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(This section must be signed)

Individuals **outside your company**, including the companies listed above and other third parties, potentially including your competitors and others in your industry, may receive and/or review award submissions. All information submitted should address the program's management, leadership, and processes in a manner that you are comfortable sharing with third parties freely and without restriction, and may not include any classified or proprietary information or materials. Do not include any materials marked Confidential or Proprietary or bearing any similar legend. All responses and other submissions, whether in whole or in part ("Submissions"), shall be deemed not to be confidential, proprietary, and/or nonpublic information of any sort for any purpose.

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Thank you for participating,

Gregory Hamilton
President
Aviation Week Network

Acknowledged, agreed, and submitted by

Nominee's Signature

06/05/2023
Date

Nominee's Name (please print): Miquelle Milavec

Title (please print): President

Company (please print): Spectrolab

NOMINATION FORM

Name of Program: Spectrolab ISS Solar Power Module (SPM) Program

Name of Program Leader: Miquelle Milavec

Phone Number: 626-340-8785

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☒ Customer Approved

- Date: 06/04/2023
- Customer Contact (name/title/organization/phone): Matthew Mickle, Boeing Developmental Projects Manager, The Boeing Company, matthew.s.mickle@boeing.com, 832-683-3576

☐ Supplier Approved (if named in this nomination form)

- Date: ______________________________
- Supplier Contact (name/title/organization/phone): ______________________________

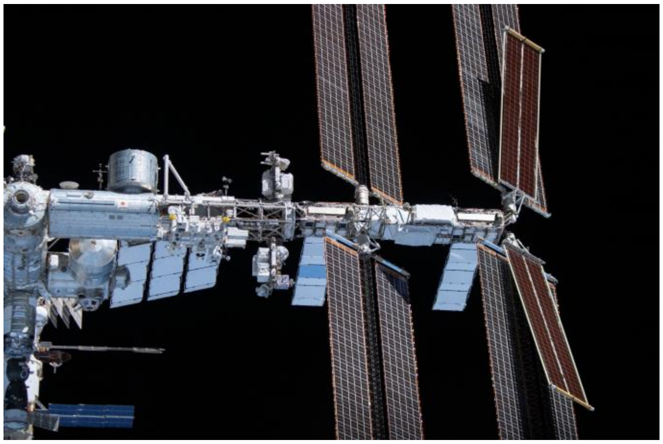
PLEASE REFER TO PROGRAM EXCELLENCE DIRECTIONS AS YOU COMPLETE THIS FORM.

EXECUTIVE SUMMARY: Make the Case for Excellence
Value: 10 points
Use 12 pt. Times Roman typeface.

What is the vision for this program/project? What unique characteristics and properties qualify this program for consideration?

[LIMIT YOUR NARRATIVE TO THIS PAGE.]

The Spectrolab ISS Solar Power Module (SPM) Program is a collaboration between Spectrolab, Boeing and Redwire that will augment the existing solar arrays and allow the International Space Station (ISS) to continue to operate to 2030 and beyond. The solar arrays on the ISS serve a critical capability that has helped humans live in space continuously for more than two decades. As part of a power system that provides more than 120 kW, the solar arrays power ISS daily operations - facilitating crew life, research and international science goals to advance deep-space technology and find answers to perplexing scientific questions to benefit Earth.



NASA Credit

A subsidiary of Boeing, and a premier supplier of space solar cells and panels to the aerospace industry for more than 67 years, Spectrolab designed and built over 200,000 solar cells that generated electricity as part of the original eight solar arrays aboard the ISS. Twenty-five years after the ISS began operations in low Earth orbit, a new generation of advanced solar cells from Spectrolab, twice as efficient as their predecessors, are supplementing the existing arrays. The unique attribute of this program was the development and manufacture of a modular solar power assembly and a novel production line to make a high-confidence, advanced technology and repeatable implementation in a relatively short timeframe. From project launch to the new arrays being successfully delivered in-orbit, Spectrolab was part of a supplier team that delivered a system to space in less than 42 months.

