CEE 4674 Airport Planning and Design

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Sample Integrated Noise Model Case Study

Noise Model Analysis Data Needs

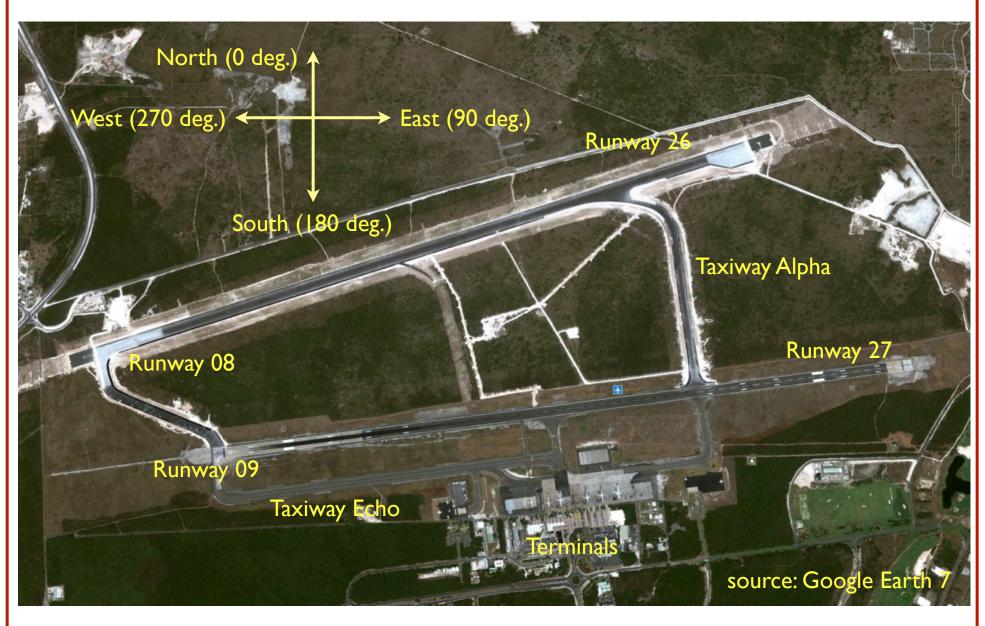
ltem	Source	Remarks
Airport characteristics (runway information, runway grades, orientation)	Airport authority	Airport CAD files in DXF
Wind Rose and weather data	Airport authority	Wind measurements used in the airport master plan to derive runway use
Air traffic data	Air traffic service provider	Aircraft operations by individual aircraft types by runway use.
Air traffic procedures	Air traffic service provider	Arrival and departure procedures. Standard terminal arrival and departure procedures. Any special procedures (i.e., noise abatement, etc.). Information on how flight
Terrain data	Airport authority	Needed if noise masking effects are expected to play a role in the analysis.

Integrated Noise Model Analysis Data Needs (continuation)

ltem	Source	Remarks
Airline data	Airlines	Load factor and aircraft stage length data to model runway landing and takeoff roll operations in the INM model
Radar track data	Air traffic service provider	Data is needed to draw realistic departure and arrival patterns to the airport
Takeoff roll distributions	Modeling team	Data will be collected to verify takeoff and landing roll distributions
Runup operations	Airlines/Airport authority	Expected number of runup operations (engine testing operations)
Noise data at points of interest for calibration	Modeling team	Geo-refenced data of sensitive sites used for model calibration

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The Punta Cana Airport (PUJ)

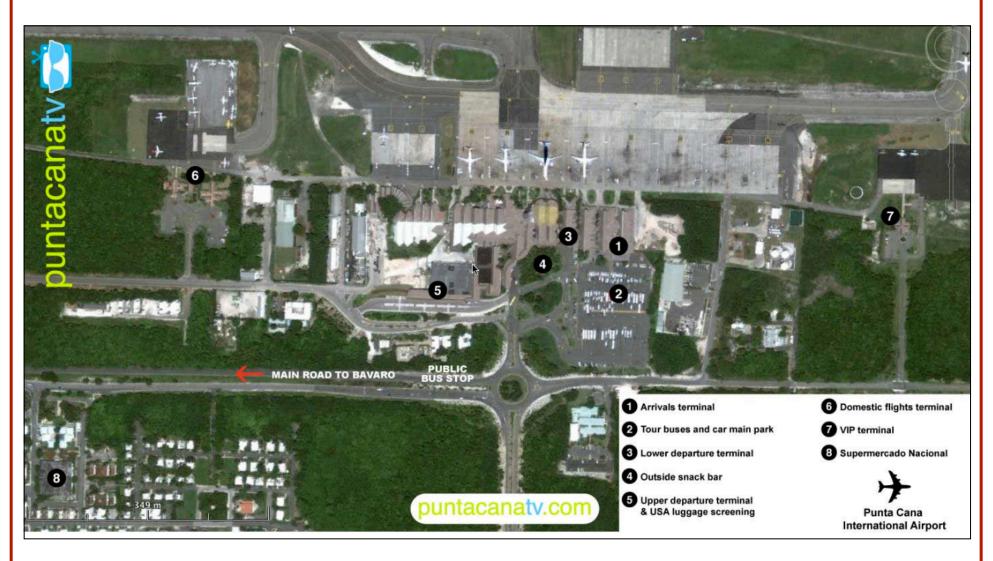


Some Facts

- Runway 08-26 is the primary runway
- Runway 09-27 is seldom used (departure operations overfly populated areas to the SouthEast)
- 98% of the time runway 08 is used for landings and departures (wind prevails from the Ocean or from the East)



Punta Cana Landside Terminals

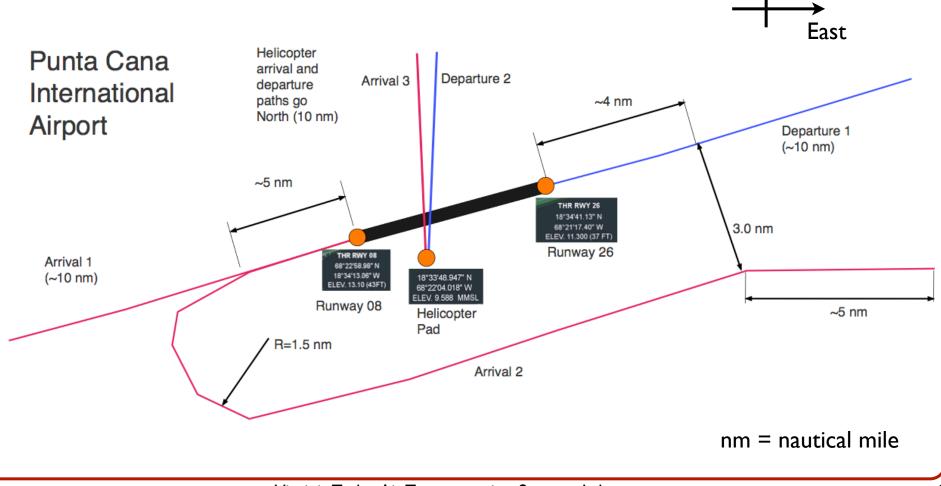


http://puntacanatv.com/wp-content/uploads/2011/03/punta-cana-airport-map.jpg

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Flight Paths In and Out of the Airport

 98% of the operations occur from the West (landings on Runway 08)



Night and Day Time Commercial Operations at PUJ

Тур	pical Day Operation	ns for Manual Calcul	ations				
Aircraft	Daily Operations	Night Operations	Day Operations	Night Takeoffs	Night Landings	Day Takeoffs	Day Landings
Boeing 737-800	25.30	1.00	24.00	0	1	12	12
Boeing 737-200	0.90	0.00	1.00	0	0	1	0
Boeing 757-200	5.16	1.00	4.00	1	0	2	2
Boeing 767-300	6.49	1.00	5.00	1	0	2	3
Boeing 747-400	2.49	0.00	2.00	0	0	1	1
Boeing 777-200	1.49	0.00	1.00	0	0	0	1
Airbus A310	2.64	1.00	2.00	0	1	1	1
Airbus A320	18.81	1.00	18.00	0	1	9	9
Airbus A330	8.83	1.00	8.00	1	0	4	4
ATR72	5.62	0.00	6.00	0	0	3	3
MD-80	3.28	1.00	3.00	1	0	2	1
EMB-190	2.31	0.00	2.00	0	0	1	1
DC9-30	0.68	0.00	1.00	0	0	0	1
Operations	84.00	7.00	77.00	4.00	3.00	38.00	39.00

• 38 daily takeoffs, and 39 daily landings

• 4 night takeoffs and 3 night landings

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General Aviation Night and Day Operations at Punta Cana

Typical Day	Operations for Manu	al Calculations					
Aircraft	Daily Operations	Night Operations	Day Operations	Night Takeoffs	Night Landings	Day Takeoffs	Day Landings
Cessna C172	3.00	0.00	3.00	0	0	1	2
Cessna Citation II Bravo	6.00	1.00	5.00	0	1	2	3
Gulfstream IV	3.00	1.00	2.00	1	0	1	1
Falcon 20	2.00	1.00	1.00	0	1	1	0
BAE Jetstream 31	10.00	1.00	9.00	1	0	5	4
Operations	24.00	4.00	20.00	2.00	2.00	10.00	10.00

- Total of 24 daily operations
 - 20 daytime and 4 night time
 - 10 daytime takeoffs and 10 daytime landings
 - 2 nighttime takeoffs and 2 nighttime landings

11

Step-by-Step Computer Noise Analysis Using Integrated Noise Model

Create the Punta Cana Scenario

- INM uses a folder/scenario database approach
- Create a new scenario and called it Punta Cana

