General Atomics Aeronautical Systems, Inc.
MQ-9 Reaper Extended Range (ER) Program

I. PROGRAM OVERVIEW

<table>
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<tr>
<th>Organization</th>
<th>General Atomics Aeronautical Systems, Inc. MQ-9 Reaper® Extended Range (ER)</th>
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<tbody>
<tr>
<td>Program Leader</td>
<td>Scott D. Krambeck</td>
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<tr>
<td>Name/Position/Contact</td>
<td>Program Manager, Aircraft Systems</td>
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<tr>
<td>Information – E-mail, Phone</td>
<td>14200 Kirkm Way, Poway, CA 92064 858-312-2195 <a href="mailto:scott.krambeck@gaiasi.com">scott.krambeck@gaiasi.com</a></td>
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<tr>
<th>Program Background</th>
<th>System Production</th>
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<tbody>
<tr>
<td>What is this program all about? (No more than one page). Describe:</td>
<td>IRAD: In May 2012, GA-ASI initiated an Independent Research and Development (IRAD) project to significantly extend MQ-9 Reaper operational range and mission endurance. This was based on an urgent operational need of the warfighter. The overarching need for this IRAD was to maintain MQ-9 operational effectiveness / preclude loss of effectiveness in theatres despite access to fewer and more distant airfields. GA-ASI, having developed and produced 730 unmanned aircraft, 316 ground control stations, and hundreds of subsystem improvements, was keenly aware of the need to prepare for Reaper ER early on. This IRAD initiative led to Government funding of ER development and installation. <strong>Phase 1:</strong> In October 2012, GA-ASI notified the Government of the ER IRAD, and in March 2013 the Government awarded the company a Quick Reaction Capability (QRC) contract to develop, test, and field a Reaper ER capability within 16 months. This contract--for five kits to be installed in operational MQ-9s (plus one spare/test kit)--is referred to as Reaper ER Phase 1. Based on the GA-ASI IRAD and existing MQ-9 capabilities/systems, the QRC product would feature: 1) The addition of two wing-mounted fuel tanks to increase operational range and mission duration. The ER configuration provides the capability to fly with 2, 1, or 0 fuel tanks for tactical versatility. Existing MQ-9 external weapons/payload stations did not change, i.e. “mix and match” flexibility. 2) The addition of an alcohol/water injection system and a 4-bladed propeller for the added thrust needed to compensate for increased gross weight and drag (fuel, tanks, and associated subsystem hardware). 3) Incorporation of the production MQ-9 heavyweight, trailing arm landing gear system to enable safe ground operations at the heavier gross weight. 4) Addition of an ice protection system to enable extended operations in icing conditions. 5) Appropriate software changes to enable required functionality of the newly integrated subsystems. The first aircraft began modification in October 2013 and first flight occurred in February 2014. Testing concluded in June 2014 and the first operational flight was in July. Phase 1 ended in September 2014. <strong>Phase 2:</strong> In August 2013, the Government awarded GA-ASI a second Reaper ER contract (Phase 2, 24 months) for seven additional ER kits--five for installation on operational MQ-9s and two test/spare kits. Knowing that rate production and installation of ER kits was impending; GA-ASI planned a transition from prototyping/limited production to rate production of ER kits. Completion of the first Phase 2 aircraft was in February 2015 with flight testing concluding, on-schedule, in June 2015. QRC: In February 2014 the Government issued a Quick Reaction Capability (QRC) contract for production and installation of 38 ER kits by March 2015 and shortly thereafter increased the order to 44. Based on rigorous schedule management, the first 21 kits were delivered two weeks early, while the next 17 kits (for a total of 38) were delivered and installed on time. The final six kits are expected to deliver per the customer’s requested schedule. <strong>Summary:</strong> The GA-ASI IRAD (10.5 months/$1,173,658) clearly enabled early fielding of the ER capability and lowered ER cost to the Government. To date, ER modified aircraft have flown more than 26,000 incident free hours. It is significant that GA-ASI received a Contractor Performance Assessment Report (CPAR) score of “very good” for schedule performance when the overarching requirement for Reaper ER was “very rapid fielding of increased endurance.”</td>
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<th>Total Kits Produced</th>
<th>57</th>
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<tr>
<td>Phase 1</td>
<td>6 Kits</td>
</tr>
<tr>
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<tr>
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<td>Kits installed</td>
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</tr>
<tr>
<td>Test (Spare) Kits</td>
<td>8</td>
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<tr>
<td>Status: Production and installations all complete</td>
<td></td>
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<tr>
<td>Projections:</td>
<td>128 Additional Installed Kits</td>
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Reaper ER History, Status and Projection:

