A New Concurrent Engineering Tool for the Mission Design Center at NASA Ames Research Center

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Abstract—**The Mission Design Center at NASA Ames Research Center is in the midst of a transformation, with focus on personnel, physical space, tools, and training. Towards the goal of becoming a Concurrent Engineering Center, the MDC is developing Poseidon, a new concurrent engineering (CE) tool which will facilitate CE sessions beginning in 2021. The tool is being developed with heavy stakeholder involvement, with subject matter experts providing (informal) requirements and providing iterative feedback throughout the development process as a means to effectively generate buy-in. The tool stores all information centrally so as to be accessible to all registered users for a given concept, and provides for an effective de-confliction process should the need arise. Poseidon is designed to support three levels of analysis fidelity: preliminary parametric sizing (first-order analysis), subsystem-level analysis (technical resources allocated by subsystem), and component-based analysis (at which point users are selecting hardware from a database). Each of the traditional spacecraft disciplines has a tailored workspace within the tool; additional workspaces support cost accounting, systems engineering, and mission summary information (including risk tracking). These additional workspaces help allow the entire team to work together in a CE session more effectively and efficiently, providing real-time feedback within the entire team. Throughout 2021, additional analysis features and improvements will be added, as well as implementing feedback from real CE sessions.**

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1. INTRODUCTION

The Mission Design Center (MDC) at NASA Ames Research Center (ARC) has undergone a significant transformation process in recent years to better align with the Center's goal and vision, working towards becoming a true Concurrent Engineering Center (CEC). The underlying goal of this transformation is to better serve the Ames science community in a cost-effective and rapidly-responsive way, providing quality products pivotal to the decision-making process and proposal strategy for new spaceflight projects at the center. The four pillars of the change focus on: personnel, physical places, tools, and training.

Personnel

The MDC switched from using a dedicated pool of engineers, mostly entry-level career, for a matrixed approach with Subject Matter Experts (SMEs), usually having significant current and past spaceflight project experience. These SMEs are detailed to the MDC for the duration of a study on a part-time or full-time basis.

Physical places

To foster collaboration, the MDC places significant emphasis on the layout of a new Engineering building and a new dedicated concurrent engineering (CE) space. The current plan includes a dedicated area for concurrent engineering sessions as well as dedicated project rooms for concept studies.

Tools

The MDC team is developing a new in-house concurrent engineering tool to facilitate CE sessions. The team leveraged the many lessons learned and insight gained from using the former tool (Atlas, described below) in use since 2008. SMEs have been involved throughout Poseidon's design and development, ensuring accuracy and providing validity for the implementation approach. This new tool is database-enabled and allows a team to work concurrently on the same model of a mission concept. "Workspaces" are provided for each of the traditional spacecraft mission design disciplines, including cost accounting and systems engineering. There are multiple tiers of fidelity available within each workspace, which can be completed parametrically or independently from the other disciplines as needed or synchronously with the other disciplines. A "commit" step synchronizes a workspace with a central database (called the Mission Database) and identifies any potential conflicts, along with the user who entered the conflicting data. A Mission Summary workspace enables a Study Lead to run an effective CE session, displaying key graphics, workspace status information, and technical and programmatic budget information. This new CE tool was debuted in a limited Beta status with its primary user base in the summer of 2020. The team plans to release the first operational version in December 2020.

Training

Early concept development and maturation for a space mission requires a unique mindset; one has to be able to work with uncertainties in an environment where requirements are not yet fully developed, and where changes and trade-offs happen at a high tempo. The MDC started a weekly training program to ensure a common knowledge base for developing and maturing early concept studies, as well as effectively operating in a concurrent engineering environment.

The MDC transformation will provide the Ames community a powerful tool to address and mature early concepts more effectively and efficiently, with a particular focused on cost-effective small satellite scientific missions

2. THE NEED FOR CHANGE

The Mission Design Center (MDC) is a facility within Spaceflight Division of the NASA Ames Research Center's Engineering Directorate. The MDC specializes in conceptual mission design. While experienced in multiple regimes of design and mission implementation, the MDC focuses on low-cost, small spacecraft missions. Ames created the MDC in 2007 to develop concurrent engineering capabilities in support of early mission concept development. Over the years, the composition and structure of the MDC has evolved greatly. Initially, the MDC supported a variety of functions spanning from early concept development, developing an in-house concurrent engineering tool, supporting flight projects as well as leading proposal efforts for Discovery class missions. Initially, the center staffed the MDC with a large staff (~20) of mostly junior engineers. The MDC staff would support MDC activities as well as other activities and projects, including flight missions, within the Engineering Directorate. Over time, Center management realized that it needed a more focused organization, with access to mid- and senior-level Subject Matter Experts. The transformation process started a few years ago and it is culminating with the transformation of the MDC into a more effective Concurrent Engineering Center (CEC) with a clearer vision and mission.

The MDC vision is for the CEC to be NASA's paradigm for cost effective robotic space missions. The MDC Mission is to adopt, apply and continuously improve industry best practices on concurrent engineering, developing tailored CE tools and practices, and developing a team of CE practitioners. The MDC plays a critical role within the NASA Ames ecosystem of small and cost-effective spaceflight missions. As the MDC progresses in its transformation, it aims to serve ARC in two key areas:

1. Spaceflight mission concept idea lab. The MDC provides all support Principal Investigators (PIs) need to understand whether their idea for a robotic spaceflight mission is feasible within set constraints (both technical and programmatic).

2. Concurrent Engineering Services. The MDC is a CEC which provides concurrent engineering services, infrastructure, training, and trained personnel for spaceflight mission concept development.

ARC is transforming the MDC by focusing on four key areas: Personnel, (physical) Space, Training, and Tools. We will next offer an overview of the activities in the first three areas before delving into the main subject of this paper: the new CE tool under development.

3. PERSONNEL, SPACE, AND TRAINING PILLARS

The transformation of the Ames MDC into a Concurrent Engineering Center (CEC) is based on addressing four core elements, here defined as the four pillars: Personnel, (physical) Space, Training, and Tools. While the focus of this paper is on the Tools pillar, i.e. software tools, this section provides an overview on the other pillars to give the reader a better understanding of the context in which Poseidon, the concurrent engineering tool, will operate.

