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## 6 DOF with Trades Example

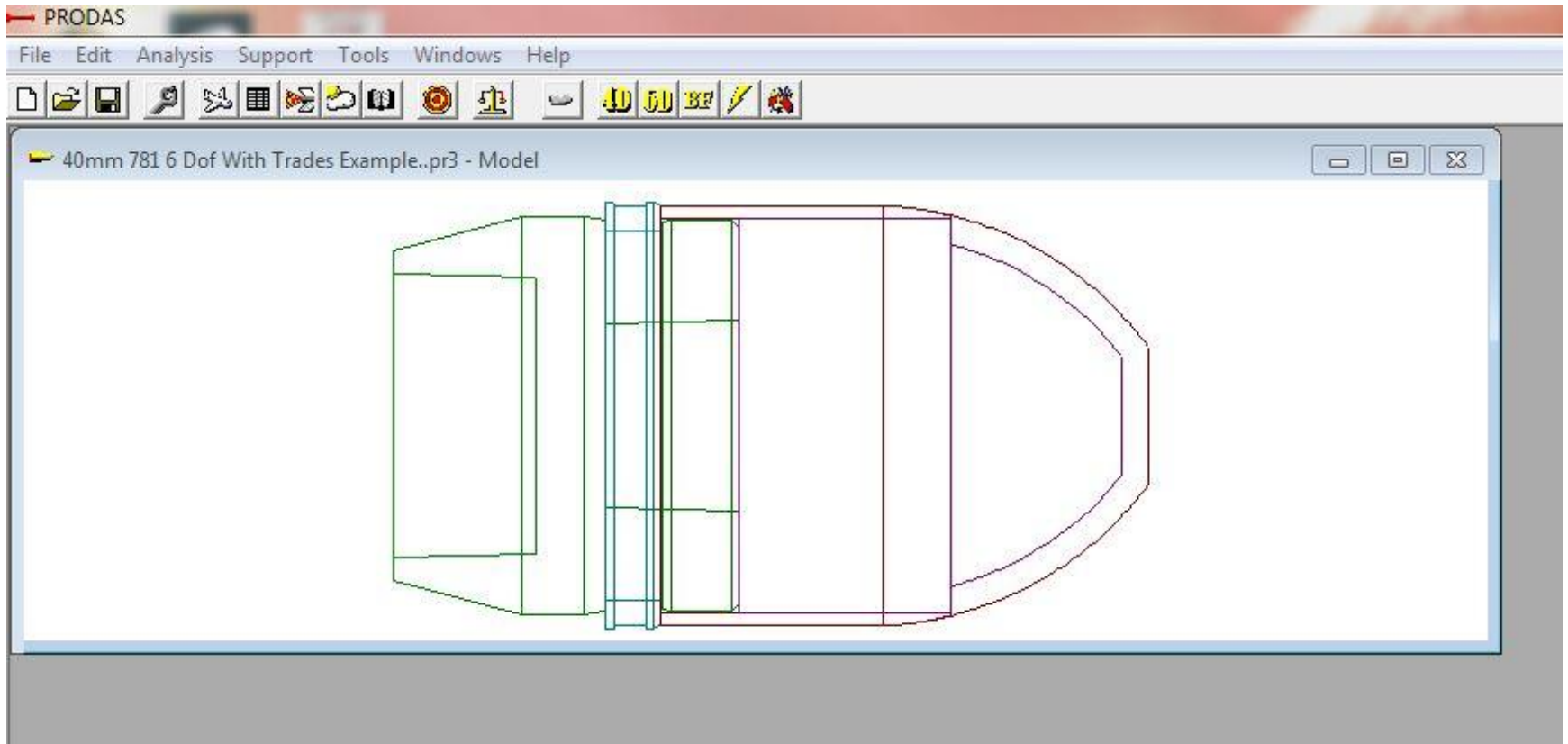
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## PRODAS 6 Dof with trades example

The following presentation is an example of using the 6 degree of freedom trajectory module within PRODAS with the trade study options. For this example we will run the following:

- 40mm M781 Grenade fired from a M203 Launcher
  - Study the horizontal impact patterns of projectiles fired at 3 different quadrant elevations
  - Introduce an error budget for the following initial conditions – Muzzle Velocity, Temperature, Pressure, Winds and Ammunition Dispersion
  - Verify Dispersion Performance by firing against a 100m vertical target
  - Simulate 3000 separate 6 DOF of freedom trajectories at each Quadrant Elevation

# Projectile Model



40mm M781

# Projectile Data

- Projectile Data

- -----
- 
- Projectile Dia.                    4.054 cm
- Weight                                171.100 gm
- Axial Inertia                        393.590027 gm-cm<sup>2</sup>
- Trans Inertia                        445.42001 gm-cm<sup>2</sup>
- CG (from nose)                      5.02 cm

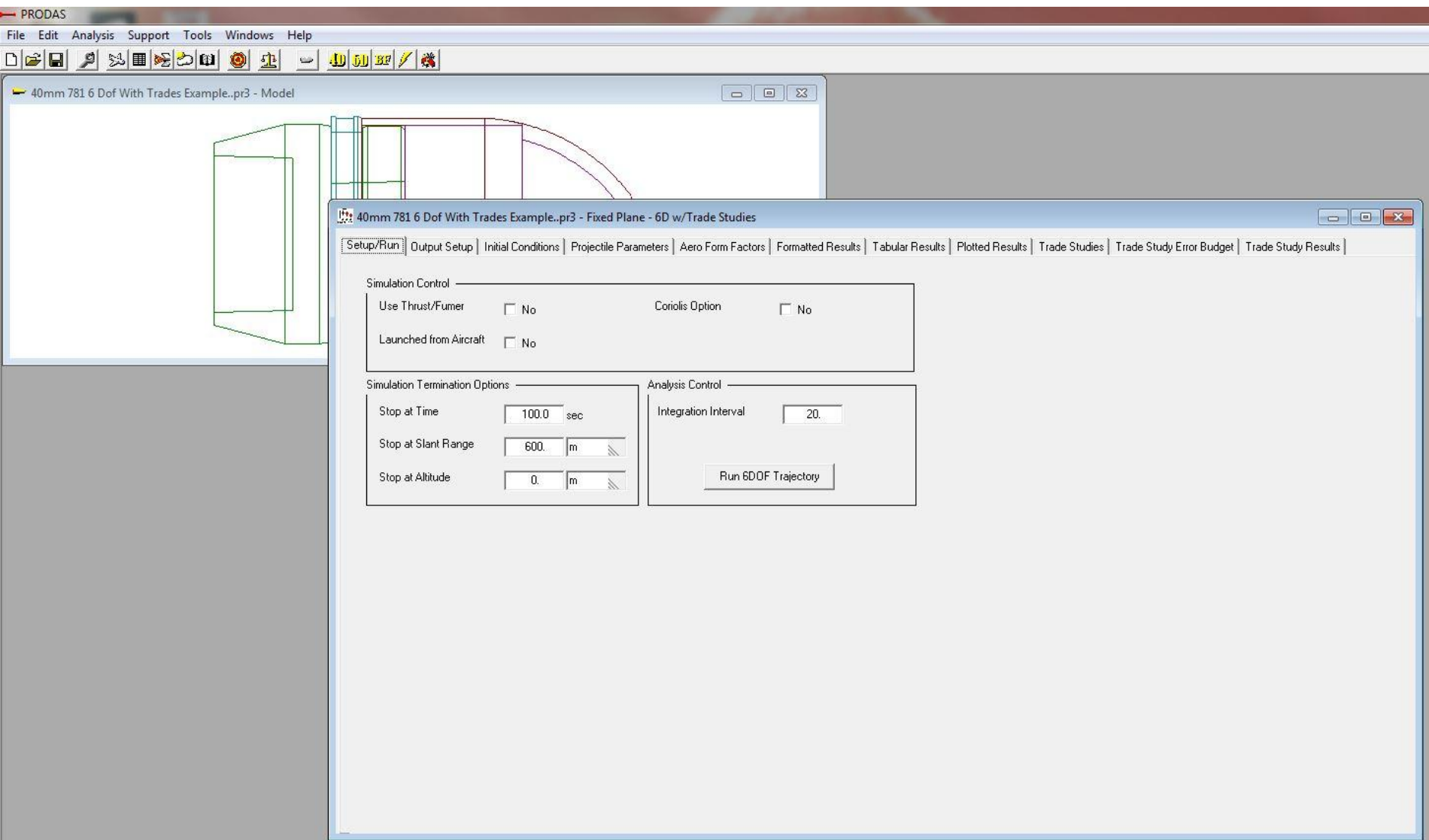
- Initial Conditions

- -----
- 
- Muzzle Velocity                    75.0 m/sec                    Initial Pitch Angle +up        0.000 deg
- Initial Spin                        385.8 rad/sec                Initial Yaw Angle +rt        0.0 deg
- Quadrant Elevation                28.125 deg                    Initial Pitch Rate +up        30.0 rad/sec
- Gun Azimuth (from N)              0.000 deg                    Initial Yaw Rate +rt        30.0 rad/sec
- Initial Range                        0.0 m
- Initial Deflection                  0.0 m
- Initial Altitude (re sl)            0.0 m

- Met Data at the Launch Location

- -----
- 
- Gun Altitude above SL              0.0 m                    Density                        1.2250 kg/m<sup>3</sup>
- Temperature                        15.0 C                    Range Wind                    0.0 m/sec
- Pressure                            1013.2 millibars        Cross Wind                    0.0 m/sec
- Gravity Acceleration                9.80665 m/sec\*\*2

# 6DOF With Trades Interface



The screenshot displays the PRODA software interface. At the top, the menu bar includes File, Edit, Analysis, Support, Tools, Windows, and Help. Below the menu is a toolbar with various icons for file operations and simulation controls. The main workspace is divided into two windows:

- 40mm 781 6 Dof With Trades Example..pr3 - Model:** This window shows a 3D wireframe model of a projectile and its trajectory, which is a curved path.
- 40mm 781 6 Dof With Trades Example..pr3 - Fixed Plane - 6D w/Trade Studies:** This is the active configuration window, featuring a tabbed interface with the following tabs: Setup/Run, Output Setup, Initial Conditions, Projectile Parameters, Aero Form Factors, Formatted Results, Tabular Results, Plotted Results, Trade Studies, Trade Study Error Budget, and Trade Study Results. The "Setup/Run" tab is selected and contains the following controls:
  - Simulation Control:**
    - Use Thrust/Fuser:  No
    - Coriolis Option:  No
    - Launched from Aircraft:  No
  - Simulation Termination Options:**
    - Stop at Time: 100.0 sec
    - Stop at Slant Range: 600. m
    - Stop at Altitude: 0. m
  - Analysis Control:**
    - Integration Interval: 20.
  - Run 6DOF Trajectory:** A button to execute the simulation.

