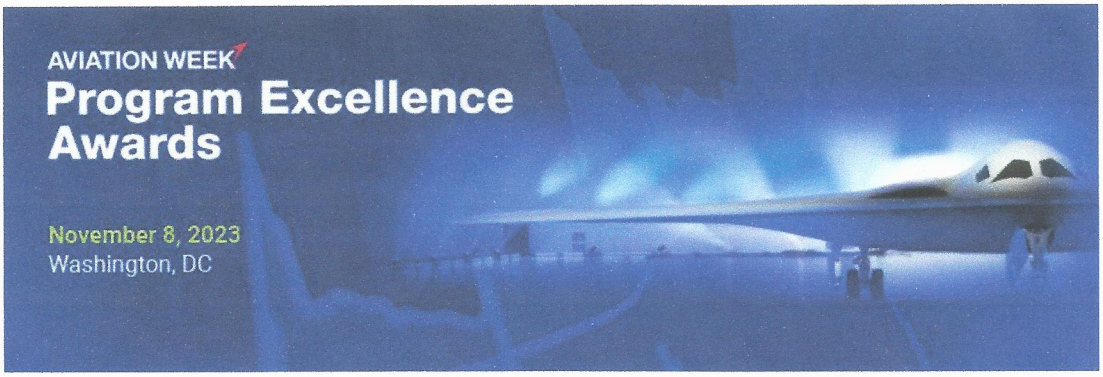

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(This section must be signed)

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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President
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Acknowledged, agreed, and submitted by

Nominee's Signature _____ 05/26/23 Date

Nominee's Name (please print): Brian Hansen

Title (please print): Manager, C-17 Digital Engineering Services

Company (please print): The Boeing Company

NOMINATION FORM

Name of Program: C-17 Sustainment Program

Name of Program Leader: Dr. Richard A. Gomez

Phone Number: (562) 593-0442

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Postal Address: 4060 N. Lakewood Blvd., Long Beach, CA 90808

☒ Customer Approved

- Date: 5/26/23
- Customer Contact (name/title/organization/phone): Squadron Leader Paul Allen, Senior Engineer Officer 99 Squadron, RAF, +44 (0) 1993 896765

☐ 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 points)*
[Use 12 pt. Times Roman typeface.] [LIMIT YOUR NARRATIVE TO THIS PAGE.]
What is the vision for this program/project? What unique characteristics and properties qualify this program for consideration?

The Boeing C-17 Digital Engineering Services (DES) team is leading the vision in developing and operationalizing aircraft data analytics to bring ever increasing tangible outcomes to platform users. These analytics are utilized across multiple user communities; from maintenance (predictive maintenance recommendations, reduced troubleshooting time, increased aircraft availability and depot maintenance optimization), operations (improved flying safety and fuel savings), training (playback and flight monitoring), and supply (optimized supply posture). Foundational to the success of this team has been the digital transformation that has shifted both customer and OEM-managed sustainment from a reactive construct to a predictive and prescriptive sustainment methodology. The DES team's vision is aligned to our customers' desire to improve system readiness and availability in support of daily and war-time surge operations by integrating aircraft parametric data into all aspects of the C-17 Systems level Performance Based Logistics (PBL) contract (i.e. supply chain, tech pubs, safety, training, design engineering) aimed at fleet optimization.

Boeing is the Original Equipment Manufacturer of the C-17 Globemaster III designed in 1980's. The **Prime Contractor/Sustainment** category was selected for the innovative solutions the DES team is providing; modernizing a "pre-digital" platform with a data backbone that rivals modern commercial aircraft. The C-17 Sustainment PBL incentivizes innovation, creativity, and partnership with our USAF and FMS operators. To optimize fleet performance of an aging platform, the Boeing team developed a data recorder unlike any other and assembled a team comprised of Field Service Engineers (aircraft subject matter experts) and data scientists to establish the Data Analytics Service (DAS). The DAS employs many "First-of-its-kind" and unique characteristics:

