CEE 4674
Airport Planning and Design

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Sample Integrated Noise Model Case Study

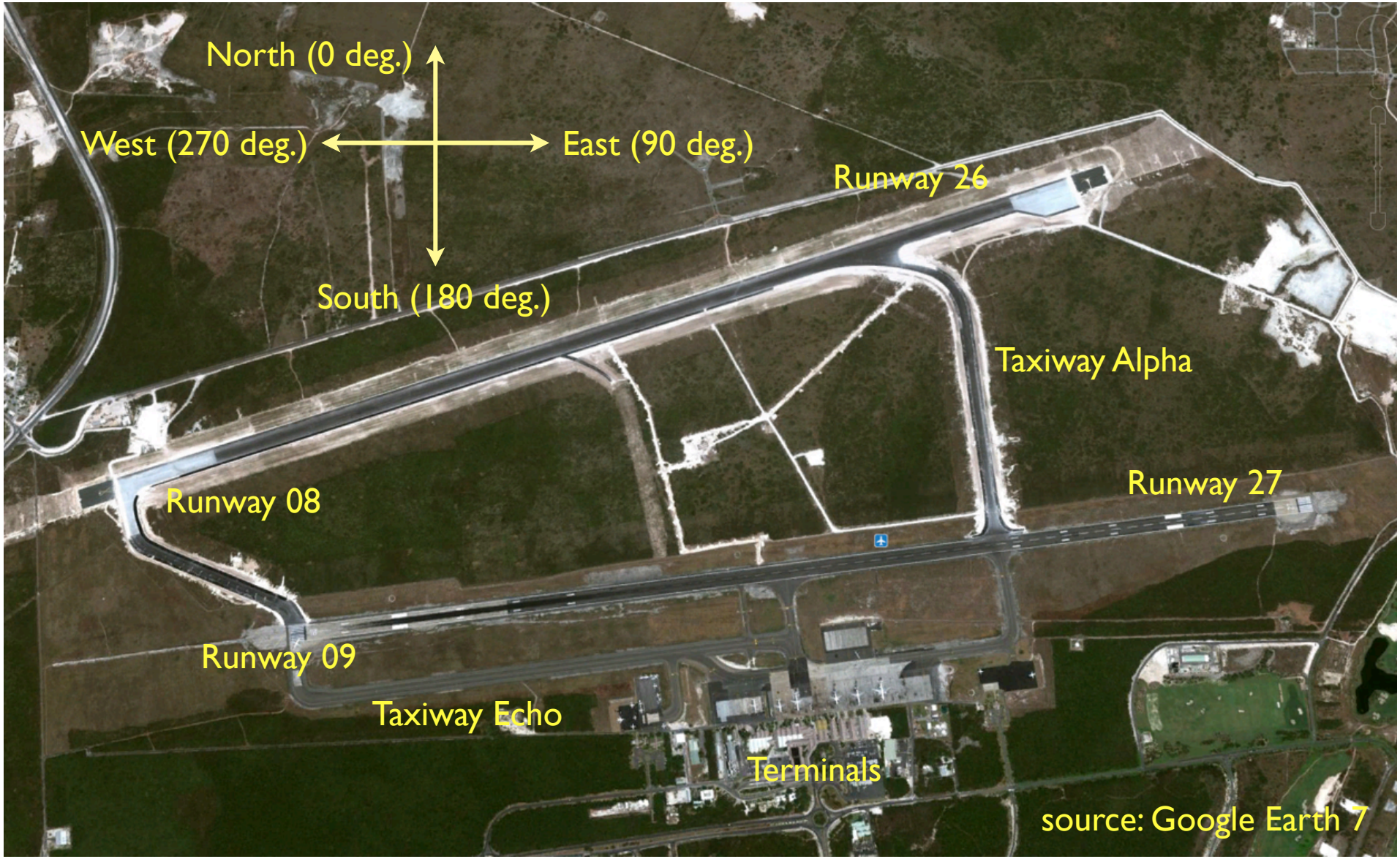
Noise Model Analysis
Data Needs

Item	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)

Item	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

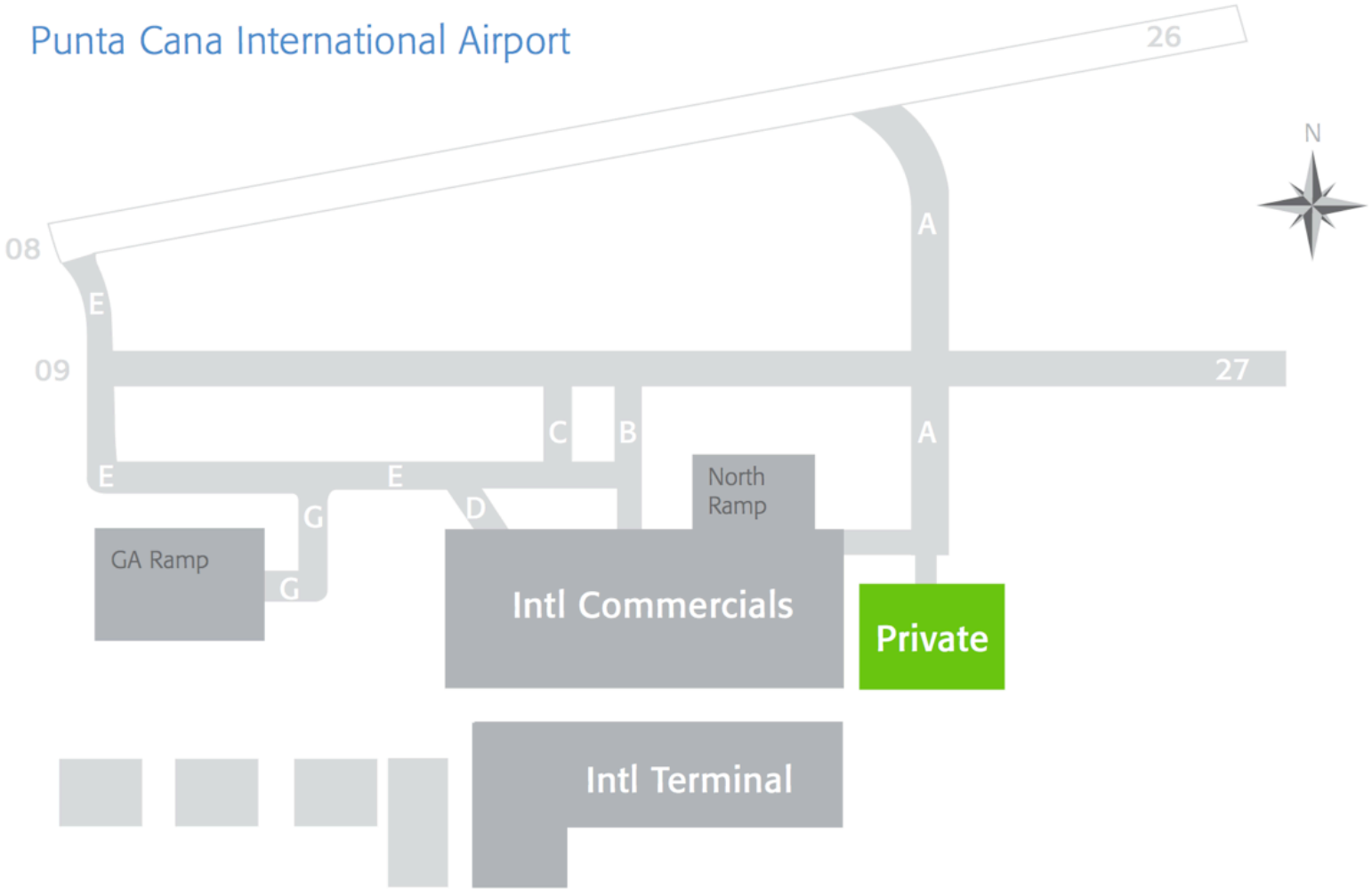
The Punta Cana Airport (PUJ)



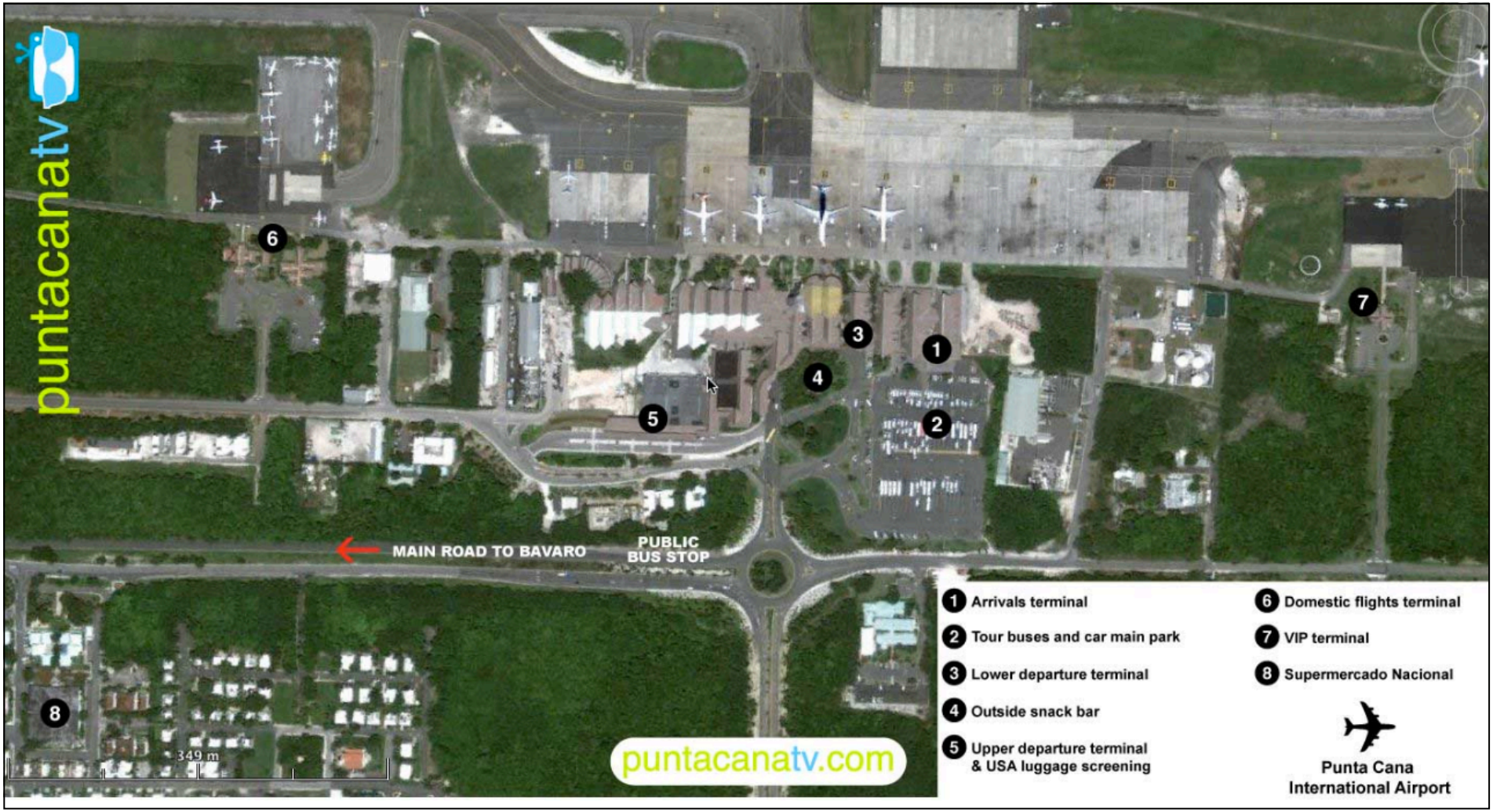
Some Facts

- 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 Airport
(to get you familiarized with the airport)



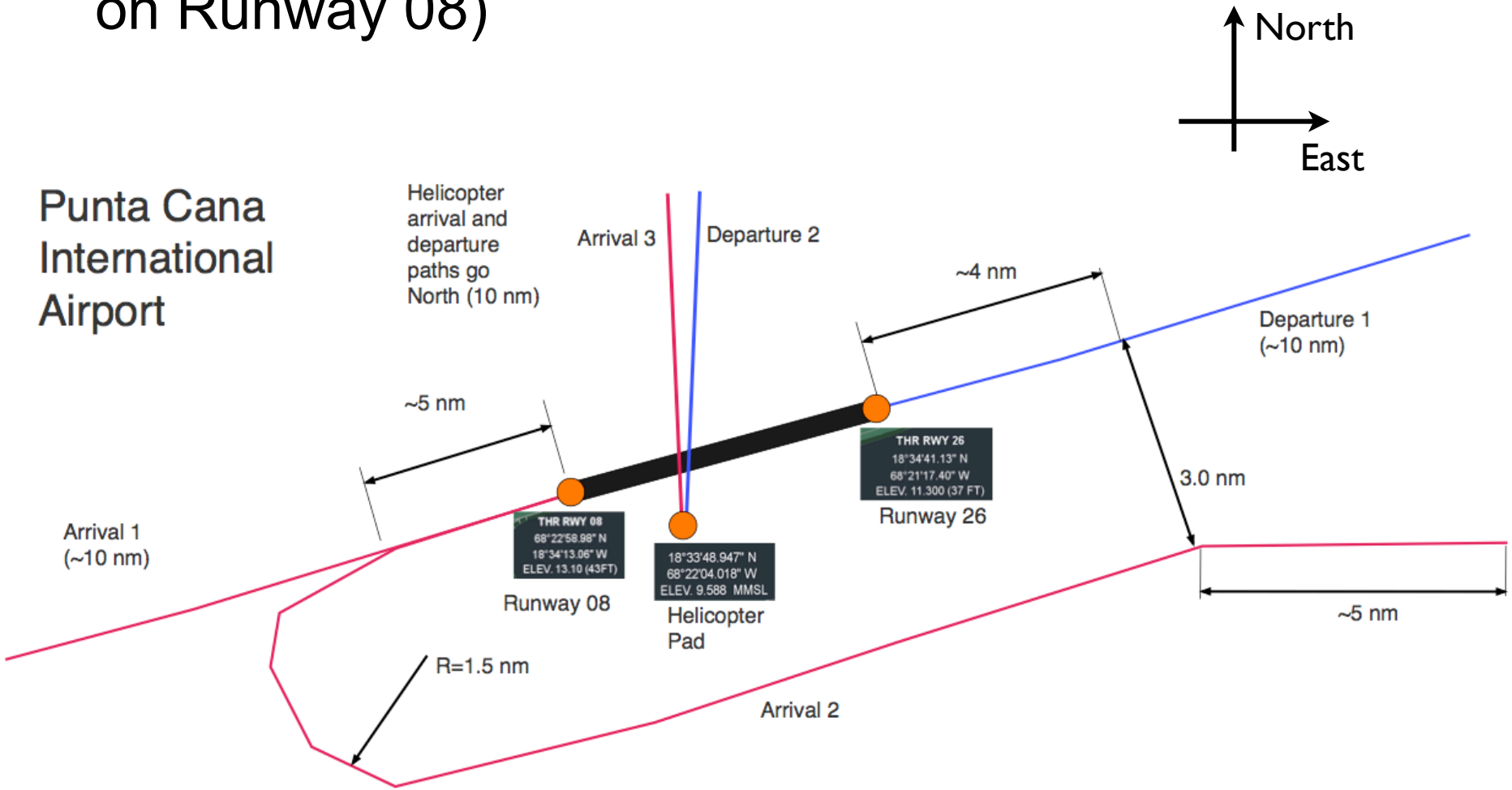
Punta Cana Landside Terminals



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

Flight Paths In and Out of the Airport

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



nm = nautical mile

Night and Day Time Commercial Operations at PUJ

Typical Day Operations for Manual Calculations							
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

General Aviation Night and Day Operations at Punta Cana

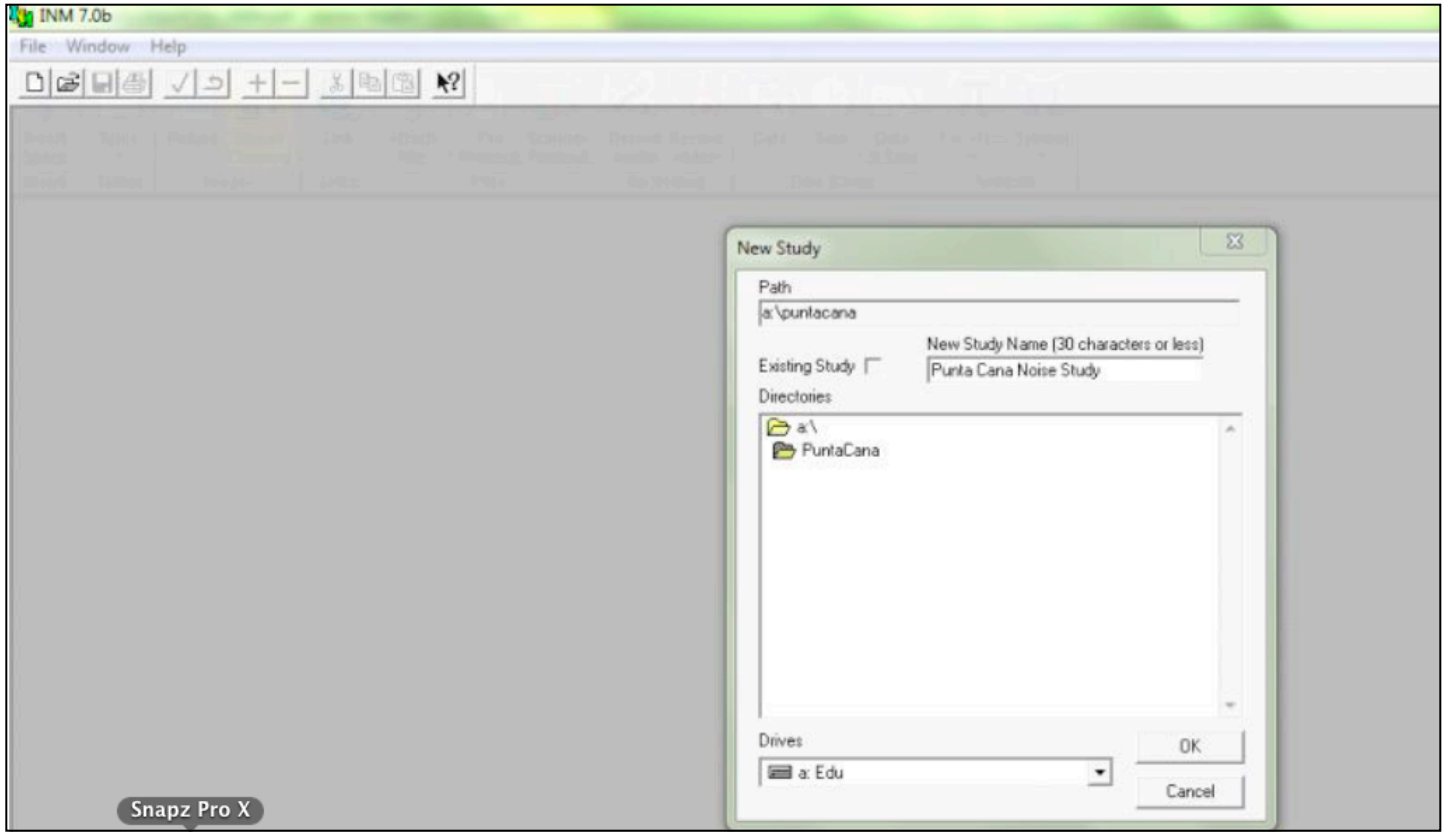
Typical Day Operations for Manual Calculations							
Aircraft	Daily Operations	Night Operations	Day Operations	Night Takeoffs	Night Landings	Day Takeoffs	Day Landings
Cessna C172	3.00	0.00	3.00	0	0	1	2
Cessna Citation II Bravo	6.00	1.00	5.00	0	1	2	3
Gulfstream IV	3.00	1.00	2.00	1	0	1	1
Falcon 20	2.00	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

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

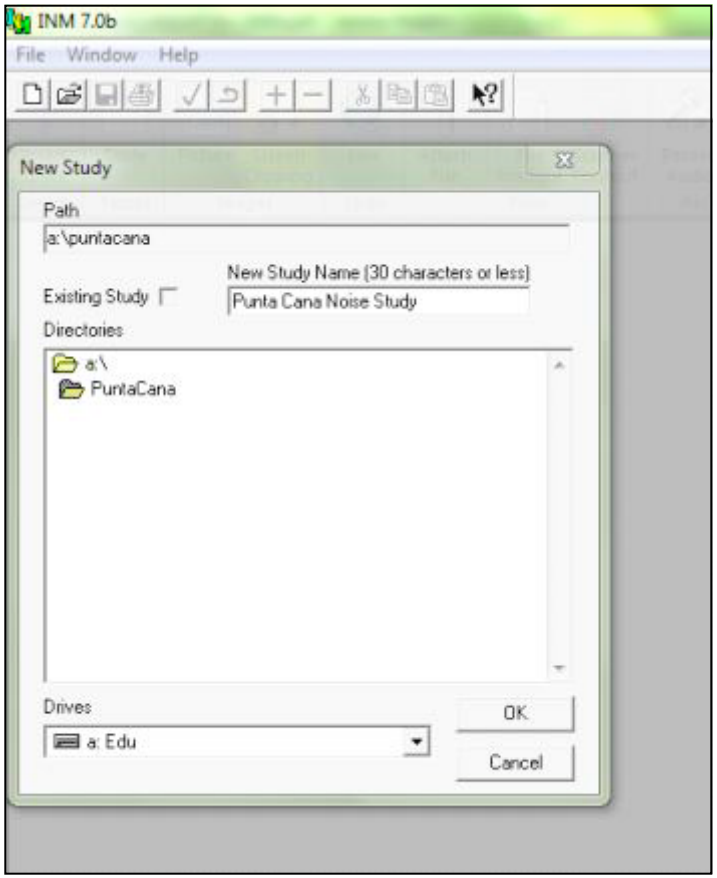
Create the Punta Cana Scenario

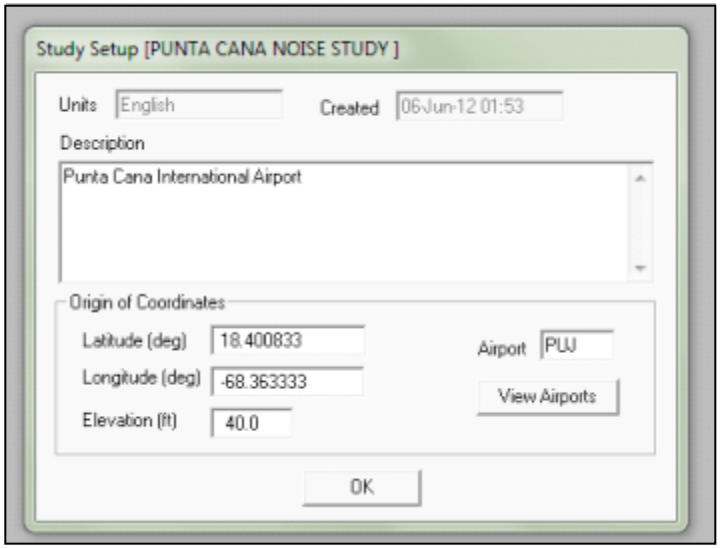
- INM uses a folder/scenario database approach
- Create a new scenario and called it Punta Cana



