United States
Air Force
Energy Analysis Task Force

E-3 Line Operations Efficiency Analysis

16 June 2016



Secretary of the Air Force for Installations, Environment, and Energy

Deputy Assistant Secretary for Operational Energy

Air Force Energy Vision: Sustain an assured energy advantage in air, space, and cyberspace.

…Air Force Energy Strategic Plan 2013

Preface

The Air Force Vice Chief of Staff and Deputy Undersecretary of the Air Force jointly chartered the Energy Analysis Task Force (EATF) in 2010 and assigned it to the Assistant Secretary of the Air Force for Installations, Environment, and Energy (SAF/IEN). The EATF analyzes and quantitatively validates energy efficiency opportunities, reduces investment risks by increasing data fidelity for energy decisions, and identifies and removes barriers to implementation.

EATF projects focus on supporting one or more of the four priorities outlined in the 2013 Air Force Energy Strategic Plan: improving resiliency, reducing demand, assuring supply, and fostering an energy aware culture.

This analysis effort aims to support fostering an energy aware culture.

Acknowledgement

Personnel on the staffs of Headquarters Air Force (HAF), Secretary of the Air Force (SAF), Air Combat Command (ACC), and the 552d Air Control Wing (552 ACW) extensively supported this analysis effort. The Energy Analysis Task Force (EATF) identifies and evaluates energy initiatives across the Air Force enterprise; however, the EATF could not accomplish its mission without the support provided by these staff members and the men and women of the 552 ACW, who patiently provided data and background information. We wish to recognize and thank all participants for their commitment and support in meeting the Department of Defense (DoD) and Air Force Strategic Energy goals.

Executive Summary

The Air Force Deputy Assistant Secretary for Operational Energy directed the Energy Analysis Task Force (EATF) to accomplish a Line Operations Efficiency Analysis (LOEA) on the E-3 Airborne Warning and Control System (AWACS). The EATF partnered with Air Combat Command (ACC) and the 552 ACW to accomplish the LOEA in 2015 and early 2016.

The EATF patterned the LOEA after the Air Mobility Command (AMC) and Federal Aviation Administration (FAA) Line Operations Safety Audits: a non-attributional peer-to-peer observation, versus a checkride. We aggregated data at the Wing level and did not identify individual crewmembers. The LOEA objectives were threefold:

- Observe operations and make recommendations on efficiency opportunities
- Document and share best practices from the 552 ACW operations
- Provide a reference point for aviation Operational Energy awareness in the E-3 community

The EATF accomplished the LOEA by:

- Observing five representative, airborne training sorties and recording data for analysis
- Reviewing flight manuals and operational guidance materials
- Surveying crew members to understand E-3 energy efficiency techniques and mindsets
- Soliciting ideas from crew members and leaders for additional efficiency opportunities

We accomplished all five flights, spent one session in the E-3 simulator, and had unrestricted access to leadership, crewmembers, and maintenance personnel. The EATF identified the following best practices:

- Training range utilization
- Cruise speed selection
- Engine compressor wash
- Reduced thrust takeoffs
- Reduced engine taxi-in

The EATF identified six primary recommendations that show opportunities for improvement in mission effectiveness and costs savings. We also identified seven secondary recommendations as opportunities, although implementation may not be straightforward or benefits as easily measured. We detail all recommendations in Section 4 and list primary recommendations below:

- Optimize cruise altitude selection
- Add Long Range Cruise altitude to aircrew aid
- Expand efficiency data collection program
- Reduce Auxiliary Power Unit use
- Reduce landing fuel weights
- Add fuel efficiency discussion to debrief

Based on the Secretary of the Air Force's Make Every Dollar Count campaign, we identified $9.5M in efficiencies including $4.5M associated with identified best practices and $5.0M associated with recommendations. Although we identified monetary savings, our emphasis rests squarely on the enhanced mission effectiveness associated with operational energy efficiency. The 552 ACW has a solid focus on operational energy efficiency and implementation of the recommendations will help maximize mission effectiveness. We applaud their support of the LOEA.

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1.0 Introduction

1.1 Purpose

The purpose of the E-3 Sentry Line Operations Efficiency Analysis (LOEA) is to observe and analyze aviation operational efficiency. The LOEA's goal is to determine the current implementation and potential adoption of fuel efficiency best practices identified by Air Force units as well as the commercial airline industry. The LOEA also identifies best practices already in place with a unit and shares these best practices throughout the Air Force.

The LOEA is comprised of five inflight observations and one simulator observation, augmented with data analysis, looking for overall Operational Energy (OE) efficiency of a unit during normal day-to-day training operations. It is not designed as a deep dive analysis, but a surface analysis to gather data. The EATF uses this data to make recommendations to the Wing. The EATF also presents this data to Air Force (AF) senior leaders as a glimpse of the current OE culture.

In support of the United States (U.S.) Air Force Energy Strategic Plan (March 2013), SAF/IEN directed an analysis of aircrew efficiency operations across the United States Air Force (USAF). The goal is to provide a baseline of where the USAF aviation community is in regards to the evolution of the energy aware culture. A current snapshot of AF culture will provide USAF senior leaders better clarity when analyzing data to make operational decisions, thereby enhancing effectiveness with limited resources in a fiscally constrained environment.

We designed the LOEA to enhance commanders' operational decision-making capabilities and in no way diminish their command authority.

1.2 Project Objectives

First, the EATF observed E-3 major weapons system (MWS) operations and made recommendations on efficiency opportunities. Second, the EATF documented and shared best practices from the 552d Air Control Wing (ACW) operations. Finally, the EATF provided a reference point for the level of aviation operational energy awareness in the E-3 community.

The EATF understands that multiple variables affect our observations. Some of these variables the Wing can control and some they cannot. There is no requirement for the Wing to reply to the observations or recommendations in this report. The goal is for the Wing to use the recommendations to enhance mission effectiveness.

1.2.1 E-3 Operations vs Established Best Practices

The EATF observed E-3 operations and compared those operations with techniques and best practices in use across the USAF and the commercial airline industry. Not all the techniques we gather are applicable or feasible for every MWS. For instance, landing at less than full flaps is a best practice when allowed by aircraft technical order, thus the technique is on our observation list for every weapons system. However, the E-3 technical data only allows landing at full flaps, thus this technique is not applicable. Section 3 covers the details for each of the techniques.

1.2.2 552 ACW Fuel Efficient Techniques

Each MWS has similar operational parameters that it might share across the USAF. Each MWS employs their own techniques in day-to-day operations. The EATF documented and shared the 552 ACW operational energy efficiency techniques.

1.3 Background of LOEA

The LOEA concept is comprised of in-flight observation of USAF MWS aircrews, interviews with aircrews and maintainers, and a review of MWS-specific Technical Order (T.O.) data and operational procedures. The EATF modeled the inflight observation portion after the Air Mobility Command (AMC) Line Operations Safety Audits (LOSAs) as well as the guidelines in the Federal Aviation Administration (FAA) Advisory Circular 120-90 "Line Operations Safety Audits."

The LOEA is a non-attribution observation, not a checkride. While the observers are rated USAF aviators, they are not required to be qualified in the MWS they are observing. The purpose is not to validate Major Command (MAJCOM) and/or MWS aircrew training; instead, the EATF designed the LOEA to observe the level of energy efficiency culture within the USAF. The EATF anonymizes and aggregates the results in order to prevent the identification of any specific aircrew or aircrew member. The intent is not to identify individuals but to observe the energy efficiency culture within USAF operations.

1.4 Timeline

The EATF designed the LOEA concept in September 2014 and briefed SAF/IEN for approval in October 2014. SAF/IEN provided an initial brief to the ACC Vice Commander (ACC/CV) in October 2014 and followed up with clarifying information. ACC granted approval for five sorties per MWS (at home station) in November 2014 with the 552 ACW identified as the first LOEA, followed by the 55th Wing, and the 461 ACW. The EATF completed initial coordination with 552 ACW leadership in March 2015. The EATF conducted subsequent coordination with the 552 ACW/CC, 552d Operations Group (552 OG), and 552d Maintenance Group (552 MXG). The first round of observations took place on 19-24 April 2015. The second round of observations, including a simulator session, took place on 3-8 May 2015. The EATF conducted a total of five airborne observations and one short simulator session during the two periods in April and May of 2015.

1.5 Study MWS

1.5.1 Airframe

"The E-3 Sentry is a modified Boeing 707/320 commercial airframe with a rotating radar dome. The dome is 30 feet (9.1 meters) in diameter, six feet (1.8 meters) thick, and is held 11 feet (3.33

meters) above the fuselage by two struts." [1] The E-3 is powered by four TF-33-100, low bypass ratio engines.

1.5.2 Mission

"The E-3 Sentry is an airborne warning and control system, or AWACS, aircraft with an integrated command and control battle management, or C2BM, surveillance, target detection, and tracking platform. The aircraft provides an accurate, real-time picture of the battlespace to the Joint Air Operations Center. AWACS provides situational awareness of friendly, neutral and hostile activity, command and control of an area of responsibility, battle management of theater forces, all-altitude and all-weather surveillance of the battle space, and early warning of enemy actions during joint, allied, and coalition operations."[2] The E-3 requires an airborne battle management crew to operate the airborne system.

1.6 Study Unit

The E-3 operated by the 552 ACW, Tinker Air Force Base (AFB), Oklahoma, was the first MWS selected for the LOEA. The 552d ACW is an E-3 wing with five flying squadrons: four operational and one formal training unit. They routinely fly multi-hour operations and training missions. Their training missions consist of training for 552 ACW flight deck aircrews, 552 ACW mission crews, and other external MWS operators. The LOEA focused on training missions executed from home station (Tinker AFB).

1.7 Current State

On average, the 552 ACW currently executes approximately seven training sorties a day, Monday through Friday each week. The average duration of the sorties is approximately 7 hours. Standard training sorties (not including pilot proficiency-only sorties) include the following profile: mission planning with aircrew and mission crew the day prior to mission, mission update brief the day of the mission, preflight of aircraft, starting engines, taxi and takeoff, departure procedures, mission crew training in transit to the military operations area (MOA), operations within the MOA, mission crew training during return to base (RTB), pilot transition currency training, taxi in, engine shutdown procedures, and mission debrief.

From the beginning, wing leadership welcomed an outside observation to assist in identifying additional efficiency best practices and opportunities. Currently there is no single "focused" (office or individual) effort for operational energy efficiency within the 552 ACW. The Wing has an analysis branch, but currently the analysis branch is not focused on aviation efficiency data analysis.

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[1] AF E-3 Fact Sheet. http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104504/e-3-sentry-awacs.aspx.

[2] AF Fact Sheet. http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104504/e-3-sentry-awacs.aspx.

1.8 Future State

The EATF does not foresee significant changes in operational procedures to implement recommended fuel efficiency techniques for the 552 ACW. With successful implementation, the 552 ACW will continue to refine OE efficiency efforts within the E-3 MWS, incorporate the recommended techniques, and embrace a fuel efficient culture that strengthens efficiency while increasing mission effectiveness.

1.9 Assumptions

1.9.1 Local Annual Training Plan

The 552 ACW executes approximately 1,350 training sorties a year, which is based on programming 1,521 sorties and an 11.25% attrition rate. Average normal sortie duration is approximately 7 hours.

1.9.2 Aircrews Trained to Operate Conservatively

The USAF initially trains flight crew to fly conservatively with very little training focusing on operating efficiently. With a defined timeline for Undergraduate Pilot Training, Undergraduate Navigator Training, and Flight Engineer Technical School, instructors focus their efforts toward producing aircrew that can fly safely. This time limitation supports efforts focused on teaching and validating techniques that instruct the student how to be safe and conservative in aircraft operations. This "conservative" theme continues through other follow-on training courses focused on training USAF crewmembers. Conservative training builds a strong foundation for safe worldwide USAF operations. The EATF believes crews can be effective and efficient…and improved efficiency directly leads to improved effectiveness.

1.9.3 Operating Environment Awareness

Aircrews would increase their effectiveness if they were more aware of how they interact with other factors within their operating environment. With a better awareness of the operating environment, aircrews can and will operate USAF aircraft more efficiently. The operating environment is made up of factors the crew cannot control (weather, air traffic control priorities, maintenance) and factors the crew can control (fuel load requests, timing of actions to make a scheduled event). Many factors interrelate and have an effect on each sortie. Understanding the interaction of the environment as a whole enhances the aircrew decision process, increasing their effectiveness.

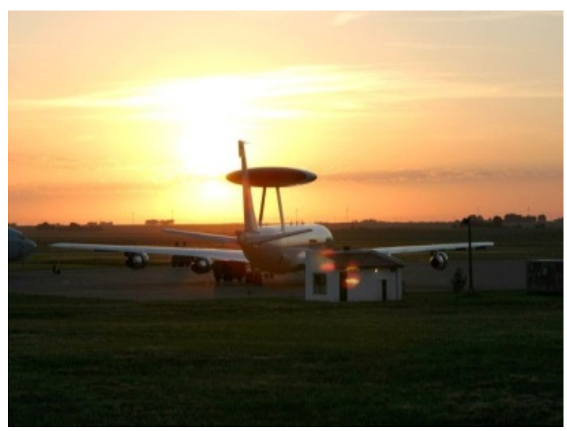

Figure 1 E-3 Sentry

2.0 Methodology

The EATF desired to work closely with E-3 operators to ensure a successful outcome of the LOEA effort. Without their participation and desire to improve their effectiveness, this process would be unsuccessful. The EATF worked with ACC and wing leadership to set the conditions for a successful project. Coordination was extensive, with the Wing Project Officer (PROJO) setting up both the initial introduction meetings as well as the inflight and simulator observation sorties. The EATF reviewed reference materials (T.O.s, local operating instructions [OIs]) prior to the first observation to better understand the operating characteristics of the E-3.

2.1 MAJCOM Approval

The EATF began coordination for approval with ACC in September 2014. The EATF made the initial presentation to the ACC/CV and the ACC/CV requested follow-up information from that presentation. In September 2014, the EATF provided the requested information to ACC and ACC granted approval in October 2014. ACC approved five airborne observation sorties for each MWS.

2.2 552d Air Control Wing Project Officer Coordination

The EATF initiated coordination with the 552 ACW following ACC approval. The 552 ACW provided the 552d Operations Group Deputy Commander as the PROJO, who coordinated the initial visitation schedule with group and wing leadership. The PROJO also assisted with the observation sorties scheduling by deconflicting the 552 ACW's temporary duty (TDY) and exercise schedule. The PROJO arranged aircraft egress training and a tour of the base, along with E-3 facilities, to include the aircraft and flight deck simulator. The PROJO was instrumental in the success of the LOEA.

2.3 Aircraft Performance and Efficiency Program Review

The EATF reviewed various publications including T.O.s 1E-3A-1 and 1E-3A-1-1, AFI 11-2E-3 V3 and AFI 11-2E-3 V3 552OGSUP instructions, for E-3 operating parameters, guidance, and any fuel efficient techniques that the AF publishes for E-3 operations. Appendix 3 lists the publications and reference material the EATF reviewed.

2.4 Wing Leadership Coordination

The EATF traveled to Tinker AFB in March 2015 for initial meetings with the 552 ACW/CV and other wing senior leadership to discuss the LOEA and address any questions or concerns prior to the LOEA observations. The 552 ACW PROJO coordinated a schedule of two separate visits for the LOEA. The first visit (19-24 April 2015) consisted of observing two crews mission plan and execute individual sorties. The next visit (3-8 May 2015) included the planned observation of one crew mission planning, along with observations of three sorties during the next three days, and ended with a simulator observation. .

Methodology

2.5 Inflight Observations

The EATF conducted five inflight observations, as planned with Wing leadership. The observations consisted of two different sortie types. Four sorties were typical training missions with mission crew training. One sortie was a Pilot Proficiency (Pilot Pro) sortie that included a pilot checkride administered by the 552d Standardization and Evaluation Branch (552 OG/OGV). The observations encompassed all activities from mission planning through debriefing. The observations documented the following activities accomplished by the aircrews: mission planning activities the day prior to flight, mission briefing on the day of the flight, pre-flight, engine start and taxi, takeoff climb out, enroute operations, Military Operating Area (MOA) activities, Return to Base (RTB) route activities, descent and approach, transition, taxi in, engine shutdown, and debriefing. The EATF used its observations to gather data for later analysis.

2.6 Simulator Observation

Simulator sessions provided a valuable opportunity to compare specific fuel efficiency techniques in a controlled environment by factoring out weather and air traffic control (ATC) constraints and biases, which allowed for a true comparison of techniques. The EATF coordinated with the 552 ACW and completed one observation sortie in the E-3 simulator.

2.7 Data Analysis

The EATF reviewed several reports and publications (Appendix 3) for techniques and best practices around the USAF and commercial industry that might provide opportunities for increased efficiency and effectiveness. The EATF selected these techniques (Section 3) for initial observation. Once the observations were complete, the EATF aggregated the data, looking for trends that would signal or outline events that would highlight opportunities for modifications to improve efficiency.

The EATF then divided these techniques into specific phases of flight and created observation forms to capture data for analysis. The EATF observer captured data on the observation forms and then transferred the data into Excel spreadsheets for analysis. The EATF then checked the data against T.O. 1E-3A-1 and Air Force Instruction (AFI) 11-202 Volume 3 to determine if there were any disconnects between AFIs and operations. Additionally, the EATF captured external factors for inclusion in the analysis to ensure the team had considered all factors. The EATF broke down each targeted technique into Technique Title, EATF Analysis, Finding, Recommendation, and Potential Savings. Section 3 presents analysis of each technique.

2.8 Follow up

The 552 ACW was very receptive and responsive to various requests for information (RFIs) needed to complete specific observations. Several RFIs were extensive and 552 ACW personnel graciously took the time to provide the required data.

2.8.1 Operations

The individual aircrews, 552d Operational Support Squadron (OSS), the 552 OG leadership, and 552 OG/OGV availed themselves for questions and clarification of any observation. Ongoing collaboration occurred with the 552 OG after the observations, clarifying any questions that arose from the observations or initial analysis.

2.8.2 Maintenance

The 552 MXG was available for clarification questions. Several questions arose referencing the actual weight and balance for the MWS aircraft. They clarified the information and supplied a reference sheet listing all the weight and balance data for the aircraft. Maintenance was also involved after the observations, answering various questions including those regarding aircraft fueling.

3.0 Techniques

This section outlines 24 fuel efficiency techniques and processes the EATF observed during the LOEA. The ensuing pages provide a snapshot of each technique as well as our analysis approach, finding, recommendation, and estimated savings.