10 INM 7.0b	
File Window Help	
	Citize discloses (TT 1 TO
Taller Invest- Little Pille Boytelling	
	New Study
	Path
	a \puntacana
	New Study Name (30 characters or less) Existing Study Punta Cana Noise Study
	Directories
	📂 PuntaCana
	Drives OK
	a:Edu 🔹
Snapz Pro X	Cancel

Punta Cana Scenario Setup

- INM uses a folder/scenario approach
- INM uses a database approach to store information you supply

Study			23
ath	10025(11100		
Npuntacana aisting Study ┌┌ rectories	New Study Name (30 characte Punta Cana Noise Study	rs or less)	
the second second second second second			*
i∂ a:∖ MartaCana			*
		OK	*

)reated	06Jun-120	1:53	
Description Punta Cana International Airport				1
Origin of Coordinates				
Latitude (deg) 18.400833		A	irport PUJ	
Longitude (deg) .68.363333			View Airports	1
Elevation (ft) 40.0		_	The Palpons	1
	0K	1		

Airport reference point coordinates

INM Database Issue

- As you enter data into the INM model, the data is saved to a database
- Make sure you commit the record changes every time you make a change

1 <mark>4</mark> 10	NM 7.0 - [Study C:V	PROGRAM FILESVIN	M7.0\EXAMPLES\TEST50\simpleDCAStudy]	
File	Edit View Setup Tra	acks AcftType Civil	Operations Run Output Window Help	
D	Commit Record Ctrl+ Revert Record Ctrl+			
	Add Record Ctrl+ Delete Records Ctrl+	+A		
	Cut Records Ctrl- Copy Records Ctrl- Paste Records Ctrl-	+C	Case ID (40 characters or less) Created MD80Departure_Contours 23-Apr-08 22	2:48
			Description Simulates departure contours for an MD80	
			Airport Parameters Temperature (F) 57.9 Pressure (in-Hg) 29.92	
			Modify NPD Curves	
			Headwind (kt) 8.0	

INM Database Issue (2)

- As you enter data into the INM model, the data is saved to a database
- To enter records to the INM database, you need to add a record

100014	
	INM 7.0 - [Study C:\PROGRAM FILES\INM7.0\EXAMPLES\TEST50\SIMPLEDCASTUDY\simpleDCAStudy2Aircraft
	File Edit View Setup Tracks AcftType Civil operations Run Output Window Help
	Output Setup
	Output ID 40 characters or less)
	Metric CEXP -
Empty window	Contour Levels
	Min Max Inc
N I I	
Needs a new	Output Type OneScenario
record	Scenario Comparison scenario 👻
	Scenario 2 Comparison scenario
	Scenario 3 -NONE-
	Scenario 4 -NONE-
	Scenario 5 NONE-

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Punta Cana Scenario Runway Setup

Here we define the runway at the airport to be modeled

Digie		ks AcftType Civil Ope	auora nun ouq	-Qit
	-	(1994) N		
	Runway and H	elipad Identifiers		
	26 -08	Airport	PW	
			C Helpad	
		Runway End #1	26	
			08	
		Runway End #2	100	- 1

Airport runway and helipad identifiers

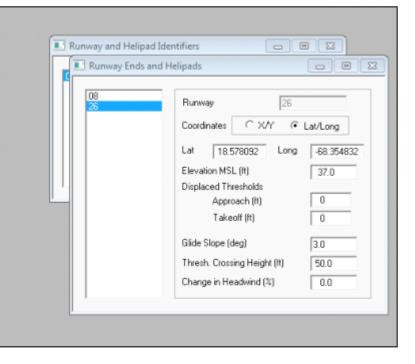
For US airport studies, this step is not needed because INM has 1500 airports in its database

Punta Cana Scenario Runway End Points Definition

 Here we define the runway lat/longitude points for the Punta Cana runway 08-26

Runway End	s and Helipads	<u> </u> Σ
08 26	Runway 08	
	Coordinates C X/Y @	Lat/Long
	Lat 18.570294 Long	-68.383050
	Elevation MSL (ft)	37.0
	Displaced Thresholds	
	Approach (ft)	0
	Takeoff (ft)	0
	Glide Slope (deg)	3.0
	Thresh. Crossing Height (ft)	50.0
	Change in Headwind (%)	0.0

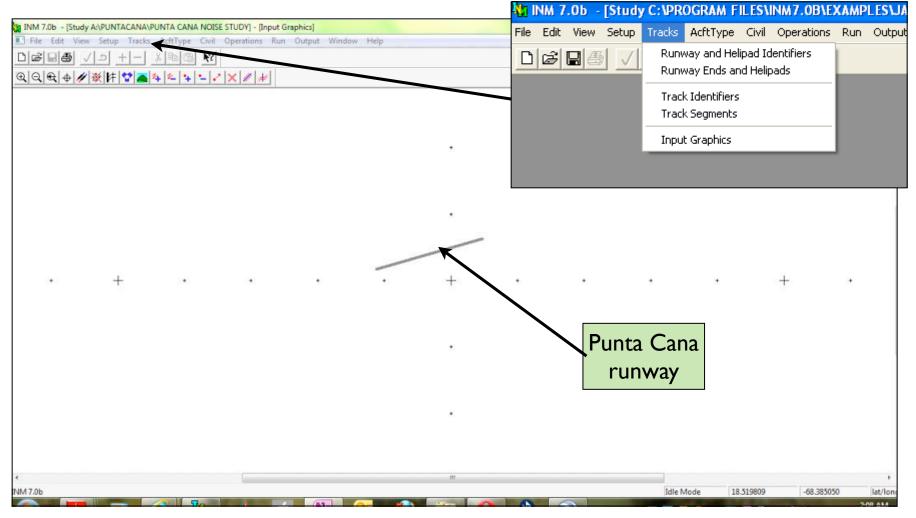
Runway 08



Runway 26

View the Runway Defined in Input Graphics

 You can see the runway defined under the "Tracks" pull down menu and Input Graphics



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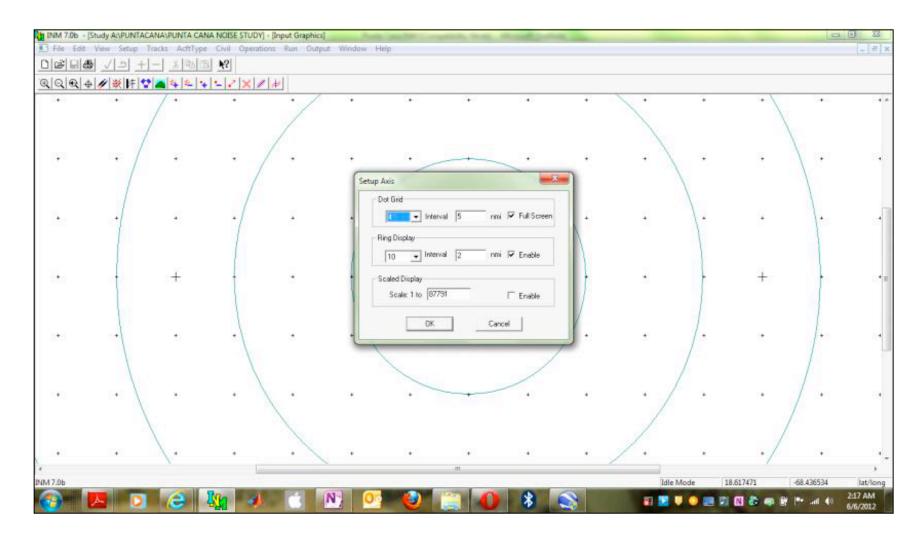
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Axis Setting for Improved View

 Define a grid to view your scenario under "View" pulldown menu and Axis

Zoom In	<u>N</u>		Setup Axis	
EX 4 Zoom Out Previous Zoom Zoom Home Center Tracks Census CAD Locations Ternain Geo Units Anis Fores	. <mark> </mark>		Dot Grid 4 Interval 5 nm Ring Display	i
Lat/Long Calculator. Thrust Calculator.		· + ·	+ OK Car	

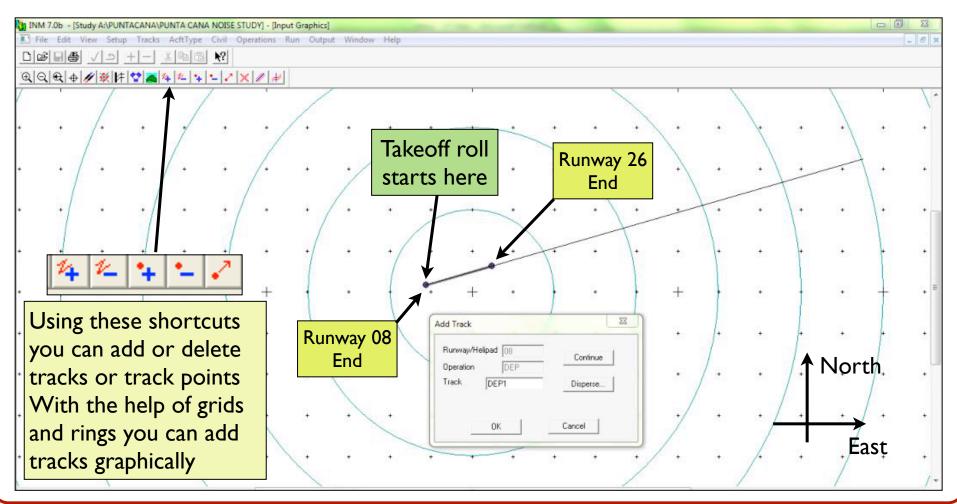
View of Airport with Concentric Rings (Helps Construction)



Add Tracks to the Punta Cana Runway

Track points are always created in the order that the aircraft flies along the track Adding departure I track

