

# **WRT-1011: Fostering human learning from cognitive assistants for design space exploration**

**Sponsor: OUSD(R&E) | CCDC**

**By**

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**FHI 360 CONFERENCE CENTER**

**1825 Connecticut Avenue NW, 8<sup>th</sup> Floor**

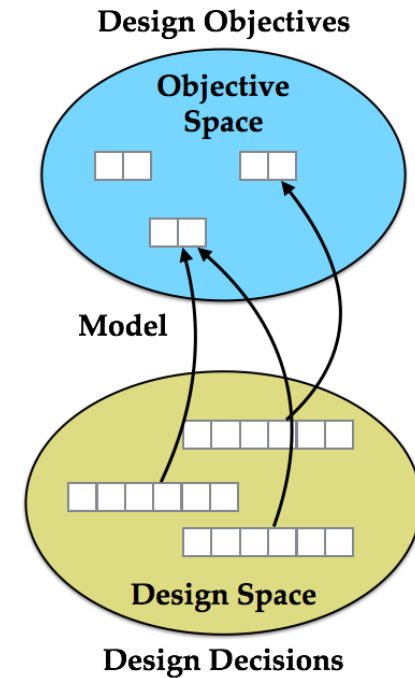
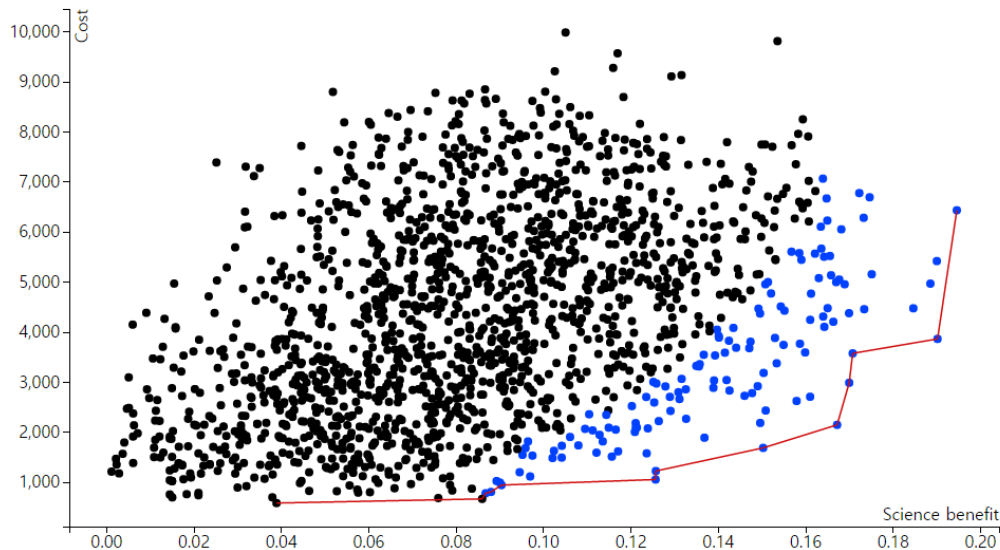
**Washington, DC 20009**

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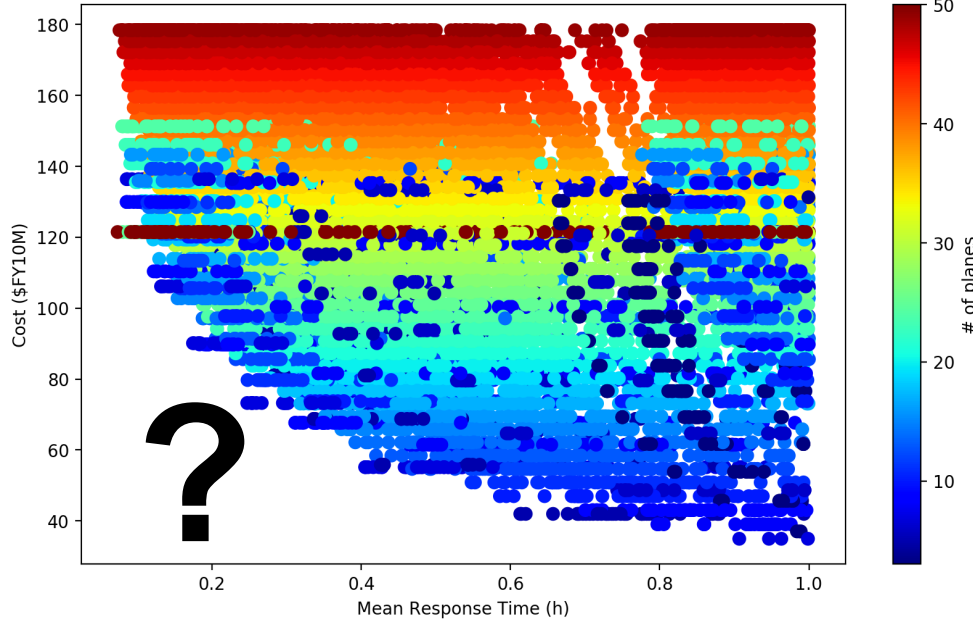