Para	Title	Short Description
3.1	Collecting Data	Analyzed unit's fuel efficiency data collection efforts.
3.2	Inflight Guide (IFG)	Analyzed MWS IFG use for fuel efficiency.
3.3	Training Range Utilization	Analyzed the unit's approach to using available resources.
3.4	Local Airspace Usage	Analyzed efficient use of airspace when transitioning to/from base.
3.5	APU Use	Analyzed crews' efficiency of balancing ground APU use with Ground Power Units (GPUs) and Ground Air Carts (GACs).
3.6	Flight Planning Software	Analyzed the efficiency options available with mission planning software and the MWS utilization of those efficiency options.
3.7	Mission Fuel Loads	Analyzed landing fuel weights to determine efficiency.
3.8	Engine Start Times	Analyzed engine start time policy to determine if policy drives excessive engine run time on the ground using unnecessary fuel.
3.9	Taxi: Reduced Engine Taxi-Out	Analyzed use and potential for Reduced Engine Taxi-Out to conserve fuel and engine operating time.
3.10	Minimizing Taxi Time Prior to Takeoff	Analyzed crews' focus on minimizing taxi time by using optimal taxi routes and ability of crews to forecast potential delays.
3.11	Takeoff Flap Setting	Analyzed the potential and execution of minimum flap takeoffs.
3.12	Reduced Power T/O	Analyzes the potential and execution of reduced power takeoffs.
3.13	Initial Climb Cleanup	Analyzed efficiency of clean up technique following takeoff.
3.14	Climb Technique at 10,000 feet	Analyzed efficiency of climb technique at 10,000 ft during acceleration.
3.15	Cruise Altitude	Analyzed crew selection and use of optimal cruise altitude.
3.16	Cruise Speed	Analyzed crew selection and use of optimal cruise speed.
3.17	Descent Technique	Analyzed crew use of fuel efficient descent techniques.
3.18	Approach Configuration	Analyzed when and how crew configures aircraft for approach.
3.19	Landing Flaps	Analyzed the potential and execution of reduced landing flaps.
3.20	Taxi: Reduced Engine Taxi-In	Analyzed the potential and execution of reduced engine taxi in to conserve fuel and engine operating time.
3.21	Debrief – Efficiency	Analyzed crew use of debrief to review & measure fuel efficiency.
3.22	Maintenance – On Wing Engine Wash	Analyzed unit's engine wash program.
3.23	Contract Fighters	Reviewed 552 ACW initiative to contract civilian fighters to support training.
3.24	Reduction of Weight	Analyzed removal of unnecessary weight from the aircraft.

Table 1 Efficiency Techniques

Techniques

3.1 Collecting Data

Any effort to control a process requires an ability to ascertain where you are and where you want to go. Without the data, there is no way to track progress towards goals and there is no way to measure the effectiveness of your actions. Collecting data allows organizations to define where they are and allows them to measure progress towards defined goals. The data collection completes the feedback loop. Defining a process to gather data for analysis will help define what to measure and where to focus future emphasis. It enhances the ability to provide quick corrective action in the event efforts are outside of the parameters established for the process.

EATF Analysis

The EATF discussed operational efficiency tracking mechanisms used in day-to-day training operations with the 552 OG leadership and individual crews.

Finding

Following the observation flights, the 552 ACW added several fuel efficiency tracking data points to their local 552 OG Form 49, which is an existing mission data sheet the Analysis Branch uses to compile and analyze data from each mission. The Analysis Branch now tracks ramp fuel, shutdown fuel, and air-refueling on-load fuel. The Analysis Branch can now use this data to track sortie fuel consumption and the accuracy of mission planning fuel loads and the impact of flying with unnecessary fuel/weight.

The 552 ACW's incorporation of fuel tracking data on an existing local mission data collection form is an excellent approach to tracking fuel efficiency. The EATF notes the 552 ACW could also collect data on enroute cruise altitudes and speeds to and from the mission area to track the efficiency of altitude and speed selections. The Wing could also collect data on APU versus ground power use to better understand potential efficiencies with greater emphasis on ground power versus APU use.

Recommendation

The EATF recommends the Analysis Branch produce regular metrics, such as landing fuel loads, with the data they now collect on the OG Form 49. The EATF also recommends the 552 ACW collect and analyze enroute cruise speed/altitude data and APU usage data via the OG Form 49.[3]

Figure 2 E-3 Sentry

Potential Savings

This process will be the bedrock for all future efficiency technique data collected and analyzed by the 552 ACW.

[3] For additional information on collecting additional data points, see Appendix A2.20.

3.2 Inflight Guide

Inflight guides (IFGs)/Aircrew Aids (AAs) provide quick reference material to aircrews for all phases of flight. Historically, studies show that aircrew will consult and use information that is readily and easily available with more frequency than data that is difficult to find or decipher. IFGs/AAs can contain operating parameter data for quick decision-making and initial performance targets. IFGs/AAs, which include optimal routes, altitudes, and speeds for common ranges and orbits provide a go-to reference and make it easy for the flight crews to select the most efficient altitudes and speeds. Appendix A Figure A2.16 shows the Navigator's AA Long Range Cruise (LRC) Altitude table for aircraft gross weight. IFGs/AAs which include optimal cruise speeds for common cruise altitudes based on headwind or tailwind component are also valuable. As an example, Appendix 2.10 shows the optimal winded cruise speeds for the T-1A aircraft for example purposes.

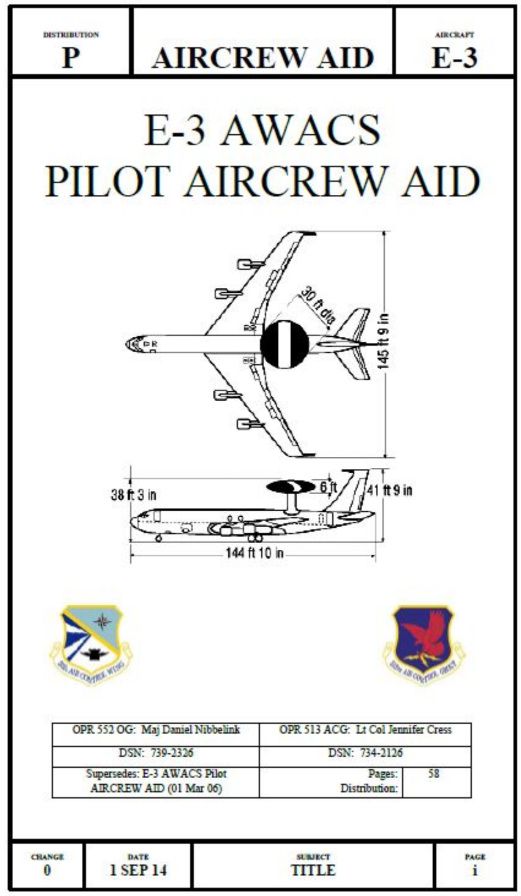

Figure 3 E-3 Pilot Aircrew Aid

EATF Analysis

The EATF reviewed the 552 ACW's Pilot's and Navigator's AA for available data and reviewed maximum endurance calculation procedures in T.O. 1E-3A-1-1 (Section 6).

Finding

The 552 ACW's Pilot's AA is 57 pages long and the Navigator's is 65 pages long. Both contain detailed information for aircrew use, but only the Navigator's AA contains an LRC altitude table (page 20) based on aircraft gross weight. We discussed the benefit of porting optimal maximum endurance cruise speeds from the T.O. 1E-3A-1-1 into an easily referenced chart in the AA. We included details of this thought provoking discussion in Appendix 2, Paragraph 2.19.

Recommendation

The EATF recommends the 552 ACW add the Navigator's AA LRC altitude chart to the Pilot's AA. The forthcoming DRAGON modification further necessitates this addition. We also recommend the 552 ACW look into developing a maximum endurance cruise chart for the AA.

Potential Savings

See Optimal Cruise Altitude and Speeds sections for potential savings (Sections 3.15 and 3.16). Efficiencies gained with a maximum endurance cruise chart are a mere refinement of the existing best practice of flying maximum endurance profiles, thus savings aren't calculated.

3.3 Training Range Utilization – TDY (Best Practice)

The USAF expends a significant amount of time transitioning to and from training ranges and air refueling tracks. Commanders and schedulers labor to find suitable ranges with adequate size and availability that are in close proximity to base. These challenges often create less than optimally efficient operations.

EATF Analysis

The EATF reviewed the training ranges in use, and the customers supported, by interviewing schedulers and observing range use. The EATF examined the unit's initiative to deploy aircraft closer to the training ranges and send crews TDY to and from the deployed location. The EATF analyzed one 552 ACW TDY package to Seymour Johnson AFB, which is 45 minutes from the training area compared to the 6.5 hour round trip transit time from Tinker AFB to this training area. Analysis shows there are cost savings and efficiencies gained by sending aircrew and mission crew along with support crews TDY in lieu of extended flight times to repetitively used training areas. Shorter flight times from a TDY base will extend the on-station times for increased "customer" training and reduce hours on each jet, which will increase cost savings.

Finding

The closest East Coast ranges suitable for E-3 training are approximately three hours' transit time from Tinker AFB. Most of the range location limitations are driven by the fighter aircraft squadron locations, which are close to the East and West coasts. Fighters are limited on the amount of gas they carry, so they use ranges closer to their home stations. These fighter efficiencies drive inefficiencies with the E-3. The 552 ACW mitigated some of this inefficiency by sending crews and aircraft TDY for several weeks at time. The TDYs usually last two weeks with an aircrew/mission crew swap in the middle. The TDYs consist of two aircraft with flight and mission crews and maintenance support that deploy to a location closer to the training area. This allows each mission crew (four total with swap out in the middle of the TDY) to execute five sorties worth of training and saves 76.5[4] hours for the two-week period.

Recommendation

The EATF identified the TDY training initiative as a Best Practice and recommends the 552 ACW maximize this practice and investigate a West Coast TDY location for additional savings.

Potential Savings

At $11.5K[5] per E-3 flight hour, this 552 ACW initiative saves approximately $831K each time they execute the TDY training initiative, even when factoring in TDY costs. The 552 ACW utilized this initiative three times in Fiscal Year (FY) 2015 for an annual savings of $2.5M. The potential exists for similar savings with a West Coast TDY location. The EATF, working with the 552 ACW, determined the 552 ACW could save approximately $675K for each West Coast TDY training action. See Appendix 2, Section A2.1 and Section A2.2 for additional details.

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[4] See Appendix 2, Figure A2.2 for additional details.
[5] E-3 Cost Per Flying Hour from Factor Set (FS) 140 from AF Cost Analysis Directorate AFCAA/FMCY.

3.4 Local Airspace Usage

Often there are local airspace rules and patterns based on airspace congestion, restricted airspace, commercial routes, and local FAA practices. There are times when crews can use awareness of local procedures to improve efficiency. For example, if the crew knows a fuel efficient descent with limited speed changes is available for an arrival from the south, but arrival from the southwest of the base requires numerous step-down descents, vectors for traffic, and speed changes, the experienced crew may choose to return to base on a less direct, but more efficient route. This knowledge is typically local in nature. Sometimes wings publish this data in a local OI or IFG/AA, but usually they do not.

EATF Analysis

The EATF discussed local area ATC procedures and experiences with aircrews and the 552 OG training flight. We also observed arrival and departure procedures on all five sorties.

Finding

Tinker AFB departures and arrivals are constrained by commercial operations at Will Rogers International Airport (OKC) a mere 7 miles from Tinker AFB. The FAA effectively manages both military and civilian traffic in the Oklahoma City terminal area. The EATF did not identify any unique local area airspace procedures, either constraining or enhancing, during the LOEA. The 552 ACW did highlight concerns on potential impacts to arrival and departure procedure availability with the FAA decision to change the Will Rogers (IRW) VORTAC to Very High Frequency Omnidirectional Range (VOR) only service. Until the E-3 fleet completes the DRAGON cockpit modernization upgrade there is risk the E-3 fleet will have airspace access issues both domestically and especially internationally.

Recommendation

As a general recommendation we make for all wings, the 552 ACW should analyze local airspace procedures to identify any best practices and document those best practices in an IFG or local operating instruction. This could become especially important as airspace access constraints grow due to outdated avionics until the AF completes the DRAGON upgrade.

Potential Savings

None identified.

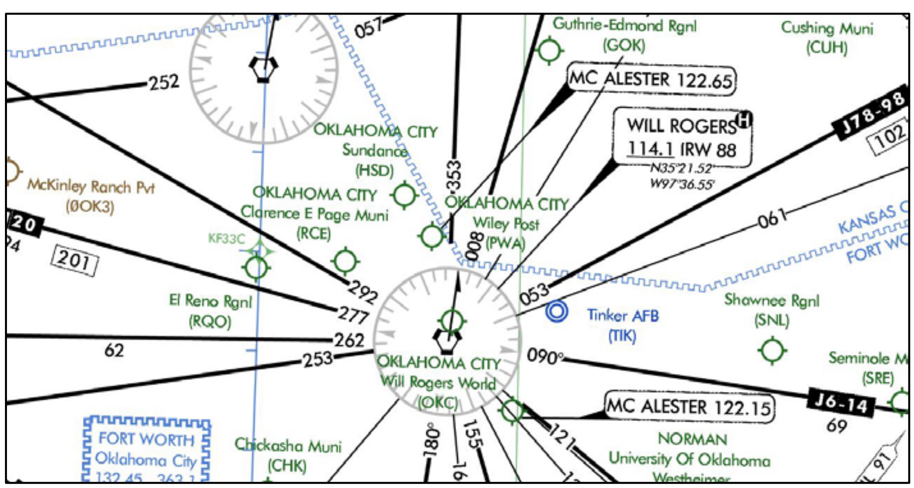

Figure 4 IFR High Altitude En Route Chart H6

3.5 APU Use

Managing Auxiliary Power Unit (APU) use can reduce unnecessary fuel burn. APUs burn more fuel than Ground Power Units (GPUs) and Ground Air Carts (GACs). Where appropriate, crews can use GPUs and GACs to power and cool equipment on the aircraft in lieu of the APU. If aerospace ground equipment (AGE) is available, standard operating procedures (SOPs) coordinated with maintenance can streamline positioning of AGE equipment for more efficient operations. Some wings and weapons systems use ground power exclusively, and only use the APU for engine start. Other wings and weapons systems use the APU and never use ground power or cooling.

Power Source	Fuel Burn (gph)[6]
APU	52.0
GPU	6.0
AC Unit	7.3

Table 2 Fuel Consumption

EATF Analysis

The EATF reviewed T.O. 1E-3A-1 to determine appropriate APU use and monitored APU use during all observation sorties. We also discussed APU, GAC, and GPU use with the 552 MXG.

Finding

T.O. 1E-3A-1 requires APU use at certain points during the preflight if ground power is unavailable, and for engine start. On all five observations:

- APUs were running when the flight engineer (FE) arrived at the aircraft (2+20 minutes prior to takeoff [T/O]). The EATF did not observe any available GPUs.
- Crews shut down the APUs between 2 and 6 minutes after completion of the engine start (avg 5 min). Minimum run time to cool APU after closing APU bleed air switch is 2 min.[7] The crews started APUs between one to three min after full-stop landing (avg 2 min).
- Maintenance requested crews to leave the APU running on all five sorties.
- APU run per sortie was at least 2+40 minutes.

Recommendation

The EATF recommends establishing a specific policy and procedure to maximize the use of available ground power and ground air. Crews should start the APU for engine start, and stop the APU following engine start. Crews should start the APU after landing, and shut down the APU once they connect ground power after landing. This change requires a culture change, tracking, and policy change. See Appendix A2.3 for discussion on benefits and challenges.

Potential Savings

Using GPU and GAC carts to reduce APU use by 2 hours per sortie results in a savings of $273K per year. This is a conservative estimate, and only accounts for the time when the aircrew are at the aircraft. It is quite possible, if maintenance uses the APU for all power requirements, the savings associated with use of ground power and cooling could be four or more times greater.

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[6] Data from 552 MXG.

[7] 1E-3A-1 (1 Feb 14) (Ch1 15 Jul 14), page 2-55, Taxi checklist, step 5.a.3.

3.6 Mission Planning Factors – Flight Planning Software

Flight planning software that can incorporate all facets of a mission profile is very effective and efficient. Robust flight planning software should be able to analyze inputs that can affect the mission such as routing, altitudes, weather, aircraft configuration, and mission environmental factors. Effective mission planning software interfaces with outside sources to gather data and create a comprehensive plan for the aircrews for execution on the day of the sortie. The E-3 currently uses the Joint Mission Planning System (JMPS) software for flight planning.

EATF Analysis

The EATF observed flight planning on three of the five sorties. The EATF discussed JMPS on all five of the observed sorties.

Finding

The EATF found the current JMPS version was adequate for flight planning but suboptimal for efficient operations. JMPS did take into account aircraft weight and adjusted fuel burn calculations accordingly. However, the current JMPS version cannot connect to the internet through the 552 ACW's internet firewall to access wind aloft forecasts, which would allow for the inclusion of more precise airborne winds. Crews must manually input forecast winds aloft from the 72d Air Base Wing (or Tinker AFB) weather shop. Aircrews only receive general winds for flight level (FL) 240 and FL 300 and not multiple altitude winds for each fix along the route of flight. These FLs are closest to the normal altitudes of air refueling (FL 240) and orbits (FL 300) on training missions flown out of Tinker AFB. JMPS used by aircrew of other MWS aircraft has access to the internet and uploads multiple level wind forecasts for each fix along the route of flight. This ability would allow the crew to mission plan more effectively and select the best altitude for the portions of flight based on more complete flight planning data.

The EATF inquired about the reason that JMPS does not have access to internet and the 552 ACW indicated it is a firewall issue with Tinker AFB communications and the version of JMPS. In early 2016, the 552 ACW began testing an updated version of JMPS that is programmed to correct some of the connectivity issues with the off-base internet.

Recommendation

The 552 ACW is currently working through the existing contract vehicles with the Systems Program Office (SPO) to improve JMPS and regain connectivity to the internet allowing aircrews to access up-to-the-minute data to make efficient planning choices. The EATF recommends the 552 ACW continue supporting the ongoing JMPS upgrade.

Potential Savings

The 552 ACW will gain efficiencies with the JMPS upgrade; however, we are not able to quantify potential savings. There are too many variables and assumptions that we can't verify until the SPO completes development and testing.

3.7 Mission Planning Factors – Mission Fuel Loads

Accurate fuel planning can reduce the amount of unnecessary fuel carried for each sortie. Industry studies backed up with AMC/A9 analysis show that the cost to carry unneeded fuel is approximately 3-4%. Conservatively at 3%, the E-3 burns an additional 237 lbs of fuel for each 1,000k of unneeded fuel it carries on an average 7.0-hour sortie.

EATF Analysis

The EATF reviewed T.O. 1E-3A-1-1 (Section 9). We also reviewed the International Air Transport Association (IATA) Fuel Book cost of weight analysis and consulted with AMC/A9 to approximate the cost-to-carry for the E-3. Finally, the EATF observed flight planning and landing fuel loads on five sorties.

Findings

1. The 552 ACW tracks shutdown fuel loads; however, they are not yet analyzing this data to determine the accuracy of pre mission fuel planning.