The Spectrolab ISS SPM Program is unique in both execution and technology. Woven onto blankets and rolled up for launch, Spectrolab's solar power modules, consisting of 48 cells each, are integral to six new solar arrays that are being installed on the ISS in orbit. Known as iROSAs, for ISS Roll-Out Solar Array, the new arrays incorporate an innovative carbon fiber composite structure from Redwire that allows the arrays to be carried to orbit inside a cargo spacecraft and installed by astronauts for eventual deployment.

The SPM had to be qualified, through the use of engineering models and a rigorous environmental test program, while a new factory production line had to be simultaneously set up that accommodated a production of over 1,100 units within a year of contract signing.

The overall vision of the project was two-fold: to facilitate a pressing customer need to extend the ISS life to 2030 and beyond while also developing a new production capability that reduced cycle time via modularity, efficient manufacturing and test flow while reducing the complexity of the material system – increasing overall program predictability for space solar arrays of the future.

DIRECTIONS

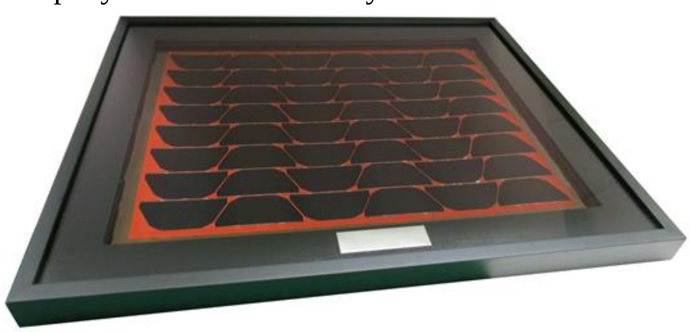
- **Do not exceed 10 pages in responding to the following four descriptions**.
  - Allocate these 10 pages as you deem appropriate, but it is important that you respond to all four sections.
- DO NOT REMOVE THE GUIDANCE PROVIDED FOR EACH SECTION.
- Use 12 pt. Times Roman typeface throughout.
- Include graphics and photos if appropriate; do not change margins.

VALUE CREATION
Value: 15 points

Please respond to the following prompt:

➢ **Clearly define the value of this program/project for the corporation; quantify appropriately**

The value of this SPM program was to accelerate development of modular, flexible solar array designs that could enable space missions in a better cycle time. By eliminating the use of customized rigid structures that support the solar cells directly, the design implemented and made use of materials that are common in industry with shorter lead-times. The design also prioritized design for manufacturability and test (DFMAT) cycle time and continuous flow in selection of processes, test validation points and adhesive curing. Going forward, there was significant value created by demonstrating performance to plan. Achieving or bettering targets on part attrition, operational metrics, test program efficiency and overall delivery schedule instilled confidence in an emerging customer base that sees value in flexible solar arrays. It is estimated that this product line could represent >25% of industry demand to the company in the next several years.



By working closely with downstream integrators Redwire and Boeing, the SPMs created value for customers by being modular and lightweight. The SPMs were easily integrated into a mesh backing as part of the innovative carbon fiber composite structure from Boeing supplier Redwire. The rolled-up assembly then provided a volume advantage enabling packaging inside a cargo spacecraft to the ISS, which then allowed installation by astronauts, and ultimately a roll-out deployment to provide power augmentation to this international asset.

More than a generation removed from the original ISS solar cells, the SPMs are stronger, generate twice as much power per unit area and can be incorporated into a rolled-up array while maintaining structural robustness. Each iROSA produces 20 kW of energy. Overall they will add more than 30 percent more energy to the ISS' power system.

