NASA HEADQUARTERS
SCIENCE MISSION DIRECTORATE
JOINT AGENCY SATELLITE DIVISION

JPSS-2 – LOFTID Best Practices Report

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1. Acknowledgements

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2. Purpose and Workshop Overview

The Joint Polar Satellite Sysytem-2 (JPSS-2) - Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) best practices (BP) workshop occurred over two days, on February 15th and 16th hosted by the Launch Services Program (LSP) at Kennedy Space Center (KSC). Led by the Joint Agency Satellite Division (JASD) JPSS-2 Program Executive, the workshop served as an opportunity for all members of the JPSS-2/LOFTID teams, which included Program and Project managers, mission managers, chief engineers, and contractors, to collectively reflect upon and discuss key elements across the lifecycle of the missions, and identify what factors led to the successful launch.

In the past, NASA has learned from both mission success and launch failures, and as a result, there is an organizational impact related to each mission at NASA, and in particular the JPSS-2/LOFTID launch. There were complexities related to these missions that made them unique and yet the fundamental elements remain similar in so many capacities to other missions – rideshare, relationship between Primary and Secondary, and communication, cost, and schedule implications.

Workshop participants were encouraged to submit topics in advance for discussion ideas, which were then added to the agenda. Each participant offered their own unique perspective but also contributed to the overall collective, complex, dynamic, and collaborative success of this launch. The pertinent mission management information and knowledge collected is intended to be shared across JASD, the Science Mission Directorate (SMD), and ideally throughout NASA so that others may leverage from this experience and potentially implement the success criteria and processes into future similar missions.

In total, the two-day workshop had 20+ attendees, both in person and virtual via Microsoft Teams, with representation from over 7 organizations:

- NASA Headquarters
- Goddard Space Flight Center (GSFC)
- Langley Research Center (LaRC)
- Kennedy Space Center (KSC)
- NASA Launch Service Program (LSP)
- United Launch Alliance (ULA)
- Booz Allen Hamilton Knowledge Management Team

The workshop was organized around main topic areas: Programmatic, Technical, and Communications/Stakeholder Engagement, and outlined as 1) Pre-Launch and 2) Launch Week/Site activities. The main goals included:

- ✓ Discuss the successes factors and criteria of the JPSS-2-LOFTID launch
- ✓ Discuss major challenges and lessons learned (LL)
- ✓ Document key takeaways, identify trends and highlights to be shared, as well as identify gaps and areas for improvement

Purpose of the document: While the JPSS-2/LOFTID launch resulted in a success for both missions, both teams faced numerous challenges along the way such as the COVID-19 pandemic, staff changes, rideshare mission difficulties, and launch day anomalies. This report provides details how the various teams and stakeholders navigated these challenges together, which led to a successful launch. The hope is that this successful experience can serve as an example for other NASA-rideshare missions and provide BP and LL that can be used

across the Agency to ensure the continued success of all NASA missions. *In particular, this was an especially critical launch because the JPSS-2 and LOFTID rideshare partnership ultimately allowed for both missions to accomplish their science goals.*

3. Overview of JPSS-2 & LOFTID

In the early morning of November 10th, 2022, National Oceanic and Atmospheric Administration (NOAA)'s JPSS-2 and NASA's LOFTID launched aboard an Atlas V 401 rocket from Vandenberg Space Force Base in California. On November 16th, the JPSS-2 satellite officially changed name to the NOAA-21 satellite whose mission involved reporting data to help scientists forecast severe weather such as blizzards, hurricanes, tornados, and wildfires. NOAA-21 orbits the Earth 14 times a day with an altitude of 512 miles to track the following: Water Vapor in the Atmosphere; Temperature across the Earth; Health of the Ozone Layer; Smoke, Ash, Dust, and other particles in the atmosphere; Greenness moisture and plane temperature; and Flooding, Power Outages, and more in severe weather events

To accomplish this data tracking, NOAA-21 houses 4 major instruments. In sum, all four instruments convert their weather data into radio waves to be sent to ground stations across the globe. NOAA collects, manages, and disperses all the weather data so that the public can benefit from all the information their weather satellites provide. While NOAA manages the weather data, they also provide the funding and requirements for the satellites they want built. JASD within SMD takes in the requests from NOAA and leads the effort to acquire and develop the space systems that match NOAA's needs as well as meet the NASA 7120.5F requirements. Due to the success of NASA in building hundreds of space instruments in accordance with 7120.5F requirements, NOAA trusts NASA and specifically, the JASD team to handle many of their satellite needs. The two organizations have worked together to build and launch satellites for over ten years and have plans to continue working together for years to come. The success of the JPSS-2/NOAA-21 satellite program continued the string of successful launches and shows the value of having the two organizations work together.

