

Routine Instrument Landing System (ILS) Flight Inspections Conducted From a Remote Location

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ABSTRACT

This document addresses the origin of the remote ILS flight inspection concept, the benefits of conducting flight inspections remotely, and the hardware, software, and methods used to conduct remote flight inspections.

To fully support the Air Force Materiel Command (AFMC) Centralized Navigational Aids Maintenance concept, a method of conducting routine ILS periodic-with-monitors flight inspection was developed. This document will describe how that was accomplished and the methods used to implement the program.

Some of the issues presented in this document include:

- A short history of remote ILS Maintenance concepts and current activities
- Software/hardware utilized for all types of ILS periodic-with-monitors flight inspection
- Hardware installed for Capture Effect Glideslope (CEGS) and Sideband Reference Glideslope (SBRGS) flight inspection
- Equipment/methods used to interact with the flight inspection aircraft from a remote location
- Utilization and training level of local augmentation personnel
- Benefits realized from remote flight inspection
- Drawbacks encountered and methods used to overcome them

In this time of shrinking budgets, this document presents an alternative method of conducting flight inspections that realizes time and manpower savings.

INTRODUCTION

This document is not intended to be an endorsement or recommendation of any commercial entities by the Air Force or DoD.

Centralized maintenance of ILS in AFMC began as an equipment modernization in 2002 with a view toward the possibility of conducting remote maintenance in the future. Once the first system was fielded in November 2002 at Wright Patterson Air Force Base, Ohio, headquarters leadership and the AFMC Airfield Systems Customer Support Team (CST) recognized the remote maintenance potential of the new equipment and decided to exploit the capability sooner rather than later. Without going into unnecessary detail, AFMC embarked on a transformation effort that resulted in the CST remotely maintaining eleven single transmitter category I instrument landing systems, two localizer-only systems, five Tactical Air Navigation (TACAN) systems, one Very High Frequency Omni-range (VOR), and one Distance Measuring Equipment (DME) system at seven airfields from the center located at Eglin Air Force Base, Florida. The airfields are located in California, Utah, Oklahoma, Ohio, Georgia, and Florida. The CST is currently manned with five highly qualified technicians and one work group manager/administrative specialist, all civil service employees. Due to the fact that all of the replacement systems are covered under a 15-year warranty, all maintenance and certification activities are conducted well within a \$90K annual operations and maintenance budget. Our fleet availability rate exceeds 99.6%. Mean time to repair is less than 15 minutes from notification when a replacement part is not required, and is approximately 26 hours when a replacement part is required.

Centralized maintenance of ILS facilities loses its punch if technicians must travel all over the country to conduct routine, regularly scheduled periodic-with-monitors flight inspections. AFMC recognized that a true centralized maintenance capability would address conducting routine functions, including flight inspection, remotely. Methods to accomplish the following flight inspection tasks that are currently required to complete a periodic-with-monitors flight inspection were developed and are discussed in the next section.

1. Localizer Single Frequency – Alignment, modulation, normal width, and wide alarm adjustments.
2. Localizer Dual Frequency – Alignment, modulation, normal width, and course wide, clearance wide alarm adjustments.
3. Null Reference Glideslope – Modulation, normal width, wide alarm, and advance and retard phase to alarm adjustments.
4. Sideband Reference Glideslope – Modulation, normal width, wide alarm, low angle alarm, and advance and retard upper antenna to alarm adjustments.
5. Capture Effect Glideslope – Modulation level, normal width, course wide and clearance modulation percentage alarm, middle antenna advance and retard phase to alarm, and upper antenna attenuate to alarm. [1]

SOFTWARE FLIGHT INSPECTION CONTROLS

Localizers and null reference glideslope inspections are performed using only the software controls available in the equipment. Some checks on the sideband reference and capture effect glideslopes are also performed using the software controls. The following descriptions apply to the single transmitter Category I systems maintained by AFMC.

Flight Inspection Preliminaries

The CST initiates a remote maintenance session by using the Portable Maintenance Data Terminal (PMDT) program to contact the Remote Control and Status Unit (RCSU), normally located in the control tower equipment room, through a dial-up connection. The RCSU has two primary functions; it provides navigational aid status indications to the Remote Status Display Unit (RSDU) located in the Air Traffic Control (ATC) operations area, and it allows access to the navigational aid systems via the equipment status lines.

