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Title: CMRR Project Calculation Cover Sheet
Aircraft Impact Analysis
July 29, 2011

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Los Alamos
NATIONAL LABORATORY
EST. 1943

CMRR Project Calculation Cover Sheet

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ORIGINAL AND REVISED CALCULATION/ANALYSIS APPROVAL

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Originator:	Tomas M. Sanchez	Tomas M. Sanchez	Tomas M. Sanchez	Tomás M. Sánchez TMS 07/29/2011 Tomas M. Sanchez
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RECORD OF REVISION

Rev.	Reason for Revision
0	Original issue.
1	New facility dimensions and to address issues raised in ANR S-06-1-002.
2	Complete replace of previous revision to facilitate 1) revising the minimum aircraft missile criteria for the structural evaluation, and 2) a technical basis for not designing the CMRR air intake plenum to accommodate the fireball caused by an aircraft impact.
3	Replace pages 20 and 21 to remove minimum aircraft missile criteria for the structural evaluation.
4	Revised facility dimensions, included an analysis for the tunnel to PF-4 and the tunnel's air intake and exhaust stack.
5	Revised analysis to account for the new elevations and dimensions associated with the facility. Revised methodology for obtaining distances from CMRR to airports.
6	Removed figure of PF-4 Tunnel and removed UCNI markings.

ATTACHMENTS

Attachment #	Title	Total Pages
A	Attached References	8
B	Orthonormal distances using MS Excel 2007	4
C	Equations for Effective Areas and Impact Frequencies Used in MS Excel 2007	20
D	Numerical Results obtained by MS Excel 2007 for Effective Areas and Impact Frequencies	8

TOTAL CALCULATION PAGE COUNT 86

CMRR Project Calculation Checklist Preparer

Item	Remarks
Purpose and Objective	
☒ Clear, concise statement of problem	
☒ Objective of calculation presented	
☒ Initiating documents identified	
Methodology and Acceptance Criteria	
☒ Method/approach of calculation identified	
☒ Steps of the analysis method/approach clearly identified	
☐ Acceptance criteria clearly stated (N/A if there is no acceptance criteria)	NA
☒ If computer programs used, document codes/model name/ version/run and computer ID number	Microsoft® Excel 2007 on Dell Optiplex GX620 – Dell Service Tag CN3TL81
Assumptions and Engineering Judgments	
☒ Assumptions have been provided with Qualifications	
☐ Engineering judgments have been provided with supporting attributes to permit verification (qualitative, quantitative, bounding)	NA
☐ Assumptions/engineering judgments which require final verification prior to construction have been identified	NA
Design Inputs	
☒ All design inputs used have been listed for traceability	
References	
☒ References include title, section, paragraph, page number, or table numbers, and revision and date of issue.	Sufficient information provided to acquire reference.
Calculations	
☒ Accuracy, legibility, reproducibility issues addressed	
☒ Calculation number, revision number and sheet number are provided on each page of calculation body. (Does not apply to computational attachments)	
☒ Formulae consistent with source documents, with units	
☒ Correct selection of formulae and methods per problem statement and calculation objective	
Results and Conclusions	
☒ Summary and conclusion clearly state results and responds to problem and objective	
☒ Conclusion clearly identifies acceptability of results	
☒ Any limitations of conditions to maintain calculation validity have been identified	
☒ List of assumptions that <u>must</u> be verified prior to construction (if any) has been included	
Attachments	
☒ Reference attachments. All pages have attachment identifier, calculation and revision number and all pages are numbered.	
☒ Computational attachments have a cover page with calculation and revision number, originator and checker signature and total number of pages. Each computational page is numbered (except data files) and indicates the computer run.	

CMRR Project Calculation Checklist Reviewer

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CMRR PROJECT CALCULATION SHEET

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Rev. No. 6	**CHECKER:** Lanny N. Smith **DATE** 7/29/2011 Print & Sign Above
Calculation Title Aircraft Impact Analysis	Lanny N. Smith

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ACROYNMS

AFD	Airport Facilities Directory
CMRR	Chemistry and Metallurgy Research Replacement
DOE	Department of Energy
E14	Ohkay Owingeh Airport
EFF	Effective
HVAC	Heating, Ventilation, and Air Conditioning
LAM	Los Alamos County Airport
LANL	Los Alamos National Laboratory
PDSA	Preliminary Documented Safety Analysis
PF	Plutonium Facility
SAF	Santa Fe Municipal Airport
SP	service pack
STD	Standard
TA	Technical Area
WS	wingspan

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this calculation is to analyze the frequency of an aircraft unintentionally impacting the Chemistry and Metallurgy Research Replacement (CMRR) Facility and select associated structures, which are to be located in Technical Area 55 (TA-55) of Los Alamos National Laboratories (LANL). This calculation follows the methodology prescribed in the Department of Energy (DOE) Standard (STD)-3014-96, *Accident Analysis for Aircraft Crash into Hazardous Facilities* [Ref. 1] and will support the CMRR Preliminary Documented Safety Analysis (PDSA) requirements of evaluating the hazards posed by man-made external accident initiators.

1.2 Scope

The scope of this calculation is limited to analyzing the frequency of an aircraft unintentionally impacting the CMRR facility using the methodology prescribed in DOE-STD-3014-96 [Ref. 1]. Aircraft that exceed the impact frequency evaluation guideline of 1E-6 impacts/year will be noted so that the CMRR facility designers can design the CMRR facility accordingly.

This calculation also provides a technical basis for not designing the CMRR air intake plenum to accommodate the fireball caused by an aircraft impact.

Finally, the tunnel from CMRR to PF-4 is evaluated for aircraft impacts, despite the fact that the current design has this tunnel below ground. Further, the PF-4 tunnel air intake and exhaust stacks are analyzed also, but as a separate building from the tunnel itself.

2.0 BASIS

2.1 Design Inputs

2.1.1 CMRR Facility (including the Vault and Auxiliary Building)

Design inputs for this calculation regarding the CMRR facility structure are the length and width of the facility. The height of facility will be discussed further under Section 2.3, Assumptions.

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DI1. The length, or the measurement taken from the outer west wall of CMRR to the outer east wall of CMRR with respect to Plan North, is 342.5 ft. This measurement was obtained from References 2-6.

DI2. The width, or the measurement taken from the outer north wall of the CMRR to the outer south wall of the CMRR, with respect to Plan North, is 304 ft. This measurement was obtained from References 2-6.

DI3. The top elevation of the exhaust stack is 7387 ft. This measurement was obtained from Section H-6 of Reference 7.

2.1.2 Aircraft Characteristics

This calculation involves inputs regarding aircraft wingspans, impact angles, skid distances, etc. The design inputs regarding aircraft characteristics and LANL site-specific crash data are given below and are taken from Appendix B of DOE-STD-3014-96 [Ref. 1].

DI4. The generic aircraft crash rates by category, subcategory, and flight phase used in this analysis are given in Table B-1, page B-3 of DOE-STD-3014-96 [Ref. 1].

Table 1 - Generic aircraft crash rates [Ref 1].

Aircraft	Crash Rate (P) [crashes per takeoff/landing]	
	Takeoff (per takeoff)	Landing (per landing)
General Aviation		
Representative Fixed Wing	1.1E-5	2.0E-5
Representative Helicopter	2.5E-5	[1]
Commercial		
Air Carrier	1.9E-7	2.8E-7
Air Taxi	1.0E-6	2.3E-6
Military		
Large Aircraft	5.7E-7	1.6E-6
Small Aircraft	1.8E-6	3.3E-6

1. Helicopter crashes are considered on a per-flight basis and are reported under takeoff for convenience [Ref. 1].

DI5. Representative wingspans (WS), cotangents of the impact angle and mean skid distances for commercial, general aviation, and military aircraft are presented in Table

2 and is taken from pages B-28 through B-29, Tables B-16 through B-18 of DOE-STD-3014-96 [Ref. 1].

Table 2 - Representative wingspans, mean of the cotangent of the impact angle, and mean skid distances used for this analysis [Ref. 1]

Category/Subcategory	Wingspan [ft]	Cotangent of the Impact Angle ($\cot\Phi$)	Mean skid distances [ft]
General Aviation	50	8.2	60
Helicopter	50	0.58	60[1]
Commercial Aviation			
Air Carrier	98	10.2	1440
Air Taxi	59	10.2	1440
Military Aviation			
Large Aircraft	223	7.4 Takeoff 9.7 Landing	780 Takeoff 368 Landing
Small Aircraft (low performance)	110	8.4 Takeoff 10.4 Landing	246 Takeoff 447 Landing

1. DOE-STD-3014-96 uses a mean skid distance of 0 ft for helicopters. This calculation assumes a mean skid distance of 60 ft for helicopters for conservatism.

DI6. DOE LANL site-specific values of *NPf(x,y)* for general, commercial, and military aviation for non-airport operations [crashes per square mile, per year, centered at the site] are presented in Table 3 and is taken from Tables B-14 and B-15, pages B-24 through B-25 of DOE-STD-3014-96 [Ref. 1].

Table 3 - LANL site-specific values of NPf(x,y) for non-airport operations.

Site	General Aviation	Commercial Air Carrier	Commercial Air Taxi	Large Military	Small Military
LANL	2E-4	2E-7	3E-6	1E-7	5E-6

2.1.3 CMRR Air Intake Plenum

Additional design inputs are needed to analyze the impact frequency associated with the air intake plenum.

DI7. The floor of the air intake "room" has an elevation of 7326.3 ft. [Ref. 9, Section G-4].

DI8. The top of the air intake "room" has an elevation of 7349.3 ft [Ref. 9, Section G-5].

2.2 Criteria

This aircraft impact analysis is based on DOE-STD-3014-96, which is a non-criterion based standard [Ref. 1]. However, aircraft impacts that occur less than 1E-6 times/year are considered incredible accidents and no further analysis or controls are needed to alleviate their consequences.

2.3 Assumptions

The assumptions used in this analysis are listed below.

2.3.1 CMRR Facility (including the Vault Building and Auxiliary Building)

AS1. A good portion of the CMRR facility will be located below grade. It is unreasonable to assume that the portion of the CMRR facility that is located below grade would be susceptible to an aircraft impact. For this reason, the height of the CMRR facility will be modeled as the distance from the top of the exhaust stacks to 10 ft below grade. This results in a facility with a height of 110.6 ft (7387 ft. – 7286.4 ft + 10 ft). Further reasoning for assuming this height is given below.

a. It is conservative to model the entire CMRR facility as having a roof with the same elevation as the exhaust stack. In reality, the CMRR exhaust stack will only occupy a small portion of the CMRR footprint. However, the added height will increase the overall size of the CMRR facility making it a larger target for an aircraft impact. The elevation of the CMRR facility exhaust stack is 7387 ft. See DI3 for more information.

b. It is highly unlikely the portion of the CMRR facility located 10 ft below grade or lower would be affected by an aircraft impact given the small size of aircraft commonly used in the Los Alamos area and the robust design of the CMRR facility. The grade elevation around the CMRR varies. For conservatism, the lowest grade evaluation is used for this analysis and is assumed to be 7286.4 ft [Ref. 10, Section D-5].

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2.3.2 Los Alamos County Airport (LAM)

AS2. The Los Alamos County Airport (LAM) is 2.1 miles from CMRR and therefore within the range of the crash location tables given in appendix B of DOE-STD-3014-96 [Ref. 1]. This distance has been scaled off a 1:100,000 U.S. Geological Survey map of Los Alamos, New Mexico [Ref. 11].

AS3. The bearing from CMRR to LAM is 56 degrees. This value has been obtained using a protractor and Reference 11.

AS4. The number of general aviation operations for the 12 months prior to June 30, 2008 is approximately 13,000 [Ref. 12]. The number of takeoffs and landings will be assumed to be equal with 6500 each. Because this information is subject to change over time, Reference 12 has been included as part of Attachment A.

AS5. The number of Air Taxi operations for the 12 months prior to June 30, 2008 was 60. The number of takeoffs and landings will be assumed to be equal with 30 [Ref. 12]

AS6. The number of military operations for the 12 months prior to June 30, 2008 is approximately 10 and consists of small military aircraft [Ref. 12]. The number of takeoffs and landings will be assumed to be equal with 5 each.

AS7. Los Alamos County Airport requires takeoffs to the east and landings to the west [Ref. 12].

AS8. There are 60 single engine, fixed winged aircraft and 1 multiengine, fixed winged aircraft based at LAM [Ref. 12].

2.3.3 Santa Fe Municipal Airport (SAF)

AS9. Santa Fe Municipal Airport (SAF) is approximately 20 miles from CMRR and is therefore within the range of the crash location tables given in Appendix B of DOE-STD-3014. This distance has been scaled off a 1:100,000 U.S. Geological Survey map of Los Alamos, New Mexico [Ref. 11].

AS10. The bearing from CMRR to SAF is 145 degrees. This value has been obtained using a protractor and Reference 11.

AS11. The number of general aviation operations at SAF for the 12 months prior to June 30, 2008 is approximately 67,200 [Ref. 13]. The number of takeoffs and landings

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will be assumed to be equal with 33,600 each. Because this information is subject to change over time, Reference 13 has been included as part of Attachment A.

AS12. The number of military operations at SAF for the 12 months prior to June 30, 2008 is approximately 5,500 [Ref. 13]. The number of takeoffs and landings will be assumed to be equal with 2,750 each.

AS13. The number of commercial air taxi operations at SAF for the 12 months prior to June 30, 2008 is approximately 6,000 [Ref. 13]. The number of takeoffs and landings will be assumed to be equal with 3,000.

2.3.4 Ohkay Owingeh Airport (E14)

AS14. Ohkay Owingeh Airport (E14) is 18 miles from CMRR and therefore within the range of crash location tables given in Appendix B of DOE-STD-3014. This distance has been scaled off the U.S. Department of Agriculture Santa Fe National Forest map [Ref. 14].

AS15. The bearing from CMRR to E14 is 51 degrees. This value has been obtained using a protractor and Reference 14.

AS16. The number of general aviation operations at the E14 for the 12 months prior to April 8, 2009 is around 1000 [Ref. 15]. The number of takeoffs and landings will be assumed to be equal with 500 each. Since this information subject to change over time, Reference 15 has been included as part of Attachment A.

2.3.5 Helicopter Operations Around LANL

AS17. The number of LANL helicopter overflights is assumed to be around 100, which is the approximate number of helicopter operations at LAM each year. A telephone conversation with a LAM employee stated that there were approximately 50 helicopter operations at LAM in the 12 months prior to May 2011 [Ref. 16]. Using a value of a 100 helicopter operations is a conservative assumption used to alleviate the uncertainty of the number of helicopter flights over and around LANL each year. The airspace over LANL is restricted up to 12,000 ft, so historically there have been very few LANL helicopter overflights. Assuming 100 helicopter overflights each year is very conservative because it is essentially stating that all helicopter operations at LAM result in a LANL overflight, which is not the case.

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"Local" helicopters overflights are considered by DOE-STD-3014 as "planned overflights associated with the facility operations, e.g., security flights or flights associated with the area operations, e.g., spraying flights" [Page 45 of Ref. 1]. The "Flight for Life" service at Los Alamos Medical Center is assumed negligible since an over-conservative assumption regarding helicopter overflights has already been made.

AS18. The average length of a helicopter flight, *LH*, is assumed to be the distance from LAM to the CMRR facility minus 0.25 mi, or 1.85 mi (the distance from CMRR to LAM is defined in the Section 2.3.2). This is a very conservative estimate as LH is inversely proportional to the impact frequency and helicopters typically travel much further than two miles.

2.3.6 Miscellaneous Assumptions

During the analysis, further assumptions were made. These assumptions are presented here and in Section 6.0.

AS19. The pattern side will be to the right of the direction of flight during landing for military operations at LAM.

AS20. All operations at SAF will occur on runway 15. The reasoning for this assumption is that this is the only runway that, per DOE-STD-3014-96 [Ref. 1], contributes to the frequency of an aircraft impact at CMRR based on the orthonormal distance from the center of the runway to the CMRR facility. This is a conservative assumption as there are two other runways that handle a good portion of the operations at SAF.

AS21. Takeoffs at SAF will be to the north and landings will be to the north on runway 33. The reasoning for this assumption is to force the runway to operate in a way that contributes to the aircraft impact frequency at the CMRR facility.

AS22. The SAF military landing pattern side is left of the direction of flight. The reasoning for this assumption is to force the runway to operate in a way that most conservatively contributes to the aircraft impact frequency at the CMRR facility. This approach overcomes the uncertainty associated with knowing the exact operating history of the runway.

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The calculation shows that the largest contributor to the impact frequency for the CMRR facility is general aviation and helicopter operations at LAM. Assumptions are needed to facilitate the design requirements of the CMRR.

AS23. For conservatism, the Cessna Pressurized Centurion will represent the "typical" single engine aircraft based at LAM because it is the largest of the single-engine reciprocating, fixed winged general aviation aircraft listed in Reference 17.

a. Powerplant: Continental TSIO-520-P PP [Ref. 17]
   i. Dry weight of basic engine [Ref. 18 – Page A8 of Attach. A]: 417.52 lb_f
   ii. Engine Dimensions [Ref. 18]
      1. Height is 23.54 in.
      2. Width is 33.56 in.
      3. Length is 40.91 in.

AS24. The Piper Seneca is used to represent the typical multiengine, fixed wing general aviation aircraft at LAM. It is the only multiengine fixed-winged aircraft based at LAM [Ref. 19].

a. Powerplants: 2x Continental TSIO-360-E [Ref. 17]
   i. Dry weight of basic engine [Ref. 18 – Page A7 of Attach. A]: 321.35 lb_f
   ii. Engine Dimensions [Ref. 18]:
      1. Height is 27.5 in.
      2. Width is 31.38 in.
      3. Length 56.97 in.