## Example Details

- Error Budget for the analysis example
  - Muzzle Velocity Error – 0.8 m/s (1 std deviation)
  - Ammunition Dispersion - 0.5 mils Radial (1 std deviation)
    - An Example or test of dispersion against a vertical target will be run first to determine angular motion needed at the muzzle to generate corresponding aerodynamic jump for the example projectile.
  - Met Errors (all one standard Deviation)
    - 2 deg Celsius
    - 10 millibars
    - 2.75 m/s Cross and Head/Tail Winds
- Will be fired at 3 different quadrant elevations and 3000 trajectories at each range with the error budget super imposed.
- These errors represent error levels for the analysis example
  - User encouraged to use error levels seen in live fire testing along with specific MET errors for specific mission requirements. This is just an example and the error budget ,while trying to remain realistic is just an example and does not represent an official error budget for this system

## Example Details – Determining Angular Rate

- The final assessment of the example analysis will be the pattern of the projectile on a horizontal surface. However prior to that we must determine the angular rates needed to produce the desired radial dispersion of 0.5 mils which can only be determined against a Vertical Target down range. To do this we will show examples of the following
  - Simulate firing against a vertical target
    - Stop projectile at desired range
    - Input Error Levels for angular rate at muzzle
    - Run Simulation
    - Assess results
    - Modify input error levels

- Radial Dispersion is defined as

$$\sigma_r = \frac{(\sigma_h - \sigma_v)}{2}$$

# Example Details

- For this part of the example we will be assessing projectile performance against a vertical target at 100m distance from the Weapon.
  - Go to the Ballistic Match Module (Analysis Pull down menu, “Firing Tables – Ballistic Tables”)
  - The following Interface should appear

40mm 781 6 Dof With Trades Example. - Ballistic Tables

Setup | Results Table | Formatted Output | Plots

**Analysis Options**

Trajectory Simulation Option: 6 DOF

Use Thrust/Fuser:  No

**Trajectory / Atmosphere Initialization**

Muzzle Velocity: 75.0 m/sec

Gun Altitude: 0.0 m

Met Table Source: Std

Gun Azimuth: 0.000 millrad

**Projectile Parameters**

Flight Weight: 171.10000 gm

**Range / Output Control**

Range Output Increment: 25.0 m

Table Max Range: 3000.0 m

**4/6 DOF Aerodynamic Coefficient Form Factors**

Axial Force FF: 0.920

Normal Force FF: 1.000

Roll Damping FF: 1.000

Drag FF During Burn: 1.000

Fin Cant: 1.00

**Thrust Delta Drag Form Factor**

Delta Drag FF: 1.00

**Moment and Force Coefficients**

Pitching Moment FF: 1.00

Damping Moment FF: 1.00

Magnus Moment FF: 1.00

Side Moment FF: 0.00

Induced Pitch Force FF: 0.00

Induced Side Force FF: 0.00

Induced Pitch Mom. FF: 0.00

Induced Side Mom. FF: 0.00

Induced Roll Mom. FF: 0.00

Run Analysis



# Example Details

- Make sure the 6 DOF trajectory option is chosen (vs 4DOF option) and run the simulation. Once complete please open up the Tabular Results interface and view the information at 100m

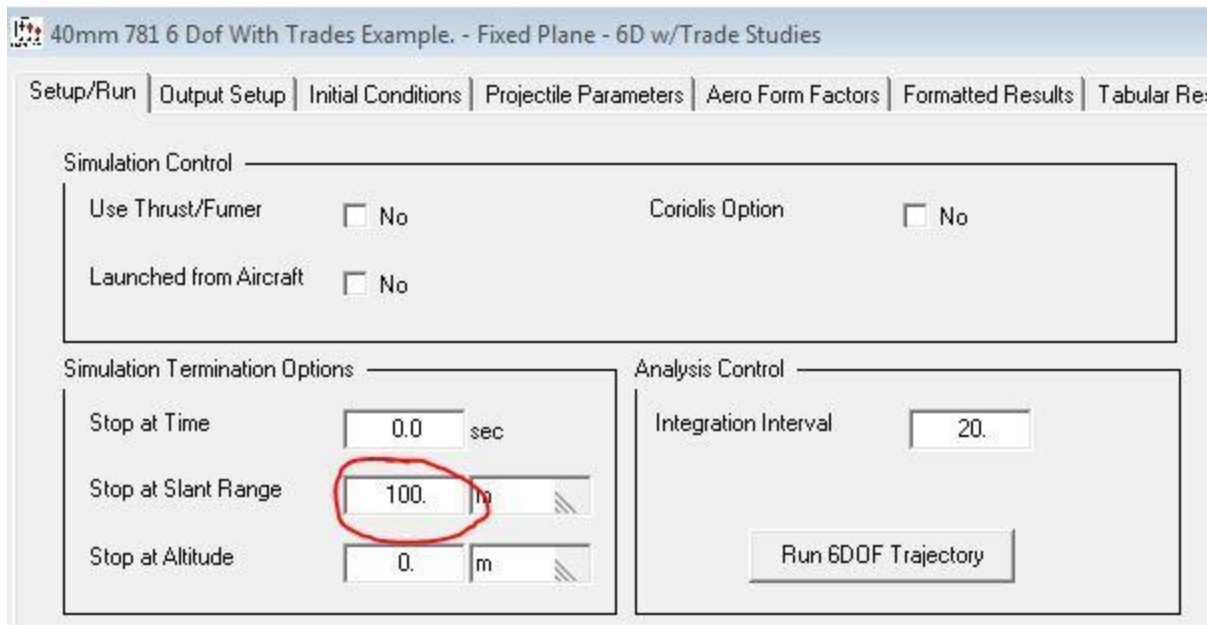
40mm 781 6 Dof With Trades Example. - Ballistic Tables

Setup | Results Table | Formatted Output | Plots

Units	Range	RemainingV	TimeOfFlight	QE	AngleOfDes	KineticEnergy	Drop	Drift	VertexHeigh	VertexRange
Red=Lock	m	m/sec	sec	Gunner Mil	deg	kilojoule	deg	deg	m	m
	0.0	75.00	0.0000	0.00	0.00	0.5	0.00	0.00	0.0	0.0
	25.0	73.77	0.3362	22.03	1.29	0.5	1.24	0.05	0.1	12.7
	50.0	72.56	0.6787	45.02	2.61	0.5	2.53	0.11	0.6	25.0
	75.0	71.38	1.0278	68.61	4.00	0.4	3.86	0.16	1.3	37.9
	100.0	70.22	1.3842	92.87	5.46	0.4	5.22	0.22	2.3	50.6
	125.0	69.09	1.7493	117.90	7.02	0.4	6.63	0.29	3.7	63.3
	150.0	67.99	2.1244	143.84	8.67	0.4	8.09	0.35	5.5	76.4
	175.0	66.92	2.5102	170.77	10.40	0.4	9.61	0.42	7.7	89.1
	200.0	65.88	2.9082	198.86	12.21	0.4	11.19	0.50	10.4	102.4
	225.0	64.89	3.3202	228.27	14.15	0.4	12.84	0.57	13.5	115.2
	250.0	63.94	3.7497	259.33	16.23	0.3	14.59	0.66	17.2	128.5
	275.0	63.03	4.1996	292.34	18.48	0.3	16.44	0.75	21.6	141.7
	300.0	62.19	4.6736	327.67	20.89	0.3	18.43	0.85	26.8	154.9
	325.0	61.40	5.1800	366.13	23.51	0.3	20.59	0.97	32.9	168.5
	350.0	60.68	5.7269	408.56	26.42	0.3	22.98	1.10	40.2	181.8
	375.0	60.05	6.3323	456.75	29.72	0.3	25.69	1.26	49.1	195.4
	400.0	59.54	7.0305	514.11	33.59	0.3	28.92	1.46	60.6	209.0
	425.0	59.20	7.9080	589.42	38.54	0.3	33.15	1.76	76.6	222.8
	425.0	60.58	11.3254	937.27	58.96	0.3	52.72	3.87	156.8	224.7
	400.0	61.13	11.9160	1012.61	62.94	0.3	56.96	4.63	173.3	212.1
	375.0	61.52	12.3296	1070.23	65.98	0.3	60.20	5.33	185.3	199.6
	350.0	61.79	12.6449	1117.58	68.54	0.3	62.86	6.01	194.6	187.5
	325.0	61.93	12.9000	1157.70	70.88	0.3	65.12	6.63	202.0	176.0
	300.0	61.79	13.1345	1193.24	73.31	0.3	67.12	7.12	208.1	165.0
	275.0	61.30	13.3613	1222.42	75.75	0.3	68.76	7.28	212.9	155.3
	250.0	59.88	13.6705	1250.33	78.41	0.3	70.33	6.91	217.1	145.5
	225.0	56.56	14.1375	1278.76	80.68	0.3	71.93	7.11	221.2	135.1
*										

# Example Details

- A QE of 92.87 mils is needed to impact at 100mm range. We will added 3 mils to this to bias the impact in altitude by 0.3 m along with raising the weapon to 2 meters altitude to ensure that all of the rounds will impact on target. Since in this part of the example we will modifying only the Angular Rates to verify the impact dispersion we now need to set up the trade analysis to stop at 100 m range
- Please open the Analysis pull down menu and go to the Trajectory submenu and choose “Fixed Plane- 6D w/ Trade Studies”
- You should see the Setup Interface appear. Notice slant range is set 100m



# Example Details

- Next go to the Initial Conditions Interface and set the QE to 95.67 Gunner's Mils.
- Set the initial Z position to 2 m altitude (This ensures that all of the impact will be captured at 100m and not fall short)

40mm 781 6 Dof With Trades Example. - Fixed Plane - 6D w/Trade Studies

Setup/Run | Output Setup | Initial Conditions | Projectile Parameters | Aero Form Factors | Formatted Results | Tabular Re...

