOM 002/1996 to which we have previously referred. One of only four such directives published that year, that document embodied the clear message that despite Air Force training, crewmembers continued to commit significant errors during emergency situations -- including becoming distracted during in-flight emergencies, delaying ejection because of futile attempts to recover failed engines, and ejecting below the published minimum altitudes. Once again, in the Air Force's commendably re-emphasizing the need to adhere to lessons learned in training, we find in its premise -- that training lessons are too often ignored -- powerful evidence that any suggestion that pilots can be counted on almost always to follow their training is not sustainable.[58]

We could rest our decision, rejecting the R2 value advanced by the Applicant, on the foregoing alone. But in examining -- for purposes of reviewing any direct "pilot avoidance" evidence -- all the F-16 accident reports submitted by the Applicant, we found something else, namely, a large number of examples of pilot error committed in other phases of the particular mishap flight being investigated. We list those in Part II, below, pp. 146-50, by quoting directly from 40 of the reports, which embody the findings and conclusions of the investigator.

As that material indicates, the pilots involved in those accidents made a number of errors. To be sure, those errors were made in entirely different phases of their flights than that in which ground-site avoidance measures would be taken. But that is not the point. The point is that <u>the evidence that pilots make such mistakes in other phases of flight</u> -- many of which involve non-emergency, less stress-filled activities than the pre-ejection sequence we have

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[58] In so finding, we do not doubt the sincerity of the beliefs of the Applicant's expert panel, who -- after lengthy and distinguished Air Force careers -- were seen clearly to take pride in the capabilities of their pilots, the training given them, and the commitment and dedication they exhibit. But the existence of those experiential filters through which the experts view the matter cannot be allowed to obscure the evidence -- <u>i.e</u>., that as superb as they and their training are, pilots make mistakes, and the Air Force recognizes it.

been considering -- provides additional support for our finding that there is no sufficient basis to declare that they will almost never err when it comes to performing, in a high stress situation, "pilot avoidance" of a ground site. [59]

In contrast, the accident reports relied upon for corroboration of the Applicant's claims were far less probative.[60] The fact that initially only 15 reports were offered for that purpose is telling. As the Board suggested during the hearing, the Applicant's assertion that the 95% R2 value was confirmed by the contents of only 15 out of a total of 121 available accident reports was questionable at the outset. See Tr. at 3663, 3668-70. As we see it, the reports are of limited value in that (1) pilot behavior is not specifically evaluated; (2) the methodology is open

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[59] We think four of those reports (PFS Exh. 187, 193, 197, and 200) warrant particular notice because of the emphasis they place on human factors. Those reports call attention to such things as "a momentary lapse into 'seat-of-the-pants' flying due to some form of distraction" and note that "the human factor continues to be the ongoing limitation to perfect results" (Exh. 187); observe that "even with the most thorough preparation and capability, the human factor continues to limit perfect success." (PFS Exh. 193); cite "failure to use proper 'see and avoid' techniques to ensure a clear flight path," and human factors, including decreased situational awareness secondary to motivation to succeed, task saturation in association with the stress performance curve, task misprioritization, channelized attention, and misperception of speed/closure rate (PFS Exh. 197); refer to how pilot "channelized his attention on some aspect of the attack and descended below the briefed recovery altitude, became spatially disoriented and impacted the terrain" (PFS Exh. 200). Again, we are not saying these particular accidents could happen in Skull Valley conditions; at the risk of repetition, these reports illustrate that pilots do not always perform as they were trained to do, i.e., they make mistakes under stress. And, as Colonel Bernard emphasized, the pre-ejection situation is the most stressful encountered during training.

[60] In making this finding, we recognize that the Applicant's witness panel made clear from the outset that, in advocating their R2 value, they placed principal reliance on their expert opinion, not on the accident reports. Tr. at 3215, 3967, 13,100 (Jefferson).

to biased selection with no meaningful objective measure of which reports should be included and which excluded; and (3) the methodology relies on inferences drawn from the investigative reports rather than on direct observation of the facts surrounding the accidents.[61]

Further in that regard, much of the problem, as we see it, stems from trying to draw conclusions about one subject from investigative reports prepared for the purpose of inquiring into a different subject. Specifically, accident reports are prepared by the Air Force for the purpose of learning why an accident occurred. See Cole/Jefferson/Fly Post Tr. 3061, at 10; Horstman Post Tr. 4214, at 26. In the course of conducting the investigation and preparing the report, additional, collateral information may be obtained. But that information is not subject to the same scrutiny given to the principal topics before us. Moreover, as we read the reports, many are silent on whether the pilot, on the verge of ejecting, had the opportunity or the need to avoid specific ground targets. Others noted that the pilot avoided a specific ground feature but did not elaborate on how difficult that might have been, or on whether there were other features that might also have been avoided. See, e.g., PFS Exh. 115, 134, 140, 158, 205.

In short, the accident reports do not carry substantial weight in the Applicant's favor. As we read them, they stand for the proposition that, all things being equal, pilots with the

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[61] As has been seen, compelling evidence exists to defeat the Applicant's R2 claim. Having come to that conclusion, we make the passing observation that it is also significant that only a few of the accident reports contain any direct evidence on the question of likely avoidance behavior of pilots in emergency situations. Instead, the Applicant's witnesses relied on inferences drawn from the accident reports to conclude that the pilots acted consistently with the witnesses' own selected acceptance criteria. For example, although the reports contain little reliable, direct information on whether pilots took any deliberate evasive action in an emergency, the Applicant would have us infer that nearly all had the opportunity to so act and then did so. Yet the other reports, as it turned out, were ambiguous or silent on the point -- and this is not helpful where near certainty is the target. As the Board continues to see it, all that was shown was what happened in 15 out of 121 cases -- a far lower percentage than that proposed for R2. And examination of the rest of the reports has revealed, as we outlined above, a large number of pilot errors -- where "near certain" flawless performance is the thesis being advanced.

opportunity to do so may well attempt to avoid ground features that should be avoided. But, as we have seen, the reports also make clear that, in many other respects, pilots frequently take action that they should not, or have been advised not to, take. This leaves us far from certain, in a nuclear regulatory safety context, that pilots can be counted on -- to the degree necessary for us to make the findings the Applicant would have us make -- not to take improper action, or to fail to take proper action, where this one particular facet of their flight activity is concerned.[62]

In the end, these reports and the related expert testimony failed to identify a rigorous test protocol whose elements would have permitted a valid statistical inference to be drawn from the data. What was presented did not contain consistent, probative data on the causes and frequency of human failure when the conditions and opportunity for successful action are present.[63] The Applicant's arguments are subjectively appealing; nonetheless, the evidence it cited is inadequate to permit a valid statistical inference on the hypothesis of reliable pilot action in an emergency.[64]

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[62] We stress that in not crediting pilot performance in the manner the Applicant has urged, we in no way mean to impugn either pilots' commitment to making their best efforts to follow their training, or the skills they bring to the service they provide this country. And we recognize that, for purposes of pilots' combat endeavors, the country must count on them to perform as trained, for there is no other choice in that regard. For purposes of nuclear safety regulation, however, there are other choices, including designing the proposed facility so that -- even if pilots, over whom the NRC has no regulatory jurisdiction, do not perform to near perfection once a stress-filled accident sequence is initiated -- the public will not be harmed by the consequences of a "credible accident."

[63] What might have been probative were data recording and evaluating what pilots do in emergency circumstances, so that rigorous answers could be obtained to the question being considered. As is not uncommon in statistical analysis, the failure to take this approach introduces subtle error and analytical bias, precisely because the protocol followed might be unconsciously designed to produce just what it did produce, i.e., to confirm what amounted to a vote of the experts as to how Air Force pilots will behave, based on their character and training. This, however, does not carry the burden of proof the Applicant must bear in this nuclear licensing proceeding.

[64] It should be added that the Applicant falls short in its attempt to support the R2 component through the United Kingdom's Atomic Energy Authority assessment. See PFS Exh. TTT, United Kingdom Atomic Energy Authority, A Method for the Site-Specific Assessment of

To be sure, we have been shown evidence both of opportunity to act and of rigorous pilot training. These certainly are necessary conditions if there is to be a reliance on pilot behavior in a nuclear licensing action. But the evidence establishes those conditions are not sufficient, and cannot be dispositive, particularly when the evidence reflects compelling examples of pilot errors made when the opportunity for taking the correct action existed.

In sum, the conflicting evidence about pilots' both following and ignoring their training leaves us with a record that shows reliable prediction of pilot behavior in an emergency is a serious and complex human factors analysis question. In the final analysis, for the Applicant to prevail -- in the face of the compelling evidence presented by the State -- we seemingly would be obliged to stand "human factors" analysis on its head.

That is, where usually there is grave concern that a human factors element will detract from safety assurances, here that element would be used to augment what would otherwise be a deficient safety showing. We have been pointed to no instance, and are aware of none, in which the nuclear licensing basis is solely dependent on reliability of human behavior without the added protection of engineered safety features. Although such an approach may not be entirely precluded, relying on it has to overcome the additional uncertainty of attempting to take credit for avoiding human error rather than, as is usually the case, making allowances for human error.

Aircraft Crash Hazards (1987) [hereinafter UK Study]. The UK Study, which provides a basis for excluding from hazard calculations crashes in which the pilot is in control of an aircraft just before impact based on observations about pilot avoidance, concludes that pilots might avoid ground sites about 50% of the time. See UK Study at 8. It is, according to the Applicant, consistent with the F-16 accident reports and the testimony of the pilots in this proceeding who agreed that when time and circumstances permit, a pilot will attempt to avoid a facility. PFS Findings ¶¶ 21-22. In the Board's judgment, however, this UK Study -- evaluating disproportionately different crash rates in urban and rural areas -- is based on too crude an analysis to benefit us.

The R2 issue cannot be resolved in the Applicant's favor either by subjective expert opinion that has not been borne out by events [65] or by an ad hoc analysis of data not collected for the purpose to which it is being put. This is particularly so in the face of the State's credible, probative evidence that significantly undercuts each of the three major premises -- visibility, time and training -- that underlie the Applicant's experts' opinions that R2 should be assigned a value of 95%.[66]

By the very nature of its claim of virtual certainty there would be no pilot error in a high stress situation, the Applicant set for itself an inherently daunting challenge to produce evidence that would successfully support its position. Having now thoroughly reviewed the showing that was made, it is clear to us that the Applicant has not met its burden of establishing by a preponderance of the evidence the validity of its claim that under emergency situations an F-16

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[65] This case demonstrates that relying almost solely on subjective expert opinion for the development of scientific or engineering parameters can have significant disadvantages. When such parameters are obtained by objective measurement, their validity can be checked through systematic inquiry into the methodology of their development. When, however, there are no reliable objective measurements available to establish the parameter in question (such as the R2 value here), there must be a significant concern that the opinions expressed, though truthful from the expert's perspective, suffer from having overlooked, or discounted inordinately, material from other wholly valid perspectives, resulting in seriously skewed conclusions.

[66] In deciding this aspect of the case, we were not aided by the Staff's sensitivity analysis (discussed at fn. 38). As explained there, the Staff claimed that it had tested the effect of variation (in the "failure to avoid" rate) on the value of R2 over a 20-fold range (1 to 20%) of pilot non-avoidance and found only a small impact on the resulting crash probability. This impressive claim invites ready acceptance. But a look at the complementary value reveals that the "successful avoidance" rate varies only from 80 to 99%. This is, of course, not a 20-fold variance, and the whole matter has far less significance than we were led to believe.

At best, then, we found in the Staff's sensitivity analysis nothing positive upon which to draw. Compare Subpart E, below, pp. 85-86, where we comment on the importance to the process of the Staff's independent review of an applicant's proposals.

pilot can almost always (95% of the time) guide a crashing plane so as to avoid a problematic land area.[67]

We are persuaded that the State has shown by a wide margin -- with evidence that is far more deeper-rooted than a few examples of failures -- that the Applicant's expert testimony advocating an R2 value of 95% is not adequately supported. We turn, then, to an analysis of the classic four-factor NUREG-0800 formula.

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[67] In reaching this conclusion, we have assumed that pilots whose mission involved flying down Skull Valley would, for one reason or another, view spent fuel casks on the site as the functional equivalent of a "populated area" that should be avoided, time permitting. For example, whether or not the Manual was intended to be read with that definition, a mission commander could simply provide pilots that instruction.

Having said that, we do note -- without relying on it to justify our decision -- that it is unclear how fine-tuned the "populated area" directive is intended to be. Even if it were re-interpreted or understood to include, broadly, something on the order of "areas that it would be better in all the circumstances not to hit," there is evidence that it simply refers to generally directing the aircraft away from a large geographic area, not from a specific site. Tr. at 13,531-32 (Horstman). In this regard, we were told that the Air Force does not teach pilots to look for specific sites on the ground in an emergency, Tr. at 8550-51 (Horstman), and that there is no Air Force training or guidance to avoid a house, a facility, or other specific ground site and pilots do not have the tools for such a task. Tr. at 13,464-65 (Horstman). It is, then, not clear that a pilot is even expected to take precise action to avoid one particular habitation or site rather than another.

Given the altitude at which ejections are supposed to take place and the distance the aircraft will thus glide before crashing, "avoidance" action may be only general in nature. To be sure, the lower the altitude before ejection, the more precise choices there may appear to be. But then there is less time and more stress. In recognition of this, the Manual's directive is prefaced with "if time permits."

C. The Four-Factor Outcome

With the "pilot avoidance" theory thus unproven, the question of whether an F-16 accident is sufficiently likely to be "credible" turns on application of the classic four-factor NUREG-0800 formula. The State's "credible accidents" contention is not, however, limited to concerns over F-16s flying down Skull Valley; it includes the potential for other aircraft, as well as ordnance, to strike the spent fuel casks on the PFS site.

In this Subpart, we evaluate the evidence presented by the three parties regarding the application of the four factors to all the asserted accident scenarios. Although some of the values required for the four-factor calculation cannot be known directly, but must be derived from other data, leaving some margin of uncertainty, we find that in any event the evidence is insufficient to establish that the accident in question has "less than a one in a million per year" chance of occurring. Accordingly, it is "credible" and must be protected against.

1. Nature of the F-16 Flights

Military air operations in the vicinity of Skull Valley include (1) Air Force F-16 fighter aircraft transiting Skull Valley from Hill Air Force Base[68] on their way to the South Area of the Utah Test and Training Range (UTTR);[69] (2) F-16s returning on occasion from the UTTR South Area to Hill AFB via the relatively little-used "Moser Recovery Route" (MRR), which runs in a northeasterly direction, crossing Skull Valley two to three miles north of the PFS site; (3) military aircraft, comprised mainly of large transports, flying on military airway IR-420 to and from Michael Army Airfield, which is located (within the Dugway Proving Grounds) about

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[68] As indicated earlier, flights down Skull Valley are not risk-free, but they are significantly less intense than the high stress, aggressive maneuvers involved in combat and similar exercises that take place over the UTTR. See Aircraft Crash Report, Tab H at 8.

[69] The UTTR, located in Utah's West Desert, is comprised of both an on-ground training range and a larger training airspace. Its land area lies on either side of Interstate 80, which runs east-west and effectively splits the UTTR into (1) a north area located on the western shore of the Great Salt Lake, and (2) a south area located west of the Cedar Mountains.

17 miles southeast of the PFS site; and (4) F-16s from Hill AFB and various other military aircraft conducting training exercises in the UTTR.[70] See PFS Findings ¶ 7.

We focus most of our attention on the first of the above categories, for it predominates the probability calculation. F-16s transiting Skull Valley en route from Hill AFB to the UTTR South Area typically use (according to information the Applicant received from the Air Force) a corridor ranging east of the proposed PFS site. See Cole/Jefferson/Fly Post Tr. 3061, at 16. The F-16s typically fly through what is called the Sevier B Military Operating Area (MOA), between 3,000 and 4,000 feet above ground level (AGL), with a minimum altitude of 1,000 feet AGL.[71] A few aircraft fly higher, through the Sevier D MOA, which overlays Sevier B between approximately 5,000 feet AGL and 14,000 feet AGL.[72] It is unusual for aircraft to fly through Skull Valley at altitudes above 14,000 feet AGL. Aircraft fly through Skull Valley at approximately 350 to 400 miles per hour.

2. Methodology for Calculating the Crash Probability

In determining whether to license facilities, the NRC considers the possibility that various accidents -- such as aircraft crashes -- may affect them. In evaluating these potential

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[70] In the UTTR's restricted airspace, pilots conduct a variety of activities with their aircraft, including air-to-air combat training, air-to-ground attack training, air refueling training, and transportation to and from Michael Army Airfield. Cole/Jefferson/Fly Post Tr. 3061, at 17.

[71] An MOA is airspace of defined dimensions allocated to the military to separate or segregate certain military operations from other flight operations. The PFS site lies below the Sevier B and D MOAs, 18 miles east of the UTTR South Area's eastern land boundary (which lies to the West of the Cedar Mountains) and two miles east of the eastern edge of UTTR-related restricted airspace (which extends eastward from the UTTR's land area over the Cedar Mountains and into Skull Valley). The Sevier B MOA airspace, approximately 145 miles long, is some 12 miles wide in the vicinity of the PFS site and extends more than 100 miles south of Skull Valley. See Cole/Jefferson/Fly Post Tr. 3061, at 13.

[72] The Sevier D MOA airspace lies directly above the Sevier B MOA. See SER at 15-59.

accidents, the Agency first determines whether these are sufficiently "credible," i.e., likely to occur, to warrant protective measures.

As explained earlier, the formula for calculating aircraft crash probability for nuclear facilities is

$$P = C \times N \times A/w$$

where P is the annual probability of an aircraft crash and the four factors represent, respectively, the Crash rate (per mile), the Number of flights (per year), the Area of the facility (in square miles), and the width of the airway (in miles). There is no dispute among the parties -- apart from that over the R factor -- that this formula is an appropriate method for calculating the aircraft crash hazard for the proposed facility. The governing Commission criterion, established in this case, allows a facility like this one to be licensed if the calculated probability of an aircraft crash on the site is less than one in a million (1×10^{-6}) annually. (See also Subparts D and E, below.)

3. Summary of Disputed Issues

The State disputes the numerical values the Applicant and Staff would assign to three of the four factors required by the NUREG-0800 equation. The disputed factors are Crash rate (C); Number of aircraft (N); and width of airway (w).[73] According to the State, both the Applicant and the Staff have selected values for these parameters that are incorrect and result in estimates of annual crash probability on the proposed site which are too low.

The crash rate factor is expressed in terms of crashes per mile for a specified aircraft type, such as the F-16. The Applicant put forward 2.736×10^{-8} per mile as the appropriate value for crash rate (C), basing that determination on Air Force crash data recorded from 1989

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[73] There is no dispute among the parties regarding the fourth factor, the effective area of the PFS site. All parties accept the area determined by the Applicant (.1337 square miles) as the appropriate value. The Board has reviewed the method by which that area value was derived and accepts it as reasonable.

through 1998, the most recent 10 year period available when it performed the analysis. The State disputes whether this was the appropriate period to use, asserting that the Applicant should have used the crash rate of 4.10×10^{-8} per mile for the F-16's entire service life. The Applicant's analysis is also inadequate, says the State, because it failed to take account of the higher crash rates that occur at the beginning and end of service life, as well as the likely higher crash rate of the Joint Strike Fighter that will replace the F-16 during the life of the facility and that will assertedly experience its own high crash rates associated with the beginning of service life. The Staff adopted the same crash rate value as that proffered by the Applicant.

The number of flights transiting Skull Valley (N) per year is also disputed. The Applicant asserts that the correct number is 5870 flights per year, which is based on Air Force data which is kept for the MOA (but not explicitly for Skull Valley). The State asserts that the Applicant's estimate is too low, and that the more correct value is 7040 flights per year. The Applicant's analysis is flawed, says the State, because it eliminated some flights from consideration and also used a historical average rather than the most recent data, which indicates a significant increase in aircraft traffic in Skull Valley. Although the Staff's basic estimate of annual Skull Valley flights agrees with the State's, the Staff went on in its analysis to reduce that value by half, based on certain analytical assumptions it made.

The Applicant asserts that the width of the airway (w) in Skull Valley is ten miles.[74] The State asserts that the Applicant has not taken into account the "buffer zone" effect the nearby "restricted area" airspace has in limiting practical airspace in the MOA, and other similar factors that reduce the effective width of the Skull Valley airway to five miles. To that end, the State points out that flights down Skull Valley are not only limited by the obvious physical presence of the mountains to both sides, but are further limited by the UTTR-related mandatory restricted

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[74] Because "w" appears in the formula's denominator, a <u>wider</u> airway results in a <u>lesser</u> crash probability. For all the other factors, the larger the value the greater the crash probability.

areas (intrusion into which, without permission, has serious adverse consequences for pilots). Thus, the State argues, even though the theoretically usable width of the Valley's airway may be as large as the ten miles asserted by the Applicant,[75] the reality is that the restrictions to the West and the presence of the Stansbury Mountains to the East cause pilots to observe "buffer zones" that as a practical matter decrease the width of the available airway.

The values the parties advance for each of the four factors are compiled in Table 1 below, the final line of which reflects the Board-calculated aircraft strike probability that is generated from use of each party's four factors:[76]

TABLE 1

	Applicant	State	Staff
Crash Rate	2.736 x 10^{-8} per mile	4.10 x 10^{-8} per mile	2.736 x 10^{-8} per mile
Number of Flights	5,870 per year	7,040 per year	7,040 x ½ per year
Facility Area	.1337 square miles	.1337 square miles	.1337 square miles
Airway width	10 miles	5 miles	10 miles
Probability [77]	2.15 x 10^{-6} per year	7.72 x 10^{-6} per year	1.29 x 10^{-6} per year

As may be seen, despite the varying views of the parties, not only the State's but also the Applicant's and the Staff's values fail to meet the 1 x 10^{-6} per year acceptance criterion adopted by the Commission in CLI-01-22.

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[75] As best we can determine from the record, the geographical width of the Valley floor at the site is some 13 miles. See FEIS at 2-3.

[76] Because the Applicant and Staff also employed the R factor, they did not themselves produce a four-factor probability. The calculation is, however, a straightforward one.

[77] The Table thus illustrates that even if we accepted the Applicant's values for the four factors (which we do not), the Commission's one-in-a-million criterion would not be met without the R pilot-avoidance factor providing more than a 50% reduction to the four-factor result. Use of the Applicant's proffered value of some 85% reduction would indeed result in a value for P of less than 1 x 10^{-6} per year. But, starting with the Applicant's R1 value of 90%, an R2 of, say, 50% would provide an R reduction of only 45%, which would adjust the Applicant's four-factor calculation to just under 1.2 x 10^{-6}.

4. Board Analysis of Four Factors

a. Crash Rate of F-16s. To calculate a crash rate, the Applicant utilized Air Force F-16 crash data reflected in the Data Development Technical Support Document for the Aircraft Crash Risk Analysis Methodology (ACRAM) Standard. As noted in the table, the final figure derived from this data was 2.736×10^{-8} per mile.[78] According to the Applicant, this figure represents an average of the Class A and Class B mishap rates [79] over the ten-year period from FY 89 to FY 98 for normal flight operations.[80] The Applicant asserts that it utilized this ten-year period in order "to minimize the effect of statistical fluctuations from year to year and to capture the most recent, and thus most relevant, period at the time the analysis was first conducted." PFS Findings ¶ 25.

The State argues that the Applicant should have used the published mishap data for all 27 years that the F-16 has been in service. See State Findings ¶ 35; State Reply at 30-34. It points out that aircraft, like other products, experience problems at the beginning and end of service life that are higher than in mainstream service. These higher beginning and ending failure rates are so well-recognized as to often be described as "bathtub curves", so named for the shape the statistical failure rate curve takes. See Horstman Post Tr. 4214, at 13. As the

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[78] The Air Force records overall crash data in terms of crashes per hour of flight. Aircraft Crash Report at 9, Tab D. To derive a Skull Valley crash rate per mile of flight, a degree of data manipulation must be employed, thereby introducing an element of estimation and uncertainty in addition to those inherent in determining (1) which operational segment of historic crash rates are most relevant to Skull Valley operations and (2) what years provide historic crash rates most predictive of the future lifetime of the facility.

[79] The Air Force defines a Class A mishap as one in which the aircraft was destroyed or suffered more than $1 million in damage or there was a fatality. A Class B mishap involves damage to the aircraft between $200,000 and $1 million. Aircraft Crash Report, Tab C at 4-4.

[80] The ACRAM data are based on four phases of flight: (1) takeoff; (2) landing; (3) normal flight; and (4) special operations. The Skull Valley operations are said by the Applicant to involve "normal flight" as they do not involve takeoff, landing or aggressive maneuvering on a training range. See Aircraft Crash Report, Tab C.

F-16 approaches the end of its service life, says the State, it may well demonstrate the high crash rate characteristic of end of life performance, and the new aircraft that replace it can be expected to encounter high rates characteristic at the beginning of life. The State argues that relying on only the best-performing years of the F-16's service life skews the crash rate too low. See State Findings ¶ 35.

In addition, the State argues that since the Air Force mishap data did not separate the mishaps into the four phases of flight and the ACRAM report did not divide the data into Class A and Class B type occurrences, the data should not be divided for our purposes. See State Findings ¶¶ 28, 37-38. On this premise, and including all years in its calculations of the crash rate, the State asserts that the more appropriate value for the F-16 crash rate is 4.10×10^{-8} per mile, i.e., some 50% higher than the rate put forward by the Applicant (and endorsed by the Staff). See State Findings ¶¶ 37, 38.

We accept that the "bathtub effect" may occur over the life of some products. But the crash data for the F-16 are not yet showing it. To be sure, when the F-16 was first put into service, it experienced a crash rate higher than later in its lifetime. But there has been no perceptible upturn in crash rate as end of life approaches.[81] This occurrence was attributed by the Applicant's experts to improvements in pilot training, technology, and maintenance practices and procedures over the life of the aircraft. See Tr. at 3370-71 (Cole).

Indeed, Air Force data indicate that aggregate crash rates for all planes have steadily decreased over time. Based on this performance trend, the Applicant's panel believes that the

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[81] We note that the State witness attempted to show an upturn in crash rate near end of life for the aircraft by correlating selected crash rates with the passage of time. Resnikoff Post Tr. 8698, at 9. We find that that selection of data involved an invalid statistical technique and place no reliance upon it. We can find no reliable evidence yet showing a significant upturn in end of life crash rate for the F-16. And it would be speculative now to attempt to predict how any changes in the world-wide deployment situation (see discussion of the "N" factor, below) might have a related, indirect effect on crash rates.

eventual F-16 replacement aircraft would not raise the crash rate for Hill AFB operations. PFS Findings ¶¶ 30-35. That is particularly true because the F-16's replacement -- the Joint Strike Fighter -- is not scheduled to undergo its break-in period in Air Force service, much less at Hill AFB. Tr. at 8656-57 (Fly), 3371-72 (Cole).

To be sure, an argument can be made that a better approach than the ten-year period the Applicant utilized would have been to use the lifetime crash data, excluding only the break-in period. But we find that such a "lifetime minus break-in" crash rate is little different from the crash rate calculated from the ten-year sample upon which the Applicant relied. PFS Findings ¶ 26. And we do not accept as representative of long-term trends the more selective data upon which the State's expert relied. We therefore find the crash rate proffered by the Applicant to be a reasonable one supported by the preponderance of the evidence.

b. Number of Flights. The Air Force does not keep records for Skull Valley transitions as a subset of Sevier B and D MOA usage and thus there exists no exact count of aircraft flying through Skull Valley. Revised Addendum at 3. Thus, the value for N, like that for C, the crash rate factor, has to be derived from data prepared for other purposes and involving different considerations.[82]

Based on the average of the previous two years' data, and a proportional increase to reflect the authorized increase in F-16s at Hill in FY01, the Applicant estimated there will be 5,870 flights per year along the airway in the future. See PFS Findings ¶ 54. That estimate began with approximately 5,000 as the two-year average number of aircraft using the Sevier B

[82] The problem stated in the text concerning the raw data, though described in superficially similar terms to the problem of attempting to use the accident reports for R2-related purposes (see p.40 above), presents a different situation. The existing data are susceptible to adjustment through various techniques (although the parties disagree as to which techniques are legitimate) to derive data having different parameters. But when reports are prepared for one purpose, there is no ready way to "adjust" them to provide sound analysis on other matters which they did not set out to address.

MOA, based on Air Force indications that was likely to be representative of the number of flights in Skull Valley. See PFS Findings ¶ 55. The Applicant took care to adjust that estimate upwards by 17.4% to account for the fiscal year 2001 increase in the number -- from 69 to 81 -- of F-16's stationed at Hill AFB. See PFS Findings ¶ 59.

The State believes the Applicant's estimate to be too low. First, the State believes that only the most recent year's data -- which showed a substantial increase from the previous year's -- rather than the average of the two years, should be used as a starting point. Second, the State would add in Sevier D flights,[83] noting that Air Force records indicate that most of the aircraft in both the Sevier B and D MOAs are F-16s transiting Skull Valley. In addition, some Skull Valley F-16 flights are not reported because the flights are above both MOAs. The State asserts that those uncounted Skull Valley flights should serve as a rough offset to those in the MOAs that do not enter Skull Valley. See State Findings ¶¶ 47-50.

The State, adding the B and D MOAs together, estimated that the total number of flights in the Sevier airspace was 5,997 in FY 00. See State Findings ¶ 48. Increasing that number by 17.4%, just as the Applicant did, gave the State a total of 7,040 estimated flights per year through Skull Valley. As we explain below, as to that basic estimate we find that the preponderance of the evidence more nearly supports the State's (and the Staff's) view than the Applicant's.

For its part, the Staff adopted reasoning similar to the State's and likewise concluded that the number of flights over Skull Valley is approximately 7,040 annually. See Staff Findings ¶ 2.117. In deriving a value for N, however, the Staff -- to account for those aircraft in the usual

[83] The Applicant excluded the Sevier D aircraft count on the theory that it would include flights that took place elsewhere in the airway without overflying Skull Valley. Tr. at 3355-56 (Jefferson).

flight formations that the Staff believes would not pose a threat to the facility -- reduced the 7,040 flights by half. See Staff Findings ¶¶ 2.118-.119.

We consider first whether to begin the derivation of the N value with the Applicant's (lower) two-year average or the State's (higher) most recent year. Our purpose, of course, is to predict the number of flights that will likely take place annually during the facility's lifetime. This is an inherently problematic venture, however, given that the number of training missions down Skull Valley depends on a number of unpredictable variables.

The most notable variable is the extent of deployment of U.S. forces around the world to engage in military operations. The crucial factor is not the extra training that might be involved in the run-up to deployment, but aircraft removal from Hill AFB as part of the actual deployment to international operations. If fewer aircraft are on site, the number of training flights will, of course, be substantially diminished. See Cole/Jefferson/Fly Post Tr. 3061, at 18-20.

Another variable mentioned was the eventual replacement of the F-16 by the "Joint Strike fighter." Its existence may lead to different kinds and numbers of training missions. See Cole/Jefferson/Fly Post Tr. 3061, at 22-23.

One variable not mentioned, but apparent in federal law, is the impact of the "Base Closing Act." 10 U.S.C. § 2687 (2000). That statute calls for periodic review of the relative value of all military bases. The result is that some bases might be closed, while those remaining open would be called upon to assume the extra burden of activities previously handled at those that were closed. In either event, the number of flights down Skull Valley could be quite different in the future than it is today.

As may be seen, then, selecting a value to represent N, the number of annual flights, is another less-than-definitive aspect in the application of the four-factor formula. Not wishing (or being permitted) to speculate on future events lacking any basis in the record, we make the decisions that are within our grasp.

The first is the choice between the recent two-year average (proposed by the Applicant as smoothing out year-to-year changes) and the higher, most recent year (proposed by the State and endorsed by the Staff). We choose the latter on the basis of the general NUREG-0800 thesis (§ III.2, at 3.5.1.6-4) -- itself fully consistent with a fundamental principle of safety assessment -- that its proper use involves the selection of conservative input values. Similarly, the State's and the Staff's inclusion of flights from the Sevier D MOA is the better approach both to deriving an accurate conceptual count, and to following the NUREG-0800 thesis mentioned above.

In the absence of data neatly applicable to the issue before us, and given the resulting need to derive useful data somewhat subjectively, we see some merit in the Applicant's estimation of 5,870 flights per year over Skull Valley. But based on all the evidence, we find more persuasive the State estimate of the overall number of flights at 7,040, in which the Staff concurs. The difference represents the uncertainty of the estimate, which is not further reducible on our record.

We turn now to the Staff's suggestion that the overall number of flights thus derived (upon which it and the State agree) should be reduced by one half. See Staff Findings ¶ 2.119. The Staff came to that conclusion by looking at the lateral offset within each two-ship formation (and by considering a normal four-ship formation as two formations of two aircraft each, one formation flying in front of a second one). The Staff asserts that because of that offset, the aircraft more to the East of the two (and the two easternmost aircraft in the usual formation of four) would pose a negligible probability of impacting the facility and thus can be discounted as contributors to the impact probability calculation. See Staff Findings ¶ 2.118.

The Staff would therefore say that the number of aircraft to be considered is only half the total estimated to be flying down Skull Valley. Thus, the Staff would use 3,520, not 7,040, as the value of N in the probability equation. See Staff Findings ¶ 2.119. Correspondingly, the Staff technique would thus reduce the calculated probability by a factor of two.

Applying that halving concept to reduce "N" has, however, an obvious additional direct impact on another aspect of the four-factor formula. That is, when the Staff reduces the number of aircraft by half, it does so because aircraft occupying certain offset portions of the available airway are said to produce negligible hazard to the facility. See Staff Findings ¶ 2.119. But this has significant implications for another factor, i.e., the definition, and the width, of the effective airway. Manifestly, that width must be reduced by half to account for the Staff's elimination from the probability calculation the flights in the other half.

Put another way, it was certainly not demonstrated -- and in fact seems facially invalid -- that the technique the Staff used in deriving a value for the N factor can be employed, while at the same time leaving the value for the width of airway unchanged.[84] On the other hand, if the halved N value (appearing in the numerator of the formula) were to be accompanied by an equivalent halving of the airway width (appearing in the denominator), the result of the four-factor calculation would remain the same (as would the density of the remaining aircraft), and the calculated result would again be in accord with the realities of the situation.

Before leaving this subject, we note that NUREG-0800 makes provision for offset airways, but not in the fashion the Staff would employ here. It does so, in the very definition of the "w" value, by adding to the actual width of the airway another width value, namely, twice the

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[84] The Staff formulation, while invalid as it stands, does have within it an acceptable concept, i.e., that narrower flight paths, offset from the site (see text this page), might exist (in actual practice, not in mathematical construct) which would reduce the probability of aircraft crashes to acceptable levels. As suggested elsewhere herein, the Applicant may wish to explore with the Air Force discretionary modification of the effective airway.

distance that the nearest edge of the airway is offset from the facility.[85] But in situations like that we face here, in which the nearest edge of the airway in effect lines up with at the facility, the formula suggests no adjustment from the values applicable to an airway centered on the facility. In effect, then, NUREG-0800 treats an airway centered over a site the same as one with its edge at the site, thereby again providing an element of conservatism that is fully in keeping -- for purposes of a screening formula -- with the overall approach that NUREG-0800 explicitly adopts.

Viewed in this light, the Staff's attempted reduction of N is, in effect, simply a different way of making the very adjustment for an "edge of site" airway that NUREG-0800 declined -- apparently deliberately -- to recognize. For that reason, as well as because it failed to make the fundamental change to the width of the airway that should accompany the elimination of the flights in one-half of that airway,[86] we reject the Staff's proposal as inconsistent with the premises underlying the four-factor formula as well as lacking any sound technical basis.

c. Effective Area of Facility. The Applicant calculated the effective area of the facility to be 0.1337 square miles. This figure was obtained by considering how the facility's actual ground area is enlarged as a target in relation to the glide angle of the crashing aircraft as it approaches the site. In proffering this maximum area figure, the Applicant points out that it is conservative in that it considers the facility to be at full capacity (4,000 spent fuel storage casks) -- a status that may never be achieved. See PFS Findings ¶ 38.

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[85] NUREG-0800 at 3.5.1.6-3 (§ III.2).

[86] Perhaps to avoid this criticism, the Staff indicated that, after halving the number of flights, it would treat the remaining flights as if spread over the original width of the airway and thus keep the "w" value unchanged. That adjustment is unavailing, however, in that if the airway remains at its original width (as the Staff would have it) after N is reduced by half, then that entire airway would still be available to the remaining half of the aircraft. Presumably, half of those aircraft would then occupy the eastern portion of the airway that the Staff found produced a negligible crash hazard. But in keeping with the Staff's offset notion, those aircraft now in the eastern half could then be ignored.

The Staff and the State did not dispute the Applicant's calculation. See State Findings ¶ 52; Staff Findings ¶ 2.51. The Board has reviewed it and we find that 0.1337 square miles is reasonable and supported by the preponderance (indeed all) of the evidence before us.[87]

d. Width of Skull Valley Airway. In calculating a value for w, the Applicant assumed that the Sevier B MOA could be treated like an airway, with F-16 flights evenly distributed across its width from the Stansbury Mountains on the east to the edge of the restricted airspace (east of the Cedar Mountains) in the west. Taking the maximum potential useable airspace in that corridor at the latitude of the facility, the Applicant came up with a ten-mile width for the airway. See PFS Findings ¶ 43.

The State countered by arguing that the portion of the Sevier B MOA in actual use by F-16 formations is narrowed because of pilots' practices. In the State's view, the airway width is about six miles, extending from east of the western Sevier B MOA boundary to west of the eastern MOA boundary (near the Stansbury Mountains). See State Findings ¶¶ 43-44. It points out that State Exhibit 156B, which is an illustration originally taken from the Applicant's

[87] The conservatism in the Area factor to which the Applicant points, based on less-than-full capacity, we see only as offsetting a potentially non-conservative feature of the facility. Specifically, we have been told from time to time in the proceeding that if the facility were filled to capacity and future events established that the crash rate or number of flights were understated, the Staff could investigate and take remedial action, as it does with nuclear power plants. See Tr. at 4156-58 (Campe). In that regard, if the Staff discovers a problem at an operating power plant, it has the option to order the plant to shut down, thus relatively quickly reducing the nature of the particular risk in issue.

But we asked in vain about what prompt remedial action the Staff would be able to direct PFS to take, as possible future licensee of a facility at full capacity, if it were determined, based on changed circumstances, that the crash probability then exceeded what had previously been envisioned. The record before us indicates that bringing spent fuel to the proposed facility will be a slow process, limited by the facility's capability of off-loading and transferring the canisters in which the fuel rods will be transported. By the same token, it is not apparent on this record how it would be possible to effectuate, significantly faster than the casks were delivered, any Staff order to remove casks. Of course, if the facility were not at capacity, the Staff could halt delivery of any more casks. Other than to that extent, then, we cannot rely on any future Staff remedial action as a protection against understating the crash probability.

Crash Report, indicates that at an altitude of 3,000 to 4,000 feet AGL, the maximum airspace available is ten miles wide at the latitude of the facility. See State Reply at 12-13. By the State's reckoning, however, most pilots will not use the full airspace available to the West to avoid straying into the bordering Restricted Area further West, and likewise, to give the Stansbury Mountains a wide berth, will not use all the airspace in the East. See State Reply at 13 n.21.

Because of these buffer zones, the State asserts, most F-16s that pass through Sevier B MOA tend to fly, for all practical purposes, within about a six-mile-wide flight path. Allowing for other adjustments, the State concludes that the value that should be utilized in the formula for the airway width is five miles. See State Findings ¶ 44.

The parties are in accord that F-16s do not fly further west than approximately one mile east of the UTTR Restricted Area. See Tr. at 8572 (Horstman); Tr. at 3415-16 (Fly); SER at 15-63. With respect to airspace on the east, there is evidence that the distance pilots remain west of the Stansbury Mountains varies from "a couple thousand feet" (Tr. at 8647-48 (Fly)) to up to three miles. Tr. at 8613-14, 8571-72, 8593-94 (Horstman), 8648 (Fly).[88] Thus, notwithstanding that pilots have about ten miles of potentially usable airspace in Skull Valley, the preponderance of the evidence compels the conclusion that the State is correct in its assertion that, in practice, the effective airspace used in formation flying is narrower than that ten miles.

To determine how much narrower so as to arrive at a "w" value, we must return to first principles, namely, that probability of impact is a function of average flight density in the vicinity of the site. Density, in turn, is a function of airway width. The logical construct behind these elements suggests that the airway width, for purposes of the formula, should appropriately be

[88] The Air Force has not established a minimum distance that pilots must maintain from the Stansbury Mountains. Tr. at 4343 (Horstman).

determined based on where aircraft predominantly fly, not on the simple geographic width of the available airspace.

