Congressional Research Service

Memorandum October 23, 2003

TO: Senate Commerce Committee
Attention: Pablo Carrillo

FROM: Christopher Bolkcom and Daniel Else
Foreign Affairs, Defense, and Trade Division

SUBJECT: Observations on KC-135 corrosion and KC-767 sole-source logistics support

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This memo is in response to your request for an assessment of the Secretary of the Air Force's October 9, 2003 letter to the Chairman and Ranking Minority Member of the Senate Armed Services Committee in which he describes recent corrosion documentation for the KC-135E fleet and the rationale for a sole-source logistics support contract for the KC-767.

Below you will find our observations divided into two sections; the first relating to corrosion documentation, the second to the logistics support contract. Please contact us at 7-2577 (Christopher) or 7-4996 (Dan) if you have any questions or require additional information. Please note that CRS does not take a position on any public policy issue.

Studies on, and Concerns about, KC-135 Corrosion

The October 9th letter discusses why Secretary Roche considers the Economic Service Life Study "flawed," and the implications of aircraft corrosion's unpredictability. This section of the memorandum examines the issues raised by Secretary Roche and, as requested, potential alternative views on corrosion.

Air Force Arguments Regarding KC-135 Corrosion. The Air Force has taken the position that its Economic Service Life Study (ESLS) was conceptually flawed because it did not adequately predict fatigue and corrosion problems in the current KC-135 tanker fleet. When published in February 2001, the ESLS stated that the KC-135 fleet would be "structurally viable until 2040." Because airframe corrosion and fatigue can directly affect the safety of flight of any aircraft, their mitigation can be a matter of strong concern to the fleet manager and inaccurate or inadequate predictions can add significant unanticipated costs to the maintenance of aircraft. The Secretary mentions two follow-on studies, which he believes better represent the true state of affairs regarding corrosion and fatigue in the KC-135.

From June to November 2002 the Air Force Air Mobility Command and Materiel Command conducted a study on the expected lifetime of the KC-135 tanker fleet, the Aging Aircraft Study (also called the *KC-135 Corrosion and Service Life Report*). The Study's findings led the Air Force to conclude that corrosion, not the number of flight hours flown or the mission assigned to the KC-135, had the most significant impact on the expected life span of each airframe. The KC-135s now flying were designed in the 1950s and built during the 1960s. The state of technical knowledge concerning metal fatigue and corrosion has advanced significantly in the decades since, and the aircraft have been exposed to a corrosion-inducing environment throughout this period. The Air Force has found that, as airframes advance in age, the diagnosis and treatment of airframe fatigue and corrosion in the KC-135 has tended to demand greater numbers of labor man-hours during the aircraft's heavy, or depot-level, maintenance. Secretary Roche notes that only complete re-manufacture of the aircraft can eliminate corrosion, and that airframe corrosion in the KC-135E is "significant, pervasive, and represents an unacceptable risk."

In the Aging Aircraft Study, the Air Force states that "Although corrosion susceptibility is understood, there are no accurate growth rate models."[1] This statement is consistent with other Air Force and DoD assertions such as "One of our greatest concerns is a potential fleet-wide ground event that could emerge with little or no warning because of the unforeseeable effects of corrosion on the aircraft."[2]

On May 1, 2003, the Air Force published its KC-135 Business Case Analysis (BCA) that combined information from the ESLS, updated depot maintenance cost data, and the Aging Aircraft Study. The Air Force concluded that corrosion, increased operating costs, and other operating uncertainties justified a decision to retire 44 of these aircraft in Fiscal Year 2004. Airframe corrosion, not metal fatigue, is the key factor motivating this decision. The Secretary notes that between 1991 and the date of his letter, KC-135E corrosion-related depot maintenance increased more than three times, and that 30 percent of the tanker's heavy maintenance man-hours are now devoted to the mitigation of corrosion damage.