Personnel

Personnel is a fundamental aspect of every organization, and in particular for a CEC where close interaction and exchange of ideas is paramount. As discussed above, the MDC has recently moved from a framework where the majority of the SMEs were in-residence engineers with entry to mid-level experience to a matrixed approach with mid- to senior-level SMEs on a temporary basis. This matrixed approached is commonly used by other CECs. Currently, the MDC personnel can be divided into a resident core team and a matrixed pool of SMEs. The resident core team is limited to a few individuals with a high level of effort (LOE) devoted to the MDC (half-time or greater). Members of the core team account for the MDC organizational leadership, concept study leadership, and systems engineering, as well as tool software development and maintenance. The SMEs reside primarily in the engineering division (Code RE) where they are routinely involved in flight project activities. When they are tasked to the MDC for a mission concept study, they dedicate an average LOE up to 50% for the duration of the study. A study duration is usually in the range 8 – 26 weeks. Normally, only SMEs who had undergone the MDC training are eligible to be part of a concept study (see Training below).

(Physical) Space

Concurrent engineering requires SMEs to interact with each other in a fluid and obstacle-free way. The MDC has been involved in the planning of the CE facilities for the new ARC engineering building which should be operational in 2023-2024 (estimates pre-COVID-19). The MDC will have access to a dedicated concurrent engineering room, with the capability to host dedicated workstation(s) for each SME required for a concept study and for running Poseidon. In addition to the main CE room, there will be two dedicated project rooms (see **Figure 1**). Each project room is a space dedicated to a specific concept study, with exclusive and ready access to the concept study team members. The current plan assumes that the project rooms are adjacent and linked with the main concurrent engineering room to facilitate the transition of the team from the project room to the CE room. The presence of two project rooms will allow for the MDC to conduct two concept studies simultaneously. Equally adjacent to the main CE room are two break out rooms to allow impromptu conversations between SMEs, PIs, and Management during a CE session cycle.

Training

Formal education and a typical engineering career does not usually prepare engineers (or scientists, or managers) for early concept exploration and maturation. It requires dealing with a wide range of options (trades), contrasting requirements, and in most cases it requires identifying the key driving mission requirements in collaboration with the Principal Investigator. Hands-on training and experience is the best teacher for this type of ever-changing work environment, but training dedicated to the key fundamental products, tools, and issues typically encountered is one way the MDC tries to prepare new personnel. The MDC started a pilot program of a series of seminars, one hour long on a weekly basis, to provide a common knowledge base for the initial candidate pool of SMEs for MDC concept studies. This pilot program, informally called the MDC Training Series, spanned for 31 weeks, from February to September 2020,

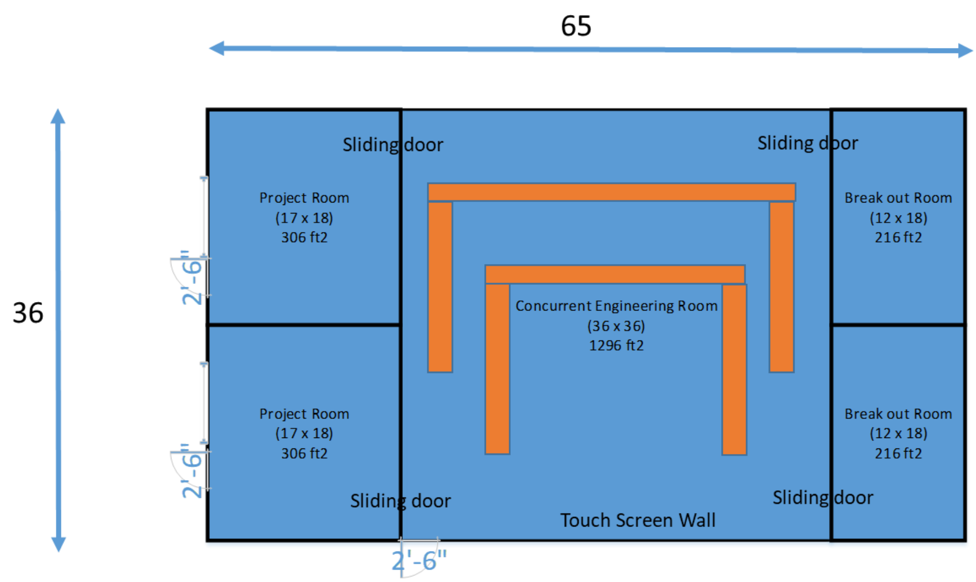

Figure 1. The proposed floor plan for the Mission Design Center in the new engineering building currently being planned at NASA Ames Research Center. Ames plans to have the new engineering building completed in 2024. Note the large concurrent engineering room which is adjacent to two project rooms. The project rooms are each dedicated to one concept study, giving the MDC capability of running two concept studies at the same time with dedicated spaces. The break-out rooms serve for impromptu meetings during the concurrent engineering sessions.

covering a wide range of topics relevant to early mission concept design. One secondary goal achieved by the training series was some foundational teaming, encouraging technical exchange and dialogue with one another, as many of our SME pool had never worked together before. The MDC Training Series was a huge success and its seminars were attended by personnel center-wide, as it provided a valuable training venue—especially in the early phases of the COVID-19 pandemic when NASA ARC moved to mandatory teleworking on March 6th, 2020[1]. The MDC is currently planning a second training series for 2021.

The list below summarizes some of the topics covered during the first edition of the MDC Training Series:

- Mission Concept development overview
- Concurrent engineering software tool: hands-on training
- Teaming exercise
- Primers[2] on the following disciplines:
  - Flight Dynamics
  - Propulsion
  - Communication, RF & Optical
  - Attitude Determination & Control Subsystem (ADCS)
  - Cost
  - Thermal
  - Mechanical
  - Technology Readiness Level (TRL) identification & assessment
  - Risk identification & mitigation
  - Mission Operations and Ground Data Systems
- Case Studies, both moderated & self-study

[1] The MDC team managed the transition from in person seminar to 100% on-line delivery seamlessly in the span of a couple of days.

[2] The primers aimed to give the team an overview of what was required by that specific SME. During the primer, the SME hosting the seminar put emphasis on the challenges s/he faced and, in particular, on the information needed from other SMEs. These seminars provided valuable insight to the SMEs as they better understood what their colleagues were asked to achieve and how their own discipline impacted others.

