Evaluation of a Human-Machine Teaming Approach for Probabilistic Maritime Mission Planning

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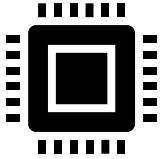
HMT for Complex Planning Problems

Complex planning problems are ideal for human-machine teaming (HMT):



Transform data

Explore large decision spaces

Uncertainty and probabilities

Optimize over multiple constraints

Understand mission goals

Incorporate context

Reason about trade-offs

Adaptability to new information

Effective HMT requires careful design to create collaborative workflow and enable efficient decision-making

Maritime Missions with Commercial Vessels

DARPA Phorcys:
Develop planning and execution monitoring tools for employing commercial vessels for asset deployment, monitoring, and recovery

Phorcys goals:

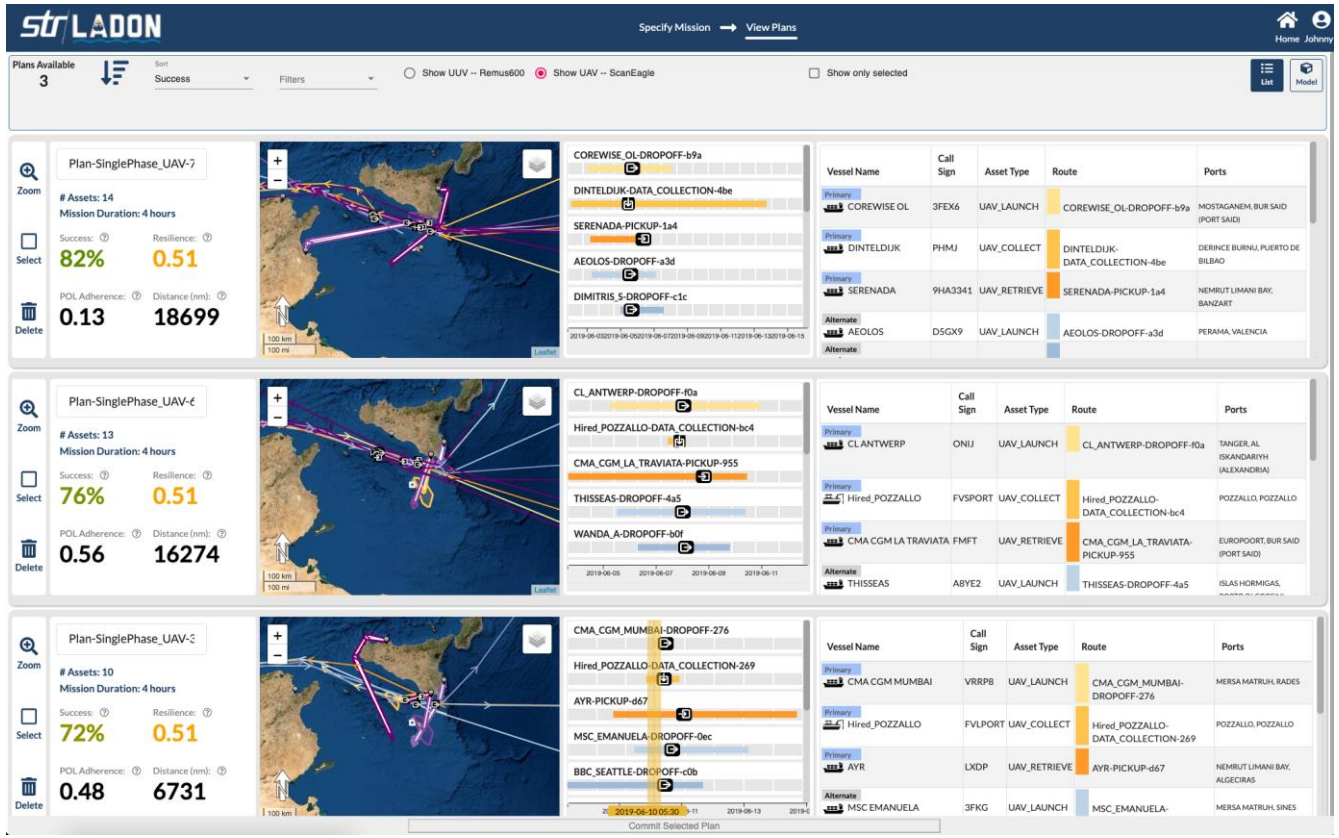
- Expand options for missions
- Provide resiliency in operations
- Reduce risk to traditional platforms

