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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

20220525
Date

Nominee's Name (please print): Gregory S. Callahan

Title (please print): Program Manager

Company (please print): Moog Inc

NOMINATION FORM

Name of Program: Gremlins Actuation Systems

Name of Program Leader: Gregory Callahan – Program Manager

Phone Number: 716-510-8023

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Postal Address: 500 Jamison Rd, Elma NY 14059

☐ Customer Approved

- Date: Pending
- Customer Contact (name/title/organization/phone): Tim Keeter / DARPA Gremlins Program / Dynetics Inc / 1-256-964-4389

☐ Supplier Approved (if named in this nomination form)

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

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

EXECUTIVE SUMMARY: Make the Case for Excellence *(Value: 10 pts)*

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

(12 pt. Times New Roman) LIMIT YOUR NARRATIVE TO THIS PAGE.

Vision of the Program:

The X-61A is an unmanned air vehicle, referred to as "GAV" or Gremlins Air Vehicle, being developed by Dynetics for the Defense Advanced Research Projects Agency (DARPA). The GAV can be integrated with strike, reconnaissance, and cargo aircraft, as well as ground support systems operational with the US Armed Forces. The Gremlin (X-61A) is a reusable unmanned platform designed to deliver airborne capability in denied environments with an open architecture to allow the integration of multiple mission packages. The air vehicle can be recovered by a C-130 aircraft upon completion of its mission and redeployed within 24 hours.

Moog's vision was to provide the tail fin control and wing deploy systems for the GAV and the tail fin control for the active retrieval bullet on the RS. Each system consisted of actuator(s) and a fully programmed integrated controller.

In October 2021, the Gremlins (X-61A) program, in conjunction with DARPA, executed an aviation first airborne recovery of a jet powered air vehicle. This 'first of its kind' event validated Moog's approach of leveraging existing actuation technology, modified to the specific requirements of the Gremlins Program, to achieve increased technology readiness level (TRL), decreased schedule, development time, and cost targets.

Unique Characteristics:

- **Moog's Customer Relationship and Communication:**

The Moog's team mission statement for this program was to focus on the customer from tip to tail. Moog's focus on the customer experience allowed us to build a lasting relationship of trust and mutual respect. This enables our teams to work together as "one company", eliminating the negative connotations of a supplier/customer relationship. Aligning with the customer relationship approach, the team worked to develop a communication protocol that would allow the company stakeholders to be a part of the communication loop without needless interfering in the day-to-day design development work. The shift in team relationship enabled a highly effective collaborative environment, achieving a high level of intercompany team efficiency. This enabled the team to reduce the iterations of requirements, leading to a shorter development timeline.

- **Moog's approach to TRL/Development for Technology:**

This program is an example of blending re-use of heritage design and technology with new design to overcome program challenges on schedule and technology readiness. The uniqueness of this program required standard program management tools as well as innovative techniques for distribution of information, team building, leveraging existing supply chain without disruption to the production hardware and delivering a system that would enable an aerospace industry first!

- **Moog's approach to Supply Chain:**

Moog's one customer approach flowed down to our suppliers, relying on their expertise on certain components to reduce risk and schedule. This greatly reduced lead times of modified components and non-recurring engineering efforts to set up manufacturing runs of the parts.

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.

VALUE CREATION *(*Value: 15 pts*)*
Please respond to the following prompt:

- Clearly define the value of this program/project for the corporation
- Clearly define the value of this program/project to your customer
- Clearly define the value of this program/project to members of your team
- Clearly define the contribution of this program/project to the greater good (society, security, etc.)

(12 pt. Times Roman)

Value for the Corporation:
Working on the Gremlins program provided Moog an amazing opportunity to be part of an aviation first, airborne capture of an unmanned air vehicle. The achievement of capturing a Gremlins Air Vehicle (GAV) was recognized as a finalist in the 2021 Collier Award and Defense Highlight of 2021 by Graham Warwick of Aviation Week. The prestige and brand recognition will help future customers differentiate from our competitors in aviation flight control development programs.

The engineering and production teams used a cross section of different Moog locations around the US to leverage in production hardware. This opened a wealth of knowledge and lessons learned to benefit not only the Gremlins program, but all the heritage programs.

