

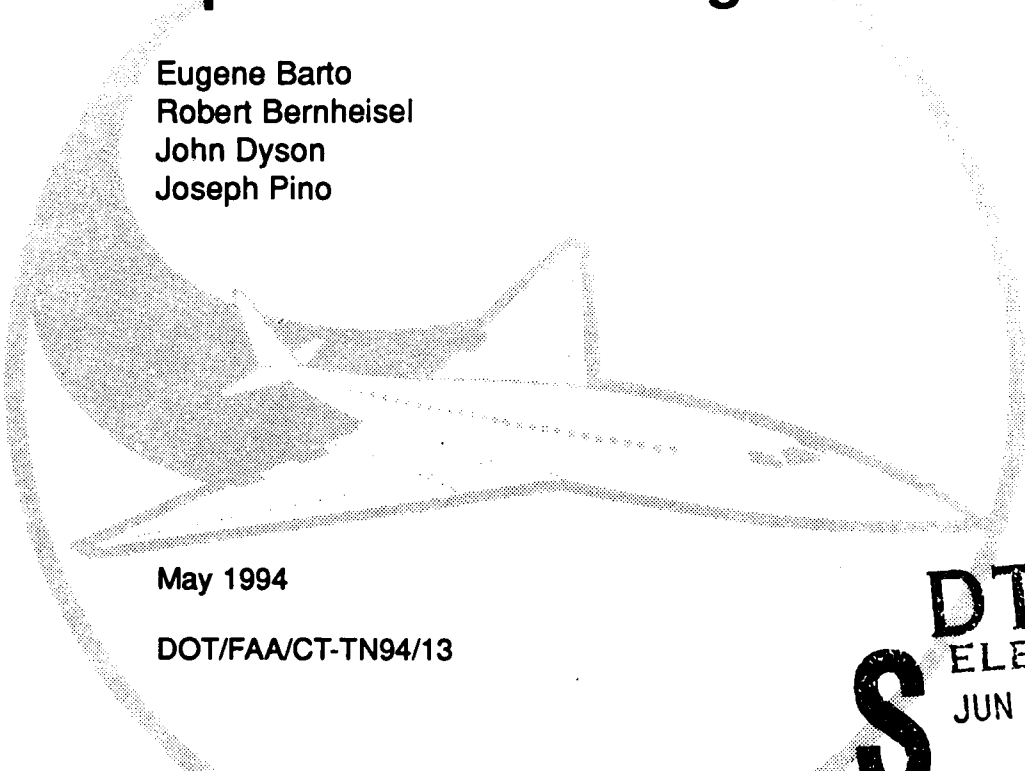
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VHF Direction Finder (VDF) Operational Test and Evaluation (OT&E) Integration and OT&E Operational Test Logs and Data

Eugene Barto
Robert Bernheisel
John Dyson
Joseph Pino



May 1994

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16. Abstract Preliminary Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing was conducted on the Very High Frequency (VHF) Direction Finder (VDF) at the Green Bay, WI, Automated Flight Service Station (AFSS), from March 29 through April 9, 1993. Formal OT&E Integration and OT&E Operational testing was conducted from June 21 through June 24. Testing was categorized into the areas of integration and maintenance, display and keyboard functions, and operational flight testing. This document provides the logs and processed data from the OT&E Integration and OT&E Operational tests. This document supplements the VHF Direction Finder (VDF) Operational Test and Evaluation (OT&E) Integration and OT&E Operational Test Report, DOT/FAA/CT-TN94/12.			
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TABLE OF CONTENTS

SECTION

- 1 PRELIMINARY OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION AND OT&E OPERATIONAL TEST LOGS: MARCH 29 THROUGH APRIL 9, 1993
- 2 OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION AND OT&E OPERATIONAL TEST LOGS: JUNE 21 THROUGH JUNE 24, 1993
- 3 PRELIMINARY OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION AND OT&E OPERATIONAL TEST LOGS: MARCH 29 THROUGH APRIL 9, 1993
- 4 OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION AND OT&E OPERATIONAL TEST LOGS: JUNE 21 THROUGH JUNE 24, 1993
- 5 CORRELATED POSITION DATA SPREAD SHEETS PRELIMINARY AND FORMAL OT&E
- 6 COMMENTS ON TECHNICAL INSTRUCTION AND MAINTENANCE ISSUES
- 7 ACRONYMS AND ABBREVIATIONS

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EXECUTIVE SUMMARY

The Direction Finder (DF) network is maintained and operated by the Federal Aviation Administration (FAA) as a position location service for aircraft. The present network is made up of a mix of tube-type and solid-state equipment. The tube-type equipment will be replaced by new solid-state equipment; the FA-10121, which incorporates operator task automation, remote maintenance monitoring, and control and certification capabilities.

Preliminary Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing was conducted on the Very High Frequency (VHF) Direction Finder (VDF) at the Green Bay, WI, Automated Flight Service Station (AFSS), from March 29 through April 9, 1993, using software release 4.05. Formal OT&E Integration and OT&E Operational testing was conducted from June 21 through June 24, 1993, using VDF software release 4.07. Testing was categorized into the areas of integration and maintenance, display and keyboard functions, and operational flight testing. Flight testing used the Federal Aviation Administration (FAA) Technical Center Aero Commander 680E aircraft.

This document provides the logs and processed data from the OT&E Integration and OT&E Operational tests. This document supplements the VHF Direction Finder (VDF) Operational Test and Evaluation (OT&E) Integration and OT&E Operational Test Report, DOT/FAA/CT-TN94/12.

SECTION 1

PRELIMINARY OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION AND
OT&E OPERATIONAL TEST LOGS: MARCH 29 THROUGH APRIL 9, 1993

DIRECTION FINDER TEST OBSERVER/MONITOR NOTES

Test Category/Number: Flight Scenario 1 Date: 4/5/93 Time: 1:30 PM
Test Observer/Monitor: Bill Swart (SEIC ANN-600 support)
Observations/Comments:

Observations at IDCU #2 with Charlie Warner operating and Bob Bernheisel taking data:

- * Lost Positions two and three due to lack of pilot audio.
- * Began getting other aircraft transmissions around positions three and four.
- * Had AF technician change GRB audio level from -16 dB to 0 dB and squelch from -97 dB to -140 dB. This improved pilot audio.
- * Position 6 was the transmission announcing that position 6 would be in 10 seconds.
- * IDCU #2 operator stated aircraft passing over STE; within 5 seconds IDCU reported same.
- * IDCU #2 was switched from Automatic Mode to Manual Mode prior to position 9.
- * STE DF was deselected after position 12.

Direction Finder Test Mission Log

Test Category/Number: 3/Flight Scenario 1 Date: 04/05/93 Time: 13:35

Test Manager : John Dyson/Joe Pino

Hardware Configuration:

Software Configuration: CM Version 4.05

Personnel Name	Title	Function
John Dyson	Test Director	Test Director
Sam Barto	Computer Scientist	Lead Data Collector
Bob Bernheisel	Electronics Technician	Data Collector
Charlie Parks	ATZ-120	Data Collector/Monitor
Joe Pino	APMT	Test Monitor
Ron Lockhart	Support Engineer	Airborne Data Collector
Theos McKinney	Flight Test Pilot	Test Pilot
Dale Walker	AT Specialist	Floor IDCU Operator
Charlie Werner	AT Specialist	Training Room IDCU Operator

Discussion Items:

- * AT Specialist provides a DF Approach to Green Bay Airport.
- * Training given AT specialists will be assessed during scenario.
- * DF reported positions at both floor and training room IDCU's will be compared against GPS derived aircraft data.
- * Floor IDCU in manual mode; training room IDCU in automatic mode/manual mode.

Deviations/Discrepancies:

(1) Keyline inhibit not meeting intent of specification

- AT specialist keying mike after an aircraft transmission caused a strobe update even though strobe inhibit was enabled causing aircraft history to be lost.

Direction Finder Test Mission Log

Test Category/Number: 3/Flight Scenario 1 Date: 04/05/93 Time: 13:35

Test Manager : John Dyson/Joe Pino

Hardware Configuration:

Software Configuration: CM Version 4.05

(2) Channel selection illuminator was observed to extinguish upon some at specialist transmissions. Drop or block of received aircraft transmissions was observed upon at least 3 occurrences.

(3) Strobes and aircraft symbol was replaced in manual mode with strobe inhibit on D-1 upon several occurrences

- Observed at IDCU of training room and AFSS floor position.

(4) A strobe was placed at 189 (SFC site) on the IDCU in the training room while in automatic mode on several occasions. This occurred even during a continuous aircraft transmission.

Test Category/Number: Flight Scenario 1 Date: 4/5/93 Time: 13:35
Test Observer/Monitor: Charlie Werner, AT Specialist Green Bay
Observations/Comments:

On three occasions the equipment placed a strobe when I was in manual mode and had not depressed the strobe key.

On several occasions during the approach to Green Bay the equipment placed a strobe to 189 (the SFC site), not the ACFT. This occurred even during a continuous ACFT transmission.

DIRECTION FINDER TEST OBSERVER/MONITOR NOTES

Test Category/Number: Flight Scenario 1 Date: 4/5/93 Time: 13:35

Test Observer/Monitor: Dana K. Dias, (Pragmatics ANN-600 Support)

Observations/Comments: (IDCU# 1- the floor)

(1) During the scenario the system was operated in the "Manual Mode." I witnessed, although connected to the ICSS with keyline inhibit activated, whenever the operator communicated with the aircraft, a new placement was established. The intent of the keyline inhibit is to prevent ground to air transmission placements.

(2) The Grimm Audio Box located on the IDCU console would toggle off and on during the latter part of the scenario. Will check for a repeat of this occurrence during other flight scenarios.

(3) The operator displayed exceptional skill during DF approaches. The system responded well to all commands and provided the necessary assistance to orient the aircraft safely to an airport.

DIRECTION FINDER TEST SUMMARY FORM

Test Category/Number: 3/Flight Scenario 1 Date: 04/05/93

Observations/comments:

DF approaches conducted by AT specialist were considered very good from the test aircraft flight crew's vantage point; Shawano Lake was missed by approximately 2 miles.

Significant Anomalies/Deviations:

Keyline Inhibit did not meet intent of specification; channel selection illuminator extinguished during AT specialist transmissions upon several occasions; received aircraft transmissions were dropped or blocked on at least 3 occasions; strobes and aircraft positions symbols replaced in manual mode in strobe inhibit.

Preliminary assessment:

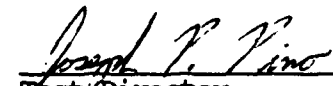
Further flight scenarios will allow more investigation of observed anomalies. The keyline inhibit observation appears to be noncompliant with the specification. Flight test went well overall with satisfactory coordination. Better communication is required between floor IDCU and training room IDCU personnel (ICSS in training room should allow pertinent frequency selections).

Grimm audio monitor on floor IDCU was noted as giving poor fidelity by some test monitors/observers and could be a reliability concern.

Different AT specialists will be used on further flight scenarios to allow a greater sample for training assessment.

A keyboard anomaly is speculated as a keyboard hardware failure (training room IDCU) and will be investigated prior to further flight testing.

Atch: Test Mission Log, As run test procedure, Test Conduct Log, Test Monitor/Observer Notes, Test Problem Reports.


Test Director

Direction Finder Test Mission Log

Category/Number: 3/Flight Scenario 2 Date: 04/06/93 Time: 9:05

Test Manager : Joe Pino/John Dyson

Hardware Configuration:

Software Configuration: CM version 4.05

Personnel Name	Title	Function
John Dyson	Test Director	Test Director
Sam Barto	Computer Scientist	Lead Data Collector
Bob Bernheisel	Electronics Technician	Data Collector
Charlie Parks	ATZ-120	Observer/Collector
Joe Pino	APMT	Test Monitor
Ron Lockhart	Support Engineer	Airborne Data Collector
Theos McKinney	Flight Test Pilot	Test Pilot
Kevin Hodina	AT Specialist	Floor IDCU Operator
Bill Swart	ANN-600 Support Engineer	Training Room IDCU Operator

Discussion Items:

- * Induced failure of RMMC 1 at scenario point #20 via powerdown.

Deviations/Discrepancies:

(1) RMMC 2 was failed via powerdown approximately 10 minutes after assuming primary status. System had to be manually initialized since RMMC 1 had not manually been set to backup mode after previously induced failure. AF technician successfully restored the system. Data could not be taken after event #20 due to required initialization.

(2) System was accidentally reinitialized early in the scenario via operator error at IOT-2. The operator at IOT-2 was not the AF technician, but project office support requested by the APMT.

DIRECTION FINDER TEST SUMMARY FORM

Test Category/Number: 3/Flight Scenario 2 Date: 04/06/93

Observations/Comments:

Good AT specialist operations.

Significant Anomalies/Deviations:

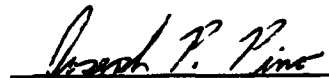
None.

Preliminary Assessment:

Switchover at RMMC 1 to RMMC 2 upon induced failure of RMMC 1 by powerdown was nearly transparent to the operator. An audible alarm and a COMM failure were indicated to the operator as expected.

Training given AT specialists has been further reinforced via this scenario and overall operator performance.

Atch: Test Mission Log, as run test procedures, Test Conduct Log, Test Monitor/Observer Notes, Test Problem Reports.


Test Director

Direction Finder Test Mission Log

Category/Number: 3/Flight Scenario 3 Date: 04/06/93 Time: 13:15

Test Manager : Joe Pino/John Dyson

Hardware Configuration:

Software Configuration: CM version 4.05

Personnel Name	Title	Function
John Dyson	Test Director	Test Director
Sam Barto	Computer Scientist	Lead Data Collector
Bob Bernheisel	Electronics Technician	Data Collector
Joe Pino	APMT	Test Monitor
Ron Lockhart	Support Engineer	Airborne Data Collector
Theos McKinney	Flight Test Pilot	Test Pilot
Bill Swart	ANN-600 Support Engineer	Training Room IDCU Operator
Mike Shew	AT Specialist	Floor IDCU Operator
Kevin Harrington	FAA ATR-220	Data Collector/Monitor

Discussion Items:

- * RMMC 1 will be failed by powerdown after flight scenario event #7
- * RMMC 2 will be failed by powerdown after flight scenario event #13

Deviations/Discrepancies:

(1) Operator lost communications with test aircraft disallowing the collection of data at scenario event #16. This is not a system problem, however.

(2) System rebooted spontaneously near scenario event #19 - prior to, (GMT 19:57:20). Last time noted on IDCU from RMMC #1 was at GMT 19:46:xx. Dumped message data for RMMC #1 & #2 for analysis.

(3) Keyboard located audible alarm not loud enough for operational situations.

DIRECTION FINDER TEST SUMMARY FORM

Test Category/Number: 3/Flight Scenario 3 Date: 04/06/93

Observations/Comments:

AT specialists prefer use of VDF to existing fielded system (FA-9964 DDF, FA-5530).

Significant Anomalies/Deviations:

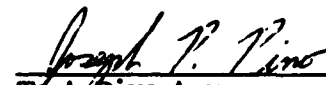
Spontaneous reboot of system prior to scenario event #19 causing truncation of flight scenario.

Preliminary Assessment:

Intentional failures of RMMC#1 and RMMC#2 resulted in acceptable recoveries nearly transparent to the operator. It was the opinion of several test observers that the audio level of the audible alarm was not high enough to be of optimum use in a true operational environment.

Spontaneous reboot of system during scenario requires further investigation, RMMC1 was set to primary with RMMC 2 as backup. A nontest personnel (automatic) switch was noted at GMT 19:52:50 where RMMC2 assumed primary status for some as yet unknown reason. At GMT 20:02:51, a NO COMMS alarm was sounded at the IDCU followed by a system initialization (reboot). The message buffer data for RMMC1 & 2 was printed out by the assigned AF technician for analysis. This occurrence must be investigated in an attempt to determine the cause(s) since it could be a liability during actual field operation if it occurs often.

Atch: Test Mission Log, as run test procedures, Test Conduct Log, Test Monitor/Observer Notes, Test Problem Reports.


Test Director

Direction Finder Test Mission Log

Category/Number: 3/Flight Scenario 5 Date: 04/06/93 Time: 16:15

Test Manager : Joe Pino

Hardware Configuration:

Software Configuration:

Personnel Name	Title	Function
John Dyson	Test Director	Light Aircraft Pilot Support
Sam Barto	Computer Scientist	Lead Data Collector
Bob Bernheisel	Electronics Technician	Data Collector
Joe Pino	APMT	Test Monitor
Ron Lockhart	Support Engineer	N50 Aircraft Pilot Support
Theos McKinney	Flight Test Pilot	Test Pilot
Bill Swart	ANN-600 Support Engineer	Training Room IDCU Operator
Paul Hilsher	AT Specialist	Floor IDCU Operator

Discussion Items:

- * Two-aircraft scenario intended to measure AT specialists' ability to handle two aircraft.