Image from: https://www.darpa.mil/program/phorcys

Shown in image: a UAV is launched autonomously from a commercial vessel, flies a surveillance mission, and is recovered by a specially provisioned container on another vessel

LADON for Phorcys

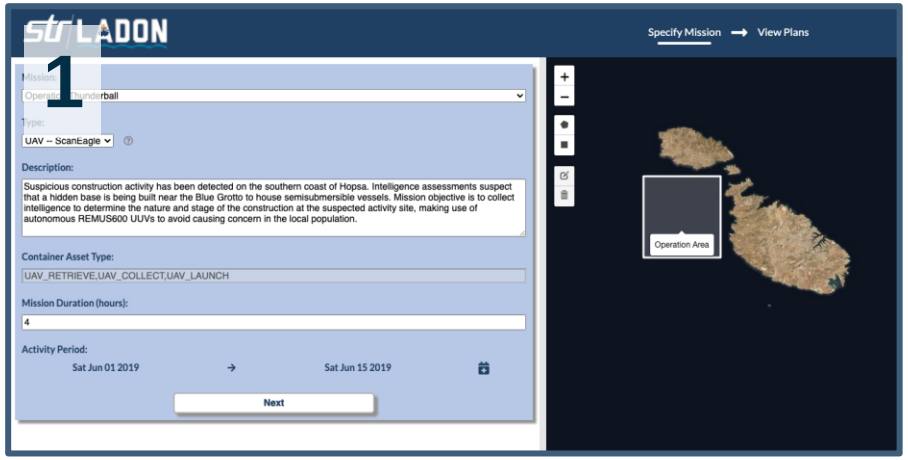
- Lift and Deployment for Naval missions (LADON) is a software suite developed by STR and Aptima to address Phorcys challenges.
- The LADON Planner:
  - Reasons over current commercial schedules and historical traffic to provide robust launch, monitoring, and recovery plans for containerized assets.
  - Significantly reduces the lead time required for planning by utilizing commercial vessels and containers pre-positioned in regional ports.

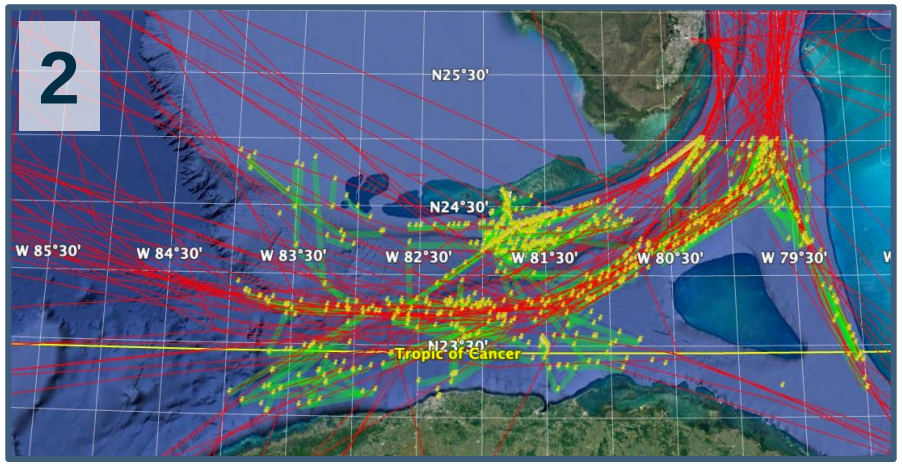


The LADON planner uses evolutionary algorithms to search the space of commercial vessel schedules and assemble and assess feasible sealift support options.