Equally inventive, Boeing engineers worked with stakeholders to devise an architecture to connect the new arrays and unfurl them over the existing arrays without completely disconnecting the legacy arrays. That means the original arrays, some in operation for 20 years already, will continue producing power for the station, while the new arrays augment the supply to give ISS flexibility to host new modules and advanced research equipment and to operate years into the future. The connection required engineers to work with a design that was not meant to be replaced. They formulated a support structure and a wiring modification that could be safely performed by spacewalkers.

The Spectrolab ISS SPM program brings value to Spectrolab and Boeing by helping to showcase the ingenuity and performance of Spectrolab (and Redwire / Boeing) to the collective customer base who are looking for improved cycle time, higher predictability and $/Watt economics. The awe-inspiring visuals of these iROSA deployments during NASA spacewalks, coupled with the on-orbit pedigree in producing power right after deployment, provides a tremendous platform to showcase Spectrolab, Redwire and Boeing products as flight-proven.

- **Clearly define the value of this program/project to your customer**

The Spectrolab ISS SPM program brings value to Boeing, Spectrolab's customer, and NASA, Boeing's customer, by providing additional power generation capability to the ISS. These upgrades will enable the ISS, a jewel of the NASA portfolio, to fly and support scientific investigations through 2030 and beyond.

- **Clearly define the value of this program/project to members of your team; quantify if possible**

The Spectrolab ISS SPM program brings value to members of the Spectrolab team as it illustrates innovation and technical evolution within the same workforce that built legacy ISS solar cells. The project continues to provide career-enriching moments as employees contribute to a landmark in aerospace history while sustaining human space presence in low Earth orbit. This drives employee morale, retention and pride.

It has also facilitated our business development team in being able to leverage the value of on-orbit success of a working product line vs. a theoretical concept. This evidence of on-orbit success has facilitated additional business via improved cycle time and lower dollar per watt and creates a product line to bridge to the future by envisioning the increasing use of flexible solar arrays.

In 2020, NASA recognized the engineers of Spectrolab for the work they have done to improve the efficiency, reliability and maintainability of ISS's power systems with a Space Flight Awareness team award to Spectrolab engineers and a Silver Snoopy award to William Wise, a Product and Test engineer. Each year, less than one percent of NASA's industry workforce are recognized with the Silver Snoopy award for outstanding contributions to flight safety and mission success.

- **Clearly define the contribution of this program/project to the greater good (society, security, etc.)**

The Spectrolab ISS SPM program brings value to society by providing power for ISS scientific investigations in life sciences and material sciences that may reap benefits for all of humanity. It also enables thorough investigation of technologies onboard the ISS prior to their use in humanity's venture back to the Moon and then on to Mars. The technology of this program is now being used by additional customers to facilitate space exploration on other missions. The SPM technology itself can be envisioned to provide higher velocity response to support space power missions across a range of missions to better connect, protect and transform by creating more capability in a smaller packaging volume in more repeatable building blocks.

ORGANIZATIONAL BEST PRACTICES AND TEAM LEADERSHIP

Value: 35 points

Use 12 pt. Times Roman typeface

Please respond to the following prompts:

- ***15 points:* Describe the innovative tools and systems used by your team, how they contributed to performance and why**

The SPM production for the ISS program provided a unique opportunity that enabled the Spectrolab team to establish a "fresh vision" assembly line that incorporated many Lean manufacturing concepts as well as some of the recent innovations on other projects. The team faced the challenges of a large hardware delivery request and a very ambitious delivery schedule. Utilizing Lean principles such as AIW (Accelerated Improvement Workshop) helped in the initial assembly line setup phase. The team was able to brainstorm and mock up the entire self-directed assembly line based on the constraints provided. This exercise provided the team with a clear picture of where the challenges and opportunities were and allowed them to develop actionable improvement and mitigation steps while standardizing lessons learned from recently completed rigid solar array programs.

Process dry-runs were performed numerous times with many alterations and restarts, some of which required a completely new process and/or flow. The insertion of this process within the assembly line had to consider the application of the paint (both process and safety), the cure time, the environmental concern and overall line balancing.