Alternative views on Corrosion and the KC-135 Fleet. Most, if not all observers agree with the Air Force that the KC-135E fleet suffers from corrosion problems. In its Business Case Analysis (BCA), the Air Force documents increases in the actual cost of KC-135 programmed depot maintenance that are notably higher than ESLS projections.[3] There appears to be no basis for challenging the Air Force's actual cost data. However, KC-767 lease opponents may point out that the increases in KC-135 maintenance costs correspond with significant improvements to the speed with which these aircraft are processed through the depots and a reduction in the number of KC-135s in depot at any one

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[1] *KC-135 Corrosion and Service Life Report.* U.S. Air Force. October 2003. p.5. Provided to CRS by USAF Office of Legislative Liaison, October 20, 2003.

[2] Letter from Deputy Secretary of Defense Paul Wolfowitz to Senators Warner and Levin. September 22, 2003.

[3] While the ESLS projected 2001 O&S costs to be $2.1 billion, the Air Force actually spent $2.26 billion, an increase over ESLS estimates by $250 million or 11.9 percent. See CRS Report RL32056 for more information.

time.[4] Thus, KC-767 lease opponents might argue, the increased costs are offset to some degree by increased KC-135 availability.

Some may dispute the Air Force's projections of future KC-135E corrosion-related maintenance costs. The Air Force states that the cost growth rate models used in the BCA (which predict an annual real growth rate 50% higher than the ESLS's) are more realistic than the estimates used in the ESLS. Some observers note however, that the Air Force also states that "USAF cannot (yet) accurately predict the extent or cost of corrosion."[5] Therefore, skeptics may argue, because the Air Force says that it can't predict corrosion or its costs, the BCA estimates may be no more reasonable than the ESLS estimates.

Some may disagree with the Air Force's position that corrosion is unpredictable, and its implication that this unpredictability imposes an unacceptable risk of grounding the entire KC-135 fleet. They may note, for instance, that the Air Force Research Laboratory is developing a Corrosion Prediction Model that "...can assess corrosion damage and project a structure's future corrosion condition." It is hoped that this model will be able to assess the growth of corrosion for all aircraft components. The current version "can be used for corrosion and structural assessment of the current status of aircraft lap joints and wings."[6]

Lease opponents may argue that the Air Force's Corrosion Prediction Model is just one diagnostic tool that has been developed during decades of scientific and engineering research on corrosion prediction.[7] The Air Force Corrosion Program office at Warner-Robbins AFB, for example, has sponsored research since the mid 1990s on predicting the effects of corrosion and fatigue on the structural integrity of Air Force aircraft.[8] In 1999, research conducted under a contract from the Corrosion Program Office found that the corrosion growth models were "...sufficiently mature that their integration into the current ASIP (the Air Force's Aircraft Structural Integrity Program) framework is both logical and feasible."[9]

The United States is not the only country facing the challenge of maintaining aging aircraft, many of which are experiencing corrosion problems. Canada, for instance, also operates an aging aircraft fleet, and its National Research Council has collaborated with agencies in the United States to develop a suite of tools for predicting the onset of corrosion, and its growth, and for projecting the effect that this corrosion will have on an aircraft's

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[4] By some estimates, KC-135s are today spending 45 percent less time in depots than they were two years ago, and more aircraft are now available to the warfighter than in July 2000. See CRS Report RL32056.

[5] *USAF Need for KC-135 Recapitalization: Operational, Maintenance & Economic Implications*. A September 2002 Reassessment of the KC-135 Economic Service Life Study. U.S. Air Force.

[6] M.M. Altynova, *et al.* "Engineering Prediction Model for Aircraft Structures." 6th Joint FAA/DoD/NASA Aging Aircraft Conference. September 16-19, 2002. p.1.

[7] See for instance: David W. Hoeppner. "Model for Prediction of Fatigue Lives Based Upon a Pitting Corrosion Fatigue Process." Fatigue Mechanisms, Proceedings of an ASTM-NBS-NSF Symposium, J.T. Fong, Ed., ASTM STP 675 American Society for Testing and Materials, 1979, pp. 841-870

[8] Email correspondence between CRS and David W. Hoeppner, P.E., Ph.D. Professor of Mechanical Engineering, University of Utah.

