RAS 5621 72-22-ISFSI - State Exhibit 157 - Rec'd 4/12/02
DOCKETED
USNRC
NUCLEAR REGULATORY COMMISSION
Docket No. _____ Official Exh. No. 157
In the matter of PFS
Staff _____ IDENTIFIED ✓
Applicant _____ RECEIVED ✓ per 8/21 Joint Rept
Intervenor ✓ REJECTED _____
Other _____ WITHDRAWN _____
DATE 4-12-02 Witness _____
Clerk D. Kent
2003 JAN 31 PM 1:54
OFFICE OF THE SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF
YM_Aircraft_Crash_1

# PRELIMINARY AIRCRAFT CRASH HAZARD ASSESSMENT AT PROPOSED YUCCA MOUNTAIN REPOSITORY

**Amitava Ghosh**
*Center for Nuclear Waste Regulatory Analyses*
*Southwest Research Institute*
*6220 Culebra Road*
*San Antonio, Texas 78238-5166*

**Budhi Sagar**
*Center for Nuclear Waste Regulatory Analyses*
*Southwest Research Institute*
*6220 Culebra Road*
*San Antonio, Texas 78238-5166*

## Introduction

The proposed geologic repository at Yucca Mountain will be designed for permanent disposal of high-level nuclear waste. The Department of Energy (DOE) has conducted analyses to identify natural and human-induced hazards and their potential for becoming initiating events that may lead to radiological release during the operations period prior to permanent closure. The proposed site lies beneath the R4808N airspace of the Nellis Air Force Range. Crash of aircraft is considered to be one of the initiating events that has potential for radiological release. If the estimated frequency of potential aircraft crashes onto structures containing radioactive materials exceeds $10^{-6}$ per year, a consequence analysis is necessary. Additionally, significant modifications of the facility design may be necessary if the consequence analysis shows the dose limits proposed in10 CFR Part 63 may be exceeded. In this paper, a preliminary analysis of the aircraft crash hazard is presented. This analysis, based on published information, will help the Nuclear Regulatory Commission staff to determine whether the aircraft crash hazard is appropriately analyzed and whether it has the potential to exceed the proposed dose limits.

## Methodology

The proposed site for a high-level waste repository at Yucca Mountain does not satisfy requirement 1(b) of NUREG-0800[1] that states, "The plant is at least 5 statute miles from the edge of military training routes, including low-level training routes, except for those associated with a usage greater than 1,000 flights per year,



UT-49895
Template=SECY-028
SECY-02

or where activities (such as practice bombing) may create an unusual stress situation." As the number of annual flights in 1996 (the latest year for which data were available) through the restricted area R4808N significantly exceeded 1,000, a detailed review of aircraft crash hazard of the site is required for all potential sources of aircraft[1]. Potential crash probabilities of all types of aircraft (commercial, chartered, general aviation, and military) flying in the vicinity of the proposed site should be summed to estimate the total probability of aircraft crash.

The crash probability, $P_{FA}$, of aircraft flying federal airways or aviation corridors is[1]

$$P_{FA} = N \times C \times \frac{A_{eff}}{W} \qquad (1)$$

where,

C = inflight crash rate per mile for a given aircraft

N = number of flights per year along the airway

$A_{eff}$ = effective area of the plant in square miles

W = width of the airway (plus twice the distance from the airway edge to the site when the site is outside the airway) in miles.

NUREG-0800 states that this methodology "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."

**Crash Probability Estimation Using Available Information**

Estimation of aircraft crash probability requires reliable information on the parameters of Eq. (1). In addition, justifiable information on types of aircraft and flight activities is required for military aviation, especially when

a facility is inside a restricted airspace.

Commercial and limited charter aircraft takeoff or land at McCarran International, North Las Vegas, and Tonopah airports. These airports are beyond 30 mi from the proposed facility. General aviation aircraft primarily use McCarran International, North Las Vegas, Beatty, Frans Star, and Jackass airports[2]. The last three airports are more than 10 mi from the proposed facility. Military aircraft use Nellis Air Force Base, Tonopah Test Range, and Indian Springs Air Force Auxiliary Base airports located at distances greater than 30 mi from the proposed site. DOE aircraft use Desert Rock, Yucca, and Pahute Mesa airfields within the NTS. Military aircraft along with DOE aircraft and aircraft chartered by DOE fly through the R4808N airspace. The number of commercial and general aviation aircraft taking off and landing at these airports currently is small (less than $1000D^2$, where D is the distance between an airport and the site) and allows their exclusion from the hazard estimation[1]. However, if the projected growth at any of these airports increases traffic significantly such that the criterion in [1] is exceeded, a detailed analysis may become necessary.

