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U.S. ARMY AVIATION
AND MISSILE COMMAND,
RESEARCH, DEVELOPMENT &
ENGINEERING CENTER

# TITLE: Laser Obstacle Detection System Flight Testing


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Platform Technology Division

**COMPANY ADDRESS:** 401 Lee Boulevard
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The USSOCOM Mission Needs Statement (MNS) and Joint Operational Requirements Document (JORDS) on a Cable Warning / Obstacle Avoidance System define the need for an obstacle detection sensor for US Military helicopters. The Helicopter Laser Radar System (HELLAS) was developed in Germany by EADS-Dornier. The Laser Obstacle Detection System (LODS) Foreign Comparative Test (FCT) program began in March 2002 with the objective of evaluating the HELLAS on a US Army helicopter. The managing agency of the LODS-FCT is the US Army Night Vision and Electronic Sensors Directorate (NVESD). The Aviation Applied Technology Directorate (AATD) was contracted to mount the HELLAS sensor on the nose of a UH-60L Blackhawk helicopter and to conduct flight tests to evaluate the HELLAS obstacle detection sensor. The UH-60L aircraft chosen as the host platform was Tail Number 468.

**15. SUBJECT TERMS**

LODS, Obstacle Detection, Obstacle Avoidance, Cable Warning

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# TABLE OF CONTENTS


TABLE OF FIGURES ..... iv
TABLE OF TABLES ..... iv
ENCLOSURES ..... v
REFERENCES ..... v
1. INTRODUCTION ..... 6
2. AIRCRAFT MODIFICATION ..... 9
3. INSTRUMENTATION ..... 9
4. COCKPIT ..... 10
5. FLIGHT TEST PLAN ..... 10
6. FLIGHT TEST NUMBERING ..... 11
7. FLIGHT TEST AREAS ..... 12
8. ADDITIONAL TESTING ..... 16
9. ISSUES/CONCERNS/PROBLEMS ..... 19
10. TEST PILOT COMMENTS ..... 21
11. POINT OF CONTACT ..... 21

## TABLE OF FIGURES

**FIGURE 1:** UH-60 BLACKHAWK WITH MOUNTED HELLAS OBSTACLE DETECTION SENSOR ................ 7
**FIGURE 2:** HELLAS OBSTACLE DETECTION SENSOR ................ 8
**FIGURE 3:** UH-60 CABIN FLOOR PLAN FOR LODS ................ 10
**FIGURE 4:** JAMES RIVER BRIDGE (WIRE SET #1) ................ 12
**FIGURE 5:** (WIRE SET #2) ................ 12
**FIGURE 6:** (WIRE SET #3) ................ 13
**FIGURE 7:** POLE IN OPEN FIELD (WIRE SET #4) ................ 13
**FIGURE 8:** (WIRE SET #5) ................ 14
**FIGURE 9:** HARRISON ROAD FORT EUSTIS (WIRE SET #6) ................ 14
**FIGURE 10:** (WIRE SET #7) ................ 15
**FIGURE 11:** SHIP TEST SITE ................ 15
**FIGURE 12:** AREA AROUND FIRST FLIGHT AIRFIELD (WIRE SET #8) ................ 16
**FIGURE 13:** THERMOCOUPLE #1 BONDED TO TOP OF CASE ................ 17
**FIGURE 14:** THERMOCOUPLE #2 MOUNTED TO EXHAUST FAN ................ 17
**FIGURE 15:** RAW DATA IMAGE BEFORE AND AFTER FAILURE ................ 18
**FIGURE 16:** RAW DATA IMAGE BEFORE AND DURING MODERATE RAIN ................ 19
**FIGURE 17:** RAW DATA IMAGE OF SUN AND REFLECTION ................ 20
**FIGURE 18:** RAW DATA IMAGE OF SHIP ON WATER ................ 20

## TABLE OF TABLES

TABLE 1: FLIGHT NUMBERS, DESCRIPTIONS AND CARD AVAILABILITY ................ 11
TABLE 2: TEMPERATURE TEST DESCRIPTION ................ 18

## ENCLOSURES

1. CHPPM Laser Safety Test Report
2. LODS FCT Flight Test Plan
3. Daily Flight Reports
4. Flight Test Cards (Pilot)
5. Flight Test Cards (System Operator)

## REFERENCES

a. USSOCOM Mission Needs Statement, *Cable Warning / Obstacle Avoidance System –Aircraft Survivability Equipment*, #95-001 and #95-003, 24 August 1995

b. USSOCOM Joint Operational Requirements Document, *Cable Warning / Obstacle Avoidance System*, # JORD ID:J002GN04, 11 August 1999

c. Technical Manual 1-1520-237-10, 31 Oct 1996, *Operator's Manual for UH-60A, UH-60L, and EH-60A Helicopter, with all changes*

d. Interface Specification Document, *HELLAS Nordic HC*, Document # EIS5097-000000A/02, 22 Feb 2000, Dornier Defense and Civil Systems

e. Airworthiness Substantiation Document (ASD), Flight Test of a UH-60L Helicopter with Laser Obstacle Detection System (LODS), 31 January 2003

# 1. INTRODUCTION

a. Background:

The USSOCOM Mission Needs Statement (MNS) and Joint Operational Requirements Document (JORDS) on a Cable Warning / Obstacle Avoidance System (References 1a and 1b) define the need for an obstacle detection sensor for US Military helicopters. The Helicopter Laser Radar System (HELLAS) was developed in Germany by EADS-Dornier. The HELLAS system is currently qualified and in operation with the German Border Patrol. The Laser Obstacle Detection System (LODS) Foreign Comparative Test (FCT) program began in March 2002 with the objective of evaluating the HELLAS on a US Army helicopter. The managing agency of the LODS-FCT is the US Army Night Vision and Electronic Sensors Directorate (NVESD). The Aviation Applied Technology Directorate (AATD) was contracted to mount the HELLAS sensor on the nose of a UH-60L Blackhawk helicopter and to conduct flight tests to evaluate the HELLAS obstacle detection sensor. The UH-60L aircraft chosen as the host platform was Tail Number 468.

b. Program Objective

The primary goal of the LODS-FCT flight demonstration was to evaluate, on a helicopter platform, the capability of the EH-60L mounted HELLAS system to detect wires along the flight path and as an aide to avoid the wires. To achieve this objective, sensor installation, aircraft checkout, and flight testing were conducted. Concurrent with this testing, laser raw data (angle-angle-range) including INU/GPS data to support studies was collected to determine the ability of the HELLAS system to detect general obstacles (poles, towers, etc) and to provide precision landing information to assist rotary wing aircraft and UAV's during the critical landing phases of shipboard operations.

c. Aircraft Description

The UH-60L is a two pilot (side by side seating) aircraft used for a host of utility, cargo, and medical missions. Tail number 468 was used for this flight test, shown in Figure 1. A complete description of the aircraft and related subsystems is presented in Reference 1c (Operator's Manual).

**FIGURE 1:** UH-60 BLACKHAWK WITH MOUNTED HELLAS OBSTACLE DETECTION SENSOR

d. System Description

The HELLAS obstacle detection sensor, shown in Figure 2, contains a 1.54 µm wavelength Erbium-Fiber eye-safe laser system is manufactured by EADS Dornier and weighs approximately 62 lbs. The system generates a 3D LADAR image with a 32 degrees of elevation and 32 degrees of azimuth field of view. The sensor uses a two-axis scanning laser radar system to measure the 3-dimensional geometry of objects. The distances to targets are measured with a pulsed laser using time of flight measurements. A more detailed description of the HELLAS is presented in Reference 1d (HELLAS Interface Specification Document). Eye safety was tested by U.S. Army Center For Health Promotion and Preventive Medicine (CHPPM) and the report is included in enclosure 1.

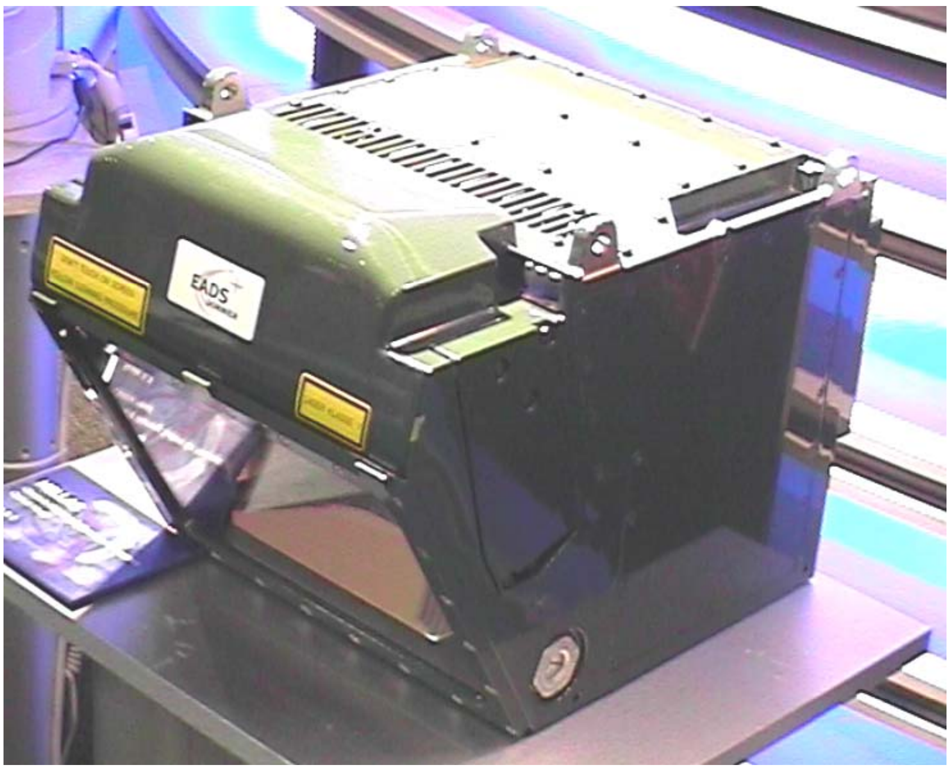


**FIGURE 2:** HELLAS OBSTACLE DETECTION SENSOR

## 2. AIRCRAFT MODIFICATION

The modifications to the UH-60L aircraft for the LODS-FCT included a nose mount for the HELLAS, instrumentation pallets and racks, an inertial navigation system (INS), electrical power taps, cockpit warning indicators and display, and a different cabin floor. A more detailed description of the aircraft modification is presented in Reference 1e (Airworthiness Substantiation Document (ASD), Flight Test of a UH-60L Helicopter with Laser Obstacle Detection System (LODS)).