- Industry leading (commercial and military) parametric data capture and analysis
- Developed and applying over 43,000 algorithms and counting to interrogate the data
- Developed unique data visualization tools and analysis technologies
- Leveraged OEM knowledge combined with best practices from commercial aircraft and the field of data analytics to apply individual aircraft-level specificity

Since 2016 Boeing has been providing the DAS to a number of C-17 Foreign Military partners, outfitting all of their C-17 fleets with the Aircraft Data Reasoner (ADR) along with the DAS. Over this time the DAS has produced the following results:

Availability Improvement	2-3%
Maintenance Man Hours (MMH) Saved	35,000+
Non-Mission Capable (NMC) Hours Mitigated	26,000+
Fuel Saved (pounds of fuel)	4.5 Million+

In addition, the DAS has mitigated numerous unsafe flying conditions, many of which have resulted in expedited aircraft operational flight profile (OFP) software and training changes.

What makes DAS stand out, is the talent, dedication, continuous improvement and strong customer relationships that drive better outcomes for warfighters around the world. We have been fortunate in our partnership with the Royal Air Force at RAF Brize Norton as they have been leading the way with DAS implementation and continuous improvement. Many of the examples referenced below are graciously included with their permission.

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.]*

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

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

Value to the Corporation

Achieving Contract Metrics and Incentives – The DES team's performance has exceeded the contract requirements since inception. This has resulted in all current customers renewing their DAS contracts and expanding them. Value in the sense of Customer satisfaction results in solid CPAR ratings and business growth. There are currently several customer-driven requirements in-work to expand DAS coverage.
Planning for the future – The C-17 Globemaster III life cycle is beyond 2070. To keep the platform viable, the program must have a long-term perspective to sustainment. Investment in, and deployment of, the DAS ensures the C-17 is well positioned to perform for the next 40 years. Boeing is using DAS analysis to forecast early warning of potential fleet-wide impacts as the aircraft ages. This enables customers to establish priorities and maintain optimum aircraft availability to meet mission needs. DAS validates and improves the current model for material and labor forecasting.
Affordability – Data driven analysis and engineering investigations drive faster resolutions and has a proven track record driving labor and material costs down. Leveraging DAS recommendations allows for more efficient base level and depot level maintenance (less maintenance man-hours). DAS reports allow customers to take advantage of scheduled aircraft downtime by taking care of identified future maintenance tasks at the time of their choosing. The use of data and analytics is permeating all aspects of Boeing's Services business.
Supply Chain Efficiency –Because of DAS, our Supply Chain team makes more informed choices on spares procurement based on predictive and trend metrics that feed into our commercial best practices spares modeling tools. Ensuring we only procure the right parts in the right quantities and distribute them to the right locations reduces waste and improves supply chain efficiency throughout the system. By utilizing DAS to zero in on the right part needing maintenance, suppliers are being exercised less for the removal and replacement of "good" parts. A byproduct of this precision is a reduction in Total Non-Mission Capable for Supply (TNMCS).
Market Growth & Sharing of Best Practices – The success of the C-17 DES has driven expansion within the C-17 fleet, bringing the total to four of eight FMS partners now adopting the C-17 DAS. The C17 DES team's best practices are also being shared across the Boeing Enterprise to drive improvements into other existing Boeing platforms and the development of future programs. The successes being realized on C-17 are driving customers to leverage capability on other legacy platforms.
Business Objectives – Executing on the DAS, and setting the foundation for additional contract awards is key to Boeing's business obligations to our stakeholders. By continually exceeding customer expectations with our innovation, we are setting the stage for a renewal of our PBL contract in line with our business goals and objectives while best serving our customers and respective tax payers.

