ACRP Report 50

Improved Models for Risk Assessment of Runway Safety Areas

Runway Safety Area Risk Analysis Version 2.0 (RSARA2)

Software User's Guide

Software developed by Applied Research Associates, Inc. in 2011
and updated by ASM Consultants in 2017

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** Main screen photo by Dennis Janssen*

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Runway Safety Area Risk Analysis v.2 (RSARA2)

User's Guide

1. Introduction

This software was originally developed by Applied Research Associates, Inc. (ARA) as part of ACRP Report 50 - Improved Models for Risk Assessment of Runway Safety Areas (RSA) and is intended to serve as a tool to help airport operators evaluate risk associated with their RSA conditions.

The risk associated with the following five types of aircraft accidents may be evaluated with this software:

- Landing overruns (LDOR)
- Takeoff overruns (TOOR)
- Landing undershoots (LDUS)
- Landing veer-offs (LDVO)
- Takeoff veer-offs (TOVO)

The user may perform two types of analysis with this software. In the first type of analysis, the user can evaluate the probability that the aircraft will exit the runway and stop beyond the limits of the RSA or, in case of undershoots, that the aircraft will touch down prior to the RSA. In the second type of analysis, the user may consider the obstacles inside or in the vicinity of the RSA to evaluate the risk of an accident with catastrophic consequences (substantial aircraft damage and/or multiple injuries/fatalities).

This tool is particularly helpful to evaluate RSA configuration alternatives that may include the use of EMAS, changing declared distances or extending the existing areas when the existing RSA does not comply with the standards.

2. System Requirements

Component	Requirement
Computer and processor	500 megahertz (MHz) processor or higher
Memory	256 megabyte (MB) RAM or higher
Hard disk	1.5 gigabyte (GB); a portion of this disk space will be freed after installation if the original download package is removed from the hard drive
Display	1024x768 or higher resolution monitor
Operating system	Microsoft Windows 7, or later operating system, except Windows Vista
Other	RSARA2 utilizes modules from Microsoft Office Suite 2010, 2013 or 2016. The MS Office Suite must be 32-bit. The system uses Microsoft Access to handle the databases and Microsoft Excel to handle data

	input and output results. Therefore, the user must have32-bit Microsoft Office with Excel and Access to run RSARA2.

3. Using the Guide

To facilitate reading and comprehension of this user's guide, please note the following styles and conventions used throughout:

Menu Selection

Analysis/Run Full Analysis means click on *Analysis* on the main menu and then click on *Run Full Analysis* in the *Analysis* sub-menu.

Main Window

The main window contains the top title bar with the main menu name and the Minimize, Maximize, and Close buttons.

Runway Safety Area

When defining the RSA geometry in this model, the area is associated with **the arrival end of the runway**. For example, RSA 14R is the RSA adjacent to the arrival end of runway 14R.

Movements Challenging the RSA

In a given airport one movement (landing or takeoff) will challenge specific RSAs. Each landing will challenge the RSA located at the arrival end for landing undershoots, and the same landing movement will also challenge the RSA adjacent to the departure end for landing overrun. During the takeoffs, only the RSA at the departure end is challenged for overrun. During landings and takeoffs, both sides of the RSAs will be challenged for landing veer-offs and takeoff veer-offs, respectively.

Level of Risk Format

The program provides results in scientific format (e.g., 2.3E-07 or 0.00000023). These results can also be read as number of movements to occur one event. To read in this format, you have to take the inverse of the value in scientific format (e.g. 1/2.3E-07 = 4,347,826). In the example provided, a risk of 2.3E-07 is equivalent to one accident in 4,347,826 movements.

4. Software Installation

The installation of RSARA2 is the same process applied to other Windows programs. Go to the folder where you downloaded RSARA2 and double click on *setup.exe*. Then follow the on-screen instructions to install the program. It will add the program to your program group and place a shortcut on your desktop.

If you want to install a new version to replace the existing one, you first need to remove RSARA or RSARA2. To remove RSARA2, select *Start/Control Panel* in your desktop window. Select *Add or Remove Programs*. When the program list is populated, select *RSARA2* and click *Remove*.

When clicking *setup.exe* you may see a message that windows prevented an unrecognized app from starting. In this case, please click *More info* and then click *Run anyway*.

To properly run RSARA 2, it is also necessary to install Microsoft Access Database Engine 2010 Version SP2. Without this engine there may be a conflict between Microsoft 32bit and 64bit applications, which will generate unhandled exceptions when transferring data from one application to another, particularly MS Excel and MS Access. Please download Microsoft Access Database Engine 2010 Version SP2 (https://www.microsoft.com/en-us/download/details.aspx?id=13255) and install AccessDatabaseEngine.exe. Additional instructions to perform the installation can be found in Attachment C of this Guide.

5. Opening the Program

To open RSARA2, double click on the shortcut to open the program and the *Disclaimer* screen. Please read the disclaimer and if you accept the conditions, click *I Accept*, otherwise the program will be closed. The main screen will open.

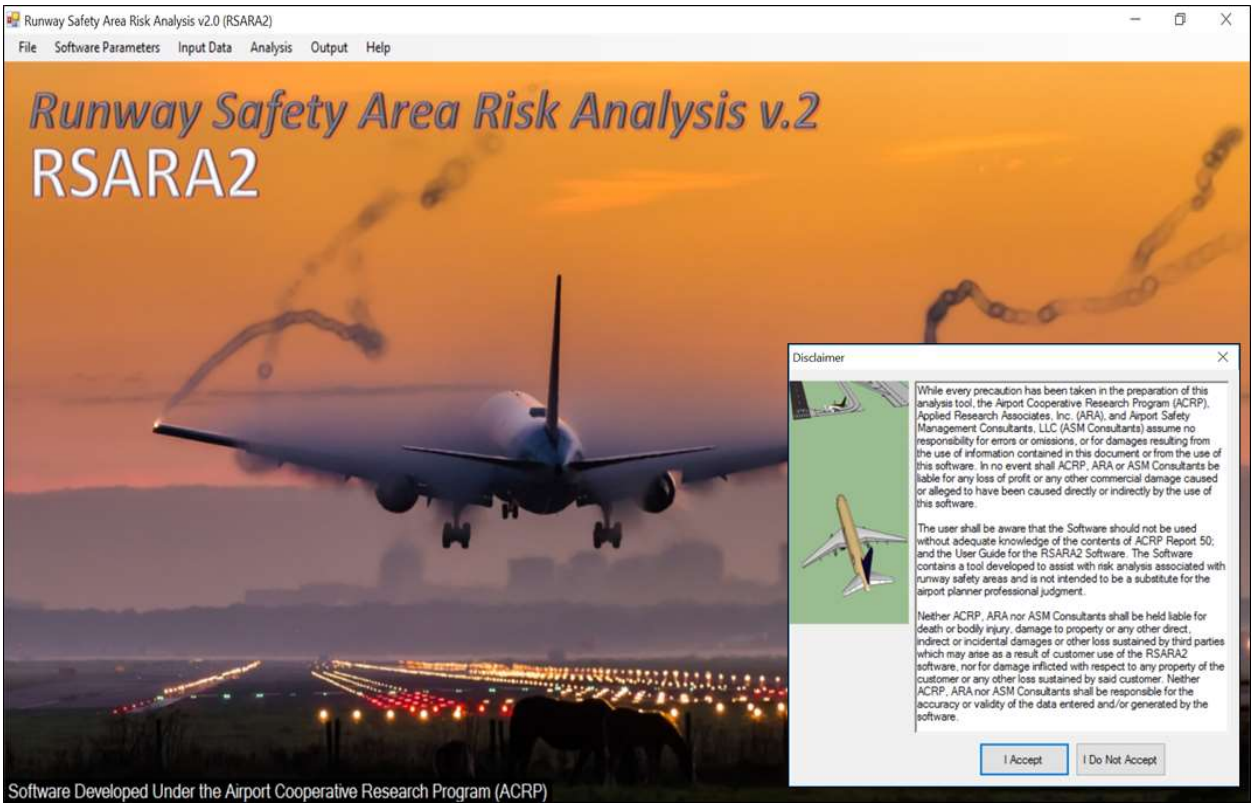
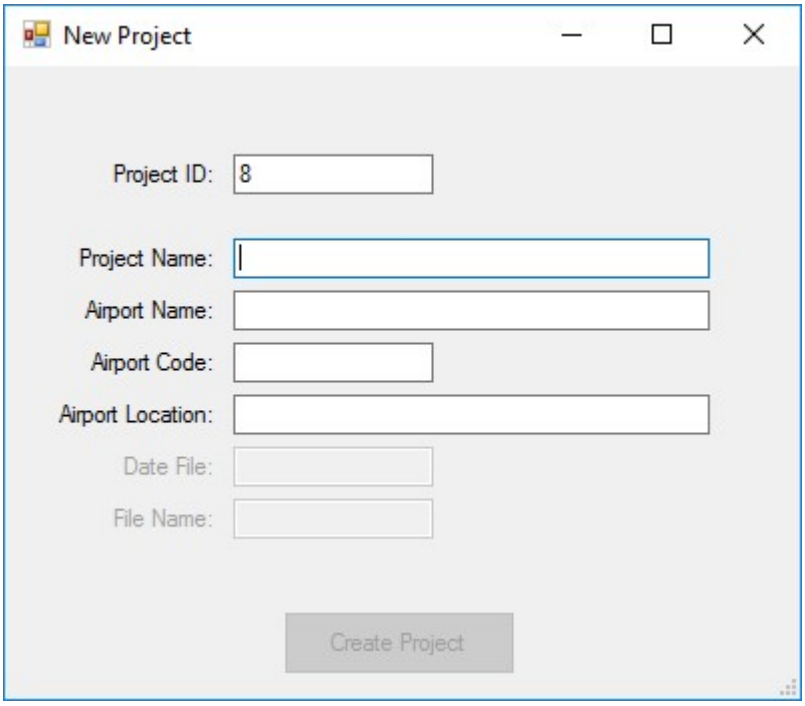


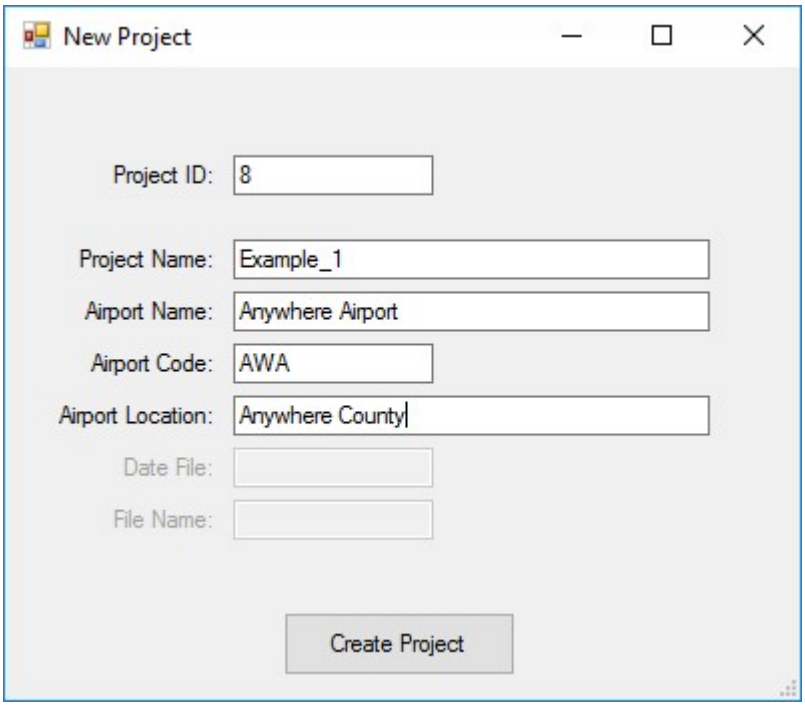
Photo by Dennis Janssen

6. Creating a New Project

Click on *File/New Project* and the following screen will appear.



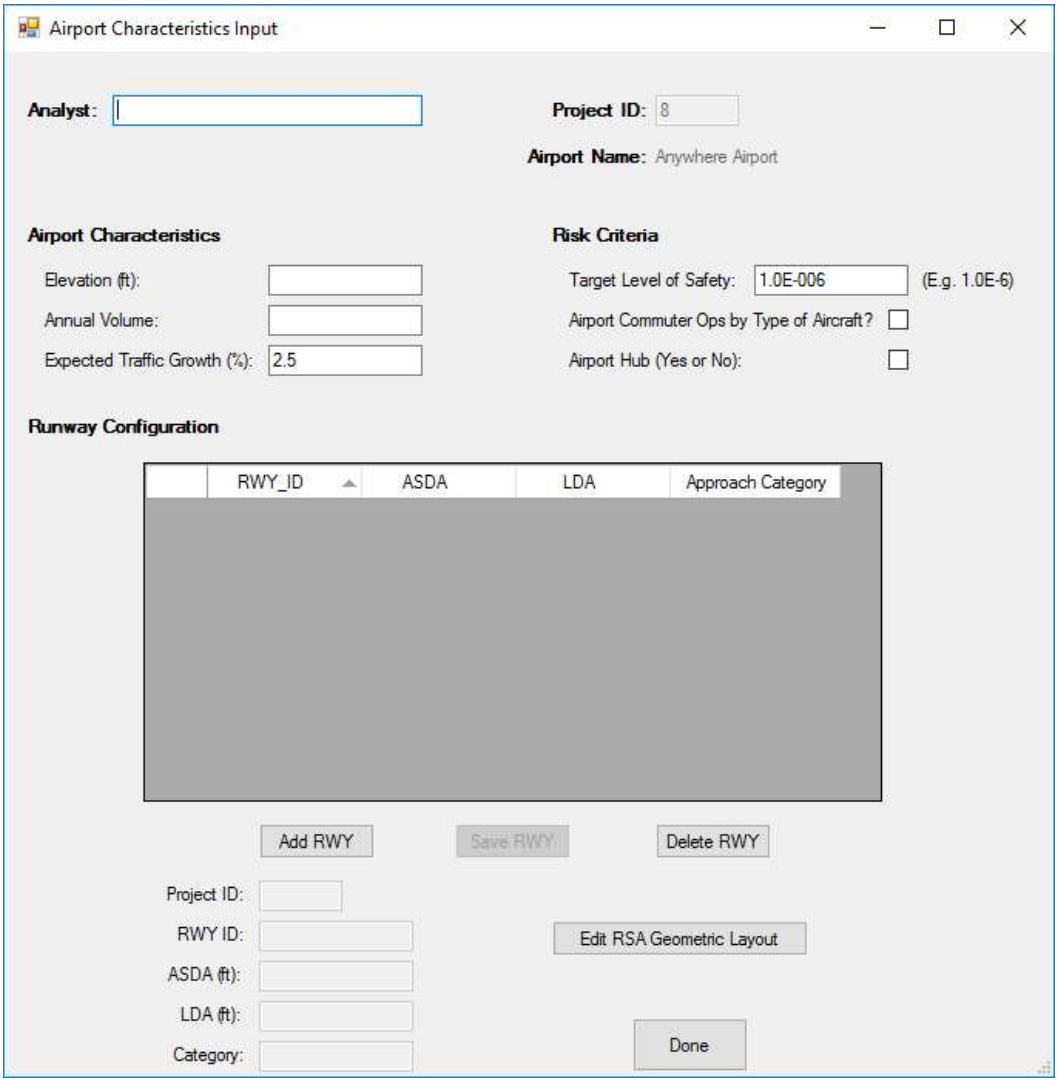
Fill up the fields as shown in the example below and click *Create Project*. The project name cannot have spaces.



7. Entering Data

Defining Airport Characteristics

The following screen will appear when you click on the *Create Project* button or when select *Input Data/ Airport Characteristics* in the main menu.



Enter the specific characteristics of the airport, including the runways characteristics and available distances. Each of the fields and commands are described in the following table.