## 3. INSTRUMENTATION

Instrumentation mounted in the cabin for the LODS FCT flight test included two instrumentation racks and a video pallet.

One instrumentation rack (AATD Rack) contained a global positioning system (GPS), a data acquisition unit and laptop for monitoring accelerations and temperatures of the HELLAS and nose mount. The second rack (Dornier Rack) consisted of the HELLAS data acquisition unit, the HELLAS camera video recorder, a keyboard and trackball, two video monitors, the INS Control Display Unit and Mode Selector Unit, the HELLAS caution display box, and an obstacle warning indicator box. The video pallet recorded signals from the cockpit mini camera, the mini camera recording the cockpit warning indicators, and the HELLAS safety line output.

In addition to the racks and pallet, an inertial navigation system (INS) was mounted in the cabin. The INS consisted of an Inertial Navigation Unit (INU), a Control Display Unit (CDU), a Mode Selector Unit (MSU), a Battery Unit (BU) and Standard Pallet System (SPS). The SPS is designed to hold the INU and BU. The INS provided inertial rate and speed data to the HELLAS unit. A diagram of the cabin floor plan is shown in Figure 3.

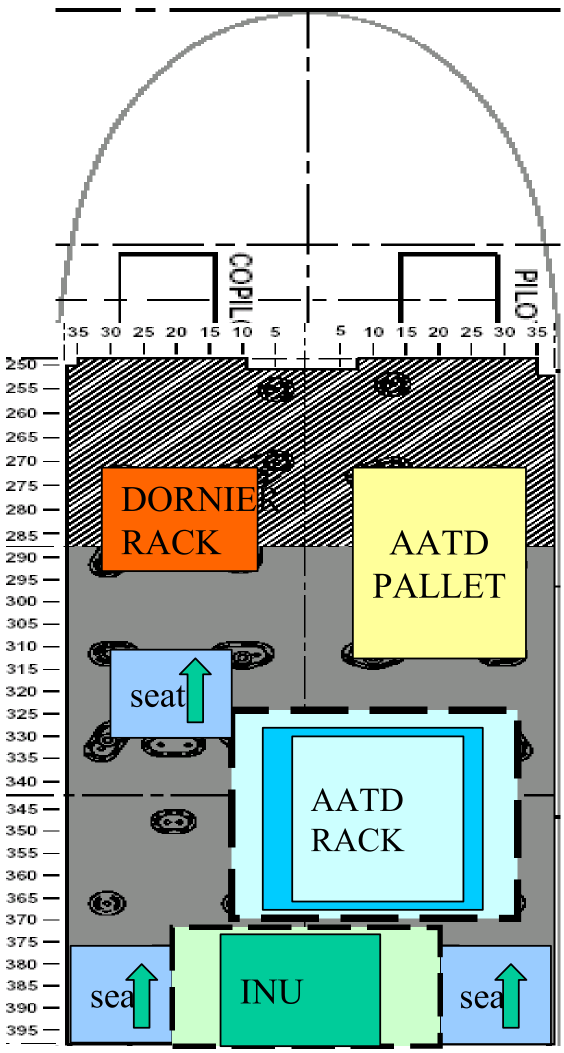


**FIGURE 3:** UH-60 CABIN FLOOR PLAN FOR LODS

## 4. COCKPIT

Modifications to the UH-60 cockpit included the addition of two video mini-cameras, a monitor to display the HELLAS safety line output, an obstacle warning indicator, and an IRIG display. The two video mini-cameras were used to record the obstacle warning indicators and the view out the cockpit windshield.

## 5. FLIGHT TEST PLAN

Details on the flight test plan can be found in Enclosure 2 (LODS FCT Flight Test Plan).

## 6. FLIGHT TEST NUMBERING

The following table lists the flights conducted under the Flight Test Plan.

Not all flight cards are available for each flight. This happened primarily when that card was not applicable to the test being conducted. Available flight cards can be found in enclosures 3, 4 and 5.

**TABLE 1:** FLIGHT NUMBERS, DESCRIPTIONS AND CARD AVAILABILITY

| Flight number | Date | Time | Wire Set | Description | Data recorded | Flight Cards Available |
|---|---|---|---|---|---|---|
| 1 | 2/5/2003 | 900 | N/A | Handling Qualities | AC only: "dummy laser" | |
| 2 | 2/11/2003 | 830 | N/A | HQ / EMC | AC / DV | |
| 3 | 2/12/2003 | 915 | Set 1 & 2 | Preliminary 1 | RD, 8mm, DV | D |
| 4 | 2/12/2003 | 1315 | Set 3 | Preliminary 2 | RD, 8mm, DV | D |
| 5 | 3/4/2003 | 1120 | Set 1 | | RD, 8mm, DV, AC | D, P, O |
| 6 | 3/4/2003 | 1520 | Set 1 | | RD, 8mm, DV, AC | D, P, O |
| 7 | 3/5/2003 | 1300 | Set 1 | Hover points | RD, 8mm, AC | D, P, O |
| 8 | 3/7/2003 | 948 | Set 2 | | RD, 8mm, AC | D, P, O |
| 9 | 3/7/2003 | 1307 | Set 2 & 3 | Rain / Fog | RD, 8mm, AC | D, P, O |
| 10 | 3/12/2003 | 1011 | Set 2 | | RD, AC | P, O |
| 11 | 3/12/2003 | 1320 | Set 3 | | RD, 8mm, AC | O |
| 12 | 3/13/2003 | 1030 | Set 3 | | RD, 8mm, AC | D, P, O |
| 13 | 3/13/2003 | 1330 | Set 4 | | RD, 8mm, AC | D, P, O |
| 14 | 3/14/2003 | 930 | Set 5 & 6 | | RD, 8mm, AC | O |
| 15 | 3/18/2003 | 1400 | Set 6 | | RD, 8mm, AC | D, P, O |
| 16 | 3/19/2003 | 1000 | N/A | Ship flight | RD, 8mm | D, P, O |
| 17 | 3/28/2003 | 1007 | N/A | Ship and airfield | RD, 8mm, DV | P, O |
| 18 | 5/21/2003 | 1130 | Set 7 | | RD, 8mm, DV, AC | P, O |
| 19 | 6/6/2003 | 1000 | Set 8 | Sand Dune | RD, 8 mm, DV, AC | O |
| 20 | 7/7/2003 | 2000 | Set 3 | Night Flight | RD, DV | O |

**Abbreviations:**
RD = HELLAS Raw Data, 8mm = videos of safety line, warning indicator, cockpit view
DV = mini digital video, AC = Aircraft data file (accelerations, GPS, etc)
D = Daily, P = Pilot's flight card, O = Operator's flight card

## 7. FLIGHT TEST AREAS


**FIGURE 4:** JAMES RIVER BRIDGE (WIRE SET #1)
6 LARGE WIRES AND 2 SMALLER GUIDE WIRES
EASILY DETECTED VISUALLY WITH NO BACKGROUND


**FIGURE 5:** (WIRE SET #2)
MANY LARGE WIRES AND SMALLER GUIDE WIRES
HEAVILY WOODED BACKGROUND


**FIGURE 6:** (WIRE SET #3)
MANY LARGE WIRES AND SMALLER GUIDE WIRES
HEAVILY WOODED BACKGROUND


**FIGURE 7:** POLE IN OPEN FIELD (WIRE SET #4)
2 VERY SMALL WIRES AND NO GUIDE WIRES
NOT EASILY DETECTED VISUALLY


**FIGURE 8:** (WIRE SET #5)
2 VERY SMALL WIRES AND NO GUIDE WIRES
NOT EASILY DETECTED VISUALLY, POLES ARE IN OR NEAR TREE LINE


**FIGURE 9:** HARRISON ROAD FORT EUSTIS (WIRE SET #6)
4 VERY SMALL WIRES AND NO GUIDE WIRES
HEAVILY WOODED BACKGROUND FROM WATER SIDE


**FIGURE 10:** (WIRE SET #7)
4 VERY SMALL WIRES AND NO GUIDE WIRES
NOT EASILY DETECTED VISUALLY, TOWERS ARE IN TREE LINE


**FIGURE 11:** SHIP TEST SITE
ANTENNAS, TOWERS AND POLES
NO BACKGROUND


**FIGURE 12:** AREA AROUND FIRST FLIGHT AIRFIELD (WIRE SET #8)
3 OR 4 SMALL WIRES AND SMALLER GUIDE WIRES
LARGE SAND CONCENTRATION AND TERRAIN CONTOUR

## 8. ADDITIONAL TESTING

### LODS – Night Flight Test

July 7, 2003

Wire Set #3 was flown during the day and repeated after sunset. The evening flight was cut short due to weather. No additional night flights were flown prior to removal of the system and program completion. During the night flight, no cockpit displays were operational due to hardware and flight release limitations. From the operator's position, the LODS system functioned comparable to the earlier day flight. Additional flights would be required to determine if the range is increased or decreased under low light conditions.

### LODS – High Temperature Test

July 9, 2003

The only HELLAS system failure was linked to ambient temperature greater than 90 deg F. This prompted a test to determine maximum temperature the system could withstand before failure and if the failure was repeatable. Since the system was installed on the test aircraft, outside ambient temperature was used to achieve test temperatures and is the reason higher temperatures were not evaluated.