Security protocols against unauthorized equipment adjustment are described as follows:

1. The Air Force utilizes a telephone system to block unauthorized modem traffic into the bases; this acts as an initial security barrier.
2. The maintainer must possess the site or RCSU telephone number. This information is controlled under For Official Use Only rules.
3. The site computer will only communicate with the most current PMDT program. The RCSU or RMS will direct the on-site modem to disconnect immediately if the incoming data packets are not recognized as originating with the PMDT program. Copies of the PMDT program and the computers on which it is installed are carefully protected.
4. All levels of maintenance have user names and passwords and must have access to the highest security levels in order to affect signal in space. The passwords follow Air Force rules for complexity and are changed periodically, when employees leave the CST, or when a compromise is suspected.
5. Passwords and user names are encrypted with a special, proprietary binary protocol that has not been distributed outside of the manufacturers control to protect against interception.
6. In order to affect signal in space, the technician must take control of the system; air traffic control is notified immediately by the system when this occurs. The indication they receive is that of an off-the-air facility. The CST is notified and can begin investigating; meanwhile the site is removed from service by the controlling agency.
7. A connection log is maintained by the equipment and is periodically scanned by the CST to detect incursions by unknown users; we have yet to encounter one.

Upon completing the secure login procedure, a graphic of the airfield systems is displayed (See Figure 1). The technician merely right clicks the desired ILS component to gain access to its Remote Maintenance System (RMS) program. As a backup in the event of a status line failure, the PMDT can contact the RMS directly through a separate dial-up connection. The RCSU connection is preferred due to the speed at which the CST can transition from one ILS component to another during a flight inspection. The CST technician will perform any necessary pre-flight inspection checks and adjustments at this time.



Figure 1. RCSU System Display Screen

The remote flight inspection radio is then contacted and initialized in preparation for flight inspection. The radio system is covered in greater detail later in this document. Once the CST is in contact with the panel technician, the flight inspection begins.

Localizer Flight Inspection

Localizer alignment, modulation and normal width are adjusted utilizing the PMDT Transmitter Configuration screen (See Figure 2).



Figure 2. Localizer Transmitter Configuration Tab

Alignment adjustments are made using the CSB Modulation Balance Offset control. This control is very accurate and direct; if the panel technician calls out a 5 left alignment, adjusting this control 5 ddm in the 90 Hz direction will cause alignment to snap back to centerline. Modulation adjustments are made using the CSB Modulation Percentage Scale control.

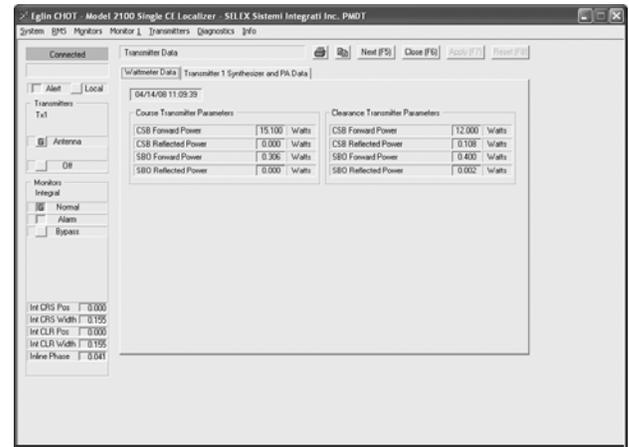


Figure 3. Wattmeter Data Tab

If a normal width adjustment is required, the existing sideband power is obtained from the Transmitter Data Wattmeter Data screen (See Figure 3), and applied to the formula: $existing\ sideband\ power \times (existing\ width \div desired\ width)^2 = new\ sideband\ power$. The sideband power is adjusted to the new level using the SBO RF Voltage Level Scale control while observing the Transmitter Data Wattmeter screen. If correction adjustments were made during normal flight inspection runs, it will be necessary to correct the monitor readings before proceeding into the alarm checks. This is done via the Monitor 1 Offsets and Scale Factors screen, Integral tab (See Figure 4), while observing the Monitor 1 Data screen, Integral tab (See Figure 5).