Employing that standard, the remaining discrepancy among the parties' views reflects differing approaches which are, again, a part of the overall analytical uncertainty of the estimate. The evidence presented only serves to establish that the actual value of the airway width is indeterminate to the extent that it depends upon individual pilot preference. From that perspective, the preponderance of the evidence supports the State's viewpoint, but only to the extent that the State has correctly urged that the airspace actually used is six miles. The State's further adjustment to five miles lacks evidentiary support, while the ten miles advocated by Applicant and Staff does not account for the predominant pilot practice shown by the evidence.

5. Calculated Four-Factor Probability

Utilizing in the NUREG-0800 equation the four values found in Section 4, above, the Board calculates the probability of impact on the site as follows:

P = <u>C</u>rash Rate x <u>N</u>umber of Flights x <u>A</u>rea of Facility ÷ <u>w</u>idth of Airway

= (2.736×10^{-8})/mile x 7,040/year x 0.1337 sq. miles ÷ 6 miles

= 4.29×10^{-6} per year.

Consequently, we find on the basis of the evidentiary record before us that the Applicant has failed to meet the Commission's acceptance criterion articulated in CLI-01-22.

We note, as Table 1 reflects, that without the aid of the R factor none of the parties' inputs produces a result that would satisfy the 1×10^{-6} per year standard. In fact, the variance that exists (a more than threefold difference between the Applicant and the State, and a sixfold difference between the Staff and the State) reflects the unavailability of direct, observable data that, in turn, results in input values having to be derived by indirect means. Not surprisingly, therefore, the arguments in favor of one or another estimate -- for example, both estimates of N

-- are supported by plausible arguments. Be that as it may, pursuing the four factors analysis any further to attempt to reach a more precise resolution of these differences would not be productive given that, as we noted earlier, the evidence is insufficient to give the critical second component of the proposed R factor the weight the Applicant would assign it.

6. Other Aircraft Risks

Although the predominant contributor to hazard to the PFS site is F-16 flights over Skull Valley, the Board must also consider hazards arising from other sources in order to arrive at an overall assessment of the overflight crash probability. We do so at length for some scenarios, but briefly for those whereupon examination it is apparent that the probabilities in most instances are so low (in the 10^{-8} range) that our decision would not be materially affected by even relatively large changes in their values.

a. Moser Recovery Route. The major area of additional concern for the State involves aircraft activity on the Moser Recovery Route (MRR). [89] The MRR provides an alternative for aircraft returning from the UTTR South area to Hill AFB.[90] It is utilized only during marginal weather conditions, or at night, under specific wind conditions that require the use of a northwest-heading approach to Runway 32 at Hill AFB. See Cole/Jefferson/Fly Post Tr. 3061, at 11. The Air Force is not otherwise inclined to use the MRR because it can create conflicts with Salt Lake City International Airport commercial and other traffic. Cole/Jefferson/Fly Post Tr. 3061, at 11; Aircraft Crash Report at 48a & n.56A.

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[89] The MRR runs from southwest to northeast and passes two to three miles north of the PFS site. SER at 15-80.

[90] The vast majority return to Hill AFB from the UTTR South Area by exiting the northern edge of that range (which is not near the PFS site). Cole/Jefferson/Fly Post Tr. 3061, at 96-97.

The Air Force does not keep precise data on the number of flights per year that use the MRR.[91] All parties, therefore, had to look elsewhere to derive estimates of annual MRR flights.

The Applicant estimates that approximately 5% of the F-16 flights return to Hill AFB via the MRR. Cole/Jefferson/Fly Post Tr. 3061, at 97. That estimate drew upon conversations between General Cole and the Vice Commander of the 388th Fighter Wing at Hill AFB and a civilian air traffic controller in the Salt Lake City Air Traffic Control Center. Tr. at 3456-58 (Cole).

To estimate the number of flights that will occur on the MRR in the future, the Applicant assumed that the sortie rates on the UTTR, and thus the number of flights on the MRR, increased proportionally to the number of F-16 flights in Skull Valley. Using FY 98 data for UTTR F-16 sorties, the Applicant estimates that some 280 flights used the MRR in 1998.[92] The Applicant then increased this number of sorties proportionally to account for the increase in F-16s in FY 00 and FY 01, and to account for the increase in number of F-16s to be stationed at Hill AFB in the future. Cole/Jefferson/Fly Post Tr. 3061, at 97.

Defining the MRR airway width as 11.5 miles, and using previously selected values for the crash rate, effective area, and R, the Applicant estimated the crash impact probability to be 2.0×10^{-8} per year. Cole/Jefferson/Fly Post Tr. 3061, at 97. Without the R factor of 85.5% reduction, which we have previously rejected, that probability would have been approximately 1.4×10^{-7} per year.

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[91] See Cole/Jefferson/Fly Post Tr. 3061, at 96-97; Aircraft Crash Report at 48a-49.

[92] According to the Air Force, 5,726 F-16 sorties were flown on the UTTR South Area in FY 98, almost all of which flew from Hill AFB (not all aircraft transit Skull Valley en route to the South Area). From this, the Applicant determined that 286 aircraft (5% x 5,726) from Hill and elsewhere used the Moser Recovery Route on their return flights for FY 98. Cole/Jefferson/Fly Post Tr. 3061, at 97.

The Staff prepared an independent analysis of the number of flights on the MRR using actual FY 00 UTTR data, estimating there are 353 flights per year on the MRR. See SER at 15-80 to 15-82; Staff Findings ¶ 2.529. The Staff agreed with the Applicant that about 5% of UTTR sorties used the MRR, because (1) the MRR is used only under specific wind conditions; (2) the MRR is not favored by Air Force pilots due to conflicts with Salt Lake City International Airport air traffic; and (3) because Air Force personnel have confirmed that the MRR is rarely used. See Staff Reply ¶ 143. Using the NUREG-0800 formula, the Staff determined the hazard probability from aircraft traversing the MRR to be 2.5 x 10^{-8} per year using a value similar to the Applicant's to account for pilot avoidance. Campe/Ghosh Tr. 4078, at 40; SER at 15-82.

The State asserts that future flight numbers along the MRR are likely to be substantially larger than projected by either the Applicant or the Staff. See State Findings ¶ 110. The increase will occur, says the State, because the Air Force plans to increase the frequency of night flying to train pilots in using night vision goggles. According to the State, up to 33% of all future flights on the UTTR are likely to be night training flights, all of which, it says, will return via the MRR. Horstman Post Tr. 4214, at 30.

The State also asserts that there will be some 10,410 aircraft using the UTTR in future years. This estimate is substantially larger than estimates used by the Staff or Applicant, each of which relied on their previous estimates of F-16 flights transiting Skull Valley.

The State calculates, using the foregoing data, that the projected number of aircraft using the MRR will be 3,436 per year (10,411 x 33%). That value for N resulted in the State's estimating crash probability on the PFS site from MRR flights as 1.64 x 10^{-6} per year. See State Findings ¶ 111. If accepted, this estimate would, by itself, and without regard to the contribution of other accident scenarios to cumulative risk, indicate sufficient probability of impact to exceed the NRC acceptance criterion of 1 x 10^{-6}.

In estimating the MRR use factor, the State assumed that a 33% increase in UTTR night training activity automatically translated to a corresponding numerical increase in MRR use because of its understanding of an Air Force report that all those increased night flights would use the MRR for recoveries. That Air Force statement was, however, of a contingent nature: use of the MRR for night flight recovery is contingent upon the existence of certain wind conditions. Indeed, the Air Force expects no overall increase in MRR usage resulting from its night training. Campe/Ghosh Post Tr. 4078, at 39; Cole/Jefferson/Fly Post Tr. 3061, at 98 & n.168. The State's assertion that 33% of all UTTR flights will use the MRR is therefore lacking in record support.

As to the other part of its estimate, the State derived its view that approximately 10,410 flights would use the UTTR by extrapolating from fluctuations in use data for prior years. Specifically, the State viewed the data as reflecting an upward trend portending more flights on the MRR after the year 2001 than had occurred up to that time.

The UTTR data do not, however, show any such unambiguous upward trend before 2001. A more realistic interpretation of the data is that UTTR flight numbers simply fluctuated from year to year without showing any overall trend. We find it invalid to select a particular short period's incidental upturn in fluctuating data for extrapolation as if it were a trend. The Board therefore finds that the State's projected number of UTTR flights was derived by invalid techniques, and is thus lacking in record support.

We find that the State's overall analysis of the crash probability on the PFS site arising from flights on the MRR is not appropriate, because both its estimate of future aircraft use on the UTTR and its estimate of the percentage of UTTR flights returning along the MRR are overstated. We therefore reject the State's MRR crash probability estimate of 1.64×10^{-6} as unfounded. On the other hand, the Board finds that the Staff estimate of crash probability of approximately 1.6×10^{-7} per year (without credit for a pilot avoidance factor) is reasonable, as is the Applicant's somewhat different estimate of 1.4×10^{-7}, for the reasons expressed in their analyses.

The Board recognizes that all numerical values used in this analysis are derived from indirect estimates, rather than consisting of actual counts of aircraft using the MRR. All such estimates are subject to considerable but unmeasured uncertainty. Nevertheless, even in the face of this analytical uncertainty, we can conclude there is reasonable assurance of only small crash probability from MRR traffic because, in this instance, there is some margin between any of the reasonable estimates and the acceptance criterion. In other words, the screening formula worked well enough here -- unlike the analysis of Skull Valley flights -- to permit this particular accident scenario to be put aside (other than for cumulative risk purposes).

b. Michael Army Airfield. Another State concern is the hazard posed by aircraft flying to and from Michael Army Airfield (MAA) on IR-420. MAA is located on Dugway Proving Ground, 17 miles south-southwest of the PFS site. IR-420 is a military airway that runs from the northeast to southwest and terminates about seven miles north of the PFS site, at the northern edge of the Sevier B MOA. See Cole/Jefferson/Fly Post Tr. 3061, at 98; Campe/Ghosh Post Tr. 4078, at 41.

The majority of flights to and from MAA are F-16s conducting training exercises. See Campe/Ghosh Post Tr. 4078, at 41. The Applicant used the same method to calculate the probability of an MAA-related aircraft impacting the PFS site it did for F-16s transiting Skull Valley. See PFS Findings ¶ 195.

There are also a number of large cargo aircraft flying to and from MAA. NUREG-0800 provides an in-flight crash rate of 4.0×10^{-10} per mile for large commercial aircraft. The Applicant applied that crash rate to its estimated maximum of approximately 414 annual flights to MAA by aircraft other than F-16s.[93] See PFS Findings ¶ 195. PFS calculated the effective area of the site as .2116 square miles, using the same method employed to calculate the effective area of the PFS site relative to an F-16. Using the NUREG-0800 formula, the probability of any of these aircraft impacting the PFS facility is negligible, i.e., 3.0×10^{-9} per year. See PFS Findings ¶ 195.

The State did not submit any testimony on the hazard posed from aircraft flying to and from MAA in the direction of IR-420. See PFS Findings ¶ 195. Similarly, the Staff does not dispute the Applicant's estimate of risk posed from flights transiting IR-420. See Staff Findings ¶ 2.542. For our part, we have examined the calculations and find them reasonable and supported by the preponderance of the evidence, allowing this accident sequence to be put aside as well.

c. Utah Test and Training Range. The State has also expressed concern over the hazard to the facility from aircraft training on the UTTR. Aircraft on the UTTR South area perform a variety of activities, including air-to-air combat training, air-to-ground attack training, air-refueling training, and transportation to and from the MAA. See Cole/Jefferson/Fly Post Tr. 3061, at 90-91. The Applicant asserts that the hazard from air-to-air combat training on the UTTR poses a negligible hazard to the PFS facility because activity on the UTTR occurs too far away from the facility. See PFS Findings ¶¶ 185-86.

The UTTR South area is composed of four restricted areas, and the PFS site is located two miles from the eastern edge of two of the restricted areas. In much the same manner that pilots try to avoid encroaching into restricted airspace when flying down Skull Valley, it is

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[93] This estimate was derived from FY 97 data obtained from MAA. Based on the total number of aircraft that took off and landed at MAA in later years (FY 98 to FY 00), a lesser number resulted, i.e., 212 non-F-16 flights per year. The Applicant also points out that the total number of aircraft flying over Skull Valley would actually be less than that total, for it includes aircraft flying to and from the airfield in all directions. See PFS Findings ¶ 195 & n.138.

reasonable to assume that pilots will also try to avoid performing restricted activities outside of the controlled area for fear of harming other aircraft as well as to avoid serious consequences for violating Air Force policy. Hence, the Applicant assumes a three-mile buffer zone inside the UTTR restricted airspace as a practical limitation on how close pilots will fly to the outer edge of the UTTR.

Review of the F-16 crash reports indicates that most accidents would occur toward the center of the restricted ranges. Relying on the asserted five mile glide distance of the plane (see PFS Findings ¶¶ 186-89), the Applicant asserts that accidents that did not leave the pilot in control of the aircraft would not pose a threat to the PFS facility: the facility would be two miles from the eastern boundary of the UTTR airspace, and a three mile buffer will be observed inside that boundary. Using the NUREG-0800 formula, the Applicant thus calculated that the crash probability from F-16s performing activities in the UTTR is less than 1×10^{-8} per year.

In response, the State asserts that the Applicant's estimate of crash hazard is unrealistic because it is reduced by the R factor. See State Findings ¶ 123. In addition, State's witness Dr. Resnikoff argued that an aircraft could indeed pose a hazard to the facility, based on the assumption that a crashing F-16 could fly ten miles before impact. See Resnikoff Post Tr. 8698, at 17-19; Tr, at 8792-94 (Resnikoff). Using this data, the State calculated the hazard to facility from this activity to be 2.74×10^{-7} per year.

We agree with the Applicant that a five-mile-glide for an F-16 is a reasonable estimate. The State's witness based his belief in a ten-mile glide distance from a preliminary estimate the Applicant made before it obtained and analyzed the actual accident reports, which showed different data. In any event, even after removing the R factor, the UTTR risk is small compared to that posed by F-16s in Skull Valley.

d. Military Ordnance. The final area of concern for the State involves the potential hazard to the facility from ordnance explosions. Ordnance can pose a hazard to the PFS facility both directly and indirectly in four respects: (1) an F-16 carrying ordnance might crash directly into the facility; (2) an F-16 carrying ordnance might jettison ordnance directly onto the facility; (3) an F-16 carrying ordnance might crash near the facility causing an explosion that can impact the facility; and (4) an F-16 carrying ordnance might jettison it near the facility with similar explosive impact.

Although the Applicant and the Staff assessed the probability of each of the four scenarios in their respective analyses (see Aircraft Report at 74-83k; SER at 15-83 through 15-93), the State addressed only the second scenario, the probability of jettisoned ordnance directly striking the facility. See Resnikoff Post Tr. 8698, at 19-20; see also State Findings ¶¶ 114-122; State Reply at 53-54. We consider below each of the four scenarios.

(i) Hazard from Direct Impact from F-16 Carrying Ordnance. The Applicant has determined that the probability that an F-16 transiting Skull Valley with live ordnance on board would crash into the facility is about 7×10^{-9} per year. Aircraft Crash Report at 78. This estimate is based on the assumptions that: (1) the fraction of crashing F-16s that do not jettison their ordnance is 10%, and (2) only 5% of all F-16s carry bombs. Id. The Board finds these assumptions reasonable, and even with the uncertainties involved, the estimated probability of 7×10^{-9} per year is well within the acceptance criterion of 1×10^{-6} per year.

(ii) Hazard from Direct Impact of Jettisoned Ordnance. In calculating the probability of jettisoned ordnance directly hitting the facility, the Applicant used the following formula: $P = N \times C \times e \times A/w$. See PFS Findings ¶ 196. In this modification of the NUREG-0800 formula, N represents the number of annual flights through Skull Valley carrying live and/or inert ordnance; C is the F-16 crash rate per mile; e is the percentage of crashes that leave the pilot in control of the aircraft and able to jettison the ordnance; A is the combined dimensions of the CTB and storage pad area; and w represents the width of the airway. See PFS Findings ¶ 197.

The Applicant estimates that *N*, the number of aircraft carrying live or inert ordnance through Skull Valley per year, is 150. See PFS Findings ¶ 197. This estimate is based on the average number of F-16s carrying ordnance through Skull Valley in FY 99 and FY 00 (2.556% of the total number of Skull Valley sorties, increased by 17.4% to account for the additional aircraft based at Hill AFB in FY 01) -- or 2.556% of 5,870. See PFS Findings ¶ 197; Cole/Jefferson/Fly Post Tr. 3061, at 102.

For *C*, the Applicant used the crash rate for F-16s calculated above, or 2.736×10^{-8} per mile. See PFS Findings ¶ 197. The Applicant then assumed that the pilot would jettison ordnance in 90% of all crashes, when the pilot is in control of the aircraft (in crashes attributable to other causes, it was assumed that the pilot would eject quickly and would not jettison ordnance). See PFS Findings ¶ 197. Therefore, *e* is equal to .9.

The Applicant determined A, the product of the width and the depth of the cask storage area, plus the product of the width and depth of the CTB, to be .08763 square miles. See PFS Findings ¶ 197. Finally, the Applicant treated Skull Valley as an airway with a width, *w*, of ten miles. See PFS Findings ¶ 197. Based on these input values, the Applicant calculated the hazard to the facility from jettisoned ordnance to be 3.2×10^{-8} per year. See PFS Findings ¶ 197.

The State, on the other hand, uses an unmodified NUREG-0800 formula to calculate the crash probability for jettisoned ordnance: $P = N \times C \times A/w$. See State Findings ¶ 120. The State disputes the Applicant's use of *e*, asserting that PFS offered no evidence in support of the assumption that ordnance will be jettisoned less frequently than the F-16 crash rate. See State Findings ¶ 122. In calculating *N*, the State relied on the following data for combined sorties carrying ordnance for the 388th and 419th Fighter Wings: 866 sorties in FY 98, 193 sorties in FY 99, and 164 sorties in FY 00. See State Findings ¶ 115. Because the Applicant does not know the reason for the decline in the number of sorties carrying ordnance from FY 98 to

FY 00, the State argues that it is neither realistic nor conservative to assume that future flights through Skull Valley will carry ordnance less often than flights in FY 98. See State Findings ¶ 116.

Thus, using data from FY 98, the State posits that 21.2% (866 flights carrying ordnance/4,086 total flights through Skull Valley) of Skull Valley flights carried ordnance in 1998. See State Findings ¶ 117. Using the total number of estimated flights for Skull Valley per year -- 7,040 -- (see State Findings ¶¶ 46-48) the State then determined *N*, the number of F-16s that will carry ordnance through Skull Valley, to be 21.2% of 7,040, or 1,492. See State Findings ¶ 119. In its calculation of *N*, the State assumed that all F-16 sorties with ordnance transit Skull Valley. See State Findings ¶ 117.

Alternatively, the State suggests that even if the Board were to accept the Applicant's methodology of determining the percentage of all flights carrying ordnance by dividing the number of sorties carrying ordnance (866) by the number of UTTR South Area sorties (5,726),[94] rather than Skull Valley sorties, the Applicant's value for *N* is not sufficiently conservative. See State Findings ¶¶ 118-19. Using the Applicant's reasoning, the State calculates that 15.1% of all flights (866/5,726), including those through Skull Valley, carried ordnance in FY 98. See State Findings ¶ 118. The State further argues that it would be neither conservative nor realistic to adopt a value for *N* of less than 1,063 (15.1% x 7,040). See State Findings ¶ 119.

With respect to the remaining variables, the State used an F-16 crash rate, *C,* of 4.10×10^{-8}. See State Findings ¶ 120; see also State Findings ¶ 38. For *A*, the State determines the area to be .12519 square miles, assuming a skid distance similar to that of an F-16 and a 35-degree impact angle. See State Findings 120; Resnikoff Post Tr. 8698, at 20. Finally, the State finds the width of the airway, *w*, to be five miles. See State Findings ¶ 120;

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[94] See Aircraft Crash Report at 82.

see also State Findings ¶ 44. Based on these input values, and a value of *N* of 1,492, the State estimates the annual probability of impacts from jettisoned ordnance to be 1.53×10^{-6}. See State Findings ¶ 120. Using the alternative value of *N*, 1,063, the State argues that it would not be realistic to use an annual probability of less than 1.09×10^{-6}. See State Findings ¶ 121.

For its part, the Staff agrees with the Applicant's use of *C*, 2.736 x 10-8; of *e*, 90%; and of *w*, ten miles. See Staff Findings ¶¶ 2.483-84. Relative to variable *N*, although the Staff considers the Applicant's value of 150 (2.556% of 5,870) to be acceptable, the Staff estimates *N* to be slightly higher. See Staff Findings ¶ 2.493. The Staff used only the data from FY 00 in calculating *N*. See Staff Findings ¶ 2.487. The fraction of the number of flights carrying ordnance, adjusted to account for the number of additional flights due to the 12 additional F-16s stationed at Hill AFB, was estimated by the Staff to be 2.3%. See Staff Findings ¶ 2.493. Thus, *N* was found by the Staff to be 2.3% of 7,041 flights, or 162. See Staff Findings ¶ 2.493.

With regard to *A*, the Staff finds the Applicant's estimation of the cask storage area to be acceptable; however, in its calculation, the Staff increased the size of the area of the CTB by using the length and width of the CTB at its widest point, resulting in a marginal increase. See Staff Findings ¶ 2.495. Based on the above input values, the Staff estimates the annual probability of jettisoned ordnance impacting the facility to be 4.4×10^{-8}. See Staff Findings ¶ 2.499.

The Board finds the Applicant's and the Staff's use of the modified NUREG-0800 formula ($P = C \times N \times e \times A/w$) to be appropriate in estimating the probability of jettisoned ordnance directly impacting the facility. The Board finds, however, that the values for *N* and *w* should be different from what the Applicant proposes, as will be explained below.

As we determined above in our discussion of the probability of an F-16 crashing into the PFS facility, we find the value of *C* to be 2.736×10^{-8} (see p. 50-52, 58-60, above) and *w* to be six miles. See p. 30, above. Based on the reasoning presented, we find the Applicant's estimation of *e* and *A* to be reasonable. As was noted above in Section B, we are satisfied that pilots would be able to maintain control of their aircraft in 90% of crashes (see p. 30, above), and it is reasonable that they would jettison their ordnance -- one of the first things they are instructed to do, and one that enhances their own safety -- on those occasions.[95] Thus, we find the value of *e* to be 90%.

With respect to *A*, the State's expert asserted that the Applicant should have used a "skid area" surrounding the facility to account for jettisoned ordnance potentially skidding into the facility, which it asserted should be based on a skid distance similar to that of a crashing F-16. See Resnikoff Post Tr. 8698, at 20. General Jefferson testified, however, that unlike an F-16, which would crash at a very shallow 7-degree angle, jettisoned ordnance would not skid because it would fall and impact the ground at a very steep angle. Tr. at 8869 (Jefferson). Because the sole basis for Dr. Resnikoff's assertion was an undocumented conversation between himself and Lieutenant Colonel Horstman, see Tr. at 8801-05 (Resnikoff), we find the Applicant's estimation of the area of the facility reasonable and conclude that *A* is .08763 square miles.[96]

The parties arrived at widely different values for the remaining variable, *N*. Of the three years of data available for the number of F-16s carrying ordnance, the Applicant chose to use the two most recent years of data, FY 99 and FY 00, in calculating the percentage of flights

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[95] We think the jettisoning of ordnance thus involves a different analysis than does avoiding a ground site. The matter need not be explored further, however, for the fewer pilots that succeeded in jettisoning ordnance, the lower would be the calculated probability for the accident scenario now under scrutiny -- i.e., the risk of jettisoned ordnance. In other words, the Applicant's assumption of 100% success in jettisoning ordnance is the most conservative it can make here.

[96] Although the Staff increased the size of the area calculated by PFS by using the length and width of the CTB at its widest point, the Staff, rather than providing a final value for *A*, merely asserted that the increase in area would marginally increase the probability, *P*, by 1 x 10^{-9}. See Staff Findings ¶ 2.495. Thus, we accept the Applicant's estimation of *A*.

carrying ordnance per year. See PFS Findings ¶ 197. The State, on the other hand, considered only the data from FY 98, the year with the highest number of flights carrying ordnance. See State Findings ¶ 116. For its part, the Staff took into account data for FY 00 only, the most recent year available. See Staff Findings ¶ 2.493.

The Board finds that the most appropriate method of determining *N* is to use all of the data available, that is, data from FY 98 through FY 00. Therefore, we find the percentage of flights carrying ordnance through Skull Valley per year to be 8.34%. We arrived at this percentage by dividing the number of 388th and 419th Fighter Wings' flights carrying ordnance over the three years for which data was available by the total number of flights: (866 + 193 + 164)/(4086 + 4586 + 5997) = 0.0834. See Revised Addendum, Tab HH at 3, 13, 14 n.30. We previously estimated the number of flights along the Skull Valley airway in the future to be 7,040. See p. 52-59, above. Thus, we estimate *N* to be 587, or 8.34% of 7,040.

Based on the above inputs, we calculate the probability of jettisoned ordnance directly impacting the PFS facility as follows:

$$P = C \times N \times e \times A \div w$$

$$= 2.736 \times 10^{-8}\text{/mile} \times 587 \times .90 \times .08763 \text{ sq. miles} \div 6 \text{ miles}$$

$$= 2.11 \times 10^{-7} \text{ per year}$$

For clarity, we display the parties' calculations, and ours, in Table 2, below. As thus indicated, we find that the Applicant has met the Commission's acceptance criterion of 1×10^{-6} per year articulated in CLI-01-22.

Table 2

Estimated Probability of Jettisoned Ordnance Directly Impacting the PFS Facility

	Applicant	**State**	**Staff**	**Board**
N	150	1,492 or 1,063	162	587
C	2.736×10^{-8}	4.10×10^{-8}	2.736×10^{-8}	2.736×10^{-8}
e	.90	1.0 (no factor)	.90	.90
A	.08763 sq. mi	.12519 sq. mi	slightly larger than .08763 sq. mi	.08763 sq. mi
w	10 mi	5 mi	10 mi	6 mi
P	3.2×10^{-8}	1.53×10^{-6} or 1.09×10^{-6}	3.5×10^{-8}	2.11×10^{-7}

(iii) Hazard Posed by Nearby Explosions of Ordnance (on Board an F-16 or Jettisoned from an F-16). The Applicant provided analyses on the potential hazard posed by nearby explosions of ordnance on board or jettisoned from an F-16. See PFS Findings ¶¶ 200-03. The State did not challenge any of these findings.

Before adopting the Applicant's findings by default, the Board examined the merits of the underlying analysis; we find it to be logical and reasonable. A detailed description of that analysis is provided in PFS Findings ¶¶ 200-03, and PFS Reply ¶¶ R170-R172, as well as in Staff Findings ¶¶ 2.500 to 2.516. The Applicant's use of an "explosion damage radius" for a 2,000 pound ordnance employing overpressure limits for the spent fuel storage cask and the Canister Transfer Building is appropriate, since the 2,000 pound ordnance is the largest carried on board an F-16. The Applicant's assumption of a 1% chance of explosion for ordnance jettisoned from, or carried aboard, a crashing F-16 (see PFS Findings ¶ 203) is reasonable based on the testimony that Air Force pilots do not arm the live ordnance they are carrying while transiting Skull Valley near the facility. PFS Findings ¶ 202. Therefore, the Applicant's estimate of a 1×10^{-10} per year probability of explosion of ordnance sufficiently nearby that the overpressure would impinge on the facility is reasonable.

In summary, the Board finds that the Applicant's analysis is adequate in estimating the hazard probability posed by military ordnance in three of the four respective ways discussed above. The Board's own analysis indicates, however, that a higher hazard probability is more appropriate for that posed by jettisoned ordnance, but the Board's raised estimate, 2.11×10^{-7} per year (relative to the Applicant's value of 3.2×10^{-8} per year), is still within the Commission's 1×10^{-6} per year acceptance criterion.

7. Cumulative Hazard

Because of the risk from F-16 flights down Skull Valley alone, the estimated cumulative hazard posed to the PFS facility from aviation activity in the Skull Valley fails to meet the Commission's threshold criterion for credible accidents of less than 1.0×10^{-6} per year. The additional hazard from flights on the MRR and from jettisoned ordnance accidents adds somewhat to the potential excessive risk.

This finding would ordinarily mean that our analysis was for now at an end, and that a grant of the license would not be justified. But the Staff believes that the probability criterion is flexible enough to avoid that result. We consider and reject that argument in Subpart D, below.

D. <u>Compliance with the Commission's Safety Criterion</u>

As has been seen in Subpart C, the Applicant has fallen well short in its attempt to establish that the accidents in question have less than a one in a million per year chance of occurring -- we found that the accident likelihood is over four times that high. Rather than have that result be determinative, however, the Staff asserts that the governing Commission criterion (established in CLI-01-22) is not a rigid one, but is flexible in its application. Indeed, the Staff says, through both counsel and a witness, the standard is sufficiently flexible that it is really only intended as an "order of magnitude" guide. See Tr. at 3000-01(Turk); Tr. at 8914 (Campe).

In response to our inquiry, the Staff indicated that it would have that order of magnitude flexibility "bracket" the criterion. Explaining further, the Staff opined that the Commission's "less than one in a million" really means that a showing of as much as " $5x10^{-6}$ " would still pass muster. See Tr. at 3003-06 (Turk); Tr. at 8914 (Campe). In other words, the Staff's view is that an accident scenario with a probability as high as "one in two hundred thousand" would pass a test that seems to demand "less than one in a million,"[97] which itself was a (legitimate) markdown (see p. 13-15, above) from "less than one in ten million."

While there may well be uncertainty in the accuracy of the various estimates now before us for the four factors (see Subpart C, above), we find that uncertainty not troublesome if the formula is utilized as it apparently was intended, i.e., as a rough screening device (see Tr. at

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[97] Because we decide this matter on the legitimacy of the concept the Staff is advancing, we do not pause to resolve questions that could be raised about its details, such as where the lower end of the order of magnitude "bracket" would most appropriately fall, which depends on whether the probability scale is viewed, for this purpose, as arithmetically-based or log-based, and might, instead of 5×10^{-6}, be at 2×10^{-6}, or "one in five hundred thousand." Another more important question would concern why the Staff's focus was only on the lower end of the so-called "bracket;" if it is truly a "bracket," it would seem the State could focus on its upper end and argue that a superficially compliant showing ("less than one in a million") failed for not being as infrequent as, depending on how the scale is interpreted, "one in two million" or "one in five million."

4127-28 (Campe)).[98] Indeed, this view is fully in keeping with the thinking of the authors of the formula, at least as expressed in nonadversarial circumstances at the time of the formula's creation and embodiment in the Standard Review Plan.[99] At that point, they indicated that use of the NUREG-0800 four-factor formula "gives a conservative upper bound on aircraft impact probability if care is taken in using values for the individual factors that are meaningful and conservative." NUREG-0800 at 3.5.1.6-4 (§ III.2, emphasis added).

As we read that text, it indicates clearly that the formula was intended to be applied cautiously.[100] Yet, reformulating the acceptance criterion in the Staff-proposed manner would amount to overriding the conservatism that apparently was deliberately built into the formula.[101] We thus disagree with the Staff that in the face of such analytical uncertainty we should create, and rely upon, an order of magnitude confidence interval bracketing or surrounding the

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[98] The State, for example, called our attention to a Licensing Board decision in another case where the acceptance criterion was 1×10^{-6} per year and yet the Board closely scrutinized crash probabilities of 1×10^{-10} to be sure the criterion was indeed met. See fn. 103, below.

[99] Cf. Bowen v. Georgetown Univ. Hosp., 488 U.S. 204, 212-13 (1998). There, the Court disapproved agency counsel's attempt to express a position during litigation that was different from the established agency position. Here, even though the changed position was not put forward by agency counsel, but by staff involved in later litigation, we think the principle analogous, in that the new litigating position is inconsistent with that taken in creating the position initially.

[100] As we have adverted to throughout, that conservatism is not meant to deprive an applicant of its desired license. Rather, as we cover in detail in Subpart E, it is intended simply to require an applicant -- in order to earn that license -- first to take one of several possible steps, or to make one of several possible showings, to demonstrate that (notwithstanding the potential concern identified by the formula) the public health and safety will not be put at risk by an award of the license.

[101] It is of no moment to this discussion, of course, that the acceptance criterion mentioned in NUREG-0800 is 1×10^{-7}, while the criterion applicable here is 1×10^{-6}. That difference simply reflects that the formula was initially derived for nuclear power plants and is being used here for a different type of facility. See pp. 13-15, above.

acceptance criterion.[102] This is particularly true in this instance, given that NUREG-0800 places special focus on "military training routes," and precludes any waivers of full examination if such routes are "associated with a usage greater than 1000 flights per year" (Section II.-1.(b)). Here, there are multiple thousands of flights.

In the end, this illustrates the wisdom of using the classic NUREG-0800 formula only to the degree to which it was intended. As we see it, and as the Staff's Dr. Campe described it during the trial (Tr. at 4126-28 (Campe)), the formula provides an excellent screening device for those concerned about unlikely accidents. That is, even when the values for the formula's four factors are imprecise, the calculation might produce a result not close to the governing criterion. In that circumstance, the formula will have told its user with a reasonable amount of confidence either that (1) the accident being inquired about has so little likelihood of occurring that no further thought need be given it;[103] or (2) that it has so great a likelihood of occurring that the proposed site may be unsuitable.[104]

In sum, it comes down to this: the one-in-a-million "credible accidents" criterion derives from the NRC's site suitability regulations. The Applicant selected this site in full knowledge that it was under a busy military training airway. Rather than stretch the one-in-a-million criterion to let the Applicant move forward, the appropriate course is to let that criterion and the screening formula serve their purpose -- that of alerting the Applicant and the Staff to a problem so that

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[102] We mention again (see fn. 97, above), that a troubling question, involving fairness considerations, could arise if this "bracket" -- even if otherwise permissible -- were for practical purposes to extend, as the Staff seems to intimate, in only one direction.

[103] See, for example, the decision in Big Rock Point (brought to our attention by the State for another purpose), where the formula gave a result in the 10^{-10} range. Consumers Power Co. (Big Rock Point Plant), LBP-84-32, 20 NRC 601 (1984), aff'd, ALAB-796, 21 NRC 1 (1985).

[104] Unsuitable, that is, in the sense of the NRC's site suitability regulations, if the facility is not adequate, or cannot be hardened, to preclude excessive radiological consequences.

the Applicant has the opportunity to address it.[105] If, instead, all that happened was to stretch the criterion as the Staff argues -- or to alter the basic formulaic result through hypotheses not borne out by the facts as the Applicant proposes -- the result would be to look away from, rather than to look more closely at, an identified problem.

In this instance, the Applicant needs to take the next step and address the "consequences" issue (see Subpart E, below), either by demonstrating that an F-16 would not penetrate a cask (either as now designed or as it might be hardened), or that, even if it did, there would be no significant radiation impact for the public.[106] If the Applicant can make either of those showings,[107] the NUREG-0800 formula and the "credible accidents" standard will have served their purpose of assuring that the thousands of military overflights neither render the site unsuitable nor threaten to unleash any significant consequences.

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[105] By the same token, the screening purpose for which the formula was created also suggests that, as the "one in a million" criterion is approached, the appropriate response is to look more closely at the problem under scrutiny. For example, if the formulaic calculation indicated that the likelihood of the accident in question was 1.01 per million, would that result truly be any different from one in which the calculation indicated that the likelihood was .99 per million? Is there more reason to round down the 1.01 to reach a decision in an applicant's favor, than there is to round up the .99 to reach a decision against an applicant? In such circumstances, rather than the agency's addressing a marginal proposal by sharpening an analytical pencil, the approach in NUREG-0800 seems to suggest that it would be better to proceed by sharpening an applicant's focus on identified problematic areas.

[106] As noted earlier, the issue before us involves accidental crashes, but it would seem that any studies of aircraft impacts commissioned (after the September 11 attacks on the World Trade Center and the Pentagon) to assess the consequences of deliberate crashes, might be found to have a bearing on the analogous issue before us. See CLI-02-25, slip op. at 22; fn. 4, above and fn. 128, below).

[107] Or it can attempt to make arrangements to reduce significantly the likelihood of the accident. In that regard, NUREG-0800 indicates that "past experience has been that military authorities have been responsive to modification of military operations and relocation of training routes in close proximity to" sites in question. NUREG-0800 at 3.5.1.6-5, § III.2. As already noted (pp. 2-3, above), we have no role to play in any such modification and pause simply to note that whether such "military authority responsiveness" will obtain here appears problematic in light of the April 23, 2002 "limited appearance" affidavit submitted on behalf of the Secretary of the Air Force early in our hearing. See p. 3, above.

E. Accident Consequences

We indicated earlier in this decision that we had rejected from consideration in the 2002 hearings certain testimony the Applicant had proffered on the “consequences” issue. Because that issue may now prove crucial to the eventual outcome of this proceeding, we think it appropriate to provide an explanation of why that testimony was not then entertained, but similar testimony may well now be.

Under the Commission’s site evaluation regulations (covering nuclear reactors and adapted for spent fuel storage facilities), an applicant must show that if a credible accident were to occur, the consequences would not result in the release of radioactivity that would cause doses in excess of 10 C.F.R. Part 100 guidelines. See 10 C.F.R. §§ 72.90, 72.94, 72.98, 110.10; NUREG-0800 at 3.5.1.6-2; Campe/Ghosh Post Tr. 4078, at 4-6. As a legal matter, then, the ultimate focus is on a unified question, i.e., the probability of an accident that would lead to radiation doses beyond Part 100.

As a practical matter, however, the regulatory focus and approach often turn out not to be on that unified question but on one of two separate, subsidiary issues, either of which can be determinative in particular circumstances. Specifically, if it can be shown that the likelihood of the triggering accident is so low that the accident can be discounted as not credible, there is no need for an inquiry into whether the radiation dose consequences would be excessive if the accident were to occur.[108] At other times, the opposite approach is taken -- an applicant will assume the accident would occur, but will attempt to demonstrate that even if the event

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[108] For example, for purposes of analysis, it can be assumed that the radiological consequences of a direct strike by a large meteor onto a nuclear power plant would be enormous. But because a meteor strike is so unlikely (i.e., in regulatory terminology, “incredible”), nuclear plants need not be designed to withstand them.

happens there would be no dose consequences. Usually, this would be because the facility's "design basis" is shown to be such that it can withstand the postulated accident, or mitigate it adequately. [109]

Throughout this proceeding, in the pleadings and in Commission and Licensing Board decisions, there was great emphasis on, and full development of, the "probability" issue, involving the likelihood of an aircraft accidentally striking the facility. On the other hand, the "consequences" issue -- that of excess dose -- emerged not only belatedly, but also obliquely and scantily, in the State's and Applicant's proffered pretrial testimony in the form of discussions about the likelihood of cask penetration.[110] For related reasons which will be seen, the Staff proffered no testimony on the subject.

The validity of the State's proffered testimony was put into play two weeks before trial in the form of the Applicant's and the Staff's motions in limine to have that testimony excluded on legal grounds.[111] For its part, the Applicant called our attention to what it perceived as a problem about the scope of this evidence by urging us to exclude the State's proposed testimony on one aspect of the cask penetration issue.[112] In this regard, at oral argument

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[109] That result was reached in this proceeding with respect to the lack of any real effect from an impact by a general aviation aircraft. See fn. 18, above.

[110] In this regard, we note the categorization of the issue regarding cask penetration is a grey area that depends on how the "accident" is defined. Thus, cask penetration was spoken of on a few occasions as constituting part of the "accident probability" question (when the accident is defined as cask breach by a crashing aircraft), and on other occasions as part of the "dose consequences" evaluation (when the accident is defined, as it most often has been here, as cask impact by such an aircraft). Compare our analysis of the "nearby ordnance" issue in Paragraph C.6.d.iii, above.

[111] The motions on which we heard oral argument on April 8, the eve of trial, had been filed two weeks before the start of the hearing, on March 25, with responses filed a week later, on April 1.

[112] Although the Applicant's motion appeared primarily directed at the State's proposed testimony on "dose consequences" for being outside the scope of the proceeding, it also challenged the State's proposed testimony on an aspect of "cask penetration" as lacking any basis. See Applicant's Motion to Strike (Mar. 25, 2002), pp. 4-5.

Applicant's counsel confirmed the Board's assumption that, in the belief the accidents under scrutiny had less than a one in a million likelihood of occurring, the PFS application had in effect represented to the Staff "don't worry about the military accidents . . . we don't have to design against" them. Tr. at 2986 (Farrar). Counsel indicated that the radiological dose consequences issue was not within the confines of our proceeding and assured us that Applicant would not attempt to litigate that issue. Tr. 2986-87, 2990-91, 2995-96 (Barnett). Instead, as Applicant's counsel explained and its testimony stated[113], its limited "cask penetration" testimony was offered merely to demonstrate the overall conservative nature of its accident probability calculations. Tr. 2986-87, 2988 (Barnett). [114] See also proffered Johns Testimony, A7, last sentence; proffered Cole/Jefferson/Fly Testimony, A163, p. 112.