Input ICs with Table (Use Either u,v,w or Vx,Vy,Vz)

Met

Met Table Source: Std

User Met Type: Altitude-Based

Gun Setup

Quadrant Elevation: 95.570 Gunner

Gun Azimuth: 0.000 millrad

Projectile Spin Rate

Muzzle Velocity: 75.0 m/sec

Spin at Muzzle: 386. rad/sec

Twist: 30.49 cal/rev

Exit Spin Ratio: 1.00

Calculate Spin

Projectile Initial Position

Initial X position: 0. m

Initial Y position: 0. m

Initial Z position: 2. m

Start at Time: 0.000 sec

Projectile Angles and Rates

Initial Pitch Angle: 0.0 deg

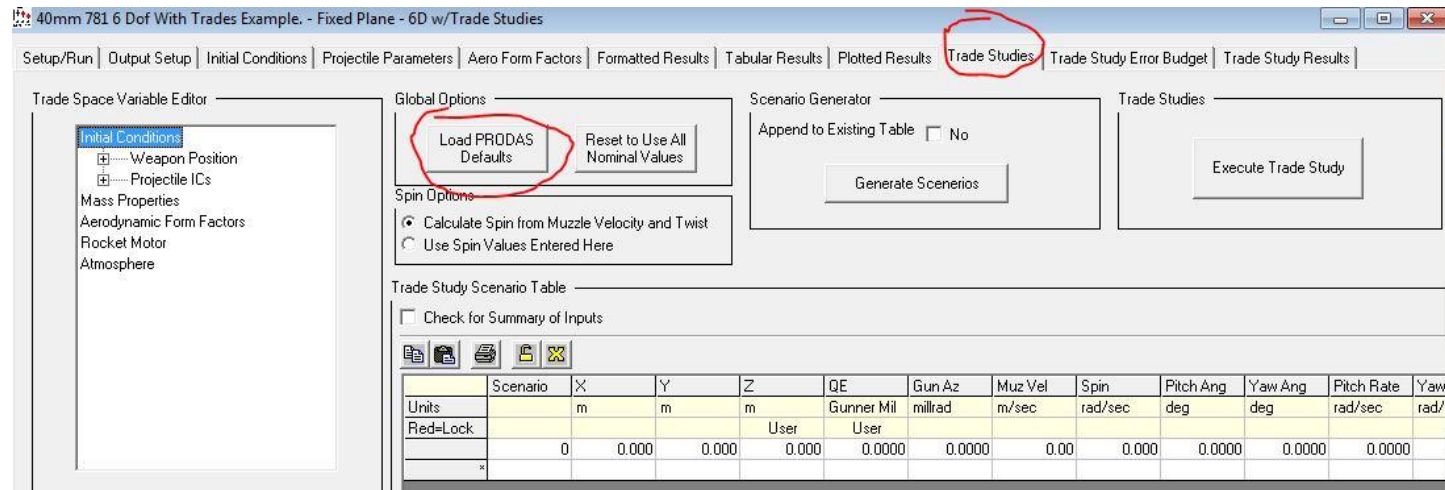
Initial Yaw Angle: 0.0 deg

Initial Pitch Rate: 0.0 rad/sec

Initial Yaw Rate: 0.0 rad/sec

# Example Details

- Please save the file at this time via the File pull down menu at the top left of the PRODAS interface.
- Now please go to the trade Interface with the 6D w/Trade Studies Interface



Please use the “Load PRODAS Default” command which will load the saved data from the prior input screens.

# Example Details

- Using the “Trade Space Variables Editor” section please expand the input tree and verify the following values for Z position, Quadrant Elevation and Muzzle Velocity

The image displays three sequential screenshots of the 'Trade Space Variable Editor' software interface. Each screenshot shows a tree view of 'Initial Conditions' and a 'Nominal' value field at the bottom. Red circles highlight the specific variables and their values.

- First Screenshot:** The 'Initial Conditions' tree is expanded to 'Weapon Position' > 'Z'. The 'Z' variable is highlighted with a red circle. The 'Nominal' value field at the bottom shows '2.000 m', also circled in red.
- Second Screenshot:** The 'Initial Conditions' tree is expanded to 'Weapon Position' > 'Z' > 'Quadrant Elevation'. The 'Quadrant Elevation' variable is highlighted with a red circle. The 'Nominal' value field at the bottom shows '95.5700 Gunner', also circled in red.
- Third Screenshot:** The 'Initial Conditions' tree is expanded to 'Projectile ICs' > 'Muzzle Velocity'. The 'Muzzle Velocity' variable is highlighted with a red circle. The 'Nominal' value field at the bottom shows '75.00 m/sec', also circled in red.

## Example Details

- This data was populated by the interface itself when the “Load PRODAS Default” Command was used. The user can override these if they choose.
- Please use the “Generate Scenarios command to populate the “Trade Study Scenario Table”
- You will now see the Trade Study Scenario Table has been populated with the Initial Conditions Saved in the file.
- This table will be used as our baseline trajectory setup to which we will add errors to.



# Example Details

Global Options

Scenario Generator

Trade Studies

Append to Existing Table  No

Generate Scenerios

Execute Trade Study

Spin Options

Calculate Spin from Muzzle Velocity and Twist  
Use Spin Values Entered Here

Trade Study Scenario Table

Check for Summary of Inputs

	Scenario	X	Y	Z	QE	Gun Az	Muz Vel	Spin	Pitch Ang	Yaw Ang	Pitch Rate	Yaw
Units		m	m	m	Gunner Mil	millrad	m/sec	rad/sec	deg	deg	rad/sec	rad/:
Red-Lock				User	User							
	1	0.000	0.000	2.000	95.5700	0.0000	75.00	385.850	0.0000	0.0000	0.0000	

PRODDAS SCENARIO GENERAT... X

GENERATED 1 SCENARIOS

OK

## Example Details

- Now the user should go to the “Trade Study-Error Budget Interface”
  - Interface allows input of errors to the input sources available in the Trade Space Variables Error Editor
- In this case we are only interested in the angular rates at launch.
- Please expand the Initial Conditions- Projectile IC Error Tree and choose “Pitch Rate”
- Please Check the “Include this Error in the Trade Study” box and input a 4 rad/sec rate (1 std deviation) in the Pitch Rate Error level box
- Do the same for Yaw Rate
- (See next page for details)



# Example Details

40mm 781 6 Dof With Trades Example. - Fixed Plane

Setup/Run | Output Setup | Initial Conditions | Projectile P

Trade Space Variable Error Editor

- Initial Conditions
  - Weapon Position
  - Projectile ICs
    - Muzzle Velocity
    - Spin
    - Pitch Angle
    - Yaw Angle
    - Pitch Rate**
    - Yaw Rate
- Mass Properties
- Aerodynamic Form Factors
- Rocket Motor
- Atmosphere

Include this Error in the Trade Study?

Pitch Rate  Yes

Round to Round Error in

Pitch Rate  rad/sec

Setup/Run | Output Setup | Initial Conditions | Projectile P

Trade Space Variable Error Editor

- Initial Conditions
  - Weapon Position
  - Projectile ICs
    - Muzzle Velocity
    - Spin
    - Pitch Angle
    - Yaw Angle
    - Pitch Rate
    - Yaw Rate**
- Mass Properties
- Aerodynamic Form Factors
- Rocket Motor
- Atmosphere

Include this Error in the Trade Study?

Yaw Rate  Yes

Round to Round Error in

Yaw Rate  rad/sec

## Example Details

- Please go to the Error Generator section and modify the Number of Errors input to 4000 (This just gives us a lot of errors to minimize random number generator noise)
- Hit the Generate Errors command and you will see the Error Table Populate itself.
- Notice the only errors input to the table are the initial Pitch and Yaw rates at launch.
- If you check the “Check for Input summary and statistics” you will notice the output in the windows summarizes the errors generated for this run

# Example Details

**Error Generator**

Number of Errors to Generate

No. Rounds/Weapon

**Execute Trade Study with Errors**

**Error Table**  Check for Summary of Inputs and Statistics

	Error #	X	Y	Z	QE	Gun Az	Muz Vel	Spin	Pitch Ang	Yaw Ang	Pitch Rate	Yaw Rate	Mass	Ixx
Units		m	m	m	Gunner Mil	deg	m/sec	rad/sec	deg	deg	rad/sec	rad/sec	gm	gm
Red=Lock														
	1	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-2.8803	-3.2859	0.00000	
	2	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-0.2404	-0.4656	0.00000	
	3	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-7.1804	7.8779	0.00000	
	4	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	4.8160	3.3063	0.00000	
	5	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	8.7873	1.4188	0.00000	
	6	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-9.7330	0.4243	0.00000	
	7	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-12.0740	-3.1618	0.00000	
	8	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	0.9960	8.6349	0.00000	
	9	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	2.2961	4.2092	0.00000	
	10	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	1.6789	7.5399	0.00000	
	11	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	2.1921	1.7591	0.00000	
	12	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-2.5396	6.6724	0.00000	
	13	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-2.3567	0.9062	0.00000	
	14	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-1.8869	-5.4763	0.00000	
	15	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	0.8737	1.3996	0.00000	
	16	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-7.5540	2.4535	0.00000	
	17	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	0.4559	-7.1167	0.00000	
	18	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	0.4348	3.0849	0.00000	
	19	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-1.3393	-0.7419	0.00000	

**PRODAS SCENARIO GENERATOR**

GENERATED 4000 SETS OF ERRORS

Error Table

Check for Summary of Inputs and Statistics

40mm 781 6 Dof With Trades Examp - 0  
02/23/2015 11:17  
ScenarioGenerator Version 1.0

