OFFICE OF THE SECRETARY OF DEFENSE
1700 DEFENSE PENTAGON
WASHINGTON, DC 20301-1700

OPERATIONAL TEST
AND EVALUATION

INFO MEMO

FEB 15 2013

FOR: SECRETARY OF DEFENSE

FROM: J. Michael Gilmore, Director, Operational Test and Evaluation

SUBJECT: F-35A Ready For Training Operational Utility Evaluation (OUE)

- I have attached at TAB A the F-35A Ready For Training OUE Report. At the request of the Joint Strike Fighter Program Executive Officer, the OUE evaluated the capability of the F-35A air vehicle and the infrastructure at Eglin Air Force Base to train an experienced initial cadre of pilots using a very basic syllabus designed to familiarize pilots with aircraft that possessed no combat capability. It also evaluated the ability of the F-35A maintenance and Autonomic Logistics Information System to sustain a sortie generation rate consistent with the limited training contained in the Block 1A syllabus. In the report I conclude the following:

    - The limitations, workarounds, and flight restrictions in place on the F-35A at this early stage of its development substantially limit the utility of training. However, the evaluation indicates areas where the program needs to focus attention and make improvements.

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        - Discrepancies between the courseware and the flight manuals were frequently observed, and the timelines to fix or update courseware should be shortened.

        - The training management system lags in development compared to the rest of the Integrated Training Center and does not yet have all planned functionality.

        - Plans and procedures for training pilots to recover the aircraft in the event of an engine problem or flameout should be reviewed for adequacy and to assure such training can be conducted in an appropriate venue.

    - Sustainment of the six Block 1A F-35A aircraft was sufficient to meet the relatively low student training sortie demand of the syllabus, but only with substantial resources (aircraft and manpower) and workarounds to the intended sustainment system in place.

- The demonstrated reliability of the F-35A is significantly below the program office's projected targets for the reliability it expected the aircraft to achieve at the 2,500 flight hours the F-35A fleet has now accumulated.

- I am providing copies of my report to the Under Secretary of Defense for Acquisition, Technology and Logistics; the Secretary of the Air Force; the Secretary of the Navy; and the Vice Chairman of the Joint Chiefs of Staff. The professional staff of the Congressional defense committees have also requested the report and I will provide them copies next Thursday. By law, I must provide the Congress with any test-related material it requests.

COORDINATION: None

Attachment: TAB A

Prepared by: Curtis Cook, OSD-DOT&E, 703-697-1038

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WASHINGTON, DC 20301-1700

OPERATIONAL TEST AND EVALUATION

FEB 15 2013

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY AND LOGISTICS

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Director

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MEMORANDUM FOR VICE CHAIRMAN JOINT CHIEFS OF STAFF

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J. M. Gilmore

J. Michael Gilmore
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Director, Operational Test and Evaluation

F-35A Joint Strike Fighter

Readiness for Training Operational Utility Evaluation

February 2013

J. Michael Gilmore
Director

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Executive Summary

This document reports on the F-35A Ready For Training Operational Utility Evaluation (OUE) conducted at Eglin Air Force Base (AFB), Florida, from September 10 through November 14, 2012. This assessment is based primarily on data collected during the evaluation by the Joint Strike Fighter Operational Test Team (JOTT), but is augmented by data collected for suitability analyses on F-35A aircraft at Eglin and at the Air Force Flight Test Center at Edwards AFB, California. The OUE evaluated both the capability of the F-35A air vehicle and the training system to train an experienced initial cadre of pilots in the equivalent of the familiarization phase of a fighter aircraft transition syllabus. It also evaluated the ability of the F-35A maintenance and Autonomic Logistics Information System (ALIS) to sustain a sortie generation rate for the Block 1A syllabus.

In mid-2010, the Joint Strike Fighter Program Executive Officer (JSF PEO) requested an assessment of the readiness to begin F-35A pilot training, which, at that time, was planned to begin in August 2011. In early 2011, the JSF Program Office (JPO), JOTT, and the Air Force Air Education Training Command (AETC) began coordinating plans for the assessment, which became the F-35A Ready For Training OUE. Throughout 2011 and part of 2012, the JPO and the Air Force worked to achieve a flight clearance that would allow pilot training to begin. The JOTT completed a test plan using AETC-developed evaluation criteria in mid-2011. The JSF PEO certified the system ready for test following an Operational Test Readiness Review in July 2012, leading to the start of the OUE in September.

The JOTT, JPO, and AETC designed the Ready for Training OUE to assess whether the F-35A aircraft and the training system are ready to begin transition training of pilots in the Block 1A syllabus. Transition training is for experienced pilots who have flown in other fighter aircraft and are transitioning to the F-35. The Block 1A syllabus includes basic aircraft systems training, emergency operating procedures, simulated instrument flying procedures, ground operations (taxi), and six flights in the F-35A, the last of which is a qualification and instrument procedures check ride.

The Block 1A training syllabus used during the OUE was limited by the current restrictions of the aircraft. Aircraft operating limitations prohibit flying the aircraft at night or in instrument meteorological conditions, hence pilots must avoid clouds and other weather. However, the student pilots are able to simulate instrument flight in visual meterological conditions to practice basic instrument procedures. These restrictions are in place because testing has not been completed to certify the aircraft for night and instrument flight.

The aircraft also is currently prohibited from flying close formation, aerobatics, and stalls, all of which would normally be in the familiarization phase of transition training, which typically is an introduction to aircraft systems, handling characteristics throughout the aircraft envelope, and qualification to operate/land in visual and instrument meteorological conditions. This familiarization phase is about one-fourth of the training in a typical fighter aircraft transition or requalification course. In a mature fighter aircraft, the familiarization phase is followed by several combat-oriented phases, such as air combat, surface attack, and night tactical operations.

The F-35A does not yet have the capability to train in these phases, nor any actual combat capability, because it is still early in system development.

Sustainment of the six Block 1A F-35A aircraft was sufficient to meet the student training sortie requirements of the syllabus, but with substantial resources and workarounds in place. Some aircraft subsystems, such as the radar, did not function properly during the OUE, although they were not required for accomplishing the syllabus events. Had the syllabus been more expansive, where these subsystems were required to complete training, these subsystem problems would have hampered the completion of the OUE. Three additional F-35A aircraft in the Block 1B configuration were also flown during the OUE, by the instructor pilots, to meet sortie requirements.

The limitations, workarounds, and restrictions in place in an air system this early in development limit the utility of training. Also, little can be learned from evaluating training in a system this immature. However, the evaluation indicates areas where the program needs to focus attention and make improvements. The radar, the pilot's helmet-mounted display (HMD), and the cockpit interfaces for controlling the radios and navigational functions should be improved. Discrepancies between the courseware and the flight manuals were frequently observed, and the timelines to fix or update courseware should be shortened. The training management system lags in development compared to the rest of the Integrated Training Center and does not yet have all planned functionality.

System Description

The F-35 Lightning II Air System is a multi-service, multi-nation program consisting of a single-seat, single-engine aircraft built in three variants intended to perform a wide array of missions to meet an advanced threat of year 2010 and beyond. The variants include a conventional take-off configuration (F-35A), a short take-off/vertical landing configuration (F-35B), and an aircraft carrier-compatible configuration (F-35C).

Eventually, when fielded with capabilities as described in the Operational Requirements Document (ORD), a force equipped with F-35 units should permit the Combatant Commander to attack targets day or night, in all weather, and in highly-defended areas of joint operations. The F-35 will be used to attack fixed and mobile land targets, enemy surface units at-sea, and air threats, including advanced cruise missiles.

Currently, the Air Force has accepted early production aircraft, which will be used to train experienced pilots from other fighter aircraft in the F-35A. These aircraft are assigned to the 33rd Fighter Wing (33 FW) at Eglin AFB, Florida, where the first of several pilot and maintainer training units is located. The aircraft are operated only in the training environment and under numerous flight restrictions, including no night or weather capability, and no combat capability. The Wing is home to the Integrated Training Center, which houses classrooms for instructor-led lectures and self-paced, computer-based, interactive lessons; full mission simulators (FMS); and student training resource centers. Ground training instructors are civilian contractors. They are supervised and augmented by uniformed Service members assigned to the 33 FW, such as evaluator pilots who perform procedural check rides in the simulators. The 33

FW also operates ancillary training areas, such as survival and life support training, and pilot equipment fitting. Military instructor pilots assigned to flying squadrons in the 33 FW provide flying training.

Conduct of the OUE

The JOTT conducted testing from September 10 through November 14, 2012, at Eglin AFB, Florida. During the OUE, the Air Force completed the Block 1A syllabus events and graduated 4 student pilots in 46 training days, which met the test plan criteria of within 65 training days. Sustainment data were collected on the F-35A aircraft assigned to Eglin from March 2012 through the end of the testing period for analyses of measures; however, some measures could not be assessed as the data were not recorded or the system was too immature. Survey data were collected and used extensively to assess air vehicle performance and the academic training environment (classroom and simulators). The aircraft used in the evaluation were not instrumented. The manner in which the surveys were written and the limited sample sizes involved in the test precluded any meaningful quantitative analyses of the responses; however, useful qualitative data were obtained from the survey comments.

Flight Training in the F-35A Air Vehicle

The F-35A air vehicle enabled the successful completion of the Block 1A syllabus for four student pilots during the period of the OUE, training them to safely take-off and fly in clear weather conditions, accomplish formation flight with another F-35 or F-16 aircraft, and land the aircraft—but not train for combat. There are a number of restrictions on the aircraft that are typical of a test aircraft only part way through its flight test program, but very atypical of a fighter aircraft used for student training. The utility of training with an aircraft this early in development is limited because of the extensive aircraft operating limitations and lack of mission capability. Only a very limited set of the full mission systems capability are working. Pilot comments from the surveys identified performance deficiencies with the radar, the HMD, and the touch screen interfaces to control radios and navigation. Although weather was favorable during the OUE period – only one student sortie and the associated instructor pilot sortie were cancelled due to weather – the current restrictions preventing flight in instrument meteorological conditions severely limit training opportunities. The pilot's flight manuals and checklists are still maturing and procedures for training and practicing simulated flameout patterns in the aircraft may need further review.

Training in the Classroom and F-35 Flight Simulator

The academic training environment, consisting of classroom and simulator instruction, enabled the successful completion of the Block 1A syllabus for the four student pilots during the period of the OUE. Overall, the FMS training device and the contractor instructors provided adequate training to the student pilots to prepare them for simulator events and flight training, within the context of the syllabus and within the objective number of training days. Deficiencies were noted in courseware (due to errata and lengthy timelines to make corrections), in the surrogate helmet used in the simulator, and in the training management system.

Sustainment

The sustainment environment at Eglin AFB is a hybrid of government and contractor support personnel that relies heavily on workaround procedures, non-standard support procedures, and specialized support equipment to generate sorties and maintain the F-35A fleet. The sustainment team was able to meet the thresholds defined by the training command for sustainment for the OUE by generating the sorties needed for four student pilots to complete Block 1A training in 46 training days. However, the Air Force provided generous resources, particularly in manpower and aircraft, to assure a successful evaluation. Additionally, the F-35A Block 1A and 1B aircraft remain immature and include few functional aircraft mission systems, which resulted in far fewer failure modes and a narrower scope of demand on the supply chain. Due to the immaturity of the aircraft, the workarounds required to support flight operations, and very limited mission systems capability little knowledge can be gained from the OUE applicable to F-35 sustainment under normal squadron training operations or to sustainment of combat capable aircraft in operational units. Additionally, the F-35 Joint Reliability and Maintainability Evaluation Team (JRMET) data for the F-35A fleet suggest that the program is not meeting reliability growth targets to meet ORD requirements.

Given its many significant limitations, the results of the OUE should not be used to make decisions regarding the readiness of the JSF system to support training inexperienced pilots in an F-35A initial qualification course.

Recommendations

The program should:

- Complete testing of the pilot escape system (transparency removal and ejection seat) under off-nominal ejections as soon as possible.
- Complete certification and installation of the water-activated-release system for the ejection seat as soon as possible to enhance pilot survivability in the event of an overwater ejection.
- Fully resolve Category 1 deficiency reports relevant to training operations at Eglin AFB as soon as possible.
- Continue to track air and ground abort rates and discovery rates as indicators of system maturity.
- Implement pilot-vehicle interface improvements in the cockpit displays and touch screen controls for communication and navigation functions as identified by pilots in the OUE.
- Address the discrepancies identified in the simulation certification report, coupled with the student pilot's experience in the aircraft during the OUE, to assure the simulated flameout training for F-35 pilots is adequate.

- Re-evaluate the 96 information assurance controls once the information assurance deficiencies and the lack of an Information Assurance Manager have been corrected for the Unclassified Operational Environment.
- Once the classified network is in place, accomplish an assessment similar to the information assurance assessment of the Unclassified Operational Environment.
- Evaluate reliability performance and make adjustments to assure interim reliability growth targets and, eventually, ORD thresholds can be met.
- Assure adequate sparing of HMD parts and equipment are in place at the training center and at follow-on field units to meet requirements.
- Track all hours for personnel supporting F-35A sustainment to enable accurate assessments of direct and indirect maintenance man hours.
- Collect information on ALIS availability, reliability, maintainability, logistics supportability, and data administration to support evaluation of performance.

J. Michael Gilmore
Director

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Contents

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Section One
System Overview

F-35 System Description

The F-35 Lightning II air system is a multi-service, multi-national program consisting of a single-seat, single-engine aircraft built in three distinctly different variants intended to perform a wide array of missions to meet an advanced threat (year 2010 and beyond). The variants include a conventional take-off configuration (the F-35A), a short take-off/vertical landing configuration (the F-35B), and an aircraft carrier-compatible configuration (the F-35C).

The system includes an integrated information system that connects training units, maintenance operations, mission planners, pilots, and the logistics system. This Autonomic Logistics Information System (ALIS) includes the Training Management System (TMS), which is intended to build and track training syllabi and schedules, and provide courseware and other training materials to the students. ALIS also includes software to build and track flying schedules, track maintenance actions and aircraft availability, monitor inspection requirements, and schedule and track parts delivery among other functions.

The F-35 mission capability software is being delivered in three blocks with increasing capability. The current Block 1 software (consisting of two increments – Block 1A and 1B) is intended to provide only basic pilot training and has no combat capability. The current aircraft have a number of significant operational restrictions, known as aircraft operating limitations, compared to the final planned capabilities, such as limited maneuvering, speeds, and constrained descent rates; no carriage of weapons, no use of countermeasures, and no opening of weapons bay doors in flight.

Eventually, when fielded with capabilities as described in the Operational Requirements Document, a force equipped with F-35 units should permit the Combatant Commander to attack targets at day or night, in all weather, and in highly-defended areas of joint operations. The F-35 will be used to attack fixed and mobile land targets, enemy surface units at-sea, and air threats, including advanced cruise missiles.