For the launch, JPSS-2 sat atop the Atlas V rocket with the LOFTID payload sitting underneath JPSS-2. After launch, JPSS-2 planned to separate at 28 minutes. At 66 minutes, LOFTID would power on and 9 minutes later would separate. LOFTID served as a demonstration that an inflatable aerodynamic decelerator technology could help land humans on Mars in the future. NASA's Space Technology Mission Directorate worked with ULA for the LOFTID mission. The LOFTID design presented a step forward in deceleration technology with the LOFTID re-entry vehicle measuring in at 19.7 feet, the largest blunt body aeroshell to ever go through atmospheric entry. LOFTID had the goal of decelerating from hypersonic speed to subsonic flight (under 609 miles per hour). It was the first orbital flight with heat shield

4. Workshop Key Takeaways

This section outlines the most important key messages collected during the workshop, and includes trends, BPs, and recommendations related to programmatic, technical, and communications issues.

- The most critical takeaway of the workshop that directly impacted the success of the mission launch was the ability to establish commitment to the mission, continuous team building, and recognition in the strength of positive working relationships, which drove collaboration and mutual respect across all teams.

No doubt technical expertise contributed to the launch success, but the overall sentiment was that by clearly defining roles and responsibilities, establishing commitment, mutual respect and open communications resulted in an environment of trusted partnerships across all teams that lead the JPSS-2/LOFTID mission's success. The teams were complex and diverse in experience, skill sets, location, and expertise. However, collectively they succeeded because there was a shared vested interest from all in the success from the beginning and continued until launch of each mission.

A few opportunities were also identified for future missions based on this launch:

- **Culture of Trust:** Recognize that **open, transparent communication styles from all team leads is fundamental** to creating and establishing an **environment of trust and respect** across all teams
  - o Missions should identify tools, training, and methods such as reviewing lessons learned to establish this skill and enhance it across the teams; teams should also **create regular feedback loops** and discussions to address any concerns or improvement areas as all must lead by example and be able to recognize where growth and learning opportunities might exist
- **Resource Sharing/Rideshare Training: NASA's Rideshare Users Guide (RUG) and other helpful resources** related to rideshares and mission LL should be readily referenced, socialized, and shared amongst all mission teams
  - o **Consider establishing a common knowledge management process with clear resources and communications outline that is set up at the start of missions** to ensure all teams are informed, have the right resources, expertise, and tools available and continuously accessible
- **Team Expertise: Evaluating skill sets, experience and learning gaps prior and during** the mission is critical to avoid any mishaps especially at the last minute or later in the timeline, both at centers and launch site
  - o Ensure a balanced team of all levels of experience, so that team members can ask for help when needed and rely on the working knowledge of more experienced staff; ideally, this knowledge should be shared across all teams and levels whether related to launch vehicle, site and clean rooms expectations, etc.
  - o Managers can **identify skill/expertise gaps and create roadmap** to fill these with training and/or additional experienced resources
  - o **LSP, ULA, and GFSC all stepped up to share working experienced knowledge** with team members that were either unfamiliar or less informed of certain processes and requirements; **this learning environment was fundamental to success across programmatic and technical challenges**

Key Takeaways Table

Topic Area	Key Messages	Recommendations
Programmatic	- **Outlining roles and responsibilities** at the start of the project was critical to establish common understanding of reporting requirements and expectations which was critical to communications, funding profile, and tracking risks; **resulted in culture of trust that fostered success** - **Commitment**, **mutual respect, and collaboration** was critical across both missions' collective success. Team members were committed to being honest, having open communications on issues and risks,	- Revisit outlined team roles and responsibilities regularly over the duration of the mission due to varying factors, such as, staff/leadership changes, technical impacts, pandemic/external, etc. to provide clarity on expectations related to reporting, communications, and even funding - Each team ensure buy-in at the start of the mission project, to establish success criteria which involved trust, transparency, and commitment to avoid resistance, rework, and other workload challenges