Punta Cana Scenario Setup

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

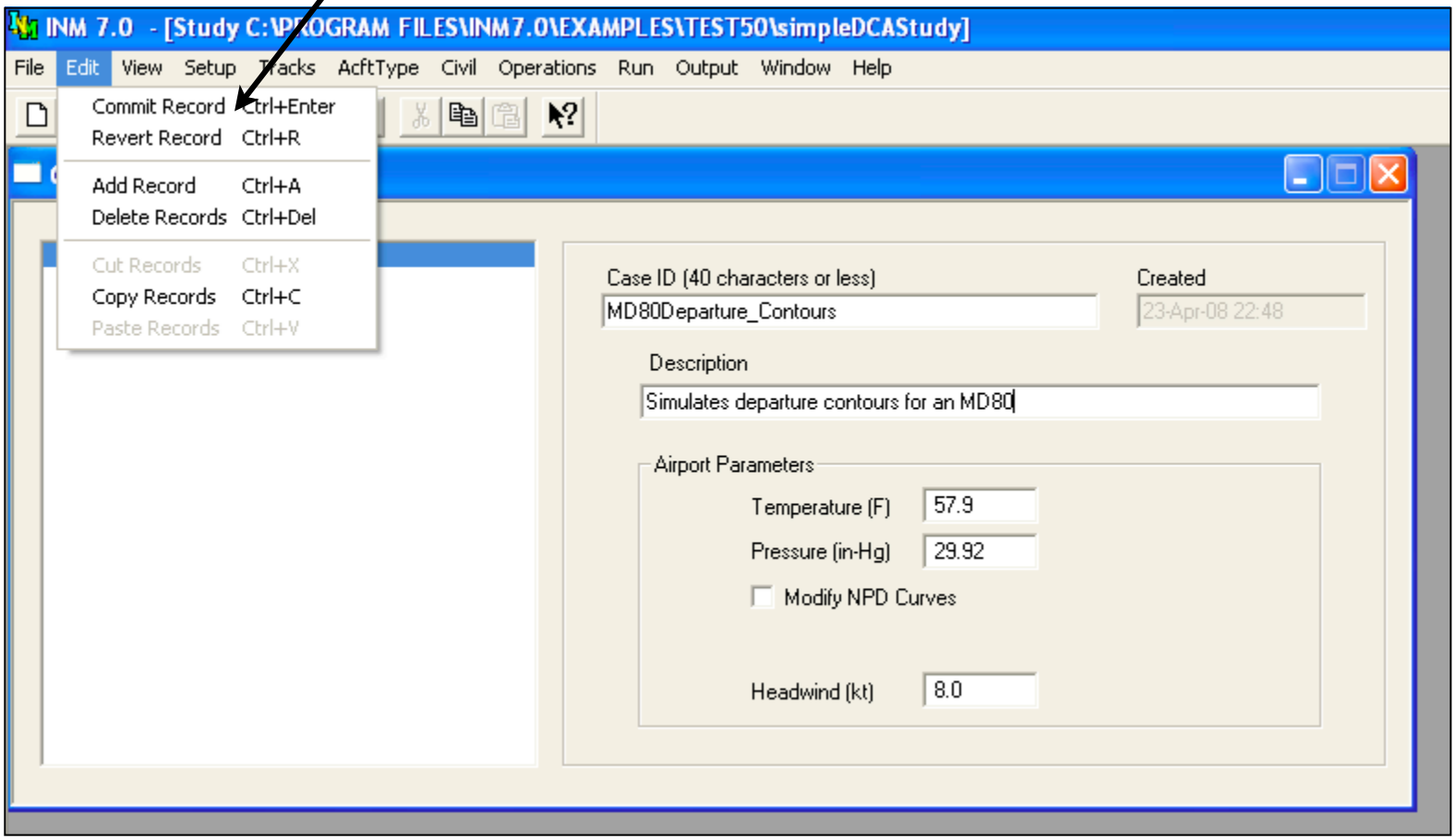




Airport reference point coordinates

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

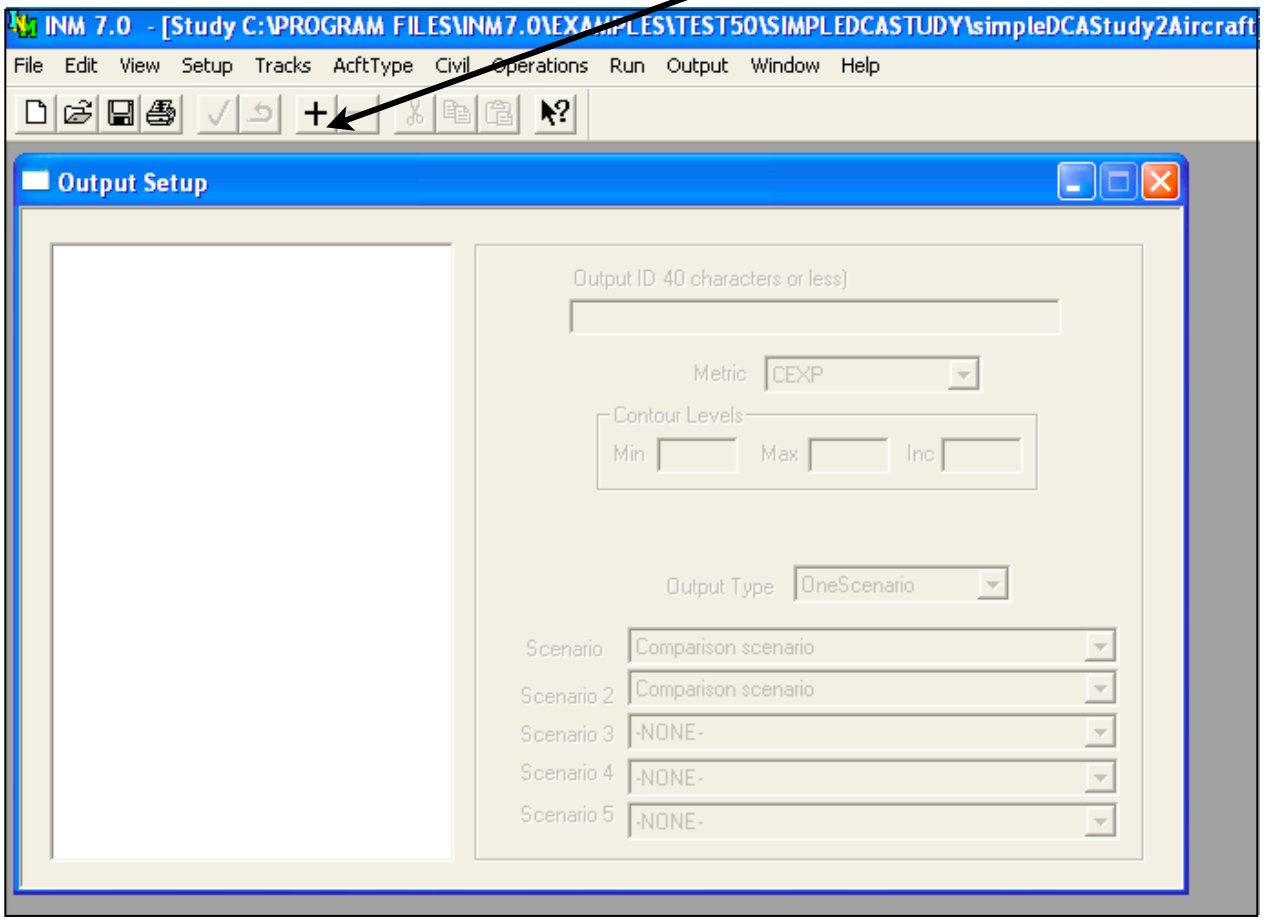


INM Database Issue (2)

- 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

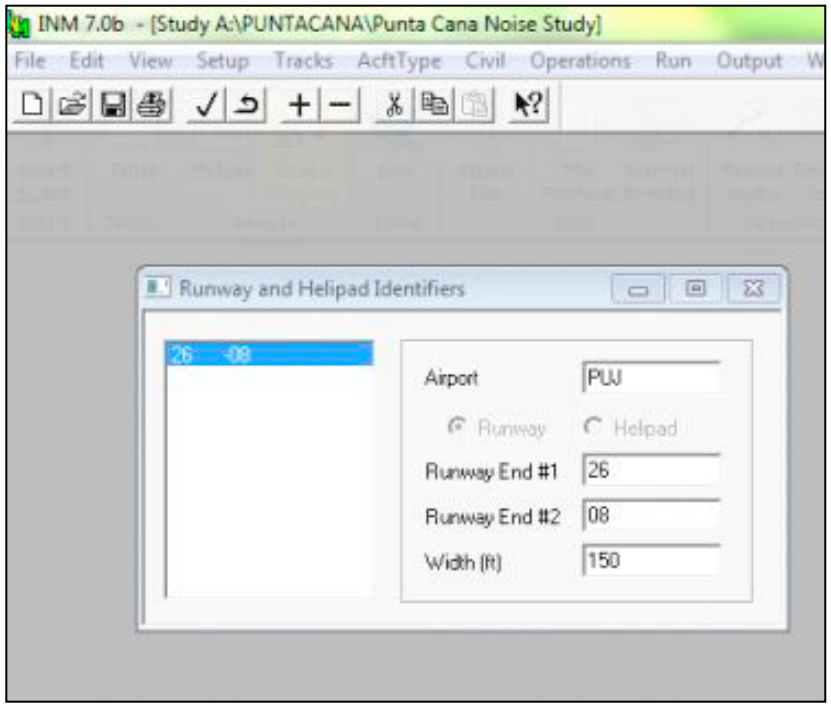
Empty window

Needs a new record



Punta Cana Scenario Runway Setup

- Here we define the runway at the airport to be modeled

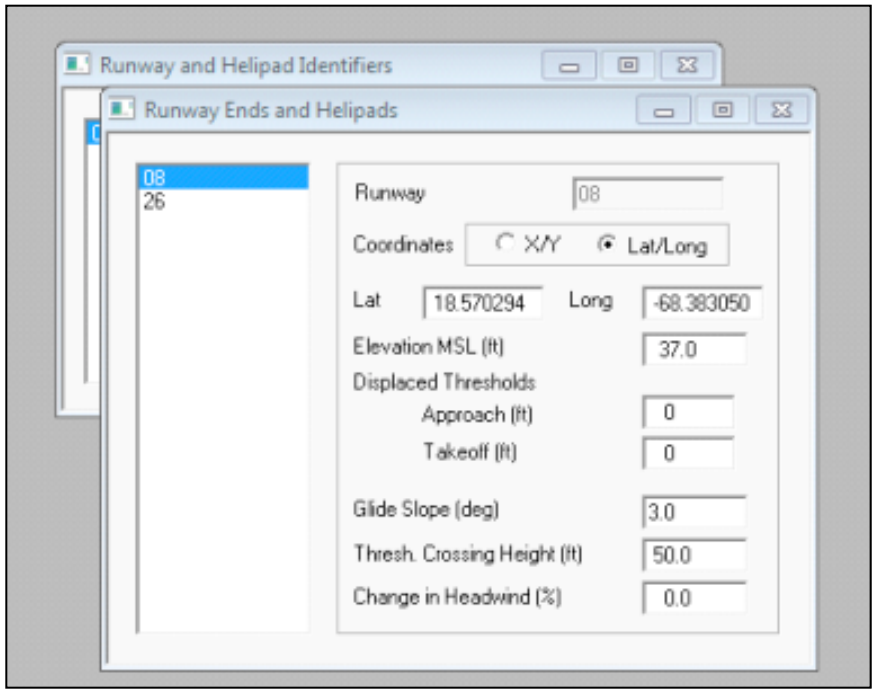


Airport runway and helipad identifiers

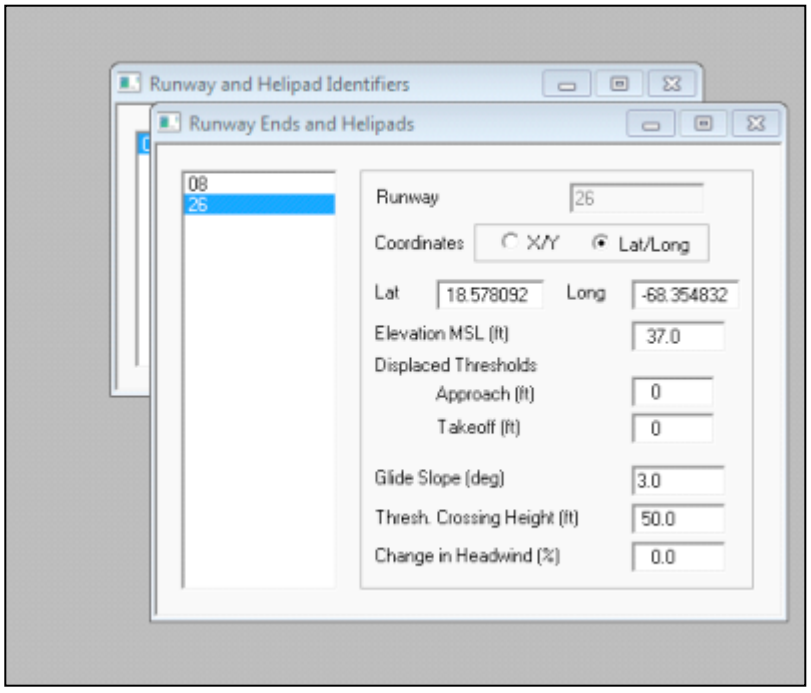
For US airport studies, this step
is not needed because
INM has 1500 airports in its database

Punta Cana Scenario Runway End Points Definition

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



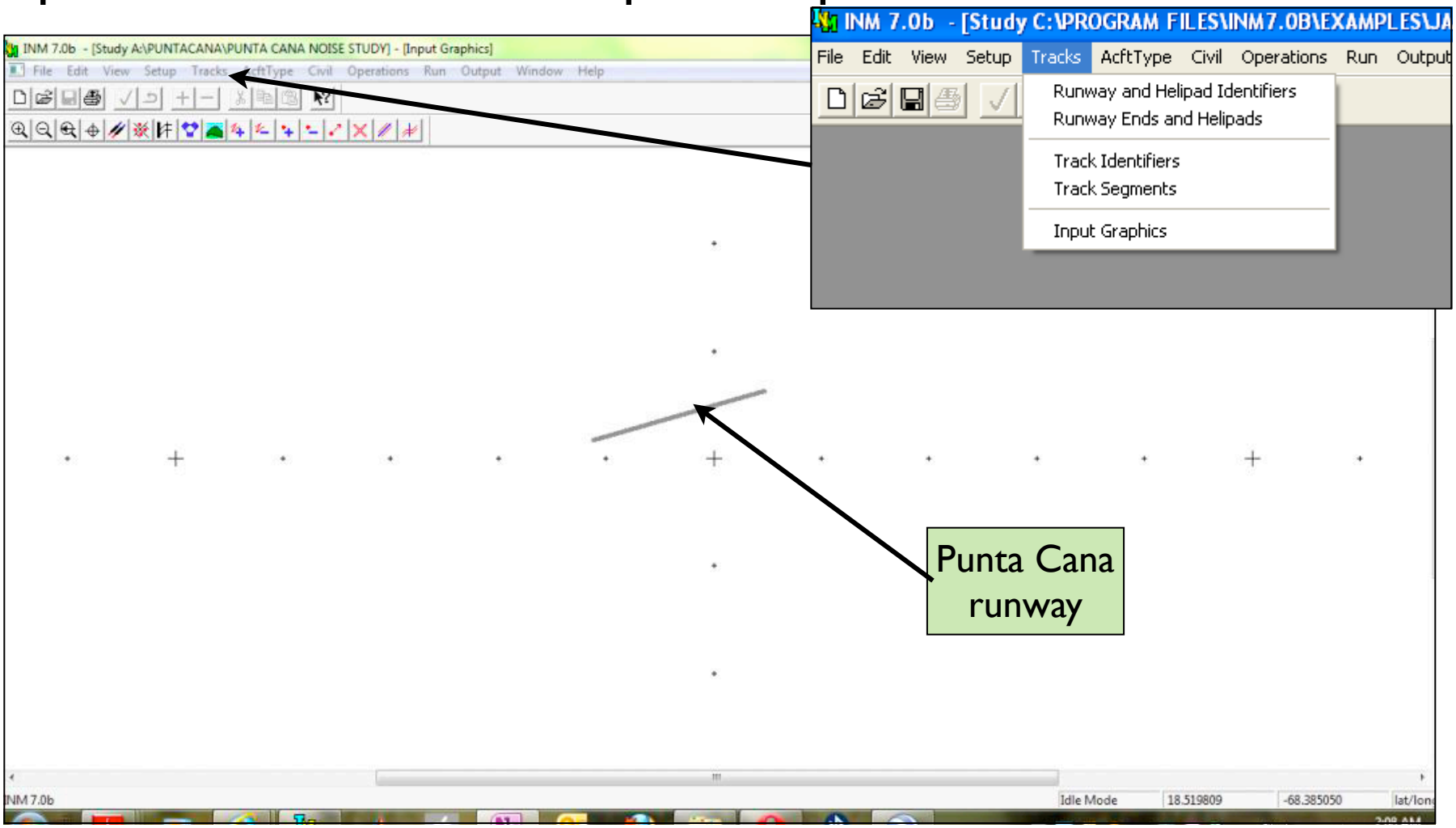
Runway 08



Runway 26

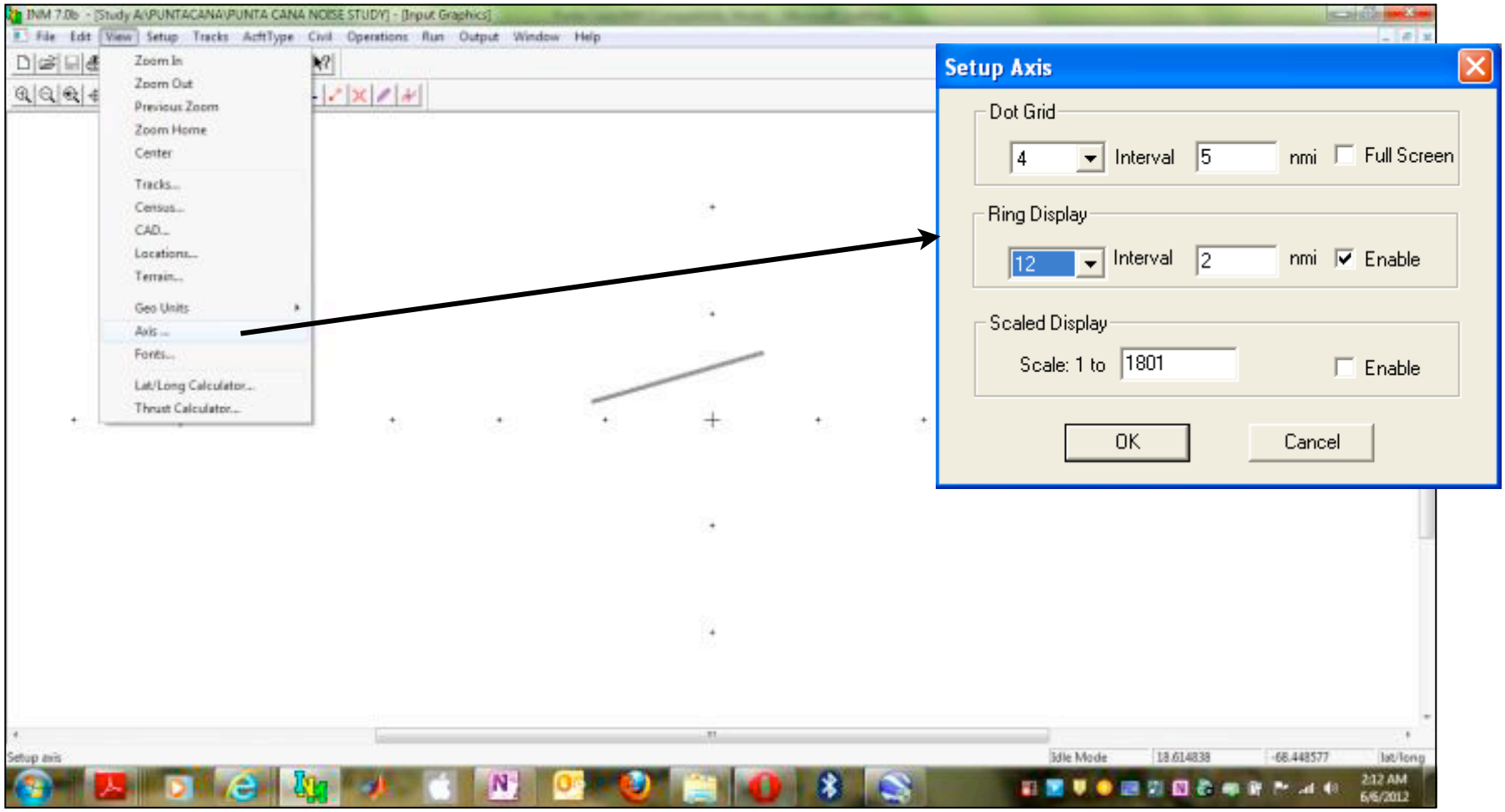
View the Runway Defined in Input Graphics

- You can see the runway defined under the “Tracks” pull down menu and Input Graphics

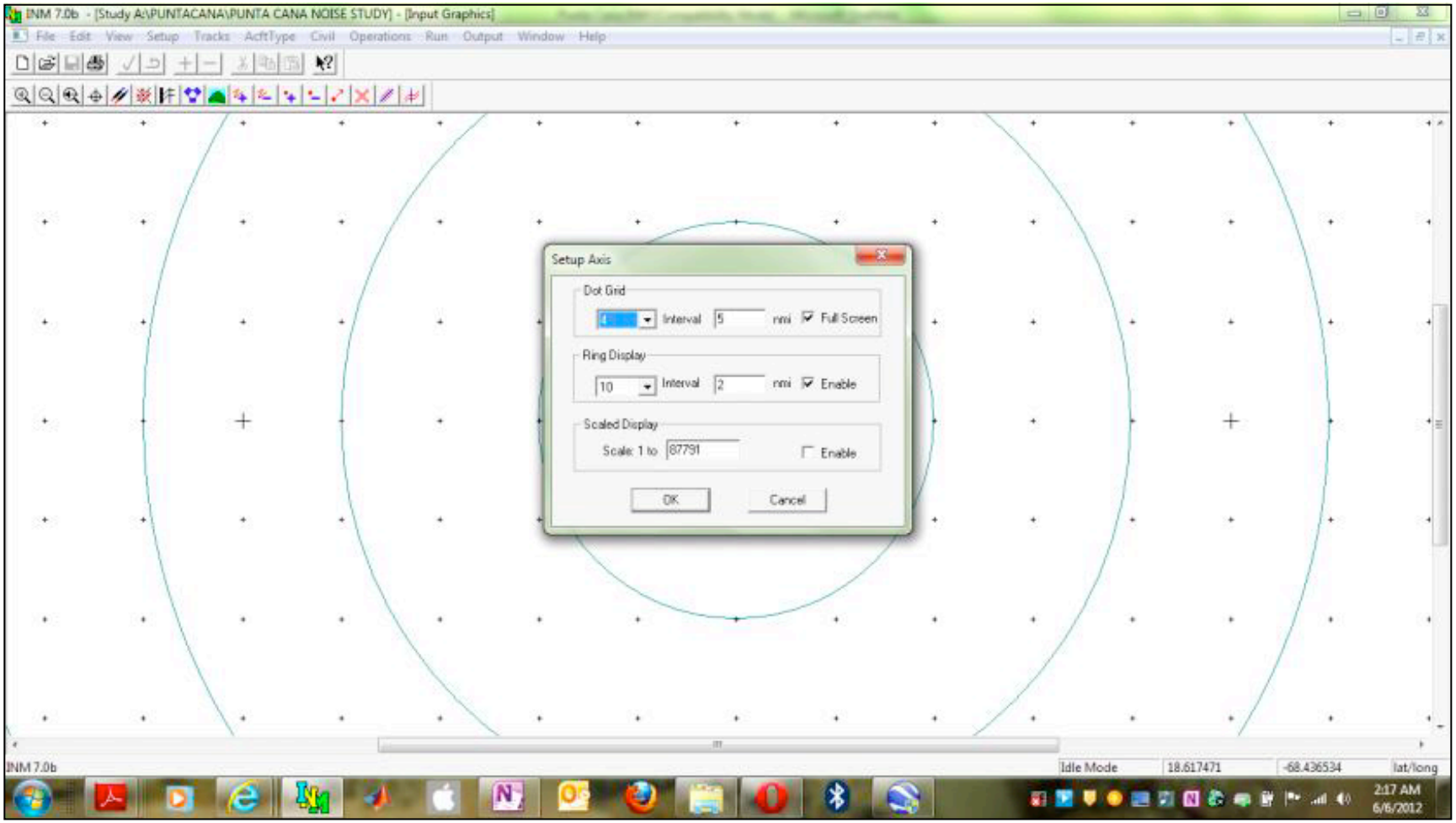


Axis Setting for Improved View

- Define a grid to view your scenario under “View” pull-down menu and Axis



View of Airport with Concentric Rings (Helps Construction)