DOE aircraft use federal airway V105-135 to reach the Desert Rock airfield. The proposed repository surface facilities are 11 statute miles away from the nearest edge of this 10 mi wide airway. The types of aircraft used by DOE flying though this airspace have not been indicated in [2]. As many of these flights use charter aircraft, we have assumed that the aircraft would be similar to commercial aircraft ("Air Carrier" in the DOE Standard[3]) in crash statistics. However, this assumption should be verified in the license application. Crash rate, C, for commercial aircraft is $4 \times 10^{-10}$ per flight mile[1]. As this is a heavily traveled air corridor (more than 100 daily flights), a detailed analysis may also be required in the future to more accurately estimate the crash rate[1].

Approximately 54,000 annual flights of DOE aircraft utilize the three airfields – Desert Rock, Yucca, and Pahute Mesa[2]. However, information is not available about the number of annual flights to each of these airfields. To make a conservative estimate of the crash probability, we have assumed that all 54,000 flights use Desert Rock airfield. We have also made another estimate assuming one-third of the 54,000 flights for each airport. Better information on the number of flights for each airport is needed for future analysis.

The effective area of the surface facilities at the proposed repository is calculated as the sum of the effective area of each of the five structures where radioactive materials can be potentially located[2]. Based on the parametric values given in the DOE Standard[3], the representative values used in estimating the effective areas for wingspan, WS, cotangent of the impact angle, cot f , and mean skid distance, S, are 98 ft, 10.2, and 1440 ft, respectively. Using the formula given in the DOE Standard and proposed building dimensions[2], the estimated effective areas are given in Table 1.

**Table 1. Estimated effective area of the target structures for DOE aircraft**

| Structure | Length (ft) | Width (ft) | Height (ft) | Effective Area ($ft^2$) | Effective Area ($mi^2$) |
|---|---|---|---|---|---|
| Waste Handling Building | 540 | 536 | 117 | 2,625,703 | 0.094 |
| Waste Treatment Building | 260 | 200 | 60 | 957,273 | 0.034 |
| Carrier Preparation Building | 160 | 120 | 33.17 | 567,960 | 0.020 |
| Truck Parking | 200 | 100 | 10.5 | 535,089 | 0.019 |
| Rail Parking | 1200 | 150 | 15 | 2,291,764 | 0.082 |
| **Total Effective Area of Surface Facilities** | | | | | 0.251 |

The width of the airway, W, is $10 + 2 \times 11$ or 32 mi. Therefore, the annual probability of crash from DOE chartered aircraft is

$$P_{FA} = 54000 \times 4 \times 10^{-10} \times \frac{0.251}{32} = 1.7 \times 10^{-6}.$$

Assuming only one-third of the aircraft use Desert Rock airfield, the annual crash probability is $6 \times 10^{-7}$.

Any aircraft in the inventory of the Department of Defense or other NATO countries can fly through the restricted airspace of R 4808N. As the probability of aircraft crash onto the proposed facility is directly proportional to the number of aircraft flying nearby, it is necessary to get a good estimate of the number of aircraft overflights in the vicinity of the proposed site. Considerable uncertainty also exits in the estimated number of military aircraft overflights in restricted airspace R 4808N[5]. A previous study estimated the annual number of military overflights of restricted airspace R 4808N to be approximately 73,000[3]. Estimates over the years vary as the mission of Nellis Air Force Base Range evolves. Only 6 months of flight data has been given in [2]. The number of flights per year, N, has been estimated to be (i) 12,716 (mean), (ii) 17,542 (90% confidence), and (iii) 18,910 (95% confidence)[7] by fitting a normal distribution to the six months' data. Fitting a normal distribution to six data points leaves too few degrees of freedom to carry out any meaningful statistical analysis[4]. Additional work is necessary to monitor the level of flights and to re-estimate the aircraft crash probability at the proposed repository site.

In the absence of specific information about the flight activities, it is conceivable that the aircraft fly in "Special" inflight mode in R4808N (low level and maneuvering operations in restricted area)[6]. It has been assumed in [2] that 29 percent of all aircraft will be F-16s, 63 percent F-15s, and 7 percent A-10s. However, adequate justification is lacking for the assumed distribution of these aircraft into these three types.