2. Every crew landed with more fuel than required at mission termination. The fuel loads exceeded the Vol 3 minimum[8] for landing by 8k to 22.8k (average was 15.1k).

3. Ramp fuel loads at Tinker AFB are established in 5k lb increments ranging from 85k to 135k. Multiple ramp load options are valuable, but limiting the options to 5k increments, versus 1k increments, can lead to over fueling the aircraft.

4. Crews take on more fuel than required when accomplishing air refueling (A/R) training. On the two A/R sorties observed, crews on-loaded 35k of fuel even though they only needed 17k.[9]

5. Crews relay fuel loads to maintenance after pre-mission flight planning the day prior to each mission. This best practice provides the greatest opportunity for accurate aircraft fueling.

6. Crews are not mission planning long range cruise altitudes when determining fuel loads.

Recommendations

- The Wing analyze landing fuel weights and create goals to minimize carrying extra weight.
- Crews plan and execute air refueling events to only on load the amount of fuel needed.
- The 552 ACW investigate feasibility of changing ramp fuel load increments to 1k versus 5k.
- Utilize LRC Altitude table in the Navigator's AA to plan appropriate altitudes for training missions.
- ACC refine 11-2E3V3 guidance to precisely communicate overhead fuel requirements.

Potential Savings

Reducing excess fuel for 1,350 local missions from Tinker AFB to Vol 3 minimums has the potential to save $1.8M per year. See Appendix A2.4 for more detailed calculations.

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[8] AFI 11-2E-3 Vol 3 para 4.20.4: Normal Fuel at Initial is 18,000 lbs. Minimum landing fuel is 15,000 lbs for IFR. VFR flights may conduct practice approaches and landings until 12,000 lbs.

[9] For a broader discussion on E-3 A/R requirements see Appendix A2.4.

3.8 Engine Start Times

For optimal efficiency, taking into account minimum engine warm up times, the crew should start the engines to minimize the overall time between engine start and takeoff (T/O). Many units have local timing flow policies that prescribe the amount of time crews should start engines prior to a scheduled T/O. This scheduled engine start time often includes additional time to correct unforeseen maintenance issues and ensure an on-time take-off. A critical on-time takeoff warrants an early engine start time. However, on many missions, especially training missions, the cost of the measures needed to minimize risk of a late takeoff outweigh benefits.

EATF Analysis

The EATF reviewed AFI 11-2E-3V3 and local supplements to determine existence of engine start time guidance. The EATF recorded and analyzed the engine start, taxi, and T/O times.

Finding

The AFI 11-2E-3V3_522OG/513ACG_ SUP1 Table 6.1 lists engine start times of 1+00 prior to T/O and taxi 0+30 minutes prior to T/O. The 552 ACW released FCIF 15-35 in October 2015 changing engine start times of 0+30 prior to T/O and taxi 0+15 minutes prior to T/O. The 552 ACW originally implemented the local engine start policy to alleviate late T/Os due to maintenance issues during and immediately after engine start. After further analysis by maintenance personnel, the 552 ACW determined the early engine start time was not appreciably impacting on-time T/O rates, hence the reduction from 1+00 to 0+30 for engine start.

During the five observed sorties, crews started engines 14 to 34 minutes prior to the scheduled takeoff time, averaging 21 minutes before takeoff time. The crews taxied between 7 and 19 minutes prior to takeoff time, averaging 10 minutes. All sorties were on time to their first scheduled activity. During the observation, crews demonstrated the ability to start engines 20 minutes prior to T/O, taxi to the T/O runway, run checklists, and T/O on time.[10]

Recommendation

The EATF recommends the 552 ACW modify the supplement during the next scheduled revision to eliminate mandatory engine start times. We recommend the 552 ACW change the mandatory 0+30 engine start time to a targeted (not required) range between 0+20 and 0+30. Using the target allows crews to work towards a standard while allowing the flexibility of sliding the time based on mission needs, crew experience, and mission conditions. The EATF also recommends a range to allow crews the flexibility to meet mission requirements while operating as efficiently as possible.

Potential Savings

If aircrews were following the original 1+00 guidance, implementation of starting engines 20 minutes prior to T/O would save the USAF $1.5M[11] in unnecessary fuel expenditures annually.

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[10] The local supplement to AFI 11-2E-3V3, Page 24, lists on-time T/O timing requirements as +/-29 minutes.

[11] Based on ground fuel flow of 5,400 lbs/hr, 1,350 sorties/yr, and 40 minutes saved per sortie.

3.9 Taxi – Reduced Engine Taxi-Out

Reduced engine taxi-out is a proven fuel conservation measure. Most Air Force weapons systems take roughly 20 minutes between when the final engine is started and the aircraft commences the takeoff roll. Waiting to start any number of the four engines on a multi-engine aircraft until just before takeoff can typically save 15 minutes of engine run time and fuel per engine. There are valid systems restrictions or heavy gross weights that could prevent crews from taxiing on two engines; however, most of the challenge is cultural resistance.

EATF Analysis

The EATF reviewed T.O. 1E-3A-1 (Section 2), T.O. 1E-3A-1-1 (Section 9), and AFI 11-2E-3V3 for guidance on reduced engine taxi out and observed engine start and taxi procedures on each sortie. The EATF calculated taxi fuel burn and average taxi times to analyze potential savings.

Finding

The EATF found no guidance for reduced engine taxi-out located in any of the T.O.s or AFIs. None of the aircrews observed on the five sorties taxied out on less than all engines running. The EATF calculated the potential reduced engine taxi-out savings of operating for 15 of the average 21-minute taxi on two engines. The EATF observed a 1,000 to 1,200 lbs/hour per engine fuel flow at ground idle while taxiing. The take-off weight of the four mission crew training sorties was between 305k and 318k lbs. The E-3 community would need to consider the unique engine driven generator requirements prior to changing policy.

Recommendation

The EATF recommends ACC and the E-3 Program Office explore the feasibility of developing and implementing reduced engine taxi-out procedures for the E-3 in T.O. 1E-3A-1. The unique nature and systems requirements of the E-3 may make reduced engine taxi-out unfeasible for the E-3, but many systems and mission concerns for other weapons systems are cultural versus technical in nature, thus we feel exploring the feasibility is warranted.

Figure 4a E-3 Taxiing

If reduced engine taxi-out is feasible, the EATF recommends adding guidance in AFI 11-2E-3V3 allowing the pilot in command (PICs) to determine the use of reduced engine taxi on a sortie-by-sortie basis.

Potential Savings

Taxiing out on two engines and starting the last two engines 6 minutes prior to takeoff saves 500-600 lbs of fuel per sortie, and can save approximately $294K based on 1,350 annual sorties. See Appendix 2 Section A2.8 for more detailed calculations.

3.10 Minimizing Taxi Time Prior to Takeoff

Minimizing taxi out for T/O is a proven fuel efficiency measure. Shorter taxi routes to T/O on closer runways can shorten the time spent on the ground and reduce fuel burn. When crews use the most efficient route to the runway, take advantage of opposite direction takeoffs when safe and available, and discuss targeted taxiway turn offs during the approach briefs, they save fuel.

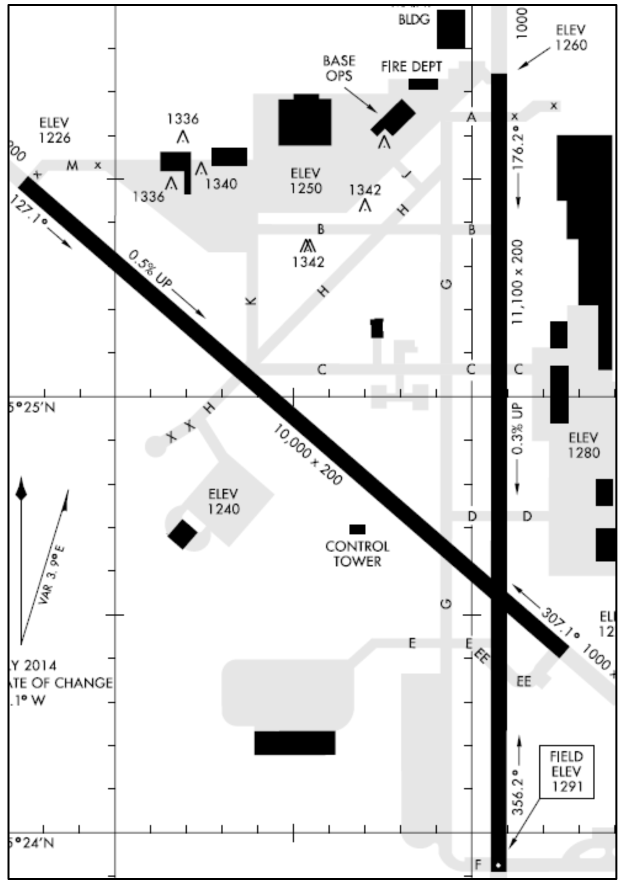

Figure 5 Tinker AFB Airfield Diagram

EATF Analysis

EATF reviewed T.O. 1E-3A-1-1 (Section A3) for takeoff performance considerations and observed ground operations for all five sorties. The EATF did not record data to analyze time waiting at the end of the runway awaiting release for T/O.

Finding

The 552 ACW's taxi procedures appear efficient. All of the crews worked with the navigator to ensure they remained on mission timing while executing ground operations. Crews used common taxi routes that led directly to departure runways. There were no unnecessary detours or intermediate stops. There were no appreciable air traffic control departure delays during the five observation sorties. T.O 1E-3A-1-1 Section A3, Page A3-15, discourages tailwind takeoff, thus this technique is not applicable to the E-3 for efficiency purposes.

The EATF did not analyze the wait time at the end of the runway for air traffic control departure release. The unit could analyze this to determine if changes in coordination between the crews and local ground, tower, and departure controllers could reduce taxi time.

At publication of this report, a Tinker AFB ramp construction project is affecting taxi times; however, the 552 ACW expects to resume normal operations once the construction is complete.

Recommendation

No recommendations.

Potential Savings

Not applicable.

3.11 Takeoff Flap Setting

Reduced flap settings on departure reduce aerodynamic drag resulting in fuel savings. Lower flap settings also improve performance on the follow on climb segments. For aircraft which have options on takeoff flap settings, using the lowest flap setting for a given aircraft weight and runway will typically enhance fuel efficiency. Before weighing use of reduced flap setting for a given airframe, the MAJCOM should evaluate impacts to reduced thrust takeoffs, potential for tail strikes, and necessary training modifications to ensure safety.

EATF Analysis

The EATF reviewed T.O. 1E-3A-1, T.O. 1E-3A-1-1, and AFI 11-2E-3V3 to determine the possible E-3 flap configurations for takeoff. The EATF monitored the flap setting for all five observation sorties.

Finding

T.O. 1E-3A-1, Section II Normal Procedures, Before Takeoff Checklist, Step 2, indicates "Flaps 14" is the only flap setting for takeoff. All of the T.O. 1E-3A-1-1 TOLD (takeoff and landing data) is based on the Flaps 14 setting (T.O. 1E-3A-1, Page 2-57). Currently there is no data available for anything other than a Flaps 14 T/O. On all five observation sorties, the aircrews complied with the T.O. 1E-3A-1 and departed with Flaps 14.

Recommendation

Because there is a single takeoff flap setting prescribed in the T.O. 1E-3A-1, the EATF has no recommendations for this technique.

Potential Savings

Not applicable.

Figure 5a E-3 Takeoff

3.12 Takeoff – Reduced Power (Best Practice)

Reduced thrust takeoffs independently do not reduce fuel consumption. Reduced thrust takeoffs lead to slower acceleration and longer time to reach clean up speeds and clean up heights offsetting the reduced fuel burn associated with the lower takeoff thrust setting. They do prolong engine life by reducing the wear and tear on the combustion section of the engine. A healthier and better performing engine reduces fuel consumption. Also, numerous studies and T.O. 1E-3A-1-1 indicate substantially reduced maintenance costs over the life cycle of the engine when using reduced thrust takeoffs.

EATF Analysis

The EATF reviewed T.O. 1E-3A-1 (Section 2) (Section 3), AFI 11-2E-3V3 (Section 4), and AFI 11-2E-3V3_522OG/513ACG_SUP1 (Section 6) for guidance on using reduced thrust takeoffs. The EATF observed takeoff power settings on all five observation sorties.

Finding

T.O. 1E-3A-1-1 contains verbiage for application of reduced thrust takeoff techniques. T.O. 1E-3A-1-1 contains the performance data for reduced thrust takeoffs. AFI 11-2E-3V3 states: "Whenever practical, a reduced thrust Takeoff should be made." Crews are following guidance listed in AFI 11-2E-3V3. On all five observations, crews mission planned and used reduced thrust takeoff procedures.

Subsequent to the observation flights, the 552 ACW discovered a problem with their flight planning software calculations. The impact of this software problem forced the 552 ACW to require full power takeoffs until the engineers correct the software calculations.

Recommendation

The EATF recorded 552 ACW's reduced thrust takeoff procedures as a Best Practice. We also recommend the 552 ACW continue to work with the program office to resolve the software program deficiencies and return to accomplishing reduced thrust takeoffs as soon as safely possible.

Potential Savings

Not applicable.

Figure 5b E-3 Takeoff

Techniques

3.13 Initial Takeoff Climb and Cleanup Technique

For optimum efficiency, during a normal takeoff (no restrictions for decreased turn radius or climb requirements due to obstacle clearance issues), aircrews should clean up the gear, flaps, and leading edge flaps/slats as soon as possible after takeoff and maintain the technical order climb schedule. Leaving the landing gear, flaps, and leading edge flaps/slats out longer than normal increases drag and requires more power to attain and maintain climb speeds.

EATF Analysis

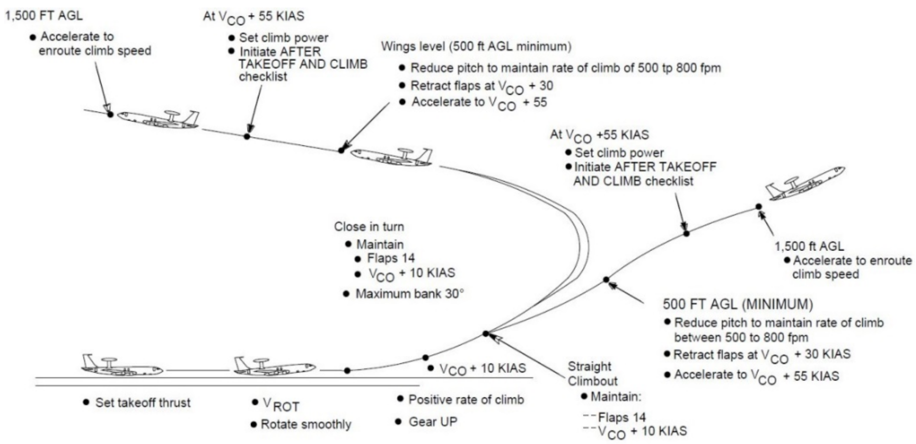

Figure 6 E-3 Typical Takeoff, Climb, & Cleanup

The EATF reviewed climb procedures in T.O. 1E-3A-1 (Section 2) and T.O. 1E-3A-1-1 (Section 4). T.O. 1E-3A-1, Page 2-66, discussed cleanup techniques reference required turns in the departure area. The flight manual provides guidance for leaving flaps out for immediate turns after T/O. T.O. 1E-3A-1-1 provides charts for Normal Rated Thrust (NRT) and Military Rated Thrust (MRT) climb. It states: "MRT is primarily intended for use in other than normal situations at the discretion of the pilot, or where flight at maximum allowable thrust is necessary for flight operating conditions." The EATF observed the initial takeoff climb and cleanup techniques for all five sorties.

Finding

All five sorties used NRT for takeoff power. One sortie took off and stayed in the radar pattern for flight crew transition training. The cleanup technique of not retracting the flaps is normal for this type of activity. Of the four sorties, one crew elected to climb out at 220 knots indicated airspeed (KIAS) below 10,000 feet to get above weather along the climb out route; the other three lowered the nose to 800-1,000 feet per minute (fpm) at 3,100 to 3,300 feet mean sea level (MSL) until reaching 250 KIAS. They then continued the climb to 10,000 feet at 250 KIAS. This procedure is consistent with the T.O. 1E-3A-1 procedures and techniques. There were no delayed actions observed during initial climb segment.

Recommendation

The EATF has no recommendation.

Potential Savings

Not applicable.

3.14 Climb Technique Passing 10,000 feet

There are numerous techniques to accelerate the aircraft when climbing through 10,000 feet. Some transition techniques are more efficient than others.

EATF Analysis

The EATF reviewed climb procedures in T.O. 1E-3A-1 (Section 2) and T.O. 1E-3A-1-1 (Section 4). T.O. 1E-3A-1 normal procedures call for a climb schedule of 250 KIAS to 10,000 feet then 280 KIAS until reaching 0.70 Mach. Page 2-66 provides guidance that: "Climb charts in T.O. 1E-3A-1-1, Part 4 are based on accelerating to 280 KIAS with 500 fpm rate of climb. This speed schedule approximates the best rate of climb speed schedule…." T.O. 1E-3A-1 does not mandate that 500 fpm is the only acceptable rate of climb during speed transition at 10,000 feet.

T.O. 1E-3A-1-1, Page A2-4, supports transition to 280 KIAS at 10,000 feet and 0.70 Mach when able as the "best overall climb performance." The EATF observed climb techniques for five sorties.

Finding

The EATF observed a normal initial climb segment for all sorties except one. All five sorties used NRT for takeoff power. One sortie took off and stayed in the radar pattern for flight crew transition training. The other four sorties cleaned up normally using T.O. 1E-3A-1 procedures and techniques. As the four sorties transitioned through 10,000 feet, each accelerated to 280 KIAS but each used a different fpm to accelerate. The vertical velocity values were 700; 1,000; 1,200; and 1,500 fpm. One sortie elected to continue the climb to cruise altitude at 250 KIAS to facilitate mission timing. Due to a limited number of observed sorties (five) and different environmental conditions for each (winds, weight, temperature), it is difficult to determine if all sorties use exactly 500 fpm and how much fuel would have been saved during the acceleration process at 10,000 feet. In addition, lightweight aircraft will most likely accelerate very quickly at higher fpm climb rates above 500 fpm. Analysis of other aircraft shows that small changes in climb profiles do impact fuel efficiency; however, the EATF noted the length of time the crews spent accelerating from 250 KIAS to 280 KIAS when passing through 10,000 feet was minimal both at 700 fpm and 1,500 fpm climb rates. Fuel efficiency will improve with greater emphasis on the T.O. 1E-3A-1 500 fpm climb rate when accelerating through 10,000 feet; however, the EATF did not calculate the associated savings, which are unlikely to be significant.