Field	Description	Example	Meaning
Elevation (ft)	The airport elevation, in feet	1200	The highest point on any of the airport's runways is 1,200 ft relative to sea level
Expected Traffic Growth (%)	The average expected annual growth for aircraft movements	2.5	The average annual growth for future years is expected to be 2.5%
Airport Hub (Yes or No)	If the airport is a hub (large, medium or small), enable the check box	☑	If the box is checked, the airport is a hub
Target Level of Safety (TLS)	The acceptable level of is expressed in the form of a Target Levels of Safety (TLS) or Criteria.	1.0E-07	In this case, the acceptable level of risk is 1 accident in 10,000,000 movements, or 0.0000001 (or 1.0E-07) accident per aircraft movement
Assume Commuter Ops by Type of Aircraft?	The frequency models use the type of flight (commercial, cargo, taxi/commuter or GA). Sometimes the information on commuter flights is not available and if the check box is marked, the type of aircraft will dictate if the flight is commuter or not	☑	The program will assume commuter flights for every aircraft typically used for commuter operations. For example, ERJ-45 (Embraer jet airliner)

For runway configuration, enter all the runways that will be evaluated. The analysis provides results for each runway and for all runways as the total risk for the airport. **For this model, each runway pavement is treated as two runways**. To enter the runway information, click on *Add RWY* to enable the runway fields. The information required is the following:

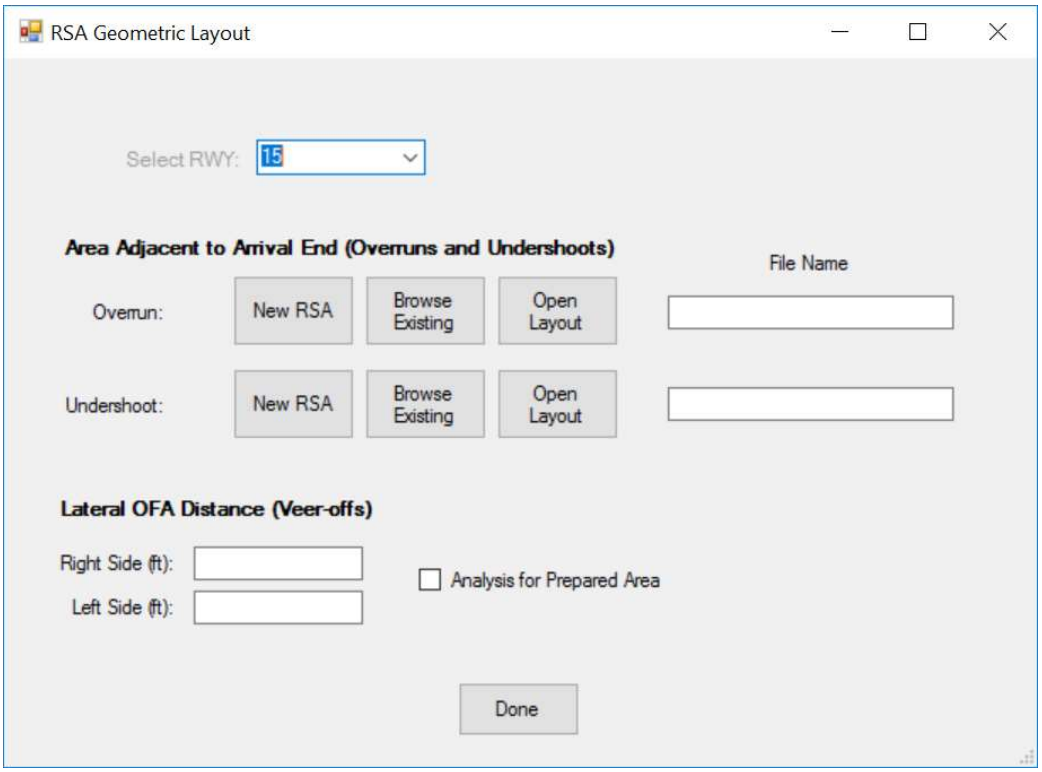
Field	Description	Example	Meaning
RWY ID	Enter the runway designation	15	This is the designation for runway 15
ASDA (ft)	Accelerate-Stop Distance Available for takeoff, in feet	8300	Runway 15 has an ASDA of 8,300 feet
LDA (ft)	Landing Distance Available, in feet	7900	Runway 15 has an LDA of 7,900 feet
Category	Type of instrument approach available	CAT I	Runway 15 approach category is precision level 1. Other possibilities are: V (visual), NP (non-precision), CAT II and CAT III

Once the runway fields are filled, save the information by clicking *Save RWY*. You may continue adding the basic information for each runway before defining the RSA geometry for the runway. Changes to

runway declared distances can be made directly in the table and the program will automatically save the changes.

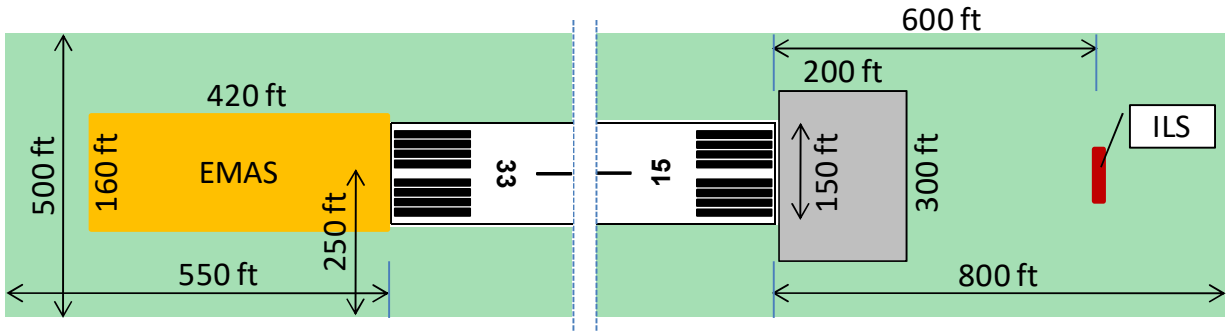
Defining RSA Geometry and Obstacles

Next, enter the RSA information, including the geometry and existing obstacles. To perform this step, click *Edit RSA Geometric Layout* and the following screen will appear.



The dropdown list includes all runways entered. In the example above, runway 15 is selected. The screen contains two sets of buttons: one set to define RSA geometry for overruns and one set for undershoots. It is important to note that these two geometries may be different when the threshold is displaced. The runway that is selected defines the RSA to be characterized. The two fields for *Side OFA Distance* are used to define the **distance from the runway edge** (not from the runway centerline) to the closest obstacle. If the box *Analysis for Prepared Area* is not selected, the aircraft wingspan is considered in the analysis to estimate the probability that the aircraft will cross the limits of the RSA. If the box is selected, the width of the main landing gear is considered in the analysis to estimate the probability that aircraft will cross a ground obstacle (e.g. drainage ditch).

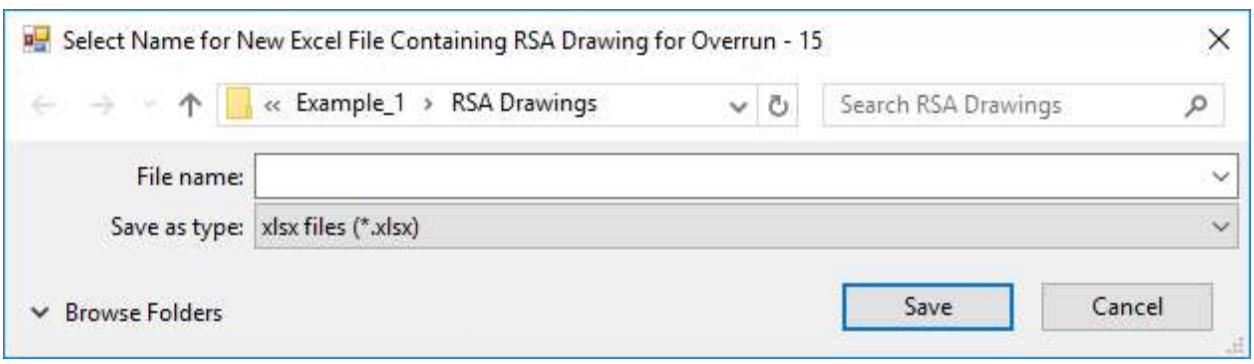
There are two stages to define the safety area for each runway. The example shown in the following figure illustrates how to define the RSA dimensions.



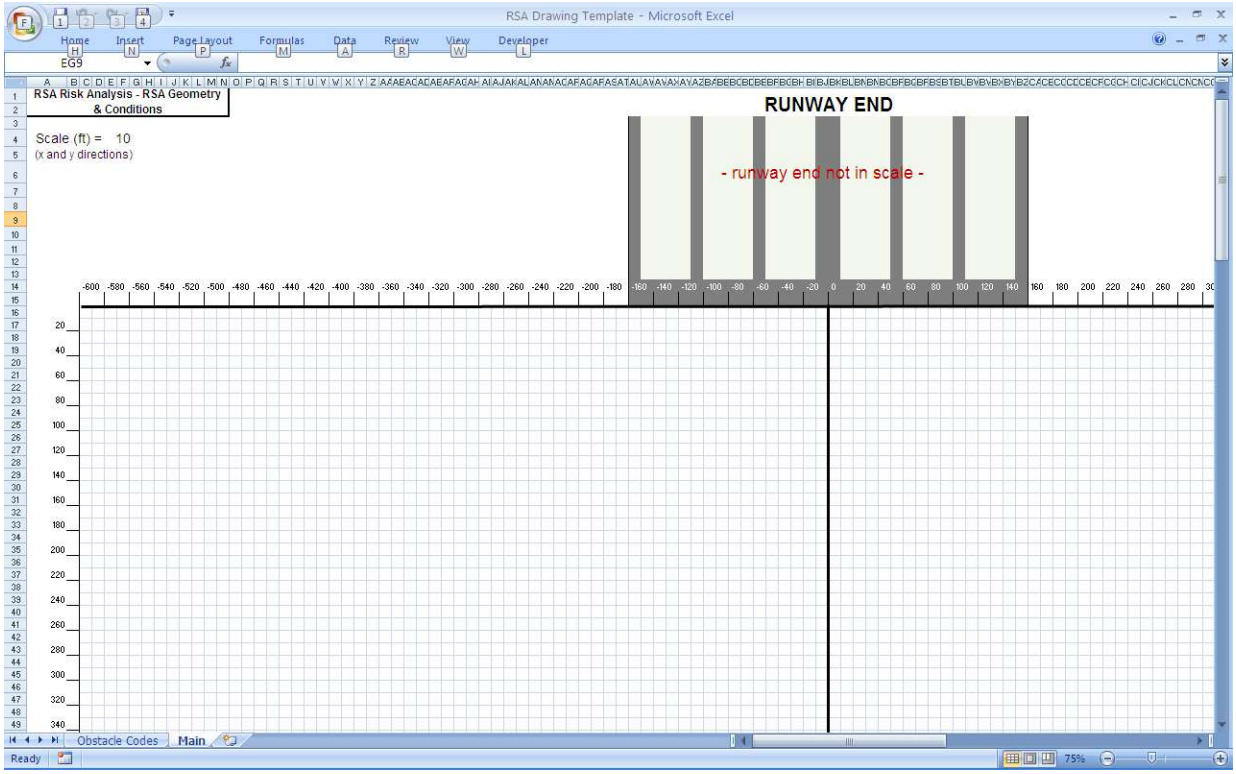
The runway in the example is 150 ft wide, and the total width of the RSA is 500 ft. The RSA adjacent to the runway 15 arrival end extends to 800 ft, with part of the RSA (200 x 300 ft) being paved and there is a Localizer 600 ft from the runway end. The RSA adjacent to runway 33 arrival end extends to 550 ft and has an EMAS bed measuring 420 x 160 ft.

The first step is to define the RSA geometry next to the runway ends. This area helps protect aircraft overrunning runway 33 or undershooting runway 15. The designation **RSA 15** means the RSA section adjacent to the runway 15 arrival end.

To define this area, click on *New RSA* next to the label *Overrun* to define the RSA geometry. A dialog box prompting you to create a Microsoft Excel spreadsheet will appear, as shown below.



It is recommended that you name the file for the RSA 15 overrun (e.g., RSA 15 OR). Click *Save* and the Excel spreadsheet will open, as shown in the following screen.



Initially, the spreadsheet contains an “empty” RSA. The template has two folders: *Main* and *Obstacle Codes*. The *Main* folder is where you will define the RSA geometry and obstacles. The second folder, *Obstacle Codes*, is where you may obtain information on codes to define the areas and obstacles, and contains three tables, as shown below.

Codes for RSA Surface

Type of Area	Code
Grass	n
Soil	n
Unpaved area	n
Paved	p
Asphalt	p
Concrete	p
EMAS	e
Cement stablized	p

Obstacle Categories	Max Speed
Category 1	nil
Category 2	5 knots
Category 3	20 knots
Category 4	40 knots

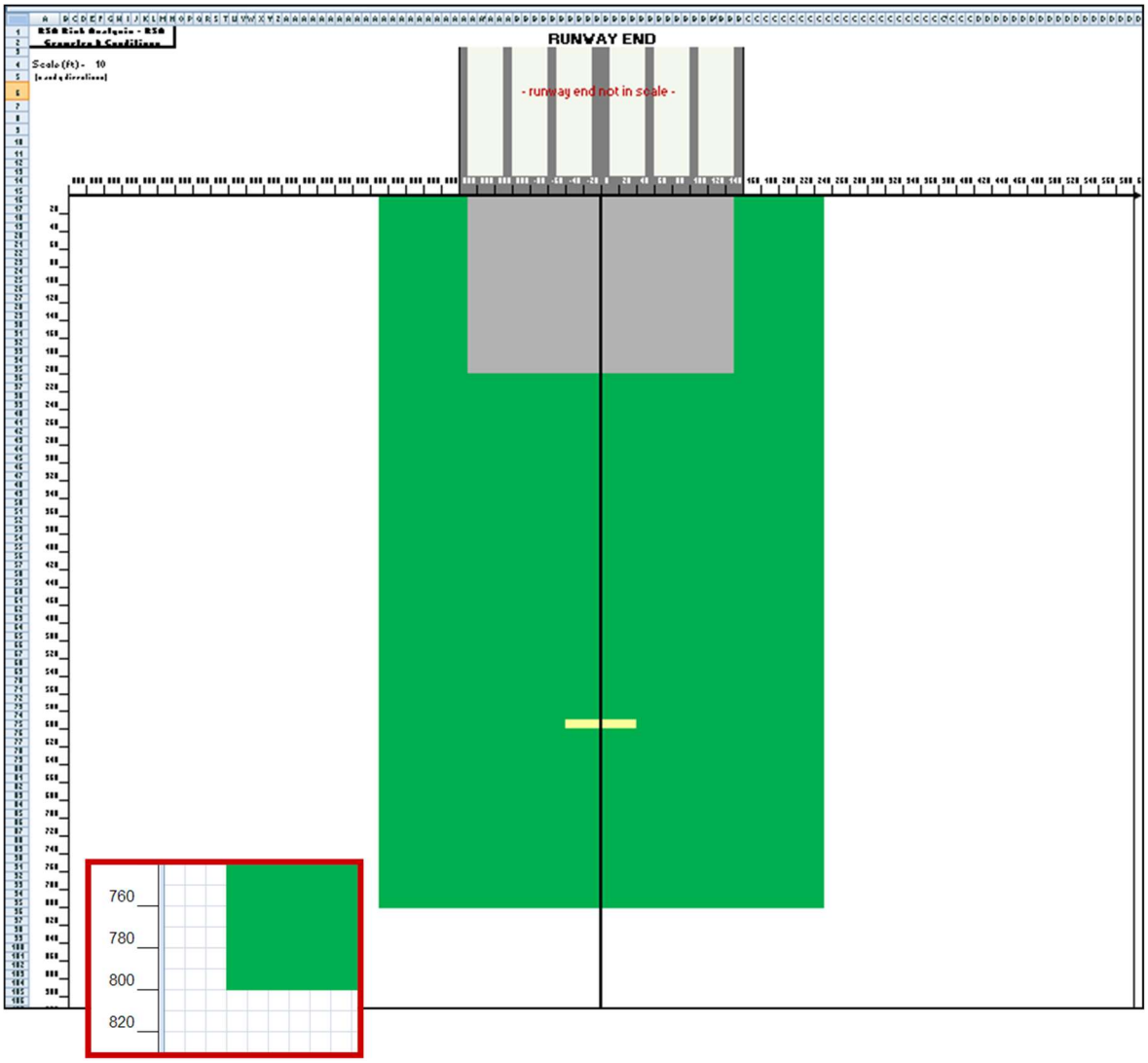
Codes for Obstacles

Type of Obstacle	Code
Concrete buildings	1
Concrete walls	1
Cliffs	1
Large holes	1
Body of water (undershoot)	1
Stockpiles	1
Highways	1
Flammable material pipeline	1
Gas station	1
Body of water (overrun)	2
Brick wall	2
Non frangible blast fences	2
Large ditches	2
Small ditches	3
Fences	3
Irregular terrain	3
Small depressions	3
Large frangible structures	4
Localizer	4
ALS	4
Frangible blast fences	4
Non prepared areas	4
Lights	no code
Signs (frangible)	no code

The runway end is represented at the top of the spreadsheet. Please note the runway section shown is only a representation to facilitate locating its position and is not on the same scale as the RSA. On the top left (line 4), you may select an appropriate scale for representation of each cell; the runway width will not match the coordinates used to define the RSA geometry. In this case, the scale selected was 10 ft, meaning that each cell in the RSA is a 10 x 10 ft square in the terrain.