F-35A Training System Description

The 33rd Fighter Wing (33 FW) at Eglin Air Force Base (AFB), Florida, is the first of several pilot and maintainer training units planned by the Services. The Wing has nine F-35A aircraft and a sustainment infrastructure to enable flight operations. The Wing operates the Integrated Training Center, which houses classrooms for instructor-led lectures and self-paced, computer-based, interactive lessons; full mission simulators (FMS); and student training resource centers. Ground training instructors are civilian contractors who are supervised and augmented by uniformed Service members assigned to the 33 FW, such as evaluator pilots who perform procedural check rides in the simulators. The 33 FW also operates ancillary training areas, such as survival and life support training and pilot equipment fitting. Military instructor pilots assigned to flying squadrons in the 33 FW provide flying training.

The training syllabus used in this evaluation, the Block 1A syllabus, is an early phase – termed here as the familiarization phase – of what will eventually become the complete training syllabus for experienced pilots who have flown in other fighter aircraft and are transitioning to the F-35A. This partial syllabus is the first 6-8 weeks of a full syllabus that will take approximately 40 weeks to complete. Another syllabus, used for initial qualification of inexperienced pilots, is under development and will be more robust, include a more expansive familiarization phase, and take longer to complete. The Air Force intends to start training with inexperienced pilots in 2014.

A typical familiarization phase of a fighter training syllabus should include the learning of the basic aircraft skills needed to take-off, land, fly basic formation, and handle emergency procedures. Additionally, this phase would include opportunities to explore the full flight envelope that will be used in offensive and defensive maneuvering during later phases of the syllabus. Examples include maneuvers designed to gain an understanding of aircraft handling characteristics under various flight conditions in the operating envelope, such as high angle-of-attack and high-g maneuvering, aerobatics, and approach to and recovery from stalls. This phase normally also includes night flying. For this training OUE however, as a result of the immaturity of the F-35A, student pilots were limited in flight maneuvering to very basic aircraft handling, such as simple turns, climbs, and descents as the flight envelope of speed and altitude was limited, angle-of-attack and g-loading were restricted, and maneuvers normally flown during a familiarization phase of a syllabus were explicitly prohibited. Further, the aircraft were prohibited from flying in instrument meteorological conditions (i.e. flying in clouds) and at night, limiting flights to daylight and clear weather conditions only. Table 1-1 compares flight training events of a typical familiarization phase of a fighter training syllabus with the F-35A Block 1A syllabus used for the OUE.

Acknowledging that Block 1A flight training was to be conducted in an immature air system concurrent with early F-35 development and flight test, the Air Force Air Education and Training Command (AETC) syllabus permits deviations if maneuvers or training events are restricted by the Air Force, as was the case during this OUE. For example, the Block 1A syllabus requires student pilots to demonstrate proficiency in execution of simulated flameout (SFO) approaches in both the simulator and the aircraft. This event is prohibited in flight training by Air Force directives, and is allowed only in the flight simulator.[1] Table 1-1 also compares the Block 1A syllabus events planned and events accomplished during the OUE, with remarks for planned events not accomplished.

1 Air Force Instruction 11-2F-35A V3 Change 7 states "live fly SFOs are prohibited and shall only be practiced in the full mission simulator."

Table 1-1. Comparison of Training Tasks from Typical Fighter Transition Syllabus to F-35A Block 1A Syllabus

Typical Fighter Transition Syllabus Tasks, with examples	F-35A Block 1A Syllabus		
	Included?	Accomplished during OUE?	Limitations
Basic aircraft handling Ground operations Cockpit setup and controls Use of flight controls and autopilot Take-off Landing Climbs, turns, descents	Yes	Partial	Hot pit refueling (ground crew refueling while operated by the pilot on the ground) was planned, but not accomplished. F-35 system immaturity prevented the training from being accomplished.
Emergency procedures for simulated engine-out landing	Yes	No	Simulated flameout (SFO) approaches were prohibited in the aircraft; training occurred only in the simulator. Pilots of other single engine aircraft train for this regularly in the aircraft.
Instrument procedures Instrument departures Instrument turns Navigation Unusual attitude recovery Instrument approaches	Yes	Yes	Pilots were prohibited from flying in actual instrument meteorological conditions (weather).
Formation procedures Take-offs, approaches, landings Tactical formation Rejoins	Yes	Partial	Pilots were prohibited from close formation and formation take-offs and landings.
Advanced handling Maximum angle-of-attack (AOA) Slow flight Maximum g Afterburner/speedbrake demonstration Stall approach and recovery Low/high speed dive and nose high recoveries Aerobatics	No	No	Some maneuvers were accomplished to show pilots the limits of the most severe current restrictions, for example, how to not exceed AOA limits in the landing pattern.

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Section Two
Evolution, Planning, and Conduct of the OUE

In mid-2010, the Joint Strike Fighter Program Executive Officer (JSF PEO) requested an assessment of the readiness to begin F-35A pilot training, which, at that time, was planned to begin in August 2011. In early 2011, the JSF Program Office (JPO), Joint Strike Fighter Operational Test Team (JOTT), and Air Force Air Education and Training Command (AETC) began coordinating plans for the assessment, which became the F-35A Ready For Training Operational Utility Evaluation (OUE). Throughout 2011 and part of 2012, the JPO and the Air Force worked to achieve a flight clearance that would allow pilot training to begin. The JOTT completed a test plan using AETC-developed evaluation criteria in mid-2011. The JSF PEO certified the system ready for test following an Operational Test Readiness Review in July, 2012, leading to the start of the OUE in September.

Evolution

The JSF PEO asked the operational test agencies in 2010 to conduct a flying assessment to inform the Service's decision to start pilot training at Eglin AFB, Florida. The JOTT leadership and the JPO, in coordination with DOT&E, began planning a Ready For Training OUE for the Air Force with the F-35A aircraft. The JOTT created measures of effectiveness and measures of suitability for test planning. The Air Force AETC, in coordination with the JOTT, developed a set of seven entrance criteria for starting the OUE. The criteria were as follows:

- The F-35 air vehicle is cleared for unmonitored flight and capable of flying the Block 0.5 syllabus (which later became Block 1A) within the currently tested and cleared flight parameters.
- The AETC-approved syllabus, courseware, and training devices are in place and ready for training.
- Full complement of Service System Command's approved F-35 Flight Series Data (FSD) and the flight publications required by AETC, the 33rd Fighter Wing (33 FW), and the training squadron are available to support operations.
- Pilot flight equipment required for operation of the F-35 is available to Integrated Training Center personnel and has been approved by the Service Systems Command.
- Facilities are accepted and capable of hosting classroom, simulator, and training device instruction.
- Contract Logistics Support (CLS) and sustainment is in place.
- The AETC-approved F-35 Minimum Essential Functions List is available for syllabus execution.

Since the aircraft is still only approximately one-third of the way through development, requirements and thresholds from the Operational Requirements Document (ORD) were not applicable for use in the OUE. Instead, the JOTT worked with AETC to develop a set of required capabilities, associated criteria, and thresholds as listed in Table A-1 found at the end of this report. For comparison, included in the table are notional thresholds for a mature combat-capable training aircraft. The AETC thresholds were set low, not comparable with requirements expected for a training program of a combat aircraft. For example, the threshold for aircraft handling included the requirement to have no aircraft depart controlled flight during the OUE, a requirement which would not be applicable in a normal training unit. The goal for maintenance man hours per flight hour were set to 50 for the OUE, while the ORD requirement is 9.

In the summer of 2011, the JPO added approximately 60 hours of flight testing in mission systems aircraft to assess the maturity of the Block 1A-configured aircraft. Data generated in these test flights were used to determine that production aircraft, which would not be monitored by flight test personnel, could be operated at the training center. The Air Force accepted delivery of the six Block 1A aircraft from the prime contractor, Lockheed Martin, between July and October 2011, and issued a one-time military flight release (MFR) to ferry the aircraft to Eglin AFB, Florida.

In October 2011, DOT&E cited safety concerns that needed to be addressed in order for the OUE test plan to be approved.[2] These concerns were based, in part, on risk assessments completed by the Air Force airworthiness authority as part of the process to issue an MFR for flight operations and training missions at Eglin. For the F-35A Block 1A aircraft, the Air Force identified eight areas of non-compliance with certification criteria, which carried a "serious" risk, requiring mitigation plans and risk acceptance by the Air Force PEO for Aircraft prior to the issuance of a flight release. The risk areas, issues, and associated risk levels are listed in Table 2-1. The mitigations documented by the Air Force for the "serious" risk assessments were primarily actions that would occur for a mature air system beginning training. The main mitigations permitting flight operations, and eventually flight training, were that only very experienced pilots would be involved and that very limited flight operations would be conducted. It should be noted that absent the mitigations cited by the Air Force, some of the risks would have otherwise been assessed as "high" rather than "serious," requiring acceptance by the Service Acquisition Executive rather than the PEO.

After changes were incorporated to ground procedures and aircraft modifications were complete, the Air Force airworthiness authority eventually issued an MFR at the end of February 2012 for initial flight operations at Eglin, called "local area orientation flights," which began in March. This flight clearance did not permit training students; the local area orientation flights were flown only by previously qualified F-35 test pilots. One purpose of these flights was to collect data on the F-35A performance (e.g., abort rate) and maintenance metrics for consideration in updating the flight clearance to later permit pilot training.

2 See DOT&E memorandum, "Concerns Regarding Plans for the Joint Strike Fighter (JSF) to Begin Training Flights and Conduct an Operational Utility Evaluation (OUE)," dated October 21, 2011.

Table 2-1. "Serious" Risk Areas Identified by the Air Force

Risk Area	Issue	Risk Level Assessment
Lack of F-35A Maturity	Lack of maturity, as indicated by the low number of flight test hours, along with a higher Air Abort Rate than typical for operational aircraft, increases the chance of a Class A mishap (catastrophic loss of aircraft/aircrew) occurring.	Hazard Risk Index (HRI) 8 - SERIOUS
Reduced Pilot Situational Awareness during an Emergency	If the Integrated Caution Advisory Warning System does not adequately convey warning and caution information to the pilot in a fashion that permits recognition in sufficient time to take actions, flight essential cues may be missed or misinterpreted with a potential for loss of aircraft/aircrew.	HRI 8 - SERIOUS
Pilot Escape System testing shortfalls	The F-35 US-16 E-21 ejection seat and -1 Transparency Removal System (TRS), as installed on low-rate initial production (LRIP) aircraft 2 & 3, have not completed full qualification testing. In addition, the F-35 canopy panel fly-away model has not been validated. If there is an unknown failure mode due to incomplete qualification testing and/or invalid fly-away model results, then there is potential for loss of aircrew.[A]	HRI 8 - SERIOUS
Potential for aircrew drowning in the event of an overwater ejection	LRIP 2 & 3 aircraft do not include the Martin Baker water activated release system (MWARS). Without a water activated release system, there is a risk of drowning for the unconscious crewmember post ejection. [B]	HRI 8 - SERIOUS
Fuel Barriers and potential fire risk	The F-35 fuel system design's lack of a double barrier, when coupled with inadequate leak detection and capability for visual examination of the seals, can result in fuel leakage and potential fire leading to loss of aircraft/aircrew.	HRI 8 - SERIOUS
F-35A Pilot Vehicle Interface (PVI) Problems	Delayed, incorrect, or untimely aircrew response during a time-critical task will result in a potential error and Class A mishap. The F-35A has documented deficiencies in PVI (Helmet-Mounted Display, Pilot Checklist, Communication, Head-Down Display). A comprehensive Human Systems Integration (HSI) assessment has not been completed. Therefore, there is no confidence that the pilot can perform critical tasks safely. If current PVI deficiencies are not corrected immediately, then risk will increase as capability/functionality is added to future LRIP Blocks.	HRI 8 - SERIOUS
Lack of Lightning Protection	F-35A aircraft do not have a qualified lightning protection system. Without a qualified lightning protection system, a lightning strike could result in loss of aircraft/aircrew.	HRI 8 - SERIOUS
Safety Critical Function Integration Process Shortfalls	The F-35 design does not incorporate the necessary process rigor for safety critical systems and software, including test. Consequently, safety critical systems/software may not operate correctly, resulting in loss of aircrew/aircraft.	HRI 8 - SERIOUS

[A] DOT&E considers full qualification of the ejection seat, including testing of the interaction between the seat and the canopy during off-nominal (i.e., other than straight-and-level) conditions, to be safety critical, and should be completed as soon as possible.

[B] DOT&E considers the full testing, qualification, and installment of the MWARS to be safety critical, and should be completed as soon as possible.

The Air Force issued an updated MFR in July 2012 authorizing flights for training in the OUE, with restrictions that training flights would be conducted with a chase aircraft (not necessarily another F-35) and with a manned operations desk with conference capability to the contractor's support and engineering staff. Also, all engine starts had to be monitored using special support equipment to ensure proper operation of a valve in the integrated power package (IPP). This procedure was put in place to reduce the likelihood of an IPP fire from improper operation of the valve, as occurred previously during developmental testing. In issuing this new flight clearance, the Air Force airworthiness authorities did not alter the risk assessments shown in Table 2-1. The updated MFR permitted the Air Force to train three additional instructor pilots who would be available teach the student pilots during the OUE.

Planning

The JPO and the JOTT conducted a ready-to-test process simultaneous with test planning. Templates from the Air Force Manual for Certification of System Readiness for Dedicated Operational Testing – AFMAN 63-119 – were used to identify program issues, which would either affect the start of or the successful completion of the OUE. The process identified numerous shortfalls and obstacles for starting the OUE. The JPO and AETC either resolved these problems or created a workaround. The JSF PEO conducted an Operational Test Readiness Review on July 2, 2012, and certified the F-35A Block 1A air system ready for the OUE.[3] The test plan created by the JOTT specified adequate content to conduct an evaluation of the F-35 air vehicle, training environment, and sustainment system in the context of executing the limited scope of training in the Block 1A syllabus. In late July, DOT&E cited several reasons not to proceed with the OUE at that time, including no improvement in the air abort rate, the flat trend in discovery rate (indicated by formal program level deficiency reports), the high number of workarounds for sustainment, the lack of water-activated release system for the parachute, incomplete testing of the escape system, the low availability rate of aircraft at Eglin, and the lack of new data on pilot workload or deficiencies in the Integrated Caution and Warning System. DOT&E recommended delaying the OUE until the JSF system possesses actual combat capability relevant to an operational evaluation.[4]

Conduct

The JOTT conducted the evaluation from September 10 through November 14, 2012, at Eglin AFB, Florida. DOT&E representatives observed the entire evaluation. The 33 FW trained four student pilots in the classroom, simulator, and flight training events of the Block 1A syllabus during the OUE period. The average total flight time of the student pilots was 1,588 hours, ranging individually from 1,350 to 2,100 hours (the Air Force designates 500 hours in a fighter aircraft as the "experienced" threshold). The student pilots were all current and qualified in legacy fighter or attack aircraft: three in the F-16 and one in the A-10. The OUE

3 See JSF PEO memorandum for the record, "Certification of F-35A LRIP-2 Block 1A Air System for Operational Utility Evaluation (OUE)," dated July 9, 2012.