The HELLAS laser was equipped with two thermocouples placed at the exhaust of the laser and taped to the top surface of the HELLAS case. See the following pictures:

**FIGURE 13:** THERMOCOUPLE #1 BONDED TO TOP OF CASE

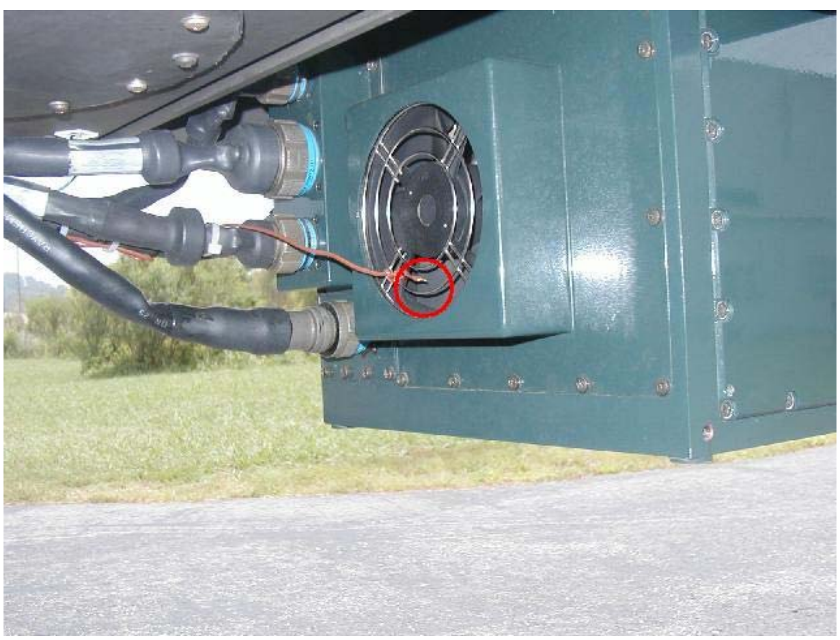

**FIGURE 14:** THERMOCOUPLE #2 MOUNTED TO EXHAUST FAN

The following temperature and observations were recorded:

**TABLE 2:** TEMPERATURE TEST DESCRIPTION

| Time | TC#1 | TC#2 | System Status | Comments |
|---|---|---|---|---|
| 0925 | 90F | 86F | Working | System powered for ~5min, off for ~10min |
| 0940 | 96F | 88F | Working | System powered for ~5min, off for ~15min |
| 1000 | 97F | 88F | Working | System powered for ~5min, off for ~5min |
| 1010 | 100F | 89F | Working | System powered for ~5min, off for ~15min |
| 1030 | 103F | 91F | **Failed** | System powered for ~5min, off for ~25min |
| 1100 | 101F | 95F | **Failed** | System powered for ~5min, off for ~70min |
| 1215 | 105F | 97F | Working | System powered for ~5min |
| 1300 | | | | Thunderstorm came through and the temperatures dropped to low 80s with rain. Test stopped |

**Note:**
The lens cover was off and the laser case and some internal components were exposed to direct sunlight during the entire test.

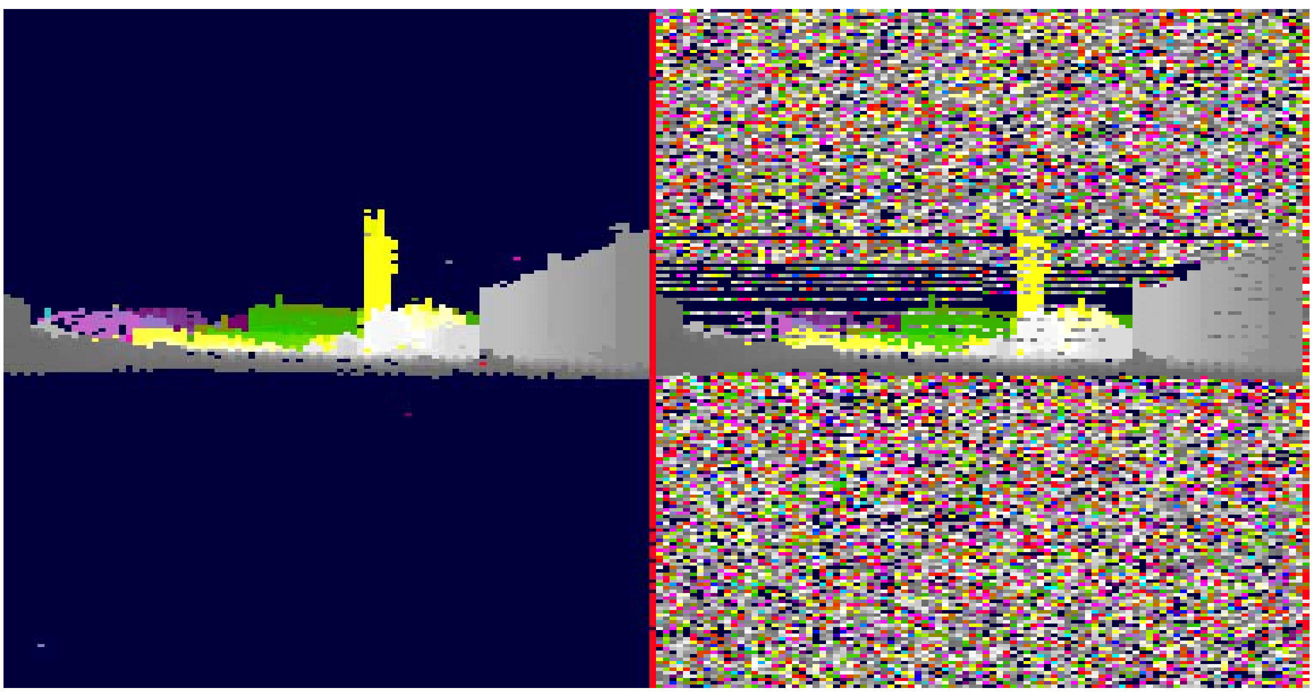

**FIGURE 15:** RAW DATA IMAGE BEFORE AND AFTER FAILURE

This testing confirmed that the failure was due to temperature and was repeatable. More testing in a more controlled environment is required to better understand the full extent of the problem. The manufacturer believes this problem may have been caused by a bad resistor and is planning on verifying that conclusion upon receipt of the HELLAS laser.

## 9. ISSUES/CONCERNS/PROBLEMS

The following is a list of issues, concerns or problems encountered during this flight test program. However, most problems encountered were related to aircraft installation or data acquisition. The HELLAS laser system was very reliable during this testing except for the temperature problem encountered near the end of testing (see item 4).

1. The INU did not provide vertical speed or altitude. This problem affected the warning indicators both visual and audible. The effect of this problem on the indicators made all evaluation of the indicators suspect.
2. Inclement weather, such as rain and fog, reduce obstacle detection range of HELLAS. Range reduction was as much as 50% in moderate rain. For a more quantitative evaluation of this problem, more testing would be required. Additional comments can be found in the flights cards for flight #9.

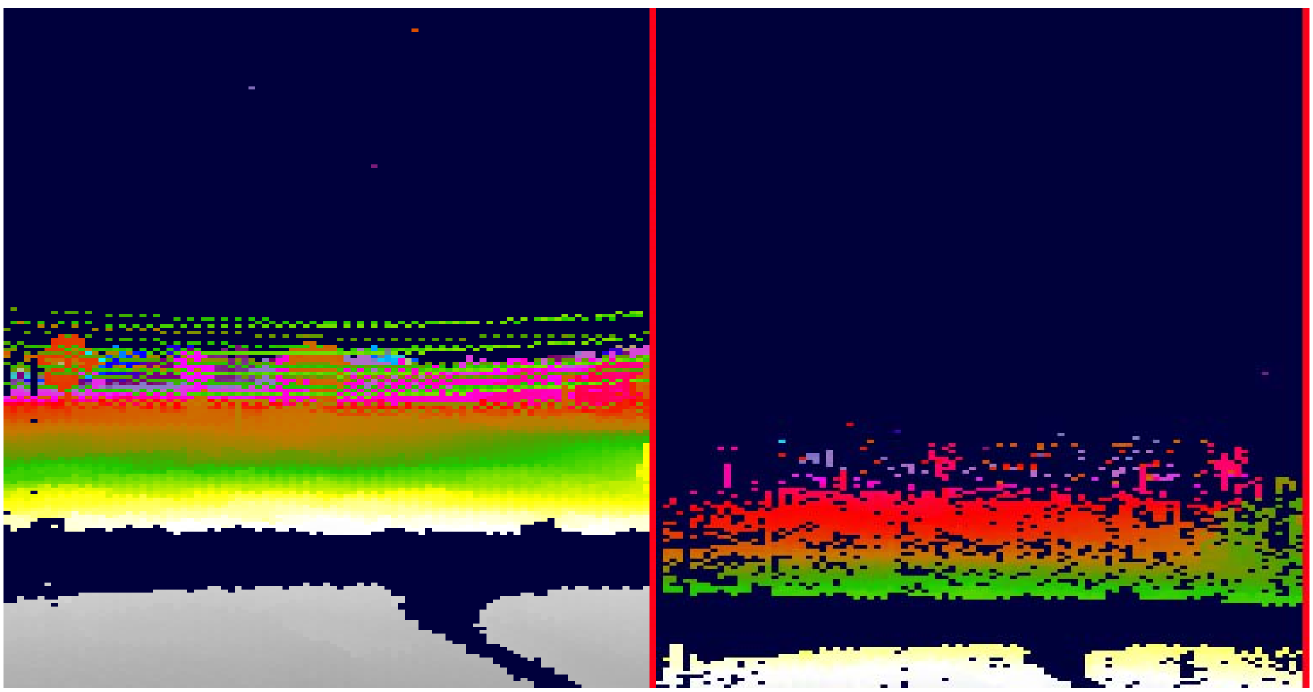

**FIGURE 16:** RAW DATA IMAGE BEFORE AND DURING MODERATE RAIN

3. The HELLAS malfunctioned multiple times at ambient temperatures around 103 degrees Fahrenheit. A separate test was conducted to try and repeat the problem, see the additional testing section #8. This problem requires further evaluation in a more controlled environment.

4. Sun and the reflections of the sun appear as obstacles on the HELLAS display. The manufacturer believes filters within the HELLAS laser can reduce this problem. This problem was most evident on the data from flight #5.