AS25. News and military helicopters are assumed to conduct the most helicopter operations near LANL. A typical helicopter used by the news media is a Bell 206 [Ref. 20] and is very similar to the military UH-1.

a. Impact velocity: 50 mph [Ref. 20]
b. Helicopter engine weight: 500 lb [Ref. 20]
c. Helicopter engine diameter: 4 ft [Ref. 20]

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d. The Bell 206 fully loaded weighs 3000 lb_f.

2.3.7 CMRR Air Intake Plenum

Concerns have been raised regarding an accident in which an aircraft unintentionally impacts the CMRR air intake plenum and creates a fireball within the plenum. An impact frequency is analyzed for the "room" that houses the air intake plenum. The following assumptions are needed for this analysis.

AS26. The length (north to south dimension with respect to building north) of the room that makes up the air intake plenum is conservatively scaled to be 46 ft [Ref. 6].

AS27. The width (east to west dimension with respect to building north) of the room that makes up the air intake plenum is conservatively scaled to be 20 ft [Ref. 6].

AS28. The height of the room that makes up the air intake plenum is assumed to be 23 ft. This measurement is based on the highest point of the air plenum roof, 7349.3 ft, and floor of the room, 7326.3 ft [Ref. 9].

AS29. Only general aviation aircraft are analyzed for the air intake plenum analysis since previous revisions of this calculation have shown general aviation to be the only aircraft impact hazard to the CMRR. Further, helicopters are neglected in this analysis because the accident scenario is focused on fuel spilling through the air intake louver. Helicopters tend to crash vertically rather than horizontally and would be less capable of passing fuel through the air intake louver than the fixed winged aircraft.

AS30. The effective fly in area of the CMRR air intake plenum is assumed to be half the value calculated using the methodology given in DOE-STD-3014. A reduction in fly-in area is based on engineering judgment due to the fact that the concern isn't just an aircraft impacting the plenum, but that an aircraft makes a direct hit on the intake louver. The intake plenum is a robust structure that is protected on two sides by other CMRR construction. Furthermore, the exposed wall is of robust concrete construction, implying that a general aviation plane is unlikely to breach it and spill the majority of its fuel through the breach. This leaves the intake louver as the only credible way that a plane could deliver fuel to the intake plenum. For these reasons, the fly-in area for the intake plenum is reduced by half.

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2.3.8 Plutonium Facility (PF) 4 Tunnel

AS31. The PF-4 Tunnel is an "L" shape with an approximate east-west dimension (with respect to building north) of 183 ft [Ref. 8].

AS32. The PF-4 Tunnel is an "L" shape with an approximate north-south dimension (with respect to building north) of 218 ft [Ref. 8].

AS33. The PF-4 Tunnel has a height of 13 ft from the bottom side of the concrete floor to the top side of the concrete ceiling [Ref. 21].

AS34. Distances of the PF-4 Tunnel to the airport runways are assumed to be the same as those used for the CMRR facility.

2.3.9 PF-4 Tunnel HVAC Intake Shaft and Exhaust Stack

The intake and exhaust stacks for the PF-4 Tunnel extend above ground and may be susceptible to impacts from aircraft.

AS35. The PF-4 Tunnel Heating, Ventilation, and Air Conditioning (HVAC) intake shaft has an assumed length of 10 ft based on a scaled measurement of the concrete walls shown in Reference 8.

AS36. The PF-4 Tunnel HVAC intake shaft has an assumed width of 7 ft based on a scaled measurement of the concrete walls shown in Reference 8.

AS37. The PF-4 Tunnel HVAC intake shaft has an assumed height of 23 ft. This value is based on the top elevation of the HVAC intake shaft (7319 ft) to the top of the PF-4 Tunnel (7296 ft) [Ref. 21]. The top of the PF-4 Tunnel is chosen as it is several feet below grade and would likely not be damaged in the event of general aviation impact.

AS38. The PF-4 Tunnel HVAC exhaust stack has an assumed length of 9 ft based on a scaled measurement of the concrete walls shown in Reference 8.

AS39. The PF-4 Tunnel HVAC exhaust stack has an assumed width of 7 ft based on a scaled measurement of the concrete walls shown in Reference 8.

AS40. The PF-4 Tunnel HVAC exhaust stack has an assumed height of 31.3 ft. This value is based on the top elevation of the HVAC exhaust stack (7327.3 ft) to the top of the

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PF-4 Tunnel (7296 ft) [Ref. 21]. The top of the PF-4 Tunnel is chosen as it is several feet below grade and would likely not be damaged in the event of general aviation impact.

AS41. Distances of the PF-4 Tunnel stacks to the airport runways are assumed to be the same as those used for the CMRR facility.

3.0 REFERENCES

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4.0 METHODS

The methodology for determining the likelihood of an aircraft unintentionally impacting the facility is prescribed in DOE-STD-3014-96, *Accident Analysis for Aircraft Crash into Hazardous Facilities* [Ref. 1] and is summarized here for completeness.

4.1 Four-Factor Formula

The overall frequency of an aircraft unintentionally impacting a specific facility is the sum of the facility impact frequencies associated with local airport operations, non-airport activities, and local helicopter overflights. Airport and non-airport operations involve several categories and subcategories of aircraft that have historically different statistics for accidents. The categories and subcategories of aircraft are listed in Table 4.

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Table 4 - Aircraft categories and subcategories

Category	Subcategory
General Aviation	Fixed Wing Single Engine Reciprocating
	Fixed Wing Multiengine Reciprocating
	Fixed Wing Turboprop
	Fixed Wing Turbojet
Helicopters	NA
Commercial	Air Carrier
	Air Taxi
Military	Large Aircraft[1]
	Small Aircraft[2]

1. Large military aircraft includes bombers, cargo aircraft, and tankers.
2. Small military aircraft includes, but is not limited to, fighters, attack aircraft, and trainers.

The frequency of an aircraft unintentionally impacting the facility is estimated using a "four-factor formula," which considers: (1) the number of operations; (2) the probability that an aircraft will crash; (3) given a crash, the probability that the aircraft crashes into a one-square-mile area where the facility is located, and (4) the size of the facility.

The "four-factor formula" is given as [Ref. 1]:

$$F = \sum_{i,j,k} N_{ijk} P_{ijk} f_{ikj}(x,y) A_{ij} \qquad (4.1)$$

Where:

F = estimated annual aircraft crash impact frequency for the facility of interest [number/year]

N_{ijk} = estimated annual number of site-specific aircraft operations (i.e., takeoffs, landings, and in-flights) [number of takeoffs/year, etc.]

P_{ijk} = aircraft crash rate (per takeoff or landing for near-airport phases and per flight for the in-flight (non-airport) phase of operation for each applicable summation parameter [crashes/takeoff, etc.]

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$f_{ijk}(x,y)$ = aircraft crash location conditional probability (per square mile) given a crash evaluated at the facility location for each applicable summation parameter

A_{ij} = the site-specific effective area for the facility of interest that includes skid and fly-in effective areas (square miles) for each applicable summation parameter, aircraft category or subcategory, and flight phase for military aviation [mi^2]

i = (index for flight phases): i =1, 2, and 3 (takeoff, in-flight, and landing)

j = (index for aircraft category or subcategory): $j=1,2,...11$

k = (index for flight source): k=1,2,…,K (there could be multiple runways and non-airport operations.

Σ = $\Sigma_k \Sigma_j \Sigma_i$

ijk = Site-specific summation over flight phase, i; aircraft category or subcategory, j; and flight source, k.

The "four-factor formula" is implemented in two different ways for planes, depending on the flight phase. For near-airport operations ($i=1,3$), the "four-factor formula" is applied as seen above in Equation 4.1 through a combination of site-specific information obtained by the analyst, and a set of tables provided by Appendix B of DOE-STD-3014-96 [Ref. 1]. For non-airport activities ($i=2,$), Reference 1 provides DOE site-specific estimates for the expected number of crashes per square mile per year in the vicinity of the sites, or the product of $NPf(x,y)$ in Equation 4.1.

It is also important to consider the likelihood of a helicopter unintentionally impacting the facility. Reference 1 states that only local helicopter overflights need to be analyzed because the contribution to impact frequencies associated with non-local helicopter overflights is

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insignificant based on historical helicopter crash data. The estimated frequency of an unintentional helicopter impact for a specific facility is given below in Equation 4.2 [Ref. 1].

$$F_H = N_H P_H \frac{2}{L_H} A_H \tag{4.2}$$

Where,

F_H = Estimated annual helicopter crash impact frequency for the facility of interest [number/year]

N_H = Estimated number of local helicopter overflights per year [flights/year]

P_H = Probability of a helicopter crash per flight [crash/flight]

L_H = The average length of a flight [mi]

A_H = Effective area [mi^2]

Specific steps for determining the frequencies for the airport activities, non-airport activities, and local helicopter overflights are provided in DOE-STD-3014-96 [Ref. 1] and are repeated here with specific information regarding the CMRR site.

4.1.1 Impact Frequency from Airport Operations

The first step was to identify all flight sources that could affect the CMRR facility. This involved identifying all airports that lay within the range of aircraft crash location probabilities given in Tables B-2 through B-13 of DOE-STD-3014-96 [Ref. 1]. All flight sources within 22 mi of the facility are considered since this is the maximum distance considered for the crash frequencies in Appendix B of DOE-STD-3014 [Ref. 1]. The Los Alamos County Airport (LAM), the Santa Fe Municipal Airport (SAF), and the Ohkay Owingeh Airport(E14) were identified as being within the 22 mi radius of the proposed CMRR facility. Also, Los Alamos Medical Center has a single helicopter pad used for "Flight for Life" emergency services that could impact the CMRR facility. The aircraft categories for each airport, the number of operations associated with each aircraft category, and the pattern side of the runway for military aviation were also determined using the Airport Master Records [Refs. 12, 13, 15] and are listed in assumptions AS2 – AS22.

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The second step was to determine the orthonormal distance from the closest point of the facility to the center of each runway using Cartesian coordinates defined by Appendix B in DOE-STD-3014-96 [Ref. 1]. The length of the runway is the *x*-axis with the positive direction defined as the direction of flight. The positive *y*-axis is simply taken to be 90° counter clockwise from the positive x-axis.

The *x* and *y* components of the facility with respect to a specific runway were determined using Microsoft® Excel 2007 programmed to solve for the *x* and *y* distances from the runways to the facility as defined by DOE-STD-3014-96 [Ref. 1]. Distances from CMRR to the airports were determined by scaling distances on maps [Refs. 11 and 14]. The spreadsheet has been included as Attachment B.

The *x* and *y* coordinates of the facility with respect to the runway is given below [Ref 1].

$$x = -R\cos(\theta - \phi) \quad (4.3)$$

$$y = R\sin(\theta - \phi) \quad (4.4)$$

Where,

R	=	Distance from the facility [miles]
θ	=	Bearing from the facility to the airport [degrees]
ϕ	=	Runway bearing as an angle with respect to magnetic north (this equals the runway number times ten) [degrees].

Note: Microsoft® Excel requires θ and ϕ to be given in radians and the runway number is the runway bearing as an angle with respect to magnetic north rounded to the nearest ten degrees.

The third step was to determine the generic aircraft crash location probability per square mile, i.e., *f(x,y)*, for take-off and landing for each aircraft category given the orthonormal distances determined in the previous step, using Tables B-2 through B-13 of Appendix B in DOE-STD-3014-96 [Ref. 1].

The fourth step was to determine the generic aircraft takeoff and landing crash rates, *P*, for each aircraft category from Table B-1 of Appendix B in DOE-STD-3014-96 [Ref. 1]. These crash rates are given in Design Input DI4.

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The fifth step was to determine the effective area, A, of the facility for each aircraft category or subcategory. It is important to note that an aircraft can crash into the structure either by skidding or by flying directly into it. Equations for determining the effective area are given in DOE-STD-3014-96 and are repeated here for completeness [Ref. 1].

$$A_{eff} = A_f + A_s \tag{4.5}$$

Where

$$A_f = (WS + R)\cdot H\cot\phi + \frac{2\cdot L\cdot W\cdot WS}{R} + L\cdot W \tag{4.6}$$

and

$$A_s = (WS + R)\cdot S \tag{4.7}$$

Where

A_f	=	Effective fly-in area
A_s	=	Effective skid area
WS	=	Aircraft wingspan, provided in Table B-16 of Reference 1
R	=	Length of the diagonal of the facility, = $(L^2+W^2)^{0.5}$
H	=	Facility height, facility-specific
$\cot\phi$	=	Mean of the cotangent of the aircraft impact angle, provided in Table B-17 of Reference 1 (for in-flight crashes use the takeoff mean of the cotangent of the impact angle, if available)
L	=	Length of the facility, facility-specific
W	=	Width of the facility, facility-specific
S	=	Aircraft skid distance (mean value), provided in Table B-18 of Reference 1 (for in-flight crashes used the takeoff skid length, if available)

Note: The areas are originally determined in units of ft^2 and are then converted to mi^2.

The sixth step for airport operations used Microsoft Excel® to determine the frequency F, or the product of N, P, $f(x,y)$, and A, for each combination of flight source, flight phase, and aircraft category/subcategory. Calculation of the areas, category/subcategory impact frequencies for each airport, and the cumulative impact frequency from all airports are obtained using Microsoft Excel®. The equations coded into the spreadsheet are presented in Attachment C and the numerical results of the spreadsheet are presented in Attachment D.

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4.1.2 Impact Frequency from Non-airport Operations

Impact frequency calculations for non-airport operations are performed based on the same "four-factor formula" used for airport calculations except that the first three terms are lumped together (i.e., $NPf(x,y)$). The product of N and P yields the expected number of in-flight crashes per year. Multiplying the product of N and P with $f(x,y)$ then yields the expected number of crashes per year per specific square mile. DOE-STD-3014-96 [Ref. 1] has tabulated values of $NPf(x,y)$ for each category/subcategory of aircraft for specific DOE sites.

4.1.3 Helicopter Impact Frequency

DOE-STD-3014-96 [Ref. 1] specifically states that the contribution to impact frequencies associated with non-local helicopter overflights is insignificant and need not be considered in the impact frequency calculations. However, it is necessary to consider local overflights. The estimated frequency for a facility-specific helicopter impact is given by Equation 4.2 and follows a very similar methodology as that given for airplane impact frequency. A key difference between frequencies calculated for airplane impacts and helicopter impacts is that the airplane frequencies are based on the likelihood of an accident for each phase of flight, while helicopter frequencies are based on the likelihood of the helicopter crashing for every flight it performs as well as the length of the flight.

4.1.4 Calculated Impact Frequency

The overall frequency of an aircraft unintentionally impacting a facility for all types of aircraft and for all phases of flights is the summation of all previously determined frequencies.

4.2 CMRR Air Intake Plenum Analysis

Previous revisions of this calculation have shown that the unintentional aircraft impact frequency for the CMRR facility is greater 1E-6 impacts/year. As a result, the CMRR facility will need to be designed to withstand the aircraft impact scenarios described in Section 5.0 of this calculation. However, a concern has been raised regarding an accident scenario in which an aircraft impacts the air intake louver and causes a fireball within the plenum. The "room" that makes up the air intake plenum is expected to withstand the impact but the concern has to do with fuel finding a way through the air intake louver and down the air intake shaft resulting in a fire.

To show that this event is beyond extremely unlikely (i.e., has frequency less that 1E-6 impacts/year), a ratio of the one-half effective area of the exposed air intake plenum "room" and the effective area of the hexahedron used to conservatively represent the CMRR facility will be multiplied by a modified CMRR aircraft impact frequency (see Assumptions AS29 – AS30), thus giving the impact frequency of an aircraft impacting the air intake plenum.

The ratio of the air intake plenum surface area and the CMRR facility surface area is given as

$$Ratio = \frac{Area_{\text{"room"}}}{Area_{CMRR}} \tag{4.8}$$

It is important to note that the effective area represents the ground surface area surrounding a facility such that if an unobstructed aircraft were to crash within the area it would impact the facility, either by direct fly-in or skid into the facility. However, the air intake plenum is not truly unobstructed as it is in immediate contact with other "rooms" and the CMRR has other structures (i.e., exhaust stack) that provide some additional protection from aircraft. For this reason, the fly-in area of the intake, as determined using the methodology of DOE-STD-3014, is reduced to half (see assumption AS30).

4.3 PF-4 Tunnel Impact Frequency

The impact frequency for the tunnel will be performed similar to that of the CMRR air intake plenum. A ratio of the assumed building effective fly-in area for the PF-4 tunnel to the assumed CMRR effective fly-in area will be multiplied by the CMRR impact frequency. This is a conservative approach as it accounts for additional volume that is not part of the PF-4 Tunnel and the tunnel will be buried.

4.4 PF-4 Tunnel HVAC Intake Shaft and Exhaust Stack Impact Frequency

The methodology for determining the unintentional impact frequency for the tunnel's air intake and exhaust stack is similar to that described in Section 4.2. The HVAC intake shaft and exhaust stack are analyzed individually.

5.0 RESULTS AND CONCLUSIONS

Table 5 presents the total annual aircraft impact frequency for airport operations, non-airport operations, and helicopter overflights.

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It should be noted that calculations that were performed in attachments were done on Microsoft® Excel 2007 Service Pack (SP) 2 on Dell Optiplex GX620 – Service Tag CN3TL81. Further, the calculations were checked using by hand using a calculator.

5.1 Overall CMRR Unintentional Aircraft Impact Frequency

Table 5 – Estimated annual unintentional aircraft impact frequency for the CMRR facility.

Type of Crash	Aircraft Operation	Aircraft Impacting CMRR Frequency [crashes/year]
Airport	General aviation and small military	1.448E-05
Non-airport	Commercial aviation (air carrier and taxi), general aviation, and military aviation (large and small aircraft)	4.754E-06
Helicopter	-	1.841E-05
	Total Aircraft Impact Frequency	**3.8E-05**

The estimated frequency of an aircraft unintentionally impacting the facility is 3.8E-05 impacts per year and this exceeds the guideline value of 1.E-6 impacts per year as specified in DOE-STD-3014-96 [Ref.1]. Section 6.0 *Calculations and Analyses* illustrates that the largest contributors to the frequency of an aircraft unintentionally impacting the CMRR facility is the general aviation airport operations at LAM and local helicopter operations.