4 See DOT&E memorandum, "Test Plan for the F-35A Joint Strike Fighter Readiness for Training Operational Utility Evaluation," dated July 20, 2012.

evaluated both the capability of the F-35A air vehicle and the training environment at the 33 FW to train this initial cadre of experienced fighter pilots in the familiarization phase of a transition syllabus. It also evaluated the ability of the F-35A maintenance and Autonomic Logistics Information System (ALIS) to sustain a sortie generation rate for the Block 1A syllabus.

All syllabus events (ground and flight training) for the 4 students were completed over a period of 46 training days. Table 2-2 shows the dates, phases of training, and associated events for the OUE period. All student sorties were considered "effective" by the instructor pilots, although not all training events were accomplished on each sortie. All student pilots met the necessary training objectives in the allotted syllabus time – no additional training flights were required. Although there was one air abort of a student sortie, sufficient training was completed on the flight for the instructor pilot to consider the training sortie to be effective.

Table 2-2. Phases of Training Evaluated During the OUE

Dates	Phase of Training	Events
Sep 10 – 25, 2012 (12 training days)	Academics	61 Events (in-processing, equipment issue, classrooms); approx 130 hours of instruction
Sep 26 – Oct 25, 2012 (21 training days)	Simulator Training	14 simulator events (including one emergency procedures evaluation)
Oct 26 – Nov 14, 2012 (13 training days)	Flight Training	1 ground (taxi) event and 6 flights

The JOTT designed surveys to obtain pilot ratings of the air vehicle performance, classrooms, and the simulators to meet the syllabus objectives. Analysis of sustainment is based in part on quantitative data collected during the OUE period on aircraft maintenance and sorties, including data analyzed by the F-35 Joint Reliability and Maintainability Evaluation Team (JRMET). The JRMET also provided suitability data for F-35A fleet sustainment outside of the OUE period, and included data from the test center at Edwards AFB, California. All maintenance actions for the OUE time period were observed by JOTT observers. They also observed daily maintenance operations, production and sortie generation meetings, and supply support actions during the OUE period. The maintenance metrics collected were used to assess sortie generation, abort rate, supply support, support equipment availability, efficacy of flightline Portable Maintenance Aid/Joint Technical Data, and the stability of the ALIS.

Test Limitations

The aircraft flight operations and simulator events were constrained by the current aircraft operating limits of the Block 1A aircraft and the immature state of mission systems software and integration. This precluded the ability to train to the legacy aircraft standards of mission complexity that will be in effect when F-35 training operations reach maturity. In particular, the Block 1A syllabus did not cover key F-35A mission capabilities for radar, sensor fusion, datalink, helmet-mounted display features, night operations, flight in instrument meteorological conditions, and basic fighter maneuvering and advanced handling characteristics; in essence, everything that makes the F-35A a modern, advanced fighter.

The pilot surveys developed and administered by the JOTT provided limited data. The construction of the surveys and the limited sample sizes precluded any meaningful quantitative analyses of the responses. DOT&E offered a revised set of survey questions to the JOTT, designed with "best practices" of survey design from the human factors community, but they were not used. Most of the survey questions were written as dichotomous questions, where the respondent was asked whether an aspect of the air vehicle or training environment was either "Adequate" or "Not Adequate." Only if the respondent selected "Not Adequate" to the first part of the survey question was he then required to answer a second question on the degree to which the deficiency impeded or degraded training effectiveness for the Block 1A syllabus. Using such a design, the results of the surveys did not present a clear picture of the actual effects of the various issues commented on by the pilots. Similarly, the standards for rating an issue "Totally Adequate" or "Not Totally Adequate" were inconsistent both between the pilots and among same-pilot responses from flight to flight. However, even with the shortcomings of the survey design, the pilot comments were helpful in identifying various issues that arose during the course of the OUE. Additionally, the JOTT conducted individual interviews with the student pilots at the completion of the OUE, which added to the qualitative data from the pilot comments in the surveys.

Some of the measures of effectiveness and measures of suitability planned for the OUE could not be fully resolved. Elements of the measures pertaining to mission planning, and the Prognostic and Health Management (PHM) system could not be fully assessed due to system immaturity. Elements assessing indirect maintenance man hours and ALIS suitability could not be resolved, as data planned to be collected for these elements were not collected by the JOTT.

Any assessments made and conclusions drawn from the OUE are very limited in their extensibility to future F-35 training under different conditions, such as expanded aircraft capability, an expanded syllabus, greater student throughput loading, or different weather conditions. This was the first and the only class to be trained with the Block 1A syllabus and provided a one-time "snap shot" of the training system, which will be challenged to keep pace with the changing configurations and increments of increased capability. Since it was designed solely as a familiarization phase of a larger training syllabus for experienced pilots and because only experienced pilots were trained during the OUE, the evaluation should not be used to make decisions for training inexperienced pilots in an F-35A initial qualification course.

The OUE also could not assess the ability of the air system, training systems, and maintenance and logistics systems to meet the requirements of the full throughput of simultaneous student pilot and maintenance training events that are anticipated when training operations are conducted at a higher student load. This was the case for a number of reasons. During the course of the OUE, there was a greater number of aircraft available to meet the requirements of training operations, per student, than there will be when training operations are in full swing. This allowed more margin in the flight schedule for maintenance and logistics problems. Secondly, Academic Training Center computer network problems precluded the simultaneous training of student pilots and maintainers, which will be required when training reaches full rate. The small numbers of personnel trained during the OUE permitted time-sharing of network capacity that will not be possible under any higher number of student training rate conditions.

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Section Three
Flight Training in the F-35A Air Vehicle

In accordance with the syllabus, during the OUE, students accomplished six flights and one taxi-only event in Block 1A-configured F-35A aircraft. Instructor pilots supervised students while flying F-35A aircraft as chase aircraft or as a formation flight member. The following assessments are a result of observing and evaluating flight training in the F-35A aircraft during the OUE.

The aircraft is still very immature; utility of the available training is limited.

The utility of training with an aircraft at this early point in development is limited because of the extensive operating limitations and limited capability. Table 3-1 lists the F-35A operating limitations in effect at the time of the OUE, and the effect those limitations had on the current Block 1A or future familiarization phases of a training syllabus, as well as on a notional combat training portion of a syllabus. Also, training in aircraft at this early stage in development, with the aircraft operating limitations (AOLs) currently in effect, burdens the student pilot with the requirement to continually cross-check the maneuvers he is performing against the unusually restrictive envelope to ensure that exceedences of an aircraft restriction do not occur. One of the student pilots identified this issue as his top safety concern with the aircraft, citing the need to focus attention on limitations and restrictions vice clearing visually for other aircraft.

Discovery of problems, as indicated by the rate of new deficiency reports and the number of open deficiencies, is an indicator of overall system immaturity. As of July 9, 2012, the program had 28 open category 1 (i.e., safety of flight related) deficiency reports related to the F-35A air vehicle, propulsion system, and associated support systems that were relevant to the OUE. DOT&E recommended that six of these deficiencies be fully resolved, not just waived, prior to the OUE start.[5] By the end of October, only 2 of the 28 – and only 1 of the 6 – deficiencies had been fully resolved. Additionally, since July, the program has identified 8 new category 1 deficiencies, which DOT&E considers relevant to continued flight operations with early production aircraft at Eglin and elsewhere.

Although not required for the training events of this limited syllabus, the radar system exhibited shortfalls that – if not corrected – may significantly degrade the ability to train and fly safely under a typical transition training syllabus, where an operational radar is required. The radar performance shortfalls ranged from the radar being completely inoperative on two sorties to failing to display targets on one sortie, inexplicably dropping targets on another sortie, and taking excessive time to develop a track on near co-speed targets on yet another sortie. In two instances, a student pilot cited the need to use head-down actions to see the displayed altitude of airborne targets as a shortfall. The restrictions to fly only in daytime and visual meteorological conditions (VMC) in effect throughout the OUE, and the limited operating areas used for training, mitigated the adverse impact of these radar deficiencies. Training under a more

[5] See DOT&E memorandum, "Test Plan for the F-35A joint Strike Fighter Readiness for Training Operational Utility Evaluation," dated July 20, 2012.

expansive syllabus – which includes flying under instrument conditions, operations in more congested airspace, and monitoring aircraft in formation with the radar – would be adversely affected by the radar performance observed during the OUE. For example, a radar trail departure (pilots maintaining a set formation position using radar information, but having no visual contact) is often used to facilitate a formation of aircraft transiting weather, a situation common in a more typical training syllabus. Additionally, in more congested airspace typical of a busy training center or combat operations, the radar performance display deficiencies would increase the pilot's mid-air collision avoidance workload.

Weather restrictions to remain 25 nautical miles clear of lightning and to maintain VMC at all times during flight could have affected the execution of the OUE, but did not due to unusually favorable conditions. Weather was the cause for cancellation and rescheduling for only one training mission of two sorties – one for the student pilot and one for the instructor pilot. The previous summer's more typical weather would have caused a much higher flight cancellation rate. The lack of clearance for instrumented flight will likely affect the throughput of student pilots until the aircraft become capable of flight in instrument conditions.

Table 3-1. F-35A Aircraft Operating Limitations in Effect During OUE Period

Operating limit or restriction	Effect on the familiarization phase of a training syllabus	Effect on the combat employment phase of a training syllabus
Maximum descent rates for maneuvering [any vertical descent that exceeds 6,000 feet per minute requires a four minute level off in the altitude block 8K-20K MSL]. Maneuvering in the 8K-20K block can be executed up to 50K per minute rate of descent as long as the four minute level off is accomplished prior to further descent	Student pilots cannot accomplish advanced handling training, including aerobatics, and must modify flight profiles (including clearances from air traffic control) to meet descent restrictions.	Student pilots cannot conduct combat employment training including basic fighter maneuvers, and certain air-to-ground deliveries, and most air-to-air scenarios.
Airspeed limited to 550 KCAS or 0.9 Mach above 8K MSL. Below 8K MSL airspeed is limited to 500 KCAS	Student pilots are not able to explore aircraft handling characteristics at the full operational envelope and must monitor airspeed to avoid exceedence.	Student pilots cannot conduct combat employment training.
Angle-of-attack (AOA) limited to between -5 and +18 degrees and aircraft limited to -1 to +5.0 g's	The limitations on aircraft AOA and g's severely curtail the ability to perform most advanced handling maneuvers. High AOA/g maneuvers are fundamental to conducting a familiarization syllabus.	Student pilots cannot conduct combat employment training.
No formation take-offs or landings	Student pilots cannot complete planned Block 1A syllabus training events.	Student pilots cannot conduct combat employment training.

Operating limit or restriction	Effect on the familiarization phase of a training syllabus	Effect on the combat employment phase of a training syllabus
No night or instrument meteorological conditions flight	Student pilots are restricted to day, visual meteorological conditions only, precluding night flying qualifications. Sorties that would normally be effective are cancelled for weather, extending training times.	Student pilots cannot conduct night combat employment training.
No weapon capability [either real or simulated]	No significant effect on familiarization phase of the syllabus.	Student pilots cannot conduct combat employment training.
No rapid stick or rudder inputs	Student pilots cannot accomplish advanced handling training, which requires unrestricted use of flight controls in the full envelope. Instead, student pilots must monitor their flight control inputs to ensure compliance with the restriction, causing increased workload.	Student pilots cannot conduct combat employment training. This type of aircraft operating limitation is typical of an aircraft in flight test that has not been fully characterized under extreme conditions, and are practically difficult for operational pilots to comply with, without specific training for avoidance.
No simulated air-to-air or air-to-ground tracking maneuvers	No significant effect on familiarization phase of the syllabus.	Student pilots cannot conduct combat employment training.
No aerial refueling capability	No significant effect on familiarization phase of the syllabus.	Student pilots cannot complete full combat employment qualification without air refueling training.
No flight operations [including ground maintenance activities] within 25 nautical miles (nm) of lightning	Limits maintenance readiness and ability to generate sorties, limits training schedule, for both aircraft and available training ranges.	Same limitations as on the familiarization phase of the syllabus.
No use of countermeasures	No significant effect on familiarization phase of the syllabus.	Student pilots cannot conduct combat employment training.
No anti-jam, secure communications, datalink	No significant effect on familiarization phase of the syllabus; however student pilots would normally learn basic functions of these systems during familiarization phase.	Student pilots cannot conduct representative cooperative combat employment training with joint assets, such as other 5th generation aircraft, ground units, command and control platforms, and joint forces.

Operating limit or restriction	Effect on the familiarization phase of a training syllabus	Effect on the combat employment phase of a training syllabus
No Electro-Optical Targeting System (EOTS)	No significant effect on familiarization phase of the syllabus, although student pilots would normally have operational mission systems capabilities to become familiar with cockpit switches and subsystem functionality.	Student pilots cannot conduct combat employment training involving air or ground targeting or weapons.
No Distributed Aperture System (DAS)	No significant effect on familiarization phase of the syllabus, although student pilots would normally have operational mission systems capabilities to become familiar with cockpit switches and subsystem functionality.	Student pilots cannot conduct combat employment training in a simulated threat environment.
No Identification Friend or Foe Interrogator (IFFI)	No significant effect on familiarization phase of the syllabus, although student pilots would normally have operational mission systems capabilities to become familiar with cockpit switches and subsystem functionality.	Student pilots cannot conduct combat employment training involving the use of aircraft identification tactics and procedures. Decreases pilot's ability to perform mid-air collision avoidance.
Do not use the helmet-mounted display (HMD) as a primary reference	Any instrument flight must be done "head's down" using the cockpit displays. The current training habit patterns will have to be "unlearned" when/if the HMD is certified.	Same limitations as on the familiarization phase of the syllabus.
Limited air-to-air or air-to-ground radar modes (no electronic attack, sea search, ground-moving target, or close-in air combat modes)	No significant effect on familiarization phase of the syllabus.	Student pilots cannot conduct combat employment training. Decreases pilot's ability to perform mid-air collision avoidance.

The helmet-mounted display (HMD) system presented problems for pilots.

