THE C-17 PROGRAM
A MODEL IN SUPPORTABILITY/SUSTAINABILITY

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ABSTRACT
The C-17 acquisition strategy requires the contractor to demonstrate successful achievement of key supportability parameters before system acceptance by the government. To implement this strategy, the C-17 Full Scale Development, Production, Spares, and Interim Contractor Support contract requirements were negotiated and defined, placing the responsibility of providing an integrated, comprehensive effort to field and initially support the C-17 with defined supportability criteria on the contractor. In addition, the C-17 program has been structured with major emphasis on utilizing advancing computer data systems technologies to truly integrate logistics support requirements. These logistics initiatives can serve as a model for development of future Computer-Aided Acquisition and Logistics Support (CALS) tools for other programs. This paper describes the elements of this supportability/sustainability strategy for the C-17 program.

SYSTEM DESCRIPTION
The C-17 is a multi-engine turbofan, wide-body aircraft capable of airlifting payloads over 172,200 pounds over intercontinental ranges without refueling. The aircraft is similar in size to the C-141 and is capable of air refueling. The aircraft will also be capable of moving out-size cargo, such as the M-1 tank, directly to austere runways of 3,000 feet. Configuration variations will allow this aircraft to carry troops, cargo, and litters, or any combinations of these. The system is capable of either the airland or the airdrop/extraction mission. The projected aircraft procurement of 210 is scheduled to be spread over five active and four Air Force Reserve locations.

BACKGROUND
The C-17 Program was originally conceptualized in the early 1980s, being carefully structured and integrated, around a comprehensive acquisition strategy that would result in a reliable and supportable weapon system. Included in the C-17 contract is planned Interim Contractor Support (ICS) until the design stabilizes and the organic logistics system can be efficiently developed. The C-17 approach requires the contractor to demonstrate successful achievement of key supportability parameters before system acceptance by the government. The supportability parameters are identified in the system specification and validation procedures which will utilize the results from Development Test and Evaluation/Initial Operational Test Evaluation (DT&E/IOT&E), an initial squadron operation, and the Operational Readiness Evaluation (ORE) to determine compliance. This approach places greater responsibility on the contractor for managing the initial system support. Specifically, the contractor is responsible for providing all organizational and intermediate level (O/I) support equipment (SE) required to maintain the initial squadron operations to meet specification supportability requirements, along with the required technical orders and spare parts. By firmly placing responsibility for initial support on the contractor, the government can effectively manage supportability specification compliance. In addition, the C-17 program has developed, implemented, and integrated many initiatives to complement this acquisition strategy. Included in these initiatives are its automation, reliability/maintainability, and design to life cycle cost efforts.

COMPUTER-AIDED ACQUISITION AND LOGISTICS SUPPORT (CALS)
Computer-Aided Acquisition and Logistics Support (CALS) is a Department of Defense initiative to move from the current reliance on paper-oriented design manufacturing and support processes to a highly automated, integrated way of doing business for future weapon systems. In a memorandum dated 24 September 1985, the Deputy Secretary of Defense defined the following as objectives of CALS:

 o To encourage and accelerate the automation and integration of contractor processes for generating weapon system technical information in digital form.
 o To rapidly increase DOD's capabilities to receive, store, distribute, and use logistic technical information in digital form to improve weapon system maintenance, training, and spare parts reprocurement.

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The C-17 program has been closely tracking the CALS progress through AFSC and AFLC focal points. As a result, the C-17 has incorporated the above objectives in a number of CALS-like initiatives. A discussion of these initiatives follows.

C-17 APPROACH

In 1981, the C-17 Full-Scale Development contract was negotiated. Included in that contract's statement of work (SOW) was the following tasking:

"Management Information Systems - The contractor shall implement and maintain a Management Information System (MIS) which will give both the Government and the contractor the necessary visibility to plan and control the program. The MIS shall integrate and encompass the various management and data systems such as scheduling, logistics, engineering management data, Cost/Schedule Control System Criteria (C/SCSC), Design to Life Cycle Cost (DTLCC), etc., into a conceptually single disciplined, and responsive management data base. The MIS output data for both Government and contractor use shall then flow from a conceptually single source up to one or more record files or systems which are manual or automated. The contractor shall integrate the MIS with the LSA process and LSAR to ensure complete compatibility of communications linkage and data."

As a result of this tasking, Douglas Aircraft Company (DAC) is developing a single integrated logistics support data base for C-17 logistics requirements. Included in this data base is the information required for:

- Logistics Support Analysis
- Integrated Logistics Support Management Information System
- Enhanced Resident Integrated Logistics Support Activity (ERILSA)
- Reliability and Maintainability
- Design to Life Cycle Cost

Coupled with the challenges resulting from the above tasking has been the progress in personal computer capability. As a result, several CALS-like initiatives have evolved in the C-17 Program. Included in these initiatives are the following:

- Comprehensive Logistics Support Analysis System (CLASS)
- Enhanced Resident Integrated Logistics Support Activity (ERILSA)
- Reliability and Maintainability Models
- Design to Life Cycle Cost Program

The following provides additional information on the above.