	and helping each mission succeed **resulting in an environment of trusted partnerships**; everyone had vested interest in flying JPSS-2 and LOFTID • **Working collectively** with Program, Project, and ULA (responsible for launch vehicle) to **identify potential schedule, cost and mechanical issues and risks on an ongoing basis** proved helpful for troubleshooting issues amongst all the teams	• Ensure teams have sufficient resources and the skill sets required to support long term missions; identify gaps and create roadmap to fill these with training and/or additional experienced resources
Technical	• Establish clear understanding of break points and gates, and how **technical components can affect spacecraft requirements** • Identify at what point a **rideshare mission can determine its mass/weight load and breaking points**. The earlier, the more flexibility the mission can have when it comes to launch readiness • **Identify suitable mass simulator back-up or other launch options** early in case secondary is not ready within the launch window • With multi-payload missions, outlining and defining **"Do no harm" criteria is essential** from the start and integrating into reviews • Consider at the beginning of rideshare missions the desire to use the $20M integration budget for SMD **rideshare missions to offset the costs of analysis for additional payload** • Importance of **visual data sets of launch video feed**: ability to have imaging from the launch vehicle and associated data was critical to documenting and capturing the visual aspect of the launch	• If there are unique needs related to "Do no harm" to ensure mission success from the rideshare payload, outline these for budget and cost implications and to ensure certainty • Important to distinguish Do no harm to mission success vs. Do no impact to programmatic effort • ULA subject matter experts provided guidance and review of "Do no harm" requirements and outlined criteria to make it clear for everyone; this should be a requirement because this also led to credibility when it was folded into reviews to help mitigate risk and eliminate surprise challenges • Having cameras at the launch should be a requirement; can drive community impact and outreach
Communication and Stakeholder Engagement	• **Relationship building** was essential as all leaned on each other at some point; **respectful working relationship between the Primary and Secondary** was essential and helped to reemphasize the importance of both payloads; they did not have competing missions but yet both were aimed to succeed with separate resources • LOFTID team understood and preached at all times their **secondary missions understanding to Do No Harm status to the primary**. At no time was there a press to alter primary risk posture. Rather focused on mitigation techniques with willingness to not fly if unresolvable.	• ULA should continue to share LL and be integrated into mission reviews, which brought opportunity, analysis, recovery, and integration support (this was their financial obligation since it was a "no funds exchanged agreement"), and was valuable since they had prior experience and key insight • Primary and Secondary relationship was a balanced partnership; missions should strive for this type of relationship to drive results • Evaluate how STMD (or any partner) can be integrated and is an important partnership

	• **Frequent and consistent meeting cadence** was established for technical leads to share progress and risks; this was carried through the duration of the mission and set expectations from the start related to information sharing and discussing concerns and issues head on • NASA should be open to **public/private partnerships;** there is value and enhanced technology that comes out of these maintained relationships • Stakeholder involvement and continuous reiteration of commitment to launch, at key reviews, was important to keep the mission on track • Leadership and media were too eager to communicate success; therefore, the **Program and Project Team should outline and take the lead in launch messages/timing**	• Establish a main point of contact/ gatekeeper from Primary Project Team and Engineering team to manage unexpected challenges on the day of the launch and outline related roles and communications to these challenges
Opportunities	• As this mission was enacted in 2017 only a few months after the initial NASA direction to enable rideshare on future missions, there was a **learning curve** related to multiple mission processes (**launch environments and for payload safety process** for LOFTID); GSFC, ULA, and LSP were able to share experiences and provide instruction when needed on informing team members • **LSP brought a lot of insight and education** on expectations related to mechanical and space flight, rideshare, and gate reviews and how to be a good hosted payload • The common understanding of **standard operating procedures and protocols related to cleanroom environments** and launch site expectations needed to be shared with all involved before proceeding • Working styles and communications can vary, but a common understanding of expectations was embedded throughout this mission which was a key piece in enabling success	• Evaluating skill sets, experience and learning gaps prior and during the mission is critical to avoid any mishaps especially at the last minute or later in the timeline • Providing training or further informational materials to ensure any unknown components are addressed when it comes to knowledge gaps • LSP, ULA, and GFSC all stepped up to share working experienced knowledge with team members that were either unfamiliar or less informed of certain processes and requirements; this learning environment was fundamental to success • Communicate common understanding of cleanroom and launch site expectations to all team members to ensure seamless operational integration at launch site • Recognize that open communication styles from Project and Program leads is fundamental to creating environment of trust; identify tools and methods to establish this skill and enhance it across the teams and create regular feedback loops and discussions to address any concerns or improvement areas
	Question for NASA: How do you leverage from existing missions, yet also be innovative?	