Another early opportunity involved the Kapton polyimide substrate final configuration. A trade-study was performed to determine whether it was more beneficial to purchase from an outside vendor vs. fabrication in-house. The team worked with a key supplier to deliver a ready-to-use bondable polyimide sheet cut to exact configuration along with the proper features for tooling installation. In summary, the program put many Lean tools to use, as well as implementing many of the latest process innovations.

- ***10 points:* Define the unique practices and process you used to develop, lead and manage people?**

Spectrolab continually strives for operational excellence. The development of the SPM production line demonstrated our commitment to using Lean, point of use, batching, and cross-training to meet our customer commitment. Spectrolab transformed from the traditional product-centric work cell design into the world of a process-centric work-cell design. This layout relied heavily on a push-system with visual indicators, to drive day-to-day productivity.

The SPM self-directed assembly line was a success because it was designed with Spectrolab team members as the focal point. Each team member understood exactly what was needed for each day with the latest status of each SPM visually available, as cycle time was a key parameter.

Key work centers were created that were synchronized and co-located to support a cadence for takt-time. Material, part and product flow were optimized using a standard batch size to ensure no bottlenecks were created across operations. Electronic work instructions were implemented which made accessing drawings and process specifications, via hyperlinks within operational steps, seamless. Countless hours of cross-training influenced the implementation of a small dedicated team that worked tirelessly to produce quality products safely.

The overall flow of the product was designed to reduce travel time. Tools and materials were ergonomically designed and staged at strategic locations to maximize point of use. Materials input from various feeder-lines was deliberately timed to allow one-piece flow smoothly through the line. Processes with relatively higher cycle time were designed and set up as individual work cells to batch process multiple SPMs in parallel to support overall line balancing. Quality Control inspection was improved with cameras and software to reduce human interaction and improved accuracy by electronic-build record keeping. New internally developed mobile workstations and software were implemented for easy access to assembly drawings, procedures as well as build traceability documentation.

With this program, team members had more information, real-time feedback and avenues for issue escalation at their fingertips. With the implemented production line, tools and materials were at the point of use, which ultimately improved efficiency and empowered team members. Ultimately, the team was able to build and deliver over 1,100 SPMs on time for a satisfied customer.

➤ ***10 points:* How did you leverage skills and technologies of your suppliers?**

Throughout the SPM program, constant communication with our customer and suppliers was critical, especially regarding feedback on what worked for them, and more importantly, what needed improvement in order to make the proper adjustments. Minor but important adjustments like the way the SPMs were packaged and queued for shipment were communicated to ensure smooth flow of SPMs from Spectrolab to our customer.

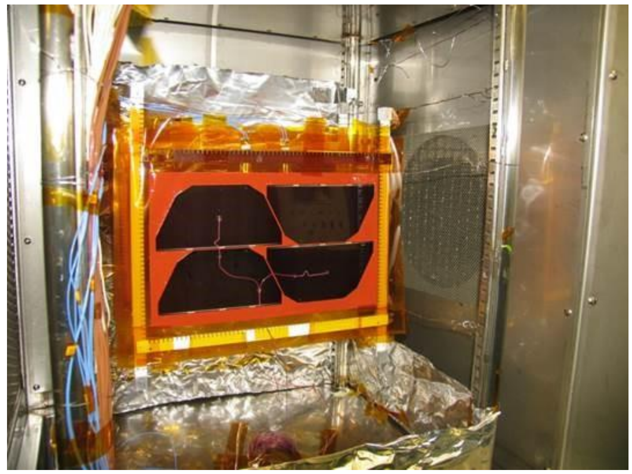
We worked with our suppliers to provide us with consistent, reliable built-to-print thin metal parts, substrate and bonding materials. With consistent dependable quality of parts and materials, we were able to reduce incoming and in process material verification/inspection and standardized fixturing knowing that the parts would fit and worked within our processes each time.

