Porter

The Maneuver Visualization Tool

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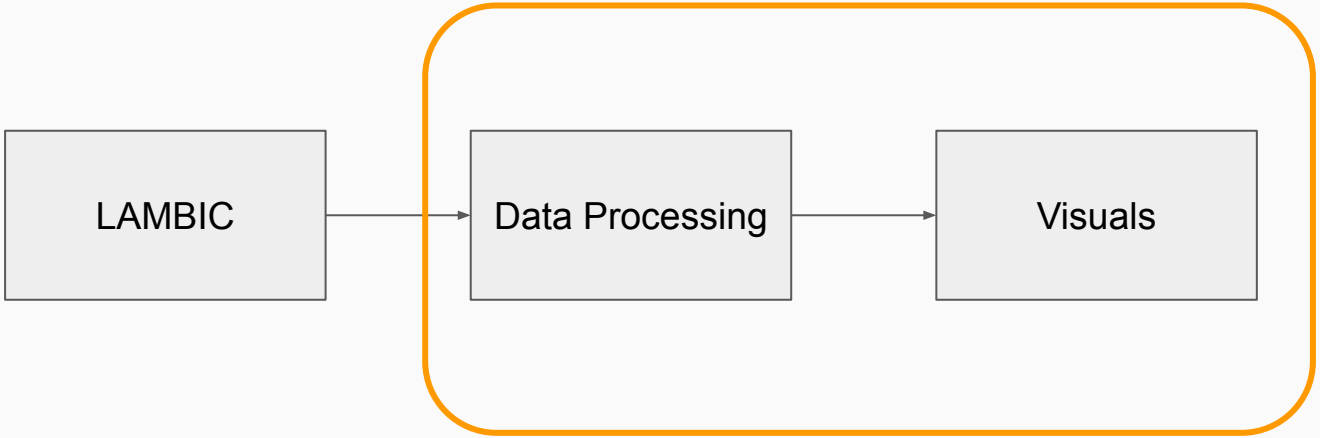
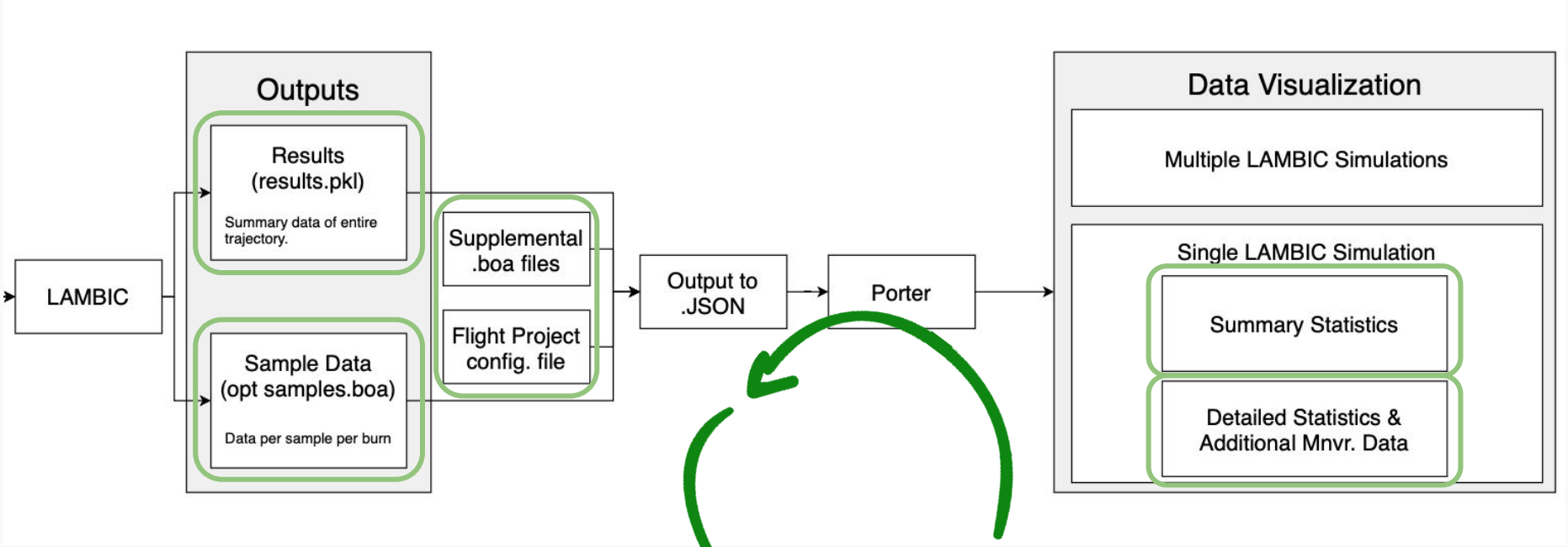
How can we support maneuver designers to more conveniently and effectively work with MONTE LAMBIC output data?


LAMBIC
Data Processing
Visuals

Previous Project Focus



Current Project Focus

Create an intuitive and all-inclusive way to access:

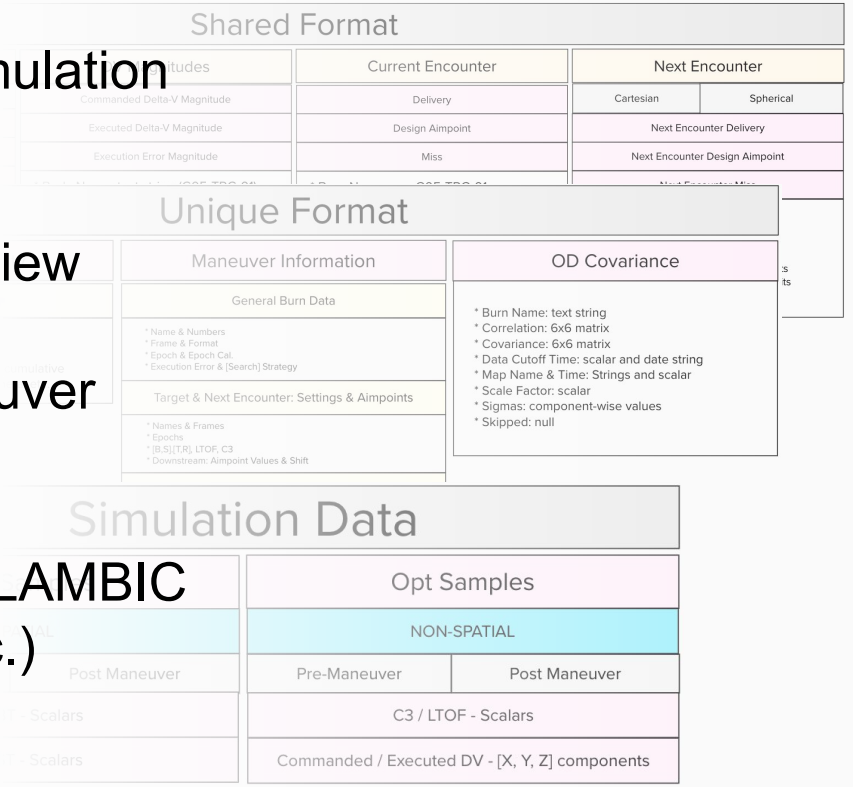
LAMBIC Summary Statistics Data

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

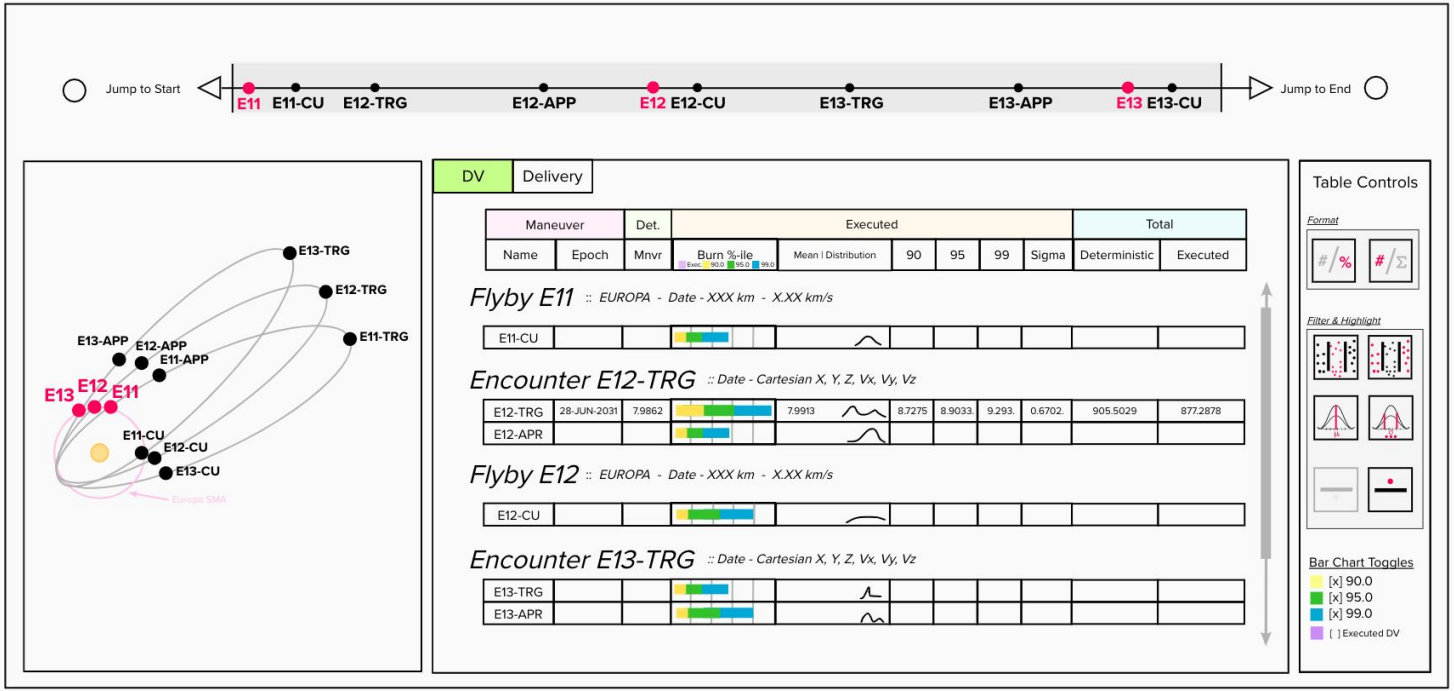
Event (Currently B-Plane Encounters for EC data):
> Name
> Flyby Altitude
> Vinfinity
> Impact Probability %
> Ellipse Properties

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

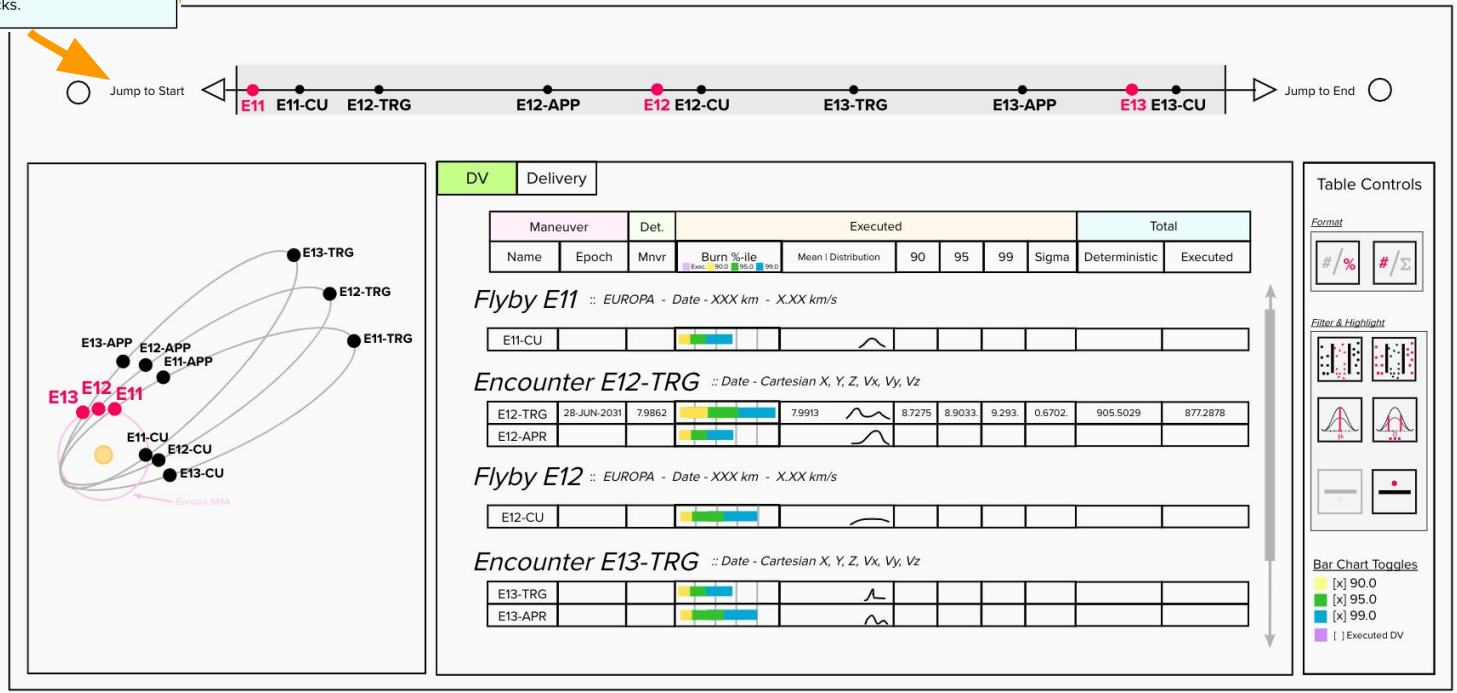


Porter Organization: Overview Mode Example

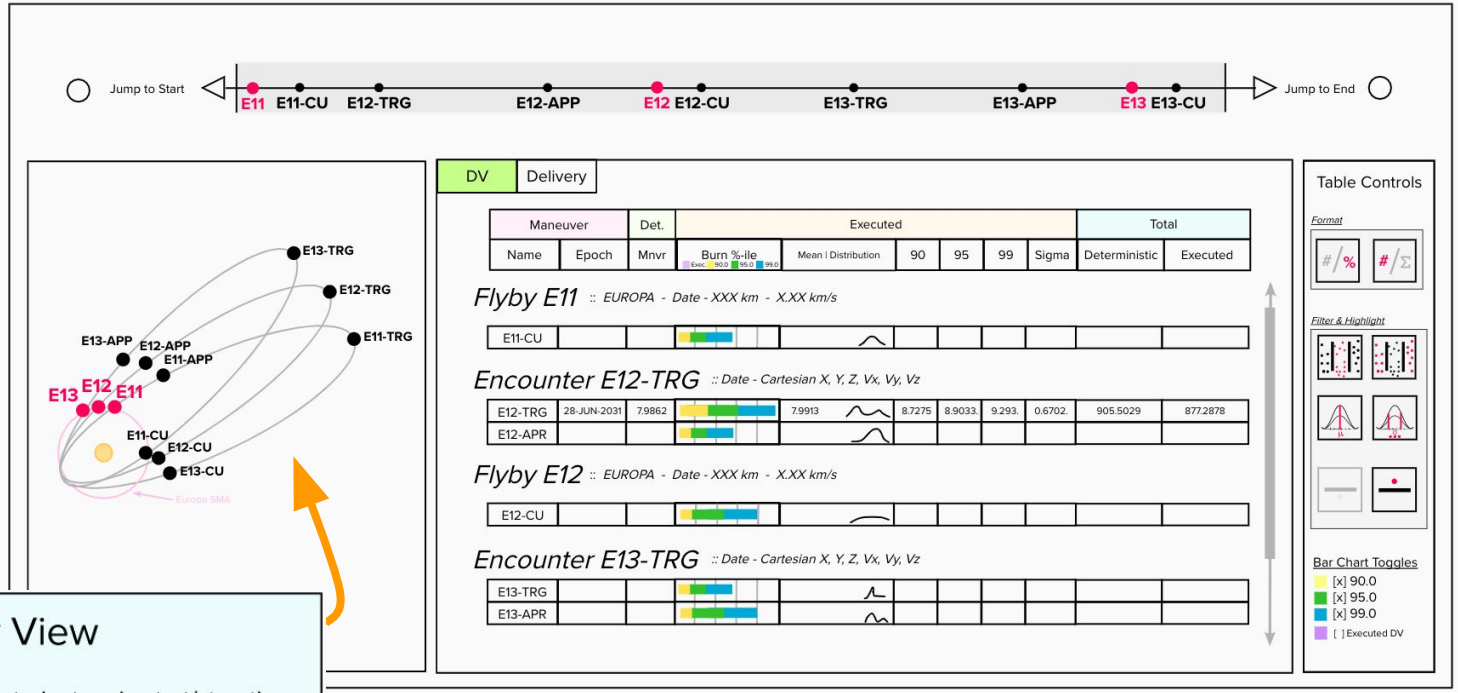
Timeline

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.