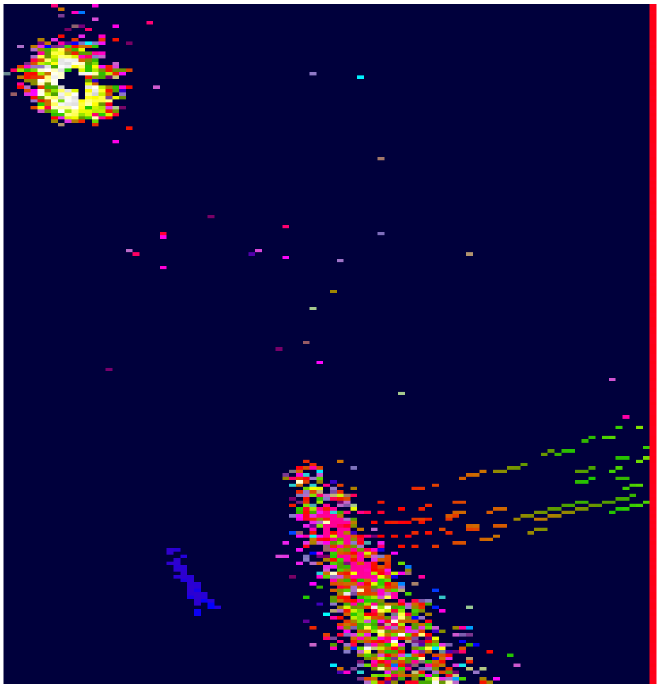

**FIGURE 17:** RAW DATA IMAGE OF SUN AND REFLECTION

5. The HELLAS does not see water as an obstacle. This problem was most evident on the data from flights #5 though #7.

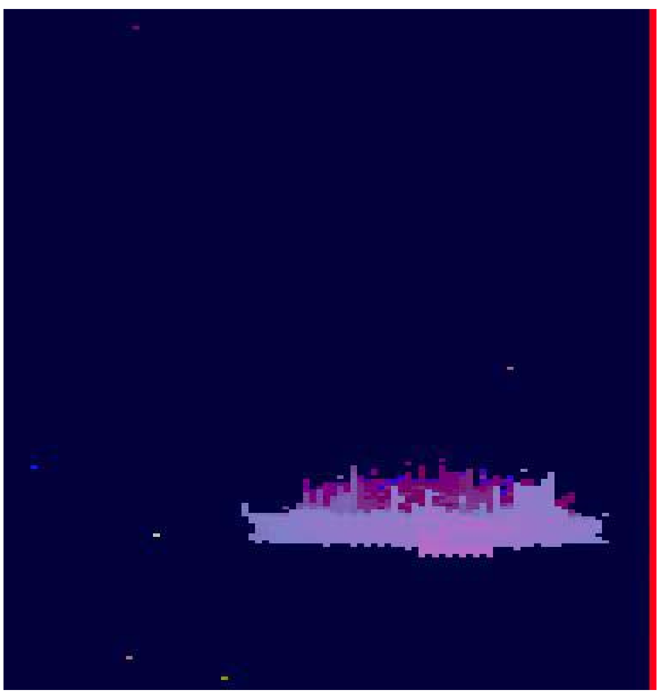

**FIGURE 18:** RAW DATA IMAGE OF SHIP ON WATER

## 10. TEST PILOT COMMENTS

The following is a list of pilot comments on both what they observed during testing and what they believe is required from a obstacle detection system.

1. Any obstacle detection system must not give many false warnings or it will not be used.
2. Both visual display and audible warning are necessary.
3. Current obstacle display is unacceptable.
4. Current visual warning indicator is unacceptable.
5. Would like to see the wires on a video image

## 11. CONCLUSIONS AND RECOMENDATIONS

The primary goal of evaluating the capability of the HELLAS system to detect wires was achieved. The system detected obstacles at the ranges expected. This HELLAS did show significant potential for use as an aid in detecting obstacles. The specific range capability and limitations should be part of the NVESD evaluation of the flight test data.

The following issues encountered during testing of the HELLAS are recommended for further investigation:

1. *Obstacle detection range reduction due to inclement weather.*
   This issue should be further evaluated in a laboratory where the conditions can be controlled. Weather conditions during flight vary continually and only limited weather conditions were allowable under the LODS Air Worthiness Release.
2. *Temperature effects on system*
   Similar to weather, this should be further evaluated in a laboratory where the conditions can be controlled.
3. *Sun and glare representations as obstacles.*
   Filtering this data return may affect other capabilities of the system while not filtering may increase the false alarm rate. This problem needs to be considered in future evaluations of this or any follow along system.
4. *Water not being represented as an obstacle.*
   This may or may not be a problem depending on the mission or system purpose. If not corrected, this limitation needs to be a documented.

The following areas are recommended for further development:

1. Visual display of obstacles
2. Audible warning of impending collision with obstacle.

## 12. POINT OF CONTACT

The point of contact for this report is Timothy Davis, Mechanical Engineer, Platform Technology Division, AATD, phone: 757-878-4035, FAX: 757-878-4330, email: tdavis@aatd.eustis.army.mil

**DEPARTMENT OF THE ARMY**
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MARYLAND 21010-5422

REPLY TO
ATTENTION OF

MCHB-TS-OLO 9 December 2002

MEMORANDUM FOR Commander U.S. Army Aviation and Missile Command (AMSAM-RD-AA-F), Aviation Applied Technology Directorate, Fort Eustis VA 23604-5577

SUBJECT: Nonionizing Radiation Protection Study No. 25-MC-00KP-03, Optical Radiation Hazard Evaluation of the Helicopter Laser Radar (HELLAS), 31 October 2002

Copies of the report with Executive Summary are enclosed.

FOR THE COMMANDER:

Encl DAVID H. SLINEY
Program Manager
Laser/Optical Radiation

CF (w/encl):
HQDA (DACS-SF)
MEDCOM (MCHO-CL-W)
POPM-SA (MCPO-SA)
AMC (AMCSG)
AMC (AMCSF-P/Manfre)
TRADOC (ATBO-SO)
USA MED RESEARCH DET (SGRD-UWB-L)

**Enclosure 1**

NONIONIZING RADIATION PROTECTION STUDY
25-MC-00KP-03
OPTICAL RADIATION HAZARD EVALUATION OF THE
HELLICOPTER LASER RADAR (HELLAS),
31 OCTOBER 2002



**Enclosure 1**

**DEPARTMENT OF THE ARMY**
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MARYLAND 21010-5422

REPLY TO
ATTENTION OF

EXECUTIVE SUMMARY
NONIONIZING RADIATION PROTECTION STUDY
25-MC-00KP-03
OPTICAL RADIATION HAZARD EVALUATION OF THE
HELLICOPTER LASER RADAR (HELLAS),
31 OCTOBER 2002

1. PURPOSE. To evaluate the potential health hazards associated with the optical radiation emitted by the HELLAS and to make recommendations designed to eliminate the exposure of personnel to potentially hazardous optical radiation produced by this device.

2. CONCLUSIONS. The HELLAS laser emits laser radiation that is less than the Class 1 limit making it safe for use in any scenario.

3. RECOMMENDATIONS.

a. Request USACHPPM re-evaluate this laser should the system's design be altered, or if the system enters into a development phase [AR 40-5, paragraph 9-9a(1)].

b. Ensure that laser eye protection with an optical density (OD) of at least 2.3 at 1550 nm is used if maintenance procedures make exposure to the laser in a non-scanning mode possible [AR 40-5, paragraph 9-9c(5), with TB MED 524, paragraph 3-23].

DEPARTMENT OF THE ARMY
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MARYLAND 21010-5422

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MCHB-TS-OLO 9 December 2002

MEMORANDUM FOR Commander U.S. Army Aviation and Missile Command (AMSAM-RD-AA-F), Aviation Applied Technology Directorate, Fort Eustis VA 23604-5577

SUBJECT: Nonionizing Radiation Protection Study No. 25-MC-00KP-03, Optical Radiation Hazard Evaluation of the Helicopter Laser Radar (HELLAS), 31 October 2002

1. REFERENCES.

a. American National Standards Institute (ANSI): "Safe Use of Lasers," American National Standard Z-136.1-2000, Orlando, FL., Laser Institute of America.

b. TB MED 524, 20 June 1985, Control of Hazards to Health from Laser Radiation.

c. AR 11-9, 28 May 1999, The Army Radiation Safety Program.

d. AR 40-5, 15 October 1990, Preventive Medicine.

2. AUTHORITY. Memorandum, Commander, USAAMCOM, AMSAM-RD-AA-F, 17 October 2002, subject: Request for Laser Safety Certification of the HELLAS Laser Obstacle Detection Sensor.

3. PURPOSE. To evaluate the potential health hazards associated with the optical radiation emitted by the HELLAS and to make recommendations designed to eliminate the exposure of personnel to potentially hazardous optical radiation produced by this device.

4. GENERAL.

a. Background. The HELLAS is a commercially available, scanning laser based, obstacle detection system manufactured by Dornier Corporation. Mr. Rodney Wood, Mr. Shawn Sparks, and Mr. Jeffrey Pfoutz, physicists in the Laser/Optical Radiation Program, at USACHPPM, conducted measurements on 31 October 2002 at the Aviation Applied Technology Directorate, at Fort Eustis, VA.

b. Instrumentation.

(1) Ophir Model NOVA Power/Energy Meter, SN 27135.

(2) Ophir Model PE50 Pyroelectric Detector, SN 25787.

(3) Tektronix Model THS730A Oscilloscope, SN BO30855.

(4) Thorlabs Germanium Detector.

(5) Miscellaneous Support Equipment.

c. Abbreviations. A table of radiometric terms and units used in this report is provided in the Appendix.

5. FINDINGS.

a. System Description. The HELLAS obstacle detection laser system includes a 1550 nm diode-pumped erbium fiber laser, and a fiber-optic scanner, consisting of 96 fibers (core diameter of 200 μm), scanner motor, optics array, and nutation mirrors. The fiber-optic scanner distributes a laser pulse successively from a single fiber-coupled laser source to a circular 96-fiber array. The fibers end in a linear array mounted at the focus of the array optics forming a horizontal beam fan that is then deflected in the vertical direction by an oscillating mirror forming a rectangular output beam. One of the fibers is used as a reference to measure distance, and not transmitted. Figure 1 shows a line drawing of the optical components. A photo of the HELLAS system mounted on the base of a helicopter is shown in Figure 2.