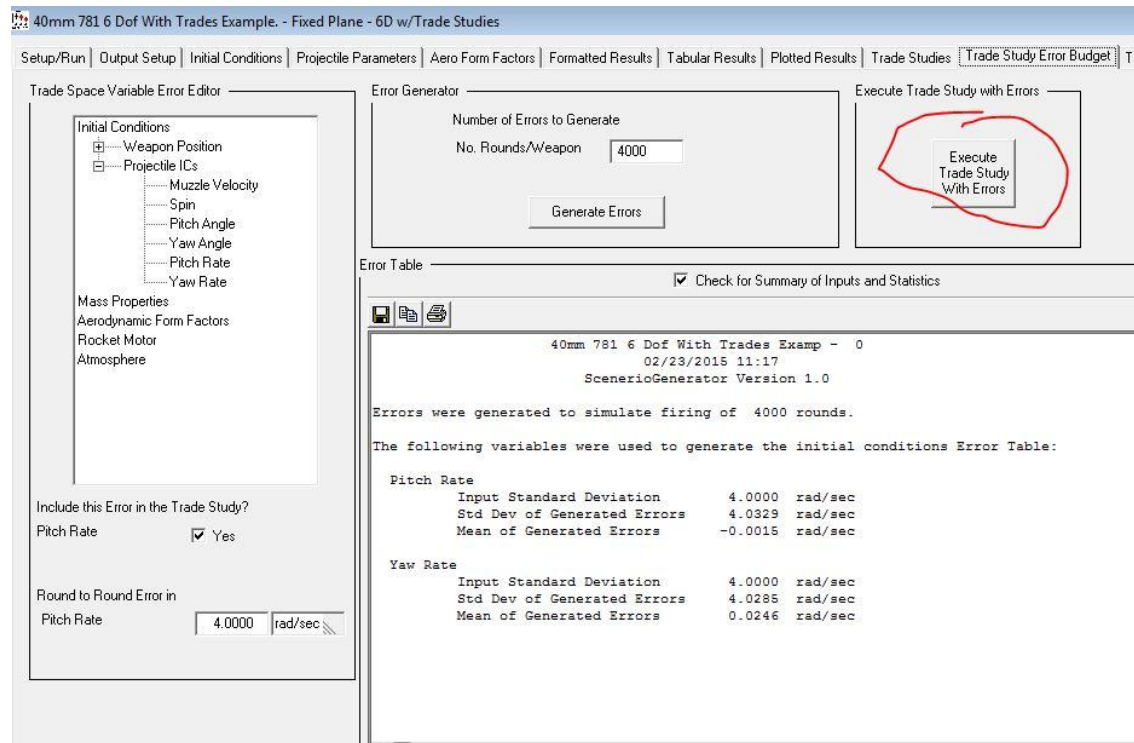
Errors were generated to simulate firing of 4000 rounds.

The following variables were used to generate the initial conditions Error Table:

Pitch Rate		
Input Standard Deviation	4.0000	rad/sec
Std Dev of Generated Errors	4.0329	rad/sec
Mean of Generated Errors	-0.0015	rad/sec
Yaw Rate		
Input Standard Deviation	4.0000	rad/sec
Std Dev of Generated Errors	4.0285	rad/sec
Mean of Generated Errors	0.0246	rad/sec

# Example Details

- Now that we have generated our baseline Trade Study and the Trade Study Errors please use the “Execute Trade Study With Errors” command within the “Trade Study Error Budget Interface” window
- Wait for the analysis to finish – you may get some VB script warnings about how long the analysis is taking –ignore these.



# Example Details

- Once the analysis is complete we can take a look at the output in the “Trade Study Results interface. The first set of results are in tabular form and show the impact points relative to the nominal trajectory
  - Note the 1<sup>st</sup> Scenario Number 0 represent the nominal flight of the projectile without any error

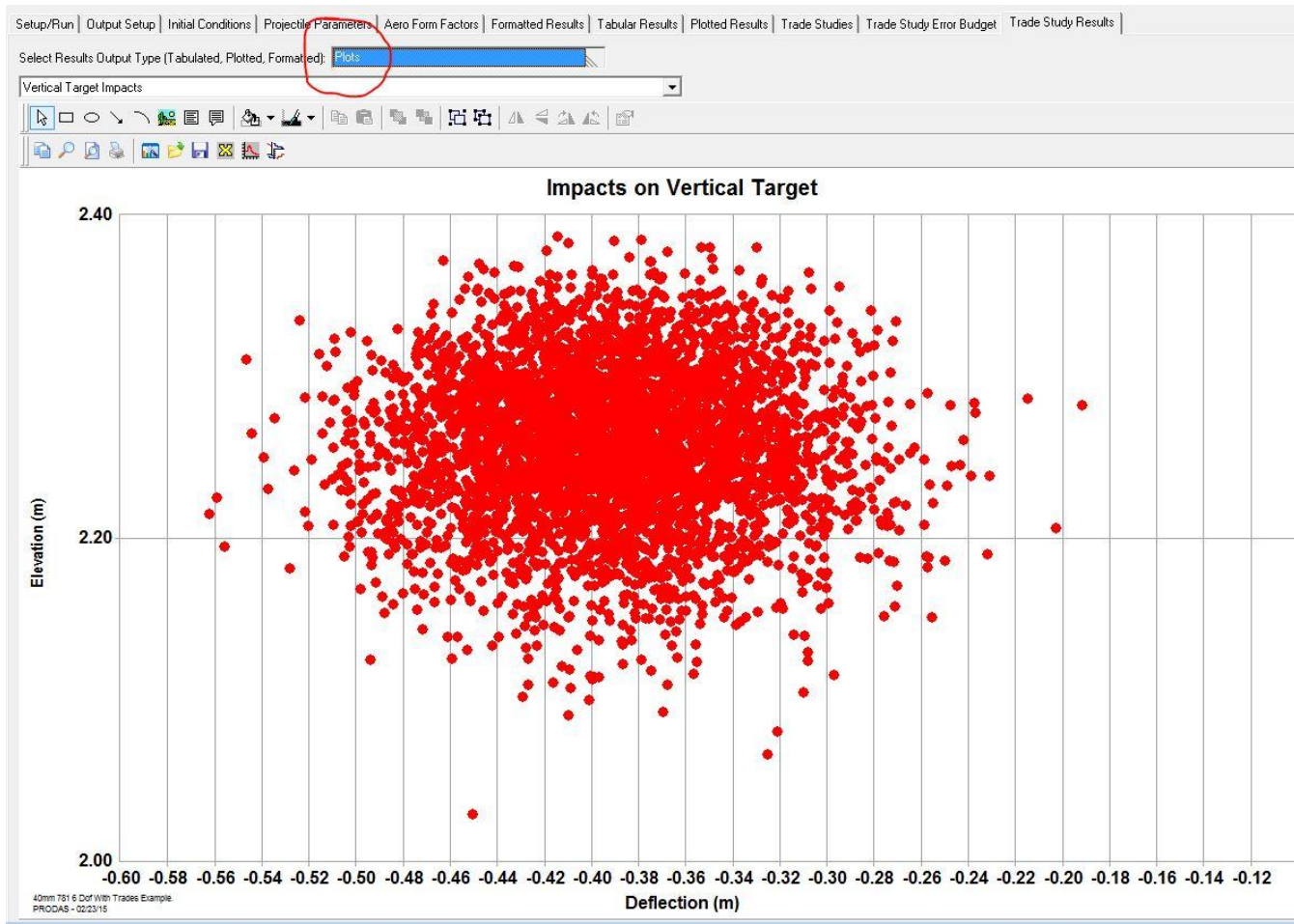
Setup/Run | Output Setup | Initial Conditions | Projectile Parameters | Aero Form Factors | Formatted Results | Tabular Results | Plotted Results | Trade Studies | Trade Study Error Budget | Trade Study Results

Select Results Output Type (Tabulated, Plotted, Formatted):

	Scenario	Error #	X Final	Y Final	Z Final	Velocity	TOF	ADF	Spin	X Miss	Y Miss	Z Miss	R Miss
Units			m	m	m	m/sec	sec	deg	rad/sec	m	m	m	m
Red=Lock													
	1	0	100.00	-0.39	2.26	70.19	1.3846	5.1712	370.2340	0.000	0.000	0.000	0.000
	1	1	100.00	-0.43	2.30	70.13	1.3853	5.6161	370.2340	0.000	-0.036	0.036	0.051
	1	2	100.00	-0.40	2.27	70.18	1.3847	5.2391	370.2340	0.000	-0.005	0.003	0.006
	1	3	100.00	-0.28	2.32	69.97	1.3873	4.6898	370.2340	0.000	0.110	0.055	0.123
	1	4	100.00	-0.36	2.20	70.17	1.3849	4.7685	370.2340	0.000	0.034	-0.066	0.074
	1	5	100.00	-0.39	2.15	70.12	1.3855	5.0495	370.2340	0.000	0.005	-0.116	0.116



- The next set of outputs are the plotted outputs. In this case we are interested in the Vertical Target Impacts so please select that plot.



- The final option for output is the “Formatted Output” which gives our input summary and impact statistics so the we verify the dispersion performance at the angular rate errors input.

Setup/Run | Output Setup | Initial Conditions | Projectile Parameters | Aero Form Factors | Formatted Results | Tabular Results

Select Results Output Type (Tabulated, Plotted, Formatted): Formatted Output

Range Wind                    m/sec                    0.000  
{NEWPAGE}

4000 Monte Carlo error runs with the following error characteristics were completed for:

		Mean Shift	Std Dev
Pitch Rate	rad/sec	-0.00153	4.03343
Yaw Rate	rad/sec	0.02455	4.02898