**Total Kits Produced:** 57

**Phase 1:** 6 Kits
**Phase 2:** 7 Kits
**QRC:** 44 Kits

**6 Phase 1 Kits** built at Advanced Development Center at Adelanto, CA

**51 Phase 2 / QRC Kits** built at MQ-9 Factory, Poway, CA

**Kits installed:** 49

**Test (Spare) Kits:** 8

**Status:** Production and installations all complete

**Projections:** 128 Additional Installed Kits

**IRAD:** In May 2012, GA-ASI initiated an Independent Research and Development (IRAD) project to significantly extend MQ-9 Reaper operational range and mission endurance. This was based on an urgent operational need of the warfighter. The overarching need for this IRAD was to maintain MQ-9 operational effectiveness / preclude loss of effectiveness in theatres despite access to fewer and more distant airfields. GA-ASI, having developed and produced 730 unmanned aircraft, 316 ground control stations, and hundreds of subsystem improvements, was keenly aware of the need to prepare for Reaper ER early on. This IRAD initiative led to Government funding of ER development and installation. **Phase 1:** In October 2012, GA-ASI notified the Government of the ER IRAD, and in March 2013 the Government awarded the company a Quick Reaction Capability (QRC) contract to develop, test, and field a Reaper ER capability within 16 months. This contract--for five kits to be installed in operational MQ-9s (plus one spare/test kit)--is referred to as Reaper ER Phase 1. Based on the GA-ASI IRAD and existing MQ-9 capabilities/systems, the QRC product would feature: 1) The addition of two wing-mounted fuel tanks to increase operational range and mission duration. The ER configuration provides the capability to fly with 2, 1, or 0 fuel tanks for tactical versatility. Existing MQ-9 external weapons/payload stations did not change, i.e. “mix and match” flexibility. 2) The addition of an alcohol/water injection system and a 4-bladed propeller for the added thrust needed to compensate for increased gross weight and drag (fuel, tanks, and associated subsystem hardware). 3) Incorporation of the production MQ-9 heavyweight, trailing arm landing gear system to enable safe ground operations at the heavier gross weight. 4) Addition of an ice protection system to enable extended operations in icing conditions. 5) Appropriate software changes to enable required functionality of the newly integrated subsystems. The first aircraft began modification in October 2013 and first flight occurred in February 2014. Testing concluded in June 2014 and the first operational flight was in July. Phase 1 ended in September 2014. **Phase 2:** In August 2013, the Government awarded GA-ASI a second Reaper ER contract (Phase 2, 24 months) for seven additional ER kits--five for installation on operational MQ-9s and two test/spare kits. Knowing that rate production and installation of ER kits was impending; GA-ASI planned a transition from prototyping/limited production to rate production of ER kits. Completion of the first Phase 2 aircraft was in February 2015 with flight testing concluding, on-schedule, in June 2015. QRC: In February 2014 the Government issued a Quick Reaction Capability (QRC) contract for production and installation of 38 ER kits by March 2015 and shortly thereafter increased the order to 44. Based on rigorous schedule management, the first 21 kits were delivered two weeks early, while the next 17 kits (for a total of 38) were delivered and installed on time. The final six kits are expected to deliver per the customer’s requested schedule. **Summary:** The GA-ASI IRAD (10.5 months/$1,173,658) clearly enabled early fielding of the ER capability and lowered ER cost to the Government. To date, ER modified aircraft have flown more than 26,000 incident free hours. It is significant that GA-ASI received a Contractor Performance Assessment Report (CPAR) score of “very good” for schedule performance when the overarching requirement for Reaper ER was “very rapid fielding of increased endurance.”
II. VALUE CREATION = 20 POINTS

**Value to Customer:** Government valuation of MQ-9 Reaper ER is documented by multiple ER kit and installation orders and initiatives to increase the number of ER capable MQ-9s available to warfighters rapidly. There is clear evidence of national value when Reaper ER performance is examined, especially when fielding was rapid and the affordable cost of ER is considered. The Government clearly considers the ER Program “high value for money,” especially when MQ-9 endurance and mission radius was significantly increased. This translates to more on-station time with fewer takeoffs and landings to achieve desired area coverage. The increase in thrust (alcohol/water injection and 4-bladed propeller) significantly increases MQ-9 payload, yet takeoff ground run is reduced significantly on high altitude, hot temperature airfields despite the heavier gross weight. ER kits can be installed in the field, which means that aircraft need not be returned to the factory for installation. A Government order of another 128 ER modifications is anticipated in the near future. **Value to the Company:** MQ-9 is now one of GA-ASI’s most important products, and it is possible that most operational U.S. MQ-9 Reapers will be retro-fitted eventually with ER kits. GA-ASI provides global logistic support of MQ-9 and its derivatives 24/7/365, and ER sustainment would become part of that business. GA-ASI is a privately-held company.