It was also important to maintain communication and support after the program had delivered. Our thin metal welding SME (Subject Matter Expert) was involved in helping to enhanced the welding process at the customer's site during SPM integration to the iROSA structure. Partnership with the customer did not end after we shipped the last SPM, as we continued to support them on an enduring basis, including through launch, installation and on-orbit checkout.

DEALING WITH PROGRAM COMPLEXITY
(VOLATILITY, UNCERTAINTY, COMPLEXITY, AMBIGUITY, or VUCA)
Value: 25 points
Use 12 pt. Times Roman typeface

Please respond to the following prompts:

- ***10 points:*** **Describe UNIQUE areas of VUCA faced by your program and why. (Please avoid the issues surrounding Covid-19 pandemic, which was faced by all programs.)**



One of unique challenges faced by our teams centered in the environmental testing of the novel SPM on flexible sheet.

Typically, all space solar panel designs are validated through cycling between hot and cold extremes in an atmospheric pressure thermal chamber, with ranges of +120C to -65C typical for a cycle and for low Earth orbit environments, there can be as many as 55,000 cycles to demonstrate the durability. Even accelerated testing can require many months to simulate accurately 10 years of flight.

While previous solar array assemblies had been qualified to 75,000 thermal cycles, the ISS SPMs are designed to be flexible and integrated onto a rolled-up mesh. All substrate changes carry risk for unpredictable results because of the extreme temperature ranges in space and from differences between the test environment and space. Technical issues were identified on the initial samples in thermal cycle testing, jeopardizing the test phase closure and program start timing. The team needed a rapid solution that ensured space flight qualification and enabled an on-time manufacturing start.

- ***15 points:*** **Explain how your team responded to these challenges. What changes did you make, what were the results?**

A multi-disciplinary investigation team was formed across Boeing, Redwire, Spectrolab and NASA engineering, technicians and leadership to quickly drive to a root cause and solution. Using best practices of Six Sigma and Boeing Lean problem-solving models, the team was able to devise the root cause and implement simple changes without repeating testing campaigns, thus maintaining cost and schedule for the overall program. Over the course of the investigation and through multiple customer review team engagements the team generated buy-in needed to proceed quickly at the conclusion. This solution successfully closed the qualification testing demonstrating the durability of the SPM to the space thermal environment and produced a pathway to accurately simulate such solar array structures for future development and qualification efforts.

Everyone involved appreciated the significance of the solution. In response to the event, Redwire provided the following statement regarding the collaboration with Spectrolab: “The team at Spectrolab has acted as a trusted partner throughout the Boeing iROSA program. Their exceptional expertise in developing a photovoltaic SPM solution was a cornerstone of their indispensable contributions to the iROSA program. Their adept handling of the program’s nuanced and often-evolving technical demands exemplified their well-established proficiency. Spectrolab consistently delivered durable and efficient SPM products on time, demonstrating their capacity to adapt and innovate rapidly.”

“In the complex world of space technology, Spectrolab’s involvement provided Redwire with much-needed peace of mind. Furthermore, Spectrolab’s commitment to the project’s long-term success was evident in their exceptional on-site and post-delivery support, which ensured punctual delivery to NASA and guaranteed a continuous power supply to the ISS, fortifying the future of space exploration.”

METRICS
Value: 15 points
Use 12 pt. Times Roman typeface

Please respond to the following prompts, where predictive metrics indicate items that provide a view of how yesterday’s actions and today’s actions will affect the future timeline, cost or other requirement.

