SOLVING PROBLEMS OF GLOBAL IMPORTANCE

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Runway Protection Zones Risk Assessment Tool and Methodology

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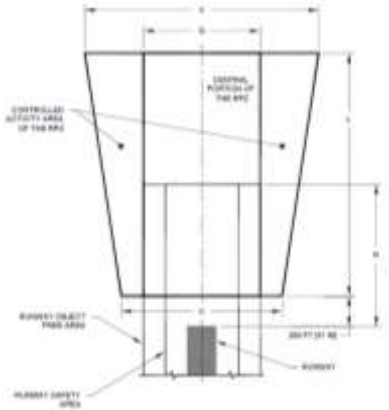
March 21-23, 2016

NATIONAL SECURITY | ENERGY & ENVIRONMENT | INFRASTRUCTURE | HEALTH SOLUTIONS

Runway Protection Zone: Background and FAA Policy

Runway Protection Zone Standards

- Enhance the protection of people and property on the ground
- RPZ dimensions depend on aircraft approach category and runway visibility minimums
- Approach RPZs are larger than departure RPZs when the visibility minimums are less than 1 mile; otherwise they are equal in size (1,000 to 2,500 feet long)
- Where practical, airport owners should own the property under the runway approach and departure areas to the limits of the RPZ
- Desirable to clear the entire RPZ of all above-ground objects
- As a minimum, should maintain the RPZ clear of all facilities supporting incompatible activities



FAA Guidance on RPZ Land Use

- FAA issued interim policy guidance on Land Uses within RPZs in 2012 to address incompatible land uses within RPZs
- RPZ analysis is required if a change is being made to land uses as a result of:
  - ✓ An airfield project (e.g. runway extension, runway shift)
  - ✓ A change in the critical aircraft that increases the RPZ dimensions
  - ✓ A new or revised instrument approach procedure that increases the RPZ dimensions
  - ✓ A local development proposal in the RPZ (either new or reconfigured)
- Compatible land uses:
  - ✓ Farming that meets airport design standards
  - ✓ Irrigation channels that meet the requirements of "Wildlife Hazard Management"
  - ✓ Airport service roads, as long as not public roads and are directly controlled by the airport
  - ✓ Underground facilities, as long as they meet other design criteria, such as RSA requirements
  - ✓ Unstaffed NAVAIDs and facilities, such as equipment for airport facilities that are considered fixed-by-function in regard to the RPZ

FAA Guidance on RPZ Land Use

Incompatible Land Uses:

- Transportation facilities Examples include, but are not limited to:
  - ✓ Rail facilities - light or heavy, passenger or freight
  - ✓ Public roads/highways
  - ✓ Vehicular parking facilities
- Above-ground utility infrastructure (i.e. electrical substations), including any type of solar panel installations
- Hazardous material storage (above and below ground)
- Wastewater treatment facilities
- Fuel storage facilities (above and below ground)
- Buildings and structures (Examples include, but are not limited to: residences, schools, churches, hospitals or other medical care facilities, commercial/industrial buildings, etc.)
- Recreational land use (Examples include, but are not limited to: golf courses, sports fields, amusement parks, other places of public assembly, etc.)

FAA Guidance on RPZ Land Use

Analysis-

- Develop a full range of alternatives
- Field staff consult with the National Airport Planning and Environmental Division

Criteria and Documentation

- Avoid or minimize RPZ land use issues
- Mitigate risk to people and property on the ground within the RPZ
- Feasibility in terms of cost, constructability and other factors
- Central Portion and Controlled Activity Area
- Percentage of RPZ affected
- Distance from runway end/landing threshold
- Land ownership and control
- Other factors

RPZ Guidance and Airport Safety Management

Two Different Goals

- Safety of people and property and the ground
- Aviation safety

Mitigation Measures

- Relocate runway ☆
- Shorten runway ☆
- Declared distances ☆
- Relocate and/or protect incompatible use
- Operational measures ☆

Safety Management means consider all hazards and risks associated with proposed system changes

Develop a Strong Safety Case!