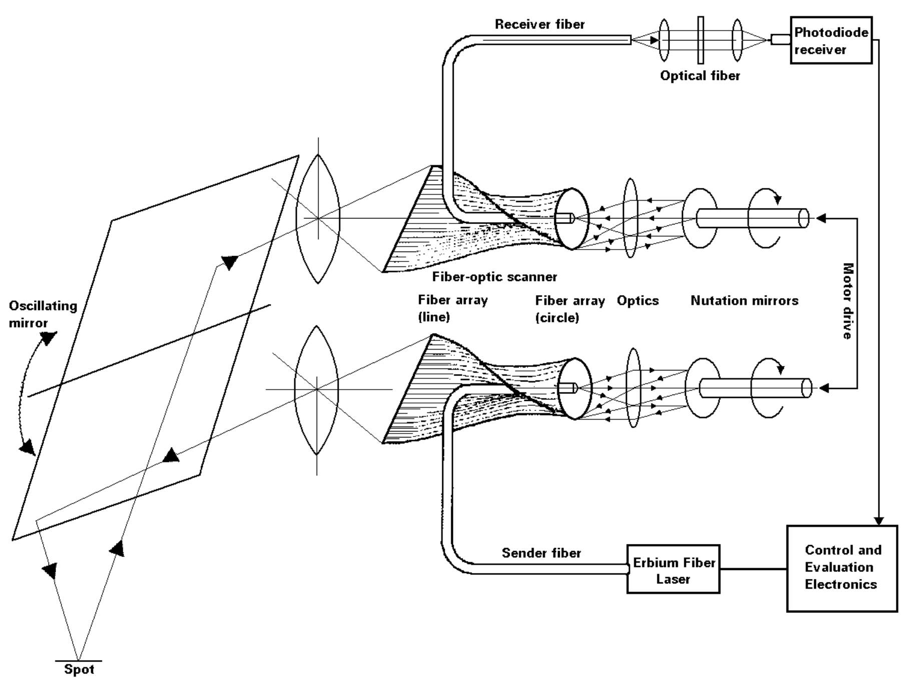


**Figure 1.** Line drawing of the optical components of the HELLAS.

b. Measurements. Measurement of the output energy, single beam divergence, and single beam diameter were not performed due to a combination of the inability to stop the scanner and the limited type of detectors available in this wavelength region. Thermal detectors, calorimeters and pyroelectrics, are commonly used in this region. The PRF is far too high for the pyroelectric detectors and the inability to obtain a constant signal, i.e. defeat the scanner, made getting a stable reading from the calorimeter impossible. The manufacturer reported values were used for the hazard analysis. The laser output parameters are summarized in Table 1.

**TABLE 1.** HELLAS Laser Output Parameters

| | Measured | Reported |
|---|---|---|
| Lasing Medium | ----- | Diode-pumped Erbium fiber |
| Wavelength | ----- | 1550 nm (±5 nm) |
| Pulse Repetition Frequency (PRF) | 45.8 kHz | 45 kHz within a burst of 430 ms duration |
| Pulse Width | ~9 ns | 5 ns |
| Single Beam Diameter (1/e points) | ----- | 6 cm @ exit aperture |
| Single Beam Divergence | ----- | 1.4 mrad |
| Total Radiant Energy (Q) | ----- | 50.0 μJ/pulse |
| Scanner Mirror PRF | 1.0 Hz | ----- |

b. Classification. This laser system was classified from a hazard standpoint as a Class 1 laser, according to ANSI Z136.1 and TB MED 524 (references 1 and 2, respectively).

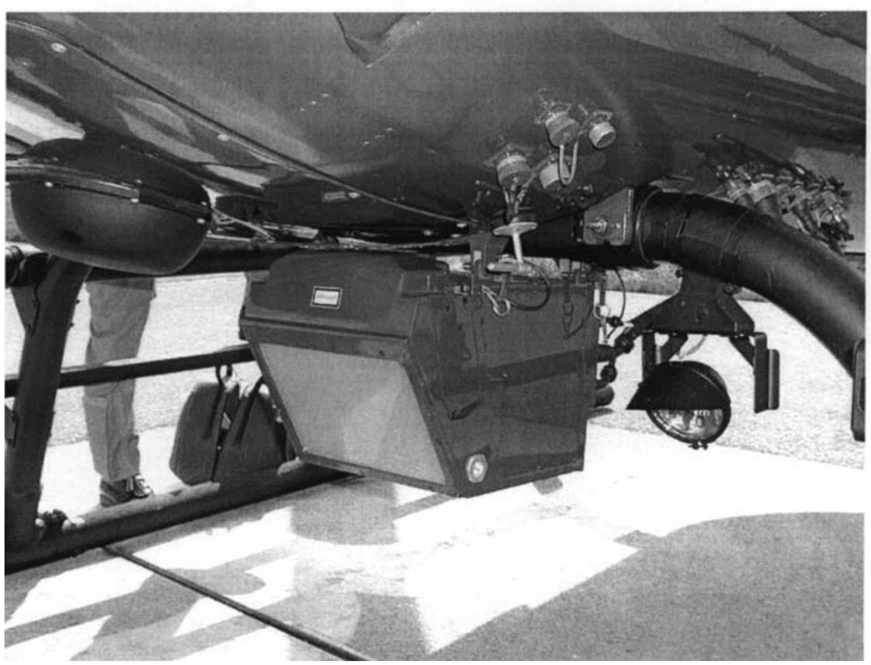

**Figure 2.** HELLAS mounted on helicopter.

6. DISCUSSION.

a Maximum Permissible Exposure (MPE). The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye for a repetitively pulsed laser is the more restrictive of several MPE calculations. The calculated MPE for the HELLAS laser system was based on the systems energy per pulse output and the number of pulses one could receive. Since the HELLAS is a scanning system, as you move away from the laser exit aperture, you are exposed to fewer laser pulses, thus continuously changing the MPE. Figure 3 shows the number of pulses one would receive at different distances for both unaided and optically aided viewing of the HELLAS. After calculating the number of pulses in an exposure, the MPE and accessible emission limit (AEL) at that distance could be calculated. The AELs, levels of laser radiation that can be received continuously without chance of injury, for both unaided and optically aided viewing are the top two curves in Figure 4. The lower curves are calculations of the radiant exposures for the HELLAS at various ranges for unaided viewing (Without Optics) and aided (Optics) viewing of the system. The point where the AEL curve crosses the corresponding radiant exposure curve is the lasers nominal ocular hazard distance (NOHD). Beyond this range the laser is safe to view under those condition. In the case of the HELLAS, the only curves that cross are those for optically-aided viewing. It crosses at a range of about 0.5 meter (m), which is shorter than the two-meter measurement distance for optics. Therefore, the laser is safe to view at any distance with or without optics.

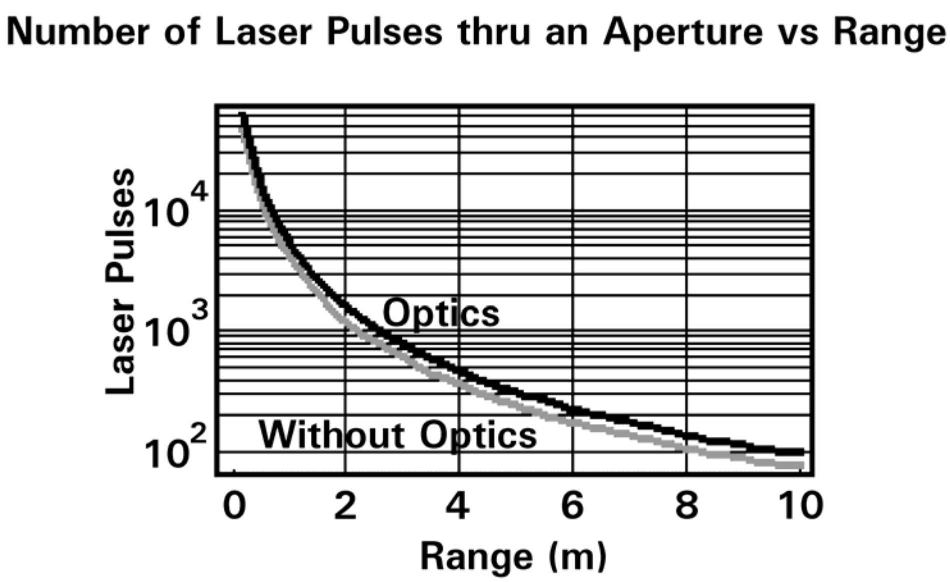


**Figure 3.** The number of laser pulses emitted by the HELLAS that one would be exposed to a various distances for unaided (3.5 mm) and optically aided (2.5 cm) viewing of the beam.

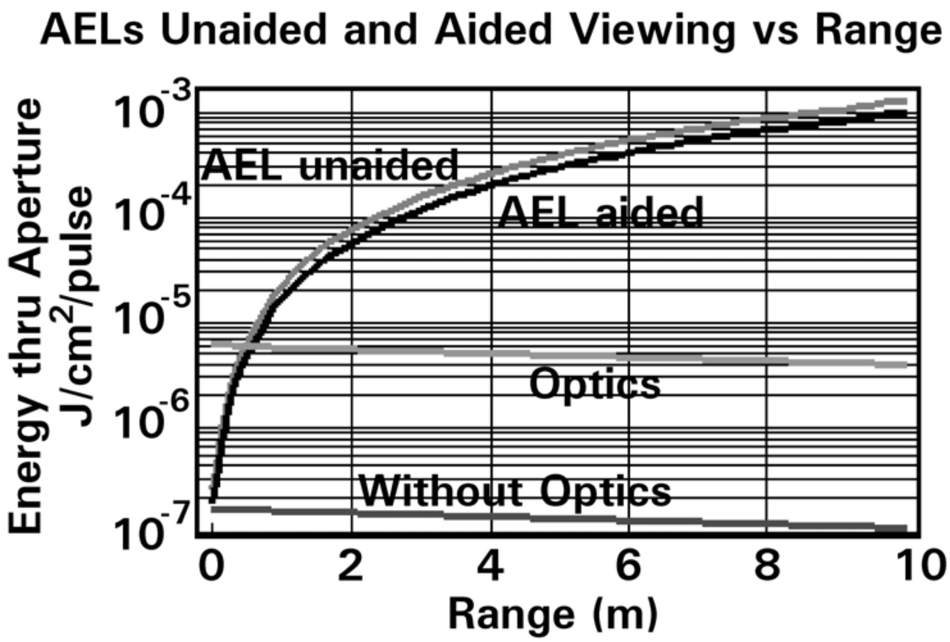


**Figure 4.** AELs versus Range

b MPEs for Maintenance. Defeating the scanner motor would make any exposure to the HELLAS laser more hazardous. If, during maintenance of the system, the laser were not scanning, maintenance workers would be required to wear eye protection with an OD of at least 2.3 at 1550 nm.