While the helmet-mounted display (HMD) functioned more or less adequately for the purposes of the OUE (even though it could not be used as a primary flight reference), the system presented frequent problems for the pilots. All four student pilots and one of the five instructor pilots identified a problem with the HMD on at least one of their training flights. Problems cited in the survey comments included misalignment of the virtual horizon display with the actual horizon, inoperative or flickering displays, and focal problems – where the pilot would have either blurry or "double vision" in the display. The pilots also mentioned problems with stability, jitter, latency, and brightness of the presentation in the helmet display; all of which are problems being worked by the program in developmental testing. Pilots also commented on the usability of the HMD, comparing it to the heads-up display in other aircraft; one citing that the HMD is too large of a presentation causing the heading display is to be overlaid on the canopy bow [and hence hard to see], and another citing the lack of HMD data when looking off to the side of the aircraft, such as during traffic pattern operations.

Due to the very limited scope of the Block 1A syllabus, none of the HMD issues cited by the pilots had any significant adverse impacts on the execution of the OUE itself. Based on pilot survey comments, however, it is clear that some of these issues have the potential to significantly hamper more advanced combat training and operational capability in the future if not rectified.

Due to design, the pilot-vehicle interface causes increased workload.

Deficiencies in the design of the pilot's communication and navigation controls causes increased workload. Cited by one of the instructor pilots during the OUE and by test pilots in other venues, the touch screen used to control the radios is not readily accessible, requires more channelized attention, has no tactile feedback, and is error prone – particularly during demanding phases of flight or under turbulent flight conditions.[6] This pilot was the only one, instructor or student, to explicitly call out an issue on controls and displays other than the HMD issues discussed previously in his OUE survey responses. Because this issue was not addressed in the end-of-course interviews with each of the primary student pilots, it is unknown whether or not, or to what extent, the other pilots may have shared his concerns. In any case, as a member of the instructor cadre, and having had enough hours to have developed a level of familiarity with the controls and displays and the mechanization of their different functions, his criticisms cannot be dismissed as being due to lack of experience. This shortfall of touch screens is well documented in the Human Systems Integration (HSI) literature, where there is not a performance problem in low-workload/low-stress situations, but can be the cause of significant failures in high stress or high workload conditions.[7] The program should implement pilot-vehicle interface improvements.

The out-of-cockpit visibility in the F-35 is less than other Air Force fighter aircraft.

All four student pilots commented on the out-of-cockpit visibility of the F-35, an issue which not only adversely affects training, but safety and survivability as well.[8] One rated the degree to which the visibility deficiencies impeded or degraded training effectiveness as "Moderate;" the other three rated it as "High" or "Very High." The majority of responses cited

6 This deficiency had been identified in the Joint Cockpit Working Group, which is a JPO-managed forum for F-35 pilots to identify items in the pilot-to-vehicle interfaces that can be modified to reduce pilot workload or increase pilot situational awareness.

7 MIL-STD-1472G is the human factors design standard for the DoD. Concerning the use of touch screens, the standard states "A touch-screen shall not be used if the interface will be used to enter large amounts of data frequently. A touch-screen shall not be the sole input means if system movement or vibration degraded user performance…" The JSF program intends to integrate voice recognition software which is designed to allow the pilot to command radio channel changes, vice using the touch screen interface.

8 Three of the pilots were previously qualified in the F-16; the other pilot was previously qualified in the A-10. The Air Force intends to replace both the F-16 and A-10 aircraft with the F-35A.

poor visibility; the ejection seat headrest and the canopy bow were identified as causal factors. "High glare shield" and the HMD cable were also cited as sources of the problem. Of these, only the HMD cable has the potential to be readily redesigned.

In three cases, student pilots explicitly cited visibility-related impacts that could be directly applicable to the Block 1A syllabus (a largely benign visual search environment); several other implicitly did so. One student pilot commented, "Difficult to see [other aircraft in the visual traffic] pattern due to canopy bow." Another stated, "Staying visual with wingman during tactical formation maneuvering a little tougher than legacy due to reduced rearward visibility from cockpit."

Three student pilot comments predicted severe impacts of the visibility shortfalls in combat or in training of a more tactical nature. One said, "A pilot will find it nearly impossible to check [their six o'clock position] under g." Another commented, "The head rest is too large and will impede aft visibility and survivability during surface and air engagements," and, "Aft visibility will get the pilot gunned every time," referring to close-range visual combat.

Aft visibility could turn out to be a significant problem for all F-35 pilots in the future, especially in more tactical phases of combat training than were conducted in the OUE, such as basic fighter maneuvering (BFM) and air combat maneuvering (ACM), and possibly in tactical formation as well. It remains to be seen whether or not, in these more advanced aspects of training, the visibility issues will rise to the level of safety issues, or if, instead, the visibility limitations are something that pilots adapt to over time and with more experience. Unlike legacy aircraft such as the F-15, F-16, and F/A-18, enhanced cockpit visibility was not designed into the F-35. There is no simple relief to limitations of the F-35 cockpit visibility. In all likelihood, it is partially a result of designing a common pilot escape system for all three variants to the requirements of the short-take-off and vertical landing environment.

Pilot's flight equipment (PFE), below the neck, creates a thermal burden on the pilots.

F-35 pilots are fitted with and required to wear a jacket on every flight as part of their flight equipment, which works with the escape system and personal flotation devices. Three of the four student pilots and one instructor pilot commented on thermal burden created by the jacket in their survey comments. The discomfort to the pilots due to excessively hot pilot's flight equipment (PFE) did not significantly hamper the execution of the OUE, but the outdoor temperatures during the evaluation were nowhere near the maximums experienced during the summer months at Eglin AFB or at other training sites, such as Marine Corps Air Station (MCAS) Yuma, Arizona, where the first operational F-35B unit is located. While the thermal loading of the PFE was tolerable during the OUE time period, it may very well turn out to more significantly hamper training at hotter times of the year.

During the flying portion of the OUE, the average, daily high temperature at Eglin AFB was 71 degrees Fahrenheit, with a peak high temperature during that period of 86 degrees Fahrenheit. In contrast, during the summer, the average, daily high temperature was 87 degrees Fahrenheit with a peak high temperature of 95 degrees Fahrenheit. The average, daily high temperature at the Yuma MCAS during the summer had been 105 degrees Fahrenheit, with a peak temperature for the period of 117 degrees Fahrenheit.

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Section Four
Training in the Classroom and F-35 Flight Simulator

The academic training environment, consisting of classroom and simulator instruction, enabled the completion of the ground training portions of the Block 1A syllabus by the student pilots, but observed training device deficiencies will likely have increasingly negative effects on training as demand on the training environment increases.

Academic sessions were generally effective, and contractor instructors were very good, but the Pilot Training Aids (PTAs) were not an efficient use of classroom time.

During the end-of-course interview, all student pilots stated that the academic portion of the training adequately prepared them for the simulator portion of the syllabus. The electronically-mediated lectures and interactive courseware lessons were generally effective for achieving syllabus objectives, and the contractor instructors teaching the courseware were knowledgeable and effective teachers. However, all student pilots identified the pilot training aid sessions as "Not Totally Adequate" for at least a portion of the syllabus objectives. Most of the student pilots identified technical problems with the Pilot Training Aids (PTAs) (slow in responding, screens locking, system resets being required) as contributing to their "Not Totally Adequate" assessment.

Other comments identified discrepancies between the flight manuals and the courseware (some identified and corrected by the instructor before the class began) and the redundancy between the PTA sessions and other forms of academic training. Student pilots differed in their view of the value added to the course from the PTAs. Two of the student pilots commented that the PTAs were "ineffective" and "a waste of time," while one student pilot (least familiar with the F-35) considered the PTA to be a "huge benefit." This disparity is at least partly attributable to the way the PTA was used. In the classroom, the PTA sessions stepped very slowly through various controls, like clearing cautions and warnings. However, for an inexperienced pilot, the ability to have a "take home simulator" afforded by the laptop PTAs likely is extremely helpful in learning to navigate the complex pilot interface and gain familiarity with the information intensive displays.

***Computer servers in the Academic Training Center (ATC) have memory problems requiring frequent resets*.**

The Learning Management System (LMS), which provides the classroom electronic media, relies on computer servers that were not stable. They required rebooting approximately every two hours to clear the memory cache, which filled over the time of class activity, so that the individual training modules at the student stations would not freeze/lock-up and become unusable. The academic training environment depends on the students having access to electronic media, often interacting with lesson plans on their individual workstations inside the classroom while simultaneously referencing the Flight Series Data (FSD) publications and pilot checklist. While the classrooms were set up with 12 workstations each, the OUE student pilot workload caused the LMS to run slowly and even lock up during PTA and interactive courseware (ICW) lessons. Student pilots commented in the surveys that computer or server deficiencies degraded the effectiveness of the academic training environment. The degree to which the deficiencies impeded or degraded execution of the syllabus varied from "Very Low" to "Moderate."

In addition to requiring system reboots, server problems prevented maintenance classes on the daytime shift from using ICW while student pilots were using the PTAs. During the OUE, the maintenance side of the Academic Training Center (ATC) included 10 classes, 4 during the day, and 6 at night. Because the servers could not accommodate all the necessary users simultaneously, the classes had to be re-scheduled at extended time periods outside the normal working day. For example, many maintenance courses were conducted late at night (4:00 pm to 1:00 am) to deconflict with the need for the student pilot classes to be on the LMS during the daytime. Future class loads will be 10 maintenance classes during the day and 10 at night; the current workaround of clearing the memory cache by rebooting the servers will not be sufficient to meet this increased load.

Full Mission Simulators (FMS) are excellent; however, some deficiencies were noted with minor impacts on training.

The Full Mission Simulator (FMS) environment, including the contractor instructors and instructor workstations, was effective in training the students in the syllabus events and preparing them for flight, although correction of minor deficiencies would improve training effectiveness. Comments from the pilots and observations indicated that the simulator was an excellent training device, with higher fidelity than simulators used for training in legacy fighter aircraft. One of the four primary student pilots stated that it was "one of the best parts of the whole program." However, the following three issues with the simulator training were identified by the student pilots, which adversely affected the effectiveness of the simulator.

- Student pilots identified deficiencies in the helmet used in the simulator (which is different than the helmet issued to pilots for the aircraft). The simulator uses a functional surrogate of the helmet used in the aircraft, which is not fit uniquely to each pilot's head. Problems included fit (too tight), improper optical alignment of the helmet-mounted display information, blurry presentations, and excessive weight. Student pilots reported that the helmet caused headaches due to the poor alignment. Some of the student pilots used only one of the two optical sights (monocles) to avoid blurry or double vision.
- Simulation stability was also a deficiency, although the disruption to training was usually minimal. Most of the simulator training sessions involved emergency procedures to be "programmed in" to the flight profile and then handled by the student pilot to an acceptable conclusion. After addressing the emergency procedures, the contractor instructor pilot would reset the simulator to a normal configuration to continue the training event. The process of resetting the simulator did not always work effectively, and required repeated attempts on multiple occasions. The time spent resetting the simulator detracted from the effective training time and interrupted the logical training flow during some of the simulator sessions. One on occasion, however, the disruptions and resets resulted in the simulator

training session being terminated and not effective (1 of 88 during the OUE period). The simulator event had to be rescheduled.

- Concerning the accuracy of the FSD to meet the execution of the simulator syllabus events, all student pilots rated the FSD as "Not Totally Adequate" for at least a portion of the simulator events. Pilots identified errors between the FSD, the pilot's checklist, and annunciations of emergency conditions in the simulator. The JSF Operational Test Team (JOTT) submitted identified shortfalls in the FSD in deficiency reports to the JSF Program Office (JPO).

During end-of-course interviews, each student pilot stated that the simulators adequately prepared them for the flying training portion of the syllabus.

Courseware contains errata, takes too long to update, and is incomplete.

Inconsistencies between the courseware and the FSD were frequently observed. Student pilots commented in the surveys that there were discrepancies between the courseware information presented in class and the latest FSD published for the aircraft. The contract instructors often identified and corrected the discrepancies in the classroom, mitigating this problem. The student pilots rated the degree to which these discrepancies impeded the execution of the syllabus from "Very Low" to "Moderate." Due to the large volume of changes being generated and the complex configuration control process, both the FMS and courseware lag as much as a year from changes to the aircraft software and technical data.

The cycle for fixing syllabus courseware discrepancies is lengthy. Student pilots commented that the time it takes to correct errors in the courseware and FSD impedes or degrades syllabus execution, varying in the degree from "Low" to "Moderate." For example, in preparation for the OUE, the contractor addressed 51 problem reports written for the courseware used for the OUE, which were generated through dry runs, small group tryouts, and instructor pilot checkout courses completed prior to the start. The time period between problem reports being written and the change being fielded varied from 24 to 187 days. At the time of the OUE, over 1,400 problem reports were being worked by the program to correct anomalies reported in training.

Academic training for mission planning was incomplete during the OUE as the training laboratory in the ATC did not have authority to operate. Although the Block 1A syllabus contains a 3-hour lesson designed to give the student pilots an overview and "hands on" training of the mission planning environment, only the instructor-led overview could be completed. One student pilot identified the need to add academic material covering classified mission systems capability, including sensor management and fusion.

Training management and learning management systems are deficient and require workarounds.

The Training Management System (TMS), which includes student pilot scheduling, grade books, and other course material, is immature. TMS has no Autonomic Logistics Information System (ALIS) connectivity between the ATC and the flying squadron. Workarounds in effect during the OUE included:

- Student pilots were required to login to the workstations one at a time to ensure the servers could handle the load, whether they were doing administrative tasks, such as checking their grade book or doing course lessons.
- Student schedules had to be coordinated manually between two different scheduling processes. In the ATC, student schedules were managed in the TMS. On the flightline, student schedules were managed independently using a separate software application. The squadron scheduler had to coordinate daily with the ATC to ensure student training events were scheduled and resources available. On at least one occasion, the ATC had to adjust student schedules to accommodate changes in simulator availability (moving the scheduled simulator event earlier), but the two students didn't get notified in time. The simulator training events were delayed approximately 30 minutes for one student and an hour for the other while the students were notified and made their way to the training center.
- Grade books had to be managed separately at the flying squadron and at the ATC. "Official" student grade books are maintained electronically in the ATC on the TMS, but paper training folders duplicating those of legacy training units were fully maintained by the flying squadron. Student grade sheets completed for the flightline portion of training (i.e., the taxi event and flights) had to be manually completed and faxed to the ATC for inclusion in the student's grade book. Training folders from the training center are not available to the flying squadron for review. This process caused extra workload in the squadron and in the ATC.
- Tests were administered in paper copy, vice electronically through the LMS, because experience with the electronically-generated tests showed that the students do not always receive the correct test or same tests. Also, the tests administered electronically were not always scored correctly. Paper copies and manual grading are adequate workarounds to electronically-generated tests.
- Students cannot electronically view student guides for test preparation, but must rely on hardcopies provided by the contractor instructor pilots.