The first point in a departure track should be the runway end where aircraft starts its takeoff roll (RWY 08 in this case) and second point should be the opposite end (RWY 26 in this case)



Input Graphics Functions

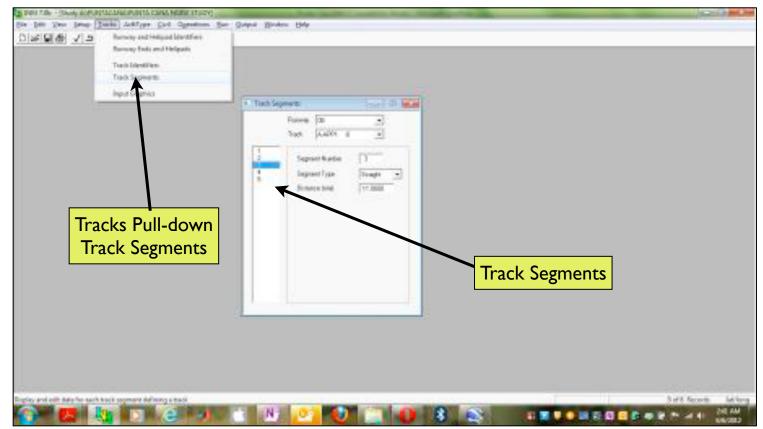
• Zoom in, Zoom out, terrain, adding tracks, deleting tracks are some of the options available

L <mark>it</mark> ij II	NM 7.	.0 - [Study	C:\PRO	GRAM FIL	ES\IN	M7.0	EXAN	MPLE	S\TEST5	io\simpl	.ED
File	Edit	View	Setup	Tracks	AcftType	Civil	Opera	tions	Run	Output	Window	H
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Input Graphics												
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Adding More Complex Tracks to the Punta Cana Runway

For more complex tracks like arrival 2 in PUJ, tracks can be added by giving vectors as input. Vectors are defined by segment type (straight or turn) and distance or radius (nm)

NOTE: vector tracks **cannot be dispersed**. This is a weakness about the vector tracks.



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INM Types of Tracks

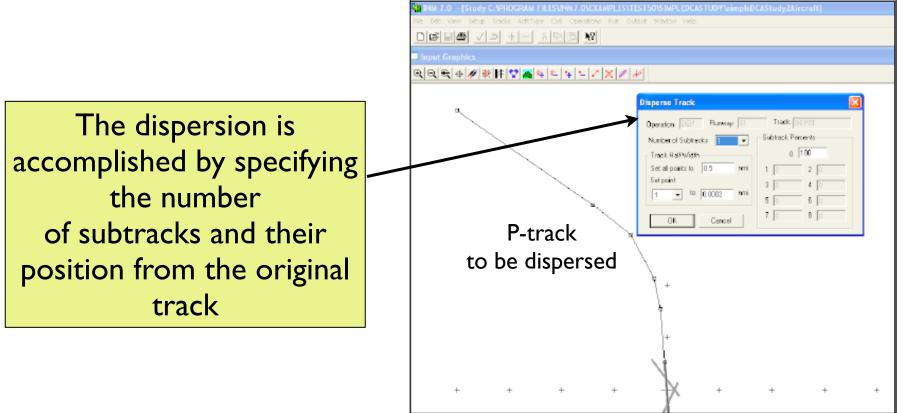
- P-tracks (point tracks) = created interactively using the Input Graphics function
- V-tracks (vector tracks) = created by defining line segments and circular arcs

- V-tracks cannot be dispersed
- P-tracks can be dispersed

 V-tracks are more realistic in terms of aircraft turning performance

A Note on Track Dispersion

- Dispersion of a track is to more realistically simulate random profiles flown
- Go to Edit pull-down menu and select "Disperse Track"



After Tracks Dispersion

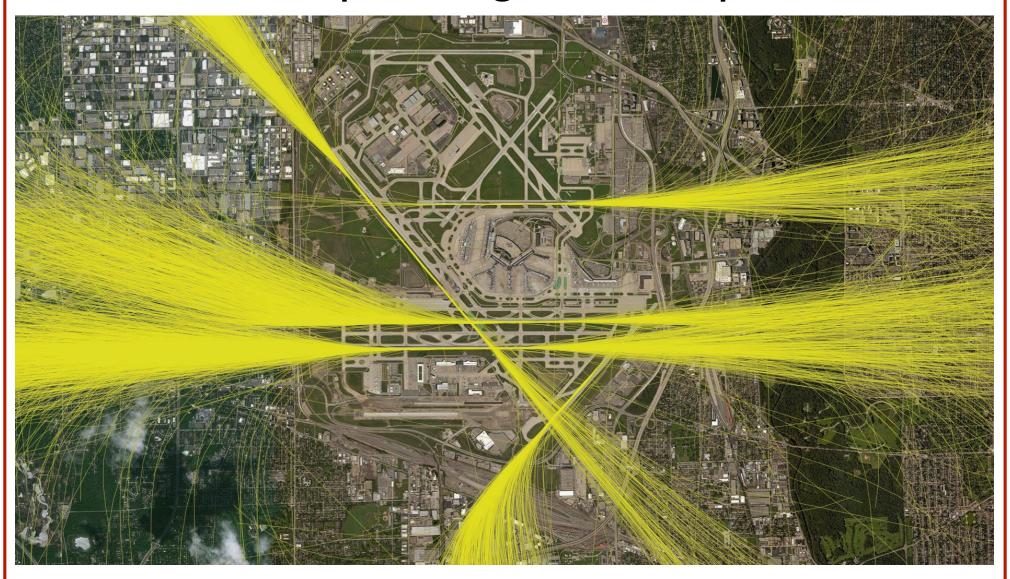
- After track dispersion, the track is divided into n segments
- Each subtrack gets a percentage of the traffic loaded on the original track

INM 7.0 - [Study C:\PROGRAM FILES\NW7.0\EXAMPLES\TEST50\SIMPLEDCASTUDY\wimpleDCAStudy2Aircreft]	Input Graphics
File Edit Wew Setup Tracks AcRType Civil Operations Run Output Window Help	
DGEA VƏ TI VAR M	
Input Graphics	a, l
RQ€₽∅₩₩₽₩₽₽₽₽₩	
Cycreation DEP Purewap II Track DEPCT Number of Subtrack Percents Track HalfWidth Set all paints to 0.5 mmi Set paint 1 1 1 10 10 0002 mmi 5 10 5 10 5 10 10 10 10 10 10 10 10 10 10 10 10 10	+ Dispersed
Original P-track	Dispersed P-track

Track Dispersion Notes (1)

- Tracks dispersion depends on many factors:
 - Departure and arrival procedures (straight-in and straight-out paths or turning paths)
 - Fleet mix
 - Navigation accuracy of aircraft
 - Noise abatement procedures
- Generally, departures have more dispersion than arrivals

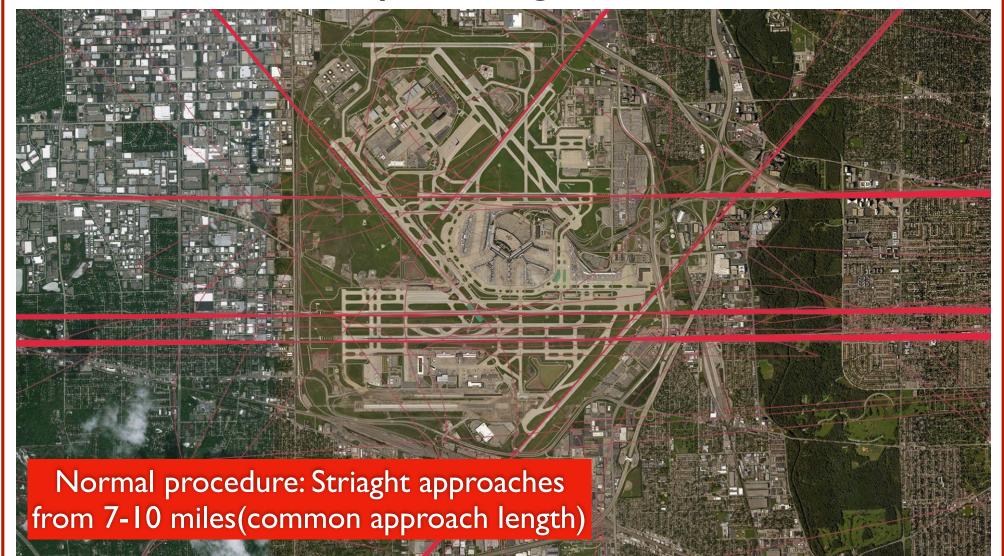
Example of Flight Track Dispersion



source of data: Chicago Department of Aviation

Airport Planning and Design (Antonio A.Trani)

