



Porter

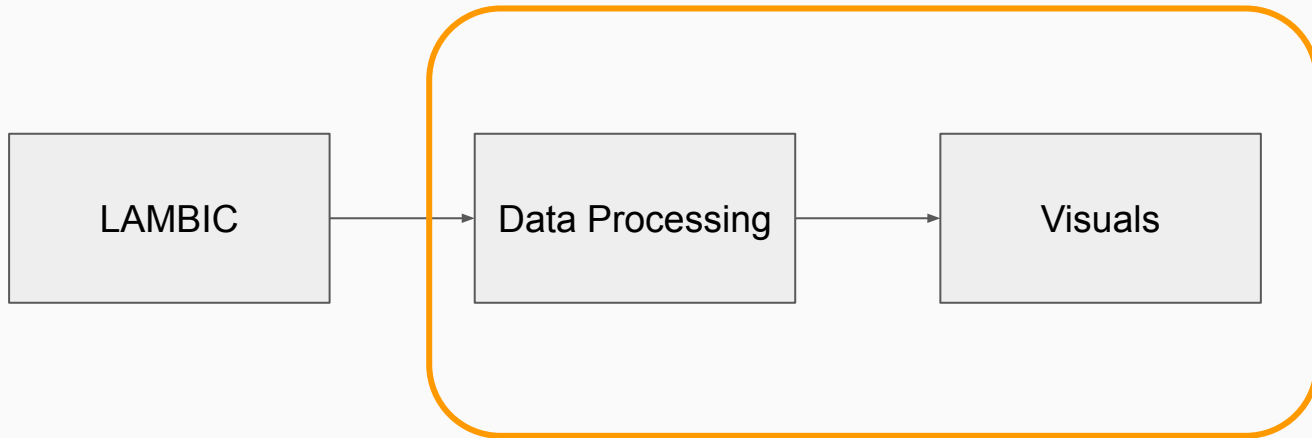
The Maneuver Visualization Tool

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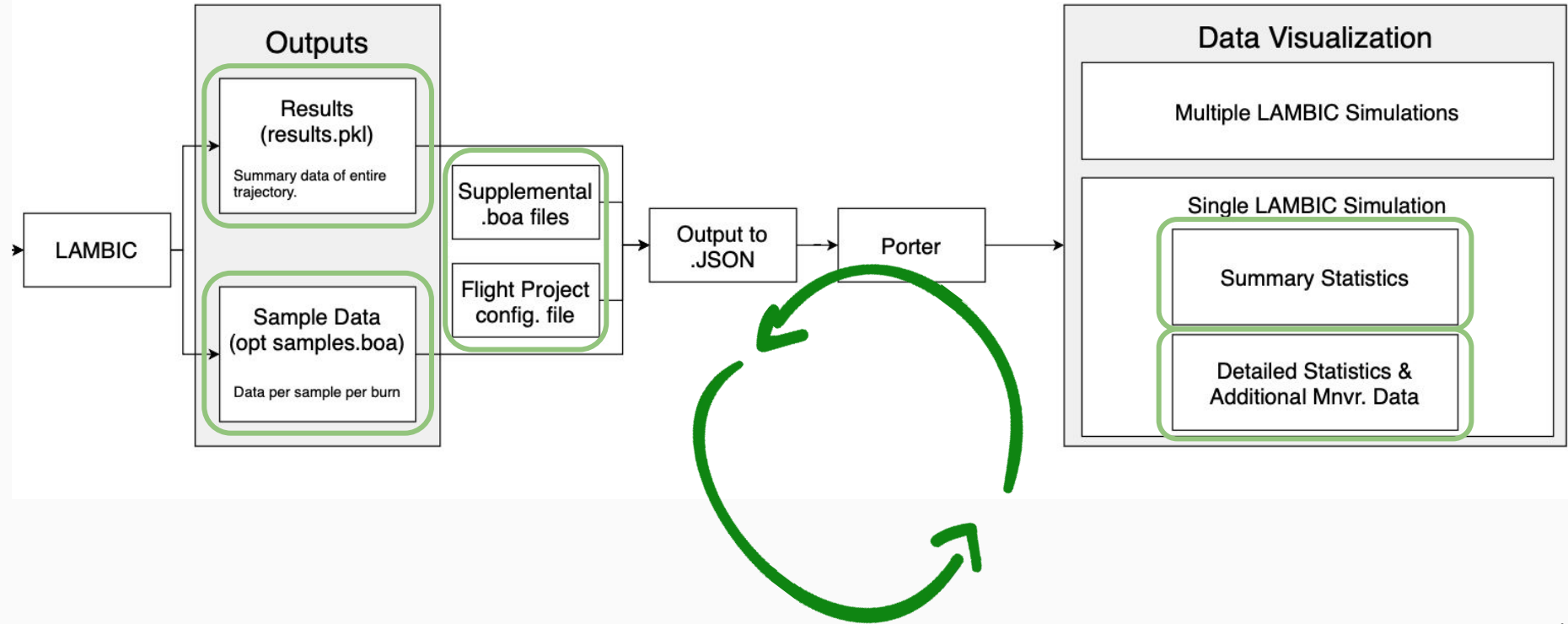
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How can we support maneuver designers to more conveniently and effectively work with MONTE LAMBIC output data?



Previous Project Focus



Current Project Focus

Create an intuitive and all-inclusive way to access:

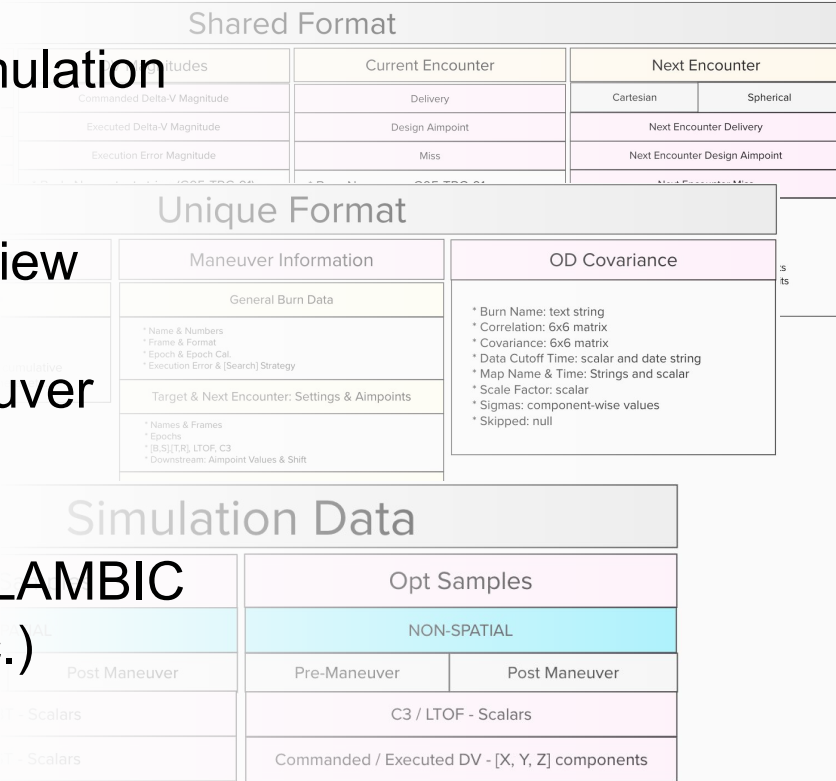
LAMBIC Summary Statistics Data

Detailed Result Blocks and M.C. Sample Data from LAMBIC

Capel Plots

Understanding the Data

- Full JSON conversion for LAMBIC simulation output
- ΔV and delivery data for simplified review
- Monte Carlo distributions for all maneuver variables available
- External data sources to supplement LAMBIC information (Capel, flyby specifics, etc.)



Overarching Design Idea

Analysis is conducted from a high level overview to a low level detailed approach (currently sorted by maneuver).

Overview

I want to see all maneuvers and their respective encounters between a start and stop time that I define.

Maneuver:

- > Name
- > Deterministic DV
- > Executed Mean DV
- > Executed Sigma
- > Executed Percentiles
- > Cumulative Deterministic DV
- > Cumulative Executed DV

Event (Currently B-Plane Encounters for EC data):

- > Name
- > Flyby Altitude
- > Vinfinity
- > Impact Probability %
- > Ellipse Properties

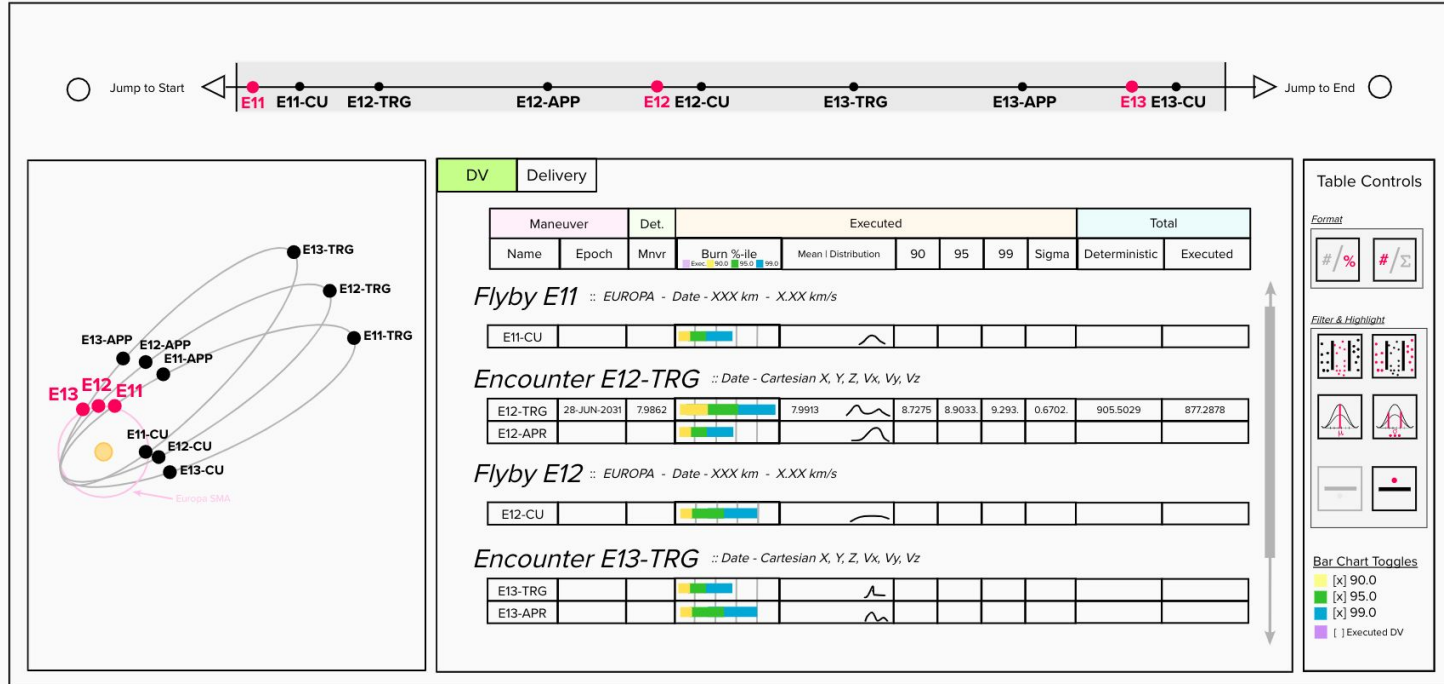


Detail (Per Maneuver)

I am interested in the nitty gritty details of a single maneuver. Show me all the data regarding this specific one.

- > Next Encounter
- > Impact
- > Delivery
- > Miss
- > Executed DV Mag Stats.
- > Commanded DV Mag Stats.
- > Error DV Mag Stats.
- > Execution Error
- > OD Covariance
- > Delivery Plots
 - > B-Plane w/ Samples and Ellipses
 - > C3, S*R, S*T, LFT distributions
- > Capel Plots
 - > Choose from 29 plot options

Porter Organization: Overview Mode Example



Porter Organization: Overview Mode Example

Timeline

The navigation bar at the top of all screen with the maneuver and encounters.