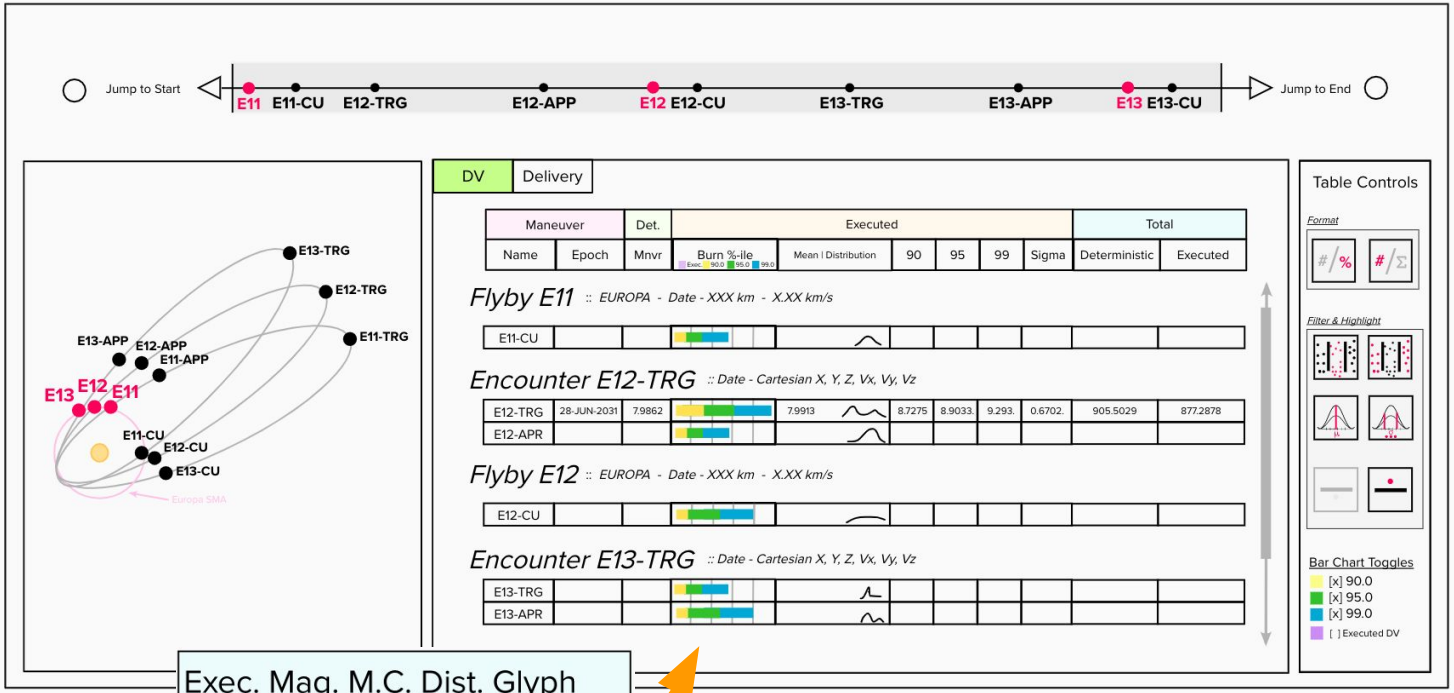
Porter Organization: Overview Mode Example



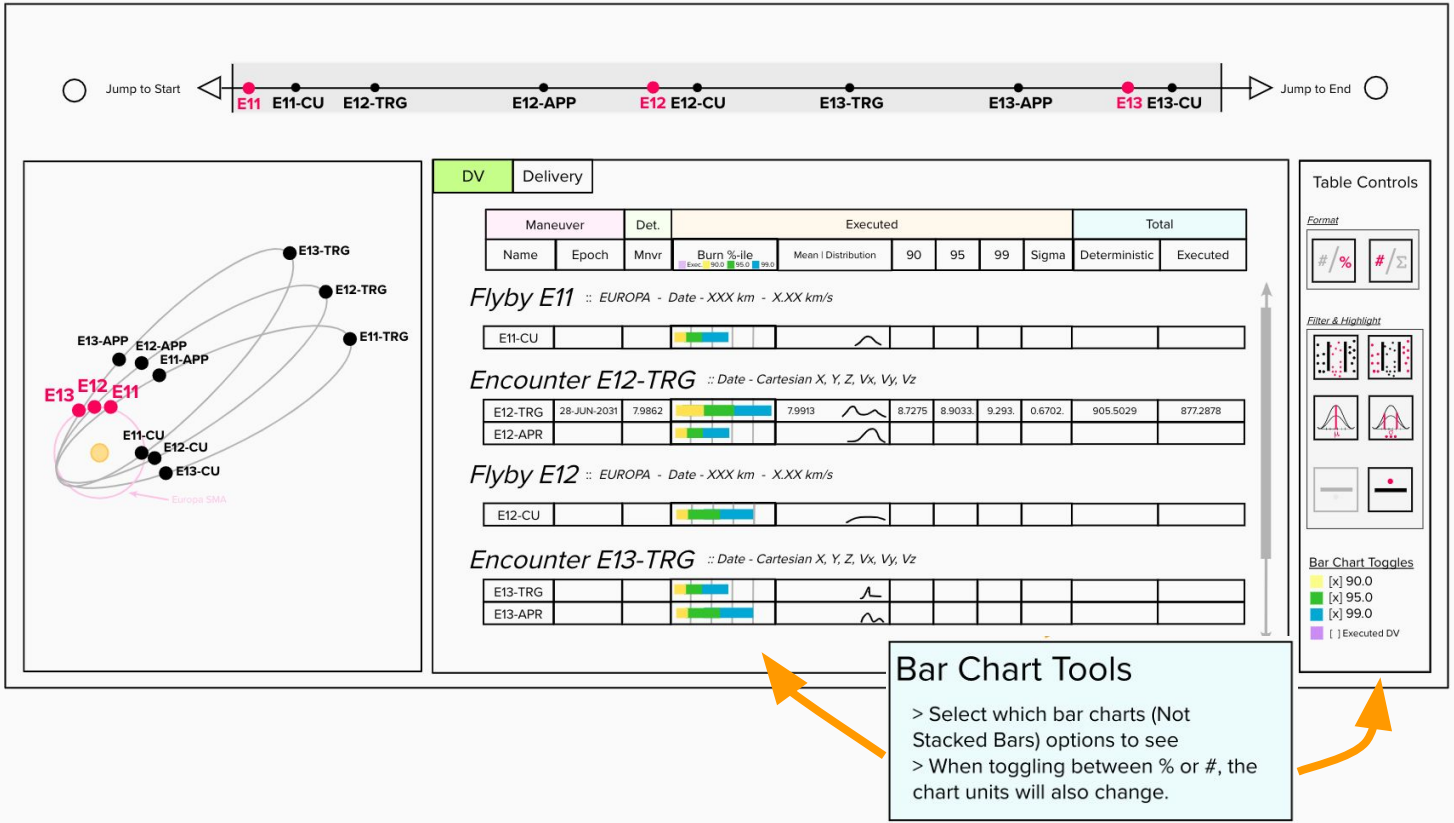
Trajectory View

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

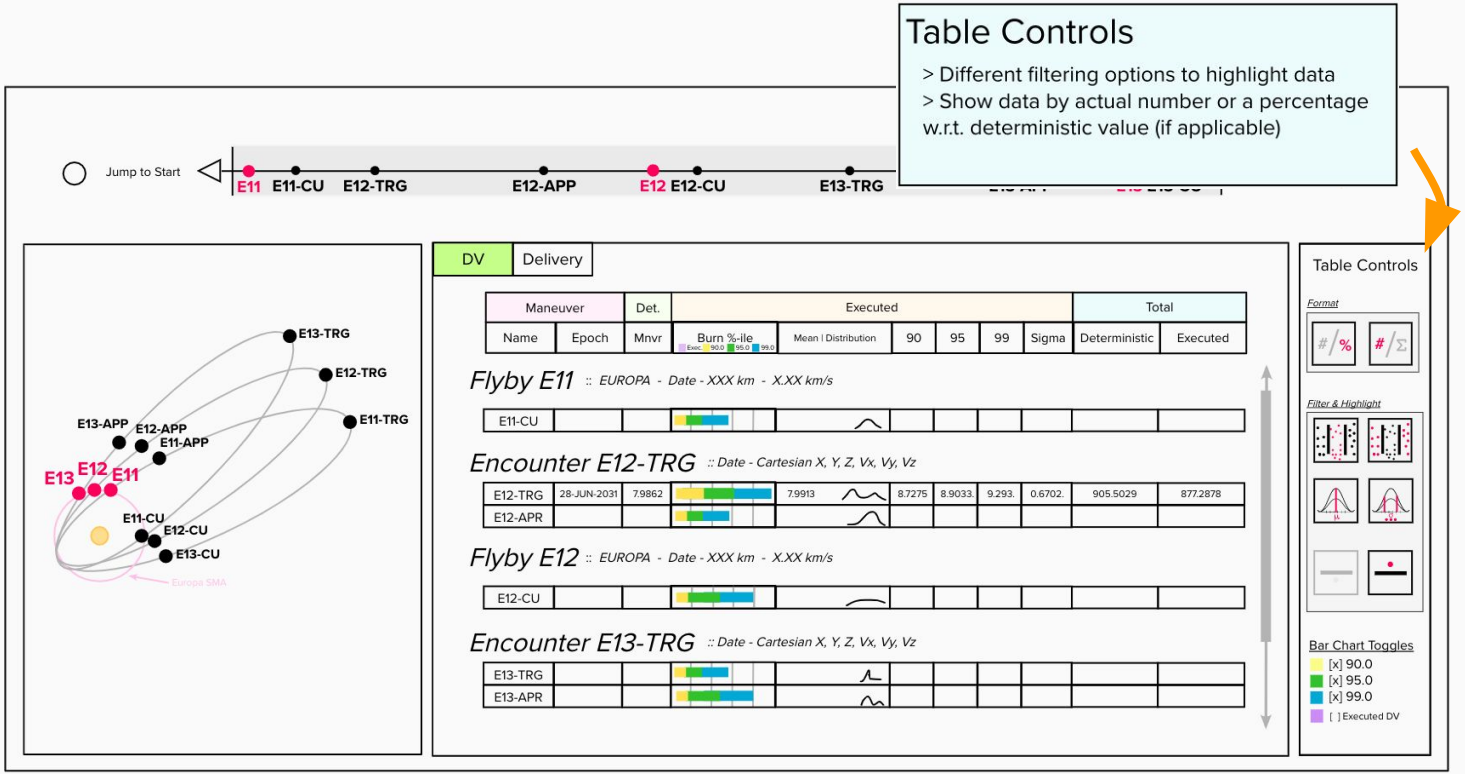
Porter Organization: Overview Mode Example



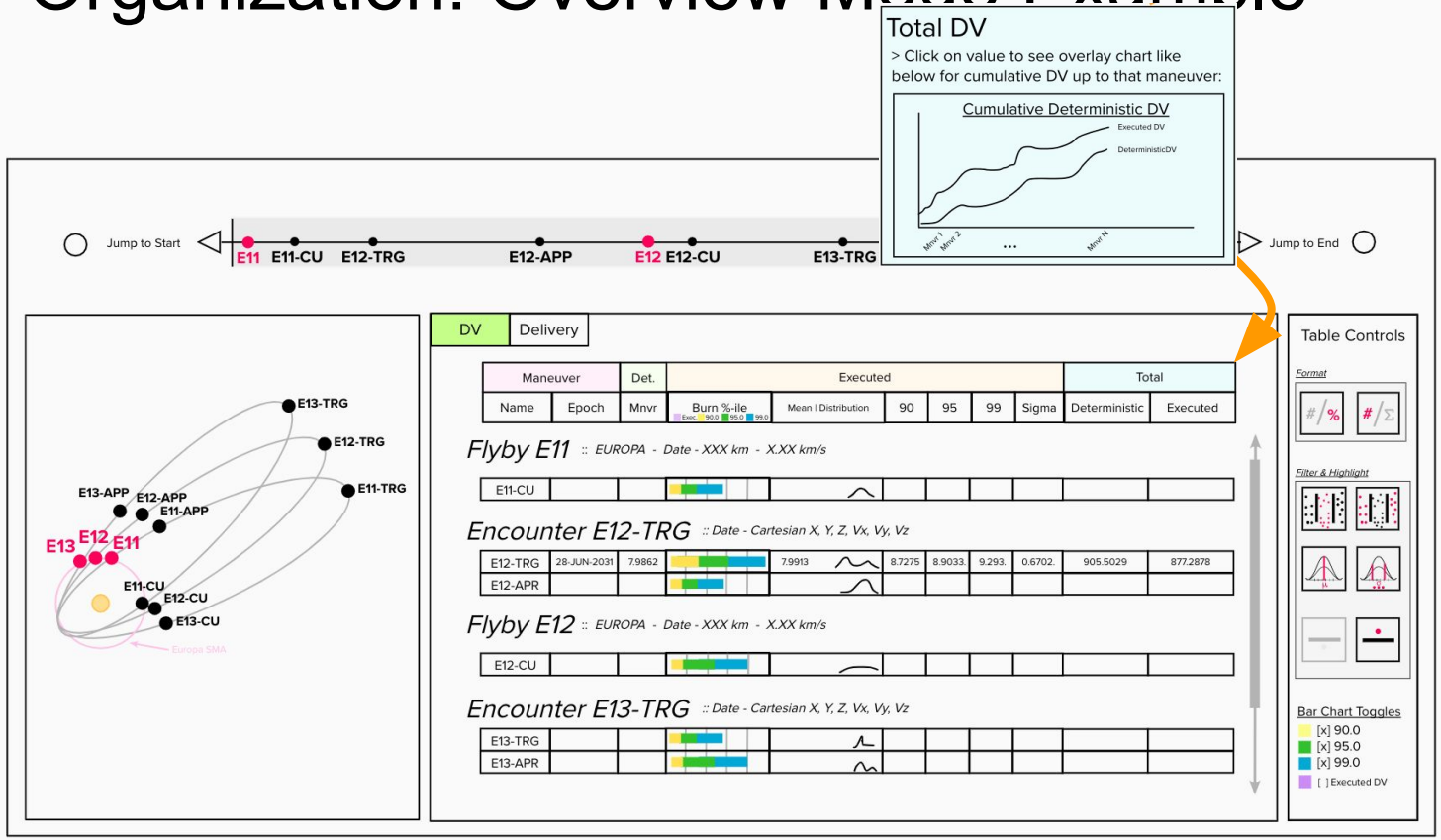
Porter Organization: Overview Mode Example



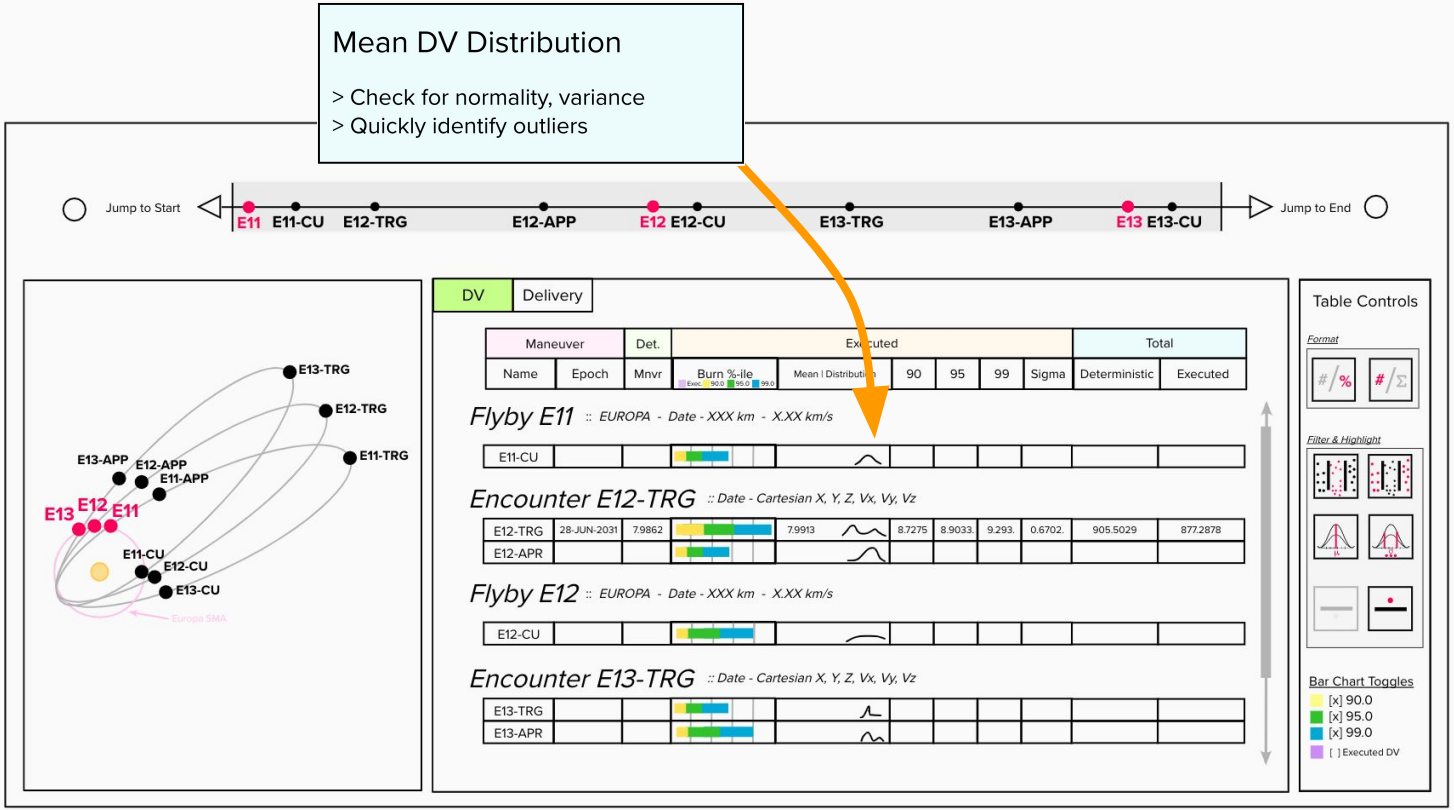
Porter Organization: Overview Mode Example