**Scientific/Technical Value:** The Reaper ER “modification” is a system level effort because multiple subsystems are involved, i.e. fuel, propulsion, structural, landing gear, ice protection, relevant software, and all subsystems had to be integrated into the existing MQ-9 design/configuration. Considerable aerodynamic (predictions, wind tunnel, flight test data) and mass properties analysis (weight, center of gravity, etc.) was required and subsystem changes had to be integrated at the system level to produce a safe and effective aircraft for rugged operations. The increase in thrust also provides the opportunity to increase total payload significantly, which similarly increases Reaper ER selected load out of fuel, weapons, or other payloads. MQ-9 mission effectiveness is significantly increased with Reaper ER. **Excellence and Uniqueness:** QRC contracts are unique because they require accelerated technical development, prototyping, production, and operational fielding, along with product support infrastructure. **The ER IRAD initiative was a significant enabler of on-time and early ER kit deliveries and installations based on mature design work and rapid prototyping performed under IRAD prior to any contract award.** The IRAD work made it possible to complete an ER Preliminary Design Review (PDR) only one month after Phase 1 contract award and Critical Design Review (CDR) only five months later. This gave the Government an opportunity to field ER capabilities quickly. Overlapping Phase 1, 2, and QRC kit deliveries and installations meant a very steep ramp up of engineering, tooling, material procurement, production, testing, and preparation for sustainment. GA-ASI formed a dedicated Reaper ER Joint Integrated Product Team (IPT) that included all required company disciplines plus key Government decision authorities, namely the U.S. Air Force MQ-9 Program Office and their Detachment 3. This “Tiger Team” focused on innovative ways to reduce ER schedule without adding appreciable risk to engineering and production. A Joint ER Risk Board evaluated every proposed approach to reducing cost and schedule. The Joint IPT reduced individual aircraft modification time by two weeks. GA-ASI made the decision to produce and install kits at its MQ-9 factory in Poway, CA, and this enabled DD-250 sell-off without an acceptance flight for each aircraft – a significant savings. **The important result is that the first 21 ER kits were delivered two weeks early and remaining kits were delivered on schedule.**
IV. ORGANIZATIONAL PROCESSES/BEST PRACTICES: (HOW DO YOU DO THINGS) = 30 POINTS