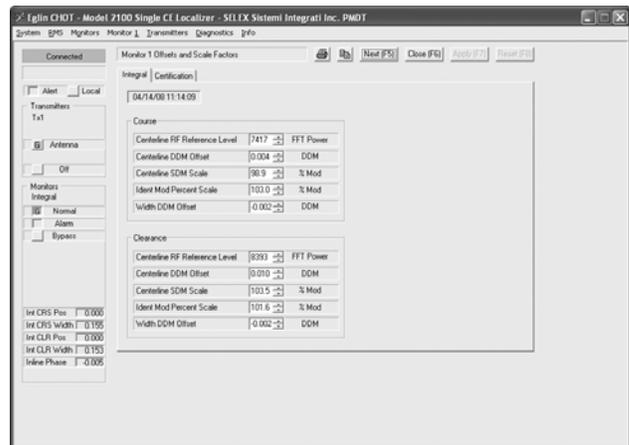


Figure 4. Monitor Offsets and Scale Factors Tab



Figure 5. Monitor Integral Data Tab

Alarm conditions are set up prior to flight inspection using the Transmitters Waveforms screens. The Waveform Data Names tab (See Figure 6) allows the technician to name the various alarm configurations that are applied during flight inspection.

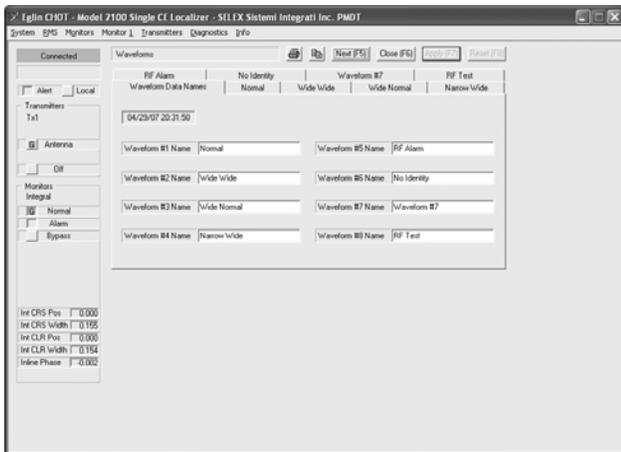


Figure 6. Waveform Data Names Tab

The Normal tab is the default selection for normal operations. The other tabs are copies of the Normal tab, with the specific parameters adjusted to duplicate the named alarm conditions.

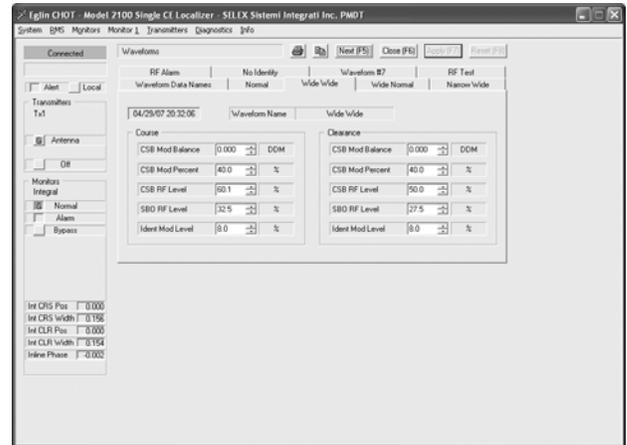


Figure 7. Waveforms Wide Wide Setup Tab

For example, the Wide Wide tab (See Figure 7) is adjusted for the course wide, clearance wide configuration by decreasing the Course and Clearance SBO RF Level % field until the Monitor 1 Data screen indicates wide alarm in both course and clearance. It should be noted that the waveform fields apply a proportional adjustment; if the normal width was adjusted prior to the alarm checks, and the monitor was reset to normal width, application of the Wide Wide waveform will take the monitors to the correct alarm limit that was set up previously.



Figure 8. Transmitter Commands Drop Down Menu

When the panel technician asks for course wide clearance wide, the CST merely selects Wide Wide from the Transmitters→ Commands→ Transmitter 1→ Select Waveform drop down menu (See Figure 8), verifies the monitor is in alarm, and reports attainment back to the panel technician. Returning to normal merely involves selecting Normal from the same drop down menu. This point and click method of performing alarm checks has decreased the time required to perform flight inspection and has reduced accidental adjustment errors (adjusting too far/not far enough) during flight inspection to zero.