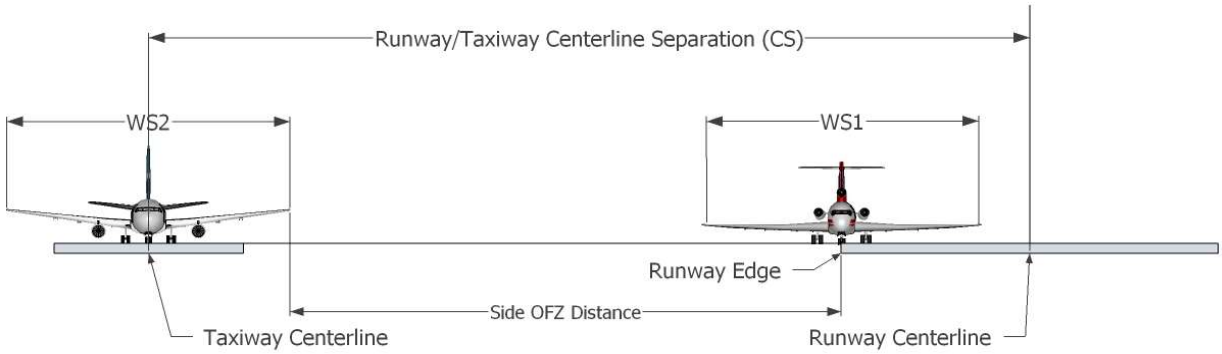
To define the area, select the appropriate code for the type of Area/Obstacle from the tables shown above and available in folder *Obstacle Codes*. In this case part of the area is paved and the remaining is grassy. For grass, you should use the letter “n”. To define the grassy areas, insert an “n” (non-paved) in each cell that comprises the grassy area. In this example, the width of the RSA is 500 ft and the RSA is centered on the runway, so you should mark 250 ft to the right of the runway centerline and 250 ft to the left, and 800 ft from the runway end (please note it is easier to copy and paste the cells, rather than manually entering one “n” at a time). When an “n” is entered in a cell, the cell will change color (in this case, to green). After marking the grassy area, the same process is used to define the paved area using the letter “p”.

Finally, you should define the ILS location. The same process is used to enter an obstacle. For this example, a 90-ft long Localizer is located 600 ft from the runway end, the code to enter for a Localizer is “4,” and this number should be entered in the cells located 600 ft from the runway end for a total length of 80 ft, centered at the extended runway centerline. The total length should be 40 ft to the right and 40 ft to the left of the centerline.



Use the Excel menu to save the RSA geometry for overruns on RSA 15, and close the spreadsheet. The action will take you back to the *RSA Geometric Layout* screen. Define the RSA 15 geometry for undershoot using the same process; in many cases the RSA area for undershoot will be the same for overrun. It is important to note that depending on the runway declared distances (includes displaced thresholds), the RSA for overrun may be different from the RSA for undershoot on the same runway end.

The next step is to define the *Side Obstacle Free Area (OFA) Distance*. This distance is the clearance from the runway edge to the nearest obstacle, fixed or movable. In some cases, the object may be a hangar or another fixed object; however, in most cases it will be an aircraft located in a parallel taxiway. In this latter case, the Side OFA Distance will be the distance between the runway edge and the wingtip of the taxiing aircraft, as shown below. The location of the wingtip is associated with the Aircraft Design Group (ADG), or it may be the aircraft with the largest wingspan operating at the airport.



In the figure, WS2 is the wingspan of the taxing aircraft and WS1 is the wingspan of the aircraft in the runway. The *Side OFA Distance* can be calculated as follows:

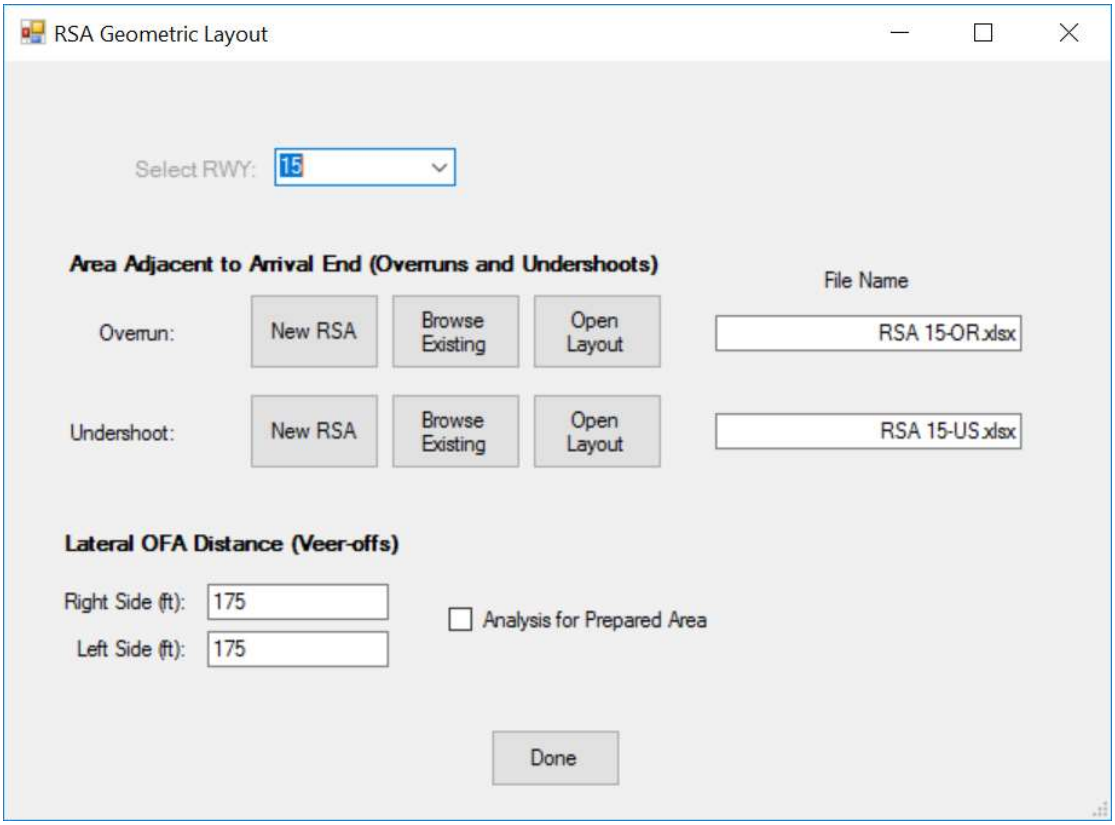
$$SOFAD = CS-RW/2-WS2/2$$

Where:

- SOFAD is the Side OFA Distance
- CS is the runway/taxiway centerline separation
- RW is the runway width
- WS2 is the wingspan of the aircraft in the taxiway, usually characterized by the largest wingspan of the Aircraft Design Group of the airfield

Because of the symmetry, the Side OFA Distance to the right and to the left is the same. In the example, the width of the OFA is 500 ft and the Side OFA Distance is simply half the OFA width minus half of the runway width, or 250 ft minus 75 ft, equal to 175 ft. The RSARA2 software takes into consideration the wingspan of the aircraft landing or taking off and uses the actual wingtip clearance to estimate the probability of collision when large lateral deviations take place during the veer-offs.

As described earlier, if the box *Analysis for Prepared Area* is selected, the width of the main landing gear is considered in the analysis to estimate the probability that aircraft will cross a ground obstacle (e.g. drainage ditch).



When the RSA characteristics are entered for each runway available in the drop down list, you may click *Done* to exit the screen, taking you back to the *Airport Characteristics Input* screen. The program will automatically save the information entered.

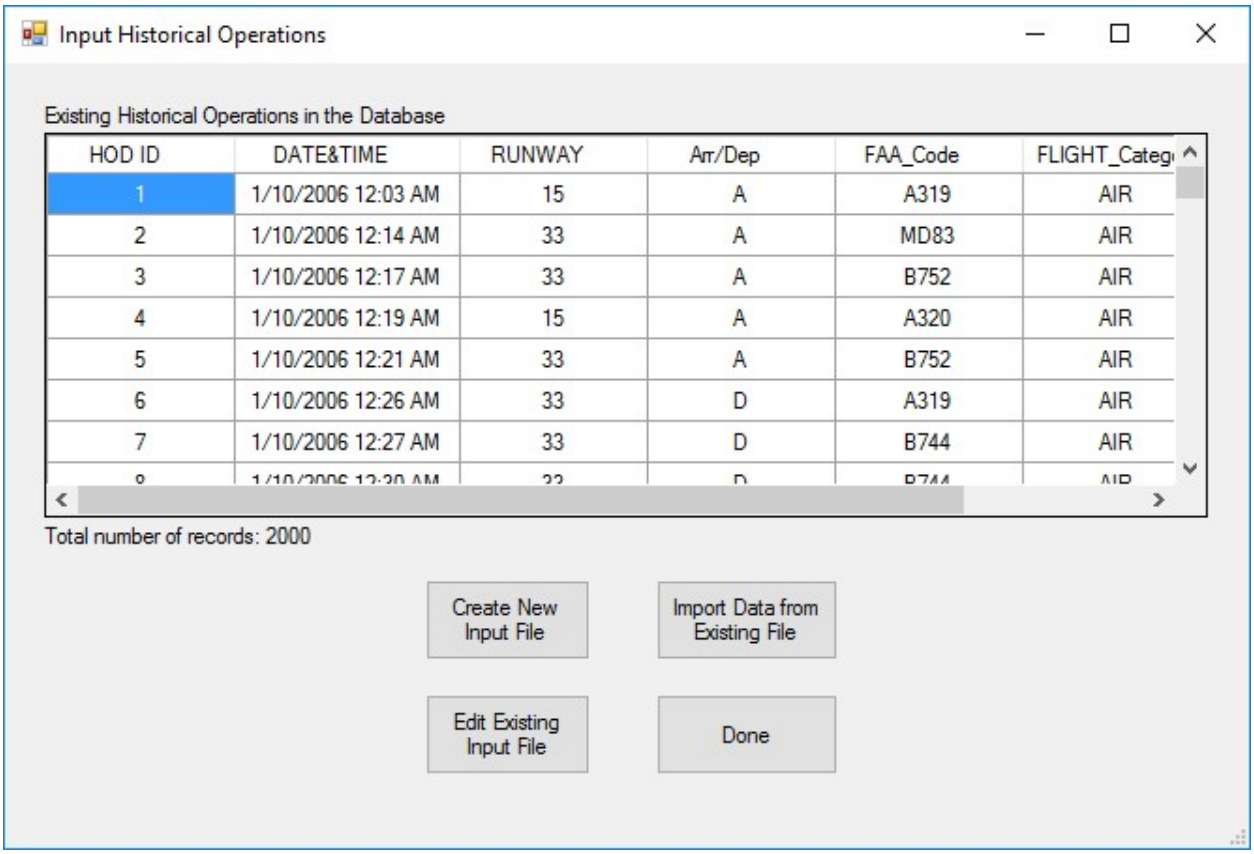
Historical Operations Data (HOD)

The next step is to enter HOD. Ideally historical data for the airport should be collected for at least one year. The information is placed in the template spreadsheet for this type of data. The columns, the field, and the format to save this data in the spreadsheet are presented in Attachment A to this guide. To enter the historical data into the analysis, click *Analysis/Input Data/Historical Operations Data* to open the screen to load the file.

Please note that the HOD can be edited using Microsoft Excel, however you **should not change the name of column headers or the tab name that contains the data**. RSARA2 uses the labels to identify the type of data to load into the program.

For towered airports it is possible to retrieve the records for operational data from the tower log or from the FAA's Aeronautical Information Management Lab. In some cases, the records are available, however the runway used is not identified. For airports in the Aviation System Performance Metrics (ASPM), under the Enhanced Traffic Management System Counts (ETMSC), it is possible to identify the runway configuration used in an hourly basis. The information is available online at *aspm.faa.gov*.

For non-towered airports, a sample of operations during one month or even one week may be repeated over the one-year period of records for the analysis. The information will be matched to the weather data retrieved for the airport to create a representative sample for analysis.

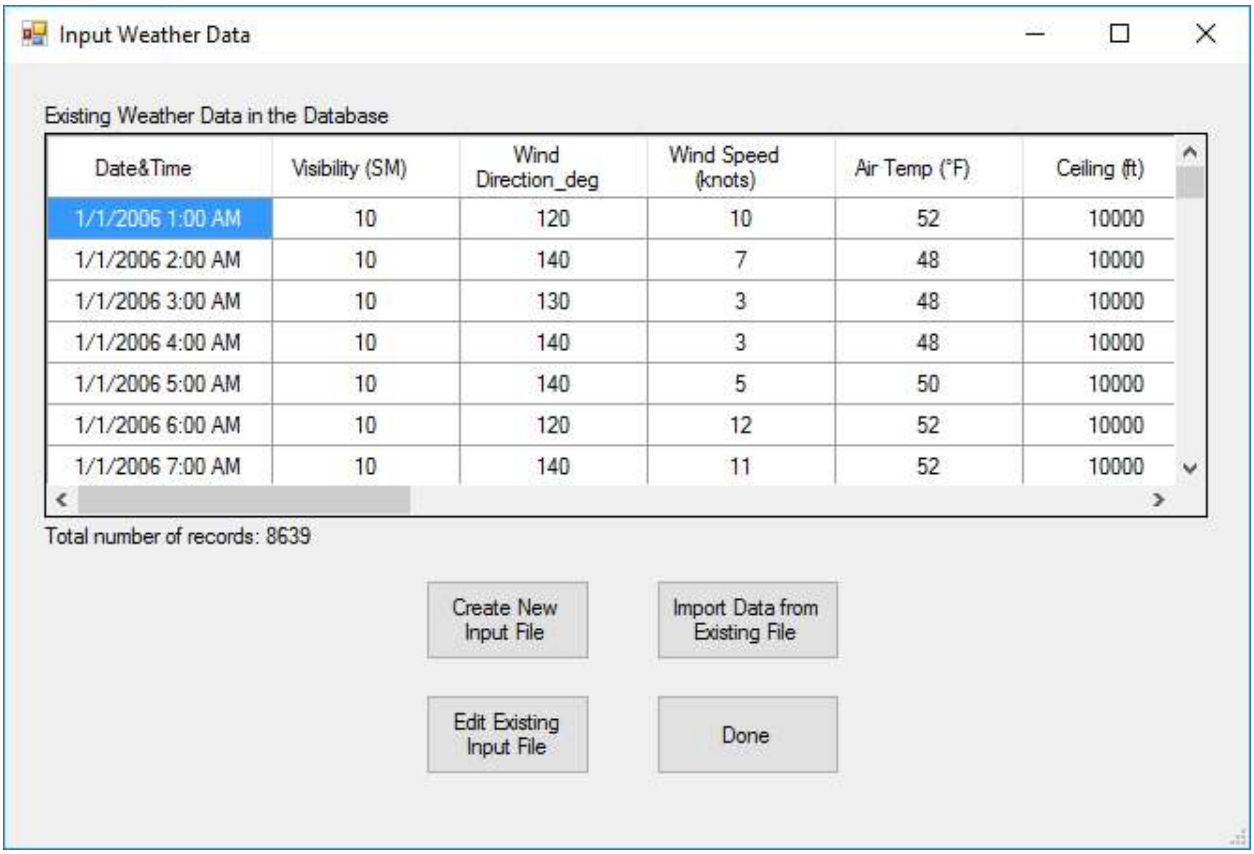


The screen allows the user to create, edit, import, or view the HOD required to run the analysis.

Historical Weather Data (HWD)

The file containing the HWD data will be loaded using a similar process to that used to load the HOD. The period for the weather data must match the period of operational data. The RSARA2 program will match the operational and weather data to characterize the actual weather conditions for each operation. The preparation of weather data is described in Attachment B to this guide.

It is important to note that the HWD can be edited using Microsoft Excel, however you **should not change the name of column headers or the tab name that contains the data**. RSARA2 uses the labels to identify the type of data to load into the program. The screen to enter the file containing weather data is the following.