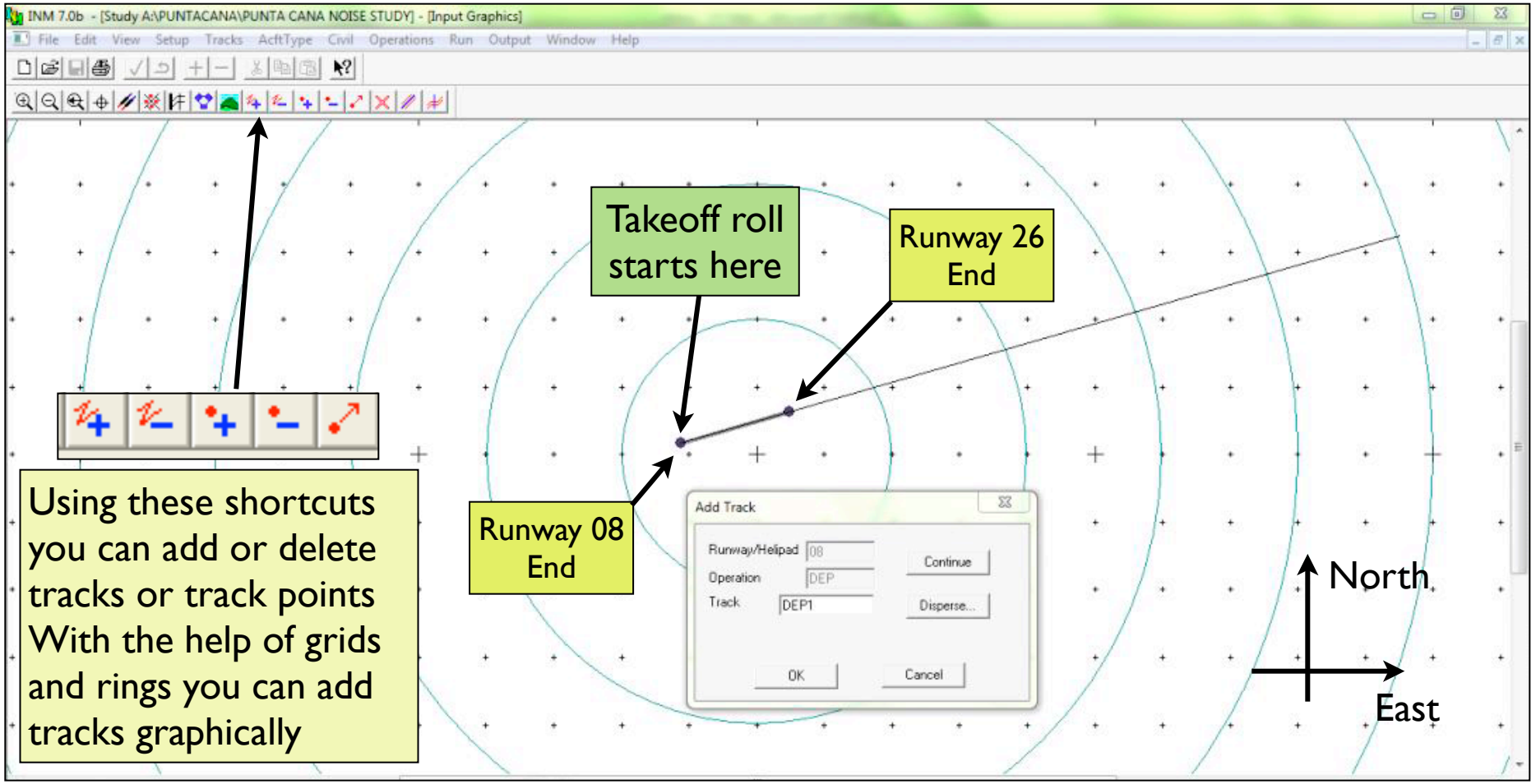


Add Tracks to the Punta Cana Runway

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

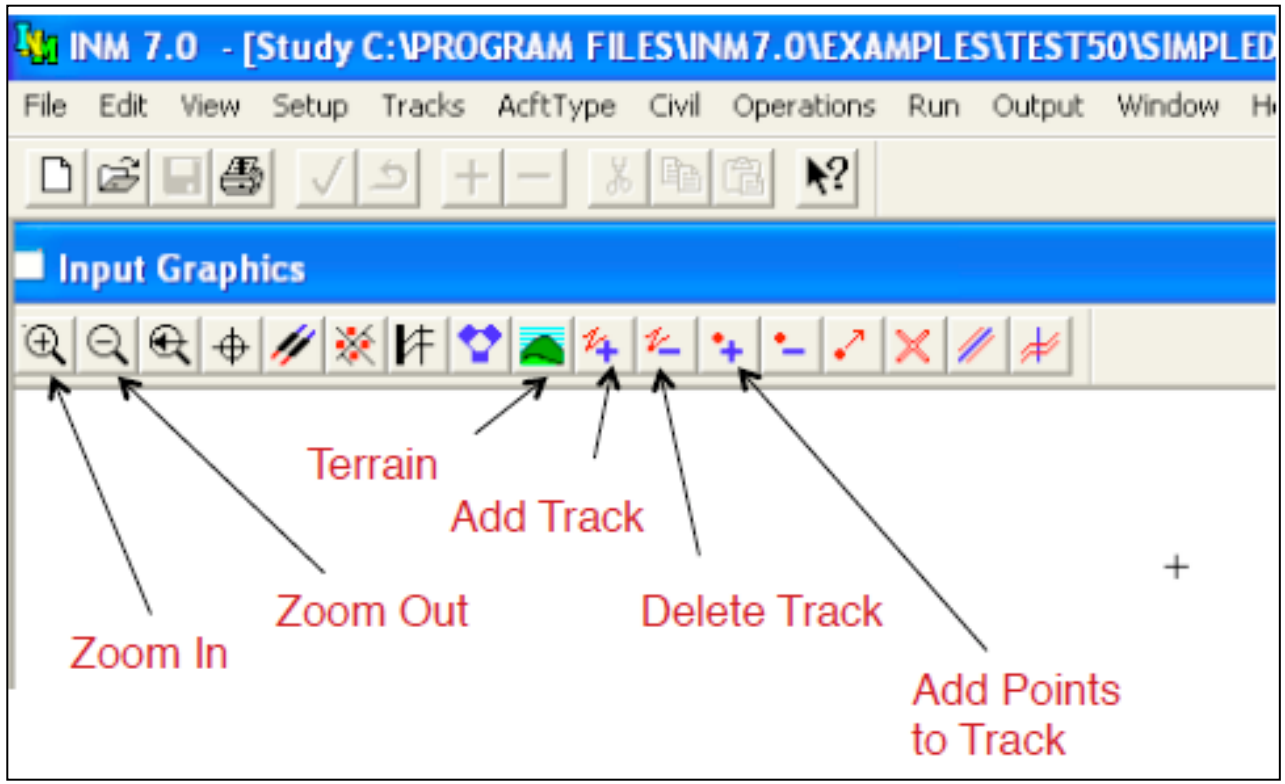
Adding departure I track

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

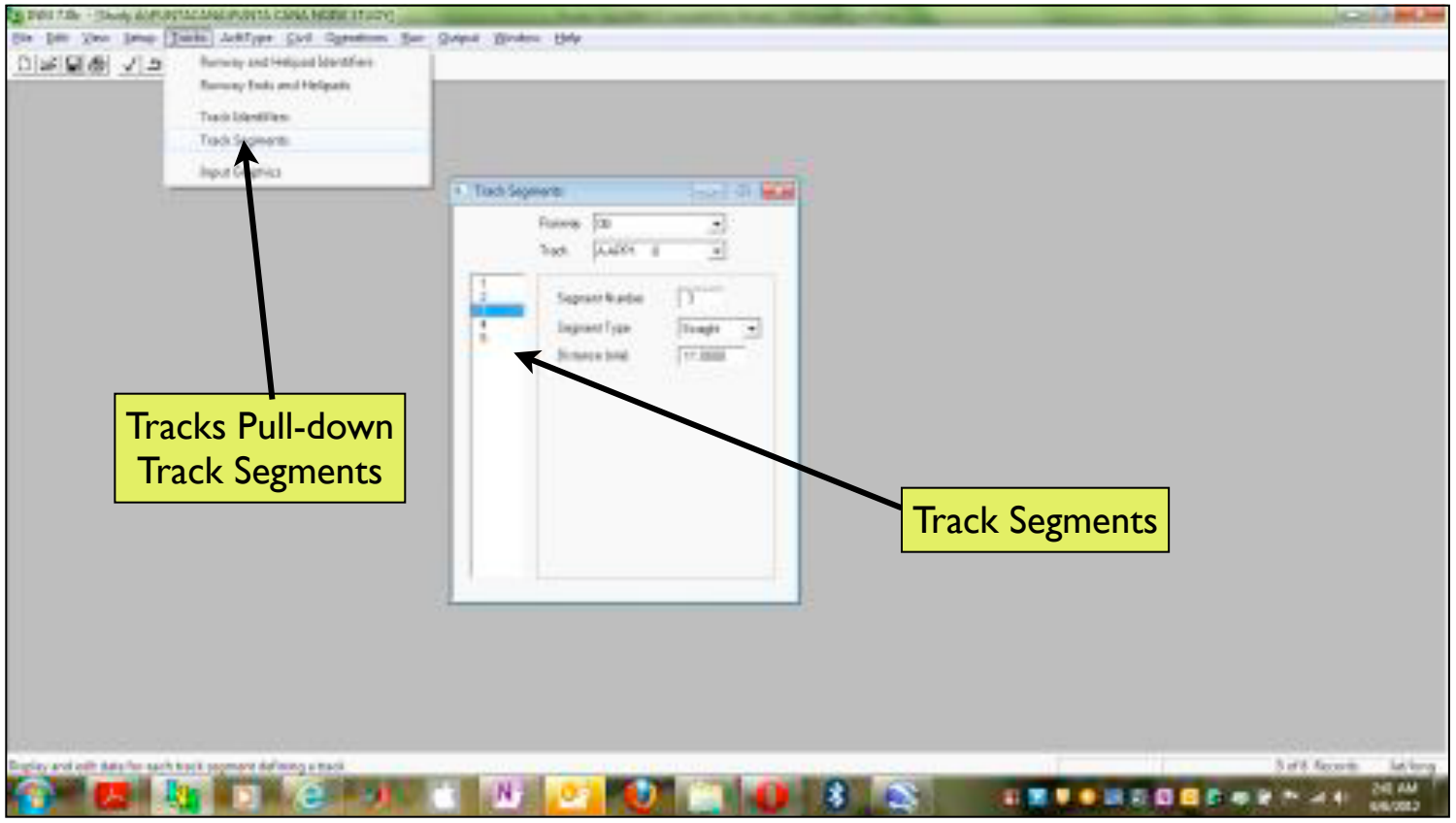
- Zoom in, Zoom out, terrain, adding tracks, deleting tracks are some of the options available



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.



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

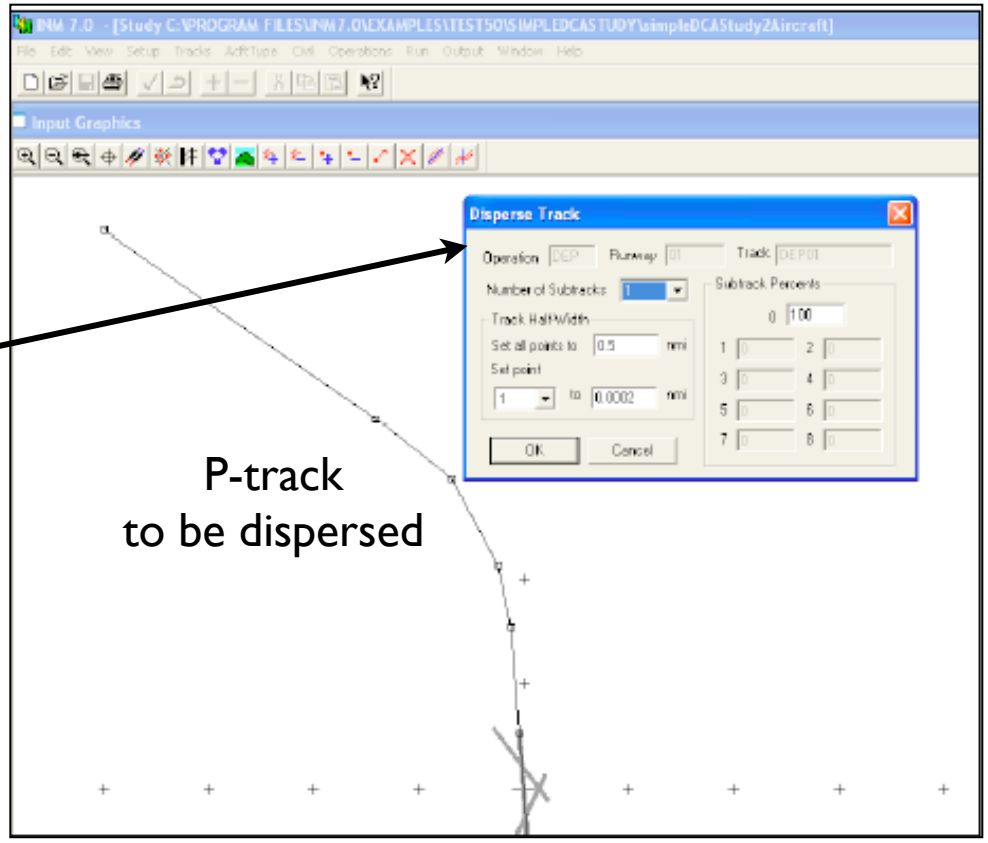
- V-tracks cannot be dispersed
- P-tracks can be dispersed

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

A Note on Track Dispersion

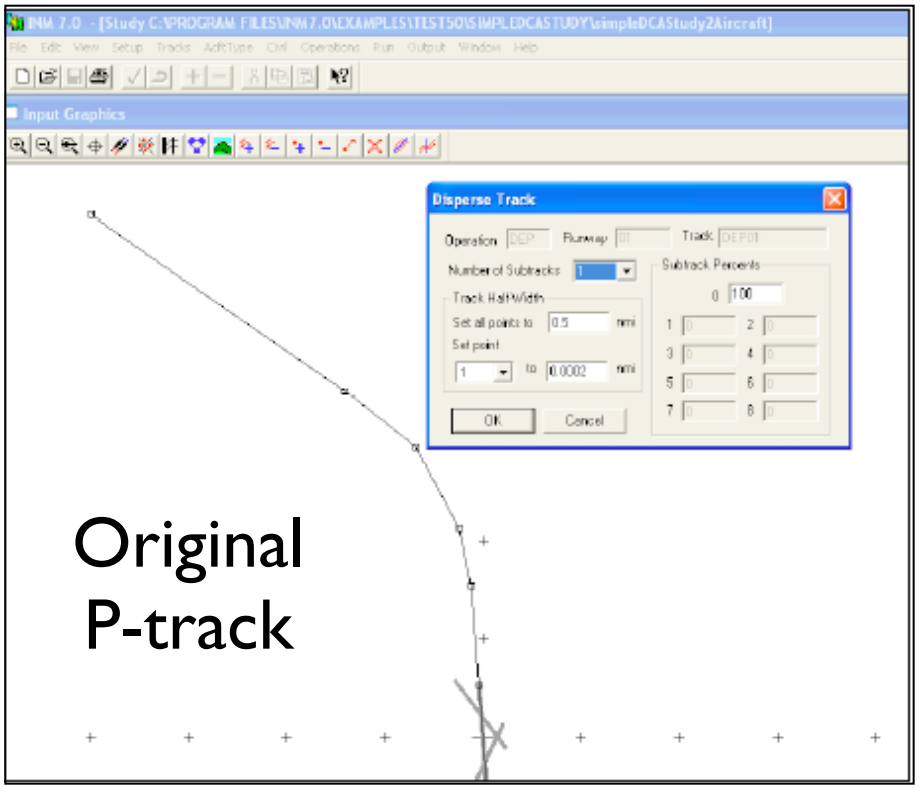
- Dispersion of a track is to more realistically simulate random profiles flown
- Go to Edit pull-down menu and select “Disperse Track”

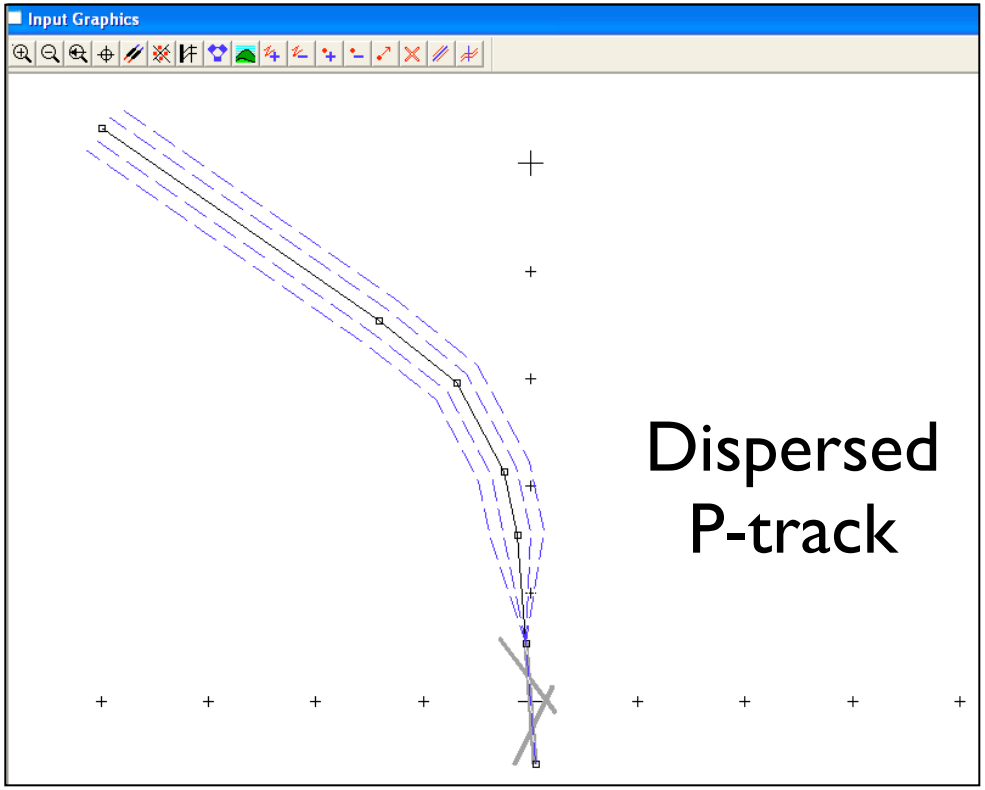
The dispersion is accomplished by specifying the number of subtracks and their position from the original track



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





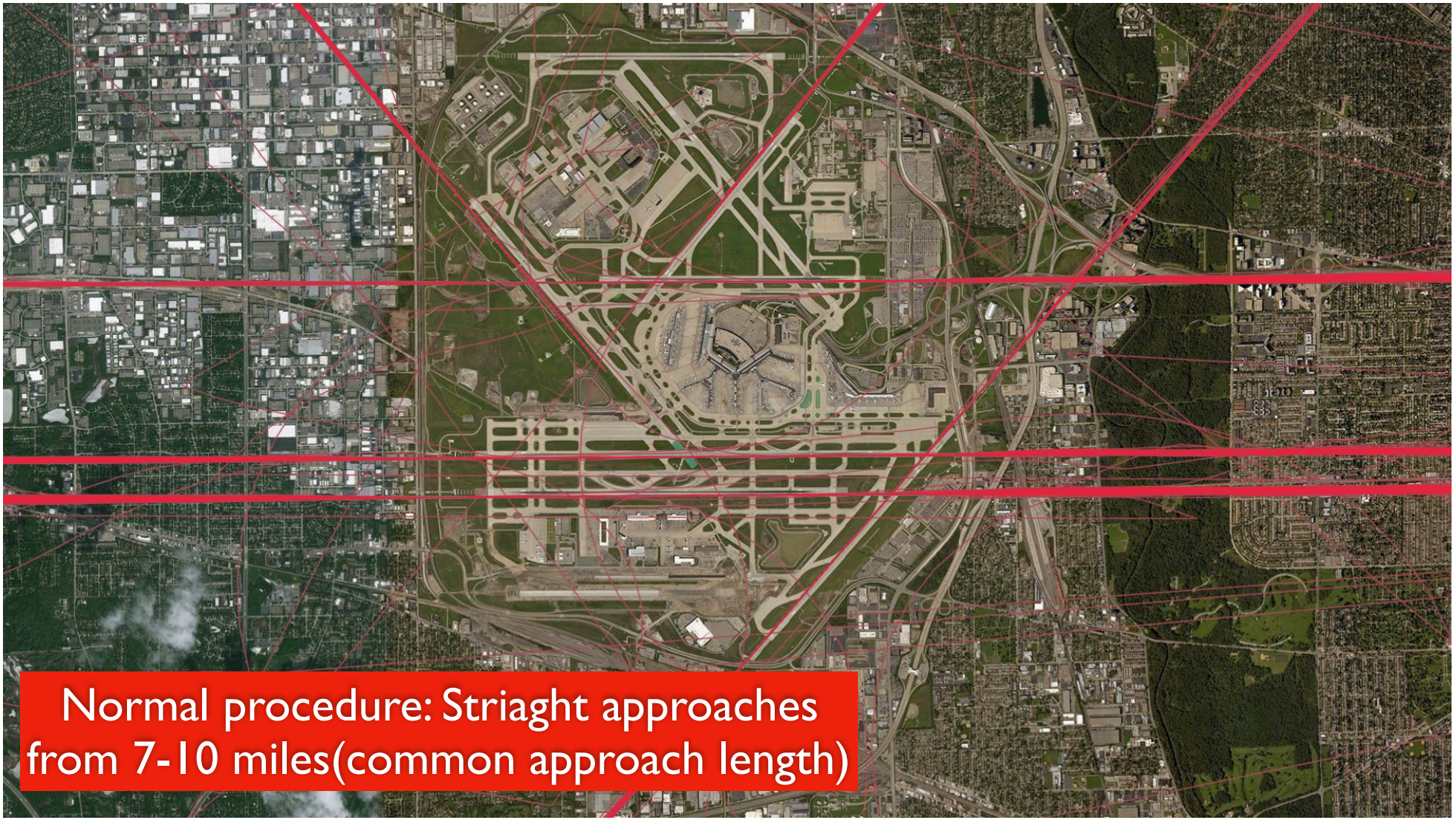
Track Dispersion Notes (1)