☆ = Potential aviation safety changes

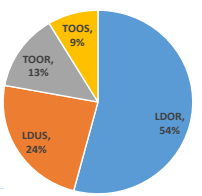
RPZ Risk Assessment Modeling Framework (ACRP 04-18, ongoing)

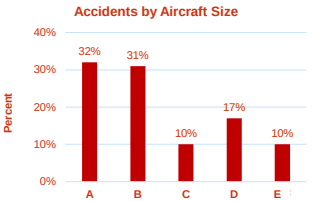
Types of Events (Accidents & Incidents):

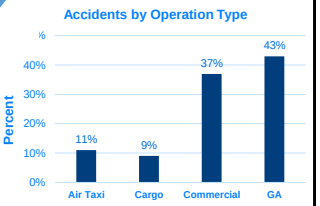
- Landing Overrun (LDOR)
- Takeoff Overrun (TOOR)
- Takeoff Overshoot (TOOS)
- Landing Undershoot (LDUS)

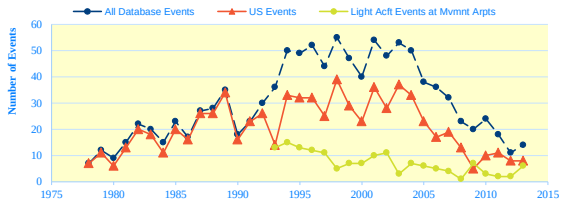
Source: NLR (Netherlands Aerospace Center)

Accident Database Makeup: 1,000+ events



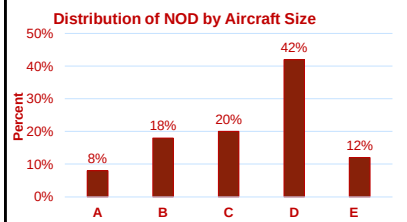


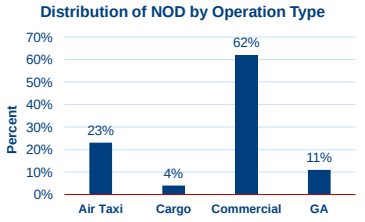


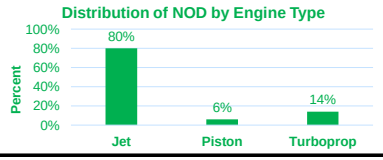


Normal Operations Database Makeup

- 263,000 movements from a sample of 78 airports of all sizes
- GA airports were included in the sample as well as light and piston engine aircraft types