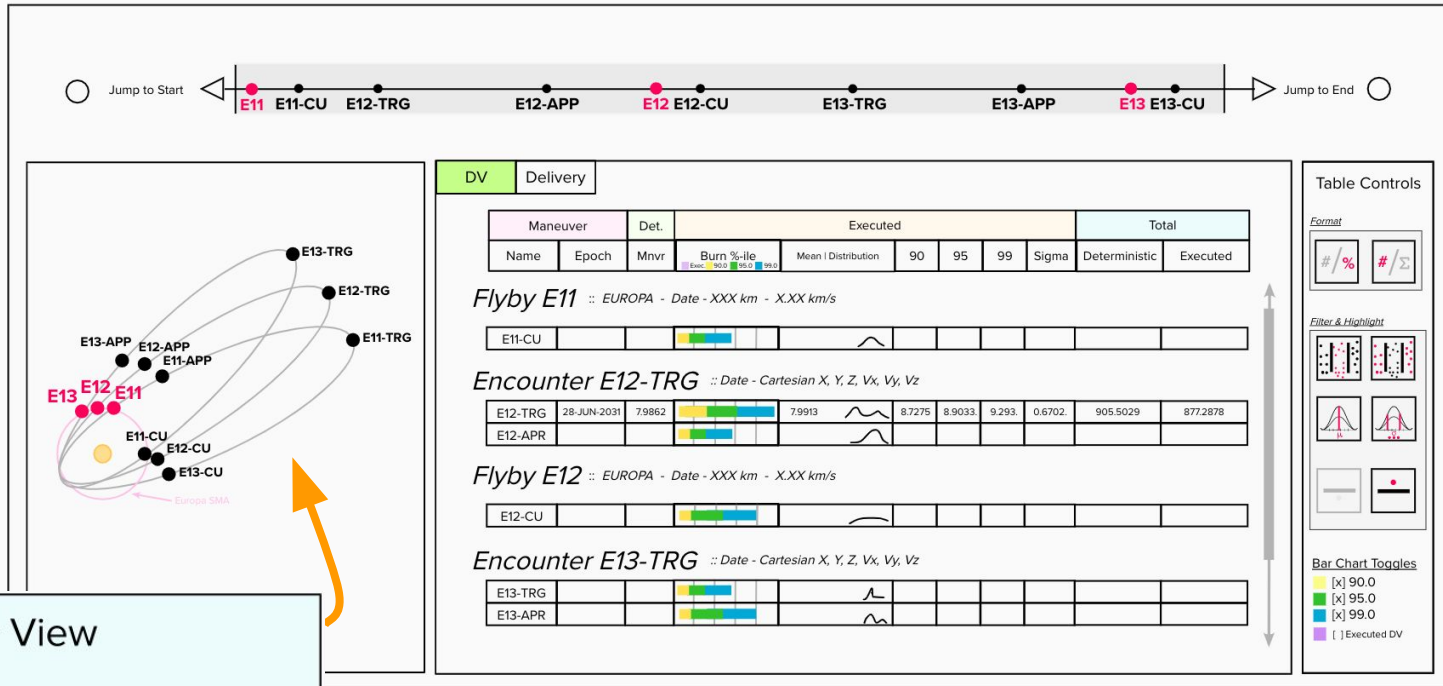
The timeline contains a **user set shaded region** that controls what maneuvers are presented in the Overview screen mode blocks.

The interface displays a timeline at the top with markers for maneuvers and encounters: E11, E11-CU, E12-TRG, E12-APP, E12, E12-CU, E13-TRG, E13-APP, and E13, E13-CU. A shaded region highlights E11, E12, and E13. Below the timeline is a 3D orbital diagram showing the spacecraft's path around Earth, with labels for E11, E12, E13, and their corresponding CU (Closest Approach) and TRG (Target) points. The main data table is titled 'DV Delivery' and contains the following information:

Maneuver		Det.	Executed				Total			
Name	Epoch	Mnvr	Burn %-ile	Mean Distribution	90	95	99	Sigma	Deterministic	Executed
<i>Flyby E11 :: EUROPA - Date - XXX km - X.XX km/s</i>										
E11-CU										
<i>Encounter E12-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz</i>										
E12-TRG	28-JUN-2031	79862		7.9913	8.7275	8.9033	9.293	0.6702	905.5029	877.2878
E12-APR										
<i>Flyby E12 :: EUROPA - Date - XXX km - X.XX km/s</i>										
E12-CU										
<i>Encounter E13-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz</i>										
E13-TRG										
E13-APR										

Table Controls: Format (# / %, # / Σ), Filter & Highlight (grid, bar, line, area), Bar Chart Toggles (x] 90.0, x] 95.0, x] 99.0, [] Executed DV).

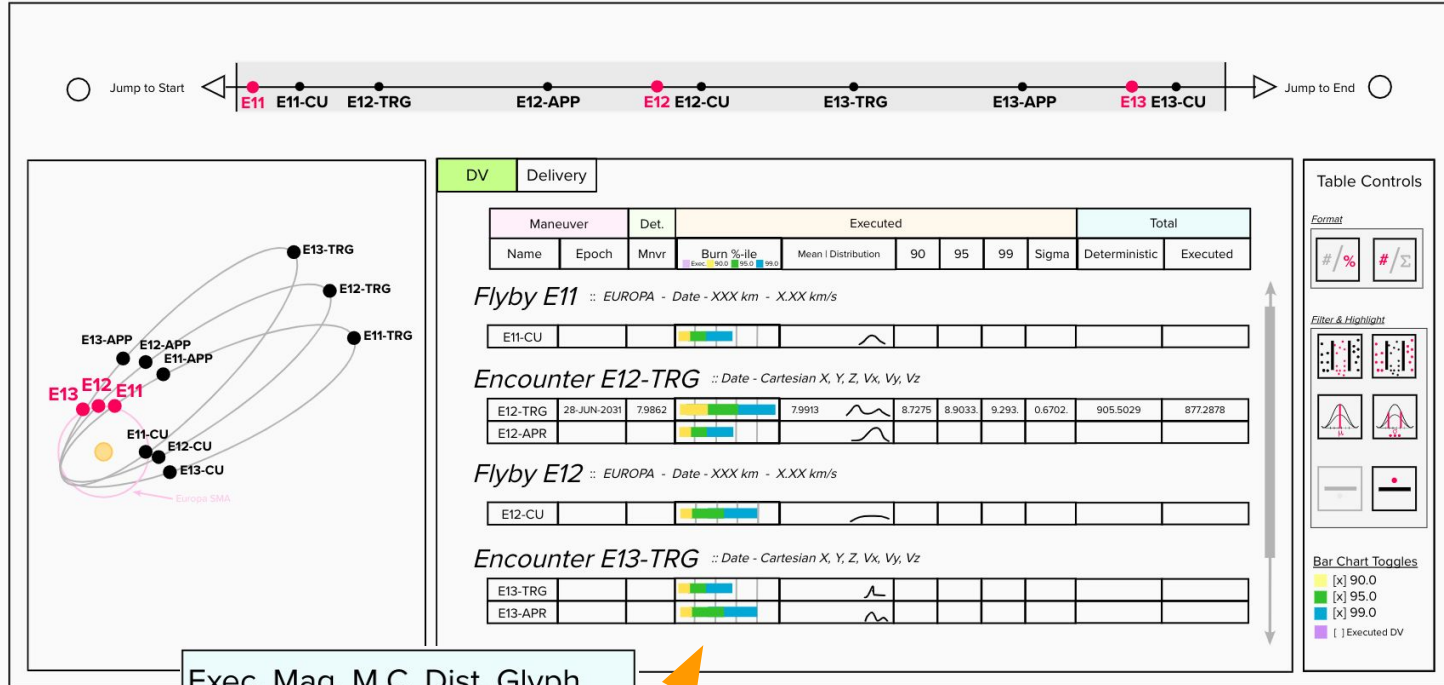
Porter Organization: Overview Mode Example



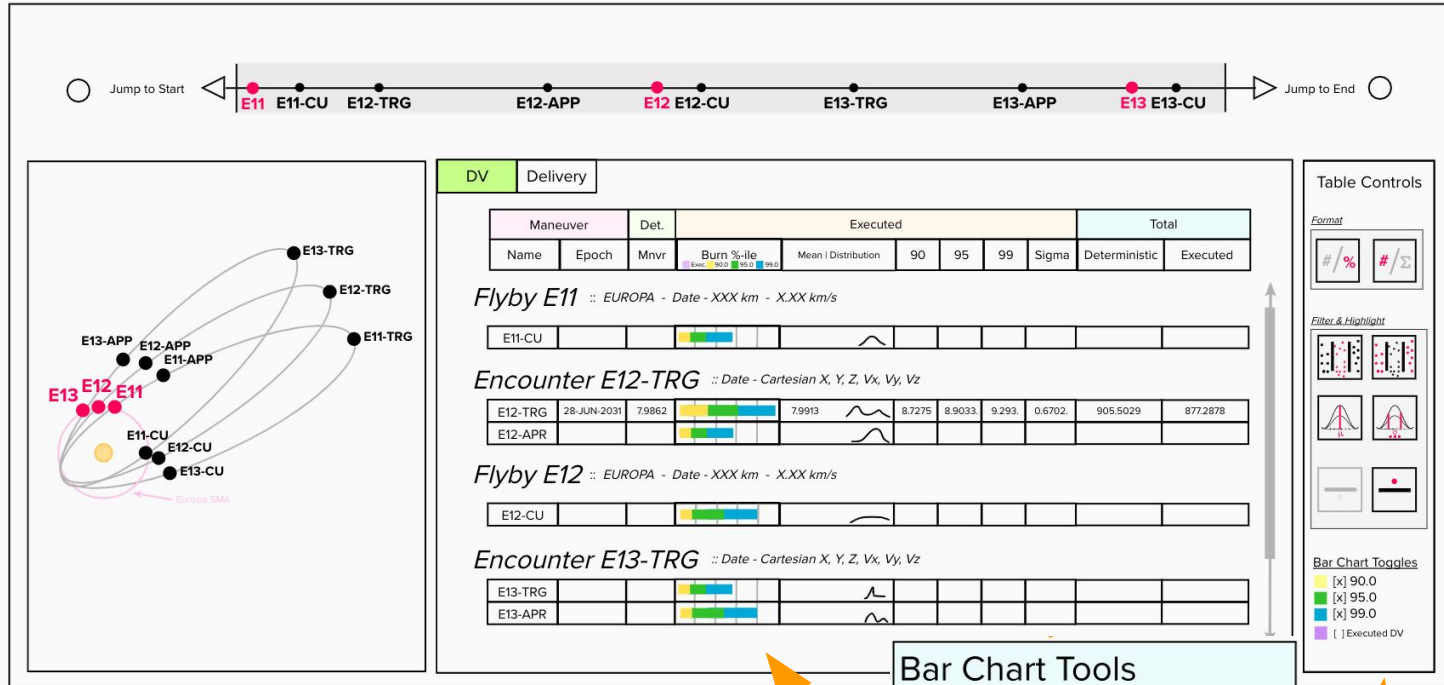
Trajectory View

- > Auto-updating
- > Bolded lines for trajectory in start/stop time
- > Flybys and bodies in different color
- > Rest of trajectory in light color

Porter Organization: Overview Mode Example



Porter Organization: Overview Mode Example



Bar Chart Tools

- > Select which bar charts (Not Stacked Bars) options to see
- > When toggling between % or #, the chart units will also change.

Porter Organization: Overview Mode Example

Table Controls

- > Different filtering options to highlight data
- > Show data by actual number or a percentage w.r.t. deterministic value (if applicable)

DV		Delivery									
Maneuver	Det.	Executed						Total			
Name	Epoch	Mnvr	Burn %-ile	Mean Distribution	90	95	99	Sigma	Deterministic	Executed	
<i>Flyby E11 :: EUROPA - Date - XXX km - X.XX km/s</i>											
E11-CU			<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>								
<i>Encounter E12-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz</i>											
E12-TRG	28 JUN 2031	79862	<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>	7.9913		8.7275	8.9033	9.293	0.6702	905.5029	877.2878
E12-APR			<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>								
<i>Flyby E12 :: EUROPA - Date - XXX km - X.XX km/s</i>											
E12-CU			<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>								
<i>Encounter E13-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz</i>											
E13-TRG			<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>								
E13-APR			<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>								

Table Controls

Format

/ %

/ Σ

Filter & Highlight

Bar Chart Toggles

[x] 90.0

[x] 95.0

[x] 99.0

[] Executed DV

Porter Organization: Overview Mode Example

Jump to Start

Total DV

> Click on value to see overlay chart like below for cumulative DV up to that maneuver:

Jump to End

DV		Delivery									
Maneuver		Det.	Executed					Total			
Name	Epoch	Mnvr	Burn %-ile	Mean Distribution	90	95	99	Sigma	Deterministic	Executed	
<i>Flyby E11 :: EUROPA - Date - XXX km - X.XX km/s</i>											
E11-CU			<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>								
<i>Encounter E12-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz</i>											
E12-TRG	28 JUN 2031	79862	<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>	7.9913		8.7275	8.9033	9.293	0.6702	905.5029	877.2878
E12-APR			<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>								
<i>Flyby E12 :: EUROPA - Date - XXX km - X.XX km/s</i>											
E12-CU			<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>								
<i>Encounter E13-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz</i>											
E13-TRG			<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>								
E13-APR			<div style="width: 100%; height: 10px; background: linear-gradient(to right, yellow, green, blue);"></div>								