7. CONCLUSIONS. The HELLAS laser in its current operating configuration does not emit optical radiation that exceeds the current protection standards.

8. RECOMMENDATIONS.

a. Request USACHPPM re-evaluate this laser should the system's design be altered, or if the system enters into a development phase [AR 40-5, paragraph 9-9a(1)].

b. Ensure that laser eye protection with an optical density (OD) of at least 2.3 at 1550 nm is used if maintenance procedures make exposure to the laser in a non-scanning mode possible [AR 40-5, paragraph 9-9c(5), with TB MED 524, paragraph 3-23].

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# APPENDIX

## Useful Radiometric Units[1,2]

| Term | Symbol | Definition | Unit and abbreviation |
|---|---|---|---|
| Radiant Energy | Q | Energy emitted, transferred, or received in the form of radiation | joule (J) |
| Radiant Power | $\Phi$ | Radiant Energy per unit time | watt (W)<br>defined as J/s |
| Radiant Exposure (Dose in Photobiology) | H | Energy per unit area incident upon a given surface | joules per square centimeter ($J{\cdot}cm^{-2}$) |
| Irradiance or Radiant Flux Density (Dose Rate in Photobiology) | E | Power per unit area incident upon a given surface | watts per square centimeter ($W{\cdot}cm^{-2}$) |
| Integrated Radiant Intensity | $I_P$ | Radiant Energy emitted by a source per unit solid angle | joules per steradian ($J{\cdot}sr^{-1}$) |
| Radiant Intensity | I | Radiant Power emitted by a source per unit solid angle | watts per steradian ($W{\cdot}sr^{-1}$) |
| Integrated Radiance | $L_P$ | Radiant Energy emitted by a source per unit solid angle per source area | joules per steradian per square centimeter<br>($J{\cdot}sr^{-1}{\cdot}cm^{-2}$) |
| Radiance[3] | L | Radiant Power emitted by a source per unit solid angle per source area | watts per steradian per square centimeter<br>($W{\cdot}sr^{-1}{\cdot}cm^{-2}$) |
| Optical Density | OD | A logarithmic expression for the attenuation produced by a medium<br>$OD = -\log_{10}\left(\frac{\Phi_O}{\Phi_L}\right)$ | unitless<br>$\Phi_O$ is the incident power;<br>$\Phi_L$ is the transmitted power |

1. The units may be altered to refer to narrow spectral bands in which the term is preceded by the word *spectral* and the unit is then per wavelength interval and the symbol has a subscript $\lambda$. For example, spectral irradiance $E_\lambda$ has units of $W{\cdot}m^{-2}{\cdot}m^{-1}$ or more often, $W{\cdot}cm^{-2}{\cdot}nm^{-1}$.

2. While the meter is the preferred unit of length, the centimeter is still the most commonly used unit of length for many of the terms below and the nm or µm are most commonly used to express wavelength.

3. At the source $L = \frac{dI}{dA \bullet \cos\theta}$ and at a receptor $L = \frac{dE}{d\Omega \bullet \cos\theta}$.

# TEST PLAN

## Laser Obstacle Detector System (LODS)
## Installed on the UH-60L Helicopter
## For The
## Foreign Comparison Test (FCT)

**11 December 2002**

U.S. ARMY AVIATION APPLIED TECHNOLOGY DIRECTORATE
FORT EUSTIS, VIRGINIA 23604-5577

**Enclosure 2**

**TABLE OF CONTENTS**

*PAGE*

*INTRODUCTION*

Background ....... 1
Test Objective ....... 1
Description of Test Aircraft ....... 1
Description of Test Installation ....... 2
Test Scope ....... 2

*DETAILS OF TEST*

General ....... 3
Wire Detection ....... 3
Non Wire Obstacle Detection ....... 4
Shipboard Terminal Guidance ....... 4
Data Requirement ....... 5

*APPENDICES*

A. References ....... A-1
B. Test and Test Conditions ....... B-1
C. HELLAS System Description ....... C-1
D. Safety/Risk Assessment ....... D-1
E. Test Operations Plan ....... E-1
F. Support Requirements ....... F-1
G. Instrumentation ....... G-1
H. Navy Deck Landing Approach Flights ....... H-1
I. EMC Ground/Flight Checklist ....... I-1

## INTRODUCTION

### Background

The United States Special Operations Command (USSOCOM) Mission Needs Statement (MNS) and Joint Operational Requirements Document (JORDS) on a Cable Warning / Obstacle Avoidance System (References 1a and 1b) define the need for an obstacle detection sensor for US Military helicopters. The Helicopter Laser Radar System (HELLAS) was developed in Germany by EADS-Dornier. The Laser Obstacle Detection System (LODS) Foreign Comparative Test (FCT) program began in March 2002 with the objective of evaluating the HELLAS on a US Army helicopter. The managing agency of the LODS-FCT is the US Army Night Vision and Electronic Sensors Directorate (NVESD). The Aviation Applied Technology Directorate (AATD) was contracted to mount the HELLAS sensor on the nose of a UH-60L Blackhawk helicopter and to conduct flight tests to evaluate the HELLAS obstacle detection sensor. The host platform for this evaluation is EH-60L 85-24468.

### Test Objective

The primary goal of the LODS-FCT flight demonstration is to evaluate, on a helicopter platform, the capability to successfully perform wire detection measurements as previously performed. The HELLAS system is currently qualified and in operation with the German Border Patrol. The EH-60L mounted HELLAS system will be used to show that this technology is a viable solution to detect any obstacles, including wires, along the flight path, and as an aide to avoid these obstacles. Helicopter installation, checkout and flight demonstration is planned for the Dec 02-March 03 period. Concurrent with this testing, the team will also collect laser raw data (angle-angle-range) including INU/GPS data to support studies to determine the HELLAS systems ability to detect general obstacles (poles, towers, etc) and to provide precision landing information to assist rotary wing aircraft and UAV's during the critical landing phases of shipboard operations.

### Description of Test Aircraft

The testbed aircraft is a production EH-60L helicopter with all of the EH peculiar equipment removed making it essentially a UH-60L, Army Serial Number (ASN) 85-24468. The UH-60L is a dual piloted, twin turbine engine, single main rotor helicopter manufactured by Sikorsky Aircraft Division of United Technologies Corporation. The primary mission capability of the helicopter is tactical transport of troops, supplies and equipment. It has a mission gross weight of 16,825 lb., a maximum gross weight of 22,000 lb. for internal loads and 23,500 lb. for external loads. The standard UH-60L aircraft is defensive weapons capable only, equipped with left and right side gunner's window installations, which allow for the mounting of single 7.62mm M60D machine guns in each window. The drive train consists of a main transmission, intermediate gear box and tail rotor gear box with interconnecting shafts. The propulsion system has two T700-GE-701C engines operating in parallel with a maximum standard day, sea level, installed rating of 1700 shaft horsepower (ESHP). The engines drive a fully articulated main rotor which turns counter-clockwise when viewed from above. The main rotor consists of four blades made of titanium and fiberglass, with an average chord of 20.8 inches and a diameter of 53.7 feet. The tail rotor consists of four blades with a chord of 9.7 inches and diameter of 11 feet, mounted on the right, canted upwards 20 degrees, and is designed to provide 2.5% of the total lift. The tail rotor turns clockwise when viewed from the left. The non-retractable landing gear consists of the main landing gear and a tailwheel. The irreversible conventional helicopter flight controls (cyclic, collective, and yaw control pedals), installed for both pilot and copilot, utilize three hydraulic pressure supply systems, number 1, number 2, and backup. All hydraulic pumps are completely independent and each is fully capable of providing essential flight control pressure for maximum system redundancy. The automatic flight control system (AFCS) consists of a stability augmentation system (SAS), electric trim, flight path stabilization (FPS) and an automatic stabilator. Each SAS provided 5% control authority , for a total of 10%, and is designed to enhance dynamic stability in the pitch, roll, and yaw axes. Additionally, both SAS 1 and 2 enhance turn coordination by deriving commands from lateral accelerometers which together with roll rate signals are sent to their respective yaw channels automatically at speeds greater than 60 knots. The FPS system is designed to provide control positioning and force gradient functions as well as basic autopilot functions. The variable angle of incidence stabilator, controlled by the AFCS and actuated by electromechanical actuators, is designed to enhance static and dynamic stability about the pitch axis. The UH-60L incorporates a flight control mixing unit installed at the output of the pilot-assist servos and is designed to minimize inherent control coupling by providing control mixing. Flight control mixing includes collective to pitch, collective to yaw, collective to roll, and yaw to pitch. A more detailed description of the UH-60L and its systems can be found in the Operators Manual, reference 1.

## Description of Test Installation

The test aircraft has been modified with a LODS fixed provision mount (A-kit) mounted on the aircraft nose, just below the avionics bay door. The HELLAS Obstacle Detection Sensor is mounted to the underside of the fixed provision mount using the LODS mission mount (B-Kit). A "mockup" fixture with the same weight as the HELLAS system will be mounted to the LODS fixed provision mount for initial vibration and handling qualities testing. The cockpit is equipped with two video mini-cameras, a monitor to display the HELLAS safety line output, an obstacle warning indicator, and an IRIG display. Instrumentation, including two instrumentation pallets and a video rack are mounted in the cabin with seat fittings. A detailed description of the HELLAS test installation is presented in the Airworthiness Substantiation Document (ASD), reference 2. The HELLAS system is described in detail in appendix C.

## Test Scope

Flight testing will begin with ground and airborne EMC checks IAW Appendix I followed by a handling qualities evaluation IAW table B-1. A ground HELLAS functionality check will be completed as well as a cockpit evaluation of the HELLAS equipment. The HELLAS flight demonstration will be conducted in three phases. Phase I will evaluate the systems ability to detect wires of various sizes and orientations in the Felkar AAF local flight test area. Phase II is a demonstration phase to allow guest pilots to observe the HELLAS capability to detect wire obstacles in the Fort A.P. Hill area. Phase III will be conducted at a location to be determined to evaluate the ability of the HELLAS system to detect wire obstacles in a sand dune type environment. As time permits, an evaluation of the feasibility of utilizing the HELLAS wire detection system as a means of providing "terminal" guidance to rotary wing and UAV systems during the final phases of a shipboard approach and landing will be conducted. Approaches will be conducted to the James River reserve fleet during phase I and then to Navy air-capable ships transiting the Norfolk and Virginia Capes Operating Areas when available. Specific scenarios (described in detail below) will be flown and data will be recorded for analysis and presentation. Test will be conducted with a minimum crew of one experimental test pilot and one aircraft model qualified pilot. A system operator and data recorder may be included as determined by the Test Director. Only normal ground support personnel and facilities required for standard flight operations will be required.