Value for the Customer:
Moog values our relationship with Dynetics, and successfully executing this program on time and achieving an aviation first helps cement that relationship. Our goal is for our customer to think 'Moog' for all needs in the actuation/controller missile business. Our level of enthusiasm and timely support helps our customer know we are not another supplier, but a partner that is willing to invest our own personal equity into the success of the program!

Dynetics is working to advance the technology and capability of our nation's airborne unmanned systems. The Gremlins program, developed with funding from the Defense Advanced Research Projects Agency (DARPA), is designed to integrate with most existing strike, reconnaissance, and cargo aircraft. The overarching goal of the Gremlins Program, managed by DARPA's Tactical Technology Office, is to demonstrate aerial launch and recovery of multiple low-cost reusable unmanned aerial systems (UASs), effectively enabling the distribution and management of swarms of sensors in denied environments, while allowing humans to keep a safe distance from adversarial threats. These GAVs were used to demonstrate airborne recovery, moving the Gremlins Demonstration System closer to an operationally relevant capability.

Moog's actuation and controller solution provided a high technology readiness level that enabled the Dynetics Gremlins program team burn down technical risk and focus their efforts in other areas. The actuation system is a flight/mission critical components that if failed, would result in possible loss of Gremlins Air Vehicle, or miss on the capturing process. The Dynetics team could rely on Moog to pivot with them and work on additional scope (active bullet fin control) with other heritage hardware, reducing design and procurement times.

Value for the Team Members:
The Moog team takes a gigantic sense pride knowing the work we have completed will be used to keep our military at the leading edge of technology and support of true partner in Dynetics. The team members realized early on that making this a success was a once in a lifetime opportunity. Many people go through their entire careers without the opportunity, let alone a true success on something of this scale within the aviation industry. The recognition will remain with the team for the rest of their careers and beyond.

Value for the Greater Good:
The Gremlins program demonstrated the feasibility of safe, reliable airborne recovery that could then be refurbished within 24 hours and flown again.

Gremlins is aimed at developing low-cost swarming drones that can be outfitted with different payloads, launched, recovered during flight, and then reused — a capability that the military services do not have today. The technology has unlimited potential across multiple platforms, benefiting our country's military capabilities. Successful testing of this technology keeps the United States and its allies at the forefront in today's uncertain world and equipping those who defend freedom!

PHOTO COURTESY OF DYNETICS INC. – GREMLIN CAPTURE BY THE ACTIVE BULLET (GRS)

METRICS (Value: 15 pts)
Please respond to the following prompt:

- What are your predictive metrics?
- How did you perform against these metrics?
- How do your predictive metrics drive action toward program excellence? Please provide examples.

(12 pt. Times Roman)

Part Procurement / Production Planning
Predictive Metrics - On time Delivery
The Gremlins Control Actuation System (CAS) was a complex procurement that mixed development hardware along with production to meet the delivery constraints and provide a high technology readiness solution. The idea of re-use of production hardware with modifications reduces lead times but increases the potential risks associated with part procurement. The production program takes priority over the development program for need of parts which required a delicate balance of part usage for the Gremlins program.

The Gremlins program team established a network of supply chain analysts across multiple sites to track each component, the production v. development plan for building. Supplier interaction was critical for success in meeting the program needs for on time, slightly modified parts while support the production run for our heritage program.

Performance Against - On Time Delivery
The use of the on-time delivery metrics help identify early risks based on lead-time or production requirements. Enabling up front and honest communication with our supplier allowed the Gremlins to pivot as required to support our customer delivery requirements. The re-use enabled Moog to provide Hard in the Loop (Development Hardware) quickly using stocked parts. The production model cut down on expected delivery times, which in turn allowed Moog to meet the customer requirements for delivery of the hardware on time.