- **The time is ripe for adoption of this technology in the workplace**
- **Technology push:** Advances in Machine Learning (NLP)
- **Societal push:** Digital assistants are ubiquitous in our daily lives
- Still some challenges, need to better understand and improve human-VA interaction in engineering context

- **Context:** Early system architecture and concept studies
- 1. Define a solution space (or design space) by means of a set of decisions and allowed values
- 2. Define an objective space by means of a number of metrics
- 3. Compose models to map solution space to objective space
- 4. Use search/optimization to generate large dataset of alternatives
- 5. Use visual and data analytics to explore dataset and draw conclusions
- 6. Iterate



# DSE is challenging



- **Information overload**, especially when the solution and/or objective spaces are high-dimensional
- **Information retrieval**: Need information from many different sources (time-consuming)
- **Sense-making**: How do we interpret the results?
- **Garbage-in-garbage-out**: All models are wrong, and optimization tools are good at exploiting unrealistic model assumptions
- **Simultaneously doing model validation and tradespace exploration**

**A. Cover Categories**  
 Mail covers are issued only to agencies empowered by statute or regulation to conduct investigations and are strictly controlled to ensure proper use. They are not to be used as an internal investigative step.

Mail covers are restricted to the following categories of investigations:

- To protect national security against actual or potential threats to the U.S. by agents, spies. Only those agencies with national security investigative authority may request covers in this category through the U.S. Postal Inspection Service's Office of Counsel to Agencies & Attorneys.
- To acquire evidence of a commission or attempted commission of a crime punishable by one year or more in prison (felony violations).
- To acquire evidence of a violation or attempted violation of a crime punishable by one year or more in prison (felony violations).
- To assist in the identification of properly processed or security threats information.

**B. Mail Contents and Disclosures**  
 Approved mail covers authorize the receipt of information from the submitter and intended classes of mail. Mail covers do not authorize the disclosure of the original information to a third party. Mail covers are issued for a period of 120 days. Cover extensions beyond 120 days in an extension must be approved by the Chief Postal Inspector. Information received may be disclosed at the request of the recipient. The addressee of a cover mail cover request must be identified to the Chief Postal Inspector. Information received may be disclosed at the request of the recipient. The addressee of a cover mail cover request must be identified to the Chief Postal Inspector. Information received may be disclosed at the request of the recipient. The addressee of a cover mail cover request must be identified to the Chief Postal Inspector.

**C. Regulatory Compliance**  
 Each request is reviewed to ensure that it contains enough information to the cover and fully complies with all applicable requirements.