**Strategic Operations – (Tracking):** GA-ASI tracks every flight of all aircraft delivered to customers, as well as each flight of the company’s own Capital aircraft. This tracking also is applied to all Predator®/Reaper ground control systems, worldwide. (Value Improvement): The ER modification gives the Reaper ER four possible mission configurations: 1) clean aircraft, i.e. no external fuel tanks or weapons 2) two external fuel tanks 3) one external fuel tank and one weapon/payload station and 4) weapons/payloads on both wing stations. The Reaper ER modification can be installed in the field, eliminating the need to return aircraft to the factory for kit installation. These flexible configurations give warfighters choices, including the ability to tailor fuel, weapons, and payloads for the operational situation. GA-ASI shares operational performance, maintenance, and logistics/sustainment data with its customers to understand how well the company’s systems are performing and to assure customer value as products mature over time. (Processes, Tools, Practices). GA-ASI (Aircraft Systems business unit) holds an AS9100 Certification (October 1, 2014) and a CMMI Level 5 Process Maturity Rating (October 4, 2013). The company also holds a European Design Approved Organization Scheme (DAOS) as of January 30, 2014. These industry credentials form the basis of the strategic processes, tools, and practices the company applies to its contracts/programs. Most of GA-ASI’s Government customers evaluate and document the company’s contract management performance and delivered products in CPARs that detail how well its products are performing (value to customer) and how well it manages individual programs/contracts (customer and corporate value). CPAR ratings indicate where improvement is needed and are distributed throughout the company (practice) to create wide understanding of customer value by GA-ASI organizations and employees. Quotes from the most recent CPAR relevant to the Reaper ER Program follow: 1) “The Contractor developed a process to DD250 and deliver ER modified aircraft directly from the production line using Production Test Procedures (PTP) and Functional Test Procedures (FTP), without requiring an Acceptance Test Procedure (ATP) Flight at the GA-ASI flight facility. This unique process, which was validated with two successful aircraft FTP at the GA-ASI flight facility, was key to meeting an unprecedented accelerated schedule.” 2) “The Contractor exceeded the required 20 modified ER MQ-9 aircraft requirement of 31 Dec 14 requirement by one additional aircraft and 2 weeks ahead of schedule and remains on track to deliver the 17 remaining aircraft by the required 31 Mar 15 deadline.” 3) Additionally, the Contractor reorganized its internal procedures to expedite documentation needed to support the ER program. 4) The Software Engineering effort on this contract centered on the Lead-Off Hitter software to support the time critical ER programs. The Lead-Off Hitter process reduced software development cycle time from three years to six months.” 5) The consistently high MQ-9 Unmanned Aircraft System (UAS) availability rates in the field attest that the technical quality of the MQ-9 Unmanned Aircraft Vehicle (UAV) system is very good.” 6) A Crisis Action Team (CAT) established by the Contractor aggressively investigated failures and promulgated a series of solutions.” 7) “The Contractor, working jointly with the Government, developed and agreed to 44 Mandatory Government Inspections (MGI) to provide Government Product Assurance and Subject Matter Experts with continuous monitoring and expedited Nonconformance Report disposition of the 38 MQ-9 ER aircraft modifications while on the production line. This new process, coupled with high success rates and increased collaboration, resulted in joint agreement to reduce the number of MGIs from 44 to 22 MGIs while saving roughly two weeks in schedule per aircraft.” Summary. GA-ASI’s high level of performance on the Reaper ER Program is proof that when the Government and the company collaborate closely, it is possible to significantly accelerate delivery schedules, lower cost, and get warfighting capabilities in the field where they are needed.
The accelerated schedule required by the Reaper ER Program mandated unique processes and practices and aggressive executive leadership. GA-ASI senior executives were actively involved in Reaper ER from beginning to end. The company’s leaders provided needed priorities, resources, and personnel to minimize schedule with manageable risk. Program managers were given authority for temporary and/or short term waivers or deviations from published policies, processes, and practices after review of risk assessments and proposed mitigations. Likewise, the company’s Government customers granted temporary changes to published processes and practices once assured that there would be no violations of the contract. GA-ASI knew that the schedule could only be met by fully establishing (and co-locating) an Integrated Product Team (IPT) with a “laser focus” on schedule compression. It was immediately obvious that functions normally executed in series would have to be performed in parallel and that many of these parallel tasks would require Government approval. GA-ASI manned this team with personnel from all required disciplines – engineering, manufacturing, logistics, program management, etc., and requested participation by relevant Government organizations and offices. The company knew that significant schedule compression would induce risk; therefore it formed a joint company/Government risk management team. Each technical or management function was examined for “risk and realism” and proposed risk mitigations were analyzed jointly with the Government. This process/practice ultimately resulted in a culture of “ownership” by all members of the Joint IPT, a shining example of Government/Industry cooperation. When “standard practices” were insufficient to make ER schedule, alternate practices were created and approved by management and the Government. The Joint IPT became effective through a rigorous op-tempo of team and sub-IPT meetings with the goal of removing barriers to schedule performance. The ultimate result was identification of work that could be accomplished in parallel, significant reduction of finish to start tasks, and temporary waiver of selected steps without adding significant risk. Examples of innovations, processes and practices follow: 1) The Government tailored normal Mandatory Government Inspections (MGIs) to save time. 2) Manufacturing used rigorous PTPs on the production floor and proved that aircraft could be modified, delivered, and accepted in the Poway, CA, factory, eliminating the need to package and transport aircraft and ER kits to Palmdale for acceptance testing (the normal practice). This was a very significant innovation that enabled on-time delivery and DD-250 acceptance of Reaper ER kitted aircraft. 3) Both GA-ASI and the Government tailored document reviews that reduced formal kit sell-off in a single day instead of a week. Quotes from CPARs that document the effectiveness of the company’s teaming approach for the Reaper ER program follow: 1) The Contractor’s performance during this period meets contractual requirements and exceeds some to the Government’s benefit. 2) During the period of evaluation, the Contractor was tasked in response to a QRC to modify 38 MQ-9 Block 1 aircraft to the ER configuration by 31 Mar 15. This was an extraordinarily aggressive schedule requiring tremendous effort on the part of the Contractor. The Contractor delivered all 38 aircraft in the ER program ahead of schedule without impacting the contractual deliveries of the remaining 25 MQ-9 Block 1 aircraft scheduled to be delivered during the period of performance. The Contractor was able to accelerate deliveries of these last 25 MQ-9 Block 1 aircraft while concurrently managing the MQ-9 ER modification program in parallel on the same production line to ensure timely induction, preventing delays to the delivery of the 38 ER aircraft required to meet the QRC requirement. A related effort, the development of the Lead Off Hitter software, showed similar performance. Overall, during the period of evaluation, the operational MQ-9 fleet increased by 68 MQ-9 Block 1 (UHK97000-12) and 1 Block 5 (UHK97000-15) aircraft, delivered on an average of 65 days ahead of contractual schedule requirements, with all acceptance tests accomplished without any significant issues.
Supply Chain: GA-ASI believes that a strong supplier base that can deliver quality products, on-time, at a reasonable cost, is essential to delivery schedules. Although the company is highly vertically integrated, it has a number of strategic, critical, and non-critical suppliers. GA-ASI has several processes to facilitate management of its supplier base and the ordering of materials and services, as follows: 1) Supplier Rating System (process). This tool/process enables monitoring and measurement of suppliers on a quarterly basis. GA-ASI requires root cause analysis and corrective action when quality or delivery ratings fall below 98% (quality) or 95% (on-time delivery). An integrated procurement team, including purchasing, supplier quality, and engineering, reviews all ratings monthly, monitoring for adverse trends. The company takes early and positive action to mitigate identified risk. Actions include supplier visits, supplier inspections, supplier counseling and possible removal of a supplier for sub-standard performance. 2) Supplier Portal (practice). This is a web-based tool that suppliers log onto weekly to record status on open purchase orders, within a specific time window. The tool provides continuous two-way communication with suppliers 24/7/365. 3) Subcontract Management (practice). A dedicated Subcontract Program Manager (SPM) is assigned to manage each “strategic/critical supplier.” SPMs are attached to any/all program managers who need materials, supplies, or services from the strategic supplier. Non-critical subcontractors are managed by permanently assigned Subcontract Management Teams (SMTs) consisting of buyers and subcontract administrators. 4) Long-term Agreements and Supplier-Managed Inventory (practice). GA-ASI uses long-term agreements and vendor managed inventory when appropriate. This reduces lead-time, controls cost, improves productivity, and mitigates risk. 5) Common Inventory (practice). GA-ASI buys most products to a common inventory account and transfers to projects, as required, for maximum material management flexibility. 6) Planned, Scheduled Monitoring and Review (practice). The company conducts monthly Senior Management reviews of strategic/critical subcontractors and assigns action items if issues are surfaced. Supplier performance metrics are reviewed as a part of monthly Program Management Reviews (PMRs). 7) Obsolescence and Diminishing Suppliers (process/practice). The tracking of parts obsolescence and diminishing suppliers is led by GA-ASI’s engineering department; however, supplier/subcontract professionals are part of the team that monitors the supplier base for early warning of material obsolescence or diminishing sources of supply (practice).