Value to the Customer

Customer Satisfaction – By far the leaders in innovative data driven improvements are the Royal Air Force's 99th Squadron at Brize Norton in the United Kingdom. As early adopters of this game changing

technology and in partnership with the Boeing analytics team they have dramatically improved tactics, techniques and procedures in both the maintenance and aircrew areas. The utilization of real time actionable data has improved the squadron maintenance team's ability to repair aircraft quickly and most importantly identify the best candidate aircraft for specific mission profiles based on near real-time platform data. Nowhere was this more evident than during the run up to Operation Pitting (see vignette below). Additionally, the aircrew have innovatively utilized the tremendous volume of in-flight data provided by Boeing to institute their Flight Data Monitoring (FDM) program which is a peer-based review of non-standard crew actions. This program has resulted in a tremendous increase in safety culture, training improvements and awareness of pioneering tactics producing an even more capable crew force.

When Operation Pitting non-combatant evacuation transpired (Afghanistan withdrawal, Operation Allies Refuge in the US) creating an urgent need to move as many citizens, personnel and allies from the region the RAF had been experiencing some issues with their APUs and were uncertain whether some of their C-17s were healthy enough to support surge operations into a hostile environment. The DES team was able to quickly show the RAF customer that seven of eight of their C-17s were ready to support. After completing additional analysis and testing on the eighth jet the DES team was able to provide procedural steps to allow the eighth jet to participate safely which the 99th Squadron implemented maximizing the RAF's airlift capability at a critical moment. Those improved procedural changes are still in place today. All eight 99th Squadron C-17s performed flawlessly during this time critical event transporting over 10,000 personnel to safety. The eighth jet was the last RAF C-17 out of Afghanistan.

Increased Readiness – During the period-of-performance the application of DAS recommendations has improved the availability of customer fleets by an average of 2-3%, saved over 35,000 Maintenance Manhours and mitigated over 26,000 Non-Mission Capable hours ensuring customer aircraft are more available more of the time to fulfill more mission needs.

Reduced Operational Costs – The DAS service has resulted in significant reduction in maintenance hours required to keep the fleet flying. Additionally, shifting heavily from unplanned maintenance to scheduled maintenance has reduced the strain on maintenance operations. The accuracy of the analysis produced by the DES team has produced narrowly precise and specific corrective actions for maintainers. DAS delivers multiple cost benefits to include fewer engine runs along with commensurate reduction in fuel costs, fewer "good" parts being removed, less strain on the supply chain, and fewer maintenance manhours expended.

During a post-flight debrief, a C-17 crew member identified a particular engine that was running "hot" exhibiting heavy fuel burn. After interrogating the data, the DES team identified an issue that saved C-17 operators more than $1M in the first 5 months of the DAS analysis due to degraded fuel pumps that proved to be a fleetwide problem associated with worn bearings inside the pump causing excessive fuel burn. Over 80 engines in the C-17 fleet were affected that were burning more then 400lbs of fuel more per hour. The resulting fuel burn signature is now part of the baseline engine trending analysis.

Improved Safety &Training – As a testament to the value of the DAS performance customer buy-in has increased dramatically. The granularity of the DAS data capture enables complete playback of flights including every stick movement, button push and indications on the displays. This enabled the RAF customer to implement a Flight Data Monitoring component to the DAS. Through direct flight playback and performance feedback to RAF crews and the RAF Standardization and Evaluation team the RAF have made changes to their operating doctrine and enhanced the proficiency and safety of their crews. The DES team is now delivering weekly FDM reports to Squadron gatekeepers which generates continuous improvement and development of FDM-specific algorithms.

Customer flight safety data highlighted the approach into a specific European airport frequently generated unstable approach. The precise flight pattern required a high banking turn on a short approach to avoid neighboring airspace. Using the platform parametric data, the DES team was able to work with RAF crews to develop an altered flight pattern, adjusted the turning point altitude and eliminated the high bank angle below 500 feet resulting in safer and more consistent approaches.

Strengthening Coalition Partnership – As a leader in implementing data analytics, DAS customers have identified C-17 fleetwide issues and improvements extending the benefits to non-DAS paying customers. The eight (8) C-17 FMS customers willingness to share their experiences has been instrumental in giving the total fleet partnership the confidence to proceed with implementation of data capture and data analytics for the entire program. The C-17 fleet has a unique shared spares pool, and the benefits identified for FMS DAS customers flow to the broader C-17 fleet as a result. Likewise, safety and training improvements permeate the entire C-17 fleet when identified.