Example of Flight Track Dispersion ORD Airport Nighttime Arrivals

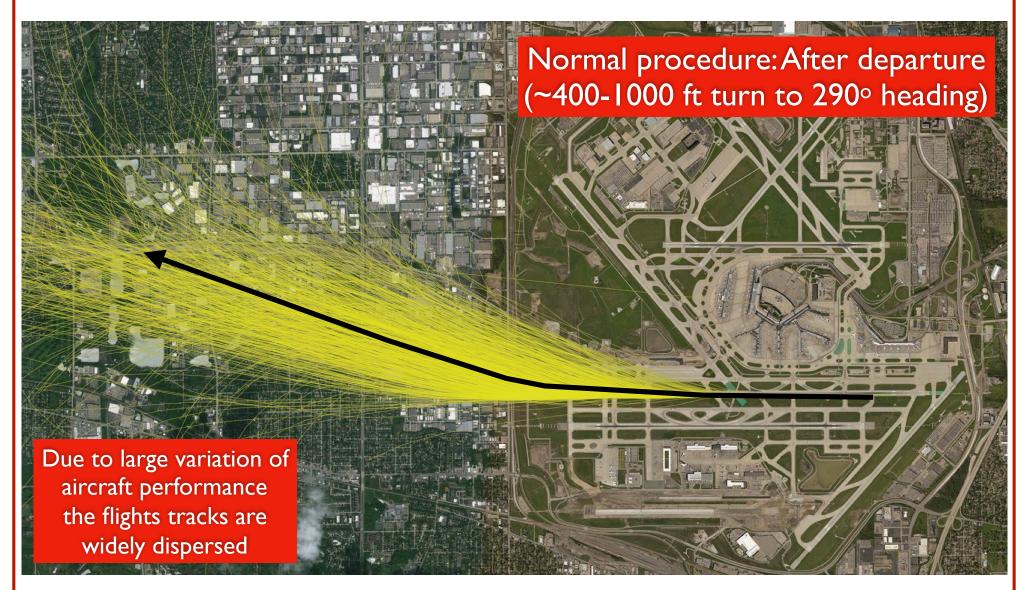


source of data: Chicago Department of Aviation

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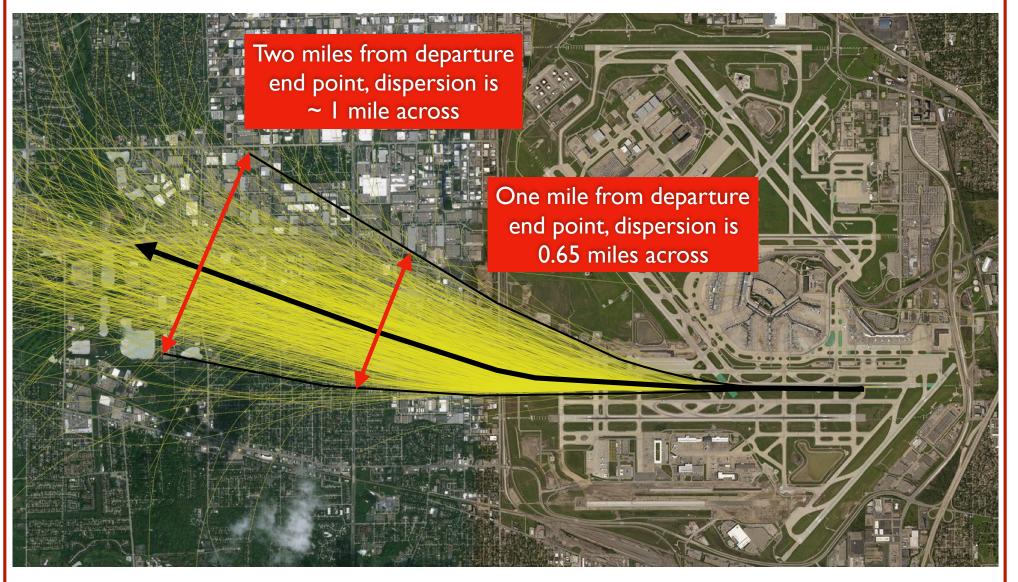
Example of Flight Track Dispersion ORD Airport Nighttime Departures: Runway 28R



source of data: Chicago Department of Aviation

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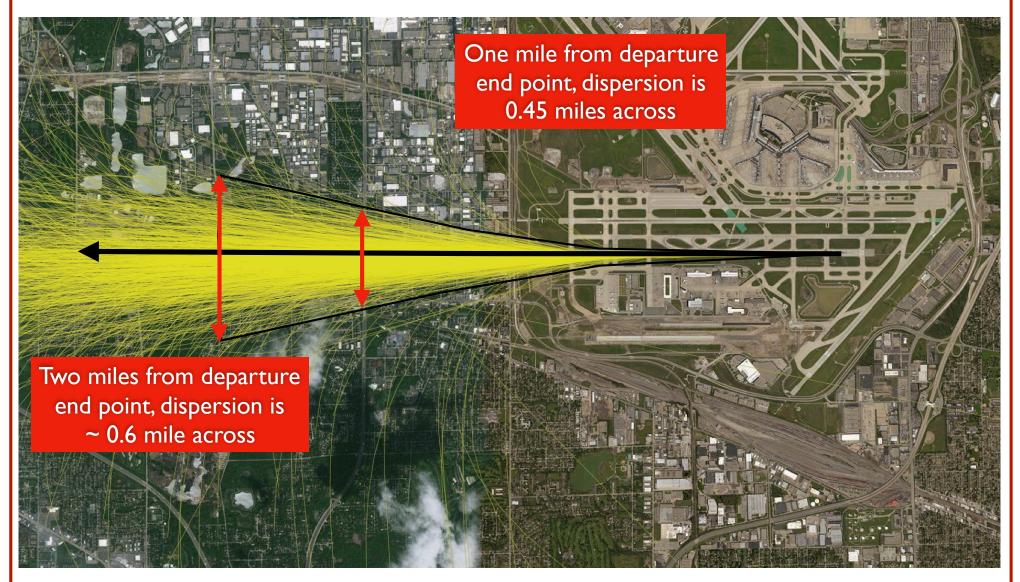
Example of Flight Track Dispersion ORD Airport Nighttime Departures: Runway 28R



source of data: Chicago Department of Aviation

Airport Planning and Design (Antonio A.Trani)

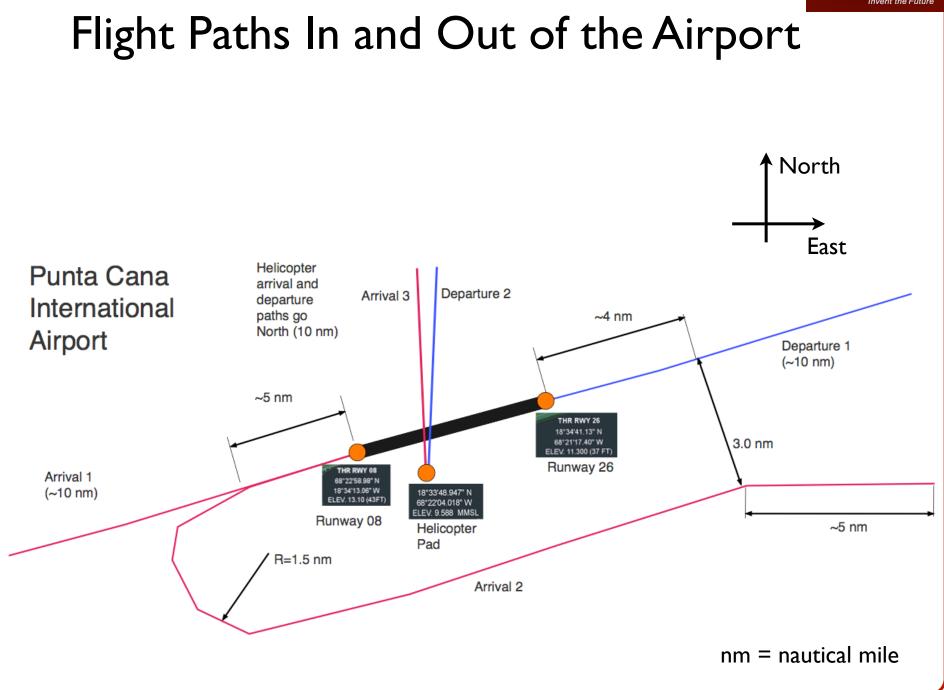
Example of Flight Track Dispersion ORD Airport Nighttime Departures: Runway 28C



source of data: Chicago Department of Aviation

Airport Planning and Design (Antonio A.Trani)

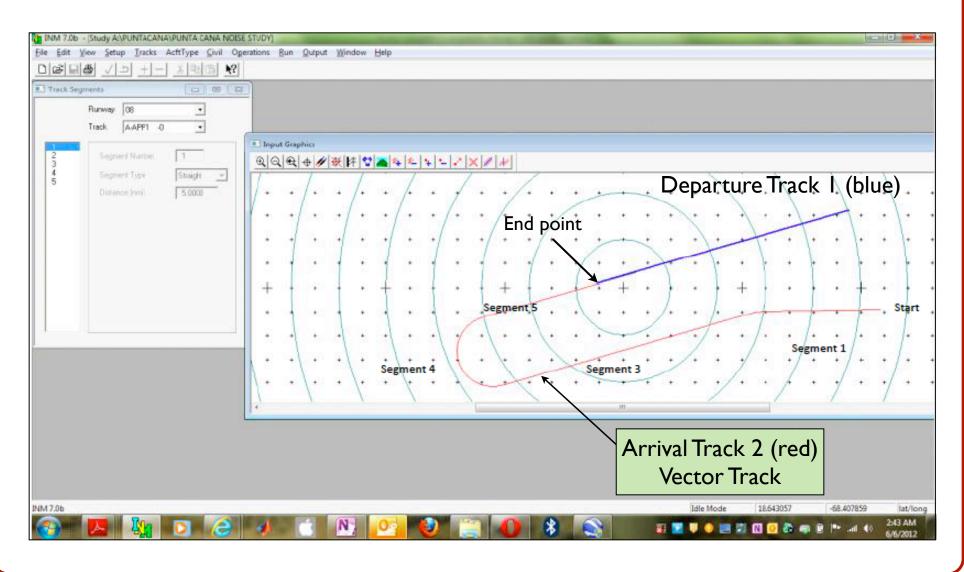
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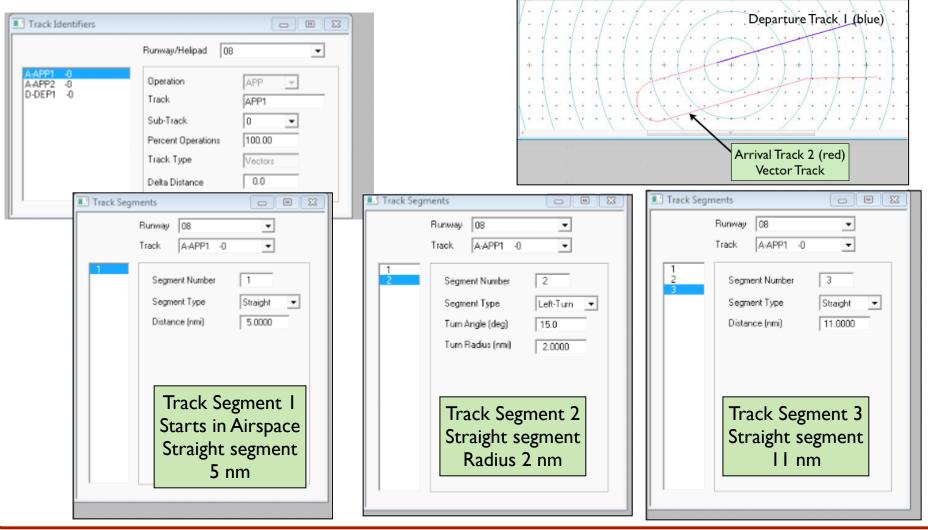
Arrival Track 2 at Punta Cana