Achieving Program Excellence – On Time Delivery / Risk Management
Imagine a program as a prime where your supplier tells you were will have the hardware on order when you get us a contract. Amazing to consider that in a development program's early phases, but with the use of the production supply chain approach and re-use of heritage hardware, Moog was able to procure long lead items ahead of contract award at risk. The cost risk was reduced with the potential of using this hardware on the production run, enabling Moog to take the bigger risk on the dollar amount. In most cases, Moog was able to procure within stated lead times the hardware required to build, test and delivery prototype hardware. The leaning forward mentality was supported by all the stakeholders, and with the use of template communication, was informed of the risks and the mitigation to ensure both companies would be able to recover in case of a down select during the phases did not go as planned.

Predictive Metrics - IMS / Work Break Down
The Gremlins team used a typical IMS for initial planning and baselining of the program. The use of a common template that the organization is used to for information is helpful in quickly delivering a message without additional context. The issue is the continual updating by the development team which is primarily focused on completion of technical tasks that will allow the next parts to be procured and milestone objectives met. Managing the effort on a per line basis for an IMS would not be an efficient way to assess budget, schedule and value associated with the work complete. The Gremlins team used a blended IMS/WBS that provided a bucket of hours to keep detailed level tasks associated with a high-level work breakdown structure. This allowed the engineering team to flex hours across the multiple

disciplines and complete engineering tasks on time. The responsible engineer could use the resources on the team as needed to complete the tasks in the time associated to the overall bucket of hours. The team was cognizant of the amount of time allocated and was able to keep the work for the high-level tasks under budget, increasing MR to cover additional expedite fees to meet delivery schedule.

Performance Against - IMS / Work Break Down

As the program progressed over the 5-year period, the Moog team improved every phase with allocation of hours and tasks completion. The early stages of the development failed to achieve a CPI or SPI above 1. As the team matured and the communication between the two engineering teams aligned, the tasks were completed more efficiently, with additional hours allocated to other areas of need. At the end of the third phase, with scope changes included, the CPI finished about 1 with SPI just south of 1.

	Work Package Title: Concept Design LVPS CCA			
	Work Package Weekly Status		Work Package Set Up	
	Latest Statused Date	9/15/18	WP Charge Number	MC09484724
	Actuals Hours Charged	729	WP Owner	Inderjit Singh
	Hours Earned	750	WP Start Date	2-Feb-18
	Actuals as % of Total Hrs Allocated	91%	Target Duration (Wks)	12
	% Complete of Total WP	93%		
	Allocated Work Package Hr Total	805	Budget Total Hrs	805
			M68 EE Design	632
			M68 EE Component	0
			M66 Drafting	173
			N/A	0
			N/A	0

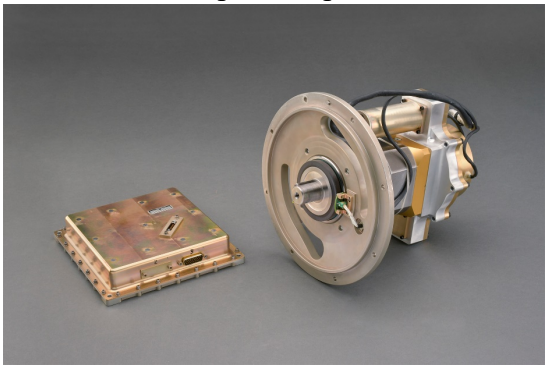
Project Unique ID	Task Description	Allocated Hours	Task % Complete	WP Wk	23
		805		Wk Ending	7-Jul
763	Concept Design LVPS CCA		93%		
764	Perform CCA Circuit Design		100%		
	Review Allocated Controller Specification	29	100%		
	Create Block Diagram	17	100%		
	Create EDP for Drafting	12	100%		

Example of Desk Top Metrics used by Engineering Team to track task completion

Achieving Program Excellence – On Time Delivery

This unique approach of giving more control to the team doing to work to allocate the hours allowed for up front conversations on required time and tasks. The open communication between the engineering teams enabled certain tasks to be eliminated or modified based on the time/cost associated with completing them and the associated value to the customer. The stakeholders were in the loop on the work that was completed or modified. This program evolved into a cohesive collection of individuals tracking their work to meet the objective of the entire team. The ownership of the budget and tasks allowed them to make decisions on work that was necessary versus "nice to have". The improvement of the task's completion and budgeted work improvement over the course of the three phases speaks for itself.