{NEWPAGE}

TRADE STUDY RESULTS FOR THE FIRST            1 OF THE            1 SCENARIOS

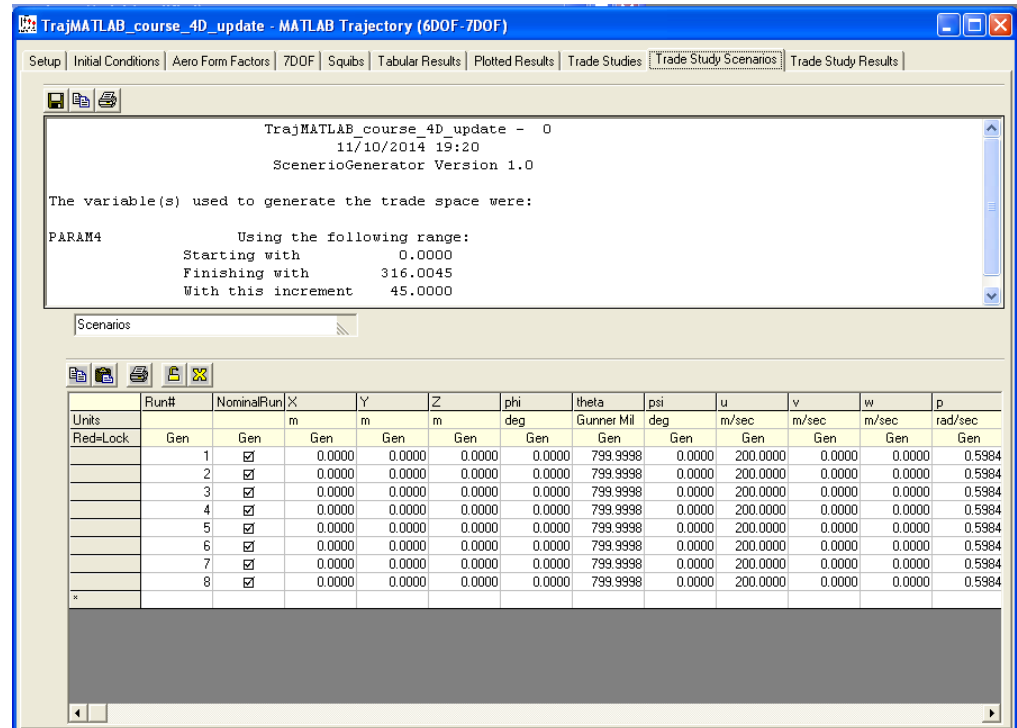
Scenario    1

Nominal Trajectory Terminated at:				Error Runs had a Mean and Std Dev of:			
X	99.999	m		X	100.000	0.001	m
Y	-0.392	m		Y	-0.391	0.050	m
Z	2.263	m		Z	2.258	0.048	m
Time	1.385	sec		Time	1.385	0.001	sec



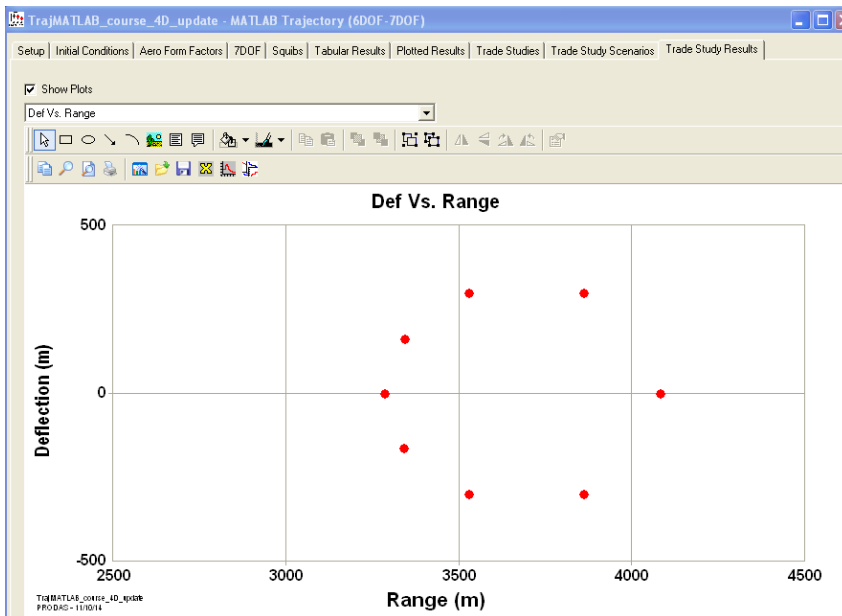
# Trade Study Scenarios Tab

- Text Window shows results of generating an error table or generating scenarios.
- List box to select one of three tables to display
- Scenarios Table
  - Table of IC's to be used in the simulation
  - Each row is a run
- Error Level Table
  - Summary table of all errors and trade space variables that generated the scenarios
- Errors Table
  - Table of error deltas based on the error definitions



# Trade Study Results

- Summary data brought back to PRODAS when a trade studies run is complete
- One row for each run



run	X	Y	Z	velocity	TDF	ADF	ADA	Spin	DRmiss	CRmiss	RadMiss	Pare
Units	m	m	m	m/sec	sec	deg	deg	rad/sec	m	m	m	
Rede=Lock												
1	4083.48	-2.40	0.00	169.54	31.0411	58.8009	4.0730	69.1535	0.000	0.000	0.000	0.
2	3861.77	297.27	0.00	170.92	29.8678	52.8925	4.1264	69.4532	0.000	0.000	0.000	0.
3	3531.70	297.73	0.00	173.01	27.9614	40.1733	4.1321	69.8141	0.000	0.000	0.000	0.
4	3343.60	160.70	0.00	174.26	26.7646	29.2802	4.1849	69.9739	0.000	0.000	0.000	0.
5	3287.87	-1.86	0.00	174.57	26.3980	25.4078	4.1766	69.9942	0.000	0.000	0.000	0.
6	3343.16	-164.73	0.00	174.10	26.7819	29.3338	4.2002	69.9148	0.000	0.000	0.000	0.
7	3531.40	-302.44	0.00	172.77	27.3943	40.2718	4.1214	69.7160	0.000	0.000	0.000	0.
8	3861.94	-302.29	0.00	170.71	29.9004	53.0689	4.2408	69.3681	0.000	0.000	0.000	0.

## Example Details

- From the Results we can see that our standard deviation in Y is .050 m or 0.5 mils and our standard deviation in Z is 0.048m or .48 mils which is ~ 0.49 mils Radial Dispersion. Please increase the initial std deviation in Pitch Rate to 4.3 rad/sec in the “Trade Study-Error Budget Interface”. This will result in a std deviation I impact in Z of .050m which equates to 0.5 mils dispersion and the desired radial ammunition dispersion of 0.5 mils

$$\sigma_r = \frac{(\sigma_h - \sigma_v)}{2}$$

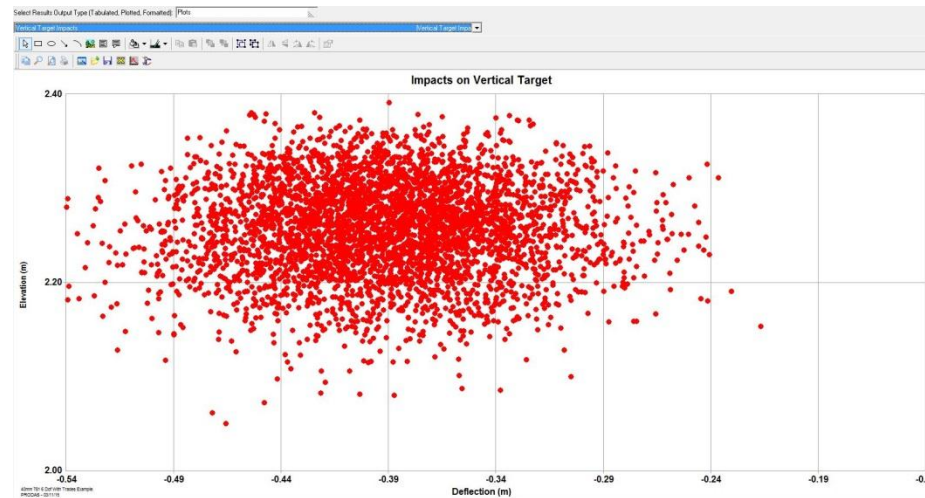
4000 Monte Carlo error runs with the following error characteristics were completed for each scenario.

		Mean Shift	Std Dev
Pitch Rate	rad/sec	0.05779	4.21041
Yaw Rate	rad/sec	-0.06350	4.03027
{NEWPAGE}			

## TRADE STUDY RESULTS FOR THE FIRST 1 OF THE 1 SCENARIOS

Scenario 1

Nominal Trajectory	Terminated at:	Error Runs had a Mean and Std Dev of:
X	99.999 m	X 100.000 0.001 m
Y	-0.392 m	Y -0.392 0.050 m
Z	2.263 m	Z 2.257 0.050 m
Time	1.385 sec	Time 1.385 0.001 sec



# Initializing full error budget

- Now that we have verified the ammunition dispersion against a vertical target performance we can now add the other error contributions and now evaluate against a horizontal or ground impact scenario.
- Error Budget for the analysis example
  - Muzzle Velocity Error – 0.8 m/s (1 std deviation)
  - Ammunition Dispersion - 0.5 mils Radial (1 std deviation)
    - An Example or test of dispersion against a vertical target will be run first to determine angular motion needed at the muzzle to generate corresponding aerodynamic jump for the example projectile.
  - Met Errors (all one standard Deviation)
    - 2 deg Celsius
    - 10 millibars
    - 2.75 m/s Cross and Head/Tail Winds
    - Will be fired at 3 different quadrant elevations and 1000 trajectories at each range with the error budget super imposed.

# Example Details

- Since we are now interested in evaluating the ground impact patterns at 3 different Quadrant Elevations we need to modify the simulation termination options within the Setup interface window. Please modify the slant range input from 100 to 0. This ensures that the rounds will fly to ground impact regardless of the input QE.

The screenshot shows the 'Setup/Run' window with several tabs: Setup/Run, Output Setup, Initial Conditions, Projectile Parameters, Aero Form Factors, Formatted Results, and Tabular Results. The 'Setup/Run' tab is active.