Recommendation

Because the savings are small, it's hard to push for increased emphasis to the T.O. 1E-3A-1 500 fpm climb rate when accelerating through 10,000 feet. However, the EATF has seen improvements in both climb performance and efficiency in other weapons systems by closely following the flight manual climb techniques.

Potential Savings

Potential savings is undetermined at this time and requires further data and analysis. The 552 ACW could estimate savings by comparing the fuel burn for different profiles in the simulator.

3.15 Cruise Altitude Selection

Crews attain optimum aircraft performance by selecting the correct cruise altitude for conditions of flight. The optimal altitude takes into account mission timing, aircraft weight, ride conditions, environmental conditions, and other factors. Crews can realize large efficiency gains when selecting and operating at the optimum altitude.

EATF Analysis

The EATF reviewed cruise procedures in T.O. 1E-3A-1-1 (Section 5) and the Navigator's AA, page 20. The EATF also observed cruise procedures on five sorties and used four sorties for the analysis. One sortie was a pilot proficiency/checkride sortie without a sustained cruise segment for analysis. Because the airspace structure can prevent an aircraft from operating exactly at the OA, the EATF considered an aircraft to be at optimum altitude (OA) if the selected altitude (SA) was within 1,000 feet. For example, if the OA was FL 310 (31,000 feet) and the SA was FL 300 (30,000 feet), the EATF considered the aircraft at OA for this analysis.

Finding

Outbound: Three of the four crews selected the OA for outbound leg. One crew flew two FLs below the OA.

RTB: The altitudes requested for RTB were much further from OA than the outbound portion of the sortie. All the requested altitudes for the RTB were below the OA. Three crews flew four and one crew flew eight FLs below the OA.

The EATF compared JMPS flight plans representative of the observed training sorties, with optimum and non-optimum altitudes based on the Navigator's AA page 20 LRC Altitude table. Flying at the OA, versus the observed SAs, saves approximately 1000 lbs of fuel per sortie based on typical training sortie weights and profiles.

Recommendation

The EATF recommends crews use the Navigator's AA, LRC table, for OA mission planning and filing to and from working areas. Optionally, the Wing could also add training emphasis.

Potential Savings

Operating at the OAs for training missions at Tinker AFB can potentially save $525K per year in fuel costs, based on 1,350 sorties per year. It also increased the LRC speed, saving an additional $306K in flight time annually on the aircraft. Total savings per year could potentially be $832K. See Appendix 2, Section A2.6, for more detailed calculations.

GW	FL250 MACH	FL270 MACH	FL290 MACH	FL310 MACH	FL330 MACH	FL350 MACH	FL370 MACH
220K	.64	.65	.67	.69	.70	.71	.73
230K	.65	.66	.67	.69	.71	.72	**.73**
240K	.65	.67	.68	.70	.71	.72	**.73**
250K	.66	.67	.69	.70	.71	**.72**	.74
260K	.67	.68	.70	.70	.72	**.73**	.74
270K	.67	.69	.70	.71	**.72**	.73	.74
280K	.68	.70	.71	.72	**.73**	.74	.75
290K	.69	.70	.71	.72	**.73**	.74	.75
300K	.69	.70	.71	**.72**	.73	.74	.75
310K	.70	.71	.72	**.73**	.74	.75	---

Figure 6a LRC Altitude Table, Navigator's AA, Page 20

3.16 Cruise Speed Selection (Best Practice)

Crews attain the optimal aircraft performance by selecting the correct speed for conditions of flight. The optimal speed accounts for mission timing, aircraft weight, winds aloft, ride conditions, and other factors. Crews can realize large efficiency gains by selecting and operating at the appropriate speed. Normally, the optimum speed is Long Range Cruise (LRC), which is 99% of maximum range speed.[12] Additionally, aircraft that have automated systems to calculate the optimal cruise speed based on winds gain additional cruise speed efficiencies.

EATF Analysis

The EATF reviewed cruise procedures in T.O. 1E-3A-1-1 (Section 5). The EATF also observed cruise procedures on five sorties and used four sorties for the analysis. The omitted sortie was a pilot proficiency/checkride sortie without a sustained cruise portion.

The EATF observed flight engineers providing LRC numbers for the crew to fly for the given weight of the aircraft. The crews set these power settings and flew LRC speeds. The technique was to set the power setting provided by the Flight Engineer (FE), check the resulting airspeed for accuracy, fine tune the throttles, and recheck the airspeed. The 552 ACW SOP dictates the FE to update the settings every two hours to compensate for aircraft weight reduction due to fuel burn.

Finding

Outbound all four crews flew LRC speed to the Military Operating Area (MOA). All four aircrews arrived at the MOA at the scheduled arrival time. For the RTB, all four crews selected LRC. The flight engineers updated the LRC speeds every two hours.

Crews did not have an automated system, such as Mission Index Flying (MIF[13]), to calculate optimum speeds based on headwinds/tailwinds.

Recommendation

The EATF recorded 552 ACW use of LRC airspeed as a Best Practice. The EATF recommends ACC explore acquiring MIF for the E-3.

Potential Savings

The EATF did not calculate the cost benefit for acquiring MIF. Air Mobility Command implementation of MIF shows fuel savings and a positive return on investment.

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[12] T.O. 1E-3A-1-1 Chapter 5, Page A5-3.

[13] MIF is a military software application that is a derivative of commercial Cost Index Flying. MIF uses algorithms to balance the cost of time and the cost of fuel acknowledging there is more to the hourly cost of operating an aircraft than the cost of fuel. MIF accounts for aircraft performance and real-time atmospheric conditions while factoring in flight restrictions. MIF allows flight crews to optimize cruise altitude and speed selection real time.

3.17 Descent Profile and Descent Technique

Continuous Descent Operations (CDOs) or Optimial Profile Descents (OPDs) are efficient by design. They are constructed to keep the throttles at idle for the majority of the descent, reducing fuel use for most, if not all, of the descent. They provide lateral and vertical guidance beginning on the Standard Terminal Arrivals (STARs) and link via transitions to approaches terminating at airports. In the absence of published CDOs, aircrews should compute their own descent points when offered "Pilot's Discretion" (PD) descents by ATC in order to use idle descent profiles (or descent procedures close to idle in accordance with T.O. procedures). Travis AFB CDO studies identified a savings of 300-500 lbs per CDO arrival for the C-17. The IATA Fuel Book shows that the commercial aviation industry saves 140 lbs for the Boeing 737 and 727 lbs for the Boeing 747 for each CDO.

EATF Analysis

The EATF reviewed T.O. 1E-3A-1 (Section 2) for operational descent procedures. The EATF observed descent procedures on four of the five sorties. The EATF reviewed the IATA Fuel Book for Continuous Descent Operation savings in the commercial aviation industry.

Finding

There are no CDOs/OPDs published for Tinker AFB. On four of the five sorties (one sortie had multiple checkrides so the descent was unobserved), initially ATC directed descents that allowed crews to maintain engines at or close to idle. All crews used the technique outlined in T.O. 1E-3A-1, Page 2-72, where outboard engines are brought to idle and inboard thrust is used to maintain a cabin descent rate of 300~400 fpm. During all four observed sorties, multiple air traffic conflicts required one or more intermediate level-offs to maintain aircraft separation. While aircrews are doing an excellent job of adhering to the efficient descent procedures described in the T.O. 1E-3A-1, there could be additional savings realized by using a CDO procedure if one was available for Tinker AFB, and the E-3 is equipped to fly those procedures.

Recommendation

The EATF recommends the AF work with the Federal Aviation Administration (FAA) to initiate work on CDO STARs in the Oklahoma City area. This is a typical recommendation, and is not unique to Tinker AFB. The EATF notes that many new CDO STARs require the Area Navigation (RNAV) equipment approval for the aircraft, and that the E-3 will not have this capability until completion of the DRAGON avionics upgrade. With the avionics limitations, the AF does not need to immediately emphasize the CDO STAR development.

Potential Savings

Potential annual savings for Tinker AFB, if CDOs were available and approved 40% of the time, would be $63K annually if each CDO saved 300 lbs and $105K if each CDO saved 500 lbs. Savings are based on 1350 sorties per year. See Appendix 2, Section A2.7 for calculations.

3.18 Approach Configuration

There is a balance between efficient management of configuration changes and overly conservative changes in approach configurations. Configuring the aircraft early increases drag and is inefficient. Keeping the aircraft clean as long as possible increases efficiency. Factors affecting configuration timing are dependent on pilot experience, the approach controller's directions to slow down or maintain a high speed for other traffic, terminal weather, and different types of approaches. Additionally, practicing non-standard procedures leads to earlier configuration changes, which ensures aircrew can complete non-standard checklists and keep the aircraft stabilized for the final portion of the approach and landing.

EATF Analysis

The EATF reviewed approach configuration illustrations in T.O. 1E-3A-1 Section 2 and the EATF observed 19 approaches during the five sorties.

Finding

T.O. 1E-3A-1, Section 2, clearly illustrates the approach configuration procedures along with speeds and lead points. These illustrations detail steps for the proper sequences of configuration for all represented approaches and visual patterns. Section 3 of the T.O. 1E-3A-1 contains illustrations of aircraft emergency (non-normal) landing configuration sequence of events. During all of the observed approaches, the crews discussed where and when they would configure the aircraft. Procedures used by all five crews followed T.O. 1E-3A-1 guidance for both normal and simulated non-normal approaches. Crews executed all approach configuration changes at a reasonable time during each approach.

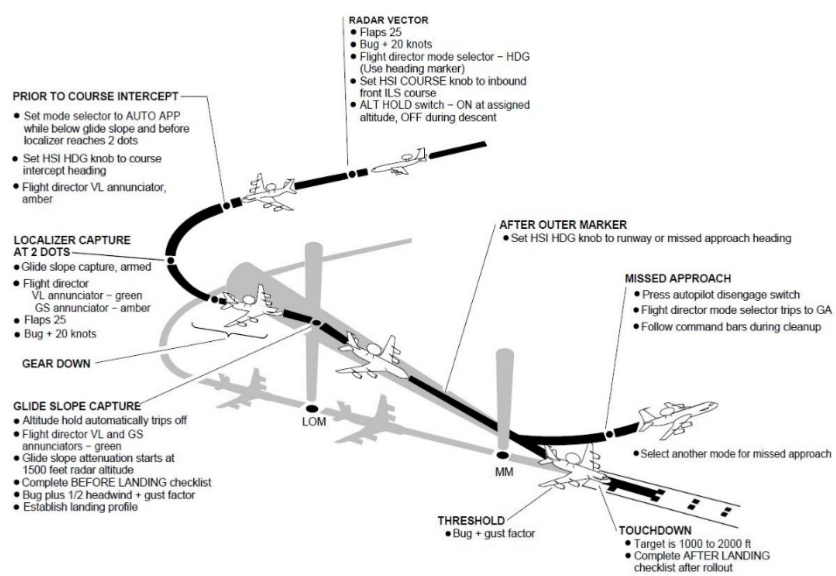

Figure 7 T.O. 1E-3A-1 Figure 2-9 Instrument Approach Pattern

Recommendation

The EATF has no recommendation.

Potential Savings

Not applicable.

3.19 Landing Flaps

Landing flaps increase lift but also increase drag. As the flap setting nears the E-3's maximum landing flap setting of 50 degrees, increased drag necessitates a higher power setting to maintain the approach speed. This higher power setting increases fuel use on final approach. Some aircraft have the ability to land at multiple flap settings, which presents an opportunity to save fuel on final approach. The IATA Fuel Book indicates reduced flap landings can save 55 lbs of fuel per approach for a Boeing 737 and 165 lbs per approach on a Boeing 777.

EATF Analysis

The EATF reviewed approach configuration illustrations in T.O. 1E-3A-1 Section 2. The EATF observed the flap settings for 19 approaches during the five sorties.

Finding

The normal landing flap setting for the E-3 is flaps 50 and crews used the flaps 50 setting on all landings during the observation flights. The operating procedures in 1E-3A-1 and guidelines in AFI 11-2E-3 Vol 3 don't specifically allow or prohibit flaps 40 landings. Figure 2-10 in 1E-3A-1 shows a normal visual pattern and depicts only a flaps 50 landing. AFI 11-2E-3 Vol 3 makes several implications to flaps 40 being acceptable. Discussions with crew members indicated most land with flaps 50 all the time. A small subset of pilots will land at flaps 40 when dealing with higher cross winds and the landing field length is adequate.

Reducing the flap setting from 50 to 40 increases landing distance from a 50 ft height from 600 to 800 feet. (T.O. 1E-3A-1 Figure A8-34 with a 10 kt threshold speed increase above V_{REF}.)

Historically, Boeing 707 airliners reduced landing flaps to 25 degrees to comply with Stage 2 and Stage 3 noise certification[14]. The landing penalty in this instance was 1,500 to 2,250 feet; however, it was a price airlines were willing to pay to enable the aircraft to continue operating in locations where the noise limitations existed.

The EATF did not compare flaps 40 with flaps 50 approach and landings in the simulator, but we estimate, based on IATA data, the E-3 could save 50 to 100 lbs per approach, and accomplish reduced flap approaches on 50 to 75% of sorties.

Recommendation

The E-3 could safely accomplish flaps 40 landings at Tinker AFB, and the practice would likely save fuel for landings on runway 36. However, neither technical guidance, existing training nor culture favors the change, thus we do not make this recommendation at this time.

Potential Savings

Implementing E-3 reduced flaps landings at Tinker AFB could save \$14K to \$39K annually.

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[14] FAA Advisory circular 36-1H "Noise Levels for U.S. Certificated and Foreign Aircraft" http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%2036-1H.pdf

3.20 Taxi – Reduced Engine Taxi In (Best Practice)

Reduced engine taxi is a proven fuel conservation measure. The commercial airline and multiple Air Force major weapons systems have demonstrated and documented the associated savings. Post flight, aircraft weigh much less than preflight and many times are able to taxi on reduced engines at idle power.

EATF Analysis

The EATF reviewed T.O. 1E-3A-1 (Section 2) for guidance on reduced engine taxi in and observed the taxi in during all five sorties.

Finding

The T.O. 1E-3A-1 after landing checklist directs crews to shut down outboard engines after bleed air valves have closed. Four of the five crews on the five observed sorties followed T.O. guidance and shut down the outboard engines soon after exiting the landing runway. On one of the sorties, multiple pilot checkrides were occurring, the taxi in was not observed so the actual shutdown time was not recorded. One aircrew returned to Tinker AFB in between weather patterns and elected not to shut two engines down for the taxi-in. The average taxi-in time with two engines shut down on three sorties was 10 min per sortie. Observed fuel flow on the TF-33 engine is 1.2k per hour at ground idle. Shutting down the two outboard engines per T.O. 1E-3A-1 reduces the total fuel flow by half for the remainder of the taxi in. 552 ACW crews are doing an excellent job of executing the efficient practice of shutting down the outboard engines, which is identified as a Best Practice.

Recommendation

The EATF documented the 552 ACW's standard operating procedure of reduced engine taxi in as a Best Practice. No further recommendation.

Potential Savings

Since this technique is currently in practice there are no additional savings. We calculated that Tinker AFB saves over $210K per year with this initiative. See Appendix 2, Section A2.9 for calculations.

3.21 Debrief – Fuel Efficiency Discussions

Debrief is important for providing feedback. Feedback is essential for improvement in any operation because it closes the loop and provides perspective on how well the task was accomplished and/or highlights any area for improvement. Debrief items become focus items, and with focus on efficiency comes improvement in efficiency and effectiveness.

EATF Analysis

The EATF observed debrief for all five sorties. The EATF also engaged aircrews to determine if "Hanger Flying" sessions or other venues included fuel efficiency discussions.

Finding

Aircrews debriefed via different techniques, some at the end of the sortie and others as they transitioned to different events during the sorties. The crews did discuss fuel efficiency issues with the EATF observer, but there was not a debrief among the crew members specifically on fuel efficiency. The EATF expected this since there is no fuel efficiency metric that the Wing measures. The aircrews have no frame of reference to judge or measure their performance toward fuel efficiency. This is common across the Air Force. AMC utilizes a fuel tracker tool that generates discussion and tracks events that affect fuel efficiency. This fuel tracker is a viable debrief tool for fuel efficiency.

Recommendation

The EATF recommends the 552 ACW develop a fuel efficiency debrief tool/process covering all stages of the mission. Debriefing these items will enhance awareness and lead to improvements in efficiency and effectiveness. See Appendix 2, Section A2.11 for example efficiency debrief tool/process covering all stages of the mission.

Potential Savings

Undetermined at this time.

C-17 Master Fuel Tracker Worksheet POC HQ AMC/A3F (Mar 2014)

Aircraft Commander: | Wing: | Squadron:

Mission #: | Dept Date (Zulu): | ICAO From: | ICAO To:

Ramp Fuel (Klbs)		Land Fuel (Klbs)		Duration (h.h)		Cargo + Pax (Klbs)		Takeoff CG		APU (h.h)		AR Onload (Klbs)	
Plan	Act	Plan	Act	Plan	Act	Plan	Act	Plan	Act	Pre	Post	Plan	Act

Did you tanker fuel? No | Yes for Cost Avoidance | Yes for Operational Requirement | Amount Tankered: (Klbs)________

Flight Plan Used: ☐ ACFP using MI Values ☐ ACFP Using "NA" MI Values ☐ PFPS ☐ None

Was MIF Used:
☐ Yes
☐ No, Flight times less than 1 hour
☐ No, Sortie did not operate above 10,000 ft
☐ No, Unable to use both MIF altitudes and airspeeds
☐ No, Due to slot time or airfield operating hours
☐ No, Due to crew duty day restrictions
☐ No, Mission computer inop/not available
☐ No, Tanker could not use MIF due to Coronet
☐ No

First half ERCC? Yes No | Hvy Wt A/R Training? Yes No | Airdrop/Low Level Sortie: Yes No

GPU Used Before Takeoff:
☐ No, GPU Not Functional
☐ No, Operational (Combat/Austere Ops)
☐ Yes
☐ No, A/C would not accept power
☐ No, Not Required
☐ No, Not at aircraft before engine start
☐ No, Weather precluded use

GPU Used At Destination:
☐ No, GPU Not Functional
☐ No, Operational (Combat/Austere Ops)
☐ Yes
☐ No, A/C would not accept power
☐ No, A/C Requires Tow to Parking
☐ No, Not at aircraft before engine start
☐ No, Weather precluded use
☐ No, Not Required

Ramp Fuel Deviation Reason: (Required if greater than 1,500 Lbs difference in plan vs. actual)
☐ N/A
☐ Additional Cargo/PAX
☐ AC Adjusted fuel (FM Agrees)
☐ AC Adjusted fuel (FM Disagrees) (Please Comment)
☐ Mission/Routing change
☐ Enroute WX
☐ Fuel Service Over-Fuel
☐ ERCC
☐ Tail Swap/Could not defuel
☐ Other (Please Comment)
☐ Tankered fuel (Ops/FM Directed)
☐ Burned less than Plan on previous leg

Landing Fuel Deviation Reason: (Required if greater than 3,000 Lbs difference in plan vs. actual)
☐ N/A
☐ Airfield Ops
☐ ATC (Hold Downs, Excessive Vectors, etc
☐ BASH
☐ Flew less than scheduled duration-TNG or MSN complete
☐ Air Abort: Tanker (Due to IFE, Tanker, MX or WX)
☐ Air Abort: Receiver (Due to IFE, Receiver MX, or WX)
☐ Mission Index Flying
☐ Cruise Wind/Temp Deviations
☐ Enroute WX Deviations
☐ Excessive Fuel Burn in Cruise
☐ Overflew Original Destination
☐ Extra Cargo Loaded
☐ Ramp Fuel Deviation
☐ Maintenance
☐ Receivers did not show
☐ Receivers took less fuel than planned
☐ Receivers took more fuel than planned
☐ Able to climb earlier than ACFP Forecast
☐ Other________________

Comments:

Figure 7b C-17 Fuel Tracker Worksheet

3.22 Maintenance – On Wing Engine Wash (Best Practice)

AMC has seen small performance increases on several fleets as a result of an "On Wing Engine Wash" program. Any performance gain will translate into increased efficiency.