[9] Craig Brooks, et al. "Predictive Modeling for Corrosion Management: Modeling Fundamentals." September 1999. Analytical Processes Engineered Solutions Inc. (APES) St. Louis MO.

structural integrity.[10] These tools include nondestructive inspection methods for detecting corrosion in inaccessible parts of an aircraft, and computer models to conduct preliminary corrosion risk assessments.

KC-767 lease opponents may also point out that corrosion prediction is well established in the petroleum and nuclear industries. Several PC-based computer models are available to predict the onset and growth of corrosion in oil pipelines.[11] Also, the Department of Energy uses a computer model to predict stress corrosion in nuclear reactor pipes.[12] According to some experts in the corrosion field, advances in corrosion prediction in these other fields could be readily applicable to corrosion prediction in aircraft because the "tools and methods are the same."[13] Understanding the aircraft's environment and the impact of that environment on the aircraft's materials appears to be the greatest difference between the fields.

Finally, it is unlikely that observers would disagree with Secretary Roche's statement that "Only complete re-manufacture can eliminate corrosion. Some may, however, question the statement's relevance. KC-767 lease opponents may argue that corrosion does not need to be eliminated from the KC-135E fleet. It only needs to be monitored and managed, they may argue.

Sole-Source Maintenance and Logistics Support Contracting

The Secretary's letter discusses the reasoning behind the award of a sole-source contract to the Boeing Co. for initial maintenance and logistics support for the KC-767A aircraft. This section of the memorandum examines the issues raised by the Secretary in the context of standard industry practices for the civil 767 fleet and similar aircraft.

Aircraft Maintenance and Logistics Support Overview. All aircraft operated by U.S.-flag carriers (U.S.-based scheduled and charter airlines, freight carriers, and others) and foreign-flag carriers that operate in U.S. airspace are required to meet Federal Aviation Administration (FAA) airworthiness standards.[14] The FAA has established a system that requires such aircraft to undergo periodic maintenance at FAA-certified maintenance facilities. These facilities are located within the United States and in several countries overseas. Boeing's aviation maintenance unit is not, therefore, the only, or even the largest, organization capable of handling the maintenance needs of the 767.

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[10] Jerzy P.Komorowski. "New Tools for Aircraft Maintenance." *Aircraft Engineering and Aerospace Technology.* Vol. 76, No. 5. pp. 453-460.

[11] Press Release. "InterCorr Licenses Internal Corrosion Prediction Software to Technical Toolboxes Inc." July 8, 2003, InterCorr International. Inc. and GTT-News, The News Letter from GTT-Technologies. Issue 30, November 22, 2002. "Asset, a corrosion prediction system." http://gttserv.lth.rwth-aachen.de/~sp/tt/gtt-news/gttn_30.html

[12] F.P. Ford. "Quantitative Prediction of Environmentally Assisted Cracking." *Corrosion.* Vol. 52, No. 5, 1996. NACE International. pp. 375-395.

[13] October 21, 2003 CRS telephone interview with Mr. Michiel Brongers, contributor to *Corrosion Cost and Preventive Strategies in the United States.* Report by CC Technologies Laboratories, Inc. to Federal Highway Administration, Office of Infrastructure Research and Development, Report FHWA-RD-01-156. September 2001.

[14] Information regarding airworthiness certification, maintenance facility certification, and other FAA regulatory issues is available online through the FAA web site: http://www1.faa.gov/.

Many major and regional U.S. airlines outsource their maintenance work to numerous third party "maintenance, rework, and overhaul" (MRO) specialist companies, while retaining a in-house maintenance capability. Indeed, according to a recently published trade journal article, "the largest U.S. airlines spent $2.5 billion, or 47 percent of their total maintenance costs" in 2002 on outsourced service.[15] In May 2002, the value of the MRO worldwide market was estimated at $37.8 billion and was estimated to grow to $44.8 billion by 2007. There are also reports that the aircraft maintenance industry is faced with an overcapacity situation in the wake of the airline downturn, particularly for aircraft that have been in service for many years. One industry analyst recently stated that, "I think there is definitely overcapacity in the segments where there are older technology aircraft ...."[16]