LOGISTICS SUPPORT ANALYSIS (LSA)

Logistics Support Analysis (LSA) has been developed to provide a balance between the engineering and logistics systems of the contractor. This interface ensures system readiness as a result of logistics support requirements planning under the parameters of life cycle cost. LSA is a two-part process accomplished by the contractor and monitored by the government. The analysis includes engineering and logistics interfaces which result in an integrated support development effort. The resulting data is entered into the Logistics Support Analysis Record (LSAR). The LSAR is a single logistics data source which is utilized to produce item requirements.

Early in the C-17 Program, a working group was formed to develop an LSA milestone program. The objective of the overall LSA scheduling system was to divide the work into three levels of effort. The first focus was on documentation of the remove-and-replace tasks plus the support general tasks associated with organizational-level maintenance. This documentation was started over one and a half years before the engineering drawings were released. The LSAR has been iterated as final drawings have been released. This work has helped the Air Force and the contractor to focus on the maintenance actions, support equipment requirements, and common tools. As less than one-third of the effort completed, this process of generating the record has resulted in:

- Douglas LLS engineers have identified over 150 design changes;
- Air Force review teams have identified over 80 design changes.

The intermediate-level (I-level) documentation effort is ongoing, and currently over 50 personnel are working the LSA process at Douglas Aircraft. Additionally, subcontractors are documenting data in the early stages of their development process. The goal has been to document all O&I-level requirements and tasks so that the maintenance requirements are passed to the support equipment engineers and these requirements are turned into Support Equipment Recommendation Data (SERDS). The object of this effort is to have all SERDS submitted and reviewed by the Air Force prior to an O&I support equipment preliminary design review.

Over the past year, there has been extensive effort to automate the LSA data base. At Douglas Aircraft Company, they have developed a method of taking the LSA maintenance procedures and overlaying the text into the technical work processor. Additionally, they have added extensive software quality assurance edits into the LSAR data base and provided a comment screen for Air Force personnel to address concerns to the author. Maintenance task data is retrieved from the LSA data base and displayed on a split screen. Data is copied from one side of the screen to the job guide development screen; i.e., a split screen test editor. With this system, the technical writers are using procedural information that has previously been reviewed by the government maintenance teams. Plans are in place to acquire 24 additional "ATEX" terminals for growth through 1988. Also, 24 ATEX and 24 EZVISION work stations have been requested for 1989. These terminal stations, coupled with 34 intergraph work stations, will provide the Air Force and Douglas Aircraft with a totally automated technical order development and printing capability. Interfaces of this system with the Air Force digital Automated Technical Order System is the ultimate objective of this data transfer. Along with this is the goal
of the elimination of technical order negatives. Comprehensive LSA Automated Support System (CLASS) is the computer software that collects and stores C-17 LSA data and produces management reports. CLASS has been designed by McDonnell Douglas Automation Company/Washington Operations Division (MDAC-WOD) to meet the requirements of MIL-STD-1388/2A (LSAR). A Joint Services validation of the McDonnell Douglas Type II LSAR Automatic Data Processing (ADP) was completed July 1986. This certifies DAC is capable of generating LSA Master Files in accordance with MIL-STD-1388-2A, relying on Joint Services ADP software to generate these output reports. CLASS automates the data collection requirements of LSAR Data Records A through J which are developed by LSA. From the data base, periodic management evaluations are extracted. If baseline objectives are not being met, analysis and trade studies are conducted and comments are tracked. In addition, quality assurance data reviews are utilized to ensure accurate information is utilized.

INTEGRATED LOGISTICS SUPPORT/INFORMATION SYSTEM (ILS/IS)

The central requirement of the C-17 Integrated Logistics Support/Information System (ILS/IS) is to provide reporting, based upon critical path scheduling of C-17 ILS tasks at the Line Replaceable Unit (LRU), support equipment, and technical order levels based upon information contained in existing C-17 data systems. These systems primarily include the Comprehensive LSA Automated Support System (CLASS), the Customer On-line Order Processing System (CO-OP), and various others. This system is currently being developed by Douglas Aircraft Company. When completed, it will provide both Douglas and the Air Force with a system for tracking critical logistics support requirements/deliveries for C-17 activations down to the LRU/Work Unit code level.