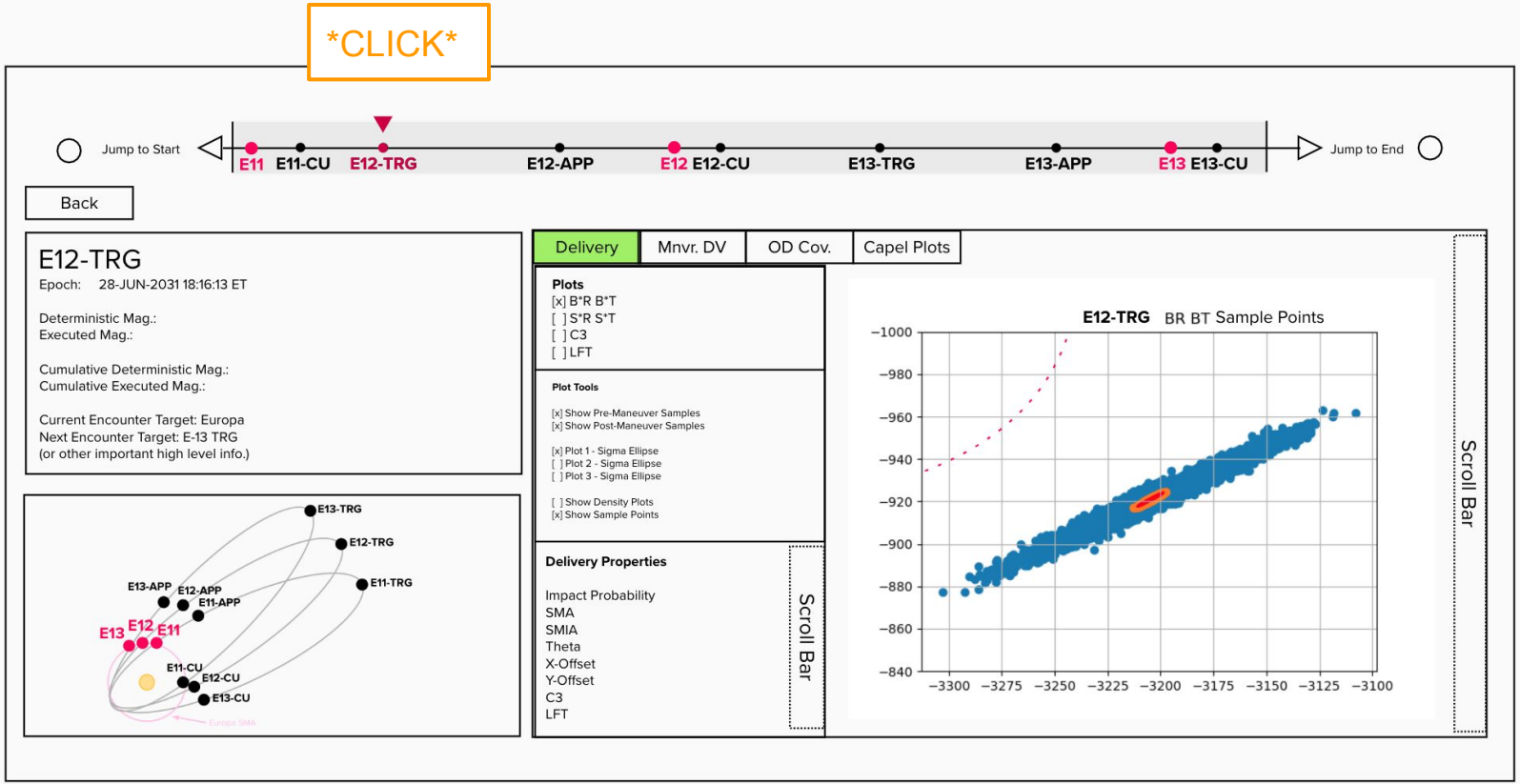
Porter Organization: Overview Mode Example



Porter Organization: Overview Mode Example



Porter Organization: Detailed Mode Example

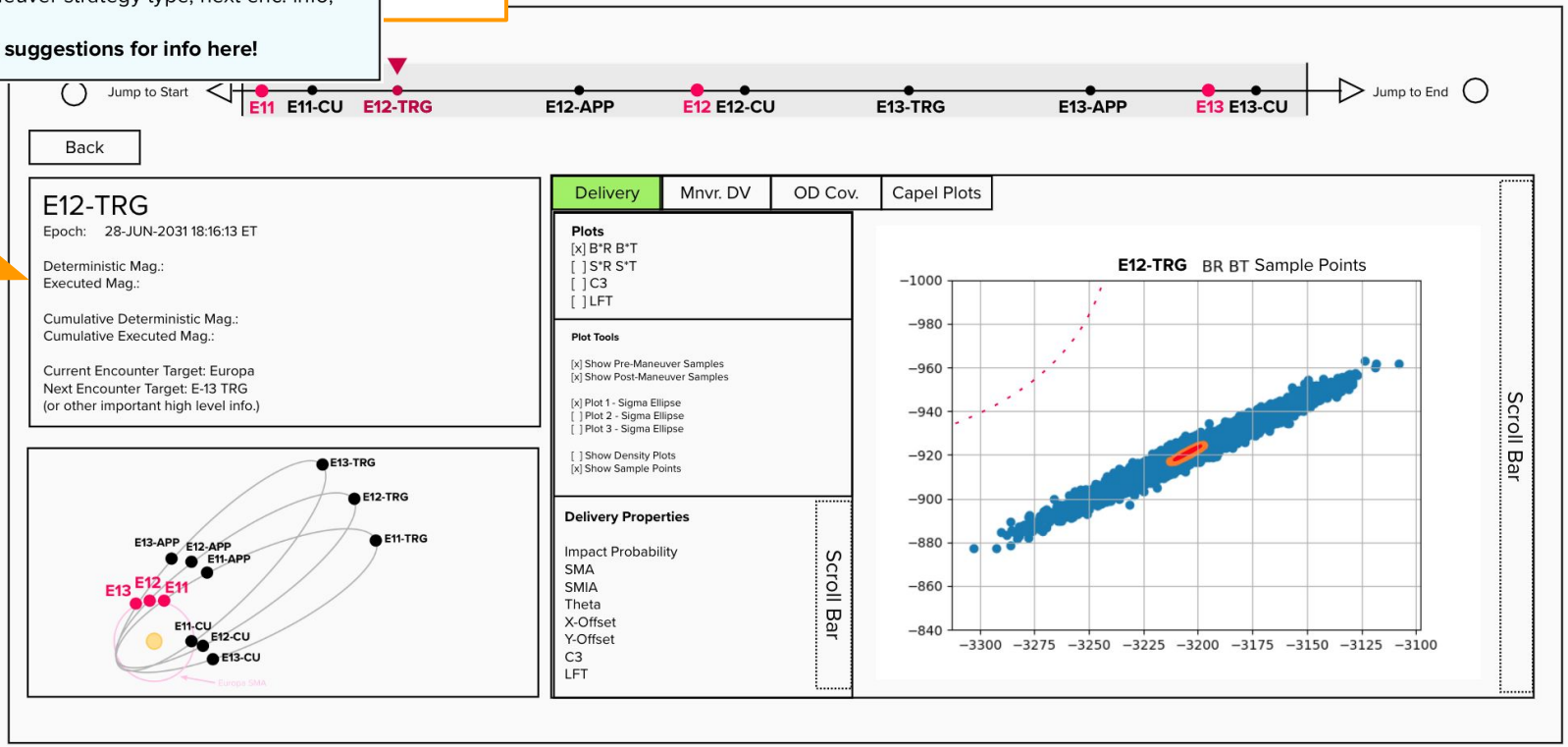


Porter Organization: Detailed Mode Example

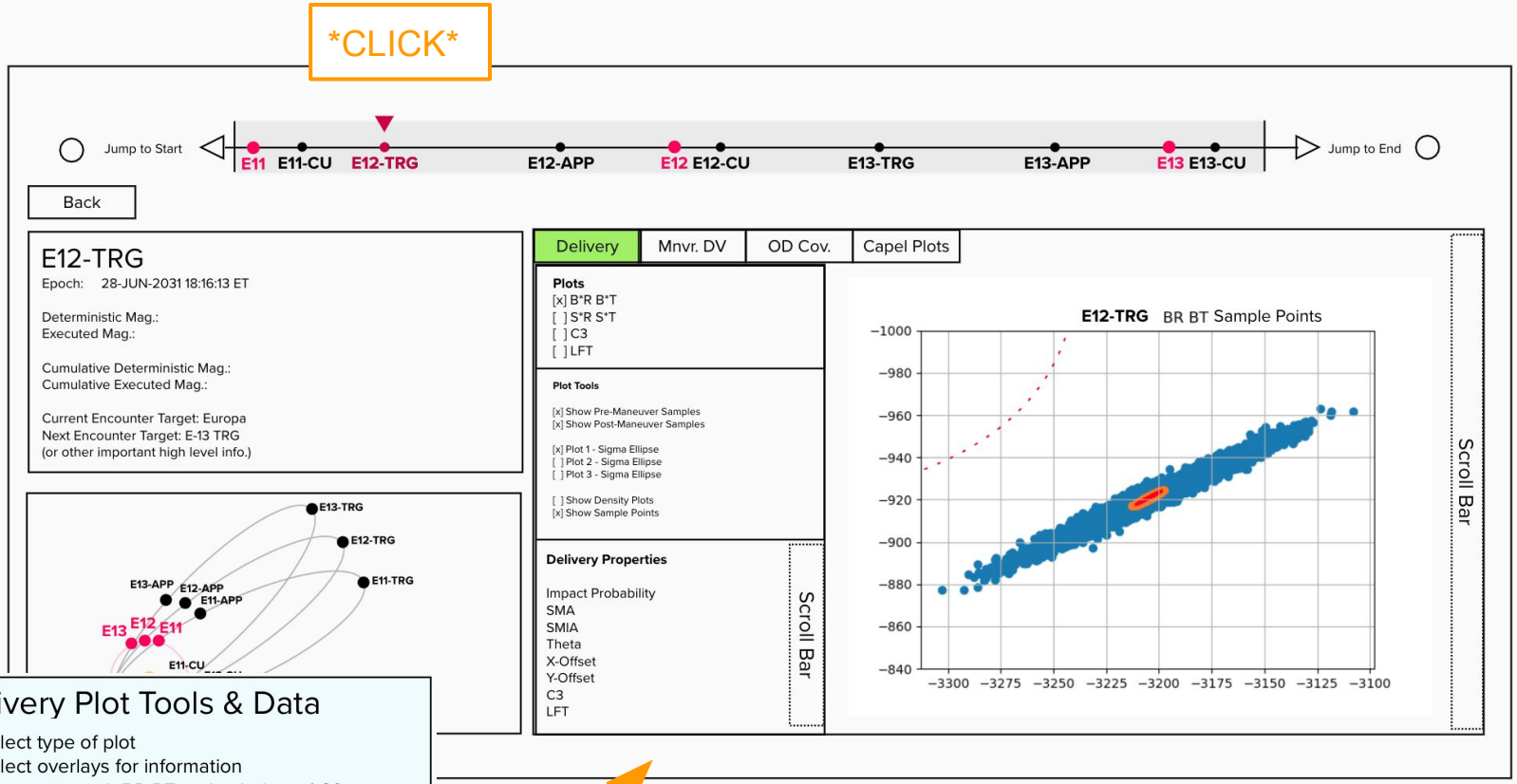
Summary Section

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

LICK



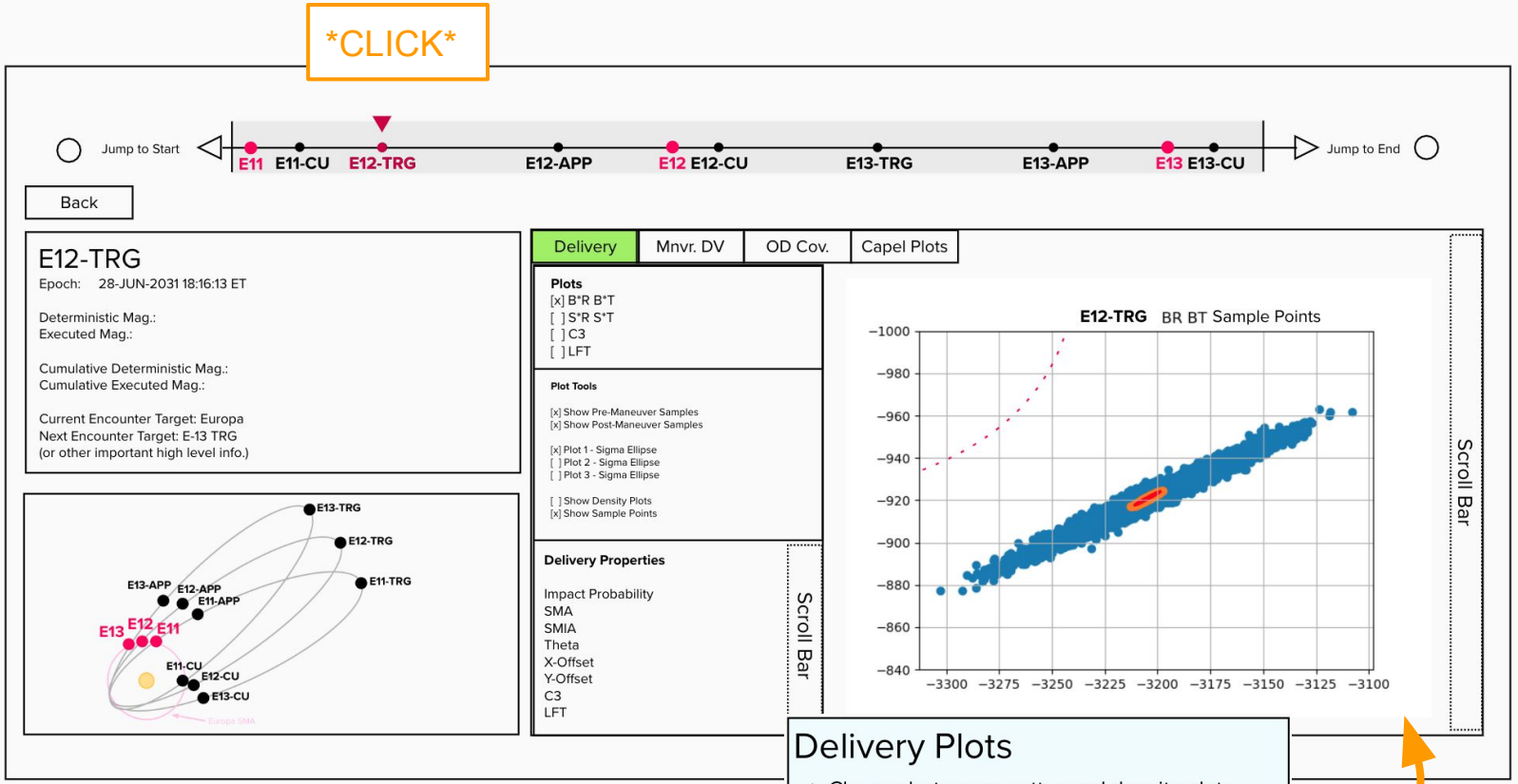
Porter Organization: Detailed Mode Example



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?