• Arrival Track 2 to Punta Cana International Airport



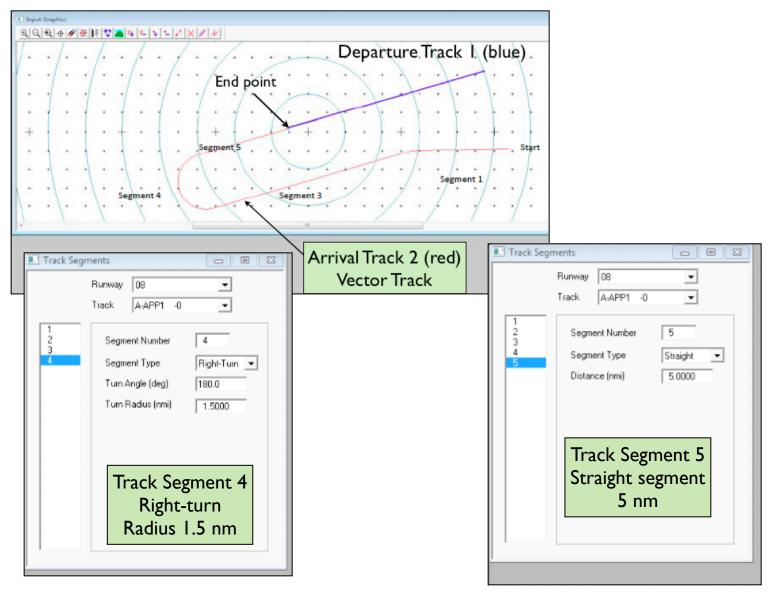
Arrival Track 2 at Punta Cana

- Step-by-step procedure to create Arrival 2 track (5 segments)
- Arrivals should always begin in the airspace and end at the runway threshold



Arrival Track 2 at Punta Cana (cont.)

• Step by step procedure to create Arrival 2 track (5 segments)

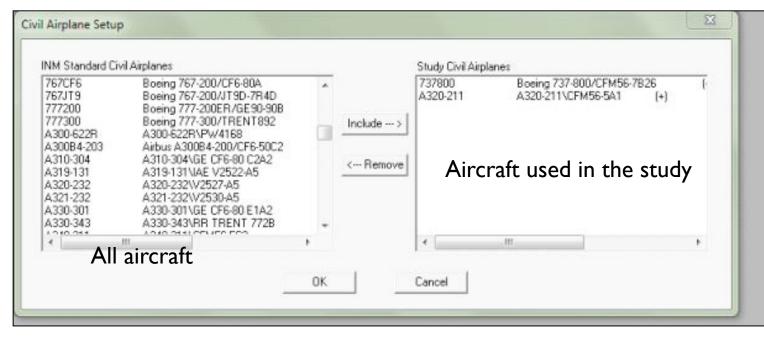


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Adding Aircraft to the Scenario

- INM has a large database of aircraft
- Each aircraft has an engine associated with it
- Consult airlines on which airframe/engine combinations are used at the airport

Go to SETUP --> Civil Airplanes



Setup a **Case** After Adding Aircraft

- INM aircraft performance model is sensitive to airport temperature
- Enter airport temperature and pressure

Cases		
Case_1	Case ID (40 characters or less) Case_1	Created 06-Jun-12 18:13
	Description	
	This is the baseline case	
	Airport Parameters Temperature (F) 58.9 Pressure (in-Hg) 29.92 Modify NPD Curves	
	Headwind (kt) 8.0	

Setup a Scenario After Creating a Case

 Multiple scenarios can be used to investigate variations of default parameters in the model

Scenarios				
Scenario_1		Scenario ID (40 characters or less) Scenario_1 Description	Created 06-Jun-12 18:14	
		This is the baseline scenario		
	Study Cases	Inclu	Ide>	

Defining Aircraft Operations

This can be done in two methods based on available aircraft operations data

- 1. By defining Civil Aircraft groups and specifying the number of operations for each group
- 2. Specifying the number of operations for each aircraft type
- **Example:** Two aircraft operating at the airport (B737-800 and A320-211)
- Total operations is 80 per day (60 day and 20 night; half of them arrivals and half departures)

Aircraft Operations (2) Sample Operations

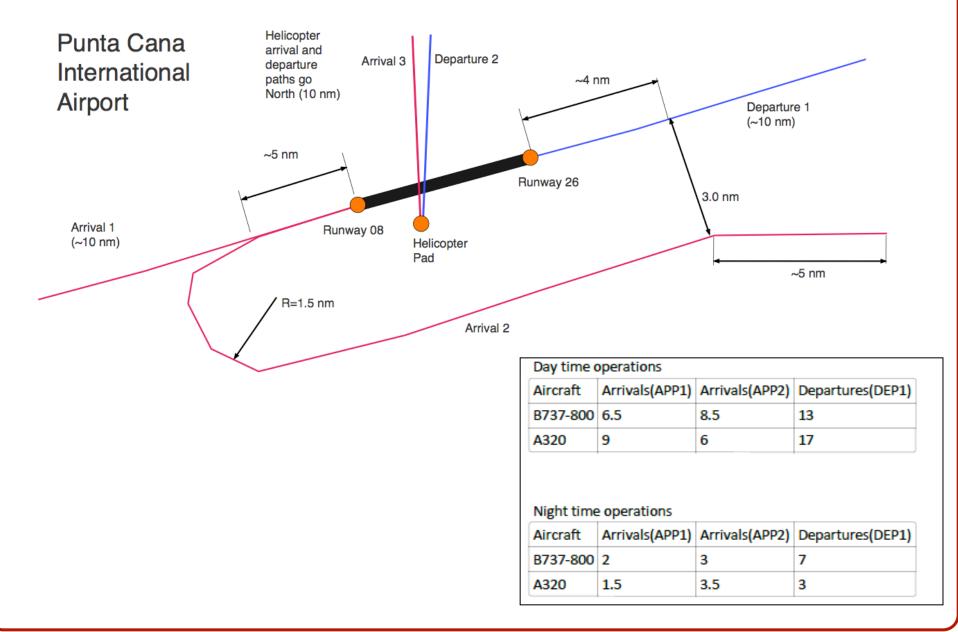
Day time operations Aircraft Arrivals(APP1) Arrivals(APP2) Departures(DEP1) B737-800 6.5 8.5 13 Aircraft operations are defined for each arrival and departure track Night time operations Kight time operations Kight time operations Kight time operations Kight time operations

<u> </u>	•		
Aircraft	Arrivals(APP1)	Arrivals(APP2)	Departures(DEP1)
B737-800	2	3	7
A320	1.5	3.5	3

After calculating the no. of operations for each aircraft and for each track (arrivals and departures) and for day and night enter these numbers into Civil flight operations. Go to Operations --> Civil Flights

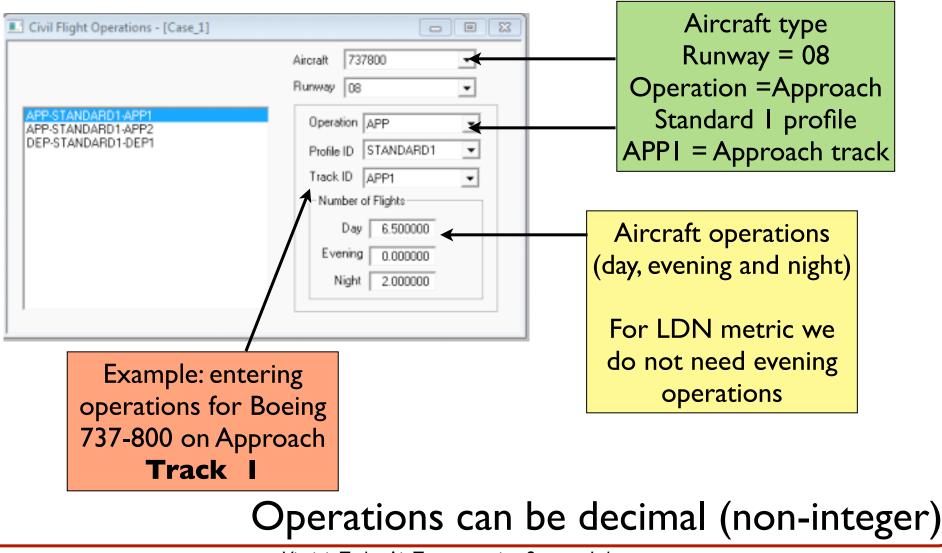
> Aircraft operations are also distinguished between day and night