**D. Submissions Requirements**  
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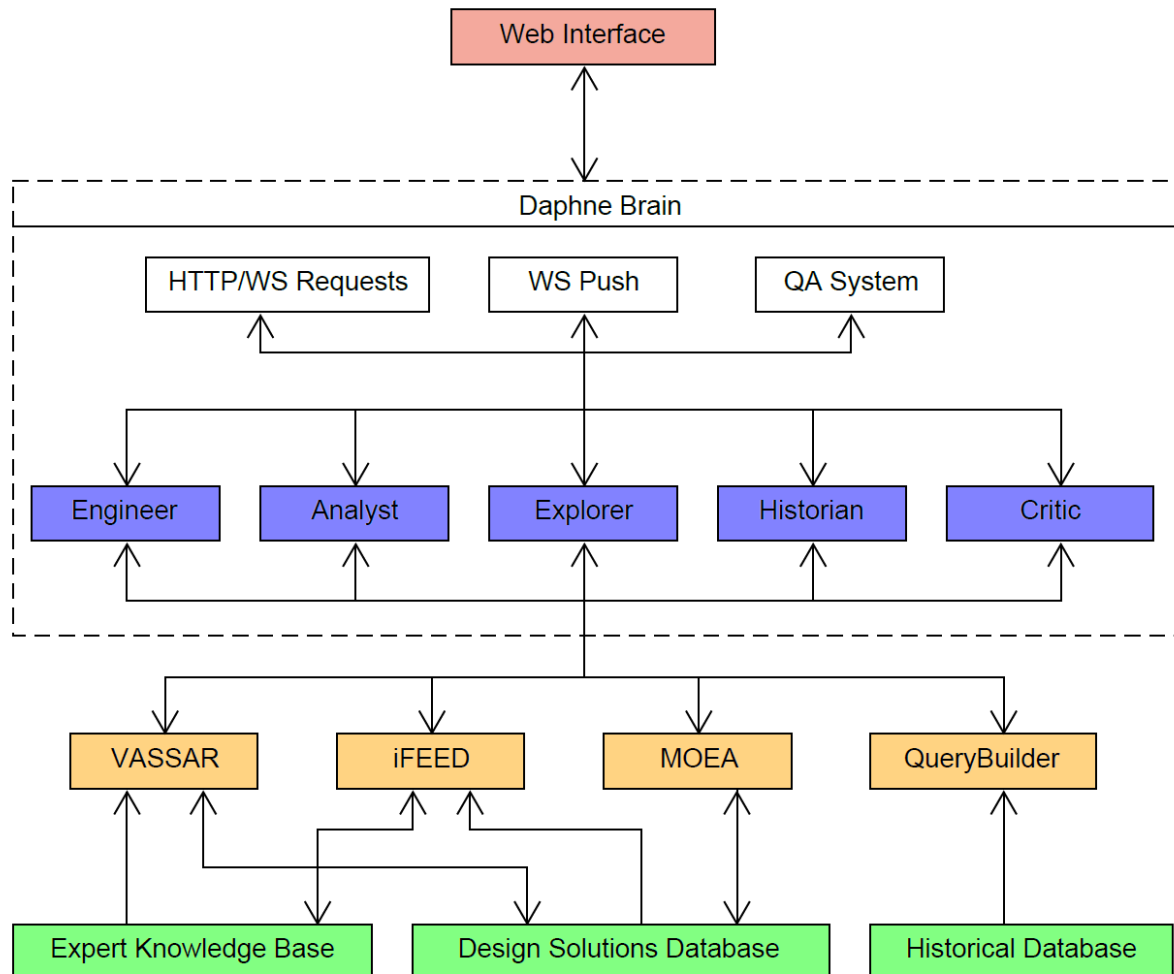
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- **Cognitive assistant:** An AI agent that augments human cognition for a specific task
- Usually has a Question Answering (QA) system with a natural language interface
- 5 main components
  - **Front-end:** GUI, robot
  - **QA system:** ML for NLP (query intent classification)
  - **Skills/roles:** Specialized QA agents (e.g., weather)
  - **Back-ends:** Functions needed to help skills answer requests
  - **Data/knowledge sources:** relational databases, ontologies, knowledge graphs.