- 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 ORD Airport Nighttime Departures

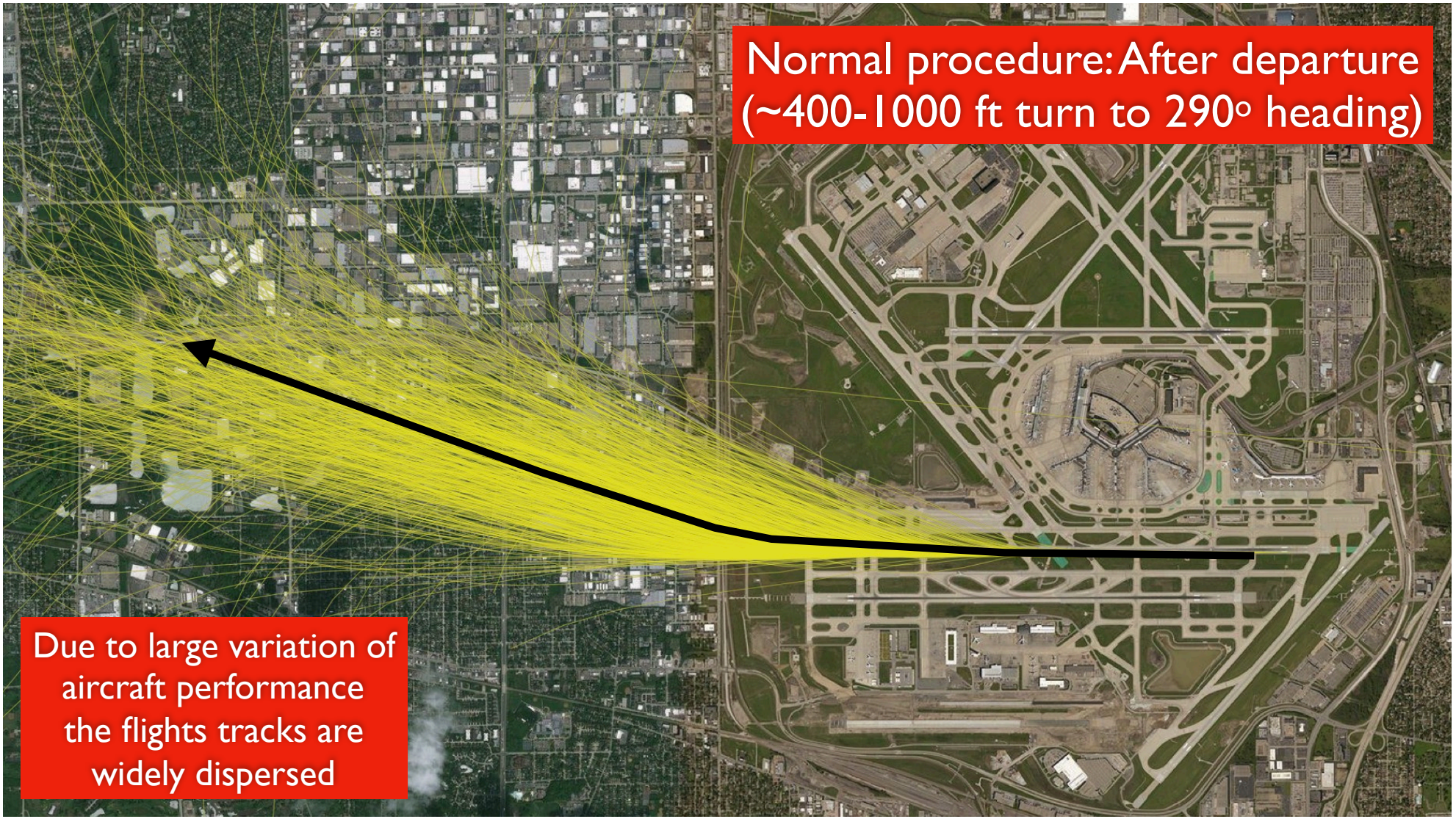
source of data: Chicago Department of Aviation

Example of Flight Track Dispersion ORD Airport Nighttime Arrivals



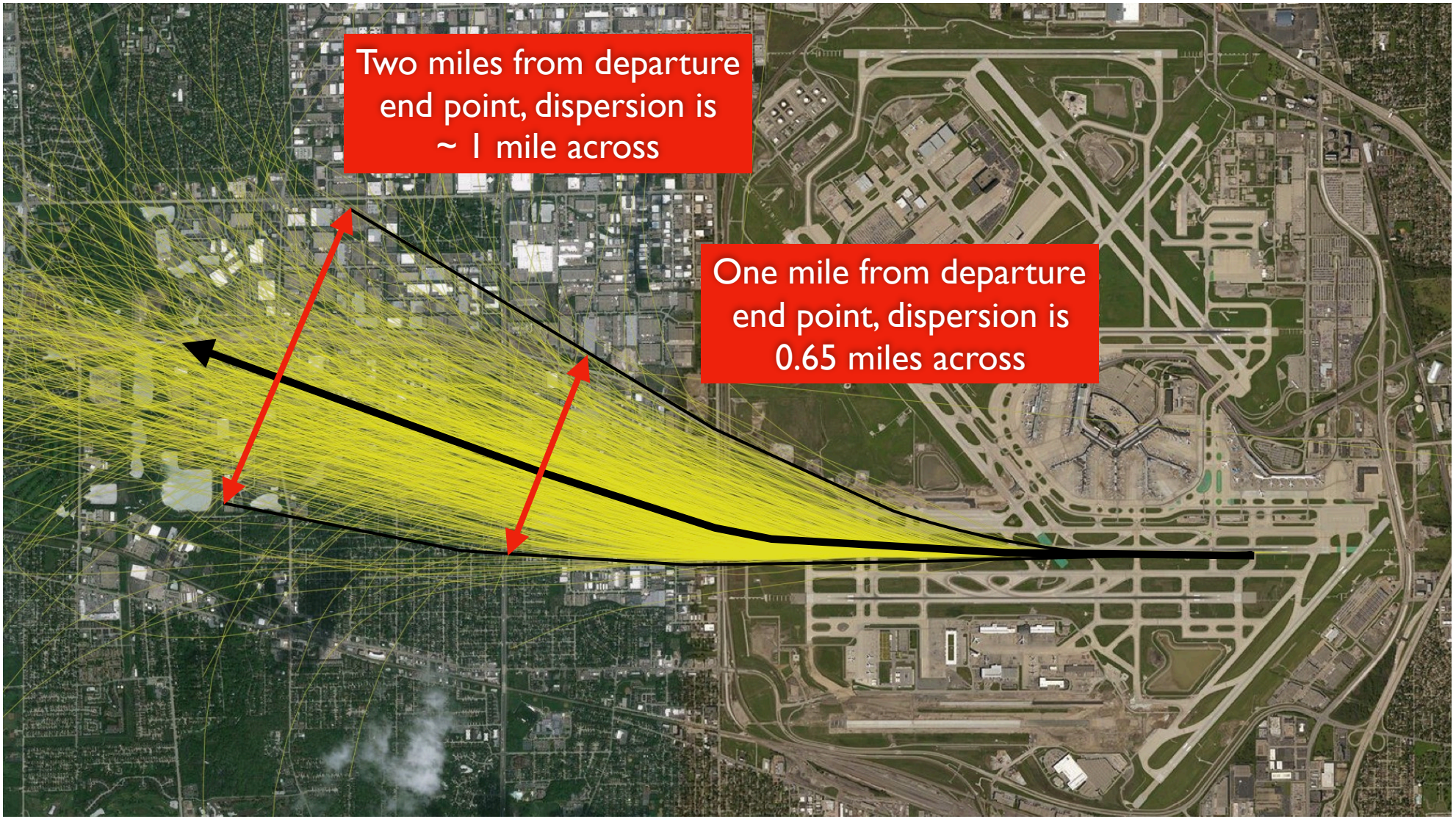
source of data: Chicago Department of Aviation

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



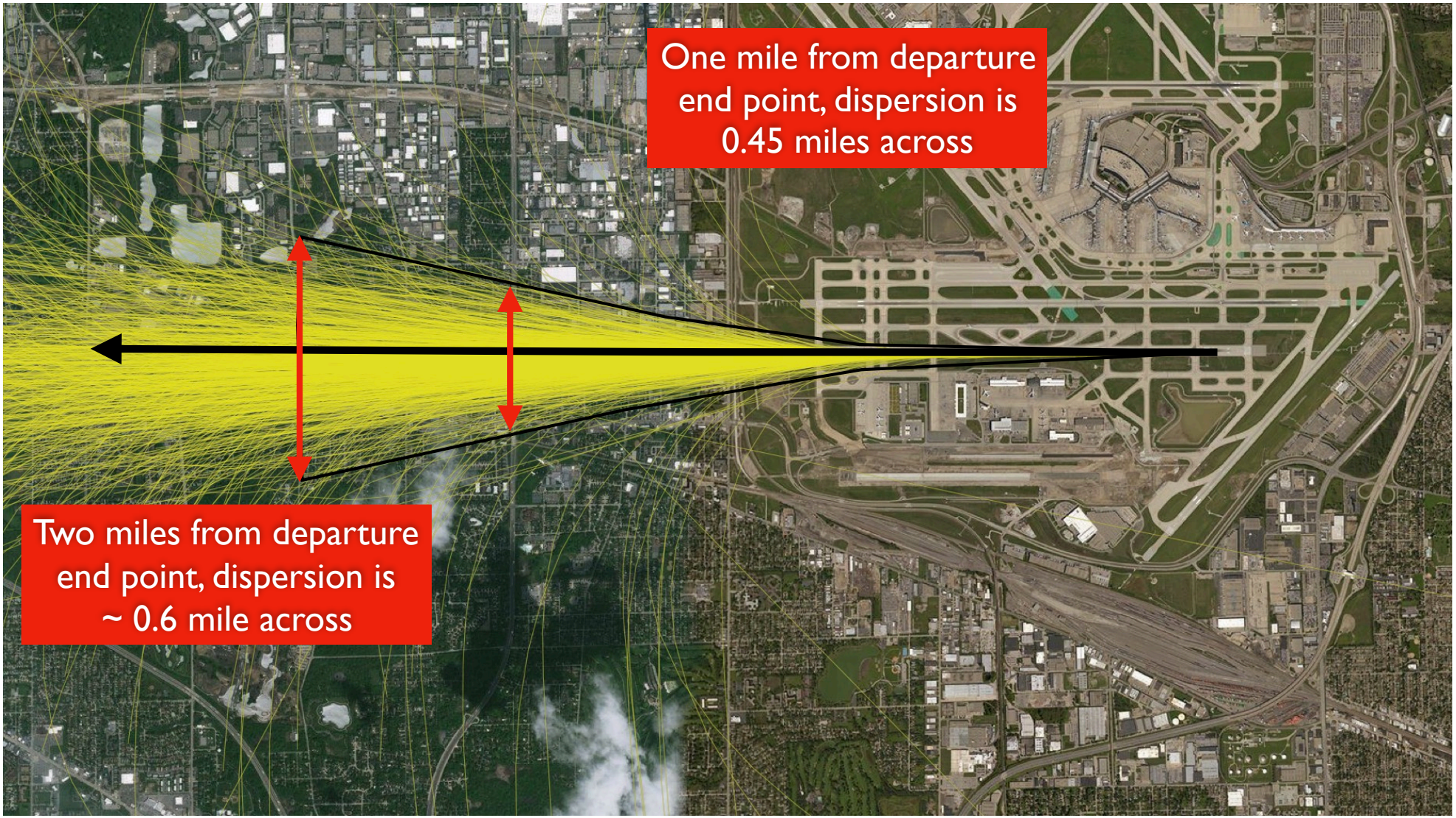
source of data: Chicago Department of Aviation

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



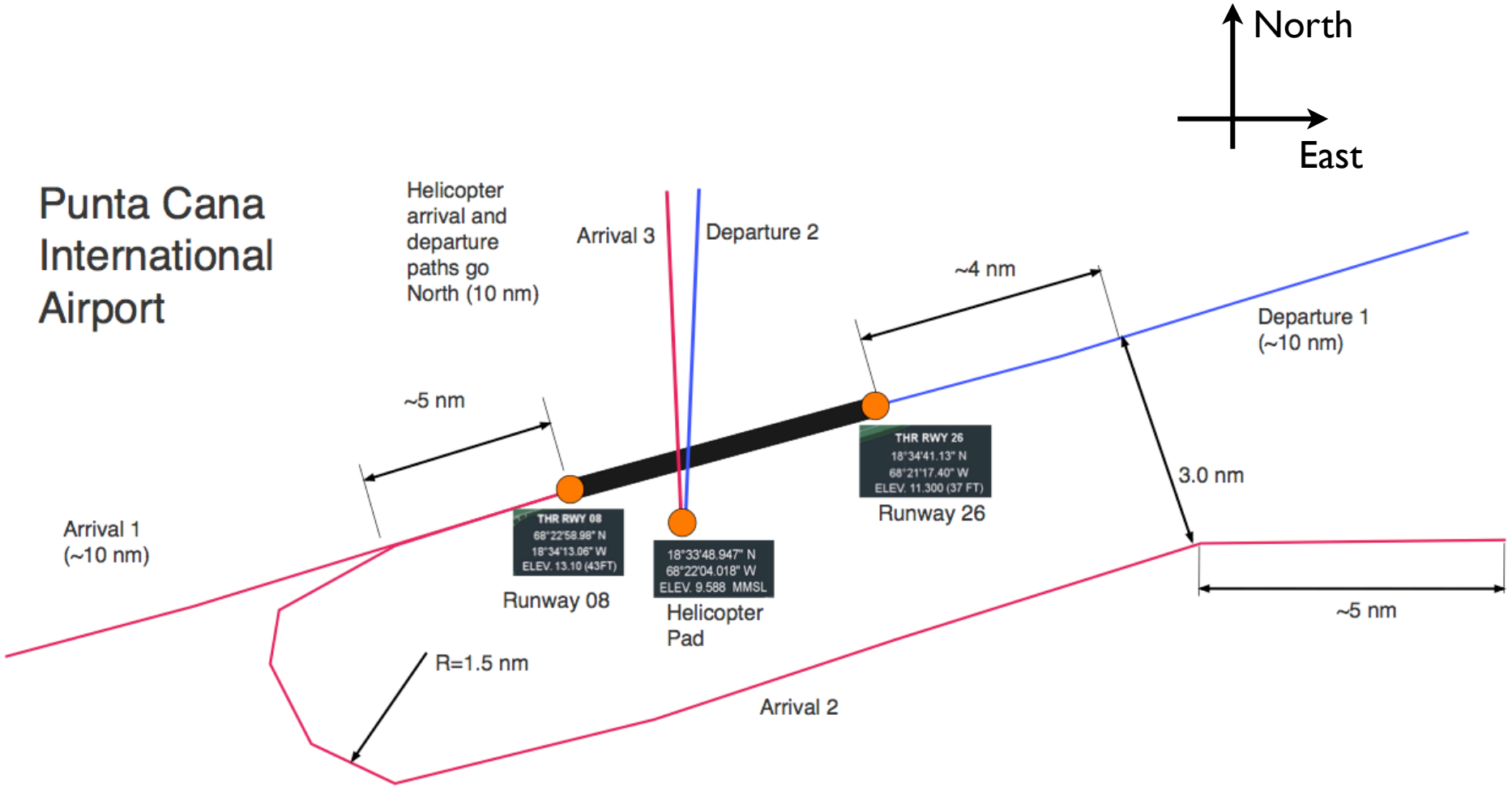
source of data: Chicago Department of Aviation

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



source of data: Chicago Department of Aviation

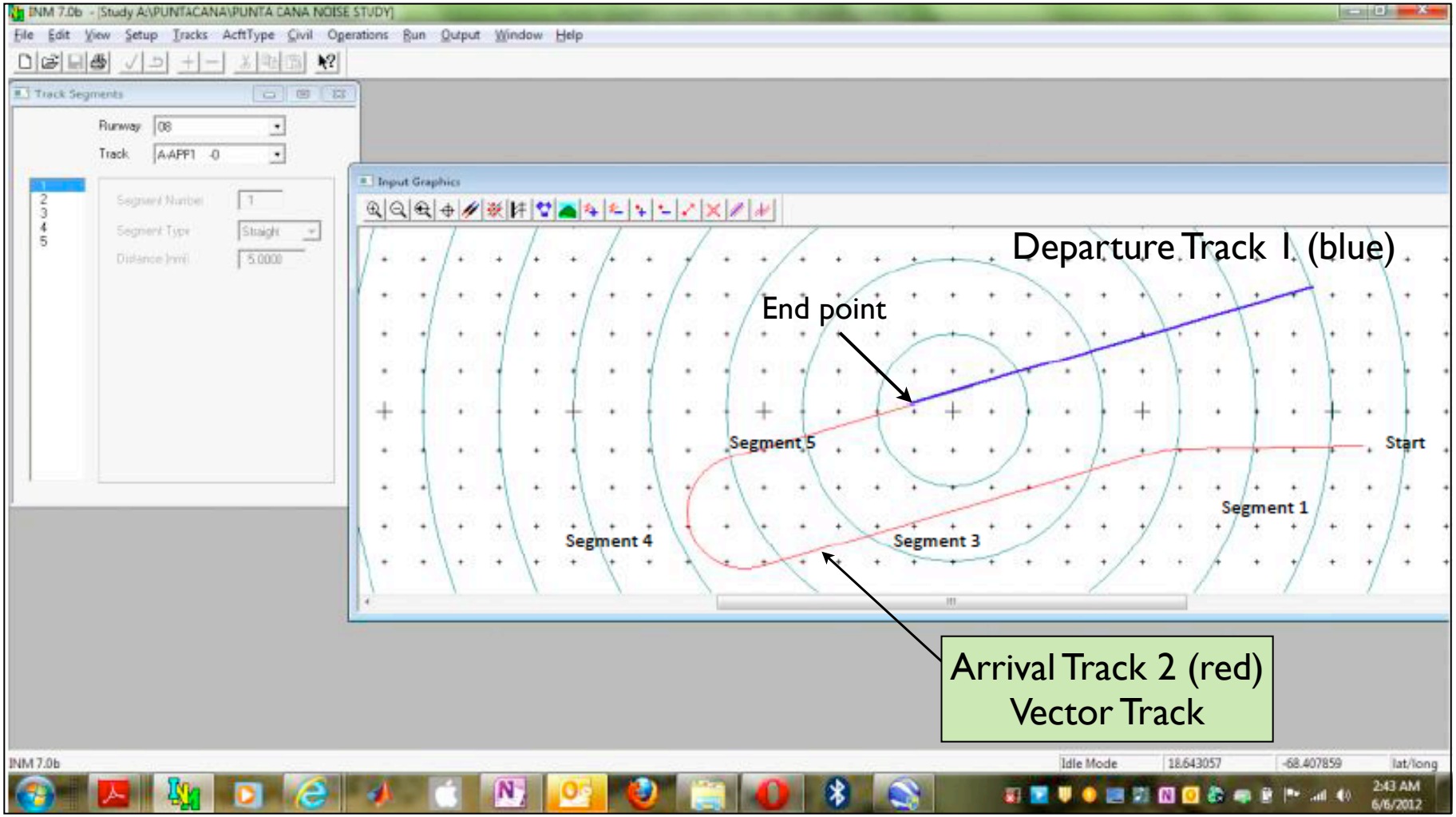
Flight Paths In and Out of the Airport



nm = nautical mile

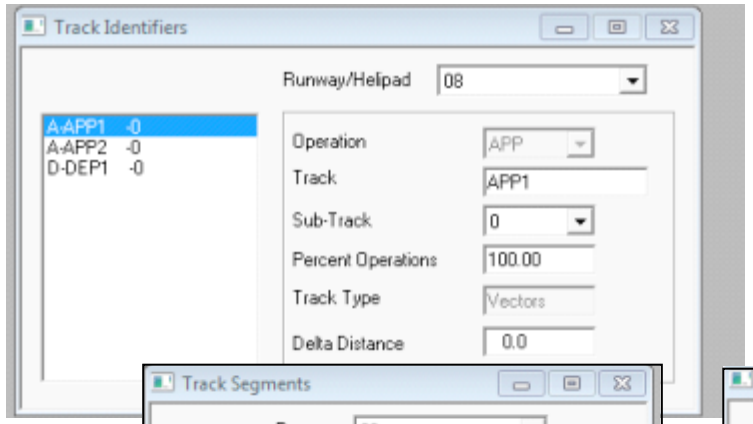
Arrival Track 2 at Punta Cana

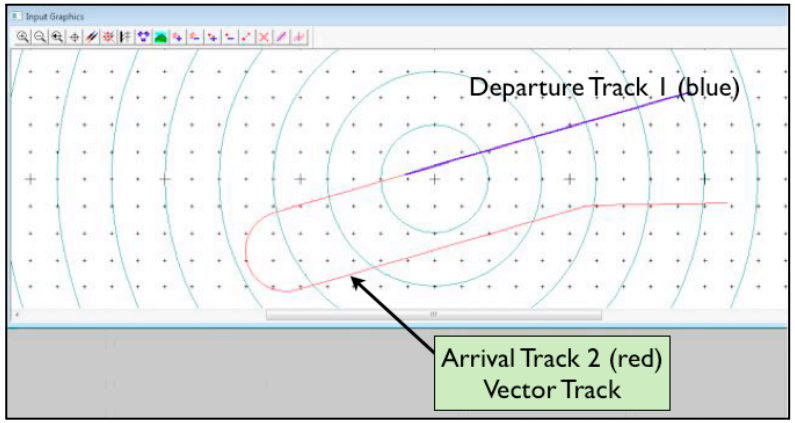
- Arrival Track 2 to Punta Cana International Airport