For similar reasons, the Staff urged an even broader exclusion of the State's testimony, reaching another aspect of the cask penetration issue. Staff Motion § 4. This position was in harmony with the fact that the Staff had proffered no testimony whatsoever on the cask penetration and dose consequences matter; its counsel explained that the Staff had taken that approach "because we believe that [given] the probability it does not have to be addressed." Tr. at 2983 (Marco) (emphasis added).

This explanation was repeated a few minutes later, when Staff counsel explained that because the Staff "conservatively assume[s] that the impact of the plane will result in [excessive] consequences," it "doesn't get to" the consequences issue and instead "start[s] by looking to see what is the probability of occurrence." Tr. at 2998 (Turk) This was in keeping

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[113] See Testimony of Jeffrey Johns on Aircraft Crash Hazards at the PFSF Contention Utah K/Confederated Tribes B [hereinafter Johns Testimony] (Feb. 12, 2002).

[114] In indicating whether "consequences is part of" this proceeding, Applicant's counsel did draw a distinction between "specific, radiological dose consequences," which it thought not before us, and its proffered testimony that "certain impacts . . . would not result in a release of radioactive material," which it had included "to show that our probability calculations were conservative." Tr. at 2986 (Barnett). We discuss that purpose below.

with the Staff's testimony, indicating that, in practice, only the annual probability of occurrence of an aircraft crash is calculated, as if a conservative assumption was made that the crash would cause the Part 100 guidelines to be exceeded. Campe/Ghosh Post Tr. 4078, at 6. In other words, the Staff proceeds initially as if the probability of exceedance is 1. Id.

Notwithstanding its position, the Staff did not take directly parallel action against the Applicant in that it did not formally challenge, by way of a separate motion, the Applicant's testimony on one of the same subjects on which it had challenged the State. The Staff did, however, present an understated challenge by noting in its motion to exclude the State's testimony that, if that testimony were indeed to be excluded, fairness would dictate that the Applicant's proposed testimony on "cask penetration" should be excluded as well. Staff's Motion in Limine (Mar. 25, 2002) at 5 n.4.

For its part, the State was willing to let all the testimony on this subject remain, pointing out that its position -- that "consequences" could be a legitimate part of the case -- was founded, in part, on a ruling of our predecessor Board on an earlier motion for summary disposition.[115] But the State, like the Staff, noted the obvious, i.e., that if the State's testimony on the "consequences" issue were to be excluded, so should be the Applicant's (Tr. at 2992 (Soper))[116].

That earlier Board ruling does bear on the issue. The Applicant had then urged, as did the Staff in its support of the Applicant's motion, that in light of the low probability of an aircraft crash accident, "such accidents are not credible and hence the [facility] need not be designed to

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[115] State Memorandum in Opposition (Apr. 1, 2002) at 6 (citing LBP-01-19, 53 NRC 416, 431 n.5 (2001)).

[116] In other words, given the failure of either the State or the Staff to challenge it frontally, a primary reason the Applicant's proffered testimony on "cask penetration" was subject to exclusion was because the Applicant's and Staff's challenge to the State's testimony had triggered consideration of the overall matter.

withstand their effects."[117] Disagreeing, our predecessor Board, chaired by Judge Bollwerk, made it clear that there remained room in the proceeding for that issue, and refused to rule it out at that point.[118]

But even though the door had thus been left open for "consequences" to become part of the case, by the time we came to make our ruling on the Applicant's and Staff's in limine motions, we concluded that door had since been shut, at least for purposes of the mid-2002 hearing.[119] Because our ruling there (Tr. at 3008 (Farrar)), referring to the "way the contention was framed," was rendered in extremely shorthand fashion in light of the lengthy argument and the other matters still to be addressed at the time, at this juncture we think it worth providing a further explanation of our reasoning.

In short, although the question of accident consequences was touched on from time to time prior to the hearing,[120] we concluded the issue had not generally been framed with the focus or quantification that would have allowed at the hearing a considered, precise decision on

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[117] Applicant's Motion for Summary Disposition (Dec. 30, 2000) at 9. See also Staff Response to Motion to Strike (Feb. 20, 2001) at 1 n.1 (arguing that consequences of an F-16 crash impact accident are beyond the scope of this contention). As we read that argument, the Applicant was at least suggesting at that point that the "penetration" issue was not in play by virtue of the State's contention, for hardening the casks would provide an obvious starting point for avoiding an accident's untoward consequences.

[118] LBP-01-19, 53 NRC at 431 n.5.

[119] As it turned out, Judge Bollwerk was, for other reasons, present at the April 8 oral argument on the in limine motions. Tr. at 2923-24 (Farrar). This Board took advantage of his presence to consult with him on this matter, and he did not disagree with our resolution of it. See Tr. at 3007-08 (Farrar).

[120] We note again in this regard (see fn. 20, above) that a discussion of consequences had arisen in the case during the period when we, and the Commission, were considering what the criterion should be for determining when an accident was credible. In the course of such consideration, distinctions were drawn between what the criterion should be for nuclear power plants and for spent fuel installations, and a key factor in that distinction was the perceived difference between the consequences of an accident at one and an accident at the other. But the consideration of consequences in that context was in a global, generic sense, not in a targeted, specific fashion, and had no bearing on how the case had been pleaded in terms of trial preparation. See LBP-01-19, 53 NRC at 429-32.

the likelihood either of cask penetration or of exceeding Part 100 dose levels.[121] This lack of focus or quantification was apparent in two respects.

1. The first involved the absence of Staff review of, or a position on, the matter. Whatever may have transpired between the Applicant and Staff during the lengthy application review process,[122] on this subject the Staff did not put forward its own analysis, either in the Safety Evaluation Report (SER) it produced or in the testimony it proffered to us. See SER; Campe/Ghosh Post Tr. 4078.

As a result, we were reluctant to undertake to decide an issue of such potential significance without the benefit of any formal review of it (or presentation of evidence on it) by the Staff. To be sure, the Staff's conclusions based on its safety and environmental reviews --

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[121] As is apparent, the proposed consequences testimony we excluded from the hearing was rather sparse compared to the State's and the Applicant's thorough, detailed testimony on the likelihood of the accident.

[122] Early on, as it conducted its internal review triggered by the filing of the PFS application -- which presented an analysis of the likelihood of crashes into the facility -- the Staff had asked pointedly for an analysis of certain crash consequences. See Commitment Resolution Letter # 18 from Applicant to Staff of 10/13/99, reciting the Staff's earlier conference call question about certain "potential consequences" issues if the Applicant was "unable to show the lack of any credible hazard from aircraft crashes . . . ." The Applicant responded, however, that any such analysis was unnecessary. Although the Applicant eventually was more forthcoming (see next paragraph), it appears that that initial Staff-Applicant exchange may have permanently set the tone for how the Staff approached this matter.

In Revision 22 of its Safety Analysis Report (SAR), the Applicant on the one hand re-asserted at one point that because "aircraft crashes do not present a credible hazard . . . the facility does not need to be designed to withstand the impact of an aircraft crash." SAR at 2.2-6. The Applicant went on in that same revision, however, to address crash impacts in two not entirely consistent fashions, viz., by (1) pointing out that "no credit was taken" in calculating the annual impact probability "for the resistance to the effects of an air crash impact provided by the concrete storage casks" (except where "light general aviation aircraft" were concerned), but (2) urging, based on material it had submitted on that subject, that "[t]his resistance of the casks to penetration further reduces significantly the calculated risk . . . from aircraft crashes . . . ." SAR at 2.2-22 (emphasis added).

whether contained in the SER and FEIS documents,[123] or reflected in witness testimony -- are ultimately subject to the same testing in the hearing as those of any other party, and are not given by virtue of their source any more importance than that of any other party.[124] But under the Commission's time-tested licensing and hearing processes, the Staff's evaluation of an applicant's proposal -- reached as it conducts its independent review of the application -- is considered an integral part of the record that is developed regarding any contentions challenging what an applicant has put forward.[125] Even though the Staff's position may not prevail at trial, it is presumed that the development and exploration of a contested issue will benefit from the Staff's analysis and presentation.

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[123] The NRC's basic rule is that the actual hearing of particular issues (as distinguished from prehearing pleadings and discovery matters related to those issues) is expected to await the Staff's preparation of, respectively, the Final SER (not just the Preliminary SER) and the Final Environmental Impact Statement (EIS) (not just the Draft EIS), or the functional equivalent of those documents. In other words, until the Staff is ready to present its final, complete analyses, a case is usually deemed not ready to move forward. Statement of Policy on Conduct of Adjudicatory Proceedings, CLI-98-12, 48 NRC 18, 20-21 (1998). Here (presumably because of the nature of the Applicant's presentations to it), the Staff had neither conducted nor provided any analysis on the issue in question.

[124] It has long been the rule that the Staff "does not occupy a favored position at hearings," in that Boards "must evaluate the staff's evidence and arguments in the light of the same principles which apply to the presentation of the other parties," for "the staff's views 'are in no way binding upon' the boards . . . [and] cannot be accepted without passing the same scrutiny as those of the other parties." Consolidated Edison Co. (Indian Point, Units No. 1, 2, and 3), ALAB-304, 3 NRC 1, 6 & n.15 (1976) (footnotes omitted) (quoting Southern California Edison Co. (San Onofre Units 2 and 3), ALAB-268, 1 NRC 383, 399 (1975)). See also Texas Utilities Generating Co. (Comanche Peak Steam Electric Station, Units 1 and 2), LBP-82-87, 16 NRC 1195, 1200 (1982), vacated on other grounds, CLI-83-30, 18 NRC 1164 (1983) (describing how the Board and the Staff have different roles in licensing hearings).

[125] While Staff review of a subject may thus be a prerequisite to the conduct of a hearing in ordinary circumstances, we do not mean to exclude totally the possibility that Staff review could be dispensed with in an unusual situation, even in a complex case. In some relatively simpler types of proceedings, the Staff conducts its review but, under NRC Rules, has the option (subject to Board approval) not to participate in any hearing that later takes place. See 10 C.F.R. §2.1213. Here, we were not faced with any such unusual situation, or presented any other reason to take up a subject of this magnitude without benefit of Staff analysis.

2. Additionally, a serious question existed in this instance about whether a comprehensive record on consequences could have been developed, based upon the prefiled testimony offered just before the hearing, that would have allowed us to make an informed decision. As we have just emphasized, the Staff put forward no proposed testimony on either penetration or consequences. The State's proposed testimony simply presented limited material on consequences to illustrate that the accident in question, if it occurred, was a matter significant enough to devote attention to. Nor was the Applicant's pre-filed testimony at all extensive. [126] Rather, the Applicant sought to present limited material on consequences simply to add conservatism to its incredibility calculations, i.e., to reassure the public and the decision-makers that not only was the accident so unlikely that it need not be guarded against, but that any lingering doubts in that regard could be safely disregarded because of the asserted lack of consequences.[127]

Having sufficient other reason to exclude the testimony, we were pointed in the same direction by the just-described paucity of it. As we listened to the April 8 oral arguments, it became clear that -- because of the pendency of the "probability" issue that could moot the need to consider "consequences" -- that latter matter had not been fully developed and certainly appeared not ripe for trial.[128] No party asked us to reconsider our ruling setting the issue aside.

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[126] The prefiled testimony had indicated that its coverage of the "cask penetration" subject was qualitative, not quantitative. See Cole/Jefferson/Fly Post Tr. 3061, at 111-12. In short, there has been throughout -- perhaps understandably -- a degree of vacillation in the Applicant's position, and a degree of ambiguity both in the purpose for which material was being put forward and in the conclusions being urged to be drawn from it. See fn. 117, 122.

[127] See Tr. at 2986-87 (Barnett); the excluded testimony of the Applicant's expert panel (Cole/Jefferson/Fly Post Tr. 3061 at Q&A 163-164); and the excluded testimony of Applicant's expert Jeffrey Johns (Johns Testimony).

[128] Given the time and resources that the Commission has devoted, in the wake of the events of September 11, 2001, to assessing the potential consequences of aircraft striking NRC-regulated facilities (see CLI-02-25, slip op. at 22), any further proceedings on this subject (whether in open or closed session) may well now benefit from much more detailed evidence than was proffered to us last year.

That was the situation on the eve of the evidentiary hearing in Salt Lake. That situation has now changed, with our ruling today indicating that -- in connection with the significant presence of F-16 military aircraft in Skull Valley airspace -- the Applicant has failed to demonstrate that its proposed facility will meet the applicable cumulative probability acceptance criterion regarding aircraft crashing at or affecting that facility. In light of that ruling, the door is now again open[129] -- at the Applicant's option -- for a "consequences" presentation,[130] which might include cask penetration and radiation dose issues. In that connection, at the appropriate juncture (see fn. __, above), the State will have the opportunity to continue to participate (see inquiry from State counsel, Tr. at 3007 (Soper)).[131]

The question remains as to how further consideration of this issue should proceed. On the one hand, given that all we have held thus far is that the Applicant's F-16 crash probability showing was inadequate to meet the Commission-endorsed acceptance criterion, it is clear that our decision does not foreclose the Applicant from eventually obtaining a license; further proceedings before us on the consequences issue may thus well be in the offing.

On the other hand, the Applicant may want to seek early Commission review of our decision on the probability issue. Certainly, the steps likely needed to make the necessary further showing on the consequences issue -- such as assembling a revised licensing presentation, undergoing staff review, and participating in possible prehearing and hearing proceedings before this Board -- will take some period of time. Thus, even if the Applicant

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[129] See p. 84, above.

[130] In light of what we have said earlier, we assume that presentation must first go to the Staff, in the form of an application amendment or in some other fashion, for review before re-entering the hearing process.

[131] Assuming the State is able to show, in a then-timely fashion, that it meets the procedural and substantive ground rules for such participation, hurdles with which it is thoroughly familiar.

believes it can prevail regarding a further consequences showing, it nonetheless may want to seek reversal of our decision that its showing on the aircraft crash probability issue fell short.

Conscious of the Commission's instructions that we should adopt case-management techniques that will help move licensing proceedings along as expeditiously as possible,[132] allowing the Applicant to proceed on parallel tracks before us and before the Commission -- rather than forcing it to proceed sequentially -- seems likely to best achieve that objective. Indeed, NRC precedent supports just such an approach.

Specifically, in the Byron reactor operating license proceeding, the Appeal Board was called upon to consider a Licensing Board decision concluding that, notwithstanding the possibility the applicant might be able to make a further showing that would support a license, the applicant's initial failure to make its case mandated a final decision denying the license. In reversing that decision, the Appeal Board indicated that the Licensing Board should have retained jurisdiction for the receipt of further evidence, without prejudice to the applicant seeking "discretionary appellate review of the [Licensing] Board's appraisal of the existing" record. Commonwealth Edison Co. (Byron Nuclear Power Station, Units 1 and 2), ALAB-770, 19 NRC 1163, 1169-70 (1984).[133]

In the situation before us, there may be some question about whether today's decision is now appealable as of right, since it may or may not be deemed to dispose finally of a

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[132] CLI-98-12, 48 NRC at 19-20.

[133] To be sure, the Appeal Board in Byron indicated it would likely not have taken on such discretionary review in the circumstances before it (an issue concerning the adequacy of the applicant's quality assurance plan). 19 NRC at 1170. In contrast, we think prompt review here is fully appropriate and we see nothing in Byron suggesting that there cannot here take place simultaneously (1) review by the Commission of the findings on probability underlying our refusal now to approve the license; and (2) consideration by us of a presentation on consequences. The final say here on whether there should be expedited discretionary appellate review of the decision and whether we should simultaneously retain jurisdiction for further trial proceedings, of course, rests with the Commission; we simply note that the Byron precedent would indicate there is no legal barrier to proceeding in that fashion.

"significant portion of the case."[134] Given the significance of our ruling here, and the fact it builds upon a previous Commission determination dealing with this subject, we perceive no reason to put upon the parties the burden of coming before us to debate whether we should refer our ruling to the Commission for its review (and, if we declined, of then asking the Commission to direct us to refer our ruling). Accordingly, pursuant to 10 C.F.R. § 2.730(f), we are referring today's ruling to the Commission for immediate review.[135] Of course, whether such review should indeed be undertaken is for the Commission to decide. 10 C.F.R. §2.786(g).

Although appellate proceedings ordinarily deprive a lower tribunal of jurisdiction over the substance of the matter that was before it, we perceive no fundamental inconsistency between (1) the Commission's conducting a referred review of the accident probability matters we have decided today, and (2) our simultaneously undertaking consideration of the matter of accident consequences (which we have explained is, as a practical if not a legal matter, a separate issue). Certainly, following such a course appears to be what the Appeal Board in Byron had in mind.

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[134] The applicable section of the rules, 10 C.F.R. § 2.760(a), allows for Commission review of partial initial decisions. NRC jurisprudence prior to the 1991 restatement of that rule suggests, however, that only partial initial decisions that dispose of a "major segment of the case" may be appealed immediately. More recently in this proceeding, the Commission declined an invitation to indicate whether it would adopt that principle, enunciated by the Appeal Board. See CLI-00-24, 52 NRC at 354 n.5. Although the Commission has the final word on the applicability of that test in this instance, today's decision on crash "probability" does appear to us to dispose of a major segment of the case (cf. Subpart A, above, first sentence); it certainly does so if the Applicant chooses not to make a presentation addressing consequences.

[135] Ordinarily, we would have given the State, the party prevailing before us, an opportunity to be heard on the immediate referral question before taking that step. But if there can ever be matters that are a foregone conclusion, this is one, and there thus seems little point in putting the State, and the other parties in response, to the effort of briefing that procedural issue. We recognize that in following this course we appear to be violating an important principle -- "audi alteram partem" ("hear the other side") -- we cited at an earlier stage of this proceeding. LBP-02-08, 55 NRC 171, 201. That salutary principle is intended to assure fairness to the parties, and to keep judges from making mistakes, but the circumstances before us appear to justify the risk of its non-observance here.

Accordingly, we will take that approach (unless the Commission directs us otherwise). To that end, we request that within twenty days of the issuance of this decision, the Applicant, the State (as the lead intervenor on the contention that is focal point of our ruling today), and the NRC Staff provide us with a report that outlines their views, either jointly or separately, as to how they wish to proceed on the matter of accident consequences relative to Skull Valley F-16 aircraft crashes.

II. DETAILED ANALYSIS OF RECORD AND FINDINGS OF FACT

In this Part of our decision, we provide the detail that underlies the reasoning expressed in the "Narrative" first part. This "Detailed" Part II contains three Subparts, each with its own Table of Contents. Each of the three Subparts is, however, constructed somewhat differently.

The first, Subpart A, beginning on page 94, simply presents the background and contextual matters that set the stage for the major issues covered in the second and third Subparts. Most of what It covers was essentially non-controversial.

As will be explained in the opening of Subpart B (see p. 117), which deals with the proposed "R" factor, most of that Subpart consists of a detailed analysis of the evidentiary record. We take that approach because our ultimate finding there (rejecting the Applicant's 95% "pilot avoidance" theory) is based less on disagreement with the individual factual threads the Applicant wove into its argument than with our determination -- based on our view of the impact of the State's countering evidence as a whole -- that the Applicant's proposals about the existence of the conditions necessary for success do not provide the appropriate framework for deciding the matter. Instead, we find in essence that those conditions are not sufficient for success, given the evidence of human error, under stress, leading to failure.

We take a more traditional approach in Subpart C (see p. 176). There, we do make the more customary "findings of fact" on the various disputed matters concerning the application of the four-factor formula not only as to the main issue -- the risk from F-16 flights down Skull Valley -- but also as to the other potential aircraft and ordnance hazards to the facility.

Beyond what is expressed in this Part II, we have carefully considered all of the other arguments, claims and proposed findings of the parties relative to the matters in dispute. To the extent those party positions are not specifically addressed herein, it is either because we find them immaterial, without merit, and/or unnecessary to this decision, or because they are subsumed in the rulings we do make.

A. Introduction and Summary

1. Procedural Background

A.1 In ruling initially on the admissibility of contentions, the Board was faced with several petitioners having presented similar issue statements. Accordingly, the Board prepared "Contention Utah K/Confederated Tribes B" to consolidate the elements of the separately-filed "credible accident" contentions. That new contention read:

> CONTENTION: The Applicant has inadequately considered credible accidents caused by external events and facilities affecting the ISFSI and the intermodal transfer site, including the cumulative effects of the nearby hazardous waste and military testing facilities in the vicinity and the effects of wildfires.

LBP-98-7, 47 NRC 142, 253, recons. granted in part and denied in part on other grounds, LBP-98-10, 47 NRC 288, aff'd on other grounds, CLI-98-13, 48 NRC 26 (1998).

A.2 As required by the Commission's rules in 10 C.F.R. § 2.714(b), several "bases" in support of the contention were submitted by the petitioners. In admitting the contention, however, the Board limited the contention's scope to the following matters: (1) the impact upon the facility from (a) accidents involving materials or activities at or originating from the Tekoi Rocket Engine Test Facility, the Salt Lake City International Airport, Dugway Proving Ground (including the Michael Army Airfield), Hill Air Force Base, and the Utah Test and Training Range; and (b) wildfires occurring in Skull Valley; and (2) the impact upon the Applicant's Rowley Junction Intermodal Transfer Point (ITP) of activities or materials from the aforementioned facilities, as well as hazardous materials from other facilities in the area. LBP-98-7, 47 NRC at 190-91, 214, 234-35, 247-48.[136]

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[136] As admitted in this proceeding, the contention also included a portion of a contention (Castle Rock 6 - Emergency Planning and Safety Analysis Deficiencies) submitted by former intervenors Castle Rock Land and Livestock, L.C. and Skull Valley Co., Ltd. (Castle Rock/Skull Valley) in the rewritten contention. See LBP-98-7, 47 NRC at 214, 247-48. This part was dismissed upon Castle Rock/Skull Valley's withdrawal from this proceeding in 1999. See LBP-99-6, 49 NRC 114, 120-21 (1999).

A.3 Following the Board rulings on admissibility of contentions, the parties proceeded with discovery on the remaining issues. On June 7, 1999, the Applicant filed a motion for partial summary disposition of Contention Utah K/Confederated Tribes B, arguing that there was no genuine dispute of fact as to those portions of the contention relating to hazards posed by Tekoi; wildfires; the testing and storage of biological, chemical and hazardous materials at Dugway; ordnance disposal and unexploded ordnance on Dugway; landings at Michael AAF of aircraft carrying "hung bombs;" and the X-33 experimental space plane.[137]

A.4 The Board granted in part, denied in part, and deferred in part the Applicant's Motion. See LBP-99-35, 50 NRC 180, recons. denied, LBP-99-39, 50 NRC 232 (1999). In light of its ruling, the Board then rewrote the contention to read:

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

LBP-99-39, 50 NRC at 240. In a subsequent ruling clarifying LBP-99-35, the Board dismissed those portions of contention Utah K/Confederated Tribes B relating to the ITP. LBP-99-39, 50 NRC at 236-38; see LBP-99-34, 50 NRC 168 (1999).

A.5 In 2001, pursuant to another Applicant summary disposition motion, the Board dismissed issues pertaining to ordnance usage at Dugway and cruise missile testing on the UTTR. LBP-01-19, 53 NRC at 422-29. As discussed below, in the same order the Board further defined the scope of the issues concerning hazards posed by aviation activities in and around Skull Valley and resolved specific issues concerning all the civilian aviation hazards and some of the military aviation hazards.

A.6 In analyzing aviation-related hazards, the Applicant prepared a comprehensive report on

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[137] See PFS Motion for Partial Summary Disposition of [Contention Utah K/Confederated Tribes B] at 2-18 (June 7, 1999).

the aviation activities in the vicinity of the site and the specific hazards each activity posed to the facility. See PFS Exh. N, Aircraft Crash Impact Hazard at the Private Fuel Storage Facility (Rev. 4) (Aug. 10, 2000) [hereinafter Aircraft Crash Report]. The report was prepared principally by Brigadier General James L. Cole, Jr., USAF (Ret.), Major General Wayne O. Jefferson, Jr., USAF (Ret.), and Colonel Ronald E. Fly, USAF (Ret.), who served as expert consultants to the Applicant on military and civilian aviation and who eventually testified as witnesses for the Applicant in this proceeding. Their analysis drew upon their broad experience and professional judgment, and incorporated extensive information obtained from the U.S. Air Force.

A.7 The report first assessed the scope of the military and civilian activities in the vicinity of the Applicant's site. It then assessed the aviation traffic associated with each activity and calculated the crash impact probability at the facility for each activity. In calculating the crash impact probabilities, the report determined specific crash rates for each type of aviation activity and accounted for the specific locations and volume of aviation traffic relative to the Applicant's site.

A.8 In assessing the hazard posed by potential F-16 crashes, the report assessed in depth the ability of a pilot to direct a crashing aircraft away from the facility before it struck the ground. That assessment was based on (1) analysis by General Cole, General Jefferson, and Colonel Fly of all of the available Air Force aircraft accident reports concerning F-16 crashes over the ten-year period from Fiscal Year (FY) 1989 to FY 98 and (2) their professional judgment regarding the ability of F-16 pilots to respond to in-flight emergencies. In the end, the report assessed the cumulative hazard to the proposed facility and concluded that the crash and jettisoned ordnance impact probability was less than 4.17×10^{-7} per year.

A.9 That report, as amended, played a principal role when the remaining issues were litigated in a hearing which began on April 9, 2002 and continued intermittently (along with other unrelated contentions) through July 3, 2002. These issues -- all tied to the “inadequate consideration of credible accidents” contention -- included: (1) F-16s transiting Skull Valley, including the problems of both aircraft crashes and jettisoned ordnance; (2) aircraft flying on the Moser Recovery Route (MRR); (3) aircraft flying to and from Michael Army Airfield (MAAF) on the flight path designated as IR-420; (4) aircraft conducting air-to air combat training on the UTTR; (5) impact from jettisoned ordnance; and (6) the cumulative hazard to the Applicant’s facility from aircraft accidents and ordnance.

A.10 In accordance with timelines we established, the parties submitted pre-filed testimony, presented other evidence relevant to their respective positions, and filed extensive post-hearing briefs. Our findings of fact and conclusions of law regarding the credible accidents contention are based upon our review and analysis of all those materials.

2. Legal Standards

A.11 The Commission has established criteria for evaluating those characteristics of a proposed site that may directly affect the safety of an ISFSI to be located there. As set forth in 10 C.F.R. Part 72, Subpart E, §§ 72.90, 72.94, and 72.98, proposed sites must be examined with respect to, among other things, the frequency and severity of naturally-occurring and man-induced external events that could affect the facility’s safe operation, and the existence of man-made facilities and activities that might endanger the proposed facility or affect the facility design.

A.12 The regulations further provide that “design basis” external events must be determined with respect to a proposed facility’s site and design. 10 C.F.R. § 72.90(c). Design bases are defined, in 10 C.F.R. § 72.3, in pertinent part, as follows:

§ 72.3 Definitions

> . . . .
>
> Design bases means that information that identifies the specific functions to be performed by a structure, system, or component of a facility or of a spent fuel storage cask and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be restraints derived from generally accepted state-of-the-art practices for achieving functional goals or requirements derived from analysis (based on calculation or experiments) of the effects of a postulated event under which a structure, system, or component must meet its functional goals. The values for controlling parameters for external events include - -
>
> . . . .
>
> (2) Estimates of severe external man-induced events to be used for deriving design bases that will be based on analysis of human activity in the region, taking into account the site characteristics and the risks associated with the event.

A.13 In accordance with 10 C.F.R. § 72.24, an application for an ISFSI under Part 72 must include a Safety Analysis Report (SAR) describing the proposed facility, which must contain, among other things, "[a] description and safety assessment of the site on which the ISFSI . . . is to be located, with appropriate attention to the design bases for external events," 10 C.F.R. § 72.24(a) as well as information concerning the facility's design, including identification of the design criteria, design bases, and "the relation of the design bases to the design criteria." 10 C.F.R. § 72.24(c)(2). Further, the design and performance of structures, systems and components (SSCs) important to safety must be analyzed for those events that are considered to be within the design for the facility, including consideration of "[t]he adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents, including . . . manmade phenomena and events." 10 C.F.R. § 72.24(d)(2).

A.14 The Commission has established "General Design Criteria" for an ISFSI, as set forth in 10 C.F.R. Part 72, Subpart F. Pursuant to 10 C.F.R. § 72.120(a), an application to store spent fuel in an ISFSI "must include the design criteria for the proposed storage installation," which "establish the design, fabrication, construction, testing, maintenance and performance requirements for structures, systems, and components important to safety as defined in § 72.3."

A.15 Minimum requirements for an ISFSI's design criteria include, among other things, "[p]rotection against environmental conditions and natural phenomena," 10 C.F.R. § 72.122(b), whereby SSCs "must be designed to accommodate the effects of, and to be compatible with, site characteristics and environmental conditions associated with normal operation, maintenance, and testing of the ISFSI . . . and to withstand postulated accidents," 10 C.F.R. § 72.122(b)(1). Events that do not constitute credible accidents need not be included within the design bases of the facility. See CLI-01-22, 54 NRC at 259. As noted above, the Commission specifically approved the use of a 1×10^{-6} annual probability of occurrence standard for design basis accidents for away-from-reactor ISFSIs. CLI-01-22, 54 NRC at 263.

A.16 In practice, only the annual probability of occurrence of an aircraft crash is calculated, as if a conservative assumption was made that the crash would cause the Part 100 guidelines to be exceeded. Campe/Ghosh Post Tr. 4078, at 6. In other words, the Staff proceeds initially as if the probability of exceedance is 1. Id.

3. Testimony Presented

A.17 Prefiled written testimony concerning Contention Utah K/Confederated Tribes B was submitted by the Applicant, the NRC Staff, and the State of Utah. The Applicant's witnesses appeared first, followed by the Staff's witnesses, with the State's witnesses testifying last.

A.18 The Applicant submitted three sets of prefiled testimony, which consisted of the testimony of a total of five witnesses. The witnesses presented in the Applicant's first set of prefiled testimony were: (1) Wayne O. Jefferson, Jr., a retired U.S. Air Force Major General, who assisted the Applicant with the quantitative calculations and modeling the Applicant performed concerning the probability that a crashing aircraft would impact the facility as well as with the review of relevant F-16 accident reports; (2) James L. Cole, Jr., a retired U.S. Air Force Brigadier General, who assisted the Applicant with the assessment of the aircraft crash hazard to the facility, and whose primary focus pertained to overall aviation safety, general Air Force issues, and certain F-16 operations; and (3) Ronald E. Fly, a retired U.S. Air Force Colonel, who assisted the Applicant in its assessment of the risk to the facility posed by aircraft crashes and ordnance impacts, and whose primary focus was F-16 operations, F-16 emergency procedures, and flight operations in and around the UTTR. "Testimony of James L. Cole, Jr., Wayne O. Jefferson, Jr., and Ronald E. Fly on Aircraft Crash Hazards at the Facility - Contention Utah K/Confederated Tribes B" [hereinafter Cole/Jefferson/Fly] Post Tr. 3061, at 1-7.

A.19 Applicant witness Wayne Jefferson retired from the Air Force in 1989 with the rank of Major General. He served in the Air Force for over 30 years and has accumulated 4,450 flying hours in nine different types of aircraft. General Jefferson served as a B-52 wing commander with the Strategic Air Command and has held other positions of responsibility with the Strategic Air Command. For example, in 1983-84, he was Assistant Deputy Chief of Staff for Operations, overseeing the entire scope of the Strategic Air Command's worldwide bomber, tanker, missile and reconnaissance operations, including training range development and flight operations. In addition, General Jefferson has been formally trained by the Air Force to serve as an Accident Board president including management of the investigating team, preservation of the crash site, working with law enforcement officials, and interviewing participants and witnesses.

A.20 Since retiring from the Air Force, General Jefferson has been a consultant in management, management training and quantitative probabilistic analysis. He holds a master's degree in operations research from Stanford University and a master's degree in business administration from Auburn University. Cole/Jefferson/Fly Post Tr. 3061, at 4-5; Jefferson Qualifications at 1.

A.21 General Jefferson has never flown an F-16 fighter aircraft, has never flown through Skull Valley, and has never ejected from any aircraft. Tr. at 3189, 3216 (Jefferson). General Jefferson performed all crash probability calculations for the Applicant. Tr. at 3187 (Cole), 3189 (Jefferson). General Jefferson has no prior experience using NRC guidance document NUREG-0800 nor prior experience in using the DOE Standard for aircraft crash analysis DOE-STD-3014-96. Tr. at 3193, 3699 (Jefferson).

A.22 We find General Jefferson to be qualified as an expert witness on the subjects of U.S. Air Force aircraft operations, weapons testing and training operations, and probabilistic analysis.

A.23 Applicant witness James Cole retired from the Air Force in 1994 with the rank of Brigadier General. Over his career, he accumulated 6,500 total flying hours in seven different types of aircraft, with 3,000 flying hours in heavy jet aircraft. General Cole served as Chief of Safety of the U. S. Air Force from 1991 to 1994 and in that capacity directed the entire Air Force safety program. He was responsible for accident prevention and investigation in all aspects of ground and air operations and personally reviewed and approved every Air Force Accident Safety Investigation report for all types of aircraft. General Cole was also commander of the 89th Airlift Wing, where he directed air transportation for the President of the United States and other senior government officials and foreign dignitaries. He has served as a pilot flight commander, chief pilot, assistant operations officer, operations officer and squadron commander of a C-141 heavy jet transport squadron. General Cole flew airdrop missions, special operations low level missions, night vision goggle missions, including clandestine approaches to airfields and blackout landings. Cole/Jefferson/Fly Post Tr. 3061, at 1-2; Cole Qualifications at 1-2.

A.24 General Cole has never flown in an F-16 fighter aircraft, has never flown through Skull Valley, and has never ejected from any aircraft. Tr. at 3142, 3158-3160 (Cole). General Cole has not previously done a crash impact evaluation or performed a study on the issue of whether a F-16 pilot would be able to avoid a ground site. Tr. at 3156, 3157 (Cole).

A.25 We find General Cole qualified as an expert witness on the subjects of military aircraft operations and aviation safety matters.

A.26 Colonel Fly, who has piloted but never ejected from an F-16, retired from the Air Force in 1998. Cole/Jefferson/Fly Post Tr. 3061, at 6; Tr. at 3125, 3217 (Fly). He served in the Air Force for 24 years as an F-16 pilot, instructor, fighter squadron commander, operations group commander, and wing commander. Cole/Jefferson/Fly Post Tr. 3061, at 1-2. Colonel Fly has approximately 1,200 flying hours in the F-16 as a pilot and instructor. Colonel Fly served as Commander of the 388th Fighter Wing at Hill AFB from 1997-1998 and has flown F-16s on the UTTR and through Skull Valley. Cole/Jefferson/Fly Post Tr. 3061, at 1-2. He was also Commander of the UTTR when the range was transferred to the 388th Fighter Wing in 1997. Cole/Jefferson/Fly Post Tr. 3061, at 1-2. Colonel Fly routinely reviewed accident reports as a pilot and has experience in strategic planning, operational analysis, international affairs, space operations, and logistical support. Cole/Jefferson/Fly Post Tr. 3061, at 1-2. He is specifically knowledgeable about the operations of military and civilian aircraft that fly in and around Skull Valley, Utah, including military aircraft that fly from Hill AFB and on the UTTR. Cole/Jefferson/Fly Post Tr. 3061, at 6; Fly Qualifications at 1-2.

A.27 We find Colonel Fly to be qualified as an expert witness on the subjects of U.S. Air Force F-16 aircraft operations and training operations, including operations at Hill AFB.

A.28 The Applicant also presented prefiled testimony of two other individuals. They were: (1) Stephen A. Vigeant, a Certified Consulting Meteorologist employed as a Lead Environmental Scientist by Stone & Webster, Inc., who obtained and evaluated information regarding the weather in the region of the Applicant's facility to support an analysis of the impact of weather on aviation activities in the region; and (2) Jeffrey R. Johns, a Licensing Engineer employed by Stone & Webster, Inc., who was responsible for the preparation of the Applicant's Safety Analysis Report pertaining to accident analyses and radiation protection for the proposed facility. "Testimony of Stephen A. Vigeant on Aircraft Crash Hazards at the PFSF - Contention Utah K/Confederated Tribes B" [hereinafter Vigeant], Post Tr. 3090, at 1-2; "Testimony of Jeffrey Johns on Aircraft Crash Hazards at the PFSF - Contention Utah K/Confederated Tribes B" [hereinafter Johns]; Post Tr. 3205, at 1-2. By stipulation of the parties, Mr. Johns' testimony was accepted into evidence without cross-examination. Tr. 3204-07 (Johns).

A.29 Applicant witness Stephen Vigeant received a Bachelor of Science degree from Lowell Technological Institute in meteorology and a Master's degree in meteorology from Pennsylvania State University. Vigeant Post Tr. 3090, at 1; Vigeant Qualifications at 2. Mr. Vigeant has been involved in meteorological aspects of nuclear power plant licensing and environmental impact assessment and licensing for more than 20 years. He has provided consulting services in the areas of climatological analyses, meteorological monitoring, meteorological field studies, and design basis meteorological investigations. Vigeant Qualifications at 1. However, he is not a pilot, has not flown through Skull Valley, and has not studied the extent to which a pilot can see under various cloud conditions and altitudes. He provided only meteorological data. Tr. at 4047-50 (Vigeant).

A.30 We find Mr. Vigeant to be qualified as an expert witness on the subject of meteorology.

A.31 Applicant witness Jeffrey Johns received a Bachelor of Science degree from Stanford University in Biological Sciences. Johns Qualifications at 2. Mr. Johns has over 20 years of experience in the nuclear power industry and ten years of experience with the licensing of ISFSIs. Johns Post Tr. 3205, at 1; Johns Qualifications at 1. He has experience in accident analyses for ISFSIs and was responsible for preparation of portions of the Applicant's Safety Analysis Report. Johns Post Tr. 3205, at 1-2. As a Licensing Engineer for the PFS project, Mr. Johns is familiar with the shielding design provisions of the HI-STORM 100 storage system, confinement design provisions of the canister, and the protection afforded the canister by the HI-STORM 100 storage overpack from postulated events such as tornado-driven missiles and explosions. Johns Post Tr. 3205, at 1.

A.32 We find Mr. Johns to be qualified as an expert witness on the subject of the susceptibility of the Applicant's facility design to overpressure produced by an explosion.

A.33 In addition to the above witnesses who pre-filed their testimony, the Applicant presented Michael Cosby, who testified individually by telephone regarding his experience as a pilot who had ejected from an F-16. Tr. at 3977-4031 (Cosby). Michael Cosby is an active-duty Colonel in the U.S. Air Force and is presently stationed with the 177th Fighter Wing in Atlantic City, New Jersey. Colonel Cosby is the operations group commander for the Fighter Wing and has been in that position for three years. Tr. at 3985 (Cosby). He has over 2,500 flight hours in the F-16, with a total of 8,900 flight hours in various aircraft. Tr. at 3986 (Cosby). Colonel Cosby has been an F-16 pilot during his entire career in the Air Force and has served as a functional check flight pilot, a four-ship flight lead, and an instructor pilot. Tr. at 3982, 3984, 3985 (Cosby). He flew 78 combat missions during Desert Storm and flew over 308 combat sorties during Operation Northern Watch and Operation Southern Watch. Tr. at 3984 (Cosby). Colonel Cosby ejected from an F-16 on April 21, 1993. Tr. at 3978-82 (Cosby).

A.34 We find Colonel Cosby to be qualified as an expert witness on F-16 operations, including ejection therefrom.

A.35 The Staff presented a panel of two witnesses concerning this contention. They were: (1) Kazimieras M. Campe, a Senior Reactor Engineer in the Probabilistic Safety Assessment Branch, Division of Systems Safety and Analysis, NRC Office of Nuclear Reactor Regulation, who reviewed the Applicant's Safety Analysis Report (SAR) pertaining to external hazards and participated in the Staff's preparation of the SER; and (2) Amitava Ghosh, a Principal Engineer at the Center for Nuclear Waste Regulatory Analyses, a Federally-funded research and development center, which is a division of Southwest Research Institute, in San Antonio, Texas. "NRC Staff Testimony of Kazimieras M. Campe and Amitava Ghosh Concerning Contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents)" [hereinafter Campe/Ghosh], Post Tr. 4078, at 1-3; see Staff Exh. C [hereinafter SER]. Dr. Ghosh also reviewed the Applicant's SAR pertaining to external hazards and participated in the preparation of the Staff's SER. Campe/Ghosh Post Tr. 4078, at 1-3; see SER.