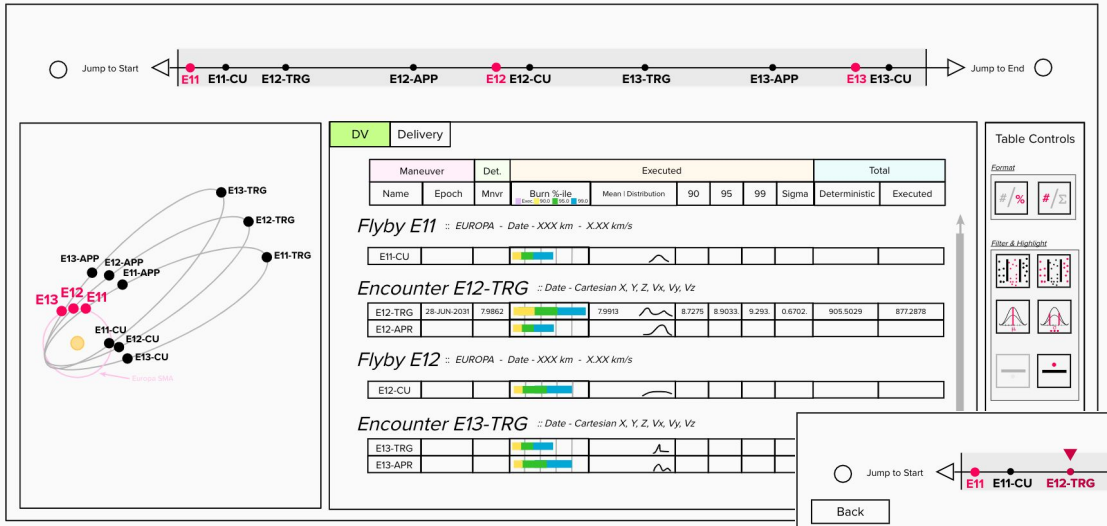
Porter Organization: Detailed Mode Example

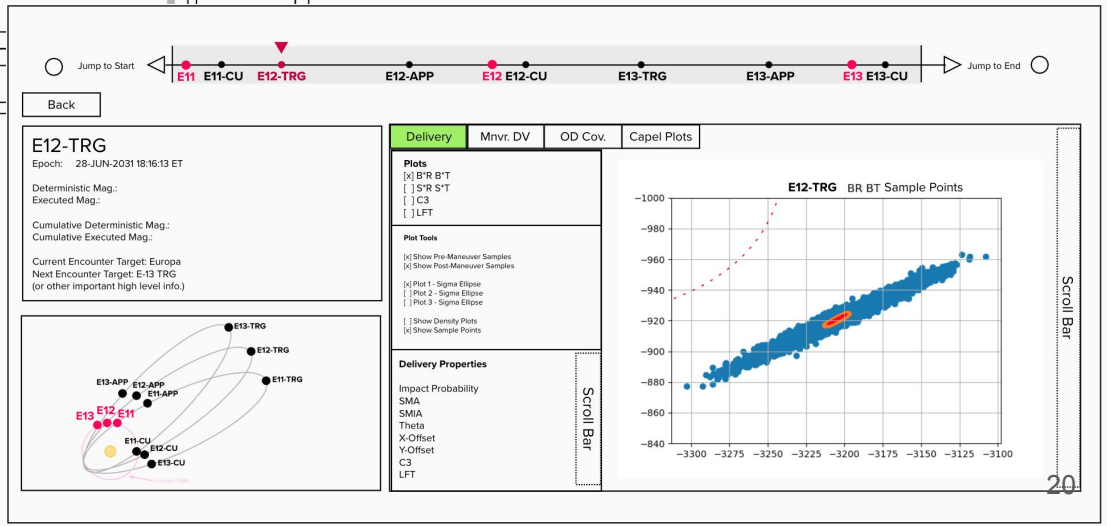


Delivery Plots

> 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





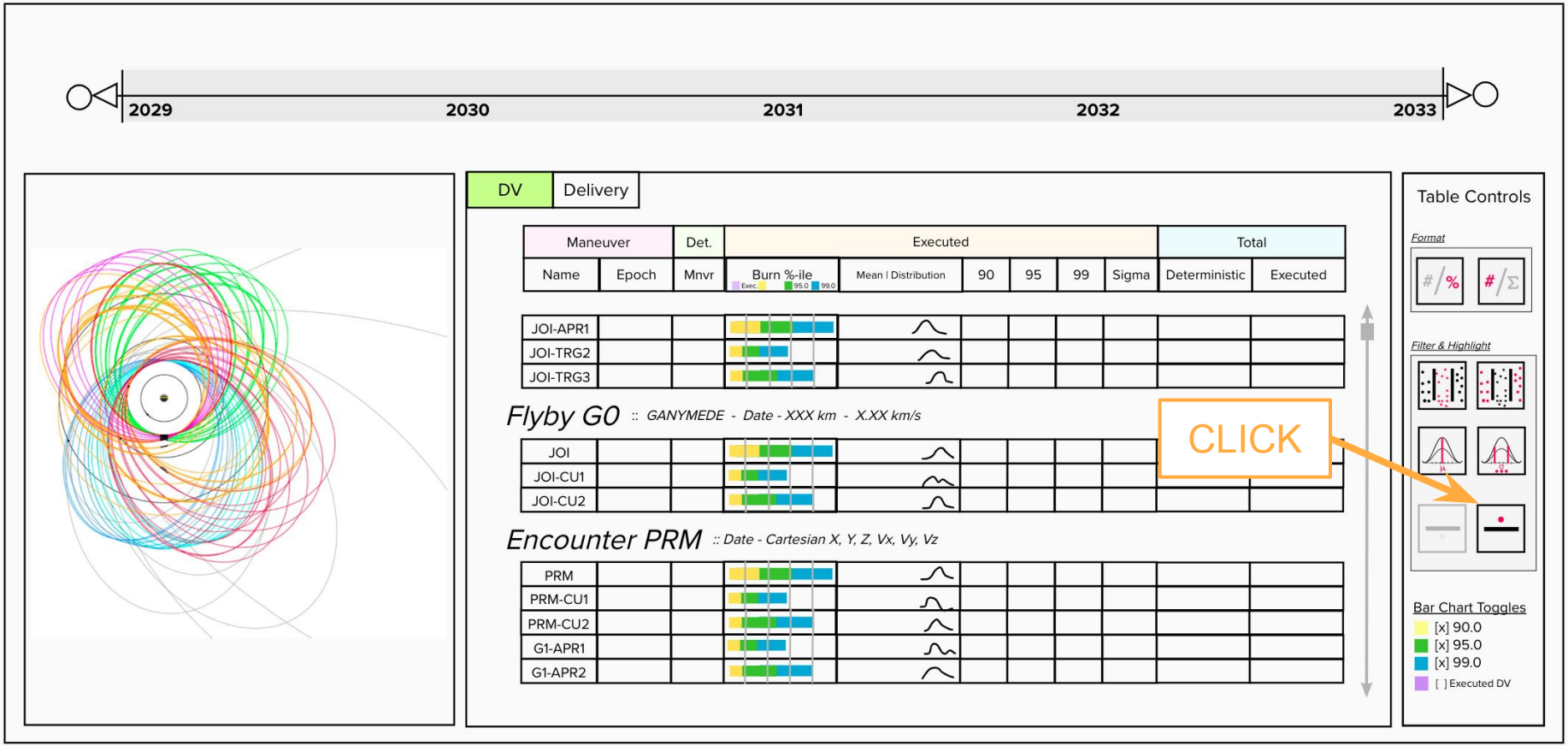
Switch between multi-maneuver and single maneuver analysis.

Example Use Case

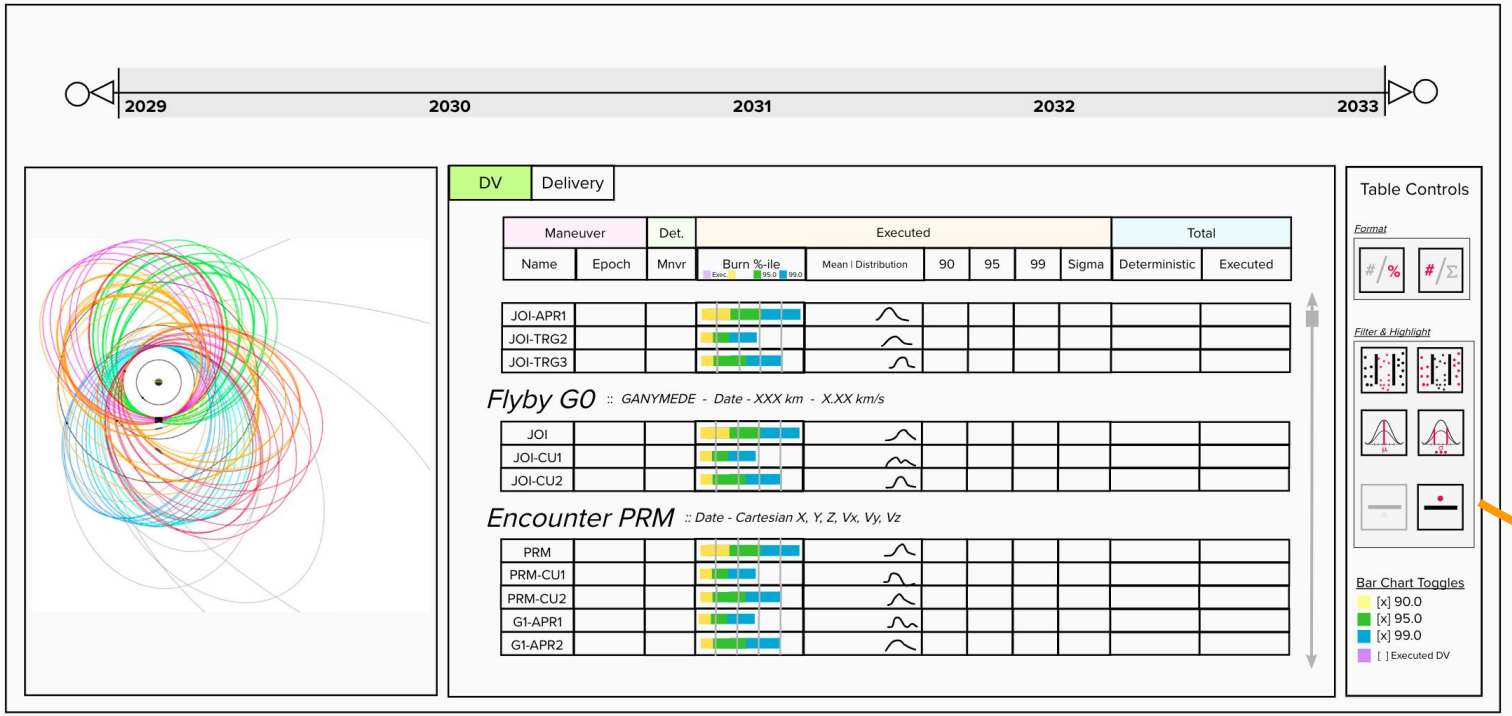
> Review Europa Clipper tour LAMBIC file to find maneuvers with outstanding DVs

> Exploring detailed maneuver-specific result components

Step 1: Review EC Data



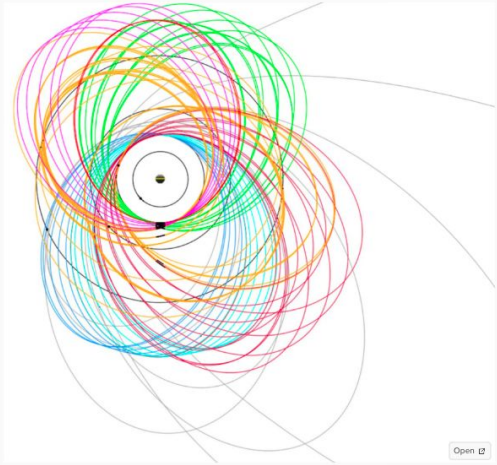
Step 2: Find a Maneuver of Interest



Step 2: Find a Maneuver of Interest

Change Start/Stop Period

2029 2030 2031 2032 2033



DV | Delivery

Maneuver		Det.	Executed						Total	
Name	Epoch	Mnvr	Burn %-ile (Exec. 90.0 95.0 99.0)	Mean | Distribution	90	95	99	Sigma	Deterministic	Executed
Flyby E11 :: *EUROPA - Date - XXX km - X.XX km/s*										
E11-CU										
Encounter E12-TRG :: *Date - Cartesian X, Y, Z, Vx, Vy, Vz*										
E12-TRG	28-JUN-2031	7.9862		7.9913	8.7275	8.9033	9.293	0.6702	905.5029	877.2878
E12-APR										
Flyby E12 :: *EUROPA - Date - XXX km - X.XX km/s*										
E12-CU										
Encounter E13-TRG :: *Date - Cartesian X, Y, Z, Vx, Vy, Vz*										
E13-TRG										
E13-APR										