Table Controls

Format

/ % # / Σ

Filter & Highlight

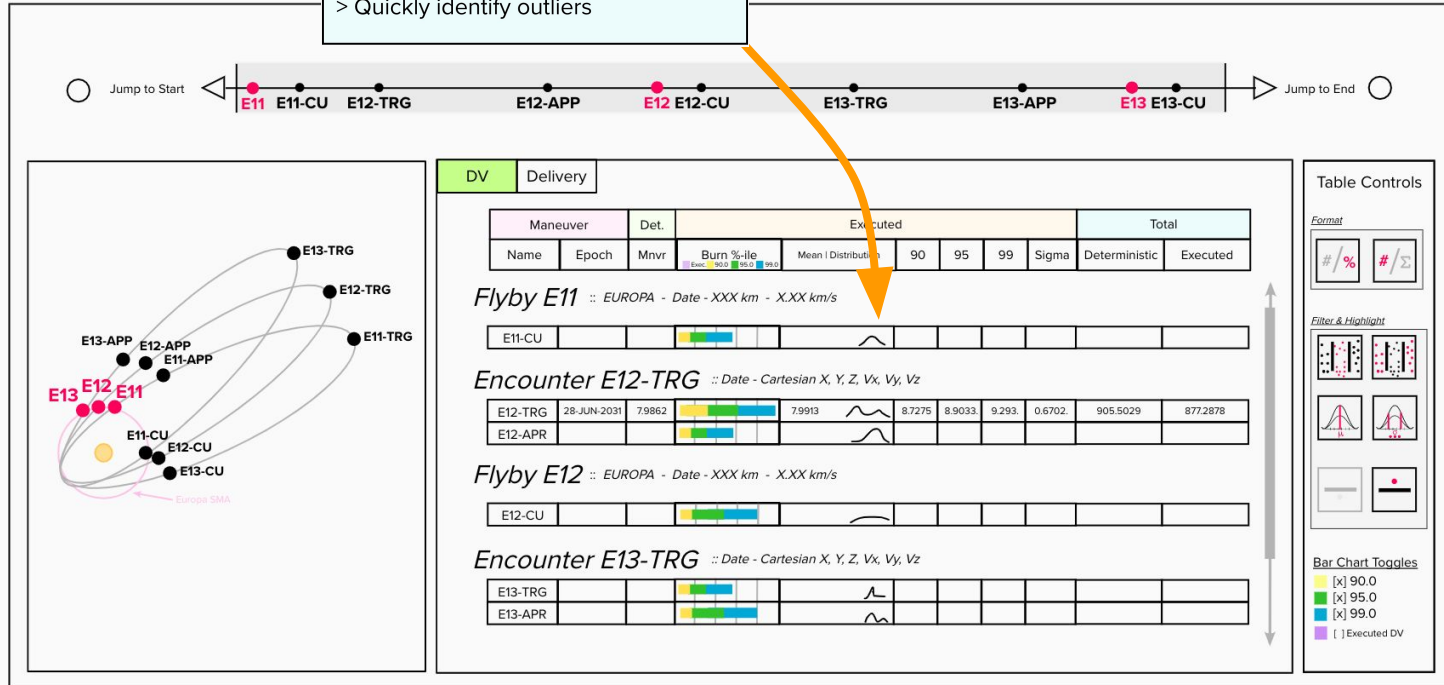
Bar Chart Toggles

[x] 90.0
[x] 95.0
[x] 99.0
[] Executed DV

Porter Organization: Overview Mode Example

Mean DV Distribution

- > Check for normality, variance
- > Quickly identify outliers



Porter Organization: Detailed Mode Example

CLICK

○ Jump to Start

▼

▶

● E11
 ● E11-CU
 ● E12-TRG
 ● E12-APP
 ● E12
 ● E12-CU
 ● E13-TRG
 ● E13-APP
 ● E13
 ● E13-CU

○ Jump to End

Back

E12-TRG

Epoch: 28-JUN-2031 18:16:13 ET

Deterministic Mag.:
Executed Mag.:

Cumulative Deterministic Mag.:
Cumulative Executed Mag.:

Current Encounter Target: Europa
Next Encounter Target: E-13 TRG
(or other important high level info.)

Delivery	Mnvr. DV	OD Cov.	Capel Plots
Plots <input checked="" type="checkbox"/> B*R B*T <input type="checkbox"/> S*R S*T <input type="checkbox"/> C3 <input type="checkbox"/> LFT			
Plot Tools <input checked="" type="checkbox"/> Show Pre-Maneuver Samples <input checked="" type="checkbox"/> Show Post-Maneuver Samples <input checked="" type="checkbox"/> Plot 1 - Sigma Ellipse <input type="checkbox"/> Plot 2 - Sigma Ellipse <input type="checkbox"/> Plot 3 - Sigma Ellipse <input type="checkbox"/> Show Density Plots <input checked="" type="checkbox"/> Show Sample Points			
Delivery Properties Impact Probability SMA SMIA Theta X-Offset Y-Offset C3 LFT			

Scroll Bar

E12-TRG BR BT Sample Points

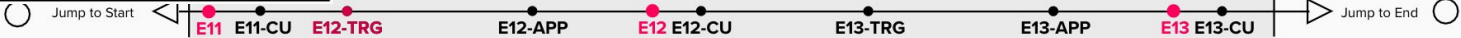
Scroll Bar

Orbiter Organization: Detailed Mode Example

Summary Section

- > Has high level quick info on maneuver
- > Has maneuver strategy type, next enc. info, etc.
- > **Open to suggestions for info here!**

CLICK*



Back

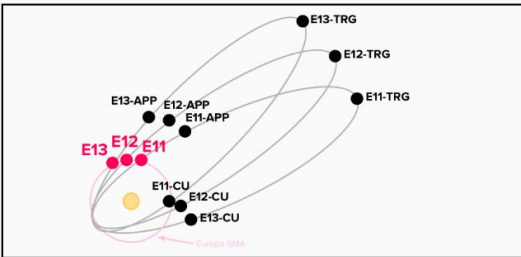
E12-TRG

Epoch: 28-JUN-2031 18:16:13 ET

Deterministic Mag.:
Executed Mag.:

Cumulative Deterministic Mag.:
Cumulative Executed Mag.:

Current Encounter Target: Europa
Next Encounter Target: E-13 TRG
(or other important high level info.)



Delivery | Mnv. DV | OD Cov. | Capel Plots

Plots

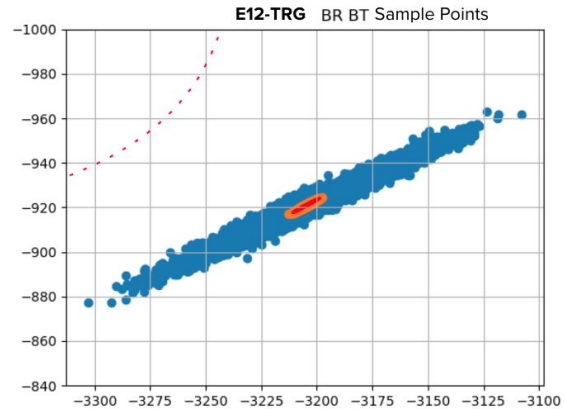
- B*R B*T
- S*R S*T
- C3
- LFT

Plot Tools

- Show Pre-Maneuver Samples
- Show Post-Maneuver Samples
- Plot 1 - Sigma Ellipse
- Plot 2 - Sigma Ellipse
- Plot 3 - Sigma Ellipse
- Show Density Plots
- Show Sample Points

Delivery Properties

- Impact Probability
- SMA
- SMIA
- Theta
- X-Offset
- Y-Offset
- C3
- LFT



Scroll Bar

Scroll Bar

Porter Organization: Detailed Mode Example

CLICK

Jump to Start
Jump to End

E11
E11-CU
E12-TRG
E12-APP
E12
E12-CU
E13-TRG
E13-APP
E13
E13-CU

Back

E12-TRG

Epoch: 28-JUN-2031 18:16:13 ET

Deterministic Mag.:
Executed Mag.:

Cumulative Deterministic Mag.:
Cumulative Executed Mag.:

Current Encounter Target: Europa
Next Encounter Target: E-13 TRG
(or other important high level info.)

Delivery	Mnvr. DV	OD Cov.	Capel Plots
Plots <input checked="" type="checkbox"/> B*R B*T <input type="checkbox"/> S*R S*T <input type="checkbox"/> C3 <input type="checkbox"/> LFT			
Plot Tools <input checked="" type="checkbox"/> Show Pre-Maneuver Samples <input checked="" type="checkbox"/> Show Post-Maneuver Samples <input checked="" type="checkbox"/> Plot 1 - Sigma Ellipse <input type="checkbox"/> Plot 2 - Sigma Ellipse <input type="checkbox"/> Plot 3 - Sigma Ellipse <input type="checkbox"/> Show Density Plots <input checked="" type="checkbox"/> Show Sample Points			
Delivery Properties Impact Probability SMA SMIA Theta X-Offset Y-Offset C3 LFT			

Delivery Plot Tools & Data

- > Select type of plot
- > Select overlays for information
- > See scatter with BR BT and colorbar of C3, LFT, or SR/ST mag values.
- > Question: Do you want these plots to be interactive?



Porter Organization: Detailed Mode Example

CLICK

Jump to Start ◀ | ◻ E11 E11-CU E12-TRG | E12-APP E12 E12-CU | E13-TRG E13-APP E13 E13-CU | ▶ Jump to End ◯

Back

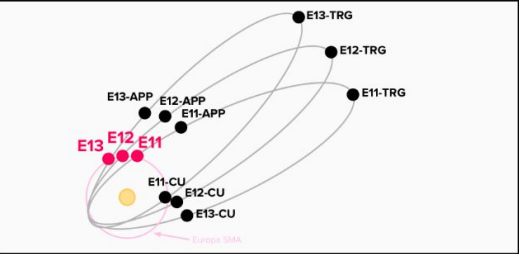
E12-TRG

Epoch: 28-JUN-2031 18:16:13 ET

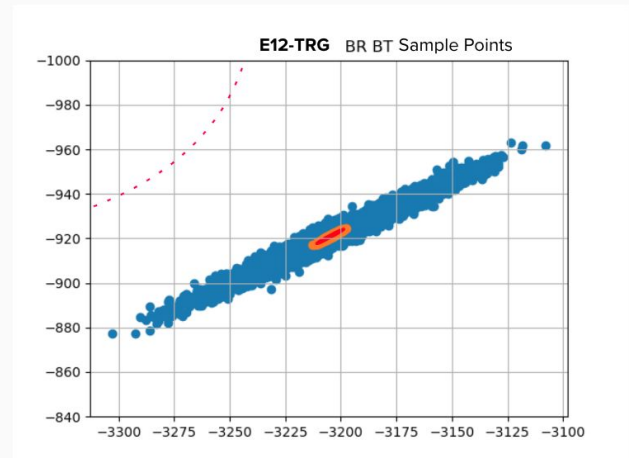
Deterministic Mag.:
Executed Mag.:

Cumulative Deterministic Mag.:
Cumulative Executed Mag.:

Current Encounter Target: Europa
Next Encounter Target: E-13 TRG
(or other important high level info.)



Delivery	Mnvr. DV	OD Cov.	Capel Plots
Plots			
<input checked="" type="checkbox"/> B*R B*T <input type="checkbox"/> S*R S*T <input type="checkbox"/> C3 <input type="checkbox"/> LFT			
Plot Tools			
<input checked="" type="checkbox"/> Show Pre-Maneuver Samples <input checked="" type="checkbox"/> Show Post-Maneuver Samples			
<input checked="" type="checkbox"/> Plot 1 - Sigma Ellipse <input type="checkbox"/> Plot 2 - Sigma Ellipse <input type="checkbox"/> Plot 3 - Sigma Ellipse			
<input type="checkbox"/> Show Density Plots <input checked="" type="checkbox"/> Show Sample Points			
Delivery Properties			
Impact Probability			
SMA			
SMIA			
Theta			
X-Offset			
Y-Offset			
C3			
LFT			



Scroll Bar

Scroll Bar

Delivery Plots

- > Choose between scatter and density plots
- > Plot pre and post maneuver data
- > Plot ellipse data
- > Plot non-spatial distributions like C3 and LFT

Porter Organization: Overview & Detail

Jump to Start ◀ ▶ Jump to End

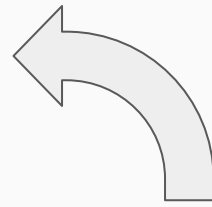
DV Delivery

Maneuver	Det.	Executed							Total	
Name	Epoch	Mnvr	Burn %ile	Mean Distribution	90	95	99	Sigma	Deterministic	Executed
<i>Flyby E11 :: EUROPA - Date -XXX km - X.XX km/s</i>										
E11-CU										
<i>Encounter E12-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz</i>										
E12-TRG	28 JUN 2031	79862		79913	8.7275	8.9033	9.293	0.6702	905.5029	877.2878
E12-APP										
<i>Flyby E12 :: EUROPA - Date -XXX km - X.XX km/s</i>										
E12-CU										
<i>Encounter E13-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz</i>										
E13-TRG										
E13-APP										

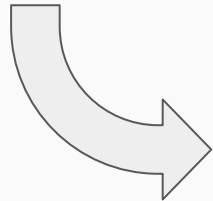
Table Controls

Format: # % # / %

Filter & Highlights: [Icons for various filters]



Switch between multi-maneuver and single maneuver analysis.



Jump to Start ◀ ▶ Jump to End

Back

E12-TRG
Epoch: 28 JUN 2031 18:16:13 ET
Deterministic Mag.:
Executed Mag.:
Cumulative Deterministic Mag.:
Cumulative Executed Mag.:
Current Encounter Target: Europa
Next Encounter Target: E13 TRG
(or other important high level info.)