Deviations/Discrepancies:

- * Late takeoff by N50 Aerocommander test aircraft caused additional scenario runtime.
- * High traffic at time of flight caused additional operator burden (AT specialist had not been trained in handling two aircraft simultaneously).

DIRECTION FINDER TEST SUMMARY FORM

Test Category/Number: 3/Flight Scenario 5 Date: 04/06/93

Observations/Comments:

Headings given by DF operator/ AT specialist were considered very good by test flight personnel. Some ranges were off up to 4 miles in the vicinity of Sturgeon Bay (Navaid restrictions must be taken into account during data analysis).

Significant Anomalies/Deviations:

Strobes off Stevens Point (STE) 9964 DF site were static and similar to someone having placed a line on the IDCU display.

Preliminary Assessment:

Another two aircraft situations will be incorporated into flight scenario 4 in order to further assess real life two aircraft encounters. Restrictions on some of the Nav aids may have attributed to range inaccuracies.

Atch: Test Mission Log, as run test procedures, Test Conduct Log, Test Monitor/Observer Notes, Test Problem Reports.


Test Director

Direction Finder Test Mission Log

Category/Number: 3/Flight Scenario 4 Date: 04/07/93 Time: 9:30

Test Manager : John Dyson/ Joe Pino

Hardware Configuration:

Software Configuration: CM Version 4.05

Personnel Name	Title	Function
John Dyson	Test Director	Test Monitor
Sam Barto	Computer Scientist	Lead Data Collector
Bob Bernheisel	Electronics Technician	Data Collector
Joe Pino	APMT	Test Director
Ron Lockhart	Support Engineer	Airborne Data Collector
Theos McKinney	Flight Test Pilot	Test Pilot
Rick Akers	AMA-571	Data Collector
Will Showers	AT Specialist	Floor IDCU Operator
Charlie Werner	AT Specialist	Training Room IDCU Operator

Discussion Items:

- * Ad hoc aircraft scenario to be instituted by ATM-110 for comparison of VDF operator reported positioning reference terminal ARTS III secondary surveillance reports after scenario event #12 with test aircraft inbound to Green Bay Airport.

Deviations/Discrepancies:

- * Audio dropout or block of aircraft transmission occurred near completion of scenario event 12.
- * A 17-mile difference was noted between reported aircraft position versus VDF triangulation using RHI and MQT.
- Distance to RHI was 62 miles which is beyond recommended usable distance (40 nmi) for a DF site.

Direction Finder Test Mission Log

Category/Number: 2.1.1.1/2.1.1.2 Date: 04/07/93 Time: 15:20

Test Manager : John Dyson/ Joe Pino

Hardware Configuration:

Software Configuration: CM Version 4.05

Personnel Name	Title	Function
John Dyson	Test Director	Test Director
Sam Barto	Computer Scientist	Test Operator
Bob Bernheisel	Electronics Technician	Data Collector
Joe Pino	APMT	Test Monitor
Ed Lugo	AOS-240	Test Observer

Discussion Items:

- * Help function key checkout.
- * IDCU map and symbols checkout.

Deviations/Discrepancies:

- * Minor deviations noted in help text of several functions
- no operational impact.

Direction Finder Test Mission Log

Test Category/Number: 2.2.7.3 Date: 4/09/93 Time: 7:00

Test Manager: John Dyson/Joe Pino

Hardware Configuration:

Software Configuration: CM Version 4.05

Personnel Name	Title	Function
John Dyson	Test Director	Test Director
Sam Barto	Computer Scientist	Lead Data Collector/Test Operator
Bob Bernheisel	Electronics Technician	Data Collector
Joe Pino	APMT	Test Monitor
Ed Lugo	AOS-240	Test Observer

Discussion Items:

- * Grounding of RMC equipment and IDCU racks
- * Maintenance menu function checkout

Deviations/Discrepancies:

- * System crash noted at beginning of test exercise
- Occurred during previous night according to message data derived at IOT-2

DIRECTION FINDER TEST SUMMARY FORM

Test Category/Number: 3/Flight Scenario 4 Date: 04/07/93

Observations/Comments:

Scenario event #5 data collection was missed due to loss of communication with test aircraft. A loss of audio occurred at the floor IDCU requiring the operator to re-depress the channel selection button. This occurred near completion of DF approach (scenario event 12). DF approach was very good as reported by test aircraft flight crew. Ad hoc scenario run by ATM-110 upon completion of event 12 yielded acceptable results. Two aircraft not utilized as desired due to weather conditions.

Significant Anomalies/Deviations:

- * Drop or block of received aircraft transmission audio occurred in one instance (previously observed on 04/05/93 executing flight scenario 1).
- * 17-mile difference noted before scenario event 7 between VDF and aircraft GPS based positions. Strobes were off RHI & MQT, RHI at 62 miles (beyond usable range).

Preliminary Assessment:

- * Ad hoc scenario conducted by ATM-110 upon test aircraft approach to Green Bay. Green Bay approach radioed AFSS for assistance in using the VDF to provide positional information. The intent was to simulate a situation where radar contact is lost. Aircraft was under IFR prior to simulated loss of radar contact. Aircraft position as reported to ATC by the VDF operator was compared to ARTS III radar beacon reports presented on the ARTS III display. Position was accurate upon visual inspection. A single strobe off GRB DF site and triangulation off a VOR was used by the VDF operator to report position.
- * IDCU updates without actual change of presented information was distracting to operator. Labels move around even though strobes don't change. "Sideways" movement of aircraft due to position variances being reported by the VDF was annoying to AT specialist. Aircraft was noted as moving 4-5 miles sideways at 1000 feet altitude and 35 miles from DF site. Operator comment was that training on the DF site simulator/emulator was significantly different than working a live aircraft.

DIRECTION FINDER TEST SUMMARY FORM

Test Category/Number: 3/Flight Scenario 4 Date: 04/07/93

Observations/Comments:

Preliminary Assessment (continued):

* It was noted that air traffic opinions are that DF approaches should only be conducted within Navaid limits.

Atch: Test Mission Log, As run test procedure, Test Conduct Log, Test Monitor/Observer Notes, Test Problem Reports.


Test Director

Direction Finder Test Mission Log

Category/Number: 2.1.1.3/2.1.2 Date: 04/08/93 Time: 8:30

Test Manager: John Dyson/Joe Pino

Hardware Configuration:

Software Configuration: CM Version 4.05

Personnel Name	Title	Function
John Dyson	Test Director	Test Operator/Monitor
Sam Barto	Computer Scientist	Test Operator
Bob Bernheisel	Electronics Technician	Data Collector
Joe Pino	APMT	Test Monitor
Charlie Parks	ATZ-120	Test Observer
Ed Lugo	AOS-240	Test Observer
Chuck Patrick	AF Technician	Test Observer
Bill Swart	ANN-600 Support Engineer	Test Observer

Discussion Items:

- * IDCU map and symbols checkout
- * IDCU database consistency checkout

Deviations/Discrepancies:

- * IDCU 2 locked up after default scale key was depressed requiring a hard reset, a coldstart instituted at IOT-2 had no effect.
- * Data derived from IOT-2 indicates that key depression was probably not responsible for IDCU lockup (mutually exclusive events.)

Direction Finder Test Mission Log

Test Category/Number: 2.2.3 Date: 4/08/93 Time: 11:20

Test Manager: Joe Pino

Hardware configuration:

Software Configuration: CM version 4.05

Personnel Name	Title	Function
Sam Barto	Computer Scientist	Test Director
John Dyson	Test Director	Test Monitor
Bob Bernheisel	Electronics Technician	Data Collector
Joe Pino	APMT	Test Monitor
Ed Lugo	AOS-240	Test Monitor

Discussion Items:

- * RMC control checkout

Deviations/Discrepancies:

SECTION 2

OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION AND OT&E
OPERATIONAL TEST LOGS: JUNE 21 THROUGH JUNE 24, 1993

DIRECTION FINDER TEST SUMMARY FORM

Test Category/Number: 3/Flight Scenario 1 Date: 06/21/93

Observations/Comments:

AT specialist displayed great skill during entire scenario. Using DF sites beyond 40 nmi has to be taken into consideration with respect to positional accuracy.

Significant Anomalies/Deviations:

None

Preliminary Assessment:

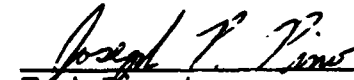
Limitations of DF sites beyond 40 nmi were manifested in displacement during triangulation.

Time-distance problem appeared to overburden IDCU operator.

Intentional interruption/failure of primary RMMC2 resulted in an acceptable switchover.

Gross changes in aircraft position were not considered an operational problem since displacements were obviously inaccurate; operator asks for another transmission from aircraft to update display.

Atch: Test Mission Log, As run Test Procedure, Test Conduct Log, Test Monitor/Observer Notes, Test Problem Reports.


Test Director

DIRECTION FINDER TEST MISSION LOG

Test Category/Number: 3/Flight Scenario 1 Date: 6/21/93 Time: 15:00

Test Manager: John Dyson/Joe Pino

Hardware Configuration:

Software Configuration: CM Version 4.07

Personnel Name	Title	Function
John Dyson	Test Director	Test Director
Sam Barto	Computer Scientist	Lead Data Collector
Bob Bernheisel	Electronics Technician	Data Collector
Gib Shade	AOO AFSS	Data Collector
Joe Pino	APMT	Test Monitor
Ron Lockhart	Support Engineer	Airborne Data Collector
Theos McKinney	Flight Test Pilot	Test Pilot
Mike Shew	AT Specialist	Floor IDCU Operator
Charlie Werner	AT Specialist	Training Room IDCU Operator
Kevin Harrington	ATR-220	Test Monitor

Discussion Items:

- * DF reported positions will be compared to aircraft GPS derived data.
- * AT specialist provides a DF approach to Stevens Point Airport.
- * RMC 2 (active) was set to cause alarm at scenario event #11. Interrupt button was depressed on computer front panel.
- * Operations used system in automatic mode.

DIRECTION FINDER TEST MISSION LOG

Test Category/Number: 3/Flight Scenario 1 Date: 6/21/93 Time: 15:00

Test Manager: John Dyson/Joe Pino

Hardware Configuration:

Software Configuration: CM Version 4.07

Deviations/Discrepancies:

- * Feedback on audio channel.
- * Anomaly on time-distance problem.
- * 15 nmi displacement noted with strobe 47 nmi off STE triangulated with GRB.
- * 12 nmi DF reported versus 20 NMI with GPS after scenario event 11 near GRB.
- * Late takeoff of Aerocommander N50 test aircraft due to head temperature gauge failure.

DIRECTION FINDER TEST SUMMARY FORM

Test Category/Number: 3/Flight Scenario 2 Date: 06/22/93

Observations/Comments:

- * Time-Distance calculation performed before scenario event #15 was accurate per AT operational standards.
- * Stevens Point (STE) FA9964 site showed errors of 3 nmi at 60 nmi - good site environment characteristics.
- * Activation of emergency feature between scenario events 17&18 showed accurate positional information.

Significant Anomalies/Deviations:

System took approximately 20 seconds to alarm after induced failure of primary RMMC1. Operator attempted to change frequencies during this time period and system did not respond.

Preliminary Assessment:

- * Time-distance calculation based on DF information was considered accurate per air traffic (AT) operational standards. Aircraft DME and time-distance calculation matched.
- * Induced failure of primary RMMC 1 resulted in proper system switchover. RMMC 2 assumed primary status as required.
- * In emergency mode when there is no aircraft placement, DF goes to previous placement.
- * Twenty second alarm period could possibly be shortened via change of software settable parameter.

DIRECTION FINDER TEST SUMMARY FORM

Test Category/Number: 3/Flight Scenario 2 Date: 06/22/93

Preliminary Assessment (continued):

- * Oscillations in strobe positions was noted when receiving information from DF antennas beyond 40 nmi, the useful range of this navigational aid.
- * AT specialists displayed much skill in operating the DF. One specialist had not used system for 3 months yet displayed great proficiency.

Atch: Test Mission Log, as run test procedures, Test Conduct Log, Test Monitor/Observer Notes, Test Problem Reports.


Test Director

DIRECTION FINDER TEST MISSION LOG

Test Category/Number: 3/Flight Scenario 2 Date: 6/22/93 Time: 9:06

Test Manager: John Dyson/Joe Pino

Hardware Configuration:

Software Configuration: CM version 4.07

Personnel Name	Title	Function
John Dyson	Test Director	Test Director
Sam Barto	Computer Scientist	Lead Data Collector
Bob Bernheisel	Electronics Technician	Data Collector
Joe Pino	APMT	Test Monitor
Ron Lockhart	Support Engineer	Airborne Data Collector
Kevin Harrington	ATR-220	Data Collector
Gib Shade	AOO-AFSS	Data Collector
Theos McKinney	Flight Test Pilot	Test Pilot
Dale Walker	AT Specialist	IDCU Operator - Floor
Kevin Hodina	AT Specialist	IDCU Operator - Floor
Charlie Werner	AT Specialist	IDCU Operator - Training Room

Discussion Items:

- * Will perform time-distance problem near scenario event 15
- * Floor IDCU in manual mode; training room IDCU in automatic mode.
- * Aircraft placed manually on floor IDCU via holding strobe.
- * Floor IDCU put in automatic mode after scenario event #5; back in manual mode at scenario event #11; automatic mode after event 14.
- * Induced failure of RMMC1 during scenario event 18.

DIRECTION FINDER TEST MISSION LOG

Test Category/Number: 3/Flight Scenario 2 Date: 6/22/93 Time: 9:06

Test Manager: John Dyson/Joe Pino

Hardware Configuration:

Software Configuration: CM version 4.07

Deviations/Discrepancies:

- * Oscillations in strobe positions noted when information received from DF antenna site beyond 40 nmi.
- * No audio being received from La Crosse FA9964 DF site (Not a test issue).
- * In emergency mode when there is no aircraft placement, DF goes to previous placement.

DIRECTION FINDER TEST MISSION LOG

Test Category/Number: 3.1/alignment orbitals Date: 6/23/93 Time: 9:10

Test Manager: John Dyson/Joe Pino

Hardware Configuration:

Software Configuration: CM Version 4.07

Personnel Name	Title	Function
John Dyson	Test Director	Test Director
Sam Barto	Computer Scientist	Lead Data Collector
Bob Bernheisel	Electronics Technician	Data Collector
Joe Pino	APMT	Test Monitor
Ron Lockhart	Support Engineer	Airborne Data Collector
Kevin Harrington	ATR-220	Data Collector
Gib Shade	AOO-AFSS	Test Monitor
Theos McKinney	Flight Test Pilot	Test Pilot
Dale Walker	AT Specialist	IDCU Operator - Floor
Mike Shew	AT Specialist	IDCU Operator - Floor

Discussion Items:

- * Marquette FA 10121 Site accuracy
- * Rhinelander FA 9964 Site accuracy
- * 10 nmi radius orbitals, 5 seconds radio transmissions, 1 minute spacing
- * 20 nmi arc around Rhinelander FA 9964

Deviations/Discrepancies:

DIRECTION FINDER TEST MISSION LOG

Test Category/Number: 1.2, 2.1.1 Date: 6/23/93 Time: 9:10

Test Manager: John Dyson/Joe Pino

Hardware Configuration:

Software Configuration:

Personnel Name	Title	Function
John Dyson	Test Director	Test Director
Sam Barto	Computer Scientist	Lead Data Collector
Bob Bernheisel	Electronics Technician	Data Collector
Joe Pino	APMT	Test Monitor