Value to Members of Our Team

Job Satisfaction – C-17 DES team members are frequently integrated into the warfighter operations onsite; in planning meetings, and responding to critical events. Frequently our team is recognized for their efforts by the customer and the program. Positive feedback from customers is nearly a constant and our customers are now our best advocates for DAS. The customer acknowledgement and trust exhibited by merging DES team into operations results in significant team job satisfaction and validation of their efforts.

Professional Development – The DES team is trailblazing new territory with the implementation of DAS. This enables them to work on industry leading- and cutting-edge big data analytics technologies. Their work is foundational to the Boeing Enterprise Data Analytics strategy.

Professional Growth – As the DES team uncovers more and new ways to propagate the value of the data they are being drawn into more and varied aspects of the business. Broad exposure widens their perspective and opens new opportunities for career growth.

Value to the Greater Good

Establishing & maintaining a ready force - Aligned with associated countries National Defense Strategies, the DES team is keeping warfighters in the fight and supporting emergent humanitarian relief missions. Through application of DAS our team has improved customer Air Force's availability by 2-3% maximizing on-demand airlift capacity.

Cost Efficiency - Efficient operations reduce the cost to operate for customers and taxpayers. Our PBL has consistently saved money by incentivizing innovation; we continue to find ways to bring more value and reduce the overall cost to operate the C-17 weapon system. Historical data demonstrates year over year savings during a time when other Contractor Logistics Support (CLS) costs increased.

Safety/Security - Improving the safety of operating large fleets through the application of direct playback/feedback to pilots to support training and teachable events, benefits crews, maintainers, passengers and the population in general.

Following a near miss airport departure incursion, with less than 1000ft separation from a Russian freight cargo jet at a downrange location, the DAS team quickly identified the leading contributor to the event was due to the Identification Friend or Foe (IFF) system and Traffic Collision Avoidance System (TCAS) was left in "standby" mode during the subject departure. Placing these systems in STBY was a common practice by crews during taxi, but failing to activate the system prior to departure was an oversight that occurred on 2.73% of ALL departures. The DAS team alerted the squadron to the finding so that they could work this into their training, while at the same time implementing algorithms to track

and alert crews for future events. Since implementation of this algorithm, the data shows crews have eliminated this oversight from their airmanship. The DES team did not stop at this milestone, but also worked with C-17 design engineering to implement a crew alert if the system is inadvertently left in STBY at takeoff roll benefitting the entire C-17 fleet.

Sustainability – Significant fuel efficiencies and savings based on analytics-based recommendations not only drives down operational costs but reduces the platform's carbon footprint in operation. Fuel efficiencies and savings from many different DAS findings or recommendations have extended fleetwide and throughout the supply system.

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**
- ***10 points:*** **Define the unique practices and process you used to develop, lead and manage people?**
- ***10 points:*** **How did you leverage skills and technologies of your suppliers?**

<u>Innovative Tools & Systems Used</u>

The nature of the DAS approach to data collection, recording all-the-data-all-the-time, provides some unique challenges that are not faced by many other aircraft health management services. When a C-17 returns to home station after completing a handful of missions it is common for the size of the data downloaded to exceed 80GB compressed for that single aircraft. To swiftly extract meaningful insights, the DES team has developed an efficient and scalable extraction method. This involves ingesting raw binary data, identifying sortie and engine run start/stop times, interpretation of the data, and executing over 43,000 algorithms against the data within a matter of hours using enhanced desktop computers. Thanks to this extraction and analysis method, DES analysts can rapidly review data upon the aircraft's return to base, providing tactical and actionable information to the maintenance teams.

As our data service scales to encompass the entire C-17 fleet, comprising 274 aircraft, the DES team anticipates ingesting over 400 terabytes of data annually and surpassing 1 petabyte every three years. To address this substantial data volume, the DES team has developed tools with cloud computing capabilities in mind. Our analysis tool suite has been containerized to ensure scalable processing and compatibility with a data lake environment. Adhering to the US DoD DevSecOps approach, the DES team has prioritized security and aligned ourselves with current industry standards. This approach guarantees that the DES team is well-equipped to meet the evolving demands of data analysis and management.