Many of these MRO companies have operated for many decades and are licensed to conduct all levels of repair and overhaul on mature Boeing aircraft such as the 767, in addition to aircraft manufactured by other companies. Like aircraft manufacturers that offer continued maintenance of their products, these third-party maintenance organizations have developed extensive vendor, repair base, and customer support networks and have FAA-approved repair practices in place. Many MRO specialist companies engage in more maintenance work than the manufacturers. During 2000, Boeing Airplane Services, the company's MRO arm, ranked third among U.S. companies, compiling 3.0 million labor man-hours compared with the 5.4 million labor man-hours of industry leader TIMCO Aviation Services, and tied for only eighth place worldwide.[17] Many of the larger firms are certified to perform 767 maintenance at all levels.

Much of the intellectual property necessary to maintain aircraft at the level to meet certification requirements, such as engineering drawings and instruction manuals, is proprietary. Aircraft manufacturers retain the rights to this information and routinely license its use to airlines and third-party maintenance organizations. The Intellectual Property Management Division of the Boeing Co. routinely offers Maintenance, Repair, and Overhaul proprietary information licenses to organizations certified by their local (U.S. or foreign) civil aviation authority to perform work on aircraft. Licensing arrangements and fee schedules are posted on the Boeing Co. web site and are available for airframe maintenance, component maintenance, and aircraft modification and improvement.[18]

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[15] Frank Jackman, "O&M: MRO Market Value Down More than 10%," *Overhaul & Maintenance*, May 17, 2002, available online at: http://www.aviationnow.com/avnow/news/channel_maint.jsp?view=story&id= news/rmro40517.xml.

[16] Jerome Greer Chandler, "The Outsourcing Imperative," *Overhaul & Maintenance*, October 2003, pg. 27.

[17] Companies ranking equal to or exceeding Boeing Aircraft Services in annual labor man-hours in 2000 included TIMCO Aviation Services (U.S.), Lufthansa Tecknik (Europe), Goodrich MRO Division (U.S.), HAECO (Asia), SIA Engineering (Asia), KLM Engineering & Maintenance (Europe), Alitalia Technical Operations (Europe), and Bedek (Europe). See Jim Proulx, "TIMCO Tops in North America, But for How Long?" Overhaul & Maintenance, June 1, 2001; and Aviation Week's "MRO in Asia-Pacific Region," available online at http://www.awgnet.com/shownews/02asia1/mro09.htm, downloaded on October 23, 2003.

[18] The Boeing Intellectual Property Management Division web site can be found online at: http://www.boeing.com/commercial/ipm/.

Major aircraft manufacturers, like automobile manufacturers, operate primarily as designers and as assemblers of components subcontracted to other firms.[19] These subcontractors, the engine manufacturers, avionics firms, metal forging and machining companies, and the like, are the original equipment manufacturers (OEM), not the aircraft assemblers. Some aircraft manufacturers, including Boeing, also provide continued maintenance and logistics support of their products.

Compliance with Federal Aviation Administration (FAA) Regulations. The maintenance and airworthiness of civil aircraft operating in U.S. airspace are regulated by the FAA. Maintenance and operation of military aircraft are regulated by the Department of Defense.

If the KC-767A is considered a civil aircraft, its operation will require compliance with FAA airworthiness standards, including maintenance accomplished at an FAA-approved maintenance facility. This maintenance could be carried out by the Aircraft Services Division of Boeing Commercial Airplanes, but it could also be carried out by any of the other appropriately certified U.S.-based or foreign MRO organizations. Additionally, it is not clear that an Air Force contract with Boeing Aircraft Services for the maintenance of the KC-767A would provide any preferred access to the extensive and long-standing commercial component supply base that exists to support the worldwide fleet of civil 767s. This commercial supply base is the same one used by both Boeing Aircraft Services and other MRO providers.