4. POSEIDON: A NEW TOOL LEVERAGING LESSONS LEARNED FROM ATLAS

The Mission Design Center has an existing CE tool, Atlas, that has been in use since early 2008. Atlas supports a single spacecraft per mission configuration, provides a SMAD-level [1] of analysis for each subsystem within that spacecraft, and is capable of automatically generating key system level summaries such as a Master Equipment List (MEL) and system level Mass and Power budgets. Atlas utilizes a client/server architecture using two separately maintained databases: a Mission Database for storing information about specific mission configurations and a Parts Database that stores part data and specifications. An Atlas mission configuration includes references to the parts selected for each subsystem of a spacecraft, and the parts data required to complete analysis for that subsystem is automatically pulled from the Parts Database. Most of the concurrent engineering logic behind Atlas resides server side, allowing for easier client development. Additionally, Atlas included advanced features that allowed parameters to be linked across missions or mission configurations by including a concept of inheritance.

The design and development of Poseidon has been heavily influenced by the experience gained over the past twelve years while developing, maintaining and using Atlas. Concepts that worked well, such as a client-server architecture, have been retained. Features that added excessive complexity resulting in seldom usage, such as inheritance, were dropped. Inflexibilities that hindered engineers' work flows, such as requiring the selection of subsystem parts to complete an analysis and the always-live CE paradigm (preventing engineers from working in draft mode or automatically ingesting changes without their awareness) have been upgraded. Additionally, a more user friendly interface has replaced Atlas's Excel front end (see **Figure 2**).

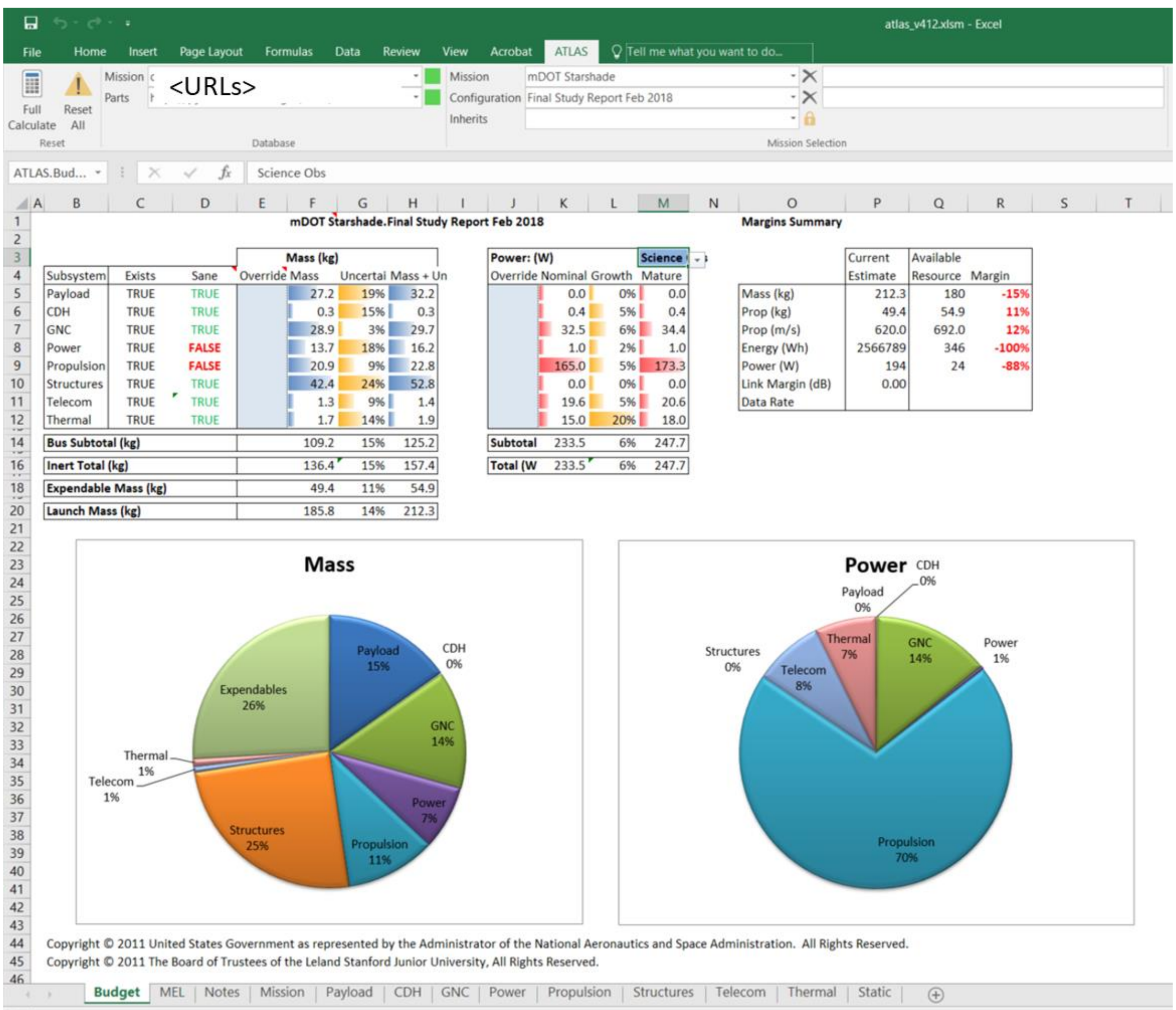

Figure 2. Atlas has been used for MDC concept studies since 2008 at varying levels of support and use since its inception. Many valuable lessons-learned from Atlas have been incorporated into the development of our newest tool, Poseidon.

5. POSEIDON: THE METHODOLOGY

The Mission Design Center needed a tool that would it allow to provide Ames a more effective and efficient way to assess early concepts for space missions both consistently and with high quality standards established. The typical study flow for a concept being raised from Concept Maturity Level (CML)1 to CML2[3] [2] is illustrated in **Figure 3**. The MDC Team is indicated via the blue boxes in the flow; efforts contained within the dashed purple marker are those which Poseidon is designed to facilitate in particular.

Central to the process of CE is configuration management of the study data. There must be a single verifiable, unique source for all information in use by the study team. A self-consistent study can only have one accurate value for each mission parameter at a given point in time within a current branch of the trade tree (e.g. the spacecraft cannot have two values for the dry mass at the same time). If two members of the team are using different values for the same parameter, or there are two different values for this parameter contained within current study documentation, one of the values must be invalid. Out-of-date or invalidated information such as this can be difficult to identify in-place in disparate calculations, the study report, or elsewhere that mission parameters are used or stored. Keeping all members of the team "on the same page" regarding what options are being analyzed and when is crucial.