The CMRR impact frequencies due to small military operations at LAM are three orders of magnitude lower than the CMRR impact frequencies due to the LAM general aviation operations. Also, general aviation non-airport operations impact frequencies for the CMRR facility were an order of magnitude greater than all other categories for non-airport operations.

5.2 Selection of Missiles for Structural Analysis

Given the results of the aircraft impact frequency analysis, the CMRR facility should be designed to withstand an impact from either a general aviation fixed-winged aircraft or a helicopter. Since these are broad descriptions it is important to select a "representative" aircraft for both the general aviation and helicopter categories.

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The Cessna Pressurized Centurion, as described in Reference 17 and for the reasons given in Assumption AS23 and Section 6.2 of this analysis, is the preferred aircraft to analyze the local structural damage. The Piper Seneca, as described in Reference 17 and for the reason given in Assumption AS24, is the preferred aircraft to analyze global structural response. News crews and military helicopters are assumed to be the most common helicopters in use around LANL. *Analysis of Aircraft Crash Accident for WETF* [Ref. 20] selected a Bell 206 to represent helicopters commonly used around Los Alamos. That helicopter is considered appropriate for use in the CMRR structural evaluation. However, it is expected that the CMRR structural consequences from the helicopter will be bounded from the consequences due to the fixed-winged aircraft described above.

5.3 Unintentional Aircraft Impact Frequency for the Air Intake Plenum

Section 6.3 shows that the unintentional aircraft impact frequency for the air intake plenum is 4.3E-7 impacts/year. This is below the impact frequency guideline value given by DOE-STD-3014-96 [Ref. 1] and implies that the air intake plenum louver does not need to be designed to accommodate the fireball caused by an aircraft impact.

5.4 Unintentional Aircraft Impact Frequency for the PF-4 Tunnel

Section 6.4 show the resulting frequency of a general aviation aircraft unintentionally impacting the PF-4 tunnel is 3.36E-6 impacts/year and is just above the threshold for considering this a credible accident. The tunnel should be designed to withstand the missiles described in Section 5.2.

5.5 PF-4 Tunnel Intake Shaft and Exhaust Stack Impact Frequency

Section 6.5.1 determined the unintentional impact frequency associated with the PF-4 Tunnel HVAC Intake Shaft is 4.9E-7 impacts/year and is below the guideline value of 1E-6 given by DOE-STD-3014-96 [Ref. 1]. Similarly, Section 6.5.2 determined the unintentional impact frequency of associated with the PF-4 Tunnel HVAC Exhaust Stack is 6.1E-7 impacts/year. These results imply that an unintentional aircraft impact into the PF-4 Tunnel HVAC Intake Shaft or Exhaust Stack is incredible and no further analysis or controls are needed to prevent or mitigate the consequences of such accidents.

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6.0 CALCULATIONS AND ANALYSES

6.1 Overall CMRR Unintentional Impact Frequency

The resulting x and y distances from each runway to the facility is given, along with the bearing of the runway with respect to the CMRR facility in Table 6.

Table 6 - Geographic relationships of CMRR to nearby runways.

Runway	Distance [mi]	Initial Bearing [degrees]	Runway Bearing [degrees]	*X Component Distance [mi]*	Y Component Distance [mi]
LAM					
Runway 9	2.1	56	90	-1.7	-1.2
Runway 27	2.1	56	270	1.7	1.2
SAF					
Runway 2	20	145	20	11.5	16.4
Runway 20	20	145	200	-11.5	-16.4
Runway 10	20	145	100	-14.1	14.1
Runway 28	20	145	280	14.1	-14.1
Runway 15	20	145	150	-19.9	-1.7
Runway 33	20	145	330	19.9	1.7
E14					
Runway 16	18	51	160	5.9	-17.0
Runway 34	18	51	340	-5.9	17.0

Table 7 presents the crash probability associated with each runway and aircraft category. These values are obtained using the *x* and *y* component of each runway and looking up the values according to aircraft category and operation in Appendix B of DOE-STD-3014.

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Table 7 - Generic crash frequencies used for this analysis based on x and y distances [Ref 1].

Runway	**Operation**	***x*** **[mi]**	***y*** **[mi]**	**Crash location probability, *f(x,y)* [crashes/year]**[1]
Los Alamos County Airport				
09 – Takeoff 27 - Landing	Commercial aircraft takeoff	-1.7	-1.2	Negligible
	Commercial aircraft landing	1.7	1.2	Negligible
	General aviation aircraft takeoff	-1.7	-1.2	1.1E-3
	General aviation aircraft landing	1.7	1.2	4.4E-3
	Large military aircraft takeoff	-1.7	-1.2	Negligible
	Large military aircraft landing	1.7	1.2	9.3E-3
	Small military aircraft takeoff	-1.7	-1.2	Negligible
	Small military aircraft landing	1.7	1.2	4.7E-3
Santa Fe Municipal Airport				
02	Commercial aircraft takeoff	11.5	16.4	Negligible
	Commercial aircraft landing	11.5	16.4	Negligible
	General aviation aircraft takeoff	11.5	16.4	Negligible
	General aviation aircraft landing	11.5	16.4	Negligible
	Large military aircraft takeoff	11.5	16.4	Negligible
	Large military aircraft landing	11.5	16.4	Negligible
	Small military aircraft takeoff	11.5	16.4	Negligible
	Small military aircraft landing	11.5	16.4	Negligible

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Table 10 - Generic crash frequencies used for this analysis based on x and y distances [Ref. 1] (continued).

Runway	Operation	x [mi]	y [mi]	Crash location probability, *f(x,y)* [crashes/year][1]
20	Commercial aircraft takeoff	-11.5	-16.4	Negligible
	Commercial aircraft landing	-11.5	-16.4	Negligible
	General aviation aircraft takeoff	-11.5	-16.4	Negligible
	General aviation aircraft landing	-11.5	-16.4	Negligible
	Large military aircraft takeoff	-11.5	-16.4	Negligible
	Large military aircraft landing	-11.5	-16.4	Negligible
	Small military aircraft takeoff	-11.5	-16.4	Negligible
	Small military aircraft landing	-11.5	-16.4	Negligible
10	Commercial aircraft takeoff	-14.1	14.1	Negligible
	Commercial aircraft landing	-14.1	14.1	Negligible
	General aviation aircraft takeoff	-14.1	14.1	Negligible
	General aviation aircraft landing	-14.1	14.1	Negligible
	Large military aircraft takeoff	-14.1	14.1	Negligible
	Large military aircraft landing	-14.1	14.1	Negligible
	Small military aircraft takeoff	-14.1	14.1	Negligible
	Small military aircraft landing	-14.1	14.1	Negligible
28	Commercial aircraft takeoff	14.1	-14.1	Negligible
	Commercial aircraft landing	14.1	-14.1	Negligible
	General aviation aircraft takeoff	14.1	-14.1	Negligible
	General aviation aircraft landing	14.1	-14.1	Negligible
	Large military aircraft takeoff	14.1	-14.1	Negligible
	Large military aircraft landing	14.1	-14.1	Negligible
	Small military aircraft takeoff	14.1	-14.1	Negligible
	Small military aircraft landing	14.1	-14.1	Negligible

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Table 10 - Generic crash frequencies used for this analysis based on x and y distances [Ref. 1] (continued).

Runway	Operation	*x* [mi]	*y* [mi]	Crash location probability, *f(x,y)* [crashes/year][1]
15	Commercial aircraft takeoff	-19.9	-1.7	Negligible
	Commercial aircraft landing	-19.9	-1.7	Negligible
	General aviation aircraft takeoff	-19.9	-1.7	Negligible
	General aviation aircraft landing	-19.9	-1.7	Negligible
	Large military aircraft takeoff	-19.9	-1.7	Negligible
	Large military aircraft landing	-19.9	-1.7	Negligible
	Small military aircraft takeoff	-19.9	-1.7	Negligible
	Small military aircraft landing	-19.9	-1.7	1.6E-4
33	Commercial aircraft takeoff	19.9	1.7	Negligible
	Commercial aircraft landing	19.9	1.7	Negligible
	General aviation aircraft takeoff	19.9	1.7	Negligible
	General aviation aircraft landing	19.9	1.7	Negligible
	Large military aircraft takeoff	19.9	1.7	Negligible
	Large military aircraft landing	19.9	1.7	Negligible
	Small military aircraft takeoff	19.9	1.7	Negligible
	Small military aircraft landing	19.9	1.7	Negligible
Ohkay Owingeh Airport				
16	Commercial aircraft takeoff	5.9	-17.0	Negligible
	Commercial aircraft landing	5.9	-17.0	Negligible
	General aviation aircraft takeoff	5.9	-17.0	Negligible
	General aviation aircraft landing	5.9	-17.0	Negligible
	Large military aircraft takeoff	5.9	-17.0	Negligible
	Large military aircraft landing	5.9	-17.0	Negligible
	Small military aircraft takeoff	5.9	-17.0	Negligible
	Small military aircraft landing	5.9	-17.0	Negligible

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Table 10 - Generic crash frequencies used for this analysis based on x and y distances [Ref. 1] (continued).

Runway	Operation	*x* [mi]	*y* [mi]	Crash location probability, *f(x,y)* [crashes/year][1]
34	Commercial aircraft takeoff	-5.9	17.0	Negligible
	Commercial aircraft landing	-5.9	17.0	Negligible
	General aviation aircraft takeoff	-5.9	17.0	Negligible
	General aviation aircraft landing	-5.9	17.0	Negligible
	Large military aircraft takeoff	-5.9	17.0	Negligible
	Large military aircraft landing	-5.9	17.0	Negligible
	Small military aircraft takeoff	-5.9	17.0	Negligible
	Small military aircraft landing	-5.9	17.0	Negligible

1. A crash probability of negligible is assigned to situations in which DOE-STD-3014-96 does not list a number in the Appendix B tables. This is not to say that there is no chance of a crash occurring for a specific situation, but only that it its contribution to the overall aircraft impact analysis is negligible.

For airports other than LAM, it is difficult to determine the distribution of takeoffs, landings, and takeoff and landing directions for each runway. Finding and applying the worst-case scenarios at SAF and E14 alleviate these uncertainties. This assumes that all operations for SAF and E14 will occur on their respective runway and direction that would result in the most severe impacts to the CMRR facility. Specific details are listed in assumptions AS19 – AS22. However, it was determined that no combination of directions with takeoffs or landings could produce a crash probability higher than negligible for the Ohkay Owingeh Airport.

The length of the diagonal of the facility is calculated below using Equation 6.1 and design inputs DI1-DI2.

$$R = \sqrt{342.5^2 + 304^2} \quad (6.1)$$

$$R = 458.0 \text{ ft} \quad (6.2)$$

The effective area of the facility is calculated for each category/subcategory of aircraft using Microsoft® Excel. Attachment C contains the formulas for the spreadsheet and Attachment D contains the numerical values used by the spreadsheet to calculate the A_f, A_s, and A_{eff}. The resulting areas are presented below in Table 8.

Table 8 - Effective areas for the CMRR Facility for each aircraft category/subcategory.

Category/ Subcategory	Effective fly in area[1], A_f [mi^2]	Effective skid area[2], A_s [mi^2]	Effective Area[3], A_{eff} [mi^2]
General Aviation	2.107E-02	1.093E-03	**2.217E-02**
Helicopter (w/ 60 ft skid in distance)	5.719E-03	1.093E-03	**6.812E-03**
Commercial Aviation			
Air Taxi	2.562E-02	2.670E-02	**5.232E-02**
Air Carrier	2.783E-02	2.872E-02	**5.655E-02**
Military Aviation			
Large Aircraft Takeoff	2.736E-02	1.905E-02	**4.642E-02**
Large Aircraft Landing	3.358E-02	8.989E-03	**4.257E-02**
Small Aircraft Takeoff	2.446E-02	5.012E-03	**2.947E-02**
Small Aircraft Landing	2.896E-02	9.107E-03	**3.807E-02**

1. See Equation 4.6.
2. See Equation 4.7.
3. See Equation 4.5.

The estimated annual frequency of unintentional aircraft impacts due to local airport operations is determined using Equation 4.1. A spreadsheet programmed with the equations and parameters was used to solve for the frequency of impact for airport operations. Attachment C gives the formulas used by the spreadsheet and Attachment D gives the input and output values of the spreadsheet. Table 9 presents the resulting unintentional aircraft impacts due to the various flight sources. Ohkay Owingeh Airport is not included in Table 9 because of negligible crash location probabilities for all aircraft types.

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Table 9 - Estimated unintentional frequency of an aircraft impact due to operations at local and nonlocal airports.

Category/Subcategory	N [1]	P [2]	f(x,y)[3], [6]	A[4]	F[5]
Los Alamos County Airport (LAM)					
General Aviation (Takeoff)	6,500	1.1E-05	1.1E-03	2.217E-02	1.744E-06
General Aviation (Landing)	6,500[l]	2.0E-05	4.4E-03	2.217E-02	1.268E-05
Commercial Air Carrier (Takeoff)	0	1.9E-07	Negligible	5.655E-02	0
Commercial Air Carrier (Landing)	0	2.8E-07	Negligible	5.655E-02	0
Commercial Air Taxi (Takeoff)	30	1.0E-06	Negligible	5.232E-02	0
Commercial Air Taxi (Landing)	30	2.3E-06	Negligible	5.232E-02	0
Military Large (Takeoff)	0	5.7E-07	Negligible	4.642E-02	0
Military Large (Landing)	0	1.6E-06	9.30E-03	4.257E-02	0
Military Small (Takeoff)	5	1.8E-06	Negligible	2.947E-02	0
Military Small (Landing)	5	3.3E-06	4.7E-03	3.807E-02	2.952E-09
Total Aircraft Impact Frequency for LAM [crashes/year]					**1.443E-05**
Santa Fe Municipal Airport (SAF)					
General Aviation (Takeoff)	33,600	1.1E-05	Negligible	2.217E-02	0
General Aviation (Landing)	33,600	2.0E-05	Negligible	2.217E-02	0
Commercial Air Carrier (Takeoff)	0	1.9E-07	Negligible	5.655E-02	0
Commercial Air Carrier (Landing)	0	2.8E-07	Negligible	5.655E-02	0
Commercial Air Taxi (Takeoff)	3,000	1.0E-06	Negligible	5.232E-02	0

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Table 12 – Estimated frequency of an aircraft impact due to operations at local and nonlocal airports (continued).

Category/Subcategory	N [1]	P [2]	f(x,y) [3], [6]	A [4]	F [5]
Santa Fe Municipal Airport (SAF)					
Commercial Air Taxi (Landing)	3,000	2.3E-06	Negligible	5.232E-02	0
Military Large (Takeoff)	0	5.7E-07	Negligible	4.642E-02	0
Military Large (Landing)	0	1.6E-06	Negligible	4.257E-02	0
Military Small (Takeoff)	2,750	1.8E-06	Negligible	2.947E-02	0
Military Small (Landing)	2,750	3.3E-06	1.6E-4	3.807E-02	5.528E-08
Total Aircraft Impact Frequency for SAF [crashes/year]					**5.528E-08**
Local Helicopter Overflights					
Operation	N_H	P_H	$2/L_H$	A_H	F_H
Helicopter	100	2.5E-05	1.081	6.812E-03	**1.841E-05**
Non-airport Operations					
Operation	**NPf(x,y) [crashes/mi²/year, centered at Site]**			**A [mi²]**	**F [crashes/year]**
GA Airplanes	2E-04			2.217E-02	4.434E-06
Air Carrier	2E-07			5.655E-02	1.131E-08
Air Taxi	3E-06			5.232E-02	1.570E-07
Large Military	1E-07			4.642E-02[7]	4.642E-09
Small Military	5E-06			3.087E-02[8]	1.473E-07
Total non-airport crash frequency [crashes/year]					**4.797E-06**
Total Aircraft Impact Frequency for all local airports and operations					***3.769E-5***

1. Estimated annual number of site-specific aircraft operations (i.e., takeoffs, landings, and in-flights) each applicable summation parameter [number/year].
2. Generic aircraft crash rate (per takeoff or landing for near-airport phases and per flight for the in-flight [non-airport] phase of operation) for each applicable summation parameter as given by DOE-STD-3014-96 and repeated in assumption DI4.

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3. Aircraft crash location conditional probability (per square mile) given a crash evaluated at the facility location for each applicable summation parameter.
4. The site-specific effective area for the facility of interest that includes skid and fly-in effect areas [mi^2] for each applicable summation parameter, aircraft category or subcategory, and flight phase for military aviation.
5. Estimated annual aircraft crash impact frequency for the facility of interest [number/year].
6. Values of 0 are assigned to situations where the tables in Appendix B of DOE-STD-3014-96 have no assigned frequency given.
7. The landing area is chosen since it is larger than the takeoff area for Large Military planes.
8. The takeoff area is chosen since it is larger than the landing area for Small Military planes.

The total aircraft impact frequency for the CMRR facility is 3.8E-5 and exceeds the guideline value of 1E-6 given by DOE-STD-3014-96. Representative aircraft missiles for each category/subcategory that exceed the guideline value are chosen below so that the facility may be designed accordingly.

6.2 Selection of Missiles For All Applicable Categories/Subcategories

DOE-STD-3014-96 (page 58) states that two bounding missiles are needed for each applicable aircraft category/subcategory. One missile is used to analyze the structural local damage evaluation and the other for the structural collapse evaluation. Furthermore, the bounding missile for local damage evaluation will be the aircraft engine (or any of the nearly rigid and compact components) having the highest kinetic energy (i.e., one-half the engine mass times the square of the impact velocity). However, equations given by DOE-STD-3014-96 for use in evaluating scabbing and perforation thicknesses are inversely proportional to the diameter of the rigid missile. This implies that it is not necessarily the engine with the most mass that is the biggest threat for local damage. The bounding missile for structural collapse is the aircraft having the highest kinetic energy of impact (i.e., one-half the total mass times the square of the impact velocity).