Delivery Mnvr. DV OD Cov. Capel Plots

Plots
 B'R B'T
 S'R S'T
 C3
 LFT

Plot Tools
 Show Pre-Maneuver Samples
 Show Post-Maneuver Samples
 Plot 1 - Sigma Ellipse
 Plot 2 - Sigma Ellipse
 Plot 3 - Sigma Ellipse
 Show Density Plots
 Show Sample Points

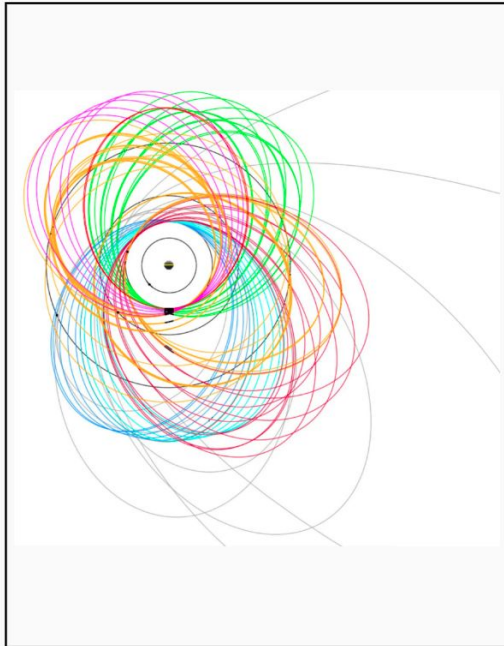
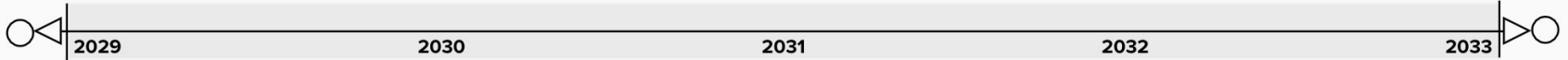
Delivery Properties
 Impact Probability
 SMA
 SMIA
 Theta
 X-Offset
 Y-Offset
 C3
 LFT

Scroll Bar

Example Use Case

- > Review Europa Clipper tour LAMBIC file to find maneuvers with outstanding DVs
- > Exploring detailed maneuver-specific result components

Step 1: Review EC Data



DV		Delivery											
Maneuver		Det.	Executed							Total			
Name	Epoch	Mnvr	Burn %-ile			Mean Distribution	90	95	99	Sigma	Deterministic	Executed	
JOI-APR1													
JOI-TRG2													
JOI-TRG3													
Flyby G0 :: GANYMEDE - Date - XXX km - X.XX km/s													
JOI													
JOI-CU1													
JOI-CU2													
Encounter PRM :: Date - Cartesian X, Y, Z, Vx, Vy, Vz													
PRM													
PRM-CU1													
PRM-CU2													
G1-APR1													
G1-APR2													

CLICK

Table Controls

Format

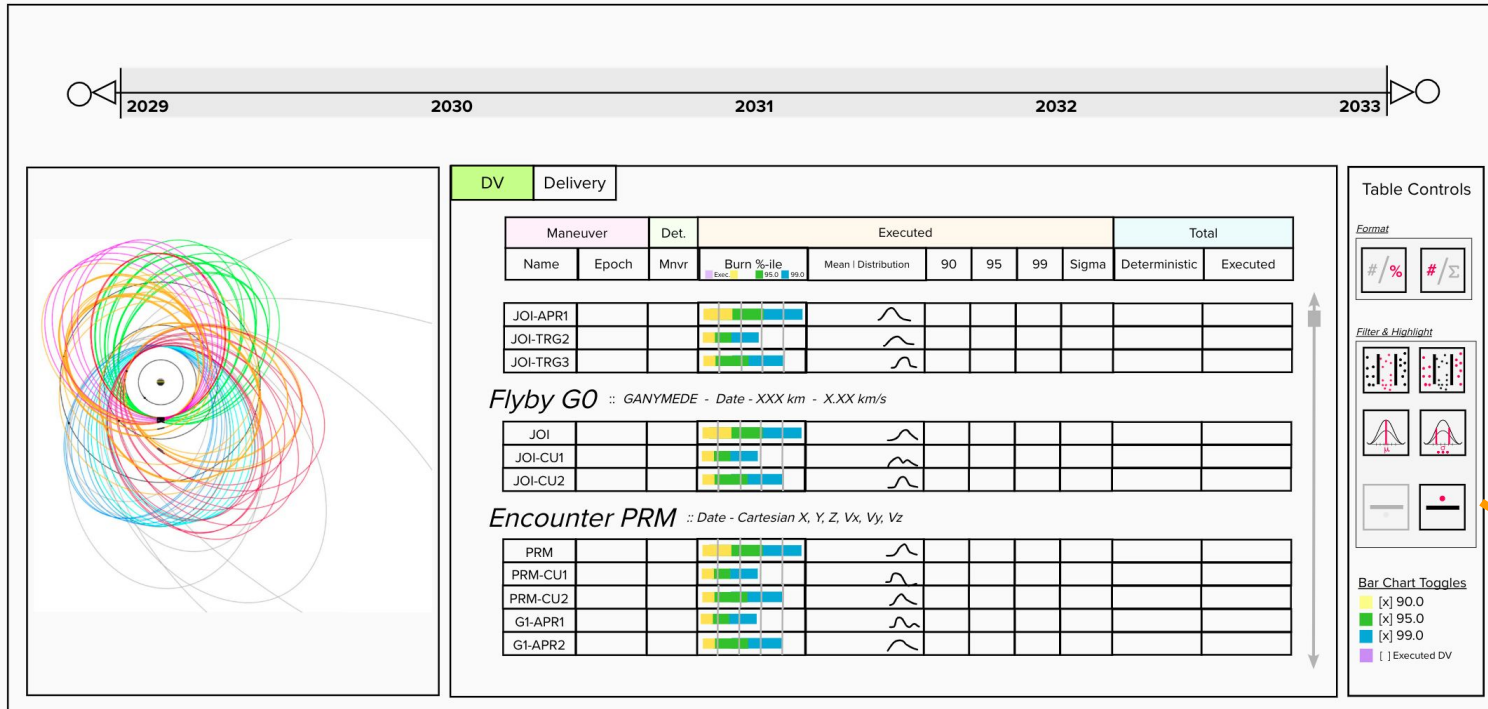
/ % # / Σ

Filter & Highlight

Bar Chart Toggles

[x] 90.0
[x] 95.0
[x] 99.0
[] Executed DV

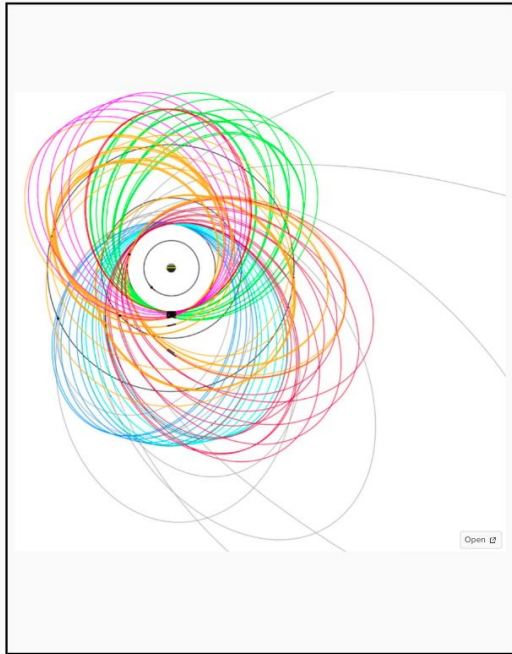
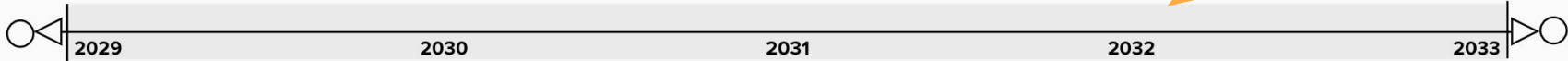
Step 2: Find a Maneuver of Interest



A/B
 #/%

Step 2: Find a Maneuver of Interest

Change Start/Stop Period



DV		Delivery										
Maneuver		Det.	Executed							Total		
Name	Epoch	Mnvr	Burn %-ile			Mean Distribution	90	95	99	Sigma	Deterministic	Executed
Flyby E11 :: EUROPA - Date - XXX km - X.XX km/s E11-CU [Progress bar] [Waveform] [] [] [] [] [] [] [] [] [] []												
Encounter E12-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz E12-TRG 28-JUN-2031 7.9862 [Progress bar] 7.9913 8.7275 8.9033 9.293 0.6702 905.5029 877.2878 E12-APR [Progress bar] [Waveform] [] [] [] [] [] [] [] [] [] []												
Flyby E12 :: EUROPA - Date - XXX km - X.XX km/s E12-CU [Progress bar] [Waveform] [] [] [] [] [] [] [] [] [] []												
Encounter E13-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz E13-TRG [Progress bar] [Waveform] [] [] [] [] [] [] [] [] [] [] E13-APR [Progress bar] [Waveform] [] [] [] [] [] [] [] [] [] []												

Table Controls

Format

/ % # / Σ

Filter & Highlight

[Grid icons]

[Graph icons]

[Toggle icons]

Bar Chart Toggles

- [Yellow] [x] 90.0
- [Green] [x] 95.0
- [Blue] [x] 99.0
- [Purple] [] Executed DV

Step 3: Assess DV Stats.

CLICK

○ Jump to Start ◀
▶ Jump to End ○

DV		Delivery												
Maneuver		Det.	Executed							Total				
Name	Epoch	Mnvr	Burn %-ile				Mean Distribution	90	95	99	Sigma	Deterministic	Executed	
<i>Flyby E11 :: EUROPA - Date - XXX km - X.XX km/s</i>														
E11-CU														
<i>Encounter E12-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz</i>														
E12-TRG	28-JUN-2031	7.9862					7.9913		8.7275	8.9033	9.293	0.6702	905.5029	877.2878
E12-APR														
<i>Flyby E12 :: EUROPA - Date - XXX km - X.XX km/s</i>														
E12-CU														
<i>Encounter E13-TRG :: Date - Cartesian X, Y, Z, Vx, Vy, Vz</i>														
E13-TRG														
E13-APR														

Table Controls

Format

/ % # / Σ

Filter & Highlight

Bar Chart Toggles

[] Executed DV

Step 4: Assess Delivery Stats.

○ Jump to Start
○ Jump to End

CLICK

OR CLICK

DV Delivery
Key: B-Plane Cartesian

Maneuver		Impact		Delivery Properties						More?	
Name	Epoch	Prob.	Gaussian	SMA	SMIA	Theta	X offset	Y offset	Ellipse		
				Mean X	Mean Y	Mean Z	Mean Vx	Mean Vy	Mean Vz		
Flyby E11 :: Body = Europa Date Flyby Alt = XXX km Vinf = X.XX km/s											
E11-CU											
Encounter E12TRG :: Date Cartesian: X, Y, Z, Vx, Vy, Vz											
E12-TRG									○		
E12-APR									○		
Flyby E12 :: Body = Europa Date Flyby Alt = XXX km Vinf = X.XX km/s											
E12-CU											
Encounter E13TRG :: Date Cartesian: X, Y, Z, Vx, Vy, Vz											
E13-TRG									○		
E13-APR									○		

Table Controls

Format

/ %
/ Σ

Filter & Highlight

Bar Chart Toggles

[x] 90.0
 [x] 95.0
 [x] 99.0
 [] Executed DV

Step 5: See Delivery Details

Jump to Start ◀ | ◻ E11 E11-CU E12-TRG | ◻ E12-APP E12 E12-CU | ◻ E13-TRG E13-APP E13 E13-CU | ▶ Jump to End ◻

Back

E12-TRG

Epoch: 28-JUN-2031 18:16:13 ET

Deterministic Mag.:
Executed Mag.:

Cumulative Deterministic Mag.:
Cumulative Executed Mag.:

Current Encounter Target: Europa
Next Encounter Target: E-13 TRG
(or other important high level info.)

CLICK

Europa SMA

Delivery	Mnvr. DV	OD Cov.	Capel Plots
Plots [x] B*R B*T [] S*R S*T [] C3 [] LFT			
Plot Tools [x] Show Pre-Maneuver Samples [x] Show Post-Maneuver Samples [x] Plot 1 - Sigma Ellipse [] Plot 2 - Sigma Ellipse [] Plot 3 - Sigma Ellipse [] Show Density Plots [x] Show Sample Points			
Delivery Properties Impact Probability SMA SMIA Theta X-Offset Y-Offset C3 LFT			

E12-TRG BR BT Sample Points

Scroll Bar

Scroll Bar

27

Step 5: See Delivery Details

Jump to Start ◀
▶ Jump to End

Back

E12-TRG
Epoch: 28-JUN-2031 18:16:13 ET

Deterministic Mag.:
Executed Mag.:

Cumulative Deterministic Mag.:
Cumulative Executed Mag.:

Current Encounter Target: Europa
Next Encounter Target: E-13 TRG
(or other important high level info.)