Manual error checking comes at a cost to efficiency and, therefore, effectiveness of a study. Each individual self-checking their own work cannot find errors caused by miscommunication with others, from making inappropriate assumptions, or by using values which are obsolete. Implementing a process by which participants' work is checked for global accuracy (consistency with the "truth") can be time consuming to devise and implement. The former negatively impacts consistency, the latter impacts how deeply

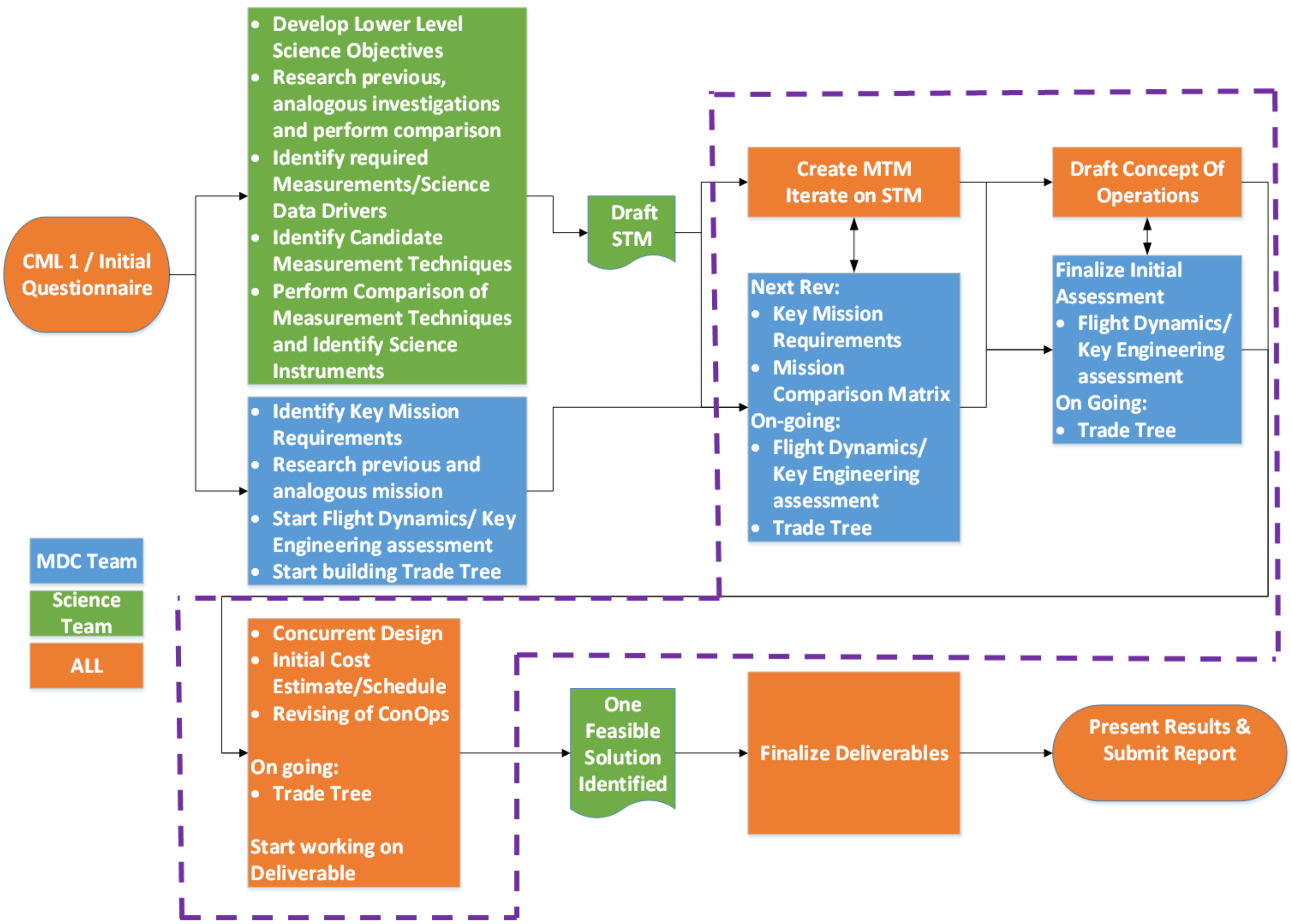

Figure 3. Notional process flow for raising a concept from CML1 to CML2. Poseidon is designed to support the MDC Team in performing the work indicated by the dashed purple outline in the figure.

[3] The MDC adopted the general CML framework from JPL; see [2]

a concept can be developed. Both, as a result, affect the quality of a study.

One efficient way to manage these erroneous values is by making the determination that there is one reference for all current, validated information about a study, and if a value outside of that reference conflicts with one on the inside, the one on the outside must be expired or invalid (configuration management). This validated information could be contained in a document, on a whiteboard, or in a designated software application. Poseidon utilizes the latter option as the most effective and efficient way for all participants to be accurately and concurrently engaged in a study.

To maintain the quality and consistency of each team member's work we have devised a client-database software schema. The client (front-end, back-end) is the user interface to each study, and the (mission) database stores all committed data. The committed data, as it exists on the server, is the authoritative information source. This architecture, coupled with change tracking and configuration management features, stores the users' input and retrieves up-to-date output (data) from other users. The retrieved data is presented in a way that allows other users, working concurrently, to fold this new data in to their own work without their own work (or the parameters upon which it relies) being overwritten or becoming invalid. Higher fidelity analysis relies on an additional (parts) database, from which (rows) components are selected and copied to the mission database.

There are several, low-fidelity quantitative assessments that can accompany a qualitative mission architecture to bring stakeholders and team members to the "same page." These nominally address the Size, Weight, Power and Cost (SWaP-C) of the payload(s) and spacecraft involved in a mission. A tool that can efficiently organize and achieve this stage of analysis, as well as effectively communicate this key information to the study team (between the Systems Engineer [SE] and the SMEs, bi-directional) will benefit from the SMEs being able to contribute their insight and experience to higher-level mission architectures. Consequently, study trades will be able to capture more meaningful architectures. The greater number of architectures that a team can assess in an effective way at the beginning of the program, the better options there are to choose from when the time comes for down-selection. The more developed a study trade tree is, the more it effective it is at illustrating the "best" architecture for a mission. The more time a team can spend developing the limbs of the study trade tree, the clearer that illustration becomes. With all of this information, including rationale, being captured in the same tool, trades that do not make this "first cut" can be revisited at a later date. If new information (change in constraints, etc.) is presented, it is more straightforward to assess whether it renders an alternate architecture more desirable.