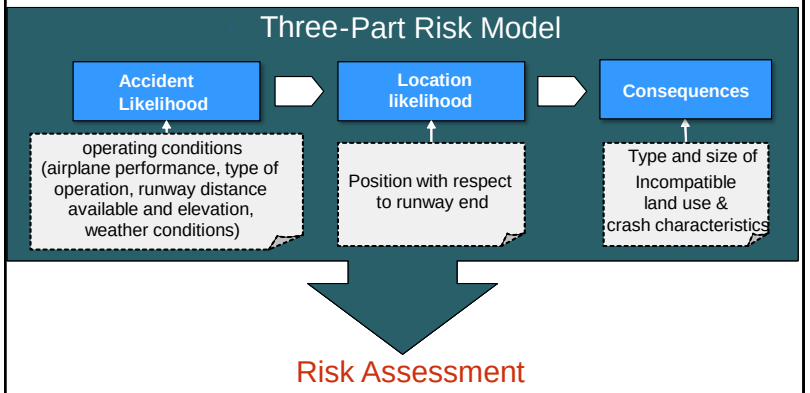






Risk Modeling Framework

Risk : Likelihood of fatality of people on the ground



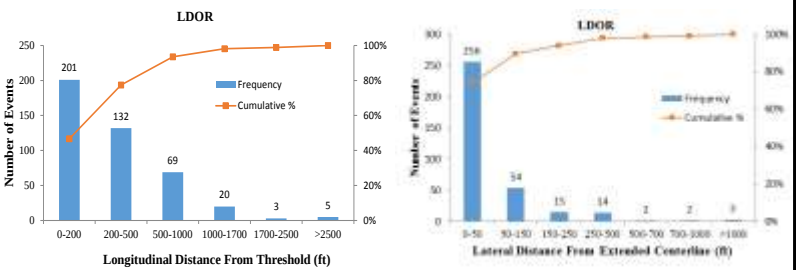
First Part: Accident Likelihood model

- Aircraft mix over one representative year
- Runways declared distances (LDA, TORA)
- Airport weather condition during the year
- Type of operation (commercial, cargo, GA, air taxi)
- Domestic or International

$$f_{excursion} = \frac{1}{1+e^{b_0+b_1X_1+b_2X_2+b_3X_3+\ldots}}$$

X_i: independent variables (e.g. aircraft size, engine type, weather elements, etc.)
b_i: regression coefficients

Second Part: Location models

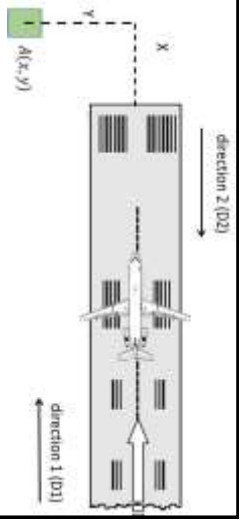


$$L(x_1, y_1) = g(x = x_1) \times h(y = y_1 | x = x_1)$$

RPZ Crash Likelihood

- Likelihood of a crash inside RPZ
- Combines likelihood models and location models
- Combines all types of accidents inside RPZ

$$Crash\ Likelihood_A = (TO_1 \times f_1^{TOOR} \times L_A^{TOOR}) + (TO_1 \times f_1^{TOOS} \times L_A^{TOOS}) + (LD_1 \times f_1^{LDOR} \times L_A^{LDOR}) + (LD_2 \times f_2^{LDUS} \times L_A^{LDUS})$$



Third Part: Consequence model

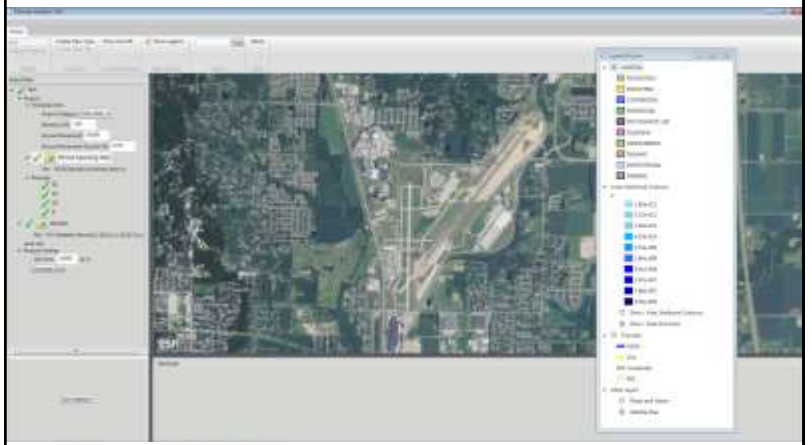
- **Population density of land use (PD)**
  - Depends on the type of the land use
- **Size of consequence area (A)**
  - Depends on crash characteristics
- **Mortality rate (M_r)**
  - Depends on crash characteristics

Consequences ≈ (PD) × (A) × (M_r)

RPZ Risk Assessment Tool (RPZ_RAT)

(ACRP 04-18, ongoing)