Simulated flameout (SFO) approaches training in the FMS may not be adequate.

For single engine aircraft, pilots must be able to train and practice procedures for both precautionary flame out approaches in response to emergency checklist situations and for actual aircraft recoveries with an engine failure. In the F-35, simulated flameout (SFO) approaches can only be accomplished in the FMS, as Air Force directives prohibit practicing SFOs in the aircraft. This restriction is due to the inability to adequately simulate the failed engine condition, which would result in ineffective training. However, the most recent simulation certification report for the FMS, completed in November 2012, cited discrepancies between the FMS and actual aircraft performance using flight test data for engine response times – the FMS demonstrated 55 percent faster spool down time and 43 percent faster spool up time than the aircraft – and recovery times for data displays in the cockpit and in the pilot's helmet – FMS projections of data in the helmet were regained 70 seconds quicker than in the aircraft. During the OUE, one of the student pilots experienced an engine problem requiring him to fly an SFO pattern as a precautionary measure (engine was operational, but pattern was flown at idle thrust). The pilot commented that his experience in the F-35 was valuable training and that pilots should be able to practice SFO patterns in the F-35 aircraft, as they currently do in the F-16. He also stated that the aircraft appeared to have more drag with the gear down than the FMS under similar conditions. Current training in other single engine fighter aircraft require routine practice of SFOs in the aircraft and experience shows that situations requiring a precautionary flameout approach (with residual idle thrust) are more common than actual flameout situations. The discrepancies identified in the simulation certification report, coupled with the student pilot's experience in the aircraft during the OUE, indicate that the program should review training plans and address shortfalls to assure the training for F-35 pilots is adequate.

Information Assurance

The F-35 program has a complex information environment, ranging from data interfaces in the air vehicle to ALIS, to off-board mission systems, such as the mission planning environment, to the training management system for monitoring student progression through the training syllabus. Such an environment depends on robust information assurance procedures to ensure data are available when needed, yet not vulnerable to access outside of appropriate channels. As an example of this dependency – although not a factor during the OUE – the interim authority to operate the ATC was rescinded in December 2011, suspending ongoing academic training for maintenance personnel for a three-month period.

During the OUE, the JOTT conducted a review of security-related documents that were in effect at the 33rd Fighter Wing (33 FW), addressing security management, antiterrorism, industrial security, operations security, personnel security, physical security, communications security, and Security Awareness Training and Education. The team completed the review of the Unclassified Operational Environment using the "JSF Operational Test Team (JOTT) Information Assurance (IA) Non-Technical Assessment Checklist for the Unclassified Operational Environment." Of the 96 information assurance controls addressed in the checklist, the JOTT rated 44 compliant with the validation criteria, 43 partially compliant, 2 non-compliant, and 7 not applicable. One critical information assurance control associated with vulnerability management (VIVM-1) was evaluated as partially compliant, although 9 of 10 criteria were not met. The one criterion that was met was due to external factors unrelated to the management of the Unclassified Operational Environment. The noncompliance of this control and several partially compliant controls are related to the fact that the Unclassified Operational Environment has no Information Assurance Manager, which is a more serious problem. The information assurance posture of the Unclassified Operational Environment needs to be improved in order to protect any F-35 capability data during pilot training. The 96 information assurance controls need to be readdressed once the information assurance deficiencies and the lack of an Information Assurance Manager have been corrected for the Unclassified Operational Environment.

Additional observations concerning information assurance include the following:

- The JPO and the 33 FW do not have classified program network connectivity, which is required to process program action requests in a timely manner and ensure the flow of classified information between organizations. Once the classified network is in place, an assessment similar to the assessment of the Unclassified Operational Environment should be accomplished.
- Contingency plans are not robust. ALIS has no backup power supply. Although ALIS has an uninterrupted power supply for the computer servers, it has no backup power supply, which would be needed to support cooling requirements. When the air conditioning goes down, as would happen in the case of generator failure, the facilities immediately heat up to room temperatures unsafe for the hard drives in question. Higher temperatures create undue wear on multiple hard drives that are high dollar assets. This undue stress on the hard drives could be very costly in delays in the student program and class completion. The possibility of shutdown due to overheating after a base-level power outage is a significant risk, and has already occurred due to thunderstorms. Also, continuity of operations plans are not written and procedures for off-site storage of back-up data are not in place.
- On October 26, 2012, in the middle of the OUE, a security issue (classified) was identified with the laptop computers for the PTAs. This resulted in the ATC recalling the PTAs from the pilots and taking them back into custody. Prior to this, the pilots had been allowed and encouraged to take the PTAs home with them to get hands-on practice with the F-35 controls and displays. The PTAs were not returned to the pilots for the remainder of the OUE, denying them the advantages of this aspect of training. In particular, this denied them any access to the FSD at home, since their only access to the FSD outside of the squadron was via the PTA.
- On January 18, 2013, the Defense Intelligence Agency and JPO officials discovered another potential security concern involving the Unclassified Operating Environment with the training syllabus at Eglin causing a suspension of all pilot and maintenance training. The issue was addressed and training was restarted a week later.

Section Five
Sustainment

The sustainment environment at Eglin AFB is a hybrid of government and contractor support personnel that relies heavily on workaround procedures, non-standard support procedures, and specialized support equipment to generate sorties and maintain the F-35A fleet. The sustainment team was able to meet the thresholds defined by the training command for sustainment for the OUE by generating the sorties needed for four student pilots to complete Block 1A training in 46 training days. However, the Air Force provided generous resources, particularly in manpower and aircraft, to assure a successful evaluation. Additionally, the F-35A Block 1A and 1B aircraft remain immature and include few functional aircraft mission systems, which resulted in far fewer failure modes and a narrower scope of demand on the supply chain. Further, the F-35 Joint Reliability and Maintainability Evaluation Team (JRMET) data for the F-35A fleet suggest that the program is not meeting reliability growth targets. Hence, due to the immaturity of the aircraft, the workarounds required to support flight operations, and very limited mission systems capability, little knowledge can be gained from the OUE applicable to F-35 sustainment under normal squadron training operations or to sustainment of combat capable aircraft in operational units.

The 33rd Fighter Wing (33 FW) possessed 9 Block 1 F-35A aircraft, 6 in the Block 1A configuration (tail numbers 746 through 751) and 3 in the Block 1B configuration (tail numbers 5001 through 5003) during the time of the evaluation. For sustainment analysis, data from all nine aircraft are considered equally, unless noted otherwise. Student pilots were required to fly in one of the six Block 1A aircraft for syllabus training flights, while instructor pilots could fly in either Block 1A or 1B aircraft.

Sustainment analysis included examining results for aircraft availability, reliability, and maintainability; logistics supportability, including spare parts and support equipment; and the ability of the Autonomic Logistics Information System (ALIS) to support flying operations during various periods of time. Although the primary time period used for sustainment analysis was the period of student flight training during the OUE, other flight periods were used to augment the data.

Aircraft Maturity and Abort Rates

The Air Force airworthiness authority identified air abort rate as an indicator of aircraft maturity in a system safety risk assessment completed in November 2011 (see Table 2-1). The JSF program identified an objective of a demonstrated air abort rate of no greater than 1,000 aborts per 100,000 flight hours to commence training in the F-35A. In the July 2012, DOT&E memo addressing the test plan for the OUE, DOT&E noted concern over maturity of the F-35A.[9] At that time, flying operations at Eglin AFB had demonstrated an air abort rate of between 4,800 and 7,200 air aborts per 100,000 flight hours, during the local area orientation flights that began

[9] See DOT&E memorandum, “Test Plan for the F-35A Joint Strike Fighter Readiness for Training Operational Utility Evaluation,” dated July 20, 2012.

in March 2012. Figure 5-1 shows the cumulative abort rate from the start of flight operations through the end of 2012 for all F-35A aircraft at Eglin AFB. Although this cumulative rate of 3,600 aborts per 100,000 flight hours remains higher than the objective identified by the Air Force for entering training, the trend observed throughout the year is favorable, as the rate halved from March to December. During this time period, 16 air aborts occurred during 338 sorties and 440 hours. System failures causing the aborts varied from flight control system (4), fuel (2), communication systems (2), exceedence of an aircraft operating limitation (2), brakes (1), engine (1) that occurred during the flight training portion of the OUE, integrated power package (IPP) (1), vehicle mission computer (1), and sympathetic/other (2).

Ground aborts also provide insight into aircraft maturity and sustainment operations. Figure 5-1 also tracks the cumulative ground abort rate as a percentage of sorties attempted over the same time period; it is fairly flat over the last six months of the year, averaging between 14 and 16 percent with no difference in results for Block 1A and 1B aircraft. This equates to approximately one in seven sortie attempts resulting in a ground abort. The causes of the aborts varied over the period. Pilot flight equipment issues, such as g-suit and helmet-mounted display (HMD) problems, which are independent of the aircraft but necessary for flight operations, caused more ground aborts earlier in flying operations. For example, on August 21 and 22, 2012, eight ground aborts were caused by g-suit problems associated with two F-35As, but could have occurred on any aircraft. Aircraft-specific issues, such as battery problems and IPP failures, caused more aborts later in the year and also generated "sympathetic" ground aborts when an instructor ground abort led to a student pilot ground abort. The program should continue to monitor abort rates as indicators of overall system maturity.

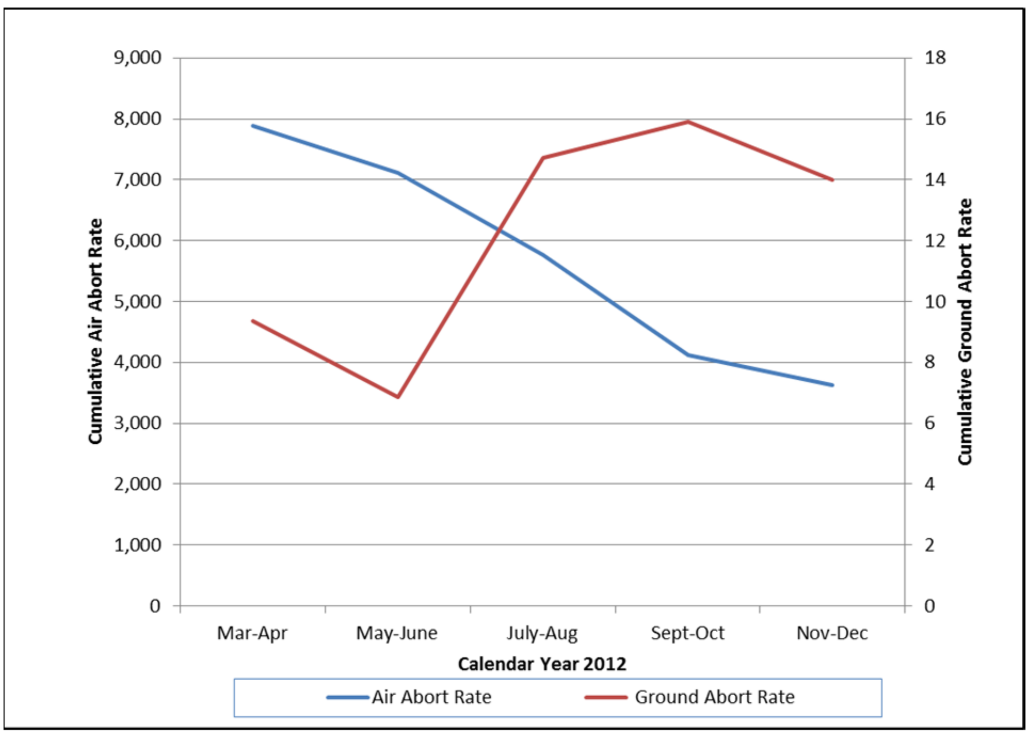


Figure 5-1. Cumulative Air and Ground Abort Rate History for F-35A Aircraft at Eglin AFB. Air Aborts expressed in aborts per 100,000 flight hours, Ground Aborts in percent of sorties attempted.

Aircraft Availability

The Air Force identified aircraft availability as a measure of readiness to begin flight training, with a desired availability rate of 33 percent for F-35A aircraft at Eglin AFB. Figure 5-2 shows the weekly average aircraft availability rate from the start of flight operations in March 2012 through the end of the year. Prior to the OUE, aircraft experienced extended periods of Not Mission Capable (NMC) time, in part due to modifications necessary for a flight clearance that would allow students to fly, such as modifications of the ejection seat. Aircraft were also NMC for extended periods for reasons other than flight clearance related modifications. For example, aircraft were used to accomplish verification of Joint Technical Data (JTD). Other maintenance activity, awaiting parts supply, and required inspections also contributed to the down-time. For example, aircraft 751 was NMC for over two months after sustaining structural damage from towing during a required inspection and waiting on maintenance and supply for a part for the ejection seat. Aircraft 749 spent 84 days NMC for replacement of damaged heat blankets, a cracked trestle mount bracket in a power amplifier module, and carbon fiber damage on a wing tip.