Glideslope Flight Inspection

Many of the glideslope checks/adjustments are performed in exactly the same manner as the localizer checks and will not be addressed. These include normal path width and modulation level on all types of image glideslopes, wide alarm on null reference and sideband reference glideslopes, and path wide/clearance modulation percentage alarm on capture effect glideslopes.

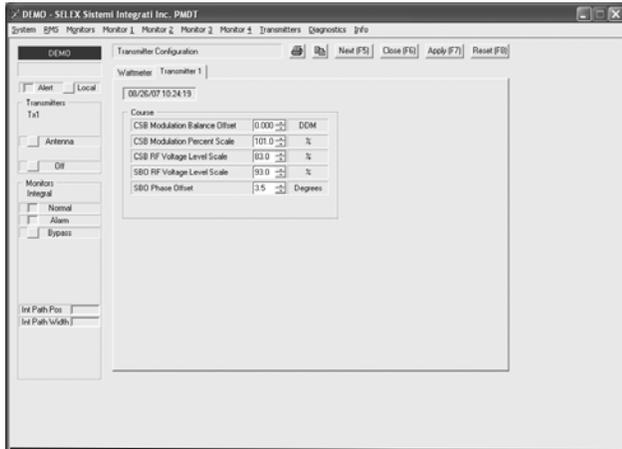


Figure 9. Glideslope Transmitter Configuration Tab

The sole remaining software controlled alarm check is the null reference glideslope advance and retard phase to alarm check. This check is performed using the PMDT Transmitter Configuration Transmitter 1 tab SBO Phase Offset control (See Figure 9). The current value of the SBO Phase Offset is recorded, and then the control is adjusted for a width alarm on the Monitor X Data screen. A positive adjustment advances the phase; a negative adjustment retards the phase. The amount of change is then reported to the panel technician as dephase required to take the monitors to width alarm. At the completion of the check, the SBO Offset control is returned to the value previously recorded. Because of a $\pm 35^\circ$ limitation in the SBO Phase Offset adjustment, it is imperative that the amount of offset entered to obtain the correct carrier to sideband phase relationship be within $\pm 5^\circ$. This was easily done with some cable trimming, until it was time to replace a failed amplifier. The offset required for the new amplifier often exceeded $\pm 5^\circ$ and the CST was not on site to trim a cable. This was okay as long as a flight inspection was not imminent, but forced a trip to correct prior to the next with monitors flight inspection. Not to mention, there is a finite amount of cable available for trimming. The immediate solution was to adjust the power amplifiers before they left the manufacturer to be within 5° of each other. Further improvements will include an increase in the range of the SBO Offset adjustment, completely solving the problem.

HARDWARE FOR GLIDESLOPE FLIGHT INSPECTION

In order to complete sideband reference and capture effect glideslope flight inspections, remote test units (RTU) were developed that duplicated alarm conditions that were previously performed by on-site technicians.

Sideband Reference Glideslope

The sideband reference glideslope RTU is used to check low angle alarm (the unit is also capable of high angle alarm checks for commissioning and special flight inspections), and advance and retard upper antenna phase to alarm checks.

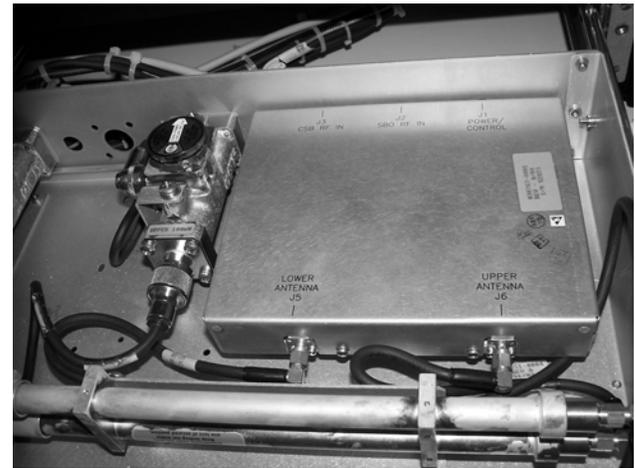


Figure 10. Sideband Reference Glideslope ATU/RTU

The sideband reference RTU (See Figure 10) is built into a special version of the sideband reference amplitude phase control unit (APCU). The unit is controlled by the PMDT program via the RMS from the Transmitter→ Commands→ Remote Tests dropdown sub menu (See Figure 11).

