



TBD

End-to-End Mission Design & Trajectory Optimization

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EXECUTIVE SUMMARY

Need: A need exists for a generalized, robust, user-friendly and accessible end-to-end mission design optimization tool.

Solution: Our solution to developing this capability was to interface two JSC tools—Copernicus and Genesis. Each of these tools has a specific area of the mission design process that it excels at. By utilizing them both, we can gain performance benefits not seen by either on their own.

- Copernicus is a trajectory design and optimization software used for in-space trajectories around multiple bodies.
- Genesis is a flight mechanics tool used to model ascent, entry, descent, and landing trajectories around a single planetary body.

Year 1 was focused on combining these 2 software packages—allowing Copernicus to incorporate the ascent/descent capabilities of Genesis into the optimization problem—and developing this end-to-end mission design capability.

Year 2 we focused on increasing the robustness of this capability by building the initial guess generator (IGG), which produces initial guesses based on simplifying assumptions and the physics of the problem.

Year 3 of our project focused on utilizing the end-to-end mission design and optimization capabilities developed in the previous 2 years to analyze specific mission scenarios—scaling up from proof of concept to real analyses—capturing any resulting performance benefits, as well as addressing the Big Data challenges we’re faced with—namely, how we’re going to manage and interpret all the data that’s generated.

INNOVATION & BENEFITS

- **Improve efficiency of the mission design process and integration of different teams.** By not constraining the handoff points between different mission design teams, this technology will improve the mission design process itself—both from a time efficiency perspective, but also from a performance efficiency perspective. Potential performance benefits include decreased propellant usage, better abort coverage, and increased mission availability.
- **Aid mission architecture decisions, pre-flight product development, and real-time operational support.** Copernicus is already used in all aspects of Orion mission design—from pre-mission design to real-time on-console support. Utilizing the added benefits of Genesis in-the-loop with Copernicus will only improve data products used in decision making.
- **Advance human spaceflight toward onboard abort autonomy.** Moving towards the goal of providing astronauts the ability to design and execute aborts on their own, this technology is a necessary stepping stone. The example scenario being a crew member who has lost comm with Mission Control and needs to run this tool to develop abort options and execute a burn back to Earth for safe return.