Overview of RPZ_RAT



Sample Movement Input File

HOD_ID	DATE&TIME	RUNWAY_DESIGNATION	BOUND	FLIGHT_NO	FAA_Code	FLIGHT_Category	FLIGHT_Type
1	2013-08-01 0:00:33	15R	A	AAL1554	B738	COM	D
2	2013-08-01 0:04:28	15R	A	SWA2354	B737	COM	D
3	2013-08-01 0:07:11	15R	A	ATN510	B752	CAR	D
4	2013-08-01 0:09:09	15R	A	SWA2699	B737	COM	D
5	2013-08-01 0:11:53	15R	A	UAL1575	B739	COM	D
6	2013-08-01 0:14:49	15R	A	AAL406	B738	COM	D
7	2013-08-01 0:17:06	15R	A	TRS1092	B737	COM	D
8	2013-08-01 0:19:48	15R	A	SWA611	B737	COM	D
9	2013-08-01 0:35:29	15R	A	SWA1641	B737	COM	D
10	2013-08-01 1:11:05	15R	A	SWA3509	B737	COM	D
11	2013-08-01 1:50:24	15R	A	UAL1608	B738	COM	D
12	2013-08-01 1:58:35	15R	A	N310ME	LJ35	GA	D
13	2013-08-01 2:01:10	15L	A	LBQ792	PC12	CAR	D
14	2013-08-01 2:12:32	15R	D	ATN510	B752	CAR	I
15	2013-08-01 2:21:35	15L	D	LBQ792	PC12	CAR	D
16	2013-08-01 2:27:46	15L	D	N310ME	LJ35	GA	D
17	2013-08-01 3:43:09	15L	A	RAX81	BE10	AIR	D
18	2013-08-01 4:02:03	15L	D	RAX81	BE10	AIR	D
19	2013-08-01 4:26:07	15L	A	MTN8308	C208	AIR	D
20	2013-08-01 5:08:15	15L	A	MTN8305	C208	AIR	D
21	2013-08-01 5:23:41	15R	A	UPS1216	B752	CAR	D
22	2013-08-01 5:25:01	15R	D	AWE1851	A319	COM	D
23	2013-08-01 5:36:50	15R	A	UPS1214	B763	CAR	D
24	2013-08-01 5:55:05	10	A	FDX1730	A306	CAR	D
25	2013-08-01 5:56:01	15R	D	UAL1411	B739	COM	D
26	2013-08-01 6:00:52	15R	D	EGF2986	E145	COM	D
27	2013-08-01 6:07:00	10	A	FDX1482	A306	CAR	D
28	2013-08-01 6:10:52	15R	D	UAL1059	B738	COM	D
29	2013-08-01 6:12:44	15R	D	JIA4601	CRJ2	AIR	D
30	2013-08-01 6:14:57	15L	D	JZA7927	DH8A	COM	I