Recall: Airport Tracks

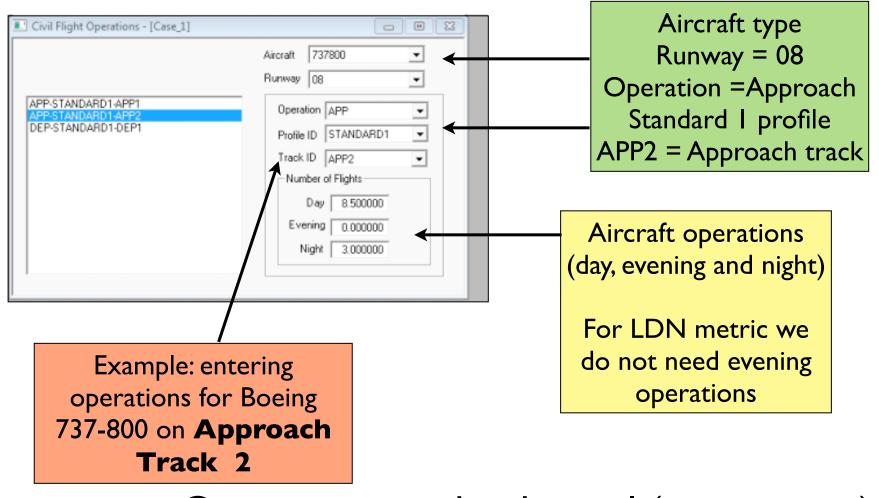


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Aircraft Operations (3) Boeing 737-800 on Arrival Track I

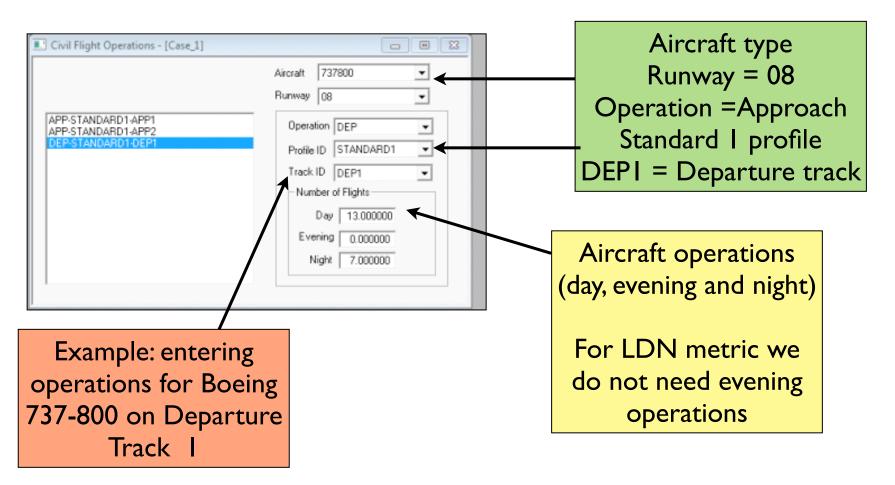


Aircraft Operations (4) Boeing 737-800 on Arrival Track 2



Operations can be decimal (non-integer)

Aircraft Operations (5) Boeing 737-800 on Departure Track I



Operations can be decimal (non-integer)

Flight Operations Summary

- Similarly enter the operations for all remaining flights
- Finally, check the total number of operations by looking at the flight operations summary

AVPUNTA CANA N	IOISE STUDY]	View Flight Operations
AcftType <u>C</u> ivil	Operations Run Output Window	
bt Operations - I	Civil Flights Civil Runups Civil Group Percents Airport Operations View Calculated Flights	Case or Scenario Case_1 View Records View Summary Flight Operations Filter Aircraft Operation Profile Runway / Helipad Track Track View Filter View Filter Cancel
		View Summary

Summary of All Flight Operations Entered in the Scenario

Flight Operations Summary - [Case_1]										
ACFT	0P	PROFILE	S	RWY	TRACK	S	GRP	DAY	EVENING	NIGHT
737800	A	88888888	8	88888888	88888888	8		15.000000	0.000000	5.000000
737800	D	88888888	&	222222222	88888888	&		13.000000	0.000000	7.000000
737800	8	*****	8	*****	88888888	8		28.000000	0.000000	12.000000
A320-211	A	88888888	8	*****	88888888	8		15.000000	0.000000	5.000000
A320-211	D	*****	8	*****	*****	8		17.000000	0.000000	3.000000
A320-211	8	*****	8	*****	88888888	8		32.000000	0.000000	8.000000
88888888888888	A	*****	8	08	APP1	8		15.500000	0.000000	3.500000
88888888888888	A	*****	8	08	APP2	8		14.500000	0.000000	6.500000
88888888888888	D	*****	8	08	DEP1	8		30.000000	0.000000	10.000000
88888888888888	D	88888888	8	08	88888888	8		30.000000	0.000000	10.000000
88888888888888	A	*****	8	08	*****	8		30.000000	0.000000	10.000000
888888888888888888888888888888888888888	8	*****	8	08	*****	8		60.000000	0.000000	20.000000
88888888888888	8	*****	8	26	88888888	8		0.000000	0.000000	0.000000
88888888888888	8	*****	8	0VF	*****	8		0.000000	0.000000	0.000000
888888888888888888888888888888888888888	D	*****	8	*****	*****	8		30.000000	0.000000	10.000000
88888888888888	A	*****	8	*****	*****	8		30.000000	0.000000	10.000000
88888888888888	Т	*****	8	*****	*****	8		0.000000	0.000000	0.000000
888888888888888888888888888888888888888	v	****	8	*****	****	8		0.000000	0.000000	0.000000
88888888888888	F	*****	8	*****	*****	8		0.000000	0.000000	0.000000
88888888888888	X	*****	8	*****	*****	8		0.000000	0.000000	0.000000
888888888888888888888888888888888888888	8	88888888	8	22222222	*****	8		60.000000	0.000000	20.000000
								^		A

Total operations (day and night)

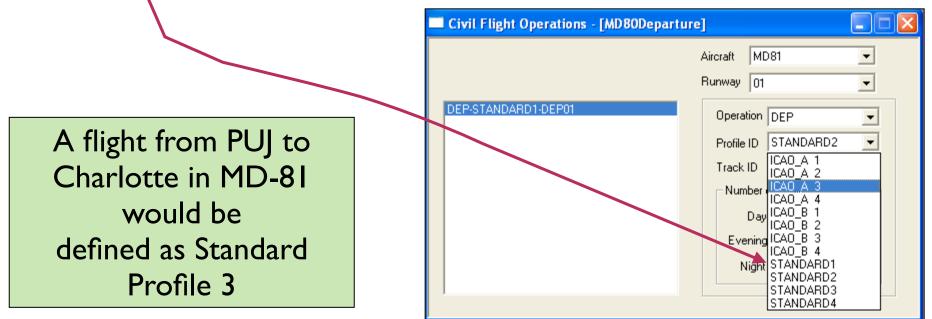
A Side Note on Departure Profiles

- INM contains aircraft performance equations that are sensitive to the stage length flown
- For the same aircraft type, a heavily loaded aircraft climbs slower than a light aircraft
- A heavy loaded aircraft generates more noise because it flies closer to the ground and the community below
- INM uses up to 9 standard or ICAO profiles to define the climb performance of the vehicle

Aircraft 737800 Runway 08 APP-STANDARD1-APP1 APP-STANDARD1-APP2 DEP-STANDARD1-DEP1 Profile ID STANDARD1 Track ID DEP1 Number of Flights Day 13.000000
Evening 0.000000 Night 7.000000

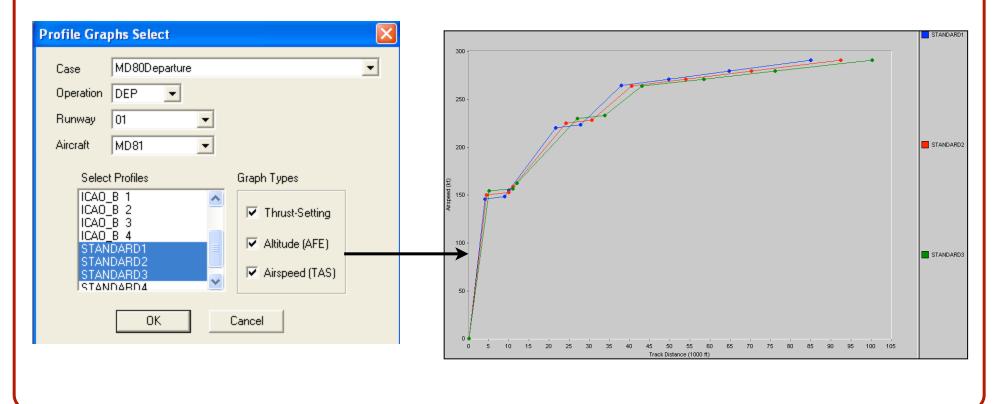
Departure Profiles (2)

- Each profile represents a change in aircraft takeoff (or landing) state at intervals of 500 miles
- Example: Boeing (McDonnell Douglas) MD-81 aircraft
 - Standard profile 1 = flights less than 500 miles
 - Standard profile 2 = flights from 500-1000 miles
 - Standard profile 3 = flights from 1000-1500 miles, etc.