TAIL FIN ACTUATORS



WING DEPLOY ACTUATOR AND CONTROLLER

DEALING WITH PROGRAM COMPLEXITY (VOLATILITY, UNCERTAINTY, COMPLEXITY, AMBIGUITY, OR VUCA) *(*Value: 25 pts*)*

Please respond to the following prompts:

- *10 pts:* Describe areas of VUCA faced by your program and why.
- *15 pts:* Explain how your team responded to these challenges.

(12 pt. Times Roman)

Volatility:

In a development phase of a complex program, each flight would translate into a new round of tweaks and analysis. This would directly result in updated testing parameters and system validation checks within a very short window to support the next test flight. This was on display during the fourth deployment, as the Dynetics teams worked to analyze the latest test data and make final changes that would allow for a success capture of the GAV. Moog was brought into the system modeling and was able to have a systems engineering pinch-hit with the original system engineer unavailable to support. The knowledge transfer and use of standard practices for building the model allow the new team member to quickly learn the model and modify to support the new data. This analysis supported decisions made by the Dynetics team that allowed for the GAV to be captured in midflight.

Volatility Response:

The length of program can make it very difficult to predict the availability of the program team throughout the duration. The initial phase began in 2016, with the conclusion in 2021. Over that timeframe, the Moog team was able to keep the core team together and ready to support during the spikes of the later phases (during and shortly after testing). Moog worked with Dynetics team to understanding timing and then turned internal to make sure the key team members would be able to support. Moog recognized that it was imperative to keep as much of the original team intact to ensure the knowledge transfer to new team members that were brought on board.

Uncertainty

There were 3 phases of the Gremlins program, with Phase 1 and 2 ending in a down select of primes based on technology readiness level and progress toward the end goal of an airborne recovery. At the end of each phase, the whole team led by Dynetics, would present our data, simulations, and flight tests with the focus on getting the next phase award and continue the drive to an aerospace industry first! There were four primes that started this Gremlins competition with only one team emerging for the chance at the launching and recovery of a Gremlins Air Vehicle.

Uncertainty Response:

Re-use of the hardware allows for quicker development and procurement of actuation systems. Moog understood the importance of this program to our customer, leaning forward in between phases to procure long lead parts at risk to ensure we would be able to meet delivery schedules of the required hardware. By re-using existing hardware, the cost risk associated with the leaning forward could partially be mitigated by using the hardware on the current production model. The electrical supply chain of the world has been hindered by the consumption of basic electrical components. To mitigate the uncertainty of availability, electrical components were managed through weekly parts status meetings and increased communications between Moog's Supply Chain and our vendors to procure the necessary amount to support the current phase and the forecasted phases.

Complexity:
The overall complexity of the Gremlins is difficult to describe. The amount of sub tier systems working in unison on one level bringing a GAV, GRS and C-130 together in point of 3D air space, allowing the autonomous unit to dock and reeled into the back of moving C-130 is absolutely breath taking from a technology standpoint.

The Gremlins Recovery System employed the use of a bullet system to capture the air vehicle in mid-flight to reel it into the C-130. The "Bullet" required fin actuation to achieve the "active" to demonstrate the ability to improve overall system performance for airborne recovery, critical to stabilization during recovery. The Moog/Dynetics used a different heritage system for ease of modification within a modular casing. This allows for direct integration into the current retrieval bullet design. Moog was able to take the design packaging constraints, work within our extensive catalogue of flight certified hardware and create a solution that raised the TRL and reduced the risk of introducing a technology late in the Gremlins design.

The GAV needed to be refurbished and flown again within a 24 hour period. Most missiles have a very short flight life, let alone multiple missions. This presented a new challenge for the heritage hardware which was designed for a one-time use.

Complexity Response:
Moog's response the complexity of the system was equally brilliant with the re-use of proven flight technology. The knowledge we have collected over time allowed Moog to overcome the life concerns of multiple sorties with the same hardware typically used for a "one-time" flight. Understanding our actuation systems from actuator to controller allow Moog to create a system that would have no problem withstanding multiple flights and meeting the 24 hour turn around.

