RAI Volume 2, Chapter 2.1.1.3, First Set, Number 7: Second Supplemental Question:

Part 1, Page 2, 4th paragraph, 1st bullet: The following is clarification of supplementary question to RAI 7. The NRC staff does not understand why the equation for flights through a corridor used in NUREG-0800, mainly crash frequency = *CNA/w*, would not yield the correct estimate of crash frequency for the 1000 overflights of the flight-restricted airspace per year. In this context of overflight, the NUREG formulation considers potential crashes of aircraft intending to overfly the flight-restricted airspace, and experiencing mishaps outside the flight-restricted airspace. In contrast, the SAR formulation in Section 4.3.2 of BSC 2007c does not appear to consider these crashes. The DOE response to supplemental question stated that the NUREG equation does not take into account the flight restrictions. But the flight restrictions can be taken into account in setting the value of parameter *C* (crashes/mi) by counting only crashes originating from aircraft operating in straight and normal flight. Thus, with parameter *C* having the same value as the parameter lambda in Equation 5 of BSC 2007c, flight restricted to straight and normal has been taken into account.

Part 2, page 3, bullet 3: Other flight restriction, i.e., flights greater than 14,000 ft MSL do not affect the calculation of crash frequency from overflights. In particular, the Staff's understanding is that the altitude restriction has no effect on the frequency calculation because the factor *C* or lambda is constant with altitude.

Part 3, page 3, Equation 5 of BSC 2007c: The factor p_c does not appear to be necessary, as the factor *CN/w* is an areal crash density over the whole ground corridor of width $w = 2R$, where *R* is the radius of the restricted area. Of these crashes, only those landing in the effective target area A count; thus all other crashes are eliminated, including those which crash beyond A or short of A. So there appears to be no need for an additional correction factor, p_c, to eliminate some of these crashes. Thus, although there may be other formulation of this calculation, it is unclear why NUREG formula *CNA/w* would not give the crash frequency into the target area.

1. SECOND SUPPLEMENTAL RESPONSE

In the public call with the NRC on July 23, 2009, the DOE stated that the response to the supplemental question would contain a supplemental evaluation of the overflight crash frequency using the NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants* (NRC 1987), equation and further explanation of the DOE methodology used to determine the crash frequency from military aircraft overflights of the repository.

1.1 NUREG-0800 EVALUATION

The response to the second supplemental question on RAI 2.2.1.1.3-002 evaluates the aircraft activity surrounding the Yucca Mountain repository using the three NUREG-0800, Section 3.5.1.6 acceptance criteria. That supplemental response demonstrates that all three NUREG-0800 acceptance criteria are met, indicating that a detailed evaluation of aircraft activity is not required. However, for further confirmation that the 1,000 military overflights of the repository do not pose a significant risk, this section provides an evaluation of the probability of crash using the NUREG-0800, Section 3.5.1.6 equation. The proposed flight-restricted airspace is conservatively modeled in this evaluation as if it were an aviation corridor.

The proposed Yucca Mountain flight-restrictions limit the annual flights over the repository to no more than 1,000 flights per year, as documented in procedural safety control (PSC) 16 of SAR Table 1.9-10. The F-16 crash rate is used for the 1,000 annual flights because it results in the highest crash frequency, as shown in *Frequency Analysis for Aircraft Hazards for License Application* (BSC 2007, Section 3.2.13). Annual crash frequency of these 1,000 annual flights is determined using the formula given in NUREG-0800 for the frequency per year of an aircraft crashing into a facility, *P(FA)*.

$$P(FA) = \frac{C \times N \times A}{w} \qquad \text{(Eq. 1)}$$

where

P(FA)	=	probability per year of aircraft impact into facility
C	=	aircraft crash rate (mi^{-1})
N	=	annual number of flights (number/yr)
A	=	effective facility area (mi^2)
w	=	width of airway (mi)

The updated F-16 crash rate is 2.74×10^{-8} mi^{-1} (BSC 2007, Section 3.2.13) and the effective facility area is 0.33 mi^2 (BSC 2007, Table 19). The annual number of overflights is limited to 1,000 per year (BSC 2007, Section 3.3.2, and PSC-16). The width of the corridor is taken as the diameter of the flight-restricted airspace. The radius of the flight-restricted airspace is 5.6 miles (BSC 2007, Section 3.3.1, and PSC-16), thus the width of the airway is 11.2 miles.

$$P(FA) = \frac{(2.74 \times 10^{-8} mi^{-1}) \times (1000 / yr) \times (0.33 mi^2)}{11.2 mi} \qquad \text{(Eq. 2)}$$

$$P(FA) = 8.1 \times 10^{-7} / yr$$

Using the NUREG-0800 equation, the annual crash frequency is 8.1×10^{-7} per year. Category 2 event sequences are defined in 10 CFR 63.2 as those events that have at least one chance in 10,000 of occurring over the preclosure period, which is taken to be 50 years of surface operations yielding an equivalent annual frequency of 2×10^{-6} per year. Therefore, applying the NUREG-0800 equation to the military overflights confirms that aircraft hazards from these overflights do not pose a significant risk to the relevant Yucca Mountain surface facilities.

