Psyche
Independent Review Board
Briefing for Planetary Science Advisory Committee

December 5, 2022

Psyche IRB Charter

- Determine project, institutional, and all other issues that were responsible for the Psyche launch delay.

- Determine why there was a lack of visibility into the factors driving this launch delay.

- Review Psyche's path forward to maximize the probability of mission success.

- Identify lessons learned with utilizing the Maxar commercial bus.

- Determine if Psyche issues are unique to Psyche or indicative of broader JPL institutional issues.

- If broader institutional issues are identified, determine corrective actions appropriate for current and future missions.

Psyche Overview

- Competitively awarded, cost-capped, Principal Investigator (PI)–led Discovery class mission:
    - PI: Lindy Elkins-Tanton, Arizona State University
    - Selected for implementation in 2017
    - Mission total cost approximately $1B
- Scientific objective is to study the unique metal-rich Psyche asteroid.
- Project management is performed by JPL, as proposed to NASA by the PI.
- Program management is provided by the Planetary Mission Program Office at Marshall Space Flight Center for NASA's Planetary Science Division.

Psyche
Findings and Recommendations

Psyche Findings and Recommendations

General

Findings

- IRB agrees that late Guidance, Navigation, and Control software delivery and lack of testbed maturity are the proximate causes of the Psyche launch delay.

- IRB assessment is that additional issues could have led to a launch delay on their own:

  - Open flight software issues

  - Incomplete verification and validation (V&V), including fault protection

  - Operational readiness

Psyche Findings and Recommendations

General

<u>Recommendations</u>

- Develop plan forward that prioritizes and completes development activities.

- Establish a new launch date with sufficient margin to have high confidence in success.

- Review work performed in last several months before the launch delay to assure it is at the required level of excellence with no embedded problems.

- Conduct a detailed review and assessment of "use-as-is" problem dispositions and "unverified failures."

Psyche Findings and Recommendations

Management and Communications

<u>Findings</u>

- Major communication failures on Psyche resulted in project management not recognizing the seriousness of issues until too late to resolve them in time for a 2022 launch.

- Psyche team members raised alarms but felt their concerns were not being heard and/or acted upon at multiple levels of management.

- No formal Independent Technical Authority (ITA) dissents were raised on Psyche.

- A culture of "prove there is a problem" led to important issues raised by team members being disregarded.

Psyche Findings and Recommendations

Management and Communications

<u>Findings, cont'd</u>

- Senior management changes in JPL's Planetary Science Directorate, including three leadership changes and a reorganization within the last two years, had an adverse effect on Psyche.

- Senior and Line management did not recognize Psyche development problems in time to take corrective action to prevent the launch delay.

- Senior management did not penetrate project execution sufficiently to recognize seriousness of the development issues.

- High demands on management's time to continually balance staffing requirements contributed to the launch delay.

Psyche Findings and Recommendations

Management and Communications

Recommendations

- Establish and implement processes to assure open, credible, and responsive communications both vertically and horizontally throughout the Psyche Project.

- The JPL Director, senior management, and Line management must establish and implement processes that assure significant insight into flight-project execution and participation in resolution of problems and risks.

- The role of the Line management function in elevating concerns needs to be emphasized and strengthened.

- The workforce should be trained that the ITA should be used for elevating unresolved issues of any nature, including programmatic.

Psyche Findings and Recommendations

Staffing

<u>Findings</u>

- Multiple staffing issues resulted from JPL having more project work than can be supported by the available workforce:

  - Inexperienced managers and technical personnel in multiple project positions

  - Worker burnout

  - Inadequate staffing

  - Excessive number in stretch assignments

  - Lack of mentoring

  - High turnover

- Key project positions were not staffed:

  - Lack of a Project Chief Engineer

  - Lack of a GNC Cognizant Engineer (CogE) contributed to late GNC subsystem technical definition, development, and testing

Psyche Findings and Recommendations

Staffing

Recommendations

- Provide additional 10–12 full-time, experienced leaders at all levels of the project.

- Adequately supplement and maintain project staffing to support the replan.

- Special attention should be given to assigning/maintaining a Project Chief Engineer, GNC CogE, and Fault Protection Lead Engineer.

Psyche Findings and Recommendations

COVID-19 Related

<u>Findings</u>

- COVID-19 is a contributing factor to the issues that led to a launch delay and the lack of visibility of these issues within JPL.

- Resulting remote work substantially reduced informal communications:

  - "Walking the floor" and "drop-in discussions" did not happen.

  - Various teams within Psyche became more isolated.

- Remote and hybrid work arrangements persist and pose a high risk to remaining Psyche Project development.

Psyche Findings and Recommendations

COVID-19 Related

<u>Recommendations</u>

- Reestablish informal communications, such as "walking the floor" and "drop-in discussions."