Delivery	Mnvr. DV	OD Cov.	Capel Plots
<p>Plots</p> <p><input checked="" type="checkbox"/> B*R B*T <input type="checkbox"/> S*R S*T <input type="checkbox"/> C3 <input type="checkbox"/> LFT</p> <p>Plot Tools</p> <p><input type="checkbox"/> Show Pre-Maneuver Samples <input checked="" type="checkbox"/> Show Post-Maneuver Samples</p> <p><input checked="" type="checkbox"/> Plot 1 - Sigma Ellipse <input type="checkbox"/> Plot 2 - Sigma Ellipse <input type="checkbox"/> Plot 3 - Sigma Ellipse</p> <p><input checked="" type="checkbox"/> Show Density Plots <input type="checkbox"/> Show Sample Points</p>			
<p>Delivery Properties</p> <p>Impact Probability SMA SMIA Theta X-Offset Y-Offset C3 LFT</p>			<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Scroll Bar</p>

E12-TRG Density Plot

KDE Bandwidth

Step 5: See DV Detailed Data

Jump to Start ◀ ▶ Jump to End ◯

Back

E11 E11-CU E12-TRG E12-APP E12 E12-CU E13-TRG E13-APP E13 E13-CU

CLICK

E12-TRG

Epoch: 28-JUN-2031 18:16:13 ET

Deterministic Mag.:
Executed Mag.:

Cumulative Deterministic Mag.:
Cumulative Executed Mag.:

Current Encounter Target: Europa
Next Encounter Target: E-13 TRG
(or other important high level info.)

	Delivery	Mnvr. DV	OD Cov.	Capel Plots

	Mag.	Cum.
Commanded	Mean	
	Sigma	
	90	
	95	
Executed	Mean	
	Sigma	
	90	
	95	
Error	Mean	
	Sigma	
	90	
	95	

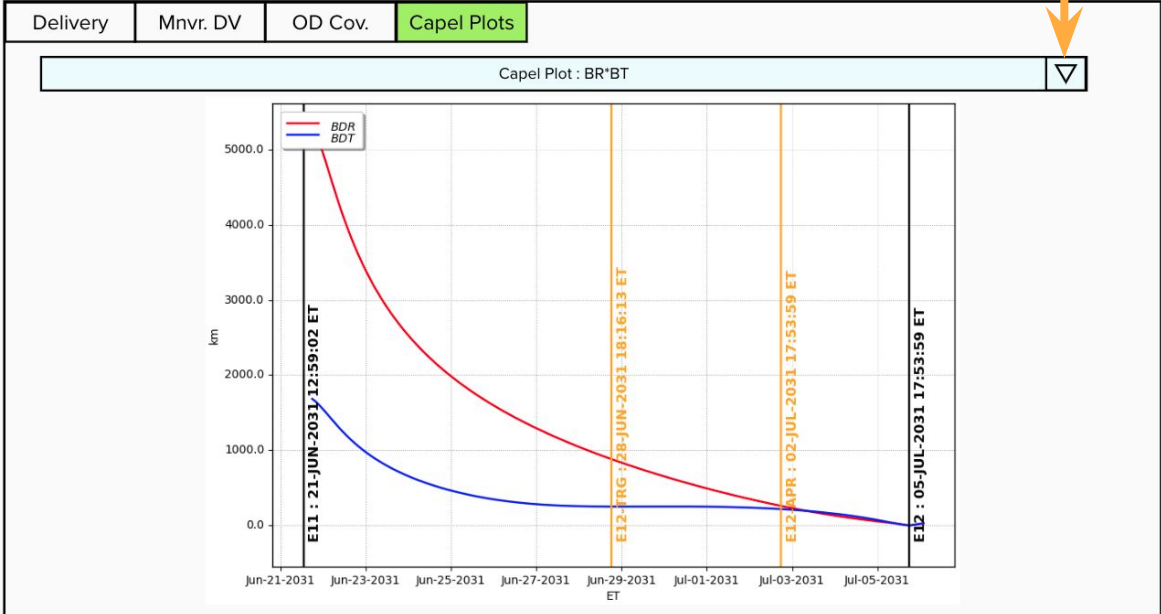
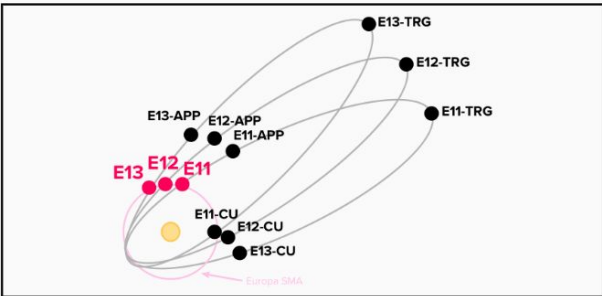
Cmd	Executed
<u>Executed DV Distribution Plot</u>	
Gaussian Parameters Goodness of Fit: Skew	

Step 6: See Capel Plots

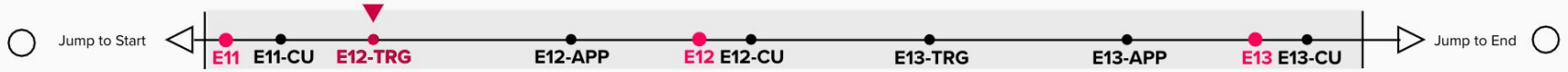


Back

E12-TRG
Epoch: 28-JUN-2031 18:16:13 ET
Deterministic Mag.:
Executed Mag.:
Cumulative Deterministic Mag.:
Cumulative Executed Mag.:
Current Encounter Target: Europa
Next Encounter Target: E-13 TRG
(or other important high level info.)



Step 6: See Capel Plots



Back

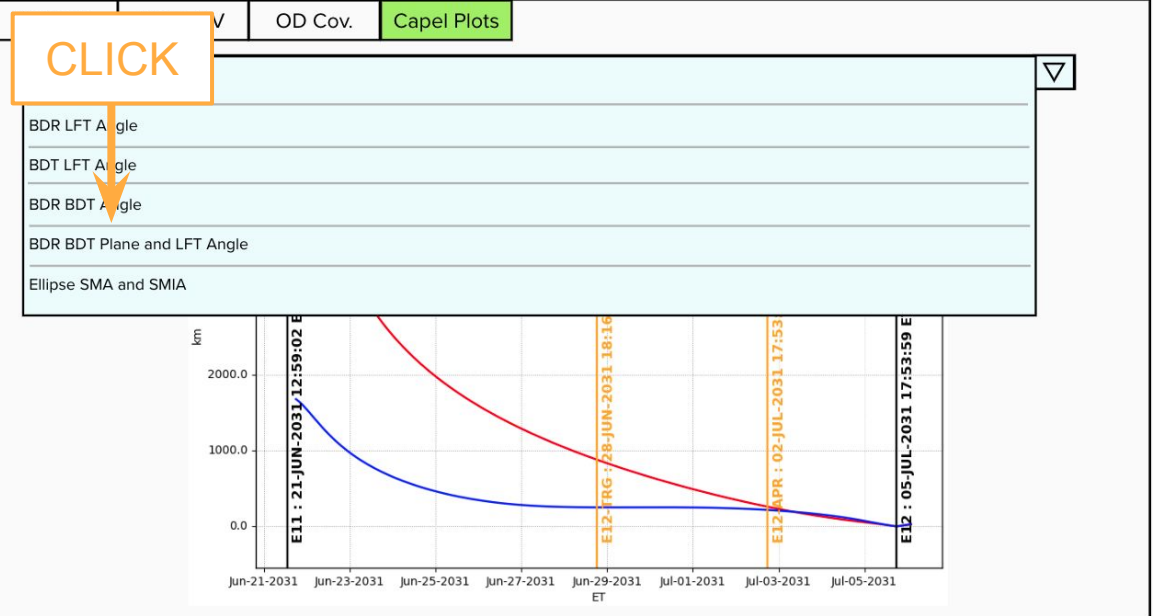
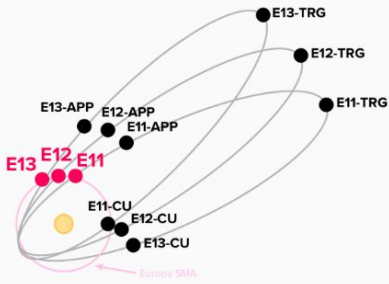
E12-TRG

Epoch: 28-JUN-2031 18:16:13 ET

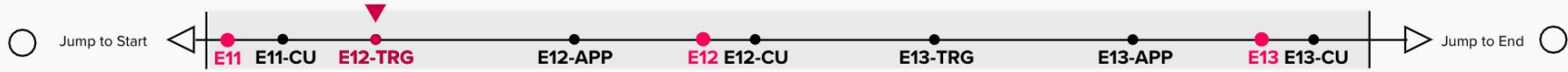
Deterministic Mag.:
Executed Mag.:

Cumulative Deterministic Mag.:
Cumulative Executed Mag.:

Current Encounter Target: Europa
Next Encounter Target: E-13 TRG
(or other important high level info.)



Step 6: See Capel Plots



Back

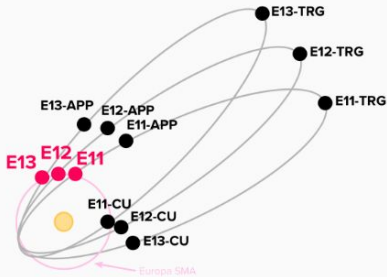
E12-TRG

Epoch: 28-JUN-2031 18:16:13 ET

Deterministic Mag.:
Executed Mag.:

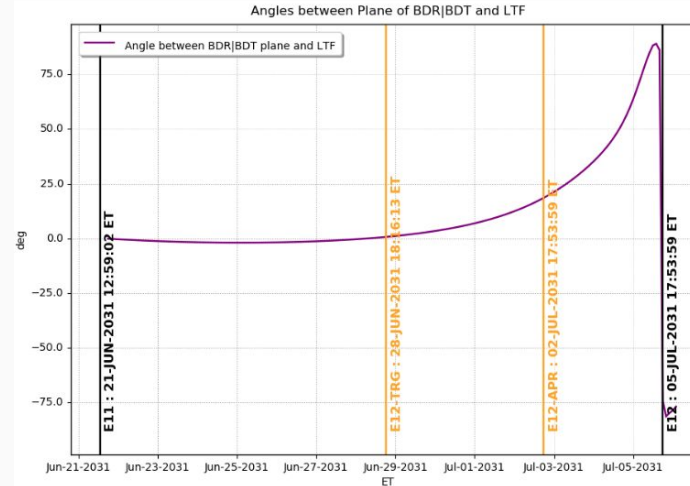
Cumulative Deterministic Mag.:
Cumulative Executed Mag.:

Current Encounter Target: Europa
Next Encounter Target: E-13 TRG
(or other important high level info.)



Delivery Mnvr. DV OD Cov. **Capel Plots**

Capel Plot : BDR BDT Plane and LFT Angle



Preliminary Feedback

- Maneuvers vs. Encounters: How engineers think of mission data
- Plotting Specifics: Modifying existing views to account for common analysis practices
 - Delivery scatter, density, or hybrid distribution plots
 - Multiple capel plots
 - Side by side plot viewing in detailed screen mode
- Seeing candidate plots lead to conversations on alternative views to include
- Table data or visualization exports for reports and presentations