## DAPHNE ARCHITECTURE



FRONTEND

ROLES

BACKENDS

DATA SOURCES

**DAPHNE**

- Answers
- Design Builder
- Data Mining
- Filter
- Feature Application
- Orbits and Instruments Information
- Available Commands
- Commands Information

**Problem:**  
SMAP

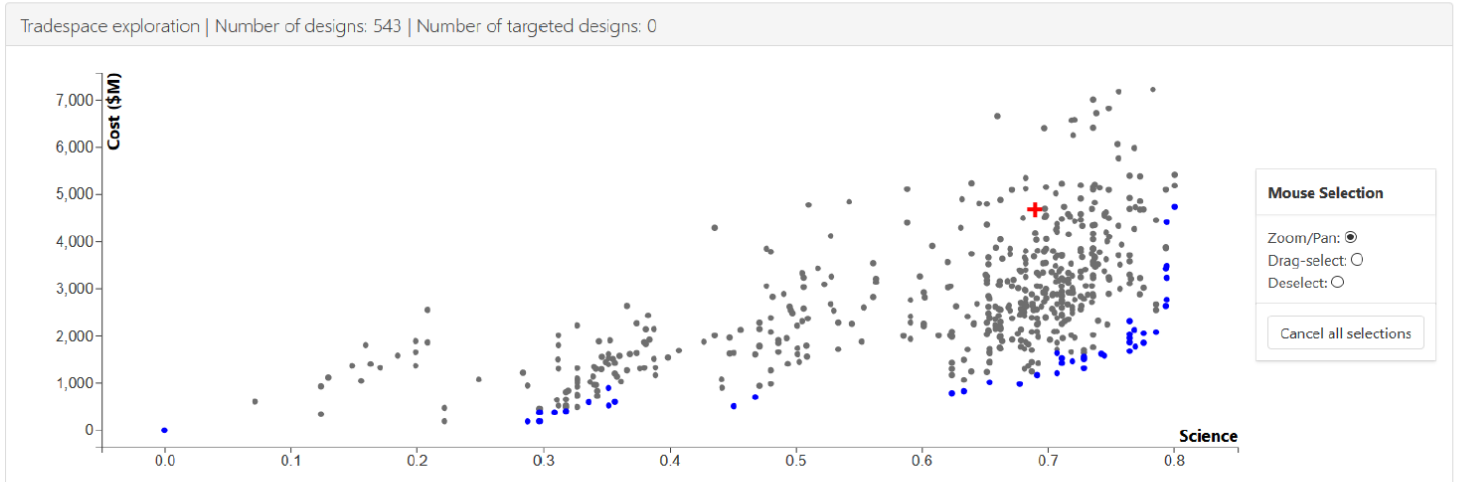
**Dataset:**  
test\_smap.csv

Load  
Save  
Download

Run Background Search  
 Show New Architectures  
 Enable Diversifier  
 Enable Suggestions

HI, antoni. [Logout](#)

Daphne  Do it!



**Design Builder**

Design ID: D498; Science: 0.6900; Cost (\$M): 4673.76; Evaluate Architecture Details

Orbit	Instruments
LEO-600-polar-NA	BIOMASS
SSO-600-SSO-AM	CMIS
SSO-600-SSO-DD	BIOMASS, SMAP_RAD, VIIRS
SSO-800-SSO-AM	BIOMASS, CMIS
SSO-800-SSO-DD	SMAP_MWR, CMIS