A.36 Staff witness Kazimieras Campe has 30 years experience in the NRC (and its predecessor, the Atomic Energy Commission) assessing the risk posed by external man-made hazards with respect to nuclear facilities. Campe/Ghosh Post Tr. 4078, at 1; Campe Qualifications at 1. "As far as looking at the issue of aircraft hazards, along with all other site related hazards," he has "looked at almost every plant in the country." Tr. at 4090; see Tr. at 4122 (Campe).

A.37 Dr. Campe was the principal contributor to the document referred to as NUREG-0800 which contains Section 3.5.1.6, "Aircraft Hazards," of the NRC's Standard Review Plan. That document is utilized by the Staff in evaluating aircraft crash hazards at nuclear power reactors and other facilities. Campe/Ghosh Post Tr. 4078, at 6. He currently conducts safety reviews of risks posed to nuclear facilities by external man-made hazards, such as aircraft activity, as well as risks posed to other modes of transportation (e.g., railroads, highways, navigable waterways, and pipelines). Campe/Ghosh Post Tr. 4078, at 1-2; Campe Qualifications at 1-2. Dr. Campe, however, has no pilot experience. Tr. at 4116 (Campe).

A.38 We find Dr. Campe to be qualified as an expert witness on the subject of the assessment of risk associated with aircraft activity.

A.39 The second Staff witness, Amitava Ghosh, has over 20 years of experience in conducting both academic and industrial research, consulting, and teaching in mining, geological, and geotechnical engineering. Campe/Ghosh Post Tr. 4078, at 2; Ghosh Qualifications at 1. Dr. Ghosh has experience with respect to probabilistic risk assessments and the design of surface and subsurface facilities. Campe/Ghosh Post Tr. 4078, at 2; Ghosh Qualifications at 1. Dr. Ghosh is currently the technical lead for preclosure activities of the proposed high-level nuclear waste repository at Yucca Mountain and is currently involved with probabilistic risk assessment, identification of hazards and initiating events, and repository design. Campe/Ghosh Post Tr. 4078, at 2; Ghosh Qualifications at 1. Like Dr. Kampe, Dr. Ghosh has no pilot experience. Tr. at 4116 (Ghosh).

A.40 We find Dr. Ghosh to be qualified as an expert witness on the subject of the assessment of risk and the identification and analysis of hazards posed to nuclear waste facilities.

A.41 In support of its contention, the State presented initially the prefiled testimony of two witnesses. They were: (1) Hugh Horstman, a retired U.S. Air Force Lieutenant Colonel, who has been assisting the State with respect to this contention since 2000; and (2) Marvin Resnikoff, a Senior Associate at Radioactive Waste Management Associates in New York, who performed calculations on behalf of the State regarding the probability and consequences of aircraft crashes at the Applicant's proposed facility. "State of Utah's Prefiled Testimony of Lieutenant Colonel Hugh Horstman (U.S.A.F. Retired) Regarding Contention Utah K/Confederated Tribes B" [hereinafter "Horstman"], Post Tr. 4214, at 1-2; "State of Utah's Prefiled Testimony of Dr. Marvin Resnikoff Regarding Contention Utah K/Confederated Tribes B" [hereinafter "Resnikoff"], Post Tr. 8698, at 1, 4.

A.42 Lt. Colonel Horstman has more than 20 years experience as a pilot in the U.S. Air Force, including over 2,500 hours as a pilot and over 1,000 hours as a navigator. Horstman Post Tr. 4214, at 1-2. He has flown over 1,800 hours as an F-16 and F-111 fighter pilot. Horstman Post Tr. 4214, at 1-2. He was also an instructor pilot for both the F-16 and F-111 fighter aircraft as well as an instructor navigator. Horstman Post Tr. 4214 at 1-2.

A.43 From October 1997 through June 1999, Lt. Colonel Horstman was the Deputy Commander of the 388th Operations Group at Utah's Hill Air Force Base. Horstman Post Tr. 4214, at 1. In this position, he commanded the F-16 Operations Group and 1,500 personnel. Horstman Post Tr. 4214, at 1. The Operations Group was responsible for the administration of all 388th Fighter Wing flying activity, including the sorties flown in the Utah Test and Training Range airspace. Horstman Post Tr. 4214, at 1. The Operations Group was also responsible for managing the UTTR air space and for managing the three fighter squadrons stationed at Hill Air Force Base. Horstman Post Tr. 4214, at 1. In addition, Lt. Colonel Horstman was responsible for the flight line maintenance of all F-16C aircraft assigned to the 388th Fighter Wing. Horstman Post Tr. 4214, at 1.

A.44 Lt. Colonel Horstman has flown over 150 training missions in the UTTR including air-to-air combat missions, air-to-ground combat missions (e.g., precision ordnance bombing), low level training missions, targeting pod, and night vision goggle missions. Horstman Post Tr. 4214, at 2. While stationed at Hill AFB he was responsible for planning training missions and instructing F-16 pilots. Horstman Post Tr. 4214, at 2. He flew F-16 training missions as an instructor pilot, as a flight lead, and as a mission commander. Horstman Post Tr. 4214, at 2. In those capacities he was responsible for assessing individual pilot performance on various tasks, including emergency procedures. Horstman Post Tr. 4214, at 2. Lt. Colonel Horstman is intimately familiar with the UTTR land and air space, including the military operating areas over the area of the Applicant's proposed site. Horstman Post Tr. 4214, at 2. He was not trained to serve on accident investigation boards, having served only once briefly as interim board president. PFS Aircraft Findings at 8; Tr. at 8496-97 (Horstman).

A.45 Lt. Colonel Horstman retired from the Air Force in 1999. Horstman Post Tr. 4214, at 1. Lt. Colonel Horstman continues to fly as a commercial pilot of Boeing 737 jets for Southwest Airlines. Horstman Post Tr. 4214, at 1.

A.46 We find Lt. Colonel Horstman to be qualified as an expert on the subjects of F-16 aircraft and training operations, including those occurring at Hill AFB and in the UTTR. We have considered the Applicant's challenge to his credibility, based on the changing positions Lt. Colonel Horstman took on the Applicant's multi-level categorization of the accident reports. We find the confusion to have been understandable in light of the manner in which the material was presented, and do not find that, or any other reason, sufficient to cast general doubt on Lt. Colonel Horstman's credibility.

A.47 State witness Dr. Marvin Resnikoff is the Senior Associate of Radioactive Waste Management Associates ("RWMA"), a private technical consulting firm based in New York City. Resnikoff Post Tr. 8698, at 2. He holds a doctoral degree in high-energy theoretical physics from the University of Michigan. Resnikoff Post Tr. 8698, at 2. Dr. Resnikoff has done research on radioactive waste issues for the past 27 years and has extensive experience and training in the field of nuclear waste management, storage, and disposal. Resnikoff Post Tr. 8698, at 2.

A.48 Dr. Resnikoff has done research on technical issues related to the storage of radioactive waste, including spent nuclear power plant fuel, and is familiar with spent fuel storage systems that are now in use or proposed for future use in the United States. Resnikoff Post Tr. 8698, at 2. Dr. Resnikoff's experience includes technical review and analysis of numerous dry cask storage designs. Resnikoff Post Tr. 8698, at 2. Dr. Resnikoff has estimated the probability of accidents regarding air, train and truck accident rates for the States of New York, Nevada and Utah. Resnikoff Post Tr. 8698, at 3.

A.49 Dr. Resnikoff stated that he has no independent expertise concerning hazards posed by aviation activities to facilities on the ground. PFS Findings at 9; Tr. at 8719-20 (Resnikoff). He has no background in aeronautical engineering or in analyzing the performance of military aircraft. Tr. at 8717-18 (Resnikoff). Prior to this case, he has not calculated the probability of an aircraft impacting a particular site on the ground. PFS Aircraft Findings at 9; Tr. at 8719-20 (Resnikoff). Likewise, prior to this case, he has not performed studies or work pertaining to the probability of impacts of external events to facilities. Tr. at 8806 (Resnikoff).

A.50 With respect to Dr. Resnikoff's expertise in the field of probability and statistics, he has not had formal training in statistics, although he considers himself a self-taught statistician and has applied elementary statistics in past assignments. Tr. at 8817 (Resnikoff).

A.51 We consider Dr. Resnikoff to be qualified to testify as an expert with respect to the calculations he performed using the NUREG-0800 equation to derive the probability of aircraft crashes at the Applicant's proposed facility and in the general techniques of mathematical analysis.

A.52 The testimony of Colonel Frank Bernard, USAF (Ret.), was also sponsored by the State of Utah. Tr. at 3880 (Bernard). Colonel Bernard's testimony, like that of Colonel Cosby, was not prefiled but was presented in person and was submitted in response to the Board's inquiry as to conflicting testimony regarding pilot ejections.

A.53 Colonel Bernard served in the Air Force from 1967-1972, as well as in the Air Force Reserve from 1972 until 1993. Tr. at 3881 (Bernard). During this time, he accumulated approximately 1200 flight hours in the F-16 and approximately 3500 total aircraft flight hours. Tr. at 3881-82 (Bernard). Colonel Bernard has flown the F-105, the D-29, the D-39, and the F-16. Tr. at 3881 (Bernard). He ejected from an aircraft twice in his career: (1) from an F-105 aircraft that had been damaged in a 1969 mid-air collision in Southeast Asia, and (2) from an F-16 that suffered an engine failure during a military exercise in Canada in 1986. Tr. at 3882-83, 3888-89 (Bernard). Colonel Bernard is also familiar with Hill AFB because he was stationed there from 1973 until his retirement. Tr. at 3881 (Bernard).

A.54 We find Colonel Bernard to be qualified in the area of F-16 operations, including the ejection experience.

4. Aircraft Operations in Skull Valley

A.55 The Board had before it a comprehensive report on the potential hazards posed to the facility by military aircraft and jettisoned ordnance. The report was submitted as PFS Exhibit N, Aircraft Crash Impact Hazard at the Private Fuel Storage Facility," Revision 4 (Aug. 10, 2000) [hereinafter Aircraft Crash Report], and PFS Exhibit O, the Revised Addendum to the Aircraft Crash Report [hereinafter Revised Addendum]. The Revised Addendum also contains the Applicant's responses to a series of Requests for Additional Information (RAIs) from the NRC Staff regarding aircraft crash hazards. The report and its addendum were principally prepared by the Applicant's expert witnesses on aviation hazards, Brigadier General James L. Cole, Jr., USAF (Ret.), Major General Wayne O. Jefferson, Jr., USAF (Ret.), Colonel Ronald E. Fly, USAF (Ret.).

A.56 Aviation activity in the vicinity of the Applicant's site consists of, in addition to civilian commercial and general aviation, military operations associated with the Utah Test and Training Range, an important training range operated by the Department of Defense. See LBP-01-19, 53 NRC at 432; State Exh. 41 [hereinafter UTTR Capabilities Guide]; Horstman Post Tr. 4214, at 4-5. This range, and the associated air space which is even larger than the ground footprint, are used for aircrew training and weapons testing. State Exh. 41. UTTR Capabilities Guide; Horstman Post Tr. 4214, at 4-5. Missions on the UTTR include air-to-air and air-to-ground combat training, both day and night as well as low and high altitude. UTTR Capabilities Guide; Horstman Post Tr. 4214, at 4-5.

A.57 The airspace over the UTTR extends somewhat beyond the range's land boundaries and is divided into restricted areas, in which the airspace is limited to military operations, and military operating areas (MOAs), which are located on the edges of the range, adjacent to the restricted areas. Horstman Post Tr. 4214, at 4-5. The Applicant's site lies within the Sevier B MOA, two miles to the East of the edge of the UTTR restricted airspace, and 18 miles east of the eastern UTTR land boundary. Horstman Post Tr. 4214, at 4-5.

A.58 The airspace directly above the proposed Applicant's site, extending from 100 feet to 5,000 feet above ground level, is within Sevier B MOA. Horstman Post Tr. 4214, at 4-5. The location of Sevier B MOA relative to the Applicant's site is shown on State Exh. 186. Sevier B is part of the UTTR air space and various portions of it are used for military low altitude training, air-to-air combat training, major exercises, and cruise missile testing. Horstman Post Tr. 4214, at 4-5.

A.59 The air space directly above the Applicant's site also contains an MOA known as Sevier D, extending from 5,000 feet to 13,750 feet above the ground. Horstman Post Tr. 4214, at 5. Sevier D is also part of the UTTR air space and major exercises as well as cruise missile testing are authorized in various portions of this MOA. Horstman Post Tr. 4214, at 5.

A.60 Military air operations posing a potential risk to the Skull Valley facility include (1) Air Force F-16 fighter aircraft transiting Skull Valley from Hill Air Force Base to the UTTR South Area; (2) F-16s from Hill AFB returning from the UTTR South Area to the base via the Moser Recovery Route, which runs to the northeast, 2 to 3 miles north of the Applicant's site; (3) military aircraft, comprised mainly of large transport aircraft, flying on military airway IR-420 to and from Michael AAF, which is located on Dugway about 17 miles southeast of the Applicant's site; (4) F-16s from Hill and various other military aircraft conducting training exercises on the UTTR; and (5) jettisoned ordnance from aircraft flying over Skull Valley. LBP-01-19, 53 NRC at 432.

A.61 Civilian aircraft also will be flying in the general area of the Applicant's site, including: (1) aircraft flying on Federal Airway J-56, which runs east-northeast to west-southwest about 12 miles north of the Applicant's site; (2) aircraft flying on Airway V-257, which runs north to south approximately 20 miles east of the site; and (3) other minimal general aviation activity, which has not been reported but nonetheless could occur in the area. We have previously ruled on the extent of the minimal hazard to the facility posed by commercial and general aviation. LBP-01-19, 53 NRC at 449-52. The cumulative potential hazard to the facility is calculated from the sum of the probabilities of hazards from both civilian aviation and military activity. LBP-01-19, 53 NRC at 452-54.

A.62 During recent years, F-16 fighter aircraft stationed at Hill Air Force Base have regularly transited Skull Valley in a southerly direction through Sevier B and Sevier D MOAs en route to the UTTR South Area range. Horstman Post Tr. 4214, at 6-8; Tr. at 3455 (Jefferson). Most of the flights through Skull Valley are in Sevier B MOA, and are concentrated in a corridor in the vicinity of the proposed Applicant's site. Horstman Post Tr. 4214, at 6-8; Tr. at 3455 (Jefferson). These F-16s conduct low altitude training, perform G(ravity) awareness turns, practice terrain masking (radar avoidance) and engage in other training maneuvers while transiting Skull Valley. Horstman Post Tr. 4214, at 8-9.

A.63 The military activity in the Sevier B and Sevier D MOA airspace varies from year to year. The number and type of missions flown as well as the number and type of bombs and other ordnance carried depend on Air Force tactics and training needs, national policy, budgets and the state of world conflict. Horstman Post Tr. 4214, at 5; Tr. at 3352-55, 3494 (Jefferson). It is difficult to anticipate changes in the level of military training in the UTTR and MOAs. The F-16 fighter has been flying for over 27 years and is scheduled to be replaced by year 2010. Tr. at 3367 (Jefferson); 3372 (Cole). The Board has before it no definitive evidence as to the nature of future Skull Valley training missions or weapon systems after the F-16 is retired.

A.64 The Applicant received information from Hill AFB indicating that F-16 fighter aircraft transiting Skull Valley en route from Hill AFB to the UTTR South Area typically pass to the east of the facility's site. Cole/Jefferson/Fly Post Tr. at 3061, at 14; Campe/Ghosh Post Tr. 4078, at 9; Tr. at 3397-98, 3402-04 (Cole); see Tr. at 3422-24 (Fly). The F-16s typically fly through the Sevier B MOA, between 3,000 and 4,000 feet above ground level (AGL), with a minimum altitude of 1,000 feet AGL.[138] Cole/Jefferson/Fly Post Tr. 3061, at 14; Campe/Ghosh Post Tr.

[138] On August 13, 2002, the Staff notified us that the Air Force had lowered from 1000 feet to 100 feet above ground level the minimum altitude for flights in Sevier B MOA at the location of the Applicant's site. The Applicant's Aircraft Crash Report relied on the previous minimum altitude of 1,000 feet AGL over the facility's site. Aircraft Crash Impact Hazard at the Private Fuel Storage Facility (Aug. 10, 2000) ("Aircraft Crash Report") (PFS Exh. N) at 6. No party sought to reopen the record or to have us take any other action exploring the significance, if any, of this development. See also Staff letter of December 19, 2002, and its enclosures..

4078, at 9; Tr. at 3396-97, 3404 (Cole), 4356-57, 4369 (Horstman). A few aircraft fly higher, through Sevier D MOA, between approximately 5,000 feet AGL and 14,000 feet AGL. Cole/Jefferson/Fly Post Tr. 3061, at 14. It is unusual for aircraft to fly through Skull Valley at altitudes above 14,000 feet AGL (18,000 feet mean sea level). Tr. at 4372-73 (Horstman). Aircraft fly through Skull Valley at approximately 350 to 400 knots indicated airspeed (KIAS). Cole/Jefferson/Fly Post Tr. 3061, at 14.

A.65 The Applicant asserts that in FY 99 and 00, an average of approximately 5,000 F-16 flights transited Skull Valley per year. Cole/Jefferson/Fly Post Tr. 3061, at 14 & n.10; Campe/Ghosh Post Tr. 4078, at 10. Because 12 F-16s were added to the 69 aircraft stationed at Hill AFB in the third quarter of FY 01, the Applicant estimated through extrapolation that approximately 5,870 flights per year will transit Skull Valley during the life of the facility. Cole/Jefferson/Fly Post Tr. 3061, at 20-21. This estimate was made by increasing the 5,000 annual flights by 17.4% to account for the additional F-16s. Cole/Jefferson/Fly Post Tr. 3061, at 16, 20-21. The Applicant's witnesses asserted that the continuing modernization and increased technological capability of newer military aircraft will likely result in fewer aircraft and a reduction in annual sorties over the life of the facility. Cole/Jefferson/Fly Post Tr. 3061, at 22-23.

A.66 F-16s use the airspace above Skull Valley primarily as a transition corridor to the UTTR. Cole/Jefferson/Fly Post Tr. 3061, at 15; Campe/Ghosh, Post Tr. 4078, at 11. Typically F-16s will start a descent after turning south from over the Great Salt Lake and descend below 5,000 feet AGL before entering the Sevier B MOA. Cole/Jefferson/Fly Post Tr. 3061, at 15; Campe/Ghosh Post Tr. 4078, at 11. They typically fly in pairs that spread out in a tactical formation which may be one to two miles across. Cole/Jefferson/Fly Post Tr. 3061, at 15; Campe/Ghosh Post Tr. 4078, at 11. The typical maneuvers that F-16s may undertake while transiting Skull Valley are part of what is referred to as the "normal phase" of flight in that it consists of activities like operations checks (to see if the aircraft is functioning properly), G-awareness turns (to ensure that the pilots' flight suits are functioning properly and to prepare the pilots to take higher G-forces in more aggressive maneuvering on the range (Aircraft Crash Report, Tab FF at 16-17; Tr. at 3523-24, 13,030 (Fly), 13,032 (Cole)), and "fence checks" (to simulate flying from friendly airspace into enemy airspace). Aircraft Crash Report, Tab E at 3; Tr. at 3522-24 (Fly). Air-to-air combat training does not take place in Skull Valley itself. Tr. at 4242-43 (Horstman).

5. NUREG-0800 Applicability and Methodology

A.67 A document known as NUREG-0800 contains the portion of the "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" applicable to the review and evaluation aircraft hazards. Campe/Ghosh Post Tr. 4078, at 5.

A.68 The formula for calculating aircraft crash probability for nuclear facilities is set forth in NUREG-0800 at § 3.5.1.6-3 as:

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

C = inflight crash rate per mile for aircraft type

N = number of flights per year along the airway

A = effective area of the facility in square miles

w = width of airway in miles

Resnikoff Post Tr. 8698, at 5-7; PFS Exh. RRR [hereinafter NUREG-0800].

A.69 As described in NUREG-0800, Section 3.5.1.6, "Aircraft Hazards," the Staff uses probabilistically-based screening criteria in determining the acceptability of an aircraft hazard with respect to a nuclear facility site. Campe/Ghosh Post Tr. 4078, at 5-6; <u>see</u> NUREG-0800, § 3.5.1.6. The Staff reviews an applicant's assessment of aircraft hazards to a facility and determines whether those hazards should be incorporated into the facility's design bases. Campe/Ghosh Post Tr. 4078, at 6; NUREG-0800 at 3.5.1.6-1.

Against this background, we turn in Subparts B and C to the detailed analysis and findings underlying our resolution of the major factual disputes that came before us.

B. Determination of R Factor -- "Pilot Avoidance"

In this Subpart, we portray in some detail the arguments and evidence which the respective parties put forward. As observed in our Narrative Opinion, this was the most critical issue before us, and we are resolving it essentially on the basis that the Applicant had not carried the burden of proof on its claim of near certain success in human performance under stress-filled conditions.

The reason that claim was unproven was not so much because of any specific showing by the State on a particular, narrow factual issue. Rather, it was because the evidence the State presented -- covering a number of different problem areas -- created a record wherein the preponderance of the evidence did not support, and indeed substantially undercut, the Applicant's assertion that pilots would, before ejecting, almost invariably (95% of the time) act affirmatively to guide their aircraft away from striking the PFS facility in the event of an impending crash.

That being the case, in this Subpart we do not articulate a Board position on each individual factual issue contested by the parties. Rather, we devote considerable attention to analyzing the record evidence and the parties' arguments in some detail, then find generally that in view of the totality of the evidence presented by the State, the Applicant has not sustained its claim that pilots will successfully avoid the site in virtually every instance. The powerful countering evidence about human error, under stress, leading to failure, carries the day.

In some instances, the material related herein covers the same ground as did the Narrative, but in more detail. To the extent that repetition therefore exists, the alternative was to expand the Narrative to include the additional details, at the expense of interfering with the flow of the Narrative's reasoning.

B.1 We begin by restating the issue. The Applicant took the position that a pilot's potential ability to avoid hitting the site in the event of a crash reduced the crash impact probability, determined by the four-factor formula, by 85.5%. Cole/Jefferson/Fly Post Tr. 3061, at 17-18. The probability that a pilot would avoid the site in the event of a crash is equal to the product of (1) the probability that a pilot would be in control of the aircraft with time to maneuver it away and (2) the probability that, given those conditions, the pilot would actually direct the aircraft away from the site before ejecting. Tr. at 3769-70 (Cole); Cole/Jefferson/Fly Post Tr. 3061, at 17.

B.2 In calculating the value for R, the Applicant first considered the percentage of accidents that could occur in Skull Valley that would leave a pilot in control of the aircraft after the event. Cole/Jefferson/Fly Post Tr. 3061, at 17. This factor, R1, as derived by the Applicant, was estimated to be 90%. Cole/Jefferson/Fly Post Tr. 3061, at 17. The Applicant then considered the percentage of the time in which the pilot would indeed direct a controllable aircraft away from the Applicant's facility. This factor, R2, as opined by the Applicant, was estimated to be 95%. Cole/Jefferson/Fly Post Tr. 3061, at 17.

B.3 The Applicant multiplied R1 by R2 to determine the percentage of crashing F-16s that would avoid the facility. Cole/Jefferson/Fly Post Tr. 3061, at 17. Thus, the Applicant considered that 85.5% (90% x 95%) of the crashing F-16s would avoid the facility. The calculated crash probability to the facility was accordingly reduced by using a value for the R factor in the equation of 14.5% (equal to 100% minus 85.5%). Cole/Jefferson/Fly Post Tr. 3061, at 18.

We provide below an outline of the many subissues involved in reaching our overall verdict that the "95% pilot avoidance" theory was unproven.

With that outline in place, we set out below the body of evidence and arguments which underlay the decision we reached in the Narrative.

1. Estimate of R1 Value

B.4 The factor R1 represents the fraction of potential accidents in which a pilot would have sufficient time and control of the aircraft to direct the aircraft away from a fixed ground site in Skull Valley. Cole/Jefferson/Fly Post Tr. 3061, at 17. The Applicant's analysis indicated that a pilot whose aircraft was experiencing an in-flight emergency would have sufficient time and control to avoid the Applicant's facility approximately 90% of the time. Cole/Jefferson/Fly Post Tr. 3061, at 17. This determination was based on the Applicant's expert panel's review of accident reports obtained from the Air Force. Cole/Jefferson/Fly Post Tr. 3061, at 17.

B.5 These accident reports were prepared after each aircraft mishap under Air Force Instruction (AFI) 51-503, which directs investigators to determine the cause of the accident, to preserve all available evidence, to provide a complete factual summary for use in claims, litigation, disciplinary actions, adverse administrative proceedings, and for other purposes in accordance with AFI 51-503. Cole/Jefferson/Fly Post Tr. 3061, at 10. The reports follow a set format which describes the circumstances surrounding the accident, including a summary of the history of the flight, the flight mission, preflight activities and planning, the actual flight activity, crash impact information, the functioning of the emergency escape mechanism, rescue activity, maintenance and mechanical factors, supervisory factors, pilot qualifications and performance, navigational aids and facilities, weather, and pertinent directives and publications. Cole/Jefferson/Fly Post Tr. 3061, at 10. The flight activity section provides relevant information as to pilot actions after the emergency begins. Cole/Jefferson/Fly Post Tr. at 3061, at 10. Each report may conclude with a statement of opinion by the investigating officer as to the cause of the accident. Cole/Jefferson/Fly Post Tr. 3061, at 10. The reports are prepared by an accident investigation board typically chaired by a Colonel and comprised of subject matter experts, including pilots of the relevant aircraft type. Tr. at 3659-60 (Cole); see Tr. at 4033-38, 4041-42 (Cole), 4038-40 (Fly), 4040 (Jefferson).

B.6 The Applicant obtained 126 Air Force F-16 Class A mishap accident reports for the period from FY 89 to FY 98. Cole/Jefferson/Fly Post Tr. 3061, at 10. These accident reports consisted of mishaps involving 121 destroyed aircraft. Cole/Jefferson/Fly Post Tr. 3061, at 17. Even though the Applicant reviewed 126 class A mishap reports, five reports were eliminated from consideration on the basis that only crashes involving destroyed aircraft would be considered, a total of 121. Aircraft Crash Report, Tab H at 3-4. One of the crash reports eliminated was the F-16 flight of December 19, 1991 that disappeared after take off and was never heard from. Tr. part two at 27-28 (Fly). PFS witness Fly testified that the F-16 was "probably" destroyed but nevertheless was not considered in the 121 crashes reviewed. Id.

B.7 Each of the three Applicant's experts independently assessed each accident report in accordance with established evaluation parameters. Cole/Jefferson/Fly Post Tr. 3061, at 58. This individual review was followed by a joint review that resolved the few differences that resulted from their individual assessments based on their combined professional judgment. Cole/Jefferson/Fly Post Tr. 3061, at 58-59; Aircraft Crash Report, Tab H at 6-7.

B.8 General Cole, General Jefferson, and Colonel Fly evaluated each destroyed aircraft accident report to assess and determine: (1) the phase of flight in which the accident occurred; (2) the cause of the accident; (3) whether the pilot had sufficient time and control of the aircraft to be able to avoid a ground site; (4) whether the accident was caused by an event that could have occurred during the operations conducted in Skull Valley (a Skull Valley-type event); and (5) whether the accident occurred under flight conditions representative of the Sevier B MOA (a Sevier B MOA event). Cole/Jefferson/Fly Post Tr. 3061, at 58. The categorization of the accident reports enabled the expert panel to draw conclusions therefrom. See Cole/Jefferson/Fly Post Tr. 3061, at 58-59.

B.9 Following this process, the Applicant's expert panel categorized each accident as (a) one that could or could not have occurred in Skull Valley (i.e., "Skull Valley-type events") and (b) one in which the pilot did or did not have control of his aircraft and time to direct it away from a site on the ground (i.e., "able to avoid"). Cole/Jefferson/Fly Post Tr. 3061, at 58-59. The Applicant's assessment of whether the accident could have occurred in Skull Valley was based on whether the initiating accident event could have occurred in Skull Valley. Aircraft Crash Report, Tab H at 11-12; see Aircraft Crash Report, Tab H at 14-16; Tr. at 3957 (Fly). Thus, for example, engine failures, in almost all cases, would be Skull Valley-type events. Aircraft Crash Report, Tab H at 8, 11-12. On the other hand, mid-air collisions during mock dogfighting would not (since such dogfighting does not take place in Skull Valley). Aircraft Crash Report, Tab H at 8; Tr. at 3856-60 (Fly).

B.10 The Applicant's assessment of whether the pilot was in control and would have time to direct his aircraft away from the facility was based on the specific information in the F-16 accident reports regarding each accident. Cole/Jefferson/Fly Post Tr. 3061, at 59-60; Aircraft Crash Report, Tab H at 10-11. An engine failure is by far the most likely cause of an accident in Skull Valley and, in every case of engine failure, the Applicant assessed that the pilot would have control and time to avoid a site on the ground. Cole/Jefferson/Fly Post Tr. 3061, at 17; Tr. at 3770 (Cole).

B.11 The Applicant initially found that 61 accidents during the ten-year period were Skull Valley-type events and in 58 of them, or 95%, the pilot retained control of the aircraft with time to direct it away from a site on the ground. Tr. at 13,007 (Jefferson); see Cole/Jefferson/Fly Post Tr. at 3061, at 81, 88; Aircraft Crash Report, Tab H at 14-20. Nevertheless, the Applicant assumed that the fraction of accidents that would leave a pilot in control of the aircraft and able to avoid a site on the ground was only 90%. Cole/Jefferson/Fly Post Tr. at 3061, at 17; Tr. at

3770 (Cole), 3214, 13,007 (Jefferson).[139] Under the approach taken by the Applicant, this assumption would make room for as many as three more Skull Valley type crashes in which the pilot was considered not to be in control without affecting the R1 percentage being advanced.

B.12 The State saw the reports differently. It pointed out that General Jefferson testified that in 42% of the 121 crashes reviewed, the pilot did not have control of the aircraft such that the pilot could avoid the Applicant's site even if he so desired. Tr. at 3817 (Jefferson); PFS Exh. X. Therefore, only 58% of the overall universe of crashes could have resulted in the pilot retaining control of the aircraft.

B.13 The higher percentage (90%) of controllable aircraft used by the Applicant is based on eliminating 60 of the 121 destroyed aircraft reports which the Applicant "found not to be relevant to Skull Valley." Aircraft Crash Report, Tab H at 8, 15.

B.14 The State asserts that the Applicant excluded many accidents from consideration by incorrectly concluding that the accident could not have occurred in Skull Valley. Horstman Post Tr. 4214, at 31. In this regard, the State contends that the Applicant incorrectly excluded: (1) accidents that occurred at altitudes higher than 5,000 feet AGL; (2) accidents that took place while the aircraft was flying under instrument flight rules; (3) accidents caused by midair

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[139] The Applicant performed an assessment where it evaluated only those accidents that occurred under parameters, such as speed and altitude, at which pilots fly in the Sevier B MOA ("Sevier B MOA flight conditions"). Tr. at 3959 (Fly); Cole/Jefferson/Fly Post Tr. 3061, at 58-60. Those accidents made up a subset of the Skull Valley-type events. The Applicant performed the assessment to evaluate if anything peculiar to the Sevier B MOA flight environment would change its conclusion regarding the fraction of accidents that would leave the pilot in control with the time to attempt to avoid a site on the ground. Nothing did. Tr. at 3959 (Fly); Cole/Jefferson/Fly Post Tr. 3061, at 58-60. The Applicant performed a third assessment in which it assessed all of those accidents that occurred in the "normal" phase of flight (as opposed to special operations, takeoff, and landing), which was also a subset of the Skull Valley-type events, to evaluate whether consideration of the phase of flight would change its conclusion regarding the fraction of accidents that would leave the pilot in control with the time to attempt to avoid a site on the ground. It did not. Tr. at 3860-64 (Fly/Jefferson), 3958-59 (Fly); Cole/Jefferson/Fly Post Tr. 3061, at 58-60.

collisions; (4) accidents caused by G-induced loss of consciousness; (5) accidents caused by bird strikes; (6) accidents caused by lightning strikes; and (7) accidents caused by poor visibility due to cloud cover. Horstman Post Tr. 4214, at 31. During his deposition, the State's witness, Lt. Colonel Horstman, identified six accidents that he contends the Applicant improperly excluded from the Skull Valley-type event category. In his prefiled testimony and at the hearing, the State's witness identified two additional accidents with which he disagrees, for a total of eight accidents. Horstman Post Tr. 4214, at 31; Tr. 4449-51; 4481-83 (Horstman). Five of the eight accidents were discussed during the hearing, and we turn to them now.

B.15 High Altitude. First, the State claims that the Applicant improperly excluded high altitude accidents, such as the March 16, 1990 accident, from the Skull Valley-type event category on the basis that they occurred above 5,000 feet AGL. Horstman Post Tr. 4214, at 31; Tr. at 4449-51, 4481-83 (Horstman). However, the Applicant asserts that it did not exclude the March 16, 1990 accident on the basis of altitude, rather it was excluded from the Sevier B MOA category. Tr. at 13,091-92 (Jefferson). Colonel Fly explained that the accident was excluded based on: (1) an abnormal combination of airspeed (90 knots) and altitude (nearly 27,000 feet AGL) that would not likely occur in Skull Valley; and (2) the engine that failed was an engine that experienced operational abnormalities when flown at high altitudes and low airspeed and is no longer used in F-16s flown today. Tr. at 13,093-95 (Fly).

B.16 Therefore, the Board finds that the Applicant did not exclude this accident from the broader Skull Valley-type event category on the basis that it occurred at high altitude. Thus, we find that the Applicant's exclusion of this accident was reasonable.

B.17 Instrument Flight Rules. The State claims that the Applicant improperly excluded accidents that took place under instrument flight rules from those events that could occur in Skull Valley. Horstman Post Tr. 4214, at 31. When questioned on two separate occasions during the hearing, however, the State's witness could not recall which specific accidents the Applicant had excluded on this basis. Tr. at 4423-24, 8510 (Horstman). The Applicant asserts that it did not exclude any accidents simply because they may have occurred while flying under instrument flight rules. Tr. at 13,091-92 (Jefferson).

B.18 We find that the Applicant did not exclude accidents from the Skull Valley-type event category solely on the basis that they took place while the aircraft was flying under instrument flight rules.

B.19 Midair Collisions. The State claims that the Applicant improperly excluded accidents involving midair collisions from those events that could have occurred in Skull Valley. Horstman Post Tr. 4214, at 31. In this regard, Lt. Colonel Horstman testified that the September 16, 1997 accident involved a midair collision that occurred after takeoff and while the pilots were preparing for a night vision goggle training mission. Horstman Post Tr. 4214, at 31. He testified that pilots conduct night vision goggle training in Skull Valley, and, therefore, a midair collision similar to this accident could occur in Skull Valley. Horstman Post Tr. 4214, at 32.

B.20 Lt. Colonel Horstman was not aware of any other accidents involving midair collisions that the Applicant improperly excluded. Tr. at 8510 (Horstman). However, to the extent that he took issue with any such evaluation, his disagreement is reflected in Table 1. Tr. at 8510 (Horstman).

B.21 The Applicant reclassified this accident as a Skull Valley-type event accident. Cole/Jefferson/Fly Post Tr. 3061, at 79. Therefore, the State and the Applicant are in accord with respect to the Skull Valley-type event categorization of this accident. The Applicant, however, continues to maintain that the accident is not a Sevier B MOA event because the accident took place at 14,000 feet AGL. Cole/Jefferson/Fly Post Tr. 3061, at 80; see PFS Exh. 195 (accident report). We find that because the accident took place at 14,000 feet AGL, it was properly excluded from the Sevier B MOA event category.

B.22 G-LOC. The State also asserts that pilots may suffer loss of consciousness (GLOC) when conducting G-awareness turns in Skull Valley. Horstman Post Tr. 4214, at 17. G-awareness turns can induce loss of consciousness when gravity pulls blood toward the lower extremities, carrying oxygen away from the brain. Tr. at 13,029-30 (Fly).

B.23 The Applicant, however, asserts that G-awareness turns do not present significant risks to pilots. Tr. at 13,030-31 (Fly/Cole).

B.24 The State also asserts that G-induced loss of consciousness accidents can occur in Skull Valley due to other maneuvers besides the G awareness turns. Horstman Post Tr. 4214, at 32. Lt. Colonel Horstman discussed the accident of May 25, 1990, which he asserted was caused by GLOC, in claiming that accidents arising from GLOC could occur in Skull Valley. Horstman Post Tr. 4214, at 32. He pointed to no F-16 accidents caused by GLOC, however, that the Applicant improperly excluded from its analysis. Tr. at 4297-99 (Horstman).[140]

B.25 The Applicant argues that neither the evidence in the record nor the official Air Force records supports Lt. Colonel Horstman's claim that the May 25, 1990 accident was caused by GLOC. Furthermore, Colonel Fly, who has significant experience instructing pilots on the effects of G-forces, testified that he knew of no one who had suffered GLOC in a G-awareness turn similar to those performed in Skull Valley. Tr. at 13,026-31 (Fly). Nor did the Chief of Safety of Air Combat Command. Tr. at 13,031-32 (Cole).

B.26 We find that the evidence in the record supports a finding that G-awareness turns are not high risk maneuvers, and that it is unlikely that a pilot will lose consciousness during a

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[140] In this respect, the Applicant included the May 25, 1990 accident in its analysis as a Skull Valley-type event on a different rationale. Cole/Jefferson/Fly Post Tr. 3061, at 63-64. The Applicant assessed the accident as having been caused by the pilot's loss of situational awareness while at low altitude. Aircraft Crash Report, Tab H at 18.

G-awareness turn. See Aircraft Crash Report, Tab F. We find that regardless of whether the May 25, 1990 accident was caused by G-induced loss of consciousness, the Applicant included this accident in the Skull Valley-type event category and in the Sevier B MOA category. See Cole/Jefferson/Fly Post Tr. 3061, at 63. Since Lt. Colonel Horstman testified that this was the only accident in which G-induced loss of consciousness was at issue, we find that the Applicant's inclusion of this accident as both a Skull Valley-type event and a Sevier B MOA event renders the State's concern with respect to this accident irrelevant. Further, we find it highly unlikely that a pilot in Skull Valley would experience G-induced loss of consciousness.

B.27 Bird Strikes. The State asserts that the Applicant improperly excluded accidents caused by bird strikes from those accidents which could have occurred in Skull Valley. Horstman Post Tr. 4214, at 31. Lt. Colonel Horstman stated that the F-16 canopy is designed to withstand a bird strike of 4 pounds at 350 knots, but that pilots typically fly at 400 to 450 knots through Skull Valley. Horstman Post Tr. 4214, at 32. The State's expert testified that the May 13, 1998 accident which involved a mishap caused by birds impacting the aircraft (Horstman Post Tr. 4214, at 32), was the only accident in which the Applicant improperly excluded an accident on the basis of a bird strike. Tr. at 4531-32, 8512 (Horstman).

B.28 Of the arguments offered by the Applicant, we find the absence of flocks of large birds in Skull Valley near the proposed facility and the history of bird strikes in the area to be the most compelling. Cole/Jefferson/Fly Post Tr. 3061, at 87. On the basis of the absence of flocks of large birds in Skull Valley near the proposed facility (Campe/Ghosh Post Tr. 4078, at 13-14) the history of bird strikes in the area (Cole/Jefferson/Fly, Post Tr. 3061, at 87) and the practice of mission planners at Hill AFB to avoid birds if they are reported (Campe/Ghosh Post Tr. 4078, at 13-14), we find that bird strikes are not reasonably likely to occur in Skull Valley and are not a significant contributor to risk. Therefore, we find that the Applicant's exclusion of the May 13, 1998 accident from the Skull Valley-type event category is acceptable.

B.29 Lightning Strikes. The State asserts that the Applicant improperly excluded from the Skull Valley-type event category accidents that occurred due to lightning strikes. Horstman Post Tr. 4214, at 31. Lt. Colonel Horstman testified that it is reasonably foreseeable that a pilot will at some time fly in lightning and that he has personally flown in lightning. Horstman Post Tr. 4214, at 33.

B.30 The Applicant, for its part, asserts that it did not exclude any accidents on the basis that they were caused by lightning strikes. Tr. at 13,092 (Jefferson). In fact, the Applicant notes that the accident of January 15, 1991 was caused by lightning and was included in the Skull Valley-type event category. Tr. at 13,092 (Jefferson); see also PFS Exh. X (Table 1).

B.31 We find the Applicant's characterization of this accident to be acceptable.