- Remote and hybrid work must be minimized on Psyche to give the team the best opportunity to coalesce in a short time.

Psyche Findings and Recommendations

Project Metrics

<u>Findings</u>

- Lack of meaningful progress metrics and risk assessment hindered visibility into, and the ability to highlight and elevate, issues.

  - Inadequate and unrealistic Integrated Master Schedule minimized the value of traditional "actuals vs. plan" metrics to assess progress.

  - Risk assessments did not accurately communicate project health (i.e., many yellow risks, no red risks). Based on interviews, there was an aversion to "going red" by project management.

  - Project schedule and progress-tracking metrics masked true development status.

- Project focused on hardware development and problem resolution, and neglected software and other non-hardware areas of activity.

Psyche Findings and Recommendations

Project Metrics

<u>Recommendations</u>

- Develop a detailed, integrated, resource-loaded, and adequately margined and verified schedule for all remaining work.

    - This must include sufficient task completion milestones in key areas like V&V, system integration and test (I&T), and mission ops preparations, such that progress in these areas can be readily tracked.

- Establish and implement a management information and reporting system that produces a credible and timely assessment of status, risks, and issues against this integrated baseline (described above).

Psyche
Summary and Conclusions

Psyche Project Summary and Conclusions

- Psyche is a project with significant scientific merit, which can greatly contribute to our knowledge of a unique class of metallic asteroids and add to our understanding of the solar system.

- The PI set a commendable tone of collaboration from the project's outset and continues to prioritize relationship building with project team members at all levels.

- Psyche's issues are much more extensive than originally understood when the launch was delayed. These include but are not limited to:
  - Significant staffing shortages and insufficient personnel with relevant experience
  - Communications issues
  - Hybrid work schedules
  - Software and system testbed development
  - V&V, including fault protection system
  - Operational readiness
  - Shortcomings in programmatic metrics

- Psyche issues require significant corrective action, including the addition of new, experienced personnel at all levels of the organization.

- Many Psyche issues are the direct result of JPL institutional issues.

- COVID-19 was a contributing factor in the various Psyche issues.

- **The IRB has reviewed the go-forward plan and believes JPL has established an executable plan for a 2023 launch.**

JPL Institution – General Observation

Many Psyche issues are not unique to Psyche and are indicative of broader institutional issues.

JPL Institution
Findings and Recommendations

JPL Institution Findings and Recommendations

Flight Project Workload

<u>Findings</u>

- JPL currently has an unprecedented workload with the concurrent implementation of 6 large spaceflight projects, plus numerous smaller missions and scientific instruments:

  - Two projects are Flagship class (Europa Clipper, Mars Sample Return).

  - Two projects are Discovery class (Psyche, VERITAS).

  - Two projects have significant payload development efforts (SWOT, NISAR).

- Large imbalance exists between workload and available JPL resources:

  - Most acute in lack of experienced managers; systems engineers; and GNC, FSW, and Avionics engineers

  - Imbalance represents a root cause for the Psyche issues

  - Adversely affects all flight project activity at JPL

JPL Institution Findings and Recommendations

Flight Project Workload

Recommendations

- Flight projects must be fully staffed with appropriately experienced personnel from the beginning, particularly in Systems Engineering, GNC, FSW, and Avionics.

- Balance must be achieved between the workforce needs of flight projects and the available JPL workforce.

  - Timing of achieving this balance is critical.

  - Psyche is an example of the major problems this imbalance is causing today.

- IRB believes that by the end of March 2023, significant corrective actions must be implemented to achieve balance.

- For any corrective actions requiring more time, a detailed plan of action must be developed and approved by JPL, Caltech, and NASA.

Options to Achieve Workforce Balance within JPL

- No new flight projects until balance is achieved

- Cancel, redirect, or delay a flight project

- Transfer required talent from non-flight projects within JPL to flight projects

- Focused personnel training and development in key areas

- Significantly increase use of industry prime and support services contractors

- Increase use of and collaboration with other NASA Centers

- Aggressive recruitment and hiring

- Accept the risk of layoffs

JPL Institution Findings and Recommendations

Line Organization Issues

<u>Findings</u>

- Significant erosion of technical acumen in the Line organization:

  - Prevents Line organization from adequately engaging with flight projects, independently assessing status, identifying problems, working with projects to develop solutions, and providing mentorship.

  - Represents loss of critical safety net.

  - Technical leadership has migrated from the Line organization to the flight projects.

  - Without this Line organization capability/safety net, Psyche issues will become the norm and not the exception.

  - The IRB recognizes the institutional need for more experienced managers and lead engineers is a primary cause of this erosion.

JPL Institution Findings and Recommendations

Line Organization Issues

<u>Findings, cont'd</u>

- Division 31 (Systems Engineering) and Division 34 (Autonomous Systems*) issues:

  - Modern space systems are complex, highly integrated, and rapidly evolving, especially in the domains of these two divisions.