The Active Bullet has a modular system that was created to support a quick turn to get it back into the area. The modular system is a plug and play system in case of any damage to the bullet during a recovery of a GAV. Allowing the crew to repair a fin in midflight greatly reduced risk to the GAV units remaining in a recovery flight pattern.

Ambiguity:
Development programs of this magnitude must have a starting point. The starting point usually contains some basic information to get your team pushed off into the right direction. It is up to the team, through multiple interactions with the prime, to determine the true intent of the design requirements and highlight areas that may be over constrained or need more attention.

Ambiguity Response:
The Moog team focused on the relationship and trust with our customer, using our expertise and knowledge in actuation to guide the design decisions that would lead the program to a successful conclusion. The relationship was not customer driving the supplier, but both of us driving each other to review and determine the best path forward to achieve successful performance.

ORGANIZATIONAL BEST PRACTICES AND TEAM LEADERSHIP *(*Value: 35 pts*)*
Please respond to the following prompts

- *15 pts:* Describe the innovative tools and systems used by your team
- *10 pts:* Define how you developed, led and managed people
- *10 pts:* How did you leverage skills and technologies of your suppliers?

(12 pt. Times Roman)

Unique and innovative process:
Moog used an agile approach to frame the development, procurement, and assembly of the required units. Moog leaned on heritage design with a proven supply chain to retire risks to delivery schedule, enabling our team to absorb changes during the development phase. Leveraging the supply chain expertise with critical components enables Moog to make changes up to the last minute, knowing that they could be easily incorporated into the production run.

The main driver of program excellence was the team relationship between all parties (other suppliers, customer, etc.) with a one team approach. This approach allowed for a unique communication cycle, eliminating middleman/pass through conversations and allowed for direct lines of communication. This greatly reduced the possibility of delay in response or incorrect information being passed amongst multiple suppliers. The collaboration between the entire table reduced the overall design cycle time and lead to efficiency across the entire program team.

The implementation of desktop metrics for the engineering team to track day to day tasks within their team increasing their productivity on the engineering tasks. The program team was able to work with the data and feed it into a large master schedule for milestone summaries to be created and shared with a larger team. Empowering the engineering teams to "own" their budgets and distribute the associated hours as required completing the tasks worked better than a pre-defined hours/tasks-based approach from a typical integrated master schedule (IMS).

Moog used a process called Initial Baseline Process or IBP to kick off each phase of the meeting. These meetings were critical to ensure alignment across all functions and sites, requiring functional managers each to sign off on the budgets and tasks. This raised awareness of the program and the special approaches to supply chain and customer relationship. The communication was critical to ensure the "One Company" approach would work across our supplier partners and our customer. This is above and beyond a typical "kick-off" meeting that would be more of communication out instead of an interaction across the organization.

Development, Led and Managed:
As a program team, we drove individual leadership and independence, empowering the team to act on behalf of Moog. We strove to install a level of trust in each individual, giving them the latitude to communicate with the suppliers and customer as needed to ensure all concerns/questions were addressed efficiently. We encouraged our customer for direct lines of communication. This added additional strain on the program management team to track the conversations and ensure scope changes were not agreed to without understanding if compensation was required to complete the work. However, the additional work for the program team was overshadowed by the relationship building and efficiency in work with our customer. As previously mentioned, building a strong customer relationship goes well beyond the overall profit and sales contribution.

As the design team wrapped up, the program needed to execute on delivery of the hardware, including additional scope for active bullet flight control system in additional to the tail fin and wing deploy

actuators. The Moog team leverage multiple Moog sites and various suppliers across the US to ensure we were able to meet demand. By leveraging the pre-existing supply chain relationships, we able to get parts quickly and efficiently, working with the supplier to use existing parts/tooling to make the minor modifications to the requirements of program driving the schedule risk lower.

The program team provided prioritization of tasks associated with delivery of components and design analysis. The team realized that reduction in schedule risk was realized by increasing the technical risk with orders started prior to completion of a complete drawing package. These technical risks were mitigated by the heritage of these parts, having been flown in a previous program adding to the confidence of analysis. This flowed up through the organization, allowing the development program to use production parts to support the overall program schedule.