Follow on work

Implementing the Current Design Prototype in Code

Timeline

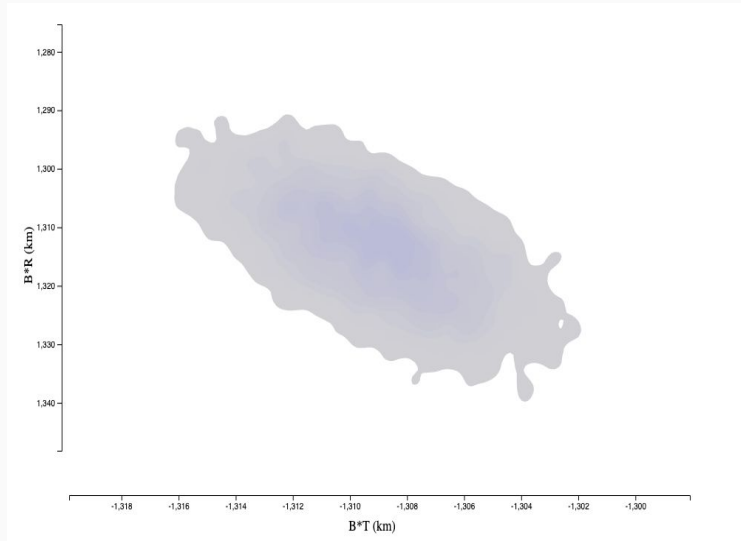
Nav Pane

DV Delivery												
Maneuver			Deterministic		Executed						Total	
Name	Epoch	Enc.	Maneuver DV	Brn%	Mean Dv	Distribution	90	95	99	Sigma	Deterministic	Executed
JOI-APR-1	03-APR-2029 07:47:25 ET	GO	0.0002730875686759255	(TBD VIS)	0.003653852614039617	(TBD VIS)	0.005739375140352693	0.006445776714028297	0.007837174429073881	0.0015595539635670768	0.003653476352096058	0.003653852614039617
JOI-TRG-2	02-JUL-2029 08:43:22 ET	GO	0	(TBD VIS)	0.00008449177361855942	(TBD VIS)	0.00015764532732797276	0.0001904575565236425	0.00025790324444715596	0.00005399713554192203	0.0000843335336781581	0.003738344387658187
JOI-TRG-3	15-SEP-2029 08:43:22 ET	GO	0	(TBD VIS)	0.00003990952832878189	(TBD VIS)	0.00006747147272825506	0.000078908461122651988	0.00009978329161208585	0.000020094114869241775	0.00003955907930014499	0.003778253915986964
JOI	30-SEP-2029 08:43:22 ET	PRM	0.7588785921089877	(TBD VIS)	0.7589059149835927	(TBD VIS)	0.7621468660332127	0.7631714175211253	0.7648796022844062	0.002527683000261853	0.7588785921089878	0.7626841688995797
JOI-CU-1	03-OCT-2029 08:43:22 ET	PRM	0	(TBD VIS)	0.007339206059557658	(TBD VIS)	0.0144057899345694674	0.016891551523182582	0.022249552390161437	0.004950173967355533	0.007338718162012946	0.7700233749591373
JOI-CU-2	15-OCT-2029 08:43:22 ET	PRM	0	(TBD VIS)	0.00009100481199901425	(TBD VIS)	0.00019954153683305383	0.0002697673661462584	0.00042781613161503763	0.0000897067779102366	0.00009065875025003134	0.7701143797711365

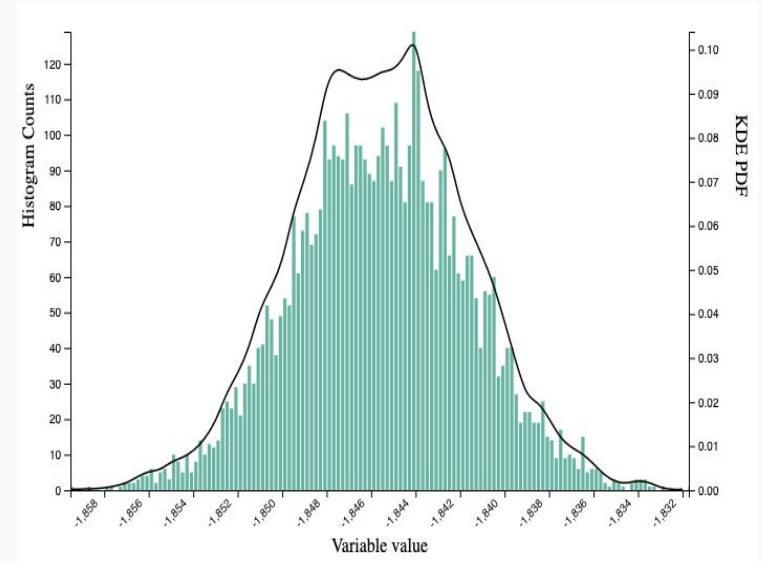
Table Controls

Feedback On Specific Features and Views

Delivery Contour Plots



Scalar MC Distributions

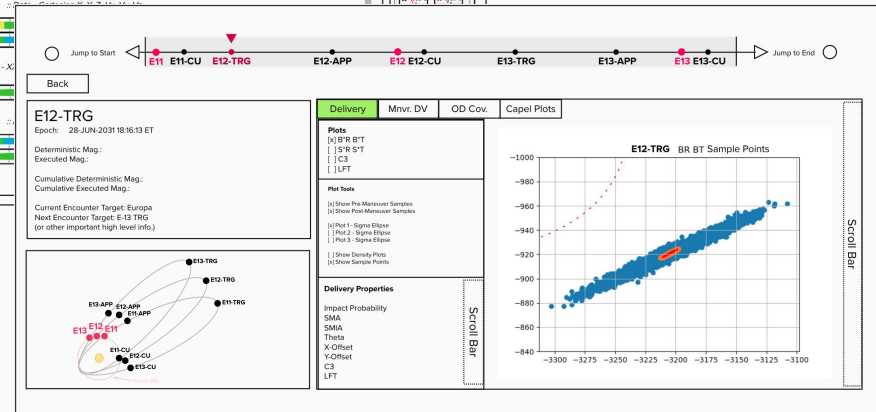
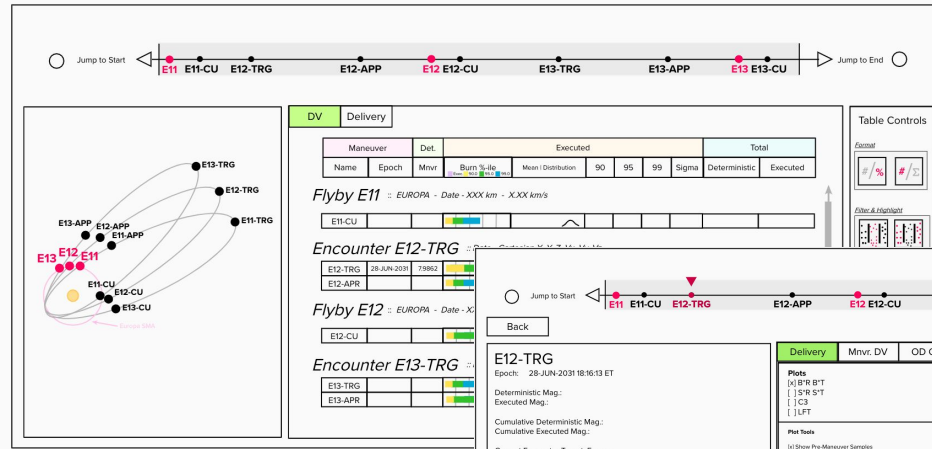


https://github.jpl.nasa.gov/pages/jamoore/impact_contour_plots/

<https://github.jpl.nasa.gov/pages/jamoore/histograms/>

Future Development Goals

- Focused design work to ensure designers needs are met
- Building out segments of the Interface UI for mini-user studies as views mature.
- Extending JSON development to include additional maneuver data products (Capel, Flybys, etc.) to simplify review and visualization of LAMBIC data
- Bulk export functionality
- General program robustness to multiple flight project needs



Thank you for Attending!

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 School Of Computing
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Rohan Patel
 Cal. Poly Pomona
 Aerospace Engineering
 rohan.d.patel@jpl.nasa.gov

Mentors

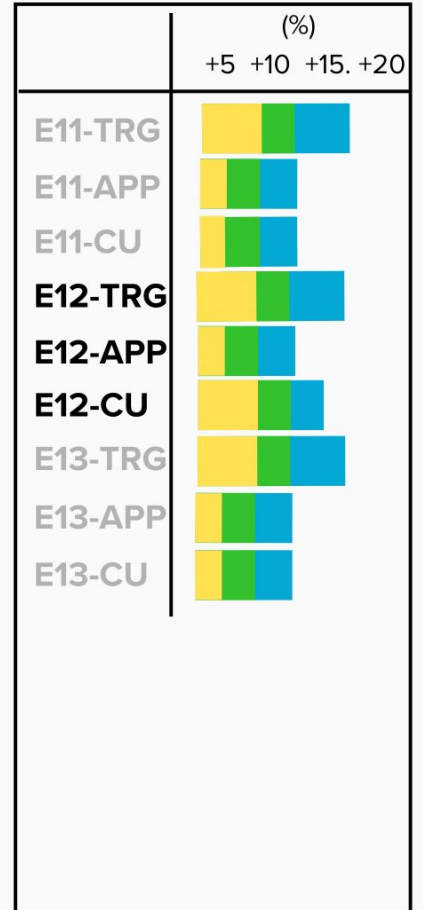
Jeff Stuart & Sonia Hernandez
 Section 392
 Mission Design & Navigation

Basak Ramaswamy
 Section 397
 Human Centered Design Group

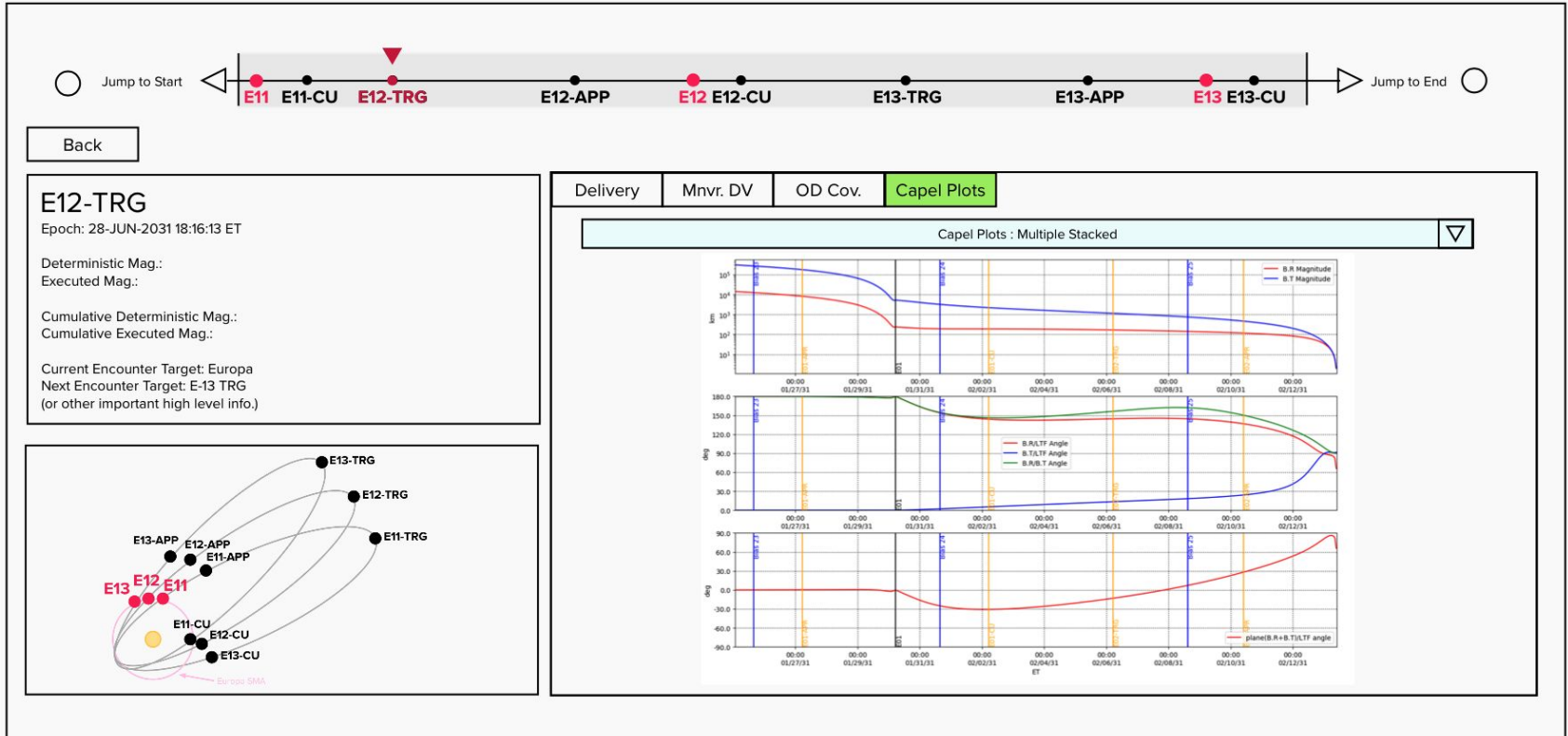
Additional Visual / Interactive Elements