EATF Analysis

The EATF consulted with the 552 MXG to see if they had an "On Wing Engine Wash "program.

Finding

The EATF discovered that 552 MXG does conduct "On Wing" engine washes, but an established criterion for tracking/measuring performance gains after the engine wash does not exist. Without any criteria, it is difficult to determine an appropriate engine wash cycle for the TF-33. Currently, the 552 MXG washes engines on a two-year recurring cycle. There is not a time schedule for recurring engine wash cycles listed in the Maintenance T.O. for the E-3. The 552 MXG is working on including a two-year wash cycle in the Maintenance T.O.

Although we did not find exact savings associated with the engine wash for the TF-33 engine, we did find fuel efficiency savings for similar commercial and military engines were approximately 0.4%.

Recommendation

The EATF documents this technique as a Best Practice. No further recommendation.

Potential Savings

No further savings. Tinker AFB saves approximately $414K annually using this technique. See Appendix 2, Section A2.15 for calculations.

Figure 7c Engine Compressor Wash

3.23 Contract Fighters

The primary AWACS mission involves controlling participating fighter assets. Thus, for most mission trainers, the AWACS requires airborne fighters they can control. The 552 ACW identified this fighter requirement as one of their most significant training challenges. First, few fighter squadrons are located in close proximity to Tinker AFB, which requires the E-3 to fly long distances to MOAs in Utah, Virginia, and North Carolina. Second, when a participating fighter unit cancels or the AWACS has a late takeoff, the overall AWACS training is often not effective.

EATF Analysis

The EATF reviewed a proposal developed by the 552 ACW in 2011 regarding an initiative to use dedicated civilian contracted fighters, based at Tinker AFB.

Finding

This grass roots idea has significant potential. At a very basic level, the 552 ACW data shows the savings associated with flying shorter sorties offsets the costs of the contract fighters. The Wing also touched on the potential for value using contract tankers; however, they have yet to explore the potential. The Wing's contract fighter proposal indicates potential to:

- Improve weapons training efficiency from 50% to over 90%
- Reduce fuel and flying hours wasted transitioning to distant ranges
- Ease reliability issues with aging E-3 fleet
- Reduce training backlogs by producing mission crews in 1/3 current time
- Save 1.45M gallons of fuel annually
- Mitigate E-3 late takeoffs resulting in lost training (Can slip contract fighter)

Recommendation

The EATF recommends the Air Force accomplish a detailed cost-benefit analysis to explore the business case; however, even with a breakeven business case, the improvements in training, readiness, and reduction in flight time on an aging weapons system warrant further and careful consideration.

Potential Savings

We did not calculate potential savings for this initiative as part of this effort.

3.24 Aircraft Weight Reduction

Industry studies backed up with AMC/A9 analysis show that the cost to carry unneeded weight on airline and cargo aircraft is approximately 3%. This means each 100 pounds of extra fuel or unnecessary equipment carried on the aircraft results in an extra 3 pounds of fuel burn per hour.

EATF Analysis

The EATF reviewed T.O. 1E-3A-1 and 1E-3A-1-1. We also reviewed the IATA Fuel Book cost of weight analysis and consulted with AMC/A9 to approximate the cost-to-carry for the E-3. The EATF also discussed weight savings measures with the crews and maintenance.

Finding

The EATF found the 552 ACW has made inroads at reducing nonessential weight carried on their aircraft such as removal of unneeded bailout chutes. The EATF also found the 552 ACW is working with depot level maintenance to utilize a nose ballast weight in lieu of having to carry 5,000 lbs of unburnable ballast fuel on sorties modified by TCTO 1E-3-891, "Installation of Block 40/45 Modification on USAF E-3B and E-3C airplanes."[15] TCTO 1E-3-891 removed and replaced outdated equipment on the aircraft. Performing this modification shifted the Center of Gravity (CG) of the aircraft requiring 5,000 lbs of ballast fuel on every TCTO 1E-3-891 modified aircraft sortie. The 552 MXG is coordinating the installation of a 1,200 lbs ballast weight in the nose of the aircraft saving 3,800 lbs of extra weight carried on each sortie, resulting in a savings of 798 lbs of fuel burn per sortie.

The 552 ACW is also working with ACC to transition to the Electronic Flight Bag (EFB). The 552 ACW determined the total weight of the publications carried on a training flight was 222 lbs. Converting to EFBs for every air and mission crew position saves 42 lbs of fuel on each flight. Organizations converting to digital publications also see a reduction in printing costs; however, the 552 ACW's recent move from each individual crew member owning a publication set to crews checking publications out from a squadron library prior to flying has already realized some of this savings.

Recommendations

- The 552 ACW continue to work with depot level maintenance for the addition of ballast weight to aircraft with the TCTO 1E-3-891 modification.
- The 552 ACW continue to pursue conversion to EFBs for all air and mission crew positions.

Potential Savings

The addition of a Nose Weight to TCTO 1E-3-891 aircraft to eliminate ballast fuel will save $420K per year once the fleet modification is complete in FY19. Converting to EFBs will save $22K per year. See calculations in Appendix 2 Section A2.17.

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[15] TO 1E-3A-1-1S-29, dated 12 December 2013, page A1-10.

4.0 Recommendation Summary

This section provides a summary of the best practices, primary recommendations, and secondary recommendations. For a roll up of the potential savings, see Appendix 2, Section A2.16.

- **Best Practices**: Techniques or processes that exemplify fuel efficiency efforts and should be shared with other units and other weapons systems.
- **Primary Recommendations**: Recommendations where adoption is straightforward and benefits to the unit are significant.
- **Secondary Recommendations**: The Wing's adoption of these recommendations is straightforward; however, implementation may face challenges, or require coordination with external parties. The Wing may find it difficult to track benefits.

4.1 Best Practices

- **TDY to Ranges**: The 552 ACW deploys aircraft closer to their East Coast ranges and sends crews TDY to fly the missions. This saves significant transition time between Tinker AFB, in Oklahoma, and the ranges on the East Coast.
- **Reduced Thrust Takeoff**: The reduced thrust takeoff is a 552 ACW standard practice.
- **Cruise Speed Selection**: The 552 ACW selects and flies the optimal long-range cruise speed.
- **Reduced Engine Taxi-In**: The reduced engine taxi-in is a 552 ACW standard practice.
- **Engine Compressor Wash**: The 552 ACW accomplishes compressor washes and is working to institute defined intervals into the maintenance technical orders.

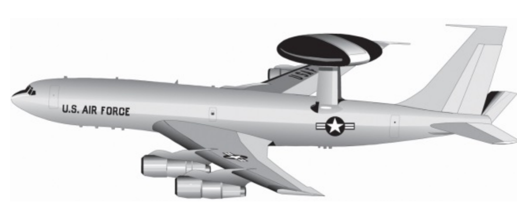
4.2 Primary Recommendations

- **Data Collection**: Expanding the fuel efficiency data collection and analysis program will lead to increased emphasis on fuel efficiency and, in time, increased mission capability and reduced fuel use.
- **APU Use**: Using ground power units and ground air conditioning units versus the aircraft's APU will save considerable fuel.
- **Landing Fuel Weights**: Reducing the average landing weight to a value closer to the prescribed landing fuel weights will reduce the cost of carrying unnecessary fuel.
- **Cruise Altitude Selection**: Choosing the optimal altitude when transitioning to and from the training ranges will save considerable fuel.
- **In Flight Guides**: Incorporate the most efficient altitudes and speeds for common ranges into the Pilot's AA. This data is listed in the Navigator's AA but not the pilot's. Optionally, add maximum endurance speed table to AA.
- **Debrief of Fuel Efficiency**: Add fuel efficiency techniques to the mission debrief to emphasize best practices. This is a blended effort with the data collection recommendation.

Recommendations

4.3 Secondary Recommendations

- **Aircraft Weight Reduction**: Continue pursuing adoption of EFB versus paper publications.
- **Engine Start Time Policy**: Eliminate time requirements for engine start and thus reduce unnecessary engine running ground time.
- **Mission Planning Software Update**: Update the mission planning software compatibility to automatically download winds aloft data. This data will improve altitude, airspeed, and route selection during mission planning leading to reduced fuel burn. This update is in progress.
- **Reduced Engine Taxi Out**: Research potential for a reduced engine taxi out.
- **Climb Technique at 10,000 Feet**: Consider emphasizing technical order procedures for acceleration at 10,000 feet during the climb.
- **Descent Technique**: Work with the FAA on implementation of continuous descent operations in the Oklahoma City airspace.
- **Contract Fighters**: Accomplish a cost benefit analysis to determine the feasibility of contracting civilian fighters to support AWACS training at Tinker AFB.



Appendix 1: Acronyms

AA – Aircrew Aid

AC – Air Conditioning

ACC – Air Combat Command

ACW – Air Control Wing

AF – Air Force

AFB – Air Force Base

AFI – Air Force Instruction

AFTOC – Air Force Total Ownership Cost

AGE – Aerospace Ground Equipment

AMC – Air Mobility Command

AoA -- Angle of Attack

APU – Auxiliary Power Unit

A/R – Air Refueling

ATC – Air Traffic Control

AWACS – Airborne Warning and Control System

C2BM – Command and Control Battle Management

CC – Commander

CDO – Continuous Descent Operation

CG – Center of Gravity

COW - Cost of Weight

CV – Vice Commander

DLA – Defense Logistics Agency

DoD – Department of Defense

EATF – Energy Analysis Task Force

EFB – Electronic Flight Bag

FAA – Federal Aviation Administration

FCIF – Flight Crew Information File

FE – Flight Engineer

FL – Flight Level

fpm – feet per minute

FS – Factor Set

FY – Fiscal Year

Appendix 1

GAC – Ground Air Cart

gph – Gallons per Hour

GPU – Ground Power Unit

HAF – Headquarters Air Force

HQ – Headquarters

IATA – International Air Transport Association

ICAO – International Civil Aviation Organization

IEN – Installations, Environment, and Energy

IFG – In Flight Guide

IFR – Instrument Flight Rules

JMPS – Joint Mission Planning System

K – Thousand

KIAS – Knots Indicated Airspeed

lbs – Pounds

LOEA – Line Operations Efficiency Analysis

LOSA – Line Operations Safety Audit

LRC – Long Range Cruise

MAJCOM – Major Command

MIF – Mission Index Flying

MOA – Military Operating Area

MRT – Military Rated Thrust

MSL – Mean Sea Level

MWS – Major Weapons System

MXG – Maintenance Group

NRT – Normal Rated Thrust

OA – Optimum Altitude

OE – Operational Energy

OG – Operations Group

OI – Operating Instruction

OPD – Optimum Profile Descent

OSS – Operational Support Squadron

PD – Pilot's Discretion

PIC – Pilot in Command

PROJO – Project Officer

RFI – Request for Information
RNAV – Area Navigation
RTB – Return to Base
SA – Selected Altitude
SAF – Secretary of the Air Force
SJ – Seymour Johnson
SOP – Standard Operating Procedure
SPO – Systems Program Office
STAR – Standard Terminal Arrival
TDY – Temporary Duty
TFB – Total Fuel Burned
T.O. – Technical Order
T/O – Takeoff
TOLD – Takeoff and Landing Data
TSFC – Total Specific Fuel Consumption
U.S. – United States
USAF – United States Air Force
VFR – Visual Flight Rules
VOR – Very High Frequency Omnidirectional Range
VORTAC – VOR and Tactical Air Navigation System

Appendix 2

Appendix 2: Detailed Analysis

A2.1 Detailed Savings Calculations for Deploying Closer to East Coast MOA

The three figures below show the detailed savings calculations with the 552 ACW's initiative to deploy two aircraft for two weeks to Seymour Johnson AFB to support East Coast fighter operations. In FY15 the 552 ACW executed three of these TDYs. All deployment and redeployment sorties included a mission. One aircraft redeployed mid-tour to return crews home for the weekend, and then deployed again following the weekend. TDY costs for the aircrew, mission crew, and ground support crews averaged $48,663 ($33K was low - $71K was high). Approximate savings for FY15 (three TDYs) was $2.5M.

Tinker Round Robin (RR) Sortie	**Hours**
Transit Time: Tinker AFB to East Coast MOA (round trip)	6.5
Transit Time: Total for 18 Missions	**117**

Figure A2.1 Flight Time, Status Quo for 18 Missions

Deploying Aircraft/Crews	**Hours**
Time to Deploy: Tinker - MOA - Seymour Johnson (SJ)	3.5
Number of Deployments	3
Total Deployment Time: Tinker - MOA - SJ	**10.5**
Transit Time: SJ - MOA - SJ (each of 12 purely "local" sorties)	1.5
Transit Time: SJ - MOA - SJ (total for 12 purely "local" sorties)	**18**
Time to Redeploy: SJ - MOA - Tinker	4
Number of Redeployments	3
Total Redeployment Time: SJ - MOA - Tinker	**12**
Total Deployment, Transit, and Redeployment Time	**40.5**

Figure A2.2 Flight Time for 18 Forward Deployed Missions

Savings Comparison	
Hours Saved: Deploying vs Tinker RR	76.5
Multiplied by E-3 Cost Per Flying Hour (FS140) ($11,502)	$879,903
Minus Avg TDY Costs (Ave of three TDYs)	$48,663
Total Avg Net Savings	**$831,240**

Figure A2.3 Savings for Deploying Aircraft and Crews to SJ

Appendix 2

A2.2 Projected Savings for Deploying Closer to an Alternative West Coast MOA

The three figures below show the detailed savings projections if the 552 ACW duplicated the East Coast deployment on the West Coast. The proposal deploys two aircraft for two weeks to March ARB to support West Coast fighter operations. All deployment and redeployment sorties include a mission. One aircraft redeploys mid-tour to return crews home for the weekend, and then deploys again following the weekend. We estimate the TDY costs for the aircrew, mission crew, and ground support crews at $50,000 per deployment, based on slightly higher per diem costs for southern California versus North Carolina.

Tinker RR	**Hours**
Transit Time: Tinker AFB to West Coast MOA (round trip)	5.5
Transit Time: Total for 18 Missions	**99**

Figure A2.4 Flight Time, Status Quo for 18 Missions

Deploying Aircraft/Crews	**Hours**
Time to Deploy: Tinker - MOA - March	3
Number of Deployments	3
Total Deployment Time: Tinker - MOA - March	**9**
Transit Time: March - MOA - March (each of 12 purely "local" sorties)	1.5
Transit Time: March - MOA - March (total for 12 purely "local" sorties)	**18**
Time to Redeploy: March - MOA - Tinker	3.0
Number of Redeployments	3
Total Redeployment Time: March - MOA - Tinker	**9.0**
Total Deployment, Transit, and Redeployment Time	**36.0**

Figure A2.5 Flight Time for 18 Forward Deployed Missions

Savings Comparison	
Hours Saved: Deploying vs Tinker RR	63
Multiplied by E-3 Cost Per Flying Hour (FS140) ($11,502)	$724,626
Minus TDY Costs	$50,000
Total Avg Net Savings	**$674,626**

Figure A2.6 Savings for Deploying Aircraft and Crews to March

A2.3 Projected APU Reduction Savings

The calculations below show the projected savings by reducing APU usage an average of 2 hours per sortie. EATF observations documented APU usage at over two hours per sortie. The APU was running when crews arrived at the aircraft and aircraft maintainers requested it to be left running at the end of each observed sortie.

The T.O. 1E-3A-1 preflight checklist procedures include options for using ground power and ground air, however the checklist favors use of the APU over ground sources. Crews are accustomed to using the APU, and the APU provides a level of ease, convenience, and reliability not available with Aerospace Ground Equipment (AGE) solutions. Culture also plays an important role. Aircrews and maintenance are accustomed to using the APU solution. Moving towards the AGE solution requires a fundamental shift in process, which the Wing will likely need to institute with a dedicated policy. Even with the policy driven process change, it will take time for the aircrew and maintainers to embrace the AGE solution. Problems with AGE availability and reliability are likely with the initial implementation and increased utilization…and these hurdles will negatively delay the necessary culture change. In the end, the AGE solution is technically acceptable, and like with most every other Air Force major weapons system, should be the preferred solution versus the alternative solution as it is with the E-3 today.

As seen in other instances within the Air Force, challenges with older AGE equipment and challenging manpower levels in the AGE career field lead to units giving up on the AGE and relying on other resources, in this case, the aircraft's APU. The correct answer is to place to appropriate emphasis on acquiring and maintaining both the AGE and manpower resources. Given, refocusing the Wing on AGE use versus APU use will be a long-term effort fraught with challenges. However, the challenges are surmountable, and the approach is appropriate, not to mention the AF standard operating procedure.

The 552 ACW also highlighted an additional benefit in that use of ground power versus the APU may increase safety by reducing noise and jet blast from APU exhausts on the flight line.

Reduced APU Use Savings	
APU Burn Rate (gph)	52.0
Ground Power Unit Burn Rate (gph)	6.0
Ground Air Conditioner Unit Burn Rate (gph)	7.3
Savings using GPU and GAC versus APU (gph)	38.7
APU Burn Reduction, Per Sortie (hours)	2.0
Savings/Sortie (gallons)	77.4
Sorties/Year	1,350
Savings/Year (gallons)	104,490.0
Cost Savings/Year (based on $2.61/gallon)	**$272,719**

Figure A2.7 Reduced APU Use Savings Calculation

Appendix 2

A2.4 Cost-to-Carry Excess Fuel

The figures below detail the annual cost to carry extra fuel for an average 7 hr training mission flown from Tinker AFB. Figures derived from AMC/A9 analysis, IATA Fuel Book, observed landing fuel loads and interviews with crews. We based these calculations on the Feb 2016 DLA fuel price of $2.61 per gallon.