It is important to note that there are 60 single engine and 1 multi-engine fixed winged general aviation aircraft based at LAM [Ref. 12]. Since the LAM general aviation operations are the highest contributor to the annual impact frequency at the CMRR facility, the most likely accident scenario would involve a single engine aircraft since there are 60 more single engine aircraft than multiengine aircraft.

For conservatism, the Cessna Pressurized Centurion is chosen to represent the typical single engine, fixed winged aircraft based at LAM because it is the largest single engine, fixed winged

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aircraft described in Reference 17 [Assumption AS23] and could be used in evaluating the local structural damage. The Cessna Pressurized Centurion is also larger than most of the single engine fixed winged aircraft at LAM. It is acknowledged that a Piper Seneca is representative of the multi-engine aircraft based at LAM and has more mass than the Cessna Pressurized Centurion. The higher mass signifies that it is more of a threat for the structural collapse. The engines associated with the Piper Seneca are lighter than the Cessna Pressurized Centurion, and might also be smaller in diameter, which implies that it could cause more local structural damage as well. To confirm which aircraft should be used for the local structural damage, the equations from Chapter 6 of DOE-STD-3014-96 for evaluation of reinforced concrete targets are presented below.

The equation to determine the scabbing thickness is given as [Ref. 1]

$$t_s = 1.84\left(\frac{U}{V}\right)^{0.13} \frac{\left(MV^2\right)^{0.4}}{D^{0.2}\left(f_c'\right)^{0.4}} \tag{6.3}$$

Where:

t_s	=	*Scabbing thickness (ft)*
U	=	*Reference Velocity = 200 ft/sec*
V	=	*Missile impact velocity (ft/sec)*
M	=	*Mass of missile = W/g*
where:		W = missile weight (lb)
		g = 32.2 ft/sec²
D	=	*Effective missile diameter*
f_c'	=	*Ultimate compressive strength of concrete (lb/ft²)*

The equation used for determining perforation thickness is given as [Ref. 1]

$$t_p = \left(\frac{U}{V}\right)^{0.25}\left(\frac{MV^2}{Df_c'}\right)^{0.5} \tag{6.4}$$

Where the parameters are same for Equation 6.3 except for t_p, the perforation thickness.

The aircraft that poses a greater local hazard to the CMRR facility can be determined using Equation 6.3 and 6.4. It is important to note that the parameters U, V, and f_c' are the same

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regardless of the aircraft considered. The impact velocity is based on a 0.0075 probability of the discretized generic effective velocity distributions by category/subcategory of aircraft and is obtained from Table 2-1 of Reference 22. Since both aircraft fall under general aviation, they both have the same impact velocity regardless of which aircraft can fly faster. The general aviation impact velocities corresponding to a 0.0075 probability for vertical and horizontal targets are 146 knots and 133 knots, respectfully.

Since the parameters *U*, *V*, and f_c' are the same regardless of the aircraft considered, aircraft comparisons can be made by simply using the mass-to-diameter ratios (or how each equation scales based on the mass and diameter of the engine) from Equation 6.3 and 6.4. Assumptions AS23 and AS24 give the weight and dimensions for each aircraft engine. The weight is converted into mass using the definition for *M* below Equation 6.3. The engine's width and height is used to find an approximate area, Equation 6.5. An approximate diameter can then be found using Equation 6.6.

$$Area_{engine}[ft^2] = Heigth_{engine}[in] \cdot Width_{engine}[in] \cdot \left(\frac{1ft}{12in}\right)^2 \qquad (6.5)$$

$$D[ft] = \sqrt{\frac{4 \cdot Area_{engine}[ft^2]}{\pi}} \qquad (6.6)$$

Table 10 gives the approximate diameter for each aircraft (calculated by hand).

Table 10 - Engine diameters for the Cessna Pressurized Centurion and Piper Seneca.

Aircraft	Engine Height [in.] [1]	Engine Width [in.] [1]	Engine Area [ft^2] [2]	Engine Diameter [ft] [3]	Dry Engine Weight [lb$_f$] [1]	Dry Engine Mass [slugs]
Cessna Pressurized Centurion	23.54	33.56	5.486	2.643	417.52	12.97
Piper Seneca	27.5	31.38	5.993	2.762	321.35	9.98

1. See Assumptions AS23 and AS24.
2. See Equation 6.5.
3. See Equation 6.6.

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Equation 6.3 scales approximately as $\frac{M^{0.4}}{D^{0.2}}$, while Equation 6.4 scales approximately as $\frac{M}{D}$. The scaling factors alone are used to show which aircraft engine possesses the greatest hazard with respect to the local structural damage. Table 11 presents the magnitude of each engine's scaling factor as calculated by hand.

Table 11 – Resulting magnitude of the each aircraft engine's scaling factor for scabbing thickness, tc, and perforation thickness, tp.

Aircraft	Engine Diameter, *D* [ft]	Dry Engine Mass, *M* [slugs]	$t_s \propto \frac{M^{0.4}}{D^{0.2}}$	$t_p \propto \frac{M}{D}$
Cessna Pressurized Centurion	2.643	12.97	2.29	4.91
Piper Seneca	2.762	9.98	2.05	3.62

It is clear from the scaling factors listed in Table 11, that the Cessna Pressurized Centurion is the preferred representative engine missile for local structural damage based on the scabbing thickness and perforation thickness scaling factors rather than the Piper Seneca. The engine for the Cessna Pressurized Centurion has more mass and a smaller diameter than the Piper Seneca, which allows the Cessna Pressurized Centurion engine more penetration into reinforced concrete than the Piper Seneca engine. However, the Piper Seneca should be used to evaluate the global structural response of the CMRR since the Piper Seneca contains far more mass the Cessna Pressurized Centurion and the impact velocities are the same.

6.3 Unintentional Aircraft Impact Frequency For The CMRR Air Intake Plenum

The effective area of the air intake "room" is calculated below using Equations 4.5 – 4.7, Assumptions AS26 – AS30, and Design Inputs DI7 and DI8.

$$R_{"room"} = \sqrt{46^2 + 20^2} = 50.2 ft \quad (6.7)$$

$$A_f = (50 + 50.2) \cdot 23 \cdot 8.2 + \frac{2 \cdot 46 \cdot 20 \cdot 50}{50.2} + 46 \cdot 20 = 2.17E4 ft^2 \quad (6.8)$$

$$A_s = (50 + 50.2) \cdot 60 = 6.01E3 ft^2 \quad (6.9)$$

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$$A_{eff\text{"room"}} = 0.5 \cdot \left(2.17E4\,ft^2 + 6.01E3\,ft^2\right) = 1.39E4\,ft^2 \qquad (6.10)$$

$$A_{eff\text{"room"}} = 1.39E4\,ft^2 \left(\frac{1mi}{5280\,ft}\right)^2 = 4.99E-4mi^2 \qquad (6.11)$$

$$Ratio = \frac{4.99E-4mi^2}{2.217E-2mi^2} = 2.25E-2 \qquad (6.12)$$

It is important to note that Equation 6.10 incorporates assumption AS30.

The only aircraft of concern is general aviation as this calculation has shown that the general aviation frequency exceeds the DOE-STD-3014-96 guideline value of 1E-6 for both airport and non-airport operations. The total CMRR general aviation impact frequency associated with airport and non-airport operations, 1.89E-5 impacts per year (this number is the sum of the frequencies for LAM general aviation operations and the non-airport operations).

$$Frequency_{\text{"room"}} = (2.25E-2) \cdot (1.89E-5) \qquad (6.13)$$

$$Frequency_{\text{"room"}} = 4.3E-7 \; {}^{impacts}\!/_{year} \qquad (6.14)$$

The unintentional impact frequency associated with the air intake plenum is 4.3E-7 impacts/year and is below the guideline value of 1E-6 given by DOE-STD-3014-96 [Ref. 1]. This implies that the air intake plenum louver does not need to be designed accommodate the fireball caused by an aircraft impact.

6.4 PF-4 Tunnel Impact

The effective area of the PF-4 tunnel is calculated below using Equations 4.5 – 4.7, and Assumptions AS31 – AS34.

$$R_{\text{"tunnel"}} = \sqrt{218^2 + 183^2} = 285\,ft \qquad (6.15)$$

$$A_f = (50 + 285) \cdot 13 \cdot 8.2 + \frac{2 \cdot 183 \cdot 218 \cdot 50}{285} + 183 \cdot 218 = 8.96E4\,ft^2 \qquad (6.16)$$

$$A_s = (50 + 285) \cdot 60 = 2.01E4\,ft^2 \qquad (6.17)$$

$$A_{eff\text{"tunnel"}} = 8.96E4\,ft^2 + 2.01E4\,ft^2 = 1.10E5\,ft^2 \qquad (6.18)$$

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$$A_{eff\text{"tunnel"}} = 1.10E5\,ft^2\left(\frac{1mi}{5280\,ft}\right)^2 = 3.95E-3mi^2 \quad (6.19)$$

The ratio of the effective fly-in for the PF-4 Tunnel to that of the CMRR is

$$Ratio = \frac{3.95E-3mi^2}{2.217E-2mi^2} = 1.78E-1 \quad (6.20)$$

The only aircraft of concern is general aviation, as this calculation has shown that the general aviation frequency exceeds the DOE-STD-3014-96 guideline value of 1E-6 for both airport and non-airport operations. The total CMRR general aviation impact frequency associated with airport and non-airport operations is 1.89E-5 impacts/year (this number is the sum of the frequencies for LAM general aviation operations and the non-airport operations).

$$Frequency_{\text{"room"}} = (1.78E-1)\cdot\left(1.89E-5\,{}^{impacts}\!/_{year}\right) \quad (6.21)$$

$$Frequency_{\text{"room"}} = 3.36E-6\,{}^{impacts}\!/_{year} \quad (6.22)$$

The resulting frequency of a general aviation aircraft unintentionally impacting the PF-4 tunnel is 3.36E-6 impacts/year is above the threshold for considering this a credible accident. The tunnel should be designed to withstand the missiles described in Section 6.2.

6.5 PF-4 Tunnel HVAC Intake Shaft and Exhaust Stack

6.5.1 PF-4 Tunnel HVAC Intake Shaft

The effective area of the PF-4 Tunnel HVAC Intake Shaft is calculated below using equations 4.7 – 4.7, and Assumptions AS35-AS37.

$$R_{\text{"room"}} = \sqrt{10^2 + 7^2} = 12.2ft \quad (6.23)$$

$$A_f = (50+12.2)\cdot 23\cdot 8.2 + \frac{2\cdot 10\cdot 7\cdot 50}{12.2} + 10\cdot 7 = 1.24E4\,ft^2 \quad (6.24)$$

$$A_s = (50+12.2)\cdot 60 = 3.73E3\,ft^2 \quad (6.25)$$

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$$A_{eff\text{"room"}} = 1.24E4\,ft^2 + 3.73E3\,ft^2 = 1.61E4\,ft^2 \quad (6.26)$$

$$A_{eff\text{"room"}} = 1.61E4\,ft^2\left(\frac{1mi}{5280\,ft}\right)^2 = 5.78E-4mi^2 \quad (6.27)$$

$$Ratio = \frac{5.78E-4mi^2}{2.217E-2mi^2} = 2.61E-2 \quad (6.28)$$

The only aircraft of concern is general aviation as this calculation has shown that the general aviation frequency exceeds the DOE-STD-3014-96 guideline value of 1E-6 for both airport and non-airport operations. The total CMRR general aviation impact frequency associated with airport and non-airport operations, is 1.89E-5 impacts/year (this number is the sum of the frequencies for LAM general aviation operations and the non-airport operations).

$$Frequency_{\text{"room"}} = (2.61E-2)\cdot\left(1.89E-5\,{}^{impacts}\!/_{year}\right) \quad (6.29)$$

$$Frequency_{\text{"room"}} = 4.93E-7\,{}^{impacts}\!/_{year} \quad (6.30)$$

The unintentional impact frequency associated with the PF-4 Tunnel HVAC Intake Shaft is 4.93E-7 impacts/year and is below the guideline value of 1E-6 given by DOE-STD-3014-96 [Ref. 1]. This implies that an unintentional aircraft impact into the PF-4 Tunnel HVAC Intake Shaft is incredible and no further analysis or controls are needed to prevent or mitigate the consequences of such an accident.

6.5.2 PF-4 Tunnel HVAC Exhaust Stack

The effective area of the PF-4 Tunnel HVAC Exhaust Stack is calculated below using equations 4.5 – 4.7, and Assumptions AS38-AS41.

$$R_{\text{"room"}} = \sqrt{9^2 + 7^2} = 11.4\,ft \quad (6.31)$$

$$A_f = (50 + 11.4)\cdot 31.3\cdot 8.2 + \frac{2\cdot 9\cdot 7\cdot 50}{11.4} + 9\cdot 7 = 1.64E4\,ft^2 \quad (6.32)$$

$$A_s = (50 + 11.4)\cdot 60 = 3.68E3\,ft^2 \quad (6.33)$$

$$A_{eff\text{"room"}} = 1.64E4\,ft^2 + 3.68E3\,ft^2 = 2.01E4\,ft^2 \quad (6.34)$$

CMRR PROJECT CALCULATION SHEET

Calculation No. 100320-NCAL-00001	ORIGINATOR: Tomas M. Sanchez (Print & Sign Above) DATE 7/29/2011
Rev. No. 6	CHECKER: Lanny N. Smith (Print & Sign Above) DATE 7/29/2011
Calculation Title Aircraft Impact Analysis	

$$A_{eff\text{"}room\text{"}} = 2.01E4\,ft^2\left(\frac{1mi}{5280\,ft}\right)^2 = 7.21E-4mi^2 \qquad (6.35)$$

$$Ratio = \frac{7.21E-4mi^2}{2.217E-2mi^2} = 3.25E-2 \qquad (6.36)$$

The only aircraft of concern is general aviation as this calculation has shown that the general aviation frequency exceeds the DOE-STD-3014-96 guideline value of 1E-5 for both airport and non-airport operations. The total CMRR general aviation impact frequency associated with airport and non-airport operations, is 1.89E-6 impacts/year (this number is the sum of the frequencies for LAM general aviation operations and the non-airport operations).

$$Frequency_{\text{"}room\text{"}} = (3.25E-2)\cdot\left(1.89E-5\,{}^{impacts}\!/\!_{year}\right) \qquad (6.37)$$

$$Frequency_{\text{"}room\text{"}} = 6.14E-7\,{}^{impacts}\!/\!_{year} \qquad (6.38)$$

The unintentional impact frequency associated with the PF-4 Tunnel HVAC Exhaust Stake is 6.14E-7 impacts/year and is below the guideline value of 1E-6 given by DOE-STD-3014-96 [Ref. 1]. This implies that an unintentional aircraft impact into the PF-4 Tunnel HVAC Exhaust Stack is incredible and no further analysis or controls are needed to prevent or mitigate the consequences of such an accident.

CMRR PROJECT ATTACHMENT COVER SHEET

Calculation No. 100320-NCAL-00001	**ORIGINATOR**: Tomas M. Sanchez (Print & Sign Above) **DATE** 7/29/2011
Rev. No. 6	**CHECKER:** Lanny N. Samith (Print & Sign Above) **DATE** 7/29/2011
Attachment A	

ATTACHMENT TITLE: Attached References

Cover Page(s)	Attachment Page(s)	Total Pages
2	6	8

CMRR PROJECT ATTACHMENT COVER SHEET

Calculation No. 100320-NCAL-00001	**ORIGINATOR**: Tomas M. Sanchez **DATE** 7/29/2011 Print & Sign Above **CHECKER:** Lanny N. Samith **DATE** 7/29/2011 Print & Sign Above
Rev. No. 6	
Attachment A	

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

AIRPORT MASTER RECORD

PRINT DATE: 05/25/2011
AFD EFF 05/05/2011
Form Approved OMB 2120-0015

> 1 ASSOC CITY: LOS ALAMOS — 4 STATE: NM — LOC ID: LAM — FAA SITE NR: 14644.6*A
> 2 AIRPORT NAME: LOS ALAMOS — 5 COUNTY: LOS ALAMOS NM
3 CBD TO AIRPORT (NM): 01 E — 6 REGION/ADO: ASW/LNM — 7 SECT AERO CHT: DENVER

GENERAL

10 OWNERSHIP: PU
> 11 OWNER: COUNTY OF LOS ALAMOS
> 12 ADDRESS: PO BOX 30, LOS ALAMOS, NM 87544
> 13 PHONE NR: 505-663-1750
> 14 MANAGER: PETER SODERQUIST
> 15 ADDRESS: PO BOX 30, LOS ALAMOS, NM 87544
> 16 PHONE NR: 505-662-8420
> 17 ATTENDANCE SCHEDULE:
ALL MON-FRI 0600-1600

18 AIRPORT USE: PUBLIC
19 ARPT LAT: 35-52-47.2870N ESTIMATED
20 ARPT LONG: 106-16-09.8950W
21 ARPT ELEV: 7171 SURVEYED
22 ACREAGE: 89
> 23 RIGHT TRAFFIC: 27
> 24 NON-COMM LANDING: NO
25 NPIAS/FED AGREEMENTS: N
> 26 FAR 139 INDEX:

SERVICES

> 70 FUEL: 100LL
> 71 AIRFRAME RPRS: MAJOR
> 72 PWR PLANT RPRS: MAJOR
> 73 BOTTLE OXYGEN:
> 74 BULK OXYGEN:
75 TSNT STORAGE: TIE
76 OTHER SERVICES:
INSTR, RNTL