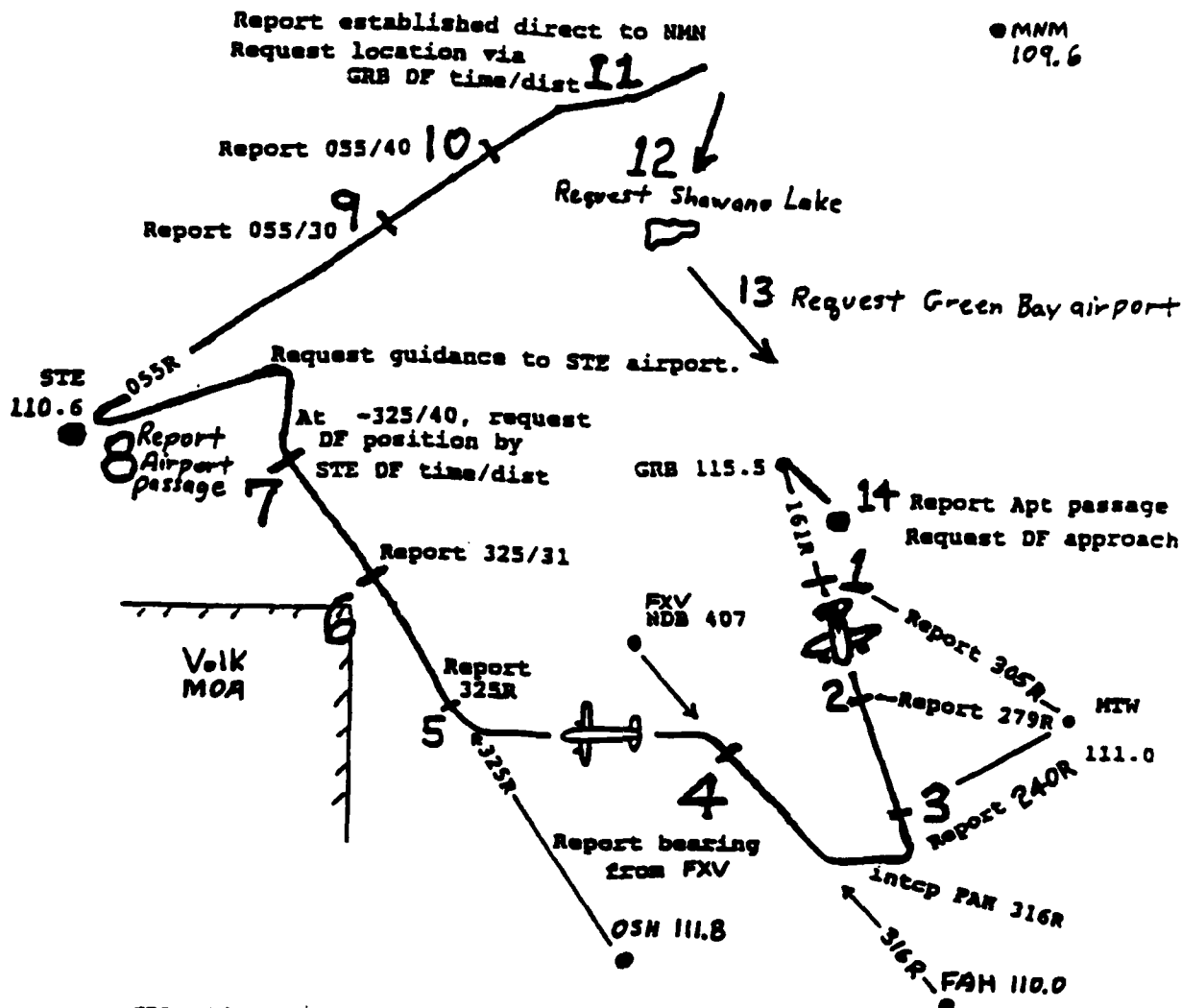
Discussion Items:

- * IOT-2 Spurious characters - no longer present
- * Implosion Protection on IDCU Display

Deviations/Discrepancies:

SECTION 3

PRELIMINARY OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION AND
OT&E OPERATIONAL TEST LOGS: MARCH 29 THROUGH APRIL 9, 1993



GRB Flight Scenario # 1. 2 + 15 @ 120 KIAS

DF freq 122.55, 123.6,

Off Time 1826 ±

Date 4/5/93

Pilot Theos McKinney

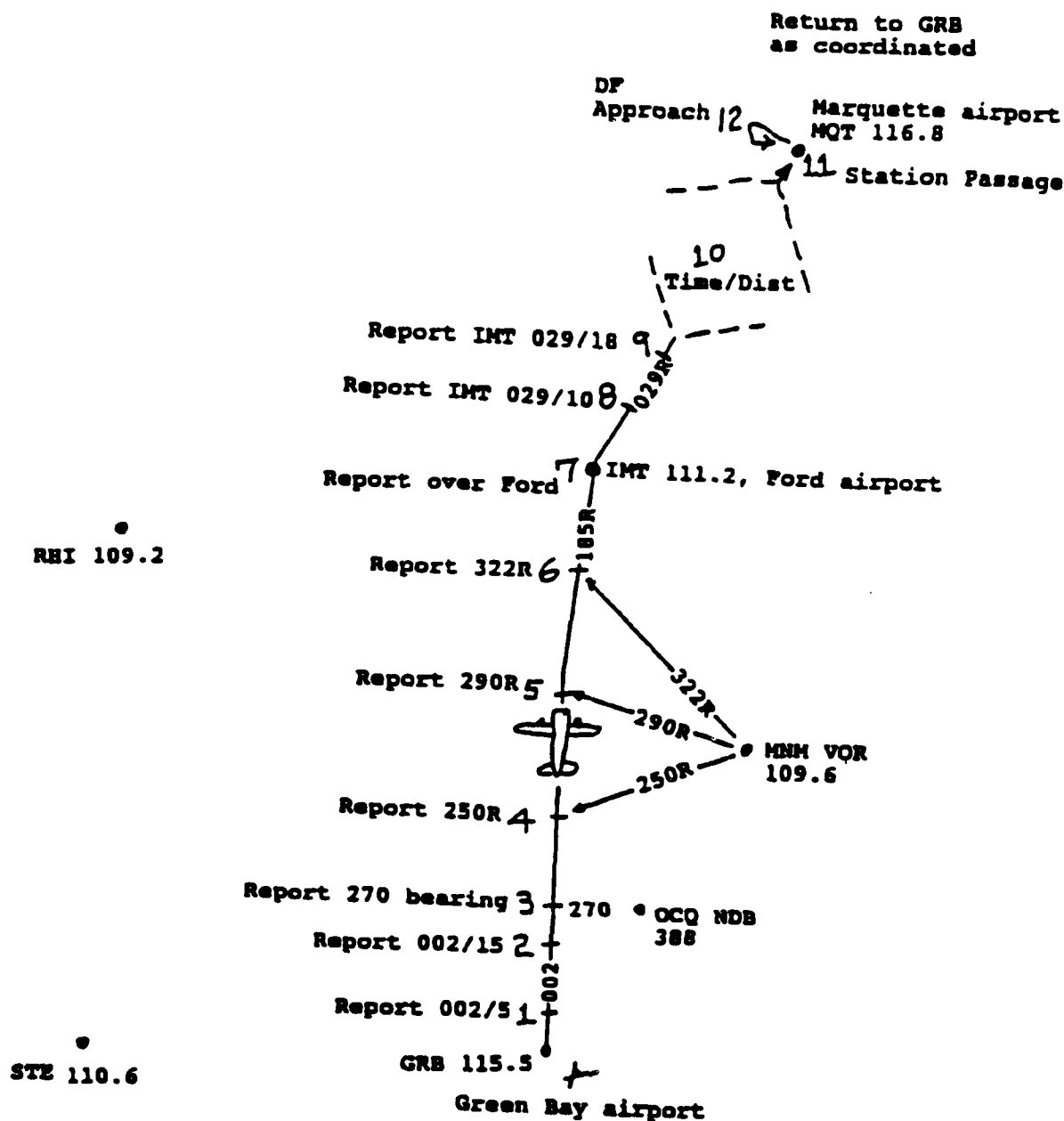
Co Pilot

Test Eng Ron Lockhart

In Flight WX VFR

Visibility 7

Scattered to broken clouds at 3500 to 4000'



GRB Flight Scenario : 4. 2 + 30 @ 120 KIAS

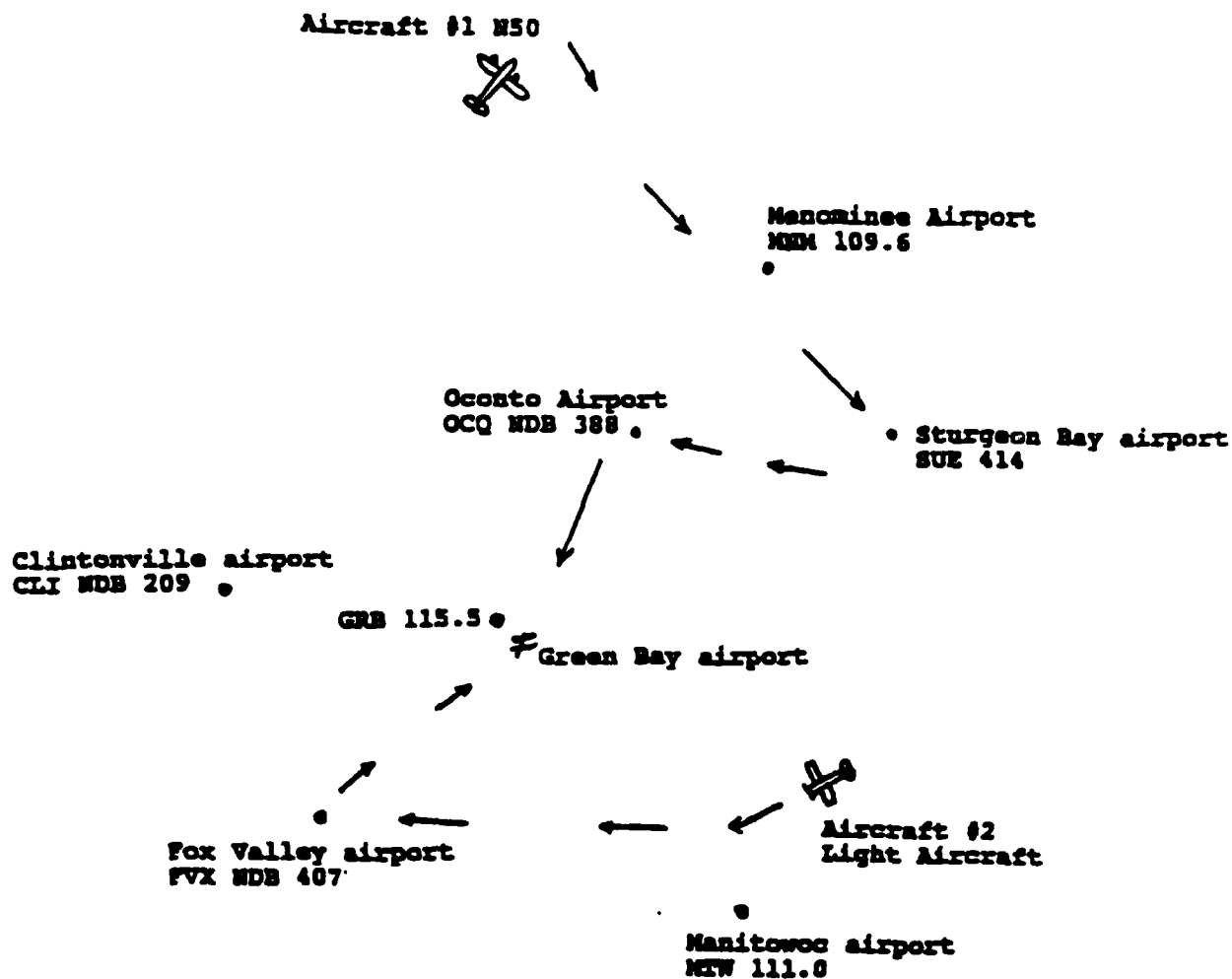
DF freq 122.55, 122.1, 119.5, Off Time 1439Z

Date 4/7/93

Pilot Thos McKinney Co Pilot

Test Eng Ron Lockhart

In Flight WX Clouds scattered Alt 3,000 to 4,500 Time Down 1705Z
 Visibility 3 to 6 mi
 + patchy 2,000' and up



GRB Flight Scenario # 5. Two Aircraft. Approximately 45 minutes.

DF Freq 122.55, 127.2, Date 4/6/93

Aircraft #1 Pilot Theos McKinney Test Eng Ron Lockhart Off time 2139Z

AC 680E. Clouds 4000 broken
In flight WX 6 mi visibility - Haze Alt 3500 Down time 2242Z

Aircraft #2 Pilot Kelly LaPointe Test Eng John Dyson Off time 2150Z

Maui XATT-180 Clouds 4000 broken-scattered
In flight WX 7 miles visibility Alt 3500 to 3500 Down time 2230Z

VHF/DF OT&E
SCENARIO # 1 DRY RUN APRIL 3, 1993

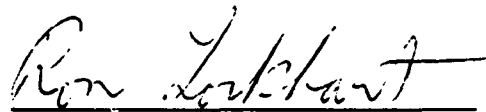
Data collected by N50, GPS unit Latitude/Longitude.
Time is Z by GPS. 120 KIAS. 3,500 feet.

Event	Time	Latitude	Longitude	Comments
	1515	44 29.61	88 06.83	Apch End, RWY 24
1	1526	44 20.75	88 06.88	Time noted is a bit late
2	1529:50	44 09.87	88 03.01	DF may have received only a 2nd report a few seconds after this event #2 report
3	1534:15	43 59.81	87 59.21	
4	1541:10	43 58.65	88 09.17	
	1542:30	44 00.34	88 11.53	5" Tx req by DF
	1543:00	44 00.89	88 12.56	5" Tx req by DF
	1545:05	44 01.12	88 17.46	5" Tx req by DF
	1551:35	43 59.98	88 34.47	5" Tx req by DF
	1559:55			Tx by unkn aircraft
5	1600:25	44 13.05	88 43.34	
	1601:45	44 15.13	88 44.07	5" Tx req by DF
	1604:05	44 18.23	88 47.86	5" Tx req by DF
	1606:05	44 21.19	88 50.95	5" Tx req by DF
6	1609:10	44 25.36	88 55.79	
	1613:10	44 31.38	88 01.93	
7	1614:35	44 33.34	89 03.72	OSH 325R/40.7DME
8				Initial 240 heading to STE by DF was excellent. Still on DF 240 heading, N50 passed 3 nm SE of airport
	1637:25	44 37.43	89 21.29	5" Tx req by DF, ~STE 055/9
	1640:25	44 40.25	89 14.17	
9	1648:00	44 48.99	88 56.04	
10	1652:10	44 53.08	88 45.05	
				Continued with procedures as redlined.
	1700:40	44 42.37	88 25.41	KGRB 318/19
	1702			N67F made numerous TX through 1704
	1704:05	44 37.05	88 18.07	KGRB 318/10.6
	1705:15	44 34.91	88 15.35	KGRB 318/7
	1706:40	44 32.41	88 12.33	

VHF/DF OT&E
SCENARIO # 1 DRY RUN APRIL 3, 1993

Data collected by N50, GPS unit Latitude/Longitude.
Time is Z by GPS. 120 KIAS. 3,500 feet.

Event Time	Latitude	Longitude	Comments
1707:50	44 30.42	88 09.87	
1708:35	44 29.09	88 08.05	
1709:55	44 27.99	88 06.38	KGRB 318
1709:55	44 26.99	88 04.70	KGRB 318
1720	44 29.06	88 08.01	Intx of 18/36 & 06/24 at KGRB



Ron Lockhart
Test Engineer, N50

VHF/DF OT&E
SCENARIO # 1 APRIL 5, 1993

Data collected by N50, GPS unit Latitude/Longitude.
Time is Z by GPS. 120 KIAS. 3,000 to 4,000 feet.

Event	Time	Latitude	Longitude	Comments
	1825	44 29.05	88 08.04	Intx of 18/36 & 06/24
1	1837:15	44 21.18	88 06.63	
2	1843:10	44 09.89	88 01.70	
3	1848:10	44 00.30	87 57.57	MTW 242R vice 240R
4	1001:20	44 09.17	88 25.89	
	1907:06	44 09.84	88 41.78	Bearing 240 fm FXV
5	1911:15	44 16.45	88 49.83	
6	1916:10	44 25.59	88 58.47	Coords taken ~1916:25
7	1920:45	44 33.06	89 05.47	DF guidance to STE
	1922:30	44 36.00	89 08.05	10" Tx requested by DF
	1925:35	44 40.18	89 13.77	10" Tx requested by DF
	1927:30	44 41.31	89 16.84	10" Tx requested by DF
8	1934			Airport at 1 O'clock, 7 nm Passed over SE boundary of STE airport on initial pass
Made	DF approach to STE	RWY 21,	excellent alignment and heading.	
	1958:10	44 37.79	89 22.53	10" Tx requested by DF
	1959:00	44 37.98	89 29.66	10" Tx requested by DF
	2000:10	44 39.02	89 18.37	10" Tx requested by DF
9	2010:30	44 48.83	88 56.36	
10	2016:25	44 54.54	88 44.37	
	2018:10	44 55.97	88 40.76	10" Tx requested by DF
11				No data taken
	2024:15	44 59.07	88 26.41	5" past event #11
	2026:03	44 59.81	88 22.61	
	2028			Cherokee 45L on frequency
	2029:10	44 57.79	88 25.16	5" Tx requested by DF
12	2033			Sighted Shawano airport
				Passed 2 nm West of airport
	2036:58	44 47.27	88 33.94	Over Shawano airport

VHF/DF OT&E
SCENARIO # 1 APRIL 5, 1993

Data collected by N50, GPS unit Latitude/Longitude.
Time is Z by GPS. 120 KIAS. 3,000 to 4,000 feet.