5. Detailed Workshop Findings

This section includes detailed comments and findings documented throughout the workshop and is organized by Pre-Launch and Launch Week/Site activities.

Pre-Launch

Communications

- The established meeting cadence drove strong, open lines of communication
- Expectation setting
  - Utilizing "swim lanes" with roles and responsibilities diagram, especially when it comes to funding, helped to set boundaries and clear expectations; created culture of trust based on outlined expectations from the beginning
  - Secondary needs to have realistic expectations of what they are in control of
  - Outline what the expectations are for the various deliverables and their associated milestones up front
  - Ensure team has skillset necessary and if not, reach to leadership for support
- Consistent communications indicating changes/issues helps to avoid surprises and fosters trust amongst the group; clear and strong messages and recognized importance of the Primary and Secondary relationship (this was communicated to all that the strength and partnership was key to success)
- Reporting remained important to keep everyone informed; often hardware became the priority but was important to not let the reporting requirements slip
- Pre-briefing amongst the Program and Project before final reviews/briefs proved to be beneficial so that all details were ironed out before presentations to leadership that discussed cost and schedule updates
- Gate reviews are necessary as they allow senior leaders to be in the same room and gain the confidence they need from the Agency on the success of the rideshare mission(s). HQ's Program Executives should make efforts to minimize overall impacts of extensive coordination and pre-briefings with all partners before major gate reviews.
- Attitude matters – having a good attitude and working together is important to success
- The teams worked more "organically", figuring out what works best for a given setting and letting relationships and communication grow as needed, which helped enable success

Relationship Building and Culture of Trust

- Recognizing the difference between being a Primary and Secondary on a mission, and working collectively to bridge any gaps between these two relationships was critical for seamless partnership and transparent communications
- Strength of team member relationships is crucial because will depend on them and the established culture of trust when navigating challenging issues/concerns to help resolve issues timely and respectfully
- Commitment to the mission, particularly after the decisional Flight Planning Board (FPB) review, was critical and a shared sentiment by all; minimized impact to JPSS-2 across all four years and enabled buy-in at all levels from all stakeholders which was impactful in all aspects: reviews, resolving technical issues, reporting requirements, etc.
- Milestone Reviews also can foster environments for relationship building and open transparency

- Make it clear to each entity that the goal is to work together and not to interfere with their respective tasks, and following through in actions that your goal is to be a "team"
- Open sharing of information enabled teams to easily see the perspectives of their partners and enabled them to see where they could step in to alleviate certain concerns
- Having a "how can we help" attitude as opposed to a "that's not my job" attitude; teaming and working environment was needed for resource and facility access
- LOFTID appreciated that JPSS/JPSS-2 leadership didn't think of LOFTID as encroaching on their territory, but instead adopted an attitude of helping out and encouraging the project at key moments, and publicly at key events. LOFTID was never made to feel like a "second class" effort, which, for smaller projects like LOFTID was vital for morale
- "Seeing is believing": visiting contractor sites to see development of instruments and launch vehicle parts was helpful to create common understanding amongst integration efforts
- In a few instances, the team used previous and existing relationships across organizations to resolve issues; maintaining good working relationships with internal and external stakeholders contributed to resolving issues and helping expedite things along

Utilize Resources

- The ULA Rideshare User Guide proved to be good reference for how to be a "good" rideshare for those that were learning about the integration and complexities of rideshares
- ULA did a really good job of capturing lessons learned and it was helpful to all that these were readily shared and discussed throughout the mission with team members
- Some individuals felt like they lacked knowledge in areas, but thankfully were able to lean on other stakeholders for support; missions had a culture of helping others and learning from experienced team members