FACILITIES

> 80 ARPT BCN: CG
> 81 ARPT LGT SKED: DUSK-DAWN
> 82 UNICOM: 123.000
> 83 WIND INDICATOR: YES-L
84 SEGMENTED CIRCLE: YES
85 CONTROL TWR: NONE
86 FSS: ALBUQUERQUE
87 FSS ON ARPT: NO
88 FSS PHONE NR:
89 TOLL FREE NR: 1-800-WX-BRIEF

BASED AIRCRAFT

90 SINGLE ENG:	60
91 MULTI ENG:	1
92 JET:	0
TOTAL:	61
93 HELICOPTERS:	0
94 GLIDERS:	0
95 MILITARY:	0
96 ULTRA-LIGHT:	1

OPERATIONS

100 AIR CARRIER:	0
102 AIR TAXI:	60
103 G A LOCAL:	10,830
104 G A ITNRNT:	2,100
105 MILITARY:	10
TOTAL:	13,000

OPERATIONS FOR 12 MONTHS ENDING 06/30/2008

RUNWAY DATA

> 30 RUNWAY IDENT:	09/27			
> 31 LENGTH:	5,550			
> 32 WIDTH:	113			
> 33 SURF TYPE-COND:	ASPH-F			
> 34 SURF TREATMENT:	PFC			
35 GROSS WT: SW	43.0			
36 (IN THSDS) DW				
37 DTW				
38 DDTW				
> 39 PCN:				
LIGHTING/APCH AIDS				
> 40 EDGE INTENSITY:	MED			
> 42 RWY MARK TYPE-COND:	BSC - G / NPI - G	- / -	- / -	- / -
> 43 VGSI:	/	/	/	/
44 THR CROSSING HGT:	/	/	/	/
45 VISUAL GLIDE ANGLE:	/	/	/	/
> 46 CNTRLN-TDZ:	- / -	- / -	- / -	- / -
> 47 RVR-RVV:	- / -	- / -	- / -	- / -
> 48 REIL:	/ Y	/	/	/
> 49 APCH LIGHTS:	/	/	/	/
OBSTRUCTION DATA				
50 FAR 77 CATEGORY:	B(V) / B(V)	/	/	/
> 51 DISPLACED THR:	/	/	/	/
> 52 CTLG OBSTN:	TREE /	/	/	/
> 53 OBSTN MARKED/LGTD:	/	/	/	/
> 54 HGT ABOVE RWY END:	60 /	/	/	/
> 55 DIST FROM RWY END:	324 /	/	/	/
> 56 CNTRLN OFFSET:	0B /	/	/	/
57 OBSTN CLNC SLOPE:	2:1 / 50:1	/	/	/
58 CLOSE-IN OBSTN:	Y / N	/	/	/
DECLARED DISTANCES				
> 60 TAKE OFF RUN AVBL (TORA):	/	/	/	/
> 61 TAKE OFF DIST AVBL (TODA):	/	/	/	/
> 62 ACLT STOP DIST AVBL (ASDA):	/	/	/	/
> 63 LNDG DIST AVBL (LDA):	/	/	/	/

(>) ARPT MGR PLEASE ADVISE FSS IN ITEM 86 WHEN CHANGES OCCUR TO ITEMS PRECEDED BY >

> 110 REMARKS:

A 017	FOR ARPT ATTENDANT AFT HRS & WKENDS CALL 505-412-9869
A 030	RWY 09/27 RY 09/27 ALL LNDGS TO THE WEST & ALL TKOFS TO THE EAST.
A 058	RWY 09 +7 FT FENCE 135 FT FM RY END; +8 FT BLAST FENCE 85 FT FM RY END.
A 081	ACTVT MIRL RY 09/27 & REIL RY 27 - CTAF.
A 110	THIS AIRPORT HAS BEEN SURVEYED BY THE NATIONAL GEODETIC SURVEY
A 110-2	RADIO COMMUNICATION REQUIRED BEFORE ENTERING TFC PATTERN
A 110-6	STRONG GUSTY CROSSWINDS.

Attachment A – Page A3 of A8
100320-NCAL-00001, Rev. 6

111 INSPECTOR: (C) — 112 LAST INSP: 04/08/2009 — 113 LAST INFO REQ:

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

AIRPORT MASTER RECORD

PRINT DATE: 05/25/2011
AFD EFF 05/05/2011
Form Approved OMB 2120-0015

> 1 ASSOC CITY: *****CONTINUED***** 4 STATE: NM LOC ID: LAM FAA SITE NR: 14644.6*A
> 2 AIRPORT NAME: 5 COUNTY:
3 CBD TO AIRPORT (NM): 6 REGION/ADO: ASW/LNM 7 SECT AERO CHT:

GENERAL

10 OWNERSHIP:
> 11 OWNER:
> 12 ADDRESS:
> 13 PHONE NR:
> 14 MANAGER:
> 15 ADDRESS:
> 16 PHONE NR:
> 17 ATTENDANCE SCHEDULE:

18 AIRPORT USE:
19 ARPT LAT:
20 ARPT LONG:
21 ARPT ELEV:
22 ACREAGE:
> 23 RIGHT TRAFFIC:
> 24 NON-COMM LANDING:
25 NPIAS/FED AGREEMENTS:
> 26 FAR 139 INDEX:

SERVICES

> 70 FUEL:
> 71 AIRFRAME RPRS:
> 72 PWR PLANT RPRS:
> 73 BOTTLE OXYGEN:
> 74 BULK OXYGEN:
75 TSNT STORAGE:
76 OTHER SERVICES:

FACILITIES

> 80 ARPT BCN:
> 81 ARPT LGT SKED:
> 82 UNICOM:
> 83 WIND INDICATOR:
84 SEGMENTED CIRCLE:
85 CONTROL TWR:
86 FSS:
87 FSS ON ARPT:
88 FSS PHONE NR:
89 TOLL FREE NR:

BASED AIRCRAFT

90 SINGLE ENG:
91 MULTI ENG:
92 JET:
TOTAL:
93 HELICOPTERS:
94 GLIDERS:
95 MILITARY:
96 ULTRA-LIGHT:

OPERATIONS

100 AIR CARRIER:
102 AIR TAXI:
103 G A LOCAL:
104 G A ITNRNT:
105 MILITARY:
TOTAL:
OPERATIONS FOR 12 MONTHS ENDING

RUNWAY DATA

> 30 RUNWAY IDENT:				
> 31 LENGTH:				
> 32 WIDTH:				
> 33 SURF TYPE-COND:				
> 34 SURF TREATMENT:				
35 GROSS WT: SW				
36 (IN THSDS) DW				
37 DTW				
38 DDTW				
> 39 PCN:				
LIGHTING/APCH AIDS				
> 40 EDGE INTENSITY:				
> 42 RWY MARK TYPE-COND:	- / -	- / -	- / -	- / -
> 43 VGSI:	/	/	/	/
44 THR CROSSING HGT:	/	/	/	/
45 VISUAL GLIDE ANGLE:	/	/	/	/
> 46 CNTRLN-TDZ:	- / -	- / -	- / -	- / -
> 47 RVR-RVV:	- / -	- / -	- / -	- / -
> 48 REIL:	/	/	/	/
> 49 APCH LIGHTS:	/	/	/	/
OBSTRUCTION DATA				
50 FAR 77 CATEGORY:	/	/	/	/
> 51 DISPLACED THR:	/	/	/	/
> 52 CTLG OBSTN:	/	/	/	/
> 53 OBSTN MARKED/LGTD:	/	/	/	/
> 54 HGT ABOVE RWY END:	/	/	/	/
> 55 DIST FROM RWY END:	/	/	/	/
> 56 CNTRLN OFFSET:	/	/	/	/
57 OBSTN CLNC SLOPE:	/	/	/	/
58 CLOSE-IN OBSTN:	/	/	/	/
DECLARED DISTANCES				
> 60 TAKE OFF RUN AVBL (TORA):	/	/	/	/
> 61 TAKE OFF DIST AVBL (TODA):	/	/	/	/
> 62 ACLT STOP DIST AVBL (ASDA):	/	/	/	/
> 63 LNDG DIST AVBL (LDA):	/	/	/	/

(>) ARPT MGR PLEASE ADVISE FSS IN ITEM 86 WHEN CHANGES OCCUR TO ITEMS PRECEDED BY >

> 110 REMARKS:

A 110-7 BLAST BARRIER AER 09.
A 110-8 NO TOUCH & GO LANDINGS.
A 110-9 RY 27 MAKE RIGHT TURN ON GO-AROUND OR MISSED APCH; RESTRICTED AREA ADJ TO SOUTH SIDE OF ARPT.
A 110-10 RY 27 GRADIENT 1.5% UP TO WEST.
A 110-11 VFR LNDG TRAFFIC REMAIN 5 MILES EAST OF THE ARPT UNTIL TURNING FINAL FOR RY 27 TO AVOID RESTRICTED AREA SOUTH OF THE ARPT.

Attachment A - Page A4 of A8
100320-NCAL-00001, Rev. 6

111 INSPECTOR: (C) 112 LAST INSP: 04/08/2009 113 LAST INFO REQ:

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

AIRPORT MASTER RECORD

PRINT DATE: 05/25/2011
AFD EFF 05/05/2011
Form Approved OMB 2120-0015

> 1 ASSOC CITY: SANTA FE | 4 STATE: NM | LOC ID: SAF | FAA SITE NR: 14728.*A
> 2 AIRPORT NAME: SANTA FE MUNI | 5 COUNTY: SANTA FE NM
3 CBD TO AIRPORT (NM): 09 SW | 6 REGION/ADO: ASW/LNM | 7 SECT AERO CHT: ALBUQUERQUE

GENERAL

10 OWNERSHIP: PU
> 11 OWNER: CITY OF SANTA FE
> 12 ADDRESS: PO BOX 909
SANTA FE, NM 87504-0909
> 13 PHONE NR: 505-955-6509
> 14 MANAGER: JAMES H. MONTMAN
> 15 ADDRESS: PO BOX 909
SANTA FE, NM 87504-0909
> 16 PHONE NR: 505-955-2900
> 17 ATTENDANCE SCHEDULE:
ALL ALL 0600-2200

18 AIRPORT USE: PUBLIC
19 ARPT LAT: 35-37-01.5910N ESTIMATED
20 ARPT LONG: 106-05-21.9220W
21 ARPT ELEV: 6348 SURVEYED
22 ACREAGE: 2128
> 23 RIGHT TRAFFIC: NO
> 24 NON-COMM LANDING: NO
25 NPIAS/FED AGREEMENTS: NGY3
> 26 FAR 139 INDEX: I A U 11/2005

SERVICES

> 70 FUEL: 100LL A1 A1+
> 71 AIRFRAME RPRS: MINOR
> 72 PWR PLANT RPRS: MAJOR
> 73 BOTTLE OXYGEN: HIGH/LOW
> 74 BULK OXYGEN: HIGH/LOW
75 TSNT STORAGE: HGR, TIE
76 OTHER SERVICES:
AMB, AVNCS, CHTR, INSTR, RNTL, SALES, SURV

FACILITIES

> 80 ARPT BCN: CG
> 81 ARPT LGT SKED: DUSK-DAWN
> 82 UNICOM: 122.950
> 83 WIND INDICATOR: YES-L
84 SEGMENTED CIRCLE: YES
85 CONTROL TWR: YES
86 FSS: ALBUQUERQUE
87 FSS ON ARPT: NO
88 FSS PHONE NR:
89 TOLL FREE NR: 1-800-WX-BRIEF

BASED AIRCRAFT

90 SINGLE ENG: 121
91 MULTI ENG: 24
92 JET: 19
TOTAL: 164
93 HELICOPTERS: 3
94 GLIDERS: 2
95 MILITARY: 11
96 ULTRA-LIGHT: 1

OPERATIONS

100 AIR CARRIER: 0
102 AIR TAXI: 5,934
103 G A LOCAL: 30,392
104 G A ITNRNT: 36,772
105 MILITARY: 5,471
TOTAL: 78,569
OPERATIONS FOR 12 MONTHS ENDING 06/30/2008

RUNWAY DATA

> 30 RUNWAY IDENT	02/20	10/28	15/33	
> 31 LENGTH:	8,342	6,300	6,307	
> 32 WIDTH:	150	75	100	
> 33 SURF TYPE-COND:	ASPH-G	ASPH-G	ASPH-E	
> 34 SURF TREATMENT	PFC	PFC	GRVD	
35 GROSS WT: SW	48.0	30.0	48.0	
36 (IN THSDS) DW	65.0		65.0	
37 DTW	105.0		105.0	
38 DDTW				
> 39 PCN:				
LIGHTING/APCH AIDS				
> 40 EDGE INTENSITY	MED		MED	
> 42 RWY MARK TYPE-COND	PIR - G / PIR - G	NPI - G / NPI - G	NPI - G / NPI - G	- / -
> 43 VGSI:	V4L / V4L	/	PSIL / V4R	/
44 THR CROSSING HGT:	54 / 54	/	33 / 62	/
45 VISUAL GLIDE ANGLE:	3.00 / 3.00	/	3.00 / 3.00	/
> 46 CNTRLN-TDZ:	- / -	- / -	- / -	- / -
> 47 RVR-RVV:	- / -	- / -	- / -	- / -
> 48 REIL:	/ Y	/	Y / Y	/
> 49 APCH LIGHTS:	/	/	/	/
OBSTRUCTION DATA				
50 FAR 77 CATEGORY:	PIR / B(V)	B(V) / C	B(V) / C	/
> 51 DISPLACED THR:	/	/	/	/
> 52 CTLG OBSTN:	HILL /	/ ROAD	/	/
> 53 OBSTN MARKED/LGTD:	/	/	/	/
> 54 HGT ABOVE RWY END:	6 /	/ 11	/	/
> 55 DIST FROM RWY END:	225 /	/ 250	/	/
> 56 CNTRLN OFFSET:	226L /	/ 260R	/	/
57 OBSTN CLNC SLOPE:	4:1 / 50:1	50:1 / 4:1	50:1 / 50:1	/
58 CLOSE-IN OBSTN:	N / N	N / N	N / N	/
DECLARED DISTANCES				
> 60 TAKE OFF RUN AVBL (TORA):	/	/	/	/
> 61 TAKE OFF DIST AVBL (TODA):	/	/	/	/
> 62 ACLT STOP DIST AVBL (ASDA):	/	/	/	/
> 63 LNDG DIST AVBL (LDA):	/	/	/	/

(>) ARPT MGR PLEASE ADVISE FSS IN ITEM 86 WHEN CHANGES OCCUR TO ITEMS PRECEDED BY >

> 110 REMARKS:

A 017 FOR SVC AFT HRS CALL 505-471-2525/2700.
A 026 PPR 24 HRS FOR ACR OPNS WITH MORE THAN 30 PSGR SEATS CALL AMGR AT 505-955-2900.
A 043 RWY 33 VASI OTS INDEFLY.
A 081 WHEN ATCT CLSD MIRL RY 02/20 PRESET LOW INTST; TO INCR INTST AND ACTVT MIRL RY 15/33 - CTAF.
A 110-3 ARMY NATIONAL GUARD AVIATION ON FIELD.
A 110-5 DOGS & WILDLIFE ACTIVITY ON & INVOF ARPT.

Attachment A – Page A5 of A8
100320-NCAL-00001, Rev. 6

111 INSPECTOR: (F) | 112 LAST INSP: 07/17/2008 | 113 LAST INFO REQ:

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

AIRPORT MASTER RECORD

PRINT DATE: 05/25/2011
AFD EFF 05/05/2011
Form Approved OMB 2120-0015

> 1 ASSOC CITY: ESPANOLA | 4 STATE: NM | LOC ID: E14 | FAA SITE NR: 14604.7*A
> 2 AIRPORT NAME: OHKAY OWINGEH | 5 COUNTY: RIO ARRIBA NM
3 CBD TO AIRPORT (NM): 03 NE | 6 REGION/ADO: ASW/LNM | 7 SECT AERO CHT: DENVER

GENERAL

10 OWNERSHIP: PU
> 11 OWNER: OHKAY OWINGEH TRIBAL COUNCIL
> 12 ADDRESS: PO BOX 1099
SAN JUAN PUEBLO, NM 87566
> 13 PHONE NR: 505-852-4400
> 14 MANAGER: RON LOVATO
> 15 ADDRESS: PO BOX 1079
SAN JUAN PUEBLO, NM 87566
> 16 PHONE NR: 505-660-6113
> 17 ATTENDANCE SCHEDULE:
UNATNDD

18 AIRPORT USE: PUBLIC
19 ARPT LAT: 36-01-34.0285N ESTIMATED
20 ARPT LONG: 106-02-43.4925W
21 ARPT ELEV: 5790 SURVEYED
22 ACREAGE: 236
> 23 RIGHT TRAFFIC: NO
> 24 NON-COMM LANDING NO
25 NPIAS/FED AGREEMENTS N1
> 26 FAR 139 INDEX:

SERVICES

> 70 FUEL: 100LL A
> 71 AIRFRAME RPRS: NONE
> 72 PWR PLANT RPRS: NONE
> 73 BOTTLE OXYGEN: NONE
> 74 BULK OXYGEN: NONE
75 TSNT STORAGE: TIE
76 OTHER SERVICES:

FACILITIES

> 80 ARPT BCN: CG
> 81 ARPT LGT SKED: DUSK-DAWN
> 82 UNICOM:
> 83 WIND INDICATOR: YES
84 SEGMENTED CIRCLE: YES
85 CONTROL TWR: NONE
86 FSS: ALBUQUERQUE
87 FSS ON ARPT: NO
88 FSS PHONE NR:
89 TOLL FREE NR: 1-800-WX-BRIEF

BASED AIRCRAFT

90 SINGLE ENG: 2
91 MULTI ENG: 0
92 JET: 0
TOTAL: 2
93 HELICOPTERS: 0
94 GLIDERS: 0
95 MILITARY: 0
96 ULTRA-LIGHT: 0

OPERATIONS

100 AIR CARRIER: 0
102 AIR TAXI: 0
103 G A LOCAL: 600
104 G A ITNRNT: 400
105 MILITARY: 0
TOTAL: 1,000
OPERATIONS FOR 12 MONTHS ENDING 04/08/2009