People Development: GA-ASI has repeatedly been recognized by Aviation Week as an Employer of Choice Finalist for Valuing the Individual/People and/or Technological Challenge in 2005 and 2006 and every year from 2008 to 2012. In 2008 and 2009, GA-ASI was in the top 15 aerospace/defense Best Diversity Companies in Engineering and Information Technologies. For years, the company has had an employee turnover rate that is approximately 5% lower than the aerospace/defense sector while growing its workforce from 1,200 in 2004 to more than 6,700 today. Maintaining continuity of leadership and management and growing the workforce are key to GA-ASI’s ability to retain and expand corporate and employee knowledge. In 2014, the company promoted 17% of its employees, documenting loyalty to our employees (practice) and the practice of promoting from within. Promoting from within has proven to be a very successful morale builder as evidenced by retention rates. Employee performance is evaluated annually (practice), employees have the opportunity to document career goals and plans (practice), and employees are encouraged to pursue education through a tuition reimbursement program (practice). When products are developed at GA-ASI’s Advanced Development Center (ADC), the leaders and employees who create new systems/products/tooling, etc., become the teachers for rate manufacturing employees. For the Reaper ER QRC effort, ADC technicians personally mentored and instructed employees on-site at the Poway manufacturing facility with unique
techniques of the ER installation early in the production run. This mentoring and instructing was a significant contributor to the success of the entire ER QRC program. Other benefits offered to employees include: a variety of healthcare options, a 401k plan and a pension plan (most companies don’t offer both), at-work recreation facilities, and discounts at local San Diego area attractions.

**Operations**

**40% of category score**

*Cycle Time*

Please describe what your program has done to reduce and continue to improve the cycle time required for the phase of life cycle in which you currently are executing (design/develop, produce, sustain). Include in your description the tools, processes and practices used as well as the metrics.

The first six ER (Phase 1) kits were built at the ADC in Adelanto, CA, which is an advanced design and rapid prototyping facility. While building these six kits, the company received a contract for seven additional kits (Phase 2), and shortly after that was awarded the QRC contract for 44 additional kits/installations. The ADC is optimized for prototyping and limited production; therefore, a plan was needed for rate production at the MQ-9 factory in Poway, CA. Accelerated fielding of the ER capability mandated fast ramp-up and high rate production, i.e. normal drawing release, engineering change, tooling, material procurement, and manufacturing practices would not suffice. In agreement with the Government, the following approach was implemented to maximize parallel tasks and eliminate serial tasks: 1) In early cases, tooling was started using redlined drawings, i.e. a temporary waiver of published procedure. 2) Construction of the first set of fuel tanks began while proofing the tooling, with changes introduced in the second and subsequent tanks. 3) The Government approved exceptions for the use of T-2 (temporary/interim modification documents) instead of Time Compliance Technical Orders (TCTOs) to start manufacturing and aircraft modifications early. 4) Materials were expedited by a dedicated subcontract/purchasing manager and team. 5) ADC technicians (who built the first six kits) were used to teach and assist kit manufacturing and installation personnel in preparation for production in the MQ-9 factory. This significantly reduced manufacturing learning curve, saved time and money, and added to product quality. 6) The Government agreed that an acceptance flight test would not be required for each ER modified aircraft prior to aircraft deliveries, eliminating the need to pack and ship each aircraft to GA-ASI’s Flight Operations Center in Palmdale, CA. 7) Not having to fly an acceptance sortie at Palmdale meant that ER kits and the MQ-9 installations could both be accepted by the Government at the Poway, CA, factory and shipped directly to specified Government delivery points. All these steps, along with others, were facilitated by scheduled, focused, daily leadership meetings, a weekly material procurement meeting, a bi-weekly Joint IPT meeting, and as-required meetings to deal with crucial near-term situations. Collectively, these steps not only accelerated schedule, but actually provided opportunities for schedule compression. For example, *On-Wing Certification of initial maintenance manuals was accelerated by six months with no reduction in document quality. This was possible because of GA-ASI/Government teamwork.*

**Efficiencies**

*Affordability and breaking the cost curve are among the most important challenges facing all program managers. Describe the areas you have targeted to improve your costs and how you resolved these challenges for each target.*