Table Controls

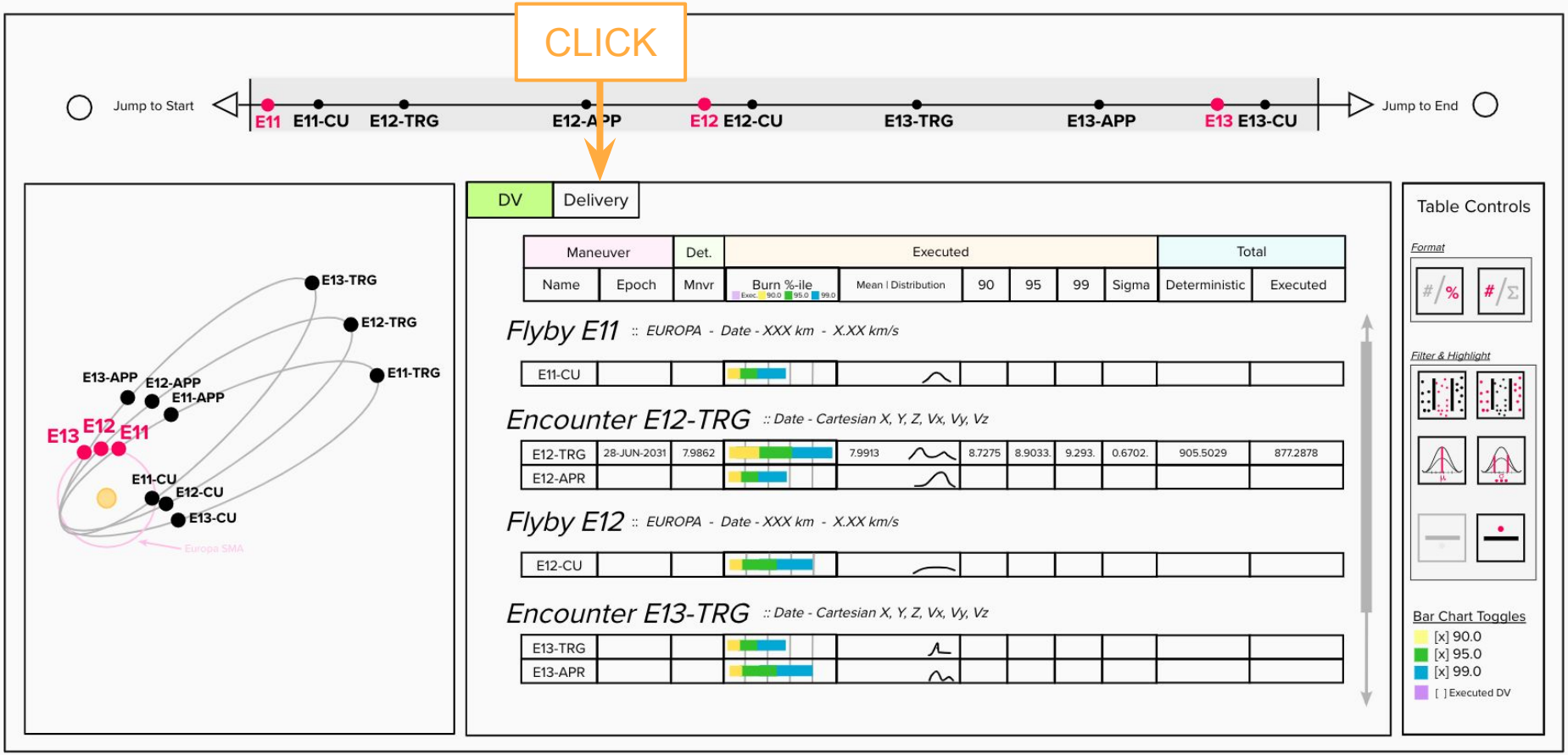
Format

Filter & Highlight

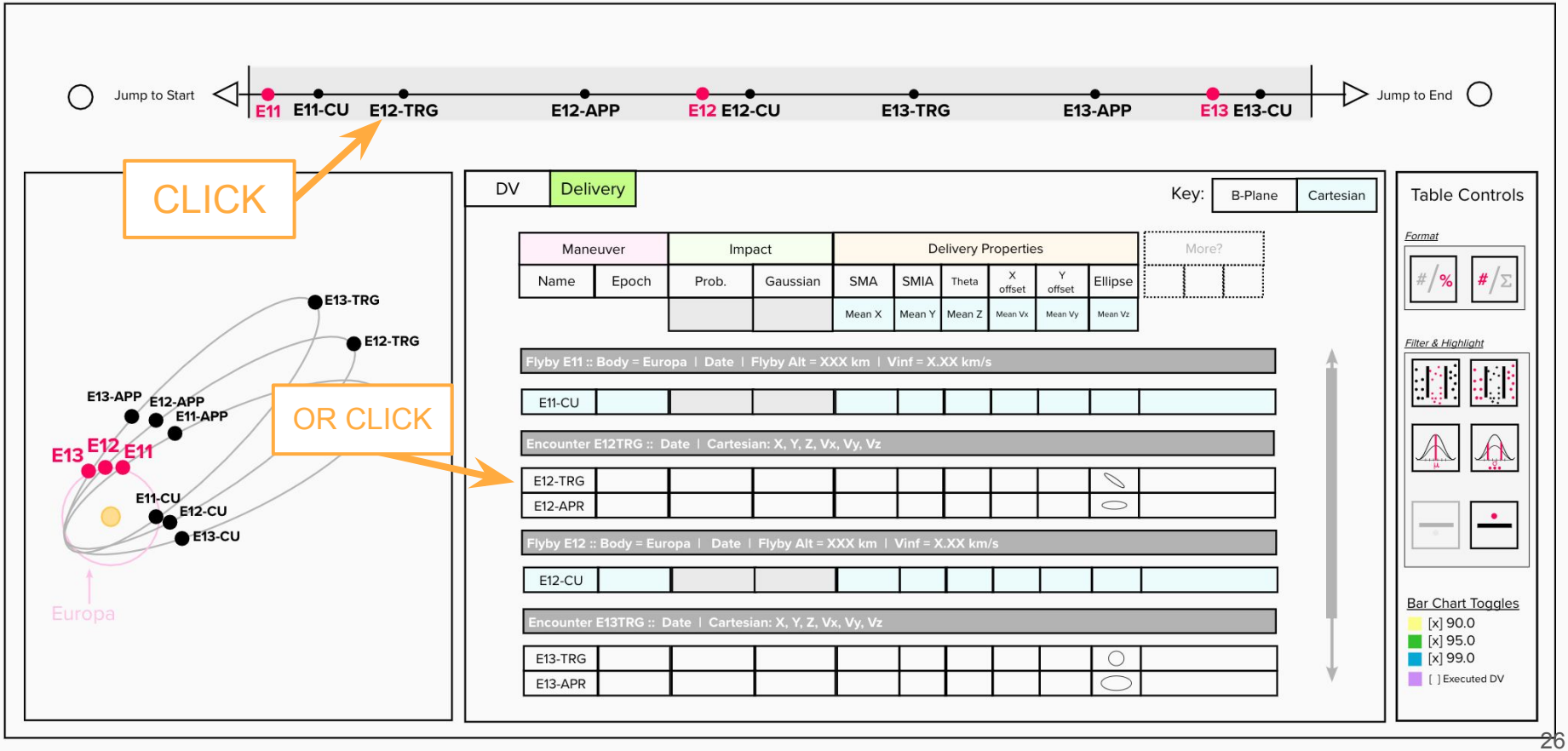
Bar Chart Toggles

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

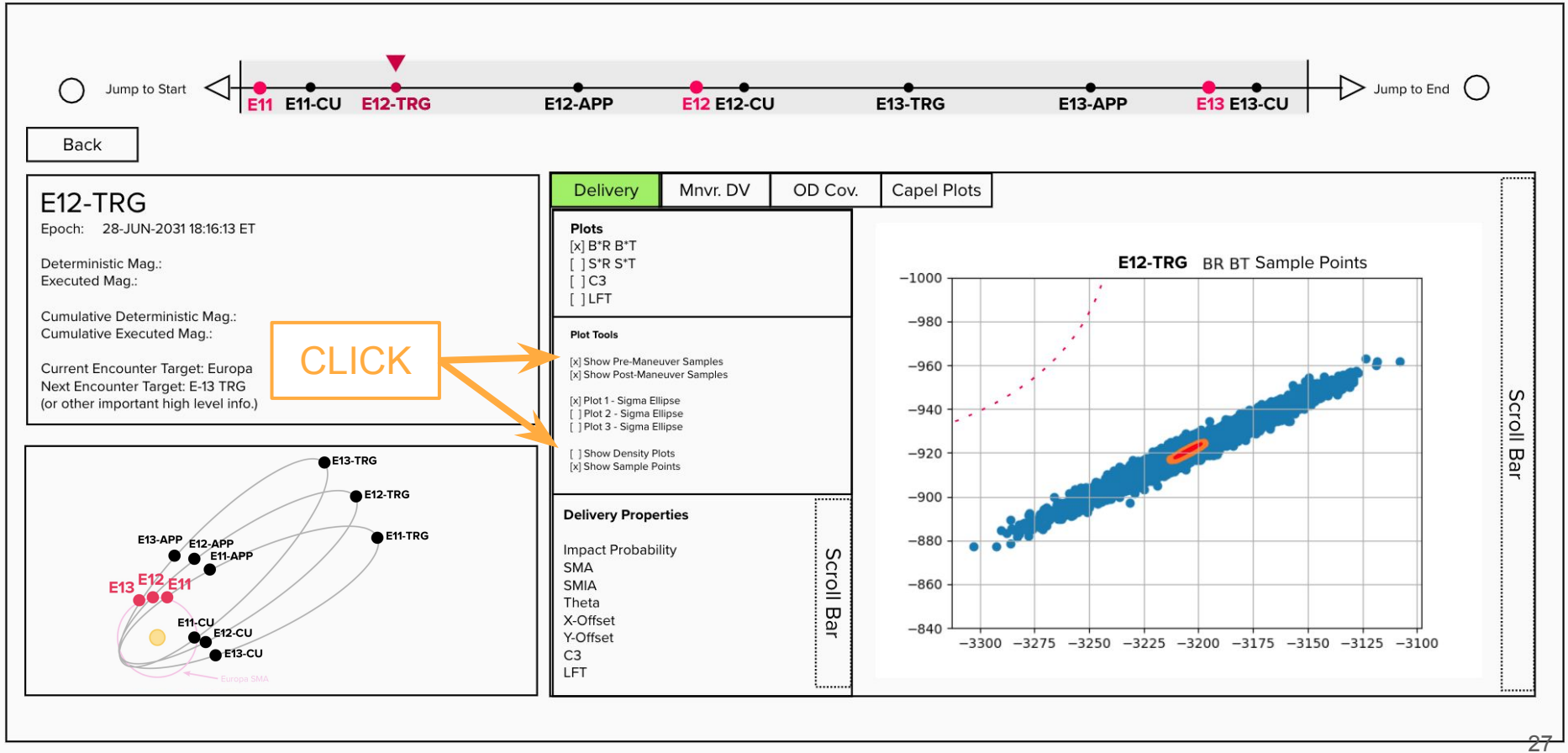
Step 3: Assess DV Stats.



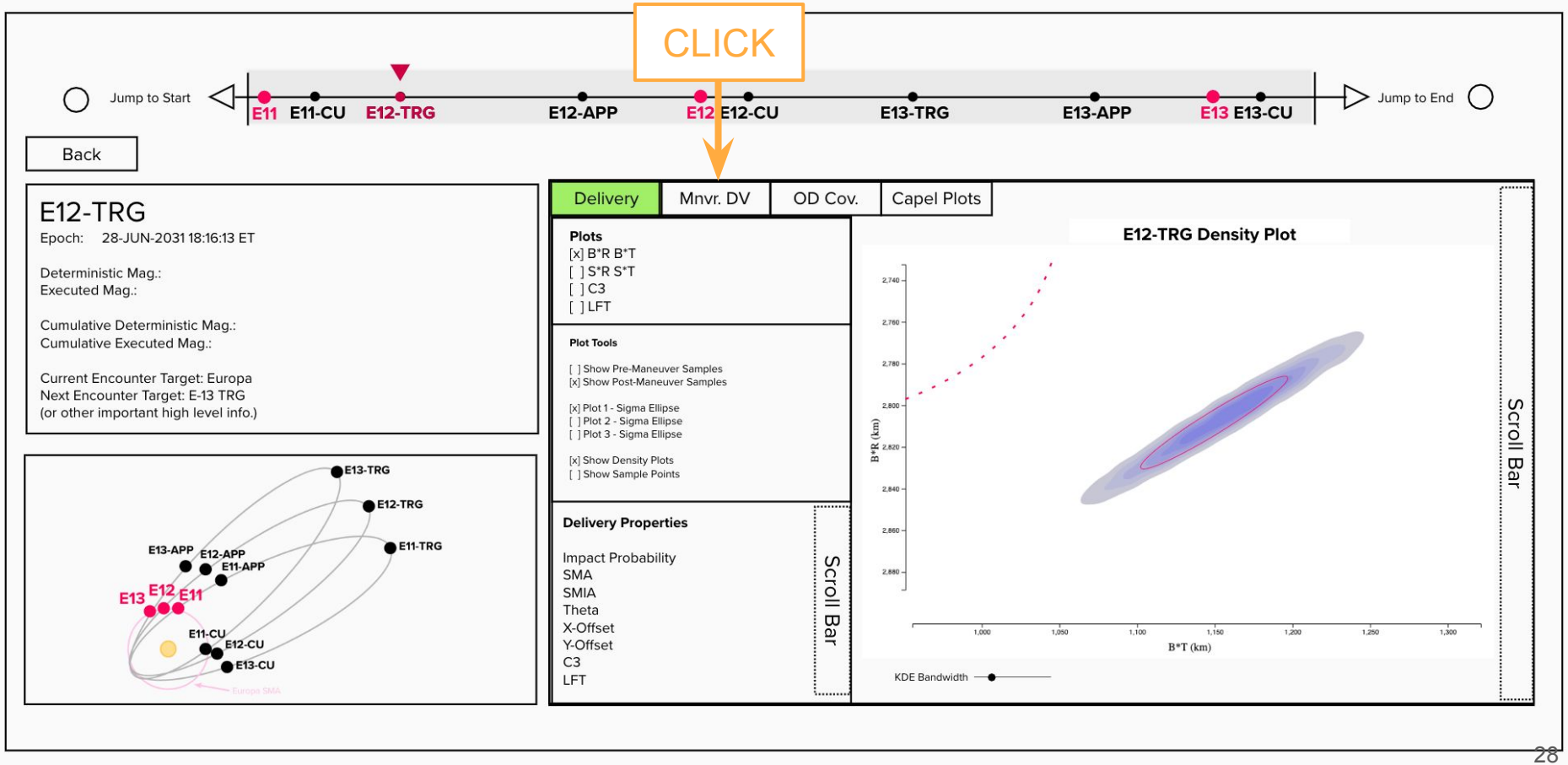
Step 4: Assess Delivery Stats.