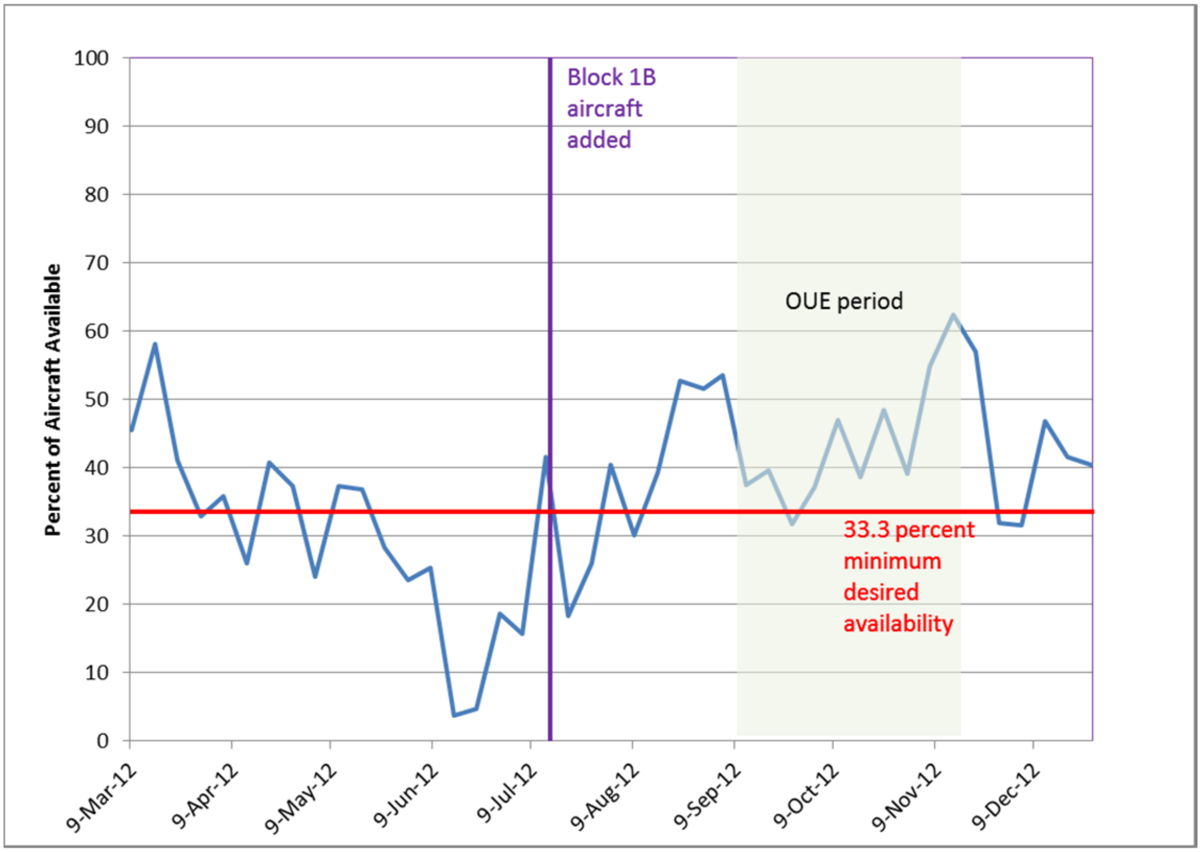


Figure 5-2. Weekly Average Aircraft Availability Rate at Eglin AFB March through December 2012

During the OUE flight training period, 33 FW was able to provide flight-ready F-35A aircraft at an adequate rate to support the limited student flight training requirements during the OUE flight training period. In the 13 training days encompassing the flying portion of the syllabus, the Wing provided F-35A aircraft for 60 scheduled sorties (including the four taxi-only sorties). Fifty out of sixty scheduled sorties launched as planned. Ten sorties could not be completed as scheduled: eight due to ground aborts of the aircraft and two due to weather. Spare aircraft were made available as well, and were required 12 times in the 60 scheduled sortie attempts. While the syllabus required student pilots fly only in one of the six Block 1A aircraft, the instructors were qualified to fly in any of the nine F-35A aircraft, or even in another dissimilar chase plane (e.g., an F-16), if an F-35A was not available. Of the 46 training sorties, 33 were flown in the Block 1A aircraft and 13 were in Block 1B, which is roughly in proportion to their respective quantities. On two occasions, an instructor flew in an F-16 aircraft to facilitate an F-35A student training mission because a second F-35A aircraft was not available.

On 43 occasions during the entire OUE period, the 33 FW successfully flew the same aircraft twice in the same day. In these instances, the aircraft turn times ranged from 3.3 to 5.7 hours, averaging 4.5 hours.

Demand for sorties during the OUE was low, as seen by the aircraft utilization rate.

$$\text{Aircraft Utilization Rate} = \frac{\text{number of sorties}}{\text{number of training days} \times \text{number of aircraft}}$$

During the OUE flight training period, the overall aircraft utilization rate was 0.33, the equivalent of each aircraft flying one sortie every three days.

Figure 5-3 shows the aircraft utilization rate of each F-35A at Eglin AFB from the start of flight operations in March 2012 for Block 1A F-35As and in late July 2012 for Block 1B aircraft through December 2012. Block 1A aircraft demonstrated a consistent utilization rate between 0.10 and 0.15 – or 1 sortie every 7 to 10 days – while two Block 1B aircraft showed a rate approximately twice that of Block 1A aircraft. During the OUE, Block 1A jets flew 96 sorties and Block 1B jets flew 52 sorties for a total of 148 sorties. Limited flight hours and differences in time on-station at Eglin prevent statistically valid comparison of the different configurations.

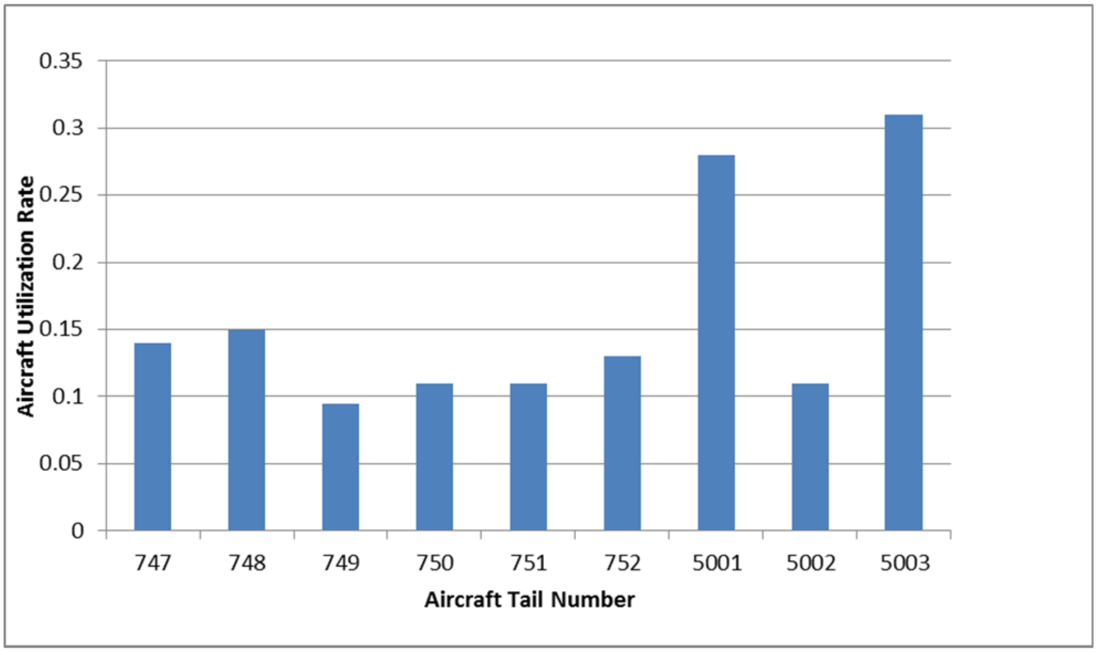
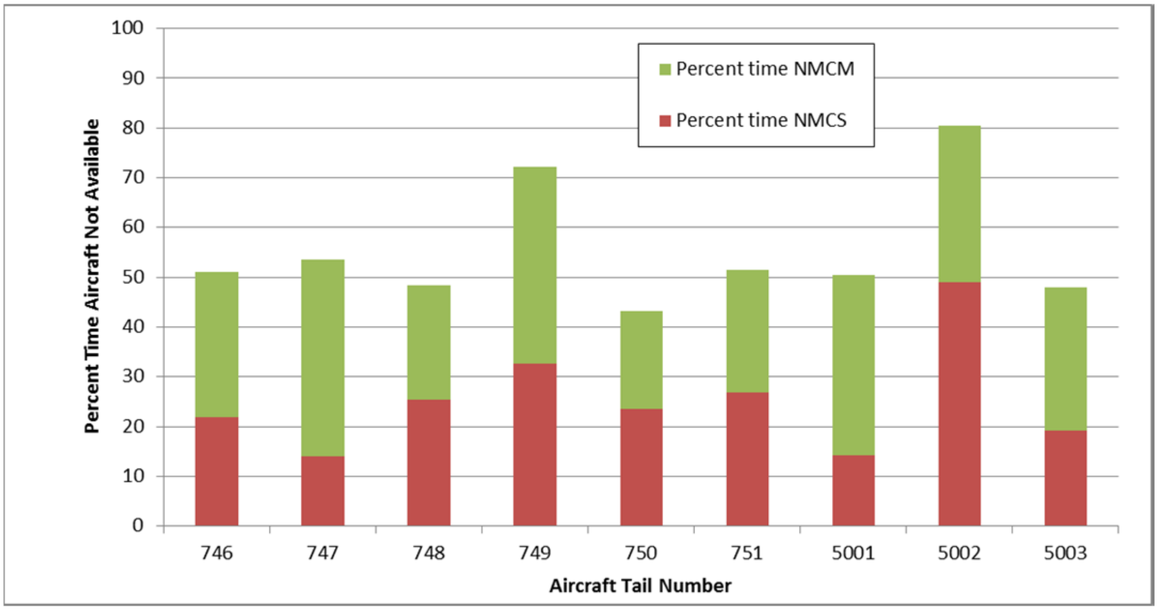


Figure 5-3. Aircraft Utilization Rate (in sorties per aircraft per day) at Eglin AFB March through December 2012

As mentioned earlier, the aircraft used for the OUE had very limited mission systems capability. Only minimal communications, navigation, and aircraft control systems were required to execute the Block 1A training sorties (radar, tactical displays, sensor fusion, electro-optical sensors, electronic warfare capability, datalinks, and simulated weapons capability were not required). When the aircraft do not meet the minimum requirements for the assigned mission, they are designated as NMC.[10] NMC status reported here is dependent only on the minimal functions required for the Block 1A syllabus. Figure 5-4 shows the percentage of time during the entire OUE period each of the nine aircraft were NMC due to maintenance (NMCM) or supply (NMCS), which are the two categories of NMC status tracked for the OUE. Two-thirds of the aircraft (six of nine) were not available 50 percent of the time; and two aircraft, tail numbers 749 and 5002, were not available 70 to 80 percent of the time.

10 System requirements for flight operations depend on the type of mission to be flown and are defined in a Minimum Essential Functions List. For the OUE, the only systems required for the student syllabus sorties were those designated for safe to fly, such as basic aircraft systems and fundamental communications, navigation, and air traffic control transponder modes.



NMCM – not mission capable due to maintenance; NMCS – not mission capable due to supply

Figure 5-4. Percent Time Each Aircraft Not Available at Eglin AFB During the Entire OUE Period

In spite of the low demand on the aircraft in number and in capability, availability at times exceeded the demand by only a slim margin. For example, at times, F-35As flew without a functioning radar. Although an operative radar was not required for the Block 1A syllabus, maintenance would normally provide aircraft with an operational radar if available. In another instance, an aircraft used for a taxi event was not flyable as maintenance personnel had removed the cover on the wingtip light to allow the seals around the light to cure. Maintenance personnel released the aircraft for the taxi event as a spare; it was needed when the originally scheduled aircraft developed problems during startup. A training syllabus requiring more capability from the aircraft would have likely reduced the availability of aircraft during the OUE.

Reliability

The Operational Requirements Document (ORD) defines reliability metrics with thresholds to be met at maturity, defined as 200,000 cumulative flight hours across all variants, and a minimum of 50,000 hours per variant. To assess progress toward the ORD threshold values, in 2012 the program developed growth curves, which can be used to project target values during development. The program reviews and scores maintenance data using a JRMET for tabulating metrics. Reliability metrics derived from JRMET data are shown in Table 5-1 for three periods of data collection, along with ORD thresholds, if specified. The last column shows the estimated target from reliability growth curves for the F-35A fleet at the current cumulative flight time of approximately 2,500 hours, and, in parentheses, the ORD threshold for the "mature" system. Metrics from the maturity demonstration period and the OUE – broken into the non-student flights and the student syllabus flights – are compared with the metrics for the entire F-35A fleet, which consists of both the System Design and Development (SDD) test aircraft and the early production aircraft. The metrics for the maturity demonstration and the OUE should be considered point estimates, as the number of flights and hours in these data are small; however, they are from aircraft flown under similar conditions and configuration. The F-35A fleet metrics can be compared with the target numbers from the growth curves and the threshold values from the ORD.

Table 5-1. JRMET Scored Reliability Metrics for F-35A

		OUE Period				
	Maturity flights	**Non-syllabus flights**	**Syllabus flights**	**All flights**	**Entire F-35A Fleet**	***2,500 Hour Target from Reliability Growth Curves (ORD Thresholds)***
Aircraft Block	1A	1A/1B	1A/1B	1A/1B	SDD/1A/1B	*3F (End SDD)*
Location	Edwards AFB	Eglin AFB	Eglin AFB	Eglin AFB	Eglin & Edwards AFB	
Dates	Jun 27 to Oct 12, 2011	Sep 10 to Oct 25, 2012	Oct 26 to Nov 14, 2012	Sep 10 to Nov 14, 2012	Start of flight testing to Nov 14, 2012	
Number of Aircraft	2	9	9	9	15	
Sorties	44	100	48	148	1,382	
Flight Hours	77.8	135.2	65.5	200.7	2,448.0	
Number of Critical Failures	43	28	21	49	636	
Mean Flight Hours Between Critical Failure	1.8	4.8	3.1	4.1	3.9	*≥11.0 (20.0)*
Mean Flight Hours Between Removals	1.3	2.4	1.9	2.2	2.5	*≥4.0 (6.5)*
Mean Flight Hours Between Maintenance Event$_{unscheduled}$	0.4	0.8	0.6	0.7	0.7	*≥1.4 (2.0)*
Mean Flight Hours Between Maintenance Event$_{scheduled}$	11.4	0.3	0.3	0.3	2.1	
Mean Flight Hours Between False Alarm	0.5	9.7	13.1	10.6	20.9	*N/A (≥50.0)*

SDD – System Design and Development

Mean Flight Hours Between Critical Failure (MFHBCF) is a reliability metric with an ORD threshold. A critical failure is one which results in the loss of capability necessary to perform an essential mission function, causing the aircraft to be down for maintenance. The failure may be discovered during maintenance actions on the ground or manifest in flight. During the OUE, 49 critical failures occurred resulting in an MFHBCF of 4.1 hours. Failures involving the Power and Thermal Management System (PTMS) were the primary driver for the rate, followed by integrated air vehicle architecture, which included processors, power supplies, and fiber channel switches, and then the electrical power system. This rate is better than the maturity demonstration period and consistent with the entire F-35A fleet value of 3.9 hours, but short of the target number from the growth curve of 11.0 hours. The ORD threshold at maturity is at least 20.0 hours.

Mean Flight Hours Between Removal (MFHBR) is another reliability metric with an ORD threshold, and is used for assessing how often individual components or parts need to be pulled from the aircraft for repair. During the OUE, the MFHBR was 2.2 hours; again, better than the maturity period of 1.3 hours, and consistent with the fleet average. Over the OUE period, the high drivers for removals were tire changes, the PTMS, and the electrical power system. Aircraft required 24 tire changes, the replacement of 4 nacelle vent fans and 3 thermal management system fans, and the removal of 8t batteries. The fleet MFHBR of 2.5 hours is lower than the objective number from the growth curve of 4.0 hours. The ORD threshold at maturity is at least 6.5 hours.

