RAI Volume 2, Chapter 2.1.1.3, First Set, Number 2: Second Supplemental Question:

On Page 1, first paragraph of the supplemental response, one of the sentences states, "BSC 2007c relies on the gamma-factors developed by Solomon." It is not clear why the DOE has not updated the Solomon-recommended gamma-factors for military aircraft crashes (Solomon 1975) using information on 282 mishaps of small military aircraft (A-10, F-15, F-16, and F-22) contained in Attachment III of *Frequency Analysis of Aircraft Hazards for License Application* (BSC 2007c).

1. SECOND SUPPLEMENTAL RESPONSE

1.1 REASONS WHY GAMMA FACTORS NOT UPDATED

The Solomon-recommended gamma-factors for military aircraft crashes were not updated using information on 282 mishaps of small military aircraft contained in Attachment III of *Frequency Analysis of Aircraft Hazards for License Application* (BSC 2007) for two reasons. First, the probability of crash from all Beatty Corridor aircraft flights (2.9×10^{-8} crashes/year) is two orders of magnitude below the Category 2 event sequence threshold (2×10^{-6} crashes/year), rendering such an update insignificant to the total aircraft crash frequency. Second, the data in Attachment III do not contain the specific parameters necessary for determining a gamma factor. Therefore, even if such an update were possible based on the data in Attachment III of the analysis, it would not significantly affect the total aircraft crash frequency.

The methodology used to evaluate the Beatty Corridor air traffic, which is one of three contributors to the overall crash frequency in the frequency analysis (BSC 2007), includes the use of the Solomon model (Solomon 1975). Small military aircraft account for 2% of the Beatty Corridor flights. With a gamma factor of 1, these 2% of Beatty Corridor flights contribute over 50% to the Beatty Corridor crash probability. However, the probability of crash from all Beatty Corridor aircraft flights is two orders of magnitude below the Category 2 event sequence threshold, confirming that the probability of an aircraft crash into repository surface facilities from flights in the Beatty Corridor is low in comparison to the categorization threshold and to the total calculated aircraft crash frequency.

The aircraft of concern for the Yucca Mountain repository are the A-10, F-15, F-16, and F-22 aircraft (BSC 2007, Section 3.2.12). While these aircraft were placed in service after the Solomon model was published, the flight testing for the A-10 and F-15 aircraft began in 1972, and the flight testing for the F-16 aircraft began in 1974. A sensitivity study on the gamma factor was performed in Attachment VI of the frequency analysis (BSC 2007). This sensitivity study applied the same gamma factor, ranging from 1 to 2, to all aircraft types. The sensitivity study did not evaluate gamma factors less than 1 because a gamma factor less than 1 is considered feasible only for aircraft landings and takeoffs, not for transitory flights, which is the flight mode for aircraft in the Beatty Corridor. However, an investigation was performed to demonstrate that updating the gamma factor for small military aircraft would have an insignificant impact on the Beatty Corridor crash probability. This was done by changing the small military aircraft gamma factor in Equation 4 of the frequency analysis (BSC 2007). In order to increase the Beatty Corridor crash probability by an order of magnitude, which would still be one order of

magnitude below the Category 2 event sequence threshold, the small military aircraft gamma factor would have to decrease from 1 to 0.5. This would be a significant change in the gamma factor that could only be realized for crashes associated with aircraft landings and takeoffs, which do not apply for aircraft traveling in the Beatty Corridor. Thus, updating the gamma-factor for A-10, F-15, F-16, and F-22 aircraft would result in an insignificant change to the overall crash probability.

Solomon states in Appendix A-3 of the estimate of probability document (Solomon 1975) that the aircraft crash probability per effective plant area uses a Gaussian-shaped probability distribution to estimate the "postulated aircraft impact location orthonormal (perpendicular) to the intended flight path at the point at which difficulty originates." Appendix A-3 of the estimate of probability document (Solomon 1975) then states that in the special case of the straight path, the probability that aircraft will impact a particular point diminishes with the projected orthonormal (perpendicular) distance from the location on the path at which the trouble began. Solomon also states that it is "very difficult to establish the exact location and distance of the plane when [*sic*] the trouble leading to the crash originated." Thus, this diminishing probability in the perpendicular direction of the flight path is modeled by Solomon with the exponential distribution and the best subjective estimate of gamma based on aircraft accidents and previous studies.

For aircraft traveling in the Beatty Corridor, the Solomon model estimates the probability of the crash at a distance outside the Beatty Corridor perpendicular to the flight path. The information necessary to update a gamma-factor is the distance from the point of the crash-initiating event to the point of impact. This distance includes the distance in the direction of the flight path and the distance that the aircraft deviated perpendicularly from its flight path.