RUNWAY DATA

> 30 RUNWAY IDENT	**16/34**			
> 31 LENGTH:	5,007			
> 32 WIDTH:	75			
> 33 SURF TYPE-COND	ASPH-G			
> 34 SURF TREATMENT				
35 GROSS WT: SW	18.0			
36 (IN THSDS) DW				
37 DTW				
38 DDTW				
> 39 PCN:				
LIGHTING/APCH AIDS				
> 40 EDGE INTENSITY	MED			
> 42 RWY MARK TYPE-COND	BSC - G / BSC - G	- / -	- / -	- / -
> 43 VGSI:	/	/	/	/
44 THR CROSSING HGT:	/	/	/	/
45 VISUAL GLIDE ANGLE:	/	/	/	/
> 46 CNTRLN-TDZ:	- / -	- / -	- / -	- / -
> 47 RVR-RVV:	- / -	- / -	- / -	- / -
> 48 REIL:	/	/	/	/
> 49 APCH LIGHTS:	/	/	/	/
OBSTRUCTION DATA				
50 FAR 77 CATEGORY:	A(V) / A(V)	/	/	/
> 51 DISPLACED THR:	324 /	/	/	/
> 52 CTLG OBSTN:	/ FENCE	/	/	/
> 53 OBSTN MARKED/LGTD:	/	/	/	/
> 54 HGT ABOVE RWY END:	/ 5	/	/	/
> 55 DIST FROM RWY END:	/ 300	/	/	/
> 56 CNTRLN OFFSET:	/ 0B	/	/	/
57 OBSTN CLNC SLOPE:	50:1 / 20:1	/	/	/
58 CLOSE-IN OBSTN:	N / Y	/	/	/
DECLARED DISTANCES				
> 60 TAKE OFF RUN AVBL (TORA):	/	/	/	/
> 61 TAKE OFF DIST AVBL (TODA):	/	/	/	/
> 62 ACLT STOP DIST AVBL (ASDA):	/	/	/	/
> 63 LNDG DIST AVBL (LDA):	/	/	/	/

(>) ARPT MGR PLEASE ADVISE FSS IN ITEM 86 WHEN CHANGES OCCUR TO ITEMS PRECEDED BY >

> 110 REMARKS:

Attachment A – Page A6 of A8
100320-NCAL-00001, Rev. 6

A 058 RWY 34 4 FT BRUSH 126 FT FROM THLD 15 FT RIGHT.
A 070 FOR EVENING FUEL CTC 505-927-6609.
A 081 ACTVT MIRL RY 16/34 - CTAF.
A 110-9 MAIN GATE LOCKED AT ALL TIMES AIRPORT ACCESS GATE COMBINATION - 4751.

111 INSPECTOR: (C) | 112 LAST INSP: 04/08/2009 | 113 LAST INFO REQ:

Attachment A

Teledyne Continental Motors - Specification Sheet (1 of 2)

MODEL	NO. of CYL	TAKEOFF POWER HP@RPM	METRO POWER HP@RPM	BORE & STROKE	DISPL. CUBIC IN.	ENGINE DIMENSIONS (INCHES)			WEIGHT DRY LBS. BASIC ENGINE	FUEL GRADE	COMPR. RATIO	RECOMMEND TBO HRS/YEARS
						HEIGHT	WIDTH	LENGTH				
O-200-A & B	4		100 @ 2750	4.06 X 3.88	200	23.18	31.56	28.53	170.18	80/87	7.0:1	1800/12
IO-240-A & B	4		125 @ 2800	4.44 X 3.88	240	23.50	31.40	29.10/29.80	205.00	100/100LL	8.5:1	2000/12
O300-A, C & D	6		145 @ 2700	4.06 X 3.88	300	27.41	31.50	35.97	248.70	80/87	7.0:1	1800/12
IO-360-C,CB, D,DB, G,GB, H & HB	6		210 @ 2800	4.44 X 3.88	360	22.43	31.46	34.03	327.25	100/100LL	8.5:1	1500/12
IO-360-ES	6		210 @ 2800	4.44 X 3.88	360	26.22	33.05	36.32	305.00	100/100LL	8.5:1	2000/12
IO-360-J, JB,	6	210 @ 2800	195 @ 2600	4.44 X 3.88	360	22.43	31.46	34.03	327.25	100/100LL	8.5:1	1500/12
IO-360-K & KB	6		195 @ 2600	4.44 X 3.88	360	22.43	31.46	34.03	327.25	100/100LL	8.5:1	#1500/12
TSIO-360-A,AB	6	210 @ 2800	210 @ 2800	4.44 X 3.88	360	22.43	31.46	35.34	283.81	100/100LL	7.5:1	1400/12
TSIO-360-C, CB	6		225 @ 2800	4.44 X 3.88	360	22.76	31.46	35.34	301.00	100/100LL	7.5:1	1400/12
TSIO-360-D, DB	6		225 @ 2800	4.44 X 3.88	360	22.76	31.46	35.34	283.81	100/100LL	7.5:1	1400/12
L/TSIO-360-E, EB	6		200 @ 2575	4.44 X 3.88	360	27.5	31.38	56.97	321.35	100/100LL	7.5:1	1400/12
TSIO-360-F –FB	6		200 @ 2575	4.44 X 3.88	360	26.44	31.38	40.53	328.35	100/100LL	7.5:1	1800/12
TSIO-360-H –HB	6		210 @ 2800	4.44 X 3.88	360	22.43	31.38	35.34	295.75	100/100LL	7.5:1	1400/12
TSIO-360-JB	6		225 @ 2800	4.44 X 3.88	360	22.43	31.38	35.34	295.75	100/100LL	7.5:1	1400/12
L/TSIO-360-KB	6		220 @ 2800	4.44 X 3.88	360	27.50	31.38	56.97	328.35	100/100LL	7.5:1	1800/12
TSIO-360-LB	6		210 @ 2700	4.44 X 3.88	360	27.53	31.38	56.97	343.35	100/100LL	7.5:1	1800/12
TSIO-360-MB	6		210 @ 2700	4.44 X 3.88	360	32.82	35.78	42.78	327.50	100/100LL	7.5:1	1800/12
L/TSIO-360-RB	6		220 @ 2600	4.44 X 3.88	360	28.00	33.00	57.5	327.50	100/100LL	7.5:1	1800/12
TSIO-360-SB	6		220 @ 2600	4.44 X 3.88	360	32.82	35.78	42.78	328.35	100/100LL	7.5:1	1800/12
O-470-GCI	6		240 @ 2600	5.00 X 4.00	470	26.81	33.56	37.14	431.60	91/96	8.0:1	1500/12
O-470-J	6		225 @ 2550	5.00 X 4.00	470	27.75	33.32	36.03	354.15	80/87	7.0:1	1500/12
O-470-K, L & M	6		230 @ 2600	5.00 X 4.00	470	28.09	33.56	36.08	380.00	80/87	7.0:1	1500/12
O-470-R & S	6		230 @ 2600	5.00 X 4.00	470	28.42	33.56	36.03	379.66	80/87	7.0:1	1500/12
O-470-U	6		230 @ 2400	5.00 X 4.00	470	28.42	33.56	36.03	388.93	100/100LL	8.6:1	1500/12
IO-470-C	6		250 @ 2600	5.00 X 4.00	470	26.81	33.56	38.14	402.48	91/96	8.0:1	1500/12
IO-470-D & E	6		260 @ 2625	5.00 X 4.00	470	19.75	33.56	43.64	426.06	100/130	8.6:1	1500/12
IO-470-F	6		260 @ 2625	5.00 X 4.00	470	23.79	33.56	36.72	399.06	100/130	8.6:1	1500/12
IO-470-H	6		260 @ 2625	5.00 X 4.00	470	26.81	33.56	38.14	402.48	100/130	8.6:1	1500/12
IO-470-J & K	6		225 @ 2600	5.00 X 4.00	470	26.81	33.39	38.14	401.90/370.56	80/87	7.0:1	1500/12
IO-470-L & M	6		260 @ 2625	5.00 X 4.00	470	19.75	33.56	43.17/47.16	411.28	100/100LL	8.6:1	1500/12
IO-470-N	6		260 @ 2625	5.00 X 4.00	470	26.81	33.58	38.14	414.44	100/130	8.6:1	1500/12
IO-470-S	6		260 @ 2625	5.00 X 4.00	470	19.75	33.56	40.91	409.37	100/130	8.6:1	1500/12
IO-470-U, V & VO	6		260 @ 2625	5.00 X 4.00	470	19.75	33.56	40.91	406.00	100/130	8.6:1	1500/12
IO-520-A & J	6		285 @ 2700	5.25 X 4.00	520	19.75	33.56	40.91	412.43	100/130	8.5:1	1700/12
IO-520-B, BA, BB	6		285 @ 2700	5.25 X 4.00	520	27.32	33.56	37.97	406.65	100/100LL	8.5:1	1700/12
IO-520-C, CB	6		285 @ 2700	5.25 X 4.00	520	18.78	33.56	42.81	398.72	100/100LL	8.5:1	1700/12
IO-520-D & E	6	300 @ 2850	285 @ 2700	5.25 X 4.00	520	23.79	33.56	36.74/47.16	411.43	100/100LL	8.5:1	1700/12
IO-520-F	6	300 @ 2850	285 @ 2700	5.25 X 4.00	520	19.75	33.56	40.91	411.43	100/130	8.5:1	1700/12
IO-520-K	6	300 @ 2850	285 @ 2700	5.25 X 4.00	520	20.41	33.56	40.91	411.43	100/130	8.5:1	1700/12

Teledyne Continental Motors - Specification Sheet (2 of 2)

MODEL	NO. of CYL	TAKEOFF POWER HP@RPM	METRO POWER HP@RPM	BORE & STROKE	DISPL. CUBIC IN.	ENGINE DIMENSIONS (INCHES)			WEIGHT DRY LBS. BASIC ENGINE	FUEL GRADE	COMPR. RATIO	RECOMMEND TBO HRS/YEARS
						HEIGHT	WIDTH	LENGTH				
IO-520-L	6	300 @ 2850	285 @ 2700	5.25 X 4.00	520	23.25	33.56	40.91	412.80	100/130	8.5:1	1700/12
IO-520-M, MB	6		285 @ 2700	5.25 X 4.00	520	20.41	33.56	46.80	411.20	100/100LL	8.5:1	1700/12
L/IO-520-P	6		250 @ 2500	5.25 X 4.00	520	20.81	33.36	40.91	384.44	100/100LL	8.5:1	2000/12
L/TSIO-520-AE	6		250 @ 2400	5.25 X 4.00	520	21.38	33.29	38.07	364.80	100/100LL	7.5:1	2000/12
TSIO-520-AF	6	310 @ 2700	285 @ 2600	5.25 X 4.00	520	19.75	33.56	40.91	435.47	100/100LL	7.5:1	1600/12
TSIO-520-B, BB	6		285 @ 2700	5.25 X 4.00	520	20.41	33.56	39.25	407.17	100/100LL	7.5:1	1400/12
TSIO-520-BE	6		310 @ 2600	5.25 X 4.00	520	33.50	42.50	42.64	442.10	100/100LL	7.5:1	2000/12
TSIO-520-C & H	6		285 @ 2700	5.25 X 4.00	520	20.04/23.54	33.56	40.91	426.30/415.06	100/130	7.5:1	1400/12
TSIO-520-CE	6		325 @ 2700	5.25 X 4.00	520	25.00	34.00	41.00	435.47	100/100LL	7.5:1	1600/12
TSIO-520-D, DB	6		285 @ 2700	5.25 X 4.00	520	29.40	33.56	39.58	406.72	100/100LL	7.5:1	1400/12
TSIO-520-E, EB	6		300 @ 2700	5.25 X 4.00	520	29.40	33.56	39.25	405.57	100/100LL	7.5:1	1400/12
TSIO-520-G	6	300 @ 2700	285 @ 2700	5.25 X 4.00	520	19.75	33.56	40.91	415.00	100/130	7.5:1	1400/12
TSIO-520-J, JB,N, NB	6		310 @ 2700	5.25 X 4.00	520	22.32	33.56	54.63	395.35/404.00	100/130	7.5:1	1400/12
TSIO-520-K, KB	6		285 @ 2700	5.25 X 4.00	520	22.32	33.56	54.63	395.35	100/130	7.5:1	1400/12
TSIO-520-L, LB	6		310 @ 2700	5.25 X 4.00	520	20.02	33.56	50.62	416.10	100/100LL	7.5:1	1400/12
TSIO-520-(M) P & R	6	310 @ 2700	285 @ 2700	5.25 X 4.00	520	(20.04)/23.54	33.56	40.91	417.52	100/100LL	7.5:1	1400/12
TSIO-520-T	6		310 @ 2700	5.25 X 4.00	520	32.26	33.56	38.20	426.30	100/100LL	7.5:1	1400/12
TSIO-520-U & UB	6		300 @ 2700	5.25 X 4.00	520	40.56	33.56	52.19	422.27	100/100LL	7.5:1	1600/12
TSIO-520-VB	6		325 @ 2700	5.25 X 4.00	520	20.41	33.56	39.25	406.50	100/100LL	7.5:1	1600/12
TSIO-520-WB	6		325 @ 2700	5.25 X 4.00	520	20.02	33.56	50.62	416.10	100/100LL	7.5:1	1600/12
GTSIO-520-D & H∇	6		375 @ 3400	5.25 X 4.00	520	26.63	34.04	63.63	484.00	100/130	7.5:1	1600/12
GTSIO-520-L ∇	6		375 @ 3350	5.25 X 4.00	520	26.41	34.04	60.84	485.00	100/100LL	7.5:1	1600/12
GTSIO-520-M ∇	6		375 @ 3350	5.25 X 4.00	520	26.41	34.04	62.39	483.00	100/100LL	7.5:1	1600/12
GTSIO-520-N ∇	6		375 @ 3350	5.25 X 4.00	520	26.41	34.04	60.84	486.00	100/100LL	7.5:1	1600/12
IO-550-A	6		300 @ 2700	5.25 X 4.25	550	20.41	33.56	46.80	414.40	100/100LL	8.5:1	1700/12
IO-550-B	6		300 @ 2700	5.25 X 4.25	550	27.32	33.56	37.97	406.65	100/100LL	8.5:1	1700/12
IO-550-C	6		300 @ 2700	5.25 X 4.25	550	19.78	33.56	43.31	415.10	100/100LL	8.5:1	1700/12
IO-550-D, E, F & (L)	6		300 @ 2700	5.25 X 4.25	550	23.79	33.56	36.74 (40.91)	425.00	100/100LL	8.5:1	1700/12
IO-550-G	6		280 @ 2500	5.25 X 4.25	550	20.41	34.04	38.43	412.00	100/100LL	8.5:1	2000/12
IO-550-N	6		310 @ 2700	5.25 X 4.25	550	20.41	34.04	38.43	412.00	100/100LL	8.5:1	2000/12
TSIO-550-B& E	6		350 @ 2700	5.25 X 4.25	550	33.50	42.50	42.57	442.00	100/100LL	7.5:1	1600/12
TSIO-550-C	6		310 @ 2600	5.25 X 4.25	550	33.50	42.50	42.57	442.00	100/100LL	7.5:1	2000/12
TSIOL-550-A	6		350 @ 2700	5.25 X 4.25	550	33.50	42.50	42.57	401.50	100/100LL	7.5:1	2000/12
TSIOL-550-B	6		325 @ 2700	5.25 X 4.25	550	30.50	39.30	46.10	415.40	100/100LL	7.5:1	2000/12
TSIOL-550-C	6		350 @ 2600	5.25 X 4.25	550	30.50	39.30	46.10	415.40	100/100LL	7.5:1	2000/12

∇ GTSIO RPM LISTINGS REFERENCE CRANKSHAFT RPM

LANL Project
Number: 100320

CMRR PROJECT ATTACHMENT COVER SHEET

Calculation No. 100320-NCAL-00001	**ORIGINATOR:** Tomas M. Sanchez (Print & Sign Above) **DATE** 7/29/2011
Rev. No. 6	**CHECKER:** Lanny N. Smith (Print & Sign Above) **DATE** 7/29/2011
Attachment B	

ATTACHMENT TITLE: Orthonormal Distances using MS Excel 2007

Cover Page(s)	Attachment Page(s)	Total Pages
2	2	6

CMRR PROJECT ATTACHMENT COVER SHEET

Calculation No. 100320-NCAL-00001	**ORIGINATOR:** Tomas M. Sanchez **DATE** 7/29/2011
Rev. No. 6	Print & Sign Above
Attachment B	**CHECKER:** Lanny N. Smith **DATE** 7/29/2011 Print & Sign Above

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Orthonormal Distances using Microsoft Excel 2007
Numerical Values

Runway	Distance [mi]	Initial Bearing [degrees]	Runway Bearing [degrees]	X Component Distance [mi]	Y Component Distance [mi]
LAM					
Runway 9	2.1	56	90	-1.7	-1.2
Runway 27	2.1	56	270	1.7	1.2
SAF					
Runway 2	20	145	20	11.5	16.4
Runway 20	20	145	200	-11.5	-16.4
Runway 10	20	145	100	-14.1	14.1
Runway 28	20	145	280	14.1	-14.1
Runway 15	20	145	150	-19.9	-1.7
Runway 33	20	145	330	19.9	1.7
E14					
Runway 16	18	51	160	5.9	-17.0
Runway 34	18	51	340	-5.9	17.0