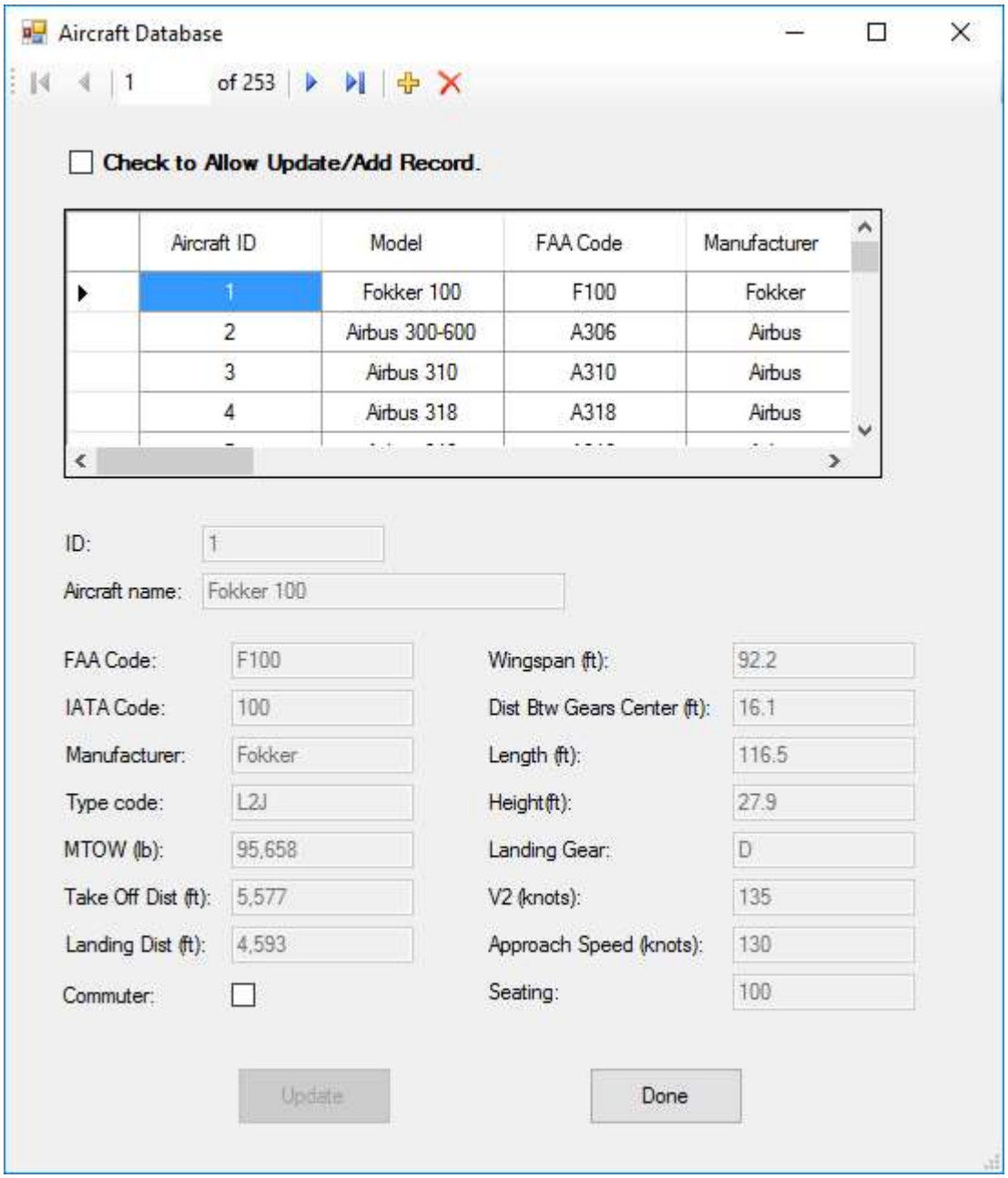


The screen allows the user to create, edit, import, or view the HWD required to run the analysis. The spreadsheet may be opened using RSARA2 or directly in Excel and saving without changing the file name.

Historical weather data can be provided by the airport's weather station or can be retrieved from the National Climatic and Atmospheric Administration (NOAA), National Centers for Environmental Information (NCEI). Information from NCEI is free and can be requested online using the Climate Data Online (CDO) - www.ncdc.noaa.gov/cdo-web/

Aircraft Library

The software contains a basic database of aircraft that may be updated to run the analysis. Click *Software Parameters/Aircraft Database* to access the database. The following screen will appear.

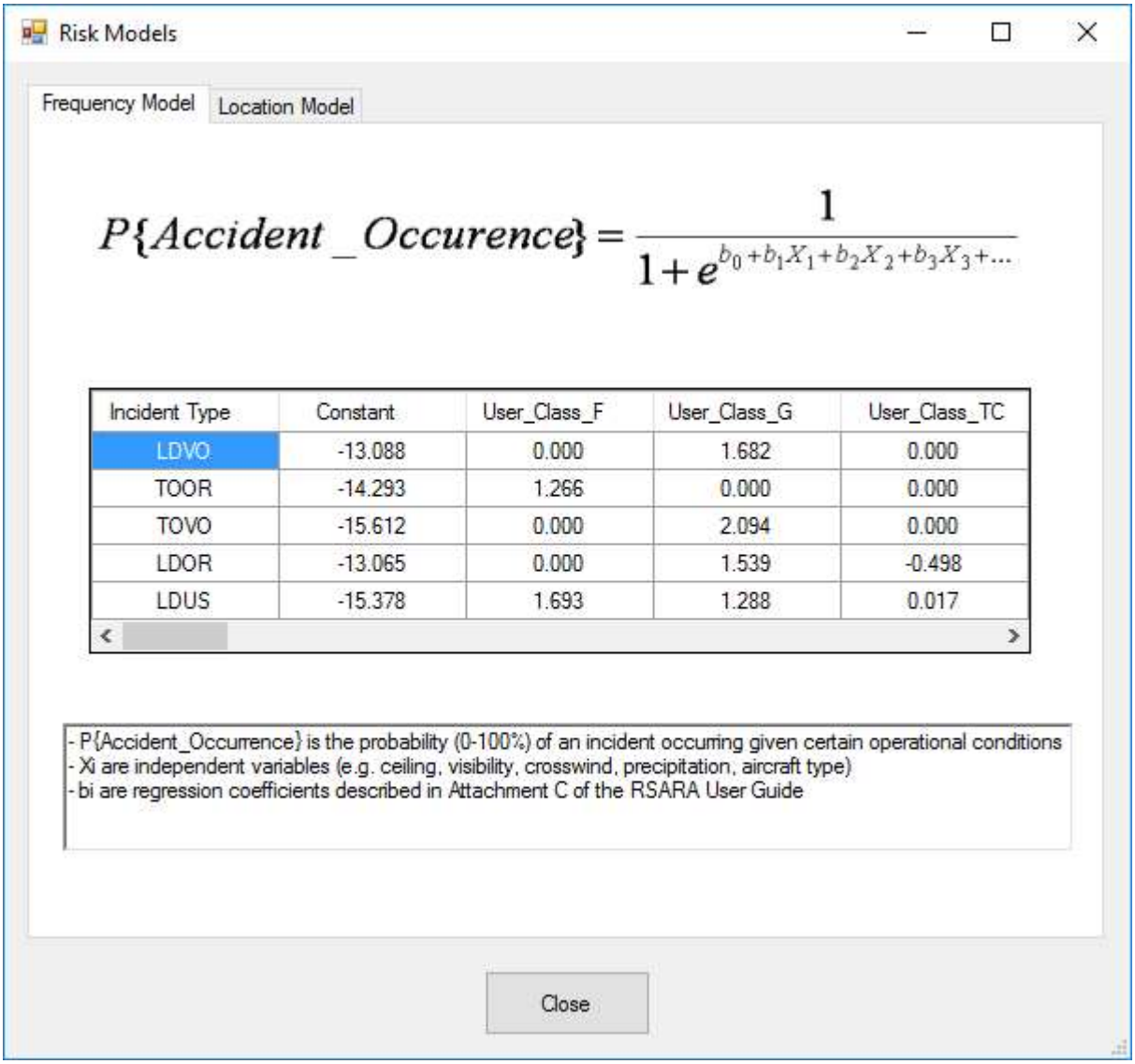


You may edit, update, or add records by clicking the check box on the top left of the screen. By checking that box the fields will be enabled for editing. It is important to note that RSARA2 identifies the type of aircraft in the historical information by the aircraft FAA Code shown in the third column.

8. Model Parameters

The user may view the frequency and location models used in the program by clicking *Software Parameters/Model Parameters*. The model parameters cannot be edited. The models incorporated to

the software are those presented in ACRP Report 50 – Improved Models for Risk Assessment of Runway Safety Areas (RSA).



Incident Type	Constant	User_Class_F	User_Class_G	User_Class_TC
LDVO	-13.088	0.000	1.682	0.000
TOOR	-14.293	1.266	0.000	0.000
TOVO	-15.612	0.000	2.094	0.000
LDOR	-13.065	0.000	1.539	-0.498
LDUS	-15.378	1.693	1.288	0.017

This screen contains two folders. The first shows the frequency models for landing overruns (LDUR), landing undershoots (LDUS), takeoff overruns (TOOR), landing veer-offs (LDVO), and takeoff veer-offs (TOVO). The second folder presents the location models for longitudinal and transverse distances relative to the runway axis for the same types of events.

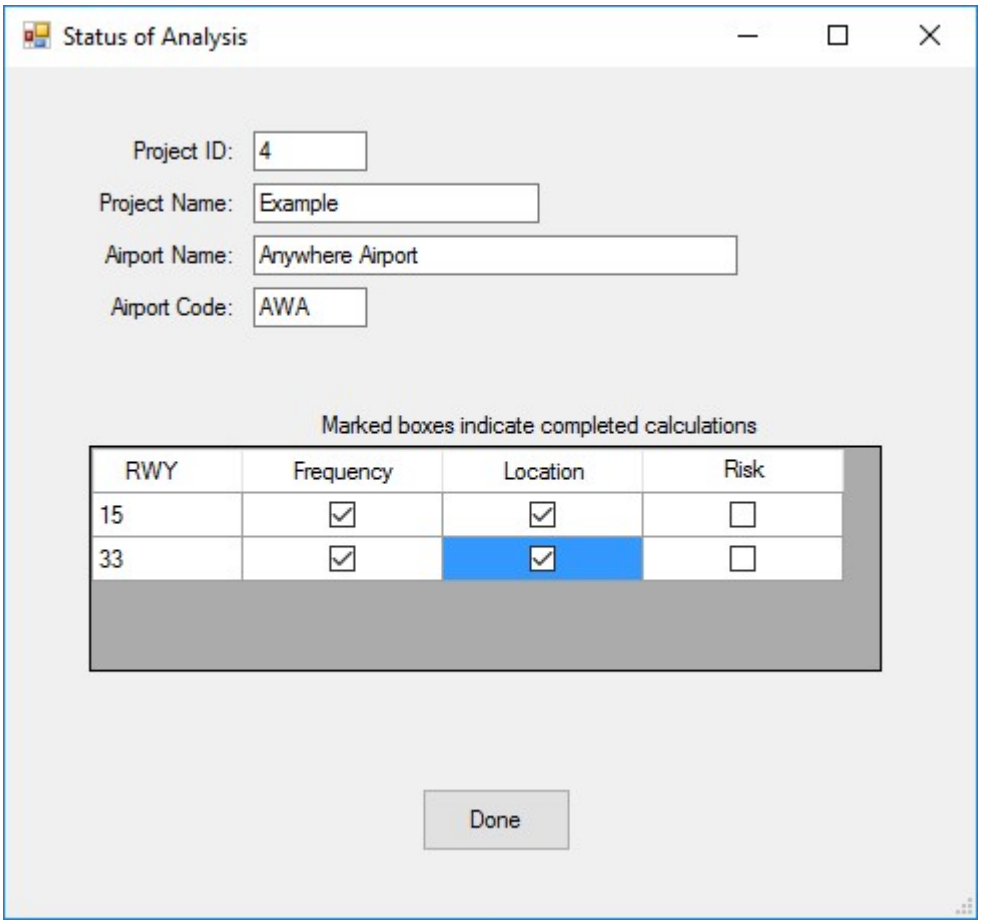
9. Running the Analysis

The analysis menu has four submenus:

- Check Analysis Status
- Run Full Analysis
- Run Simplified Analysis
- Output Missing Data

Check Project Status

The user may select *Analysis/Check Project Status* to check the status of calculations on one or more runways.

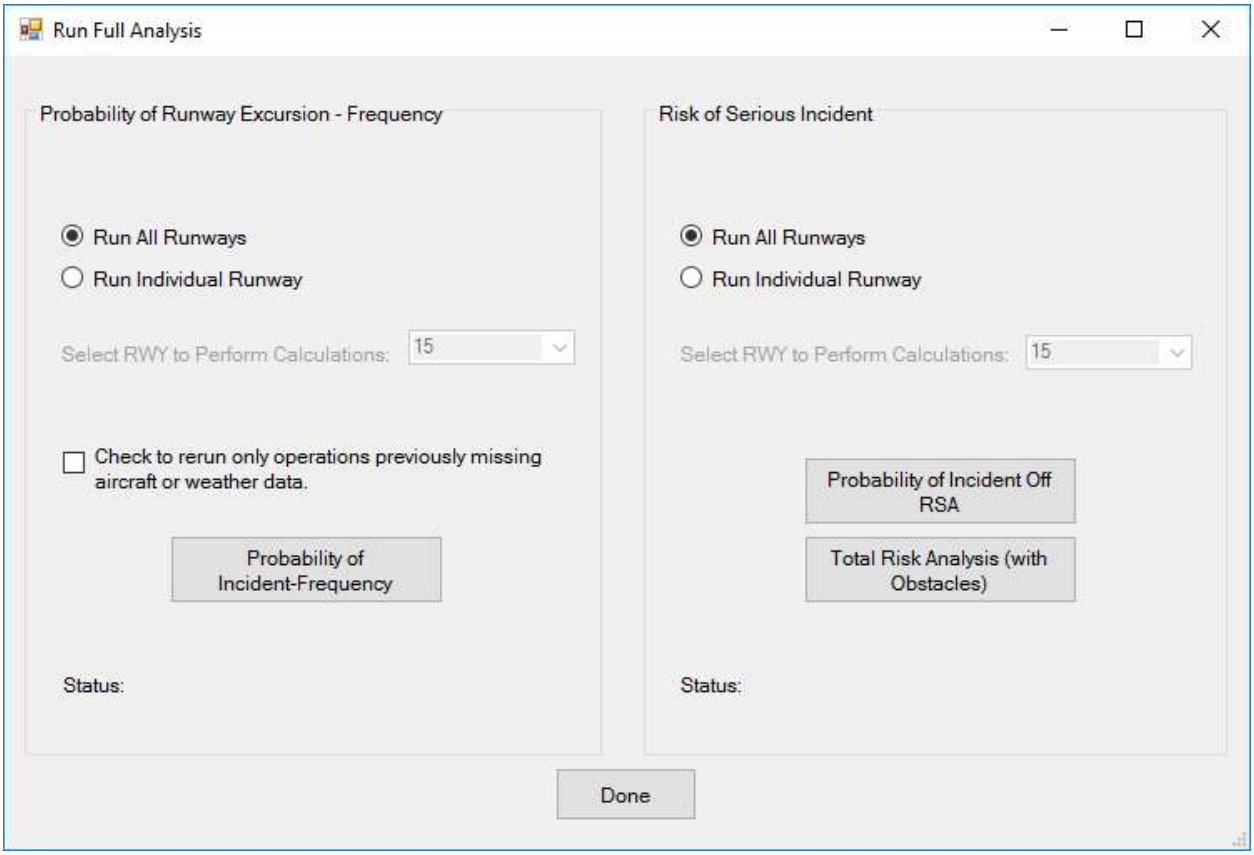


In the example presented, both the frequency and location probabilities for runways 15 and 33 were estimated.

Run Full Analysis

A full analysis requires the use of historical operations and weather information for the airport. The information is used to feed the frequency models presented in ACRP Report 50 and estimate the

probability of a runway excursion for each historical operation. To run the full analysis, select ***Analysis/Run Full Analysis***, and the following screen will appear.



You may run the analysis for individual runways or for all runways entered in the project. The selection is made on the top left of the screen, and if *Run Individual Runway* is selected, the list of runways is enabled for user selection.

After selecting *Run Individual Runway* or *Run All Runways*, the user must select one of the following three buttons to run the analysis:

- Probability of Incident-Frequency
- Probability of Incident Off RSA
- Total Risk Analysis (with Obstacles)

The analysis is conducted in two steps. First, click on *Probability of Incident-Frequency*. The program will only estimate the probability of individual incidents occurring. In this case, only the frequency model will be used to calculate the probability of overruns, undershoots, and veer-offs, no matter where the aircraft stopped or touched down. The program will store the results internally, and this step will allow the user to identify missing data on the historical records. **Running the** *Probability of Incident-Frequency* **is required before running the next steps**.

This step saves time when running the second step – when the actual RSA dimensions and obstacles will have an influence on the risk estimates. If the user wants to evaluate different RSA conditions, it will not be necessary to run the frequency model again.

The *Probability of Incident Off the RSA* button is used to estimate the probability that aircraft will overrun, veer-off, or undershoot the runway and that it will stop or touch down outside the limits of the existing or planned RSA. This analysis will not consider the risk of severe consequences, only the risk that the aircraft will cross the bounds of the RSA. Again, this analysis can be performed only after the user has run the *Probability of Incident*.

The *Total Risk Analysis* button allows the user to consider the interaction between the aircraft and the obstacles present within the RSA or its vicinity. The analysis will consider the type, location and size of the obstacles and will assume catastrophic consequences for cases when the aircraft is still moving when reaching the obstacle location. The speed of the aircraft to cause such serious consequences depends on the category of the obstacle. The end of the RSA for risk analysis is always assumed to be an obstacle of category 1 (maximum collision speed is nil, see below). **When clicking the *Total Risk Analysis* button, please wait a few minutes before the progress bar is shown**. The program is performing internal calculations before the progress bar is activated.