Mean Flight Hours Between Maintenance Event (MFHBME) is categorized as either scheduled – such as preflights and routine inspections – or unscheduled. Only the unscheduled metric has an ORD threshold and is used to assess overall reliability of the aircraft. For the OUE, the MFHBME for unscheduled activity was 0.7 hours or roughly two unscheduled maintenance events required per sortie, as the average sortie duration was about 1.4 hours. This rate was again better than during the maturity demonstration period, and consistent with the fleet performance, but half of the objective of 1.4 hours from the growth curves. The ORD threshold for MFHBME is at least 2.0 hours for unscheduled maintenance.

Mean Flight Hours Between False Alarm (MFHBFA) is used to assess the accuracy and reliability of the onboard Prognostics and Health Management (PHM) system, which has limited functionality in these early Block 1A and 1B aircraft. The aircraft flight control system was the primary driver for this rate, which was 10.6 hours during the OUE – about half of the fleet average. The ORD threshold at maturity is at least 50 hours.

Because the aircraft had few functioning mission systems and no combat capability, some of the ORD-defined measures of reliability, such as Mean Flight Hours Between Operational Mission Failure, are not relevant to an aircraft this early in development. Any operational mission failure that could occur during the OUE would be a safety of flight issue and result in an air abort. During the OUE flight training period, one air abort occurred amongst the 46 F-35A student and instructor pilot training flights.

An example of poor reliability was the helmet. Helmet reliability is low and resulted in five ground aborts during the OUE. Problems included electrical pin/connector issues, a helmet display problem, and an HMD with a six degree differential to the horizon. Pilot comments concerning the helmet showed that some experienced "double vision" in flight and misalignment of the virtual and actual horizons. The lack of ground preflight test equipment for the helmet that would check functions of communications and visual displays prevents the pilot from knowing whether the helmet is fully operational until initiating checklists at the aircraft. Additionally, pilots have difficulty distinguishing between problems with the helmet or the aircraft. One pilot was required to connect his helmet to an aircraft cockpit to check the repairs, which included the power/video cable that connects the helmet to the aircraft, prior to being scheduled for the next training sortie.

Although early in development, reliability indicators are not meeting the targets in the growth curves. The program should monitor reliability performance and determine what adjustments are necessary to ensure reliability thresholds in the ORD can be met.

Maintainability

The maintenance operations concept at Eglin AFB involves significant contractor presence at the base and engineering assistance from the Lockheed Martin facility in Fort Worth, Texas, and requires the use of workarounds for every flight. The program uses an organization called the Lightning Support Team (LST) – consisting of highly experienced government maintainers and contractor personnel, including experienced engineers and maintainers from Lockheed Martin, Pratt & Whitney, British Aerospace, and Northrop Grumman – to address problems not adequately addressed in the unit-level maintenance technical manuals. The Air Force assigned 125 maintenance personnel to the maintenance unit supporting the OUE: Lockheed Martin supplied approximately two dozen onsite Field Service Representatives (FSRs), while the other contractors also had support teams assigned to the OUE.

JRMET results for maintainability metrics are shown in Table 5-2. Because the maintenance concept used at Edwards AFB for the maturity demonstration was different than that used during the OUE, metrics for that period are not included in the table, as were the reliability metrics in Table 5-1. Further, only limited comparisons can be made between the periods of data included in Table 5-2, as differences in maintenance concepts and the inability to track contractor maintenance efforts as carefully as that of government maintainers. As with the previous table, ORD maintenance threshold requirements at aircraft maturity are included.

Table 5-2. JRMET Maintainability Metrics for F-35A

	OUE Period			Entire F-35A Fleet	*ORD Thresholds*
	Non-syllabus flights	Syllabus flights	All flights		
Aircraft Block	1A/1B	1A/1B	1A/1B	1A/1B	*3F (End of SDD)*
Location	Eglin AFB	Eglin AFB	Eglin AFB	Eglin & Edwards AFB	
Dates	Sept 10 to Oct 25, 2012	Oct 26 to Nov 14, 2012	Sept 10 to Nov 14, 2012	Start of flight testing to Nov 14, 2012	
Flight Hours	135.2	65.5	200.7	2,448.0	
Mean Corrective Maintenance Time per Critical Failure (hrs)	11.7	14.2	12.8	10.1	*≤4.0*
Total Maintenance Man Hours per Flight Hour (MMH/FH)	11.4	12.7	11.8	6.3	
MMH/FH_{sched}	8.4	8.5	8.4	1.3	
$MMH/FH_{unsched}$	3.0	4.3	3.4	5.0	
Mean Time to Repair (MTTR) (hrs)	9.9	6.2	8.4	6.5	*2.5*

SDD – System Design and Development

JRMET results show that the Mean Corrective Maintenance Time per Critical Failure during the OUE was consistent with the F-35A fleet average, but – as expected for a system this early in development – was greater than the ORD threshold of 4.0 hours or less.

JRMET data also show maintainers at Eglin spent about 12 hours of maintenance time working on an aircraft for each hour flown. Scheduled Maintenance Man Hours per Flight Hour (MMH/FH), which includes pre- and post-flight inspections, inspections of the outer mold line, and early production aircraft-unique inspections, was 8.4 hours, substantially higher than the fleet average at this time. These early production aircraft were accepted by the Air Force with limited PHM system tools, and therefore required frequent inspections not planned for later production aircraft, contributing to scheduled maintenance time being the majority of the maintenance workload. Unscheduled MMH/FH was 3.4 hours during the OUE, which is lower than for the fleet. However, the Eglin training aircraft have less operable, and no demand for, mission systems compared to those being flown at the test centers. For the OUE, the systems or components that demanded the most unscheduled maintenance work were the onboard oxygen generation system, the thermal management system fan, the engine bay heat blanket, and the IPP intake door. Accuracy of the PHM system is essential to efficient use of maintenance time. The PHM system, though limited in capability, successfully isolated a fault to the correct electronic component 75 percent of the time and to the correct non-electronic component 56 percent of the time. Incorrect fault isolations by the PHM system occurred most often on displays, indicators, and on the fire protection system.

MMH/FH includes only maintenance time directly involved with the aircraft, as the maintenance time bookkeeping function in ALIS accounts only for maintenance jobs on the aircraft. Indirect maintenance time, which the JSF Operational Test Team (JOTT) included in the test plan as a data element for assessment, could not be quantified. For example, time spent by contractors on the LST addressing action requests – which did not require logging of maintenance time in ALIS – is not included in MMH/FH data. Therefore, the complete maintenance effort is not quantified for these aircraft in the OUE. The program should track all hours for personnel supporting F-35A sustainment.

An example where maintainability needs to improve is engine replacement. One unscheduled engine removal and replacement occurred during the OUE, which required 39 hours of elapsed maintenance time. For the five unscheduled engine removal and replacements that have occurred in the F-35A fleet, the mean elapsed maintenance time for this task is 52 hours. The ORD threshold is for a maximum crew of four maintainers to remove and install the engine within 120 minutes.

Another example where maintainability needs to improve involves JTD. Although the program managed to verify nearly all of the minimum of JTD modules identified by the Air Force as needed for OUE operations and the start of training, JTD immaturity affected maintainability. The maintenance workaround for missing and incomplete JTD was to submit action requests (ARs) requiring involvement of the LST. If maintainers cannot find a solution for a maintenance issue in JTD or do not trust results from the PHM system they write an AR to request assistance from the LST. Maintainers cannot proceed with troubleshooting or ordering parts until a response to the AR is received.

In this reactive construct, the LST cannot always provide a short-term solution for an AR. A process for categorizing ARs by impact on sortie generation and report date and timeliness for providing short-term, interim, and long-term solutions exist, but this means that an older AR that is about to shift into a "late" category could get treated with a higher priority by the LST than a more recent AR that has a greater impact on sortie generation.

Portable Maintenance Aids (PMAs), which are used for electronic forms management and contain JTD, caused routine delays for maintainers throughout the maintenance cycle. It normally takes two to three minutes to login to a PMA. If the PMA is completely powered down, login takes five minutes and three logins before the maintainer can use the device. The PMA screen locks up after five minutes of non-use and requires the maintainer take another five minutes to re-login and navigate back to a JTD task. Signing off each maintenance task takes three to five minutes. More complex maintenance jobs with sub-tasks require multiple digital signatures that can extend turn times.

Furthermore, errors in the PMAs are difficult to clear. In one instance, the PMA indicated an F-35A required a left tire change when it needed a right tire change. Maintainers could not fix the error themselves; the change required an FSR and extended the aircraft turn time.

Low pilot helmet reliability increased the maintenance workload. Maintenance actions for troubleshooting helmet-to-aircraft interface problems require the use of a pilot's helmet, as no helmets or test equipment are available to maintenance personnel. The immaturity of JTD and lack of maintenance training in this area prevents assigned military specialists from performing all but the most routine maintenance on helmets and other flight equipment. When problems occurred during the OUE, the contractor helmet technician completed the repair and performed the steps needed to initiate an update to the JTD. Because the helmet is more complex than legacy systems, maintenance processes for the helmet are also more involved. When interviewed, government maintainers noted that low levels of bench stock often require cannibalizing replacement components from new helmets awaiting issue to incoming pilots, or to have parts shipped from the central supply point. This increases the chance that a pilot will miss at least one day of flying for even minor problems like a bent connector pin, such as occurred during student flying in the OUE. The program should ensure adequate sparing of helmet-mounted display parts and equipment are in place at the training center and at follow-on field units to meet requirements.

Overnight temperatures below 59 degrees Fahrenheit, the design minimum temperature for the 270 Volt Battery Charger Control Unit (BCCU), resulted in four ground aborts and the loss of two student sorties, an unacceptable condition for combat aircraft. To mitigate this problem, maintenance crews put jets in heated hangars overnight. Moving jets in and out of a hangar to keep them warm involves five personnel for three to four hours per shift. The parking of flyable jets in a hangar also interfered with maintenance because these flyable jets occupied space that would otherwise be used for jets requiring repair. In this case, the availability of an unused weapons hangar permitted maintainers to conduct low-observable and other maintenance activities despite the non-availability of the primary hangar.

The cure times for low-observable maintenance increased as temperatures cooled and caused pilots to fly some sorties using spare aircraft. As noted earlier, one aircraft was not flyable because seals around a wingtip light were still curing, but it was available for a taxi event.

Autonomic Logistics Information System (ALIS)

ALIS functionality is limited at this stage of development and workarounds are being used. Maintenance personnel and test team observers noted problems with ALIS throughout the aircraft turn cycle, which is dependent on timely downloads and processing of maintenance data. These problems include long processing times and a complex, multi-step process for transferring maintenance data from the aircraft to ALIS after flight. The post-flight maintenance process includes the following:

- Download for maintenance information is accomplished via a portable memory device (PMD). The download time for the PMD ranged from 2 to 109 minutes, and averaged just over 24 minutes for the 172 downloads completed during the OUE.
- Download for data from the Exceedence Management System (EMS). This download averaged 31.6 minutes and ranged from 15.0 minutes to 134.0 minutes. The EMS is a workaround for PHM system tools not yet mature in ALIS.
- Checking for nuisance health reporting codes and generating a list of maintenance actions. Time for this portion of the post-flight process averaged 26.5 minutes and ranged from 2.0 minutes to 247.0 minutes.
- Average run time for the three-phase process is 82.5 minutes, a timeline that makes it difficult for maintainers to prepare an aircraft for its second flight in a day. The amount of data transferred from these early training aircraft is small relative to that of combat-capable aircraft, when mission systems, sensors, and weapons data will all be included.

PMD download in general and EMS processing in particular remains inefficient and unreliable. During the course of the OUE, observers noted PMD download difficulties after 16 sorties and EMS processing difficulties after 17 sorties separate from problems or slow response times from ALIS. In several cases, delays from maintenance downloads or EMS processing caused aircraft scheduled for a second flight to take off late or required the use of a spare aircraft. Personnel assigned to this task noted that a user can logon to ALIS on only one computer at a time, even though they could manage downloads from multiple PMDs simultaneously because of the wait times involved in each stage of data processing.

Data collection plans by the JOTT assumed that Lockheed Martin routinely recorded information on ALIS availability, reliability, maintainability, logistics supportability, and data administration, but Lockheed did not. Analysis of ALIS comes from personnel surveys, interviews, and observation. DOT&E considers these data important for assessing ALIS and they should be tracked by the program.

During a meeting with JOTT representatives and Lockheed Martin ALIS administrators assigned to Eglin AFB, the Lockheed Martin representatives indicated that ALIS is effectively available at all times because it is connected to an Uninterruptable Power Supply (UPS). They noted that power at Eglin AFB does go down periodically for short amounts of time, but the UPS allows ALIS to remain functional and permits a graceful degradation of capabilities should an outage persist. For longer periods of time without power, the lack of air-conditioning will cause ALIS to automatically shut down before the UPS runs out of power. ALIS is not connected to a back-up generator. Lockheed Martin representatives noted that upgrades to the power grid at Eglin AFB in the year prior to the OUE, including a new sub-station near the 33 FW, have resulted in less frequent power outages. They also indicated that power outages do not affect

Block 1A Off-Board Management System (OMS) laptops that are battery operated. Users have two OMS laptops available for mission planning and two for mission debriefing.

Further discussions showed that Lockheed Martin tracked only the availability of ALIS servers and hardware and generated a monthly chart showing server and network uptimes and outages. They do not separately track the availability of ALIS domains, including Squadron Health Management (SHM), Customer Maintenance Management Service, and Low Observable Health Assessment System. Even though maintainers found that SHM did not function for four hours on October 11, 2012, Lockheed Martin representatives interpreted this as ALIS remaining available during that time.

In addition to the slow PMD download times, maintenance personnel also noted that ALIS response times were generally slow for all functions. This was due to the large number of users accessing ALIS through the base network switch serving the flightline. Although the overall base network infrastructure meets the requirements of the Functional Requirements Document, user demand density influences response times significantly. Personnel accessing ALIS through a network switch not on the flightline do not experience delays as significant as those on the flightline. Also, a Squadron Operating Unit (SOU) is designed to permit a maximum of 100 users simultaneous access; however, Eglin had between 700 and 800 user accounts during the OUE. Normally, the 33 FW has between 40 and 50 users at a time accessing ALIS, with peaks of 70 to 80 users during shift changes when maintainers simultaneously check tools in and out at the supply warehouse. System slowdowns were most severe during these periods of peak use.

Lockheed Martin personnel noted that ALIS hardware failures have occurred infrequently and only on redundant systems. They acknowledged that they should develop a process for tracking ALIS reliability in terms of hardware and applications, which do crash periodically even though ALIS itself remains functional. Although they did not have precise data to support this, Lockheed Martin personnel observed that the Customer Relationship Management (CRM) domain, which is used to submit ARs to Fort Worth, crashes for approximately 10 minutes each month and requires a restart. While CRM is unavailable, the maintainer can either wait for CRM to reboot or can phone the Autonomic Logistics Global Sustainment center at Fort Worth to submit an AR.