The estimated effective areas of the surface facilities are given in Table 2 using the DOE Standard[3]. Using special inflight crash rates for the F-16, F-15, and A-10[6], the estimated probabilities of crash for special flight modes are given in Table 3. A few scenarios using the normal inflight crash rates have also been given in Table 3 for comparison. This sensitivity analysis shows the importance of having justifiable information on the number of military aircraft flights with associated activities by different aircraft types.

**Table 2. Estimated effective area for the target structures for F-16, F-15, and A-10 aircraft**

| Aircraft | WS (ft) | Cot f | S (ft) | Total Effective Area ($mi^2$) |
|---|---|---|---|---|
| F-16 | 33 | 8.4 | 246 | 0.091 |
| F-15 | 43 | 8.4 | 246 | 0.093 |
| A-10 | 57.5 | 8.4 | 246 | 0.096 |

**Table 3. Estimated probabilities of crash for military aircraft for different scenarios**

| Total Number of Aircraft | F-16 (%) | F-15 (%) | A-10 (%) | Flight Mode | Annual Crash Probability |
|---|---|---|---|---|---|
| 12716 | 29 | 63.9 | 7.1 | Special | $3.8 \times 10^{-6}$ |
| 17542 | 29 | 63.9 | 7.1 | Special | $5.2 \times 10^{-6}$ |
| 18910 | 29 | 63.9 | 7.1 | Special | $5.6 \times 10^{-6}$ |
| 12716 | 100 | 0 | 0 | Special | $4.5 \times 10^{-6}$ |
| 18910 | 100 | 0 | 0 | Special | $6.7 \times 10^{-6}$ |
| 12716 | 100 | 0 | 0 | Normal | $1.5 \times 10^{-6}$ |
| 18910 | 100 | 0 | 0 | Normal | $2.3 \times 10^{-6}$ |
| 12716 | 50 | 40 | 10 | Special | $4.0 \times 10^{-6}$ |
| 18910 | 50 | 40 | 10 | Special | $5.9 \times 10^{-6}$ |
| 12716 | 50 | 40 | 10 | Normal | $1.0 \times 10^{-6}$ |
| 18910 | 50 | 40 | 10 | Normal | $1.5 \times 10^{-6}$ |

## Conclusions

Results of this preliminary investigation confirm that lack of specific information about the flight environment in the vicinity of the proposed repository site does not allow a defensible estimation of potential hazards associated with aircraft crash. The preliminary estimates of the annual probability of aircraft crash vary by a factor of 10, and under several possible scenarios exceed the threshold criterion of $10^{-6}$ per year. More information is needed on the number of annual flights by each type of aircraft, better definition of the flight path(s), and flight activities of military aircraft to develop a reasonable annual crash hazard estimation. Better information on the flight environment is necessary in the license application to reduce some of the uncertainties in this estimation.

## Acknowledgment

This work was performed by the CNWRA for the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Material Safety and Safeguards, Division of Waste Management under Contract No. NRC-02-97-009. The work is an independent product of the CNWRA and does not necessarily reflect the views or regulatory position of the NRC.

## References

[1] Nuclear Regulatory Commission. 1981. *Aircraft Hazards.* Section 3.5.1.6, Standard Review Plan, NUREG-0800. Washington, DC: Nuclear Regulatory Commission.

[2] Morissette, R. 1999. *MGR Aircraft Crash Frequency Analysis.* ANL-WHS-000001 Rev. 00. Las Vegas, NV: Civilian Radioactive Waste Management System Management and Operating Contractor.

[3] U.S. Department of Energy. 1996. *DOE Standard: Accident Analysis for Aircraft Crash Into*

*Hazardous Facilities*. DOE-STD-3014-96. Washington, DC: U.S. Department of Energy.

[4] Scheaffer, R.L., and J.T. McClave. 1999. *Statistics for Engineers*, Boston, MA, Duxbury Press.

[5] Kimura, C.Y., D.L. Sanzo, and M. Sharirli. 1998. *Crash Hit Frequency Analysis of Aircraft Overflights of the Nevada Test Site (NTS) and the Device Assembly Facility (DAF)*. UCRL-ID-131259 Rev. 1. Livermore, CA: Lawrence Livermore National Laboratory.

[6] Kimura, C.Y., R.E. Glaser, R.W. Mensing, T. Lin, T.A. Haley, A.B. Barto, and M.A. Stutzke. 1996. *Data Development Technical Support Document for the Aircraft Crash Risk Analysis Methodology (ACRAM) Standard*. UCRL-ID-124837. Livermore, CA: Lawrence Livermore National Laboratory.