Poseidon is designed to match the fidelity and rate of the analyses of all workspaces contributing to the space mission architecture during the concurrent engineering sessions. Up to four waves of analysis, with increasing fidelity and time-effort, straddle the study's concurrent engineering sessions. They are: Pre-Work, Preliminary Analysis, Subsystem-Level Analysis, and Component-Level Analysis; this is illustrated in **Figure 4**. Pre-work is performed by a sub-set of the larger

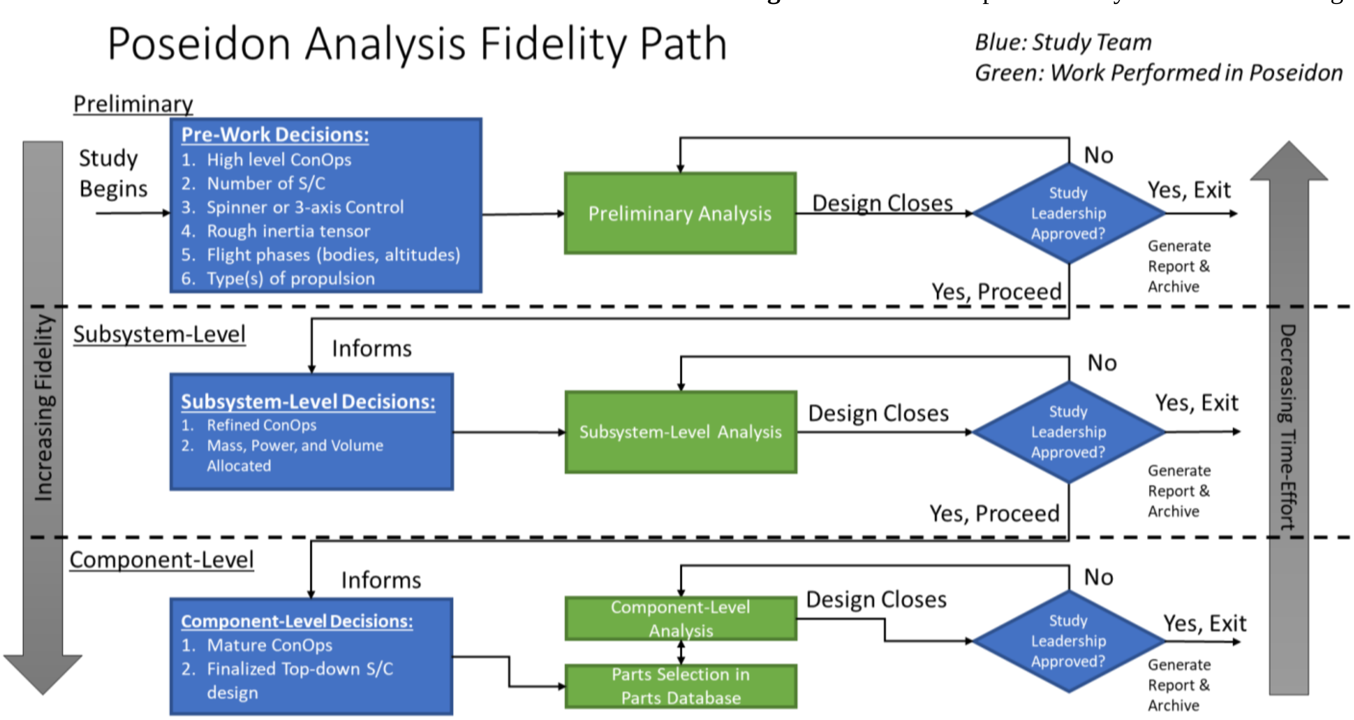

Figure 4. An agile, iterative process is used to increase the fidelity and maturity of each discipline analyses. Each of these different tiers is supported by Poseidon.

study team, in an iterative back and forth with the study PI; the result is instantiation of the key/distinguishing features of the study, captured as mission drivers. Preliminary Analysis is a rapid, top-down analysis performed by all members of the team; this develops and populates the main limbs of the study trade tree. Subsystem-Level analysis is a parametric, bottom-up analysis, wherein the SMEs parametrically reconcile their respective designs to one-another's while each remaining under the power and mass allocations set by the SE. Component-level analysis is performed by selecting hardware in the form of pre-defined "parts" from the Poseidon Parts Database.

6. POSEIDON: THE NEW FEATURES

Discussed in previous sections was the former MDC tool (Atlas), in what ways it fell short, and how the MDC has designed the architecture for a new, true CE tool. This section describes several of Poseidon's new key features, namely the new Mission Summary dashboard, re-architected workspaces, external tool support, and Commit process.

The **Mission Summary Dashboard** (see **Figure 5**) facilitates CE sessions by capturing the mission approach, implementation, system margins and other key metrics, as well as the development status for each of the workspaces. Fields are updated whenever a user commits a changed value from within any of the workspaces. The Study Lead can quickly assess progress and concerns, allowing the team's focus to be directed to highlighted issues.

The mission description table includes a column for listing assumptions, driving requirements, constraints, and trades. The second column captures SME input from within each workspace, showing the subsystem implementations which address items in the first column. The top three mission risks are also shown, color coded by the traditional red/yellow/green, for general team awareness (full risk information is captured on another page).

The discipline status field uses color-coded flags to indicate the stage of development for each of the discipline workspaces in the context of the current mission configuration. The status flags are set from within each of the workspaces. Statuses include "workspace unpopulated", "in-work (analysis)", "in-work (component selection)", "design closes", and "requesting help".

Allocations, calculated values, and resulting margins for cost, mass, power, and other key system parameters are captured in the margin table. Color-coding is used to highlight acceptable versus unacceptable margins and provides a quick visual indication towards design closure. A text field is provided for each line to include rationale or source information for the requirements. Beyond the defaults in the table, the SE can add additional parameters as needed.

Two mission graphic windows are used to display user-selected files. These can include any charts, diagrams, or tables that are useful for the entire team. Some examples include mission timelines, schedules, MEL, mission ConOps graphics, mechanical layouts with coordinate frame definitions, block diagrams, state of charge plots, etc. Each workspace provides an import function for contributing to the file library.