As with any development, prototyping, and limited production effort, the first article is the most costly. The Reaper ER Program experience was no different; however, in Phase 1 the first two articles went into production at the same time (practice unique to Reaper ER). The company experienced a typical learning curve and cost profile on the first six Phase 1 kits, i.e. the cost of each kit/installation was reduced as the learning curve increased. The overlapping Phase 2 and QRC orders mandated a rate production capability, so the decision was made to manufacture the fuel tanks at the company’s mature composite factory in the community of Saber Springs, CA (near the MQ-9 factory in Poway, CA), and finish the kitting and perform the MQ-9 installations in Poway. Although there was a cost increase for the first Phase 2 article at Poway (startup, different technicians/facilities, etc.), the cost curve began to bend again on Phase 2 kits as the production rate accelerated. The learning curve returned to normal and the cost per unit started down once again with the second Phase 2 kit. By ordering 44 QRC kits (quantity buy), the cost per kit was reduced by 32% by Kit #12. *After producing 57 ER kits, the final QRC kit cost will be approximately 50% of the cost of the first Phase 1 prototype. A similar learning curve and cost reduction on kit installations was realized (First Phase 1 Article ~*
$219K, Last QRC Article $100K). The company is currently planning for rate production of an additional 128 kits and installations. That production run, if it occurs, will further bend the cost curve downward as rate production and the installation learning curve continue to build. As these kit costs come down, other MQ-9 customers may decide to purchase Reaper ER capabilities, which will further bend the cost curve.

**Planning, Monitoring and Controlling**

What are the most significant change elements your program dealt with in the past 36 months, and what unique best practices and processes did you implement to make these changes. (Examples of change: intellectual property, shortages of critical supplies/raw materials).

GA-ASI has a long history of performing a variety of QRC and Urgent Services contracts dating back to the MQ-1 Predator Advanced Capability Technology Demonstration (ACTD) in 1993. The company performed a large number of these contracts for the Government and Government-sponsored customers in response to rapidly emerging needs in Middle East conflicts, and elsewhere. However, the Reaper ER Program was characterized by an exceptionally aggressive schedule. *Planning for ER was initiated with the company decision to implement the ER IRAD;* however, it did not foresee that the Government would order 57 modification kits and require installations over such a short period of time until it became aware of the impending QRC contract. Fortunately GA-ASI’s ADC helped accelerate planning for the first six Phase 1 kits. The aggressive ER schedule also called for close monitoring of all the functions required for completing the ER tasks: engineering, tooling, manufacturing, kit installation, and logistics sustainment. The approach to monitoring included frequent, scheduled, and focused leadership and team meetings to understand status and recognize areas where the need for control was indicated. *Unique to the ER Program was the need for very active Government participation in planning, monitoring, controlling, and approving the tailoring of Government contracting requirements to promote contractor schedule performance.* GA-ASI received strong support from the Government MQ-9 Program Office, and USAF Detachment 3 in Poway, CA, became an important partner on the Joint IPT responsible for contract and schedule performance. *Without the help of Government partners, the company would not have been able to perform to ER schedule.*

**V. ADAPTING TO COMPLEXITY: (HOW DO YOU DEAL WITH YOUR PROGRAM’S UNIQUE COMPLEXITIES) = 20 POINTS**

| Identify the Program’s Market Uncertainty level | ER modification of Reaper is a Derivative effort. ER Phase 1 (6 aircraft) and Phase 2 (7 aircraft) are complete and the QRC phase is nearing completion of kit manufacturing and installation for all 44 aircraft. To date, Reaper ER modified aircraft have accumulated more than 26,000 flight hours. GA-ASI has delivered 232 MQ-9 Reapers since 2002 and six MQ-9 Reaper variants have been flown by seven customers around the globe in both peacetime and conflicted operations. All our MQ-9 customers have an interest in long duration flights and it is reasonable to assume that some customers may desire ER capabilities for their aircraft once they are aware of increased mission performance, affordable cost, and the ability to modify MQ-9 in the field. ER endurance/mission radius and flexible fuel and payload load outs means fewer takeoffs and landings and can lower the numbers of assigned aircraft to sustain operations in-theatre. While Reaper ER is a unique solution to mission requirements we believe customers will be drawn to the ER capability due to its attractive “bang for the buck” approach and solution set. For the future we see every MQ-9 eventually undergoing a modification to a Reaper ER configuration. To deal with this future and meet customer expectations we plan to continue to deliver product at an effective price. We plan to continue to deliver high quality Reaper ER Kits on or ahead of schedule while exploring opportunities to cut cost and continue to bend the cost curve downward. |
| Identify the Program’s Technological Uncertainty using the definitions below. Then describe how you deal and address this uncertainty. | The technology uncertainty for Reaper ER development is high-technology based on the significant increase in aircraft gross weight and the requirement for increased thrust and climb rate. Safety of flight was a critical consideration based on an 11+% increase in maximum gross weight and the effect of added weight to aerodynamic performance throughout the MQ-9 flight envelope. The addition and/or modification of subsystems and the technical integration of the subsystems with the existing MQ- |

2015 AVIATION WEEK PROGRAM EXCELLENCE INITIATIVE
Identify the level of your **System Complexity** using the definitions below. Then explain how you are dealing with this level of complexity:

- **A System** – a collection of sub-systems performing multiple functions.