INTELLIGENT GATEWAY PROCESSOR

The key C-17 logistics functions have also been linked together. Logistics, as well as other C-17, personnel are able to communicate through the use of an Intelligent Gateway Processor system. This "mail service" type system can also provide connectivity to the other air logistics centers during the depot planning phase of the C-17A Program. The Logistics Operations Center (AFLC-LOG) and to the Cataloging and Standardization Center, Battle Creek, Michigan, are also "on-line". Any authorized user may access the LSAR from this network. The C-17 logistics office is currently using such access capability to speed up the review of Support Equipment Recommendation Data (SERDs). The SERD frequently references a series of tasks that may be associated with the support equipment. The System Program Office support equipment engineer can find added information on the use of the KE item through access of the referenced task.

Working in concert with HQ Military Airlift Command (MAC), SA-ALC, Kelly AFB, Texas, and Cataloging and Standardization Center, Battle Creek, Michigan, the Deputy Program Manager for Logistics (DPMNL) has established an Enhanced Resident Integrated Logistics Support Activity (ERILSA) at the contractor's facility, Long Beach, California. The ERILSA team assumed day-to-day review of the LSAR, augmented with dedicated teams of additional personnel who meet quarterly for reviews of the LSAR.

In addition to reviewing the LSAR, the SA-ALC personnel have been busy establishing a capability to access the AFLC automated provisioning D220 systems. In May 1987, equipment was installed to allow the equipment specialist access into the D220 system. This will allow printing of the item orders at the ERILSA, thus expediting the provisioning process. In addition, training data from the LSAR data base at Douglas is transferred to the training unit located at Edwards Air Force Base, California. This data is being utilized to determine C-17 training requirements and, eventually, the actual training courses.

The upfront involvement of AFLC and "user" personnel is paying dividends. More importantly, they are all working from a common data base. With software programming innovations by the contractor, the C-17A ERILSA has made significant progress toward the goal of a paperless logistics data base.

RELIABILITY AND MAINTAINABILITY (R&M)

The primary objective of the C-17A Reliability and Maintainability (R&M) program has been to attain the optimum levels of mission and logistics reliability, maintainability, and availability in the system design and production consistent with design to life cycle costs (DTLCC) and contractual system-level performance requirements and goals. This concept of system-level reliability, maintainability, and availability requirements establishes the foundation for the C-17 R&M program to obtain system-level performance. The R&M program applies to the C-17 air vehicle, its subsystems, and support equipment. Reliability and Maintainability are being considered along with cost, schedule, and performance in the implementation of the weapon system's program management plan. Contractual acquisition strategies, consisting of system-level performance requirements, warranties, R&M performance incentives, support equipment by capability, parts control, logistics support analysis, and reliability-centered maintenance have all enhanced R&M in the C-17 weapon system design.

In order to evaluate the performance of the C-17A system against its stated requirements, it will be necessary to collect and analyze reliability and field data. During Development Test and Evaluation (DT&E), the System Effectiveness Data System (SEDS) will be used to collect and process test data for R&M evaluation purposes. Following DT&E, during the growth curve tracking period
and the Operational Readiness Evaluation (ORE), similar operational data will be necessary. Currently, there are no existing AFLC or USAF data systems that will provide necessary analyses of operational RNA data. However, the Air Force has developed the Reliability, Availability, Maintainability Data Acquisition System (RAMDAS) to verify operational RNA data; the C-17 SOP will have the contractual option to use RAMDAS to verify the ORE contractual RNA requirements.

Another system being utilized in the C-17 R&M program is the Douglas Aircraft Company's Availability Model (DACAM). The purpose of this system is to evaluate the impact of airborne support systems, operational parameters, and R&M parameters on aircraft performance. This model simulates the C-17 ORE environment with the additional features of deferred maintenance, multiple basing, and automated sortie generation. From the DACAM model, the following outputs can be obtained: availability parameters, maintenance downtime per utilization, resource utilization, queuing, aircraft flight hours/mision cancellations, aircraft queuing, dispatch reliability, and total mission capable time contribution/not mission capable drivers.

In addition, the Mission Completion Success Probability Simulation Model (MCSPSM) has been created by Douglas Aircraft Company. A "Monte Carlo" model, this model utilizes an input of mean time between failure, system success logic, mean time to repair, component operating time, and mission profiles. The MCSP simulation results include mission frequency per utilization rate, individual mission MCSP for 25 specification profiles, component criticality ranking per impact on MSCP, and capability of differentiation between ground abort and mission deviation. Thus, with this model the probability that the C-17 system will complete a scheduled mission without experiencing an equipment failure or performance degradation that would result in an airborne, ground abort, or mission deviation can be determined. Actions (either corrective or preventive) can then be taken.