Event	Time	Latitude	Longitude	Comments
13	2044:09	44 41.83	88 20.40	5" Tx requested by DF
	2046:05	44 41.67	88 15.93	5" Tx requested by DF
	2047:38	44 41.59	88 12.44	5" Tx requested by DF
	2025:55	44 37.08	88 10.11	
14	2054:30			DF heading 140 puts N50 over center of GRB airport
	2103:15			DF heading 065 puts RWY 06 at N50's 12 O'clock
	2104:35			2 1/2 nm from RWY threshold DF heading remains 065, RWY is still 12 O'clock.
	2108	44 29.09	88 08.02	Intx of 18/36. & 06/24


Ron Lockhart
Test Engineer, N50

VHF/DF OT&E
SCENARIO # 2 APRIL 6, 1993

Data collected by N50, GPS unit Latitude/Longitude.
Time is Z by GPS. 160 KIAS. 3,000 to 3,500 feet.

Event	Time	Latitude	Longitude	Comments
	1358	44 29.58	88 06.77	Apch end RWY 24
1	1408:25	44 36.72	88 38.31	This is 19 vice 18 DME
2				No data collected
	1419:34	44 19.41	88 01.39	5" Tx req by DF about 5" after event 2.
3	1428:30	44 12.75	88 31.44	Radio problems, DF missed?
4	1437:30	44 05.23	90 01.87	West, vice east, shore of Pentwell Lake
5	1441:20	44 01:95	90 14.63	#5, not DF req Tx 5" later
6	1452:10	43 55.63	90 38.50	Approx 1 nm S of CMY NDB
	1444:35	43 59.09	90 26.03	5" Tx req by DF
	1456:10	43 54.33	90 52.66	5" Tx req by DF
7				N50 unable to visually ID the DF antenna site. Using landmarks, estimate passing within 1/2 nm of DF site.
8				Data collection not req.
9	1511:05	44 07.49	91 28.32	
10	1514:05	44 15.38	91 27.64	
11	1516:25	44 22.20	91 27.77	#11. not DF req Tx 5" later
12	1520:20	44 32.19	91 28.25	
13				1st pass over EAU airport 1/4 nm S of center.
14				DF approach & final alignment to EAU RWY 22 was excellent.
15	1543:25	44 54.12	91 13.41	
16	1547:05	44 54.70	90 59.86	#16, not DF req Tx 5" later
17	1551:01	44 55.12	90 46.08	

VHF/DF OT&E
SCENARIO # 2 APRIL 6, 1993

Data collected by N50, GPS unit Latitude/Longitude.
Time is Z by GPS. 160 KIAS. 3,000 to 3,500 feet.

Event	Time	Latitude	Longitude	Comments
18				No data collected
	1556:40	44 54.78	90 26.04	DF req 10" TX about 5" past event 18.
19	1603:30	44 51.79	90 02.77	Not DF req Tx at 1603:40
	1604:40	44 51.61	89 58.59	DF req 5" Tx
	1609:10			DF heading 130 to Central WI airport is excellent
20	1610:30	44 46.80	89 39.81	Over Central WI airport, still on DF 130 heading
	1613			Numerous Tx by unk aircraft at Dodge Co airport
	1615			DF guidance to GRB starts.
	1620			DF req bearing to PCZ NDB, N50 provides 166
	1628			Scenario terminated, DF system failure due to RMMC testing.
	1640	44 29.56	88 06.80	Apch end RWY 24


Ron Lockhart
Test Engineer, N50

VHF/DF OT&E
SCENARIO # 3 APRIL 6, 1993

Data collected by N50, GPS unit Latitude/Longitude.
Time is Z by GPS. 160 KIAS. 3,500 feet.

Event	Time	Latitude	Longitude	Comments
1	1823:40	44 39.55	88 43.20	
2	1832:06	44 56.85	88 59.35	
3	1837:30	45 09.14	89 09.13	
4	1842:35	45 20.90	89 16.54	This is 156/19 vice 156/20
5	1949:45	45 38.09	89 27.58	Overhead RHI airport, slightly NW of center
6	1853:45	45 41.55	89 41.51	
7	1857:40	45 44.14	89 55.43	Bearing 087 from PBH
8	1903:10	45 48.37	90 14.71	
9	1906:50	45 50.92	90 28.33	This is 285/44 vice 285/42
10				No data recorded
11	1911:50	45 52.81	90 46.07	
12	1914:15	45 53.47	90 54.78	This is 104/24 vice 104/25
13	1916:05	45 54.58	91 10.57	This is 104/19 vice 104/20
14	1921:40	45 45.37	91 05.33	Radial 130 off HYR is rough
15	1928:01	45 30.02	91 00.21	Over Rusk Co airport
	1932:15	45 23.77	90 48.64	10" Tx req by DF
	1933:40	45 21.73	90 44.77	10" Tx req by DF
	1937:50	45 14.20	90 33.27	10" Tx req by DF
16				Missed, no radio contact
17	1949:59	45 03.97	89 53.18	
				Reported the WAU 337R
18	1956:05	45 01.91	89 30.21	This is WAU 010R, vice 005R
19	2104			Scenario terminated by DF


Ron Lockhart
Test Engineer, N50

VHF/DF OT&E
SCENARIO # 4 APRIL 7, 1993

Data collected by N50, GPS unit Latitude/Longitude.
Time is Z by GPS. 120 KIAS. 3,000 to 4,500 feet.

Event	Time	Latitude	Longitude	Comments
1	1445:50	44 38.53	88 11.34	
2	1449:50	44 48.64	88 10.22	
3	1451:45	44 52.46	88 09.95	
4	1457:40	45 04.04	88 09.60	
5	1505:25	45 19.88	88 08.19	DF missed, radio problems
6	1514:10	45 37.10	88 06.97	
7	1520:10	45 48.94	88 06.84	Over Ford airport
8	1527:30	46 02.47	87 57.42	This is 029/15 vice 029/10
9	1529:15	46 05.45	87 54.38	
10	1535			Time/Dist location by DF DF says N50 is 17 nm from MQT, N50's DME is 24 nm
11	1546:30			First pass to MQT was over airport, SW boundary.
12				DF approach to MQT airport

DF guidance on heading 045 took N50 about 7 nm to north east, farther than necessary. (In debriefing, operator notes that two aircraft were being worked at the same time. He had forgotten to make N50 the selected Aircraft, and therefore did not get updated bearing information on N50). The remainder of the approach went normally.

1600

DF heading 080 puts N50 on course about 50 meters to left side of the RWY. Call to descend was late, given just prior to RWY threshold

VHF/DF OT&E
SCENARIO # 4 APRIL 7, 1993

Data collected by N50, GPS unit Latitude/Longitude.
Time is Z by GPS. 120 KIAS. 3,000 to 4,500 feet.

Event Time	Latitude	Longitude	Comments
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In debriefing, the operator noted that he realized the call was late and should have been given earlier.

After completion of the scenario, N50 worked with Green Bay approach control to do test events requested by Mr. Bill Fish. They are intended to demonstrate the ability of the DF to locate an aircraft at the request of a radar control facility on their frequencies. In this case, 119.5, Green Bay approach control was used.

1640:40	45 08.68	88 09.16	MNM VOR Radial 261
1643	45 02.60	88 09.53	MNM VOR Radial 249
1646:30	44 54.89	88 09.49	MNM VOR Radial 232

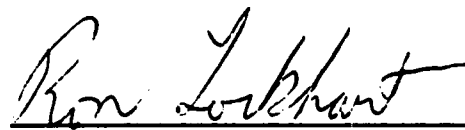

Ron Lockhart
Test Engineer, N50

VHF/DF OT&E
SCENARIO # 5 TWO AIRCRAFT APRIL 6, 1993

Data collected by N50, GPS unit Latitude/Longitude.
Time is Z by GPS. 120 KIAS. 3,500 feet.

N50 is considered Aircraft Number 1 in the scenario. Aircraft Number 2 is a light aircraft, call sign Maul 28L.

Event Time	Latitude	Longitude	Comments
2139	44 29.62	88 08.02	Apch end RWY 18 DF guidance to Menominee
2155:45	44 58.64	88 00.77	5" Tx req by DF Another aircraft was heard on frequency
2157:03 2200	44 59.14	87 56.37	5" Tx req by DF DF says N50 is 7 nm SW of Menominee, N50 concurs.
DF guidance to Sturgeon Bay			
2205			DF heading 165 to Sturgeon Bay airport is very good
2207:10 2209:30	45 00.58	87 29.76	DF says N50 is 12 nm from Sturgeon Bay. GPS dist is 6.4 nm
	44 51.19	87 25.60	165 heading puts N50 over Sturgeon Bay airport. DF calls N50 4 nm N of Sturgeon Bay, N50 is over northern end of airport.
DF guidance to Oconto			
2215:35 2218:10	44 47.96	87 29.60	5" Tx req by DF DF says N50 is 18 nm E of Oconto. GPS dist is 13 E.
2223:01			DF says N50 is 6 nm SE of Oconto. GPS agrees.
2225:00	44 49.95	87 55.45	N50 passes 2 1/2 nm SW of Oconto
2232			Scenario terminated for both aircraft.


Ron Lockhart
Test Engineer, N50

SECTION 4

**OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION AND
OT&E OPERATIONAL TEST LOGS: JUNE 21 THROUGH JUNE 24, 1993**

GRB Flight Scenario # 1. 2 + 15 @ 120 KIAS

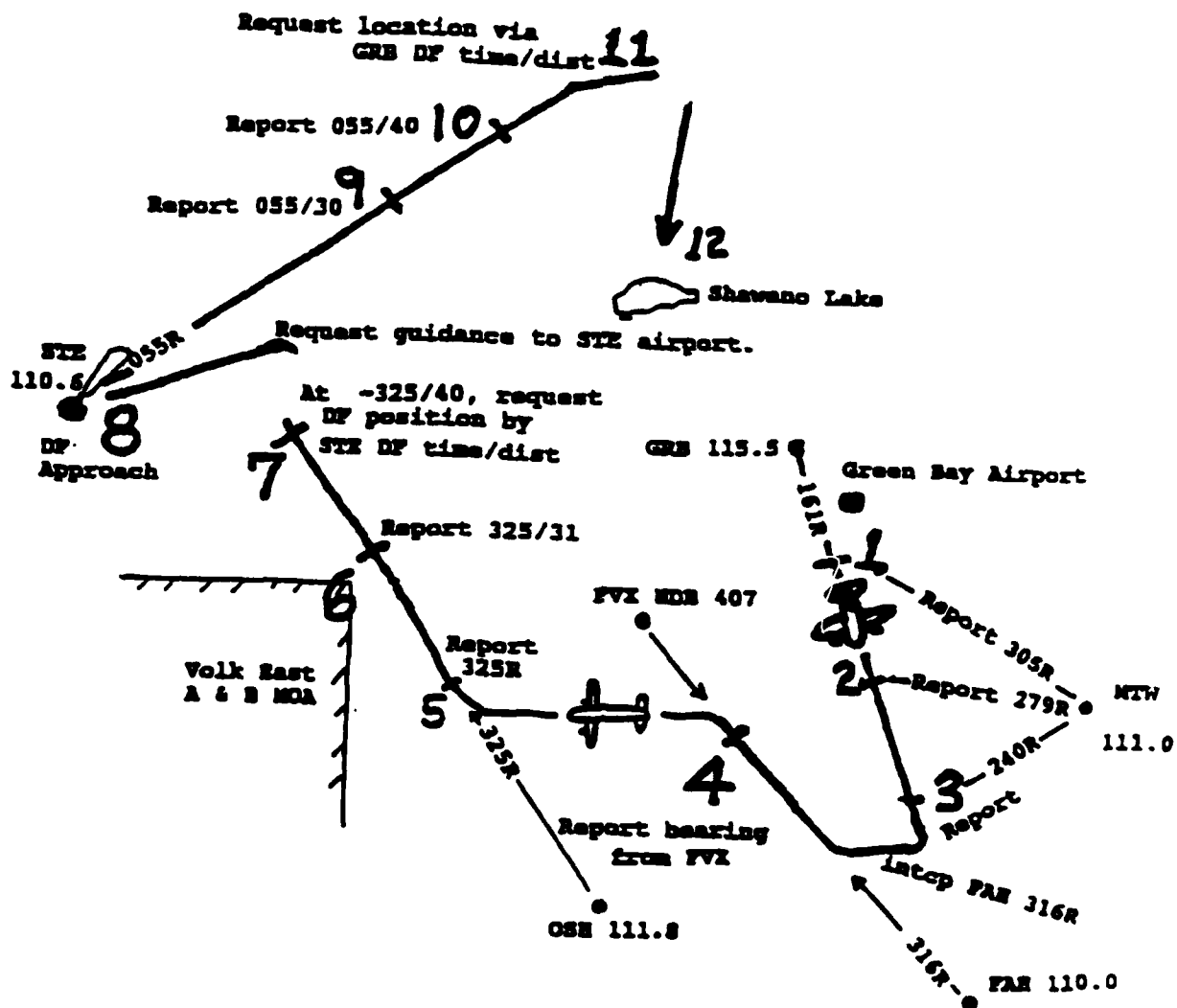
DF freq 122.55, 123.6 Off Time 1947Z

Date 6/21/93

Pilot Theos McKinney Co Pilot

Test Eng Ron Lockhart

In Flight wx Clear, 15 miles visibility



VHF/DF OT&E Green Bay AFSS WI
Flight Scenario # 1
June 21, 1993

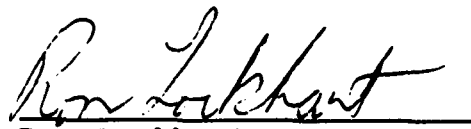
Data collected onboard N50, FAA Technical Center Aero Commander. GPS unit Latitude/Longitude, and time in Z. 120 KIAS. 3,500 to 4,500 feet. Green Bay AFSS frequency 122.55. Time hack at 2023:24 between GPS unit and DF operator was within 1 second. GPS positions recorded here are at the end of the transmission by N50 announcing the event point.

Event	Time	Latitude	Longitude	Comments
	1939	44 29.50	88 07.72	Executive Air Ramp
1		44 20.26	88 05.33	
2		44 09.42	88 00.42	
3		44 00.81	87 56.43	
		44 03.38	87 57.65	5" Xmt
4		44 03.55	88 16.29	
	2012:30	44 04.07	88 21.70	10" Xmt
	2013:09	44 03.83	88 23.28	10" Xmt
	2014:15	44 03.26	88 27.11	10" Xmt
5	2020:00	44 06.30	88 39.65	
	2029:30	44 22.03	88 54.27	
6	2031:30	44 25.82	88 57.81	
	2032:50	44 27.70	88 59.51	5" Xmt
	2034:10	44 30.03	89 01.67	5" Xmt
7	2037:45	44 36.87	89 04.70	Requested DF position by Time/Distance calculation and guidance to STE airport. DF heading given was 255°. At 15nm from STE GPS showed 253°. At 10nm GPS showed 256°.
	2028:40			N50 passed 1/2 mile south of STE RWY 3 on 255°.
8				DF approach to STE RWY 21 N50 crossed RWY 21 extended centerline, on DF heading 200° about 1/4 mile from threshold. Several garbled Xmts heard on 122.55 by N50.
	2100			
	2105:50	44 35.45	89 25.37	5" Xmt
	2108:35	44 39.78	89 17.03	5" Xmt
	2113:15	44 47.06	89 01.86	5" Xmt

VHF/DF OT&E Green Bay AFSS WI
Flight Scenario # 1
June 21, 1993

Data collected onboard N50, FAA Technical Center Aero Commander.
GPS unit Latitude/Longitude, and time in Z. 120 KIAS. 3,500 to
4,500 feet. Green Bay AFSS frequency 122.55. Time hack at
2023:24 between GPS unit and DF operator was within 1 second.
GPS positions recorded here are at the end of the transmission by
N50 announcing the event point.

Event	Time	Latitude	Longitude	Comments
9	2115:17	44 49.94	88 56.34	
10	2119:40	44 55.54	88 44.88	
11	2124:10	44 50.64	88 35.23	5" Xmt
12				N50 Requested guidance to Shawano Lake. DF correctly advised N50 that Lake should be close and straight ahead. 2128 Added DF position location by Time/Distance calculation. DF called N50 20 nm north west of Green Bay airport, GPS showed 12 nm.
	2148	44 29.57	88 07.79	Executive Air Ramp, a few hundred feet from starting point


Ron Lockhart
Test Engineer, N50

VHF/DF OT&E Green Bay AFSS WI
Flight Scenario # 2
June 22, 1993

Data collected onboard N50, FAA Technical Center Aero Commander. GPS unit Latitude/Longitude, and time in Z. 155 KIAS. 3,500 to 4,500 feet. Green Bay AFSS frequencies 122.55, 123.6, 122.5, 122.35, 122.65, and 122.4. GPS positions recorded here are at the end of the transmission by N50 announcing the event point.