Orthonormal Distances using Microsoft Excel 2007 Equations

Runway	Distance [mi]	Initial Bearing [degrees]	Runway Bearing [degrees]	X Component Distance [mi]	Y Component Distance [mi]
			LAM		
Runway 9	2.1	56	90	=-B3*COS((C3-D3)*PI()/180)	=B3*SIN((C3-D3)*PI()/180)
Runway 27	2.1	56	270	=-B4*COS((C4-D4)*PI()/180)	=B4*SIN((C4-D4)*PI()/180)
			SAF		
Runway 2	20	145	20	=-B6*COS((C6-D6)*PI()/180)	=B6*SIN((C6-D6)*PI()/180)
Runway 20	20	145	200	=-B7*COS((C7-D7)*PI()/180)	=B7*SIN((C7-D7)*PI()/180)
Runway 10	20	145	100	=-B8*COS((C8-D8)*PI()/180)	=B8*SIN((C8-D8)*PI()/180)
Runway 28	20	145	280	=-B9*COS((C9-D9)*PI()/180)	=B9*SIN((C9-D9)*PI()/180)
Runway 15	20	145	150	=-B10*COS((C10-D10)*PI()/180)	=B10*SIN((C10-D10)*PI()/180)
Runway 33	20	145	330	=-B11*COS((C11-D11)*PI()/180)	=B11*SIN((C11-D11)*PI()/180)
			E14		
Runway 16	18	51	160	=-B13*COS((C13-D13)*PI()/180)	=B13*SIN((C13-D13)*PI()/180)
Runway 34	18	51	340	=-B14*COS((C14-D14)*PI()/180)	=B14*SIN((C14-D14)*PI()/180)

CMRR PROJECT ATTACHMENT COVER SHEET

Calculation No. 100320-NCAL-00001	**ORIGINATOR:** Tomas M. Sanchez (Print & Sign Above) **DATE** 7/29/2011
Rev. No. 6	**CHECKER:** Lanny N. Smith (Print & Sign Above) **DATE** 7/29/2011
Attachment C	

ATTACHMENT TITLE: Equations for Effective Areas and Impact Frequencies used in MS Excel 2007

Cover Page(s)	Attachment Page(s)	Total Pages
2	18	20

CMRR PROJECT ATTACHMENT COVER SHEET

Calculation No. 100320-NCAL-00001	**ORIGINATOR:** Tomas M. Sanchez **DATE** 7/29/2011 Print & Sign Above
Rev. No. 6	**CHECKER:** Lanny N. Smith **DATE** 7/29/2011 Print & Sign Above
Attachment C	

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	A	B	C
1			
2	**Los Alamos County Airport**		
3	Variable		(source)
4	WS (ft)	Wingspan	(Table B-16)
5	L (ft)	Facility length	(data input)
6	W (ft)	Facility width	(data input)
7	H (ft)	Facility heigh	(data input)
8	R (ft)	Diagonal of the facility	$R=(L^2+W^2)^{1/2}$
9	cot Φ	Cotangent of aircraft impact angle	(Table B-17)
10	S(ft)	Mean skid distance	(Table B-18)
11	A_f (mile^2)	Effective fly-in area of the facility	$A_f = [(WS+R)H\cdot\cot\Phi+(2\cdot L\cdot W\cdot WS)/R+L\cdot W]\cdot(1acre/27,878,400\ mi^2)$
12	A_s (mile^2)	Effective skid area	$A_s = (WS+R)\cdot S\cdot(1acre/27,878,400\ mi2)\ [mi^2]$
13	A_{eff} (mile^2)	**Effective target area**	$A_{eff} = A_f + A_s$
14			
15			Airport Operation
16			
17			General Aviation Aircraft (Takeoff)
18			General Aviation Aircraft (Landing)
19			Commercial Aviation Air Taxi (Takeoff)
20			Commercial Aviation Air Taxi (Landing)
21			Military Large (Takeoff)
22			Military Large (Landing)
23			Military Small (Takeoff)
24			Military Small (Landing)
25			

	D	E
1		
2		
3	**General Aviation**	**Commercial Air Carrier**
4	50	98
5	=234+108+6/12	=$D$5
6	=304	=$D$6
7	110.6	=$D$7
8	=SQRT(D5^2+D6^2)	=SQRT(E5^2+E6^2)
9	8.2	10.2
10	60	1440
11	=((D4+D8)*D7*D9+(2*D4*D5*D6)/D8+D5*D6)*0.00000003587	=((E4+E8)*E7*E9+(2*E4*E5*E6)/E8+E5*E6)*0.00000003587
12	=((D4+D8)*D10)*0.00000003587	=((E4+E8)*E10)*0.00000003587
13	=D11+D12	=E11+E12
14		
15	**N_{ijk}: Number of Operations per year**	**X Direction (miles)**
16	(data input)	(data input)
17	6500	-1.7
18	=13000/2	1.7
19	30	-1.7
20	30	1.7
21	0	-1.7
22	0	1.7
23	5	-1.7
24	5	1.7
25	=SUM(D17:D24)	

	F	G
1		
2		
3	**Commercial Air Taxi**	**Military Large (Takeoff)**
4	59	223
5	=$D$5	=$D$5
6	=$D$6	=$D$6
7	=$D$7	=$D$7
8	=SQRT(F5^2+F6^2)	=SQRT(G5^2+G6^2)
9	10.2	7.4
10	1440	780
11	=((F4+F8)*F7*F9+(2*F4*F5*F6)/F8+F5*F6)*0.00000003587	=((G4+G8)*G7*G9+(2*G4*G5*G6)/G8+G5*G6)*0.00000003587
12	=((F4+F8)*F10)*0.00000003587	=((G4+G8)*G10)*0.00000003587
13	=F11+F12	=G11+G12
14		
15	**Y Direction (miles)**	**f_{ijk}(x,y)**
16	(data input)	(Tables B-2 to B-13 of STD-3014)
17	-1.2	0.0011
18	1.2	0.0044
19	-1.2	0
20	1.2	0
21	-1.2	0
22	1.5	0.0093
23	-1.2	0
24	1.2	0.0047
25		

	H	I	J
1			
2			
3	**Military Large (Landing)**	**Military Small (Takeoff)**	**Military Small (Landing)**
4	223	110	110
5	=$D$5	=$D$5	=$D$5
6	=$D$6	=$D$6	=$D$6
7	=$D$7	=$D$7	=$D$7
8	=SQRT(H5^2+H6^2)	=SQRT(I5^2+I6^2)	=SQRT(J5^2+J6^2)
9	9.7	8.4	10.4
10	368	246	447
11	=((H4+H8)*H7*H9+(2*H4*H5*H6)/H8+H5*H6)*0.00000003587	=((I4+I8)*I7*I9+(2*I4*I5*I6)/I8+I5*I6)*0.00000003587	=((J4+J8)*J7*J9+(2*J4*J5*J6)/J8+J5*J6)*0.00000003587
12	=((H4+H8)*H10)*0.00000003587	=((I4+I8)*I10)*0.00000003587	=((J4+J8)*J10)*0.00000003587
13	=H11+H12	=I11+I12	=J11+J12
14			
15	**P_{ijk}: Crash Rate**	**A_{eff}, Site specific Effective Target Area (mile^2)**	**F: Impact Frequency (per year)**
16	(Table B-1 of STD-3014)		
17	0.000011	=D13	=D17*G17*H17*I17
18	0.00002	=D13	=D18*G18*H18*I18
19	0.000001	=F13	=D19*G19*H19*I19
20	0.0000023	=F13	=D20*G20*H20*I20
21	0.00000057	=G13	=D21*G21*H21*I21
22	0.0000016	=H13	=D22*G22*H22*I22
23	0.0000018	=I13	=D23*G23*H23*I23
24	0.0000033	=J13	=D24*G24*H24*I24
25		**Total Aircraft Crash Frequency (per year)**	**=SUM(J17:J24)**

	A	B	C
1			
2	**Santa Fe County Airport**		
3	Variable		(source)
4	WS (ft)	Wingspan	(Table B-16)
5	L (ft)	Facility length	(data input)
6	W (ft)	Facility width	(data input)
7	H (ft)	Facility height	(data input)
8	R (ft)	Diagonal of the facility	$R=(L^2+W^2)^{1/2}$
9	cot Φ	Cotangent of aircraft impact angle	(Table B-17)
10	S(ft)	Mean skid distance	(Table B-18)
11	A_f (mile²)	Effective fly-in area of the facility	$A_f = [(WS+R)H \cdot \cot\Phi + (2 \cdot L \cdot W \cdot WS)/R + L \cdot W] \cdot (1acre/27,878,400\ mi^2)$
12	A_s (mile²)	Effective skid area	$A_s = (WS+R) \cdot S \cdot (1acre/27,878,400\ mi2)\ [mi^2]$
13	A_{eff} (mile²)	**Effective target area**	$A_{eff} = A_f + A_s$
14	(Input data)		
15			**Airport Operation**
16			
17			General Aviation Aircraft (Takeoff)
18			General Aviation Aircraft (Landing)
19			Commercial Aviation Air Taxi (Takeoff)
20			Commercial Aviation Air Taxi (Landing)
21			Military Large (Takeoff)
22			Military Large (Landing)
23			Military Small (Takeoff)
24			Military Small (Landing)
25			

	D	E
1		
2		
3	**General Aviation**	**Commercial Air Carrier**
4	50	98
5	=234+108+6/12	=$D$5
6	=304	=$D$6
7	110.6	=$D$7
8	=SQRT(D5^2+D6^2)	=SQRT(E5^2+E6^2)
9	8.2	10.2
10	60	1440
11	=((D4+D8)*D7*D9+(2*D4*D5*D6)/D8+D5*D6)*0.00000003587	=((E4+E8)*E7*E9+(2*E4*E5*E6)/E8+E5*E6)*0.00000003587
12	=((D4+D8)*D10)*0.00000003587	=((E4+E8)*E10)*0.00000003587
13	**=D11+D12**	**=E11+E12**
14		
15	**N_{ijk}: Number of Operations per year***	**X Direction (miles)**
16	(data input)	(data input)
17	33600	-19.9
18	33600	-19.9
19	3000	-19.9
20	3000	-19.9
21	0	-19.9
22	0	-19.9
23	2750	-19.9
24	=D23	-19.9
25	**=SUM(D17:D24)**	

	F	G
1		
2		
3	**Commercial Air Taxi**	**Military Large (Takeoff)**
4	59	223
5	=$D$5	=$D$5
6	=$D$6	=$D$6
7	=$D$7	=$D$7
8	=SQRT(F5^2+F6^2)	=SQRT(G5^2+G6^2)
9	10.2	7.4
10	1440	780
11	=((F4+F8)*F7*F9+(2*F4*F5*F6)/F8+F5*F6)*0.00000003587	=((G4+G8)*G7*G9+(2*G4*G5*G6)/G8+G5*G6)*0.00000003587
12	=((F4+F8)*F10)*0.00000003587	=((G4+G8)*G10)*0.00000003587
13	=F11+F12	=G11+G12
14		
15	**Y Direction (miles)**	**f_{ijk}(x,y)**
16	(data input)	(Tables B-2 to B-13 of STD-3014)
17	-1.7	0
18	-1.7	0
19	-1.7	0
20	-1.7	0
21	-1.7	0
22	-1.7	0
23	-1.7	0
24	-1.7	0.00016
25		

	H	I	J
1			
2			
3	**Military Large (Landing)**	**Military Small (Takeoff)**	**Military Small (Landing)**
4	223	110	110
5	=$D$5	=$D$5	=$D$5
6	=$D$6	=$D$6	=$D$6
7	=$D$7	=$D$7	=$D$7
8	=SQRT(H5^2+H6^2)	=SQRT(I5^2+I6^2)	=SQRT(J5^2+J6^2)
9	9.7	8.4	10.4
10	368	246	447
11	=((H4+H8)*H7*H9+(2*H4*H5*H6)/H8+H5*H6)*0.00000003587	=((I4+I8)*I7*I9+(2*I4*I5*I6)/I8+I5*I6)*0.00000003587	=((J4+J8)*J7*J9+(2*J4*J5*J6)/J8+J5*J6)*0.00000003587
12	=((H4+H8)*H10)*0.00000003587	=((I4+I8)*I10)*0.00000003587	=((J4+J8)*J10)*0.00000003587
13	=H11+H12	=I11+I12	=J11+J12
14			
15	**P_{ijk}: Crash Rate**	**A_{eff}, Site specific Effective Target Area (mile^2)**	**F: Impact Frequency (per year)**
16	(Table B-1 of STD-3014)		
17	0.000011	=D13	=D17*G17*H17*I17
18	0.00002	=D13	=D18*G18*H18*I18
19	0.000001	=F13	=D19*G19*H19*I19
20	0.0000023	=F13	=D20*G20*H20*I20
21	0.00000057	=G13	=D21*G21*H21*I21
22	0.0000016	=H13	=D22*G22*H22*I22
23	0.0000018	=I13	=D23*G23*H23*I23
24	0.0000033	=J13	=D24*G24*H24*I24
25		**Total Aircraft Crash Frequency (per year)**	**=SUM(J17:J24)**

	A	B	C
1			
2	**Ohkay Owingeh Airport**		
3	Variable		(source)
4	WS (ft)	Wingspan	(Table B-16)
5	L (ft)	Facility length	(data input)
6	W (ft)	Facility width	(data input)
7	H (ft)	Facility heigh	(data input)
8	R (ft)	Diagonal of the facility	$R=(L^2+W^2)^{1/2}$
9	cot Φ	Cotangent of aircraft impact angle	(Table B-17)
10	S(ft)	Mean skid distance	(Table B-18)
11	A_f (mile^2)	Effective fly-in area of the facility	$A_f = [(WS+R)H\cdot\cot\Phi+(2\cdot L\cdot W\cdot WS)/R+L\cdot W]\cdot(1acre/27{,}878{,}400\ mi^2)$
12	A_s (mile^2)	Effective skid area	$A_s = (WS+R)\cdot S\cdot(1acre/27{,}878{,}400\ mi2)\ [mi^2]$
13	A_{eff} (mile^2)	**Effective target area**	$A_{eff} = A_f + A_s$
14			
15	(Input data)		
16			**Airport Operation**
17			
18			General Aviation Aircraft (Takeoff)
19			General Aviation Aircraft (Landing)
20			Commercial Aviation Air Taxi (Takeoff)
21			Commercial Aviation Air Taxi (Landing)
22			Military Large (Takeoff)
23			Military Large (Landing)
24			Military Small (Takeoff)
25			Military Small (Landing)
26			

	D	E
1		
2		
3	**General Aviation**	**Commercial Air Carrier**
4	50	98
5	=234+108.5	=$D$5
6	=304	=$D$6
7	110.6	=$D$7
8	=SQRT(D5^2+D6^2)	=SQRT(E5^2+E6^2)
9	8.2	10.2
10	60	1440
11	=((D4+D8)*D7*D9+(2*D4*D5*D6)/D8+D5*D6)*0.00000003587	=((E4+E8)*E7*E9+(2*E4*E5*E6)/E8+E5*E6)*0.00000003587
12	=((D4+D8)*D10)*0.00000003587	=((E4+E8)*E10)*0.00000003587
13	**=D11+D12**	**=E11+E12**
14		
15		
16	**N_{ijk}: Number of Operations per year***	**X Direction (miles)**
17	(data input)	(data input)
18	500	5.9
19	500	-5.9
20	0	5.9
21	0	-5.9
22	0	5.9
23	0	-5.9
24	0	5.9
25	0	-5.8
26	**=SUM(D18:D25)**	

	F	G
1		
2		
3	**Commercial Air Taxi**	**Military Large (Takeoff)**
4	59	223
5	=$D$5	=$D$5
6	=$D$6	=$D$6
7	=$D$7	=$D$7
8	=SQRT(F5^2+F6^2)	=SQRT(G5^2+G6^2)
9	10.2	7.4
10	1440	780
11	=((F4+F8)*F7*F9+(2*F4*F5*F6)/F8+F5*F6)*0.00000003587	=((G4+G8)*G7*G9+(2*G4*G5*G6)/G8+G5*G6)*0.00000003587
12	=((F4+F8)*F10)*0.00000003587	=((G4+G8)*G10)*0.00000003587
13	**=F11+F12**	**=G11+G12**
14		
15		
16	**Y Direction (miles)**	**f_{ijk}(x,y)**
17	(data input)	(Tables B-2 to B-13 of STD-3014)
18	-17.4	0
19	17.4	0
20	-17.4	0
21	17.4	0
22	-17.4	0
23	17.4	0
24	-17.4	0
25	17.4	0.00024
26		

	H	I	J
1			
2			
3	**Military Large (Landing)**	**Military Small (Takeoff)**	**Military Small (Landing)**
4	223	110	110
5	=$D$5	=$D$5	=$D$5
6	=$D$6	=$D$6	=$D$6
7	=$D$7	=$D$7	=$D$7
8	=SQRT(H5^2+H6^2)	=SQRT(I5^2+I6^2)	=SQRT(J5^2+J6^2)
9	9.7	8.4	10.4
10	368	246	447
11	=((H4+H8)*H7*H9+(2*H4*H5*H6)/H8+H5*H6)*0.00000003587	=((I4+I8)*I7*I9+(2*I4*I5*I6)/I8+I5*I6)*0.00000003587	=((J4+J8)*J7*J9+(2*J4*J5*J6)/J8+J5*J6)*0.00000003587
12	=((H4+H8)*H10)*0.00000003587	=((I4+I8)*I10)*0.00000003587	=((J4+J8)*J10)*0.00000003587
13	=H11+H12	=I11+I12	=J11+J12
14			
15			
16	**P_{ijk}: Crash Rate**	**A_{eff}, Site specific Effective Target Area (mile^2)**	**F: Impact Frequency (per year)**
17	(Table B-1 of STD-3014)		
18	0.000011	=D13	=D18*G18*H18*I18
19	0.00002	=D13	=D19*G19*H19*I19
20	0.000001	=F13	=D20*G20*H20*I20
21	0.0000023	=F13	=D21*G21*H21*I21
22	0.00000057	=G13	=D22*G22*H22*I22
23	0.0000016	=H13	=D23*G23*H23*I23
24	0.0000018	=I13	=D24*G24*H24*I24
25	0.0000033	=J13	=D25*G25*H25*I25
26		**Total Aircraft Crash Frequency (per year)**	**=SUM(J18:J25)**