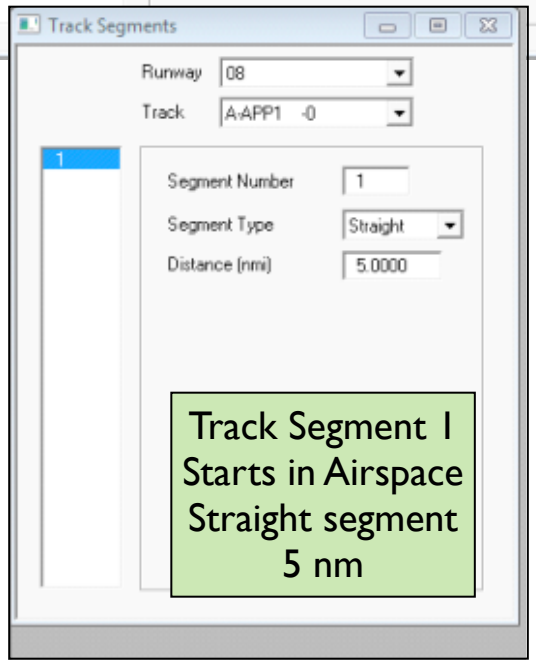


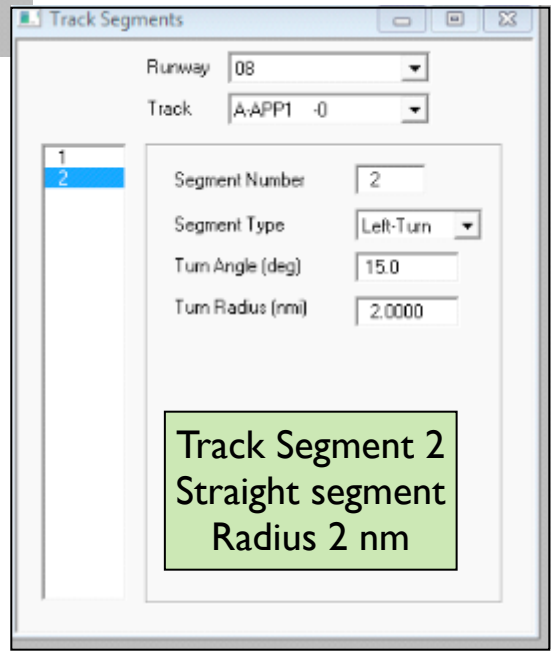
Arrival Track 2 at Punta Cana

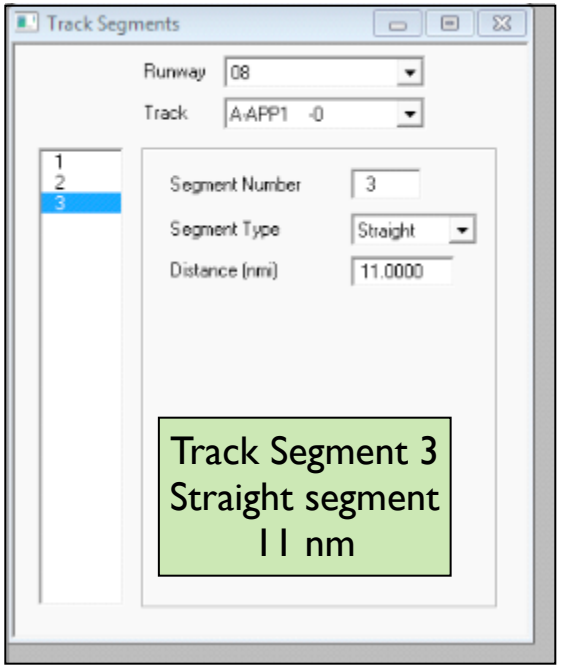
- Step-by-step procedure to create Arrival 2 track (5 segments)
- Arrivals should always begin in the airspace and end at the runway threshold





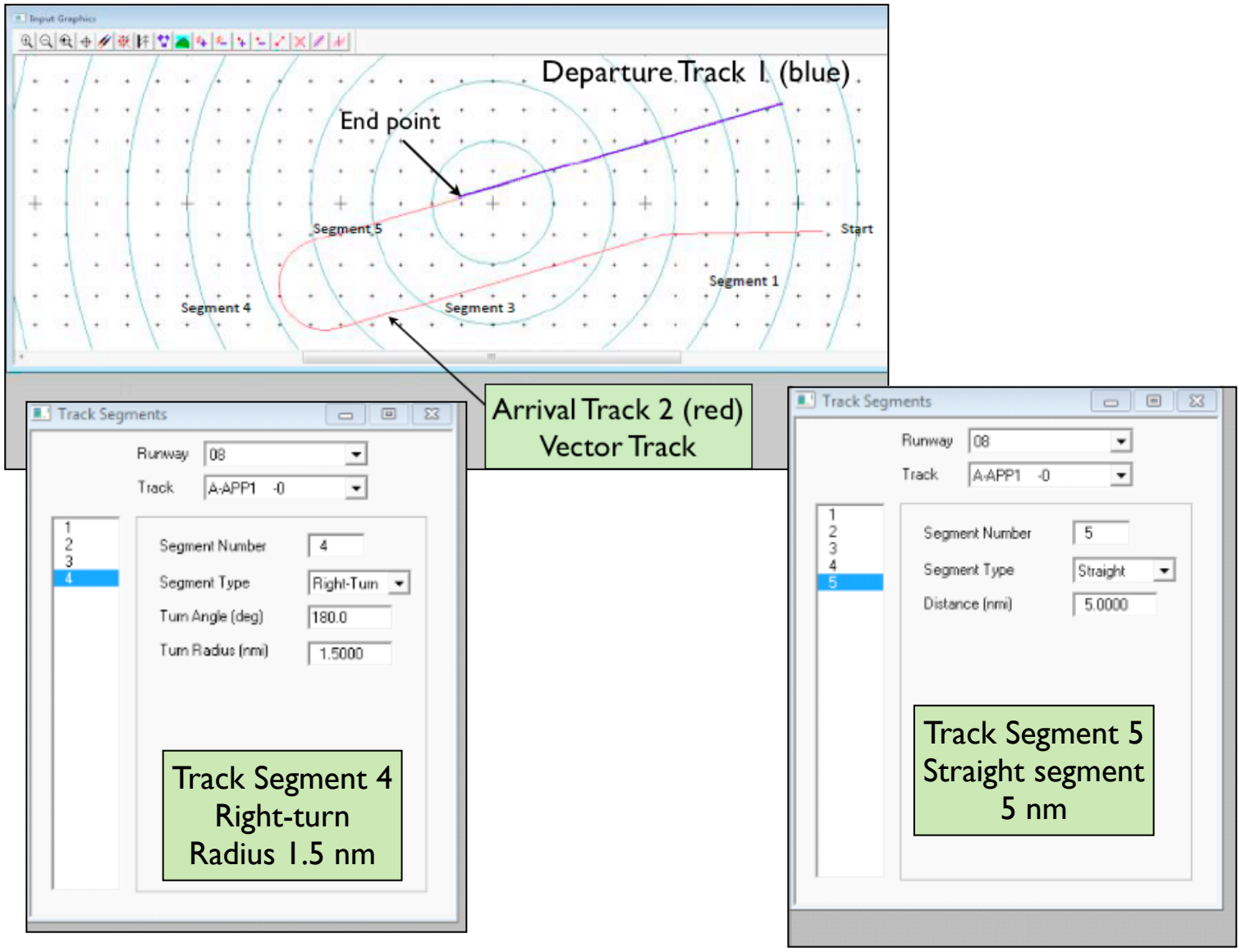






Arrival Track 2 at Punta Cana (cont.)

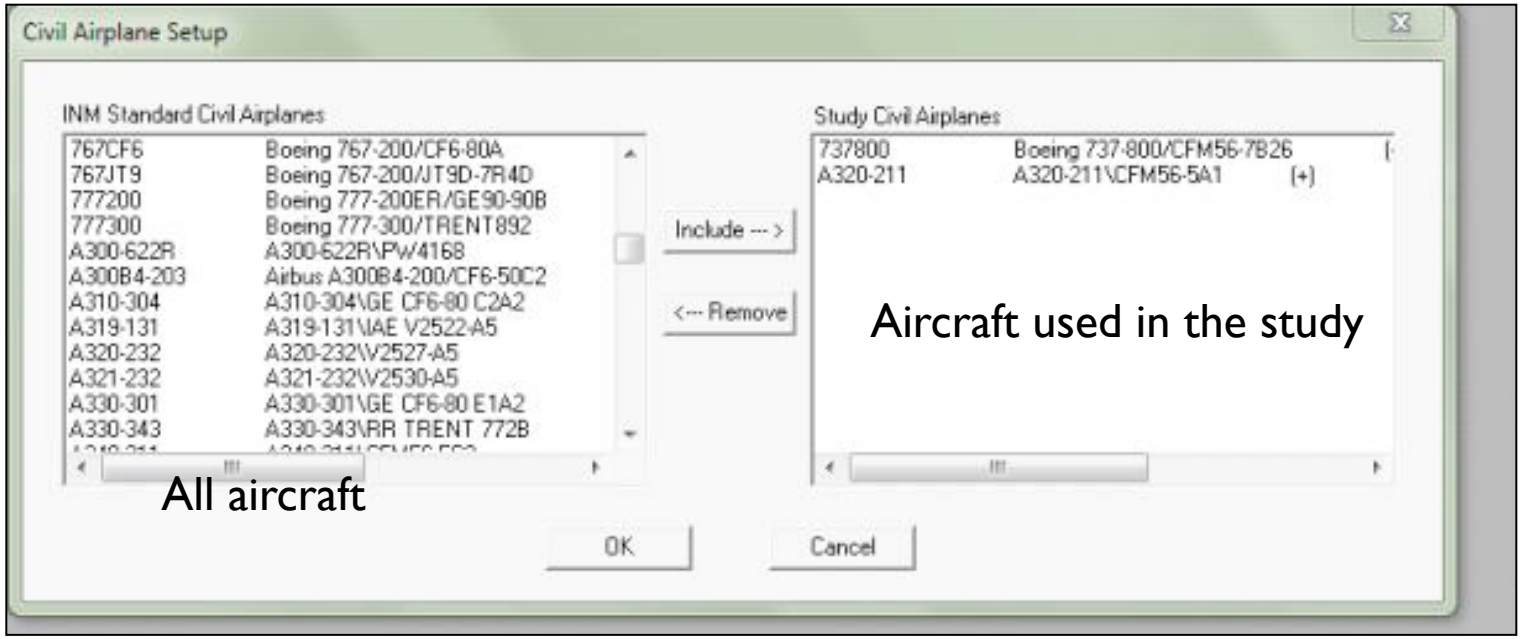
- Step by step procedure to create Arrival 2 track (5 segments)



Adding Aircraft to the Scenario

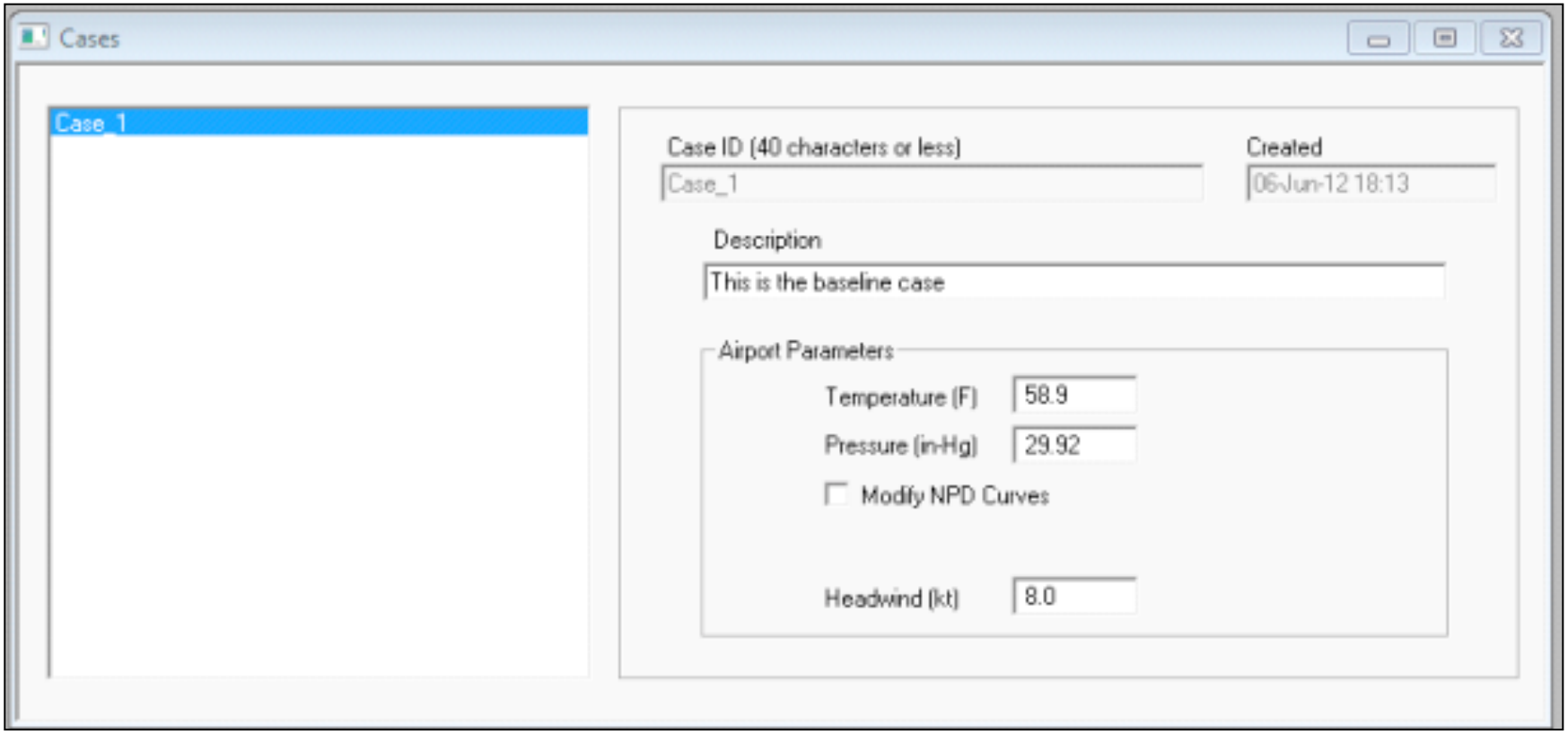
- INM has a large database of aircraft
- Each aircraft has an engine associated with it
- Consult airlines on which airframe/engine combinations are used at the airport

Go to SETUP --> Civil Airplanes



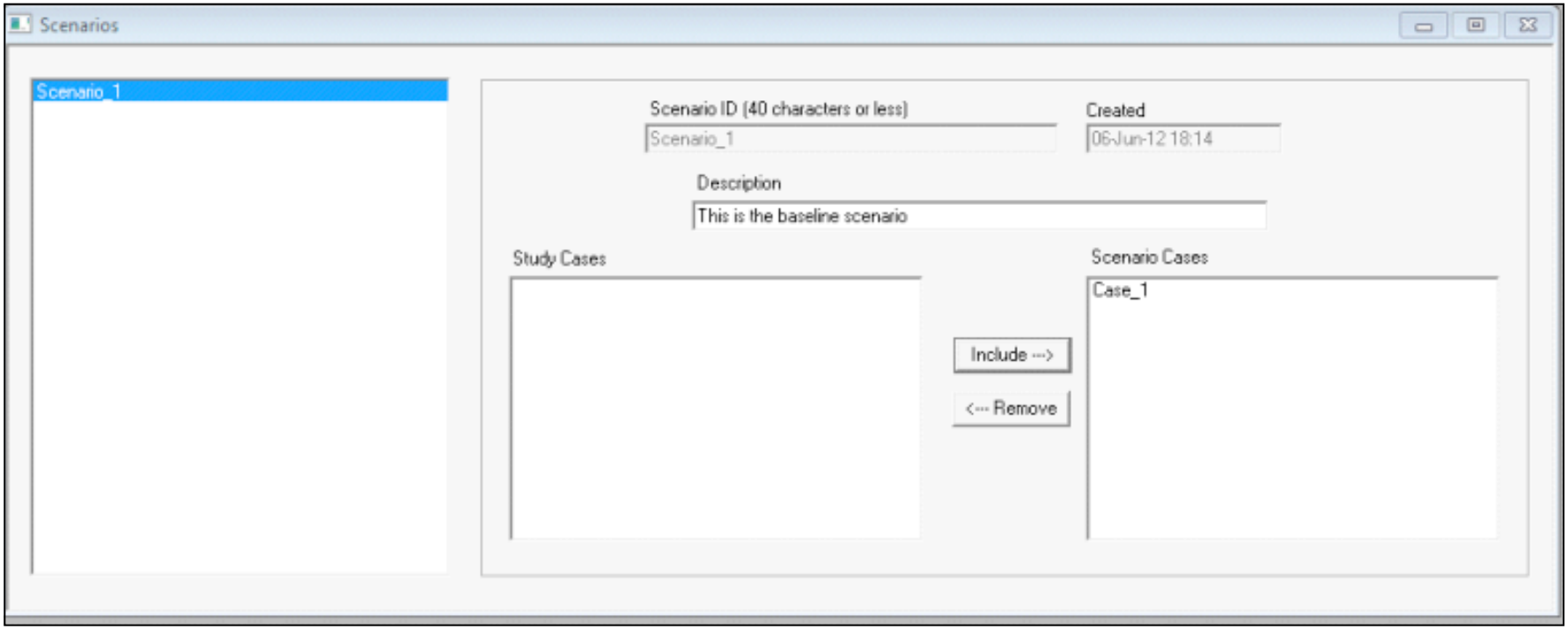
Setup a **Case** After Adding Aircraft

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



Setup a **Scenario** After Creating a Case

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



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
A320	9	6	17

Night time operations

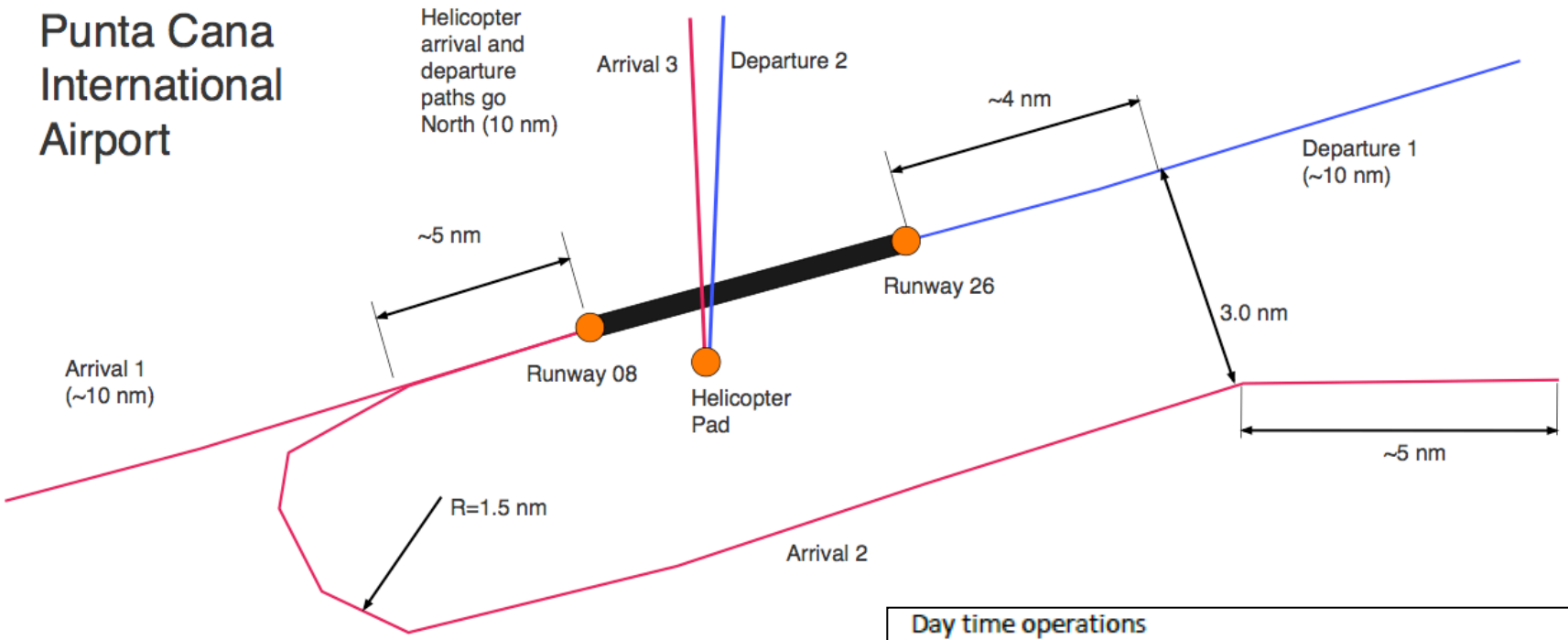
Aircraft	Arrivals(APP1)	Arrivals(APP2)	Departures(DEP1)
B737-800	2	3	7
A320	1.5	3.5	3

Aircraft operations are defined for each arrival and departure track

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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Night time operations

Aircraft	Arrivals(APP1)	Arrivals(APP2)	Departures(DEP1)
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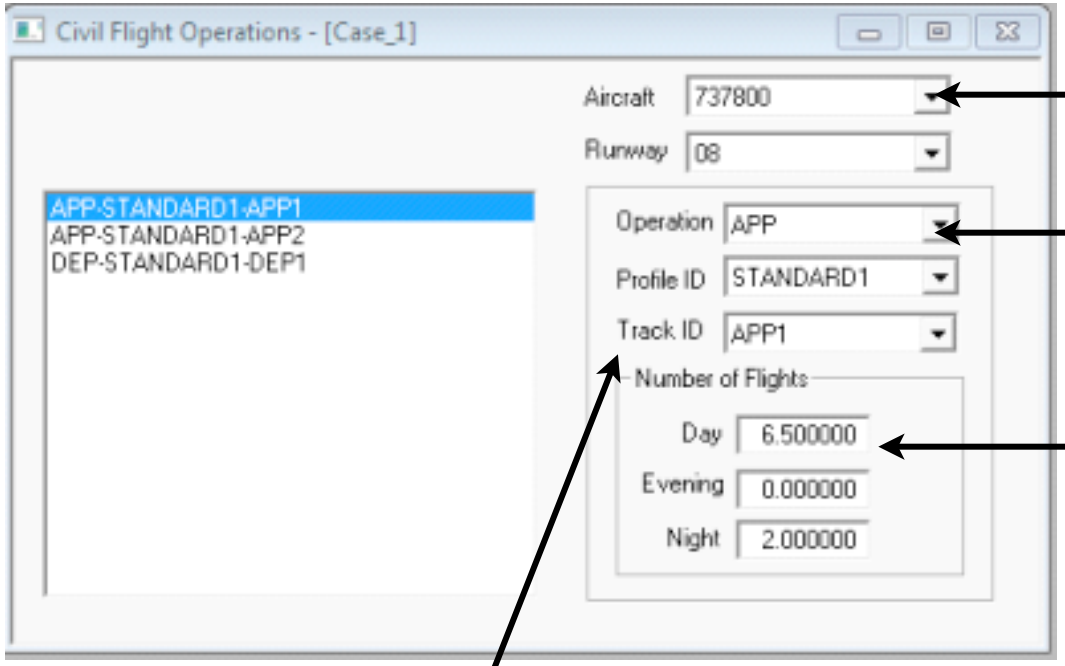
Aircraft Operations (3)
Boeing 737-800 on Arrival Track 1



Aircraft type
Runway = 08
Operation =Approach
Standard 1 profile
APP1 = Approach track

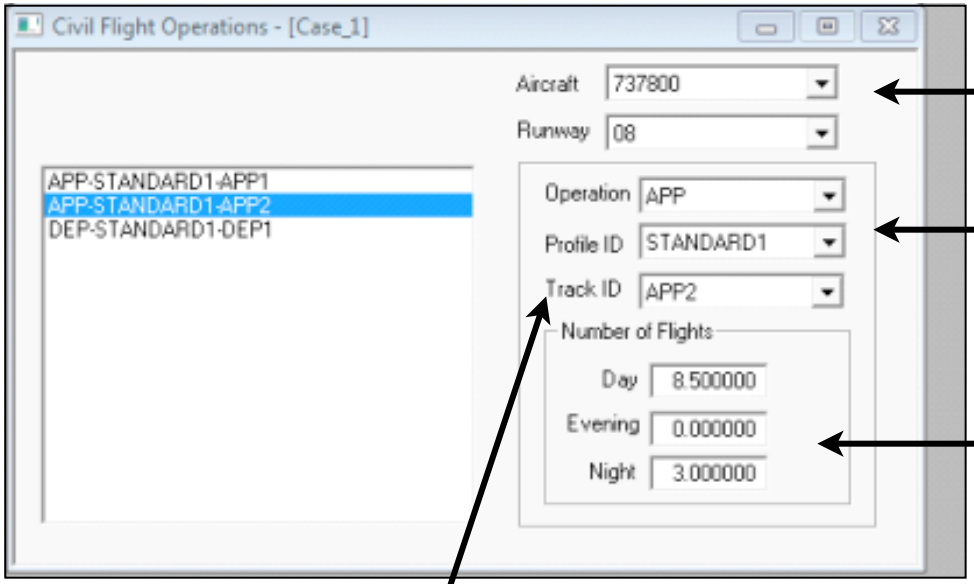
Aircraft operations (day, evening and night)