B.32 Cloud Cover. The State asserts that the Applicant incorrectly excluded accidents caused by poor visibility due to cloud cover. Horstman Post Tr. 4214, at 31. Lt. Colonel Horstman testified, however, that he could not identify any accident reports that were omitted from the Skull Valley-type events category because of poor visibility due to cloud cover. Tr. at 8519 (Horstman). If there were any such accidents, they would be reflected in his markup of Table 1. Tr. at 8519 (Horstman).

B.33 Our analysis of those accident reports in which the State disagrees with the Applicant's assessment did not reveal any accidents excluded on the basis of cloud cover. The role of cloud cover does, however, become important in our discussion of R2 below.

B.34 Of the remaining crash reports considered by PFS to be Skull Valley events, the Applicant determined that 59 represented crashes where the aircraft remained controllable with sufficient time to avoid a fixed site on the ground. Aircraft Crash Report, Tab H at 20, Table 4. Taking issue with the Applicant's categorization of the crashes, the State points out that in that group of 59 crash reports, five reports show the pilot ejected during an uncontrolled spin or the aircraft was otherwise uncontrollable. PFS Exh. 145, 118, 124, 113, 147; State Exh. 223 at entries 8, 19, 20, 46, 53. Also within that group of 59 crash reports, argues the State, are 11 reports that show the F-16 was on fire when the pilot ejected. PFS Exh.119, 145, 158, 110, 118, 127, 184, 113, 147, 180; Joint Exh. 4; State Exh. 223 at entries 3, 8, 10, 17, 19, 21, 24, 38, 46, 53, 59. The State further argues that the determination of 90% for crashes in which the aircraft is controllable is inconsistent with the evidence that engine failure is the most likely cause of a crash where the pilot retains control and the evidence that only 36% of F-16 Class A accidents are engine failures according to the manufacturer, Lockheed Martin. Aircraft Crash Report at 17b; State Exh. 56; State Findings ¶ 67.

B.35 In response, both the Applicant and the Staff argue that none of the five reports identified by the State represents a situation where the aircraft was uncontrollable. PFS Reply ¶¶ 66-71; Staff Reply ¶¶ 78-84. Both the Applicant and Staff have examined each of the five reports cited by the State and explain in some detail why the aircraft was controllable. See id.

B.36 After examining all five reports, we agree with the Applicant and Staff that, although at some point in each of these five accidents the aircraft might have been uncontrolled, in each instance the pilot had control for a sufficient time to take avoidance action. In one instance, the pilot actually turned the aircraft to avoid a building. See PFS Exh. 145. In another, the pilot completed his checklist procedures, as well as turned toward an airbase before being forced to eject. See PFS Exh. 118. In a third, the pilot had over four minutes in which to maneuver the aircraft after the emergency began. See PFS Exh. 124.

B.37 Accordingly, we agree with the Applicant and Staff that the five disputed reports were properly categorized as " in control."

B.38 As to the 11 reports in which the State asserts that fire was involved (four of which overlap with the five reports involving assertedly uncontrolled aircraft), the Applicant disputes the State's characterization of these accidents. PFS Reply ¶ 74. The Applicant described in some detail for each of the 11 reports why it considered the aircraft to still be controllable. PFS Reply ¶¶ 74-87. For its part, the Staff points out that in several of the 11 accidents in which fire was reported, the pilot took action to avoid a ground object. Staff Reply ¶ 85. In that regard, the Staff asserts that not all fires would cause an F-16 to become uncontrollable. Staff Reply ¶ 85.

B.39 We agree with the Applicant and Staff that careful examination of the reports indicates that a plane on fire is not necessarily uncontrollable in the sense being used here. Thus, four of the reports indicate that the pilot had two minutes or more in which to steer the plane away from a ground site. See PFS Exhs. 119, 158, 110, 180. Moreover, in several instances the pilot steered away from a specific ground site or a populated area before ejecting. See PFS Exhs. 119, 145, 158. Our examination of the 11 reports allows us to find that the pilot had enough time in control to take avoidance action. Therefore, we find that the Applicant and Staff properly categorized the above accidents as ones in which the pilot was in control for that purpose. In any event, as many as three of the disputed accidents could be recharacterized as "not in control" without affecting the validity of the Applicant's 90% R1 proposal. See Finding B.11, above.

2. Estimate of R2 Value

B.40 a. Eight-factor Assessment of Probability of Pilot Avoidance. Based on their professional judgment as experienced Air Force pilots, rather than on an examination of the accident reports, the Applicant's panel assessed the value of R2 -- the probability that a pilot in control of his aircraft following an in-flight emergency would actually avoid the site -- to be 95%. Cole/Jefferson/Fly Post Tr. 3061, at 17; Aircraft Crash Report at 18-23; Tr. at 3215-16 (Jefferson). The assessment was based on: (1) the time the pilot would typically have based on Air Force data concerning F-16 performance in the event of an engine failure, i.e., one minute or more; (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 site; (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 facility, which will be prominently visible and whose location will be noted, along with other nuclear facilities, in Defense Department aviation planning guides; (6) the wide open spaces around the facility, to which a pilot could safely direct his aircraft; (7) predominantly good 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. These eight factors are discussed in detail below.[141]

B.41 The State asserts that the component value of 95% used by the Applicant is a purely

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

subjective determination made collectively by Applicant's witnesses General Jefferson, General Cole, and Colonel Fly. State Findings ¶ 69. The State points out that none of the Applicant's witnesses who determined the component value of 95% have ever ejected from an F-16. Tr. at 3216 (Jefferson), 3217 (Fly). Neither General Cole nor General Jefferson have ever piloted an F-16. Tr. at 3142 (Cole); Tr. at 3189 (Jefferson). In addition, the determination of 95% was made without performing any statistical calculations, and was made prior to reviewing the F-16 accident reports. Tr. at 13,109-10, 13,121-22 (Jefferson).

B.42 The State further posits that this 95% component represents the percentage of time that a pilot will be successful, during an engine failure emergency, in performing emergency procedures including: (1) attempting to restart the engine; (2) locating the Applicant's site which will be 3.22 miles or more away at the time of ejection; (3) directing the aircraft away from the Applicant's site while also directing the aircraft way from any populated areas; and (4) ejecting at or above the minimum altitude of 2,000 feet AGL. See State Findings ¶ 70.

B.43 Although the Applicant's expert panel based the 95% R2 value on eight contributing factors, the State focused its efforts on challenging the Applicant's assessment of three of those factors, apparently based on General Jefferson's statement that the time available, pilot training, and visibility of the PFS facility were the determining factors. See Tr. at 8882 (Jefferson).

B.44 (1) Timing. The Applicant assessed that in the event of an engine failure, which would be by far the most likely accident leaving the pilot in control of the aircraft, an F-16 pilot transiting Skull Valley would have approximately one minute or more to respond to the emergency and potentially avoid a site on the ground before having to eject at the recommended altitude of 2,000 feet AGL. Aircraft Crash Report, Tab U at 19c-19e; PFS Findings ¶ 15. All parties agree that in an emergency caused by engine failure leaving the F-16 controllable, the pilot will "zoom" the aircraft, which is a climb to trade speed for altitude, and will discard all fuel tanks, bombs and other weapons, known as jettison of stores. Horstman Post Tr. 4214, at 15-16; Tr. at 3546-47, 13,080-81 (Fly); Cole/Jefferson/Fly Post Tr. 3061, at 102; Campe/Ghosh Post Tr. 4078, at 30. Zooming the aircraft provides the pilot with additional time aloft to attempt to restart the engine before the aircraft crashes. Horstman Post Tr. 4214, at 15-16. The zoom is accomplished by raising the nose to establish a 30 degree climb. Tr. at 13,080-81 (Fly). If the pilot had been flying at an altitude of 4,000 feet AGL, the zoom would take the F-16 to approximately 7,000 or 8,000 feet AGL. Tr. at 13,453 (Horstman). In accordance with the F-16 flight manual, upon reaching the airspeed of 250 knots the pilot will end the zoom by "pushing the plane over" and start a descent. Tr. at 13,299-300 (Horstman). The maneuver of pushing the plane over uses some of the F-16's energy and the aircraft slows to approximately 200 knots. Tr. at 13,300-01 (Horstman).

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

B.46 Despite the Applicant's claim of there being sufficient time for a pilot to respond to an emergency situation over Skull Valley, the State argues that in some circumstances, a pilot in an emergency will focus on the task of restarting a failed engine to the exclusion of performing other emergency procedures, including assessing where the aircraft will impact. See Horstman Post Tr. 4214, at 18-19; Tr. at 4030 (Cosby). According to the State, restarting a failed engine, like ejection, would save a pilot's life and avoid the dangers associated with ejection. Horstman Post Tr. 4214, at 19. Thus, there is an incentive for a pilot to restart the engine and avoid ejection. Tr. at 4010 (Cosby). Moreover, the cost of an F-16 is approximately $20 to $40 million. Tr. at 3339 (Fly). Thus, pilots will take every opportunity to save the aircraft by restarting the engine before ejecting. Tr. at 4010-11 (Cosby).

B.47 Lt. Colonel Horstman interviewed active duty Air Force pilot Major Tom Smith, who ejected from an F-16 on January 13, 1995. Horstman Post Tr. 4214, at 18 & n.2. Lt. Colonel Horstman and Major Smith were both in the Air Force when Major Smith ejected. Tr. at 8585 (Horstman). Lt. Colonel Horstman was Major Smith's supervisor at the time and had several conversations with Major (then Captain) Smith concerning his emergency and ejection. Tr. at 8585 (Horstman). Lt. Colonel Horstman recounted the conversation as follows:

> Following an engine failure, Major Smith zoomed the aircraft, jettisoned stores, attempted to restart the engine and ejected. Horstman Post Tr. 4214, at 19; PFS Exh. 175. Major Smith said he did not have time to think about where his jettisoned stores would impact or where the F-16 would impact. Horstman Post Tr. 4214, at 19. Major Smith also said his thoughts were focused on his survival, and if he were to again be required to eject given the same circumstances, he would again not consider where the stores or aircraft would impact. Horstman Post Tr. 4214, at 18-19.

The Applicant, however, reviewed the accident report of Major Smith's crash and determined it represented a situation where a pilot would have time to avoid a specific site. Horstman Post Tr. 4214, at 18 n.2; PFS Exh. 100A.

B.48 (2) Pilot Ability to Respond. The Applicant asserts that based on the activities that the pilot would have to perform to respond to an engine failure, the pilot would have adequate time during the zoom and glide maneuver to avoid the facility. Aircraft Crash Report at 19c-19d; Tr. at 3546-55 (Fly). The actions required to restart the F-16 engine would take only a fraction of the time available to the pilot before he reached the 2,000 feet AGL recommended minimum ejection altitude. Aircraft Crash Report at 19d; see Tr. at 3549-51, 3560-62 (Fly). Moreover, pilots are trained at multitasking, so that they are able to perform emergency procedures while simultaneously flying their aircraft. Tr. at 3994-96 (Cosby). Furthermore, it would take 45 seconds after the pilot restarted the engine for it to develop usable thrust. Aircraft Crash Report at 19c, Fig. 3; see Tr. at 13,705 (Fly). Thus, according to the Applicant's evidence, at some point in the aircraft's glide before the pilot either resumed flying or ejected, there would be a 45 second period in which the pilot would be able to attend to other matters without interfering with the restarting of the engine. Tr. at 13,704-05 (Fly); see Aircraft Crash Report at 19c.

B.49 (3) Slight Turn to Avoid Site. The Applicant further argues that to avoid any ground site visible at 2,000 feet, the turn the pilot would have to make would be slight, on the order of 4 degrees (assuming that the pilot turned just before he ejected at 2,000 feet AGL), and easily made in the time available to him while he was gliding toward the ground. Aircraft Crash Report at 22-23; Tr. at 3094-96 (Fly), 3910 (Bernard), 4023-25 (Cosby); see Tr. at 8527 (Horstman). The Hill AFB staff corroborated in its meeting with the NRC Staff that such a turn would not be difficult. See Tr. at 4186-88 (Campe). In his accident, Colonel Cosby turned 180 degrees to avoid an apartment complex and then maneuvered his aircraft further to avoid another aircraft on the ground. Tr. at 3980-81 (Cosby). Colonel Bernard also agreed that in a controllable situation it would "not be difficult at all" to direct an F-16 away from the Applicant's facility prior to ejection. Tr. at 3910 (Bernard).

B.50 (4) Pilot Training. The Applicant posits that pilots would turn to avoid the site because they are trained to avoid inhabited or built up areas on the ground. Aircraft Crash Report at 19-19a; Tr. at 3898 (Bernard), 3989-93 (Cosby).

B.51 (a) Air Force Instruction Manuals. The Applicant notes that the instruction manual for the first aircraft on which Air Force pilots are trained instructs pilots prior to an emergency ejection to "turn aircraft toward uninhabited area." Aircraft Crash Report, Tab S. In addition, the F-16 manual states that "if time permits" the pilot should "direct the aircraft away from populated areas." [142] Colonel Bernard and Colonel Cosby both stated that the objective of that instruction is to minimize damage and risk to people or property on the ground by, for example, directing the aircraft into a river or a lake. Tr. at 3920 (Bernard), 3990-91 (Cosby). Dr. Campe testified that based on the NRC Staff's meeting with the Hill AFB staff, avoidance of built-up areas on the ground if the aircraft was in control was "something that is . . . in every pilot's mind, attitude [and] training to consider that." Tr. at 4188 (Campe). Moreover, the fact that the facility will be a storage facility for nuclear material would also likely reinforce the pilot's desire to avoid it. Tr. at 3921 (Bernard).

B.52 Regarding the emergency procedure of ejection, the F-16 fight manual provides the following reference:

> **Ejection (Time Permitting**)
>
> If time permits, descend to avoid the hazards of high altitude ejection. Stow all loose equipment and direct the aircraft away from populated areas. Sit with head against headrest, buttocks against back of seat, and feet on rudder pedals.
>
> 1. IFF MASTER knob - EMER.
> 2. MASTER ZEROIZE switch (combat status) - ZEROIZE.
> 3. Loose equipment and checklist - Stow.

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[142] State Exh. 150. Lt. Colonel Horstman suggested that the manual cited by the Applicant was different with respect to emergency procedures than the manual for the F-16s currently flown at Hill AFB because the manual cited by the Applicant was for a block of aircraft that assertedly had different engines. Tr. at 13,628-29 (Horstman). In fact, the Block 30 and the Block 40 F-16 have the same engines, Tr. at 13,632-33 (Fly) and the manuals have identical language regarding the direction of the aircraft away from populated areas, Tr. at 13,637 (Farrar).

4. Lapbelt and helmet chin strap - Tighten.
5. Night vision devices - Remove (if appropriate).
6. Visor - Down.
7. Throttle - IDLE.
   Slow to lowest practical airspeed.
8. Assume ejection position.
9. Ejection handle - Pull.

Aircraft Crash Report at 19a n.16A; PFS Exh. PPP at 3-43.

B.53 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 Findings ¶ 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 Findings ¶ 74. Of the approximately 10,000 pages of directives and procedures for the F-16, the State notes that the only reference to directing the aircraft before ejecting is found embedded in the above provision: *If time permits . . . direct the aircraft away from populated areas.* Tr. at 8551 (Horstman). Except for a similar one sentence reference in flight manuals for other aircraft, there are no other Air Force documents that refer to training a pilot to avoid populated areas. Tr. at 3251-52 (Jefferson); 13,532 (Horstman).

B.54 The State makes the following arguments about pilots avoiding ground sites. The Air Force does not teach pilots to look for specific sites on the ground in an emergency. Tr. at 8550-51 (Horstman). There is no Air Force training or guidance to avoid a house, a facility, or other specific ground site and pilots do not have the tools for such a task. Tr. at 13,464-65 (Horstman). Directing the aircraft away from a populated area refers to a large geographical area, not a specific site or targets on the ground. Tr. at 13,531-32 (Horstman). F-16 pilots will make the decision as to whether they can steer away at a distance of at least 3.22 miles and possibly as far away as five miles from where the F-16 will impact. Tr. at 13,612-13 (Horstman). The task of directing an F-16 away from a populated area before ejecting requires the pilot to determine if the impact area, 3.22 or more miles in front of the aircraft, is a populated area. Tr. at 13,612-13, 13,624 (Horstman). It is relatively easy to determine if a city is within the crash impact area, because its size makes it easy to locate. Tr. at 13,470-71 (Horstman); 3290 (Fly). Conversely, the State points out that a pilot may not be able to see smaller specific ground sites as well as larger areas. Tr. at 13,470-71 (Horstman). It points out that the Applicant's site covers only 0.13 square miles and consists mostly of open space and concrete casks and does not appear to be a populated area. Aircraft Crash Report at Tab R; Horstman Post Tr. 4214, at 17-18. Lt. Colonel Horstman testified that the fact that the PFSF will be a "facility," as opposed to a "populated area," would make it less likely that a pilot would avoid the site, in that the pilot's manual for the F-16 instructs pilots to turning the aircraft away from "populated areas" before ejecting. Horstman Post Tr. 4212, at 18; Tr. at 13,532, 13,465 (Horstman).

B.55 To support its position, the State points out that the crash report of July 11, 1996 shows the pilot turned "towards what he perceived to be a less congested area" yet the impact destroyed two houses killing a child and injuring her mother. Joint Exh. 10; State Exh. 223 no. 14. In addition, the crash report of August 31, 1992 shows the pilot turned toward "what appeared to be an uninhabited area" yet impacted 150 yards from two inhabited dwellings. PFS Exh. 140; State Exh. 223 no. 7. These mishap reports, according to the State, demonstrate the level of a pilot's ability to turn away from large populated areas, and the inability to locate and avoid specific ground sites. State Findings ¶ 75.

B.56 The State also argues that the notion of directing the aircraft away from a populated area also includes the notion that a pilot would not direct the aircraft away from one area at the risk of impacting a more populated area. Tr. at 13,613 (Horstman). The decision to turn away from a populated area requires the pilot to assess the impact area of where the F-16 is pointed and alternative impact areas to turn towards. See Tr. at 13,613 (Horstman). A pilot in Skull Valley would not direct an F-16 toward the Goshute Indian Village in an effort to avoid the Applicant's facility. Tr. at 13,613 (Horstman); State Exh. 222. Lt. Colonel Horstman suggested that a pilot whose crashing aircraft was going to hit the Hoover Dam might not try to avoid it because the dam was not, strictly speaking, a "populated area," despite the fact that damaging the dam could potentially cause great harm to many people. Tr. at 13,559-60 (Horstman).

B.57 (b) Situational Awareness. Air Force pilots are taught three general principles pertaining to in-flight emergencies, which are reinforced throughout their careers: maintain control of the aircraft; analyze the situation and take appropriate actions; and land as soon as conditions permit. Aircraft Crash Report at 19. In addition, Air Force pilots are trained from the beginning of their careers to develop and maintain constant situational and positional awareness, so that regardless of where they are flying and where they are headed, they are cognizant of their surrounding environment. Tr. at 3103-04 (Cole). General Cole described situational awareness as "an active and engaged cognizance" of a pilot's location, direction, airspeed, track, and terrain features, among other things. Tr. at 3591 (Cole). Air Force pilots begin to learn and develop situational awareness from their first flights in pilot training, and pilots continue throughout their careers to improve their situational awareness skills in maintaining it. Tr. at 3591-92 (Cole). Situational awareness is integrated into pilot training through flight simulator exercises in which various emergencies are presented and through actual flight time, check rides, and flight drill instruction. Tr. at 3593-98 (Cole/Fly/Jefferson), 3334-35 (Fly). Situational awareness is also discussed as part of mission briefings and debriefings. Tr. at 3595 (Fly). Hence, loss of situational awareness is minimized as a result of training.

B.58 PFS argues that the extensive training Air Force pilots receive with respect to the development of situational and positional awareness relates to a pilot's success in avoiding structures on the ground during an emergency. Tr. at 3598-99 (Cole). General Cole explained that while addressing an emergency situation, a pilot will generally be aware of what is in front of and behind the aircraft and will have a sense of the location of a structure on the ground, before a pilot would have to act to avoid it. Tr. at 3599 (Cole). A pilot will know where the aircraft is going to land and will adjust the heading of the aircraft to ensure that the aircraft will not hit a ground structure before the pilot ejects. Tr. at 3103-04 (Cole).

B.59 The State's witness, Lt. Colonel Horstman, agreed that pilots are trained in aspects of situational awareness and are trained to know their location. Tr. 13,334-35 (Horstman). He agreed that pilots have situational and positional awareness when flying and that, generally speaking, a pilot would not look out of the aircraft for the first time at the onset of an emergency to determine the aircraft's location, because the pilot should already be aware of it. Tr. at 8606 (Horstman).

B.60 (c) Ejection Training. The State observes that during Air Force training, responding to engine failures is practiced only on simulators. See State Findings ¶ 76. Air Force training does not include practicing engine failure emergencies where the F-16 engine is failed for training purposes. Tr. at 3555-56 (Fly). If an engine fails, the pilot will for the first time be in that emergency situation. Tr. at 3556 (Fly). Engine failures are practiced only on flight simulators. Tr. at 3333-37 (Fly/Cole). Nor does Air Force training include practicing ejections from an aircraft. Tr. at 3335-36 (Fly). Pulling the ejection handle in a flight simulator merely causes the simulator to go blank and stop. Tr. at 3335 (Fly). Until a pilot actually ejects from an aircraft during an emergency, the pilot has never fully experienced that sensation nor made decisions relating to where the aircraft will impact. Tr. at 3556 (Fly).

B.61 In response, PFS argues that simulator training is thorough and realistic. Tr. at 3333-34 (Fly). The simulator looks like an F-16 cockpit and contains functioning instruments. Tr. at 3333-34 (Fly). It enables a pilot to practice navigation, flying in bad weather, air-to-air combat, and some bombing missions. Tr. at 3334 (Fly). The simulator can also simulate the failure of any of the aircraft's systems. Tr. at 3334 (Fly). "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 13,260 (Horstman). Thus, PFS asserts, 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, 3810 (Fly). Pilots rehearse emergency procedures extensively and are regularly tested on them in the simulator. Tr. at 3330-31 (Cole), 3811 (Fly), 13260 (Horstman). Colonel 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).

B.62 The Applicant further maintains that 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). Simulated ejections are practiced twice per year. Tr. at 4015 (Cosby). Colonel 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 (Fly).

B.63 (d) Emergency Stress and Pilot Error. The State further argues that pilots are under great physical and emotional stress during inflight emergencies, which causes their performance to deteriorate. Horstman Post Tr. 4214, at 20; Tr. at 3252-54 (Jefferson). A pilot's primary concern upon realizing the aircraft is about to crash is for the pilot's survival, which is dependant on ejection. Horstman Post Tr. 4214, at 17-21. Ejection from an F-16 is a violent and dangerous procedure which can cause severe injury or death. Horstman Post Tr. 4214 at 17; Tr. at 3900 (Bernard). U.S. Air Force publication Flying Safety reports that through September 2000, 6.8% of F-16 ejections have resulted in fatal injuries. Flying Safety at 11-13; Tr. 3255, 3270-71 (Jefferson). Colonel Bernard, who ejected from an F-16 during a training mission, testified that the greatest stress levels by a "significant measure" faced by a pilot occur during the moments before ejection. Tr. at 3897-98 (Bernard). Colonel Bernard testified that you have a period of divided attention during an emergency that "completely becomes focused on what you need for your survival." Tr. at 3897-98 (Bernard).

B.64 The Air Force Chief of Safety sends out messages known as ALSAFECOMs to distribute critical safety information to Air Force commands. Horstman Post Tr. 4214, at 20-21. During 1996, the Air Force Chief of Safety sent out ALSAFECOM 002/1996, one of only four ALSAFECOMs sent out that year. Horstman Post Tr. 4214, at 20-21; State Exh. 57, U.S. Air Force, ALSAFECOM 002/1996 [hereinafter ALSAFECOM 002/1996]. It advised of significant pilot errors in emergency situations, including 73% of ejections in the previous six months occurring below the published minimum altitude of 2,000 feet due to futile attempts to restart failed engines. Id. at 1. It further advised that incorrect assessment of airborne situations and timely ejections had become a problem, and that erroneous assumptions and poor airmanship flourished in emergency situations. Id. at 2-3. It concluded that crew members confronted with inflight emergency induced stress may need external intervention to alter inappropriate actions.

Id. at 3. The State notes that F-16 manufacturer Lockheed Martin has determined that 52% of Class A F-16 accidents have been caused by pilot error. Horstman Post Tr. 4214, at 20; State Exh. 56.

B.65 As an example of pilot error during an emergency situation, the State points to the testimony of volunteer witness Colonel Michael Cosby, who ejected from an F-16 after his aircraft's engine failed during a 1993 training mission. Tr. at 3978-80 (Cosby). Colonel Cosby testified that he spent too much time and attention trying to restart the failed engine. Tr. at 3980 (Cosby). The board that investigated Colonel Cosby's accident determined that if he had spent less time focusing on restarting the engine, he would probably have avoided the crash and been able to successfully land. Tr. at 4008 (Cosby).

B.66 The State presented the testimony of volunteer witness Colonel Frank Bernard, who ejected from an F-16 after the engine failed during a 1986 training mission. Tr. at 3888-89 (Bernard). Colonel Bernard testified that it was error on his part to use all his time trying to solve his failed engine problem, which drove him to eject at only 170 feet AGL. Tr. at 3895-96 (Bernard). Video recordings are routinely made during F-16 flights. Tr. at 13,133-36 (Horstman). The Air Force used the actual video recording taken from Colonel Bernard's F-16 during his ejection emergency to produce a safety training video for F-16 pilots. Tr. at 13,135-37 (Horstman); see State Exh. 220, Videotape: Late Decision to Eject (U.S. Air Force 1986) [hereinafter Bernard Video]. The video shows a portion of the training mission which is generally representative of flying conditions that normally occur in Skull Valley. Tr. at 13,435-38 (Horstman); see Bernard Video. Following disengagement from the mock battle training, the circumstances represented in the Bernard training video are representative of any F-16 with a failed engine. Tr. 13,690-91 (Fly); see Bernard Video. Colonel Bernard, a most experienced pilot, ejected only seconds prior to the aircraft impacting the ground. Tr. at 13,435-38

(Horstman). This was Colonel Bernard's second ejection. Tr. at 13,438 (Horstman). The State claims that Colonel Bernard's accident supports its notion that a pilot who suffered an engine failure in Skull Valley would be too distracted to avoid the facility. See State Findings ¶ 81.

B.67 In response, the Applicant argues that, as Colonel Fly explained, "[i]f 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 13,692 (Fly). In Skull Valley, a pilot would be at approximately 3,000 to 4,000 feet AGL and 350 to 400 knots. Cole/Jefferson/Fly Post Tr. 3061, at 14. In contrast, Colonel Bernard did not pull himself away from his combat training mission and began to focus on his emergency until he was at 170 feet AGL. See Bernard Video.

B.68 From reviewing F-16 crash reports for the ten-year period 1989 through 1998, the Applicant determined that 58 reports represented crashes where the aircraft remained controllable with sufficient time to avoid a specific ground site. The State points out, however, that in that group of 59 crash reports, 29 reports (50%) show the pilot ejected below the published minimum altitude of 2,000 feet AGL. State Exh. 223.

B.69 The Applicant responds by arguing that merely because the pilot ejected below 2,000 feet does not mean that he would not have been able to avoid the facility. PFS Findings ¶¶ 123-24,162. The Applicant argues that pilots in the reports, including Colonel Cosby, did in fact avoid sites or areas on the ground even though they ejected below 2,000 feet. See PFS Findings ¶ 123. The Applicant argues that according to the evidence in the record, ejection at below 2,000 feet is not related to a pilot's ability to avoid a site on the ground. See PFS Findings ¶ 123. It also points out that in a number of cases, the pilots specifically delayed their ejection below 2,000 feet in order to take additional actions for the express purpose of avoiding sites on the ground and were commended for doing so. PFS Findings ¶ 124. Further, PFS argues, the accident reports refer to the 2,000 feet limit as "minimum recommended ejection altitude" and not as "rule" or "regulation." See, e.g., Joint Exh. 1 at 2; Joint Exh. 6 at 4; Joint Exh. 9 at 16; PFS Exh. 205 at 17. The Applicant points out that some pilots have been specifically commended for delaying their ejection below 2,000 feet AGL in order to avoid something on the ground. See Joint Exh. 9 at 16; PFS Exh. 205 at 17.

B.70 After reviewing the accident reports offered into evidence by the Applicant, the Board identified 40 instances in which pilot error was listed as either the confirmed or suspected cause of an F-16 crash. Relevant excerpts from these 40 reports are set forth below:

> PFS Exh. 80. Collision with ground. Potential pilot error attributed to two fatalities (one pilot and one civilian) as no equipment failure was found and no ejection was attempted.
>
> PFS Exh.103. Collision with ground. Mishap pilot "inadvertently pulled his power back to idle," and after "recognizing his error," took corrective actions. The plane impacted the ground with no attempted pilot ejection, but the mishap pilot suffered no serious injury.
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> PFS Exh. 106. Live bombs dropped. Four "deviations" were cited: (1) mishap pilot "overflew manned sites. . . with live ordnance on board and with their Master Arm switch in the 'ARM' position"; (2) mishap pilot "expended six MK-82 AIR general purpose bombs on an unauthorized target"; (3) mishap pilot "did not place required navigational data. . . on his low level map"; and (4) flight "used non standard radio transmissions." Six live bombs were dropped and detonated near a manned site, and four civilians were affected.
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> PFS Exh. 107. Midair collision. One pilot fatality and one successful pilot ejection in midair collision of two F-16s. Four "known or suspected deviations" are: (1) "no air-to-air academic are documented"; (2) one pilot did not meet minimal training requirement; (3) one pilot's video showed "at least four instances, not including the collision, where his aircraft was closer than 1,000 feet to "the other aircraft, where 1,000 feet was established by USAFER 55-79 as minimum separation distance; (4) and one instance of activation of the low speed signal, where "no knock it off or terminate call was given even though safety was compromised."
>
> PFS Exh. 109. Midair collision. One pilot fatality. "All pilots in the squadron did not have the same interpretation of the leader/wingman responsibilities in MCM 3-3 and MCM 3-1," and "[t]here were also differences of opinion on whether the flight member engaging had to specifically call 'engaged' when he was assuming the role of the 'engaged fighter.'"

PFS Exh. 120. Midair collision. One pilot fatality and one safe pilot ejection. Pilot training deficiencies were cited as “demonstrated deficiencies during initial qualification that were documented on the phase grade sheets.” Deficiencies were noted in the report.

PFS Exh. 122. Collision with ground. Potential pilot error as no equipment failure was found and there was no attempted ejection. Pilot was fatally injured.

PFS Exh. 130. Crash into sea. Three training deficiencies noted: (1) mishap pilot was “not an experienced pilot in the F-16 as required by AFR 60-1"; (2) “no waiver was approved” for a crew member who was not a rated crew member; and (3) “G-straining maneuvers were not briefed,” which was required by AFR 60-1 and PACAFR 55-7.

PFS Exh. 131. Collision with ground. Potential pilot error as there was no attempted ejection. Fatal injury to the pilot.

PFS Exh. 132. Collision with mountain ridge. One cited deviation as mishap actions were “outside of the MOA” while training should be conducted within designated airspace. Two pilot fatalities in this accident.

PFS Exh. 135. Collision with ground. Potential pilot error in that “[t]he mishap pilot and flight lead both believed that sufficient cloud clearance would be available when the attack was initiated.” The plane crashed and was destroyed.

PFS Exh. 136. Midair collision. One pilot fatality. Potential pilot error.

PFS Exh. 139. Collision with ground. Pilot fatality because “ejection was initiated out of the design envelope of the ejection system.”

PFS Exh. 142. Collision with ground. Pilot using piddle-pack caused the plane to become uncontrollable.

PFS Exh. 149. Landing Accident. Cited factors causing accident: (1) had the pilot “adhered to these published altitude restrictions this accident would not have occurred”; (2) pilot “failed to follow T.O.1F-16C-1”; and (3) “pilot distraction.”

PFS Exh. 151. Collision with ground. Pilot fatality due to following potential causes: (1) the time allotted for mission brief was “insufficient to adequately cover a detailed game plan”; (2) pilot training “did not involve high G, visual Air-to-Air maneuvering”; and (3) pilot’s “low situational awareness. . . placed him in a high task environment.”

PFS Exh. 152. Collision with ground. Pilot ejection at 620 feet AGL during a contractor acceptance check flight, leading to fatal injury. “Momentary complacency. . . provided the only reasonable explanation for this accident.”

PFS Exh. 153. Midair collision. Safe pilot ejection. Pilot “misperception” and “disorientation” were cited.

PFS Exh. 154. Collision during landing. Control tower controller deficiency noted. Pilot “operated his aircraft in violation of Air Force Regulation 60-16" and pilot’s “demonstrated lack of flight discipline” was cited.

PFS Exh. 155. Collision with ground. Potential pilot error due to pilot “delayed his recovery from a near vertical dive.” Pilot was fatally injured.

PFS Exh. 159. Midair collision. Pilot’s “failure to follow established guidance for required actions” was cited.

PFS Exh. 161. Collision with ground. Pilot fatality. Pilot “misprioritizing his tasks for a very short period of time while maneuvering at low altitude” was cited.

PFS Exh. 165. Collision with ground. Potential pilot errors committed in 360-degree spiral. “Distraction/preoccupation” and “inattention/complacency” were discussed as potential causes.

PFS Exh. 168. Midair collision. Collision between F-16 and C-130 caused 23 fatalities and 100 injuries to Fort Bragg Army personnel who were paratroopers in preparation for a jump. A minor pilot error was cited as “AFR 60-16 [paragraph] 4-4b was not adhered to by the F-16 pilot.”

PFS Exh. 169. Collision with ground. Engine failed. Accident investigator found that "accident was the result of pilot error. The mishap pilot failed to follow two of the three basic rules in T.O. IF-16C-1 which apply to all emergencies."

PFS Exh. 171. Crash on takeoff. Accident investigator found that the aircraft “crashed because it was not properly trimmed for takeoff." The most likely reason for incorrect trim was found to be "the pilot's failure to return the TRIM/AP (trim/autopilot) switch to the NORM position during the after start checks and failure to check the trim in the center position prior to take off."

PFS Exh. 172. Collision with ground. Accident investigator found six deviations from directives or publications by mishap crew members or others involved in the mission after bird strike occurred. "For an unknown reason, [pilot] descended through 6000 feet mean sea level, the assigned and published base of the [operating area] and leveled off at approximately 1000 feet above the ground.... There is no evidence to show that . . . the designated element lead, made any attempt to prevent or correct the deviation from the assigned airspace."

PFS Exh. 178. Midair collision. Investigator found that cause of accident was "loss of situational awareness in the traffic pattern."

PFS Exh. 187. Collision with ground. Investigator found the pilot "failed to monitor his aircraft's position and flight path relative to the ground . . . . [T]his mishap was caused by human factors. . . . [P]reparation [and] experience . . .

can be overridden by a momentary lapse into ‘seat-of-the-pants’ flying due to some form of distraction. . . . [H]uman factors continue to be the ongoing limitation to perfect results."

PFS Exh. 190. Midair collision. Investigator found that pilot failed to maintain sight of lead aircraft and he could no longer ensure safe separation between his aircraft and aircraft 257. Pilot “engaged the auto pilot for the second photo pass, in order to provide . . . a more stable platform from which to fly . . . . [A]uto pilot [tolerances] must be closely monitored."

PFS Exh. 193 Collision with ground. Investigator found that "mishap was caused by human factors." Pilot “was unprepared for the degree of G tolerance reduction following his unloaded extension . . . . [E]ven with the most thorough preparation and capability, the human factor continues to limit perfect success."

PFS Exh. 195. Midair collision. Investigator found that "[b]y clear and convincing evidence, the midair collision] . . . was caused by pilot errors by all three pilots involved." Two pilots “failed to effectively communicate, prioritize tasks, and control aircraft performance parameters to avoid collision. In simpler terms, they lost situational awareness."

PFS Exh. 197. Midair collision. Investigator found that there were numerous deviations from training rules. There was "failure to use proper ‘see and avoid’ techniques to ensure a clear flight path." Human factors cited include decreased situational awareness secondary to task saturation, task misprioritization, channelized attention, misperception of speed/closure rate.

PFS Exh. 200. Collision with ground. Investigator found that pilot "channelized his attention on some aspect of the attack and descended below the briefed recovery altitude, became spatially disoriented and impacted the terrain."

PFS Exh. 204. Aborted takeoff. Accident investigator found that “pilot failed to execute the abort procedure properly." There was a failure to deploy the SAFE-BAR Arresting System. Had the system been deployed "it would have prevented the mishap aircraft from departing the overrun.”

PFS Exh. 206 Collision with ground. Investigator found accident was caused by "G-induced loss of consciousness (GLOC)." The cause of “the GLOC was the mishap pilot's failure to execute a proper AGSM while initiating the conversion turn during the mishap intercept."

PFS Exh. 207. Collision with ground. Investigator found that "this mishap is the result of the combined effects of several errors made by the mishap pilot." Pilot "did not maintain proper spacing from and visual contact with" other aircraft.

PFS Exh. 218. Landing gear collapse on landing. Investigator found that pilot failed "to properly control his descent rate during landing. . . . [A]ircraft was descending in a slight left bank at around 23 ft/sec, well above the 10 ft/sec design limit.” (reference omitted)

> Joint Exh. 8. Collision with ground. Investigation found that "[mishap pilot] failed to recognize . . . mechanical malfunction in a timely manner." When engine failed, mishap pilot "did not take command of the flight. . . . descended rather than maintain his altitude . . . . did not request assistance . . . . did not complete all the steps recommended by the flight manual checklist to correct [fuel situation]."
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> Joint Exh. 10. Collision with ground. Pilot attempted to avoid populated area after engine failed. Ejected at 209 feet; aircraft crashed into populated area destroying a house and killing a child.

We do not suggest any statistically-valid inferences can be drawn from the reports just mentioned. But we do find that the reports provide powerful evidence concerning the many ways human error leads to failure. And while the errors recounted therein did not take place during the "ground-site avoidance" phase of flight, they nonetheless demonstrate that errors take place in many other phases of flight. That demonstration provides us good reason not to accept the notion that in the particularly stress-filled phase of flight in which we are interested (and after the accident scenario has been initiated), near-flawless performance in ground-site avoidance will result.

B.71 (5) Pilot Familiarity with Site. The Applicant stresses that pilots flying in Skull Valley will know where the facility is because it will be prominently visible. Lt. Colonel Horstman agreed that it would be one of the largest built up areas and would have perhaps the tallest structure in Skull Valley and would be of "fairly unique" appearance. Tr. at 13,510-11 (Horstman). The restricted area will have 130-foot light poles around its boundary to provide illumination 24 hours a day. Cole/Jefferson/Fly Post Tr. 3061, at 66 n.80; Aircraft Crash Report at 22. Pilots will see the site as they fly over it from week to week, even as it is being constructed. Tr. at 3600-01 (Fly). Observing their surroundings is something pilots constantly do while they are flying their aircraft. Tr. at 3551-53 (Fly), 3599 (Cole).

B.72 Further, as the Applicant discussed in its proposed findings, in addition to its visibility, because of the nature of the facility, the location of the facility within the middle of the Valley will be well known to the pilots who fly through Skull Valley. PFS Findings ¶ 97. From the time the pilot enters Skull Valley about 25 miles to the north of the facility he will have mountains on both sides and a road down the center of the Valley. See SER at 2-3 to 2-5. 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 facility. Tr. at 8417-19 (Horstman); 13,049-52 (Fly) (discussing pilots' use of landmarks and instruments in the event of reduced visibility due to weather).

B.73 In addition to the pilot's own personal awareness and familiarity with the Valley from flying F-16s, the Applicant argues that the site's location will be noted, along with other nuclear facilities, in Defense Department aviation planning guides. Aircraft Crash Report at 90-91; see also Tr. at 3519-20 (Cole), 13,114 (Fly). The Department of Defense's Area Planning Guide provides guidance to planners of military training routes regarding location and avoidance of radioactive waste facilities and is updated every 56 days. Campe/Ghosh Post Tr. 4078, at 21.

B.74 Finally, PFS asserts, if pilots at Hill AFB determine to use the Applicant's facility regularly as a primary visual reference point, the facility will be known to those pilots. Cole/Jefferson/Fly Post Tr. 3061, at 42. In that event, pilots would be able to see or at least be aware of the location of the Applicant's facility in Skull Valley. Cole/Jefferson/Fly Post Tr. 3061, at 42. Along with other sensitive areas beneath the airspace of the UTTR, such as the chemical and biological laboratories on Dugway Proving Ground, the facility would be depicted on aviation maps and its location published in Air Force instructions for the UTTR. Tr. at 13,114 (Fly). Pilots also receive orientation with respect to safety hazards when they come to a new base which would make them further aware of the facility, assuming that the Air Force instructs pilots as to the potential hazard of hitting the facility. Tr. at 3781-82 (Cole), 3783 (Fly).