Percentile Burn plots

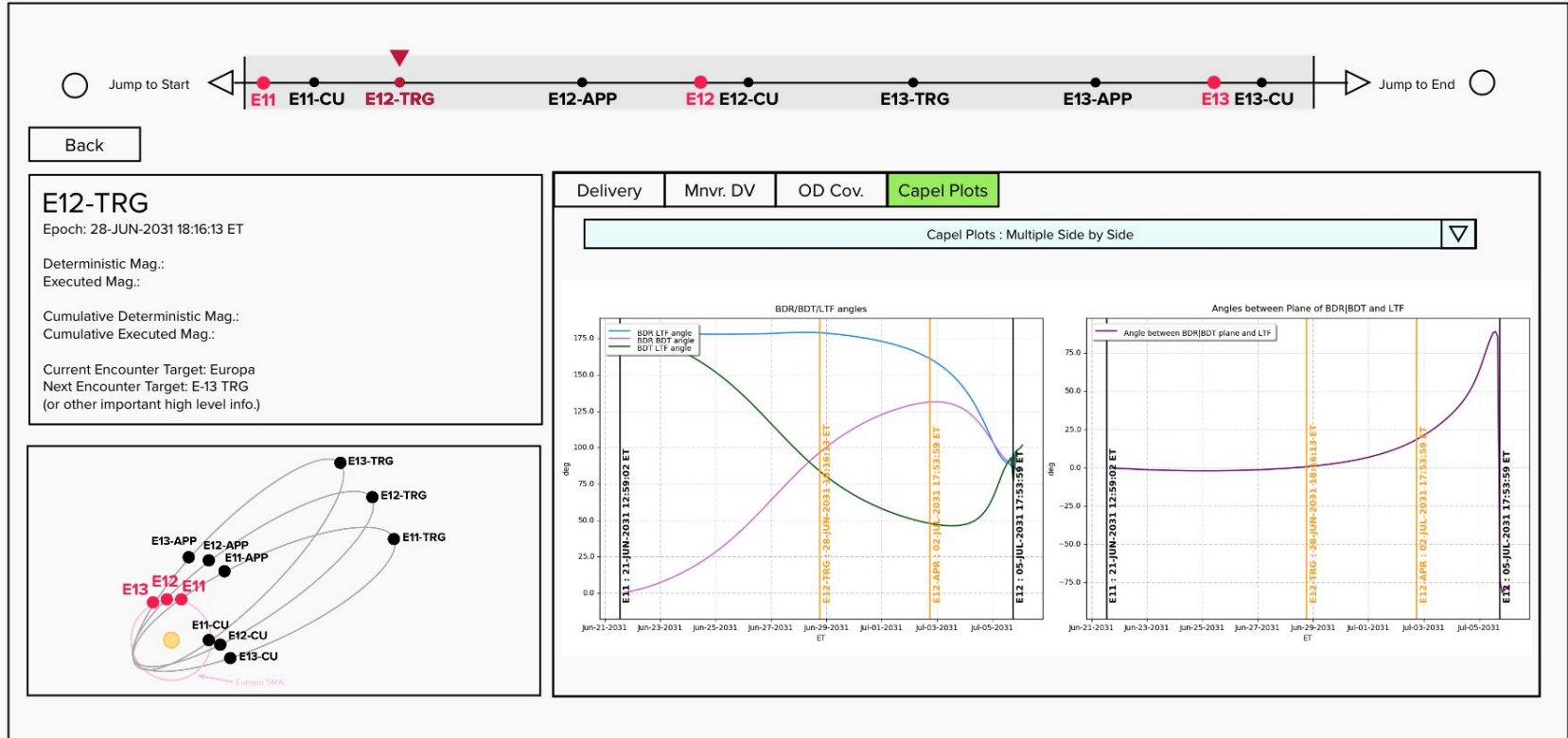
1. Is representing executed maneuvers (and its associated sigmas) with respect to the deterministic value of interest?
2. When evaluating maneuvers (like Clipper's TRG or CU) are you interested in looking at the executed maneuver magnitude with respect to other similar maneuver types?



Capel Plot Views

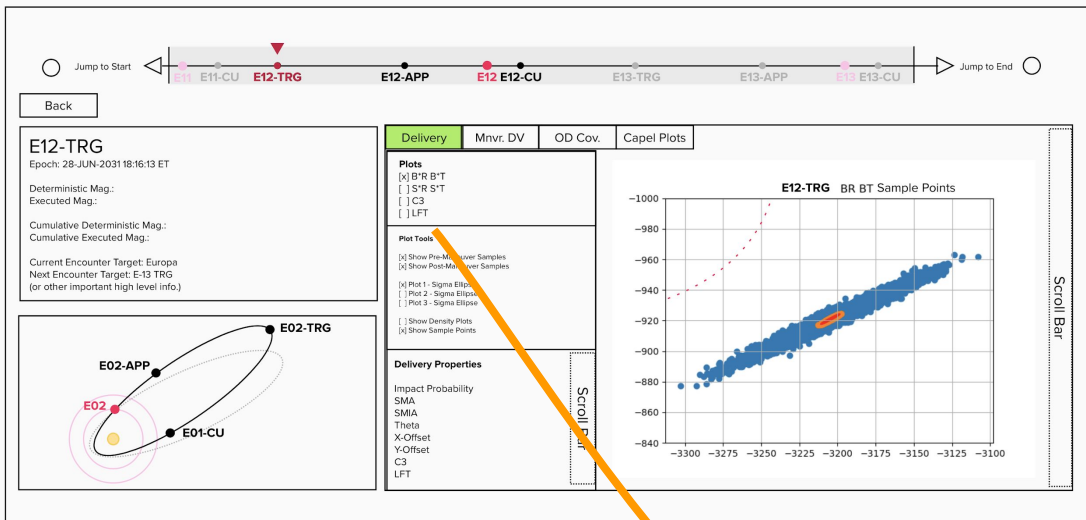


Capel Plot Views

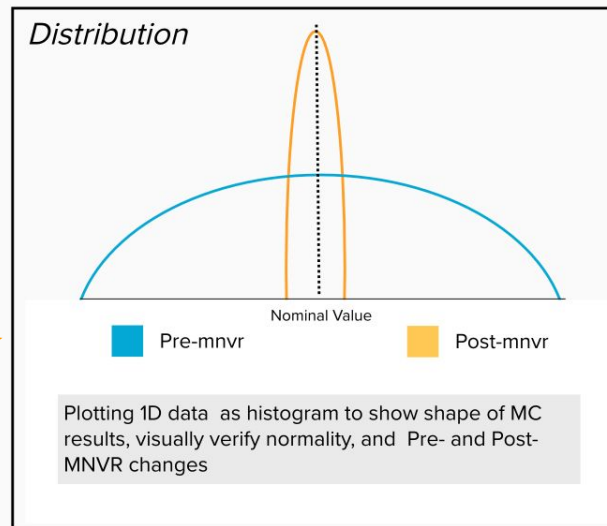


Univariate 1D views

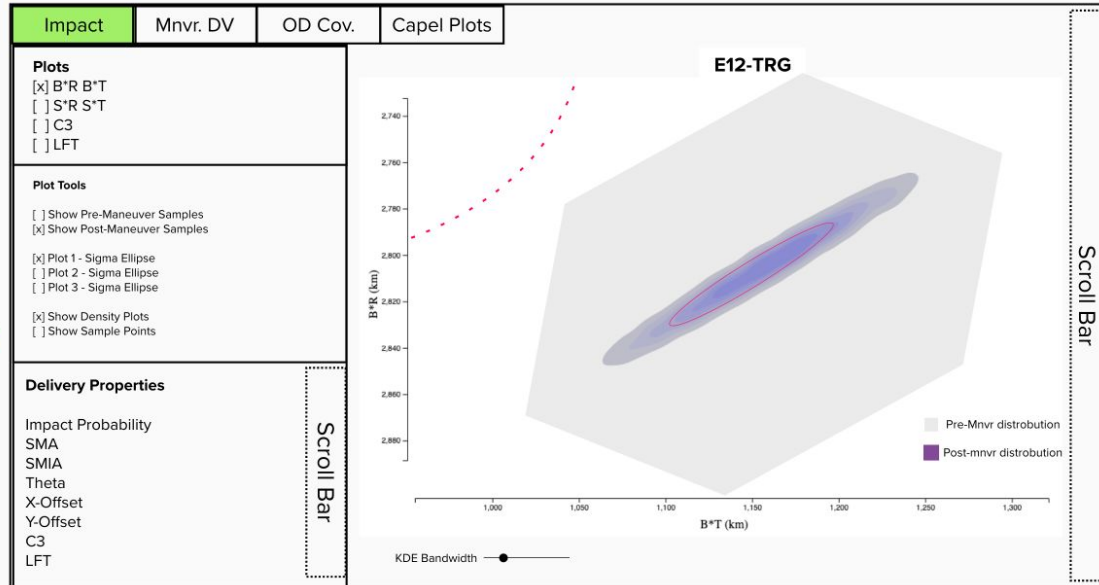
For visualizing Monte Carlo data



Pre-post-Mnvr plots (C3, LTOF)



Detail Views : Exploring Delivery Data



Impact Plotting Tools

- > Select type of plot
- > Select overlays for information
- > See scatter with BR BT and colorbar of C3, LFT, or SR/ST mag values.
- > Question: Do you want these plots to be interactive?

2D Scatter Plot distributions

SR x ST & BR x BT

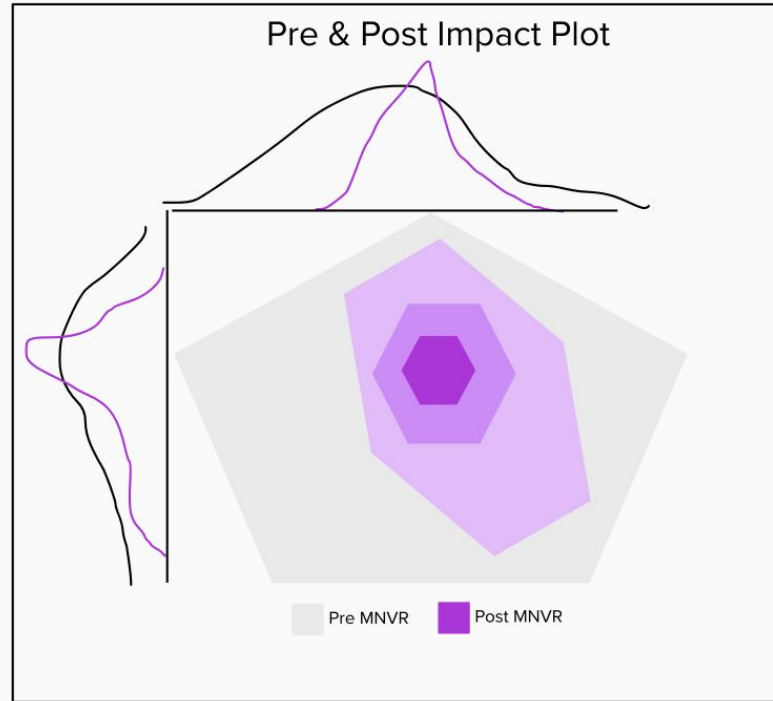


Table Conditional Formatting

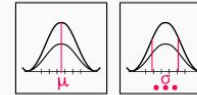
1. What are some methods you would like to see tabular data formatted in?
2. Do you see yourself wanting to find all maneuvers in X threshold across the entire tour?

How do engineers interact with data?

Interactivity

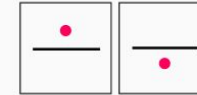
Sort By	Value	Sort by reported values, by column
	Percentage	Sort by percentage difference from that variable's deterministic value (if available)
	Normality	Check for "goodness of fit" with MC Data

Statistics Highlighting



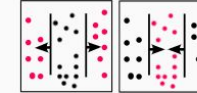
Use program logic to color values by their distance from a mean, or within a range