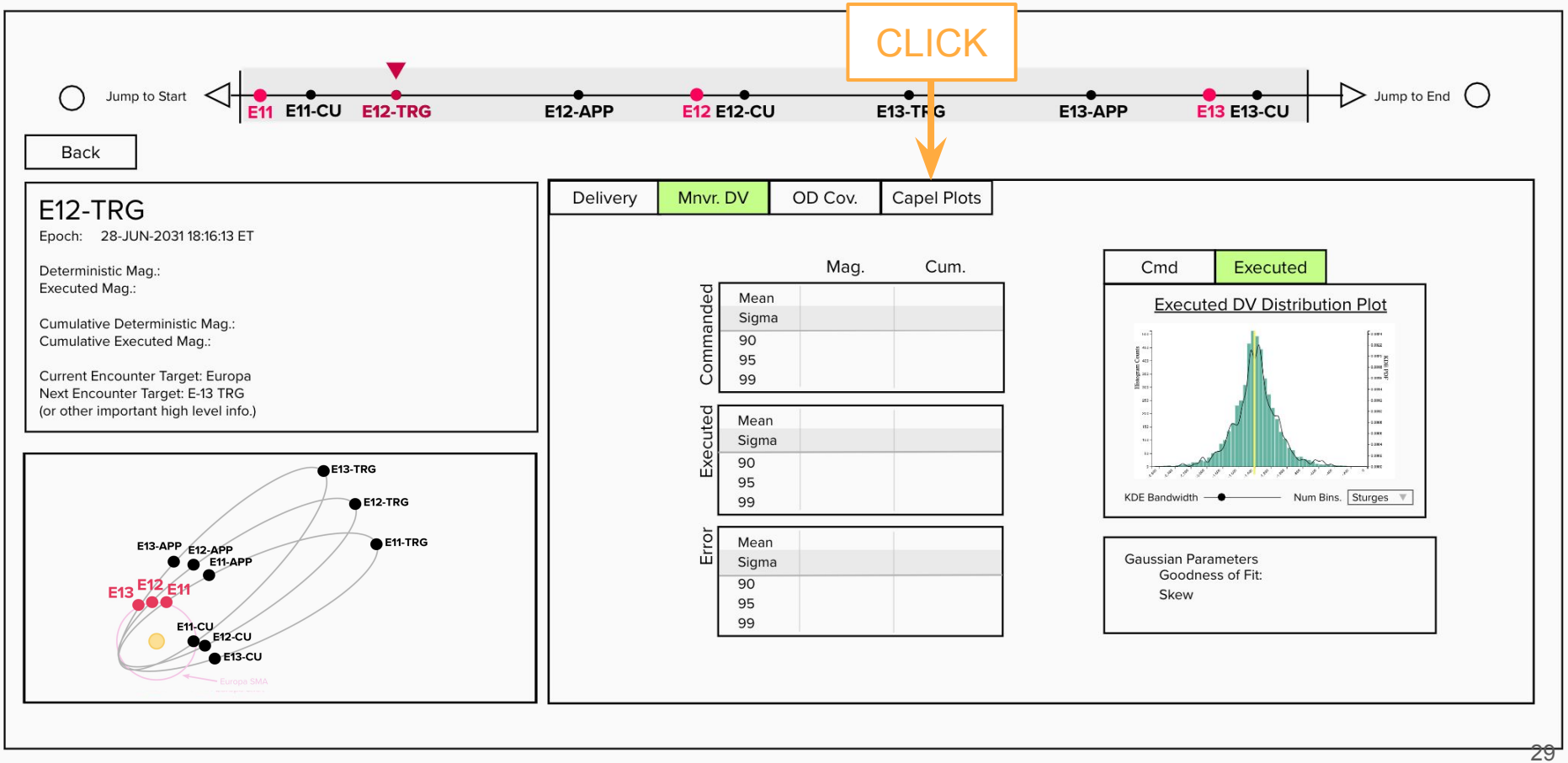
Step 5: See Delivery Details



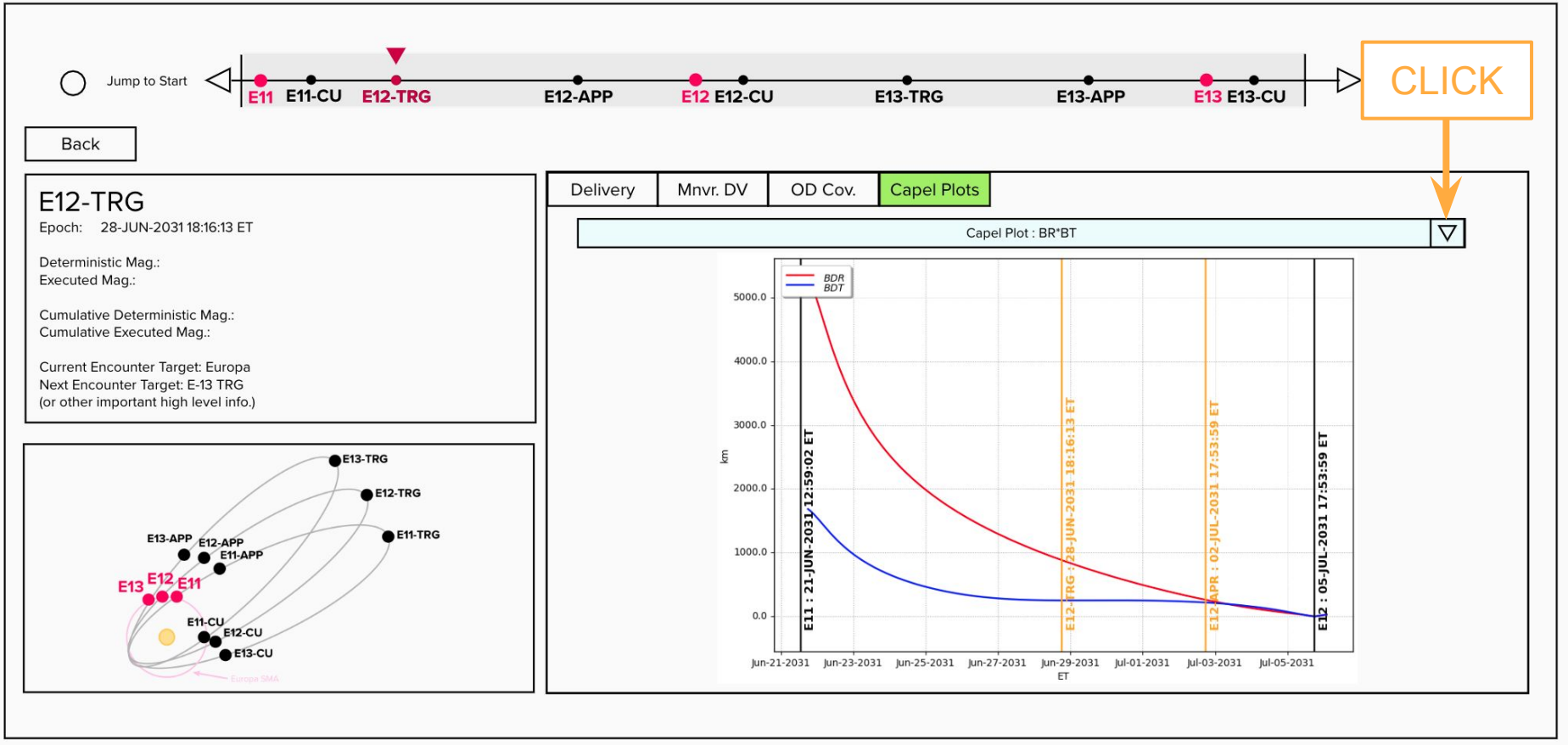
Step 5: See Delivery Details



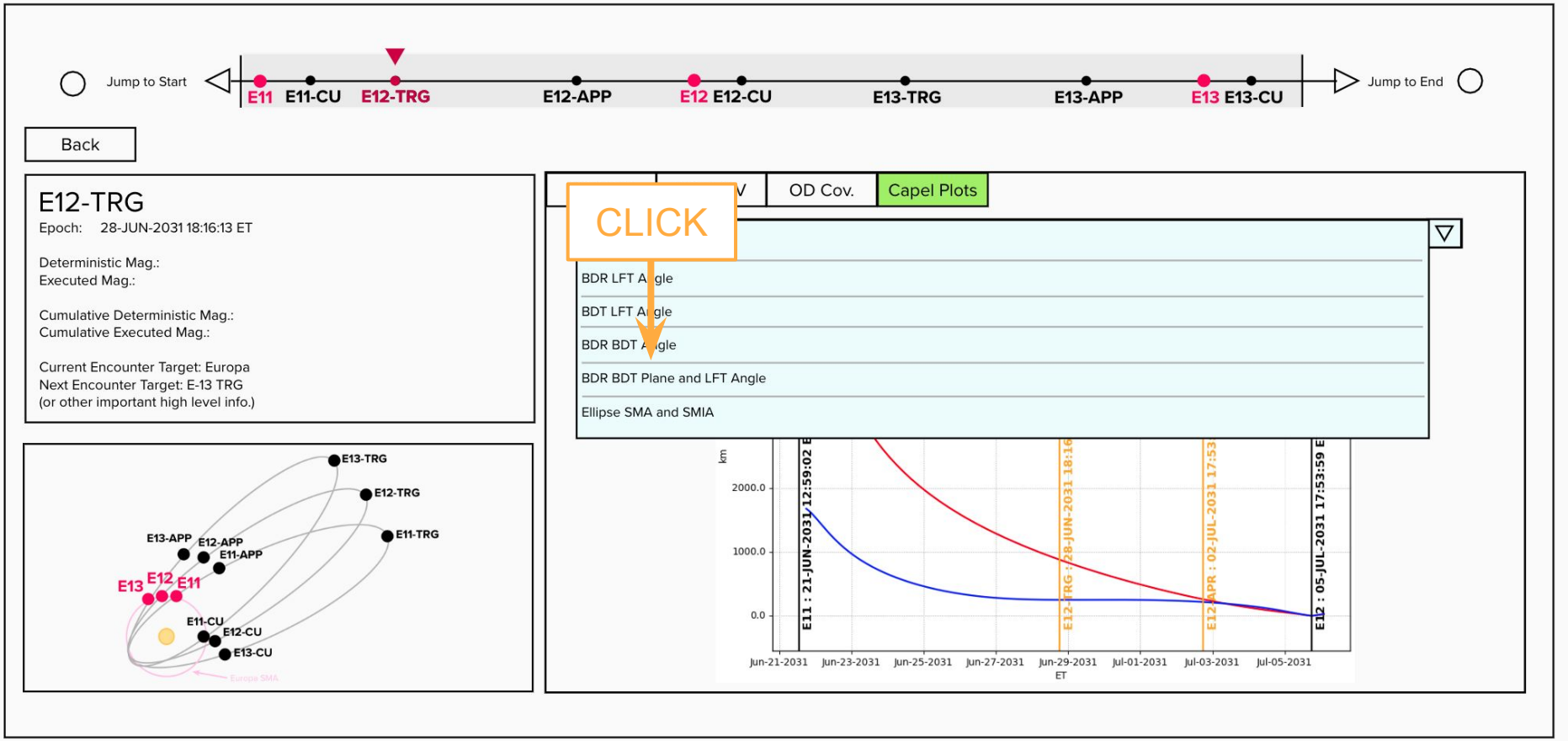
Step 5: See DV Detailed Data



Step 6: See Capel Plots



Step 6: See Capel Plots



Step 6: See Capel Plots

Jump to Start

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

Jump to End

Back

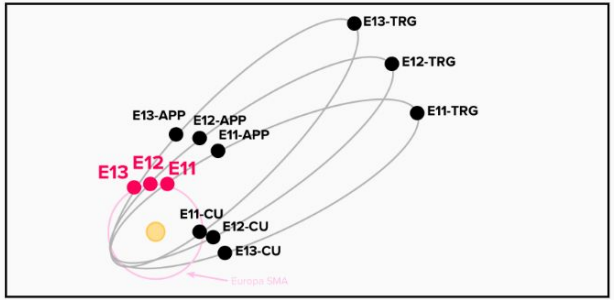
E12-TRG

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

Deterministic Mag.:
Executed Mag.:

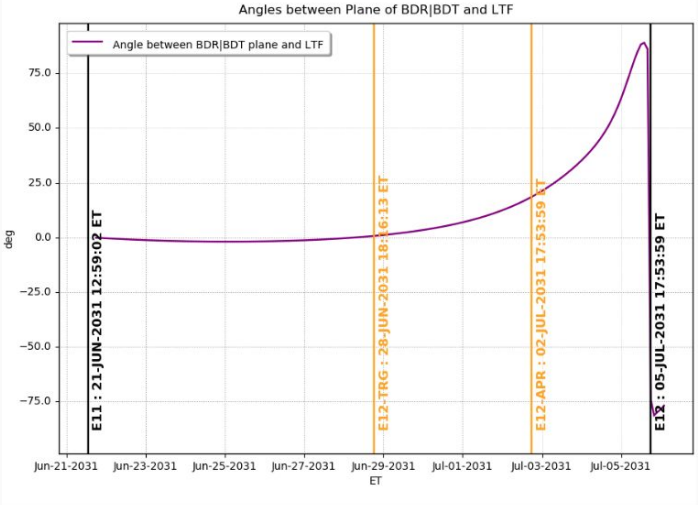
Cumulative Deterministic Mag.:
Cumulative Executed Mag.:

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



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

Capel Plot : BDR BDT Plane and LFT Angle

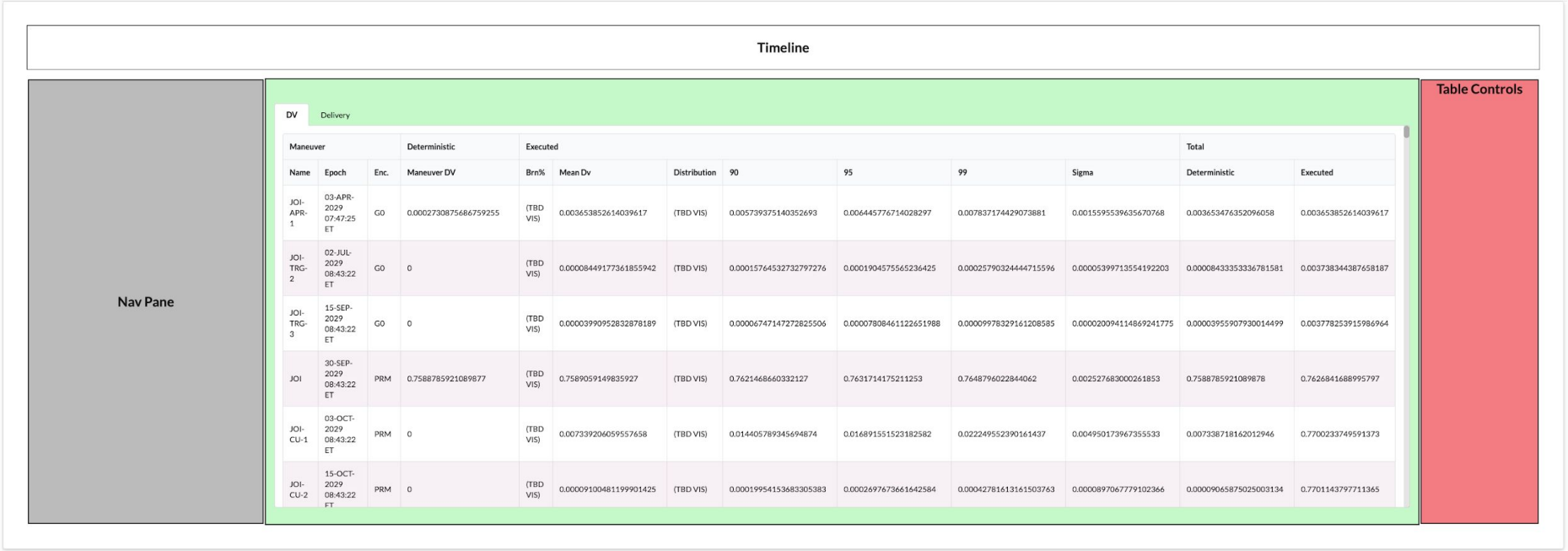


Preliminary Feedback

- 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

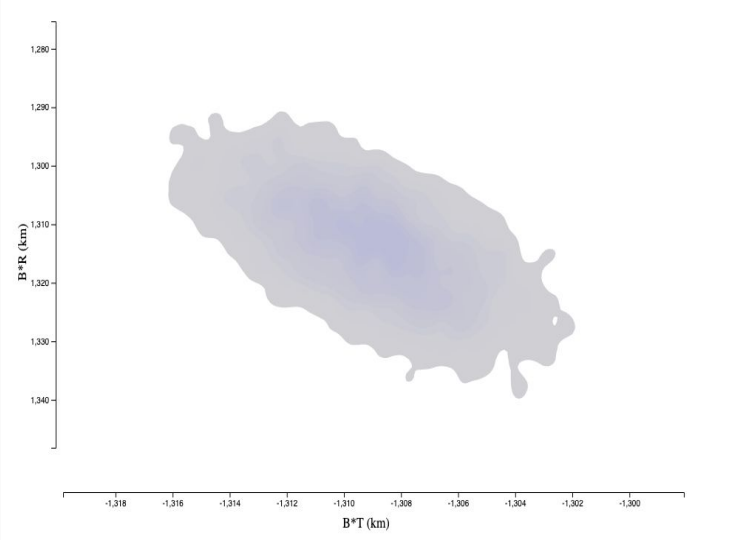


Maneuver			Deterministic	Executed							Total	
Name	Epoch	Enc.	Maneuver DV	Brn%	Mean Dv	Distribution	90	95	99	Sigma	Deterministic	Executed
JOI-APR-1	03-APR-2029 07:47:25 ET	GO	0.0002730875686759255	(TBD VIS)	0.003653852614039617	(TBD VIS)	0.0057393751403526 93	0.006445776714028297	0.007837174429073881	0.0015595539635670768	0.003653476352096058	0.003653852614039617
JOI-TRG-2	02-JUL-2029 08:43:22 ET	GO	0	(TBD VIS)	0.00008449177361855942	(TBD VIS)	0.0001576453273279 7276	0.0001904575565236425	0.0002579032444471 5596	0.0000539971355419 2203	0.0000843335333678 1581	0.003738344387658187
JOI-TRG-3	15-SEP-2029 08:43:22 ET	GO	0	(TBD VIS)	0.00003990952832878189	(TBD VIS)	0.0000674714727282 5506	0.0000780846112265 1988	0.0000997832916120 8585	0.0000200941146924 1775	0.000039559079300144 99	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)	0.0144057893456948 74	0.0168915515231825 82	0.0222495523901614 37	0.004950173967355533	0.007338718162012946	0.7700233749591373
JOI-CU-2	15-OCT-2029 08:43:22 ET	PRM	0	(TBD VIS)	0.00009100481199901425	(TBD VIS)	0.0001995415368330 5383	0.0002697673661642584	0.0004278161316150 3763	0.0000897067779102366	0.000090658750250031 34	0.7701143797711365

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

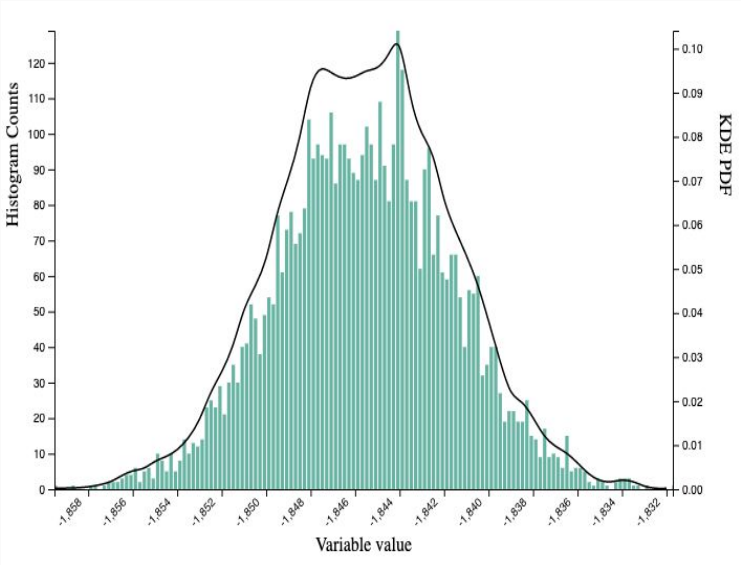
Feedback On Specific Features and Views

Delivery Contour Plots



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

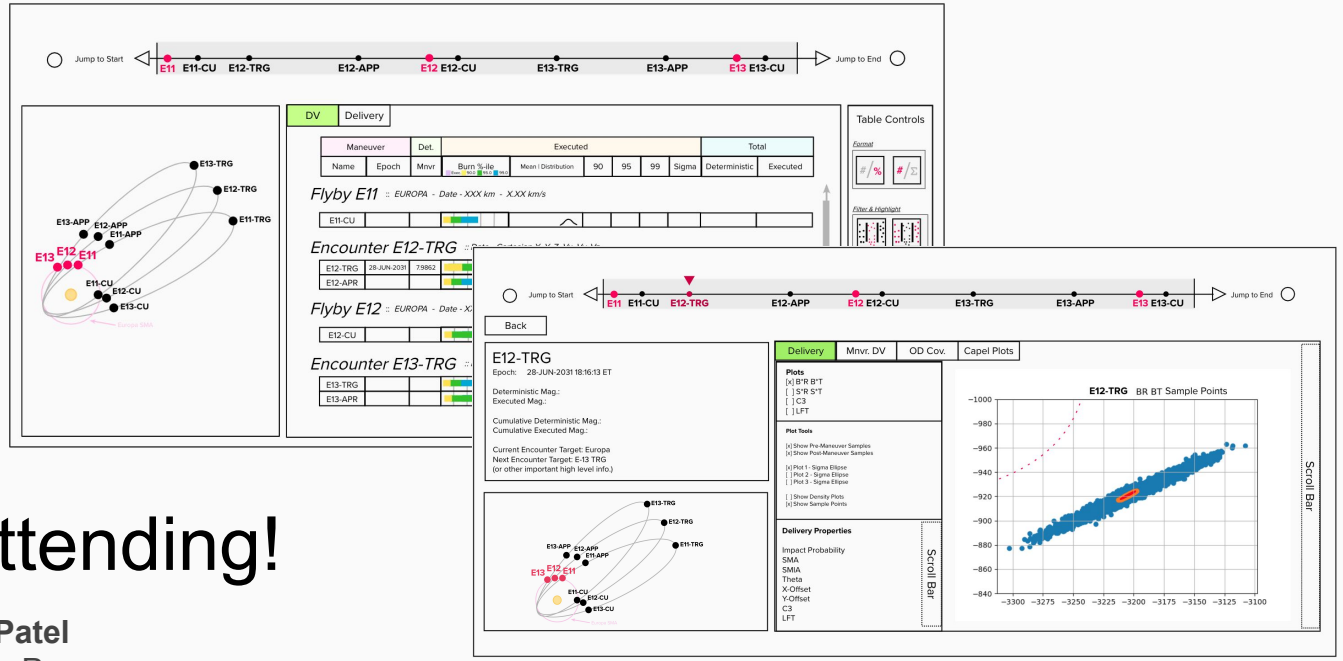
Scalar MC Distributions



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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Mentors

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Section 392
Mission Design & Navigation