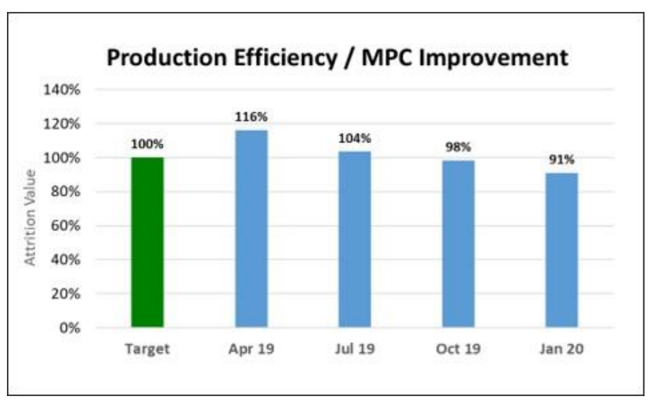
Provide charts/graphs that illustrate performance to these metrics:

- **What are your predictive metrics?**

The team utilizes metrics in our solar cell assembly line that focus on cycle time, minutes-per-operation and attrition loss. Specifically, one predictive measurement for this program was minutes per cell (MPC) for the SPM assembly – which included staging, bonding, curing and testing. The calculation involved total touch labors hours divided by the cell counts of SPMs running through the line. The predictive measurement of attrition was calculated based on a percentage fall-out as typically occurs in standard semiconductor lines at various levels of indenture. By keeping constant situational awareness via statistical process control and data trending, the team was able to predict performance and overall cycle time while also utilizing a feedback loop to improve in real-time.

- **How did you perform against these metrics?**

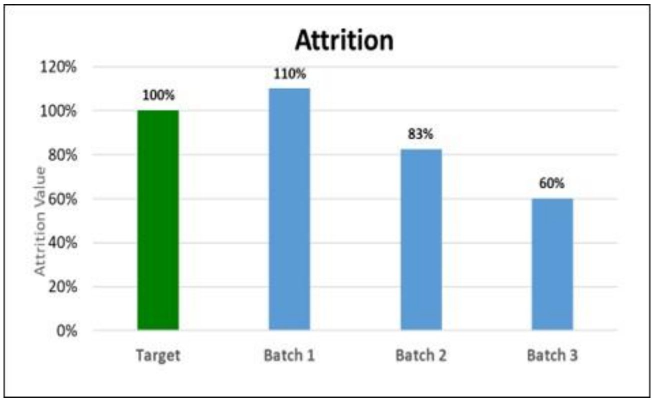
Spectrolab accomplished a 16 percent reduction in MPC and a 45 percent reduction in attrition over the course of the program. The ability to introduce Lean strategies, make the investments to create a unique product-line, identify lessons learned, and find solutions to mitigate and improve processes, were all contributors to our overall performance.



As with all new builds, lessons are learned and opportunities are identified. The overall performance is a model for “People Working Together” for a common purpose and Spectrolab’s commitment to strive for operational excellence. The team learned the benefit of Lean principles and methodology which allowed them to see and be part of the establishment of a production material flow on many levels, including safety.

➤ **How do your predictive metrics drive action toward program excellence? Please provide examples.**

Predictive metrics were used to constantly drive a "Feedback Loop" behavior. The Spectrolab team believes in continuous improvement, meeting customer expectations, and doing it right the first time, safely. That said, the metrics drove a constant dialogue on "how can we get better?"



One major improvement was streamlining work confirmations by confirming categorized groups of work instead of individual work steps realizing an 81 percent reduction from 1,600 to 300.