The Reaper ER modification is a System Level effort based on the number of subsystems affected, engineering analysis and overall system integration. Reaper ER maximum gross weight is significantly higher than a basic MQ-9. Subsystems affected/added by the ER modification are: 1) **Fuel**: Two extremely light weight external fuel tanks which can house a significant increase of JP-8 fuel to increase flight duration. Additional fuel sequencing functions maintain fuel temperature and regulate weight and balance. 2) **Landing Gear**: The heavy weight landing gear from the MQ-9 production line is added to the ER modification to accommodate the fuel fraction increase in total gross weight. 3) **Engine**: The 3 bladed propeller is replaced by a 4 bladed propeller to increase thrust based on the added fuel weight and parasite drag of the two external fuel tanks. 4) **Alcohol/Water Injection**: Thrust is further enhanced by installing an alcohol/water injection subsystem used for takeoff at the higher gross weight. 5) **Ice Protection**: An anti-ice/de-icing subsystem was added to enable flight in icing conditions. Ice protection has two elements: heat applied to the angle of attack sensor, engine inlets and wing and tail leading edge electro-mechanical protection. 6) **Software**: Basic MQ-9 software is modified to provide the additional/changed functionality required by the ER modification. 7) **Engineering Analysis**: Considerable technical analysis was required to design, integrate, produce and sustain the ER modification. Of note, the heavyweight landing gear, 4 bladed propeller, and ice protection systems were designed prior to and “ported into” the ER modification. The “unique ER designs” are the external fuel tanks, fuel sequencing modifications, the alcohol/water injection system, 4 blade propeller, and some software. Designs for the landing gear, 4 blade propeller, and ice protection were in MQ-9 production prior to ER startup.

Identify the **Pace and Urgency** of your team’s effort using the definitions below. Then describe how you deal with the program’s pace requirements:

- **Time Critical** – there is an absolute and critical-to-success deadline.

The Reaper ER Program is classified as time critical due to accelerated delivery schedules for the Phase 1, 2, and QRC contracts. The dominant schedule tasks were to maximize parallel work, eliminate as many series tasks as possible, and to minimize finish to start task relationships. Rigorous technical and programmatic risk analysis was repeatedly required to monitor critical path and pacing items as the program proceeded from design to production and kit installation. Risk mitigations were rigorously analyzed to ensure that they would not add time to the critical path. Because GA-ASI initiated the ER IRAD early and completed priority analysis and design tasks up front, the company was able to cope with the compressed and overlapping schedules for all three ER phases. The Government was an active and effective partner from beginning to end, and without its assistance the aggressive ER schedules would not have been met.

### VI. Metrics (How do you measure program’s performance) = 30 points

| 40% of category score | Customer/Performance: GA-ASI uses multiple indicators of customer satisfaction, e.g., repeat business, numbers of new customers, routine communications/feedback at all levels of management with customer counterparts, periodic customer status meetings and scheduled program reviews, etc. Most Government customers provide periodic evaluation of our contract performance in CPARs where numerious metrics are reviewed. For example, the most recent CPAR (relevant to the Reaper ER Program) evaluated GA-ASI for Schedule Performance as (Very Good), Cost |
unique/new metrics, as well as numerical evidence (normally a percentage or rate). Focus on the unique metrics developed to provide an efficient way to effectively communicate this information to your customers and within your organization beyond your program team.

Control (Satisfactory), Management (Satisfactory), Utilization of Small Business (Satisfactory), Regulatory Compliance (Satisfactory), Contracting (Satisfactory) and Flight Test Support (Satisfactory). Our assessment of customer satisfaction for customers who do not provide CPARs, which includes foreign customers, is extremely positive as measured through routine program reviews and other normally scheduled meetings. Our assessment of Government customer satisfaction is also outstanding as documented in CPARs. Important GA-ASI metrics relevant to customer satisfaction are technical (hardware and software engineering), management (cost, schedule and quality), logistics/sustainment (product and field support), contracting (proposal quality and timeliness) and security of Government classified and unclassified data. These metrics are tailored to the unique requirements of each contract and customer. Customer Satisfaction: The following elements have met or exceeded customer expectations with Reaper ER and with GA-ASI performance of the ER contract: 1) Reaper ER aircraft have a significant increase in endurance over the basic MQ-9. 2) Reaper ER provides a significant increase in maximum gross weight that translates to more payload capacity. 3) Removable fuel tanks provide the customer increased mission capability with four possible load-out categories. 4) Longer duration flights mean fewer takeoffs and landings to cover a given area. 5) ER provides a significant decrease in takeoff roll due to thrust enhancement from the 4 blade propeller and alcohol/water injection system. 6) A robust ice protection system enables Reaper ER to operate in icing conditions, increasing operational flexibility. 7) ER kits can be installed in the field, negating the need to deploy aircraft for modification. 8) ER kit and installation cost will come down even further with the Government order of 128 additional modifications. 9) MQ-9 has the highest mission ready rate (87%) of any USAF aircraft. 10.) On-time delivery of key products, to include 21 ER modified aircraft (exceeding the requirement) by December 31, 2014, supplemental maintenance and aircrew manuals and training by December 31, 2014, and 17 additional ER modified aircraft by March 31, 2015.

20% of category score Team - How do you measure and assess the impact of your program on your team development and employee satisfaction?