The standard Logistics Composite Model (LCOM), jointly developed in 1967 by Rand Corporation and the Air Force Logistics Command, is being jointly utilized and managed by ASD/AVC and ASD/ENS for C-17 manpower planning. The LCOM model reliability and maintainability factors are compatible with the USAF CLASS system. HQ MAC is also utilizing this model to determine manpower standards for the C-17 program. These standards will also be provided to Congress to satisfy mandated manpower identification requirements. A C-17 LCOM is also being developed under a Douglas subcontract to BDN Corporation. The purpose of the LCOM models is to evaluate the impact of logistics systems, operational scenarios, and maintenance policies on manpower requirements. Outputs include the following: manpower, spares, support equipment usage, availability parameters, mission downtime, and mission cancellation drivers.

The Dynamic Multi-Echelon Technique (Dyna-METRIC) has been used to evaluate the logistics requirements of MAC aircraft. The previous models are being utilized on the C-17 Program to ensure that the logistics system required to support the C-17 is developed. Through these modeling efforts, the optimum logistics support requirements can be determined and be in place when the C-17 is fielded.

**Design to Life Cycle Cost (DTLCC)**

The objective of the C-17A Design to Life Cycle Cost (DTLCC) program is to set a goal on the total system cost which includes not only acquisition cost, but also support costs as well. A contractual goal has been determined. Within this goal design tradeoffs can be made in control of the total system. Managing by total life cycle cost provides flexibility to spend money up front in acquisition for a payoff in later support costs, within budget constraints.

The C-17 contract requires that the contractor establish LCC as a design parameter and control all costs associated with the C-17 weapon system throughout its design, development, production, and deployment. The C-17 DTLCC program fulfills this requirement by establishing LCC goals for:

- **Full-scale engineering development (FSD) cost**, which include R&D costs.
- **Weapon system cost (WSC)**, which include production costs.
- **Other support cost (OSC)**, which include:
  - Type I training, interim contractor support, common support equipment, and initial spares.
  - Operating and support (O&S) cost, which includes the cost of supporting the aircraft fleet for 20 years.

The current costs for each of these goals are periodically assessed; and, thus, each goal is tracked and the results are reported. In addition to LCC goals, portions of the production and the O&S costs which are design sensitive are allocated into smaller packages to provide design to values. Also, specifically selected cost drivers are tracked, as are trade study and cost avoidance efforts.

Several management objectives and responsibilities result from the primary DTLCC program objective of establishing LCC as a design parameter through management and contractor goals to achieve the best balance among LCC performance, and schedule throughout design, development, production, and deployment.
The following are the Air Force's objectives of the C-17 DTLCC program:

- Incentivize the design organization to produce a low LCC design.
- Manage and integrate the results of DTLCC analyses, including centralization of all trade studies.
- Provide DTLCC consideration on the LCC implications of design options prior to authorization of detailed design activities.
- Coordinate and provide trade factors used by design personnel in accomplishing their informal studies.
- Measure and report DTLCC progress.

In accomplishing these objectives, the DTLCC activity is responsible for analyzing design, manufacturing, logistic, and specification alternatives to identify the lowest LCC approach and recommend selection of the lowest cost options.

In general, trade studies and cost drivers are identified to improve or select design elements in order to benefit one or more weapon system goals, such as cost, performance, maintenance, readiness, and operational utility. Examples of trade candidates include issues for cost reduction, material choice, service life improvement, hardware selection, support equipment, maintainability improvement, and evaluation of support concepts. Both the trade study process and cost driver process interface and become part of the LSA process. The criteria for selecting cost drivers are specified in the LSA section of the C-17 FSD contract.

The DTLCC reporting requirements and the continuous review procedures provide also for integration of subcontractor/vendor efforts into the DTLCC plan. The initial target goals for C-17 FSD cost, WSC, and OSC are based upon the terms and conditions of these contracts. The target cost of the fixed-price, incentive-fee contract for FSD is tracked and transmitted to DTLCC. The WSC target goals encompass the two fixed-price, incentive-fee production contracts.

These are used as a basis for determining the target goal for WSC and the allocations to establish subgoals.

The OSC cost contracts establish the basis for determining the OSC goals and subgoals.

The C-17 DTLCC program requires the contractor to track the progress of the design effort. To date, the contractor has implemented over $300 million in DTLCC savings through 393 DTLCC evaluations of design decision notices and 80 detailed DTLCC trade studies. The focus of the effort has been on reducing O&S cost with a minimum of impact on the acquisition cost.

CONCLUSION

A lot has been written about improving the reliability and logistics support of modern complex weapon systems. The C-17 program is taking great strides in making that goal a reality. The focus of the C-17 program has been on improving system reliability and reducing operation and support cost. The C-17 acquisition strategy encompasses providing the contractor incentive for improved system support and readiness.

In addition, the C-17 program has made a concerted effort to utilize advancing computer and data systems technologies in an effort to move toward a truly integrated logistics system. Overall, the goal has been to get the best value for the Air Force dollar while still buying a durable, reliable, capable and supportable weapon system.