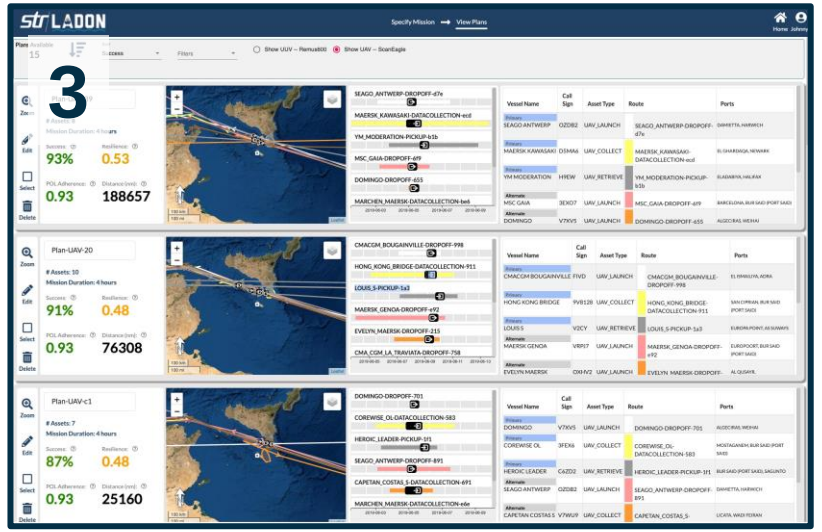
The LADON Approach

1. **User specifics** parameters & constraints
2. **Evolutionary search** generates pareto-optimal plans
3. **Visualize plans** to support evaluation & selection by user