Attachment III of the frequency analysis (BSC 2007) contains data collected on 282 mishaps of small military aircraft (A-10, F-15, F-16, and F-22). These data include, where possible, the altitude that the pilot ejected from the aircraft and the distance the aircraft traveled after the pilot ejected. The data in Attachment III (BSC 2007) are used for determining aircraft glide ratios and the cumulative distribution function of aircraft travel distance after pilot ejection for use in the other two portions of the analysis, which are addressed in the responses to RAI 2.2.1.1.3-007 and RAI 2.2.1.1.3-009. The data available on the mishaps (BSC 2007, Attachment III) do not contain the distance that the aircraft traveled from the onset of the mishap or the distance that the aircraft deviated from its initial flight path. Therefore, the data in Attachment III (BSC 2007) do not support updating a gamma factor.

1.2 BEATTY CORRIDOR FLIGHTS COULD HAVE BEEN SCREENED FROM EVALUATION

The inclusion and evaluation of Beatty Corridor flights in the frequency analysis represents a prudent and conservative approach, insofar as it accounts for aircraft activity that otherwise would not have been evaluated had the DOE followed NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants* (NRC 1987) methodology.

The aircraft hazards evaluation began with examining aircraft activity and determining an appropriate methodology to evaluate the aircraft activity. The review for an appropriate methodology began with NUREG-0800, Revision 2, Section 3.5.1.6. Subsection II of Section 3.5.1.6 states that the probability of aircraft impact in the site is considered to be "less than about 1×10^{-7} per year by inspection" if the distances from the plant meet all three acceptance criteria specified therein. If identified aircraft activity meets the three criteria, which are specified below, the probability of an aircraft impact is acceptably low, and no detailed analysis is necessary.

Aircraft activity in the area surrounding Yucca Mountain is actually screened out using the three NUREG-0800 screening criteria and appropriate flight restrictions. Screening Criterion II.1(a) relates to facility-to-airport distance and the projected annual number of airport operations. There were over 25 airports identified within a 100-mile radius of the Yucca Mountain North Portal and all airports met, with significant margin, the screening criterion. Thus, airport activity meets this NUREG-0800 screening criterion and is screened from further consideration.

Screening Criterion II.1(b) relates to the distance from the facility to the edge of military training routes. The criterion states that the facility be at least 5 statute mi from the edge of military training routes except for those routes associated with usage greater than 1,000 flights per year. Recognizing that the proposed flight-restrictions limit the number of flights within a 5.6-mile radius of the repository to no more than 1,000 per year (Procedural Safety Control-16 in SAR Table 1.9-10), this screening criterion is met.

The third criterion, Screening Criterion II.1(c), states that the facility be at least 2 statute mi beyond the nearest edge of a federal airway, holding pattern, or approach pattern. There are no holding or approach patterns in the vicinity of the Yucca Mountain repository, and the nearest federal airway, which is the Beatty Corridor, is over 8 mi away. Therefore, the Yucca Mountain repository meets this screening criterion.

Thus, with military flight restrictions, aircraft activity in the vicinity of Yucca Mountain meets the three acceptance criteria of NUREG-0800, Section 3.5.1.6, and the probability of aircraft crash is considered less than 1×10^{-7} per year by inspection. The Category 2 event sequence threshold is one chance in 10,000 over the preclosure period. This equates to 2×10^{-6} per year for a 50-year surface operation. Therefore, the hazard associated with aircraft activity is screened from further evaluation using the NUREG-0800 acceptance criteria.

However, the DOE selected a more comprehensive analysis method that included other aircraft flight activities. First, the analysis method selected by the DOE included the contribution of military training, a mode of flight that would not have been analyzed if the NUREG-0800 screening criteria had been applied. This type of flight activity occurs at a distance greater than 30 mi from the repository. Therefore, even though the DOE currently allows and schedules only military transitory type flights, it was determined that it would be prudent to also analyze aggressive maneuvering activity typical of military training exercises (e.g., Red Flag).

Second, the analysis method selected by the DOE also included analysis of potential crashes from flights in the Beatty Corridor. The Beatty Corridor is defined by the DOE in the frequency analysis (BSC 2007) to be the airspace band between the edge of the military operations areas in

California and restricted airspaces in Nevada. Aircraft flying between these two restricted airspaces fly within an approximately 26-mile wide band. As stated earlier, the edge of this airway is about 8 mi from the repository. Because of this airspace constraint, the Beatty Corridor experiences significant air traffic. Even though this significant air traffic is screened from further evaluation by the NUREG-0800 Screening Criterion II.1(c) because it is over 2 mi from the repository, the DOE determined that it was prudent to verify that this air traffic does not pose a significant risk to the repository.

1.3 CONCLUSION

In summary, the DOE performed a detailed evaluation of potential aircraft hazards instead of limiting the analysis to screening potential aircraft hazards based on the NUREG-0800 screening criteria. As such, the DOE took additional steps to assure safety, as well as transparency in the aircraft hazards evaluation, by identifying and analyzing aircraft activity that otherwise would not have been evaluated using the NUREG-0800 methodology.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC (Bechtel SAIC Company) 2007. *Frequency Analysis of Aircraft Hazards for License Application*. 000-00C-WHS0-00200-000-00F. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070925.0012.

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Solomon, K.A. 1975. *Estimate of the Probability That an Aircraft Will Impact the PVNGS*. NUS-1416, Rev. 1. Sherman Oaks, California: NUS Corporation. ACC: MOL.20070726.0004.