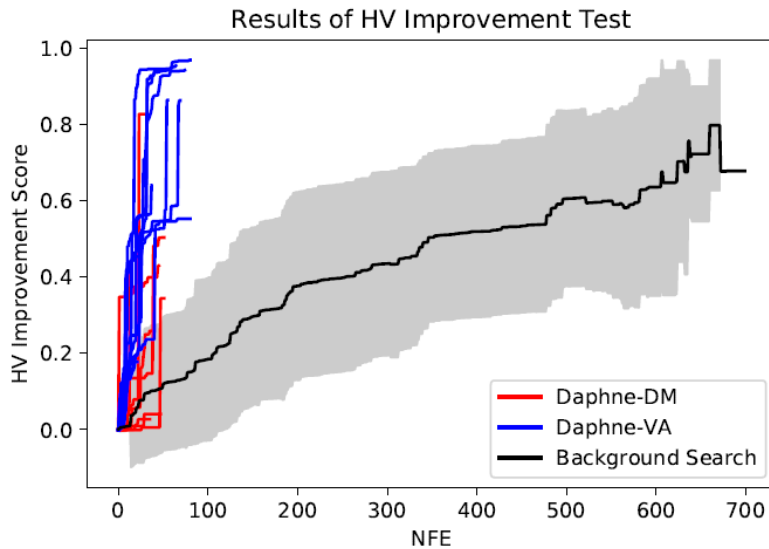
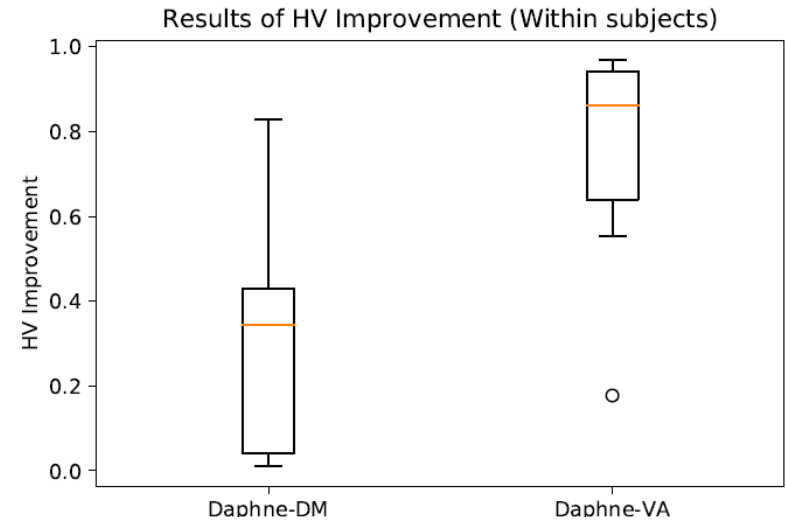
BIOMASS SMAP\_RAD  
SMAP\_MWR CMIS VIIRS

**Answers**

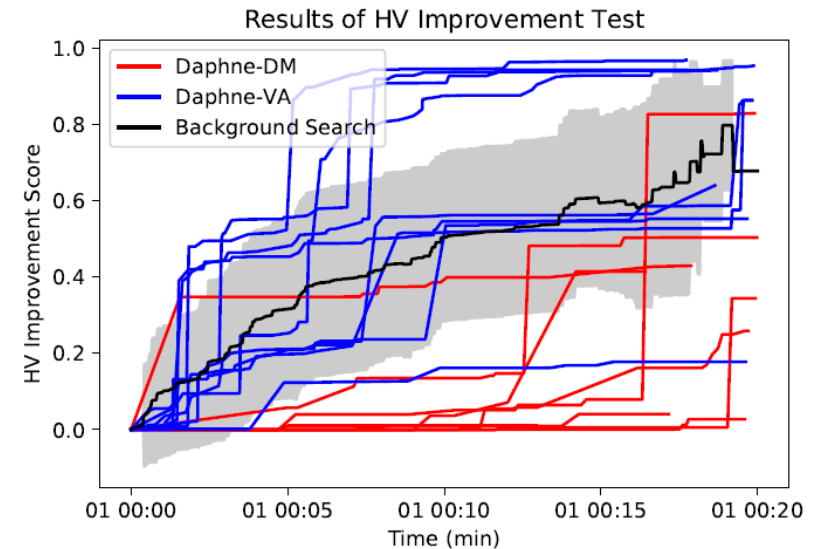
The most common orbit for soil moisture at the surface is a low earth, sun-synchronous, high altitude, no repeat cycle orbit.

Orbits and Instruments Information Available Commands Commands Information

- Conducted a study at JPL with N=9 system engineers
- 2 conditions (Daphne-VA vs no VA)
- Measured design quality, diversity, human learning, and usability
- Within-subjects, counter-balanced design