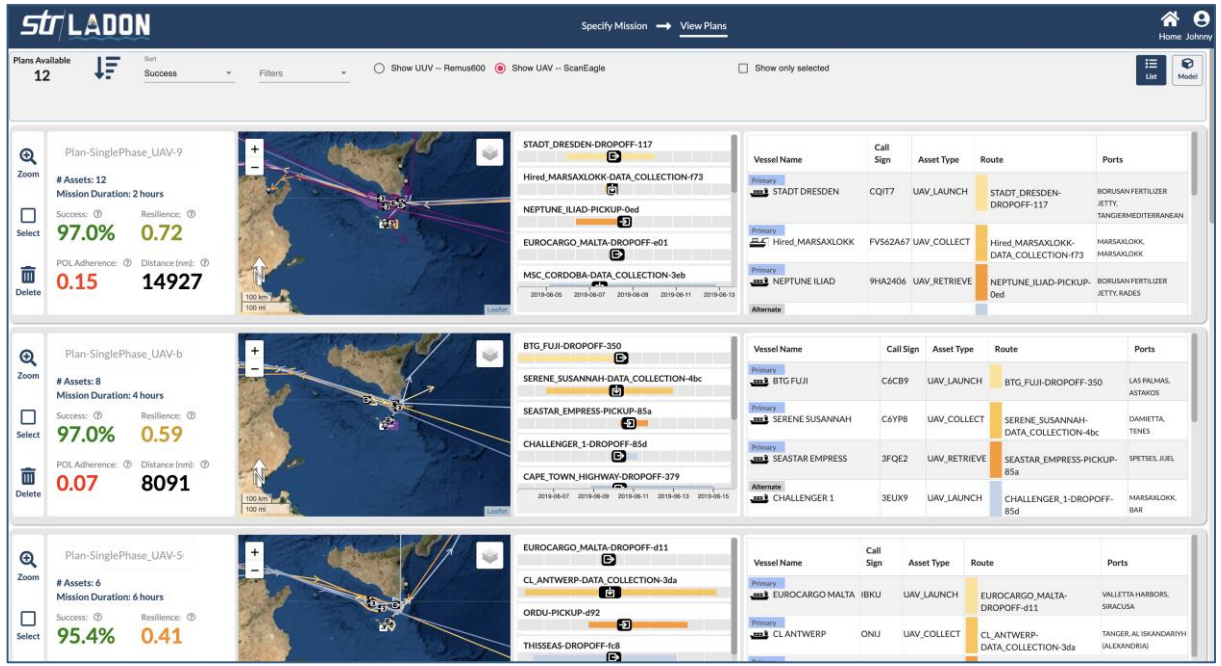
Iterate & Refine or Select & Execute



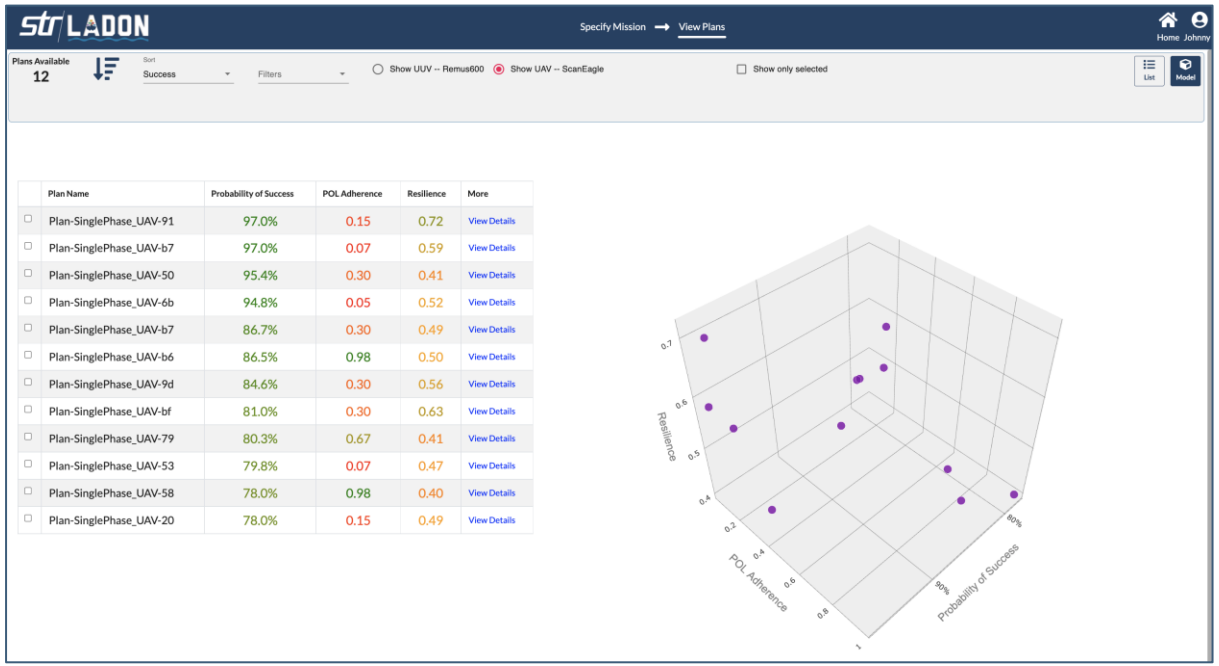
Understanding User's Interaction with Plans

2 options for viewing generated plans:

"List View"



"Model View"



How do users understand the information across multiple plans?

How do users navigate between plans and between views?

What elements are most useful for decision making?

Method: Usability Study

- Two groups of 11 participants each
  - Group 1 started with List View, then switched to Model View
  - Group 2 started with Model View, then switched to List View
- Think-aloud protocol with directed tasks, followed by feedback elicitation
  - Feedback in the form of rating statements on a 1-10 agreement scale
- After the second portion, participants were given open response questions to answer about their experience with the LADON system

Example Rating Statements:

The task was easy to complete

I feel confident that I accurately assessed the array of plans presented

The information was displayed in a way that makes sense to me

I feel confident I could use the LADON system successfully

Example Open Response Questions:

What was your impression of the two different layouts?

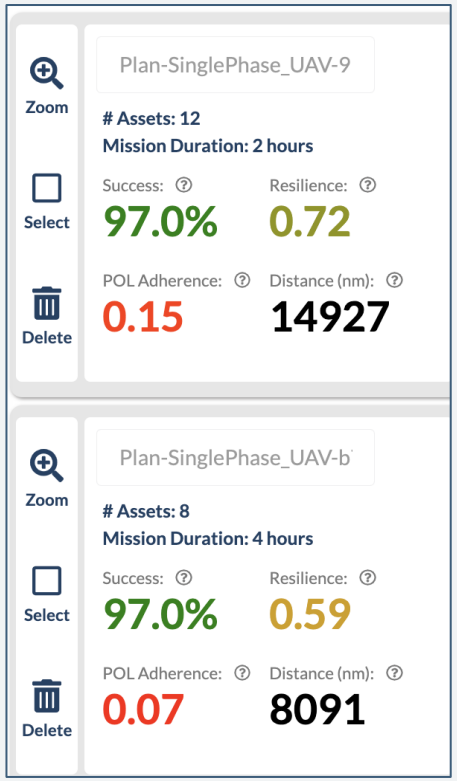
Can you offer some pros and cons of the different layouts?

Did you find it easier to choose your desired plan using one layout over another?

Which features stuck out to you, good or bad?

Results: Qualitative

- General preference for whichever UI was used second
- Desire for easier comparison of metrics between each other. Need contextualization of the metrics, and how they should influence decisions.