In addition to our exceptional process orchestration and analysis capabilities, the DES team has developed a cutting-edge visualization package. The existing tool suite boasts advanced graphing and tables, alongside a remarkable application called Playback, which recreates the flight deck experience (see Figure 1). In 2021, the DES team embarked on an ambitious project to merge a commercial-off-the-shelf (COTS) gaming product called X-plane (see Figure 2) with our parametric data, resulting in a realistic 3D representation of recorded flights. This innovative application empowers aircrews to review their flights, identify valuable training opportunities, and support safety investigations.

Figure 1: Playback Application

Figure 2: X-plane CMC Application

Unique Practices & Processes Used to Develop, Lead and Manage

The DES team made a strategic decision to integrate onsite analysts with our FMS customers, fostering a closer collaboration and understanding of their needs. By working on base, our analysts have the opportunity to actively participate in daily maintenance meetings, engage in face-to-face interactions with maintainers and crews, and gain a comprehensive grasp of the customers' pain points. To facilitate the implementation of Boeing's maintenance recommendations, our DES team organizes a weekly Product Notification (PN) meeting. During these sessions, Boeing advises the customers through open recommendations, ensuring they comprehend the potential impact of inaction and the timeframe within which actions should be completed to prevent aircraft degradation.

Embracing geographical diversity and co-location with our customers, our DES team embraced these factors as the foundation to establish a profoundly collaborative environment. To foster effective expertise sharing, the DES team conducts weekly free-form knowledge transfer meetings, dedicated to reviewing ongoing aircraft data investigations at each respective site. The team is empowered to organize cross-training events where analysts with unique system expertise provide guidance and strategies for leveraging the parametric data to identify system degradations. The resulting DES collaborative environment, combined with the implementation of proper export agreements, enables our DES analysts to provide 24/7 emergency coverage to our FMS customers, seamlessly covering all fleets across different time zones, without incurring the cost of a three-shift operation.

DES made the decision to compose a team of engineers who had considerable aircraft system knowledge. We found that it was much more effective to teach aircraft systems specialists how to utilize data science techniques versus taking engineers with a data science background and teach them how the aircraft systems operate. The analysis team is made up of engineers with extensive commercial and military platform knowledge but also diverse work experiences, such as former maintenance troops, field service engineers and design engineers both U.S and international. This diversity in work history enables the DES team to resolve complex aircraft issues while considering all possible corrective actions in the respective environment. Examples of which include, mitigating unnecessary troubleshooting steps for maintenance teams by using data to answer the fault isolation logic, updating technical manuals based on trends found in the data analysis and driving software changes back through the design team to address the issue from a long-term fleet health perspective.

The DAS contract not only entails routine data analysis to support maintenance activities but also provides Boeing with the flexibility to execute special projects and investigations on behalf of the customer. This deliberate inclusion allows the DES team to explore innovative ways to leverage the parametric data. One example is the Salt-Water Exposure algorithm, which calculates precise intervals for

customer maintenance teams to perform clear water rinses of their engines based on actual exposure to salty air. By using flying profiles and ground time data, we eliminate the need for estimated time intervals, which can result in unnecessary maintenance actions or leave engines susceptible to corrosion in cases of greater than estimated salt air exposure.

Leveraging Supplier Skills & Technologies

Ensuring proper repair of degraded parts is of utmost importance. When these parts are identified and removed from the platform, it is crucial that they undergo appropriate repairs upon induction. In many cases, parts removed through predictive maintenance programs have degrading performance which may not trigger a failure in the supplier's Acceptance Test Procedures. To address this issue, the DES team initiated a collaborative effort with select suppliers, establishing a pilot program called Component Notification (CN) for parts entering the repair cycle. The CN program involves providing suppliers with a comprehensive summary of the parametric analysis that led to the removal of the component. The CN document also offers guidance to technicians at the repair facility, enabling effective troubleshooting of the asset. Through close collaboration between the DES team, Boeing Asset Managers, and supplier engineering teams, the necessary analysis insights are identified to maximize the program's benefits. Suppliers have shown positive responses upon receiving the CNs, acknowledging the value of the data to enhance and optimize their own design and repair processes.