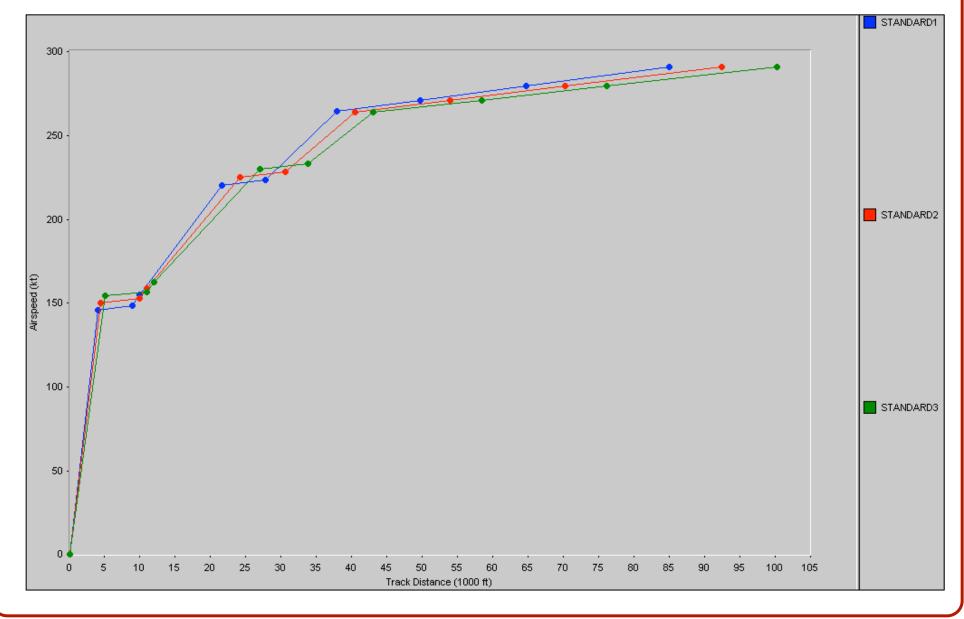
If You Want to See the Aircraft Profiles Flown by INM

- Go to CIVIL --> Profile Graphs
- Then select the graphs that you want to see for the profiles in question



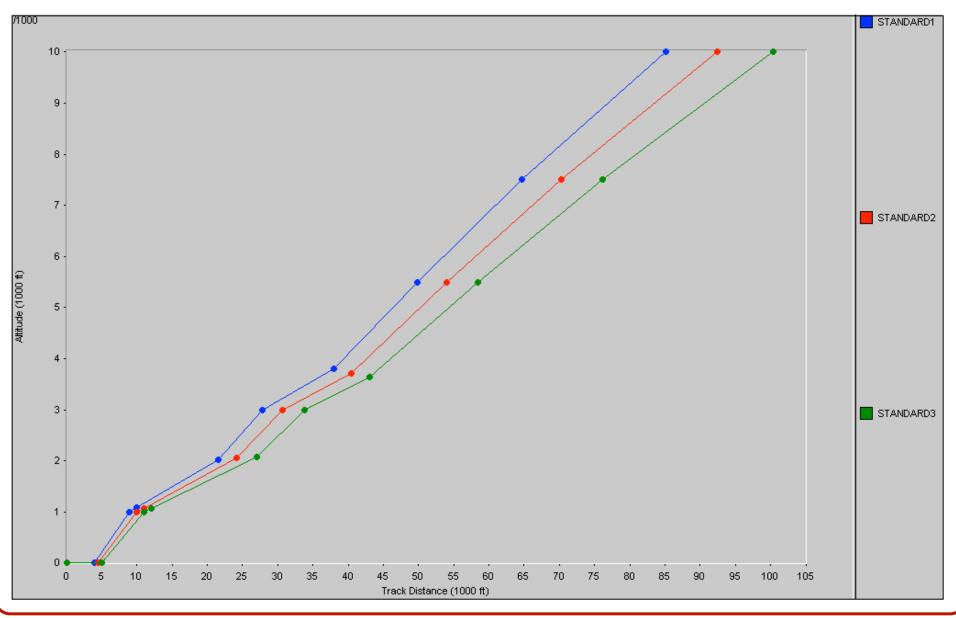
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Sample Airspeed Profiles for MD-81



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Sample Altitude Profiles for MD-81



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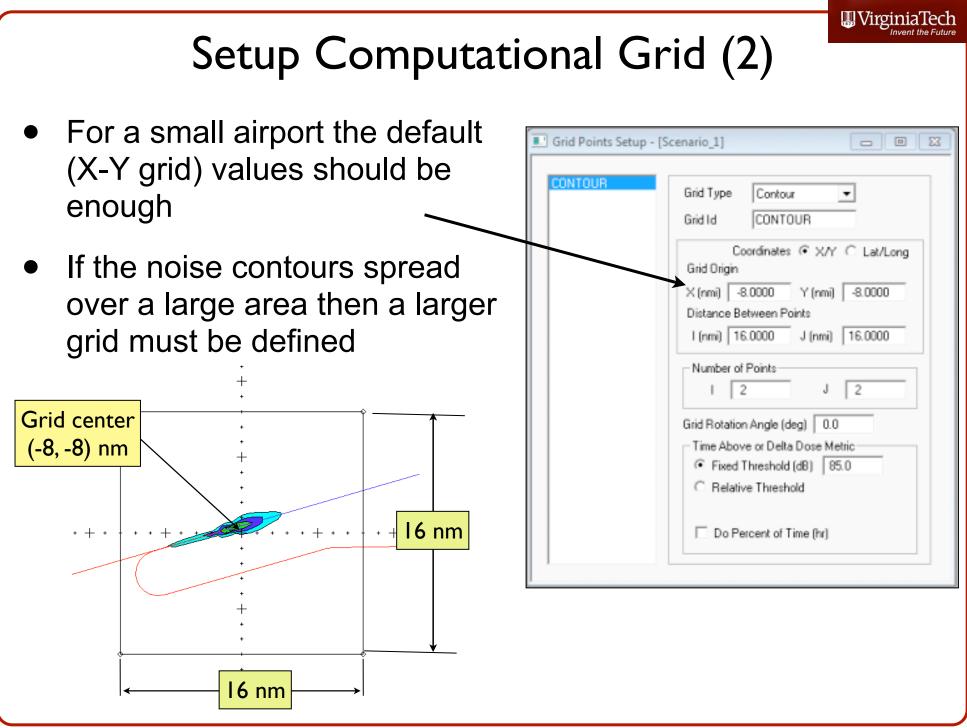
Setup Computational Grid

- INM calculates LDN or other noise metric levels at discrete points on a GRID that you define
- Then the models interpolates logarithmically to obtain equal LDN contours
- You define the grid as follows:

Grid Points Setup - [So	cenario_1]
CONTOUR	Grid Type Contour Grid Id CONTOUR
	Coordinates @ X/Y C Lat/Long Grid Drigin
	X (nmi) -8.0000 Y (nmi) -8.0000 Distance Between Points
	I (nmi) 16.0000 J (nmi) 16.0000
	Number of Points
	Grid Rotation Angle (deg) 0.0
	Time Above or Delta Dose Metric
	 Fixed Threshold (dB) 85.0
	C Relative Threshold
	Do Percent of Time (hr)

Go to RUN --> Grid Setup

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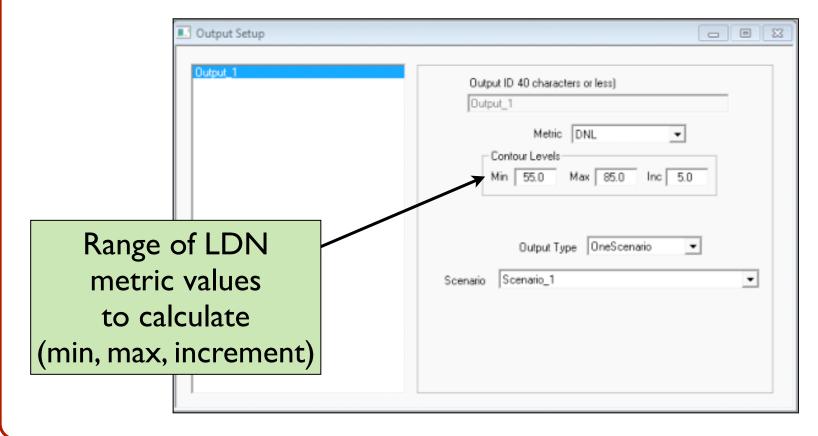


Run Options Setup

After defining Run Options - 0 X the grid set up Scenario_1 Scenario Run Type Single-Metric ٠ **Run Options** Noise Metric DNL Do Population Points Do Terrain Do Location Points Go to RUN --> Grid Do Standard Grids **Run Options** Do Detailed Grids Save 100% Flights Lateral Attenuation All-Soft-Ground -Calculate Metrics Use Bank Angle DNL DNEF CNEL WECPNL This menu Do Contours LAEQ EPNL Contour LAEQD PNLTM defines the _ Use Boundary File LAEQN TAPNL C Recursive Grid Fixed Grid SEL. CEXP C Refinement G Fixed Spacing noise metric to LAMAX 🗆 LCMAX 1000.0 (8) Spacing TALA TALC be calculated Number of Grid Points 3604 Last Run 06-Jun-12 19:21 Duration 000:00:07 Select contours

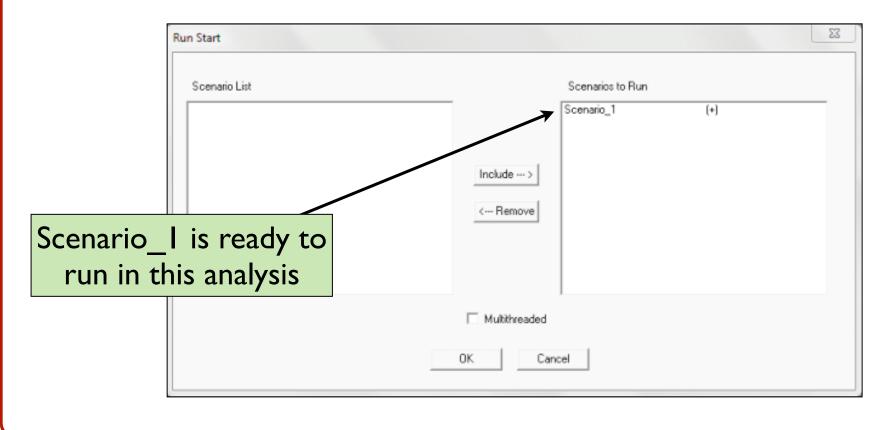
Setup the Output for the Analysis

- We need to tell INM the range of values of the noise metric to be calculated
- Go to Output --> Output Setup



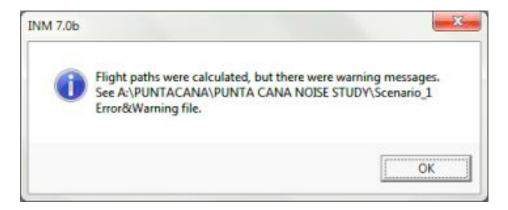
We are Ready to Run the Scenario

- Add to the right-hand side window, the scenario(s) you want to execute
- Use the include and remove buttons to add or remove scenarios to your run



Warning Messages

- If this message is seen click OK
- These are just warning messages
 - Go to the Error&Warning file and check the warnings just to make sure they are not serious warnings.