Customer engagement was a very important aspect to the success of this program. The greatest measure of success was completed in November of 2021 resulting in a successful capture of a GAV by a C-130 Hercules and Gremlins Recovery System. Dynetics reached out to Moog based on our expertise in missile fin control and wing deploy. The level of customer engagement from the entire program team truly helped drive the success of this program.

The program team held many in-person meetings, and through COVID restrictions, kept communication continuing with texting and video communication. It was important to engage the customer on a personal level as well as professional, to let them know we were as committed as they were, willing to follow them into the trenches.

The trust that was built between the two teams drove amazing communication across the entire program. The Moog program trusted the Dynetics team to act in the team's best interest and cut through red tape to make the program whole if a scope change needed to be implemented on the fly. Many prime/suppliers do not have a relationship of mutual trust and respect due to the business side of the program, however we recognized collectively for this to be successful trust needed to be a two-way street. Throughout the program, communication was open and honest, even when the news was bad. Each time, we were able to overcome the obstacles, provide the support required and deliver a successful test event. We have engaged with Dynetics on several other projects since, and a true measure of customer engagement is the amount of follow on work you are able to win with the prime!

Knowledge transfer is the key to any development program to have a successful present and future. The program team focused on gathering the information that was completed during the development phase to be readily available, follow engineering templates to allow for any team member to easily make updates as required. The original systems engineer was not available to complete critical analysis. Another system engineer was able to pick up the system model and understand it without help from the previous engineer. The rest of the team was able to support the new systems engineer in completing the analysis allowing for a success capture of GAV! The engineering team has put together an impressive collection of the specific details that informed the system model. The goal during the development was to make this interchangeable with the heritage program as required. The team used this mindset to develop and document all the design criteria through a program specific design book. The intent was for future programs that may leverage the same technology to have a better starting point that we had with the previous heritage program. Leveraging the lesson learned and the knowledge gaps, the engineering team ensured these were covered in their documentation of the design changes required to meet performance. Transfer of knowledge does not only apply to the technical team, but to the entire program team communication to all shareholders. The program office created a unique scorecard to easily status the stakeholders to progress on the program. This scorecard provided critical information to the stakeholder

team on milestone events, program financial health, top three risks, and customer perception. The team members could status the scorecard and send out in regular intervals. This eliminated multiple people being asked the same question by various stakeholder, creating a single flow of information that enabled everyone to have the consistent information at any given time.

Leverage Supplier Skills & Technology

Moog's approach to our suppliers is a partnership. As our customer's come to us for our technical expertise in creating a flight control system that is an industry leader, we go to our suppliers for the same reasons. Moog has worked to build a highly reliable and success supplier base that can be leveraged by all of Moog, not just particular sites. This was very evident in the Gremlins program. As previously discussed, the Moog team re-used hardware from heritage designs with slight modifications to meet the performance requirements of this application. In order to meet the short delivery windows, Moog worked with the partners to determine what tooling was available and how we could modify the components with minimal to no impact to the production of these units or current production units.

A specific example is the ballscrew used to transmit rotary (torque) in linear (force). The ballscrew manufacturer was already producing the current heritage design to support production run. We were able to work with the supplier on the modification required that would enable them to use the same base material blanks, same machines and programming and only require the change of one tool and inspection gauge. The supplier was able to validate the design change would deliver the required performance and was able to run a prototype on an off shift to send for initial testing. This is truly amazing for a supplier to be able to stop a production run on an off shift, make the simple tooling change, run a few prototypes, and set the machine back up to continue to run production.

As a program team, we looked internal as well to our machine capabilities to find fits for the low volume work within our cells. The team analyzed the current loading across our work centers and were able to identify cells that had availability/capability to cut the parts we required at a competitive rate. These meetings kept the program running on time and allowed for risk mitigation to our external supply chain if impacted by outside constraints (We are all looking at you COVID).

Moog's internal team of manufacturing engineering were able to engage in design for manufacturing (DFM) across multiple parts that were typically made externally where DFMs were completed with the suppliers. The internal team was able to make additional recommendations that would make the parts easier for incoming inspection and processing, passing cost savings on to the heritage program.