For LDN metric we do not need evening operations

Example: entering operations for Boeing 737-800 on Approach **Track 1**

Operations can be decimal (non-integer)

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



Aircraft type
Runway = 08
Operation =Approach
Standard 1 profile
APP2 = Approach track

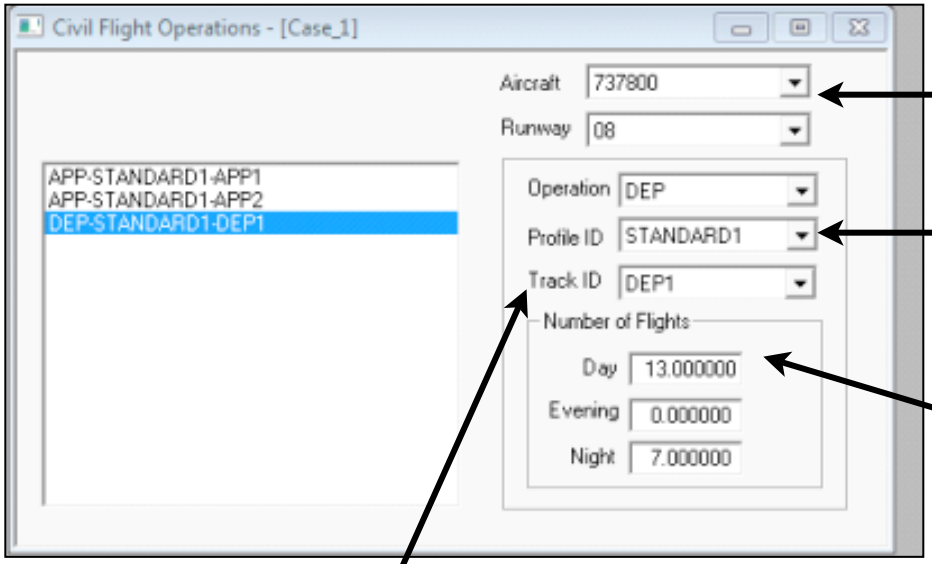
Aircraft operations (day, evening and night)

For LDN metric we do not need evening operations

Example: entering operations for Boeing 737-800 on **Approach Track 2**

Operations can be decimal (non-integer)

Aircraft Operations (5)
Boeing 737-800 on Departure Track 1



Aircraft type
Runway = 08
Operation =Approach
Standard 1 profile
DEP1 = Departure track

Aircraft operations (day, evening and night)

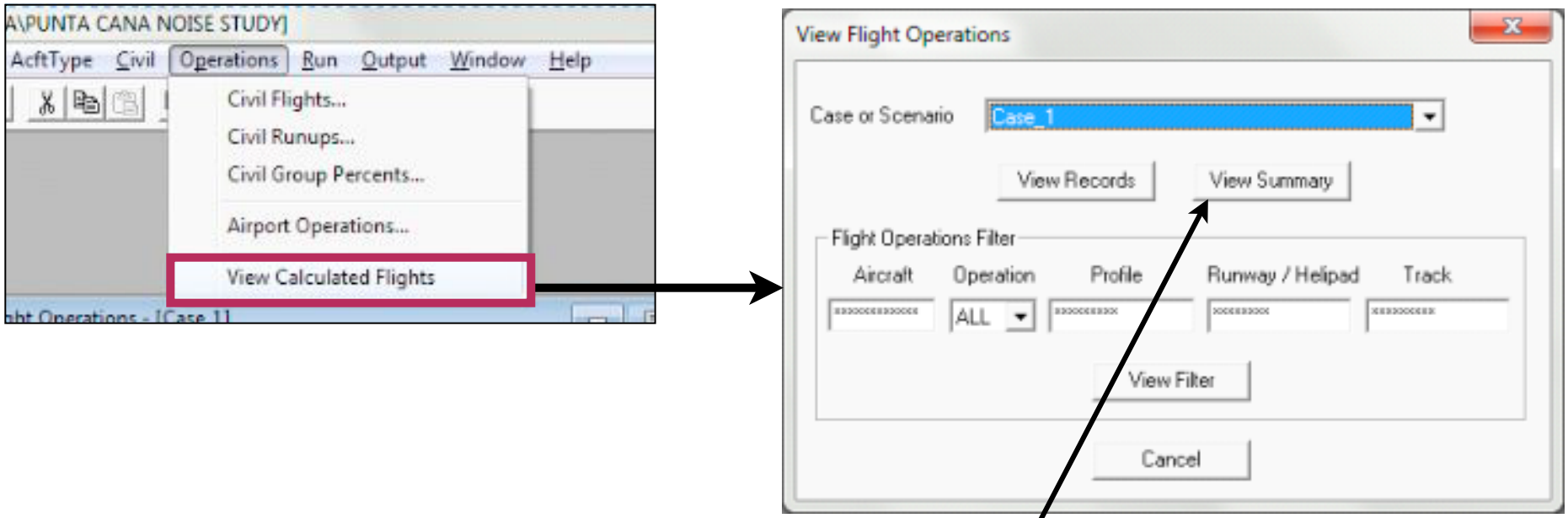
For LDN metric we do not need evening operations

Example: entering operations for Boeing 737-800 on Departure Track 1

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



View Summary

Summary of All Flight Operations Entered in the Scenario

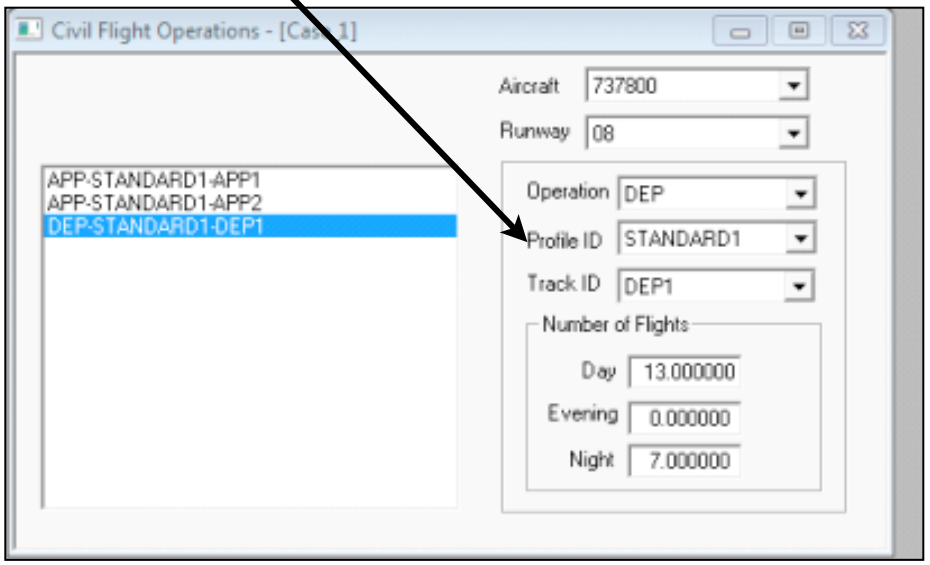
Flight Operations Summary - [Case_1]

ACFT	OP	PROFILE	S	RWY	TRACK	S	GRP	DAY	EVENING	NIGHT
737800	A	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		15.000000	0.000000	5.000000
737800	D	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		13.000000	0.000000	7.000000
737800	&	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		28.000000	0.000000	12.000000
A320-211	A	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		15.000000	0.000000	5.000000
A320-211	D	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		17.000000	0.000000	3.000000
A320-211	&	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		32.000000	0.000000	8.000000
&&&&&&&&&&&	A	&&&&&&&&	&	08	APP1	&		15.500000	0.000000	3.500000
&&&&&&&&&&&	A	&&&&&&&&	&	08	APP2	&		14.500000	0.000000	6.500000
&&&&&&&&&&&	D	&&&&&&&&	&	08	DEP1	&		30.000000	0.000000	10.000000
&&&&&&&&&&&	D	&&&&&&&&	&	08	&&&&&&&&	&		30.000000	0.000000	10.000000
&&&&&&&&&&&	A	&&&&&&&&	&	08	&&&&&&&&	&		30.000000	0.000000	10.000000
&&&&&&&&&&&	&	&&&&&&&&	&	08	&&&&&&&&	&		60.000000	0.000000	20.000000
&&&&&&&&&&&	&	&&&&&&&&	&	26	&&&&&&&&	&		0.000000	0.000000	0.000000
&&&&&&&&&&&	&	&&&&&&&&	&	OVF	&&&&&&&&	&		0.000000	0.000000	0.000000
&&&&&&&&&&&	D	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		30.000000	0.000000	10.000000
&&&&&&&&&&&	A	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		30.000000	0.000000	10.000000
&&&&&&&&&&&	T	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		0.000000	0.000000	0.000000
&&&&&&&&&&&	V	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		0.000000	0.000000	0.000000
&&&&&&&&&&&	F	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		0.000000	0.000000	0.000000
&&&&&&&&&&&	X	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		0.000000	0.000000	0.000000
&&&&&&&&&&&	&	&&&&&&&&	&	&&&&&&&&	&&&&&&&&	&		60.000000	0.000000	20.000000

Total operations (day and night)

A Side Note on Departure Profiles

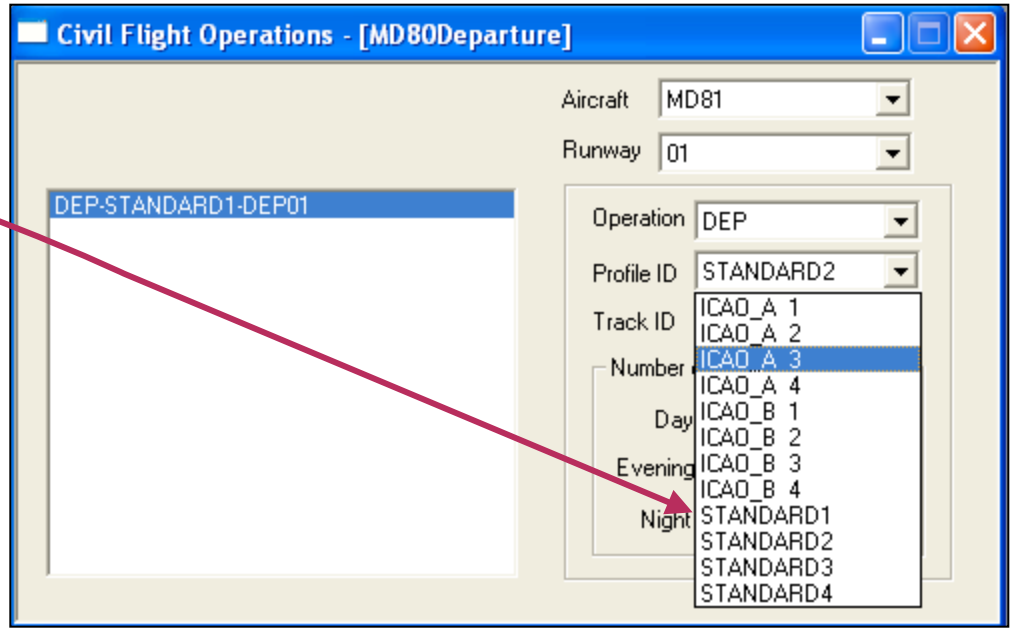
- INM contains aircraft performance equations that are sensitive to the stage length flown
- For the same aircraft type, a heavily loaded aircraft climbs slower than a light aircraft
- A heavy loaded aircraft generates more noise because it flies closer to the ground and the community below
- INM uses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



Departure Profiles (2)

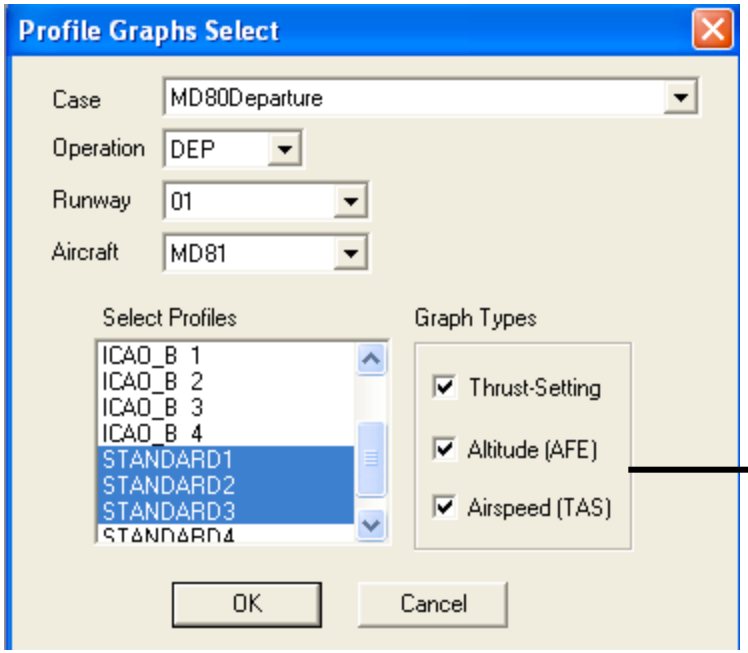
- Each profile represents a change in aircraft takeoff (or landing) state at intervals of 500 miles
- Example: Boeing (McDonnell Douglas) MD-81 aircraft
  - Standard profile 1 = flights less than 500 miles
  - Standard profile 2 = flights from 500-1000 miles
  - Standard profile 3 = flights from 1000-1500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

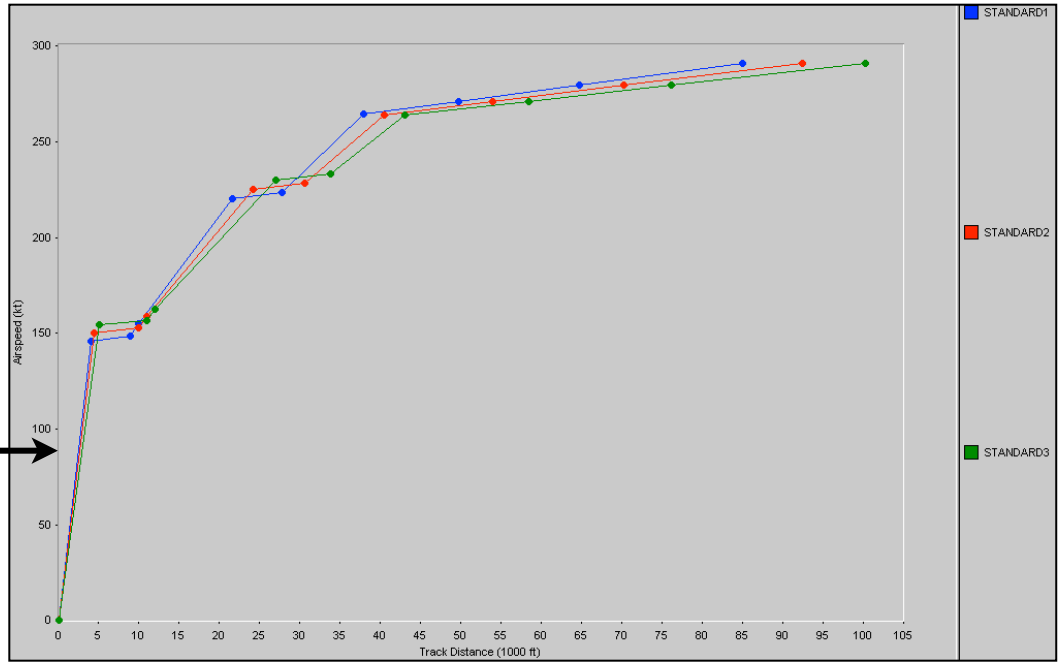
A flight from PUJ to Charlotte in MD-81 would be defined as Standard Profile 3



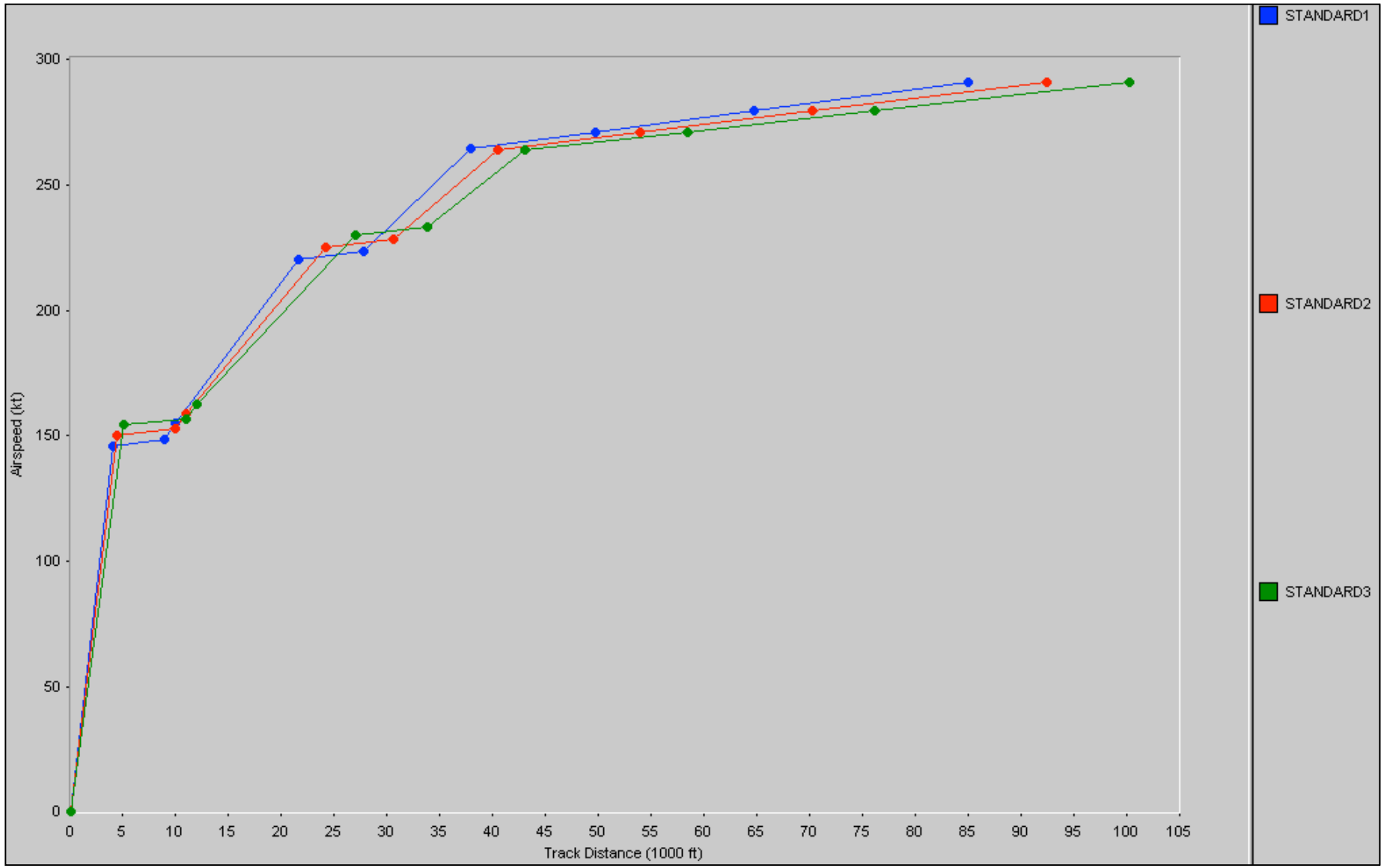
If You Want to See the Aircraft Profiles Flown by INM