Sample Weather Input File

Date&Time	Visibility _SM	Wind Direction_deg	Wind Speed_knots	Air Temp_F	Ceiling_ft	Thunder storms	Rain	Rain Showers	Freezing Rain	Freezing Drizzle	Snow	Snow Pellets	Ice Crystals	Snow Showers	Ice Pellets	Ice Pellet Show	Fog	Gusts	Night
8/1/2013 0:00	8	0	0	71	10000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
8/1/2013 1:00	10	210	5	71	6500	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
8/1/2013 2:00	10	190	4	72	1200	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
8/1/2013 3:00	7	190	3	68	5000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
8/1/2013 4:00	4	170	3	68	3300	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
8/1/2013 5:00	8	120	4	68	2700	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
8/1/2013 6:00	2	110	4	68	4000	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
8/1/2013 7:00	2	0	0	68	600	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8/1/2013 8:00	2.5	0	0	70	1100	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8/1/2013 9:00	4	230	5	72	800	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
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8/1/2013 11:00	4	230	5	72	800	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
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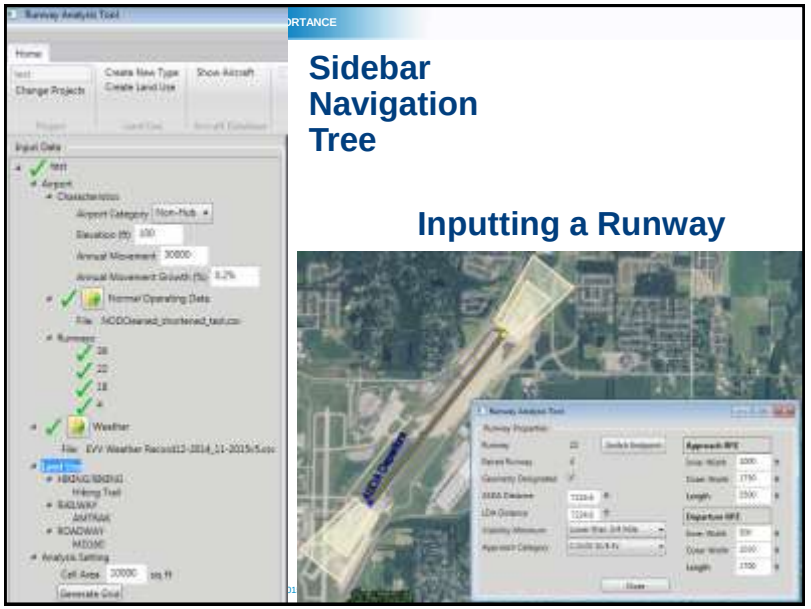
8/1/2013 13:00	8	210	3	73	900	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8/1/2013 14:00	10	160	5	77	5000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8/1/2013 15:00	10	160	4	78	6000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8/1/2013 16:00	10	200	4	80	10000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8/1/2013 17:00	10	210	5	79	10000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8/1/2013 18:00	10	210	3	78	10000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8/1/2013 19:00	10	0	0	77	10000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8/1/2013 20:00	10	0	0	75	10000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
8/1/2013 21:00	10	0	0	74	10000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
8/1/2013 22:00	10	100	3	74	7000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
8/1/2013 23:00	10	0	0	73	10000	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE



ORTANCE

Sidebar Navigation Tree

Inputting a Runway

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Inputting A Land Use

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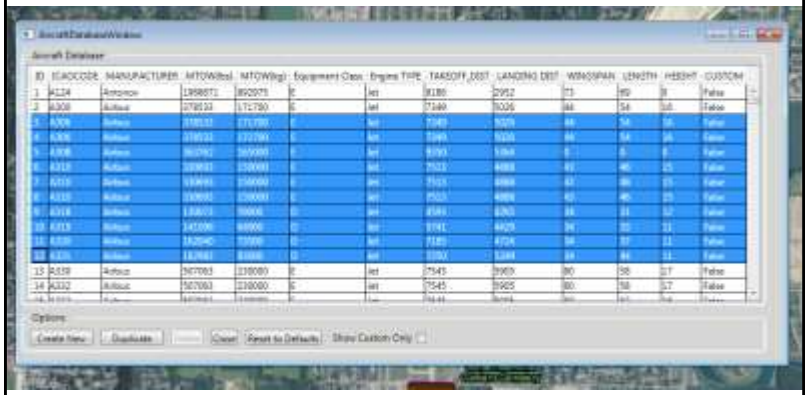
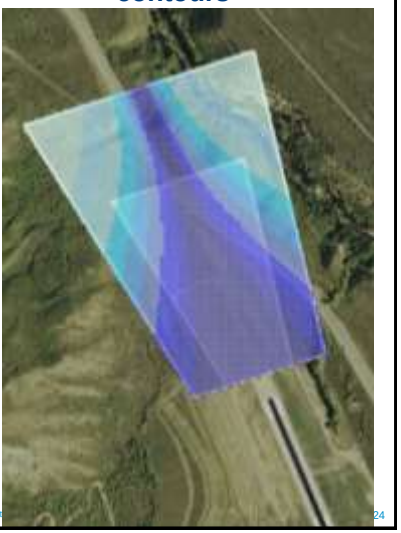
Embedded Aircraft Types Database



Generating grid cells

Crash likelihood contours



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RPZ_RAT Excel Output File

Expected excursions in every 10 million movements (frequency model).

