Peregrine Sustainer Motor Team

The motor was in the test stand. In a few seconds the team would find out how well all the analysis, planning and manufacturing fit together. The start was right on target, the thrust coming out of the solid rocket motor was smooth and strong. Then after 7 seconds, those with a trained eye could see the thrust drop off too soon. The audience saw the exciting smoke and fire of a solid rocket the motor. The Peregrine team saw that a great start did not mean a great finish. The aft closure had a burn through and the investigation began.

Dare to Try – The Marshall Space Flight Center (MSFC) Peregrine team was tasked with designing and developing a new innovative sustainer rocket motor for use on NASA's Sounding Rocket Program (NSRP) flights. The scope of the project involved vehicle development including fins, tail cans and interstage hardware. Working with Wallops Flight Facility (WFF) through Goddard Space Flight Center (GSFC), an aggressive schedule was agreed upon to meet agency mission needs and constraints (e.g. cost and schedule). The Project team developed a forward-leaning risk posture and streamlined development approach commensurate with the sounding rocket program philosophy which focused on decreasing time and money for development. Specifically, typical development and qualification plans for solid rocket motors take up to four years, require multiple development and ground test before achieving the first flight test data. The Peregrine team condensed the test phase of the project to only one ground test, and moved to achieve flight ready motors very soon after the ground test. This approach required an aggressive schedule, with several engineering and design functions being run concurrently. The risk posture was embraced by the Sounding Rocket Project, because it reduced the overall cost of program and achieved first flight model which could validate the design better than ground tests.

Peregrine (Second Stage) Flight Vehicle

Typical of development projects, the design was slow to start, and could have easily become cumbersome to maintain. The challenge from the MSFC Engineering Directorate was to move the design as quickly accepting in some cases a "best guess" on structural design with the analysis to follow. Proceeding with released drawings was a risk the project accepted as a means to start production early. As the design matured so did the analysis and in most cases predicted acceptable margins. Uncertainly in the design would always exist until the first static test motor test.

Perseverance - Structuring a multi-center project required several enhanced communication architectures. As manufacturing problems arose, the team set up a quick-acting Material Review Board to keep the hardware flowing. The project was modeled as a partnership between government and industry tapping all resources relating to solid rocket motor designs. As the design moved to the production phase, the manufacturers were encouraged to provide less costly answers to design compliance and overall operations. In the instance of the motor case, the manufacturer provided an extruded tube rather than a rounded plate. This not only saved cost by eliminating a weld joint but avoided a significant schedule issue with the heat treatment. The effort took the form of "how it could be done", not a "just follow the drawings". Again, this team was taking the appropriate and forward-leaning risk posture for the project. The drive to complete project on time made the team to come up with creative ways for manufacture.

The next day, after the static test, was a time to regroup. The team was disappointed as should be expected with any test failure. But in true NASA form, we put aside the disappointment and started the analysis necessary to determine the root cause. Support for the investigation came from many corners of the agency and helped to lift the spirits of the team. Meeting on regular basis, bringing the important findings to the team, and having the interest of many at both WFF and MSFC, gave the Peregrine team the drive to preserve and complete the investigation in as little as 8 weeks.

Learning - Several technical concerns remained for the single static test, so the team fully instrumented the test article, and set up Infrared (IR) cameras and high speed video. The motor case burn through occurred during the test, and the IR data was instrumental in determining the cause. The Peregrine team worked hard to identify the potential failure mechanisms, determine root cause and provide potential solutions to retrofit the remaining assets for further static and/or flight testing. The same rigor was applied to this test anomaly as any standard investigation requires, but again keeping costs in check (e.g. only tests that could significantly enhance the investigation were accepted). All team members were engaged in the failure analyses, providing timely input to the failure board. Having diverse team members created a true multi assessment of evidence and lead to concise conclusions.

Nominal Burn and Burn through on aft end

Using the appropriate insight and expertise, root causes and mitigation actions were recorded. The first retrofit motor to be tested at WFF incorporated appropriate instrumentation, design modification and IR cameras/set-up. Those mitigation actions are being tested now with both MSFC and WFF partners engaged. The Peregrine project proved and met many of the program objectives. It would have been easy to stop at the static test failure, but the strong NASA desire to understand and learn from failures made this failure a success in growing and improving a streamlined process to dare and try a better way for propulsion.

Collaboration - Under exceptional leadership from MSFC engineering and WFF program management, a team was organized and efforts were made to include junior engineers for this hardware development program. A streamlined approach to meeting requirements of NPR 7120, a communication plan across centers, and a board structure to resolve technical issues were implemented. This saved time and money while maintaining appropriate rigor/technical excellence. Collaboration from the project team, design engineers, and manufacturers provided avenues for new ideas and “better ways of manufacture” to work their way into the design.