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

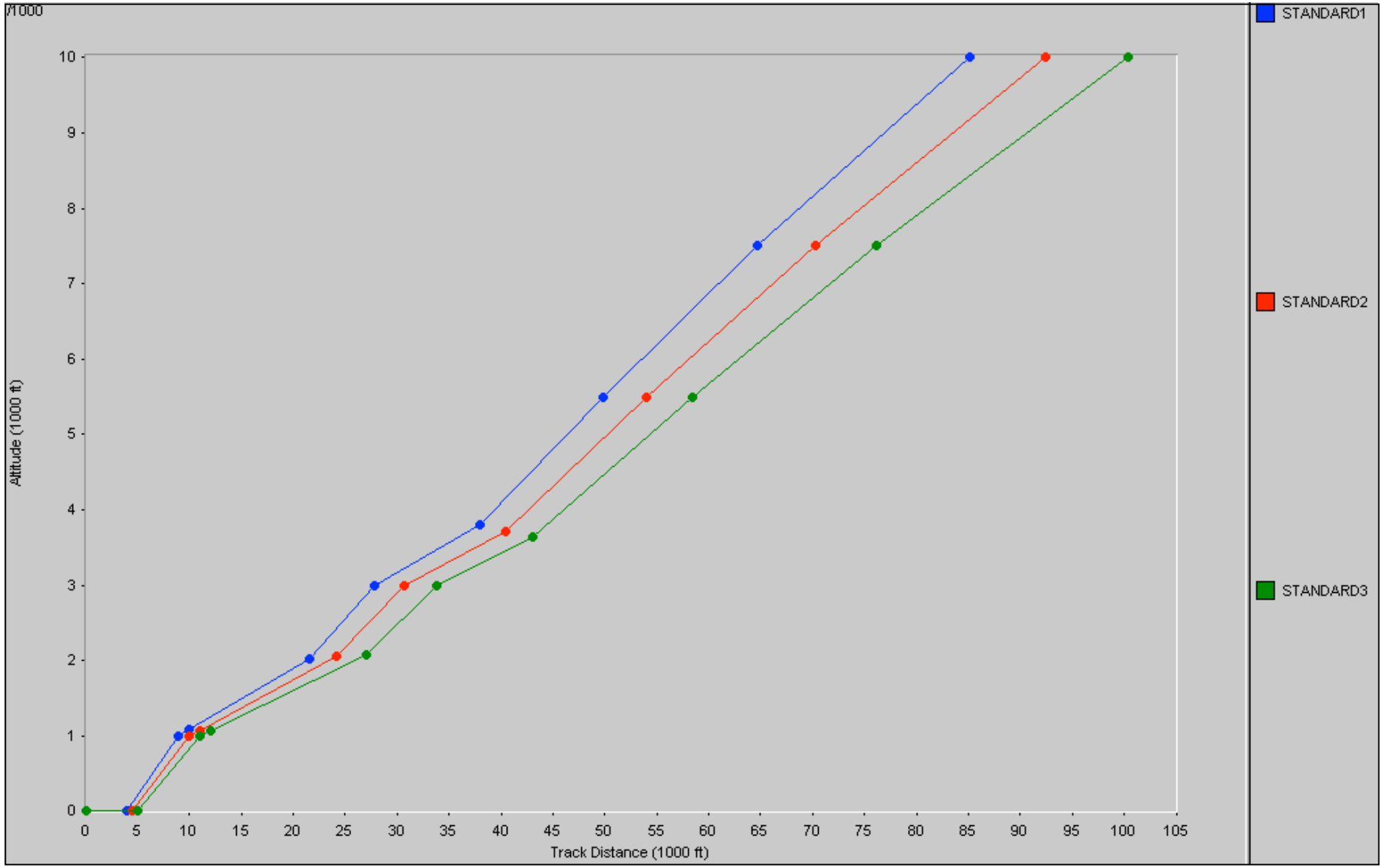




Sample Airspeed Profiles for MD-81

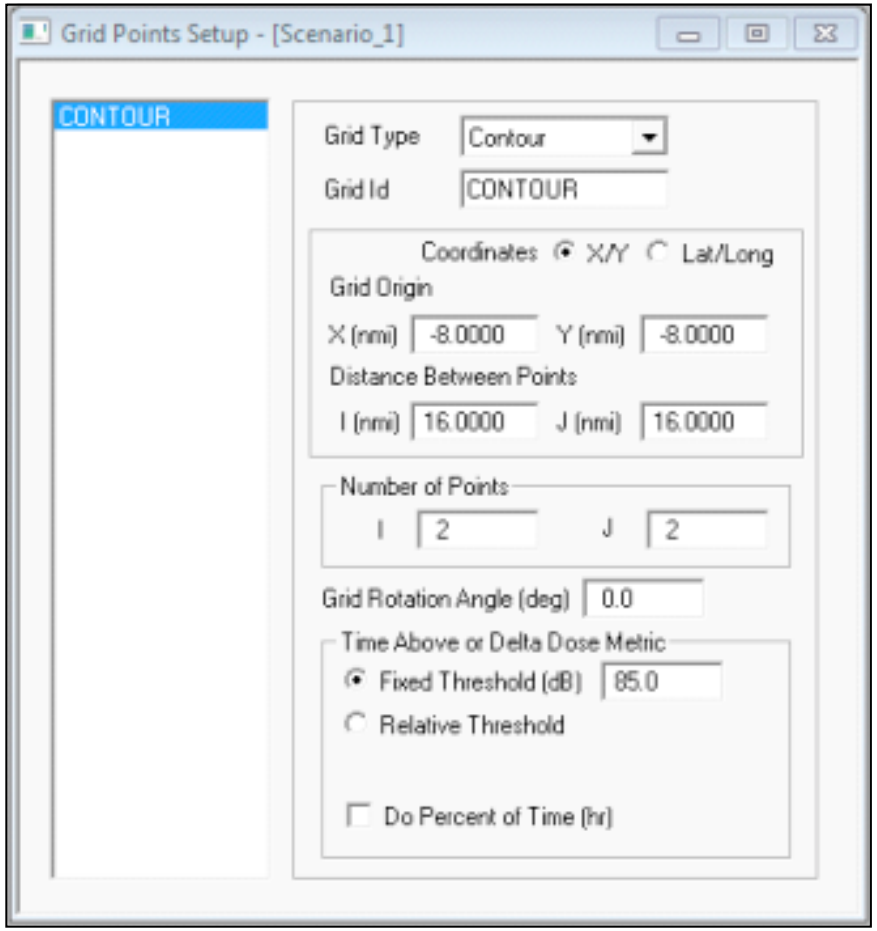


Sample Altitude Profiles for MD-81



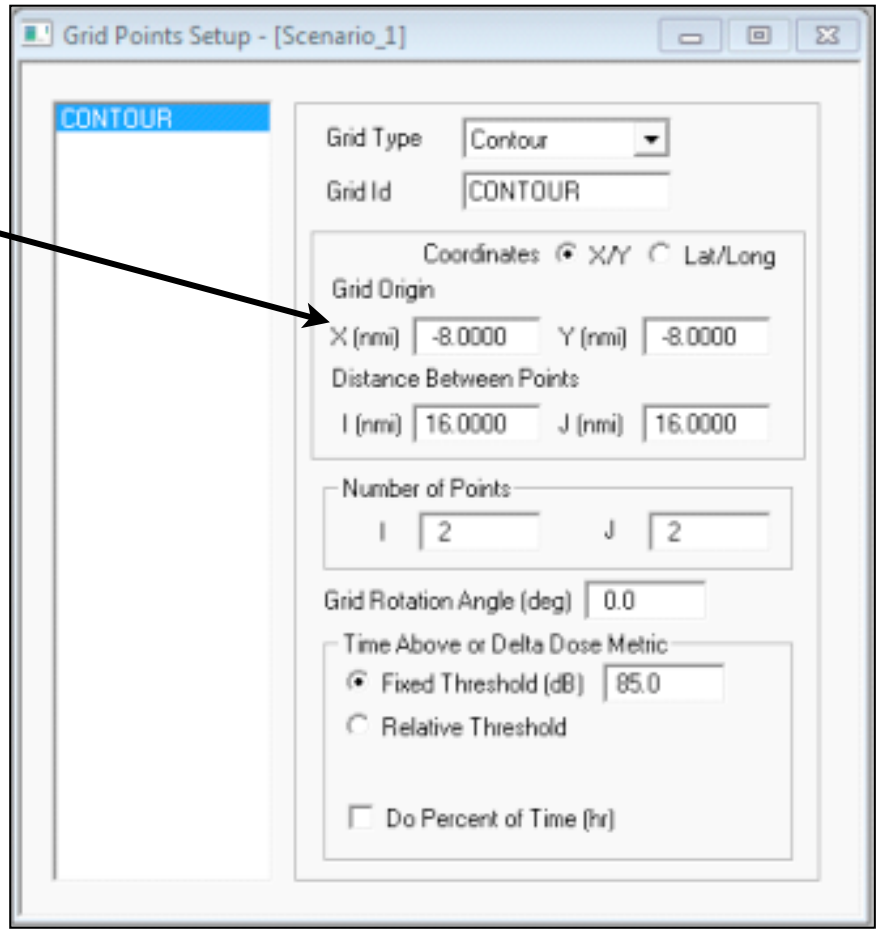
Setup Computational Grid

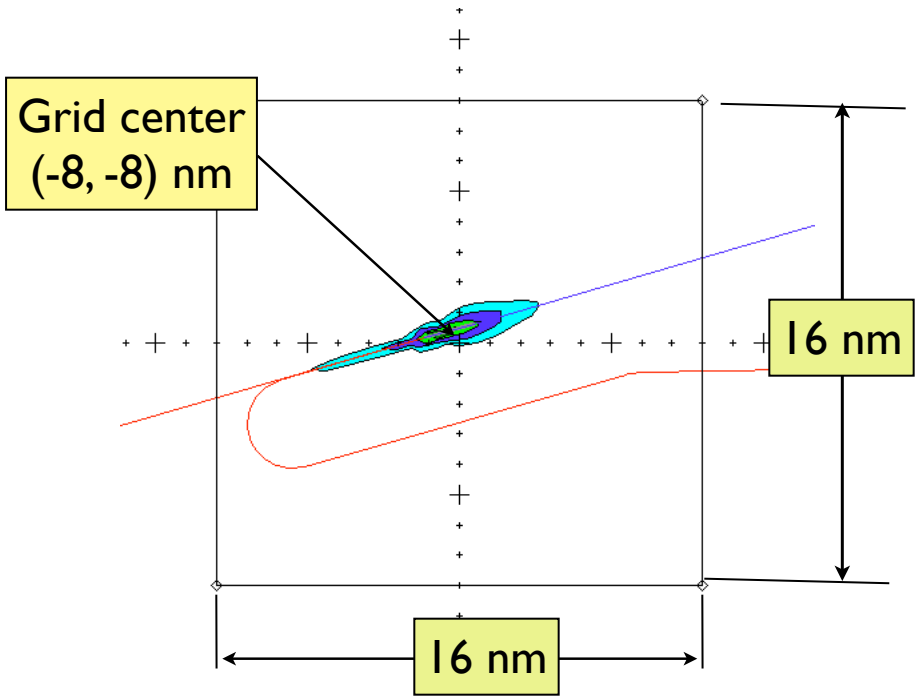
- INM calculates LDN or other noise metric levels at discrete points on a GRID that you define
- Then the models interpolates logarithmically to obtain equal LDN contours
- You define the grid as follows:
- **Go to RUN --> Grid Setup**



Setup Computational Grid (2)

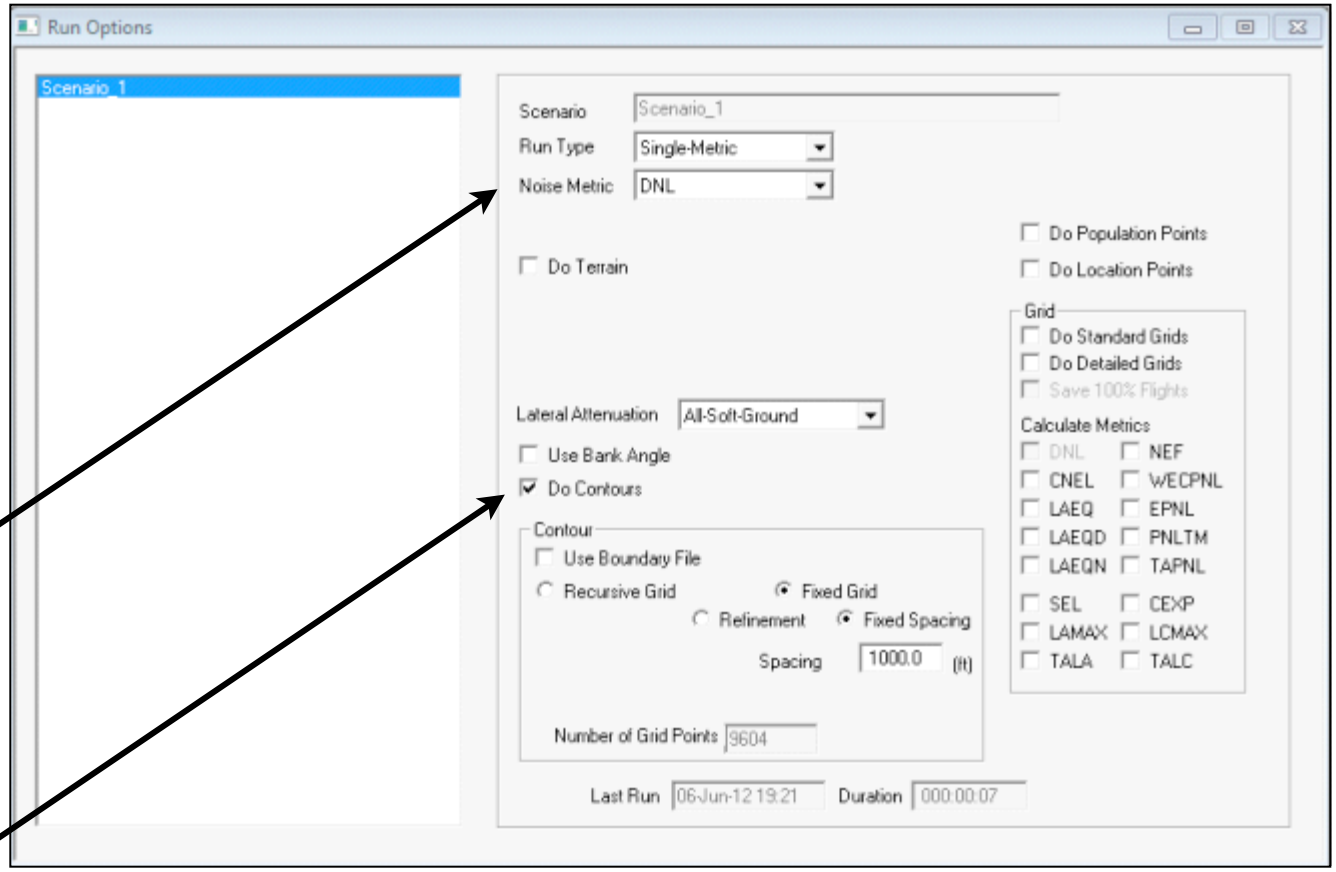
- For a small airport the default (X-Y grid) values should be enough
- If the noise contours spread over a large area then a larger grid must be defined





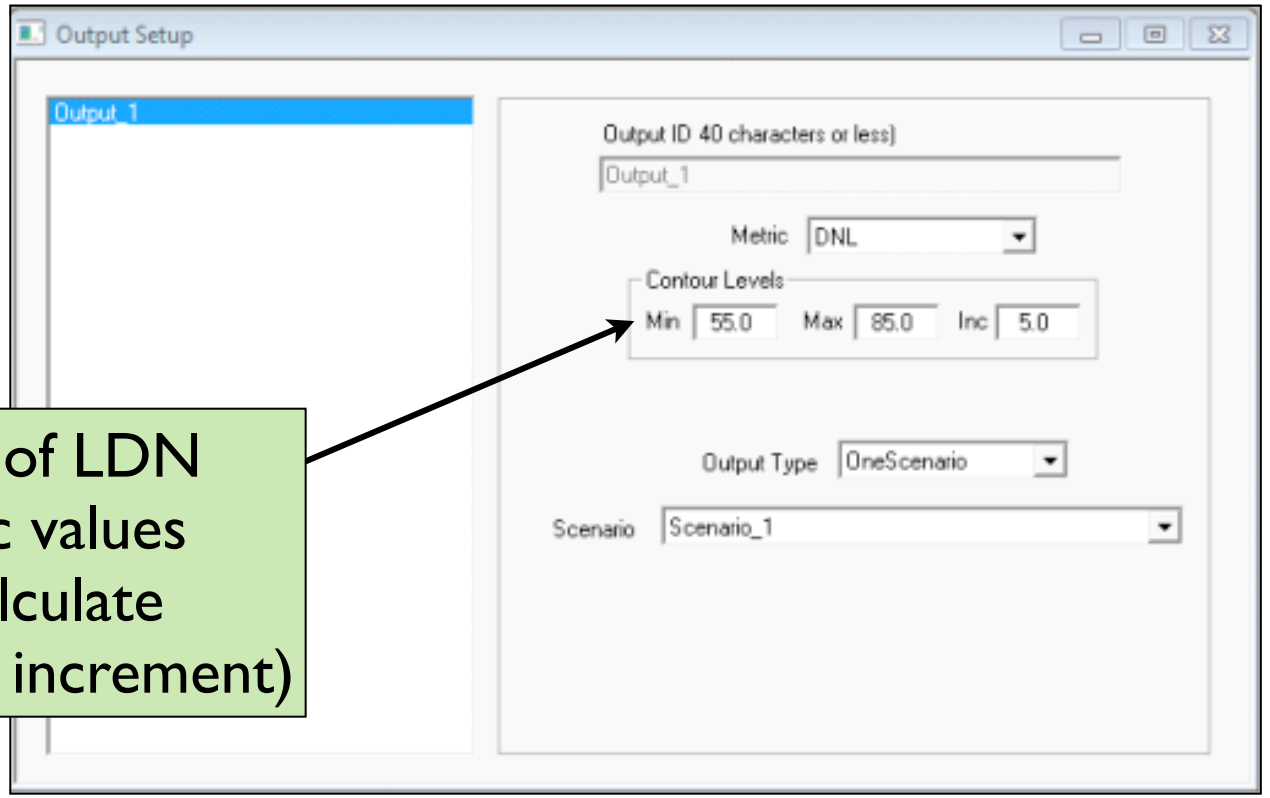
Run Options Setup

- After defining the grid set up Run Options
- **Go to RUN --> Run Options**
- This menu defines the noise metric to be calculated
- Select contours



Setup the Output for the Analysis

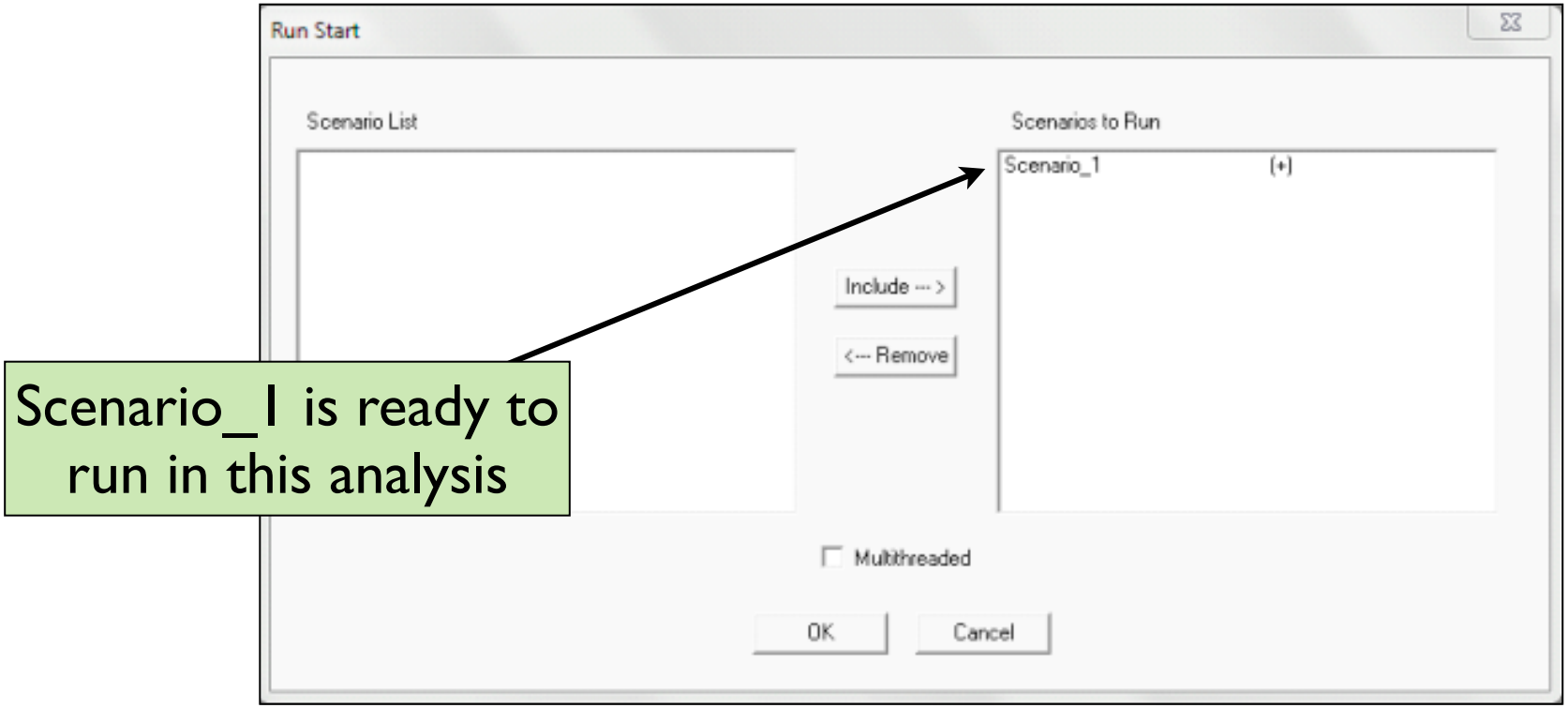
- We need to tell INM the range of values of the noise metric to be calculated
- Go to **Output --> Output Setup**



Range of LDN metric values to calculate (min, max, increment)

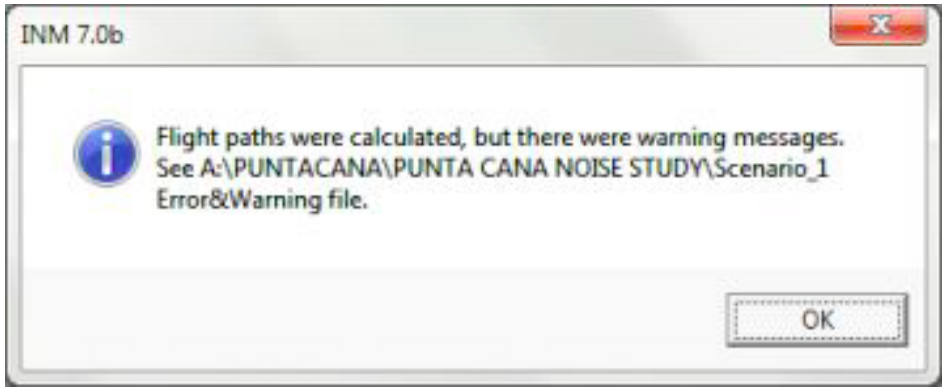
We are Ready to Run the Scenario

- 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



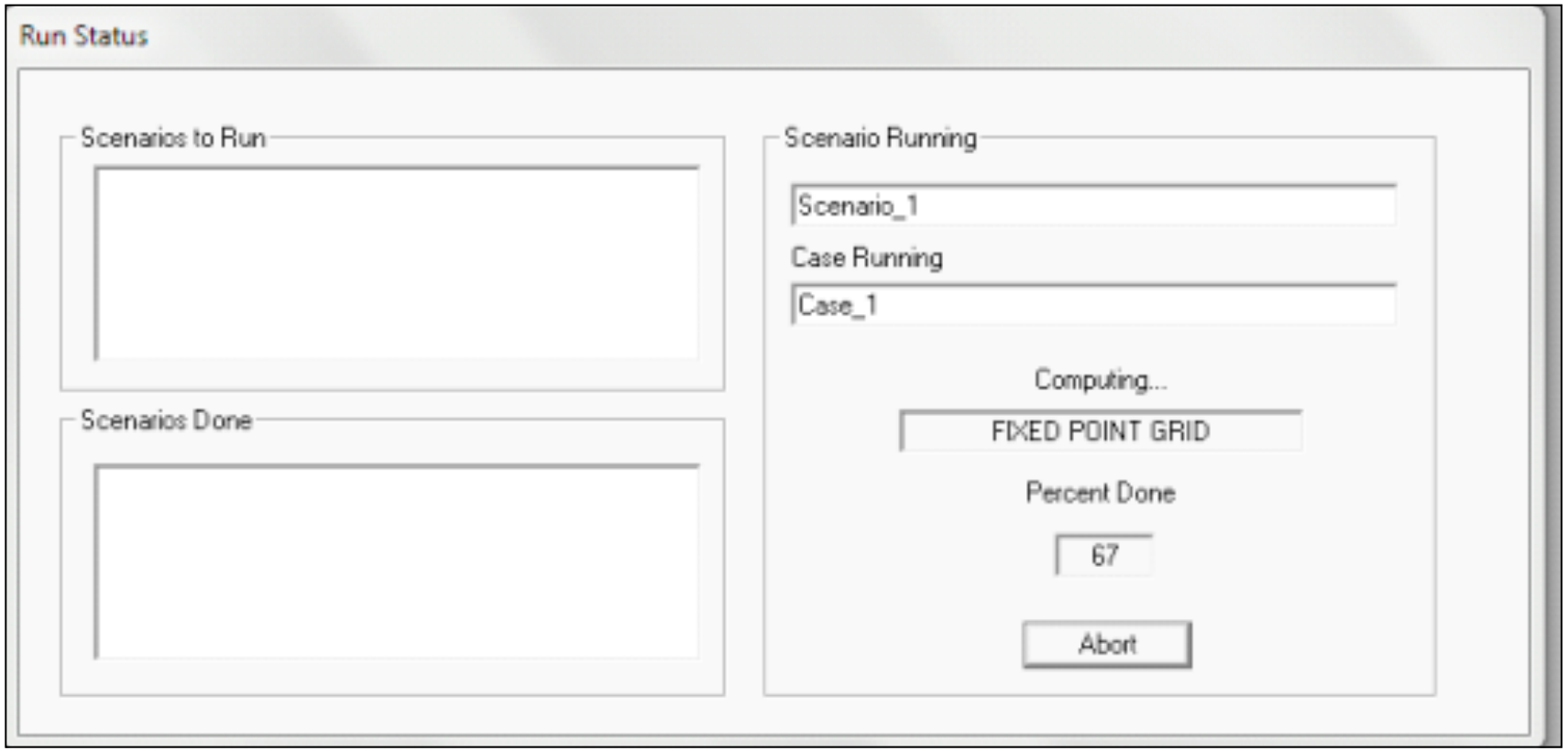
Warning Messages

- 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.