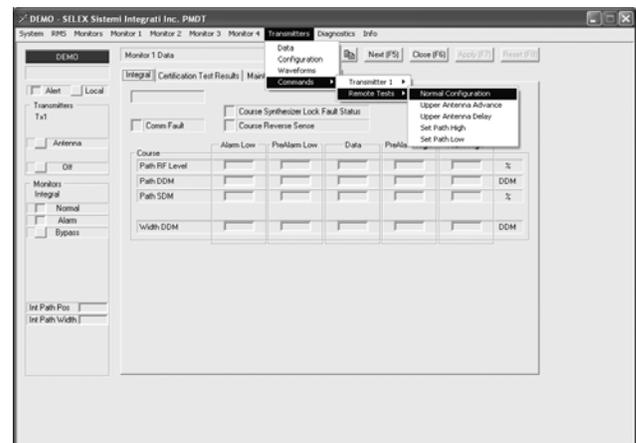


Figure 11. Sideband Reference Glideslope Remote Test Commands Drop Down Menu

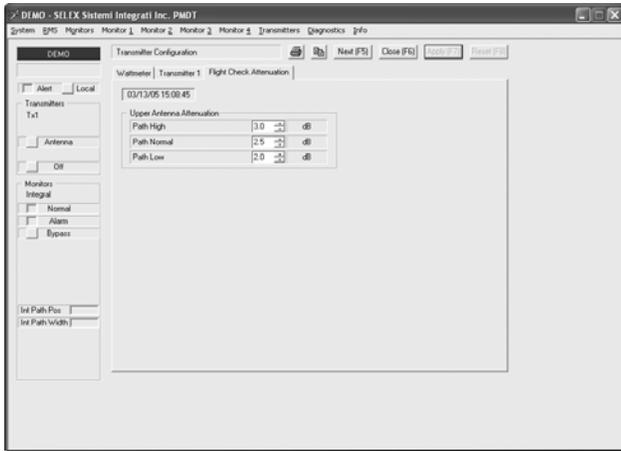


Figure 12. Sideband Reference Glideslope Upper Antenna Attenuation Tab

The amount of upper antenna attenuation required for low and high angle alarm is adjusted prior to flight inspection in the same manner that the Waveform screens are set up using the Transmitter Configuration Flight Check Attenuation screen (See Figure 12). The difference between Path Normal and Path Low is the decibel (dB) reading passed to the panel technician during the low angle alarm run. The RTU switches in a fixed phase delay of approximately $\pm 19^\circ$ for the upper antenna advance and retard phase to alarm check. This approximately simulates inserting an N-type elbow adaptor in the upper feed line for retard and the lower feed line for advance. That amount of dephase is reported to the panel technician during these alarm checks.

Capture Effect Glideslope

The capture effect glideslope RTU is used for the advance and retard middle antenna to alarm, and the upper antenna attenuate to alarm checks. The RTU is mounted on top of the capture effect APCU and is connected between the APCU and the antenna feed lines (See Figure 13).