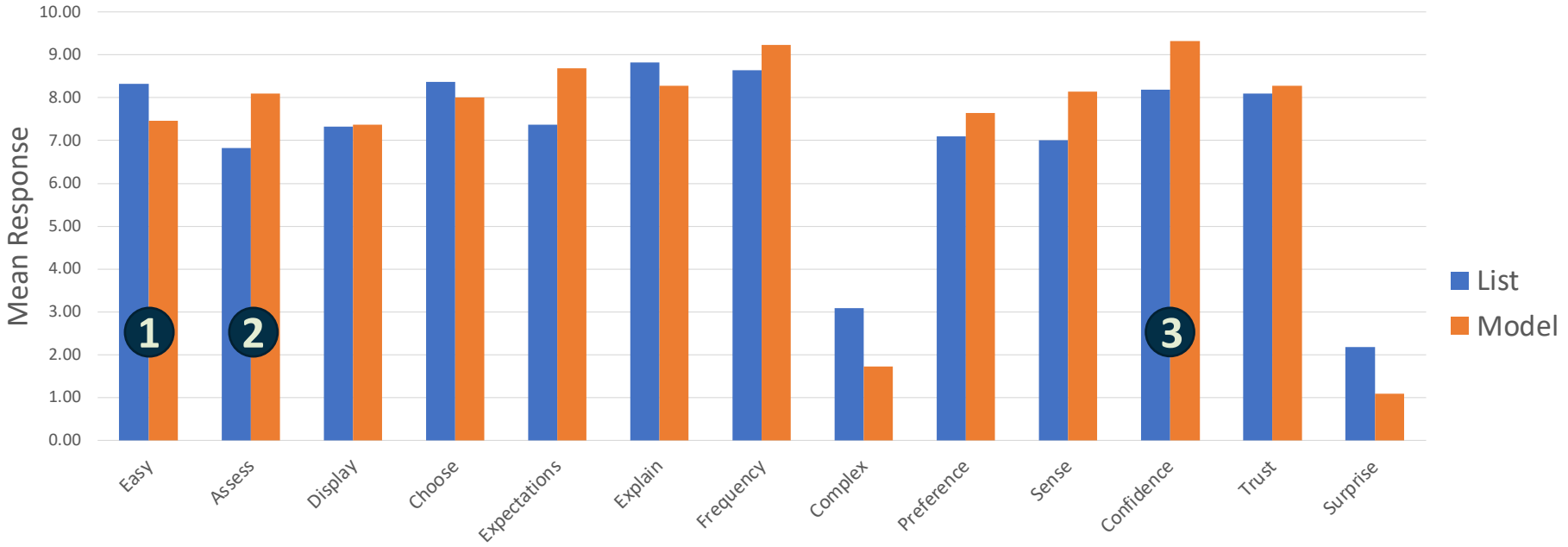
List View shows more metrics and context of plan details

Probability of Success	POL Adherence	Resilience	More
97.0%	0.15	0.72	View Details
97.0%	0.07	0.59	View Details
95.4%	0.30	0.41	View Details
94.8%	0.05	0.52	View Details
86.7%	0.30	0.49	View Details
86.5%	0.98	0.50	View Details
84.6%	0.30	0.56	View Details
81.0%	0.30	0.63	View Details
80.3%	0.67	0.41	View Details

Model View shows visually aligned metrics across multiple plans

Results: Quantitative

	Rating Statement	Result
1	"The task was easy to complete"	**List view** *(M=8.32)* better than model view *(M=7.45)* (W=93, p=.031)
2	"I feel confident that I accurately assessed the array of plans presented"	**Model view** *(M=8.09)* better than the list view *(M=6.82)* (W=33.5, p=.076)
3	"I feel confident I could use the LADON system successfully"	**Model view** *(M=9.32)* better than the list view *(M=8.18)* (W=36.5, p=.107)



Discussion: LADON-specific Lessons

Each view is good for…

List View

- Comparing between 2-3 similar plans
- Visually representing data
- Answering more in-depth questions (e.g., recovery from a faulty launch asset)

Model View

- Preliminary comparisons to narrow down the plans
- Table is useful for a high-level view of the data
- Answering metrics-based questions (e.g., which plan has lowest distance traveled)

Therefore…

Create an integrated view that combines elements of both to allow users to work in a way that meets their mental model

- Participants stated that they want to be able to easily select a top 2-3 plans they can then compare on a deeper, more detailed level.
- Multiple participants transitioned back and forth between the two views

Discussion: General Findings

Good interfaces for HMT should:

- Support easy comparison of data and metrics
- Support exploration and selection
- Help users maintain context throughout view manipulation

Key insight:

Separation of interface styles lessens utility because of the added friction of having to move back-and-forth and cognitive overhead of needing to maintain context while moving between views