Event	Time	Latitude	Longitude	Comments
	1352	44 29.56	88 07.81	Executive Air Ramp
1	1415:30	44 29.41	88 37.21	
2	1422:40	44 20.07	89 00.90	
	1428:30	44 14.52	89 20.39	5" Xmt
3	1431:40	44 13.13	89 31.57	253° bearing from PCZ
	1435:10	44 12.30	89 44.70	5" Xmt
4	1437:25	44 11.04	89 53.08	East shore Pentwell Lake
	1439:50	44 07.59	90 00.52	5" Xmt
5	1446:10	43 55.76	90 14.39	STE 205/47
	1447:50	43 54.94	90 20.58	5" Xmt
6	1452:45	43 55.80	90 39.17	190° vice 180° from CMY
	1453:20	43 55.85	90 41.61	5" Xmt
7	1457:10	43 59.04	90 55.49	Report by N50, ODI 074/54
	1500:10	44 02.16	91 05.98	Report by N50, ODI 060/17.5
	1503:05	44 04.94	91 15.79	Report by N50, ODI 036/13
	1505:10	44 07.05	91 23.11	5" Xmt
8	1511:50	44 21.55	91 26.75	EAU 356/26, & ONA 030
9				Missed
	1516			Other AC on frequency
10	1517:15	44 36.76	91 29.78	EAU 176/18, & ONA 015
11	1519			DF Guidance to EAU airport.
				DF heading 360° put N50
				directly over airport.
12				DF approach to EAU RWY 22 DF
				heading 225° on final approach
				leg put N50 parallel & about
				1nm east of RWY. Last DF
				heading 240° on final approach
				of put N50 across intx of RWYs
				at EAU.

VHF/DF OT&E Green Bay AFSS WI
Flight Scenario # 2
June 22, 1993

Data collected onboard N50, FAA Technical Center Aero Commander. GPS unit Latitude/Longitude, and time in Z. 155 KIAS. 3,500 to 4,500 feet. Green Bay AFSS frequencies 122.55, 123.6, 122.5, 122.35, 122.65, and 122.4. GPS positions recorded here are at the end of the transmission by N50 announcing the event point.

Event	Time	Latitude	Longitude	Comments
13	1544:15	44 53.47	91 14.00	
	1545:05	44 53.23	91 11.03	10" Xmt
	1546:10	44 53 21	91 07 37	5" Xmt
14	1548:05	44 53:99	91 00.19	
	1558:05			Another AC of frequency
15	1559:45	45 01.99	90 43.46	EAU 069/34, Time/Distance
	1602:00	44 57.12	90 36.19	5" Xmt
16	1604:25	44 55.59	90 27.73	
	1608:35	44 53.24	90 13.32	5" Xmt
17	1611:30	44 51.51	90 02.97	
18				DF provided headings of 105°, then 115°, then 125° to Central WI airport. The 115° would have put N50 directly over airport. On 125° N50 passed 2nm southwest of airport.
	1622:30	44 44:40	89 24.77	5" Xmt
	1624:40	44 45.12	89 16.55	5" Xmt
	1625:50	44 45.32	89 12.10	5" Xmt & AUW 105/17
	1627:20	44 45.01	89 06.64	5" Xmt
	1629:20	44 43.23	88 59.81	5" Xmt
	1629:50	44 42.29	88 58.12	5" Xmt
	1632			AC, GlasAire on freq.
19	1633:20	44 40.63	88 45.34	AUW 104/36


Ron Lockhart

SECTION 5

**CORRELATED POSITION DATA SPREAD SHEETS
PRELIMINARY AND FORMAL OT&E**

VDF Formal Operational Test and Evaluation Scenario #1 Results

EVENT	TIME (HRS)	GPS LAT LONG (DMIN)	GRB RANGE (NM)	GRB AZIM. (DEGRS)	STE AZIM. (DEGRS)	STE RANGE (NM)	IDCU1 GRB AZIM. (DEGRS)	IDCU1 STE AZIM. (DEGRS)	IDCU1 LAT. LONG. (DMS)	GPS LAT LONG (DEGRS)	GRB ERROR (DEGRS)	STE ERROR (DEGRS)
1		4420.26 8805.33	169.9	9.5	101.1	63.1	174		441832 880508	44.33767 88.08883	4	
2		4409.42 8800.42	164.6	20.8	109.4	69.5		111	440923 875902	44.15700 88.00700		2
3		4400.81 8756.43	163.1	29.9	114.8	75.5	167		440004 875606	44.01350 87.94050	4	
4		4403.38 8757.65	163.5	27.2	113.3	73.6			44.05633 87.96083			
	201230	4403.55 8816.29	192.2	26.9	118.2	61.5	194	116	440359 881445	44.05917 88.27150	2	-2
	201309	4404.07 8821.7	200.4	27.6	119.5	57.8	203	101	442036 881201	44.06783 88.36167	3	-19
	201415	4403.83 8823.28	202.3	30.0	120.3	57.0	205	112	441011 881841	44.06383 88.38800	3	-8
5		4403.26 8827.11	206.7	33.0	122.3	54.9	209	121	440254 882535	44.05433 88.45183	2	-1
	202000	4406.3 8839.65	223.2	33.0	125.2	45.7	229	126	440558 884241	44.10500 88.66083	6	1
	202930	4422.03 8854.27	255.7	34.5	111.5	28.9	261	114	442205 885937	44.36717 88.90450	5	3
6		4425.82 8857.81	262.5	36.4	105.5	25.3	268	107	442627 890526	44.43033 88.96350	6	1
	203130	4427.7 8859.51	265.6	37.4	101.9	23.6	269	103	44.46167 88.99183		3	1
	203410	4430.03 8901.67	269.1	38.9	96.7	21.7		98	44.50050 89.02783			1
7		4436.87 8904.7	278.6	41.7	77.5	19.9		79	44.61450 89.07833			2
8			89.5	3443.1	90.8	3443.9						

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HRS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

VDF Formal Operational Test and Evaluation Scenario #1 Results

EVENT	TIME	GPS LAT LONG	GRB AZIM. (DEGRS)	GRB RANGE (NM)	STE AZIM. (DEGRS)	STE RANGE (NM)	IDCU1 GRB AZIM. (DEGRS)	IDCU1 STE AZIM. (DEGRS)	IDCU1 LAT. LONG. (DEGRS)	GPS LAT LONG (DEGRS)	GRB ERROR (DEGRS)	STE ERROR (DEGRS)
	210550	4435.45 8925.37	274.6	56.1	57.7	5.6	276	59	443347 892847	44.59083 89.42283	1	1
	210835	4439.78 8917.03	280.2	50.8	55.7	12.9	280	55	443646 892309	44.66300 89.28383	0	-1
	211315	4447.06 8901.86	292.7	42.7	56.0	25.9	294	58	444504 890244	44.70433 89.03100	1	2
9	211517	4449.94 8856.34	298.7	40.5	55.6	30.8	304	54	445045 885553	44.83233 88.93900	5	-2
10	211940	4455.54 8844.88	312.5	37.3	55.6	40.7	315	58	445306 884259	44.92567 88.74800	2	2
11	212410	4450.64 8835.23	314.9	29.0	65.9	44.3	317	67	444904 883431	44.84400 88.58717	2	1

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

VDF Formal Operational Test and Evaluation Scenario #2 Results (GRB and STE)

EVENT	TIME	GPS LAT LONG	GRB AZIM. (DEGRS)	GRB RANGE (NM)	STE AZIM. (DEGRS)	STE RANGE (NM)	IDCU1 GRB AZIM. (DEGRS)	IDCU1 STE AZIM. (DEGRS)	IDCU1 LAT. LONG. (DMS)	GPS LAT LONG (DEGRS)	GRB ERROR (DEGRS)	STE ERROR (DEGRS)
1	141530	4429.41 8837.21	267.8	21.4	94.6	39.2	271	96		44.49017 88.62017	3	1
2	142240	4420.07 8900.9	254.5	39.6	119.5	25.4	257	120	441927 890142	44.33450 89.01500	2	0
	142830	4414.52 8920.39	252.5	54.5	155.8	19.8	269	156	441737 892253	44.24200 89.33983	16	0
3	143140	4413.13 8931.57	253.4	62.6	179.8	19.4	255	181	440959 893244	44.21883 89.52617	2	1
	143510	4412.3 8944.7	254.8	71.9	205.0	22.2				44.20500 89.74500		
4	143725	4411.04 8953.08	255.0	78.1	215.9	26.3		217		44.18400 89.88467		1
	143950	4407.59 9000.52	253.7	84.1	220.1	32.3		222		44.12650 90.00867		2
5	144610	4355.76 9014.39	248.6	97.4	220.4	47.8		220	440309 900709	43.92933 90.23983		0
	144750	4354.94 9020.58	249.0	101.9	223.7	51.3		224	435632 902057	43.91567 90.34300		0
6	145245	4355.8 9039.17	251.8	114.2	233.6	60.6				43.93000 90.65283		
	145320	4355.85 9041.61	252.1	115.9	234.7	62.0		234		43.93083 90.69350		-1
7	145710	4359.04 9055.49	254.9	124.6	241.8	68.7			440044 905215	43.98400 90.92483		
	150010	4402.16 9105.98	257.1	131.1	246.8	74.0			435907 910748	44.03600 91.09967		
	150305	4404.94 9115.79	258.9	137.4	250.8	79.4				44.08233 91.26317		
	150510	4407.05 9123.11	260.2	142.2	253.4	83.6				44.11750 91.30517		

DMS - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

VOF Formal Operational Test and Evaluation Scenario #2 Results (GRB and STE)

EVENT	TIME (HMS)	GPS		GRB		STE		IDCU1		IDCU1		GPS		GRB		STE	
		LAT	LONG	AZIM.	RANGE	AZIM.	RANGE	GRB	STE	GRB	STE	LAT	LONG	ERROR	ERROR	ERROR	ERROR
		(DMIN)	(DMIN)	(DEGRS)	(NM)	(DEGRS)	(NM)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)
8	151150	4421.55		266.1	142.9	263.6	82.8					44.35917					
		9126.75										91.44583					
10	151715	4436.76		272.2	144.7	274.1	84.2					44.61267					
		9129.78										91.49633					
13	154415	4453.47		279.5	135.1	287.3	75.7					44.89117					
		9114										91.23333					

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

VDF Formal Operational Test and Evaluation Scenario #2 Results (EAU and LSE)

EVENT	TIME	GPS LAT LONG	LSE AZIM. (DEGRS)	EAU AZIM. (DEGRS)	EAU RANGE (NM)	IDCU1 LSE AZIM. (DEGRS)	IDCU1 EAU AZIM. (DEGRS)	IDCU1 LAT. LONG. (DEGRS)	GPS LAT LONG	LSE ERROR (DEGRS)	EAU ERROR (DEGRS)
1	141330	44.29.41	69.4	101.5	124.6				44.49017		
2	142240	8837.21	71.3	107.9	110.5			441927	88.62017		
		44.20.07						890142	44.33450		
	142830	8900.9	72.1	113.4	99.4			441737	89.01500		
		44.14.52						892253	44.24200		
3	143140	8920.39	71.3	116.2	92.6			440959	89.33983		
		44.13.13						893244	44.21883		
	143510	8931.57	69.6	119.4	84.6				89.52617		
		44.12.3							44.20500		
4	143725	8944.7	68.8	122.3	80.0				89.74500		
		44.11.04							44.18400		
	143950	8953.08	70.2	126.5	77.5				89.88467		
		44.07.59							44.12650		
5	144610	9000.52	81.1	138.0	77.8	73		440309	90.00867	-8	
		4355.76						900709	43.92933		
	144750	9014.39	81.3	140.9	75.4	79		435632	90.23983	-2	
		4354.94						902057	43.91567		
6	145245	9020.58	74.9	149.2	66.8	76			90.34300	1	
		4355.8							43.93000	-2	
	145320	9039.17	73.7	150.5	65.8	72			90.65283		
		4355.85							43.93083		
7	145710	9041.61	51.5	157.3	58.3	52		440044	90.69350	0	-7
		4359.04						905215	43.98400	-2	-1
	150010	9055.49	19.6	163.4	52.6	18		435907	90.92483	-1	-3
		4402.16						910748	44.03600	-3	-5
	150305	9105.98	350.7	170.4	48.1	350			91.09967	-3	
		4404.94							44.08233		
	150510	9115.79	336.1	176.4	45.2	333			91.26317	-3	
		4407.05							44.11750		
EVENT	TIME	GPS LAT	LSE AZIM.	EAU AZIM.	EAU RANGE	IDCU1 LSE	IDCU1 EAU	IDCU1 LAT.	GPS LAT	LSE ERROR	EAU ERROR

VOF Formal Operational Test and Evaluation Scenario #2 Results (EAU and LSE)

	LONG (MM)	LONG (DEGREES)	(MM)	(DEGREES)	AZIM. (DEGREES)	AZIM. (DEGREES)	LONG. (DMS)	LONG (DEGREES)	(DEGREES)	(DEGREES)
8	151150	4421.55						44.35917		
		9126.75	342.1	33.8	178.6	30.6		91.44583		
10	151715	4436.76						44.61267		
		9129.78	345.2	49.0	183.3	15.3	179	91.49633	-4	
13	154415	4453.47						44.89117		
		9114	358.9	64.1	84.2	10.9	80	91.23333	-4	

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay 5 NM Radius Orbit Using 1 Second Transmissions

TIME	IDCU1 GRB LAT. LONG. (DMS)	GPS LAT. LONG. (DMM)	IDCU1 GRB AZIM. (DEGRS)	IDCU1 GRB LAT. LONG. (DEGRS)	GPS LAT. LONG. (DEGRS)	GRB ERROR (DEGRS)	GRB AZIM. (DEGRS)	GRB RANGE (NM)
213901		4423.83 8808.05	196		44.3972 88.1342	12	184.0	5.8
214001	441838 880355	4424.24 8805.86	170		44.4040 88.0977	2	167.9	5.5
214101	442550 880355	4424.86 8803.87	150		44.4143 88.0645	-1	151.4	5.3
214201	441336 874705	4425.85 8802.33	140	44.2267 87.7047	44.4308 88.0398	5	135.3	5.2
214301		4427.11 8801.37	114		44.4518 88.0228	-5	119.1	4.9
214401		4428.44 8800.75	103		44.4740 88.0125	1	102.4	4.8
214501		4429.86 8800.91			44.4977 88.0152		85.1	4.5
214601		4431.29 8801.34	71		44.5215 88.0223	5	66.4	4.5
214701		4432.50 8802.82	49		44.5417 88.0470	3	45.7	4.3
214802		4433.61 8804.66	27		44.5602 88.0777	4	22.9	4.4
214901		4434.18 8807.20	359		44.5697 88.1200	1	358.5	4.6
215001		4433.78 8809.99	338		44.5630 88.1665	5	332.9	4.6
215101		4432.72 8812.58	310		44.5453 88.2097	3	307.4	4.9
215201		4430.84 8814.28	284		44.5140 88.2380	2	281.9	5.2
215301		4428.52 8814.95	261		44.4753 88.2492	4	257.0	5.6
215401	435956 891226	4426.31 8814.20	240		44.4385 88.2367	5	234.6	6.0
215501		4424.96 8812.19	220		44.4160 88.2032	5	215.5	5.9
215601		4424.18 8809.73	200		44.4030 88.1622	4	196.4	5.7

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Stevens Point Data Collected During Green Bay 5 NM Radius Orbit Using 1 Second Transmissions

TIME	IDCU1 GRB LAT. LONG. (DMS)	GPS LAT. LONG. (DMS)	IDCU1 STE AZIM. (DEGRS)	GPS LAT. LONG. (DEGRS)	STE ERROR (DEGRS)	STE AZIM. (DEGRS)	STE RANGE (NM)
214001		4424.24 8805.56	101	44.4040 88.0977	6	95.3	62.1
214101		4424.86 8803.87	95	44.4143 88.0645	0	94.6	63.4
214201		4425.85 8802.33	103	44.4308 88.0388	9	93.6	64.4
214301		4427.11 8801.37	79	44.4518 88.0228	-13	92.4	64.9
214802		4433.61 8804.66	295	44.5602 88.0777	208	86.6	62.3
214901		4434.18 8807.20	300	44.5697 88.1200	214	86.1	60.5
215301		4428.52 8814.95	267	44.4753 88.2492	175	91.8	55.1
215401	435956 891226	4426.31 8814.20	156	44.4385 88.2367	62	94.1	55.9