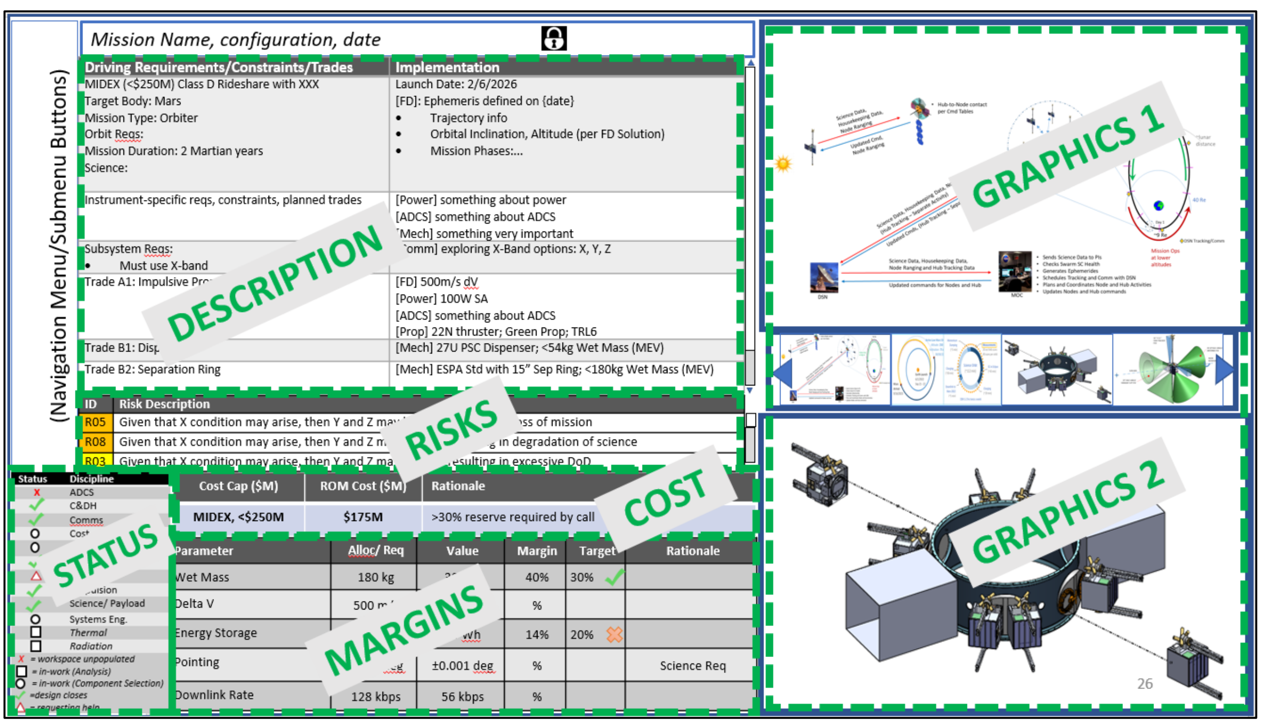

Figure 5. The Mission Summary workspace displays the mission level description and the configuration level implementations, including key metrics, graphics, and discipline workspace statuses.

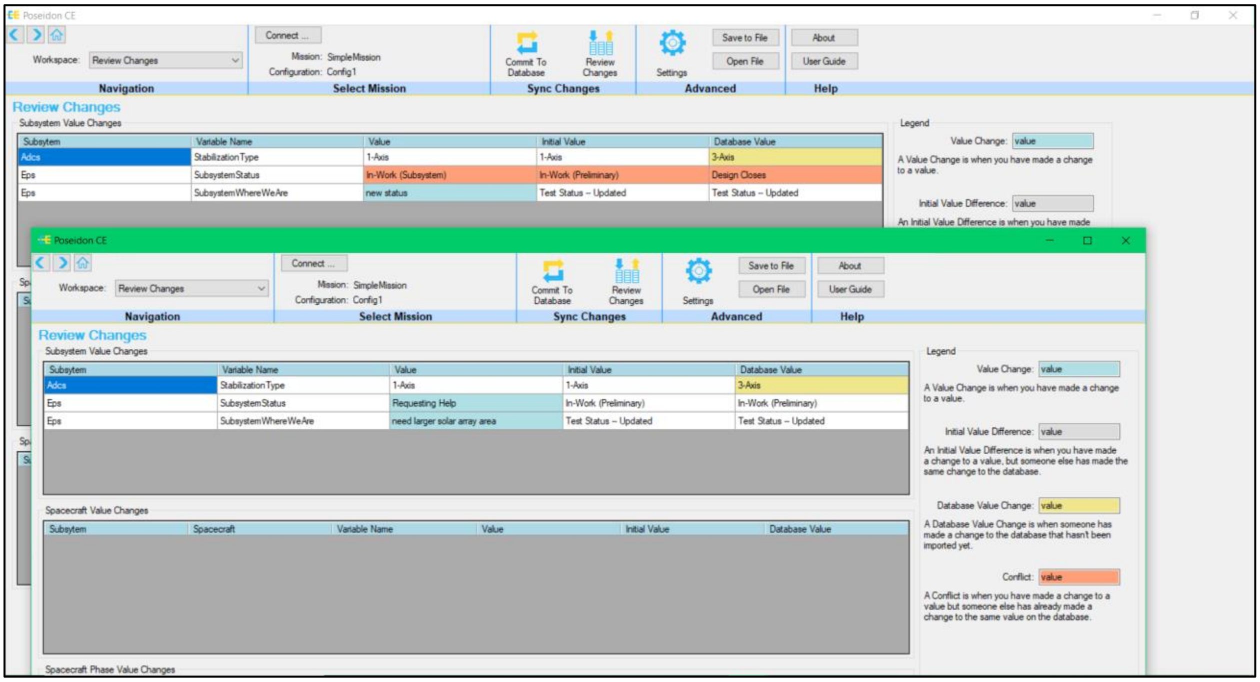

Figure 6. The Review Changes window enables review and resolution of conflicting values prior to committing changes.

Each discipline (including Cost and SE) has their own **tailored workspace** built around their needs (see **Table 1**) with validation by the SMEs who will be using the tool; supporting standard external interfaces where possible (such as STK, costing models, etc). Each workspace supports the waves of analysis described above (Pre-Work, Preliminary Analysis, Subsystem-Level Analysis, and Component-Level Analysis). The SME sets the status from within the workspace header. The status is then reported on the Mission Summary dashboard. The workspace configuration can be cloned to support an assigned system trade or to allow the SME to evaluate multiple configuration options at the SME's discretion. Workspace configurations can be saved to an external file for backup and reuse.