**Simulation Control**

- Use Thrust/Fuser:  No
- Coriolis Option:  No
- Launched from Aircraft:  No

**Simulation Termination Options**

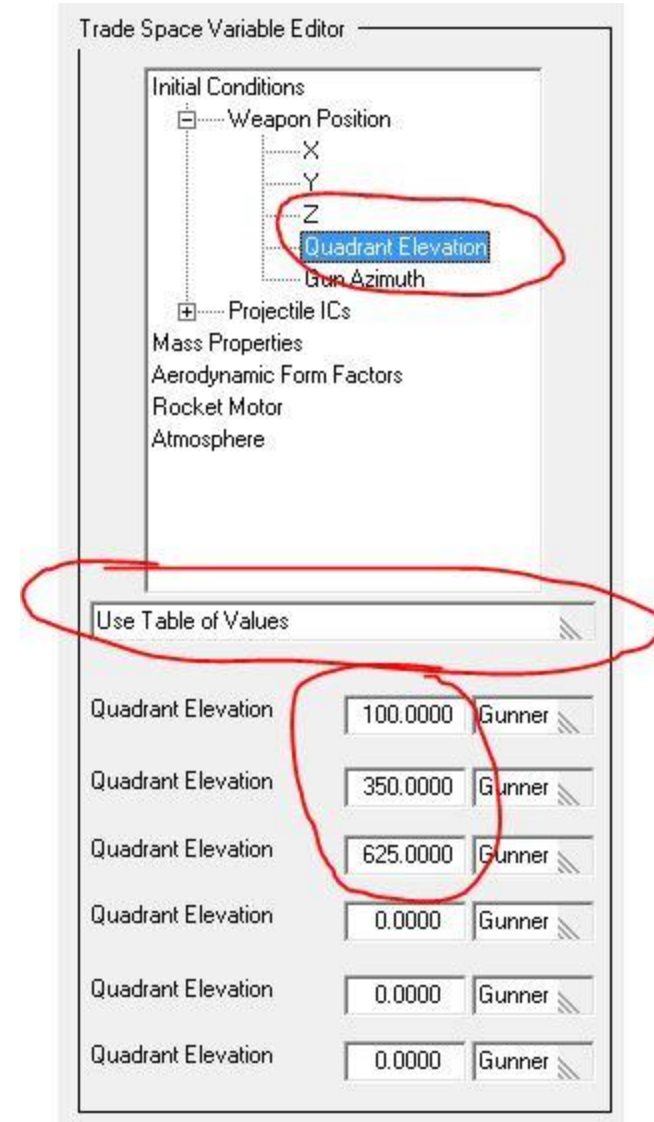
- Stop at Time: 0.0 sec
- Stop at Slant Range: 0.0 m (highlighted with a red circle)
- Stop at Altitude: 0.0 m

**Analysis Control**

- Integration Interval: 20.
- Run 6DOF Trajectory button

# Example Details

- The next step is to add the 3 QE's desired to the Trade Study Scenario Tables found under the Trade Study Interface tab. To do this please open the "Trade Study" interface tab and go to the "Trade Space Variable Editor" and open the Weapon Position input tree and highlight Quadrant Elevation.
- There is a pull down menu midway in the interface which allow you to choose the input method. These include "Nominal" (value saved with the file) "Range and Increment" (Allows user to set the initial QE and then add incremental adjustments) or "Table of Values". Please choose this last option and input the values shown to the right.
- Please use the Generate Scenarios Command to repopulate the Trade Study Scenario Tables



# Example Details

Setup/Run | Output Setup | Initial Conditions | Projectile Parameters | Aero Form Factors | Formatted Results | Tabular Results | Plotted Results | Trade Studies | Trade Study Error Budget | Trade Study Results

Trade Space Variable Editor

- Initial Conditions
  - Weapon Position
    - X
    - Y
    - Z
    - Quadrant Elevation
    - Gun Azimuth
  - Projectile ICs
- Mass Properties
- Aerodynamic Form Factors
- Rocket Motor
- Atmosphere

Use Table of Values

Quadrant Elevation: 100.0000 Gunner

Quadrant Elevation: 350.0000 Gunner

Quadrant Elevation: 625.0000 Gunner

Quadrant Elevation: 0.0000

Quadrant Elevation: 0.0000

Quadrant Elevation: 0.0000

Global Options

Load PRODAS Defaults    Reset to Use All Nominal Values

Spin Options

Calculate Spin from Muzzle Velocity and Twist  
 Use Spin Values Entered Here

Trade Study Scenario Table

Check for Summary of Inputs

Scenario	X	Y	Z	QE	Gun Az	Muz Vel	Spin	Pitch Ang	Yaw Ang	Pitch Rate	Yaw Rate	Mass
Units	m	m	m	Gunner Mil	millrad	m/sec	rad/sec	deg	deg	rad/sec	rad/sec	gm
Red=Lock	User			User	User							
1	0.000	0.000	2.000	99.9999	0.0000	75.00	385.850	0.0000	0.0000	0.0000	0.0000	171.1000
2	0.000	0.000	2.000	350.0003	0.0000	75.00	385.850	0.0000	0.0000	0.0000	0.0000	171.1000
3	0.000	0.000	2.000	624.9997	0.0000	75.00	385.850	0.0000	0.0000	0.0000	0.0000	171.1000

Scenario Generator

Append to Existing Table  No

**Generate Scenarios**

Trade Studies

Execute Trade Study

Trade Study Scenario Table

Check for Summary of Inputs

```

40mm 781 6 Dof With Trades Examp - 0
03/11/2015 09:29
ScenarioGenerator Version 1.0

The variable(s) used to generate the trade space were:

Quadrant Elevation Using the following values:
99.9998 Gunner Mil
349.9994 Gunner Mil
624.9988 Gunner Mil
                    
```

PRODAS SCENARIO GENERAT...  
GENERATED 3 SCENARIOS  
OK



# Example Details

- From the newly generated “Trade Study Scenario Tables” we can now see the added Quadrant Elevations along with the initial Z of the weapon and Muzzle Velocity we would like to use.
- At this point we should now go to the Trade Study Error Budget interface and go to the Trade Space Variable Error Editor and expand the Initial Conditions, Projectile IC’s tree and select the Muzzle Velocity Input and add the 0.8 m/s error. Also modify the number of errors to 3000 instead of 4000 (Total number of trajectories is 10000 per study. When these are combined with the 3 Scenarios this will generate 9000 trajectories.

Setup/Run | Output Setup | Initial Conditions | Projectile Parameters | Aero Form Factors | Formatted Results | Tables

### Trade Space Variable Error Editor

Initial Conditions

- [-] Weapon Position
  - X
  - Y
  - Z
  - Quadrant Elevation
  - Gun Azimuth
- [-] Projectile ICs
  - Muzzle Velocity**
  - Spin
  - Pitch Angle
  - Yaw Angle
  - Pitch Rate
  - Yaw Rate

Mass Properties

Aerodynamic Form Factors

Rocket Motor

Atmosphere

Include this Error in the Trade Study?  
Muzzle Velocity  Yes

Round to Round Error in  
Muzzle Velocity  m/sec

### Error Generator

Number of Errors to Generate  
No. Rounds/Weapon

### Error Table

	Error #	X	Y	Z
Units		m	m	m
Red=Lock				
	1	0.000	0.000	
	2	0.000	0.000	
	3	0.000	0.000	
	4	0.000	0.000	
	5	0.000	0.000	
	6	0.000	0.000	
	7	0.000	0.000	
	8	0.000	0.000	
	9	0.000	0.000	
	10	0.000	0.000	
	11	0.000	0.000	
	12	0.000	0.000	
	13	0.000	0.000	
	14	0.000	0.000	
	15	0.000	0.000	
	16	0.000	0.000	

## Example Details

- To utilize and input MET errors the user has to do 3 things. The first is to input the actual MET errors using the Trade Study Error Budget interface and Trade Space Variable Error Editor and expand the Atmosphere Error Tree. When the user selects Temp a pop up window will appear explaining the next two steps the user will need to do to get these errors in to the Trade Study. (see next Page)

# Example Details

Trade Space Variable Error Editor

- Initial Conditions
- Mass Properties
- Aerodynamic Form Factors
- Rocket Motor
- Atmosphere
  - Temperature
  - Pressure
  - Cross Wind
  - Range Wind

Include this Error in the Trade Study?  
Temp (C)  No

Round to Round Error in  
Temp (C)

Error Generator

Number of Errors to Generate  
No. Rounds/Weapon

Execute Trade Study with Errors

Error Table  Check for Summary of Inputs and Statistics

	Error #	X	Y	Z	QE	Gun Az	Muz Vel	Spin	Pitch Ang	Yaw Ang	Pitch Rate	Yaw Rate	Mass	Ixx	
Units		m	m	m	Gunner Mil	deg	m/sec	rad/sec	deg	deg	rad/sec	rad/sec	gm	gm	
Red=Lock															
	1	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	1.2920	-2.1925	0.00000		
	2	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	9.2878	0.6261	0.00000		
	3	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	-4.9783	-2.6792	0.00000		
	4	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-2.1026	0.00000		
	5	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-2.2307	0.00000		
	6	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-4.4771	0.00000		
	7	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	4.7453	0.00000		
	8	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	7.8057	0.00000		
	9	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	5.6630	0.00000		
	10	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	2.2500	0.00000		
	11	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-0.9802	0.00000		
	12	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	0.9081	0.00000		
	13	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-4.7793	0.00000		
	14	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	4.9237	0.00000		
	15	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-5.4219	0.00000		
	16	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	6.5696	0.00000		
	17	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-1.5945	0.00000		
	18	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-1.1763	-5.4986	0.00000	
	19	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	2.8959	5.9203	0.00000	
	20	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	2.8722	-6.1302	0.00000	
	21	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-2.9898	3.6198	0.00000	
	22	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	2.6582	-7.7686	0.00000	
	23	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	0.4237	0.8369	0.00000	
	24	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	1.8627	-6.4231	0.00000	
	25	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	1.5678	3.1613	0.00000	
	26	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-4.4453	-0.2982	0.00000	
	27	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	7.6959	-1.7244	0.00000	
	28	0.000	0.000	0.000	0.0000	0.0000	0.00	0.000	0.0000	0.0000	5.7850	-2.9471	-3.4332	0.00000	

IN ORDER TO INCLUDE ATMOSPHERE VARIABLES IN THE TRADE STUDY; USER MET MUST BE SELECTED ON THE INITIAL CONDITIONS TAB, THE MET TABLE MUST BE GENERATED AND MET DATA MUST BE TRANSFERRED TO THE TRADE STUDY SCENARIO TABLE BY LOADING PRODAS DEFAULTS AND GENERATING SCENARIOS.

# Example Details

- Please Insert the Temp, Pressure and Wind Errors making sure the Include Error box is checked for each

The image displays four screenshots of the 'Trade Space Variable Error Editor' software interface, arranged horizontally. Each screenshot shows a tree view of error categories on the left and configuration options on the right. Red circles highlight the error names in the tree view, the 'Include this Error in the Trade Study?' checkbox, and the numerical value in the 'Round to Round Error in' text box.