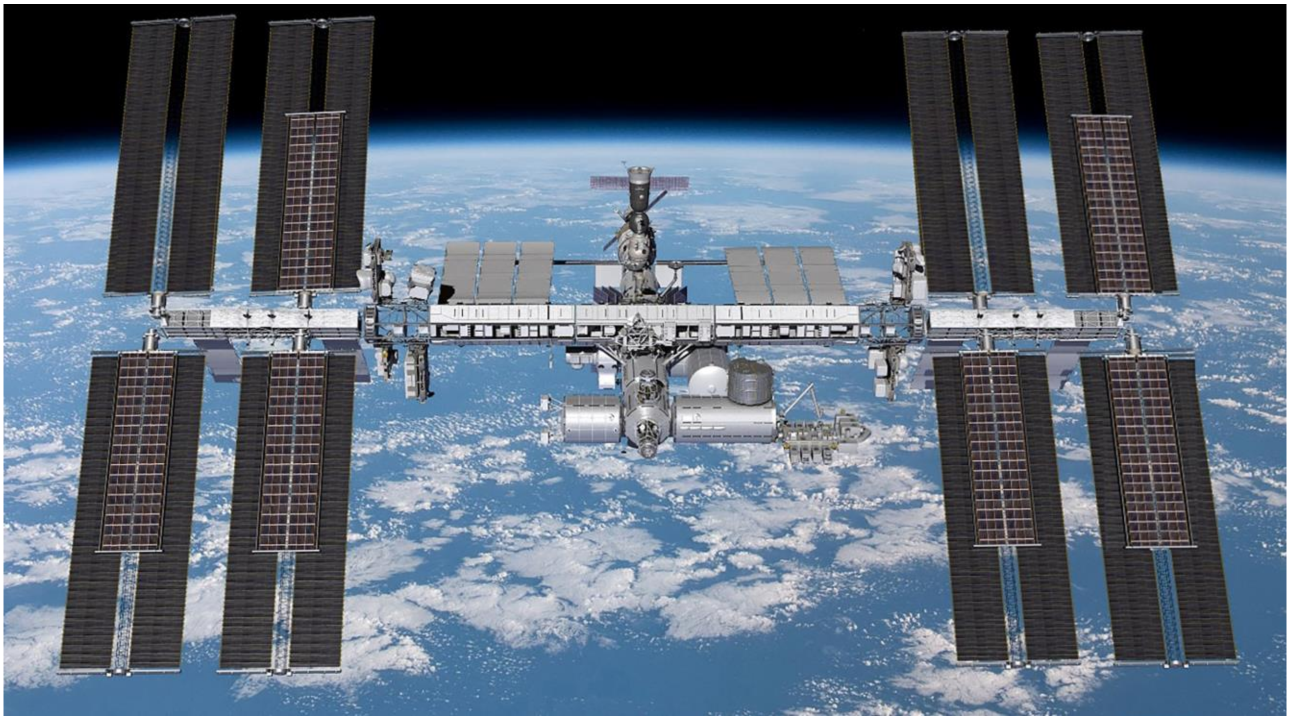
A second major improvement was modifying the thermal test fixture to increase the quantity of SPMs that can undergo thermal vacuum testing from 12 to 36.

A third improvement was revising the paint spray gun to reduce the number of passes required to paint a SPM that resulted in a reduction of paint consumption and increased the number panels that could be painted by 33 percent from 12 to 16 per day.

Additionally, the team reduced rework for post bond cleaning, grouting, over-coating, and clean and classify by minimizing the wait-time before bond material curing. The paint booth filtration system was enhanced to reduce escaped fumes, and ergonomic tilt-tables were designed for ease of technician access and posturing during panel build. In summary, the combination of all the improvements made attributed to the success of improving the attrition by ~40%.

The key drivers for reduction in MPC and attrition were attributed to the team's continuous effort to improve the overall employee-training program - including training material. Lean awareness training focused on continuously identifying and eliminating waste in everything with attention to eliminating bottlenecks. Automation of key processes to minimize errors and drive down redundancies was a key contributor along with increased use of visuals for team situational awareness.

In summary, the SPMs built were manufactured at a rate of 100 per month, bonding 4,800 individual solar cells (CICs), each and every month. In total, Spectrolab successfully delivered, according to plan and on time, 55,344 individual CICs bonded into 1,153 SPMs, to build six new wings to augment 120 kW of power to the ISS. Four of those wings are now successfully on orbit and are helping extend operations of the ISS into the next decade.



NASA credit