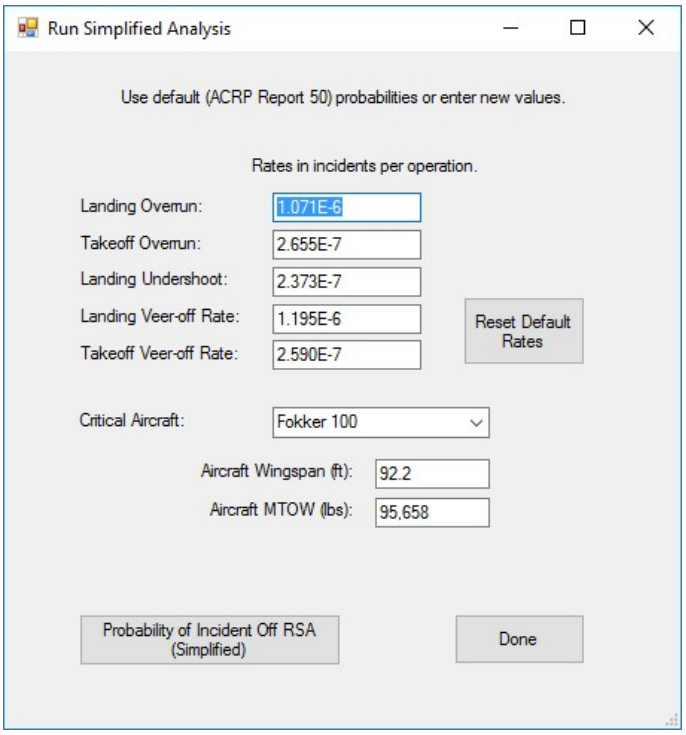
The approach to estimate the risk of catastrophic consequences uses the following assumptions:

1. Aircraft overrunning, undershooting, or veering-off the runway will strike the obstacle in paths parallel to the runway direction. This assumption is necessary to define the area of influence of the obstacle.
2. Four categories of obstacles are defined as a function of the maximum speed with which an aircraft may collide with an obstacle that produces small chances of causing hull loss and injuries to the occupants.
   a. Category 1: Maximum speed is nil (e.g., cliff at the RSA border, body of water for undershoots)
   b. Category 2: Maximum speed is 5 knots (e.g., brick buildings, non-frangible blast fences)
   c. Category 3: Maximum speed is 20 knots (e.g., small ditches, fences)
   d. Category 4: Maximum speed is 40 knots (e.g. large frangible at ground level structures such as Localizers and approach lighting systems (ALS))
3. Severe damage and injuries are expected only if the aircraft collides within the central third of the wingspan and with a speed higher than the maximum for that obstacle category.
4. The lateral distribution is random and does not depend on the presence of obstacles. This is a conservative assumption because there are events when the pilot will avoid the obstacles if he has some directional control of the aircraft. The accident/incident database contains a number of cases in which the pilot avoided a Localizer or some ALS structures in the RSA.

Run Simplified Analysis

For this alternative, no information on historical operations and weather for the airport are required. The probability of runway excursions is estimated from default, user-defined, or local historical values

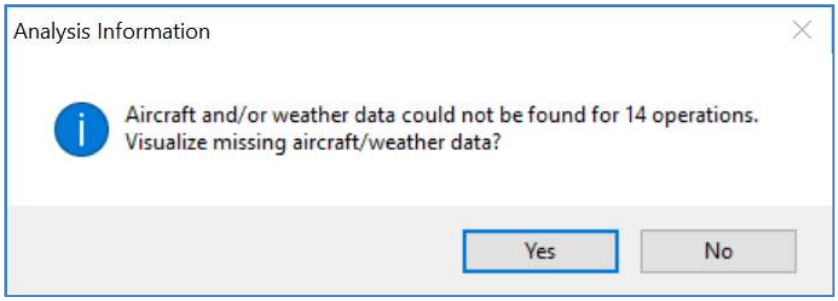
and are fixed for each type of runway excursion: landing overrun, takeoff overrun, landing undershoot, landing veer-off and takeoff veer-off. Default values were estimated based on ACRP Report 50 data used to develop the models; however, the user may change the default values as necessary. To run the simplified analysis, select ***Analysis/Run Simplified Analysis***, and the following screen will appear.



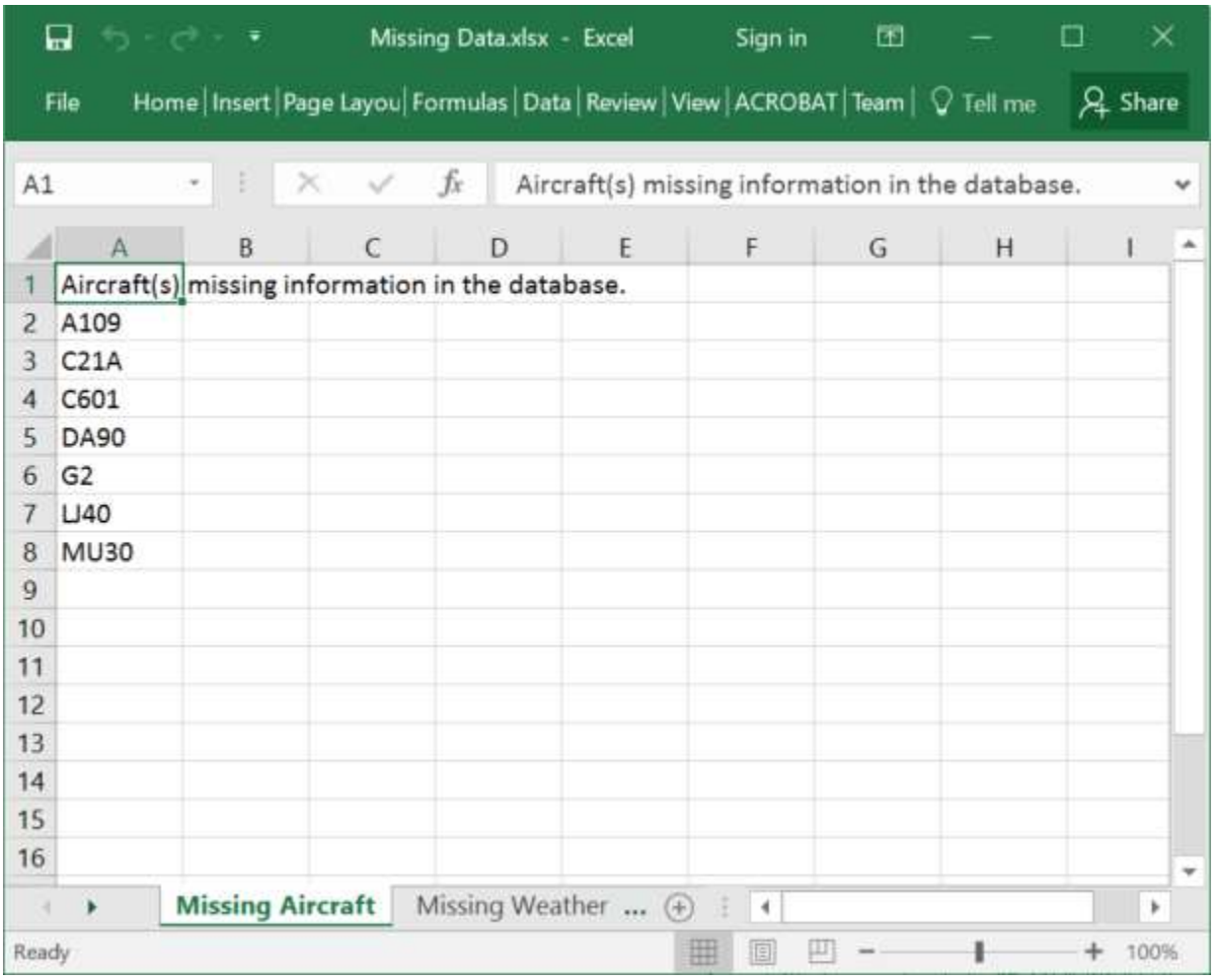
The user will select the aircraft with largest wingspan to run the analysis. The selection can be made using the drop box or enter directly the wingspan. Another information required is the Maximum Takeoff Weight (MTOW). The information is used in regression models to calculate deceleration when EMAS is installed in the RSA.

Output Missing Data

When running the analysis for a given runway for the first time, the program checks for records missing either aircraft or weather information. The analysis cannot be completed for specific records that have missing information. One common occurrence is a record for an aircraft that is not listed in the aircraft database. In most cases, the Federal Aviation Administration (FAA) code for the aircraft is a variation of the normal code; it is an aircraft that isn't widely used and is not in the default aircraft database; or it is an aircraft with maximum takeoff weight lower than 5,600 lbs. If missing records were identified during the run, the following screen will appear.



If the user selects *Yes*, an Excel spreadsheet will appear as shown below, showing the records with missing information. These records will be stored during the analysis and can be retrieved by the user at any time by clicking *Analysis/Output Missing Data*.



The user may ignore the list of records with missing data if the list contains only a few records; however, it is possible to fix the problems with such records and rerun the analysis for all runways or individual runways with only the missing records.

There are two ways to correct missing data for aircraft. If the information for the aircraft is not in the aircraft database, the user should click *Software Parameters/Aircraft Database* and add the aircraft information to the database. If the information is available and the code does not match the FAA code in the aircraft database, the user may simply edit the code by clicking *Analysis/Input Data/Historical Operations Data* and then *Edit Existing Input File*. Information on FAA codes for aircraft can be obtained from FAA Order JO 7110.65T (Feb 2010). All the mismatching codes should be replaced with the code matching the code available in the aircraft database.

If weather data is missing, the user may correct the file by clicking *Analysis/Input Data/Weather Database* and then *Edit Existing Input File* to make the necessary corrections.

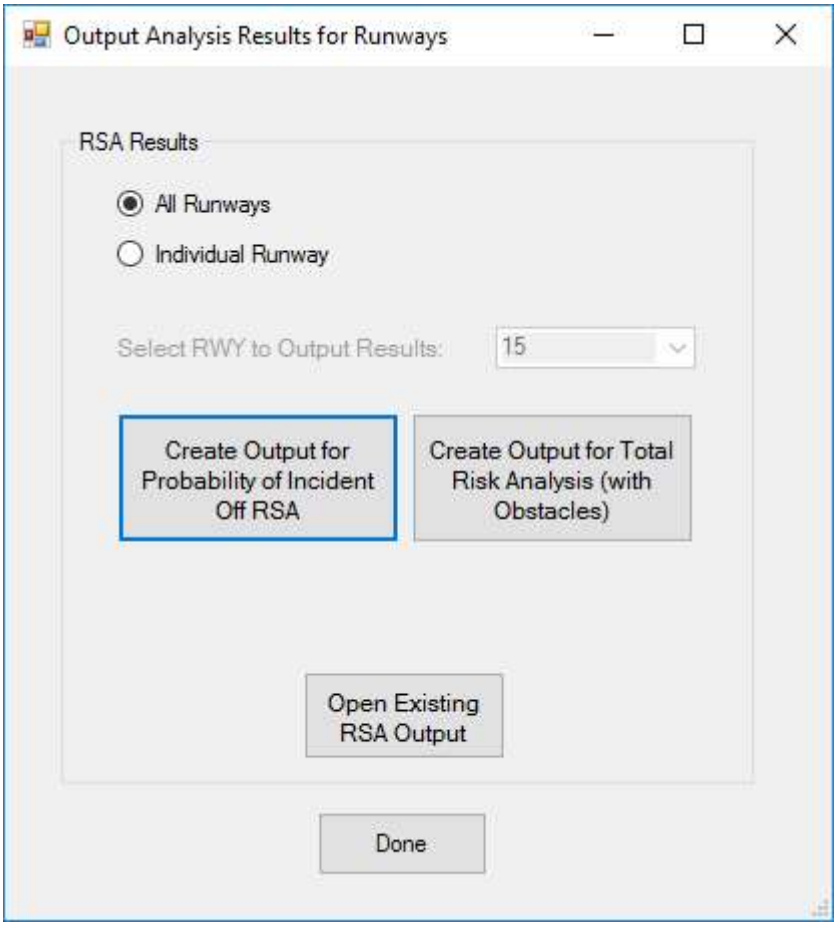
After the corrections are made, the user may run the analysis only for the missing records. This will save time, particularly for the analysis of larger airports with many historical records. To rerun the analysis for missing records, the user must check the option *Check to rerun fixed missing data* in the *Run Analysis* screen. The estimates after rerunning the analysis will consider both the previous and the new analysis of records recovered.

10. Output Results

When the analyses are completed, the user may see the results using the *Output* option of the main menu. There are two types of results: individual runways or the consolidated results for the whole airport. Within each of these options, the user can view the results for risk of events taking place outside the RSA or view the analysis output for the risk of catastrophic accidents.

Results for Runways

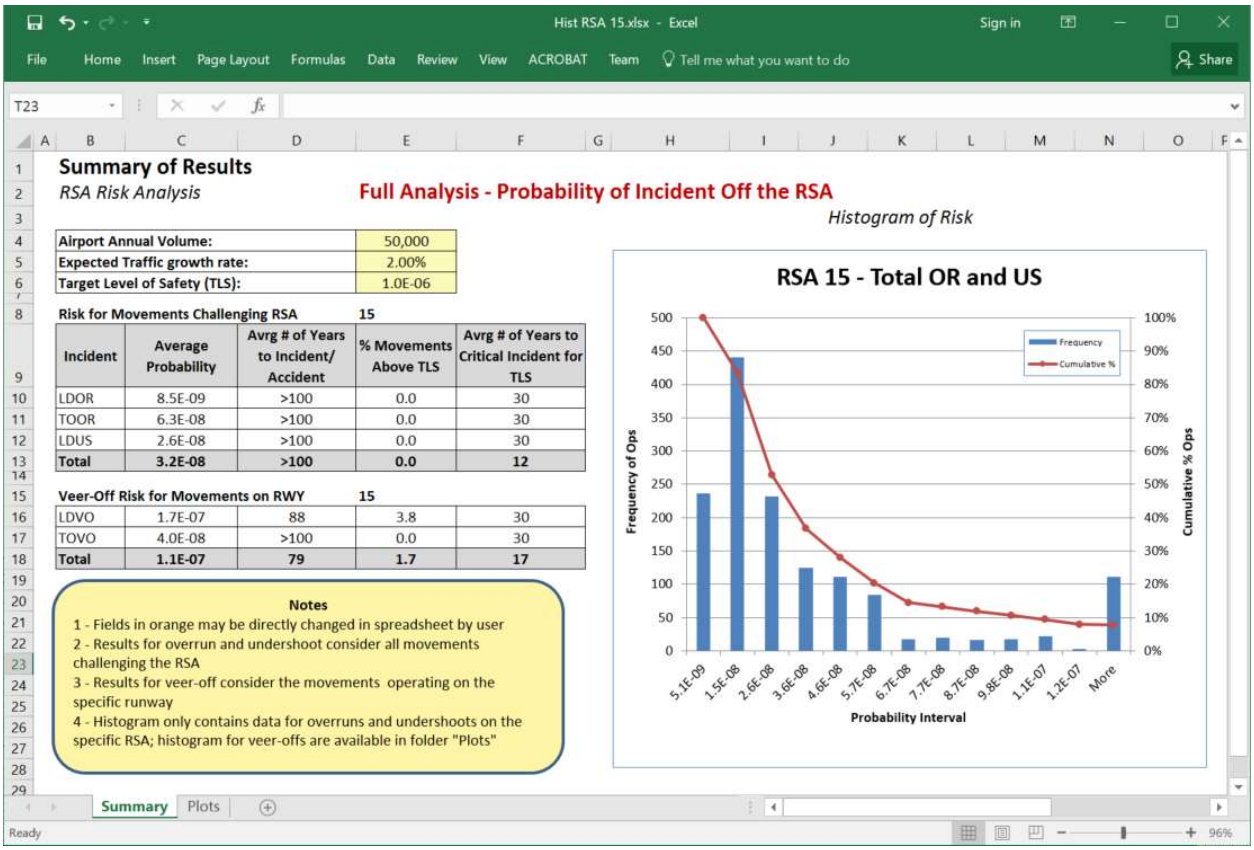
To see the results for all or individual runways, select *Output/Runway* and the following screen will appear.



The first step is to create the output and there are two alternatives, depending on the type of analysis that the user ran in the *Analysis* option of the main menu. The results are stored internally in the program and the need to create the output in this step is because the data will be transferred to an Excel spreadsheet to facilitate visualization of results.

Since this screen is for runways, the user may select one specific runway to output results, or to see the results for all the runways. In the latter case, the number of spreadsheets created will be the same as the number of runways analyzed.