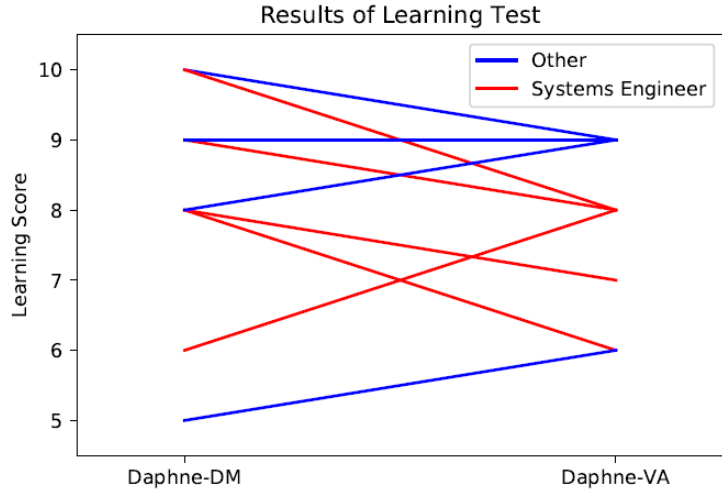


(a) Comparison in NFE

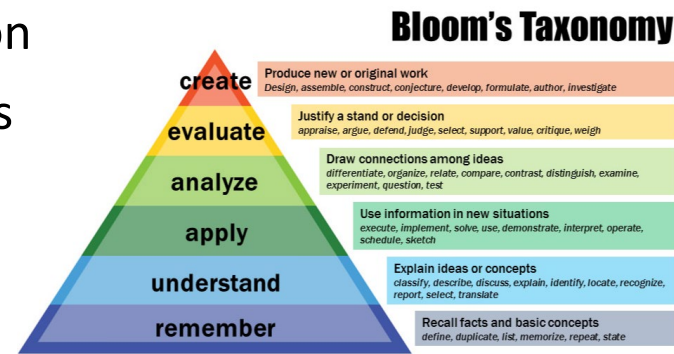
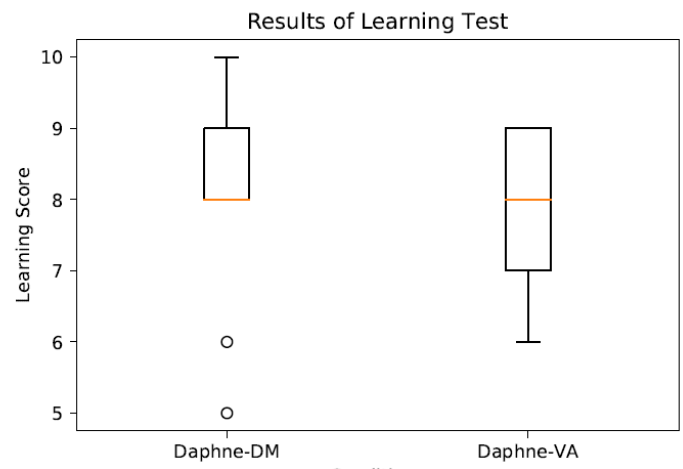


(b) Comparison in time





- What is it that people are learning with DSE tools?
  - Sensitivities, couplings between parameters, driving features, what-if questions
- How do we actually measure human learning in DSE?
  - Tests
- What types of questions?
  - Bloom's taxonomy
  - Factual information
  - Prediction
  - Synthesis



- Add a *Teacher* role that:
  1. Helps the user explore underexplored areas of the design/objective space
  2. Points out relevant information to the user (e.g., sensitivities)
  3. Asks questions to the user (e.g., about driving features) focusing on areas where the user shows less understanding



Teacher: I have found information about sensitive design decisions, would you like to learn more?

Yes

Teacher: Ok, here is what I found on first order sensitivities for the Science objective



Ask a question / Give a command / Speak it out! Send

- Studying different ways of measuring learning in DSE
- Conducting pilot study to see if *Teacher* role actually fosters learning
- How do we take into account the fact that we are simultaneously exploring the design space and estimating user learning?
  - Borrow from intelligent tutoring systems literature

- Viros, A., Member, S., and Selva, D., “Daphne : A Virtual Assistant for Designing Earth Observation Distributed Spacecraft Missions,” *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*. Accepted. 2019.
- Viros Martin, A., and Selva, D., “From Design Assistants to Design Peers: Turning Daphne into an AI Companion for Mission Designers,” *AIAA Information Systems-AIAA Infotech at Aerospace, 2019*, 2019.
- Bang, H., Viros, A., Prat, A., and Selva, D., “Daphne : An Intelligent Assistant for Architecting Earth Observing Satellite Systems,” *2018 AIAA Information Systems-AIAA Infotech @ Aerospace, AIAA SciTech Forum*, 2018, pp. 1–14.