Variable	Include in Trade Study?	Round to Round Error in	Units
Temperature	<input checked="" type="checkbox"/> Yes	2.0000	Temp (C)
Pressure	<input checked="" type="checkbox"/> Yes	10.0000	Baro Pressure (millibars)
Cross Wind	<input checked="" type="checkbox"/> Yes	2.750	m/sec
Range Wind	<input checked="" type="checkbox"/> Yes	2.750	m/sec

- Prior to generating Errors please do the following
  - Go the Initial Conditions interface tab and set the MET source to User
  - Please open the MET Table Generator (Found under “Support” pull down menu “Met” and generate a std day atmosphere with Sea Level Temp set to 15C and Pressure set to 1013.25 and hit the generate MET command. This will populate the table.
  - Please Save the PRODAS Model at this point

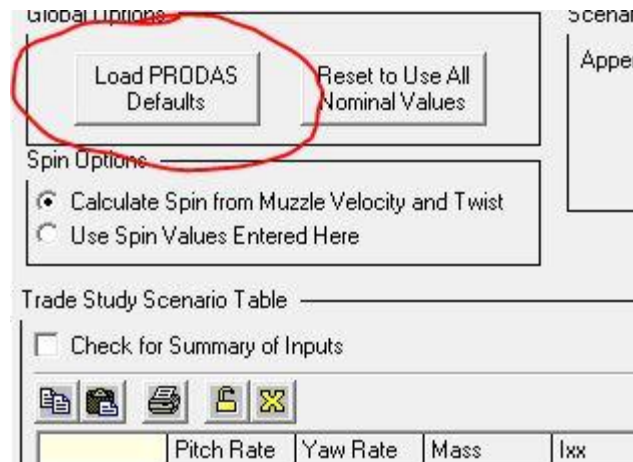
The screenshot displays the software interface for the MET Table Generator. The left panel shows the 'Initial Conditions' tab with various input fields for gun and projectile parameters. The right panel shows the 'Altitude-Based User Met Table' window, which includes input fields for Atmos Temp (15.0 C), Atmos Pressure (1013.3 millibars), Above sea level (0.0 m), Wind Direction (0.0 deg), and Wind Velocity (0.00 m/sec). A red circle highlights the 'Generate Altitude-Based User Met Table' button. The resulting table is shown below:

Units	Altitude	Temperature	Pressure	Wind/Veloc	Wind/Azimuth
	m	C	millibars	m/sec	deg
Red-Lock					
	200.	15.6	1038.1	3.3	262.00
	-100.	14.9	1026.1	3.3	262.00
	0.	14.3	1014.2	3.3	262.00
	100.	13.7	1002.3	3.3	262.00
	200.	13.0	990.4	3.3	262.00
	300.	12.4	978.7	3.3	262.00
	400.	11.8	967.1	3.3	262.00
	500.	11.2	955.5	3.3	262.00
	750.	9.6	927.2	3.3	262.00
	1000.	8.0	899.6	3.3	262.00
	1250.	6.4	872.7	3.3	262.00
	1500.	4.8	846.4	3.3	262.00
	1750.	3.2	820.8	3.3	262.00
	2000.	1.6	795.7	3.3	262.00
	2500.	-1.6	747.6	3.3	262.00
	3000.	-4.8	701.8	3.3	262.00
	3500.	-8.0	658.4	3.3	262.00
	4000.	-11.3	617.1	3.3	262.00
	5000.	-17.7	540.8	3.3	262.00
	6000.	-24.2	472.4	3.3	262.00
	7000.	-30.7	411.4	3.3	262.00



## Example Detail

- Please return to the Trade Study Interface and use the “Load PRODAS Defaults Command.”
  - This loads up the saved User MET Table that the errors produced and in the Trade Study Error Budget/Error Table will be applied.



- **Regenerate Scenario Table Also (Ensures all of the PRODAS Defaults are loaded)**
- Please return to the Trade Study Error Budget interface and use the Generate Errors Command to repopulate the table with the new Muzzle Velocity and Atmospheric Errors Input Previously.

- These error will now appear in the Table and Summary Input for the Table

Error Generator

Number of Errors to Generate

No. Rounds/Weapon

**Generate Errors**

Error Table

in	Temp (C)	Pressure millibars	Cross Wind m/sec	Range Wind m/sec
00	2.1844	13.1624	10.040	0.546
00	-4.0400	-11.7291	2.132	-0.475
00	4.0815	-0.5093	-2.269	3.755
00	-2.6737	-6.3032	4.612	-1.330
00	-2.1496	7.9107	-1.879	0.659
00	-1.4807	-18.6557	-1.671	1.817
00	2.6368	19.6137	2.717	-2.526
00	0.7940	-15.4604	-1.916	-1.794
00	-3.1636	-3.6488	2.036	0.921

Muz Vel	Spin	Pitch Ang	Yaw Ang	Pitch Rate	Yaw Rate	Mas
m/sec	rad/sec	deg	deg	rad/sec	rad/sec	gm
]	-0.06	0.000	0.0000	0.0000	1.3317	4.7474
]	-0.95	0.000	0.0000	0.0000	1.4583	-8.5974
]	-1.00	0.000	0.0000	0.0000	-9.4828	10.2070
]	0.22	0.000	0.0000	0.0000	6.9210	-3.1288
]	-0.74	0.000	0.0000	0.0000	-0.7988	1.3505
]	0.47	0.000	0.0000	0.0000	1.3090	1.8594

# Example Details

- Summary of Inputs

40mm 781 6 Dof With Trades Examp - 0

03/11/2015 10:16

ScenerioGenerator Version 1.0

Errors were generated to simulate firing of 3000 rounds.

The following variables were used to generate the initial conditions Error Table:

### Muzzle Velocity

Input Standard Deviation	0.8000	m/sec
Std Dev of Generated Errors	0.8166	m/sec
Mean of Generated Errors	0.0117	m/sec

### Pitch Rate

Input Standard Deviation	4.3000	rad/sec
Std Dev of Generated Errors	4.3045	rad/sec
Mean of Generated Errors	-0.0520	rad/sec

### Yaw Rate

Input Standard Deviation	4.0000	rad/sec
Std Dev of Generated Errors	3.9172	rad/sec
Mean of Generated Errors	0.0654	rad/sec

### Temp (deg C)

Input Standard Deviation	2.0000
Std Dev of Generated Errors	1.9690
Mean of Generated Errors	-0.0378

### Baro Pressure

Input Standard Deviation	10.0000	millibars
Std Dev of Generated Errors	9.9646	millibars
Mean of Generated Errors	0.0149	millibars

### Cross Wind

Input Standard Deviation	2.7500	m/sec
Std Dev of Generated Errors	2.8143	m/sec
Mean of Generated Errors	-0.0347	m/sec

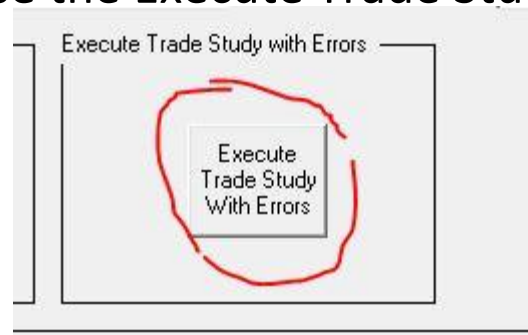
### Range Wind

Input Standard Deviation	2.7500	m/sec
Std Dev of Generated Errors	2.7088	m/sec
Mean of Generated Errors	-0.0706	m/sec



## Example Details

- At this point we have done the following:
  - Set up 3 Quadrant Elevations to simulate the input Errors and loaded in the baseline Muzzle Velocity and Atmosphere
  - Verified the Ammunition Dispersion input
  - Generated 3000 initial 1 standard deviation launch errors which will be used for the execution of the analysis which include
    - 1 std deviation in Muzzle Velocity of 0.8 M/s
    - Radial dispersion of 0.5 mils (1 std deviation)
    - Temperature std deviation of 2 deg C
    - Pressure std deviation of 10 millibars
    - 2.75 m/s of Cross and Range winds
- We are now ready to execute the study so please go the Trade Study Error Budget interface and use the Execute Trade Study with Errors command



# Results

- Once the analysis has been completed please go to the “Trade Study Results” interface where we can see the tabular output, the plotted output and the summary formatted output
  - Tabular Output summarizes the impacts and miss distance per error and scenario
  - The Plotted Output show the ground impact patterns for each scenario with input error budget (Please choose Ground Impact vs Vertical Impact )
  - Summary of Formatted output summarizes all fo the inputs used ans then shows the average impact and std devaition of the impacts due to the input error budgets

# Tabular Output

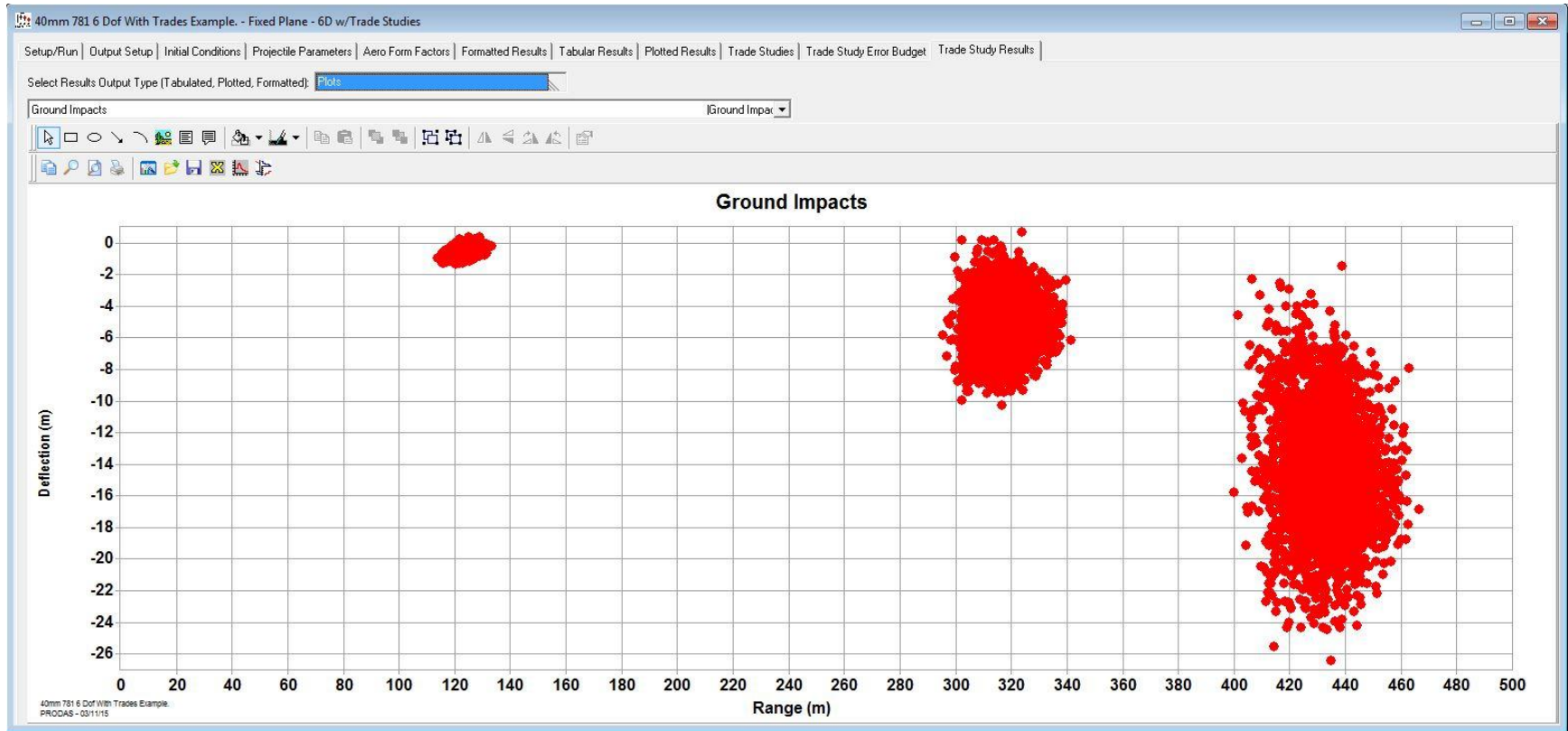
Setup/Run | Output Setup | Initial Conditions | Projectile Parameters | Aero Form Factors | Formatted Results | **Tabular Results** | Plotted Results | Trade Studies | Trade Study Error Budget | Trade Study Results