The first option is to create the output for the analysis of RSA dimensions. To perform this procedure click *Create Output for Analysis of RSA Geometry* and a progress bar will open and show when the output is completed. Next, click *Open Results*, and an Excel spreadsheet will open as shown below. Please note that the *Open Results* button will only open the last output created.



Results are presented in both tabular and graphical format. Each folder contains the risk estimates for each type of incident and individual operation and the total risk during landings and takeoffs. A summary of the results is presented in the *Summary* folder shown in the previous screen. The summary table is shown below. It is very important to understand the information contained in the three tables shown.

The first table contains the *Airport Annual Volume* and the expected *Annual Traffic Growth Rate* and these values may also be modified by the user in the output spreadsheet. By changing these values, the average number of years between incidents will also change to reflect the new volume of traffic estimated for future years. The second information, the *Target Level of Safety (TLS)*, may also be modified in the spreadsheet and the value will impact on the percentage of movements above the TLS (4th column in the large table).

Airport Annual Volume:	50,000
Expected Traffic growth rate:	2.00%
Target Level of Safety (TLS):	1.0E-06

The second table is titled *Risk of Movements Challenging the RSA* and contains results for the RSA adjacent to the arrival end of the runway selected per type of event (column 1). For example, if the user selected to output results for runway 15, this table presents the analysis results for overruns and undershoots occurring in the area adjacent to the arrival end of runway 15. These incidents are those

associated with the movements challenging this RSA, and may take place when aircraft land on runway 15 (undershoots) or when aircraft land or takeoff on runway 33 (overruns).

Risk for Movements Challenging RSA 15

Incident	Average Probability	Avrg # of Years to Incident/ Accident	% Movements Above TLS	Avrg # of Years to Critical Incident for TLS
LDOR	8.5E-09	>100	0.0	30
TOOR	6.3E-08	>100	0.0	30
LDUS	2.6E-08	>100	0.0	30
Total	**3.2E-08**	**>100**	**0.0**	**12**

The second column shows the average probability of incident outside the RSA and the third column contains the average number of years expected between events; in this case, when the result is greater than 100, the “>100” value is informed. The fourth column provides the percentage of movements with risk higher than the adopted TLS. The fact that some operations are subject to such higher risk does not means that the operations are unacceptable. However it is desired that the percentage of such flights be minimized for each runway and for the whole airport.

The third table titled *Veer-Off Risk for Movements* on the selected runway contains results for veer-off only. This is necessary because it is a different area and comprises the lateral safety areas between the runway ends. The configuration of this table is similar to that presenting the results for the RSA (second table).

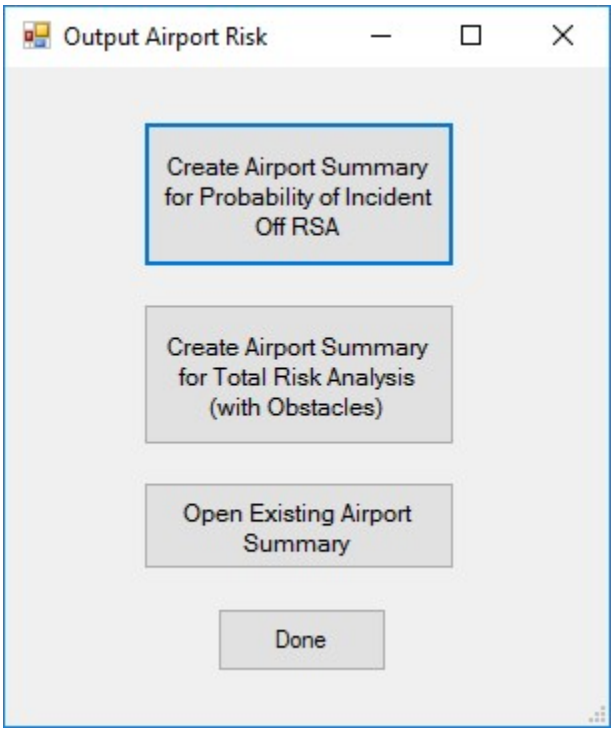
Veer-Off Risk for Movements on RWY 15

LDVO	1.7E-07	88	3.8	30
TOVO	4.0E-08	>100	0.0	30
Total	**1.1E-07**	**79**	**1.7**	**17**

The histogram shown in the *Summary* folder contains the data for each movement challenging the RSA adjacent to the arrival end of the runway selected. Therefore the data is only for overruns and undershoots only. Similar histograms for each individual type of incident are available in the *Plots* folder. Please note the total number of movements is higher than the number of movements for the airport and the reason is that one landing will challenge the arrival end RSA for undershoot, the departure end for overrun, and the lateral safety areas for veer-off.

Results for the Airport

To see the results for the airport as a whole, select *Output/Airport* and the following screen will appear.



Again, it is necessary to create the output if this procedure has not been performed earlier. The user may select the type of output and click *Open Summary for Airport* to view the results in a spreadsheet as shown in the screen below.

AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP

Full Analysis - Probability of Incident Off the RSA

Overall Results

Summary Table

Accident	Average Probability	Avrg # of Years to Critical Incident	% Ops Above TLS	Avrg # of Years to Critical Incident for TLS
LDOR	9.8E-09	>100	0.0	30
TOOR	6.8E-08	>100	0.0	30
LDUS	2.2E-08	>100	0.0	30
LDVO	1.6E-07	89	3.7	30
TOVO	4.5E-08	>100	0.0	30
Total	**6.2E-08**	**64**	**0.1**	**17**

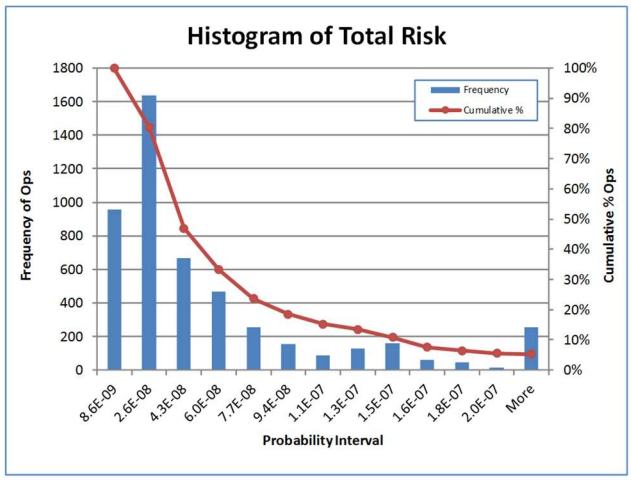
Airport Annual Volume:	50,000
Expected Traffic growth rate:	2.00%
Target Level of Safety (TLS):	1.0E-06

Airport: Anywhere Airport

Date of Analysis: 12/11/2016

Analyst: Jane Doe

Note: fields in yellow may be changed by user



Notes

1 - Fields in orange may be directly changed in spreadsheet by user
2 - Results for overrun and undershoot consider all movements challenging each RSA adjacent to the ends of each runway
3 - The total risk for the airport is per movement (landing and taking-off)
4 - Each takeoff will challenge the RSA adjacent to the departure end for overruns and the lateral safety areas for veer-offs
5 - Each landing will challenge the RSA adjacent to the arrival end for undershoots, the RSA adjacent to the departure end for overruns and the lateral safety areas for veer-off
6 - Histogram for the whole airport is for any type of event and include each movement challenging the RSA

Summary of Results by Runway

Risk in Events per Operation

Type of Accident	RSA	
	15	33
LDOR	8.49E-09	1.13E-08
TOOR	6.28E-08	7.26E-08
LDUS	2.61E-08	1.90E-08
LDVO	1.72E-07	1.57E-07
TOVO	4.03E-08	5.09E-08

Average # of Years Between Accidents

Type of Accident	RSA	
	15	33
LDOR	>100	>100
TOOR	>100	>100
LDUS	>100	>100
LDVO	88	91
TOVO	>100	>100

Percent Events Above 1.0E-06

Type of Accident	RSA	
	15	33
LDOR	0.00	0.00
TOOR	0.00	0.00
LDUS	0.00	0.00
LDVO	3.80	3.61
TOVO	0.00	0.00

Summary of Operations Challenging the RSAs

Movements Challenging each RSA

Type of Accident	RSA	
	15	33
LDOR	471	447
TOOR	520	548
LDUS	447	471
LDVO	447	471
TOVO	548	520
Total	2433	2457

The tables are similar to those presented for individual runways, except that results for all types of incidents/accidents are consolidated and data for individual risk for any type of event are consolidated into the histogram. In addition, individual tables containing results for each runway are also presented.

Similar to the output for individual runways, the spreadsheet also provides a *Plots* folder containing histograms for individual types of incidents/accidents for the airport as a whole.

An example of the first table is shown below. It contains in the second column the average probabilities for each type of event and the total average probability for the airport. In the third column, the average number of years between incidents or accidents is calculated. This number is estimated based on the event probability, the annual volume of operations challenging the RSA for the given event, and the expected growth rate. Please note that this number is not to predict how many years it will take for that accident to happen; rather, it is an indication on how frequently the event can take place if the same conditions of operations are kept for a very long period of activity at the airport.

The fourth column indicates the percentage of movements challenging the RSA that have a risk higher than the selected TLS (e.g. for landing veer-offs (LDVO), 3.7% of the movements are under a risk higher than 1.0E-06, (one in one million movements).

Finally, column 5 contains the estimated number of years between events for the selected TLS. The results in this column are calculated using the same method used to estimate the results in the third column, except that the risk used is the TLS.

The table immediately below has the airport volume of operations (annual number of movements (landings and takeoffs), the expected annual growth rate of traffic, and the selected TLS. These numbers can be directly changed in the spreadsheet and new values will be calculated for the third, fourth and fifth columns of the main table.

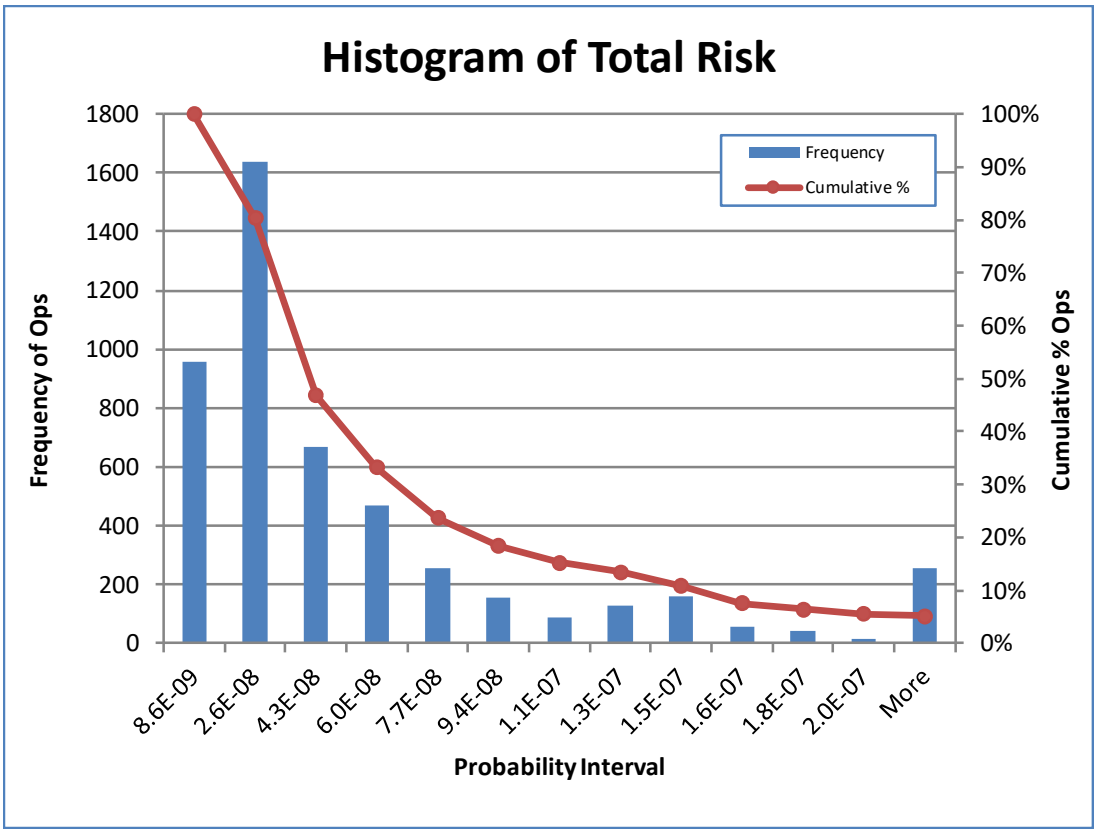
Overall Results

Summary Table

Accident	Average Probability	Avrg # of Years to Critical Incident	% Ops Above TLS	Avrg # of Years to Critical Incident for TLS
LDOR	9.8E-09	>100	0.0	30
TOOR	6.8E-08	>100	0.0	30
LDUS	2.2E-08	>100	0.0	30
LDVO	1.6E-07	89	3.7	30
TOVO	4.5E-08	>100	0.0	30
Total	**6.2E-08**	**64**	**0.1**	**17**

Airport Annual Volume:	50,000
Expected Traffic growth rate:	2.00%
Target Level of Safety (TLS):	1.0E-06

Below the main table, a plot with the total distribution of risk is shown. Data used for this plot are originated from each type of event and two results are presented. The bars comprise the histogram of risk and each bar represents a given risk level shown in the x-axis. The percentage of operations for each bar is read on the left y-axis. The red line indicates the percentage of movements that have a risk higher than the value read in the x-axis (e.g. approximately 15% of movements are subject to risk higher than 1.1E-7 (or one event in 9,090,000 movements).



Additional tables are shown on the right of the main table. The first one is shown below and presents the average risk level for each type of event and the associated RSA challenged by the movements.

Summary of Results by Runway

Risk in Events per Operation

Type of Accident	RSA	
	15	33
LDOR	8.49E-09	1.13E-08
TOOR	6.28E-08	7.26E-08
LDUS	2.61E-08	1.90E-08
LDVO	1.72E-07	1.57E-07
TOVO	4.03E-08	5.09E-08

The table below presents the average number of years to occur one accident if the operational conditions were similar during a long period of activity. Similar to the previous table, the results are provided by RSA challenged by aircraft movements at the airport.

Average # of Years Between Accidents

Type of Accident	RSA	
	15	33
LDOR	>100	>100
TOOR	>100	>100
LDUS	>100	>100
LDVO	88	91
TOVO	>100	>100

The third table in the group shows the percentage of movements challenging each RSA that are subject to risk level higher than one accident in one million operations.

Percent Events Above 1.0E-06

Type of Accident	RSA	
	15	33
LDOR	0.00	0.00
TOOR	0.00	0.00
LDUS	0.00	0.00
LDVO	3.80	3.61
TOVO	0.00	0.00

The final table shows the total number of movements that challenge each RSA. These values are based on the HOD sample used for the analysis.

Summary of Operations Challenging the RSAs

Movements Challenging each RSA

Type of Accident	RSA	
	15	33
LDOR	471	447
TOOR	520	548
LDUS	447	471
LDVO	447	471
TOVO	548	520
Total	2433	2457

Results for Simplified Analysis

An Excel file will open upon completion of the simplified analysis, as shown in the example below.

AIRPORT COOPERATIVE RESEARCH PROGRAM ACRP

Simplified RSA Risk Analysis - Probability of Incident Off the RSA

Summary Table

Accident	Average Risk of Accident	Avrg # of Years to Critical Incident
LDOR	1.24E-07	>100
TOOR	1.00E-07	>100
LDUS	7.74E-08	>100
LDVO	8.62E-07	33
TOVO	1.72E-07	88
Total	**2.67E-07**	**24**

Airport Annual Volume[1]:	50,000
Expected Traffic growth rate:	2.00%

1. Assumed 50% Landing and 50% Take-off

Airport: Anywhere Airport

Date of Analysis: 12/8/2016

Analyst: Jane Doe

Notes

1 - Fields in yellow may be directly changed in spreadsheet by user.
2 - The total risk for the airport is per movement (landing and taking-off), based on traffic distribution provided by the analyst.
3 - Each takeoff will challenge the RSA adjacent to the departure end for overruns and the lateral safety areas for veer-offs.
4 - Each landing will challenge the RSA adjacent to the arrival end for undershoots, the RSA adjacent to the departure end for overruns, and the lateral safety areas for veer-offs.