RPZ	LDOR	LDUS	TOOR	TOOS
15	0.55	2.69	0.77	0.37
33	0.84	1.20	0.88	0.44
10	0.46	0.38	0.07	0.01
28	1.03	0.19	0.08	0.03

Likelihood of an excursion within the boundary of RPZ (location model).

RPZ	LDOR	LDUS	TOOR	TOOS
15	0.51	0.43	0.71	0.24
33	0.52	0.44	0.71	0.24
10	0.96	0.46	0.94	0.31
28	0.94	0.46	0.93	0.30

RPZ crash likelihood (frequency, location models, # of movements and accident

RPZ	Annual RPZ Crash Likelihood	Avrg Years btwn accidents	Crash Likelihood Rank
15	9.47E-04	246	4
33	9.81E-04	243	3
10	1.95E-03	182	2
28	4.12E-03	124	1

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RPZ Risk (crash likelihood and consequence models combined).

RPZ	Annual RPZ Risk	Avrg Years btwn fatal accidents	Risk Rank
15	1.10E-04	454	2
33	1.24E-08	1367	4
10	1.70E-04	411	1
28	4.29E-05	548	3

Land Use Risk

Land Uses	RPZ(s)	Population	Area(sf)	Annual Risk	Risk Rank
Aviation Blvd	10	22	98,763	1.19E-04	1
Hiking Trail	10	2	18,626	1.79E-05	5
Railway	10	6	56,155	3.30E-05	4
US170	15	16	160,617	1.10E-04	2
US162	28 & 33	16	178,244	4.28E-05	3
Parking	28	2	134,150	6.79E-07	6

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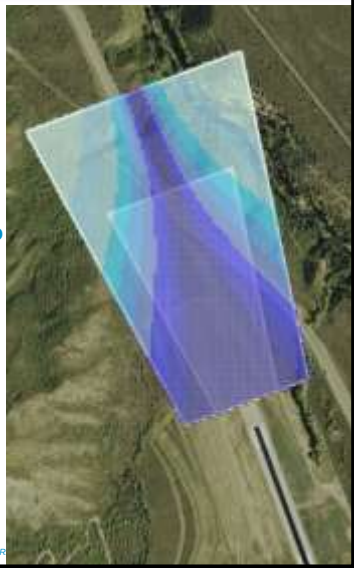
Implementation Exercise

Q: Assume tunneling the road passing through the RPZ is the only viable option to mitigate risk, and available funding allows tunneling only a portion of the road. How can you use the tool to decide where the road should be tunneled?

A: Start with areas of the road colored With the darkest shade. Expand to lighter shades as budget allows.



Implementation Exercise

Q: To optimally mitigate airport risk, which land use should be treated first?

Land Uses	RPZ	Population	Area(sf)	Annual Risk	Risk Rank
Training Facility	22	200	162,022	1.0E-06	1
State Route 57	18	2	33,940	9.5E-07	2
Parking Area	4	6	11,505	1.2E-07	3

A: It depends! If you have all the money you need, mitigate all. Otherwise, for a limited budget, plan a mitigation strategy that results in the least overall risk for the airport.

Implementation Exercise

Q: Relocation of the landing threshold to clear the RPZ from an incompatible land use is often viewed as a solution. Does it always reduce airport risk?

A: It always reduces the risk of the RPZ of the landing runway. However, it may have adverse effects on the RPZ of the paired runway end.

L&B and ARA Hershey Presentation, 2015.

Questions?