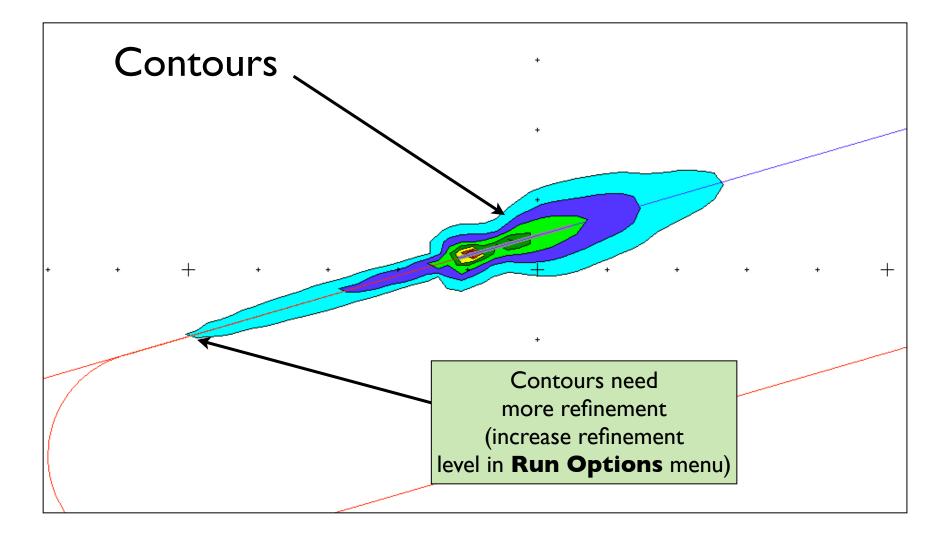
Run in Progress

 Be patient, depending on the number of flights, number of tracks and refinement level, the INM model is doing numerous computations

Scenarios to Run	Scenario Running
	Scenario_1
	Case Running
	Case_1
	Computing
Scenarios Done	FIXED POINT GRID
	Percent Done
	67
	Abort

Examining the Output

• Go to OUTPUT --> Output Graphics



Examining the Area of Contours

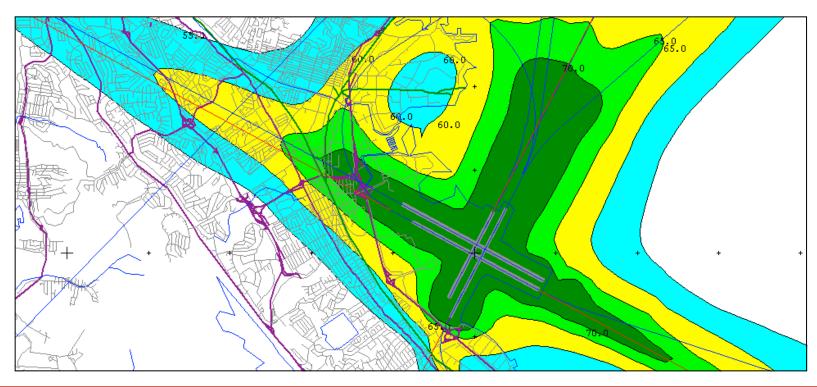
Go to OUTPUT --> Contour Area and Pop...

Run	Out	put <u>W</u> indow <u>H</u> elp								
		Output Setup								
г		Output Graphics		C1			60 KM	60 MI	N CO FT	ACDER
9		Annualize Scenario		EL 5.0	Y	OPULATION 0	SQ.KM 17.762	SQ.MI 6.858	M.SQ.FT 191.19	ACRES 4389.1
16 0		Contour Points		D.O 5.0	Y Y	0 0	7.104 2.610	2.743 1.008	76.46 28.10	1755.3 645.0
9		Contour Area and Pop		D.O 5.O		0 0	0.798 0.253	0.308 0.098	8.59 2.73	197.2 62.6
3		Area Contour Coverage	8	D.O	Y	Ō	0.083	0.032	0.89	20.5
-			U 0	5.0	T	0	0.023	0.009	0.25	5.7

Area and population (if a population file was included in the analysis) of each calculated contour

Sample Output Graphics with TIGER file Overlay

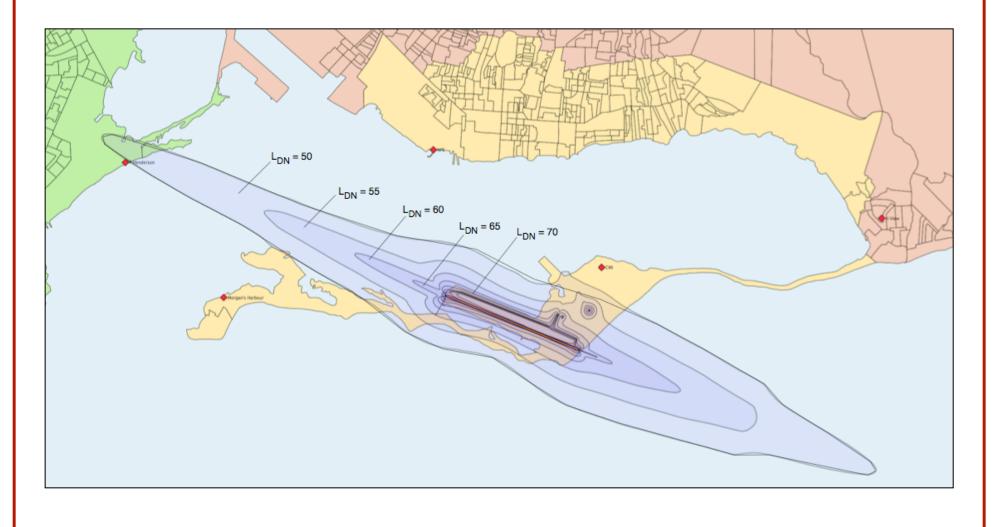
- If a TIGER file overlayed is used you can display the ground network over the INM contours
- This also includes populations for each section of the map (to estimate how many people is affected by each contour)



Exporting the Results of INM

INM 7.0 - [Study C:\PROGRAM FILES\INM7.0\EXAMPLES\TEST50\SIMPLEDCASTUDY\sim Useful to present Edit View Setup Tracks AcftType Civil Operations Run Output Window Help Close Study Ctrl+Z N? Save Study results in other Import Data into Study departures Delete Non-essential Files... applications **a** 🗆 Ctrl+U Print Setup.... Scaled Printing... Print Preview Export to Print... Ctrl+P Export as DXF... Export as ShapeFile... Autocad (DXF Export as MIF/MID... Exit file) Export to a Shapefile (for **GIS** applications)

Sample of Exported INM Contours to a GIS Application



Sample of Exported INM Contours to Google Earth

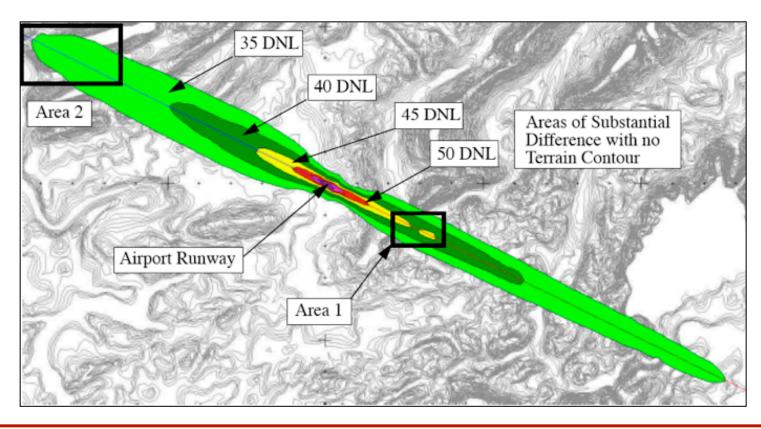
 Export to AutoCad and then create a graphic file than can be overlayed in Google Earth



Virginia Tech - Air Transportation Systems Laboratory

Terrain Data and Noise Contours

- If terrain data is available, INM can correct the noise contours due to topographical effects
- Terrain files need to be in a specific format for INM to read them



Getting the INM Model

- Go to the Syllabus Home page (<u>http://128.173.204.63/courses/</u> <u>cee4674/syllabus_ce_4674.html</u>)
- Unzip the file and launch the setup application to install INM 7.0b
- Works with Windows XP, Windows 7 and Vista