Green Bay 5 NM Radius Orbit Using 5 Second Transmissions

TIME	IDCU1 GRB LAT. LONG.	GPS LAT. LONG.	IDCU1 GRB AZIM.	IDCU1 GRB LAT. LONG.	GPS LAT. LONG.	GRB ERROR	GRB AZIM.	GRB RANGE
(MMS)	(DMS)	(DMM)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
211005	442215 880704	4424.80 8813.28 4423.68 8810.17		44.3708 88.1511	44.4133 88.2213 44.3947 88.1695		220.1	6.5
211905			204			6	197.7	6.3
212005	442607 880731	4424.15 8807.64 4424.45 8805.15	185	44.4353 88.1253	44.4025 88.1273 44.4075 88.0858	4	181.2	5.5
212105							162.1	5.4
212205	442447 880330	4425.29 8803.40 4432.11 8802.25	153	44.4131 88.0583	44.4215 88.0567 44.5352 88.0375	7	145.9	5.1
212705			57			4	53.1	4.3
212805			36			3	32.7	4.3
212905			15			5	10.1	4.4
213105			351			3	348.4	4.8
213105			326			3	322.5	4.7
213205			301			3	297.8	5.3
213305			275			2	273.0	5.3
213405	442742 881539	8814.67 4427.77 8814.85	254	44.4617 88.2608	44.4628 88.2475	5	249.5	5.8
213505	442713 881133	4425.82 8813.45	234	44.4536 88.1925	44.4303 88.2242	6	227.7	5.8
213605	442211 881254	4424.38 8811.63	210	44.3697 88.2150	44.4063 88.1938	1	209.2	6.1

DMM - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Stevens Point Data Collected During Green Bay 5 NM Radius Orbit Using 5 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 STE AZIM.	GPS LAT. LONG.	STE ERROR	STE AZIM.	STE RANGE
(MMS)	(DMIN)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
212005	4426.15 8807.64	95	44.4025 88.1273	-1	95.6	60.8
212105	4426.45 8805.15	96	44.4075 88.0858	1	95.1	62.5
212205	4425.29 8803.40	96	44.4215 88.0567	2	94.2	63.7
212905	4433.92 8805.96	159	44.5653 88.0993	73	86.3	61.4
213305	4430.06 8816.67	109	44.5010 88.2445	19	90.2	55.2
213405	4427.77 8814.85	94	44.4628 88.2475	1	92.6	55.3
213505	4425.82 8813.45	94	44.4303 88.2242	0	94.5	56.5
213605	4424.38 8811.63	99	44.4063 88.1938	3	95.7	58.0

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES MMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay 10 NM Radius Orbit Using 5 Second Transmissions

TIME	IDCU1 GRB LAT. LONG. (DMS)	GPS LAT. LONG. (DMS)	IDCU1 GRB AZIM. (DEGRS)	IDCU1 GRB LAT. LONG. (DEGRS)	GPS LAT. LONG. (DEGRS)	GRB ERROR (DEGRS)	GRB AZIM. (DEGRS)	GRB RANGE (NM)
164705	442128 881909	4421.75 8817.64	228	44.3578 88.3192	44.3625 88.2940	6	221.6	10.8
164805		4420.59 8816.90	216		44.3432 88.2483	7	209.5	10.6
164905		4419.49 8811.89	200		44.3248 88.1982	4	196.4	10.7
165005		4418.77 8808.92	186		44.3128 88.1487	1	184.6	10.9
165105		4419.35 8806.05	178		44.3225 88.1008	5	173.5	10.3
165205		4419.57 8803.26	167		44.3262 88.0543	5	162.4	10.5
165305	442526 880441	4420.44 8800.90	158		44.3407 88.0150	6	151.9	10.2
165405		4421.54 8758.70	143		44.3590 87.9783	2	141.1	10.1
165505		4422.78 8756.04	132		44.3797 87.9440	2	130.2	10.2
165605		4424.43 8755.37	126		44.4072 87.9228	6	119.6	9.9
165705		4426.09 8754.44	115		44.4348 87.9073	6	109.2	9.8
165805		4427.84 8753.71	104		44.4640 87.8952	5	98.6	9.8
165905		4429.59 8753.94	94		44.4932 87.8990	6	88.3	9.5
170005		4431.33 8754.38	82		44.5222 87.9063	4	77.5	9.3
170105		4432.97 8755.09	65		44.5495 87.9182	-2	67.0	9.3

DMS - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Stevens Point Data Collected During Green Bay 10 NM Radius Orbit Using 5 Second Transmissions

TIME	GPS LAT. LONG.	LOCAL STE AZIM.	GPS LAT. LONG.	STE ERROR	STE AZIM.	STE RANGE
(MMS)	(DMIN)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
164705	4421.75	101	44.3625	2	99.2	54.2
	8817.64		88.2940			
165105	4419.35	82	44.3225	-18	99.8	62.8
	8806.05		88.1008			
165305	4420.44	95	44.3407	-3	98.1	66.2
	8800.90		88.0150			
165405	4421.54	79	44.3590	-18	97.0	67.5
	8758.70		87.9783			
165505	4422.78	75	44.3797	-21	95.7	68.8
	8756.64		87.9440			

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay 10 NM Radius Orbit Using 10 Second Transmissions

TIME	IDCU1 GRB LAT. LONG. (DMS)	GPS LAT. LONG. (DMMN)	IDCU1 GRB AZIM. (DEGRS)	IDCU1 GRB LAT. LONG. (DEGRS)	GPS LAT. LONG. (DEGRS)	GRB ERROR (DEGRS)	GRB AZIM. (DEGRS)	GRB RANGE (NM)
(MMS)								
170406		4437.35 8756.86	36		44.6225 87.9810	0	35.8	9.8
170506		4437.88 8801.36	28		44.6313 88.0227	3	25.0	9.3
170606		4438.63 8804.03	19		44.6422 88.0672	6	12.6	9.2
170706		4439.10 8806.13	8		44.6517 88.1022	5	2.9	9.5
170806		4439.28 8808.67	367		44.6543 88.1445	5	362.1	9.7
170906		4439.08 8811.31	349		44.6513 88.1885	8	341.2	9.9
171006	445430 882352	4438.11 8813.72	338	44.9083 88.3978	44.6352 88.2287	6	329.7	9.7
171106	443521 881507	4436.98 8816.07	317	44.5892 88.2519	44.6163 88.2678	-1	317.7	9.7
171306		4434.67 8820.51			44.5762 88.3418		295.9	10.7
171406		4432.41 8821.09	287		44.5402 88.3515	3	284.1	10.3
171506		4430.17 8821.60	276		44.5028 88.3600	5	271.4	10.3
171606		4427.97 8821.72	262		44.4662 88.3620	3	259.2	10.5
171706	442519 882008	4426.83 8820.91	247	44.4219 88.3356	44.4305 88.3485	0	247.1	10.5
171806	442354 881841	4423.74 8819.61	237	44.3983 88.3114	44.3957 88.3268	2	234.6	10.6
171906	442052 881957	4421.87 8818.04	228	44.3478 88.3325	44.3645 88.3007	5	223.2	11.0
172006		4420.86 8815.78			44.3443 88.2630		212.5	10.9
172106		4419.83 8813.22			44.3305 88.2203		201.8	10.7
172206		4419.28 8810.52			44.3213 88.1753		191.0	10.6

DMMN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay 40 NM Radius Orbit Using 5 Second Transmissions

TIME	IDCU1 GRB LAT. LONG.	GPS LAT. LONG.	IDCU1 GRB AZIM.	IDCU1 GRB LAT. LONG.	GPS LAT. LONG.	GRB ERROR	GRB AZIM.	GRB RANGE	
(MMS)	(DMS)	(DMM)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)	
161505	445314	4453.99	308	44.8872	44.8998	3	305.5	40.5	
	885312	8852.69		88.8867	88.8782				
161605	445116	4452.40	306	44.8544	44.8733	3	302.8	40.5	
	885139	8854.23		88.8608	88.9038				
161805	444840	4448.40	300	44.8111	44.8067	3	296.5	40.0	
	885826	8856.78		88.9739	88.9463				
161905	444623	4446.32	297	44.7731	44.7720	4	293.3	39.9	
	885846	8857.99		88.9794	88.9665				
162005	444354	4444.51	295	44.7317	44.7418	3	290.2	40.4	
	890116	8859.84		89.0211	88.9973				
162105		4442.40	288		44.7067	1	287.0	40.3	
		8900.83			89.0138				
162205	444017	4440.30	288	44.6714	44.6717	4	284.0	40.2	
	890015	8901.55		89.0042	89.0258				
162305	443753	4438.15	284	44.6314	44.6358	3	280.9	40.0	
	890346	8901.94		89.0628	89.0323				
162405		4436.17	282		44.6028	4	278.0	40.0	
		8902.51			89.0418				
162505		4434.27	279		44.5712	4	275.2	40.0	
		8902.84			89.0473				
162605		4432.19	277		44.5365	5	272.2	40.0	
		8903.07			89.0512				
162705		4429.97	274		44.4995	5	269.0	40.0	
		8903.25			89.0542				
162805		4427.69	270		44.4615	4	265.8	40.6	
		8903.96			89.0660				

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay 40 NM Radius Orbit Using 5 Second Transmissions

TIME	IDCU1 GRB LAT. LONG. (DMS)	GPS LAT. LONG. (DDMM)	IDCU1 GRB AZIM. (DEGRS)	IDCU1 GRB LAT. LONG. (DEGRS)	GPS LAT. LONG. (DEGRS)	GRB ERROR (DEGRS)	GRB AZIM. (DEGRS)	GRB RANGE (NM)
162905	442554 890453	4425.32 8903.54	267	44.4317 89.1147	44.4220 89.0590	5	262.4	40.5
163005	442333 890445	4423.04 8903.02	264	44.3925 89.1125	44.3840 89.0503	5	259.2	40.4
163105	442003 890025	4420.93 8902.33	258	44.3342 89.0049	44.3488 89.0388	2	256.1	40.4
163205	441719 885906	4418.81 8901.87	254	44.2886 88.9850	44.3135 89.0312	1	253.0	40.6

DDMM - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Stevens Point Data Collected During Green Bay 40 NM Radius Orbit Using 5 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 STE AZIM.	GPS LAT. LONG.	STE ERROR	STE AZIM.	STE RANGE
(MMSS)	(DMIN)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
161505	4453.99	52	44.8998	2	50.3	35.3
161605	8852.69	54	88.8782	3	51.3	33.5
161805	4452.40	57	44.8733	2	55.4	29.7
161905	8854.23	60	88.9038	2	58.1	27.9
162005	4448.40	62	44.7720	2	60.2	25.9
162105	8856.78	65	88.9665	1	63.8	24.3
162205	4446.32	70	44.7418	2	68.1	23.0
162305	8857.99	74	88.9973	1	73.1	22.1
162405	4444.51	79	44.7067	1	78.0	21.3
162505	8859.84	84	89.0138	1	83.0	20.8
162605	4442.40	89	44.6358	0	88.8	20.6
162705	8900.83	96	89.0323	1	95.0	20.6
162805	4440.30	104	44.6028	3	101.5	20.5
	8901.55		89.0418			
	4438.15		44.5712			
	8901.94		89.0473			
	4436.17		44.5365			
	8902.51		89.0512			
	4434.27		44.4995			
	8902.84		89.0542			
	4432.19		44.4615			
	8903.07		89.0660			
	4429.97					
	8903.25					
	4427.69					
	8903.96					

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Stevens Point Data Collected During Green Bay 40 NM Radius Orbit Using 5 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 SITE AZIM.	GPS LAT. LONG.	STE ERROR	STE AZIM.	STE RANGE
(MMS)	(DMIN)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
162905	4425.32 8903.54	110	44.4220 89.0590	3	107.4	21.5
163005	4423.04 8903.02	116	44.3840 89.0503	3	112.6	22.7
163105	4420.93 8902.33	118	44.3488 89.0388	1	116.6	24.1
163205	4418.81 8901.87	122	44.3135 89.0312	2	120.5	25.5

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Marquette 10 NM Radius Orbit Using 5 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 NOT AZIM.	IDCU2 NOT AZIM.	GPS LAT. LONG.	IDCU1 NOT ERROR	IDCU2 NOT ERROR	NOT AZIM.	NOT RANGE	
(MMSS)	(DDMM)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)	
194405	4621.98 8730.15	169	169	46.3663 87.5025	4	4	165.2	10.1	
194500	4623.17 8727.06	154	154	46.3862 87.4510	3	3	151.2	9.7	
194600	4624.48 8723.97	142	142	46.4080 87.3995	6	6	136.4	9.8	
194700	4626.38 8721.50	126	126	46.4397 87.3583	5	5	121.5	9.9	
194800	4628.61 8719.72	112	112	46.4768 87.3287	5	5	106.7	10.0	
194900	4631.06 8718.91	96	96	46.5177 87.3152	4	4	92.3	10.0	
195000	4633.64 8719.04	82	82	46.5607 87.3173	5	5	77.5	10.1	
195100	4636.15 8720.00	68	68	46.6025 87.3333	5	5	62.7	10.2	
195200	4638.47 8721.90	52	52	46.6412 87.3650	4	4	47.8	10.3	
195300	4639.99 8724.95	38	38	46.6665 87.4158	5	5	33.3	10.0	
195400	4641.47 8728.18	22	22	46.6912 87.4697	4	4	18.3	10.3	
195500	4642.19 8731.87	9	9	46.7032 87.5312	5	5	3.8	10.4	
195600	4641.91 8735.78	353	353	46.6965 87.5963	4	4	348.8	10.2	
195700	4641.38 8739.69	341	341	46.6897 87.6615	7	7	333.7	10.5	

DDMM - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES NM - NAUTICAL MILES

Marquette 10 NM Radius Orbit Using 5 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 NOT AZIM.	IDCU2 NOT AZIM.	GPS LAT. LONG.	IDCU1 NOT ERROR	IDCU2 NOT ERROR	NOT AZIM.	NOT RANGE	
(MMS)	(DMIN)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)	
195000	4639.78 8742.83	321	321	46.6630 87.7138	2	2	318.9	10.3	
195900	4637.93 8745.71	305	305	46.6322 87.7618	1	1	303.9	10.5	
200000	4635.48 8747.18	296	296	46.5913 87.7863	7	7	289.2	10.2	
200100	4632.92 8748.39	279	279	46.5487 87.8065	5	5	274.2	10.4	
200200	4630.24 8747.97	265	265	46.5040 87.7995	6	6	259.2	10.2	
200300	4627.66 8746.60	248	248	46.4610 87.7767	5	5	243.5	10.0	
200400	4625.43 8744.65	233	233	46.4238 87.7442	4	4	228.6	10.1	
200500	4622.60 8738.34	203	203	46.3767 87.6390	5	5	198.3	9.8	
200700	4621.99 8734.55	186	186	46.3665 87.5758	3	3	182.6	9.9	
200800	4622.21 8731.04	173	173	46.3702 87.5173	5	5	168.4	9.8	
200900	4623.07 8727.49	156	156	46.3845 87.4582	3	3	153.0	9.7	

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Shuttle 10 NM Radius Orbit Using 5 Second Transmissions

TIME	GPS LAT. LONG.	100U1 RHI AZIM.	100U2 RHI AZIM.	GPS LAT. LONG.	RHI 100U1 ERROR	RHI 100U2 ERROR	RHI AZIM. GPS	RHI RANGE GPS
(MMS)	(DMIN)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
204502	4546.55	30	30	45.7758	-2	-2	32.3	9.7
	8920.68			89.3447				
204600	4547.58	17	15	45.7930	1	-1	16.4	9.7
	8924.25			89.4042				
204700	4547.86	1	0	45.7977	0	-1	0.6	9.7
	8928.05			89.4675				
204800	4547.49	349	349	45.7915	4	4	345.1	9.7
	8931.76			89.5293				
204900	4546.49	332	332	45.7748	3	3	329.4	9.9
	8935.32			89.5887				
205000	4544.8	314	314	45.7467	0	0	314.2	9.9
	8938.17			89.6362				
205100	4542.83	301	301	45.7138	1	1	299.8	10.0
	8940.38			89.6730				
205200	4540.41	285	286	45.6735	0	1	284.9	10.1
	8941.71			89.6952				
205300	4537.9	271	271	45.6317	1	1	270.5	10.0
	8942.04			89.7007				
205400	4535.38	256	256	45.5897	0	0	256.0	10.1
	8941.6			89.6933				
205500	4532.92	242	241	45.5487	1	0	241.3	10.3
	8940.32			89.6720				
205600	4531.05	226	226	45.5175	-1	-1	227.5	10.2
	8938.04			89.6340				
205700	4529.42	213	213	45.4903	0	0	213.4	10.3
	8935.34			89.5890				
205800	4528.18	198	198	45.4697	-1	-1	199.2	10.5
	8932.11			89.5352				
205900	4527.92	182	182	45.4653	-4	-4	185.5	10.3
	8928.6			89.4767				