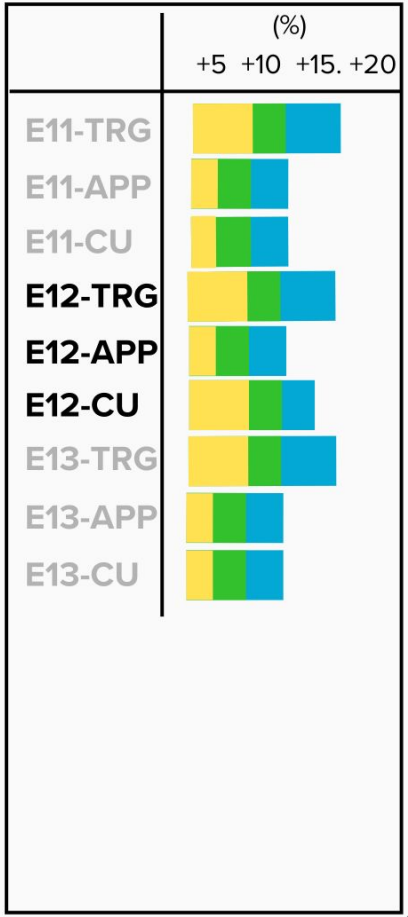
Basak Ramaswamy
Section 397
Human Centered Design Group

Additional Visual / Interactive Elements

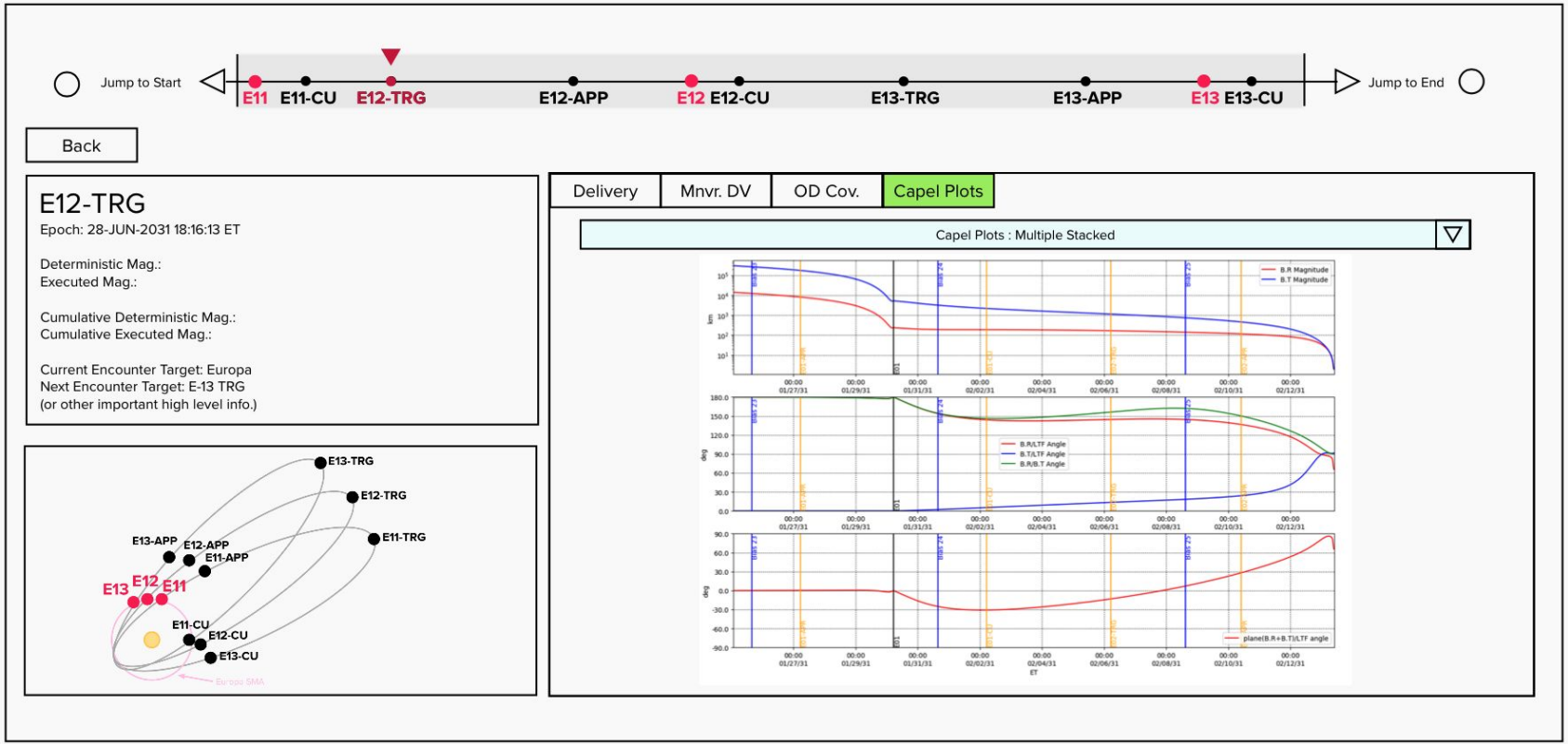
Percentile Burn plots

1. Is representing executed maneuvers (and its associated sigmas) with respect to the deterministic value of interest?

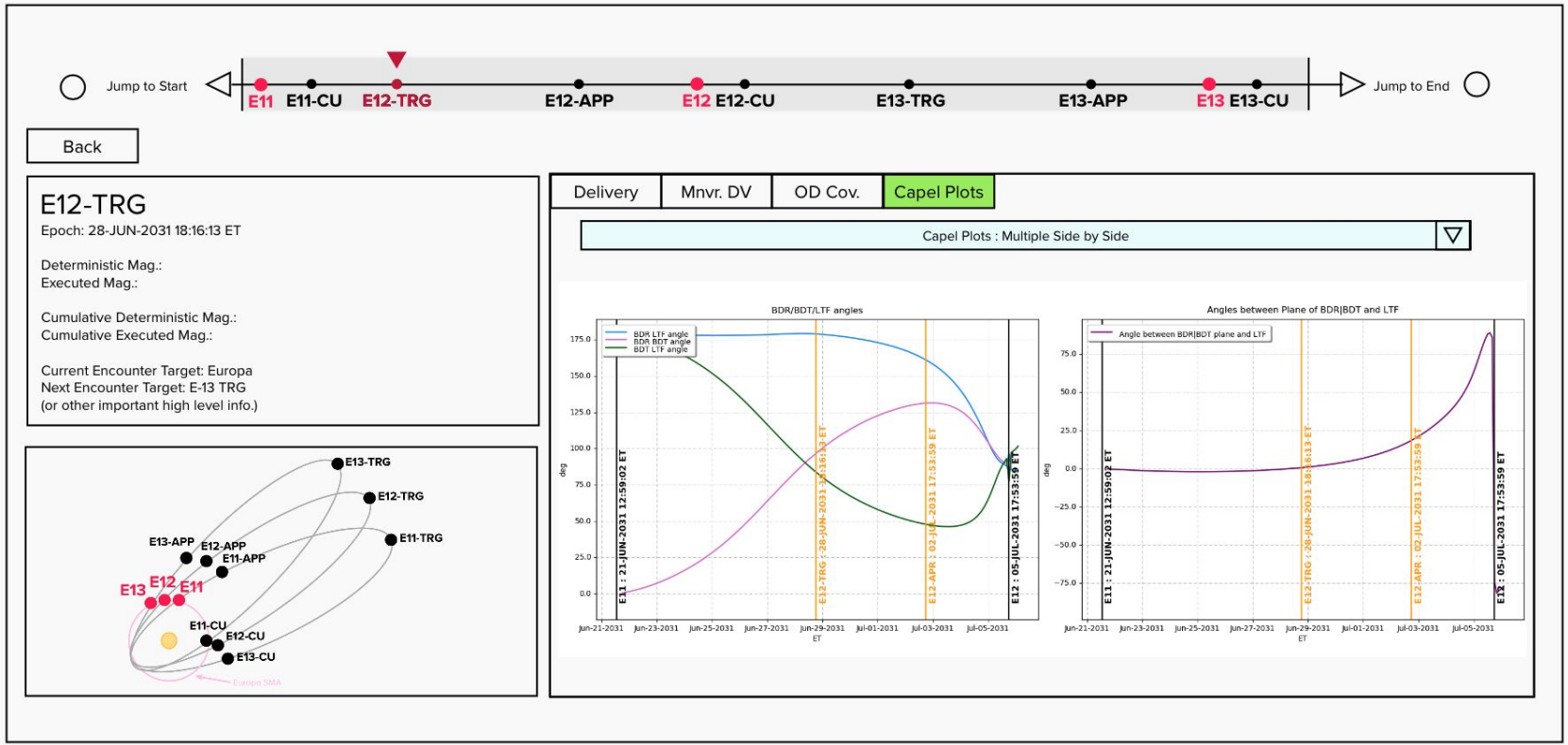
2. When evaluating maneuvers (like Clipper's TRG or CU) are you interested in looking at the executed maneuver magnitude with respect to other similar maneuver types?



Capel Plot Views

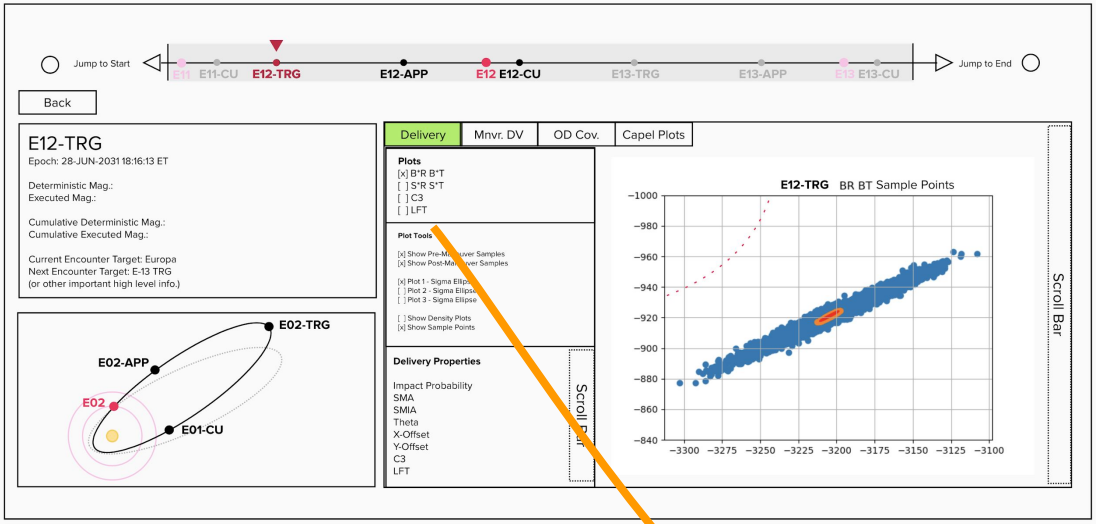


Capel Plot Views

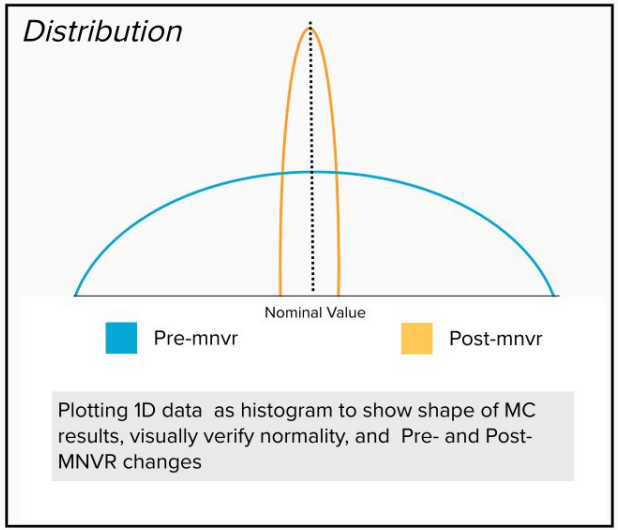


Univariate 1D views

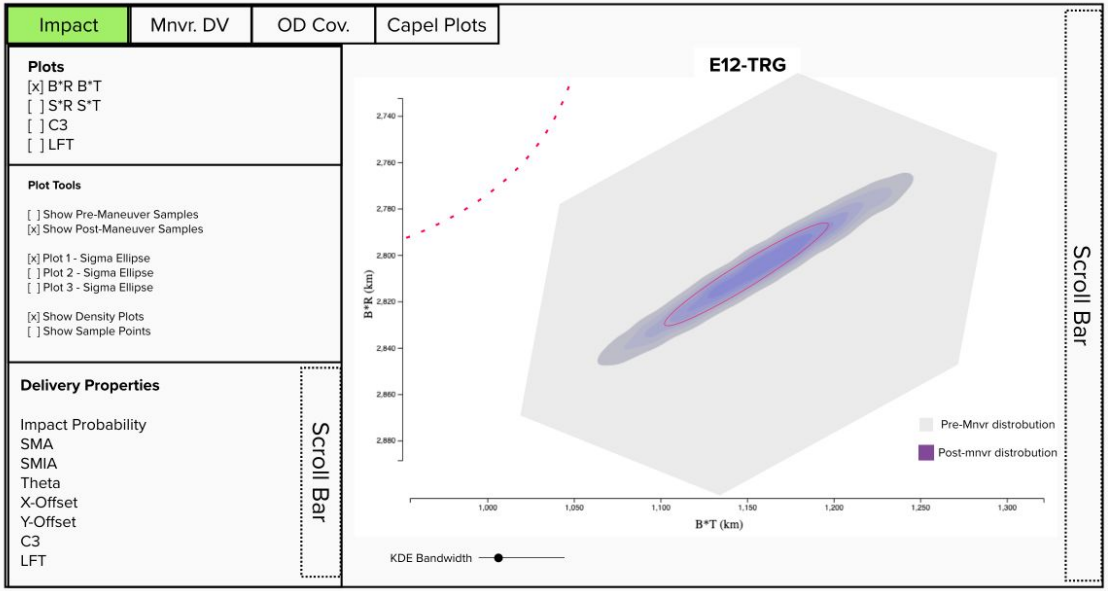
For visualizing Monte Carlo data



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

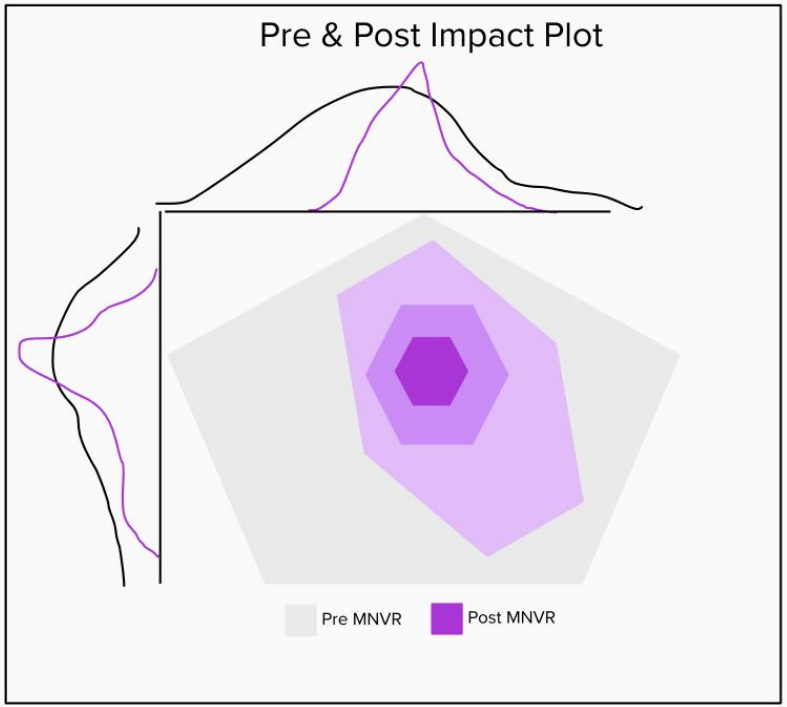
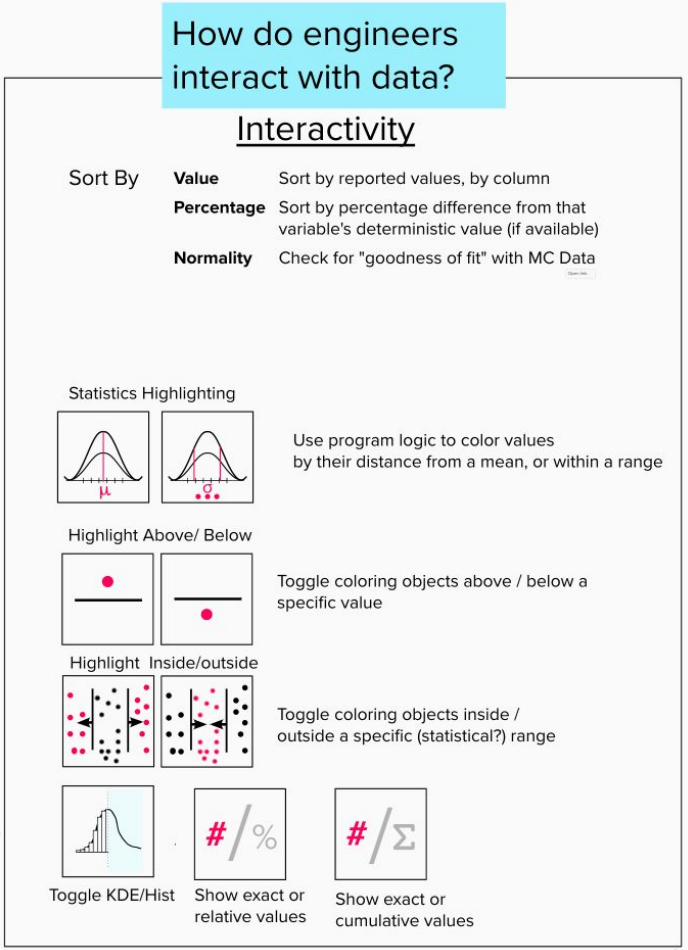