Every attempt has been made to keep the SMEs working within the tool, with new calculations and modules added to the tool as requested during ongoing SME focus sessions. The intent is to minimize the use of external calculations that will not be captured in the tool history. Tool tips are provided for each calculation to give the source and other pertinent information such as assumptions, limitations, or alternative approaches.

Interfaces with external development tools are being evaluated and implemented on a case by case basis. At a minimum, data import/export formats are used to facilitate data file exchange between Poseidon and tools such as STK, cost estimating tools, and PORT (Propulsion Optimization and Research Tool). Automation of these exchanges, where possible, will require ongoing development support to keep in step with external product releases.

Table 1. Poseidon tailors each workspace to the needs of discipline subject matter experts. Many of the traditional spacecraft disciplines are straightforward to implement; others require a more thoughtful approach. Several of these workspaces requiring additional feature design considerations are highlighted below.

Selected Workspaces	Key Features
Systems Engineering	Set technical resource allocations, interact with Trade Tree
Cost Accounting	Generates spreadsheet files formatted for ingestion with costing tools (SSCM, SEER-H & PRICE-H, PCEC) and uses a ticket system to allow SME to quickly track changes since last run of external tools
Flight Dynamics	Interface with STK Engine, with ability to start or edit existing scenarios, and see changes through the embedded STK graphics window
Propulsion	Will include same functionality as PORT (an internally-developed propulsion design tool) for subsystem sizing and hardware selection

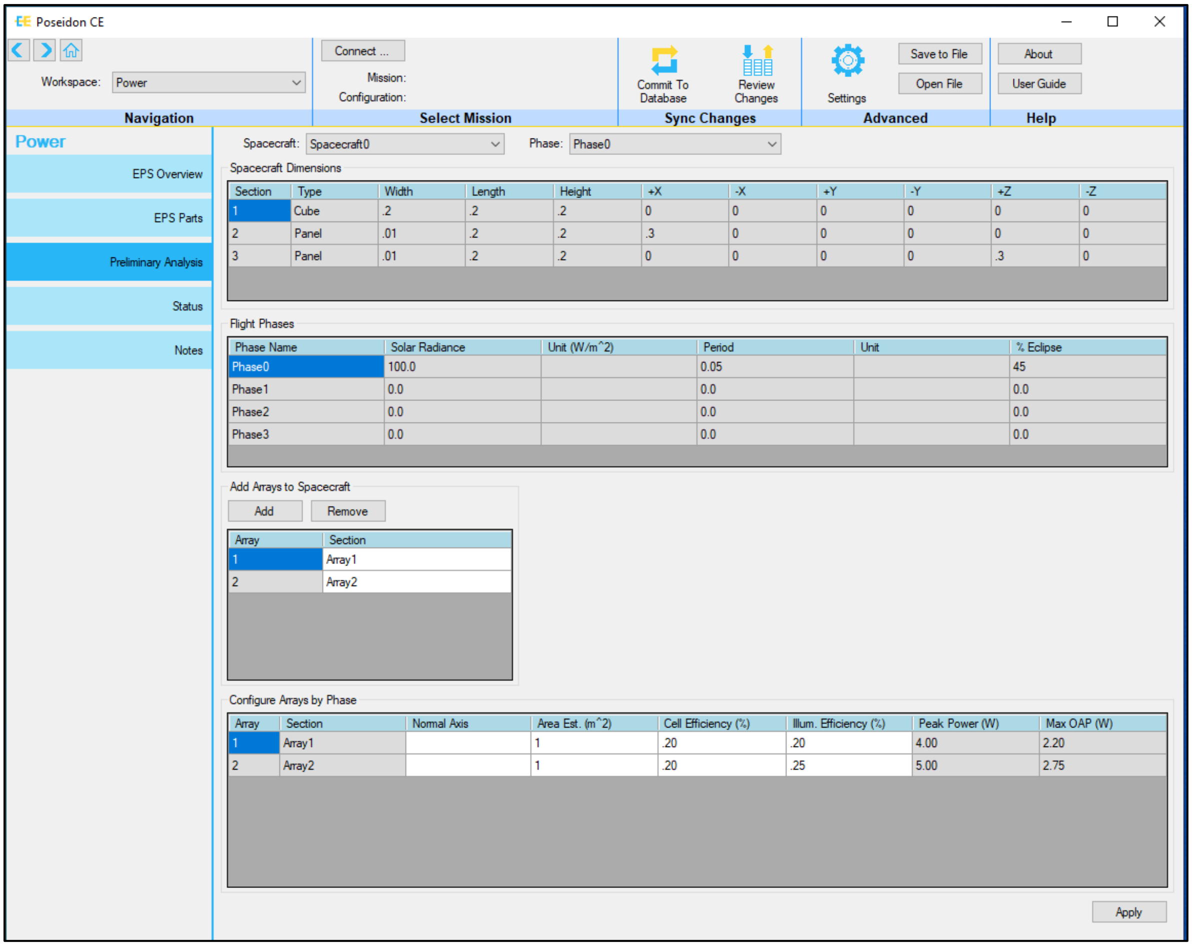

Figure 7. Placeholder screenshot of the Power Workspace in Poseidon as of September 2020. The Team plans to have all of the workspaces implemented to at least the Preliminary level for the December 2020 release. The Poseidon GUI is built in C# using Visual Studio.

A general file import function allows graphics and text files to be stored within the mission library. These are used to populate the graphics windows on the Mission Summary dashboard and are also available for inclusion in study deliverables. By default, the library includes placeholder graphics for simple system diagrams that will provide a prompt to the SMEs to update the files as development evolves for each configuration.

The **Commit** process ensures everyone is truly working concurrently, to identify conflicts and keep information current in an informed manner. **Figure 6** shows two instances of Poseidon, as what might be seen on two separate users' screens. Blue highlight indicates an area where one user (User A) has made a change within the tool since they have last synchronized with the Mission Database. Items that others (say User B) have changed since then are highlighted in yellow. In the rare circumstance where one user is trying to change a value to something different from what another user has changed (since last synchronization; here User A and User B are both trying to change the same value to a different new value), that field is highlighted in orange.