  - The magnitude of responsibility in these technical areas has necessitated the partitioning of their work into two divisions.

  - Ambiguity and confusion exists between the two divisions in terms of roles and responsibilities and accountabilities.

  - The hybrid work environment has exacerbated these issues.

  - Both are critically understaffed, especially in terms of engineers with flight project experience.

* Division 34 includes the Avionics, FSW, GNC, and Robotics product areas for JPL.

JPL Institution Findings and Recommendations

Line Organization Issues

<u>Recommendations</u>

- Repopulate the Line organization with experienced leaders and engineers to reestablish the Line organization as an equal partner with flight projects during implementation.

- Add experienced people and include them in the effort to achieve balance.

- Address the Division 31/34 staffing, accountability, and coordination issues.

- Continually examine the issues between and within Divisions 31 and 34 because of the importance of these Divisions to the execution of flight projects.

JPL Institution Findings and Recommendations

Senior Management Engagement

<u>Findings</u>

- JPL senior management did not adequately penetrate Psyche Project status.

- The large number of small projects, instrument developments, etc., dilutes JPL senior management's attention, contributing to a lack of appropriate levels of engagement in the execution of major flight projects.

- JPL's management review process and tracking metrics during the critical prelaunch period are inadequate.

JPL Institution Findings and Recommendations

Senior Management Engagement

<u>Recommendations</u>

- JPL senior management must establish regularly scheduled meetings, formal and informal communications, and "drop-in" visits to facilitate necessary engagement on major flight projects, communicate priority, and maintain cognizance of status.

- Prioritize the large number of activities competing for senior management's attention to focus on those in greatest need and importance such that commitments to NASA and the various stakeholders are met.

- Senior management should develop and codify in JPL's Flight Project Practices the metrics that will be employed for tracking progress, especially during system I&T and V&V.

JPL Institution Findings and Recommendations

Hiring and Retention

<u>Findings</u>

- JPL is experiencing difficulty attracting and retaining necessary experienced workforce, especially in critical areas such as Systems Engineering, GNC, FSW, and Avionics.

- Local competition and aggressive hiring from commercial space firms and start-up firms have changed the position of JPL and its competitiveness in hiring, including compensation and remote work options.

- Incoming workforce has different expectations about career opportunities and mobility.

JPL Institution Findings and Recommendations

Hiring and Retention

Recommendations

- JPL must develop the capability to successfully hire and retain mid-level people in this new environment.

- JPL must develop approaches for the career growth and retention of critical and high-potential personnel.

- JPL must characterize problems with retention and develop incisive and decisive actions to address the identified problems.

JPL Institution Findings and Recommendations

Hybrid Work Environment

<u>Findings</u>

- The current JPL policy for remote and hybrid work will have an adverse impact on flight projects.

  - Remote/hybrid work heightens barriers between sub-teams, which impedes communication and integration.

  - Without appropriate in-person interaction, remote/hybrid work can increase miscommunications and create reporting problems up the chain.

  - Physical access to shared resources, i.e., testbeds, helps build team rapport and familiarity with the spacecraft.

- At present, it is difficult to estimate the impact of remote/hybrid work on flight project schedule and budget planning.

JPL Institution Findings and Recommendations

Hybrid Work Environment

<u>Recommendations</u>

- JPL should immediately revisit its policy for hybrid work to make it more effective and better reflect the evolving needs of flight projects in different mission phases.

- Carefully consider which tasks, project phases, and circumstances permit hybrid and remote work arrangements.

- Any hybrid work arrangements should recognize the need for in-person interactions. In addition, it is critically important that early-career employees work alongside seasoned employees for their long-term development.

- Inefficiencies in productivity and communications associated with hybrid work must be included in the workforce, cost, and schedule plans for flight projects.

JPL Institution Findings and Recommendations

Caltech Governance

Findings

- There are deficiencies in Caltech's awareness of flight project status and progress.

- Caltech hasn't been sufficiently engaged in helping JPL address its workforce challenges.

Recommendations

- Caltech should have a better understanding of the JPL institutional issues and play a supporting role in addressing them.

- JPL should strengthen the quality of flight projects status presentations to Caltech.

- Caltech should develop a more rigorous annual review and evaluation approach for the performance of the Laboratory Director.

JPL Institution
Summary and Conclusions

JPL Institutional Summary and Conclusions

- JPL Institutional issues:
  - Inadequate flight project staffing, in both number of personnel and experience
  - Erosion of Line organization technical acumen
  - Insufficient JPL senior management engagement in flight projects
  - The post-pandemic work environment
- These issues are having a significant adverse impact on the implementation of JPL flight projects.
- Many of Psyche's issues are a direct result of the JPL institutional issues.
- Corrective actions are urgently needed, and failure to act will result in more "Psyches" and potentially in-flight failures.