**DETAILS OF TEST**

**General**

**Initial flight test will be conducted at Ft. Eustis, VA in Day/VMC conditions and will require no special ranges. A pre-test survey, for power and telephone line targets of opportunity, and for reserve fleet approach hazards, will be conducted by AATD to determine the best test areas for the scenarios described below. Support requirements are detailed in appendix F. Electrical power for all the demonstration equipment will be supplied by the power receptacles in the aft cabin of the aircraft. An electrical power converter will be supplied by AATD to provide 115V, 60Hz, 9.05 Amps of power minimum. AATD will be responsible for the system installation. EADS/Dornier will assist with the installation checkout, daily operational pretest checks and calibration tests. The detailed daily pretest check and calibration procedures will be developed during the pre-shipment final configuration test and will be documented and employed during the installation phase at Ft Eustis.**

**Wire Detection**

**General**

The purpose of this flight test is to demonstrate the systems ability to detect wire obstacles during a variety of flight regimes. The system has already demonstrated this capability during both static and actual flight tests. A video recorder will be boresighted to the same field of regard as the HELLAS system. Sensor data and video data will be recorded so as to be correlated in post flight analysis. Real time sensor data will be available for viewing via computer graphics on a control/viewer laptop computer, data collection system that will be part of the on board electronics mounted in the aft cabin. A second peripheral display for warnings only will be made available for the cockpit. Exit criteria for each test will be a minimum of 1 minute of recorded data. Prior to performing the actual flight test, the test location will be surveyed for target location and range. Wire type and sizes will be qualitatively noted and recorded.

**Hover Performa**nce – The object of this test is to evaluate the wire detection performance in a level hover, during slow hover turns and hover flight (below translational lift). The test area will be determined in the pre-test survey and will consist of an open area with wires at a distance of at least 100 meters.

**Low Speed Flight** – The object of this test is to evaluate the wire detection performance during level slow flight (translational lift to 50 kts). This will demonstrate the systems performance during the high vibration regime of translational lift. The test area should provide sufficient flight room so as to allow a minimum of one minute of flight data with the aircraft proceeding toward the wires in the translational vibration regime at angles of incidence (AOI) of 90, 60, 45, 30, and 20 degrees.

**High Speed Flight** - The object of this test is to evaluate the wire detection performance during high-speed level flight (>60kts) in 20 kt. increments up to and including allowable Vmax restrictions. The test area should provide sufficient area so as to allow for approximately one minute of flight data with the aircraft proceeding toward the wires at the AOI's listed above and at altitudes above, at and below the wires.

**NOE Performance** – The object of this test is to evaluate the wire detection performance during Nap of the Earth (NOE) flight. This is an optional test based upon the data acquired in the hover and slow flight tests. The test area should provide sufficient area and varying terrain with enough wire targets to allow target detection opportunities within the prototype's field of view and at ranges greater than 200 meters from the aircraft.

**Mission Maneuvers** – The object of this test is to evaluate the wire detection performance during standard mission maneuvers such as take-off, landings, decelerations and accelerations in various landing zones. The test areas selected should provide wire detection opportunities within the prototypes capability of FOV and range which will be established during the previous test flights.

**Non Wire Obstacle Detection –** Concurrent with other testing, the HELLAS system will be evaluated for its ability to detect obstacles other than wires. Raw data will be analyzed and onboard warning indicators qualitatively tested to determine the systems ability to accurately warn the crew of an impending collision.

**Shipboard Terminal Guidance –** Additional testing will be performed on a time available basis to determine the feasibility of utilizing the HELLAS wire detection system as a means of providing "terminal" guidance to rotary wing and UAV systems during the final phases of a shipboard approach and landing.

**Reserve Fleet Flights -** Initial flights will be conducted on a suitable ship or ships of the Reserve Fleet anchored in the James River adjacent to Ft. Eustis. Practice approaches with ~40-m pullouts will be refined during these flights.

**At-sea Approaches -** After the Reserve Fleet flights, approaches to Navy air-capable ships underway will be flown on ships transiting the Norfolk and Virginia Capes Operating Areas, as flight safety and project considerations permit.

A more detailed description of these requirements can be found in Appendix H and in the LODS Navy Phase I Test Plan (ref 6) dated 6 Dec 2002.

## Data Requirements

### General

Data to be collected for the tests will include that necessary to verify operation of the HELLAS system for the wire/obstacle detection tests. Data will include digital recorded real-time processed HELLAS products, aircraft states, auxiliary real time video data and flight crew and/or operator notes. A qualitative assessment of HELLAS specific displays and warning indicators will be evaluated concurrent with other testing.

The data that will be recorded for the HELLAS data system is the basic product data and occasional raw data. Product data generally includes velocity and SNR estimates versus range and elementary system parameters. Raw data is the digitized video signal from the HELLAS transceiver and is especially valuable in after the fact extended data processing.

*Wire/Obstacle Detection*

The wire/obstacle detection specific data that are to be recorded are HELLAS generated detections of hard targets and safety lines. This will include range and scanner angle to the target. Other products that may be recorded are velocity and SNR estimates versus range. Raw data will be recorded when appropriate. The rate of data will be approximately 2Mbyte/second with a possible recording time of over 2 hours before switching storage units. Bore-sited video will be recorded for each test run. Flight speed, altitude and attitude will be noted for each test run. Position (height, relative. direction, etc.) and visual characteristics of targets and related landmarks will be recorded. Obstacle detection specific data will be gathered concurrent with this testing.

### Shipboard Terminal Guidance

HELLAS 3-D ladar imagery will be collected during simulated helicopter deck landings and approaches to air-capable ships. The imagery will be used to analyze the performance potential of 3-D ladar for the recovery of manned and autonomous rotary-wing aircraft to Naval vessels.

**APPPENDIX A: References:**


1. Technical Manual 1-1520-237-10, 31 Oct 96, *Operator's Manual for UH-60A*, *U H-60L, and EH-60A Helicopter, with all changes*

2. AATD Memorandum, *Airworthiness Substantiation Document (ASD), Flight Test of UH-60L Helicopter with Laser Obstacle Detection System (LODS),* 4 December 02

3. AATD Memorandum No. 70-20, *Research and Development Airworthiness Flight Release for R&D Aircraft,* 25 June 1993

4. Air Force Manual 99-110, *Airframe-Propulsion-Avionics Test and Evaluation Manual,* 3 July 1995.

5. ATCOM Memorandum, *System Safety Risk Decision Authority Matrix for Army Material Command Aviation Systems*, 27 August 1996.

6. Technical Manual, TM 1-1520-237-10, *Operators Manual for UH-60A Helicopter, UH-60L Helicopter, EH-60A Helicopter*, 31 October 1996.

7. U. S. Naval Test Pilot School Flight Test Manual, USNTPS-FTM-NO. 107, *Rotary Wing Stability and Control*, December 1995.

8. LODS Navy Phase I Test Plan, 6 Dec 2002.

9. Laser Classification for HELLAS, Doc. No. TN5097-0000000A/30, Rev A, Dated 23 November 2000, EADS/Dornier

## APPENDIX B: Test and Test Conditions

Table B-1
EMC/Handling Qualities Test and Test Conditions

| Event | Configuration | Altitude (Ft) | Airspeed (KIAS) | Remarks |
|---|---|---|---|---|
| Cockpit Evaluation HELLAS system | WD | 0 – 3500 | 0 – Vmax | • Evaluate readability of displays and field of view obstruction. |
| MTF/ Vibration survey | Clean, Mockup, WD | 0 – 3500 | 0 – Vmax | • MTF performed prior to flight test. Vibration survey and shakedown of aircraft and "A" kit hardwareVibration survey of HELLAS for ground thru Vmax airspeeds (use HELLAS mockup or actual system) |
| EMI/EMC Checks | WD | Hover – 3500 | 0 – Vh | • All systems checked for normal opns while operating HELLAS systems. |
| Hover | WD | N/A | N/A | • C.G, Flight Controls, Controllability Check |
| Low Airspeed | Mockup, WD | N/A | Up to 45 KIAS | • Four Cardinal Headings<br>• Controllability Check<br>• Qualitative Trim Flight Control Positions Check |
| Trim Flight Control Positions and Speed Sweep | Mockup, WD | 1500 | 60 – Vh | • Apparent Speed Stability Check<br>• Qualitative Check Trim Flight Control Positions |
| Long Term Response | Mockup, WD | 1500 | 90,120 | • Excitation Method TBD by Test Pilot |
| Turns on One Control (Pedal and Cyclic Only) | Mockup, WD | 1500 | 90,120 | • Check Effective Dihedral, Directional Stability and Adverse / Proverse Yaw |
| Maneuver Stability | Mockup, WD | 1500 | 90,120 | • Collective Fixed LH/RH Turns @ 15,30, 45 Degrees |
| Spiral Stability | Mockup, WD | 1500 | 90,120 | • Check at 30 degrees AOB |
| Partial Power Climbs and Descents | Mockup, WD | 1500 – 3500 | 90,120 | • Power Applied and Reduced in 20% Increments<br>• Qualitative Evaluation of Handling Qualities |