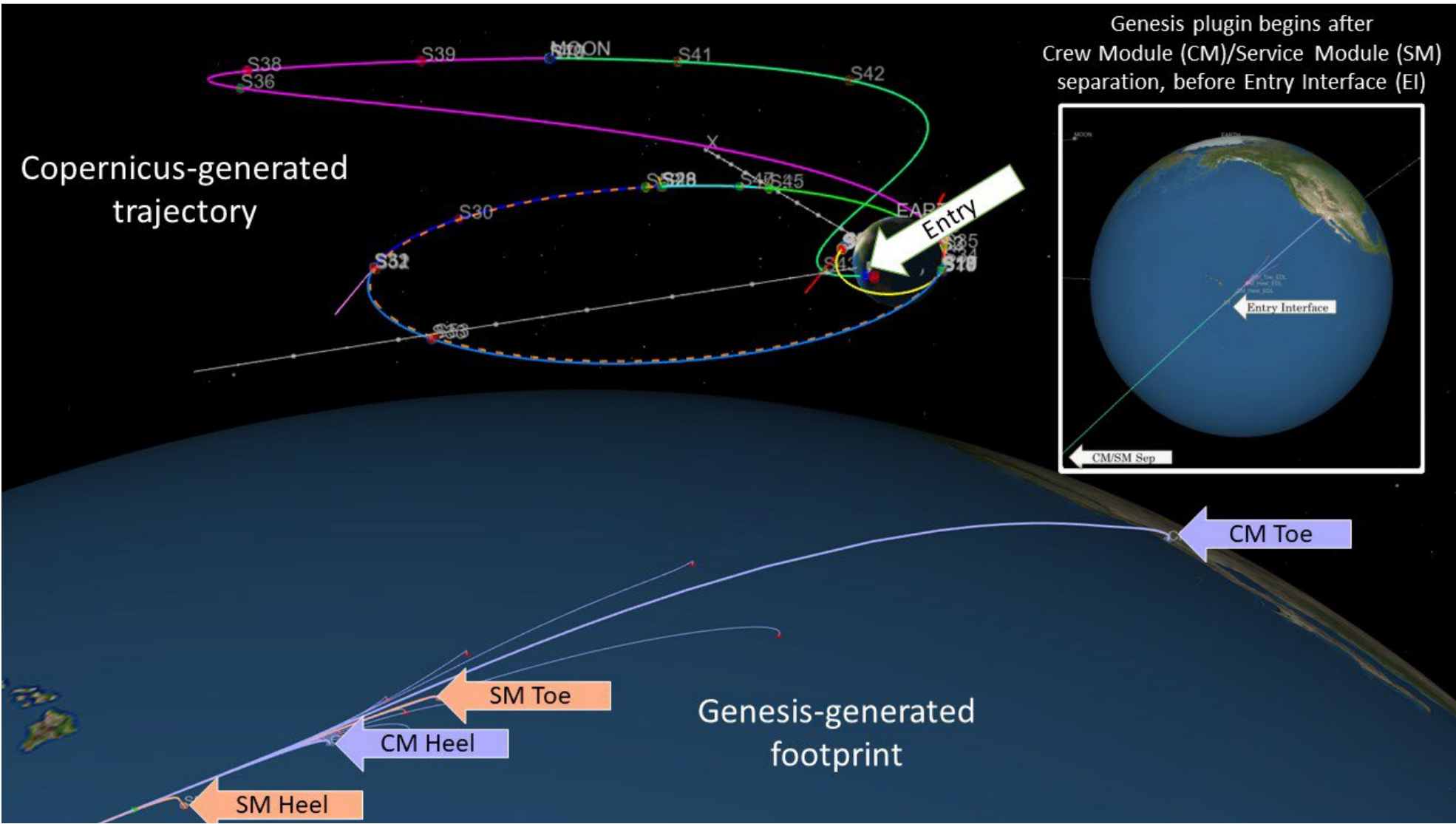
COLLABORATION

CM and EX

- Provide stakeholder review and feedback as the project developed

Draper

- Provide feedback on integration into existing Mission Manager tool capability



This plugin enables visualization of the Orion Crew Module (CM) and Service Module (SM) trajectories on Earth's surface. It will be used to expand abort and early return capability of Orion and to constrain re-entries to avoid keep out zones for Artemis missions.

OUTCOMES & INFUSION

Project Accomplishments:

Copernicus/Genesis/IGG Mission Design Application:

- Developed Orion SM + CM Footprint plugin
- Developed PEG Ascent Abort plugin

Initial Guess Generator Capability Expansion:

- Implemented multiconic propagator functionality to enable usage on wider range of cislunar trajectory types
- Developed solution scenario for abort back to Earth for Artemis III+

Big Data Management & Visualization:

- Developed client custom data package script to accommodate specific client requests and improve data access management
- Developed data standards to organize our internal data processes and to create a better data delivery strategy for our clients
- Developed data quality solutions including simpler data quality checks (i.e. missing values, incorrect data types, duplicated values, incomplete data field, outliers in data sets, etc.), data correlations, and anomaly detection
- Developed visualization frameworks and dashboards in PowerBI

Infusion Pathways:

HLS and Artemis Mission Design – design of complex trajectories involving SLS, Orion, Gateway, and commercial landers

- Developed multiple plugins specifically for these applications

Artemis Operations – for eventual use in the MCC, MER and onboard

- Developed data standards, data packaging scripts, data quality solutions, and data visualization dashboards, which directly impact and improve the decision-making process

Commercial Partners – design of lunar trajectories to maximize cargo delivery to lunar surface (see HLS/App P)

- Developed plugins for specific applications
- Developed data standards and data packaging scripts to address specific client requests