B.75 (6) Open Space Surrounding Site. In Skull Valley, the Applicant's proposed facility would be the largest structure in the area. Tr. at 3600. Skull Valley itself is sparsely populated and on the Skull Valley Band Reservation, near the proposed facility, there are two tribal homes approximately 2 miles southeast of the proposed site, additional residences about 3.5 miles east-southeast of the site, and off the Reservation, two private farm residences located approximately 2.75 and 4.0 miles northeast of the site. See SER at 2-4. Generally, the area surrounding the proposed facility is characterized by open space and is undeveloped with mostly limited grazing and agricultural uses. See FEIS at 3-41. In addition, the Applicant notes that there are no residences or structures of any kind to the west of the site. Aircraft Crash Report at 22. From these facts, the Applicant claims that a pilot flying down the middle of the Valley in the general direction of the site could divert to the west to avoid crashing into people, but would have to be cognizant of the restricted airspace. Tr. at 13,703-04 (Jefferson). Similarly, says the Applicant, an F-16 following the predominant route east of the site could be somewhat east of the other structures in the general vicinity and could before ejection continue the same direction, or make a slight turn towards the Stansbury Mountains, to ensure site avoidance. Tr. 13,700-01 (Fly).

B.76 In rebuttal to the Applicant's claims, the State points out that two F-16 accident reports presented by the Applicant show that a pilot would have difficulty avoiding the facility. See State Findings ¶ 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 Joint Exh. 10. At the point the pilot realized he could not make it to the runway, "[t]here were houses everywhere he looked below him." Joint Exh. 10 at 5. The pilot nonetheless continued maneuvering the airplane to avoid structures on the ground up to the very last moments possible. In the August 31, 1992 accident, the pilot did not hit anything. 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,” PFS Exh. 140 at 2, that “contained primarily trees and underbrush,” PFS Exh. 140 at 4.

B.77 (7) Good Weather and Visibility. The Applicant argued generally that the lack of cloud cover over Skull Valley and a pilot’s ability to maintain positional awareness in cloudy conditions through visual identification of landmarks and the use of navigational tools would assist pilots in avoiding the PFS facility in an emergency ejection situation.

B.78 (a) Presence of Cloud Cover. According to the Applicant, the weather in Skull Valley is generally excellent. PFS Findings ¶ 99. Actual ceiling data based on 30 years of climatological data from Michael AAF shows that 70.5% of the time there is no ceiling at any altitude combined with a visibility greater than or equal to 7 miles. Vigeant Post Tr. 3090, at 4. Because Michael AAF is close to the proposed facility site in Skull Valley and because the data were specifically collected by the Air Weather Service to support aviation operations at Dugway Proving Grounds, the ceiling and visibility data would be closely representative of that for the facility site. Vigeant Post Tr. 3090, at 6.

B.79 The Applicant also contends that cloud cover in Skull Valley that would affect a pilot’s ability to see the facility at the altitudes flown by the F-16s would be very uncommon. The same 30 years of climatological data from Michael AAF shows there is no ceiling below 5,000 feet AGL (where the F-16s mostly fly) and 7 or more miles of visibility 91.5% of the time. Cole/Jefferson/Fly Post Tr. 3061, at 53; Vigeant Post Tr. 3090, at 4. Because a ceiling as defined by the FAA is indicative of a pilot’s ability to maintain sight of a point on the ground for a sufficient length of time to land an aircraft without using instrument procedures, Tr. at 13,458-59 (Horstman), this data shows that more than 90% of the time clouds would not impair a pilot’s ability to see and avoid the facility while flying through Skull Valley. Further, specific cloud cover data from Salt Lake City shows that 79% of the time there would be no clouds (or fog) below 5,000 feet AGL whatsoever. Tr. at 13,061 (Fly); PFS Exh. 245. Applicant witness Vigeant collected surface weather observations from Salt Lake City International Airport for calendar year 2001. See Tr. at 13,055-56 (Vigeant); PFS Exh. 245. The information presented gives the amount of cloud cover at various layers and includes the altitude of each cloud layer. Tr. at 13,056 (Vigeant). The data shows that out of 108 observations, only 23 had any clouds reported at altitudes below 5,000 feet AGL - - the elevation threshold of the Sevier B MOA. Tr. at 13,059 (Fly); PFS Exh. 245. Thus, in 79% of the time, there were no clouds observed. Tr. at 13,061 (Fly). The data for observations reported at altitudes below 5,000 AGL[143] is set forth below:

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

PFS Exh. 245.

B.80 Based on the data collected by Mr. Vigeant, the State posits that the cloud coverage for Skull Valley represents a ceiling at 5,000 feet 12% of the time. State Findings ¶ 86. The State also asserts that a pilot's view of the Applicant's facility will be obstructed when cloud coverage is 50% or greater and there is a high probability it will be obstructed when the sky is 25% cloud covered. Horstman Post Tr. 4214, at 21-24; Tr. at 8377-84 (Horstman). As a result, it points out that a pilot will not be able to see the Applicant's facility at least 12% of the time and may

[143] Between 5,000 feet AGL and less than or equal to 14,000 feet AGL, the threshold elevation of the Sevier D MOA, the data collected by Mr. Vigeant showed that there were 31 observations of no clouds, 21 instances observed of few clouds, 18 instances of scattered clouds, 14 instances of broken clouds, and 11 instances of overcast conditions. Tr. at 13,060 (Fly); PFS Exh. 245. Some of the entries in the chart involved multiple layers of clouds at different altitudes. Tr. at 3060 (Fly); see, e.g. PFS Exh. 245 at 1 (Jan. 15, 2001 0900 entry).

not be able to see the facility up to 21% of the time. See State Findings ¶ 86. The State presented its own table, "Air Weather Service - Climatic Brief," that the State contends shows that there is greater than 50% cloud cover in Skull Valley 46% of the time at or below 12,000 feet AGL. See Horstman Post Tr. 4214, at 22; see also State Exh. 59 (Climatic Brief table).

B.81 In response, the Applicant contends that the State incorrectly interpreted the cloud data contained in the Climatic Brief table. Vigeant Post Tr. 3090, at 7. Mr. Vigeant testified that the Climatic Brief table relied on by the State indicates that there is greater than 5/10 cloud cover 46.3% of the time on an annual basis, but that it does not provide the altitude of the various cloud layers, and it does not state whether the cloud cover constitutes a "ceiling." Vigeant Post Tr. 3090, at 7. Ceiling height is the height of the lowest sky cover that results in cumulative opaque sky of more than half. Vigeant Post Tr. 3090, at 8. In contrast, sky cover is the amount of sky covered by clouds - - whether transparent or opaque. Vigeant Post Tr. 3090, at 8. Therefore, according to Mr. Vigeant, the Climatic Brief table, in referring to sky cover, does not provide any information regarding the frequency of occurrence or extent to which the sky in Skull Valley would be covered by opaque clouds. Vigeant Post Tr. 3090, at 9. Rather, the cloud cover observations were not made with respect to altitude, but, instead, were made on the basis of total sky coverage expressed in tenths. Thus, 2/10 sky cover at 1,000 feet AGL would be reported the same as 2/10 cloud cover at 20,000 feet AGL. Vigeant Post Tr. 3090, at 8.

B.82 For its part, the Staff argues that the data provided by the Applicant provides information regarding the fraction of the sky covered by opaque clouds and the altitude at which those clouds are located and, therefore, is more appropriate for an analysis of whether a pilot flying through Skull Valley would be able to locate visually a ground structure than the information provided by the State in its Climatic Brief table. See Staff Findings ¶ 2.381. Furthermore, the

Staff believes the Applicant's ceiling versus visibility chart supports a finding that the annual percentage of occurrence of "no ceiling" at or below 5,000 feet AGL, combined with a visibility of greater than or equal to 7 miles is 91.5%. See Staff Findings ¶ 2.381.

(b) Pilot Ability to Maintain Positional Awareness.

B.83 i. Pilot Ability to See in Cloud Cover. The Applicant argues that the presence of clouds, whether they constituted a ceiling or not, would not necessarily obstruct the pilot's view of the facility. That would depend on the relative positions and altitudes of the clouds, the pilot, and the facility. Cole/Jefferson/Fly Post Tr. 3061, at 52-55; Tr. at 13,032-36, 13,038-42, 13,095-96 (Fly). The Applicant's testimony showed in graphic form that where there is a ceiling, a pilot below the ceiling (and in some cases a pilot above) could see the facility with no difficulty. Cole/Jefferson/Fly Post Tr. 3061, at 53-55; Revised Addendum, Tab FF, Figs. 9-1 to 9-12. In fact, one of the accident reports describes how the pilot purposefully glided down through an overcast cloud layer, spotted farms on the ground, avoided them, and then ejected. See Tr. at 13,579-80 (Horstman); Joint Exh. 9 at 2, 13-14. Thus, the Applicant argues that even total cloud cover below a pilot might not prevent him from ultimately seeing the facility before he ejected. PFS Findings ¶ 131.

B.84 During the course of the hearing, the Licensing Board was presented with three visual demonstrations regarding the impact of cloud cover on the ability of a pilot to see objects on the ground. See Tr. at 8377-8385 (State demonstration); Tr. at 13,033-13,053 (Applicant demonstration); Tr. at 13,420-29 (second State demonstration). With respect to the first demonstration, Lt. Colonel Horstman placed Scrabble tiles across the top of a tablet of paper to depict clouds. Tr. at 8378 (Horstman). He covered 25% of the tablet with the Scrabble tiles to demonstrate scattered cloud coverage. Tr. at 8379 (Horstman). He testified when looking directly down from the top, a fairly significant portion of the tablet is visible, but when viewing at a ten degree angle, a small portion is visible. Tr. at 8380 (Horstman). The State argues that because clouds have vertical development and because a pilot's view of the ground is at an angle, a sky that is 25% cloud covered may completely block the pilot's view of the ground. Tr. at 8377-84 (Horstman). It points out that clouds are generally dense enough that they cannot be seen through. See State Findings ¶ 24. Even clouds referred to as "transparent" cannot be seen through by a pilot viewing the ground at an angle. Tr. at 8575-76 (Horstman). The State further argues that a single cloud may be positioned at any given time to preclude a view of the Applicant's site. Revised Addendum, Tab FF.

B.85 The Applicant's witness, Colonel Fly, disagreed that the State's demonstration with the Scrabble tiles accurately replicated what a pilot would see if flying over clouds in Skull Valley. Tr. at 13,032 (Fly).[144] He stated that cloud layering is an important consideration in seeing the ground. Tr. at 13,032-33 (Fly). To demonstrate cloud layering, Colonel Fly placed cardboard rectangles on clear plastic columns of varying heights. Tr. at 13,034-35 (Fly). He demonstrated conditions of cloud cover ranging from 25% to 75%. As an airplane moves, due to the different cloud heights, a pilot would be able to see a feature on the ground and will be able to see different parts of roads, buildings, and terrain features coming in and out of the pilot's view. Tr. at 13,036-41 (Fly). These reference features serve to update the pilot as to his physical location. Tr. 13,041 (Fly). The Applicant argues that cloud cover -- even at 75% -- does not preclude a pilot's general positional awareness of the area. Tr. 13,048 (Fly).

B.86 The State's witness agreed with respect to his demonstration that a pilot would have

[144] Because the tiles were laid directly upon the note pad, the demonstration did not accurately reflect the height of the clouds above the ground nor the height of the aircraft attempting to observe the facility. See Tr. at 13,041-43 (Fly). Because the note pad was blank, the Applicant argues that the demonstration did not capture the landmarks on the ground that a pilot could use to orient himself with respect to the facility even if he could not observe it directly. See PFS Findings at 113 n.102.

general situational awareness under conditions of 25% cloud coverage. Tr. at 8417 (Horstman). A pilot would be able to see portions of Skull Valley road and would be able to see portions of a rail line to the proposed facility. Tr. at 8417-18 (Horstman). Thus, Lt. Colonel Horstman agreed that generally speaking, a pilot flying above 25% cloud cover would have an idea of the location of the Applicant's site. Tr. at 8418 (Horstman).

B.87 With respect to the State's second demonstration, Lt. Colonel Horstman placed large styrofoam cups on top of plastic columns to demonstrate that cloud cover can be very difficult to see through. Tr. 13,420-21 (State second demonstration). Even in such a circumstance, however, Lt. Colonel Horstman agreed that a pilot would have a general idea of the location of the Applicant's facility. Tr. at 13,457 (Horstman). He further agreed that if 8/8 cloud cover is present below 5,000 feet AGL, the overcast would likely be too thick to fly under, and therefore, pilots would tend to fly above the clouds in the Sevier D MOA. Tr. at 13,456-57 (Horstman).

B.88 General Jefferson noted that training activities would likely not take place if heavy, floor-to-ceiling cloud cover were present, and, therefore, pilots would not be flying under those conditions. Tr. at 13,097-98 (Jefferson).

B.89 Lt. Colonel Horstman acknowledged that cloud cover above the pilot would not affect his ability to see the facility. Tr. at 8374-75, 13,456 (Horstman). The State asserts that a pilot flying beneath cloud cover, however, would not zoom the aircraft into clouds in the event of an emergency, a procedure used to gain more time, but, instead, may be forced to eject immediately depending on the altitude of the aircraft. Horstman Post Tr. 4214, at 21. The State points out that sky conditions above 5,000 feet through 14,000 feet in Skull Valley are overcast or broken (5/8 to 100% cloud covered) 23% of the time. PFS Exh. 245.

B.90 Lt. Colonel Horstman also testified, however, that a pilot would be able to zoom up to a point under the clouds. See Tr. 8425 (Horstman). Thus, if the clouds were at 3500 feet AGL, a pilot flying at 2500 feet AGL at 425 knots would zoom to 3400 feet and would have sufficient time to avoid the Applicant's facility. Tr. at 8423, 8426 (Horstman). Further, even if a pilot could not zoom, a pilot may nonetheless have time to avoid the Applicant's facility. In this regard, if cloud cover is present at 3500 feet, a pilot flying at 3000 feet should have approximately 15 seconds to glide from 425 knots to 200 or 225 knots without zooming. Tr. at 8403-04 (Horstman).

B.91 On a related matter, the State asserts that based on the Applicant's cloud layering data, if a pilot zoomed to the top of the Sevier D MOA, a significant amount of clouds would likely be below the aircraft that would impact the visibility of objects on the ground. Tr. at 13,418, 13,434-35 (Horstman).

B.92 In addition to cloud cover, the State asserts that the presence of ground fog may affect the ability of a pilot to avoid the Applicant's facility in an emergency. Horstman Post Tr. 4214, at 24. In this regard, the State claims that Utah often experiences severe ground fog in the wintertime. Horstman Post Tr. 4214, at 24.

B.93 In response, the Applicant argues that ground fog typically occurs in the morning hours and subsequently burns off. Tr. at 13,075 (Vigeant). Further, ground fog is a function of season, such that there are more occurrences of ground fog in the wintertime than in the summertime. Tr. at 13,113-17 (Vigeant). The weather data for Michael Army Airfield shows that the frequency of occurrence of ground fog is 2.5% of the observations on an annual basis. Tr. at 13,075 (Vigeant).

B.94 In the event that ground fog is present in Skull Valley, the Applicant points out that it could rise to heights in the tens of feet or the hundreds of feet, depending on the degree of cooling and the availability of moisture. Tr. at 13,111-12 (Vigeant). Thus, a pilot would be able to fly above the fog in the Sevier B and Sevier D MOAs. In such a case, a pilot would be able to maintain situational awareness by reference to the mountains, which would be visible above the fog, and would be able to use the F-16's onboard navigation systems. Tr. at 13,079-80 (Fly).

B.95 ii. Ability to Maintain Positional Awareness through Landmarks. In addition, the Applicant asserts, even clouds that obstructed a pilot's view of the facility would not deprive him of knowledge of his position relative to the facility. Tr. at 3288-90 (Fly). That knowledge is what the pilot needs to avoid the site. Tr. at 13,711 (Jefferson). He could use landmarks such as Skull Valley Road, the Applicant's railroad, and the Stansbury and Cedar Mountains to see where he was relative to the Applicant's site. Tr. at 13,038-41, 13,044-52 (Fly). Colonel Fly performed a demonstration at the hearing in which he showed that even with as much as 75% cloud cover, a pilot could see landmarks that would enable him to determine his position relative to the location of the facility. Tr. at 13,044-48 (Fly). Thus, the Applicant argues, pilots would be aware of the relative position of the PFS facility during an emergency due to the pilot's positional awareness maintained during the flight prior to an emergency or prior to a decision to eject. Cole/Jefferson/Fly Post Tr. 3061, at 53.

B.96 The State's witness, Lt. Colonel Horstman, asserts that use of the Stansbury or Cedar Mountains as reference points is unlikely to assist pilots in avoiding the Applicant's facility. Horstman Post Tr. 4214, at 25. In this regard, the State claims: (1) that it is improbable that a pilot could determine the location of the Applicant's facility in Skull Valley by reference to the mountain ranges and that, even if the location could be initially estimated, the location of the facility relative to the aircraft would be in constant change; (2) that a pilot would not attempt to head toward the mountains during an emergency because they are not safe places to eject; and (3) that the mountains themselves may be obscured by clouds and unavailable as visual reference points. Horstman Post Tr. 4214, at 25.

B.97 PFS witness Colonel Fly testified that a pilot would not necessarily have to be able to see the ground in order to avoid a site on the ground. Tr. at 3288-89 (Fly). Thus, the Applicant asserts, if a pilot can see a terrain feature, such as a mountain peak, the pilot will be generally aware that if he points the aircraft toward the mountain range, he will be clear of what he wants to avoid. Tr. at 3289-90 (Fly). With respect to Skull Valley, Colonel Fly testified that in cloud cover, the mountains in the vicinity of Skull Valley would give a "good general feel" for where the Applicant's facility was located and would be available as a guide even if the aircraft is operating under a completely solid undercast. Tr. at 3601 (Fly). Moreover, in order to use the mountains as a steering reference, according to the Applicant, a pilot would only need to make a small turn toward them. Tr. at 13,701-02 (Fly). Turning a few degrees toward either the Stansbury or Cedar Mountain ranges would be sufficient to miss the Applicant's site. Tr. at 13,700-02 (Fly).

B.98 With respect to Lt. Colonel Horstman's assertion that a pilot would not attempt to head toward the mountains during an emergency because they are not safe places to eject, PFS counters that a pilot would be able to use the mountains as a general situational awareness aiming point and would be able to eject in Skull Valley shortly after placing the aircraft on a glide path that would direct it into the mountains. See Tr. at 13,701 (Fly) (a pilot would use the mountains for positional awareness in order to avoid a ground site). Lt. Colonel Horstman agreed that if a pilot was pointing the aircraft at the mountains prior to ejection, it would be possible for the pilot to eject before the aircraft reached the side of the mountain and that the pilot would not have to wait until directly over the mountain peaks to eject. Tr. at 13,508 (Horstman).

B.99 With respect to the State's assertion that the mountains themselves may be obscured by clouds and unavailable as visual reference points, the Applicant notes that the evidence regarding clouds in Skull Valley indicates that such an occurrence in which all mountains ranges as well as the facility site would be obscured by clouds would be rare. See Revised Addendum, Tab FF. See also PFS Exh. W (describing the UTTR as having "excellent" weather and visibility.) As described in more detail below, however, the Applicant points out that pilots flying under such conditions would rely on navigational aids to maintain positional awareness.

B.100 iii. Ability to Maintain Positional Awareness through Navigational Tools. In addition to landmarks, the pilot would have available his navigational instruments, map, and flight plan to assist in determining his position relative to the location of the facility. Tr. at 13,049-52 (Fly).[145] According to the Applicant, even above a complete undercast, as he flew down the valley the pilot would be using instruments and his map and could refer to features like the mountain ranges, if visible, to maintain awareness of his position. Tr. at 3288-90, 13,052-53, 13,079-80 (Fly); 8479-80 (Horstman). These onboard navigation aids are: the Inertial Navigation System (INS), the Tactical Air Navigation System (TACAN), the Horizontal Situational Indicator (HSI), and, for those planes so equipped, the Global Positioning System (GPS). Cole/Jefferson/Fly Post Tr. 3061, at 51. During typical missions, pilots will use both visual references and onboard navigation systems together to maintain positional awareness. Revised Addendum, Tab FF at 28.

B.101 Inside the cockpit, the different instruments are physically mounted in a box, the glare shield. Tr. at 3114 (Fly). The heads up display (HUD) is mounted on top of the glare shield and consists of a thick piece of glass. Underneath the HUD, a projector generates symbology -- electronic green markings and images -- up from the bottom of the glare shield onto the HUD. A pilot can see through the symbology and glass HUD and out of the aircraft.

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[145] The relevant navigational instruments continue to show relative bearing and the distance to the pre-selected point after an engine failure. Tr. at 13,053-54 (Fly).

Tr. at 3114 (Fly). The target detection box (TD) is a green square that is projected onto the HUD and surrounds the selected steer point, a selected set of latitude and longitude coordinates. Tr. at 3114-15 (Fly). See Revised Addendum, Tab FF at 28. The TD box assists the pilot in finding the next geographical point on the planned route of flight for navigational purposes. Tr. at 3115 (Fly). Each steer point is programmed into the onboard INS, and the pilot selects which steer points he wants to use during a flight. Tr. at 3115, 13,049 (Fly) (steer points determined as part of mission planning). The INS can be used to navigate to or from the steer point or can be used to maintain awareness of the location of the steer point. Revised Addendum, Tab FF at 28. Colonel Fly noted that a pilot in Skull Valley would have a steer point programmed into the INS somewhere in the vicinity of the narrow neck of Skull Valley and would be able to figure out bearing and distance with respect to that point. Tr. at 3602 (Fly).

B.102 The F-16 is also equipped with the TACAN, which provides bearing and distance information from a selected ground station. Revised Addendum, Tab FF at 28. TACAN detects radio signals transmitted from different radio stations around the country, such as from Hill AFB, and will provide the pilot with the distance of the aircraft to the transmitting ground station. Tr. at 3289 (Fly). Thus, a pilot may know at any given time his position relative to Hill AFB. See Tr. at 3289 (Fly). In addition, some models of the F-16 are equipped with a GPS receiver, which uses the satellite navigation constellation to maintain positional awareness and makes the INS more precise. Revised Addendum, Tab FF at 28. The F-16 is also equipped with an onboard HSI, which displays distance and bearing to selected navigational steer points. Tr. at 13,050-51 (Fly). A pilot can use this equipment to maintain a ground track of the flight. Cole/Jefferson/Fly Post Tr. 3061, at 51; Campe/Ghosh Post Tr. 4078, at 23. As Colonel Fly explained, the HSI would enable a pilot to determine the aircraft's location relative to a visible course line that connects the various steer points. Tr. at 13,050-51 (Fly).

B.103 In any event, the Applicant points out that the route of flight would be thoroughly planned beforehand with turn points along the way that the pilot could use as a reference to determine his position. Tr. at 13,049-51 (Fly).

B.104 The State argues that a pilot cannot rely on navigation instruments to locate the Applicant's facility during an emergency. Horstman Post Tr. 4214, at 24. In this regard, the State asserts that during an engine failure, the precision of the navigation system is reduced, and the instruments will work on and off for short periods of time as the electrical system switches to the backup systems. Horstman Post Tr. 4214, at 24. Lt. Colonel Horstman testified that once the emergency power unit (EPU) comes up to speed, it takes more time to power the bus, which is "not instantaneous." Tr. at 8484 (Horstman). He also stated that once the HUD returns, some of the information available to pilots does not come back. Tr. at 8484 (Horstman). He agreed, however, that the HUD would continue to display the steer points. Tr. at 8486 (Horstman).

B.105 The Applicant counters that the HUD shuts down when the main generator shuts down and comes back as soon as the standby power system comes on line. Tr. at 3118-19 (Fly). The time in which the HUD is off during this time is approximately 2 seconds, which is "a very short period of time." Tr. at 3124, 3590 (Fly). The F-16 operating manual states that the emergency power unit is designated to operate automatically for main and standby generator failure "or if the engine is shut down in flight." Technical Order 1F-16C-1, at 1-94, (PFS Exh. OOO). Further "[a]fter receiving any start command, the EPU requires approximately 2 seconds to come up to speed." Technical Order 1F-16C-1, at 1-94. Colonel Fly also testified that the INS would still show the relative bearing and the distance to the selected turn point in the event of an engine failure. Tr. at 13,053-54 (Fly).

B.106 The Applicant maintains that the area around the facility is wide open so the pilot would not have to have a highly precise picture of its location in order to avoid it. Tr. at 13,711 (Jefferson) As discussed above, the only other buildings present near the facility are the Goshute village, about 3.75 miles east of the site, and two ranches, located 2.75 and 4.0 miles northeast of the site, and Tekoi (no longer in operation) two miles to the southeast. There are no structures of any kind to the west of the site. Aircraft Crash Report at 21-22.

B.107 (c) Pilot Ability to See Site During Emergency Procedures. In addition to cloud cover potentially limiting a pilot's ability to see the PFS facility, the State asserts that during an emergency zoom, a pilot's vision will be partially blocked so that he is unable to clearly see the facility. State Findings ¶ 96. The State asserts that a pilot flying straight and level in an F-16 can see only 11 degrees below the horizon before the nose of the aircraft obstructs the pilot's view. See State Findings ¶ 91. Therefore, a pilot flying through Skull Valley at 425 knots and 4,000 feet AGL would not be able to see the ground for a distance of over 4 miles in front of the aircraft. Tr. at 13,639-40 (Fly). Assuming a Skull Valley emergency caused by an engine failure, the State asserts that the task of a pilot includes the following events:

B.108 Upon realizing the engine has failed, a pilot will zoom the aircraft, trading speed for altitude to prolong the time aloft before crashing. Horstman Post Tr. 4214, at ¶ 61. During the zoom, the aircraft nose will be pointed 30 degrees nose high, blocking the view of the ground in front of the aircraft. Tr. at 13,080-81 (Fly). If the pilot had been flying at an altitude of 4,000 feet AGL, the State estimates the zoom would take the F-16 to approximately 7,000 or 8,000 feet AGL. Tr. at 13,453 (Horstman). In accordance with the F-16 flight manual, as the State points out, upon reaching the airspeed of 250 knots the pilot will end the zoom by "pushing the plane over" and start a descent. Tr. at 13,299-300 (Horstman). The maneuver of pushing the plane over uses some of the F-16's energy and the aircraft slows to approximately 200 knots. Tr. at 13,300-01 (Horstman).

B.109 The State estimates that the F-16 will then begin a glide at the speed of 200 knots with approximately a 6-degree angle of descent. Tr. at 13,301 (Horstman); see also Tr. at 13,641-42 (Fly). If the emergency occurred in the general area of Skull Valley, the State asserts the pilot would then turn the aircraft toward Michael Army Air Field, the designated emergency air field and attempt to restart the engine during the glide. Tr. at 8576-79, 8601-05, 8625-27 (Horstman). It points out that during the glide descending at 6 degrees, the pilot's view will be obscured in front of the aircraft for a distance of approximately 5,500 feet for every 1,000 feet of altitude. See State Findings ¶ 94. According to the State, as the aircraft continues on this glide path, the pilot will not be able to see ground terrain closer than 22,000 feet (4.16 miles), in front of the aircraft at the altitude of 4,000 AGL, nor closer than 13,750 feet in front of the aircraft at an altitude 2,500 feet AGL. Tr. at 13,639-42 (Fly).

B.110 The State asserts that upon reaching the altitude of 2,500 feet AGL, the pilot will slow the F-16 to the slowest possible speed in preparation for ejection. See State Findings ¶ 95. According to the State's witness, slowing the F-16 for ejection is done by raising the nose of the aircraft up to as much as 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. Tr. at 13,303 (Horstman). The F-16 will remain at as much as 20 degrees nose high until the pilot ejects. Tr. at 13,303 (Horstman). As a result, the State calculates that at the minimum ejection altitude of 2,000 AGL, the F-16 will be 3.22 miles from the crash impact site. Tr. at 13,612-13, 13,624 (Horstman).

B.111 The State further argues that after the pilot ejects, assuming the aircraft was correctly aimed, the aircraft would have to travel for over 3 miles without changing direction in order to crash at the selected site. However, if the pilot ejects at a slight bank, the aircraft's computer will hold that bank which will generate a turn in the F-16's heading. Tr. at 8525-26 (Horstman). Even if the aircraft is not initially in bank, an F-16 gliding from 4,000 feet AGL may roll and bank, causing it to deviate 10 to 20 degrees from its initial heading. Tr. at 4016-17 (Cosby). Simple trigonometry shows that an F-16 aimed at a ground site from 3.2 miles away which deviated off course by 10 degrees would miss its target by over one-half mile. In such a case, an aircraft aimed to crash one-half mile away from the Applicant's site may in fact hit the site.

B.112 The Applicant disagrees with the State's claim 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 the aircraft would be "substantially impaired." PFS Reply ¶ 144. First, PFS argues, the pilot would know where he was relative to the facility immediately prior to suffering the engine failure. Tr. at 13,053-54 (Fly). Second, 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. Tr. at 13,642-44 (Fly). Furthermore, the pilot has a larger field of view just to each side of the nose of the aircraft. Tr. at 13,640-41 (Fly). Thus, the pilot's view of sites on the ground that the aircraft might hit would not be obstructed.

B.113 PFS also contends that there is no requirement for a pilot to raise the nose of the aircraft 20 degrees above the horizon prior to ejecting. PFS Reply ¶ 145. According to the Applicant, the ejection procedures in the pilots' operation manual make no mention of raising the nose above the horizon. PFS Reply ¶145. The prescribed emergency procedure tells the pilot to eject at the "lowest practical airspeed." PFS Exh. PPP at 3-42, 3-43. Finally, a pilot would turn to avoid the facility 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 facility. Tr. at 3921 (Bernard), 3776-78 (Cole/Fly/Jefferson), 4026-27 (Cosby).

B.114 (8) Flight Controls. According to the Applicant, avoidance of the site would also be facilitated by the F-16 flight control computer, which keeps the F-16 on a straight course after the pilot ejects.[146] Aircraft Crash Report at 21; Tr. at 3507 (Jefferson), 3996-98; see Tr. at 4016-17 (Cosby). The computer will attempt to keep the aircraft flying at a constant altitude by increasing the angle of attack of the aircraft as it decelerates. Once the aircraft reaches a programmed angle of attack, the computer will hold that attitude and heading as the aircraft descends while maintaining that angle of attack. Aircraft Crash Report at 21. The aircraft will most likely impact the ground at a velocity between 170 and 210 knots at a point along the straight-ahead flight path from the point of pilot ejection. Aircraft Crash Report at 21; Tr. at 3096-99 (Fly). The aircraft may roll slightly about its longitudinal axis after the pilot ejects, but the flight path along the ground would remain basically unchanged. Tr. at 4019-20, 4025-26, 4029-30 (Cosby). This would be the case even with the aircraft canopy gone after the pilot ejects. Tr. at 3527 (Fly).

B.115 Applicant's Conclusion. Based on the above eight factors, the Applicant's expert panel concluded that "a pilot who remained in control of the aircraft after the event precipitating the crash would invariably take action to have the crashing F-16 miss the site." Aircraft Crash Report at 23; see Cole/Jefferson/Fly Post Tr. 3061, at 17. They found further support for this conclusion in the "F-16 accident investigation reports, which show that pilots do, when relevant, maneuver [the] aircraft to avoid sites on the ground." Nevertheless, to account for possible unforeseen circumstances they determined that a pilot in control of a crashing aircraft would be able to direct the aircraft away from the facility not all the time, but only 95% of the time. Cole/Jefferson/Fly Post Tr. 3061, at 17.

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

b. Evaluation of Accident Reports for Probability of Pilot Avoidance

B.116 (1) Applicant's Methodology. As discussed above, based upon its eight-factor evaluation of the time and circumstances involving likely emergencies that might occur while transiting Skull Valley, the Applicant's expert panel determined that "a pilot who remained in control of the aircraft after the event precipitating the crash would invariably take action to have the crashing F-16 miss the site." Aircraft Crash Report at 23; see Cole/Jefferson/Fly Post Tr. 3061, at 17. In addition, the Applicant's expert panel relied upon the accident reports for confirmation of their professional assessment. Cole/Jefferson/Fly Post Tr. 3061, at 17. The Applicant asserts that the accident reports showed that pilots in control of a crashing aircraft do in fact take necessary action to avoid sites on the ground after an accident-initiating event. Cole/Jefferson/Fly Post Tr. 3061, at 17. In addition, it points out that the accident reports showed no cases in which a pilot failed to take steps to avoid or minimize damage to facilities or populated areas on the ground. Cole/Jefferson/Fly Post Tr. 3061, at 17. Based on their review of the accident reports, the Applicant's panel believed that the percentage of pilots in control who would avoid the facility could reasonably be set at 100%. Cole/Jefferson/Fly Post Tr. 3061, at 17. Nevertheless, to account for possible unforeseen circumstances, they determined that a pilot in control of a crashing aircraft would be able to direct the aircraft away from the facility only 95% of the time. Cole/Jefferson/Fly Post Tr. 3061, at 17.

B.117 In response to questions from the Board, the Applicant's expert panel undertook a more formal evaluation of the accident reports for information concerning pilot avoidance. Tr. at 8662-63 (Jefferson). The evaluation focused on the F-16 accident reports for the 58 accidents that the expert panel initially determined were Skull Valley-type events in which the pilot retained control of the aircraft. See PFS Exh. 100A. Because many of the accidents occurred in military training areas with little or no civilian population, many of the accident reports do not contain any discussion of pilot avoidance because of the lack of populated or built-up areas that would require avoidance. Tr. at 13,107 (Jefferson). Therefore, in addition to direct evidence of steps a pilot may have taken or not taken to avoid populated or built-up areas, the Applicant's expert panel also looked at a pilot's maneuvering of the aircraft as indicating that he had situational awareness and knew where he needed to go, as well as the absence of actual damage on the ground caused by the impact as indicating that the pilot did not fail to take action to avoid a site or structure on the ground. See, e.g., Tr. at 13,106-07, 13,117 (Jefferson); 13,099-103 (Jefferson/Fly).

B.118 The Applicant's expert panel conceded that its evaluation of the accident reports was not a statistically-based evaluation. Tr. at 13,109-10, 13,121-22 (Jefferson). Rather, it was a qualitative evaluation of information in the reports relevant to the issue of pilot avoidance. Tr. at 13,118-24 (Jefferson/Cole). The Applicant argues that what is highly significant in this respect is that the reports show no instance in which a pilot failed to take steps to avoid or minimize damage to facilities or populated areas on the ground. PFS Findings ¶ 145.

B.119 The expert panel's evaluation of the 59 Skull Valley events in which the pilot retained control of the aircraft showed 17 instances where specific actions were taken by the pilot to avoid areas or structures on the ground after an accident-initiating event. Tr. at 8662-63 (Jefferson). In addition, the Applicant points out that the accident reports showed 29 cases in which the pilot turned toward an emergency airfield or took some other action indicating that he had situational awareness and knew where he needed to go. Tr. at 8662-63 (Jefferson). Finally, the remaining 13 accident reports showed no cases where the pilot had the opportunity to avoid a facility or populated area on the ground but failed to do so; in other words those reports showed no harm to people or structures on the ground. Tr. at 8662-63 (Jefferson).[147]

B.120 The Applicant asserts that the accident reports clearly confirm a key fact that all pilots have testified to in this proceeding -- that time and circumstances permitting, a pilot will avoid populated and built-up areas. PFS Findings ¶ 147. For example, a number of the reports show that the mishap pilot maneuvered the aircraft in order to avoid populated areas or particular structures and built up areas that were directly in their flight path. PFS Findings ¶ 147. The clearest example of this is the accident report involving Colonel Cosby as amplified by his personal testimony. The accident report succinctly states that: "Noticing a residential area in [his] flight path, [Colonel Cosby] made a 2-G left turn . . . ." PFS Exh. 79 at Bates No. 57619. The Board heard Colonel Cosby's testimony in particular that he saw an apartment complex in front of him and made a hard 180-degree turn to the left in order to avoid it. Tr. at 3980-81(Cosby). The Applicant argues that a 180-degree turn reversing direction is clearly much more than would be required for a pilot to turn and avoid the facility. PFS Findings ¶ 147. In addition, as Colonel Cosby was attempting to land he saw another plane on the taxiway on which he was trying to land and again maneuvered his aircraft ("put[ting] the airplane off in the infield") to avoid the plane. Tr. at 3980-81 (Cosby).

B.121 The Applicant argues that in addition to the reports stating explicitly that the pilot avoided an area on the ground, 29 other reports showed cases in which the pilot turned toward an emergency airfield or took some other action indicating that he had situational awareness and knew where he needed to go. Tr. at 8663 (Jefferson). Those cases show that the pilots knew where they were and acted accordingly in the event of an emergency, whether turning

[147] While the reports are required to indicate any damage or injuries on the ground, they are not required to report pilot avoidance actions. Tr. at 3661 (Cole). Thus, a case with no damage but no mention of pilot avoidance might or might not have been a case in which the pilot avoided something; the only thing such a case indicates is that the pilot did not fail to avoid something. Tr. at 3661, 3663-64 (Cole); 3670 (Jefferson).

toward an emergency airfield, away from a populated area, or both. Tr. at 13,102 (Fly). In the June 7, 1996 accident, the report specifically states that the pilot made an “instinctive” turn back towards his home base when the incident began. Joint Exh. 9 at 2. In the April 18, 1991 accident, “[t]he mishap pilot immediately zoomed the aircraft, turned toward home base and initiated engine airstart procedures.” PFS Exh. 127 at Bates no. 57137. In the September 11, 1993 accident, “During a pull up after the third bombing pass, Bronco 3 experienced a momentary airframe vibration which stopped, then reappeared moments later on the base turn. [He] terminated the bomb pass and began a climb towards the emergency divert field.” PFS Exh. 158 at 1. According to PFS, these are just a few examples in the reports which clearly show that the pilots have an awareness of where they are and what needs to be done in the event of an emergency.

B.122 Finally, the Applicant points out that, although the remaining 13 accident reports did not state whether the pilot maneuvered, they reported no harm to people or structures on the ground, i.e., they showed no cases where the pilot had the opportunity to avoid a facility or populated area on the ground but failed to do so. See Tr. at 8663 (Jefferson); see also PFS Exh. 100A.[148] While this last group of reports contains less explicit information than the first two, the Applicant says the point they stand for is important. Arguing that if the probability of failure is defined as one minus the probability of success, the Applicant posits that because the reports show no cases of failure to avoid, they support a finding that the probability of successful avoidance is 100%. Tr. at 13,117 (Jefferson); Aircraft Crash Report, Tab H at 28 n.22.

B.123 The Applicant also indicates that the accident reports highlight the assistance provided the accident pilot by his wingman (or in one case air traffic control) in terms of directing the

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[148] Accident reports must cover damage or injuries on the ground. See fn. 147, above.

aircraft away from structures and facilities on the ground and other aspects of responding to the emergency. PFS Findings ¶ 154. Colonel Fly testified that he would expect other flight members to alert a pilot of an aircraft with a problem to the location of the facility or any other area to avoid. Tr. at 13,658-59 (Fly). His testimony is supported by the accident reports describing flight members (and in one case an air traffic control) helping pilots respond to their emergencies and avoid areas on the ground.[149] Therefore, because F-16s typically transit Skull Valley in flights of two or four aircraft, there is additional reason to believe that a pilot would be able to avoid the facility in the event of an accident.

B.124 (2) State Challenge. With respect to the Applicant's review of 126 U.S. Air Force F-16 mishap reports for the ten-year period 1989 through 1998 and the 58 reports identified in PFS Exh.100A, the State argues that even before reviewing the reports, the Applicant had already concluded that 95% of pilots would be able to avoid the Applicant's site, Tr. at 3967 (Jefferson), and that the reports were reviewed and PFS Exh. 100A was prepared to justify the 95% component of the "R" factor. Tr. at 13,100 (Jefferson).

B.125 The State further challenges the use of the reports on the basis that Air Force mishap reports are not prepared for the purpose of determining if the pilot avoided a ground site or could be counted on to avoid a ground site, a fact that the Applicant acknowledges. Tr. at 13,118 (Jefferson). Air Force regulations requiring when and how mishap reports are prepared do not include guidance on the subject of the pilot's avoidance of a ground site. Tr. at 13,119 (Jefferson); State Exh. 60, Chapter 8.

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[149] See, e.g., Joint Exh. 3 at Bates no. 57126 (assistance with location of emergency airfield); Joint Exh. 5 at 2 (assistance with location of airfield); Joint Exh. 10 at 3-4 (location of airfield, safe location to jettison fuel tanks); Joint Exh. 11 at 3 (vector to clear area from air traffic control); Joint Exh. 14 at 3 (altitude and navigation assistance); Joint Exh. 15 at 3 (assistance clearing impact area of boats).