7. Poseidon: Implementation

As of September 2020, the MDC team had defined Poseidon's requirements (L1 through L3) and engaged stakeholders in the development of the requirements as well as with the development of the workspaces. The team had consolidated the overall architecture, opting for a non-relational document oriented database (NoSQL) and XML based datastore. The XML schema partitions data as being related to either Subsystem, Spacecraft, or Phase. Each variable is assigned a key and a value. When the XML file is read, the keys are used to read the variable's value. If a new variable is added to the tool, the key will not be in the XML save file. Poseidon will then assign any missing variable the default value, and they will be included in saves going forward. This prevents old saves from becoming obsolete and forcing designs to start over every time a new variable is added to the tool. Development of the database is underway and an initial capability for comparing two configurations is already present.
The front-end GUI has been created for key workspaces and pages; see **Figure 7** which shows the Preliminary Analysis Page for the Power Workspace. The GUI uses C# with Visual Studio, and the application is currently only available to the

development staff. The team had designed a core set of workspaces (Electrical Power Subsystem [EPS], ADCS, Telecommunications, Propulsion, Mission Summary, Cost, Structures & Mechanisms) and three levels of analysis: preliminary, subsystem and component. Preliminary analysis fidelity is well underway, with a target completion date of December 2020. The initial design of other workspaces (e.g. Thermal, Radiation, SE) is complete, with plans for further development and implementation in place. An early-release version of Poseidon is being created for early 2021 use and collection of feedback prior to implementing higher-level fidelity.

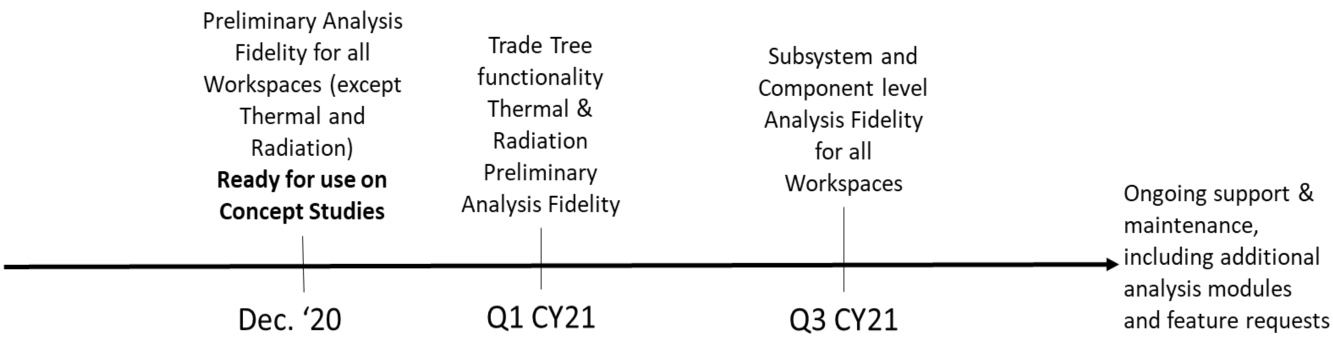

Figure 8. Notional timeline for Poseidon implementation

Poseidon has a shared, top-down architecture and vision for future development, with ongoing resources accounted for. The team designing and implementing Poseidon has also outlined a plan for ongoing improvements, new feature additions (many already designed and articulated), and regular maintenance. For example, for the year 2020 Thermal and Radiation workspaces will only be placeholders, used by SMEs for staying in communication with the rest of the team; one of the additions early in 2021 will be the implementation of those tailored workspaces (see **Figure 8**). For all disciplines, supplementary modules which support different analysis methodologies for the different disciplines—support of additional costing tools, different methods for calculating a link budget, etc, are envisioned. These modules will look like additional pages within a workspace and will support varying levels of analysis fidelity. In conjunction with this (primarily back-end) work, efforts to support several external tools which were beyond the scope for 2020, such as supporting interfaces with SPENVIS (for radiation analysis) and with STK are being planned. A key module which will be addressed is the inclusion of the ARC-developed PORT tool (used for propulsion subsystem sizing) and its supporting hardware database into the Poseidon framework. The ability to hold multiple versions of each workspace within a particular Mission Configuration, thereby enabling efficient exploration of several subsystem trades, is also in development thanks to funding received by the MDC team from a competitively-selected Ames Center Innovation Fair award. Additional collaboration features are also planned, such as the ability to see which other users are actively working within a Mission Study and where they are making modifications. Higher support of deliverables generation and calculation transparency are also on the list of future plans.

8. SUMMARY

The transformation of the MDC towards a Concurrent Engineering Center stemmed from the realignment of the MDC within the Spaceflight Division and overall within the NASA Ames Research Center. The transformation aims to turn the MDC into a proper CEC, founded upon four core pillars: Personnel, (physical) Space, Tools and Training. Here we have focused on the third pillar, the Tool, and in particular on the development of a new concurrent engineering tool: Poseidon.

Poseidon is currently (September 2020) under development. The MDC team estimates to release a version to users by the end of 2020 for in situ proof-of-concept testing in early 2021, followed by additional versions which include the upgrades and feature additions already identified for a fully-fledged version. Poseidon builds on the knowledge and lessons learned acquired developing and using the legacy concurrent engineering tool Atlas. Poseidon introduces a series of new features, such as the ability to perform parametric sizing of a spacecraft, the addition of dedicated working spaces for Systems Engineering, Mission Summary and Cost Accounting, as well as the feedback loop on changes via the "Commit" capability. The database implementation will allow users to do analysis on their own without being forced to accept other users' changes. Then users can synchronize their results with the team when ready. Additionally, the flexibility of the XML schema allows any future changes to the tool not to corrupt old designs. Early on in the process, the MDC team deliberately chose a development path which included deep involvement of the SMEs and other stakeholders to foster buy-in and generate insightful feedback. Once the full as-designed version of Poseidon is released (anticipated late 2021), the MDC plans to maintain an ongoing maintenance effort to continuously address feedback and proactively improve it. Consequently, the MDC will have a tool supporting the concept study effort in a more cost-effective, time-efficient, technically-accurate and consistent manner. We hope that this spurs a new age of concept development and subsequent proposal development efforts for the community.

Acknowledgements

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Biography

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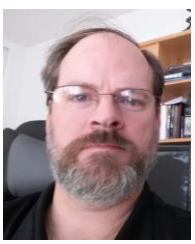

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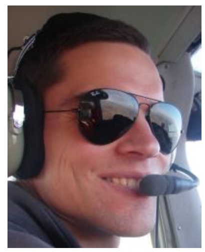

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