As stated above, using the NUREG-0800 Section 3.5.1.6 screening criteria results in screening all air activity from detailed evaluation. This result is reinforced by the following:

- The annual crash frequency of overflights using the NUREG-0800 equation is 8.1×10^{-7} per year, which is below the Category 2 event sequence annual frequency threshold of 2×10^{-6} per year.

- The annual crash frequency of overflights using the NUREG-0800 equation added to the annual crash frequency contribution from the Beatty Corridor flights using the DOE methodology (2.9×10^{-8} per year) results in an annual crash frequency of 8.4×10^{-7} per year, which is still below the Category 2 event sequence annual frequency threshold of 2×10^{-6} per year.

- The annual crash frequency of overflights using the NUREG-0800 equation added to the annual crash frequency contribution from the Beatty Corridor flights (2.9×10^{-8} per year) and the annual crash frequency of military flights outside the flight-restricted zone not intending to fly over the repository using the DOE methodology (4.8×10^{-7} per year) results in an annual crash frequency of 1.3×10^{-6} per year, which is also still below the Category 2 event sequence annual frequency threshold of 2×10^{-6} per year.

Thus, even the conservative addition of all three contributors to the annual crash frequency used in the DOE methodology (flights in the Beatty Corridor, 1,000 annual overflights using NUREG-0800 methodology, and flights outside of flight-restricted zone not intending to fly over the repository) yields a frequency that is below the Category 2 event sequence screening threshold.

1.2 DOE METHODOLOGY

The crash frequency analysis (BSC 2007) describes the DOE aircraft crash methodology. The methodology is further described in the responses and supplemental responses to the aircraft-related RAIs (RAIs 2.2.1.1.3-001 through 2.2.1.1.3-011). Specifically, the DOE crash frequency analysis (BSC 2007) utilizes a methodology that includes many types of mishaps, including engine failure with long flight durations after the initiating event. The DOE methodology explicitly ignores pilot actions, including actions that could reduce the crash frequency. Even though NUREG-0800 states that federal airways at least 2 miles beyond the site present an acceptable risk, the DOE methodology conservatively increases this distance (by a factor of 15) to 30 miles and includes airways (specifically the Beatty Corridor) that would have otherwise been excluded. The portion of the analysis that addresses flights in federal airways is addressed in the response and supplemental responses to RAI 2.2.1.1.3-002.

No crashes have occurred within 30 miles of the repository site. Nonetheless, to be conservative, the DOE methodology uses a uniform crash frequency density within the 30 mile radius that draws in crashes that occurred at distances approximately 40 to 100 miles from the North Portal, and which are indicative of the aggressive military flight characteristic of the Nevada Test and Training Range and other military operations areas. In effect, crashes that have historically occurred more than 30 miles from the North Portal in areas where aggressive flight activity is allowed are used to conservatively estimate the crash frequency density near the repository where no crashes have historically occurred. The portion of the analysis that addresses aggressive military flight activity is addressed in the response and supplemental responses to RAI 2.2.1.1.3-009.

The response and supplemental responses to RAI 2.2.1.1.3-007 address the 1,000 military overflights of the repository. Specifically, Equation 7 in Section 4.3.2 of the frequency analysis (BSC 2007) introduces the factor p_c to account for boundary conditions introduced by flight-restrictions; specifically, altitude and flight mode restriction. Equation 7 analyzes flights that are outside of the flight-restricted zone intending to fly over the repository, and flights that are over the repository when a potential mishap occurs leading to a crash. The crash rate (crashes/mile) used in Equation 7 is based on all flight modes, not just straight and level flight, and all altitudes, not just those at or above 14,000 ft mean sea level, as required by the flight restriction (PSC 15 and PSC 16). Because of the conservatisms inherent in the crash frequency analysis (BSC 2007), such as analyzing aircraft activity that would not have otherwise been evaluated, and using a crash rate that is not specifically based on flights consistent with flight-restrictions, the factor p_c is applied in Equation 7 to reduce some of the over-conservatism in the calculation. However, as shown in Section 1.1, evaluating these 1,000 overflights without the use of the factor p_c results in an annual crash frequency below the Category 2 event sequence screening threshold. Indeed, even the conservative addition of all three contributors to the annual crash frequency used in the DOE methodology (flights in the Beatty Corridor, 1,000 annual overflights using NUREG-0800 methodology, and flights outside of flight-restricted zone not intending to fly over the repository) yields a frequency that is below the Category 2 event sequence screening threshold.

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.

NRC (U.S. Nuclear Regulatory Commission) 1987. *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants*. NUREG-0800. LWR Edition. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 203894.