B.126 The same 58 crashes shown in PFS Exh.100A as examples of where "the pilot retained control and had enough time to avoid a specific site" were reviewed extensively by Lt. Colonel Horstman. Tr. at 13,362-66 (Horstman). Contrary to the Applicant's findings, Lt. Colonel Horstman's review of those 58 crashes shows that in no case did a pilot identify a specific ground site from the minimum ejection altitude of 2,000 feet and take some maneuver to avoid it. State Exh. 223,[150] Tr. at 13,370-92, 13,407-10, 13,445-47 (Horstman). According to the State, the pilot task contemplated by the Applicant's avoidance factor, the identification of a ground site from a distance of 3.22 miles or more, and turning away from that sight did not happen a single time during the ten-year period reviewed by the Applicant. Id.; State Exh. 223.

As may be seen from the above, the Applicant made a commendable attempt to demonstrate that there were no insurmountable obstacles to pilots succeeding in the site avoidance behavior upon which the Applicant's case depends. But the Applicant's showing could not overcome the State's countering showing that, first, in some circumstances obstacles would exist, and that second -- and more important -- accident experience, recognized in Air Force directives and memorialized in crash reports, establishes beyond doubt that human beings, under stress, fail even though the conditions for success exist.

Accordingly, we cannot find otherwise than that the Applicant's claim of near certain success in human performance under stress-filled conditions was simply not proven. As we said at the outset of this Subpart, we find that in light of the whole of the evidence the State presented -- covering a number of different problem areas and pointing to Air Force acknowledgment of pilot error -- the Applicant failed to carry its burden on its assertion that pilots would, before ejecting, almost invariably (95% of the time) act affirmatively to guide their

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

aircraft away from striking the PFS facility in the event of an impending crash. In short, in view of the totality of the evidence presented by the parties, the Applicant has not sustained its claim that pilots will successfully avoid the site in virtually every instance.

C. Four-Factor Formula

In this final Subpart, we address the many disputes among the parties as to the values that should be used for the standard factors that make up the classic NUREG-0800 formula. Again, a central message is that for three of those factors, the data that exist are largely not directly on point, and the values for the factors have to be derived indirectly from such data. Many of the disputes, then, turn on what is the most appropriate way to conduct those derivations.

1. Background

C.1 In accordance with the review guidelines described in NUREG-0800, Section 3.1.5.6, “Aircraft Hazards,” the Staff reviews all potential aircraft activity in the vicinity of a nuclear facility, such as a reactor or an away-from-reactor spent fuel storage site. Campe/Ghosh Post Tr. 4078, at 7. This review includes the consideration of general, commercial, and military aviation. Campe/Ghosh Post Tr. 4078, at 7. The review covers specific aviation aspects such as nearby airways and airports, taking into account aircraft types, air traffic density, and specific airway and airport characteristics. Campe/Ghosh Post Tr. 4078, at 7.

2. Formula

C.2 The formula for calculating aircraft crash probability for nuclear facilities is

$$P = C \times N \times A/w$$

where P is the annual probability of an aircraft crash and the four factors represent, respectively, the C̲rash rate (per mile), the N̲umber of flights (per year), the A̲rea of the facility (in square miles), and the w̲idth of the airway (in miles). There is no dispute among the parties -- apart from that over the R factor -- that this formula is an appropriate method for calculating the aircraft crash hazard for the proposed facility. The governing Commission criterion, established in this case, allows a facility like this one to be licensed if the calculated probability of an aircraft crash on the site is less than one in a million (1×10^{-6}) annually.

3. Basic Disagreements

C.3 The State disputes the numerical values the Applicant and the Staff would assign to three of the four factors required by the NUREG-0800 equation. The disputed factors are Crash rate (C); Number of aircraft (N); and Width of airway (w). According to the State, both the Applicant and Staff have selected values for these parameters which are incorrect and result in estimates of annual crash probability on the PFS site which are low.

C.4 There is no dispute among the parties regarding the fourth factor, which specifies the effective area of the PFS site. All parties accept the area determined by the Applicant (1.337 square miles) as the appropriate value. The Board has reviewed that determination and we accept it as reasonable.

4. Input Values

a. Crash Rate Per Mile (C)

C.5 The Applicant believes the crash rate of F-16s to be 2.736 x 10^{-8} per mile for normal in-flight mode. Cole/Jefferson/Fly Post Tr. 3061, at 16. In deriving this number, the Applicant took an average of the crash rates for the F-16 in normal in-flight operations over the ten-year period from FY 89 to FY 98. Cole/Jefferson/Fly Post Tr. 3061, at 16.

C.6 The Applicant derived its F-16 crash rate by combining the data obtained from a DOE study with the mishap rates obtained from the Air Force. Campe/Ghosh Post Tr. 4078, at 11. The DOE study is entitled, "Data Development Technical Support Document for the Aircraft Crash Risk Analysis Methodology (ACRAM) Standard," Kimura, et al. (1996) (ACRAM Study). The ACRAM Study provides F-16 crash rate data for the period from 1975 through 1993. ACRAM Study at 4-1. See Campe/Ghosh Post Tr. 4078, at 11. The ACRAM Study categorizes the crash rate data according to four modes of flight -- take off, landing, normal in-flight, and special operation. ACRAM Study at 4-4. After reviewing the four different modes of flight, the Applicant concluded that normal in-flight mode was the category that best represented the conditions in which F-16s transit Skull Valley. Campe/Ghosh Post Tr. 4078, at 11-12. Normal in-flight includes "climb to cruise, cruise between an originating airfield and an operations area, if applicable, and cruise descent portions" of flight. ACRAM Study at 4-5. According to the ACRAM Study, the per mile crash rate for F-16 normal in-flight is 3.86 x 10^{-6}. ACRAM Study at Table 4.8.

C.7 Because the ACRAM Study did not contain crash rate data for the years after 1993, the Applicant turned to data obtained from the Air Force to provide crash rate data for the second half of its ten-year period. See Aircraft Crash Report at 8-11; SER at 15-52. The Air Force maintains mishap rates categorized in terms of the number of crashes per 100,000 hours of flight for each type of aircraft. SER at 15-52. The Applicant used the Air Force mishap rates for 1994 to 1998 to update the data for the ACRAM Study in order to create a complete data set for the ten-year period from 1989 to 1998. Aircraft Crash Report at 9.

C.8 Because the NUREG-0800 formula requires an in-flight crash rate per mile and the Air Force mishap data is expressed per 100,000 hours of flight, the Air Force data must be converted to a crash rate per mile to be used in the formula. PFS used the data set forth in the ACRAM to obtain an average flight speed to be used for this conversion. Aircraft Crash Report, Tab C, D. The ACRAM document contains mishap data and the estimated milage and number of flight hours for F-16s during years 1975 through 1993. Aircraft Crash Report at 10, Tab C, D. Using this ACRAM data, PFS divided the total miles by the total hours to obtain an average flight speed of 471.85 miles per hour flown by F-16s during years 1975 through 1993. Aircraft Crash Report, Tab D.

C.9 The Air Force mishap data are also not separated into the various phases of flight, i.e., takeoff, landing, special operations and normal flight. Therefore, the Applicant was forced to further manipulate the Air Force data to ensure that only "normal flight" data was used in its crash rate calculation. To do so, the Applicant estimated the percentage of all mishaps occurring during "normal flight" and applied that percentage to the Air Force data. Aircraft Crash Report at 11-14, Tab D. The Applicant based its estimate on the ACRAM data which contain both Class A and Class B mishaps from 1975 through 1993, separated into the four phases of flight: takeoff, landing, normal flight and special operations. Aircraft Crash Report, Tab C, D. The Applicant divided the number of mishaps shown in the ACRAM data for "normal flight" by the total mishaps for all F-16 flights, obtaining 15.09% as the percentage of F-16 mishaps occurring in "normal flight" during years 1975 through 1993. Aircraft Crash Report, Tab C, D. Similarly, the Applicant estimated the flight miles occurring during normal flight by dividing the number of "normal flight" F-16 miles shown in the ACRAM data by the total F-16 flight miles, obtaining 47.18% of flight miles occurring during the "normal" phase of flight. Aircraft Crash Report, Tab C, D at 1.

C.10 The Applicant used the average speed of 471.8 miles per hour, 15.09% as the percentage of mishaps occurring during "normal flight," and 47.18% of all flight miles occurring in the "normal" phase to derive a "normal flight" crash rate per mile from the Air Force mishap data. Aircraft Crash Report, Tab C, D at 2. The Applicant calculated a crash rate using Air Force F-16 mishap data for the ten-year period 1989 through 1998, obtaining a crash rate of 2.736×10^{-8} per mile. Aircraft Crash Report at 11, Tab D. The Applicant chose this particular ten-year period because, given the downward trend in crash rate demonstrated by the data, it believed that the data for this time period best represented the actual crash rate. Aircraft Crash Report at 11.

C.11 The State argues that the mishap data for the ten-year period used by the Applicant produces the lowest ten-year average crash rate in the history of F-16. Resnikoff Post Tr. 8698, at 15. Further the State points out that the years 1995 through 2001 show an increasing trend in F-16 crash rates. See State Findings ¶ 34 (citing State Exh. 155). In that regard, the State insists that no objective basis is given by the Applicant as to why the years 1989 to 1998 were chosen as the basis for a crash rate; rather, the decision was admittedly subjective. Thus, the State insists that it is neither reasonable nor conservative to base the F-16 crash rate on data from the ten year period 1989 through 1998. See State Findings ¶ 34.

C.12 According to the State, the annual crash rate for the F-16 has varied substantially from 1975 through 2001. The State believes that the initial years of service through 1983 show a period of comparatively high accident rates. Furthermore, the State contends that every fighter aircraft the Air Force has ever had shows the phenomenon of higher crash rates in initial years. Moreover, the State also asserts that the Applicant's Aircraft Crash Report shows higher crash rates for single engine fighter aircraft even after they have been in service for 100,000 hours. See State Findings ¶ 35. The F-16 is expected to be replaced in 2010, and the replacement aircraft is expected to also have a higher start-up crash rate. Tr. at 3371-72 (Cole), at 3367-68 (Jefferson). During the most recent seven years for which data are available, the State argues that there is an increasing trend in F-16 crash rates. See State Findings ¶ 35 (citing State Exh. 155; Tr. at 8944-45 (Campe); Resnikoff Post Tr. 8698, at 11-12). According to the State's experts such a trend is common, because crash rates for fighter aircraft are typically higher at the beginning and at the end of an aircraft's service life. Thus, the State argues that using the mishap data for all available years that an aircraft has been in service is the best predictor of the aircraft's future crash rate. Horstman Post Tr. 4214, at 13-14. The State argues that even in the case of an apparent trend of decreasing crash rates, which is not the case here, it would not be reasonable to limit the database, and all years of data should be used. See State Findings ¶ 35. In that regard, the State points out that the database used for the ACRAM technical support document used all years of crash history and did not attempt to select or omit certain years of crash history for the F-16 or other aircraft. Resnikoff Post Tr. 8698, at 9. Thus, the State insists 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. See State Findings ¶ 35.

C.13 Using the average flight speed of 471.85 miles per hour, the ratio of 15.09% mishaps occurring in "normal flight" and the ratio 47.18% of miles flown in "normal" phase of flight, but using the Air Force F-16 Class A and B mishap data for years 1975 through 2000, the State derives a crash per mile for normal flight of 3.39×10^{-8}. Resnikoff Post Tr. 8698 at 15; State Exh. 76. Furthermore, the State notes that by adding the F-16 Class A and B mishap data for 2001 shown on State Exh. 154, i.e., 22 mishaps and 337,315 flight hours, to those same calculations increases the crash rate per mile for normal flight to 3.44×10^{-8}. Therefore, the State argues that at a minimum using a value for C, in-flight crash rate per mile for aircraft using airway, of less than 3.44×10^{-8} crashes per mile is not realistic. See State Findings ¶ 36.

C.14 The State also attacks the Applicant's decision to include only the normal flight phase of flight in its crash rate calculation. 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). The State calculates a fraction of destroyed aircraft accidents in the normal phase of flight for the period FY89 to FY98 of 22.3%, 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. 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 Findings ¶ 30.

C.15 Furthermore, the State argues that the problems with the Applicant's crash rate are compounded by its use of the ratio of 15.09% of all Class A and B mishaps to determine the number of mishaps occurring in "normal" flight. Aircraft Crash Report, Tab D. According to the State, this ratio of 15.09% was derived from ACRAM data which divided mishaps into the four phases of flight without indicating whether a mishap was a Class A or B mishap. Aircraft Crash

Report, Tab C, D. The State contends that a second ratio for normal flight mishaps was obtained when the Applicant analyzed 121 destroyed F-16 crashes during the ten-year period 1989 through 1998, and determined that 27 of those crashes (22.3%) occurred in the "normal" phase of flight. Resnikoff, Post Tr. 8698 at 15 (citing Aircraft Crash Report Tab H at 12). Because of the unknown distribution of Class A and B mishaps between the various phases of flight in the ACRAM study, and because of its comparatively older data, the State argues that the ratio indicating that 22.3% of all destroyed aircraft are destroyed in normal flight phase, when applied to the number of total destroyed F-16s, is the best evidence on which to base an estimate of F-16 mishaps occurring in the "normal" flight phase. See State Findings ¶ 37.

C.16 Therefore, using the average flight speed of 471.85 miles per hour, the ratio of 22.3% for destroyed F-16s occurring in "normal flight" and 47.18% of all flight miles occurring in the "normal" phase of flight, the State has determined the crash rate per mile for normal flight based on lifetime F-16 mishap data[151] is 4.10×10^{-8}. This value was obtained as follows:

> 6,644,260 hours x 471.85 = 3.135×10^{9} miles.
>
> 3.135×10^{9} miles x 47.18% = 1.479×10^{9} miles in normal flight.
>
> 272 destroyed aircraft x 22.3% = 60.66 destroyed F-16 mishaps during normal flight.
>
> 60.66 mishaps/1.479×10^{9} "normal" flight miles = 4.10×10^{-8} crashes per mile.

Thus, the State insists that the realistic crash rate for the F-16 to be used as the value for C, the "inflight crash rate per mile for aircraft using airway," is 4.10×10^{-8}. See State Findings ¶ 38.

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

C.17 We do not accept the State's crash rate. It is higher than the F-16 lifetime crash rate for normal operations of 3.86 x 10^{-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 Crash Report, Tab D; Resnikoff Post Tr. 8698, at 14-15. Further, both the Applicant's expert panel and Lt. Colonel Horstman agree that the overall crash rate 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. See Cole/Jefferson/Fly Post Tr. 3061, at 27-31; PFS Exh. Q; Tr. at 4376-77 (Horstman). Therefore, even assuming the use of a lifetime rate were appropriate, the current lifetime rate should be lower than that calculated based on the data through 1993, not higher as the State now argues for the first time.

C.18 We find 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 provides a breakdown only 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 FY 89 to FY 98. Since ACRAM looked at Class A mishaps and Class B mishaps together and the Applicant's assessment looked only at destroyed aircraft, a comparison of ACRAM data to the Applicant'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.

C.19 Further, we find no support for the State's reliance upon the ratio for destroyed aircraft used by the Applicant in Tab H of the Aircraft Crash Report (22.3%) to derive what it believes is a conservative crash rate. The State's approach is incorrect because the Applicant'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, the Applicant for this purpose included some borderline accidents as being in the normal phase of flight (e.g., the accident of May 25, 1990), which increased the number of normal phase accidents at the expense of the other categories. If the Applicant'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. See Aircraft Crash Report, Tab H.

C.20 In sum, we find the State's new crash rate, of 4.10×10^{-8}, to be inappropriate for the following reasons. First, as noted above, this is higher than the lifetime crash rate for the normal phase of flight as of 1993 of 3.86×10^{-8}, which is illogical for the reasons explained. Second, as also discussed above, when it calculated the fraction of F-16s destroyed in the normal phase of flight from FY 89 to FY 98 (22.3%), the State included accidents that could not have occurred in Skull Valley.

C.21 Further, we find the State's suggestion that the Applicant had chosen the "lowest" ten-year crash rate ever for the F-16, e.g., Tr. at 8843-44 (Soper), as a basis for its crash rate to be unfounded. A careful review of the data demonstrates that inclusion of the crash rate data for subsequent years (FY 99 to FY 01) would have practically no effect on the crash rate. Tr. at 3726-33 (Jefferson); PFS Exh. UUU. Focusing just on Class A mishaps, as of FY 98, the ten-year average crash rate was 3.54 mishaps per 100,000 flight hours. The ten-year Class A mishap rate went up slightly to 3.67 and 3.62 for the ten years ending with FY 99 and FY 00, respectively. However for FY 01, the ten-year Class A mishap rate fell to 3.53, slightly below that for the ten-year period used by the Applicant. Cole/Jefferson/Fly Post Tr. 3061, at 27. Similarly, the most recent ten-year crash rate for destroyed aircraft (3.37 per 100,000 flight hours) is slightly below that for the ten-year period used by the Applicant (3.46 per 100,000 flight hours). PFS Exh. UUU. Taking an average for the last 13 years, the rates for both Class A mishaps and destroyed aircraft are within 2% of the rates for the ten-year period used by the Applicant. PFS Exh. UUU. Thus, the inclusion of more recent data (created after the Applicant computed its crash rate) would have little or no impact on the analysis.

C.22 The State claimed that the crash rate relevant to Skull Valley will go up in the future because the F-16 crash rate is going up due to the "bathtub effect" related to the aging of the aircraft. See Resnikoff Post Tr. 8698, at 9; Tr. at 8788 (Resnikoff). While State witness Dr. Resnikoff claimed that the F-16 was exhibiting the "bathtub effect" and that its crash rates were going up, it was shown on cross-examination and in the NRC Staff's rebuttal testimony that Dr. Resnikoff chose a period of analysis in a highly selective manner that improperly found an upward trend in rates. See Tr. at 8750-77, 8782-88, 8806-13, 8817-18 (Resnikoff), 8886-92, 8899-8903 (Campe/Ghosh). Furthermore, even Lt. Colonel Horstman admitted that accident rates appeared to have been level over time since the mid-1980s and that the F-16 was not currently exhibiting an end-of-life bathtub effect. Tr. at 4376-77 (Horstman); State Exh. 52.

C.23 In fact, careful examination of F-16 crash rates, in particular that of the F-16A which is the first of the F-16 models to be retired from service, as well as the crash rates of other recently retired fighter aircraft at the ends of their service lives, shows no end-of-life bathtub effect. The crash rates have remained the same near end of life or decreased with time. Tr. at 3376-77 (Jefferson); Cole/Jefferson/Fly Post Tr. 3061, at 28-31; PFS Exh. Q, R, S, T, U, V.

C.24 Particularly instructive is the end of life crash rate for the F-16A. The F-16A was the first model of the F-16. Most of them have now been retired. Over the past five years, the five-year and ten-year average accident rates for the F-16A have remained flat. Cole/Jefferson/Fly Post Tr. 3061, at 28-29; PFS Exh. R. Thus, the F-16A is not exhibiting a bathtub effect and there is no reason to believe that other models of the F-16 will exhibit a bathtub effect. Cole/Jefferson/Fly Post Tr. 3061, at 29.

C.25 The State's experts also claimed that the crash rate for the aircraft that will replace the F-16 in the future, most likely the F-35 Joint Strike Fighter ("JSF"), will be higher in the beginning of its lifetime. Thus, Lt. Colonel Horstman argued for the use of the lifetime crash rate of the F-16, including the early years when the crash rate was very high, as a surrogate for the presumed high early crash rate for the JSF. Horstman Post Tr. 4214, at 14. However, the Applicant's expert panel convincingly explained why the JSF's crash rate, assuming it were to come to Hill AFB, would be significantly lower than the crash rate of the F-16 early in its lifetime.

C.26 First, over the history of the Air Force, the aggregate crash rate has steadily decreased over time. Tr. at 8656 (Fly); PFS Exh. 82. For example, Air Force-wide destroyed aircraft rates in 1998 were one-fourth of what they were 35 years ago. <u>See</u> PFS Exh. 82. Lt. Colonel Horstman acknowledged in this respect that "typically every few years" the Air Force crash rate goes down because "they build better planes." Tr. at 4398-99 (Horstman). In addition, better pilot selection and training, better maintenance practices and procedures, and better analytical tools and better technology are further factors that have resulted in the continual reduction of military aircraft crash rates over time. Cole/Jefferson/Fly Post Tr. 3061, at 32.

C.27 Second, approximately 35 years will elapse from the introduction of the F-16 in 1975 to the planned introduction of the JSF in 2010. The increased skill and technology in designing better aircraft, the improved maintenance practices and procedures, and the better pilot selection and training over these 35 years should result in a lower crash rate for the JSF than for the F-16. Tr. at 3369 (Jefferson), 3370-71, 3377-78 (Cole); Tr. at 4398-4401 (Horstman). This expectation is strongly supported by the history of single engine jet fighter aircraft, which shows that initial crash rates for single engine jet fighters have steadily decreased over time. Tr. at 3370-71 (Cole).

C.28 Third, it would be particularly inappropriate to use the lifetime crash rate average for the F-16, including the early years when the crash rate was very high, as a surrogate for the presumed high early crash rate for the JSF, because the F-16 was originally a technology demonstration program, which led to a higher initial crash rates than one would expect from a more traditionally managed program like the JSF. Tr. at 8657 (Fly).

C.29 Fourth, Hill AFB would not receive the first JSF aircraft, which would be expected to experience the somewhat higher initial crash rates of a new aircraft. The Marine Corps will receive the JSF before the Air Force, and the first Air Force JSFs will likely be deployed elsewhere than at Hill AFB. Tr. at 8656-57 (Fly); see Tr. at 3372 (Cole). Furthermore, initial crash rates are based on fewer accidents and lower numbers of flying hours, both of which would translate into lower numbers of flights through Skull Valley. Cole/Jefferson/Fly Post Tr. 3061, at 32.

C.30 We are relatively confident in relying on existing F-16 crash rates because long term trends are indicating a downward trend and no break-in flights will take place in Skull Valley, with other branches of the service to take delivery before the Air Force does. In any event, we note that use of the lifetime crash rate average for the F-16, excluding the early years when the break-in crash rate was very high, would yield a value reasonably consistent with the ten-year crash rate the Applicant put forward.

b. Number of Flights (N)

C.31 The dispute between the parties about the proper value for N, the "number of flights per year along the airway," involves two principal issues: (1) whether, as the State says, F-16s that fly through Sevier D should also be included in the value for N; and (2) whether, as the Applicant says, a two-year average for the number of F-16s traversing Skull Valley should be used for N, as opposed to using only the most recent year's data, as the State would do.

C.32 The Applicant projected the future number of flights per year along the airway, N, to be 5,870 flights. That number is derived from an average of the annual number of F-16 sorties through the Sevier B MOA for FY 99 and FY 00, increased proportionately for additional aircraft stationed at Hill AFB beginning in FY 01. See Cole/Jefferson/Fly Post Tr. 3061, at 18.

C.33 The State and the Staff, however, have obtained a different result by utilizing the most recent sortie data from FY 00 only, as well as using all of the flights occurring in both Sevier B and D, which is how the data are reported by the Air Force.

C.34 The Applicant used Sevier B MOA usage reports because, according to the Air Force, they are representative of the number of F-16 flights through Skull Valley. Revised Addendum at 2-5 & n.7. Based on these usage reports, the Applicant contends that in FY 99, 4,250 F-16s transited Skull Valley and in FY 00, 5,757 F-16s transited Skull Valley. Cole/Jefferson/Fly Post Tr. 3061, at 18. This is a two-year average of approximately 5,000 flights annually. Cole/Jefferson/Fly Post Tr. 3061, at 18.

C.35 The Applicant claims that the number of F-16 flights through Skull Valley in FY 99 and

FY 00 reflects current Air Force operations and the normal fluctuations in the number of sorties flown annually. Cole/Jefferson/Fly Post Tr. 3061, at 18-20. It points out that there are several reasons for the higher number of Skull Valley sorties in FY 00. First, the Air Force experienced fewer overseas deployments of aircraft (which take them away from their home bases) in FY 00. The Air Force formally adopted the Air Expeditionary Force ("AEF") concept, which began a new policy for overseas and other deployments of Air Force units away from their home bases, and initially implemented it in October 1999 (FY 00). Cole/Jefferson/Fly Post Tr. 3061, at 18-20. The AEF's purpose is to make more equal and regular the on-going deployment of Air Force units from their home bases of operations which reduces the amount of time spent away from the home base of operations. Cole/Jefferson/Fly Post Tr. 3061, at 19. The net effect relevant here was to generally increase the amount of training time available for units at their home bases when they are not deployed relative to what they had prior to FY 00. PFS Findings ¶ 56. In addition, the Applicant notes that fewer aircraft were deployed overseas in FY 00 because deployments to areas like Bosnia, Kosovo, and the Persian Gulf tapered off toward the end of FY 99. Cole/Jefferson/Fly Post Tr. 3061, at 19. Thus, the Applicant argues that the average sortie counts for FY 99 and FY 00 provide a reasonable baseline for estimating future sortie counts in Skull Valley. Cole/Jefferson/Fly Post Tr. 3061, at 20.

C.36 To project the future number of annual flights, the Applicant used the average of the FY 99 and FY 00 sortie counts of 5,000, increased proportionately to 5,870 flights to reflect the authorized increase in the number of F-16s at Hill AFB in FY 01. The combined number of F-16 aircraft (active plus reserve) assigned to Hill AFB has increased in FY 01 from 69 to 81, for an increase of 17.4%. Cole/Jefferson/Fly Post Tr. 3061, at 20-21. Assuming the same Skull Valley sortie rates per F-16 as determined above, the 12 additional F-16s would also increase the number of F-16 sorties through Skull Valley by 17.4%. Cole/Jefferson/Fly Post Tr. 3061, at

20-21.

C.37 The Applicant asserts that FY 2001 data on the number of flights through Skull Valley support the foregoing approach for projecting future sortie counts. According to the Sevier B MOA usage report for FY 01, 5,046 flights transited Skull Valley. Tr. at 13,017-19 (Cole). If that total were adjusted to account for the effect of the additional F-16s at Hill being there the entire year (as opposed to the half year they were present), the total would have been 5,435. Tr. at 13,019-20 (Jefferson). This is below the Applicant's projection of 5,870. Tr. at 13,017 (Cole), 13,020 (Jefferson). The Applicant argues that the unreasonableness of using the atypically high sortie rate of FY 00 as the basis for future projections is demonstrated by the FY 01 sortie count which was somewhat below the average of the FY 99 and FY 00 sortie counts. Tr. at 13,020-21 (Jefferson).

C.38 The Applicant also argues that it would be unreasonable to use the combined Sevier B and Sevier D sortie counts as the basis for future projections as argued by Lt. Colonel Horstman. As discussed above, the Air Force has stated that the Sevier B sortie count is representative of the traffic through Skull Valley. The Sevier D MOA airspace does lie directly above Sevier B. Because the Sevier B and Sevier D MOAs extend to the far southern edge of the UTTR, nearly 100 miles from the facility, however, both Sevier B and D MOA sortie counts include aircraft entering the UTTR from the south, such as bombers and aircraft conducting cruise missile tests, that never enter Skull Valley. Revised Addendum at 4; Tr. at 3355-56 (Jefferson). The Sevier D counts are small, approximately 5.7% of the Sevier B counts. Revised Addendum at 4. Thus, the Applicant asserts that taking Sevier B to be representative of Skull Valley accounts for the small number of aircraft that use the Sevier MOAs but never enter Skull Valley. See PFS Finding ¶ 65.

C.39 The State disagrees with the Applicant's analysis. See State Finding ¶ 49. It points out that the Air Force does not keep records showing specifically the number of F-16 flights in Skull Valley, but does report the usage of Sevier B and Sevier D MOAs for all aircraft in those MOAs, most of which are F-16s transiting Skull Valley. Revised Addendum at 3-4, Tab HH at 2. It points out that only F-16 aircraft are required to transit Skull Valley. Aircraft Crash Report at 8 n.7. In addition, some F-16 flights through Skull Valley are not reported on the usage reports for Sevier B and D MOAs because the flights are above both MOAs. See Horstman Post Tr. 4214, at 11-12.

C.40 In FY 00, the total number of flights reported in the Air Force usage reports for Sevier B and D MOAs was 5,997. Applicant Exh. O at 4. In addition, 12 additional F-16s were assigned to Hill AFB in April of 2001, raising the total number of F-16s stationed at Hill AFB from 69 to 81, an increase of 17.4%. Cole/Jefferson/Fly Post Tr. 3061, at 18-20; Horstman Post Tr. 4214, at 12. The State argues that it is reasonable to assume that the number of F-16 flights transiting Skull Valley would increase by this same percentage. The number of flights in Sevier B and D MOAs for FY 00, 5,997, increased by 17.4% representing the additional F-16s assigned to Hill AFB in 2001, gives a total of approximately 7,040 estimated annual F-16 flights through Skull Valley. Both the State and the Staff have in this manner estimated the future number of flights through Skull Valley to be approximately 7,040. Campe, Ghosh Post Tr. 4078, at 10; Horstman Post Tr. 4214, at 12.

C.41 The State highlights the fact that the Applicant's estimate of 5,870 future flights is based only on Sevier B MOA usage reports. See State Findings ¶ 50. The Applicant excluded flight counts from Sevier D usage reports on the basis that they may contain flights other than Skull Valley flights and may therefore "overcount" the number of F-16 flights through Skull Valley. Tr. at 3356-57. The State argues, however, that the Air Force has informed the Applicant that the majority of flights going through Sevier D MOA are F-16s transiting Skull Valley. See State

Findings ¶ 50.

C.42 The Staff estimated the value for N by using the Air Force upper bound data -- the 2000 data for the combined flights in the Sevier B and D MOAs (5,997) -- and increased it by 17.4% to account for the additional F-16 assignments at Hill AFB. Campe/Ghosh Post Tr. 4078, at 10. Thus, the Staff, taking the same approach as the State, estimated the annual number of flights to be 7,041. Campe/Ghosh Post Tr. 4078, at 10.

C.43 We find the State and the Staff estimate of 7,040 future flights per year over Skull Valley to be a reasonable estimate for the value of N in the NUREG-0800 calculation. First, the number of flights occurring in Sevier B and D is more representative of the number of F-16 sorties and to the extent it might overcount the true number of flights, it is consistent with the NUREG-0800 demand for conservatism. Second, we find the use of FY 00 to be a better indicator of the present situation for flight numbers over Skull Valley, which data were also used by the Staff in arriving at its estimate of 7,040 annual flights. Adhering to the NUREG-0800 admonition to employ conservative values, the Board agrees with the appropriateness of that number.

C.44 The Staff reduced that value for N, however, to account for those aircraft in formation flights that it says do not pose a threat to the Applicant's facility. Campe/Ghosh Post Tr. 4078, at 10-11. The Staff recognized that F-16 aircraft transiting Skull Valley fly in either a two-ship or a four-ship formation. Campe/Ghosh Post Tr. 4078, at 11. (Solo flights occur occasionally, for example, when a pilot's departure on a sortie is delayed.) In terms of aircraft flight path distribution, the Staff considered a four-ship formation as two formations of two aircraft each -- one formation flying a few miles behind the first, with either a left or a right offset. There is approximately a 9,000 foot lateral separation between the leader and the wingman in a two-ship formation. Campe/Ghosh Post Tr. 4078, at 11. Consequently, according to the Staff, at least one of the aircraft in a two-ship formation will not be in a position from which it can strike the Applicant's facility in the event of a crash. Campe/Ghosh Post Tr. 4078, at 11. See also State Exh. 48 (depicting F-16s in formation on cross section of MOA).

C.45 Therefore, the Staff considered that approximately half of the flights have a negligible potential for striking the Applicant's facility. This was not reflected in the Applicant's analysis, but was accounted for by the Staff in the SER by reducing the number of flights by a factor of 2. SER at 15-67 & n.2; Campe/Ghosh Post Tr. 4078, at 11. The Staff argues that this approach adequately accounts for the fact that flights in Skull Valley take place in formations of two or four ships and that half of those aircraft are far enough east so as not to pose a hazard to the Applicant's facility. Thus, the number of flights, 7,041, divided by 2, or 3,520 flights, is the Staff's estimate for N. See Staff Findings ¶ 2.119.

C.46 We disagree with the Staff's analysis that divided the number of flights through Skull Valley in half. The Staff reasons that only one of the ships could fly directly over the Applicant's site and be in a position to strike the Applicant's site, and accordingly divided the number of flights to reflect this reduced risk. Campe/Ghosh Post Tr.4078, at 10-11. For the reasons set out in the Narrative portion of this opinion, we find, however, that this is mathematically and logically inappropriate -- if half the aircraft are to be disregarded, so must the portion of the airway in which they are flying. Thus, the Board finds the number of flights cannot be reduced on this reasoning, and selects 7,040 as the appropriate number for N.

c. Effective Area of Facility (A)

C.47 The Applicant asserts that the effective area of that portion of the facility where the storage casks will be located (including the Canister Transfer Building) is 0.1337 square miles. This calculation took into account the flight characteristics and dimensions of the F-16 and the angle at which it might approach the facility, and assumes a facility at full capacity with 4,000 spent fuel storage casks on site. Cole/Jefferson/Fly 3090, at 16. This effective area accounts for the possibility that an aircraft impacting in front of the facility could skid into it and the possibility that an aircraft that would otherwise impact just beyond the facility would hit an elevated structure at the facility. See PFS Findings ¶ 38. The State does not contest the effective area put forward by the Applicant. See State Findings ¶ 52. We find that the value for A, effective area, has reasonably been calculated by the Applicant to be 0.1337 square miles. The Board has reviewed this analysis and finds it reasonable.

d. Width of Airway (w)

C.48 The major dispute among the parties regarding this Factor of the NUREG-0800 equation centers on where pilots actually fly in taking F-16 aircraft down Skull Valley. The dispute arises because of the physical contours of the Valley and the location of artificial delineations of the airspace. Below we describe the geographical relationship between these features, and why the parties differ in their calculations of the Skull Valley airway width.

C.49 Skull Valley is located between two mountain ranges, the Stansbury Mountains to the East, and the Cedar Mountains to the West. On the West side, Air Force Restricted Airspace intrudes into the Valley. Because of the configuration of the Mountains, Skull Valley varies in width -- it is approximately 17 miles at the northern tip but narrows to seven miles at the southern tip. SER at 15-62.

C.50 The Applicant took the position that the width available to pilots flying in Skull Valley is the actual width from the edge of the restricted airspace intruding in the West to the Mountains on the East, that being ten miles at the point where the facility is proposed to be built. The Staff agrees with that argument. The State, on the other hand, believes that pilots fly only in a narrower effective area that takes account of the need to observe certain buffer zones. The State asserts that, when all adjustments of this nature are taken into account, this distance is five miles near the proposed position of the facility.

C.51 We have previously described the way airspace is divided into "Military Operating Areas" (MOAs). Approximately 96% of the F-16 flights through Skull Valley are in Sevier B MOA. Resnikoff Post Tr. 8698, at 15; Tr. at 3396 (Jefferson). F-16s may fly through any part of Sevier B MOA but commonly fly at 3,000 to 4,000 feet AGL. Aircraft Crash Report at 5; Tr. at 3396-97 (Cole). F-16s fly through Skull Valley in two ship or four ship formations. Horstman Post Tr. 4214, at 5-6. According to the Air Force, it would be an exception for a solo flight to transit Skull Valley. Campe/Ghosh Post Tr. 4078, at 11.

C.52 In a two ship formation of F-16s, the wingman would fly 1.5 to 2 miles abreast of the flight leader at a position 0 to 10 degrees aft of the leader. In a four ship formation of F-16s, a wingman would similarly fly 1.5 to 2 miles abreast of the flight leader. Those two aircraft (lead and wingman) comprise the "lead element." Two additional aircraft with spacing similar to that of the lead element would follow 2 to 15 miles behind. One of the aircraft in the back element will be located somewhere between the horizontal spacing of the lead element. A four ship formation thus may vary from just over 1.5 to just under 4 miles in horizontal width and over 2 to 15 miles long. Horstman Post Tr. 4214, at 6.

C.53 A cross section of Sevier B MOA, looking north from the latitude of the proposed site, is shown in Aircraft Crash Report, Figure 1. Tr. at 3395-3401 (Jefferson). The site is identified as "PFSF" and located at "0" on the "statute miles" scale along the bottom of Figure 1. The Applicant's site is located at 4,500 feet mean sea level as indicated by the scale along the right side of Figure 1, which is also ground level or 0 AGL. Tr. at 3405 (Jefferson). The Sevier B MOA is bounded on the west by a restricted area located two miles to the west of the Applicant's site. Tr. at 3400 (Jefferson). The blacked-out area on Figure 1 labeled "GROUND" represents mountainside terrain of the Stansbury Mountains, which prevents aircraft from flying to the eastern boundary of the MOA. Tr. at 3401 (Jefferson). State Exh. 156B shows Figure 1 with the air space between 3,000 and 4,000 feet AGL shaded. See State Exh. 156B.

C.54 F-16 flights transiting Skull Valley maintain a "buffer" distance of one mile or more from the western boundary of Sevier B MOA to prevent straying into restricted air space west of the MOA. Horstman Post Tr. 4214, at 7. Aircraft must avoid flying in this restricted area or the pilot may incur very serious sanctions. Tr. at 3407 (Jefferson). Colonel Bernard, a former F-16 pilot with experience in flying through Skull Valley, testified when flying in Skull Valley he would maintain a comfortable (buffer) distance of two to three miles from the restricted airspace at the western boundary of the Sevier B MOA. Tr. at 3924 (Bernard). The Applicant's witness Colonel Fly testified that most flights are down the middle to the eastern side of Skull Valley because of the restricted air space to the west. Tr. at 3415-16 (Fly). Colonel Fly further testified that he generally flew well clear of a one mile buffer zone from the restricted air space west of Sevier B MOA. Tr. at 3424 (Fly). In light of this information, the State asserts that F-16 pilots maintain a distance of at least one mile from the western boundary of Sevier B MOA at the latitude of the Applicant's site to prevent entering restricted airspace. See State Findings ¶ 43.

C.55 The State argues that F-16 formations generally fly down the middle of Skull Valley with part of the formation over or near the Applicant's site. Horstman Post Tr. 4214, at 6. The formation leader will select a flight path to allow the furthest west aircraft to maintain a distance of at least one mile from the western boundary of Sevier B MOA, beyond which is restricted air space. Horstman Post Tr. 4214, at 7. The flight leader will also select a flight path to allow the furthest east aircraft to maintain a sufficient distance from the Stansbury Mountains, generally two miles, placing the furthest east aircraft at least five miles from the eastern border of Sevier B MOA. Horstman Post Tr. 4214, at 7. The width of the Sevier B MOA that is actually used by

F-16 formations would thus extend from one mile east of the western MOA boundary to five miles west of the eastern MOA boundary, or a width of approximately six miles. Horstman Post Tr. 4214, at 6.

C.56 Within this six mile width of usable airspace, F-16s fly in two or four ship formations which are from 1.5 to just under four miles wide. Horstman Post Tr. 4214, at 7. With one ship in the formation flying at either the east or west edge of the usable airspace, the remaining ships in the formation would be inward from the edges. Horstman Post Tr. 4214, at 7. Accordingly, the majority of F-16 flights in Skull Valley, argues the State, would therefore be within a corridor less than five miles wide within the six mile width of usable airspace. Horstman Post Tr. 4214, at 7. The usable six mile airspace and formations positioned at the outer edges of that airspace are shown on State Exh. 48. Horstman Post Tr. 4214, at 7; State Exh. 48.

C.57 The Applicant asserts, however, that the Air Force has consistently advised that the predominant or preferred route of flight for F-16s transiting Skull Valley is approximately five miles to the east of the proposed facility site. See PFS Findings ¶ 42 (citing Cole/Jefferson/Fly Post Tr. 3061, at 16; Tr. at 3397 (Cole)). This stated preference is consistent with Colonel Fly's testimony that he typically flew about four miles east of the site in a south-southeasterly direction. Tr. at 3415-24 (Fly). This preferred route is said to be a logical result of the natural configuration of the MOA and the restricted airspace to its west which serve to naturally funnel the F-16 traffic in Skull Valley toward the eastern side of the valley and the narrow seven mile wide neck in the MOA southeast of the facility site. Cole/Jefferson/Fly Post Tr. 3061, at 16; PFS Exh. P.