Excess Landing Fuel and the Cost-to-Carry	
Cost to Carry 1,000 extra pounds 7 hours (lbs)[16]	237
Average Fuel in Excess of Vol 3 Requirement[17]	15,100
Excess Fuel Burn (cost-to-carry) for Excess Fuel (per sortie)	3,579
Number of 7-hour Sorties[18]	1,350
Total Annual Excess Fuel Burn (lbs)	4,831,245
Total Annual Excess Fuel Burn (gallons)[19]	721,081
Total Annual Excess Cost (Dollars)[20]	**$1,882,021**

Figure A2.8 Excess Landing Fuel Cost to Carry Calculation

Fuel Load Discussion: E-3 crews often fuel the aircraft on the ground for the entire sortie even when they've scheduled A/R training. This is to ensure mission success even if the tanker becomes unavailable. The EATF doesn't discourage this practice, as the mission requirement trumps efficiency; however, we do recommend crews only take on enough fuel during A/R to complete the mission.

Although AFI 1E-3-Vol 1 does not list a training requirement to take on a certain weight or volume of fuel, the Wing indicated a desire to get crews experience with the following:

- Large volume on loads which appreciably change the weight and CG of the aircraft
- Large volume on loads which require fueling the center wing tank which moves the CG of the aircraft forward and impacts pitch sensitivity
- Extended time on boom to replicate longer high volume A/R events currently common in COCOM theaters

Based on in-flight observations, and discussions with crews, crews seem to commonly on load 35,000 lbs of fuel. This on load volume extends the amount of time pilots are on the boom, but does not replicate the 80,000 to 90,000 pound on loads common during COCOM operations and does not always move provide the significant CG changes associated with fueling the center

[16] Based on generic 3% per hour cost-to-carry calculation.

[17] Average from four observation sorties.

[18] From observation sorties and interviews with crews.

[19] The weight of JP-8 is 6.7 lbs/gallon.

[20] DLA Standard Fuel Price of $2.61 for JP-8 as of 1 Feb 2016.

wing tank. Thus, it appears the Wing could increase efficiency by only scheduling and on loading the necessary fuel, and just stay connected with the tanker without taking on additional gas to simulate the longer A/R times. The crews must accurately communicate their fuel requirements to the tanker to ensure the tanker doesn't end up carrying the extra weight versus the E-3 carrying the extra weight.

A2.5 Cost of Early Engine Start Policy

We base the calculations on the original 552 ACW policy to start engines 60 minutes prior to scheduled takeoff. The EATF recommends crews target 20 minutes, which reduces engine run time by 40 minutes. The ground fuel burn from the Vol 3 is 5,400 lbs per hour, or 90 lbs per minute. This equates to an extra 3,600 lbs of fuel per sortie costing $1.89M over 1,350 sorties per year. We based these calculations on the Feb 2016 DLA fuel price of $2.61 per gallon. We based the savings calculations on the original 552 ACW policy of starting engines 60 minutes prior to takeoff versus the current policy of starting engines 30 minutes prior to takeoff to emphasize the costs associated with conservative engine start guidance. Theoretically, the Wing saved $1.41M annually by moving the engine start time policy from 60 minutes prior to 30 minutes prior, and would save an additional $473,306 annually by moving from a 30 minutes prior engine start to 20 minutes prior (10 min savings).

Eliminating Mandatory Engine Start Times	
Original Engine Start Time (min prior to sched T/O) (Vol 3 local Sup)	60
Target Engine Start Time (min prior to sched T/O)	20
Engine Running Time Saved per sortie (min)	40
Ground Fuel Burn (lbs/min)	90
Fuel Saved per sortie (lbs)	3,600
Fuel Saved per sortie (gal)	537
Costs Saved per sortie	$1,402
Costs Saved per year (1350 sorties)	$1,893,224

Figure A2.9 Engine Start Time Savings

A2.6 Non-Optimal Cruise Altitude Cost

The figures below show the average observed less than optimum altitude operations and the associated costs. We derived the data from four observed sorties for both Outbound and Return to Base portions of the sorties. Outbound the average was 1000 ft off optimum altitude, which,is negligible, so the figures will concentrate on the Return To Base (RTB) portion that averaged 4000 ft off optimum altitude. Comparing JMPS flight plans generated for representative training sorties at Tinker AFB showed a savings between 900-1,100 lbs per sortie when operating at the optimum altitude. See figures in Sections A2.12 and A2.13 for the JMPS flight plans showing an 1,100 lb difference. Cruising 4,000 ft off optimum altitude will cost on average about $525K additional per FY for training sorties flown out of Tinker AFB. We based these calculations on the DLA Feb 2016 fuel price of $2.61 per gallon.

Appendix 2

Costs for Flying Off Optimum Altitude	
Average observed alt off optimum alt in feet	4,000
Increased Fuel Burn in lbs/average per sortie	1,000
Sorties/Year 1,350	1,350,000
Converted to Gallons	201,492.5
Extra costs per year	$525,895

Figure A2.10 Fuel Costs for Flying Off Optimum Altitude

There is also an associated time savings for flying at the optimum altitude. Comparing the non-optimal altitude JMPS flight plan in Section A2.12 with the optimal altitude JMPS flight plan in Section A2.13 shows a time savings of 2:29 minutes. Since we've already calculated the fuel savings we've removed the fuel cost from the FS140 CPFH and calculated the CPFH savings as shown in Figure A2.11.

Non Flying Costs for Flying Off Optimum Altitudes	
Time Savings Per Sortie	2:29 min
Min Saved (1350 Sorties/Year)	3352.5 min
Hours Saved	55.8 hours
Non Fuel CPFH (FS140)	$5,488
CPFH Savings Per Year	$306,602

Figure A2.11 Non Fuel Costs for Flying Off Optimum Altitude

We estimate the total annual cost for flying suboptimal altitudes to and from training ranges is $832,497.

A2.7 Projected Savings Calculations for Continuous Descent Operations

The figures for demonstrated C-17 CDO cost savings are used below to extrapolate potential savings for the E-3 if CDO were available at Tinker AFB. Since we don't have figures for the E-3 we used both the Low (300 lbs per sortie) and the High (500 lbs per sortie) to show a possible range of savings. The median savings (average of high and low) is $84K. We based these calculations on the DLA Feb 2016 fuel price of $2.61 per gallon.

Continuous Descent Operations Savings	Low	High
Savings per Arrival (lbs)	300	500
Sorties per Year	1,350	1,350
Sorties Able to Accomplish CDO (est 40%)	540	540
Lbs Saved per Year	162,000	270,000
Gallons Saved per Year (6.7 lbs/gallon)	24,179	40,299
Cost Savings ($/year)	**$63,107.46**	**$105,179.10**

Figure A2.12 Continuous Descent Operations Projected Savings

Appendix 2

A2.8 Reduced Engine Taxi-Out Savings

We base the following savings calculations on average taxi time observed during the LOEA and fuel burn per engine based on LOEA observations. Conservatively, crews would start the last two engines 6 minutes prior to takeoff, saving 14 minutes fuel burn on two engines. Total savings are calculated by multiplying by 1,350 E-3 sorties per year at Tinker AFB. We based these calculations on the DLA Feb 2016 fuel price of $2.61 per gallon.

Reduced Engine Taxi-Out	
Average Taxi Time (min)	20.0
Time with only 2 engines running	14.0
Fuel Burn (lbs/hr per engine)	1,200.0
Fuel Burn (lbs/min per engine)	20.0
Fuel Savings for 2-Engine Taxi for 14 min (lbs/sortie)	560.0
AWACS Sorties per year	1,350
Fuel Savings (lbs/year)	756,000
Fuel Savings (gal/year)	112,858.8
Cost Savings ($/year)	$294,501.49

Figure A2.13 Reduced Engine Taxi-Out Savings Calculation

A2.9 Reduced Engine Taxi-In Savings

We base the following savings calculations on average taxi time observed during the LOEA and fuel burn per engine based on LOEA observations. We calculated the savings Tinker AFB achieves by consistently using the reduced engine taxi in procedure. Crews on observed sorties shut down two engines on taxi-in saving an average of 10 minutes of engine time on each engine. We calculated total savings by multiplying by 1,350 E-3 sorties per year at Tinker AFB. We based these calculations on the DLA Feb 2016 fuel price of $2.61 per gallon.

Reduced Engine Taxi-In	
Average Taxi Time (min)	12.0
Time with only 2 engines running	10.0
Fuel Burn (lbs/hr per engine)	1,200.0
Fuel Burn (lbs/min per engine)	20
Fuel Savings for 2-Engine Taxi for 10 min (lbs/sortie)	400.0
AWACS Sorties per year	1,350
Fuel Savings (lbs/year)	540,000
Fuel Savings (gal/year)	80,597.0
Cost Savings ($/year)	$210,358.21

Figure A2.14 Reduced Engine Taxi-In Savings Calculation

Appendix 2

A2.10 Example In-Flight Guide Sections for Fuel Efficiency

The charts below are from the Vance AFB T-1A In-Flight Guide. The first chart is a quick reference to help choose the most efficient altitude for flight planning purposes for cross-country navigation training sorties in the T-1A. The second chart provides recommended T-1A enroute cruise speeds based on aircraft gross weights and sortie distance. Speeds are provided for multiple wind conditions.

Quick Reference Mission Planning Cruise Altitude

From↓	ADM	AFW	AMA	CSM	END	FOE	FSM	GCK	HUT	IAB	ICT	LBB	LIT	OKC	SWO	TIK	TUL	XNA
ADM	XXXX	180	FL340*	250	240	FL370*	270	FL360*	FL340*	FL340*	FL340*	FL340*	FL350*	110	220	110	230	270
AFW	170	XXXX	FL360*	FL320*	FL340*	FL370*	FL330*	FL380*	FL360*	FL360*	FL360*	FL340*	FL350*	240	FL340*	240	FL340*	FL350*
AMA	FL350*	FL360*	XXXX	260	270	FL370*	FL370*	FL310*	FL350*	FL350*	FL350*	160	[redacted]	FL330*	FL350*	FL330*	FL370*	FL370*
CSM	250	FL320*	260	XXXX	**90	FL370*	FL350*	FL320*	270	250	270	260	FL370*	170	190	170	FL310*	FL350*
END	250	FL340*	280	**100	XXXX	FL330*	FL330*	280	**130	**130	**130	FL360*	FL370*	**130	**130	**130	**230	FL330*
FOE	FL360*	FL370*	FL380*	FL360*	FL340*	XXXX	FL330*	FL360*	220	200	200	[redacted]	FL370*	280	260	280	270	260
FSM	270	FL330*	FL380*	FL340*	FL340*	FL340*	XXXX	FL360*	FL340*	FL340*	FL340*	[redacted]	190	260	260	260	**150	80
GCK	FL370*	FL380*	FL320*	FL330*	270	FL350*	FL370*	XXXX	230	250	250	FL360*	[redacted]	FL330*	FL330*	FL330*	FL350*	FL350*
HUT	FL350*	FL360*	FL360*	280	**130	230	FL350*	240	XXXX	50	50	FL380*	FL370*	250	250	250	250	FL330*
IAB	FL350*	FL360*	FL360*	260	**130	210	FL350*	260	60	XXXX	40	FL380*	FL370*	220	170	220	**150	270
ICT	FL350*	FL360*	FL360*	260	**130	210	FL350*	260	60	40	XXXX	FL380*	FL370*	220	170	220	**150	270
LBB	FL350*	FL340*	170	270	FL350*	[redacted]	[redacted]	FL350*	FL370*	FL370*	FL370*	XXXX	[redacted]	FL330*	FL330*	FL330*	FL370*	[redacted]
LIT	FL360*	FL350*	[redacted]	FL360*	FL360*	FL360*	200	[redacted]	FL380*	FL380*	FL380*	[redacted]	XXXX	FL360*	FL360*	FL360*	FL340*	220
OKC	110	250	FL340*	160	**130	270	250	FL340*	260	210	210	FL340*	FL350*	XXXX	70	40	170	270
SWO	210	FL340*	FL340*	200	**130	250	250	FL340*	260	160	160	FL340*	FL350*	110	XXXX	80	70	210
TIK	110	250	FL340*	160	**130	250	250	FL340*	260	210	210	FL340*	FL350*	40	70	XXXX	170	280
TUL	240	FL340*	FL380*	FL320*	**130	270	**150	FL360*	260	**150	**150	FL360*	FL330*	160	80	160	XXXX	**150
XNA	280	FL350*	FL380*	FL340*	FL340*	270	90	FL360*	FL340*	260	260	[redacted]	210	280	220	270	**150	XXXX

Key

FLXXX* (eg FL330*): Fly at highest non-RVSM altitude for direction of flight or request altitude in RVSM airspace

**130 or **150: LOA or MOU altitude between city pairs

Recommended Enroute Cruise Speeds

	16,000-15,000 Lbs 100 nm Cruise Distance									
	10K	12K	14K	16K	FL180	FL200	FL220	FL240	FL260	FL280
60 KT HW	280	270	270	270	270	260	260	260	260	260
30 KT HW	270	270	260	260	260	260	260	260	260	260
No Wind	260	260	260	260	250	250	250	250	250	250
30 KT TW	250	250	250	250	250	250	250	250	250	250
60 KT TW	250	250	250	250	250	250	250	250	250	250

	16,000-15,000 Lbs 200 nm Cruise Distance									
	10K	12K	14K	16K	FL180	FL200	FL220	FL240	FL260	FL280
60 KT HW	[redacted]				270	260	260	260	260	260
30 KT HW					260	260	260	260	250	250
No Wind					250	250	250	250	250	250
30 KT TW					250	250	250	250	250	250
60 KT TW					250	250	250	240	240	240

Figure A2.15 T-1A Inflight Guide Example

A2.11 Example C-17 Fuel Tracker Worksheet

HQ AMC developed the worksheet below and it is in use for tracking fuel on the C-17. This tool is very useful for data collection, correlation, and analysis and can be used by the crew as an aid for fuel efficiency issues debriefed for the flight. While this example is for the C-17, the E-3 community could tailor a fuel tracker worksheet for their needs.

C-17 Master Fuel Tracker Worksheet POC HQ AMC/A3F (Mar 2014)

Aircraft Commander:		**Wing:**	**Squadron:**
Mission #:	**Dept Date (Zulu):**	**ICAO From:**	**ICAO To:**

Ramp Fuel (Klbs)		**Land Fuel (Klbs)**		**Duration (h.h)**		**Cargo + Pax (Klbs)**		**Takeoff CG**		**APU (h.h)**		**AR Onload (Klbs)**	
Plan	Act	Plan	Act	Plan	Act	Plan	Act	Plan	Act	Pre	Post	Plan	Act

Did you tanker fuel? No Yes for Cost Avoidance Yes for Operational Requirement Amount Tankered: (Klbs)______

Flight Plan Used: ☐ ACFP using MI Values ☐ ACFP Using "NA" MI Values ☐ PFPS ☐ None

Was MIF Used:
- ☐ Yes
- ☐ No, Flight times less than 1 hour
- ☐ No, Sortie did not operate above 10,000 ft
- ☐ No, Unable to use both MIF altitudes and airspeeds
- ☐ No, Due to slot time or airfield operating hours
- ☐ No, Due to crew duty day restrictions
- ☐ No, Mission computer inop/not available
- ☐ No, Tanker could not use MIF due to Coronet
- ☐ No

First half ERCC? Yes No | **Hvy Wt A/R Training?** Yes No | **Airdrop/Low Level Sortie:** Yes No

GPU Used Before Takeoff:
- ☐ No, GPU Not Functional
- ☐ No, Operational (Combat/Austere Ops)
- ☐ Yes
- ☐ No, A/C would not accept power
- ☐ No, Not Required
- ☐ No, Not at aircraft before engine start
- ☐ No, Weather precluded use

GPU Used At Destination:
- ☐ No, GPU Not Functional
- ☐ No, Operational (Combat/Austere Ops)
- ☐ Yes
- ☐ No, A/C would not accept power
- ☐ No, A/C Requires Tow to Parking
- ☐ No, Not at aircraft before engine start
- ☐ No, Weather precluded use
- ☐ No, Not Required

Ramp Fuel Deviation Reason: (Required if greater than 1,500 Lbs difference in plan vs. actual)
- ☐ N/A
- ☐ Additional Cargo/PAX
- ☐ AC Adjusted fuel (FM Agrees)
- ☐ AC Adjusted fuel (FM Disagrees) (Please Comment)
- ☐ Mission/Routing change
- ☐ Enroute WX
- ☐ Fuel Service Over-Fuel
- ☐ ERCC
- ☐ Tail Swap/Could not defuel
- ☐ Other (Please Comment)
- ☐ Tankered fuel (Ops/FM Directed)
- ☐ Burned less than Plan on previous leg

Landing Fuel Deviation Reason: (Required if greater than 3,000 Lbs difference in plan vs. actual)
- ☐ N/A
- ☐ Airfield Ops
- ☐ ATC (Hold Downs, Excessive Vectors, etc
- ☐ BASH
- ☐ Flew less than scheduled duration-TNG or MSN complete
- ☐ Air Abort: Tanker (Due to IFE, Tanker, MX or WX)
- ☐ Air Abort: Receiver (Due to IFE, Receiver MX, or WX)
- ☐ Mission Index Flying
- ☐ Cruise Wind/Temp Deviations
- ☐ Enroute WX Deviations
- ☐ Excessive Fuel Burn in Cruise
- ☐ Overflew Original Destination
- ☐ Extra Cargo Loaded
- ☐ Ramp Fuel Deviation
- ☐ Maintenance
- ☐ Receivers did not show
- ☐ Receivers took less fuel than planned
- ☐ Receivers took more fuel than planned
- ☐ Able to climb earlier than ACFP Forecast
- ☐ Other______________________

Comments:

Figure A2.16 C-17 Master Fuel Tracker Worksheet

Appendix 2

A2.12 Navigator's LRC Altitude Table from Navigator's Aircrew Aid

GW	FL250 MACH	FL270 MACH	FL290 MACH	FL310 MACH	FL330 MACH	FL350 MACH	FL370 MACH
220K	.64	.65	.67	.69	.70	.71	.73
230K	.65	.66	.67	.69	.71	.72	**.73**
240K	.65	.67	.68	.70	.71	.72	**.73**
250K	.66	.67	.69	.70	.71	**.72**	.74
260K	.67	.68	.70	.70	.72	**.73**	.74
270K	.67	.69	.70	.71	**.72**	.73	.74
280K	.68	.70	.71	.72	**.73**	.74	.75
290K	.69	.70	.71	.72	**.73**	.74	.75
300K	.69	.70	.71	**.72**	.73	.74	.75
310K	.70	.71	.72	**.73**	.74	.75	---

Figure A2.17 Navigator's LRC Altitude Table from Navigator's Aircrew Aid (page 20)

HIGHLIGHTED Mach numbers indicate optimum long range cruise Mach/altitude. These calculations should be made for each cruise leg of the flight with consideration being given to flight and mission crew requirements.