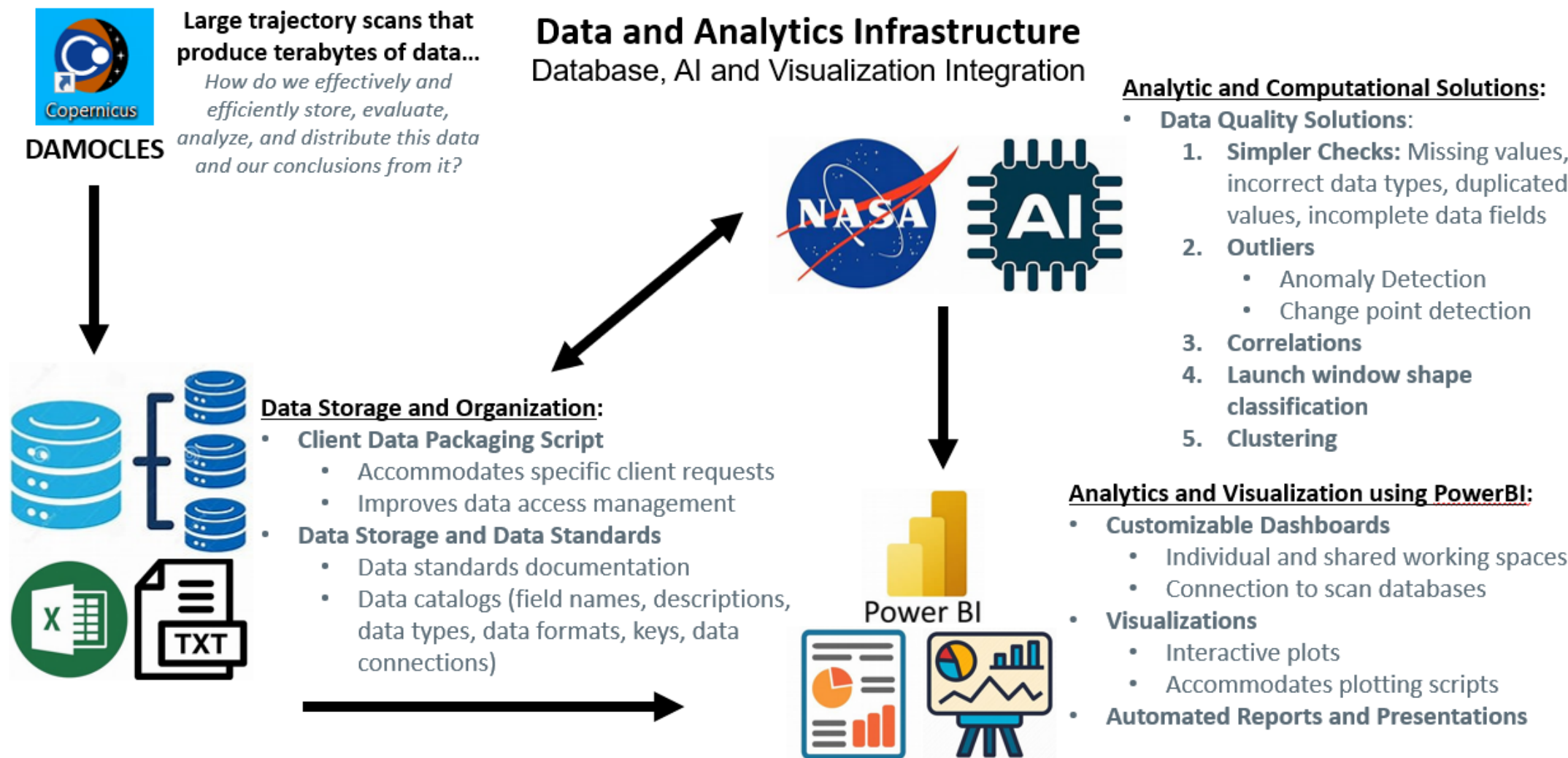
NEXT STEPS

Utilize upcoming internships to help with advancement of plugins

- Apply Orion CM/SM plugin to Artemis II+ abort/early return scans
- Apply PEG Ascent Abort plugin to App P scans

Utilize ongoing partnerships to advance and apply the technology

- Implement analytic model for powered flyby in IGG
- Tuning of anomaly detection scripts to identify relevant outliers
- Apply data quality solutions and visualizations to Artemis II+ scans



The big picture solution to our big data challenges.

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