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Rhineland 20 NM Radius Orbit Using 5 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 RHI AZIM.	IDCU2 RHI AZIM.	GPS LAT. LONG.	IDCU1 RHI ERROR	IDCU2 RHI ERROR	RHI IDCU1 ERROR	RHI AZIM. GPS	RHI RANGE GPS
(MMSS)	(DDMM)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
210600	4521.43 8912.12 4523.09 8909.29 4524.81 8908.27 4526.88 8903.99 4529.26 8902.42 4531.78 8901.15 4534.31 8859.91 4536.99 8859.59 4539.62 8859.65 4542.31 8900.22 4547.3 8902.86 4549.58 8905.04	147 139 133 124 116 109 100 93 86 77 62 53	147 139 133 124 116 109 100 93 86 77 62 49	45.3572 89.2020 45.3848 89.1548 45.4135 89.1045 45.4480 89.0665 45.4877 89.0403 45.5297 89.0192 45.5718 88.9985 45.6165 88.9932 45.6603 88.9942 45.7052 89.0037 45.7883 89.0477 45.8263 89.0840	-2 -2 -1 -2 -3 -2 -3 -2 -2 -3 -2 -3 -2 -2 -2 -2 -3 -2 -2 -3 -2 -3 -7	-2 -2 -1 -2 -3 -2 -3 -2 -2 -3 -2 -3 -2 -2 -2 -2 -3 -2 -2 -3 -2 -3 -7	148.8 141.4 133.6 126.1 118.6 110.9 103.1 95.3 87.6 79.7 64.1 56.1	20.0 19.9 20.1 20.1 19.9 19.7 19.9 19.7 19.7 19.6 19.5	

DMIN - DEGREES MINUTES

DMS - DEGREES MINUTES SECONDS

DEGRS - DEGREES

NMS HOURS MINUTES SECONDS

NM - NAUTICAL MILES

DDMM - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS HOURS MINUTES SECONDS NM - NAUTICAL MILES

Stevens Point 5 NM Radius Orbit Using 1 Second Transmissions

TIME	GPS LAT. LONG.	DMIN	DCU1 STE LAT. LONG.	DCU1 STE AZIM.	DCU1 STE LAT. LONG.	GPS LAT. LONG.	STE DCU1 ERROR	STE AZIM. GPS	STE RANGE GPS
(MMSS)		(DMS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
203401	4433.13 8925.22		81			44.5522 89.4203	-1	82.4	4.8
203701	4434.35 8925.80	443250 893034	67	44.5472 89.5094		44.5725 89.4300	0	66.9	4.8
203801	4435.67 8926.45	443321 893018	51	44.5558 89.5050		44.5945 89.4408	0	50.9	5.1
203901	4436.81 8928.24	443539 892854	33	44.5942 89.4817		44.6135 89.4707	2	31.5	5.1
204201	4436.41 8936.13	443301 893229	324	44.5503 89.5414		44.6068 89.6022	1	323.4	5.0
204401	4432.60 8939.01		273			44.5433 89.6502	1	272.2	5.1
204501	4430.53 8938.50	443222 893210	246	44.5394 89.5361		44.5088 89.6417	-2	248.3	5.1
204601	4428.81 8937.00	443041 893357	219	44.5114 89.5658		44.4802 89.6167	-6	225.4	5.1
204701	4427.72 8934.81	442711 893507	203	44.4531 89.5853		44.4620 89.5802	-1	204.1	5.2
204801	4427.37 8932.37	442711 893214	182	44.4531 89.5372		44.4562 89.5395	-2	184.1	5.1
204901	4427.67 8929.94	442633 892928	163	44.4425 89.4911		44.4612 89.4990	-1	164.1	5.0
205001	4428.32 8927.56	442648 892604	143	44.4467 89.4344		44.4720 89.4593	-1	143.5	5.2
205101	4429.50 8925.88	442736 892244	126	44.4600 89.3789		44.4917 89.4313	1	124.9	5.2
205201	4431.13 8925.40					44.5188 89.4233		106.3	4.8
205300	4432.75 8924.80		87			44.5458 89.4133	0	87.1	5.1
205400	4434.24 8924.94	443117 892824	71	44.5214 89.4733		44.5707 89.4157	0	70.7	5.3

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay Data Collected During Stevens Point 5 NM Radius Orbit Using 1 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 GRB AZIM.	GPS LAT. LONG.	IDCU1 ERROR	GRB AZIM.	GRB RANGE GPS
(MMSS)	(DDMM)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
203601	4433.13 8925.22 4434.35	276	44.5522 89.4203 44.5725	1	274.6	55.8
203701	8925.80 4435.67 8926.45	275	89.4300 44.5945 89.4408	-1	275.8	56.3
203801	4436.81 8928.24 4436.41	276	44.6135 89.4707 44.6068	-1	277.1	56.9
203901	8936.13 4432.60 8939.01	278	89.6022 44.5433 89.6502	0	278.1	58.3
204201	4430.53 8938.50 4428.21	276	44.5088 89.6417 44.4802	-1	277.1	63.8
204401	8937.00 4427.72 8934.81	275	89.6167 44.4620 89.5802	1	273.6	65.6
204501	4427.37 8932.37 4427.67	275	44.4582 89.5395 44.4612	3	271.8	65.2
204601	8929.94 4428.32 8927.56	273	89.4990 44.4720 89.4593	3	270.3	64.2
204701	4429.50 8925.88 4432.75	270	44.4917 89.4313 44.5458	1	269.3	62.6
204801	8924.80 4434.24 8924.94	270	89.4133 44.5707 89.4157	1	268.9	60.9
204901		269		0	269.1	59.1
205001		269		-1	269.7	57.4
205101		270		0	270.2	56.2
205300		273		-1	274.2	55.5
205400		276		0	275.7	55.7

DDMM - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Stevens Point 5 NM Radius Orbit Using 2 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 STE LAT. LONG.	IDCU1 STE AZIM.	IDCU1 STE LAT. LONG.	GPS LAT. LONG.	IDCU1 STE ERROR	STE AZIM. GPS	STE RANGE GPS
(MMS)	(DMIN)	(DMS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
201402	4437.09 8929.14 4437.41	443449 893012 443446	27 6	44.5803 89.5033 44.5794	44.6182 89.4857 44.6235	3 3	23.6 2.6	5.1 5.0
201502	8931.66 4436.74 8934.32	893131 444349 894535	340 312	89.5253 44.7303 89.7597	89.5277 44.6123 89.5720	1 0	338.8 312.0	4.6 4.6
201700	4435.51 8936.78 4433.89	443551 893678 443389	288		44.5918 89.6130 44.5648	2	286.4	5.3
201902	8939.03 4431.70 8939.07	893903 443170 893907	262		89.6505 44.5283 89.6512	0	262.2	5.2
202002	4429.72 8937.75 4428.22	442959 893732 443001	238 211	44.4997 89.6256 44.5003	44.4953 89.6292 44.4703	1 -2	237.3 213.2	5.0 5.0
202102	8935.72 4427.66 8933.26	893357 442650 893330	191	89.5658 44.4472 89.5583	89.5953 44.4510 89.5543	-1	191.8	4.9
202302	4427.60 8930.61 4428.04	442741 893048 442854	170 150	44.4614 89.5133 44.4817	44.4600 89.5102 44.4673	0 0	169.6 150.1	4.9 5.1
202502	8928.29 4429.06 8926.58	892909 442926 892729	133 115	89.4858 44.4906 89.4581	89.4715 44.4813 89.4430	1 1	132.2 114.0	5.1 5.0
202602	4430.45 8925.48 4432.10	443028 892606 443210	95	44.5078 89.4350	44.5075 89.4217 44.5350	0	94.7	4.7
202802	8925.31 4433.74 8925.80		74		89.4218 44.5623 89.4300	0	74.0	4.6
202902	4435.34 8926.36 4436.73	443519 892607 443521	55 37	44.5886 89.4353 44.5892	44.5890 89.4393 44.6122	1 1	54.3 35.9	4.9 5.3
203002	8927.65	892846		89.4794	89.4608			

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay Data Collected During Stevens Point 5 NM Radius Orbit Using 2 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 GRB AZIM.	GPS LAT. LONG.	GRB IDCU1 ERROR	GRB AZIM. GPS	GRB RANGE GPS
(MMS)	(DMIN)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
201402	4437.09 8929.14	277	44.6182 89.4857	-1	278.3	58.9
201502	4437.41 8931.66	277	44.6235 89.5277	-1	278.4	60.8
201600	4436.74 8934.32	277	44.6123 89.5720	-1	277.6	62.6
201700	4435.51 8936.78	276	44.5918 89.6130	0	276.3	64.2
201802	4433.89 8939.03	276	44.5648 89.6505	1	274.8	65.7
201902	4431.70 8939.07	273	44.5283 89.6512	0	272.9	65.6
202002	4429.72 8937.75	273	44.4953 89.6292	2	271.1	64.7
202102	4428.22 8935.72	273	44.4703 89.5953	3	269.8	63.3
202202	4427.66 8933.26	270	44.4610 89.5543	1	269.2	61.5
202302	4427.60 8930.61	270	44.4600 89.5102	1	269.0	59.6
202402	4428.04 8928.29	272	44.4673 89.4715	3	269.4	58.0
202502	4429.06 8926.58	272	44.4843 89.4430	2	270.4	56.7
202602	4430.45 8925.48	273	44.5075 89.4247	1	271.8	55.9
202702	4432.10 8925.31	274	44.5350 89.4218	0	273.5	55.8
202802	4433.74 8925.80	277	44.5623 89.4300	2	275.2	56.3
202902	4435.34 8926.36	278	44.5890 89.4393	1	276.8	56.8
203002	4436.73 8927.65	278	44.6122 89.4608	0	278.0	57.8

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

TIME	GPS LAT. LONG.	IDCU1 STE LAT. LONG.	IDCU1 STE AZIM.	IDCU1 STE LAT. LONG.	GPS LAT. LONG.	STE AZIM. GPS	STE RANGE GPS
(HMS)	(DMS)	(DMS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
194406	4437.26 8931.15 4434.91 8934.67	443427 893127	9	44.5742 89.5242	44.6210 89.5192 44.6152 89.5778	2	4.8
194505	4435.57 8936.88 4433.27 8938.07		313	44.5572 89.5564 44.5572 89.5564	44.5928 89.6147 44.5545 89.6345	1	4.7
194606	4430.84 8938.14 4428.73 8936.84	443326 893323 443326 893323	203	44.5286 89.5817 44.5031 89.5836	44.5140 89.6357 44.4788 89.6140	2	4.5
194705	4427.52 8934.29 4427.52 8931.43	443143 893454 443011 893501	251	44.4606 89.5756 44.4603 89.5836	44.5140 89.6357 44.4788 89.6140	0	4.7
194805	4428.21 8929.08 4429.18 8926.94	442738 893138 442815 892916	224	44.4708 89.4878 44.4814 89.4703	44.4587 89.5238 44.4702 89.4847	0	5.1
194905	4430.58 8925.39 4432.24 8924.60	442956 892402	155	44.4989 89.4006	44.4490 44.5097 44.5373 89.4100	1	5.0
195005	4433.98 8925.58 4435.64 8926.72	443346 892545 443333 893000	134	44.5628 89.4292 44.5592 89.5000	44.4863 89.4490 44.5097 44.5373	1	4.7
195105	4437.05 8928.65 4437.70 8931.21	443519 892934 443601 893112	114	44.5886 89.4928	44.4940 89.4453 44.6175 89.4775	2	4.8
195205			93		89.4232 44.5373 89.4100 44.5663	0	5.2
195305			73		89.4263 44.5940 89.4453 44.6175	1	4.8
195405			50		89.4453 44.6175 89.4775 44.6283	0	4.9
195506			30		89.4775 44.6283 89.5202	3	5.2
195605			8			2	5.3

DDMM - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Stevens Point 5 MW Radius Orbit Using 10 Second Transmissions

TIME	GPS LAT. LONG.	DCU1 STE LAT. LONG.	DCU1 STE AZIM.	DCU1 STE LAT. LONG.	GPS LAT. LONG.	STE IDCU1 ERROR	STE AZIM. GPS	STE RANGE GPS
(HMS)	(DMM)	(DMS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
200005	4436.85	443343	341		44.6142	1	339.7	4.7
	8934.27	893231			89.5712			
200105	4435.67	443852			44.5945		311.9	4.9
	8937.04	895031			89.6173			
200205	4433.74		287		44.5623	2	285.3	5.1
	8938.81				89.6468			
200305	4431.26		257		44.5210	0	256.5	4.9
	8938.60				89.6433			
200405	4429.09		229		44.4848	1	228.0	5.0
	8937.05				89.6175			
200505	4428.02	442802	203	44.4672	44.4670	1	202.4	4.8
	8934.41	893436		89.5767	89.5735			
200605	4427.87	442847	179	44.4797	44.4645	1	178.1	4.6
	8931.65	893152		89.5311	89.5275			
200705	4428.05	442826	156	44.4739	44.4675	0	155.6	4.9
	8929.05	892924		89.4900	89.4842			
200805	4428.57	442855	137	44.4819	44.4762	-1	137.6	5.3
	8926.87	892727		89.4575	89.4478			
200905	4430.04	442944	121	44.4956	44.5007	2	119.1	5.0
	8925.73	892539		89.4275	89.4288			
201005	4431.71		100		44.5285	1	99.4	4.8
	8925.32				89.4220			

DMM - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay Data Collected During Stevens Point 5 NM Radius Orbit Using 10 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 GRB AZIM.	GPS LAT. LONG.	GRB IDCU1 ERROR	GRB AZIM. GPS	GRB RANGE GPS
(MMS)	(DMIN)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
194406	4437.26	277	44.6210	-1	278.3	60.4
	8931.15		89.5192			
194505	4436.91		44.6152		277.7	62.8
	8934.67		89.5778			
194606	4435.57	276	44.5928	0	276.3	64.3
	8936.88		89.6147			
194705	4433.27	275	44.5545	1	274.3	65.0
	8938.07		89.6345			
194805	4430.84	274	44.5140	2	272.1	65.0
	8938.14		89.6357			
194905	4428.73	273	44.4788	3	270.2	64.0
	8936.84		89.6140			
195005	4427.60	270	44.4600	1	269.1	62.3
	8934.29		89.5715			
195105	4427.52	270	44.4587	1	269.0	60.2
	8931.43		89.5238			
195205	4428.21	271	44.4702	1	269.6	58.5
	8929.08		89.4847			
195305	4429.18	273	44.4863	3	270.5	57.0
	8926.94		89.4490			
195405	4430.58	273	44.5097	1	271.9	55.9
	8925.39		89.4232			
195506	4432.24	273	44.5373	-1	273.7	55.3
	8924.60		89.4100			
195605	4433.98	277	44.5663	2	275.4	56.1
	8925.58		89.4263			
195705	4435.64	276	44.5940	-1	277.0	57.1
	8926.72		89.4453			
195806	4437.05	278	44.6175	0	278.3	58.6
	8928.65		89.4775			

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES MMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay Data Collected During Stevens Point 5 NM Radius Orbit Using 10 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 GRB AZIM.	GPS LAT. LONG.	GRB IDCU1 ERROR	GRB AZIM. GPS	GRB RANGE GPS
(MMS)	(DMIN)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
199906	4437.70	278	44.6283	-1	278.7	60.5
	8931.21		89.5202			
200005	4436.85	276	44.6142	-2	277.7	62.6
	8934.27		89.5712			
200105	4435.67		44.5945		276.4	64.4
	8937.04		89.6173			
200205	4433.74	275	44.5623	0	274.6	65.5
	8938.81		89.6468			
200305	4431.26	275	44.5210	3	272.5	65.3
	8938.60		89.6433			
200405	4429.09	272	44.4848	2	270.4	64.2
	8937.05		89.6175			
200505	4428.02	271	44.4670	1	269.5	62.3
	8934.41		89.5735			
200605	4427.87	272	44.4645	3	269.3	60.4
	8931.65		89.5275			
200705	4428.05	271	44.4675	2	269.4	58.5
	8929.05		89.4842			
200805	4428.57	272	44.4762	2	269.9	56.9
	8928.87		89.4478			
200905	4430.04	272	44.5007	1	271.4	56.1
	8925.73		89.4288			
201005	4431.71	273	44.5285	0	273.1	55.8
	8925.32		89.4220			