With an anticipated backlog of 128 kits and installations, GA-ASI personnel with Reaper ER experience, especially those in manufacturing/production, will have the opportunity for kit and installation work for some time to come. With 185 ER modified aircraft, there will be additional logistics/sustainment work for employees, and with the dedicated ER production line and kit installations, they will have new opportunities for promotion and leadership. Orders from non-USAF MQ-9 customers would increase opportunity even further. Additional engineering may be necessary if new ER customers have unique requirements and/or do not have the same MQ-9 configuration as the MQ-9s modified to date. Co-location of the MQ-9 and ER kit production lines increases workforce flexibility and the value of employees who are qualified to work on either/both production lines. Some ER kit installations will take place in the MQ-9 factory and some will occur in the field, broadening the experience base of the workforce and enabling the company to offer new customers a choice of where kit installation can be accomplished.

40% of category score Unique Metrics - Describe unique metrics you are using to measure your program’s progress and how you focus it for outstanding and future success.

Key and unique metrics for successful execution of the Reaper ER Program are categorized as to schedule, cost, and quality. Key Schedule Metrics: Schedule metrics included 1) tooling percent complete 2) tooling sell-off timeline 3) drawings percent complete 4) make/buy parts line-of-balance 5) installation percent complete at Palmdale 6) installation percent complete at Poway 7) planned vs. actual installation start and complete at both Palmdale and Poway, and 8) total installation days planned vs. actual at both Palmdale and Poway. To achieve the enormous challenge of the ER QRC schedule, the ER IPT needed numerous and specific schedule metrics. In short, schedule was king and wherever days could be shaved off in the schedule, those opportunities were leveraged. The first task was to get a large number of tooling and numerous drawings complete so that manufacturing of composite parts could begin and parts could be bought on order as early as possible.
In parallel, the first composite external tanks were built while tooling was being manufactured, shaving months off the schedule while producing high-quality tooling for repeatable manufacturing tasks. As drawings were completed, orders were placed immediately and delivery times were tracked closely. To accelerate installation, the first aircraft was inducted in June 2014 while make/buy parts were delivered. The company could not wait for all parts to be delivered to initiate ER QRC installation #1; therefore, make/buy parts line-of-balance became key metrics to keep installation on-track and accurately predict completion times. With these metrics in-place, aircraft installation time was reduced by 10 weeks (~60%) within the first six months. ER QRC installation #1 took 17 weeks, while installation #21 took only seven weeks. To achieve these results, the ER IPT established a drum beat of two GA-ASI production meetings per week, with the Joint ER IPT held every two weeks. Daily meetings were initiated to keep tooling on-track. With these critical metrics in place, the ER IPT was able to measure and make corrections to production areas that needed attention, and then quickly measure the impacts of these corrections. By mid-October 2014, tooling was still on-track, parts delivery was meeting demand, and installation times were dropping dramatically. At this point, technicians were well-versed on ER kit installation at both Palmdale and Poway, and the company was meeting the schedule requirement of 20 aircraft installations by December 31, 2015. The Joint ER IPT was “all in” on meeting tight schedule constraints and finding ways to eliminate barriers to schedule performance.

**Key Cost Metrics:** ER cost metrics included 1) planned vs. actual ER kit costs 2) install costs per aircraft, and 3) monthly EVMS metrics. Based on ER Phase 1 and ER Phase 2 efforts, the ER QRC program benefited from insight of ER kit and install costs, and this contributed to confidence that the ER QRC contract was properly funded. However, additional effort was required to keep cost reduction on-track. Cost metrics showed that ER kit cost was reduced by ~50% compared to ER Phase 1 Kit #1. In concert with reduced installation times, ER kit installation costs were reduced by ~52% compared to ER Phase 1 Kit #1. Much of this reduction was in the composite external tank production at Poway where detailed production metrics for each tank were developed and tracked. Close tracking of tank production enabled meeting schedule and cost targets by mid-October 2014. The ER QRC program leveraged EVMS metrics, and this enabled the accurate prediction of Estimate To Complete (ETC) and Estimate At Completion (EAC). Currently, the overall ER QRC program is expected to complete at ~8% under budget.

**Key Quality Metrics:** Quality metrics included 1) scrap rate 2) number of Non-Compliance Reports (NCRs), 3) number of PTP failures, and 4) number of Mandatory Government Inspection (MGI) failures. Quality control and assurance metrics are an integral component of the Reaper ER Program in order to meet schedule and cost goals, and each of these quality metrics contributed to successful contract performance. As expected in the first ER kits builds, scrap rate and NCRs were higher than desired. However, these metrics were successfully used to highlight issues and improve quality performance. In meeting the first requirement of 20 aircraft installations by December 31, 2014, the last 10 aircraft had zero PTP failures. By far the greatest quality success was the reduction in MGI failures. By completing two flawless back-to-back ER FTPs on two test aircraft at Palmdale, the number of MGI failures was reduced from 44 to 22, a 50% reduction that produced a two-week schedule reduction per aircraft for the ER installation in Poway. **Future Success:** GA-ASI plans to use these same metrics on the anticipated 128 additional ER kit order to ensure that the company meets or beats schedule, bends the cost curve further down, and delivers high-quality aircraft. It will continue to mature current metrics and develop new metrics, if appropriate, to ensure that the Reaper ER program meets customer performance, cost, schedule, and quality requirements.