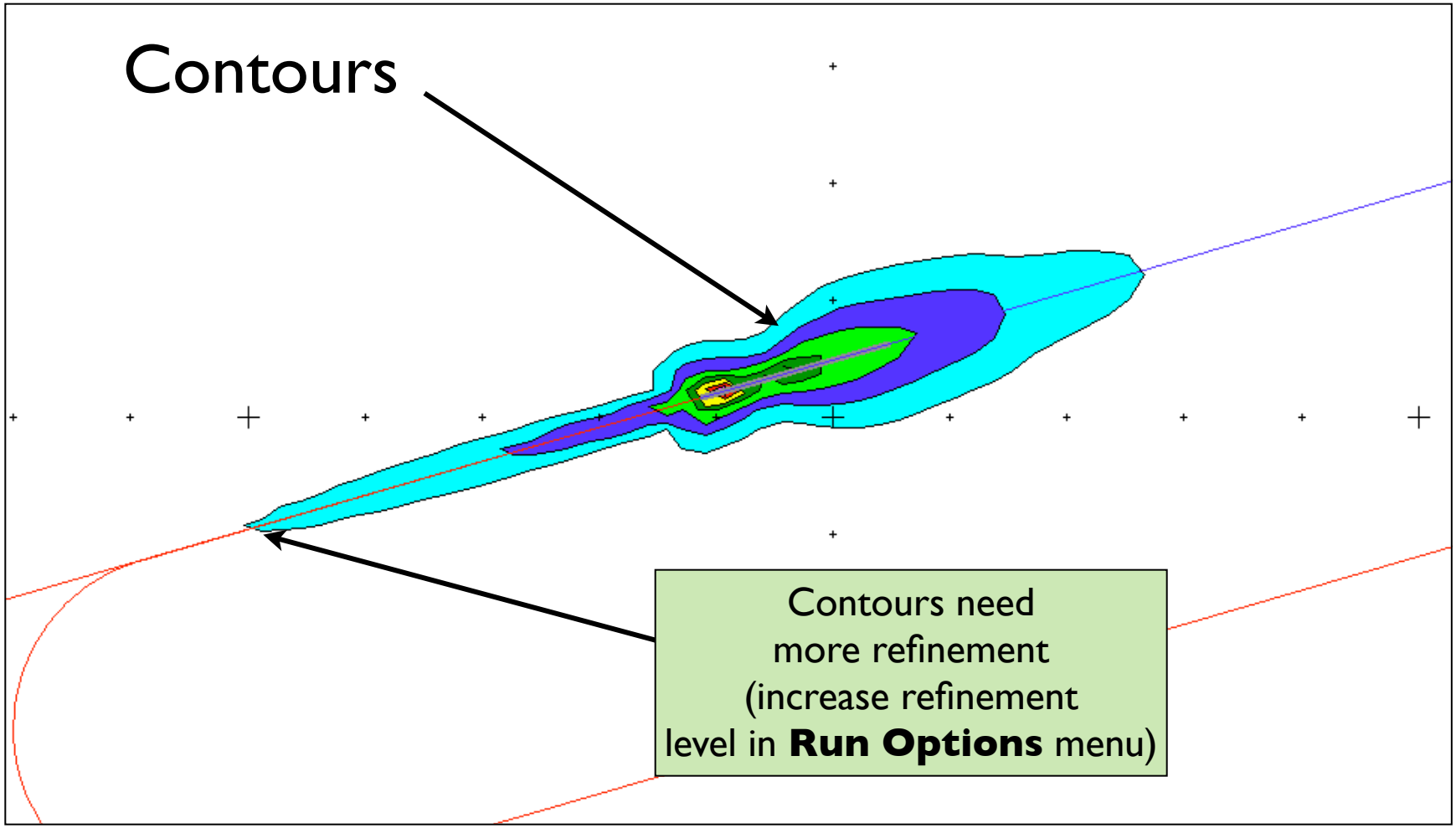
Run in Progress

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



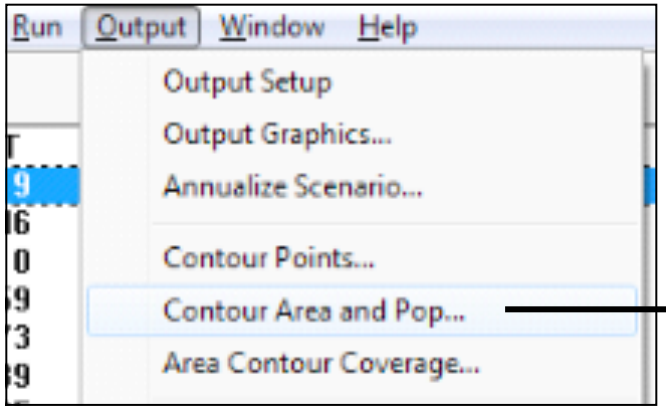
Examining the Output

- Go to OUTPUT --> Output Graphics



Examining the Area of Contours

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

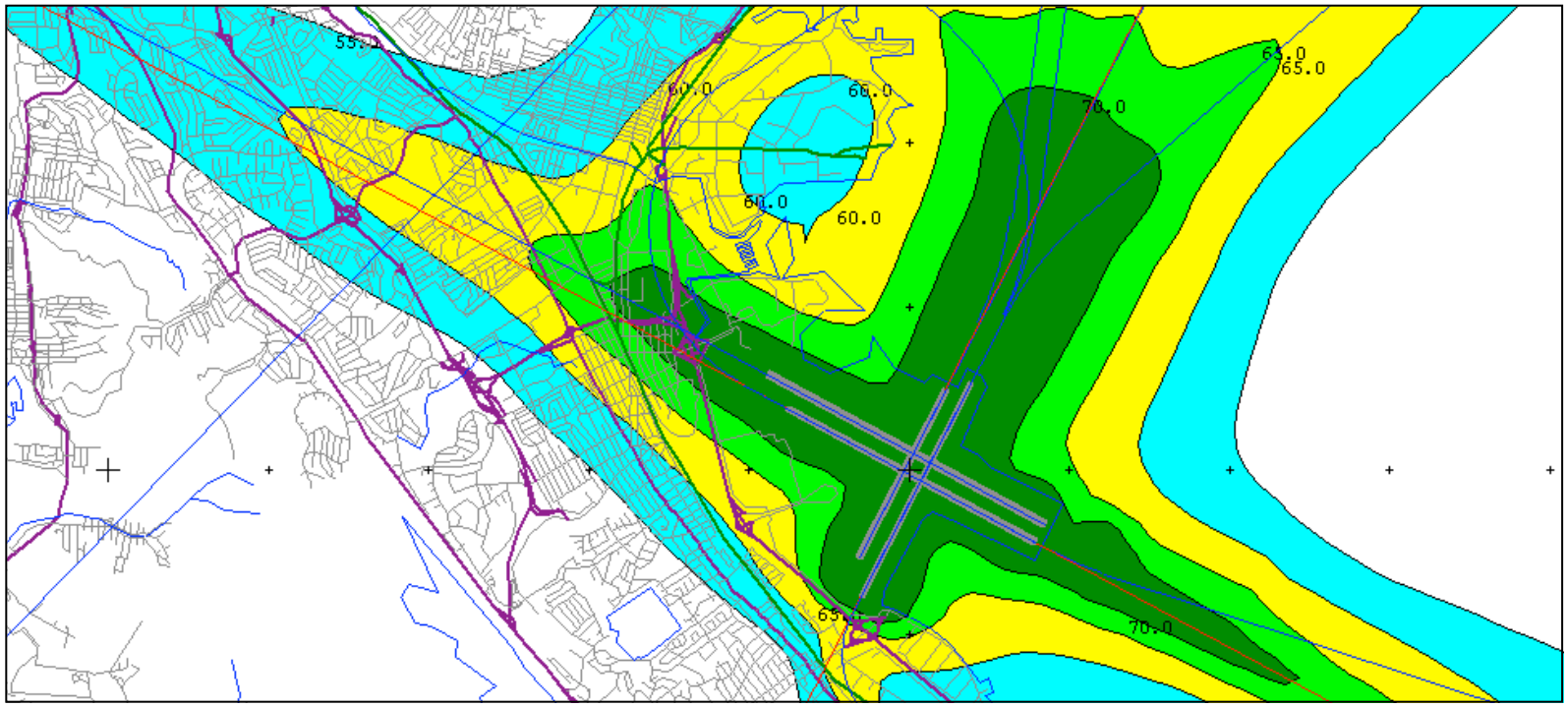


LEVEL	OK	POPULATION	SQ.KM	SQ.MI	M.SQ.FT	ACRES
55.0	Y	0	17.762	6.858	191.19	4389.1
60.0	Y	0	7.104	2.743	76.46	1755.3
65.0	Y	0	2.610	1.008	28.10	645.0
70.0	Y	0	0.798	0.308	8.59	197.2
75.0	Y	0	0.253	0.098	2.73	62.6
80.0	Y	0	0.083	0.032	0.89	20.5
85.0	Y	0	0.023	0.009	0.25	5.7

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

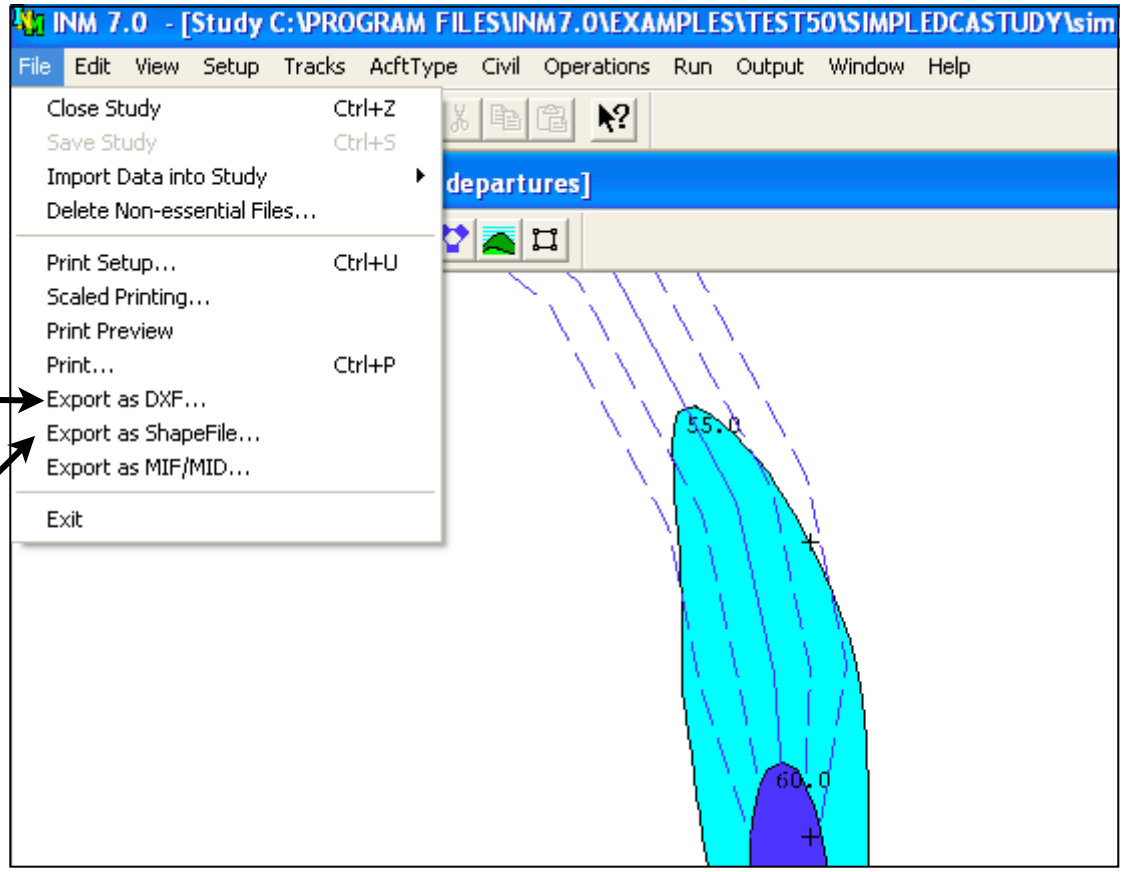
Sample Output Graphics with TIGER file Overlay

- 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)

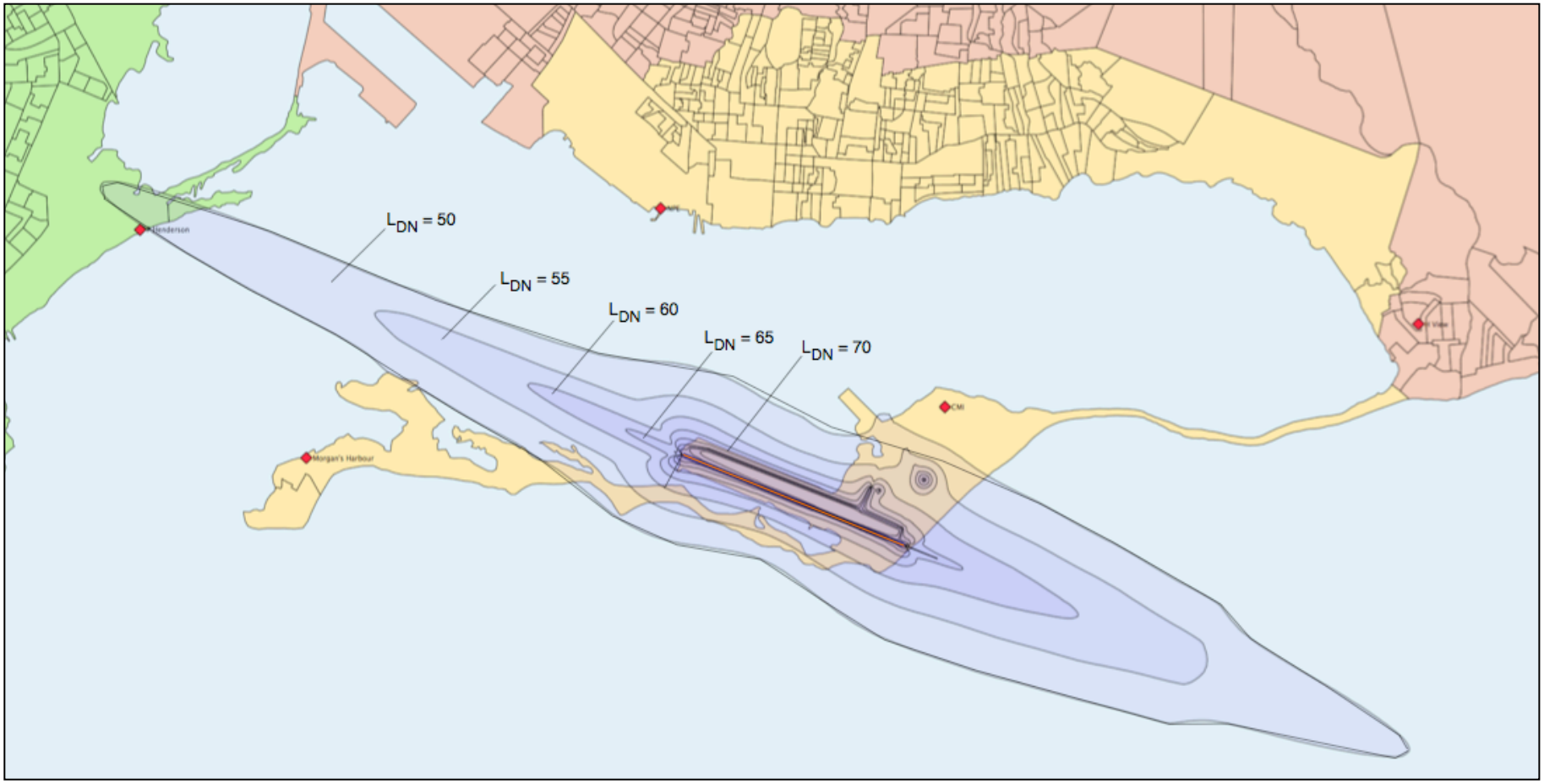


Exporting the Results of INM

- Useful to present results in other applications
- Export to Autocad (DXF file)
- Export to a Shapefile (for GIS applications)

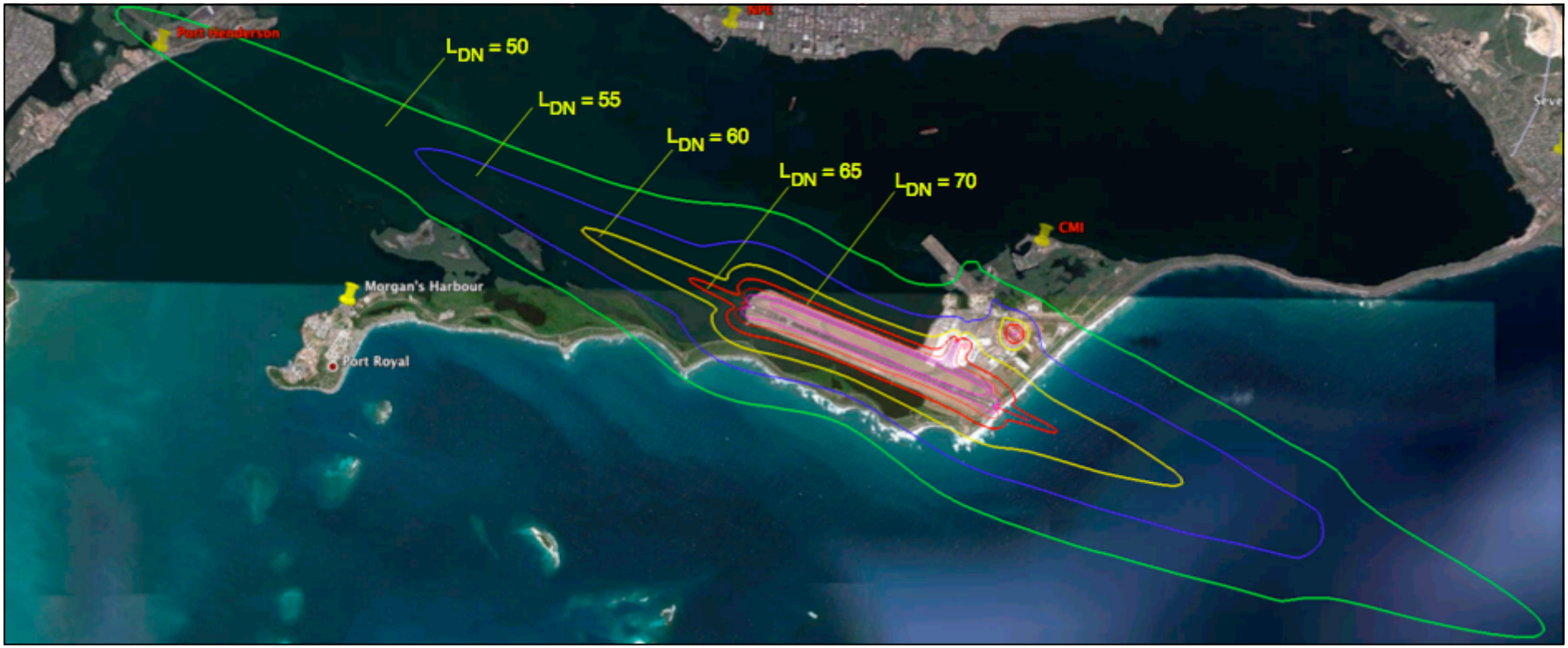


Sample of Exported INM Contours to a GIS Application



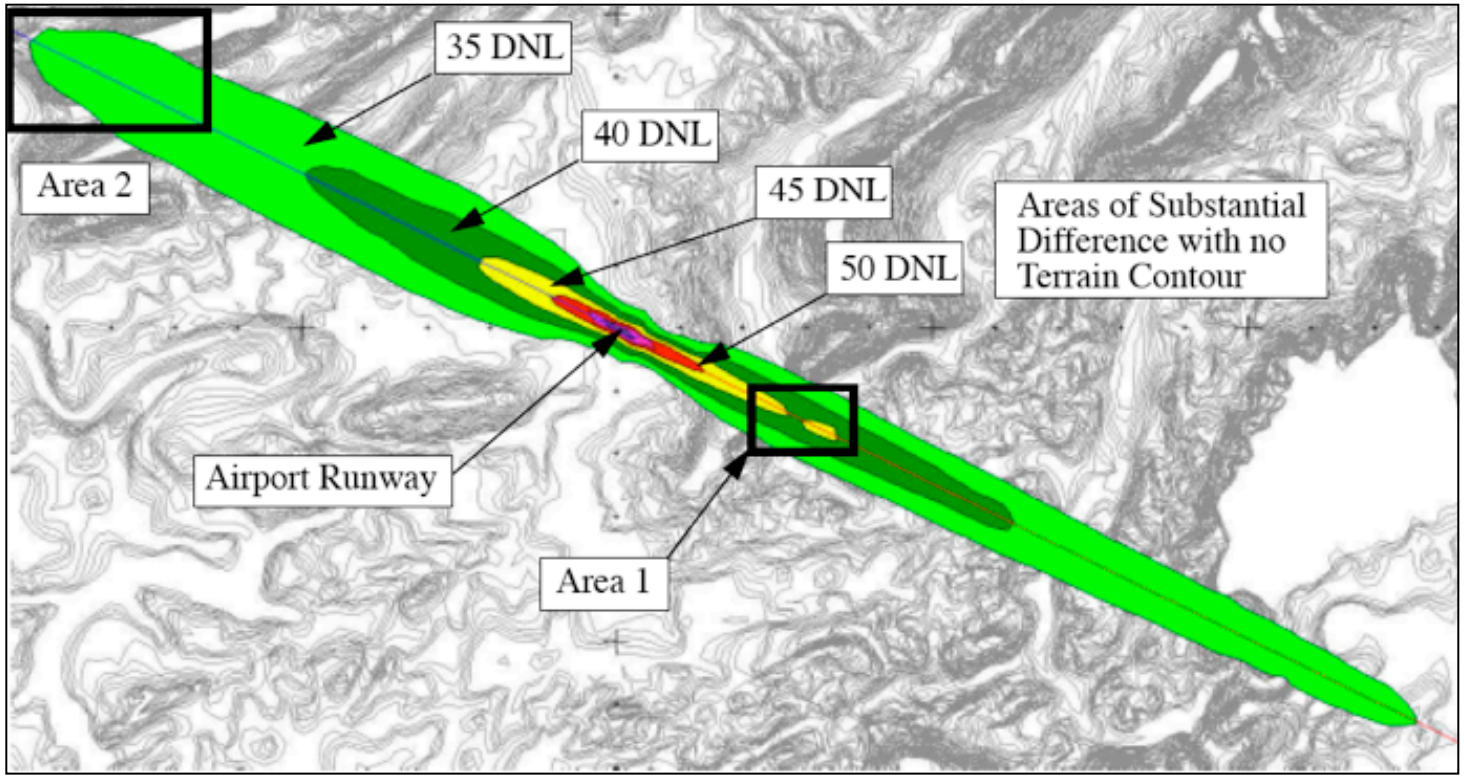
Sample of Exported INM Contours to Google Earth

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



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

Week 14	Pavement Design (Flexible Pavement) Pavement Design (Rigid Pavements)	INM BCB Files	Notes 20a - INM Case Study (BCB) Notes 20b - INM Detailed Example Noise Model Link Optional Reading **Horonjeff and McKelvey** pages 719-771 (Ch.15)

To get the FAA INM Model