The maintenance concept for ALIS 1.0.2 involves a 24-hour turn time, i.e., suppliers such as Hewlett-Packard guarantee that ALIS will not go down for more than 24 hours because of a hardware failure. Should a supplier fail to meet this contract, Lockheed Martin's back-up plan is to move assets from their facility in Orlando, Florida, where ALIS is manufactured, to Eglin AFB. However, all hardware that goes into the vault where the SOU resides must receive approval by a security officer who has up to 10 days to approve a hardware request. For a mission critical part, the Wing Commander can request the security officer expedite the finding, but this security policy could result in a delay that would prevent the repair of ALIS within 24 hours.

ALIS database administration is primarily a Lockheed Martin Fort Worth function and includes both daily and weekly back-ups of the database. Tape back-ups move from the SOU location at the 33 FW to the Academic Training Center (ATC) each week.

Aircraft release is more difficult with ALIS as the time required to sign off maintenance tasks can be lengthy due to the way the process is mechanized in ALIS. Work packages take a minimum of 30 minutes to sign off. In one instance, a "parent" task had 18 subtasks, each of which required a signature in the maintenance event field. Additionally, Lockheed Martin and Pratt & Whitney representatives must sign off on some of the tasks. Flight line personnel must coordinate to get these individual tasks performed and signed off before the work package can be completed. Even a highly recurrent task such as aircraft refueling requires three different signatures in ALIS. There were instances where aircraft launch delays occurred because unsigned tasks prevented ALIS from releasing the aircraft.

Supply Support

During the OUE, lack of supply support did not prevent the completion of the required syllabus training flights during the allotted time because there was a sufficient quantity of aircraft assigned to generate a relatively small number of sorties. However, the supply system is characterized by long delivery times and inefficiencies in accounting for parts and processing requests. The average supply delivery time for mission-limiting components was approximately 3 days for 24 items, ranging from 1.2 to 7.0 days. The average supply delivery time for non-mission limiting components was 4.5 days for 16 items, ranging from 1.2 to 15.3 days. Maintainers had difficulty at times getting spare parts stocked in the warehouse because of delays in processing, an incorrect part number, or because ALIS showed spare parts available that were actually not serviceable. On one occasion, maintenance needed a part to service an ejection seat, which was available in the supply warehouse according to supply records. However, the part was unserviceable and had to be ordered from the supplier. Since the part required a one-month lead time, maintenance had to wait an extended period to complete servicing the ejection seat. In another instance, maintainers waited 17 hours to acquire a part located on base the entire period because the process of identifying and locating the part was inefficient.

Also during the OUE, supply chain management had problems with incorrect coding, incorrect configuration management, or missing or incorrect delivery dates, which made maintenance planning more difficult. In response to supply orders, Lockheed Martin changed the expected delivery date to a set 30 days after the order date for all parts. This process made estimated delivery time arbitrary; maintainers had little insight into the supply system and could not assess whether they should wait for a part or cannibalize it from another aircraft. A maintainer indicated that estimated delivery dates remained meaningless until accompanied by a shipping tracking number.

Aircraft availability data indicate that supply support, as measured by aircraft not mission capable due to supply, or NMCS, is worsening since flying operations began at Eglin in March 2012. Early in flying operations, approximately 10 to 15 percent of aircraft were NMCS. In

November, this rate climbed and stayed in the 20 percent range. Recent data, as of January 2013, show that the weekly NMCS rate increased to over 35 percent.

It is unknown how different the stress on the supply system experienced so far will be from flying operations that require the full offensive and defensive capabilities of the F-35A. However, the demands of training for combat will be difficult to meet if dependent upon an aircraft-rich, parts-poor operating environment.

Support Equipment

In interviews, maintainers noted difficulties with tool and support equipment on 22 separate occasions including multiple difficulties associated with one aircraft launch or recovery. Issues ranged from the inability to connect an air duct to a cart or finding worn out tools after maintainers checked them out. Also, the training center had requested use of support equipment to support "hands on" academic training with the maintenance students, but no excess equipment was available to support the request.

Aircraft availability and launch relied on special support equipment. MATRIX is a non-standard laptop-based computer diagnostic tool used by Lockheed Martin FSRs as a workaround. The FSRs used the MATRIX to monitor the aircraft systems during engine start, including the IPP to ensure correct start up or to troubleshoot problems if required; this process expedited aircraft launch. The MATRIX was also used to conduct interim maintenance health checks of the Block 1A aircraft. It was designed to support interim maintenance procedures and not for combat aircraft operations. After completing a post-flight inspection and maintenance download, maintainers might classify an aircraft as Fully Mission Capable but find at the next morning's pre-flight inspection that the same aircraft has a maintenance problem. Demand for the MATRIX and a MATRIX-qualified FSR was high during the OUE. The 33 FW had six MATRIX devices with two permanently assigned to the Air Force squadron and two to the Marine Corps squadron. The MATRIX itself failed on occasion, requiring maintainers to locate a spare.

Maintainers expressed frustration with the immaturity of tool box design and tool organization as these did not always facilitate efficient maintenance. On October 25, 2012, maintainers needed to check out an unwieldy structures tool box because they needed one tool from that box. Transporting the large toolbox and completing the task took more than an hour, cutting into crew ready time and preventing the jet from achieving ready for flight status in time for its scheduled afternoon flight. To complete a tire change, which occurs regularly, the crew chief must check out several toolboxes from supply, including one in which maintainers need only one tool for this task, but which requires two personnel to transport.

Section Six
Recommendations

Given its many significant limitations, the results of the OUE should not be used to make decisions regarding the readiness of the JSF system to support training in an F-35A initial qualification course. The limitations, workarounds, and restrictions in place in an air system this early in development limit the utility of training. Also, little can be learned from evaluating training in a system this immature. However, this evaluation revealed some areas where the program needs to focus attention and make improvements. The program should:

- Complete testing of the pilot escape system (transparency removal and ejection seat) under off-nominal ejections as soon as possible.
- Complete certification and installation of the water-activated-release system for the ejection seat as soon as possible to enhance pilot survivability in the event of an overwater ejection.
- Fully resolve Category 1 deficiency reports relevant to training operations at Eglin AFB as soon as possible.
- Continue to track air and ground abort rates and discovery rates as indicators of system maturity.
- Implement pilot-vehicle interface improvements in the cockpit displays and touch screen controls for communication and navigation functions as identified by pilots in the OUE.
- Address the discrepancies identified in the simulation certification report, coupled with the student pilot's experience in the aircraft during the OUE, to assure the simulated flameout training for F-35 pilots is adequate.
- Re-evaluate the 96 information assurance controls once the information assurance deficiencies and the lack of an Information Assurance Manager have been corrected for the Unclassified Operational Environment.
- Once the classified network is in place, accomplish an assessment similar to the information assurance assessment of the Unclassified Operational Environment.
- Evaluate reliability performance and make adjustments to assure interim reliability growth targets and, eventually, Operational Requirements Document thresholds can be met.
- Assure adequate sparing of helmet-mounted display parts and equipment are in place at the training center and at follow-on field units to meet requirements.
- Track all hours for personnel supporting F-35A sustainment to enable accurate assessments of direct and indirect maintenance man hours.

- Collect information on Autonomic Logistics Information System (ALIS) availability, reliability, maintainability, logistics supportability, and data administration to support evaluation of performance.

Annex

The table below shows the set of required capabilities, associated criteria, and thresholds for performance developed by Air Education and Training Command (AETC), in coordination with the JSF Operational Test Team (JOTT) and JSF Program Office (JPO), for the OUE. For comparison, the table also includes notional thresholds for a mature combat-capable training system.

Table A-1. F-35A OUE Criteria and Thresholds

Integrated Training Center (ITC) System Capabilities and Characteristics	OUE Criteria	Air Education and Training Command (AETC) Threshold	Comparison with Notional Combat Training System[11]
Sortie Execution Rate	F-35 sustainment support through Contractor Logistics Support (CLS) provides sortie execution rate as defined by AETC.	No more than 30% maintenance cancellation rate.	No more than 10% maintenance cancellation rate (estimate).
	Post flight maintenance debrief. Able to download Air Vehicle (AV) and Propulsion Health Reporting Codes (HRC) and determine AV health and serviceability to support follow-on missions.	Successfully complete assessment in time to support sortie execution rate.	Same as current AETC threshold.
	Able to process and identify aircraft operating limitations (AOL) exceedences to determine aircraft serviceability and availability.	Successfully report non-cockpit monitored exceedences to Prognostic Health Management (PHM) system in time to support sortie execution rate.	AOLs would be minimal in a combat-capable aircraft.
F-35 capability to provide Situational Awareness	F-35 has the capability to accurately and rapidly determine and display the situation battlespace and AV status.	While executing syllabus training, pilot can navigate to and from and maintain position within the working areas; navigate to and from airfields, including home field, auxiliary fields, and divert locations.	Battlespace awareness in combat-capable aircraft includes fusion of sensors (not available in Block 1A).

11 This column represents estimates for the F-35 under more mature conditions, where combat training would be included in the syllabus.

Integrated Training Center (ITC) System Capabilities and Characteristics	OUE Criteria	Air Education and Training Command (AETC) Threshold	Comparison with Notional Combat Training System[11]
Mission planning supports syllabus	F-35 mission planning capability is sufficient to support syllabus execution.	Pilot can plan and load mission into the aircraft and the simulator (if required) for use in syllabus training.	Mission planning becomes a block of training. Pilots must learn (and use) detailed planning of sensors, routing, weapons, and networks (not available in Block 1A).
Aircraft Handling Characteristics of single-ship and two-ship sorties	F-35 aircraft handling characteristics throughout the restricted flight envelope and during both single-ship and two-ship operational tasks are at acceptable pilot workload.	Zero aircraft departures from controlled flight; aircraft handling characteristics during single- or two-ship syllabus training must support completion of syllabus events.	Full aircraft handling characteristics would be required for the full operational envelope during combat training (not available in Block 1A).
Aircrew Human Systems Integration (HSI) supports accomplishment of ITC syllabus	F-35 HSI facilitates syllabus execution resulting in an acceptable pilot workload.	Can HSI facilities measure, fit, and supply the required flight gear in the prescribed syllabus times. Pilots able to use authorized HSI without impact to safety of flight.	HSI is adequate to allow pilots to operate throughout the full operational envelope in combat representative scenarios (not available in Block 1A) and sufficient to prevent safety of flight issues.
Sortie Effectiveness	F-35 supports accomplishment of syllabus objectives.	Less than 25% non-effective sorties (after take-off) for other than student non-progression (i.e. maintenance, weather)	Similar to current AETC threshold
Flight Series Data (FSD)	FSD is usable, accurate, and available to support syllabus execution.	Aircrew and maintainers can receive Autonomic Logistics Information System (ALIS) accounts, access FSD from their workspace.	FSD adequate, and current, to train inexperienced pilots in all aircraft systems, mission systems, and weapons employment (not available in Block 1A).
Able to safely conduct initial training at Eglin	Overall system capabilities must support all aspects of aviation and ground safety during ITC operations.	Overall system capabilities must support all aspects of aviation and ground safety programs required by higher headquarters.	Similar to current AETC threshold

Integrated Training Center (ITC) System Capabilities and Characteristics	OUE Criteria	Air Education and Training Command (AETC) Threshold	Comparison with Notional Combat Training System[11]
Adverse Weather	F-35 weather restrictions allow syllabus execution in accordance with AETC weather planning factors.	Eglin can execute the F-35A syllabus, with time-to-train within 65 training days, w/expected aircraft weather restrictions.	Training flights would not be restricted to day visual meteorological conditions/flight rules (as they were in this OUE). For example, lightning restriction (currently 25NM) would be less (e.g. 5 miles), take-off and landing on wet runways would be allowed.
Academic Training	Academic training material (interactive courseware, electronic mediated lecture, and pilot training aid) must effectively prepare student to achieve syllabus objectives.	Courseware must prepare students to effectively execute simulator missions.	Training courseware would present all aircraft systems, mission systems, and weapons employment functionality (not available in Block 1A)
Training Devices	Training devices effectively prepare student to achieve syllabus objectives.	Training devices effectively prepare student to achieve syllabus objectives.	Training devices would include formation missions, mission systems functionality, and weapons employment (not available in Block 1A).
Support Personnel ITC Live Training Environment	ITC live training environment effectively prepares student to achieve syllabus objectives.	ITC live training environment supported sufficiently to meet all syllabus objectives.	ITC live training sufficient to meet the full syllabus objectives for all aircraft systems, mission systems, and weapons employment training (not available in Block 1A).
Training Management System (TMS)	TMS provides timely and accurate information to plan, schedule, manage, and track all training.	TMS (or sufficient workaround) provides information to plan, schedule, manage, and track all training; scheduler can publish schedule, which students and Instructor Pilots can view via ALIS. TMS capability must support completion of 4 students in 65 training days.	Similar to current AETC threshold

Integrated Training Center (ITC) System Capabilities and Characteristics	OUE Criteria	Air Education and Training Command (AETC) Threshold	Comparison with Notional Combat Training System[11]
Training System Support Center (TSSC)	TSSC can execute its required functions in an accurate and timely manner that results in effective training system performance.	Quality Assurance process and government oversight in place to ensure CLS training is provided per the contract.	Similar to current AETC threshold
Security	Security supports operations in all ITC environments.	Security procedures allow student in-processing in accordance with syllabus timeline and provides oversight to ensure security procedures are adhered to.	Similar, although the ATC would be teaching classes with classified material (not accomplished in Block 1A).
Weapon System Reliability (WSR) (successful missions/attempted missions)	WSR supports sortie execution rate	WSR supports sortie execution rate with a minimum of 70% WSR. Enables Eglin to execute the F-35A syllabus, with time-to-train within 65 training days.	Minimum of 92% WSR
Maintainability Mean Maintenance Hour per Flight Hour (MMH/FH)	Maintainability supports sortie execution rate.	Maintainability supports sortie execution rate. Recommend MMH/FH of 50. Enables Eglin to execute the F-35A syllabus, with time-to-train within 65 training days	Lower, ORD threshold is 9.0
ALIS	ALIS capability supports syllabus execution.	Students can get an ALIS account and use ALIS for FSD, TMS, off-board mission systems	Similar to current AETC threshold
Supply Support	Sufficient quantity of spares, and responsive transportation to support sortie execution rate.	Supply support is sufficient to support syllabus completion within 65 training days	Completion of the syllabus for 6 students within 39 days
Support Equipment	Sufficient support equipment to support sortie execution rate.	No more than 20% mission cancellations or delays due to non-availability of support equipment.	No more than 5% mission cancellations or delays due to non-availability of support equipment (estimated)