Appendix 2

A2.13 Typical JMPS Flight Plan for Non-Optimized Altitude Training Sortie

UNCLASSIFIED

FL 320 Out FL 310 Return **Landing fuel 28.8**

DATE:	TAIL/SPOT	A/C:	ON STA TIME:	DEPT BASE:	T/O TIME:
MSN NO:	CALLSIGN	NAV:	ON STA DELAY:	LAND BASE:	LAND TIME:

AIR REFUELING INFORMATION							
		A/R Altitude	FL	Pri/Sec A/R Freq	/	Onload	K
		Tanker C/S		Beacon E-3/TKR		A/R Time	+
Type Rendezvous		Tanker type	KC-	A/A TACAN	Y	TR/Offset	/
ARCT (or RZ time)		Tanker unit		EMCON			
A/R Track		Tanker T/O	Z	Tanker phone no.			

DURATION:

FUEL LOAD:

EMERGENCY AIRFIELDS:

CAUTION: The NAVIGATOR is responsible for the accuracy of all information contained on this flight plan.
SIGN:

ORBIT INFORMATION	TYPE	LOBE	LAT N / S	LONG E / W	RAD	DIR	TYPE	LOBE	LAT N /S	LONG E / W	RAD	DIR
LOA NAME:												
WORK AREA:												

PARKING SPOT COORDS:	HH COORDS:			
#2 IRW 88/114.1 N 35-21.5 W 097-36.6		(RWY 17) N 35-25.7 W 097-23.0	(RWY 35) N 35-23.9 W 097-23.0	11100 X 200
		(RWY 12) N 35-25.5 W 097-24.2	(RWY 30) N 35-24.7 W 097-23.1	10000 X 200

WPT	VOR TAC	DESCRIPTION ID / RDME	LAT LONG	TRK	W/V DCA	HDG	VAR	CH	TEMP ALT	IAS MACH	TAS GS	GDST ACDST	TIME ACTIME	ETA RETA	ATA	GROSS WEIGHT	FUEL RMNG
		TINKER AFB	N 35 24.884						+12C			10.0	00+03+00	12:33:02			4.2 K
		KTIK/A	W 097 23.198	360		360	3.9E	356	1291M			0.0	00+00+00			310.0 K	130.0 K
			N 35 34.900						+7C			10.0	00+03+00	12:36:02			4.2 K
		.stto	W 097 23.230	360		360	3.8E	356	4291M			10.0	00+03+00			305.8 K	125.8 K
	114.10M	WILL ROGERS	N 35 21.516						-8C	N/A	N/A	17.2	00+03+33	12:39:35			2.0 K
DCT	088X	IRW	W 097 36.554	219	0	219	4.0E	215	11672M	N/A	N/A	27.2	00+06+33			303.8 K	123.8 K
		CRUSR	N 35 20.125						-35C	N/A	N/A	61.7	00+10+01	12:49:36			4.5 K
J6		CRUSR	W 098 51.973	269	0	269	4.8E	265	25418M	N/A	N/A	88.9	00+16+34			299.3 K	119.3 K
			N 35 18.159						-48C	N/A	N/A	56.6	00+08+11	12:57:47			2.8 K
		.Level off	W 100 01.068	268	0	268	5.4E	264	32000M	N/A	N/A	145.5	00+24+45			296.5 K	116.5 K
	116.60M	PANHANDLE	N 35 14.104						-48C	262	425	82.7	00+11+41	13:09:28			3.1 K
J6	113X	PNH	W 101 41.942	268	0	268	6.4E	262	32000M	0.73	425	228.2	00+36+26			293.4 K	113.4 K
		TBE/E130039	N 36 44.318						-48C	262	424	113.0	00+16+00	13:25:28			4.1 K
J17		KENTO	W 103 05.952	323	0	323	7.2E	317	32000M	0.73	424	341.2	00+52+26			289.3 K	109.3 K
	111.20M	TOBE	N 37 15.519						-48C	261	423	39.4	00+05+35	13:31:03			1.4 K
J17	049X	TBE	W 103 36.003	322	0	322	7.5E	315	32000M	0.72	423	380.6	00+58+01			287.8 K	107.8 K
	116.70M	PUEBLO	N 38 17.655						-48C	261	423	73.5	00+10+26	13:41:29			2.7 K
J17/J28	114X	PUB	W 104 25.767	328	0	328	8.0E	320	32000M	0.72	423	454.1	01+08+27			285.2 K	105.2 K
		PUB/R262010	N 38 18.581						-48C	261	422	10.3	00+01+28	13:42:57			0.4 K
J28		FSHER	W 104 38.852	275	0	275	8.1E	267	32000M	0.72	422	464.5	01+09+56			284.8 K	104.8 K
		PUB/R262031	N 38 20.400						-48C	261	422	21.2	00+03+00	13:45:58			0.8 K
J28		FLOOD	W 105 05.640	275	0	275	8.4E	267	32000M	0.72	422	485.6	01+12+56			284.0 K	104.0 K
		PUB/R262045	N 38 21.507						-48C	260	422	13.5	00+01+55	13:47:53			0.5 K
J28		RODDY	W 105 22.743	275	0	275	8.5E	266	32000M	0.72	422	499.1	01+14+51			283.5 K	103.5 K
		HBU/E080033	N 38 24.944						-48C	260	422	45.6	00+06+29	13:54:22			1.6 K
J28		ELWAY	W 106 20.587	275	0	275	9.0E	266	32000M	0.72	422	544.7	01+21+20			281.9 K	101.9 K
	114.90M	BLUE MESA	N 38 27.127						-48C	260	421	32.9	00+04+41	13:59:03			1.2 K
J28	096X	HBU	W 107 02.383	274	0	274	9.3E	265	32000M	0.72	421	577.6	01+26+01			280.7 K	100.7 K
		HBU/E256074	N 38 27.055						-48C	260	421	73.8	00+10+31	14:09:34			2.6 K
J28		BDROC	W 108 36.331	270	0	270	10.0E	261	32000M	0.72	421	651.4	01+36+32			278.1 K	98.1 K
	115.90M	HANKSVILLE	N 38 25.009						-48C	259	420	98.8	00+14+06	14:23:40			3.5 K
J28	106X	HVE	W 110 41.984	269	0	269	10.8E	259	32000M	0.72	420	750.2	01+50+38			274.6 K	94.6 K
	112.10M	MILFORD	N 38 21.623						-48C	259	419	109.2	00+15+37	14:39:17			3.8 K
J28/J58	058X	MLF	W 113 00.795	269	0	269	11.6E	258	32000M	0.72	419	859.4	02+06+15			270.8 K	90.8 K
	116.30M	WILSON CREEK	N 38 15.012						-48C	258	419	65.6	00+09+24	14:48:41			2.3 K
J58	110X	ILC	W 114 23.654	265	0	265	12.0E	253	32000M	0.72	419	924.9	02+15+39			268.6 K	88.6 K
	110.60M	ELY	N 39 17.888						-48C	258	418	66.3	00+09+31	14:58:12			2.3 K
DCT	043X	ELY/E	W 114 50.898	341	0	341	12.3E	329	32000M	0.72	418	991.3	02+25+10			266.3 K	86.3 K
		ELY/E331013	N 39 30.000						-46C	262	418	12.5	00+01+48	15:00:00			0.4 K
S LOBE		.HILL S LOBE	W 114 55.000	345	0	345	12.4E	333	31000M	0.71	418	1003.8	02+26+58			265.9 K	85.9 K
		ELY/E343062	N 40 20.000						-46C	223	360	50.0	00+08+20	15:08:20			1.7 K
N LOBE		.HILL N LOBE	W 114 55.000	000	0	000	12.5E	348	31000M	0.61	360	1053.7	02+35+18			264.2 K	84.2 K
			N 40 20.000						-46C	223	360	0.0	01+51+40	17:00:00			22.3 K
		.delay	W 114 55.000	360	0	360	12.5E	347	31000M	0.61	360	1053.7	04+26+58			241.9 K	61.9 K
	110.60M	ELY	N 39 17.888						-46C	257	410	62.1	00+09+06	17:09:05			2.0 K
DCT	043X	ELY/E	W 114 50.898	177	0	177	12.3E	165	31000M	0.70	410	1115.9	04+36+03			239.9 K	59.9 K

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Appendix 2

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WPT	VOR TAC	DESCRIPTION ID / RDME	LAT LONG	TRK	W/V DCA	HDG	VAR	CH	TEMP ALT	IAS MACH	TAS GS	GDST ACDST	TIME ACTIME	ETA RETA ATA	GROSS WEIGHT	FUEL RMNG
	116.30M	WILSON CREEK	N 38 15.012						-46C	256	409	66.3	00+09+43	17:18:48		2.1 K
DCT	110X	ILC	W 114 23.654	161	0	161	12.0E	149	31000M	0.70	409	1182.2	04+45+47		237.8 K	57.8 K
	112.10M	MILFORD	N 38 21.623						-46C	256	409	65.6	00+09+37	17:28:26		2.1 K
J58	058X	MLF	W 113 00.795	084	0	084	11.6E	072	31000M	0.70	409	1247.8	04+55+24		235.7 K	55.7 K
	115.90M	HANKSVILLE	N 38 25.009						-46C	255	408	109.2	00+16+04	17:44:30		3.4 K
J28	106X	HVE	W 110 41.984	088	0	088	10.8E	076	31000M	0.69	408	1356.9	05+11+28		232.3 K	52.3 K
		HBU/E256074	N 38 27.055						-46C	254	407	98.8	00+14+34	17:59:04		3.1 K
J28		BDROC	W 108 36.331	088	0	088	10.0E	077	31000M	0.69	407	1455.7	05+26+03		229.3 K	49.3 K
	114.90M	BLUE MESA	N 38 27.127						-46C	254	406	73.8	00+10+55	18:10:00		2.3 K
J28	096X	HBU	W 107 02.383	089	0	089	9.3E	079	31000M	0.69	406	1529.5	05+36+58		227.0 K	47.0 K
		HBU/E080033	N 38 24.944						-46C	253	405	32.9	00+04+53	18:14:52		1.0 K
J28		ELWAY	W 106 20.587	094	0	094	9.0E	084	31000M	0.69	405	1562.4	05+41+50		226.0 K	46.0 K
		PUB/R262045	N 38 21.507						-46C	253	404	45.6	00+06+46	18:21:38		1.4 K
J28		RODDY	W 105 22.743	094	0	094	8.5E	085	31000M	0.69	404	1608.0	05+48+36		224.6 K	44.6 K
		PUB/R262031	N 38 20.400						-46C	253	404	13.5	00+02+00	18:23:38		0.4 K
J28		FLOOD	W 105 05.640	095	0	095	8.4E	086	31000M	0.69	404	1621.5	05+50+37		224.2 K	44.2 K
		PUB/R262010	N 38 18.581						-46C	253	404	21.2	00+03+09	18:26:47		0.6 K
J28		FSHER	W 104 38.852	095	0	095	8.1E	086	31000M	0.69	404	1642.7	05+53+45		223.5 K	43.5 K
	116.70M	PUEBLO	N 38 17.655						-46C	253	404	10.3	00+01+32	18:28:19		0.3 K
J28/J17	114X	PUB	W 104 25.767	095	0	095	8.0E	087	31000M	0.69	404	1653.0	05+55+17		223.2 K	43.2 K
	111.20M	TOBE	N 37 15.519						-46C	252	403	73.5	00+10+57	18:39:16		2.2 K
J17	049X	TBE	W 103 36.003	147	0	147	7.5E	139	31000M	0.69	403	1726.6	06+06+14		221.0 K	41.0 K
		TBE/E130039	N 36 44.318						-46C	252	403	39.4	00+05+52	18:45:08		1.2 K
J17		KENTO	W 103 05.952	142	0	142	7.2E	135	31000M	0.69	403	1765.9	06+12+06		219.8 K	39.8 K
	116.60M	PANHANDLE	N 35 14.104						-46C	251	402	113.0	00+16+53	19:02:01		3.4 K
J17/J6	113X	PNH	W 101 41.942	142	0	142	6.4E	135	31000M	0.68	402	1878.9	06+28+59		216.4 K	36.4 K
		IRW/R262062	N 35 20.125						-46C	250	400	139.3	00+20+54	19:22:55		4.1 K
J6		CRUSR	W 098 51.973	087	0	087	4.8E	080	31000M	0.68	400	2018.2	06+49+53		212.3 K	32.3 K
			N 35 28.454						-46C	249	399	18.3	00+02+45	19:25:40		0.5 K
		.Descent pt	W 098 32.095	063	0	063	4.5E	058	31000M	0.68	399	2036.4	06+52+38		211.8 K	31.8 K
		IRW/R292032	N 35 37.028						-29C	N/A	N/A	18.9	00+02+47	19:28:27		0.3 K
DCT		CAMET/W	W 098 11.422	063	0	063	4.4E	058	22340M	N/A	N/A	2055.4	06+55+25		211.5 K	31.5 K
		TINKER	N 35 26.190						+9C	N/A	N/A	41.1	00+07+48	19:36:15		0.7 K
DCT	105X	TIK/T	W 097 22.781	105	0	105	3.8E	101	3000M	N/A	N/A	2096.5	07+03+13		210.8 K	30.8 K
		TINKER AFB	N 35 24.884						+12C			1.3	00+20+00	19:56:15		2.0 K
		KTIK/A	W 097 23.198	195	0	195	3.9E	191	1291M			2097.8	07+23+13		208.8 K	28.8 K

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A2.14 Typical JMPS Flight Plan for Optimized Altitude Training Sortie

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FL 320 Out FL 350 Return — **Landing fuel 29.9**

DATE:	TAIL/SPOT	A/C:	ON STA TIME:	DEPT BASE:	T/O TIME:
MSN NO:	CALLSIGN	NAV:	ON STA DELAY:	LAND BASE:	LAND TIME:

AIR REFUELING INFORMATION

		A/R Altitude	FL	Pri/Sec A/R Freq	/	Onload	K
		Tanker C/S		Beacon E-3/TKR		A/R Time	+
Type Rendezvous		Tanker type	KC-	A/A TACAN	Y	TR/Offset	/
ARCT (or RZ time)		Tanker unit		EMCON			
A/R Track		Tanker T/O	Z	Tanker phone no.			

DURATION:

FUEL LOAD:

EMERGENCY AIRFIELDS:

CAUTION: The NAVIGATOR is responsible for the accuracy of all information contained on this flight plan.
SIGN:

ORBIT INFORMATION	TYPE	LOBE	LAT N / S	LONG E / W	RAD	DIR	TYPE	LOBE	LAT N /S	LONG E / W	RAD	DIR
LOA NAME:												
WORK AREA:												

PARKING SPOT COORDS:	HH COORDS:	(RWY 17) N 35-25.7 W 097-23.0	(RWY 35) N 35-23.9 W 097-23.0	11100 X 200
#2 IRW 88/114.1 N 35-21.5 W 097-36.6		(RWY 12) N 35-25.5 W 097-24.2	(RWY 30) N 35-24.7 W 097-23.1	10000 X 200

WPT	VOR	DESCRIPTION	LAT		W/V				TEMP	IAS	TAS	GDST	TIME	ETA		GROSS	FUEL
	TAC	ID / RDME	LONG	TRK	DCA	HDG	VAR	CH	ALT	MACH	GS	ACDST	ACTIME	RETA	ATA	WEIGHT	RMNG
		TINKER AFB	N 35 24.884						+12C			10.0	00+03+00	12:33:02			4.2 K
		KTIK/A	W 097 23.198	360		360	3.9E	356	1291M			0.0	00+00+00			310.0 K	130.0 K
			N 35 34.900						+7C			10.0	00+03+00	12:36:02			4.2 K
		.stto	W 097 23.230	360		360	3.8E	356	4291M			10.0	00+03+00			305.8 K	125.8 K
	114.10M	WILL ROGERS	N 35 21.516						-8C	N/A	N/A	17.2	00+03+33	12:39:35			2.0 K
DCT	088X	IRW	W 097 36.554	219	0	219	4.0E	215	11672M	N/A	N/A	27.2	00+06+33			303.8 K	123.8 K
		CRUSR	N 35 20.125						-35C	N/A	N/A	61.7	00+10+01	12:49:36			4.5 K
J6		CRUSR	W 098 51.973	269	0	269	4.8E	265	25418M	N/A	N/A	88.9	00+16+34			299.3 K	119.3 K
			N 35 18.159						-48C	N/A	N/A	56.6	00+08+11	12:57:47			2.8 K
		.Level off	W 100 01.068	268	0	268	5.4E	264	32000M	N/A	N/A	145.5	00+24+45			296.5 K	116.5 K
	116.60M	PANHANDLE	N 35 14.104						-48C	262	425	82.7	00+11+41	13:09:28			3.1 K
J6	113X	PNH	W 101 41.942	268	0	268	6.4E	262	32000M	0.73	425	228.2	00+36+26			293.4 K	113.4 K
		TBE/E130039	N 36 44.318						-48C	262	424	113.0	00+16+00	13:25:28			4.1 K
J17		KENTO	W 103 05.952	323	0	323	7.2E	317	32000M	0.73	424	341.2	00+52+26			289.3 K	109.3 K
	111.20M	TOBE	N 37 15.519						-48C	261	423	39.4	00+05+35	13:31:03			1.4 K
J17	049X	TBE	W 103 36.003	322	0	322	7.5E	315	32000M	0.72	423	380.6	00+58+01			287.8 K	107.8 K
	116.70M	PUEBLO	N 38 17.655						-48C	261	423	73.5	00+10+26	13:41:29			2.7 K
J17/J28	114X	PUB	W 104 25.767	328	0	328	8.0E	320	32000M	0.72	423	454.1	01+08+27			285.2 K	105.2 K
		PUB/R262010	N 38 18.581						-48C	261	422	10.3	00+01+28	13:42:57			0.4 K
J28		FSHER	W 104 38.852	275	0	275	8.1E	267	32000M	0.72	422	464.5	01+09+56			284.8 K	104.8 K
		PUB/R262031	N 38 20.400						-48C	261	422	21.2	00+03+00	13:45:58			0.8 K
J28		FLOOD	W 105 05.640	275	0	275	8.4E	267	32000M	0.72	422	485.6	01+12+56			284.0 K	104.0 K
		PUB/R262045	N 38 21.507						-48C	260	422	13.5	00+01+55	13:47:53			0.5 K
J28		RODDY	W 105 22.743	275	0	275	8.5E	266	32000M	0.72	422	499.1	01+14+51			283.5 K	103.5 K
		HBU/E080033	N 38 24.944						-48C	260	422	45.6	00+06+29	13:54:22			1.6 K
J28		ELWAY	W 106 20.587	275	0	275	9.0E	266	32000M	0.72	422	544.7	01+21+20			281.9 K	101.9 K
	114.90M	BLUE MESA	N 38 27.127						-48C	260	421	32.9	00+04+41	13:59:03			1.2 K
J28	096X	HBU	W 107 02.383	274	0	274	9.3E	265	32000M	0.72	421	577.6	01+26+01			280.7 K	100.7 K
		HBU/E256074	N 38 27.055						-48C	260	421	73.8	00+10+31	14:09:34			2.6 K
J28		BDROC	W 108 36.331	270	0	270	10.0E	261	32000M	0.72	421	651.4	01+36+32			278.1 K	98.1 K
	115.90M	HANKSVILLE	N 38 25.009						-48C	259	420	98.8	00+14+06	14:23:40			3.5 K
J28	106X	HVE	W 110 41.984	269	0	269	10.8E	259	32000M	0.72	420	750.2	01+50+38			274.6 K	94.6 K
	112.10M	MILFORD	N 38 21.623						-48C	259	419	109.2	00+15+37	14:39:17			3.8 K
J28/J58	058X	MLF	W 113 00.795	269	0	269	11.6E	258	32000M	0.72	419	859.4	02+06+15			270.8 K	90.8 K
	116.30M	WILSON CREEK	N 38 15.012						-48C	258	419	65.6	00+09+24	14:48:41			2.3 K
J58	110X	ILC	W 114 23.654	265	0	265	12.0E	253	32000M	0.72	419	924.9	02+15+39			268.6 K	88.6 K
	110.60M	ELY	N 39 17.888						-48C	258	418	66.3	00+09+31	14:58:12			2.3 K
DCT	043X	ELY/E	W 114 50.898	341	0	341	12.3E	329	32000M	0.72	418	991.3	02+25+10			266.3 K	86.3 K
		ELY/E331013	N 39 30.000						-46C	262	418	12.5	00+01+48	15:00:00			0.4 K
S LOBE		.HILL S LOBE	W 114 55.000	345	0	345	12.4E	333	31000M	0.71	418	1003.8	02+26+58			265.9 K	85.9 K
		ELY/E343062	N 40 20.000						-46C	223	360	50.0	00+08+20	15:08:20			1.7 K
N LOBE		.HILL N LOBE	W 114 55.000	000	0	000	12.5E	348	31000M	0.61	360	1053.7	02+35+18			264.2 K	84.2 K
			N 40 20.000						-46C	223	360	0.0	01+51+40	17:00:00			22.3 K
		.delay	W 114 55.000	360	0	360	12.5E	347	31000M	0.61	360	1053.7	04+26+58			241.9 K	61.9 K
			N 39 54.466						-54C	N/A	N/A	25.5	00+03+46	17:03:46			1.1 K
		.Level off	W 114 53.299	177	0	177	12.4E	165	35000M	N/A	N/A	1079.3	04+30+44			240.8 K	60.8 K