Access to Boeing Proprietary Intellectual Property. Aircraft maintenance requires the use of intellectual property in the form of engineering drawings and analysis and maintenance manuals. The rights to this material is usually held by the manufacturer, but is routinely licensed to maintenance and modification organizations. In the case of the KC-767A, this data includes tanker-specific components, such as the aerial refueling boom and its control mechanisms.

Because non-Boeing maintenance organizations have maintained the 767-series commercial aircraft for more than 20 years, any additional licensing of aircraft-specific information to third parties does not appear to present any obvious difficulties.

The KC-767, including the aerial refueling boom, does not incorporate any military-specific or security-sensitive technology. In fact, Boeing, as part of a joint venture, is offering

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[19] Boeing is considering the manufacture of a new airliner, the 7E7 *Dreamliner*, and is currently offering it for sale to airlines in Japan. If a so-called "launch customer" can be found and the company decides to initiate production, Boeing has announced that its subassemblies will originate in factories around the world. Only the vertical tail fin is expected to be manufactured near Boeing's home site in the Puget Sound region of Washington. The airplane's nose and cockpit will come from the Boeing Wichita, Kansas, operation. The remainder of the tail and the rear fuselage will be built by Alenia Aeronautica in Italy and Vought Aircraft Industries in Texas. The forward fuselage and wings will be produced in Japan, with the wing edges, flaps, and fairings coming from Boeing Winnipeg in Canada. Passenger doors will be fabricated by Latecoere in Toulouse, France. Boeing is currently soliciting offers from cities that may wish to compete to have the 7E7 assembly plant located withing their jurisdictions. Cities in Washington, Kansas, and Louisiana, among others, are reported to be bidding for the facility. See Dominic Gates, "Tail Fin May Be Only Key Part of 7E7 Made in Washington," *Seattle Times*, October 15, 2003, pg. A1; and Stewart Yerton,"Risky Business," *New Orleans Times-Picayune*, July 20, 2003, p. 1.

a group of converted former British Airways 767s as aerial tankers to the United Kingdom's Royal Air Force. In 1999, then-Deputy Secretary of Defense John Hamre stated that the Pentagon determined that the transfer of these tanker-specific technologies to Britain constituted no security risk.[20] Also, the Italian Ministry of Defense has purchased four 767s from Boeing for conversion to tanker status. Tanker-specific equipment is currently being installed in the first of these aircraft at the Boeing maintenance facility in Wichita, Kansas. Conversion of the other three aircraft will be performed by the Italian firm, *Aeronavali*, at its facility on the outskirts of Naples, Italy.

Use of Manufacturer as Initial Maintainer. Concluding an immediate agreement with an aircraft manufacturer for maintenance, rework, and overhaul could offer substantial advantages in assuring the availability of spare parts and components, and ready experience with the design and construction of the airframe. Taken together, these factors could help to ensure that the readiness of the aircraft for its military mission is kept high. In his October 9 letter to the Chairman and Ranking Minority Member of the Senate Committee on the Armed Services, Secretary of the Air Force John Roche also points out that maintenance is "something we traditionally trust to the manufacturer in the initial stages of the program." The Secretary also notes that logistic support for the KC-10A tanker was initially contracted to the manufacturer.[21]

On the other hand, during the early 1980s, when the KC-10A was built, a relatively larger share of airline maintenance was performed by the airlines themselves. Today, the situation is very different. Many independent maintenance organizations have provided maintenance to the 767 for more than two decades, and are routinely retained by the operating airlines to do so.

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[20] See Vago Muradian, "State Withholds Boeing, Raytheon Licenses for U.K. Tanker Bid," *Defense Daily*, July 14, 1999.

[21] The KC-10A *Extender*, is a derivative of the DC-10 airliner. Both were manufactured by McDonnell Douglas Corp., which is now a wholly-owned subsidiary of the Boeing Co. The commercial version of the aircraft entered airline service during the early 1970s, while the military tanker began service approximately ten years later. See Mark Lamber, ed., *Jane's All the World's Aircraft, 1991-92*, (Coulsdon (UK): Jane's Information Group, 1991, pg. 442.