Technical

- Do No Harm
  - Having a detailed list of what is expected/needed to satisfy DNH is really helpful for all
  - Contractor has an established DNH approach appropriately integrated that process in Mission Success Review lifecyle- creates deadline and ensures potential surprises are adequately addressed
  - Having vested interest in LOFTID's success to see technology move forward was one goal, but overarching was "do no harm" and tracking the data to ensure it was the "right opportunity to fly" was the mentality that led to collaborative success across both missions
  - Beyond contamination and do not harm, critical impacts include launch logistics and launch date
  - Start communicating and understanding all Do No Harm criteria very early on in the project, and meet regularly to reevaluate criteria and applicability. Make sure everyone is "on board" early in the process so there are no surprises
- The Primary and Secondary were included in the monthly JPSS Program IMSR, to share more details related to issues and progress

Financial

- Rideshare needs to budget for compensation for the primary payload as they will cause programmatic impacts just by being a part of the mission

- Rideshare must have funding to cover their costs they are responsible for – mission uniques, etc.
- Projects will always end up incurring unexpected costs – need to prepare for that
- Primary missions can incure cost impacts to SC contractors that is not currently covered as part of the Rideshare cost coverage in an instance when analysis needs to be redone

Schedule

- When setting deadlines, it is important to prepare for circumstances that could throw off the schedule
- Slips occur and technical items can arise for secondaries as delivery nears. Looking ahead for a final "real" final fly or mass simulator date can be a challenge but worth the effort to establish. Think ahead to ensure team is in agreement on core positions near launch for this and other wide areas of interest to management and mission stakeholders

Launch Site/Week

Space Act Agreement

- Overall, the Space Act Agreement potentially added a complexity that was unexpected, and further thought and analysis from the team should be shared on whether to determine how beneficial the Space Act Agreement was for the JPSS-2/LOFTID launch. A few comments included:
  - Extraordinary benefit to ULA and NASA from sharing of technology perspective
  - Launch site support capability by ULA was tested as part dual role on LOFTID. Both a SC build team and LV integrator role test manning limits
  - Changes were not totally communicated all the way through the Agreement and impacted the launch/prep site. Specifically, the facility planned to be utilized by ULA for build up of LOFTID was no longer available and LSP was asked to find a workspace that could be paid for by LaRC and traded for with ULA no exchange of funds from NASA to ULA per the SAA

Launch site

- Get the teams there at least 3 or more days in advance for dry run, and to address integration issues, and familiarize everyone with launch site requirements and expectations; teams should collaborate and be prepared to ask questions and be able to field them as well from various stakeholders and leadership during launch week/day
- Need a more integrated meeting to outline operational integration gaps and needs related to launch concerns and issues
- LSP held detailed meetings at least six months prior to launch detailing what may and may not occur which was helpful during launch
- Secondaries may not have experience with the cleanliness environment then make sure you have a conversation about it beforehand – what to expect, what and will not happen in there, things to account for, etc.
- Minimize footprint as best you can for launch – only have people in the room that need to be there
- Maintain vigilance of schedule and know the constraints and unexpected things not documented (travel, time zone, etc.)

Dress Rehearsal and Timeline of Events

- The Fit check 6 months ahead provides great value; meeting the Engineers and seeing the parts was beneficial to gain intricate understanding of the instruments and integration
- Need to outline communications for both success and failure/delays at the launch to be prepared for all situations
- Multiple dress rehearsals are beneficial, if time and cost allow, even if Secondary has been through it before
- Everyone had to be flexible and work together to trouble-shoot unexpected issues that were resolved; when leadership was on-site, there should have been some space given to the Project team to address anomalies without a larger audience
- Work with the media team in advance to address launch communications and timing

6. Next Steps/Conclusion

Following the JPSS-2/LOFTID workshop, many repeatable, valuable BPs were identified that contributed directly to the overall success of the launch, and futures launches. As the aerospace community continues to navigate rideshare launches, it is the hope that these findings will be referenced and utilized to play a role in continuing to enable launch success. Moving forward, the JPSS-2/LOFTID team will work to socialize these findings within NASA and to the broader community, as well as continue to collect LL to build upon what has already been uncovered. It will be crucial to continue to further identify BPs, while also utilizing those known, so that missions may be able to continue refining key launch processes, in hopes of making every rideshare launch as efficient and effective as possible.

By sharing this JPSS-2/LOFTID rideshare success story, it may remove uncertainty for others and in fact, it may inspire, inform, and reassure that with success always comes challenges.