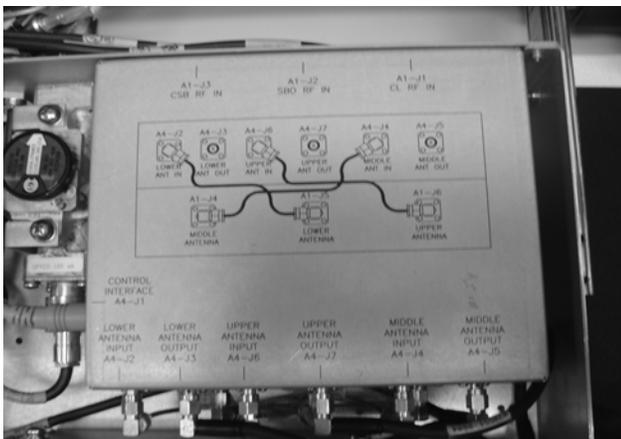


Figure 13. Capture Effect Glideslope ATU

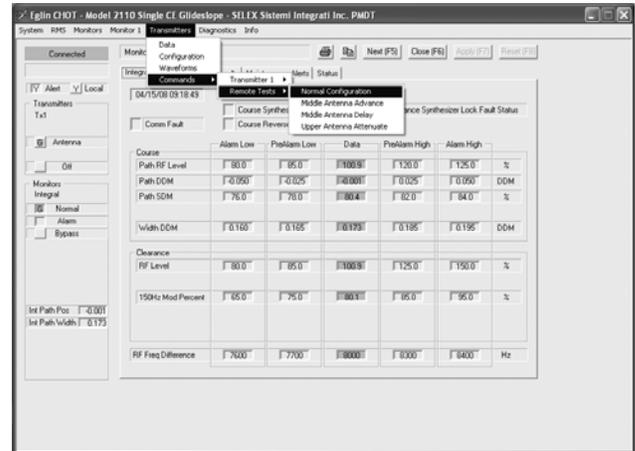


Figure 14. Capture Effect Glideslope Remote Test Commands Drop Down Menu

The controlling menu is much the same as the sideband reference glideslope menu (See Figure 14). The upper antenna attenuator is fixed at 1.4 dB; that amount of attenuation is reported to the panel technician during this alarm check. The RTU switches in a fixed phase delay of approximately $\pm 15^\circ$ for the middle antenna advance and retard phase to alarm check. This simulates sliding the middle antenna trombone phase control $\pm 15^\circ$. That amount of dephase is reported to the panel technician during these alarm checks. The one drawback to this method; because the attenuation and phase lengths are fixed, it is necessary to adjust the path width wide alarm limit to the condition that widens the path the least. This causes the CST to maintain a tighter lower alarm limit on the capture effect glideslopes than on the other two types of image systems; however, this limitation has not posed a maintainability or availability problem as yet.

REMOTE FLIGHT INSPECTION COMMUNICATIONS

The CST utilizes a dial-up radio system positioned at a glideslope on each airfield. The radio's antenna is mounted to the top of the glideslope tower for greater coverage and is fed through a low-loss cable (See Figure 15).



Figure 15. Dial-up Radio Antenna

The radio is connected to the site phone line and answers incoming calls through an interface assembly (See Figure 16).



Figure 16. Dial-up Radio System

At the CST facility, another assembly connects to a standard telephone, allowing the telephone to act like a push-to-talk radio (See Figure 17).



Figure 17. Remote Control Telephone Adapter

A key feature of this assembly is that it automatically resets an inactivity timer in the radio interface assembly to keep the CST on the air while lengthy flight inspection runs are being completed. In a pinch, the CST can also use a conventional or cellular telephone to communicate with the radio interface using a */# keying procedure. The CST has had great success in communicating with flight inspection aircraft at all of our airfields using this set-up.

LOCAL AUGMENTATION PERSONNEL

Augmentation personnel at our airfields are Airfield Systems maintenance technicians primarily responsible for those systems that are not yet remote maintenance capable. These include Radar, Meteorological, and ATC Radio systems. Their role in remote ILS maintenance is generally limited to replacing components at the direction of the CST, shipping bad parts back to the manufacturer, and maintaining the shelters to include power and communications. They also assist the CST in troubleshooting efforts by setting up the Portable ILS Receiver (PIR) and relaying data back to the CST. They have not and will not receive any formal, comprehensive training in ILS maintenance; the trained personnel are all assigned to the CST. Usually, augmentation assistance is not required for a routine ILS flight inspection, but personnel remain available should a site communications line fail, or an issue with the flight inspection radio develops. They also remain available should a new facility ground reference need to be established because of an adjustment that was required during the course of the flight inspection.