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WPT	VOR	DESCRIPTION	LAT		W/V				TEMP	IAS	TAS	GDST	TIME	ETA		GROSS	FUEL
	TAC	ID / RDME	LONG	TRK	DCA	HDG	VAR	CH	ALT	MACH	GS	ACDST	ACTIME	RETA	ATA	WEIGHT	RMNG
	110.60M	ELY	N 39 17.888						-54C	243	416	36.6	00+05+17	17:09:03			1.1 K
DCT	043X	ELY/E	W 114 50.898	177	0	177	12.3E	165	35000M	0.72	416	1115.9	04+36+01			239.6 K	59.6 K
	116.30M	WILSON CREEK	N 38 15.012						-54C	243	416	66.3	00+09+35	17:18:37			2.0 K
DCT	110X	ILC	W 114 23.654	161	0	161	12.0E	149	35000M	0.72	416	1182.2	04+45+35			237.6 K	57.6 K
	112.10M	MILFORD	N 38 21.623						-54C	242	415	65.6	00+09+29	17:28:06			2.0 K
J58	058X	MLF	W 113 00.795	084	0	084	11.6E	072	35000M	0.72	415	1247.8	04+55+04			235.6 K	55.6 K
	115.90M	HANKSVILLE	N 38 25.009						-54C	242	414	109.2	00+15+49	17:43:55			3.3 K
J28	106X	HVE	W 110 41.984	088	0	088	10.8E	076	35000M	0.72	414	1356.9	05+10+53			232.4 K	52.4 K
		HBU/E256074	N 38 27.055						-54C	241	413	98.8	00+14+20	17:58:15			2.9 K
J28		BDROC	W 108 36.331	088	0	088	10.0E	077	35000M	0.72	413	1455.7	05+25+13			229.5 K	49.5 K
	114.90M	BLUE MESA	N 38 27.127						-54C	241	413	73.8	00+10+44	18:08:59			2.2 K
J28	096X	HBU	W 107 02.383	089	0	089	9.3E	079	35000M	0.72	413	1529.5	05+35+57			227.3 K	47.3 K
		HBU/E080033	N 38 24.944						-54C	241	412	32.9	00+04+48	18:13:46			1.0 K
J28		ELWAY	W 106 20.587	094	0	094	9.0E	084	35000M	0.71	412	1562.4	05+40+44			226.3 K	46.3 K
		PUB/R262045	N 38 21.507						-54C	240	412	45.6	00+06+39	18:20:25			1.3 K
J28		RODDY	W 105 22.743	094	0	094	8.5E	085	35000M	0.71	412	1608.0	05+47+23			225.0 K	45.0 K
		PUB/R262031	N 38 20.400						-54C	240	412	13.5	00+01+58	18:22:23			0.4 K
J28		FLOOD	W 105 05.640	095	0	095	8.4E	086	35000M	0.71	412	1621.5	05+49+21			224.6 K	44.6 K
		PUB/R262010	N 38 18.581						-54C	240	411	21.2	00+03+05	18:25:28			0.6 K
J28		FSHER	W 104 38.852	095	0	095	8.1E	086	35000M	0.71	411	1642.7	05+52+26			224.0 K	44.0 K
	116.70M	PUEBLO	N 38 17.655						-54C	240	411	10.3	00+01+31	18:26:59			0.3 K
J28/J17	114X	PUB	W 104 25.767	095	0	095	8.0E	087	35000M	0.71	411	1653.0	05+53+57			223.7 K	43.7 K
	111.20M	TOBE	N 37 15.519						-54C	240	411	73.5	00+10+44	18:37:43			2.1 K
J17	049X	TBE	W 103 36.003	147	0	147	7.5E	139	35000M	0.71	411	1726.6	06+04+41			221.6 K	41.6 K
		TBE/E130039	N 36 44.318						-54C	239	410	39.4	00+05+45	18:43:29			1.1 K
J17		KENTO	W 103 05.952	142	0	142	7.2E	135	35000M	0.71	410	1765.9	06+10+27			220.4 K	40.4 K
	116.60M	PANHANDLE	N 35 14.104						-54C	239	410	113.0	00+16+33	19:00:02			3.2 K
J17/J6	113X	PNH	W 101 41.942	142	0	142	6.4E	135	35000M	0.71	410	1878.9	06+27+00			217.2 K	37.2 K
		IRW/R262062	N 35 20.125						-54C	238	408	139.3	00+20+28	19:20:30			3.9 K
J6		CRUSR	W 098 51.973	087	0	087	4.8E	080	35000M	0.71	408	2018.2	06+47+28			213.3 K	33.3 K
			N 35 23.695						-54C	238	408	7.8	00+01+09	19:21:39			0.2 K
		.Descent pt	W 098 43.478	063	0	063	4.7E	058	35000M	0.71	408	2026.0	06+48+37			213.1 K	33.1 K
		IRW/R292032	N 35 37.028						-29C	N/A	N/A	29.4	00+04+19	19:25:57			0.4 K
DCT		CAMET/W	W 098 11.422	063	0	063	4.4E	058	22283M	N/A	N/A	2055.4	06+52+55			212.6 K	32.6 K
		TINKER	N 35 26.190						+9C	N/A	N/A	41.1	00+07+49	19:33:46			0.7 K
DCT	105X	TIK/T	W 097 22.781	105	0	105	3.8E	101	3000M	N/A	N/A	2096.5	07+00+44			211.9 K	31.9 K
		TINKER AFB	N 35 24.884						+12C			1.3	00+20+00	19:53:46			2.0 K
		KTIK/A	W 097 23.198	195	0	195	3.9E	191	1291M			2097.8	07+20+44			209.9 K	29.9 K

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A2.15 On Wing Engine Wash Savings

The EATF analyzed IATA Fuel Book Total Specific Fuel Consumption (TSFC) figures to determine the approximate efficiency gained by washing the E-3's TF-33 engines. Although the IATA Fuel Book does not have documented savings for the TF-33, it does have savings rates for similar commercial engines. The EATF selected the most conservative comparable engine, which showed a TSCF improvement of 0.4%, and applied it to the average fuel burn for the total E-3 fuel consumption in FY15 to estimate the savings Tinker AFB achieved with this initiative. We based savings on the Feb 2016 DLA price of $2.61 per gallon.

On Wing Engine Wash Program Savings	
Fuel (gal) Consumed by Tinker E-3 (FY15 from AFTOC)	39,725,373
Fuel (gal) Saved (based on 0.4% savings)	158,901
Potential Savings $ per year	**$414,732**

Figure A2.18 On Wing Engine Wash Savings

A2.16 Reducing Excess Weight – 1200 lb Nose Weight vs 5,000 lbs fuel

The figures below detail the potential savings by utilizing a 1,200 lb nose weight in lieu of carrying 5,000 lbs ballast fuel on each TCTO 1E-3-891 modified aircraft, resulting in a 3,800 pound weight savings on every sortie. Crews found the ballast fuel was necessary following completion of TCTO 1E-3-891 to ensure the aircraft maintained the proper center of gravity (CG). Removal of equipment during the TCTO upgrade pushed the aircraft CG too far aft. The ballast weight is positioned farther forward in the aircraft than is possible for the ballast fuel, thus allowing a lower weight.

E-3s receive TCTO 1E-3-891 during normally scheduled depot level maintenance. As of 2016, the 552 ACW modifies approximately six aircraft per year and has 18 aircraft remaining to complete the TCTO conversion. The AF will complete TCTO 1E-3-891 in Calendar Year 2018 or 2019.

We derived the cost to carry calculations from standard industry practice outlined in the IATA Fuel Book and backed the calculations up with AMC/A9 analysis across multiple heavy weapons systems. We base the savings on 1,350 sorties per year, typical 7-hour training sortie duration, and the Feb 2016 standard DLA fuel price of $2.61 per gallon. Cost of weight (COW) factors for multiple weapons systems are outlined in Figure A2.20.

Appendix 2

Potential Savings with Ballast Nose Weight	
Weight reduction with TCTO 1E-3-891 (lbs)	3,800
Fuel saved with weight reduction (3% per hour, 7-hour sortie)(lbs)	798
Number of sorties/year with TCTO modified aircraft	1,350
Total fuel saved by using nose weight on TCTO modified acft (lbs)	1,077,300
Converted to Gallons @ 6.7 lb per gallon	160,791
Cost Savings	**$419,664**

Figure A2.19 Excess Weight 1,200 lb ballast weight in lieu of 5,000 lbs ballast fuel

Cost-of-Weight[21][22]	
C-17	3.08%
C-5	3.17%
KC-10	2.89%
KC-135	2.35%
Boeing 737	3.6%
Boeing 777	3.8%

Figure A2.20 Cost of Weight Calculations

[21] Military acft COW from AMC 2020 Fuel Consumption Metrics (AMC/A3F) 6/19/2014.

[22] Civilian acft COW from IATA "Guidance Material & Best Practices for Fuel and Environmental Mgmt Oct 2011.

A2.17 Reducing Weight – EFB vs Paper Publications

The figures below detail the annual cost to carry paper publications for missions flown from Tinker AFB. The 552 ACW weighed the standard aircrew and mission crew publications for each crew position and provided these weights to the EATF. We derived the cost to carry calculations from standard industry practice outlined in the IATA Fuel Book and backed the calculations up with AMC/A9 analysis across multiple heavy weapons systems. We base the savings on 1,350 sorties per year, a typical 7-hour training sortie duration, and the Feb 2016 standard DLA fuel price of $2.61 per gallon.

Paper Publications	
Paper publications weight (lbs)	222
EFB iPad combined weight (lbs)	23
Savings in weight not carried per sortie (lbs)	199
Fuel saved per sortie (lbs)	42
Annual fuel savings (lbs) (1350 sorties per year)	56,416
Annual fuel savings gallons[23] (gal)	8,420
Total Dollar savings	**$21,977**

Figure A2.21 Excess Weight Paper Publications

[23] Standard fuel weight of 6.7 lbs per gallon

Appendix 2

A2.18 Savings

The table below identifies each technique as a best practice, recommendation, or not applicable for the LOEA. The table also shows the potential savings for each technique where applicable. The Wing saved $4.5M by implementing the efficiency measures we identified as best practices. The Wing could save an additional $5.0M if they were able to implement all recommendations. Combined efficiency savings total $9.5M.

Para	Title	Best Practice	Recommend	N/A	Best Practice Savings	Potential Savings
3.1	Collecting Data		X			Unknown
3.2	Inflight Guide (IFG)		X			Unknown
3.3	Training Range Usage	X			$2.5M	$675K
3.4	Local Airspace Utilization		X			Unknown
3.5	APU Use		X			$273K
3.6	Flight Planning Software		X			Unknown
3.7	Mission Fuel Loads		X			$1.882M
3.8	Engine Start Times		X		$1.41M	$473K
3.9	Taxi: Reduced Engine Taxi-Out		X			$294K
3.10	Minimizing Taxi Time Prior to Takeoff			X		N/A
3.11	Takeoff Flap Setting			X		N/A
3.12	Reduced Power T/O	X				Unknown
3.13	Initial Climb Cleanup			X		N/A
3.14	Climb Technique at 10,000 feet		X			Unknown
3.15	Cruise Altitude		X			$832K
3.16	Cruise Speed	X				Unknown
3.17	Descent Technique		X			$84K
3.18	Approach Configuration			X		N/A
3.19	Landing Flaps			X		N/A
3.20	Taxi: Reduced Engine Taxi-In	X			$210K	
3.21	Debrief – Efficiency		X			Unknown
3.22	Maintenance – On Wing Engine Wash	X			$414K	
3.23	Contract Fighters		X			Unknown
3.24	Aircraft Weight Reduction		X			$442K
	Total				**$4.5M**	**$5.0M**

Figure A2.22 Potential Savings

2.19 Discussion on Selecting Maximum Endurance Speed

We had a healthy discussion with E-3 crews, aeronautical engineers, and flight test engineers regarding the most accurate method of determining maximum endurance speed for the E-3 and aircraft in general. To preface this discussion, everyone agrees the E-3 community use of a maximum endurance profile during the mission profile was a best practice. The discussion centers around whether crews should fly the maximum endurance angle of attack (AoA) on the AoA gauge, or fly the maximum endurance speed calculated from T.O. 1E-3A-1-1.

T.O. 1E-3A-1-1 provides a prescriptive method for determining maximum endurance speed for all mission conditions. The procedure in the 1E-3A-1-1 is also the only prescribed procedure for selecting maximum endurance speeds for the E-3.

The AoA gauge makes adjusting the maximum endurance extremely easy, and crews can continually adjust pitch to maintain the maximum endurance profile. Additionally, it's widely accepted that flying in reference to AoA versus speed is more accurate for most flight regimes. All pilots learn the aircraft stalls at a specific AoA, not a specific speed. AoA is a superior method for detecting stall, because the wing stalls when the critical AoA is reached, and the speed at which the aircraft reaches critical AoA varies widely depending on aircraft configuration, weight, and aerodynamic loading. However, use of AoA for determining the most efficient profile at cruise speeds for high speed jet aircraft may not be the optimal method because of the effects of higher Mach numbers on AoA. Boeing produced a technical article in their Aero Magazine in October 2000 titled "Operational Use of Angle of Attack in Modern Commercial Jet Airplanes[24]" which strongly advocates for the use of flight performance data in the flight manual to select the cruise speeds versus using AoA.

The EATF doesn't want anyone to lose sight of the fact that crews are flying maximum endurance profiles, whether it be referenced to speed or AoA. The EATF recommends crews use the 1E-3A-1-1performance tables to compute the maximum endurance speed primarily because this is the documented method for the E-3. Additionally, Boeing recommends this approach.

2.20 Additional Discussion on Data Collection

Cruise Altitude/Speed: The EATF recommends the Wing collect outbound and RTB cruise altitude and cruise speed for each mission and mission training sortie. To make this data meaningful, the crews will also need to record the optimal altitude and speed and the rationale for why they did not use the optimal altitudes/speeds if applicable. Planned altitude and speed could also provide analysis value.

APU Use: We've found that tracking APU use can go a long way in reducing APU use. Crews can only track APU use they witness for the mission. To that end, we recommend the OG Form

[24] Boeing Aero Magazine, October 2000. http://www.boeing.com/commercial/aeromagazine/aero_12/attack.html

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49 gather data such as: Was the APU operating when the crew showed for preflight? Did maintenance ask the crew to leave the APU running after the sortie? You'll also need information on why the APU was used versus ground power. Asking crews to select one of the following options could help identify the root cause:

☐ Ground Power/Air provided by maintenance and functioned properly

☐ Ground Power/Air not provided by maintenance

☐ Ground Power/Air provided, but stopped functioning

☐ Ground Power/Air provided and functioned, but not able to power/cool aircraft sufficiently

Appendix 3

Appendix 3: Reference Documents

- AF E-3 Fact Sheet. http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104504/e-3-sentry-awacs.aspx
- AFI 11-202 V3 General Flight Rules (7 Nov 14, with AFGM2015-01)
- AFI 11-202 V3 General Flight Rules (22 Oct 10) Air Combat Command Supplement (28 Nov 12)
- AFI 11-2E-3 V3 (14 Feb 12)
- AFI 11-2E-3 V3 552OGSUP (1 Mar 14)
- Air Force Audit Agency: Air Mobility Command Mission Index Flying Audit Report 16 Dec 2013
- AMC 2020 Fuel Consumption Metrics
- E-3 AWACS Pilot Aircrew Aid (1 Sep 2014)
- E-3 Weight and Balance March 2015
- Energy Analysis Task Force: Small Group Tryout Report (9 June 2015)
- FAA Line Operational Safety Audit (LOSA) Circular
- International Air Transport Association (IATA) Guidance Material and Best Practices for Fuel and Environmental Management (Fuel Book) 5th Edition
- International Civil Aviation Organization (ICAO) Flight Planning and Fuel Management Manual, Doc 9976 (Advanced 2112 Edition [unedited])
- Navigator E-3 AWACS Aircrew Aid (1 Sep 2014)
- T.O. 1E-3A-1-1 (1 Nov 11, Ch1 1 Jun 12)
- T.O. 1E-3A-1 (1 Feb 14, Ch1 15 Jul 14)

SAF/IEN Energy Analysis Task Force (EATF)

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