Recognizing the significance of comprehensive data collection, the DAS service has pursued an approach of all-the-data-all-the-time on the C-17. The DES team recently achieved a significant milestone by integrating Auxiliary Power Unit (APU) data collection, recommended by the supplier. This integration enabled the capture of an additional 80 high-value parameters essential for establishing an APU health program and greatly enhancing our understanding of APU performance. The DES team accomplished this feat through a simple wiring modification and a supplier license agreement, effectively transforming the collected data into actionable insights. Looking ahead, expanding data collection remains a top priority for the program's future roadmap, as we continue to strive for comprehensive knowledge of aircraft condition.

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

Volatility (VUCA): The DES team encounters volatility in many ways. World events drive changes in customer operations tempo and utilization along with changing mission needs. Crisis Management Team (CMT) events are infrequent, but fleet-grounding situations and/or safety situations can occur at any time and require immediate resolution. New aircraft SW implementation can result in unexpected alerts and warnings driving unfavorable mission performance (e.g. unnecessary go-arounds).

Responding to Volatility (VUCA): Software updates, while they fix known issues, sometimes create new unintended failure conditions that require the DES team to identify root cause and engage design engineering to apply corrective actions.

Uncertainty (VUCA): Uncertainty is a daily obstacle for the DES analysts. Often faced with making sense out of chaos driven by seminal events not encountered before. This “needle in the haystack” type of

problem is often hard to identify. Depot heavy maintenance activities that are far more thorough and invasive than home station checks or operational maintenance often uncover latent or hidden problems not manifested or realized during day-to-day customer operations. These unexpected discoveries create additional work over and above the planned effort. They may also drive potential customer impacts if not corrected while the aircraft is already in Depot. Customers modernize and upgrade their aircraft to address capability gaps and improve performance. New technology often comes with new "bugs" that must be identified and fixed.

Dealing with Uncertainty (VUCA): As identified above during Operation Pitting (Afghanistan withdrawal) the application DAS analysis and recommendations was instrumental in removing the uncertainty that enabled maximum airlift projection for the RAF at a critical instance.

An RAF C-17 crew experienced an un-commanded control surface movement event while supporting operations in Africa. Ordinarily this would have resulted in a Maintenance Recovery Team (MRT) deploying to the site to trouble shoot and recover the aircraft, a very expensive and time-consuming effort. The RAF customer trusted the capability of DAS to problem solve on the fly so much that they delayed initiating the MRT. The crew pulled the ADR data cartridge and flew back to Brize Norton Air Base so that the local DES team member could upload and analyze it. Within 2 hours the DES team analyst on-site identified that the Low Altitude Parachute Extraction System (LAPES) switch had been inadvertently engaged and in fact the aircraft behaved exactly as designed. The crew disengaged the switch and the aircraft returned to expected and normal operation.

The DES team, via self-directed continuous improvement, deployed ADRs and the DAS analytics to other customer's aircraft prior to scheduled depot heavy maintenance induction. These health screenings have allowed the depots and supply chain to get ahead of conditions, instead real-time discovery during the maintenance program, and have also provided customers with increased decision space to determine whether to change out degrading components on the edge of failure while much more convenient in the depot tear down state. This aligns with the DoD Condition Based Management (CBM) concept.

The DES team has been able to identify components that were on the verge of failure, recommending replacement before critical with prime benefit being avoiding broke-off-station situations. This has reduced maintenance man-hours, improved stock position and successfully adjusted supply chain ordering.

Engine maintenance is a significant cost driver and the C-17 fleet as a whole is dealing with limited engines spares. Through application of DAS the team has shown the customers how they can maximize time-on-wing, extending the life of the engines before major overhaul or removal. As the worldwide fleet participates in the spares and repairs pooling concept this benefit extends to all C-17 customers.