Summary of Results by Runway

Landing Distribution (%)

Operation	RWY	
	15	33
Landing	25.0%	25.0%
Takeoff	25.0%	25.0%
Runway Total:	50%	50%
Airport Total:	100%	

Probability of Incident Off the RSA

Type of Accident	RSA	
	15	33
LDOR	1.45E-07	1.04E-07
TOOR	1.04E-07	9.65E-08
LDUS	6.99E-08	8.49E-08
LDVO	8.62E-07	8.62E-07
TOVO	1.72E-07	1.72E-07
Total	2.70E-07	2.64E-07

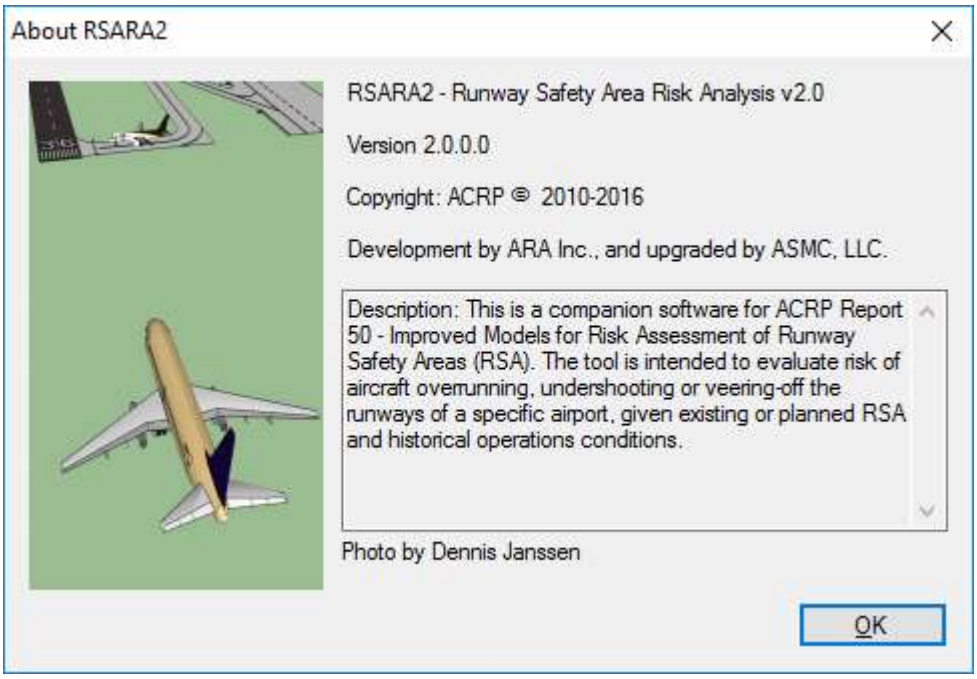
Average # of Years Between Accidents

Type of Accident	RSA	
	15	33
LDOR	>100	>100
TOOR	>100	>100
LDUS	>100	>100
LDVO	53	53
TOVO	>100	>100
Total	23	24

The functionality of this output is similar to that for the full analysis. The user may change the volume of operations, traffic growth rate and runway use to automatically change the results in the spreadsheet.

11. Help and Troubleshooting

The last option in the main menu is *Help*. When selecting this option *Help/Content*, a pdf version of this User Guide will open. If the user selects *Help/About*, the following screen will be presented.

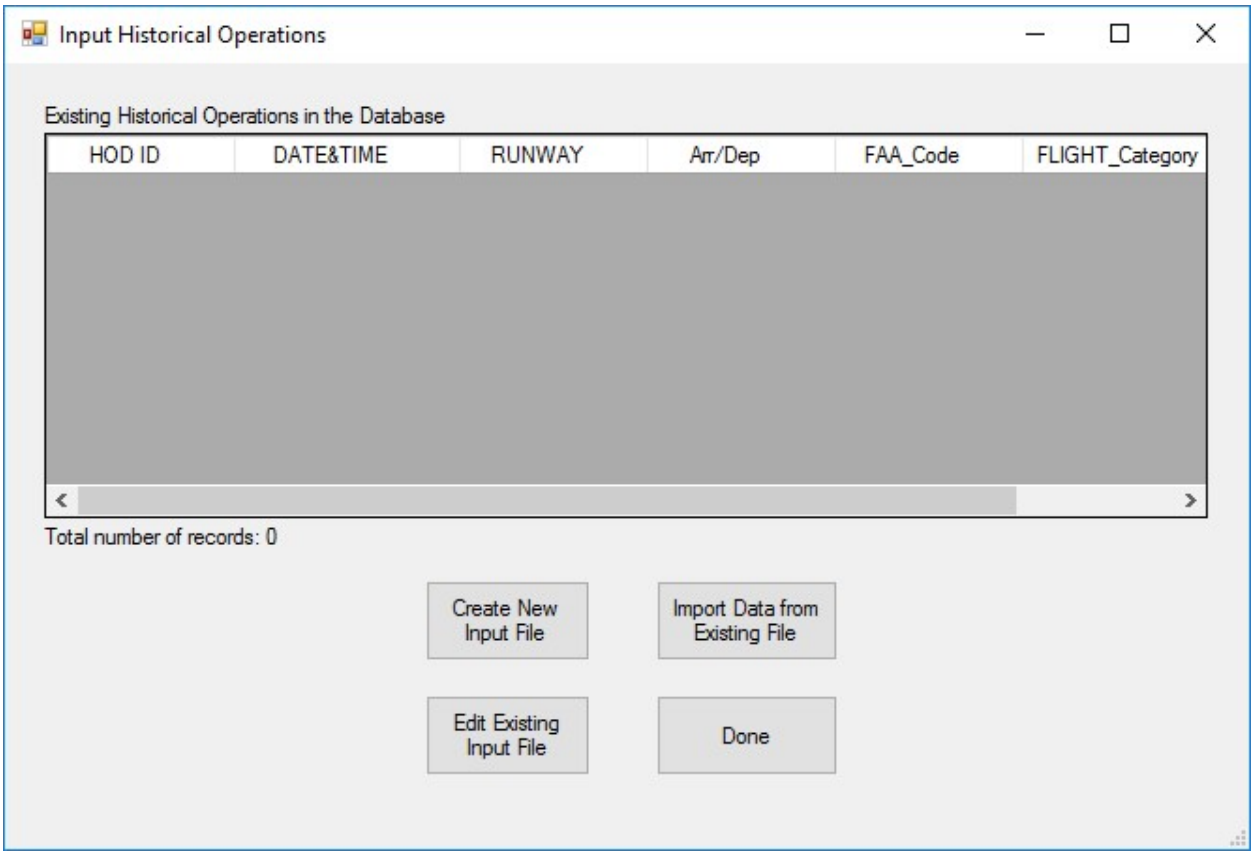


Attachment A – Historical Operations Data

This section describes the procedure to prepare historical operations data for the airport. The historical operations data provided is consolidated internally in the program with the weather information provided (see Attachment B). The process is used to characterize the sample operations for the airport and weather conditions that these operations were subject.

Ideally a sample of data covering one full year of recent operations should be prepared to run the analysis. Having one year of data will help take into consideration seasonal weather and operational variations.

A Microsoft Excel spreadsheet is used to enter the Historical Operations Data and create the sample. To create this database, select *Input Data/Historical Operations Database* and the following screen will open.

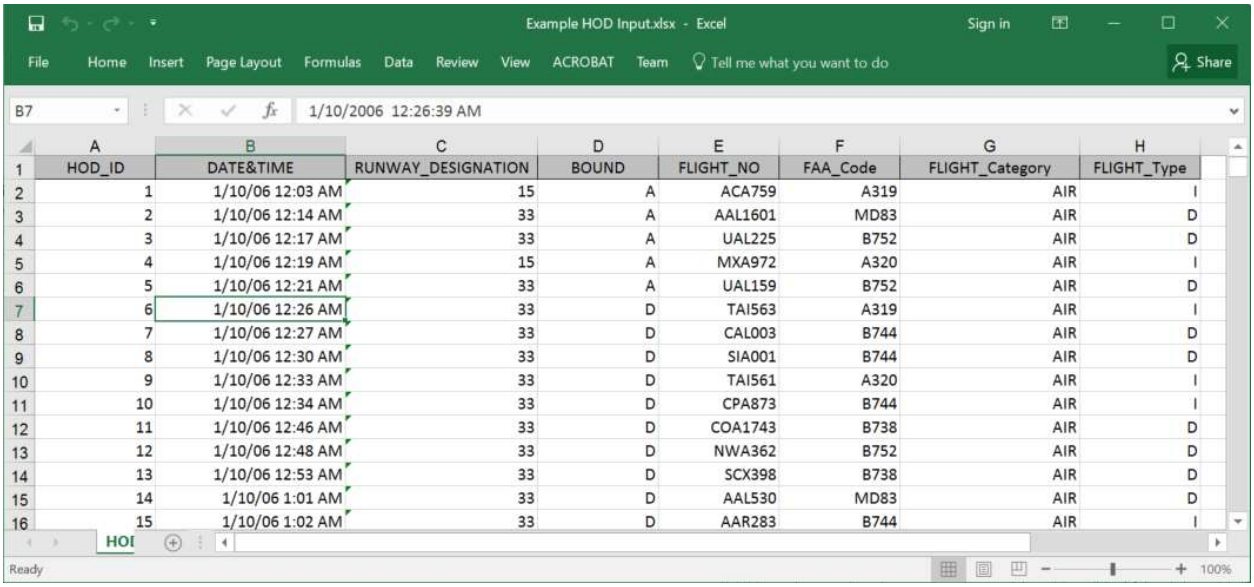


Please click on *File/Save As* and select a file name to identify the project.

Each line in the spreadsheet should correspond to one record. The following table contains a description of each field.

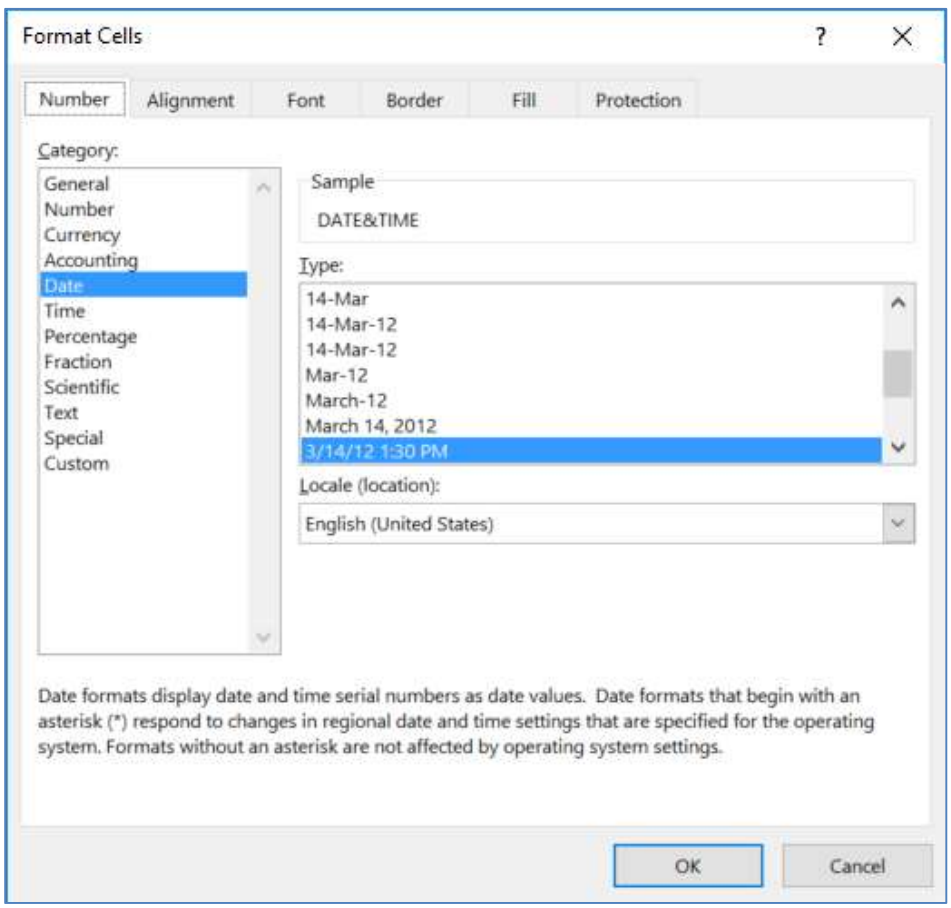
Field	Description	Format
HOD_ID	This is an ID for the record and any reference may be used by the person creating the database. We suggest to enter a number, starting from 1 to the last record number, as shown in the example below.	Any format may be used. This information is not used by the program and is intended only to be a reference for the user.
DATE&TIME	This is the date and time when the aircraft movement took place	The format includes date and time, and is already set in the template provided with the program. Please see example below.
RWY_DESIGNATION	This is the runway designation where the movement took place.	The runway number and letter should be included (e.g. 14R or 23).
BOUND	If the movement is an arrival or departure.	Use ***A*** for arrival and ***D*** for departure
FLIGHT#	The flight number for the movement.	Any format can be used (e.g. AAL622). This information is for user reference only and does not need to be filled in because the program does not require it.
FAA_CODE	This is the code used by the FAA to characterize the aircraft type and model.	The code must match those available in the aircraft database. For example B733 is used for the Boeing 737-300 aircraft. When running the analysis, the program will attempt to match this code to one of the codes in the aircraft library. If the program is unable to match to an existing aircraft code, the record will be saved in a file for missing data and later the user can insert the new aircraft in the database and rerun the analysis for missing data records.
FLIGHT_CATEGORY	This field is used to characterize the type of flight: commercial, cargo, commuter/taxi or general aviation (GA)	Use ***AIR*** for commercial, ***CAR*** for cargo, ***COM*** for commuter/taxi and ***GA*** for general aviation
FLIGHT_TYPE	This is a code used to characterize if the flight is arriving from or departing to an international destination	Use ***D*** for domestic and ***I*** for international

An example of the template filled with the information needed to run the program is shown below.



HOD_ID	DATE&TIME	RUNWAY_DESIGNATION	BOUND	FLIGHT_NO	FAA_Code	FLIGHT_Category	FLIGHT_Type
1	1/10/06 12:03 AM	15	A	ACA759	A319	AIR	I
2	1/10/06 12:14 AM	33	A	AAL1601	MD83	AIR	D
3	1/10/06 12:17 AM	33	A	UAL225	B752	AIR	D
4	1/10/06 12:19 AM	15	A	MXA972	A320	AIR	I
5	1/10/06 12:21 AM	33	A	UAL159	B752	AIR	D
6	1/10/06 12:26 AM	33	D	TAI563	A319	AIR	I
7	1/10/06 12:27 AM	33	D	CAL003	B744	AIR	D
8	1/10/06 12:30 AM	33	D	SIA001	B744	AIR	D
9	1/10/06 12:33 AM	33	D	TAI561	A320	AIR	I
10	1/10/06 12:34 AM	33	D	CPA873	B744	AIR	I
11	1/10/06 12:46 AM	33	D	COA1743	B738	AIR	D
12	1/10/06 12:48 AM	33	D	NWA362	B752	AIR	D
13	1/10/06 12:53 AM	33	D	SCX398	B738	AIR	D
14	1/10/06 1:01 AM	33	D	AAL530	MD83	AIR	D
15	1/10/06 1:02 AM	33	D	AAR283	B744	AIR	I

If the date and time format is not matching the format presented in the example above, the user may adjust by selecting the column, right-clicking and selecting *Format Cells*. In the dialog box, select Date in the *Category* box and selecting *3/14/12 1:30PM* in the *Type* box, as shown in the screen below.