REMOTE FLIGHT INSPECTION BENEFITS

While remote flight inspection was developed as part of the whole remote ILS maintenance concept, some benefits have been realized that can be applied to standard on-site maintenance as well. A few of these benefits include:

1. Time saved. Since ground personnel don't have to move from the localizer to the glideslope to complete a flight inspection, that travel time is eliminated. Also, time is saved utilizing the point and click method of achieving alarms and returning to normal versus on-site manual adjustments.
2. Errors decreased. When a technician can set up an alarm waveform file at his leisure well before a flight inspection begins, and then select it with a mouse click, rather than adjusting the equipment in the heat of battle, the chance of an error occurring are greatly diminished. Another problem is that due to the infrequency of periodic-with-monitors flight inspections, especially at small airfields, technicians find it difficult to maintain their proficiency at performing flight inspection tasks. In the case of the CST, proficiency is maintained because there are only five of us performing all of the inspections at seven airfields; there is ample opportunity for all of us to conduct flight inspections.
3. Flexibility. The CST is able to handle last minute schedule changes and unannounced arrivals of flight inspection aircraft with ease. Since we do not have to gather equipment and travel to the sites, we can be in flight check mode in less than five minutes after notification. If an aircraft is delayed, we aren't sitting around at a site; we can perform other work while we are waiting. If a crew or a scheduler should decide to knock out an inspection with little or no warning, we can easily support that.
4. Potential for monetary and manpower savings. In the conventional world, time is saved by positioning a technician at each site with his own radio, but that doubles the manpower and equipment requirement. Compare that to the potential demonstrated by the CST; we can easily conduct inspections at five airfields simultaneously with the five technicians assigned!

DRAWBACKS AND SOLUTIONS

While there have been more than a few challenges to overcome as part of centralized remote ILS maintenance, relatively few of those have affected remote flight inspection. At the outset, it was not possible to conduct remote flight inspection without local assistance with communications. This was solved with the remote radio system. It was also impossible to perform capture effect and sideband reference glideslope inspections remotely;

problem solved with the development and installation of the Remote Test Units.

CONCLUSIONS

The CST has been conducting remote flight inspection successfully since February 2003. That equates to approximately 40 periodic-with-monitors flight inspections that required no permanently assigned on-site personnel and did not require a site visit by a CST member. That has saved AFMC over \$100,000 in travel expenses alone. Less tangible, but equally important, is the flight inspection time saved using point and click methods to prepare the facilities for flight inspection, move from one site to another, and configure the equipment for alarm checks. Flexibility and concentrated CST training opportunities further contribute to an already stellar program.

FUTURE WORK

The CST is currently working the process to put the RCSU computers on the base networks with the most current security protocols. While this is meant to enhance our remote maintenance and monitoring posture, the fall-out for the remote flight inspection program will be quicker response times and less reliance on our aging copper-in-the-ground communications infrastructure while performing a flight inspection

ACKNOWLEDGEMENTS

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Our augmentation partners at each of our airfields, who are always ready to assist when required.

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REFERENCES

- [1] FAA, 15 October 2005, U.S. Standard Flight Inspection Manual, including Change 1, 2 February 2007, Order 8200.1C

Biography



MR LESLIE E ATKINSON

Mr. Atkinson is the Chief of the Air Force Materiel Command (AFMC) Airfield Systems Customer Support Team (CST), comprised of five Engineering Technicians and one Workgroup Manager, located at Eglin Air Force Base Florida. The team is responsible for centralized Navigational Aids maintenance and for administering the Air Traffic Control and Landing Systems (ATCALs) standardization and evaluation program across AFMC.

Mr. Atkinson entered the US Air Force in 1977 as a Navigational Aids technician, progressing to lead supervisory technician in 1984. In 1986, he was selected as a Special Maintenance Technician (SMT) by Headquarters, Strategic Air Command. In 1992, he was reassigned as a SMT to Headquarters, Air Combat Command, progressing to lead SMT in 1996. He retired from the Air Force in 1998.

Mr Atkinson joined the civil service ranks at Headquarters, Air Combat Command as an Air Force Engineering and Technical Services (AFETS) specialist in October 2000. He joined the CST in December 2002, and was selected as chief in August 2007. Total Navigational Aids maintenance experience is 29 years, with 20 of those years at the technician-in-depth level. Those duties included maintenance assistance above the local technician level, providing in-depth training to airfield technicians, and authoring technical orders and training materials.

He earned an AAS in Electronic Systems Technology from the Community College of the Air Force in 1996, and an AAS in Electronics Technology from Thomas Nelson Community College in 2000. He is currently a senior at Embry Riddle Aeronautical University pursuing a BS in Technical Management.