Complexity (VUCA): Complex defines what the DAS service is. The team supports multiple Air Forces, with different operations methodologies, diverse operations tempo, including unique mission profiles, geographically disparate basing and 24/7 worldwide operations. In order to serve our global customer base, the DES team likewise is globally distributed across multiple Boeing sites and time zones making the management of the team and delivery of the service all the more complicated. The DAS captures data from every major system and subsystem for which the DES team must provide analysis and recommendations. As part of the corrective action process the DES team must understand supportability constraints, limits of design, and variations in configurations, essentially, they need to be "Jacks-of-all-trades". Lastly the sheer volume of data that must be consumed to deliver the DAS is monumental, capturing over 65,000 aircraft parameters at native rate including the Meta-data (for comparison

commercial aircraft capture on average ~ 2-4K parameters). The C-17 aircraft is data rich, generating over 5GB of data per flight hour.

Mastering Complexity (VUCA): The DES leader built an organization of highly knowledgeable field engineers and data scientists from around the company and positioned at customer main operating bases. Having DES team members shoulder-to-shoulder with customers solidified the teaming between Boeing and customer. This co-location ensures timely responses to customer queries. By employing subject matter experts covering many different aspects of the platform such as environmental, propulsion, avionics, and other systems, the collective DES team can address any situation.

The teams are self-empowered and share the analysis tasks associated with delivering the DAS reports and recommendations leveraging the expertise of the team to address special situations or circumstances. To facilitate this worldwide network the team installed local servers and embraced new technologies to create a development cloud environment for storing and accessing data from anywhere.

To handle large amounts of data the DES team developed a unique tool suite to analyze, sort and visualize the data. Having a larger pool of data comprised of several customer fleets to interrogate has benefited the team and all customers by illuminating fleet problems not obvious in a singular or smaller sample.

Ambiguity (VUCA): Aircraft are complex systems creating faults that are not always apparent and can often be driven by many potential sources. Problems don't always manifest in a fault or alert while they degrade and often are affecting more than a single aircraft. Maintainers and operators don't always interpret situations in the same way leading to multiple perspectives in response to a specific event.

Any situation resulting in an Aircraft on Ground (AOG), especially in a hostile environment and often with an imperfect set of circumstances, results in heightened pressure to return the aircraft to service, timely decision making is essential.

There was no roadmap for data analytics on a scale like the DAS and the DES team had to be trailblazers working without a compass. Likewise, our customers didn't really know what to expect from this emerging technology, Data Analytics. This is reflected in the broad but simple contract language for DAS requirements.

Applying Clarity to Ambiguity (VUCA): Through the application of the DAS and exploiting the collective customer data the DES team has been able to identify many fleet-wide events. As mentioned prior a single comment led to a >$1M (and counting) savings across the entire C-17 fleet. By assessing all the fleets' trends the DES team has been able to prevent multiple fleet-wide issues.

The unique granularity of the recorded data feeding the DAS enables significant scrutiny of events, timing and conditions surrounding the trigger event or observation. The DES team is further benefitting DAS customers by successfully removing interpretation by zeroing in on exact root causes that save the customers time and money. For example, on average a C-17 maintenance engine run consumes 4,200 pounds of fuel. There are more than 800 separate fault isolation steps that require maintainers to run engines or APUs just to re-create the condition of the fault.

A common pneumatic system problem is a bleed air disagree that can be driven by one of two large valves. The first step in the TO is to perform an engine run to gather diagnostic data. DES analysts are able to use parametric data to perform a quick leak rate analysis to pinpoint exactly which valve is at

fault therefore avoiding the unnecessary diagnostic engine run and saving the engine wear and tear, fuel burn, NMC time, and Maintenance Man Hours.