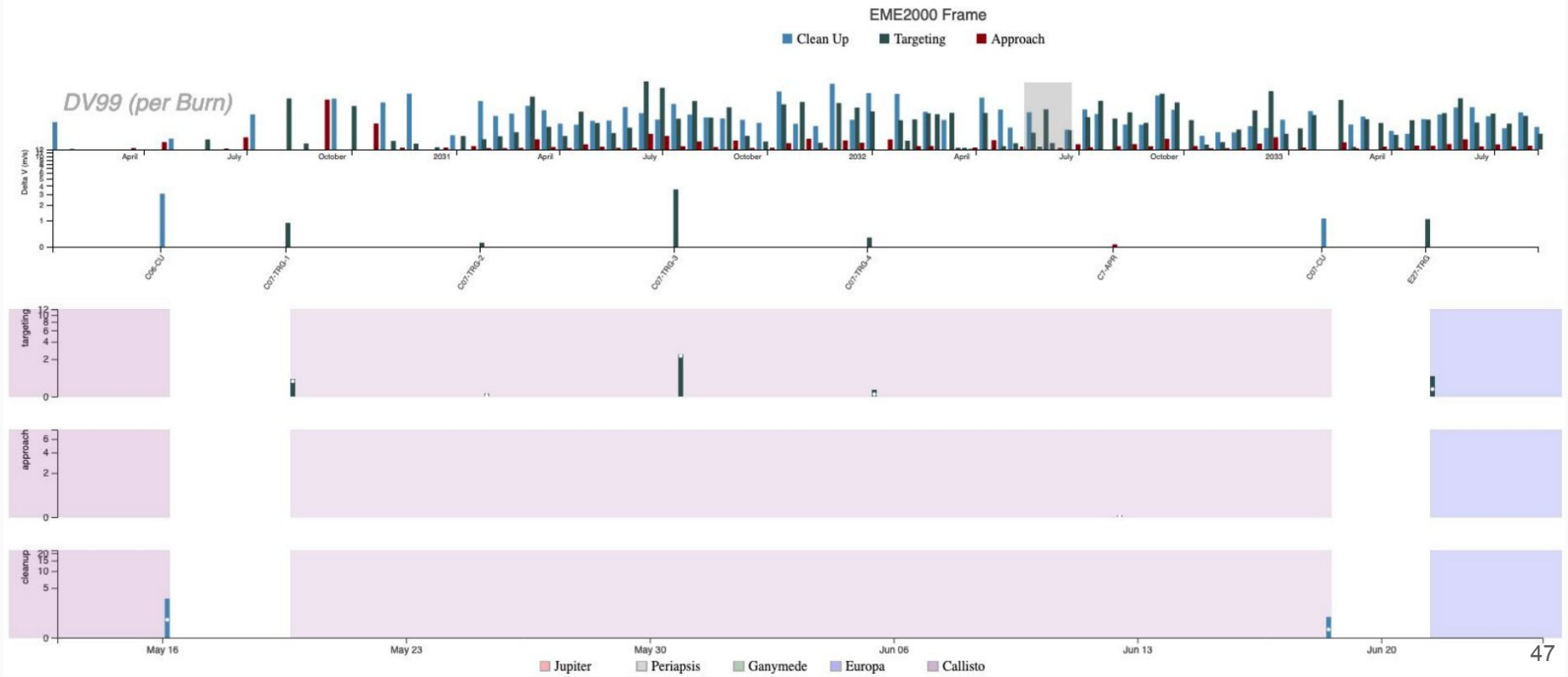
Table Conditional Formatting

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?



Maneuver Tracks



Supplemental

LAMBIC Data Dump

Shared Format

DV Parameters

Cartesian	Spherical
Commanded Delta-V	
Executed Delta-V	
Execution Error	

* Correlation: 3x3 Matrix
* Covariance: 3x3 Matrix
* Means: 3-element mean vector w/ units
* Sigmas: 3-element sigma vector w/ units
* skipped: null

DV Magnitudes

Commanded Delta-V Magnitude
Executed Delta-V Magnitude
Execution Error Magnitude

* 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]

Current Encounter

Delivery
Design Aimpoint
Miss

* 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

Next Encounter

Cartesian	Spherical
Next Encounter Delivery	
Next Encounter Design Aimpoint	
Next Encounter Miss	

* 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

Current Encounter

* Capture & Impact Radii
* Failure rate
* Impact Probability: mean, max, cumulative
* B-Error Ellipse data: sma,smi, theta, etc.

Maneuver Information

General Burn Data

* Name & Numbers
* Frame & Format
* Epoch & Epoch Cal.
* Execution Error & [Search] Strategy

Target & Next Encounter: Settings & Aimpoints

* Names & Frames
* Epochs
* [B,S].[T,R], LTOF, C3
* Downstream: Aimpoint Values & Shift

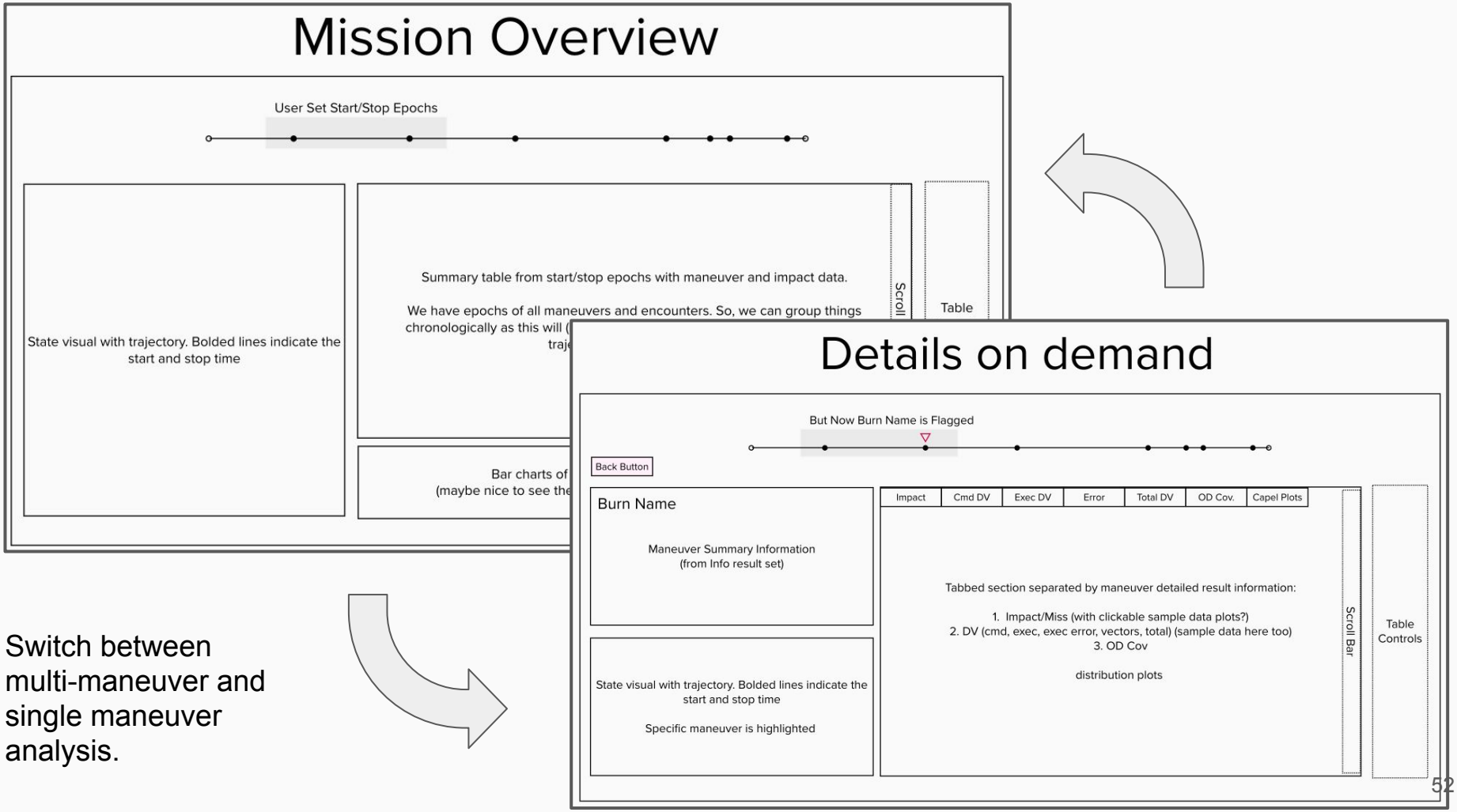
Deterministic DV, Deterministic Cumulative DV

* [dX,dY,dZ, Magnitude] DV Values
* Deterministic Cumulative DV value

OD Covariance

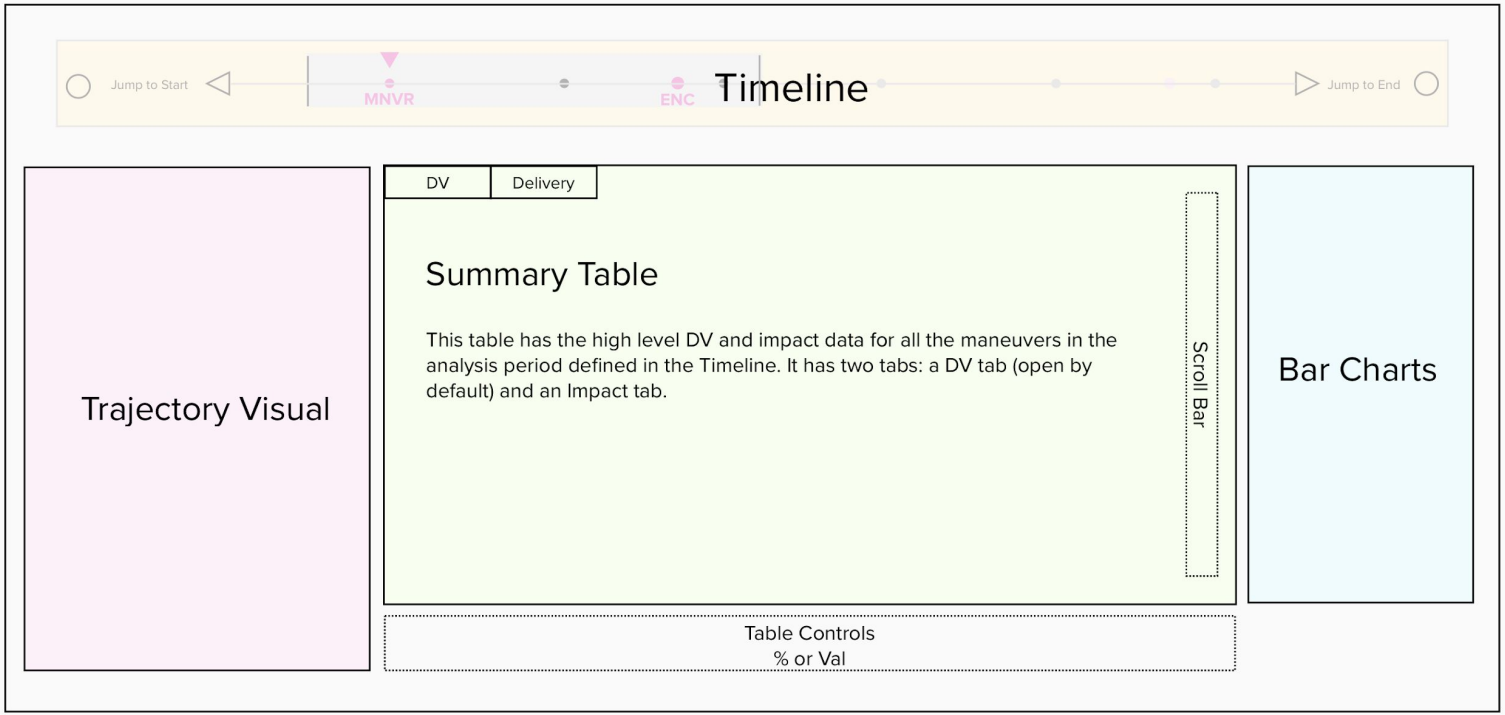
* Burn Name: text string
* Correlation: 6x6 matrix
* Covariance: 6x6 matrix
* Data Cutoff Time: scalar and date string
* Map Name & Time: Strings and scalar
* Scale Factor: scalar
* Sigmas: component-wise values
* Skipped: null

Panel Layout Descriptions



Switch between multi-maneuver and single maneuver analysis.

Porter Organization : Overview Mode



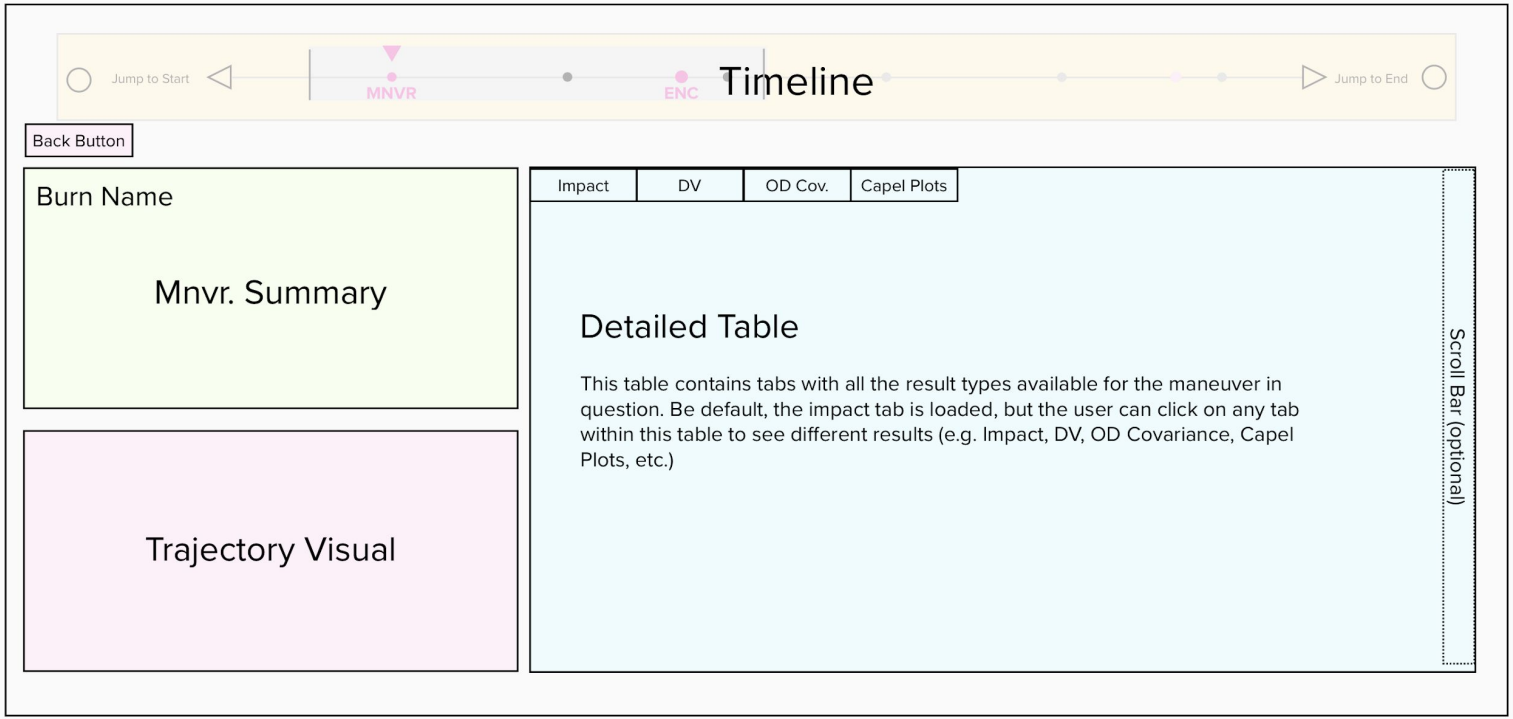
The Timeline navigation bar is at the top of all screen with the maneuver and encounters.

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