Stevens Point 10 NM Radius Orbit Using 10 Second Transmissions

TIME	GPS LAT. LONG.	DMIN	IDCU1 STE LAT. LONG.	IDCU1 STE AZIM.	IDCU1 STE LAT. LONG.	GPS LAT. LONG.	IDCU1 STE ERROR	STE AZIM.	STE RANGE
(MMS)			(DMS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
191010	4436.99 8920.74 4441.77		443609 892239 444053	60 13	44.6025 89.3775 44.6014	44.6165 89.3457 44.6962	-1 1	60.7 12.0	9.2 9.5
191610	8929.24 4442.04 8935.52		892904	346	89.4844	89.4873 44.7007 89.5920	0	345.5	9.9
191811	4439.56 8941.65 4435.76		443920 894340	317	44.6556 89.7278	44.6593 89.6942 44.5960	1	316.3 290.2	9.9 9.9
192010	8944.93 4430.86 8945.56			261		89.7488 44.5143 89.7593	0	261.3	9.9
192410	4426.44 8943.16 4423.57		442807 894020 442421	234 207	44.6686 89.6722 44.4058	44.4407 89.7193 44.3928	0 -1	233.7 207.7	10.0 10.0
192810	8938.29 4422.48 8932.72		893752 442337 893240	183	89.6311 44.3956 89.5444	89.6382 44.3747 89.5453	-1	183.8	10.0
193010	4422.96 8927.41 4424.84		442324 892748 442510	162 142	44.3900 89.4633 44.4194	44.3827 89.4568 44.4140	0 2	161.8 140.5	10.0 9.9
193210	8922.98 4427.61 8919.95		892358		89.3994	89.3830 44.4602 89.3325		120.0	9.8
193611	4431.24 8917.87 4434.51			100		44.5207 89.2978 44.5752	3	97.3	10.1
193810	8918.12 4438.06 8920.07			79		89.3020 44.6343 89.3345	0	78.6	10.1
194000			443617 892332	57	44.6047 89.3922		0	56.8	10.2

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay Data Collected During Stevens Point 10 NM Radius Orbit Using 10 Second Transmissions

TIME	GPS LAT. LONG.	DMIN	IDCU1 GRB AZIM.	GPS LAT. LONG.	GRB IDCU1 ERROR	GR2 AZIM. GPS	GRB RANGE GPS
(MMS)	(DMIN)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
191010	4436.99 8920.74	279		44.6165 89.3457	0	278.9	53.0
191410	4441.77 8929.24	283		44.6962 89.4873	0	282.7	59.8
191610	4442.04 8935.52	282		44.7007 89.5920	0	282.2	64.2
191811	4439.56 8941.65	279		44.6593 89.6942	0	279.5	68.1
192010	4435.76 8944.93			44.5960 89.7488		276.1	70.0
192210	4430.86 8945.56	275		44.5143 89.7593	3	272.1	70.3
192410	4426.44 8943.16	271		44.4407 89.7193	3	268.4	68.7
192610	4423.57 8938.29	268		44.3928 89.6382	2	265.7	65.4
192810	4422.48 8932.72	267		44.3747 89.5453	3	264.3	61.6
193010	4422.96 8927.41	266		44.3827 89.4568	2	264.3	57.7
193210	4424.84 8922.98	268		44.4140 89.3830	2	265.9	54.4
193410	4427.61 8919.95			44.4602 89.3325		268.7	52.0
193611	4431.24 8917.87	274		44.5207 89.2978	1	272.8	50.5
193810	4434.51 8918.12	277		44.5752 89.3020	1	276.4	50.9
194000	4438.06 8920.07	279		44.6343 89.3345	-1	280.2	52.7

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Stevens Point 40 NM Radius Orbit Using 5 Second Transmissions

TIME	GPS LAT. LONG.	1DCU1 STE LAT. LONG.	1DCU1 STE AZIM.	1DCU1 STE LAT. LONG.	GPS LAT. LONG.	1DCU1 STE ERROR	STE AZIM. GPS	STE RANGE GPS
(MMS)	(DMIN)	(DMS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
154205	4436.8	443622	83	44.6061	44.6133	-1	83.7	38.9
	8837.78	883822		88.6394	88.6297			
154305	4438.56	443858	79	44.6494	44.6427	-2	81.2	39.2
	8837.62	883852		88.6478	88.6270			
154405	4440.16	444014	77	44.6706	44.6693	-2	78.8	39.2
	8838.03	884118		88.6883	88.6338			
154505	4441.58	444158	74	44.6994	44.6930	-3	76.5	38.8
	8839.08	884133		88.6925	88.6513			
154605	4443.24	444250	74	44.7139	44.7207	0	74.0	38.9
	8839.54	883952		88.6644	88.6590			
154705	4444.98	444433	72	44.7425	44.7497	1	71.4	38.9
	8840.29	883810		88.6361	88.6715			
154805	4446.71	444706	67	44.7850	44.7785	-2	68.6	38.8
	8841.28	884117		88.6881	88.6880			
154905	4448.45	444802	64	44.8006	44.8075	-2	65.8	38.8
	8842.3	884504		88.7511	88.7050			
155005	4450.28	444955	61	44.8319	44.8380	-2	62.9	38.9
	8843.36	884541		88.7614	88.7227			
155105	4452.01	445119	60	44.8533	44.8668	0	60.1	39.0
	8844.54	884407		88.7353	88.7423			
155205	4453.57	445112	58	44.8533	44.8928	1	57.3	39.0
	8845.95	884848		88.8133	88.7658			
155305	4455.06	445403	54	44.9008	44.9177	-1	54.5	38.8
	8847.68	884852		88.8144	88.7947			
155405	4456.56	445522	52	44.9228	44.9427	0	51.9	38.9
	8849.08	884907		88.8186	88.8180			
155505	4457.98	445650	46	44.9472	44.9663	-3	49.1	38.9
	8850.76	885533		88.9258	88.8460			
155605	4459.28		46		44.9880	0	46.4	38.8
	8852.66				88.8777			

DMIN - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Green Bay Data Collected During Stevens Point 40 NM Radius Orbit Using 5 Second Transmissions

TIME	GPS LAT. LONG.	IDCU1 GRB AZIM.	GPS LAT. LONG.	IDCU1 GRB ERROR	GRB AZIM. GPS	GRB RANGE GPS
(MMSS)	(DDMM)	(DEGRS)	(DEGRS)	(DEGRS)	(DEGRS)	(NM)
154205	4436.8 8837.78	289	44.6133 88.6297	0	288.9	23.0
154305	4438.56 8837.62	295	44.6427 88.6270	2	293.1	23.5
154405	4440.16 8838.03	296	44.6693 88.6338	0	296.4	24.4
154505	4441.58 8839.08	299	44.6930 88.6513	1	298.5	25.7
154605	4443.26 8839.54	302	44.7207 88.6590	1	301.3	26.8
154705	4444.98 8840.29	306	44.7497 88.6715	2	303.8	28.2
154805	4446.71 8841.28	308	44.7785 88.6880	2	305.9	29.7
154905	4448.45 8842.3	306	44.8075 88.7050	-2	307.8	31.3
155005	4450.28 8843.36	309	44.8380 88.7227	-1	309.5	33.0
155105	4452.01 8844.54	312	44.8668 88.7423	1	310.9	34.8
155205	4453.57 8845.95	308	44.8928 88.7658	-4	311.8	36.6
155305	4455.06 8847.68	312	44.9177 88.7947	0	312.2	38.5
155405	4456.56 8849.08	313	44.9427 88.8180	0	312.9	40.2
155505	4457.98 8850.76	310	44.9663 88.8460	-3	313.3	42.0
155605	4459.28 8852.66	309	44.9880 88.8777	-4	313.4	43.9

DDMM - DEGREES MINUTES DMS - DEGREES MINUTES SECONDS DEGRS - DEGREES HMS - HOURS MINUTES SECONDS NM - NAUTICAL MILES

Airborne Data Collection and Geodesy Description

Orbital data was collected during OT&E activities in order to address questions of total system consistency and accuracy. The method of data collection was to transmit a series of identical messages from the aircraft to the VDF system as the aircraft orbited each of four selected VDF sites. For 10 second transmissions the GPS position was frozen for later recording at five seconds into the transmission, for the 1 to 5 second transmissions the position was frozen at the end of the transmission. This GPS position was recorded as was the angular position as reported to each of the IDCU consoles. Time was synchronized at flight start and was used as a cross check during the match of aircraft and ground collected data.

The GPS position is presented as latitude (lat.) and longitude (long.) in whole number of degrees and minutes to two decimal places. The latitude and longitude of each DF site is known in degrees, minutes, and seconds. The angle from the DF site to the aircraft was derived using the Cosine-Haversine formulas for Site Reduction in Duttons's Navigation & Piloting, 13th edition¹ on pages 553 and 554. These formulas use a spherical Earth model which is sufficiently accurate given the short distances and the 45 degree latitude of the test. The formulas are:

angle of distance =

$$\begin{aligned} & \text{ARCSINE}[\text{SINE}[\text{site lat.}] * \text{SINE}[\text{aircraft lat.}] + \\ & \text{COSINE}[\text{site lat.}] * \text{COSINE}[\text{aircraft lat.}] * \\ & \text{COSINE}[\text{aircraft long.} - \text{site long.}] \end{aligned}$$

$$\begin{aligned} \text{Azimuth} = & \text{ARCSINE}[\text{COSINE}[\text{aircraft lat.}] * \\ & \text{SINE}[\text{aircraft long.} - \text{site long.}] / \text{COSINE}[\text{angle of distance}] \end{aligned}$$

$$\text{Distance} = \text{Earth Radius (3444 NM)} * \text{COSINE}[\text{angle of distance}]$$

The azimuth is corrected for quadrant using an algorithm derived from the following picture, where the DF site is assumed to exist at the origin (center) and NORTH is up:

¹Duttons's Navigation & Piloting, 13ed.
Elbert S. Maloney, Naval Institute Press,
Annapolis, Maryland 1978

Aircraft Lat. > Site Lat.
Aircraft Long. > Site Long.

(270 to 359 degrees)

Aircraft Lat. > Site Lat.
Aircraft Long. < Site Long.

(0 to 89 degrees)

Aircraft Lat. < Site Lat.
Aircraft Long. > Site Long.

(180 to 269 degrees)

Aircraft Lat. < Site Lat.
Aircraft Long. < Site Long.

(90 to 179 degrees)

It is assumed that the difference in longitude is less than 90 degrees, and the latitudes are of the same name (NORTH). It is also assumed that spherical translation offers acceptable accuracy, nearer the poles the use of a spheroidal model would be more appropriate to compensate for the flattening of the sphere that exists there.

The final modification to the azimuth is to add the magnetic correction as entered in the VHF DF system data base at the time of the OT&E test, and to insure that the result is in the range 0 to 359 degrees.

SECTION 6

COMMENTS ON TECHNICAL INSTRUCTION AND MAINTENANCE ISSUES

Revised versions of the technical instruction manuals (TI 6530.10 and TI 6530.11) were reviewed during the Formal OT&E test. During the informal review the documents' instructions were compared with the equipment at the OT&E site. The result is a set of comments which should be addressed before deployment.

TI 6530.10 Comments:

1. Figure 3-1 should have a label on the RS-232 jack describing it as an RS-232 jack.
2. Figures 6-5, 6-6, and pages 6-15 through 6-17 have handwritten corrections that may make the document less than camera ready.
3. In paragraph 3.3, the last sentence indicates that the IOT-3 is "in the rack", IOT-3s are not rack mountable. Also, "and removed" could be changed to "and the cable removed."
4. There is a sometimes used screen labeling code on the IOT-3 display and in the document, this is a potentially useful feature. It would be best if it appeared on all screens, which it currently does not.
5. No option for exiting the DF SITE CALIBRATION MENU is apparent in the instruction book or on the IOT-3 screen. A 'Q' will allow exit from the menu.
6. Photographs on pages 7-14 through 7-17 and 7-19 are nearly illegible.
7. On page 7-60 replace the phrase "The time base modules is provides" with "The time base module provides."
8. There are occurrences of a confusing notational technique: p.5 to mean plus or minus 5, suggest either spelling this out or use the conventional symbol.

TI 6530.10 Comments:

1. In section 2.2.1.3 automatic screen dimmers are described. No such screen dimmer function was ever evidenced in the actual equipment. And there seem to be less security levels described than there are (6).

Maintenance Problems

December 1992/January 1993

The FA-10121 systems at Eau Claire and Marquette were installed and checked out. This was done in preparation for OT&E testing.

January 1993 - Green Bay antenna site experiences a failure just before testing started. A depot level adjustment was made by the contractor. This fix would have required replacement with a spare in the current maintenance plan. FAA field technicians are not trained on how to make the adjustment nor do they have the computer equipment necessary to make the adjustment.

April 1993 - Before OT&E commenced HSTX sent an engineer to the Eau Claire antenna site to make adjustments. It is believed that the same adjustment made in January at Green Bay antenna site was made at Eau Claire. This adjustment is a depot level adjustment, field maintenance would have had to swap the unit for a spare.

April 1993 - Modem failure causes replacement with spare. During the course of the test this modem also appeared to fail, swapped back to original modem. This may have been caused by overheating which the site technicians solved by removing a metal panel at the top front of the RMMC rack.

June 1993 - Before OT&E began repeated failures of remote tests of Marquette forced HSTX to send an engineer to fix the site. No report of the fix needed was given to ACW-300. The Marquette site often fails during remote maintenance tests, retesting usually gives the conflicting answer that the site has passed. The site accuracy orbits appear more stable than Green Bay's, although there is less data for the Marquette site. This site had the same problem at the April test but no attempt was made to fix it.

June 1993 - During OT&E the Trackball at the Operations console failed and was switched with the one in the training room.

These repairs imply that between the preventive maintenance and the April OT&E test all three of the installed FA-10121 sites required some form of repair. In two cases the repair was depot level, in the third case no fix was attempted until June. The third fix when made did not correct the problem, nor did it isolate the cause of the intermittent failures. The allowed mean time to failure is 4200 hours or 175 days or 4.8 months. So within the 4200 hours all three FA-10121 sites had required some form of maintenance.

It should be noted that three sites do not comprise a statistical sample. The Marquette problem may well be a combination of site and software. However, the combination of these failures is not expected from the factory tests of reliability.

The trackball was redesigned for this OT&E, and so a new one failed within 7 months. Our experience with this design is limited. However, trackballs are mechanical and they will wear out. Just as with the antenna sites we recommend that a watch be kept on this part, if only to better predict replacement requirements.

The apparent modem failure occurred in a rack with all modem case temperatures high enough to be painful to touch. Ventilation of the rack is passive with no vents at the top of the case. Removing the top front plate resulted in modems only slightly warm to the touch. No modems failed after the panel was removed, the "failed" modem was back in the rack and working at this point. This failure does not appear to be a maintenance issue.

SECTION 7

ACRONYMS AND ABBREVIATIONS

ADF	Automatic Direction Finder
AF	Airway Facilities
AFSS	Automated Flight Service Station
APMT	Associate Program Manager for Test
AT	Air Traffic
CHI	Computer Human Interface
COTS	Commercial Off-the-Shelf
CPU	Central Processor Unit
DF	Direction Finder
DME	Distance Measuring Equipment
EAU	Eau Claire VDF Antenna Site
ELT	Emergency Locator Transmitter
FAA	Federal Aviation Administration
GPS	Global Positioning System
GRB	Green Bay VDF Antenna Site
IDCU	Information Display Control Unit
IFR	Instrument Flight Rules
IOT	Input/Output Terminal
LAT	Latitude
LONG	Longitude
LSE	Lacrosse VDF Antenna Site
MDT	Maintenance Data Terminal
MOA	Military Operations Area
MPS	Maintenance Processor Subsystem
MQT	Marquette VDF Antenna Site
MTBF	Mean Time Between Failures
MTP	Master Test Plan

MSD	Multiple Signal Detect
NAS	National Airspace System
NAVAID	Navigational Aid
NDB	Nondirectional Radio Beacon
nmi	nautical mile
OT&E	Operational Test and Evaluation
PD	Purchase Description
PM	Preventative Maintenance
RHI	Rhineland VDF Antenna Site
RMM	Remote Maintenance Monitoring
RMMC	Remote Maintenance Monitor Computer
STE	Stevens Point VDF Antenna Site
TI	Technical Instruction
TVRIM	Test Verification Requirements Traceability Matrix
VDF	Very High Frequency Direction Finder
VHF	Very High Frequency
VOR	VHF Omnidirectional Radio Range
VFR	Visual Flight Rules