Select Results Output Type (Tabulated, Plotted, Formatted): **Tabular Output**



	Scenario	Error #	X Final	Y Final	Z Final	Velocity	TDF	ADF	Spin	X Miss	Y Miss	Z Miss	R Miss
Units			m	m	m	m/sec	sec	deg	rad/sec	m	m	m	m
Red=Lock													
	1	0	123.78	-0.61	0.00	69.40	1.7285	7.4946	366.5920	0.000	0.000	0.000	0.000
	1	1	125.52	-0.76	0.00	70.13	1.7366	7.4862	369.5910	1.737	-0.152	0.000	1.743
	1	2	116.97	-0.98	0.00	67.88	1.6635	10.1345	362.7350	-6.816	-0.363	0.000	6.826
	1	3	121.62	-0.38	0.00	68.52	1.7201	7.7209	362.5650	-2.163	0.231	0.000	2.175
	1	4	125.85	-0.43	0.00	68.58	1.7623	6.7771	368.0020	2.068	0.178	0.000	2.076
	1	5	120.41	-0.73	0.00	68.78	1.6977	8.8579	363.1660	-3.372	-0.114	0.000	3.374
	1	6	123.04	-0.56	0.00	68.83	1.7303	7.0996	364.4160	-0.747	0.056	0.000	0.749
	1	7	126.37	-0.38	0.00	69.47	1.7582	6.7384	368.8940	2.590	0.229	0.000	2.600
	1	8	124.93	-0.31	0.00	69.07	1.7515	7.0362	366.3150	1.149	0.300	0.000	1.187
	1	9	121.79	-0.60	0.00	68.78	1.7193	7.6954	362.7430	-1.990	0.010	0.000	1.990
	1	10	125.61	-0.35	0.00	69.02	1.7623	8.0035	366.4370	1.824	0.265	0.000	1.843
	1	11	124.99	-0.53	0.00	69.47	1.7443	6.9437	367.2050	1.209	0.079	0.000	1.211
	1	12	122.82	-0.27	0.00	68.22	1.7390	7.0560	362.8460	-0.962	0.343	0.000	1.021
	1	13	125.05	-0.49	0.00	68.80	1.7517	9.1232	366.9690	1.263	0.121	0.000	1.268
	1	14	124.76	0.00	0.00	68.11	1.7665	5.5255	364.5820	0.977	0.610	0.000	1.152
	1	15	122.88	-1.26	0.00	69.68	1.6995	9.5688	372.8620	-0.907	-0.648	0.000	1.115
	1	16	124.63	-0.35	0.00	69.05	1.7481	7.0560	365.7590	0.847	0.260	0.000	0.886
	1	17	117.88	-0.99	0.00	68.29	1.6707	9.2273	362.6640	-5.902	-0.375	0.000	5.914
	1	18	126.28	-0.73	0.00	70.12	1.7457	7.5515	370.0690	2.495	-0.113	0.000	2.498
	1	19	123.63	-0.49	0.00	68.95	1.7392	8.8562	364.3750	-0.158	0.119	0.000	0.198
	1	20	121.83	-0.61	0.00	68.72	1.7167	7.0225	363.6500	-1.950	0.001	0.000	1.950
	1	21	126.46	-0.17	0.00	68.74	1.7703	9.5785	367.9550	2.678	0.443	0.000	2.714
	1	22	119.61	-0.50	0.00	68.03	1.7035	7.3050	359.6860	-4.179	0.111	0.000	4.180
	1	23	121.72	-0.57	0.00	68.88	1.7169	8.5256	363.0590	-2.065	0.045	0.000	2.066
	1	24	118.57	-0.55	0.00	68.48	1.6831	7.6834	361.0650	-5.219	0.061	0.000	5.219
	1	25	126.98	-0.36	0.00	69.80	1.7612	6.7169	369.6280	3.201	0.256	0.000	3.211
	1	26	124.14	-0.92	0.00	70.05	1.7215	7.6689	369.0800	0.352	-0.303	0.000	0.465
	1	27	124.08	-0.78	0.00	69.65	1.7205	7.0717	369.7320	0.291	-0.172	0.000	0.338
	1	28	126.53	-0.54	0.00	70.01	1.7520	7.9231	369.7560	2.745	0.069	0.000	2.746
	1	29	126.53	-0.54	0.00	70.01	1.7520	7.9231	369.7560	2.745	0.069	0.000	2.746

# Plotted Output



# Formatted Summary

Select Results Output Type (Tabulated, Plotted, Formatted):



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
A trade study has been completed with 3 scenarios. The following inputs were used for the first 3 of the 3 scenarios.

Parameter	Units	Scen 1	Scen 2	Scen 3
<b>Weapon Position</b>				
X	m	0.000	0.000	0.000
Y	m	0.000	0.000	0.000
Z	m	2.000	2.000	2.000
Quadrant Elevation	Gunner Mil	100.000	350.000	624.999
Azimuth	deg	0.000	0.000	0.000
<b>Projectile ICs</b>				
Muzzle Velocity	m/sec	75.000	75.000	75.000
Spin	rad/sec	385.850	385.850	385.850
Pitch Angle	deg	0.000	0.000	0.000
Yaw Angle	deg	0.000	0.000	0.000
Pitch Rate	rad/sec	0.000	0.000	0.000
Yaw Rate	rad/sec	0.000	0.000	0.000
<b>Mass Properties</b>				
Mass	gm	171.100	171.100	171.100
Azial Inertia	gm-cm <sup>2</sup>	393.590	393.590	393.590
Transverse Inertia	gm-cm <sup>2</sup>	445.420	445.420	445.420
CG Location	cm	5.023	5.023	5.023
<b>Aerodynamic Form Factors</b>				
Axial Force FF		0.920	0.920	0.920
Normal Force FF		1.000	1.000	1.000
Spin Decay FF		1.000	1.000	1.000
Pitching Moment FF		1.000	1.000	1.000
Damping Moment FF		1.000	1.000	1.000
Magnus Moment FF		1.000	1.000	1.000
Side Moment FF		0.000	0.000	0.000
Trim Angle (Deg)		0.000	0.000	0.000
Trim Orientation	deg	0.000	0.000	0.000
Fin Cant (Deg)		1.000	1.000	1.000
<b>Rocket Motor</b>				
Thrust FF		1.000	1.000	1.000
Burn-On Time	sec	0.000	0.000	0.000
<b>Atmosphere</b>				
Temp (Deg C)		15.000	15.000	15.000
Baro Pressure	millibars	1013.250	1013.250	1013.250
Cross Wind	m/sec	0.000	0.000	0.000
Range Wind	m/sec	0.000	0.000	0.000

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Setup/Run | Output Setup | Initial Conditions | Projectile Parameters | Aero Form Factors | Formatted Results | Tabular Results | Plotted Results | Trade Stud

Select Results Output Type (Tabulated, Plotted, Formatted):



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inust ff          1.000    1.000    1.000
Burn-On Time     sec          0.000    0.000    0.000
Atmosphere
Temp (Deg C)           15.000    15.000    15.000
Baro Pressure       millibars  1013.250  1013.250  1013.250
Cross Wind          m/sec          0.000    0.000    0.000
Range Wind          m/sec          0.000    0.000    0.000
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3000 Monte Carlo error runs with the following error characteristics were completed for each scenario.

Muzzle Velocity   m/sec          -0.00526   0.82582
Pitch Rate        rad/sec         -0.06905   4.35881
Yaw Rate          rad/sec         -0.11604   4.03204
Temp (Deg C)      -0.04731      1.98734
Baro Pressure     millibars      0.01172   9.93553
Cross Wind        m/sec          -0.06219   2.73776
Range Wind        m/sec          -0.00204   2.66993
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TRADE STUDY RESULTS FOR THE FIRST 3 OF THE 3 SCENARIOS

Scenario 1
Nominal Trajectory Terminated at: Error Runs had a Mean and Std Dev of:
X 123.784 m X 123.579 2.719 m
Y -0.612 m Y -0.596 0.221 m
Z 0.000 m Z 0.000 0.000 m
Time 1.728 sec Time 1.729 0.026 sec

Scenario 2
Nominal Trajectory Terminated at: Error Runs had a Mean and Std Dev of:
X 319.511 m X 318.126 6.865 m
Y -5.213 m Y -5.127 1.519 m
Z 0.000 m Z 0.000 0.000 m
Time 5.053 sec Time 5.045 0.055 sec

Scenario 3
Nominal Trajectory Terminated at: Error Runs had a Mean and Std Dev of:
X 435.782 m X 433.245 10.247 m
Y -14.632 m Y -14.435 3.544 m
Z 0.000 m Z 0.000 0.000 m
Time 8.358 sec Time 8.338 0.026 sec
    
```