Design Principles for Human-Machine Teaming for Planning:

- *Let the user work from a logical starting point*
- *Guide them to a meaningful end point*
- *Give them the freedom to drill down their desired level of detail.*

Information Seeking Mantra:

"Overview first, zoom and filter, then details on demand"

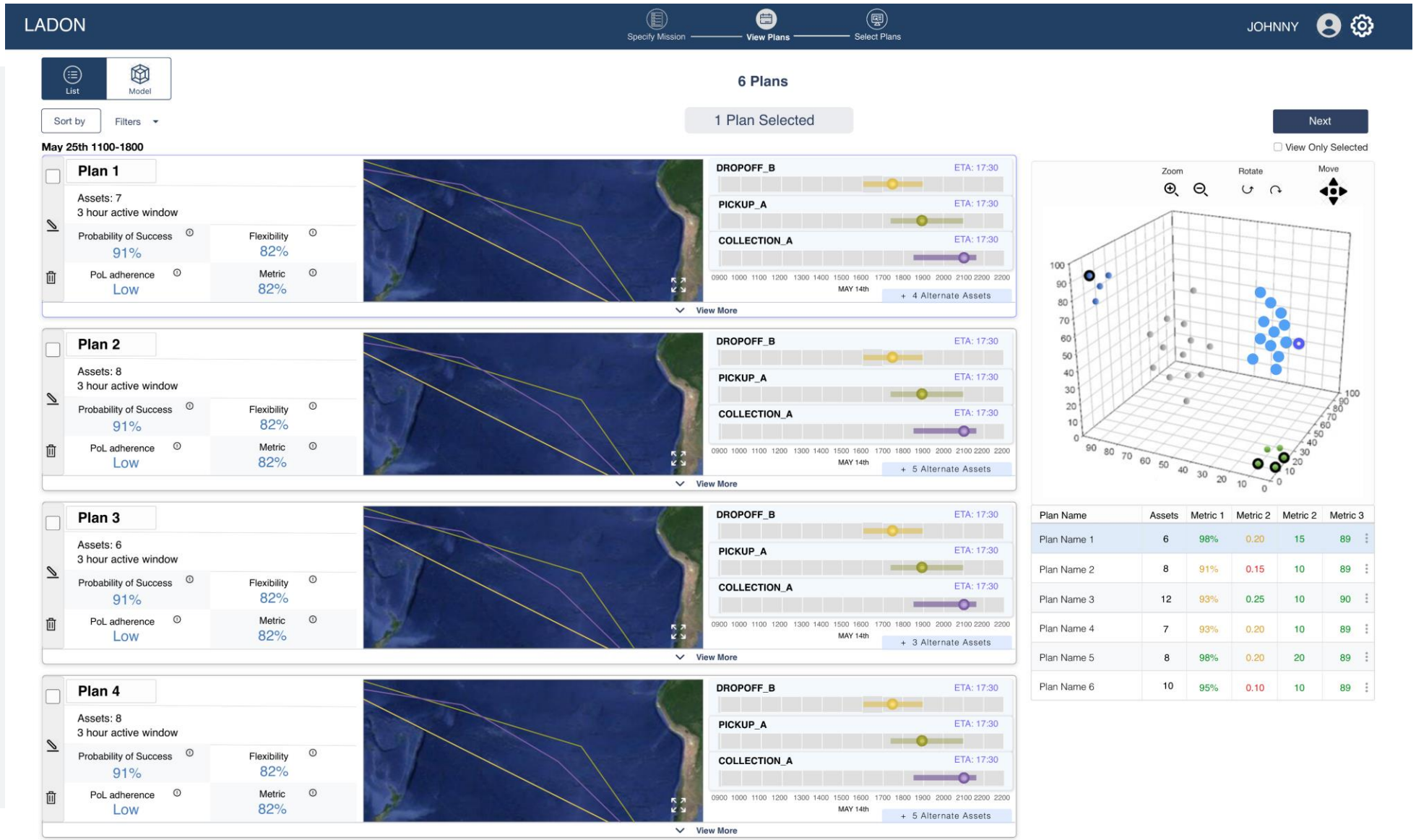
(Shneiderman, 1996)

Re-Design Concept

This concept of an integrated view demonstrates the implementation of the best parts of both the Model and List view.

From the List view, there is the main component of **being able to see metrics, map, and assets.**

From the Model view, there is the **table of metrics and the model itself.**



Thank you!

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