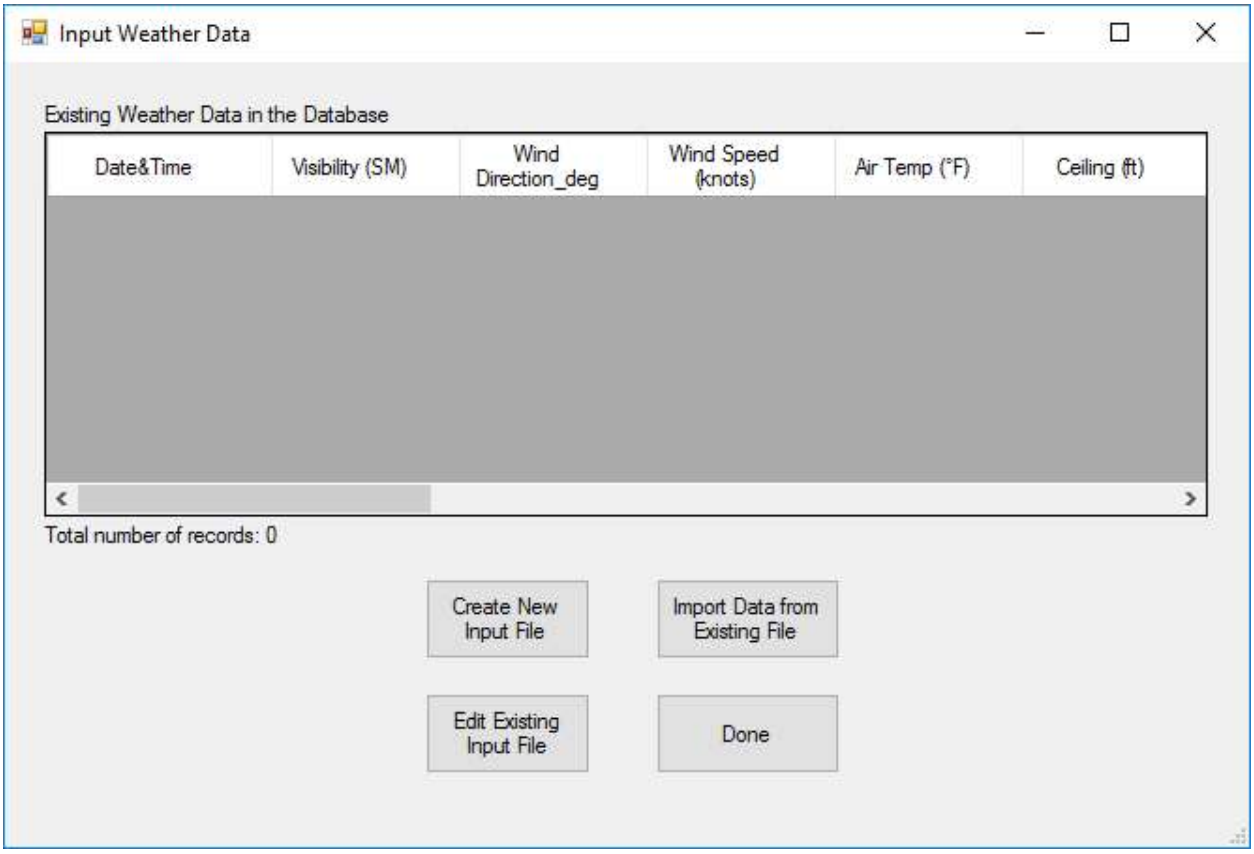


Attachment B – Historical Weather Data

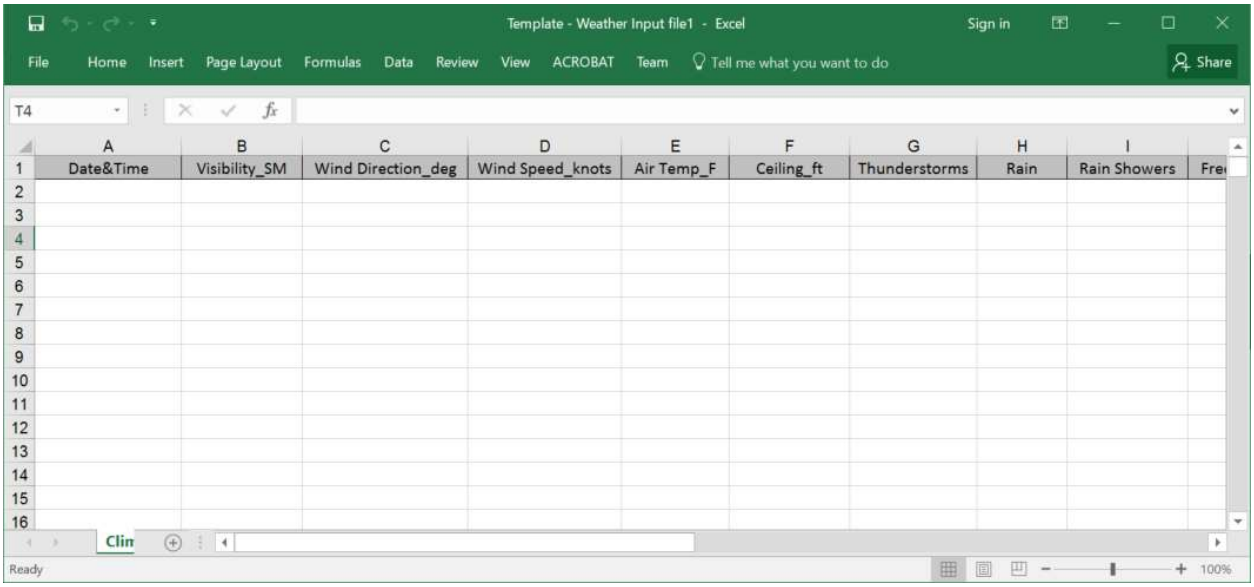
This section describes the procedure to prepare historical weather data for the airport. The historical weather data provided is consolidated internally in the program with the historical operations information provided (see Attachment A). The process is used to characterize the sample operations for the airport and weather conditions that these operations were subject.

The period for weather data must match the same period for historical operations data. Having one year of data will help take into consideration seasonal weather and operational variations.

A Microsoft Excel (2007 or later) spreadsheet is used to enter the Historical Operations Data and create the sample. To create this database, select Input Data/Weather Database and the following screen will open.



To create the weather file, click on Create New and an empty Excel file will open. Please click File/Save As and enter a file name to identify the project. The Excel spreadsheet has twenty columns as shown below.

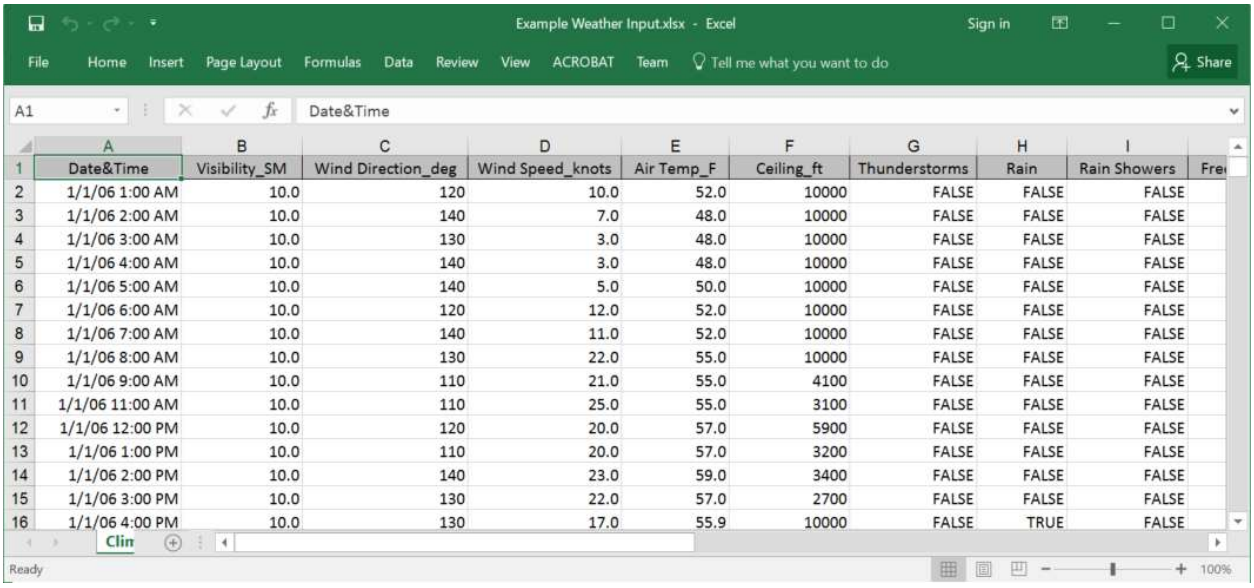


Each line in the spreadsheet should correspond to one record. The following table contains a description of each field.

Field	Description	Format
Date&Time	This is the date and time when the weather measures were taken	The format includes date and time, and is already set in the template provided with the program.
Visibility_NM	The distance at which a given standard object can be seen and identified with the unaided eye	Nautical Miles (NM)
Wind Direction_deg	The true direction from which the wind is blowing at a given location (i.e., wind blowing from the north to the south is a north wind). A wind direction of 0 degrees is only used when wind is calm.	In degrees clockwise through 360 degrees. North is 360 degrees.
Wind Speed_knots	The rate at which air is moving horizontally past a given point. It may be a 2-minute average speed (reported as wind speed) or an instantaneous speed (reported as a peak wind speed, wind gust, or squall).	Knots (kts)
Air Temp_F	The ambient temperature indicated by a thermometer exposed to the air but sheltered from direct solar radiation.	Degrees Fahrenheit (F)
Ceiling_ft	The height of the cloud base for the lowest broken or overcast cloud layer.	Feet (ft)
Thunderstorm	A local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder	Presence (TRUE) or not (FALSE)
Rain	Precipitation that falls to earth in drops more than 0.5 mm in diameter.	Presence (TRUE) or not (FALSE)

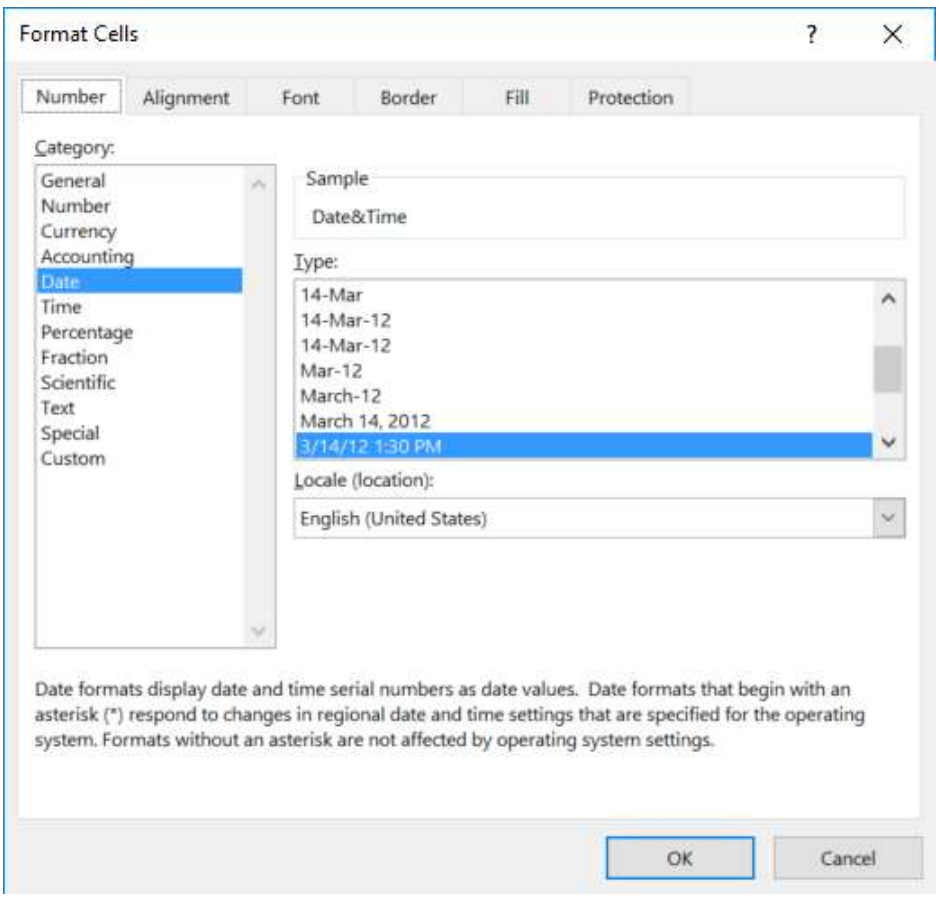
Field	Description	Format
Rain Showers	A brief period of rain	Presence (TRUE) or not (FALSE)
Freezing Rain	Rain that falls as a liquid but freezes into glaze upon contact with the ground.	Presence (TRUE) or not (FALSE)
Freezing Drizzle	A drizzle that falls as a liquid but freezes into glaze or rime upon contact with the cold ground or surface structures.	Presence (TRUE) or not (FALSE)
Snow	Precipitation in the form of ice crystals, often agglomerated into snowflakes, formed directly from the freezing [deposition] of the water vapor in the air.	Presence (TRUE) or not (FALSE)
Snow Pellets	Precipitation, usually of brief duration, consisting of crisp, white, opaque ice particles, round or conical in shape and about 2 to 5 mm in diameter. Same as graupel or small hail.	Presence (TRUE) or not (FALSE)
Ice Crystals	A barely visible crystalline form of ice that has the shape of needles, columns or plates. Ice crystals are so small that they seem to be suspended in air. Ice crystals occur at very low temperatures in a stable atmosphere.	Presence (TRUE) or not (FALSE)
Snow Showers	Short duration of moderate snowfall. Some accumulation is possible.	Presence (TRUE) or not (FALSE)
Ice Pellets	Same as Sleet; defined as pellets of ice composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes. These pellets of ice usually bounce after hitting the ground or other hard surfaces. Heavy sleet is a relatively rare event defined as an accumulation of ice pellets covering the ground to a depth of ½" or more.	Presence (TRUE) or not (FALSE)
Ice Pellet Showers	Short duration of ice pellet precipitation.	Presence (TRUE) or not (FALSE)
Fog	Fog is water droplets suspended in the air at the Earth's surface. Fog often degrades the visibility.	Presence (TRUE) or not (FALSE)
Gusts	A rapid fluctuation of wind speed with variations of 10 knots or more between peaks and lulls.	Presence (TRUE) or not (FALSE)

An example of the template filled with the information needed to run the program is shown below.



	A	B	C	D	E	F	G	H	I
1	Date&Time	Visibility_SM	Wind Direction_deg	Wind Speed_knots	Air Temp_F	Ceiling_ft	Thunderstorms	Rain	Rain Showers
2	1/1/06 1:00 AM	10.0	120	10.0	52.0	10000	FALSE	FALSE	FALSE
3	1/1/06 2:00 AM	10.0	140	7.0	48.0	10000	FALSE	FALSE	FALSE
4	1/1/06 3:00 AM	10.0	130	3.0	48.0	10000	FALSE	FALSE	FALSE
5	1/1/06 4:00 AM	10.0	140	3.0	48.0	10000	FALSE	FALSE	FALSE
6	1/1/06 5:00 AM	10.0	140	5.0	50.0	10000	FALSE	FALSE	FALSE
7	1/1/06 6:00 AM	10.0	120	12.0	52.0	10000	FALSE	FALSE	FALSE
8	1/1/06 7:00 AM	10.0	140	11.0	52.0	10000	FALSE	FALSE	FALSE
9	1/1/06 8:00 AM	10.0	130	22.0	55.0	10000	FALSE	FALSE	FALSE
10	1/1/06 9:00 AM	10.0	110	21.0	55.0	4100	FALSE	FALSE	FALSE
11	1/1/06 11:00 AM	10.0	110	25.0	55.0	3100	FALSE	FALSE	FALSE
12	1/1/06 12:00 PM	10.0	120	20.0	57.0	5900	FALSE	FALSE	FALSE
13	1/1/06 1:00 PM	10.0	110	20.0	57.0	3200	FALSE	FALSE	FALSE
14	1/1/06 2:00 PM	10.0	140	23.0	59.0	3400	FALSE	FALSE	FALSE
15	1/1/06 3:00 PM	10.0	130	22.0	57.0	2700	FALSE	FALSE	FALSE
16	1/1/06 4:00 PM	10.0	130	17.0	55.9	10000	FALSE	TRUE	FALSE

If the date and time format is not matching the format presented in the example above, the user may adjust by selecting the column, right-clicking and selecting *Format Cells*. In the dialog box, select *Date* in the *Category* box and selecting *3/14/12 1:30PM* in the *Type* box, as shown in the screen below.



Attachment C – Installing MS Access Database Engine

This section describes how to download and install MS Access Database Engine 2010. Please go to https://www.microsoft.com/en-us/download/confirmation.aspx?id=13255 and download the file AccessDatabaseEngine.exe.

*Please **don't** download and install AccessDatabaseEngine_X64.exe*

The AccessDatabaseEngine.exe download will install a set of components that facilitate the transfer of data between existing Microsoft Office files such as Microsoft Office Access 2010 (*.mdb and *.accdb) files and Microsoft Office Excel 2010 (*.xls, *.xlsx, and *.xlsb) files to other data sources such as Microsoft SQL Server. Connectivity to existing text files is also supported. ODBC and OLEDB drivers are installed for application developers to use in developing their applications with connectivity to Office file formats.

System Requirements

Windows 7, Windows 8, Windows Server 2003 R2 (32-Bit x86), Windows Server 2003 R2 x64 editions, Windows Server 2008 R2, Windows Server 2008 Service Pack 2, Windows Server 2012 R2, Windows Vista Service Pack 1, Windows XP Service Pack 3.

Install Instructions

Note: Before installing this download, you must first remove any previous versions of the Access Database Engine from your computer by using Add/Remove Programs in the Control Panel.

Download the file by clicking the Download button and saving the file to your hard disk. Double-click the AccessDatabaseEngine.exe program file on your hard disk to start the setup program. Follow the instructions on the screen to complete the installation.

Removing the Database Engine

If desired, o remove the download file itself, delete the file AccessDatabaseEngine.exe. On the Start menu, point to Settings and then click Control Panel. Double-click Add/Remove Programs. In the list of currently installed programs, select "Microsoft Access database engine 2010" and then click Remove or Add/Remove. If a dialog box appears, follow the instructions to remove the program. Click Yes or OK to confirm that you want to remove the program. Please note that removing the Database Engine may cause errors when running RSARA2.