Due to the success of the DAS in delivering effective Aircraft Health Management (AHM) outcomes, DAS customers have requested additional data analysis into other non-traditional AHM areas via special studies. Through the application of the DAS tools the DES team has been able to identify safety issues, improve training and initiated a Flight Data Monitoring (FDM) program. Working with the customer to identify flying characteristics to flag for FDM, the DES team now captures every flight for FDM review and meets quarterly with the customer to determine if any intervening action is required. The DES analysts are able to model real world events to accurately reflect aircraft limitations and show effect of operator actions.

Using the aircraft parametric data DES analysts were able to see a negative trend in stick force input resulting in steep rotation angle on takeoffs. They were able to relate pilot control stick force inputs to aircraft rotation angle on takeoff and show this to the customer to address in training. By modeling this condition, DES analysts were able to show pilots and trainers that they can achieve the needed rotation angle with less stick force reducing the safety concern of imminent tail strike.

METRICS (Value: 15 points) *[Use 12 pt. Times Roman typeface]*
Please respond to the following prompts:

- **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.**

Predictive Metrics

As part of our performance-based contract There are a limited number of metrics established and incorporate incentives and disincentives related to aircraft availability and associated leading indicators.

Customer Metrics

- Improved Availability
- Reduce NMC Rate
- Reduce Cost of Operations
    - Reduce Mx Manhours
    - Reduce Unscheduled Mx*
    - Fuel Savings
- Reduce Total Non-Mission Capable for Supply (TNMCS)*

As well as internal objectives:

- Maximize Incentives
- Market Growth

Performance to Metrics

Through delivery of the DAS, customers have realized significant performance improvements during the period-of-performance:

Metric	Value
Mx Recommendations Provided	1,500+
Algorithms Developed	43,000+

Improved Availability	+2-3%
Reduce Mx Manhours	35,000+
Mitigated NMC Hours	26,000+
Fuel Saved (Pounds of fuel)	4.5Million+
Unscheduled Mx*	-12.1%
TNMCS*	-7%
Off-Station Breaks*	-45.7%
Pilot Reported Discrepancies*	-25.6%

**From a 9-month extended demonstration of DAS completed during the PoP*

The additional value delivered to DAS customers in safety and training are non-quantifiable but hold significant customer value nonetheless.

Additional Boeing objectives met: All current DAS customers have renewed their contracts and expanded on them. Value in the sense of Customer satisfaction results in solid CPAR ratings and business growth. There are currently several customer-driven requirements in-work to expand DAS coverage.

How do your predictive metrics drive action toward program excellence? Please provide examples.
DAS parametric data and findings streamline CMT and Engineering investigations by providing accurate and high-fidelity data aiding in better root cause identification and precise, effective corrective actions in reduced time.

Following a recent CCU SW update, aircrews started to report an increase in Traffic Collision Avoidance System (TCAS) alerts for stale altitude, a potentially dangerous condition where the aircraft is not reporting proper altitude, that resulted in a CMT investigation. DES analysts started reviewing fleet trend data to see how often this was occurring and validated the increased frequency of occurrence. Using the parametric data, the DES team was able to identify that there was a systemic flaw within the SW update and the modification was temporarily halted until the SW could be corrected and validated. This early intervention prevented a fleet grounding event and possible loss of aircraft.

DAS parametric data provides the accuracy and precision to aid Design Engineering to develop better modifications, changes and fixes in less time and improves first time quality. As an example, a DAS-driven software improvement with significant cost and operational impacts is high-lighted above.

The DES team has frequently been able to provide DAS parametric data to avoid a re-fly as part of a non-ADR enabled jet.

Supply Chain is leveraging DAS findings to improve spares posture and predictive models. This benefits all C-17 operators in the virtual pool concept.

C-17 engines and APUs are both in short supply. Through the use of the DAS parametric data C-17 operators are able to increase time-on-wing for both of these critical assets. DAS data is being used to drive condition-based maintenance practices into the customer processes.

The DES team has changed customer cultures, previously operating under a fly-to-fail mentality. DAS customers have embraced the predictive power of the data to change the paradigm to a condition-based maintenance approach, a change only achievable through demonstration of real program results.