	A	B
1		
2	**Helicopter**	
3	Variable	
4	WS (ft)	Wingspan
5	L (ft)	Facility length
6	W (ft)	Facility width
7	H (ft)	Facility heigh
8	R (ft)	Diagonal of the facility
9	cot Φ	Cotangent of aircraft impact angle
10	S(ft)	Mean skid distance
11	A_f (mile^2)	Effective fly-in area of the facility
12	A_s (mile^2)	Effective skid area
13	A_{eff} (mile^2)	Effective target area
14		
15	N_H: **Expected number of local helicopter overflights per year**	P_H: **Probability of a helicopter crash per flight (Table B-1)**
16	100	0.000025

	C	D	E
1			
2			
3	**(source)**	***Helicopter***	
4	(Table B-16)	50	
5	(data input)	=234+108+6/12	
6	(data input)	=304	
7	(data input)	110.6	
8	$R=(L^2+W^2)^{1/2}$	=SQRT(D5^2+D6^2)	
9	(Table B-17)	0.58	
10	(Table B-18)	60	
11	$A_f = [(WS+R)H\cdot\cot\Phi+(2\cdot L\cdot W\cdot WS)/R+L\cdot W]\cdot(1acre/27,878,400\ mi^2)$	=((D4+D8)*D7*D9+(2*D4*D5*D6)/D8+D5*D6)*0.00000003587	
12	$A_s = (WS+R)\cdot S\cdot(1acre/27,878,400\ mi2)\ [mi^2]$	=((D4+D8)*D10)*0.00000003587	
13	$A_{eff} = A_f + A_s$	**=D11+D12**	
14			
15	**L_H: Average length, in miles, of a helicopter flight**	**A_H: Effective area**	**F_H: Helicopter Impact Frequency**
16	=1*(2.1-0.25)	=Helicopter!D13	=A16*B16*2/C16*D16

	A	B	C	D
1				
2	**Non-airport Operations**			
3	**Type of Aircraft**		**NPf(x,y) for Los Alamos National Laboratory**	**Effective Area: A_{eff} (mile^2)**
4	General Aviation Aircraft	Table B-14	0.0002	=LAM!D13
5	Commercial Aviation Air Carrier	Table B-15	0.0000002	=LAM!E13
6	Commercial Aviation Air Taxi	Table B-15	0.000003	=LAM!F13
7	Military Aviation Large Aircraft	Table B-15	0.0000001	=LAM!G13
8	Military Aviation Small Aircraft	Table B-15	0.000005	=LAM!I13
9				**Total non-airport crash frequency (per year)**

	E
1	
2	
3	**Non-Airport Crash Frequency (per year)**
4	=C4*D4
5	=C5*D5
6	=C6*D6
7	=C7*D7
8	=C8*D8
9	**=SUM(E4:E8)**

	A	B	C	D	E	F
1						
2						
3	**Type of operation**	**Estimated annual aircraft crash frequency (per year) for each**				
4		**LAM**	**SAF**	**E14**		
5	**General Aviation**	=SUM(LAM!J17:J18)	=SUM(SAF!J17:J18)	=SUM('E14'!J18:J19)		
6	**Commerical**	=SUM(LAM!J19:J20)	=SUM(SAF!J19:J20)	=SUM('E14'!J20:J21)		
7	**Military**	=SUM(LAM!J21:J24)	=SUM(SAF!J21:J24)	=SUM('E14'!J22:J25)		
8	**Total for individual airport**	=SUM(B5:B7)	=SUM(C5:C7)	=SUM(D5:D7)		
9	**Total for all local airport operations**			**=SUM(B8:D8)**		
10	**Nonairport operations**			**='Non-Airport'!E9**		
11	**Helicopter**			**=Helicopter!E16**		
12	**Total esimated annual aircraft crash frequency (per year)**			**=SUM(D9:D11)**		

	G
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	This page is intentionally blank

LANL Project
Number: 100320

CMRR PROJECT ATTACHMENT COVER SHEET

Calculation No. 100320-NCAL-00001	**ORIGINATOR**: Tomas M. Sanchez (Print & Sign Above) **DATE** 7/29/2011
Rev. No. 6	**CHECKER:** Lanny N. Smith (Print & Sign Above) **DATE** 7/29/2011
Attachment D	Lanny N. Smith

ATTACHMENT TITLE: Numerical Results Obtained by MS Excel 2007 for Effective Areas and Impact Frequencies

Cover Page(s)	Attachment Page(s)	Total Pages
2	6	8

CMRR PROJECT ATTACHMENT COVER SHEET

Calculation No. 100320-NCAL-00001	**ORIGINATOR**: Tomas M. Sanchez **DATE** 7/29/2011 Print & Sign Above **CHECKER:** Lanny N. Smith **DATE** 7/29/2011 Print & Sign Above Lanny N. Smith
Rev. No. 6	
Attachment D	

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Los Alamos County Airport

Variable		(source)	General Aviation	Commercial Air Carrier	Commercial Air Taxi	Military Large (Takeoff)	Military Large (Landing)	Military Small (Takeoff)	Military Small (Landing)
WS (ft)	Wingspan	(Table B-16)	50	98	59	223	223	110	110
L (ft)	Facility length	(data input)	342.5	342.5	342.5	342.5	342.5	342.5	342.5
W (ft)	Facility width	(data input)	304	304	304	304	304	304	304
H (ft)	Facility heigh	(data input)	110.60	110.60	110.60	110.60	110.60	110.60	110.60
R (ft)	Diagonal of the facility	$R=(L^2+W^2)^{1/2}$	458.0	458.0	458.0	458.0	458.0	458.0	458.0
cot Φ	Cotangent of aircraft impact angle	(Table B-17)	8.2	10.2	10.2	7.4	9.7	8.4	10.4
S(ft)	Mean skid distance	(Table B-18)	60	1440	1440	780	368	246	447
A_f (mile^2)	Effective fly-in area of the facility	A_f = [(WS+R)H•cot Φ+(2•L•W•WS)/R+L•W]•(1acre/27,878,400 mi^2)	2.107E-02	2.783E-02	2.562E-02	2.736E-02	3.358E-02	2.446E-02	2.896E-02
A_s (mile^2)	Effective skid area	A_s = (WS+R)•S •(1acre/27,878,400 mi2) [mi^2]	1.093E-03	2.872E-02	2.670E-02	1.905E-02	8.989E-03	5.012E-03	9.107E-03
A_{eff} (mile^2)	**Effective target area**	$A_{eff} = A_f + A_s$	**2.217E-02**	**5.655E-02**	**5.232E-02**	**4.642E-02**	4.257E-02	**2.947E-02**	**3.807E-02**

Airport Operation	N_{ijk}: Number of Operations per year	X Direction (miles)	Y Direction (miles)	$f_{ijk}(x,y)$	P_{ijk}: Crash Rate	A_{eff}, Site specific Effective Target Area (mile^2)	F: Impact Frequency (per year)
	(data input)	(data input)	(data input)	(Tables B-2 to B-13 of STD-3014)	(Table B-1 of STD-3014)		
General Aviation Aircraft (Takeoff)	6500	-1.7	-1.2	1.1E-03	1.1E-05	2.217E-02	1.744E-06
General Aviation Aircraft (Landing)	6500	1.7	1.2	4.4E-03	2.0E-05	2.217E-02	1.268E-05
Commercial Aviation Air Taxi (Takeoff)	30	-1.7	-1.2	0.0E+00	1.0E-06	5.232E-02	0.000E+00
Commercial Aviation Air Taxi (Landing)	30	1.7	1.2	0.0E+00	2.3E-06	5.232E-02	0.000E+00
Military Large (Takeoff)	0	-1.7	-1.2	0.0E+00	5.7E-07	4.642E-02	0.000E+00
Military Large (Landing)	0	1.7	1.2	9.3E-03	1.6E-06	4.257E-02	0.000E+00
Military Small (Takeoff)	5	-1.7	-1.2	0.0E+00	1.8E-06	2.947E-02	0.000E+00
Military Small (Landing)	5	1.7	1.2	4.7E-03	3.3E-06	3.807E-02	2.952E-09
	13070					**Total Aircraft Crash Frequency (per year)**	**1.443E-05**

Santa Fe County Airport

Numerical Results Obtained by MS Excel for Effective Areas and Impact Frequencies

Variable		(source)	General Aviation	Commercial Air Carrier	Commercial Air Taxi	Military Large (Takeoff)	Military Large (Landing)	Military Small (Takeoff)	Military Small (Landing)
WS (ft)	Wingspan	(Table B-16)	50	98	59	223	223	110	110
L (ft)	Facility length	(data input)	342.5	342.5	342.5	342.5	342.5	342.5	342.5
W (ft)	Facility width	(data input)	304	304	304	304	304	304	304
H (ft)	Facility height	(data input)	110.60	110.60	110.60	110.60	110.60	110.60	110.60
R (ft)	Diagonal of the facility	$R=(L^2+W^2)^{1/2}$	458.0	458.0	458.0	458.0	458.0	458.0	458.0
cot Φ	Cotangent of aircraft impact angle	(Table B-17)	8.2	10.2	10.2	7.4	9.7	8.4	10.4
S(ft)	Mean skid distance	(Table B-18)	60	1440	1440	780	368	246	447
A_f (mile²)	Effective fly-in area of the facility	A_f = [(WS+R)H•cot Φ+(2•L•W•WS)/R+L•W]•(1acre/27,878,400 mi²)	2.107E-02	2.783E-02	2.562E-02	2.736E-02	3.358E-02	2.446E-02	2.896E-02
A_s (mile²)	Effective skid area	A_s = (WS+R)•S •(1acre/27,878,400 mi2) [mi²]	1.093E-03	2.872E-02	2.670E-02	1.905E-02	8.989E-03	5.012E-03	9.107E-03
A_{eff} (mile²)	**Effective target area**	$A_{eff} = A_f + A_s$	**2.217E-02**	**5.655E-02**	**5.232E-02**	**4.642E-02**	**4.257E-02**	**2.947E-02**	**3.807E-02**

(Input data)

Airport Operation	**N_{ijk}: Number of Operations per year***	**X Direction (miles)**	**Y Direction (miles)**	**f_{ijk}(x,y)**	**P_{ijk}: Crash Rate**	**A_{eff}, Site specific Effective Target Area (mile²)**	**F: Impact Frequency (per year)**
	(data input)	(data input)	(data input)	(Tables B-2 to B-13 of STD-3014)	(Table B-1 of STD-3014)		
General Aviation Aircraft (Takeoff)	33600	-19.9	-1.7	0.0E+00	1.1E-05	2.217E-02	0.000E+00
General Aviation Aircraft (Landing)	33600	-19.9	-1.7	0.0E+00	2.0E-05	2.217E-02	0.000E+00
Commercial Aviation Air Taxi (Takeoff)	3000	-19.9	-1.7	0.0E+00	1.0E-06	5.232E-02	0.000E+00
Commercial Aviation Air Taxi (Landing)	3000	-19.9	-1.7	0.0E+00	2.3E-06	5.232E-02	0.000E+00
Military Large (Takeoff)	0	-19.9	-1.7	0.0E+00	5.7E-07	4.642E-02	0.000E+00
Military Large (Landing)	0	-19.9	-1.7	0.0E+00	1.6E-06	4.257E-02	0.000E+00
Military Small (Takeoff)	2750	-19.9	-1.7	0.0E+00	1.8E-06	2.947E-02	0.000E+00
Military Small (Landing)	2750	-19.9	-1.7	1.6E-04	3.3E-06	3.807E-02	5.528E-08
	78700			**Total Aircraft Crash Frequency (per year)**			**5.528E-08**

Ohkay Owingeh Airport

Numerical Results Obtained by MS Excel for Effective Areas and Impact Frequencies

Variable		(source)	General Aviation	Commercial Air Carrier	Commercial Air Taxi	Military Large (Takeoff)	Military Large (Landing)	Military Small (Takeoff)	Military Small (Landing)
WS (ft)	Wingspan	(Table B-16)	50	98	59	223	223	110	110
L (ft)	Facility length	(data input)	342.5	342.5	342.5	342.5	342.5	342.5	342.5
W (ft)	Facility width	(data input)	304	304	304	304	304	304	304
H (ft)	Facility heigh	(data input)	110.6	110.6	110.6	110.6	110.6	110.6	110.6
R (ft)	Diagonal of the facility	$R=(L^2+W^2)^{1/2}$	458.0	458.0	458.0	458.0	458.0	458.0	458.0
cot Φ	Cotangent of aircraft impact angle	(Table B-17)	8.2	10.2	10.2	7.4	9.7	8.4	10.4
S(ft)	Mean skid distance	(Table B-18)	60	1440	1440	780	368	246	447
A_f (mile²)	Effective fly-in area of the facility	$A_f = [(WS+R)H\cdot\cot\Phi+(2\cdot L\cdot W\cdot WS)/R+L\cdot W]\cdot$(1acre/27,878,400 mi²)	2.107E-02	2.783E-02	2.562E-02	2.736E-02	3.358E-02	2.446E-02	2.896E-02
A_s (mile²)	Effective skid area	$A_s = (WS+R)\cdot S\cdot$(1acre/27,878,400 mi2) [mi²]	1.093E-03	2.872E-02	2.670E-02	1.905E-02	8.989E-03	5.012E-03	9.107E-03
A_{eff} (mile²)	**Effective target area**	$A_{eff} = A_f + A_s$	**2.217E-02**	**5.655E-02**	**5.232E-02**	**4.642E-02**	**4.257E-02**	**2.947E-02**	**3.807E-02**

(Input data)

Airport Operation	N_{ijk}: Number of Operations per year*	X Direction (miles)	Y Direction (miles)	f_{ijk}(x,y)	P_{ijk}: Crash Rate	A_{eff}, Site specific Effective Target Area (mile²)	F: Impact Frequency (per year)
	(data input)	(data input)	(data input)	(Tables B-2 to B-13 of STD-3014)	(Table B-1 of STD-3014)		
General Aviation Aircraft (Takeoff)	500	5.9	-17.4	0.00E+00	1.10E-05	2.22E-02	0.00E+00
General Aviation Aircraft (Landing)	500	-5.9	17.4	0.00E+00	2.00E-05	2.22E-02	0.00E+00
Commercial Aviation Air Taxi (Takeoff)	0	5.9	-17.4	0.00E+00	1.00E-06	5.23E-02	0.00E+00
Commercial Aviation Air Taxi (Landing)	0	-5.9	17.4	0.00E+00	2.30E-06	5.23E-02	0.00E+00
Military Large (Takeoff)	0	5.9	-17.4	0.00E+00	5.70E-07	4.64E-02	0.00E+00
Military Large (Landing)	0	-5.9	17.4	0.00E+00	1.60E-06	4.26E-02	0.00E+00
Military Small (Takeoff)	0	5.9	-17.4	0.00E+00	1.80E-06	2.95E-02	0.00E+00
Military Small (Landing)	0	-5.8	17.4	2.40E-04	3.30E-06	3.81E-02	0.00E+00
	1000			**Total Aircraft Crash Frequency (per year)**			**0.000E+00**

Helicopter

Variable		(source)	*Helicopter*
WS (ft)	Wingspan	(Table B-16)	50
L (ft)	Facility length	(data input)	342.5
W (ft)	Facility width	(data input)	304
H (ft)	Facility heigh	(data input)	110.60
R (ft)	Diagonal of the facility	$R=(L^2+W^2)^{1/2}$	458.0
cot Φ	Cotangent of aircraft impact angle	(Table B-17)	0.58
S(ft)	Mean skid distance	(Table B-18)	60
A_f ($mile^2$)	Effective fly-in area of the facility	$A_f = [(WS+R)H \cdot \cot \Phi + (2 \cdot L \cdot W \cdot WS)/R + L \cdot W] \cdot (1acre/27,878,400\ mi^2)$	5.719E-03
A_s ($mile^2$)	Effective skid area	$A_s = (WS+R) \cdot S \cdot (1acre/27,878,400\ mi2)\ [mi^2]$	1.093E-03
A_{eff} ($mile^2$)	**Effective target area**	$A_{eff} = A_f + A_s$	**6.812E-03**

N_H: Expected number of local helicopter overflights per year	**P_H: Probability of a helicopter crash per flight (Table B-1)**	**L_H: Average length, in miles, of a helicopter flight**	**A_H: Effective area**	**F_H: Helicopter Impact Frequency**
100.00	2.50E-05	1.85	6.812E-03	1.841E-05

Non-airport Operations

Type of Aircraft		NPf(x,y) for Los Alamos National Laboratory	Effective Area: A_{eff} ($mile^2$)	Non-Airport Crash Frequency (per year)
General Aviation Aircraft	Table B-14	2.E-04	2.217E-02	4.434E-06
Commercial Aviation Air Carrier	Table B-15	2.E-07	5.655E-02	1.131E-08
Commercial Aviation Air Taxi	Table B-15	3.E-06	5.232E-02	1.570E-07
Military Aviation Large Aircraft	Table B-15	1.E-07	4.642E-02	4.642E-09
Military Aviation Small Aircraft	Table B-15	5.E-06	3.807E-02	1.903E-07
Total non-airport crash frequency (per year)				**4.797E-06**

Type of operation	Estimated annual aircraft crash		
	LAM	SAF	E14
General Aviation	1.44E-05	0.00E+00	0.00E+00
Commerical	0.00E+00	0.00E+00	0.00E+00
Military	2.95E-09	5.53E-08	0.00E+00
Total for individual airport	1.44E-05	5.53E-08	0.00E+00
Total for all local airport operations			1.448E-05
Nonairport operations			4.797E-06
Helicopter			1.841E-05
Total esimated annual aircraft crash			3.769E-05