Highlight Above/ Below

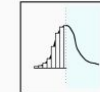


Toggle coloring objects above / below a specific value

Highlight Inside/outside



Toggle coloring objects inside / outside a specific (statistical?) range



Toggle KDE/Hist

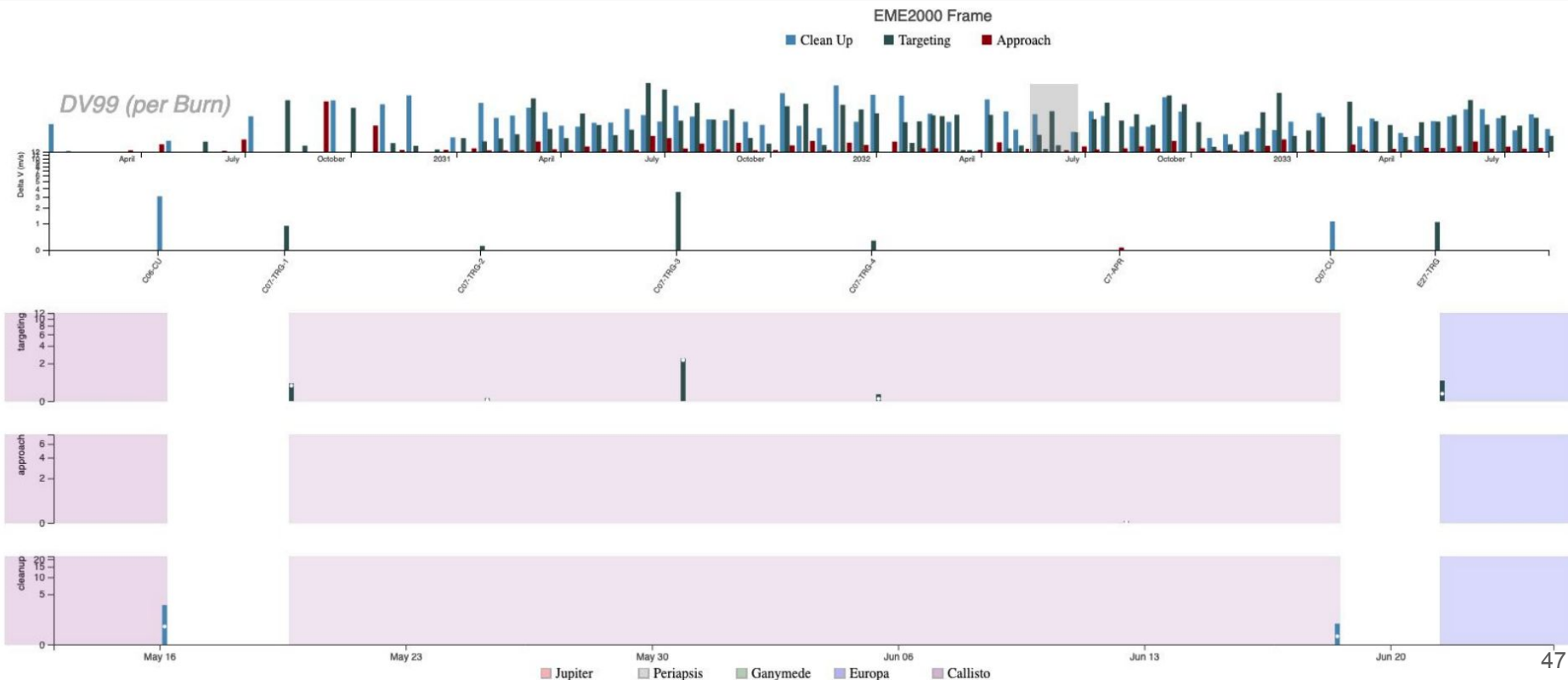


Show exact or relative values



Show exact or cumulative values

Maneuver Tracks



Supplemental

LAMBIC Data Dump

Shared Format

DV Parameters		DV Magnitudes	Current Encounter	Next Encounter	
Cartesian	Spherical		Delivery	Cartesian	Spherical
Commanded Delta-V		Commanded Delta-V Magnitude	Design Aimpoint	Next Encounter Delivery	
Executed Delta-V		Executed Delta-V Magnitude	Miss	Next Encounter Design Aimpoint	
Execution Error		Execution Error Magnitude		Next Encounter Miss	
<ul style="list-style-type: none"> * Correlation: 3x3 Matrix * Covariance: 3x3 Matrix * Means: 3-element mean vector w/ units * Sigmas: 3-element sigma vector w/ units * Skipped: null 		<ul style="list-style-type: none"> * Body Name: text string (G05-TRG-01) * Last Burn: True/False * Delta-V Magnitude Mean: [scalar, km/s] * Cumulated Mean Delta-V: [scalar, km/s] * Percentiles for Burn: [90,95,99] * Cumulated Percentiles: [90,95,99] * Sigma: [scalar, km/s] * Cumulated Sigma: [scalar, km/s] 	<ul style="list-style-type: none"> * Burn Name: e.g. G05-TRG-01 * Correlation: 6x6 Matrix * Covariance: 6x6 Matrix * Error Ellipse: all data for plotting ellipse * B-Mag Stats: mean/nom/sigma/theta/etc * Means [S,B],[R,T], LTOF, C3 as [scalar, km] * Sigma: [S,B],[R,T], LTOF, C3 as [scalar, km] * Skipped: null 	<ul style="list-style-type: none"> * Burn Name: e.g. G05-TRG-01 * Correlation: 6x6 Matrix * Covariance: 6x6 Matrix * Error Ellipse * Means: [S,B],[R,T], LTOF, C3 values w/ units * Sigmas: [S,B],[R,T], LTOF, C3 values w/ units * Skipped: null 	

LAMBIC Data Dump

Unique Format		
Impact Probability	Maneuver Information	OD Covariance
Current Encounter	General Burn Data	<ul style="list-style-type: none"> * Burn Name: text string * Correlation: 6x6 matrix * Covariance: 6x6 matrix * Data Cutoff Time: scalar and date string * Map Name & Time: Strings and scalar * Scale Factor: scalar * Sigmas: component-wise values * Skipped: null
<ul style="list-style-type: none"> * Capture & Impact Radii * Failure rate * Impact Probability: mean, max, cumulative * B-Error Ellipse data: sma,smi, theta, etc. 	<ul style="list-style-type: none"> * Name & Numbers * Frame & Format * Epoch & Epoch Cal. * Execution Error & [Search] Strategy 	
	Target & Next Encounter: Settings & Aimpoints	
	<ul style="list-style-type: none"> * Names & Frames * Epochs * [B,S],[T,R], LTOF, C3 * Downstream: Aimpoint Values & Shift 	
	Deterministic DV, Deterministic Cumulative DV	
	<ul style="list-style-type: none"> * [dX,dY,dZ, Magnitude] DV Values * Deterministic Cumulative DV value 	

Panel Layout Descriptions

Mission Overview

User Set Start/Stop Epochs



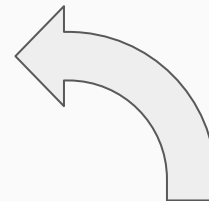
State visual with trajectory. Bolded lines indicate the start and stop time

Summary table from start/stop epochs with maneuver and impact data.

We have epochs of all maneuvers and encounters. So, we can group things chronologically as this will (traj

Scroll

Table



Details on demand

But Now Burn Name is Flagged



Back Button

Burn Name

Maneuver Summary Information
(from Info result set)

State visual with trajectory. Bolded lines indicate the start and stop time

Specific maneuver is highlighted

Impact	Cmd DV	Exec DV	Error	Total DV	OD Cov.	Capel Plots
--------	--------	---------	-------	----------	---------	-------------

Tabbed section separated by maneuver detailed result information:

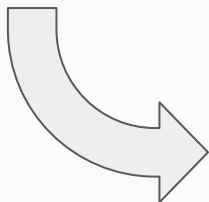
1. Impact/Miss (with clickable sample data plots?)
2. DV (cmd, exec, exec error, vectors, total) (sample data here too)
3. OD Cov

distribution plots

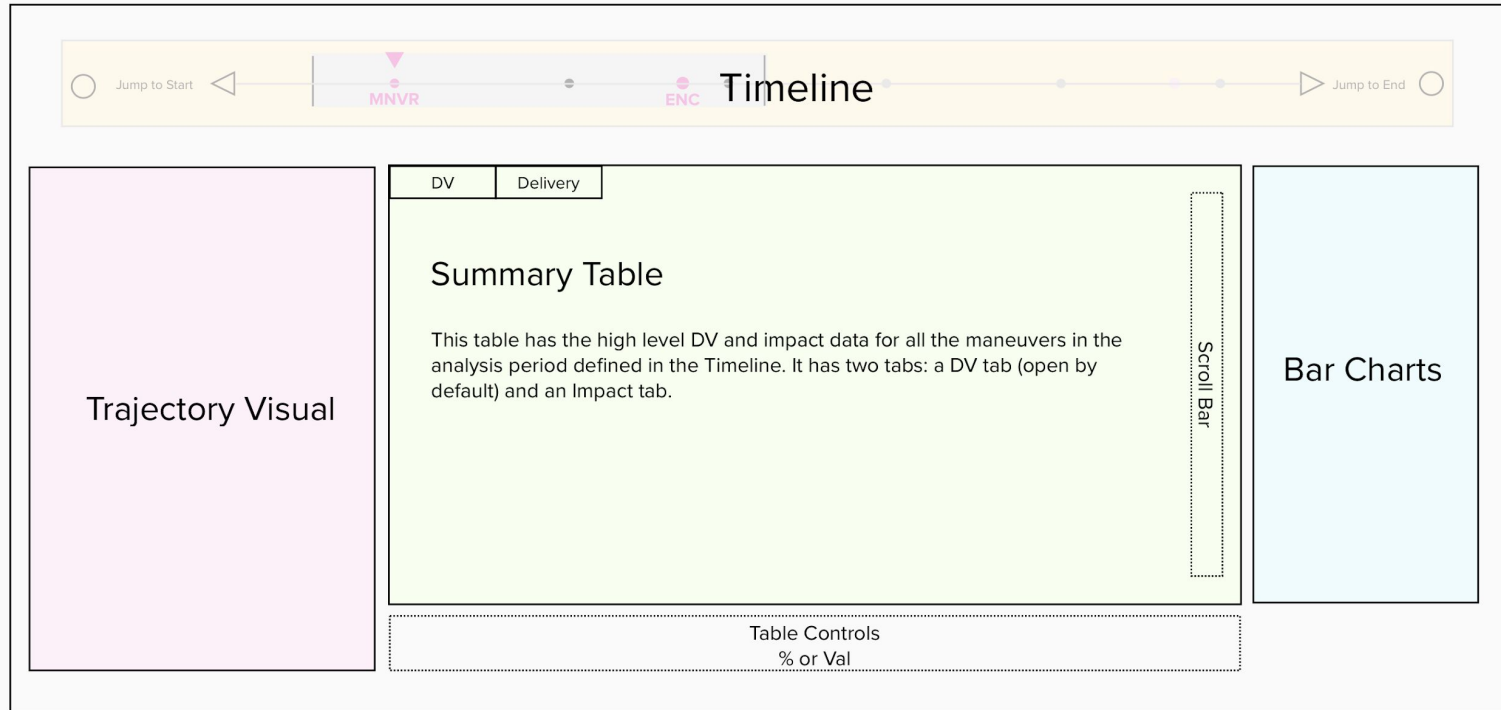
Scroll Bar

Table Controls

Switch between multi-maneuver and single maneuver analysis.



Porter Organization : Overview Mode



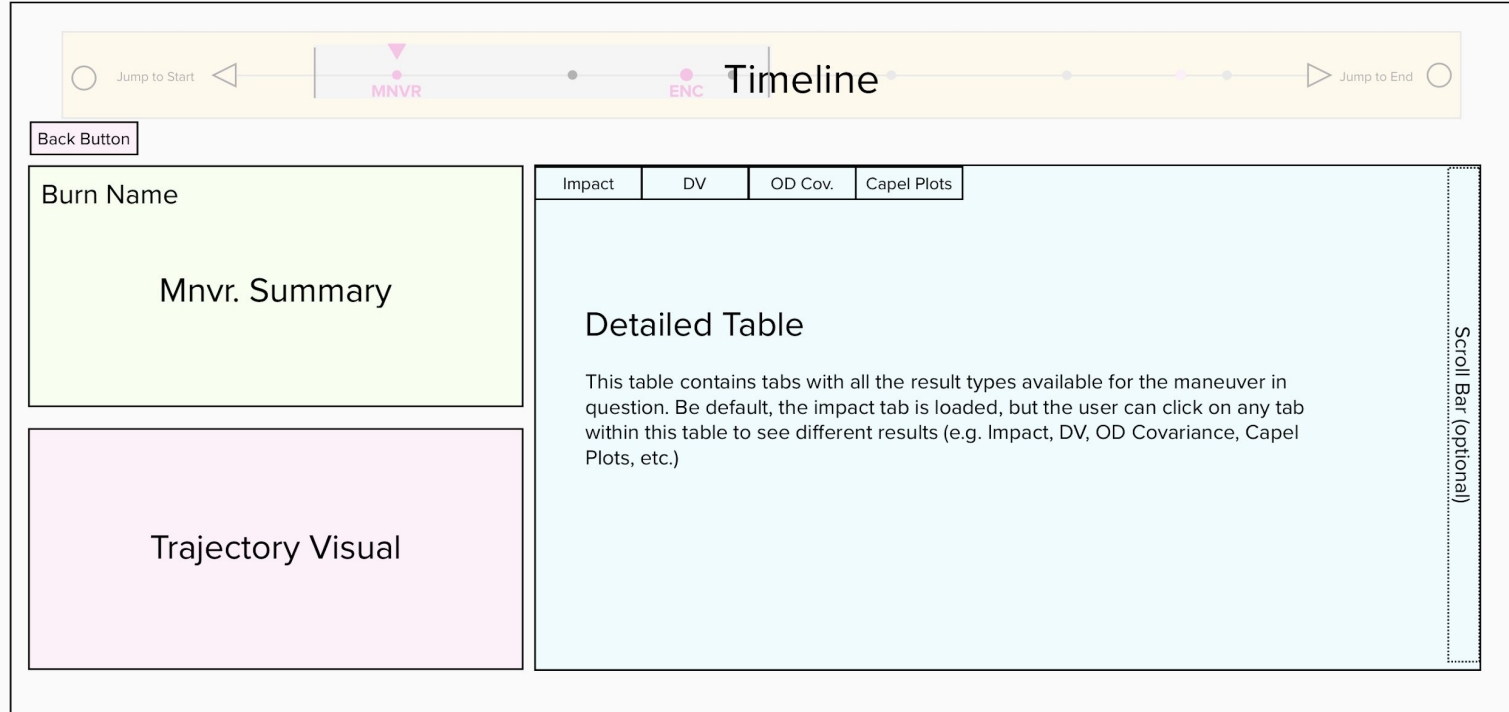
The Timeline navigation bar is at the top of all screen with the maneuver and encounters.

It contains a user controlled shaded region that controls what maneuvers are presented in the Overview screen in mode blocks.

The Bar Charts show how maneuvers perform with respect to one another, and can be toggled by a % with respect to the deterministic basis or an absolute option.

The Trajectory visual highlights the portion specified in the Timeline start and stop interval.

Porter Organization : Detailed Mode



The Mnvr. Summary contains the high level information from the Overview screen mode.

Besides the DV and Impact stats, what kind of summary data would you like to see here?