C.58 The Applicant asserts that it assumed for purpose of its calculations that the Sevier B MOA could be treated like an airway and that the F-16s were evenly distributed across the width of the Sevier B MOA, from the Stansbury Mountains in the east to the edge of restricted airspace in the west. See PFS Findings ¶ 43. The width, w, of this hypothetical airway was chosen to be ten miles based on the useable airspace in the Sevier B MOA through which the F-16s could fly at the latitude of the facility. Cole/Jefferson/Fly Post Tr. 3061, at 16.

C.59 For F-16s flying above the Sevier B MOA (i.e., above 9,000 feet MSL/4,400 feet AGL), the width of the useable airspace would the full 12 miles. See Tr. at 3795 (Jefferson). The Applicant therefore asserts that using an airway width of ten miles for the purpose of analysis is conservative. Tr. at 3443-52 (Jefferson).

C.60 The determination of the width of the airway to be used in calculating probability of aircraft crashes at the Applicant's site turns on the evidence of the type and flight patterns flown by F-16s stationed at Hill AFB. No evidence was presented as to the type of training missions, flight altitudes or routes that will be flown by the replacement aircraft. The Board has been presented with no reason to find that the width of the airway would change for a replacement aircraft.

C.61 We base our finding as to this issue on where pilots fly as a routine practice, which establishes the effective width of the airway. We agree with the State's assertion that F-16s transiting Skull Valley observe buffer zones on both sides of the MOA such that aircraft would stay one mile east of the restricted area to the west of the facility and up to three miles west of the Stansbury Mountains or the MOA's boundary to the east. Horstman Test. at 6-7; Tr. at 8571, 8613-14 (Horstman). We find the State's position to be persuasive because State Exhibit 148B demonstrates that even though Applicant's ten-mile distance is theoretically possible at 3,000 to 4,000 feet AGL, pilots are more likely to be conservative and thus allow for as great a buffer zone on the Stansbury side and the UTTR side as possible. But the State's proposed five-mile distance is too narrow -- the evidence demonstrates that six miles is the appropriate width of the airway as it is used in practice.

5. Calculated Probability

C.62 As we found in the narrative portion of our decision, the probability of an F-16 impacting the facility is 4.29 x 10^{-6} (see p. 60, above.) Consequently, the Applicant's proposal fails to meet the acceptance criterion the Commission articulated in CLI-01-22.

6. Other Skull Valley Operations

C.63 a. Moser Recovery Route. Most aircraft returning to Hill AFB from the UTTR South exit the northern portion of the range and proceed north or fly over the Great Salt Lake. SER at 15-80. Some aircraft returning to Hill AFB from the UTTR South, however, may use the Moser Recovery Route (MRR). Cole/Jefferson/Fly Post Tr. 3061, at 11. The MRR runs from the southwest to the northeast to the north, and passes approximately two to three miles north of the Applicant's site. SER at 15-80. The MRR is only used during inclement weather conditions or at night under specific wind conditions. See Cole/Jefferson/Fly Post Tr. 3061, at 11.

C.64 The Applicant estimates that approximately 5% of the F-16 flights on the UTTR return to Hill AFB via the Moser Recovery. Cole/Jefferson/Fly Post Tr. 3061, at 97. This estimate is supported by conversations between General Cole and the Vice Commander of the 388th FW at Hill AFB, and an air traffic controller in the Salt Lake City Air Traffic Control Center. Tr. at 3456-58 (Cole). Thus, based on FY 98 UTTR sortie data, the Applicant estimated 286 flights used the Moser Recovery in FY 98. Cole/Jefferson/Fly Post Tr. 3061, at 97. The Applicant defined the Moser Recovery as having an airway width, w, of 11.5 miles (equal to the width of military airway IR-420). Cole/Jefferson/Fly Post Tr. 3061, at 97. The other factors the Applicant used in its calculation were the same as those used to calculate the hazard to the facility from F-16s transiting Skull Valley: the crash rate, C, was equal to 2.736 x 10^{-8} per mile; the effective area of the site, A, was 0.1337 square miles; and 14.5% of the calculated crashes would impact the site because the pilot could not direct the aircraft away from the facility (the R factor). Cole/Jefferson/Fly Post Tr. 3061, at 97.

C.65 Because the Air Force does not keep precise data as to the number of flights per year that occur on the MRR, all parties had to look elsewhere to derive estimates of annual MRR flights. Tr. at 3455-59 (Cole); see Cole/Jefferson/Fly Post Tr. 3061, at 96-97. In order to estimate the number of flights, the Applicant assumed that the sortie rates on the UTTR, and thus the number of flights on the MRR, increased proportionally to the number of F-16 sorties through Skull Valley. Cole/Jefferson/Fly Post Tr. 3061, at 97. According to the Air Force, 5,726 F-16 sorties were flown in the UTTR South Area, most of which flew from Hill AFB. Using the 5% MRR usage factor, the Applicant calculated that approximately 286 F-16s used the MRR for return flights in FY 98. Cole/Jefferson/Fly Post Tr. 3061, at 97. The Applicant then increased the number of FY 98 Moser flights proportionally to account for the higher Skull Valley sortie counts in FY 99 and FY 00 as well as the sorties that would be flown in the future by the additional F-16s assigned to Hill AFB. Cole/Jefferson/Fly Post Tr. 3061, at 97. So for the value of N, the Applicant used 336 in the NUREG-0800 equation. See Revised Addendum at 20; Cole/Jefferson/Fly Post Tr. 3061, at 97. Thus, the Applicant calculated the crash impact probability to be 2.0×10^{-8} per year. Cole/Jefferson/Fly Post Tr. 3061, at 97.

C.66 The Staff prepared an independent estimate of the number of flights on the MRR using actual FY 00 UTTR sortie data, rather than Skull Valley flight information used by the Applicant. Campe/Ghosh Post Tr. 4078, at 39; SER at 15-81. The Staff found that the UTTR South flight count, rather than the Skull Valley flight count is more appropriate for estimating the annual number of F-16s flying through the MRR. The Staff also adjusted the FY 00 data to account for an additional 12 F-16s to be stationed at Hill AFB. Campe/Ghosh Post Tr. 4078, at 39. The

Staff estimated the number of flights on the MRR to be 5% of 7,059[152], or 353. SER at 15-80 to 15-82; Staff Findings ¶ 2.529. Using a modified number for pilot avoidance, the Staff calculated the crash impact probability to the Applicant's facility to be 2.5 x 10^{-8} per year. Campe/Ghosh Post Tr. 4078, at 40; SER at 15-82.

C.67 The State asserts, however, that the number of F-16s using the MRR is likely to be substantially higher than either the Applicant or the Staff estimates. State Findings ¶ 10. In calculating the number for N, the State asserts that the Applicant should have assumed that one-third of all flights on the UTTR returned to Hill AFB via the Moser Recovery because in the future, up to one-third of the flights on the UTTR may be conducted at night. Resnikoff Post Tr. 8698, at 16; Horstman Post Tr. 4214, at 30. The State's theory of increased use of the MRR was based on the assumption that all flights at night would use the Moser Route, purportedly due to the 388th FW's use of night vision goggles in training. Horstman Post Tr. 4214, at 30. The State relies on an Air Force document which states that night vision goggle training will increase and that of the total sorties flown in MOAs, approximately one-third will be night sorties. State Exh. 64 at 4.

C.68 The State does not dispute that the MRR is used only at night, during marginal weather conditions, and when runway 32 at Hill AFB is the active runway. See State Findings ¶ 107. The Aircraft Crash Report states that "[b]ecause pilots train on the UTTR mostly during daytime and in good weather and because aircraft landing at Hill usually use runway 14 . . . due to the wind patterns at Hill, it agrees that the Moser recovery is seldom used." Aircraft Crash Report at 48a. It points out that subsequent to preparation of the Applicant's Crash Report, however, the Air Force announced on July 18, 2001 that night vision goggle training would increase and

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[152] The Staff used FY 00 data, 7,059 flights, rather than an average of FY 99 and FY 00 because use of FY 99 sortie information would lead to an insignificant change to the estimated probability compared to FY 00 data. SER at 15-81 to 15-82.

stated that of the total training flights in MOAs, "approximately one third will be night sorties." State Exh. 64 at 4; Horstman Post Tr. 4214, at 30; State Findings ¶ 107. From this, the State argues that a realistic number of flights using the MRR could be as high as 33% of the flights returning to Hill AFB from the UTTR South Area. Horstman Post Tr. 4214, at 30. The State also asserts that there will be some 10,410 aircraft per year using the UTTR in the future. State Findings ¶ 110.

C.69 In FY 98 there were 5,726 sorties flown in the UTTR South range. Cole/Jefferson/Fly Post Tr. 3061, at 97. The State argues that, to account for the increase in sorties of F-16s and the increase in aircraft assigned to Hill AFB since 1998, the 5,726 flights in the UTTR in 1998 should be increased by the ratio of Skull Valley sorties occurring in 1998 to those occurring in 1998. Taking the number of sorties occurring in Skull Valley in 1998, which was determined to be 3,871, and increasing this number proportionally to the number of sorties occurring in 2001, which was determined to be 7,040, the State estimated that approximately 10,410 sorties would occur on the UTTR South Area in 2001. Resnikoff Post Tr. 8698, at 16. As the State sees it, as many as 33% of these flights, or 3,436 flights, might therefore return to Hill AFB on the MRR. Resnikoff Post Tr. 8698, at 16. Using a crash rate, C, for F-16s of 4.10×10^{-8}, the number of flights, N, of 3,436, the area, A, of 0.1337 square miles, and the width, w, as 11.5 miles, the State calculated the crash impact probability to be 1.64×10^{-6} per year. See State Findings ¶ 111.

C.70 The Applicant points out that the State's estimate of annual flights on the MRR, which is 33% of the total returning flights, is not consistent with the actual number of flights recorded in the UTTR South. In this regard, General Jefferson noted that the State is assuming approximately 10,410 flights in the UTTR South. Tr. 8864-65 (Jefferson). But there have been less than 10,000 flights annually on the UTTR South since 1998. Tr. 8865-66 (Jefferson).

General Jefferson testified that if he were to increase those F-16 sorties for the UTTR South by 17% to account for additional F-16s coming to Hill AFB in 2001, they would still be significantly less than 10,000. See Tr. at 8866 (Jefferson).

C.71 On the basis of complications associated with the use of the MRR that make it undesirable as an air corridor, the discussions the Applicant and the Staff had with Air Force personnel, and the comparison of the State's assumed total number of flights to the number of flights that actually occurred in the UTTR, we find that even with an increase in night sorties, much closer to 5% of flights returning from the UTTR South to Hill AFB will use the MRR than to 33%.

C.72 We disagree with the State's methods and assumptions regarding the determination of the number of sorties for the MRR. In estimating the MRR use factor, the State assumed that a 33% increase in night training would lead to a 33% increase in the use of the MRR. The State's reliance on the Air Force document for its assumption was flawed because the Air Force statement is of a contingent nature: use of the MRR is contingent upon certain wind conditions being present. As stated by the Air Force, there is no expected increase overall in MRR usage from night training. Campe/Ghosh Post Tr. 4078, at 39; Cole/Jefferson/Fly Post Tr. 3061, at 98 & n.168. Hence, we find the State's estimate of a 33% increase in MRR flights to be not well supported.

C.73 In addition, we disagree with the analysis undertaken by the State regarding the number of flights, approximately 10,410 per year, which reflected an extrapolation of fluctuations of use of the UTTR indicating an upward trend of flights using the MRR. The data, however, do not show an unambiguous increasing trend before 2001, but rather seem to have fluctuated from year to year without showing any trend. Hence, we find the State's analysis of crash probability from flights on the MRR to be not well founded insofar as its estimates of future flights on the

UTTR and its estimate of flights using the MRR in the future are concerned. We find that the Staff estimate of crash probability of 1.6×10^{-7} (without taking credit for pilot avoidance) per year is reasonable, as well as the Applicant's slightly lower estimate, for the reasons expressed in their analyses.

C.74 The Board reiterates that all numerical values derived by the parties are indirect estimates of aircraft counts using the MRR because of the unavailability of data from the Air Force. Even with this analytical uncertainty, however, we are able to find that there is only a minor risk to the facility from aircraft traversing the MRR because of the margin between the values we accept and the Commission's cumulative standard hazard of 1×10^{-6} annually.

C.75 b. Aircraft on IR-420. Michael Army Airfield is located on Dugway Proving Ground, 17 miles south-southwest of the facility. Cole/Jefferson/Fly Post Tr. 3061, at 98. IR-420 is a military airway that runs from northeast to southwest and ends about seven miles north of the facility site, at the northern edge of the Sevier B MOA (i.e., IR-420 runs from the edge of Sevier B to the northeast). Cole/Jefferson/Fly Post Tr. 3061, at 98. Aircraft flying to and from Michael AAF from the northeast, including aircraft flying to and from Hill AFB, may fly in the direction of IR-420 and pass within a few miles of the facility site. The majority of the flights to and from Michael AAF are F-16s from Hill AFB conducting training. Those aircraft using IR-420 are accounted for in Applicant's's Skull Valley-transiting F-16 calculation.[153] Cole/Jefferson/Fly Post Tr. 3061, at 98. Most of the remainder of the aircraft flying to and from Michael AAF are cargo aircraft such as the C-5, C-17, C-141, C-130 and the smaller C-21 and C-12. Cole/Jefferson/Fly Post Tr. 3061, at 98-99.

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[153] Any F-16 using IR-420 would necessarily fall into the Sevier MOA traffic count as IR-420 ends where the Sevier MOAs begin at the north end of Skull Valley. Any F-16s that went to Michael AAF without transiting Skull Valley would not be relevant to the hazard to the facility. Cole/Jefferson/Fly Post Tr. 3061, at 98 n.169.

C.76 The Applicant used the same method to calculate the hazard to the facility from F-16s to estimate the probability of an aircraft impacting the facility from aircraft flying to and from Michael AAF (i.e., P = C x N x A / w). Cole/Jefferson/Fly Post Tr. 3061, at 99. The State did not submit testimony on the hazard posed by aircraft flying to and from Michael AAF in the direction of IR-420. See Horstman Post Tr. 4214; Resnikoff Post Tr. 8698. NUREG-0800 provides an in-flight crash rate of 4×10^{-10} per mile for large commercial aircraft, which is appropriate to apply to the types of large cargo aircraft flying to and from Michael AAF. The Applicant estimated a maximum of approximately 414 annual flights by aircraft other than F-16s at this airfield.[154] Using the effective area of the facility in a manner similar to that for F-16s, the Applicant calculated an upper bound on the probability of an aircraft impacting the facility to be 3.0×10^{-9} per year. Cole/Jefferson/Fly Post Tr. 3061, at 99.

C.77 The State did not challenge the Applicant's probability calculation related to aircraft traversing IR-420 to MAA. See State Findings. Similarly, the Staff does not dispute the estimate of risk. See Campe/Ghosh Post Tr. 4078, at 41. We find that the parties are in accord with respect to the estimation of the hazard posed to the Applicant's facility by aircraft flying on IR-420. See Cole/Jefferson/Fly Post Tr. 3061, at 99; State Exh. 81; Campe/Ghosh Post Tr. 4078, at 41. Inasmuch as no dispute exists with respect to the estimate of the risk posed to the facility from flights transiting IR-420, we find 3.0×10^{-9} per year to be a reasonable estimate of the annual probability of impact to the Applicant's facility.

[154] The 414 flight estimate was based on FY 97 data from Michael AAF. Based on the total number of takeoffs and landings at Michael AAF in later years from FY 98 to FY 00, excluding those conducted by F-16s, a maximum of 212 flights per year during that period were conducted by aircraft other than F-16s. If it is taken into account that the aircraft fly to and from airfields in all directions from Michael AAF, the estimated number of flights in the direction of the facility would be even lower. Cole/Jefferson/Fly Post Tr. 3061, at 99-100.

C.78 c. Training on the UTTR. Aircraft on the UTTR South Area perform a variety of activities, including air-to-air combat training, air-to-ground attack training, air-refueling training, and transportation to and from Michael AAF (which is located beneath UTTR airspace). Cole/Jefferson/Fly Post Tr. 3061, at 90-91. We determined on summary disposition that aircraft conducting air-to-ground attack training and weapons testing using air-delivered ordnance and aircraft conducting air refueling training would pose no significant hazard to the facility. See LBP-01-19, 53 NRC at 446. The hazards posed by aircraft flying to and from Michael Army Airfield on Dugway have been discussed previously. Thus, the only activity we assess here is air-to-air combat training on the UTTR.

C.79 We find that aircraft conducting air-to-air combat training on the UTTR pose a negligible hazard to the facility. This is primarily because the activity on the UTTR occurs too far away from the facility to pose a hazard. The facility is located two miles east of the eastern boundary of the UTTR restricted airspace. The aggressive maneuvering that takes place in air-to-air combat training occurs toward the center of the restricted area range, typically more than ten miles inside range boundaries. On the basis of where F-16s fly on the UTTR, the Applicant assumed a three-mile buffer zone just inside the UTTR restricted area as a practical limit as to how far aircraft will fly from the edge of the UTTR restricted area. Thus, the facility is located five miles east of the closest point at which an event leading to a crash would be expected to occur and a crashing aircraft on the UTTR would not be able to reach the facility before impacting the ground if it were out of control. Cole/Jefferson/Fly Post Tr. 3061, at 91-92.

C.80 The assumed three-mile buffer is reasonable because it reflects what actually takes place on the range and corresponds to the practical limit that pilots observe while flying training exercises on the UTTR. Aggressive maneuvering during simulated air-to-air engagements at visual or beyond visual ranges, tends to take place toward the center of the restricted areas.

Furthermore, the Cedar Mountains provide a clear visual indication to pilots of the eastern edge of the restricted area and Clover Control provides warnings to pilots as they approach within five miles of the edge of the restricted area to prevent them from straying outside. Cole/Jefferson/Fly Post Tr. 3061, at 91-92.

C.81 Accidents on the UTTR that did not leave the pilot in control of the aircraft would not pose a hazard to the facility. Review of the F-16 crash reports for accidents occurring during special in-flight operations (i.e., operations involving aggressive maneuvers on a training range) in which the pilot does not maintain control of the aircraft (e.g., a mid-air collision or G-induced loss of consciousness) indicates that most such accidents would occur toward the center of the restricted ranges. It is most likely such crashing aircraft would travel less than five miles horizontally before impacting the ground. Even in the event of G-induced loss of consciousness, which is the type of accident that would not leave the pilot in control but would cause the aircraft to travel the greatest distance before hitting the ground, the aircraft would travel no more than about five miles. Cole/Jefferson/Fly Post Tr. 3061, at 92-93.

C.82 For accidents in which a pilot does maintain control, the aircraft would be five or more miles from the facility site when the accident occurred by virtue of the two miles that the facility is from the eastern boundary of the UTTR airspace and the three-mile buffer observed while operating in restricted airspace. The UTTR is a large, safe area to receive a crashing aircraft in an emergency. Moreover, Michael AAF, on the east side of the UTTR, 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 facility and other inhabited structures located there. Cole/Jefferson/Fly Post Tr. 3061, at 93-94.

C.83 Using the NUREG-0800 formula, the Applicant calculated the risk to the facility to be less than 1.0 x 10^{-8} year. We note that the Applicant has used an "R" factor to reduce the probability of crashes from combat training on the reasoning that "invariably the pilot would steer the aircraft away" from the Applicant's facility. Cole/Jefferson/Fly Post Tr. 3061, at 94-95. But given the flight conditions and operations in the UTTR, the R1 component would be less than in Skull Valley, and there is no more reason to credit the R2 component than there was in Skull Valley. Accordingly, the Board finds that it is not realistic nor conservative to allow a reduction in this crash probability based on a pilot's ability to avoid the Applicant's site.

C.84 The Staff agreed with the Applicant's assessment that a five-mile cutoff radius is reasonable for an F-16. On the primary basis of the five-mile glide distance, the Applicant and the Staff concluded that the annual probability of an on-site crash is negligible, i.e., less than 1 x 10^{-8} per year. Campe/Ghosh Post Tr. 4078, at 37.

C.85 We do not agree with the State's calculation for risk. State witness Dr. Resnikoff asserted that aircraft on the UTTR would pose a hazard to the facility by assuming that a crashing aircraft could fly ten miles before impacting the ground. State Exh. 78; Tr. at 8792-94 (Resnikoff). Using this figure, the State calculated the hazard to the facility to be 2.74 x 10^{-7} per year. Resnikoff Post Tr. 8698, at 18.

C.86 The only support for Dr. Resnikoff's assertion was a previous assessment the Applicant had performed, before it had obtained the information from the accident reports, in which the Applicant had conservatively assumed that a crashing aircraft could fly a maximum of ten miles before impacting the ground. Tr. at 8798-99 (Resnikoff). Thus, the only basis for Dr. Resnikoff's assumption has been superseded and there is no reason to credit his claim.

C.87 We agree that a five-mile glide is a more appropriate distance for an F-16, and thus agree with the probability calculations arrived at by the Applicant and Staff. In any event, the crash probability related to aircraft traversing the UTTR is insignificant to the overall cumulative hazard calculation.

d. Military Ordnance

(1) Direct Impact of F-16 Carrying Ordnance

C.88 We have explained in the Narrative portion of this opinion why this accident scenario can be readily disregarded.

(2) Direct Impact of Jettisoned Ordnance

C.89 Based on data from Hill AFB regarding ordnance usage by F-16s in FY 99 and FY 00, approximately 2% of the F-16s transiting Skull Valley carry jettisonable ordnance.[155] Cole/Jefferson/Fly Post Tr. 3061, at 12; Campe/Ghosh Post Tr. 4078, at 32. In the event of an incident leading to a crash in which the pilot would have time to respond before ejecting from the aircraft (e.g., an engine failure), one of the pilot's first actions would be to jettison any ordnance carried by the aircraft. Cole/Jefferson/Fly Post Tr. 3061, at 102. The potential hazard posed to the facility by jettisoned military ordnance is very small because of the small number of aircraft carrying ordnance, the rarity of aircraft jettisoning ordnance, and the small probability that ordnance jettisoned somewhere along the route would hit the facility. Cole/Jefferson/Fly Post Tr. 3061, at 102-03. Using the NUREG-0800 formula, the Applicant estimated the probability that ordnance would impact the facility to be 3.2×10^{-8} per year. Cole/Jefferson/Fly Post Tr. 3061, at 102-03.

C.90 The Applicant generally followed the same approach that it used in calculating the hazard to the facility for F-16s transiting Skull Valley as follows:

C.91 The Applicant claims the number of aircraft carrying live or inert ordnance through Skull

[155] Because of the other ways available to Air Force pilots to train to deliver the newer, laser directed or self-guided ordnance, there is very little requirement for pilots to train by dropping live or heavy weight ordnance on the UTTR. Tr. at 3501-03, 13,084-85 (Fly).

Valley per year, N, would be 150. Cole/Jefferson/Fly Post Tr. 3061, at 102-03. This is based on the average number of F-16s carrying ordnance through Skull Valley for FY 99 and FY 00 (2.556% of the total number of Skull Valley sorties), increased by 17.4% to account for the additional aircraft based at Hill AFB in FY 01. Cole/Jefferson/Fly Post Tr. 3061, at 102. The Applicant based its estimate on the two most recent years, the same years it used to estimate the Skull Valley sortie count. Cole/Jefferson/Fly Post Tr. 3061, at 102.

- The crash rate for the F-16s, C, was taken to be 2.736 x 10^{-8} per mile. Cole/Jefferson/Fly Post Tr. 3061, at 103.

- The pilot was assumed to jettison ordnance in 90% of all crashes, the fraction of the crashes, e, assumed to be attributable to engine failure or some other event leaving him in control of the aircraft (in crashes attributable to other causes it was assumed that the pilot would eject quickly and would not jettison ordnance). Cole/Jefferson/Fly Post Tr. 3061, at 103; Campe/Ghosh Post Tr. 4078, at 31. Even though some accident reports reflect that pilots will take steps to avoid jettisoning ordnance near built-up or populated areas, the Applicant conservatively assumed no "R" factor to account for such avoidance. Revised Addendum at 30-31.[156]

- Skull Valley was treated as an airway with a width, w, of ten miles. Cole/Jefferson/Fly Post Tr. 3061, at 103; Campe/Ghosh Post Tr. 4078, at 33.

- The area of the facility, from the perspective of ordnance jettisoned from an aircraft flying from north to south over the site, A, was taken to be the product of the width and the depth of the cask storage area (assuming a full facility with 4,000 casks) plus the product of the width and depth of the canister transfer building, in that pieces of ordnance are small relative to an aircraft and impact the ground at a steep angle. Cole/Jefferson/Fly Post Tr. 3061, at 103.[157] Thus, the area of the facility was calculated to be 0.08763 square miles. Cole/Jefferson/Fly Post Tr. 3061, at 103.

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

[157] Dr. Resnikoff asserted that the Applicant should have used a "skid area" in front of the facility to account for jettisoned ordnance potentially skidding into the facility. Resnikoff Post Tr. 8698, at 20. The only basis for his assertion was an undocumented conversation between Dr. Resnikoff and Lieutenant Colonel Horstman. Tr. at 8801-05 (Resnikoff). We agree with Applicant's witness General Jefferson, who testified that the ordnance would not skid because it would impact the ground at a steep angle. Tr. at 8868-69 (Jefferson).

Based on these input values, the Applicant calculated the hazard to the facility from jettisoned ordnance to be 3.2×10^{-8} per year. Cole/Jefferson/Fly Post Tr. 3061, at 103.

C.92 The Board notes that the Applicant used a modified NUREG-0800 formula to calculate the probability as shown by:

$$P = N \times C \times e \times A/w$$

Cole/Jefferson/Fly Post Tr. 3061, at 103. The Applicant has included an additional factor, “e,” which reduces the probability of ordnance impacts by assuming that the pilot would jettison ordnance in only 90% of crashes. Cole/Jefferson/Fly Post Tr. 3061, at 102-03. The Applicant assumed the pilot would eject quickly in the other 10% of crashes without time to jettison ordnance. Cole/Jefferson/Fly Post Tr. 3061, at 103.

C.93 The Board finds the Applicant’s overall approach to be logical. As explained below, however, the Board finds that the input values for N and w should be modified.

C.94 The State claimed that the Applicant should have assumed that the fraction of sorties in Skull Valley carrying jettisonable ordnance would be no less than it was in FY 98 increased by the increase in sorties since FY 98, rather than what it was in FY 99 and FY 00. Horstman Post Tr. 4214, at 29. The FY 98 fraction was higher than the FY 99 and FY 00 fractions.[158] Lieutenant Colonel Horstman asserted that lower ordnance usage in FY 00 was due to some of the F-16s at Hill AFB having been deployed to the Caribbean for drug interdiction missions. Horstman Post Tr. 4214, at 29. The deployment to the Caribbean was, however, much smaller than other past deployments and the training of the F-16s is not based on one particular

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[158] The State did not claim that the Applicant should have used FY 98 as the baseline for estimating the sortie count for Skull Valley. See Horstman Post Tr. 4214, at 12. Had the State done so, its estimated sortie count would have been approximately 4,500 (increasing the FY 98 Sevier B MOA count by 17.4% to account for the additional F-16s added to Hill AFB in FY 01). Horstman Post Tr. 4214, at 11.

deployment. Tr. at 13,090-91 (Fly). Moreover, the State did not account at all for the FY 99 ordnance usage, which was almost identical to the usage in FY 00. Revised Addendum, Tab HH at 14. Requirements for F-16 ordnance usage in training are established by Air Force regulations and each unit's designated operational capability. Tr. at 13,082-84 (Fly). Those requirements do not change frequently. Tr. at 13,086-87 (Fly). Furthermore, the Air Force Safety Agency has stated that ordnance expenditures are not expected to increase in the future. Tr. at 13,087-88 (Cole).

C.95 The State asserts that F-16s transiting Skull Valley may carry up to six ordnance per flight and an F-16 may carry two MK-84 2,000 lb. bombs per flight. Horstman Post Tr. 4214, at 27. After a pilot zooms the aircraft in an emergency, the pilot will release the bombs and fuel tanks from the aircraft, a procedure known as "jettison all stores." Horstman Post Tr. 4214, at 28. Horstman Post Tr. 4214, at 28. The State asserts that typically a pilot will take no action to select where the ordnance will impact. This is because the immediate jettison of all stores may be necessary to control the aircraft, and also because the pilot's attention may be focused on tasks relating to the pilot's survival, such as restarting a failed engine or ejecting. Horstman Post Tr. 4214, at 28.

C.96 In FY 98, the 388th fighter wing carried ordnance on 678 sorties. Revised Addendum, Tab HH at 13. That number was reduced to 151 sorties with ordnance in FY 99 and 128 sorties with ordnance in FY 00. Revised Addendum, Tab HH at 13-14. The 419th FW at Hill AFB also carries ordnance but no records showing ordnance carried by the 419th are available. Revised Addendum, Tab HH at 12 n.27. The Applicant points out that according to the Vice Commander of the 388th FW, it is reasonable to assume the 419th FW carries ordnance of the same type and at the same rate as the 388th FW. Revised Addendum, Tab H at 12 n.27. The Applicant has used the ratio of aircraft assigned to the 388th and 419th FWs to determine that by multiplying the number of 388th sorties by 1.278 the total 388th and 419th fighter wing sorties is obtained.[159] Revised Addendum, Tab H at 12 n.27. The total number of sorties carrying ordnance is therefore estimated to be 866, 193, and 164 for FY 98, FY 99, and FY 00 respectively.

C.97 The State asserts that the number of sorties that carry ordnance varies dramatically and is dependent on Air Force training tactics and budget, national policy and world conflict. Horstman Post Tr. 4214, at 28; Tr. at 3494 (Jefferson). On February 1, 2001, 388th FW Operations Group Commander Colonel Coots advised that current training needs require more sorties to carry ordnance than the training conducted in FY 00. Horstman Post Tr. 4214, at 29. The Applicant does not know the reason for the decline in the number of sorties carrying ordnance from FY 98 to FY 00. Tr. at 3500 (Jefferson). Hill AFB is capable of flying 678 sorties with ordnance through Skull Valley in a single year. Tr. at 3499 (Jefferson). The State argues that it is unrealistic and not conservative to assume that future flights will carry less ordnance than flights in FY 98 data in calculating the number of sorties carrying ordnance. State Findings ¶ 63. Using FY 98 data, the State calculates that 21.2% (866/4,086) of Skull Valley flights carried ordnance in 1998. State Findings ¶ 117.

C.98 The Applicant reasons that most of the ordnance is delivered to the UTTR South Area, and not all flights to the UTTR South Area will transit Skull Valley. Aircraft Crash Report at 81. The Applicant therefore determines the percentage of all flights carrying ordnance by dividing the number of sorties carrying ordnance by the number of UTTR South Area sorties, rather than Skull Valley sorties. Aircraft Crash Report at 81-82. There were 5,726 F-16 sorties in the UTTR South Area in FY 98. Aircraft Crash Report at 82. Using the reasoning adopted by the

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

Applicant, 15.1% (866/5726) of all flights, including those through Skull Valley, carried ordnance in 1998.

C.99 Using the State's crash rate, C, for F-16s of 4.10 x 10^{-8}; taking 21.2% of 7040 as the number of flights, N, or 1492; the area, A, of 0.12519 square miles, including an assumed skid area for ordnance;[160] and its asserted width, w, of five miles,[161] the State's calculated annual probability of impact from jettisoned ordnance is 1.53 x 10^{-6} per year. State Findings ¶ 120.

C.100 Given the wide range of claims by the Applicant and the State about the number N, and given only three years of data were available (FY 98, 99, and 00), it is reasonable to use the average of the three-year data to estimate the percentage of all flights carrying ordnance. This approach provides (866+193+164)/(4086+4586+5997) = 0.08337, the proportion of all flights carrying ordnance. Multiplying 7040 (the number of flights the Board has found) by that percentage, yields an estimate for N of 587, or about 40% of the value the State would assign. We have already indicated our findings on the other factors. Thus, based on the above inputs, we calculate the probability of jettisoned ordnance directly impacting the PFS facility as follows:

$$P = C \times N \times e \times A \div w$$

$$= 2.736 \times 10^{-8}\text{/mile} \times 587 \times .90 \times .08763 \text{ sq. miles} \div 6 \text{ miles}$$

$$= 2.11 \times 10^{-7} \text{ per year}$$

Although meeting the Commission's governing criterion, this probability is high enough to warrant inclusion in the cumulative risk.

(3) Nearby Explosion

C.101 The Applicant also addressed the potential hazard to the facility posed by jettisoned live ordnance that might land near the facility (without hitting it) and explode on impact, as well as

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[160] Resnikoff Post Tr. 8698, at 20; <u>see</u> <u>also</u> State Exh. 79 and 80.

[161] Resnikoff Post Tr. 8698, at 20; <u>see</u> <u>also</u> State Findings ¶¶ 40-45.

the hazard posed by a potential explosion of live ordnance carried aboard a crashing aircraft that might impact the ground near the facility (also without hitting it) and found both to be insignificant. See Cole/Jefferson/Fly Post Tr. 3061, at 104-06. The State submitted no testimony on these potential hazards.

C.102 The U.S. Air Force has specifically stated that "[n]o aircraft flying over Skull Valley are allowed to have their armament switches in a release capable mode. All switches are 'SAFE' until inside DOD land boundaries." Cole/Jefferson/Fly Post Tr. 3061, at 101-02. The Air Force has also stated that "[t]he UTTR has not experienced an unanticipated munitions release outside of designated launch/drop/shoot boxes." Cole/Jefferson/Fly Post Tr. 3061, at 102. Consequently, the likelihood or probability of an inadvertent weapons release from F-16s flying over Skull Valley impacting or affecting the facility is very small.

C.103 As stated above, Air Force pilots do not arm the live ordnance they are carrying while transiting Skull Valley near the facility. Furthermore, the likelihood that unarmed live ordnance would explode when impacting the ground after being jettisoned is "remote" and the Air Force has no records of such incidents in the last ten years. Cole/Jefferson/Fly Post Tr. 3061, at 104; see also Tr. at 8444 (Horstman). Thus, it is highly unlikely that jettisoned live ordnance or live ordnance carried aboard a crashing aircraft that did not directly impact the facility would damage the facility.

C.104 Nevertheless, the Applicant conservatively assumed that ordnance jettisoned from or carried aboard a crashing aircraft would have a 1% chance of exploding and calculated the hazard that potentially exploding ordnance landing nearby the PFSF would pose to the facility. Cole/Jefferson/Fly Post Tr. 3061, at 105-06. The Applicant assumed that a storage cask or the Canister Transfer Building could be damaged if a bomb exploded close enough to exceed their explosive overpressure limits. Johns Post Tr. 3205, at 5-6; Aircraft Crash Report at 83b. The

Applicant conservatively assumed that each F-16 carrying ordnance through Skull Valley was carrying a 2,000 lb. bomb, the largest single piece of ordnance they carry. Cole/Jefferson/Fly Post Tr. 3061, at 105. The Applicant then calculated the probability that the jettisoned ordnance would land close enough to explode and damage the facility, or an F-16 would crash near the facility without jettisoning the ordnance using a method similar to what it used to calculate the probability that an F-16 would crash and hit the facility. Cole/Jefferson/Fly Post Tr. 3061, at 105. The Applicant concluded that there would be an annual probability of less than 1×10^{-10} per year that the facility would be damaged by a nearby explosion of ordnance. Cole/Jefferson/Fly Post Tr. 3061, at 105-06. Again, the State did not challenge the impact of nearby exploding ordnance, and in addition, the Staff found the Applicant's assessment to be reasonable. Staff Findings ¶ 2.517.

(4) Conclusion

C.105 We find that the Applicant used logical methodology to calculate the hazard to the facility posed by ordnance. As noted above, the Applicant's assessment of the crash impact hazard posed by F-16 transits of Skull Valley is based on reasonable data and analysis in three of the four respective ways ordnance can impact the facility. The Board has determined, based on its own analysis, that a higher hazard probability is more appropriate for the hazard posed by jettisoned ordnance. But the Board's estimate of 2.1×10^{-7}/year (relative to the Applicant's value of 3.2×10^{-8}/year) is still within the Commission's 1×10^{-6} acceptance criterion. The State did not challenge the Applicant's assessment of the hazard posed by potential nearby explosions of ordnance.

C.106 In summary, we find that the risk posed to the facility from jettisoned ordnance is within the acceptance criterion of 1×10^{-6}/year stated in CLI-01-22. This risk level, however, adds to the already excessive risk posed by F-16s transiting Skull Valley.

III. CONCLUSIONS OF LAW

The Licensing Board has considered all of the material presented by the parties on contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents). Based upon a review of the entire evidentiary record in this proceeding and the proposed findings of fact and conclusions of law submitted by the parties, and in accordance with the views set forth in Parts I and II above -- which we believe are supported by a preponderance of the reliable, material and probative evidence in the record -- the Board has decided the matters in controversy concerning this contention and reaches the following legal conclusions:

1. Pursuant to 10 C.F.R. §§ 72.90, 72.94, and 72.98, proposed sites for an ISFSI must be examined with respect to the frequency and severity of external man-induced events that could affect the safe operation of the ISFSI. The facility must be designed to accommodate the effects of credible accidents and must include them in the design bases of the facility. See 10 C.F.R. § 72.122(b)(1). The Commission previously approved an annual probability of occurrence criterion of 1×10^{-6} for determining whether aircraft crash accidents must be included in the design bases of an ISFSI. See CLI-01-22, 54 NRC 255, 263 (2001).

2. The Applicant has not demonstrated, as required by that Commission decision, that the cumulative probability of a civilian or military aircraft (including jettisoned ordnance) crashing at or affecting the PFS facility is within the acceptance criterion of 1×10^{-6} per year. Specifically, PFS has not provided reasonable assurance that F-16 aircraft crash accidents do not pose a significant threat to the facility. Consequently, the PFS application for a Part 72 license to construct and operate an independent spent fuel storage facility in the Skull Valley cannot be granted at this juncture.

For the reasons set forth in this opinion, it is this 10th day of March 2003, ORDERED that:

1. Contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents) is RESOLVED in favor of intervenor State of Utah relative to the issue of the hazard of F-16s transiting Skull Valley, as it impacts on the cumulative hazard to the PFS facility from aircraft accidents and ordnance.

2. In accordance with 10 C.F.R. § 2.730(f), the Licensing Board's rulings in Part I above, as supported by the Detailed Analysis of the Record and Findings of Fact in Part II above, and the brief Conclusions of Law in Part III above, are REFERRED to the Commission for its consideration and further action, as appropriate.

3. In accordance with Subpart I.E above, Applicant PFS, intervenor State of Utah, and the NRC Staff shall FILE within 20 days a joint report outlining their positions regarding further proceedings on the issue of the consequences of an F-16 accident at the Skull Valley facility.

4. In the absence of Commission acceptance of our referral of this ruling under ordering paragraph two above, and upon a determination by Applicant PFS (as may be expressed in the report submitted under ordering paragraph three above) not to proceed further relative to the issue of the consequences of an F-16 accident at the Skull Valley facility, pursuant to 10 C.F.R. § 2.760(a), this Partial Initial Decision will constitute the FINAL ACTION of the Commission within forty (40) days of its date unless a petition for review is filed in accordance with 10 C.F.R. § 2.786, or the Commission directs otherwise.

5. Any party wishing to file a petition for review on the grounds specified in 10 C.F.R. § 2.786(b)(4) must do so within fifteen (15) days after service of this decision, which shall be considered to have been served by regular mail for the purpose of calculating that petition filing date.

THE ATOMIC SAFETY
AND LICENSING BOARD

/RA/

Michael C. Farrar, Chairman
ADMINISTRATIVE JUDGE

/RA/

Jerry R. Kline
ADMINISTRATIVE JUDGE

/RA/

Peter S. Lam
ADMINISTRATIVE JUDGE

Rockville, Maryland

March 10, 2003

Copies of this Memorandum and Order were sent this date by Internet e-mail transmission to counsel for (1) applicant PFS; (2) intervenors Skull Valley Band of Goshute Indians, OGD, Confederated Tribes of the Goshute Reservation, Southern Utah Wilderness Alliance, and the State of Utah; and (3) the NRC Staff.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of PRIVATE FUEL STORAGE, L.L.C. (Independent Spent Fuel Storage Installation)	))))))	Docket No. 72-22-ISFSI

CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing LB PARTIAL INITIAL DECISION (REGARDING "CREDIBLE ACCIDENTS") (LBP-03-04) have been served upon the following persons by express mail as indicated by an asterick (*), by deposit in the U.S. mail, first class, as indicated by double asterisks (**), or through NRC internal distribution, as indicated by a plus sign (+).

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Docket No. 72-22-ISFSI
LB PARTIAL INITIAL DECISION
(REGARDING "CREDIBLE ACCIDENTS")
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[Original signed by Emile L. Julian]

Office of the Secretary of the Commission

Dated at Rockville, Maryland,
this 10th day of March 2003