Table B-2
HELLAS System Test and Test Conditions

| **Test** | **Configuration** | **Altitude** | **Airspeed** | **Remarks**[1,2] |
|---|---|---|---|---|
| Pre-test and calibration | WD | NA | NA | Procedures developed by Dornier and AATD will be performed each day as pre-flight check. CIPUM will certify laser safety. |
| Wire Detection [2] | | | | |
| Hover | WD | 10-50 ft | Translational lift | Test area determined by AATD in pre-test survey. Require wires >200 meters distant. |
| Low Speed | WD | 10-200 ft | Translational lift – 50kts | Test area determined by AATD in pre-test survey. Requires sufficient run in distance for 1 minute data collection at varying AOI's. |
| High Speed | WD | 150-1500 ft | 50- Vmax | Test area determined by AATD in pre-test survey. Requires sufficient run in distance for 1 minute data collection at varying speed and AOI's |
| NOE | WD | 0-200 ft | Up to 60 kts | Test area determined by AATD in pre-test survey. Wires must be beyond prototype minimum usable range of 200 meters. |
| Mission Maneuvers | WD | 0-1500 ft | 0-Vmax | Test area determined by AATD in pre-test survey. Effective range and FOV will be determined by previous tests. Takeoff, landing and low altitude maneuvers to be evaluated. |
| ***- NOE Decel*** | WD | 10 – 40 ft | 0 – 60 kt | Varying levels of aggressiveness |
| - NOE Accel | WD | 10 – 40 ft | 0 – 60 kt | Varying levels of aggressiveness |
| - Confined area T/O | WD | As required | As required | Minimum power takeoff to clear barriers. Wires will be at departure end of t/o area |
| - Confined area Appch | WD | As required | As required | Approach to land in confined area. Wires to be located in approach path. |
| - Gunnery Bump maneuver | WD | As required | 60 – 100 kts | From low level flight (~ 100 kts) perform a pitch up maneuver back to ~ 60-80 kts and pitch over (~15 deg N/D) to engage simulated targets. Wires will be located in the terminal end of the aircraft's flight path (just prior to disengagement). |
| ***- Deck Landing Approaches*** | WD | 100-50 ft | 0 – 80 kts | Approach/landing to various helicopter capable ships (TBD) from different aspect and approach angles. Approach will be terminated prior to touchdown (~ 120 ft). 3-5 minutes of data will be required. |

Clean = Only A-Kit Hardware installed on the nose
Mockup = HELLAS Mockup installed
WD = HELLAS system installed and operational
AOI = Angle Of Incidence from wires: 20, 30, 45, 60 and 90 degrees
Vmax = Maximum airspeed for testing as a result of vibrations/loads or other system limitations
MTF = Maintenance Test Flight (functional check of all organic H-60 systems)

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[1] Large, medium, and small wires will be evaluated in and around the FT Eustis area.
[2] HELLAS cruise and/or landing/approach mode will be utilized as determined most effective for each maneuver. Obstacle detection will be evaluated concurrently.

## APPENDIX C: HELLAS System Description

**System Description**

The Laser Obstacle Avoidance System for helicopter HELLAS is a laser radar based on 1.54 um wavelengths Erbium-Fiber laser system. The system generates a 3D LADAR image in 32 degrees of elevation and 32 degrees of azimuth. The sensor is a two-axis scanning laser radar system for measuring 3-dimensional geometry of objects. The distances to targets are measured with a pulsed laser using time of flight measurements.

**Laser Classification**

The delivered HELLAS-FCT unit SN 1004 with a 10kW Laser is in compliance with laser class 1 according to EN 60825-1:03.1997

TECHNICAL DATA

| | | | |
|---|---|---|---|
| **MODEL** | HELLAS 5097-100000A00C | **PRF** | 45 kHz in burst, 38 kHz avg |
| **SERIAL NUMBER** | 1004 (HELLAS FCT) | **BEAM DIAMETER** | 60 mm at beam exit window |
| **LASER** | ERBIUM FIBER LASER, PULSED | **BEAM DIVERGENCE** | 0.08 degrees (1.33mrad) |
| **WAVELENGTH** | 1550 nm | **FIELD OF VIEW** | 32 degrees vert x 31.5 degrees hor |
| **PULSE PEAK PWR** | 10kW (FCT) | **NO. OF PIXELS** | 200 vert x 95 hor |
| **PULSE ENERGY** | 0.05mJ | **APPARENT SOURCE** | 13000 mm2 at exit window |

### Laser Classification of the HELLAS-FCT System

The following calculations were performed using American National Standard for the Safe Use of Lasers, ANSI Z136.1-1993 as the reference. The data (laser specifications) were obtained from: 1. Laser Classification for HELLAS-FCT Unit SN 1004, 2. Technical report No. 70001954, Revision 0, 2001-11-22, and 3. Project: HELLAS Preparation for Laser Classification, Doc. No. TN5097-0000000A/30, Revision A, 2000-11-23.

The technical data for the HELLAS-FCT laser are given as:

Model: HELLAS 5097-100000A00C
Serial Number: 1004 (HELLAS-FCT)
Laser: Erbium Fiber Laser, Pulsed
Wavelength: 1550 nm
Pulse Peak Power: 10 kW (for FCT-model)
Pulse Length: 5 ns
Pulse Energy: 0.05 mJ
PRF: 45 kHz in burst, 38 kHz avg.
Beam Diameter: 60 mm at beam exit window
Beam Divergence: 0.08$^{o}$ (1.33 mrad)
Field of View: 32$^{o}$ vert. x 31.5$^{o}$ hor.

No. of Pixel: 200 vert. x 95 hor.
Frame Rate: 2 Hz
Apparent Source: 13000 $mm^2$ at exit window

Maximum Permissible Exposure (MPE) for Ocular (Intrabeam Viewing) to a Laser Beam

**1. Single Pulse Assessment:** From ANSI Z136.1-1993, Table 5, page 41, for a single pulse, at a wavelength of 1.500-1.800 □m and with an exposure of $10^{-9}$ to 10 seconds, the MPE is 1.0 $J/cm^2$.

For the HELLAS-FCT laser, the peak pulse energy of the laser (10 kW peak power, duration 5 ns) is calculated to be 10 kW * 5 ns = 0.05 mJ. The peak pulse energy density, at the beam exit window, is calculated to be (0.05 mJ) / $[\pi (6 cm / 2)^2]$ = 0.18 $mJ/cm^2$ = $1.8 \times 10^{-4}$ $J/cm^2$. Based on a single pulse, the HELLAS-FCT laser is eye-safe since its peak pulse energy density of $1.8 \times 10^{-4}$ $J/cm^2$ is less than the ANSI MPE of 1.0 $J/cm^2$.

**2. Multiple Pulse Assessment:** The ANSI Standard states, "For lasers with wavelengths greater than 1.5 μm but less than 1.8 μm, the single pulse MPE is the same as the CW MPE for a 10 second exposure. Therefore, for a 10 second exposure to such lasers, the MPE for each pulse in the train of pulses is simply the single-pulse MPE divided by the number in the train." For the HELLAS-FCT laser, the revised MPE is $(1.0\ J/cm^2) / [(38 \times 10^3\ s^{-1})\ (10\ s)] = 2.63 \times 10^{-6}\ J/cm^2$ per pulse.

At the exit aperture of the HELLAS-FCT laser, the peak fluence for a Gaussian beam is:
$1.27\ (0.05 \times 10^{-3}\ J) / [\pi (6\ cm / 2)^2] = 2.25 \times 10^{-6}\ J/cm^2$ per pulse

This value is less than the MPE limit of $2.63 \times 10^{-6}$ $J/cm^2$, thus the HELLAS-FCT laser is eye-safe at the aperture.

**3. Laser Classification** of the HELLAS-FCT System:

Based on the ANSI Z136.1-1993 Standard, the HELLAS-FCT is a Class I eye-safe laser system, when operating under conditions as specified by the manufacturer.

APPENDIX D: Safety / Risk Assessment

**GENERAL**

The highest level of concern for safety will be maintained throughout the conduct of this test program. Human and material resources will be protected and conserved by the early identification, evaluation, and correction of any system hazards that may appear during the conduct of these tests. The program will be subjected to a thorough review by the Aviation Applied Technology Directorate (AATD) Safety of Flight Review Board. Specific items affecting safety are discussed in this section.

**SAFETY DURING CONDUCT OF TESTING**

Aircraft operating limits applicable to this test will be briefed prior to flight. Data recording, lookout responsibilities, unusual attitude recovery techniques, and crew coordination will be briefed prior to flight. During dynamic maneuvers the aircraft attitude, rates, rotor speeds, and engine instruments will be monitored to detect the approach of any limits. If aircraft limits are being approached (without being exceeded) the test sequence will be terminated. Any test team member will call "knock it off" if any adverse trend in aircraft attitude, rate, or instrument indication is detected. The pilot on the controls will then terminate the maneuver. Wire and obstacle locations within the test area will be identified and appropriately marked by the test crew. Only those areas previously cleared for wire/obstacle detection testing will be used. If at anytime visual contact with the wire or obstacle set is lost, the test point will be terminated and the aircraft will immediately be flown to a known safe altitude and airspeed. Safe clearance (altitude and/or distance) will be maintained at all times. The system under test will not be used as the sole source of determining safe separation between the aircraft and the obstacle. All crewmembers will be present for the preflight briefing. Shipboard operations will require the proper floatation/survival gear as appropriate for the conditions. Shipboard operations will be conducted IAW Navy procedures and guidelines as provided by the host vessel and NAVAIR LODS IPT project engineers.

**AIRCRAFT**

The test aircraft will be inspected by the test director, project crewmembers, and test engineers to insure system airworthiness, ingress/egress routes are not impaired by test equipment installation, and that all safety implications are considered.

**RISK LEVELS**

The System Safety Risk Decision Matrix for US Army Material Command Aviation Systems, found in reference 5, was used in assigning risk level.

a) Risk level High – Close supervision is required for these tests. The Commander, AMC is the risk decision authority.
b) Risk level Medium - These tests require more than routine supervision. The Commander, AMCOM is the risk decision authority.
c) Risk level Low – The Commander, AATD is the risk decision authority.

Tests are assigned risk levels as follows:

| TEST | Level |
|---|---|
| Pre-test and calibration | Low |
| Wire/Obstacle Detection * | |
| Hover | Low |
| Low Speed | Low |
| High Speed | Low |
| NOE | Low |
| Mission Maneuvers | Low |
| Shipboard Approaches | Low |

- All flights conducted in Day/VMC conditions

If during the conduct of these tests, a situation, arises which increases the risk level of any test, completion of the evaluation will be delayed until a thorough review of the specific test is completed by the safety officer and the test director. If the risk level is increased, it will require review by the Safety of Flight Review Board.

HELLAS SAFETY:

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Personnel Safety

Appropriate physical handling measures must be used for moving heavy objects. Appropriate procedures must be followed for working with electrical equipment – only trained personnel should operate or work on the HELLAS system and associated equipment.

The HELLAS is a class 1 laser. During normal operation this system is eye-safe. Operating personnel when working with the system in ground-based test modes and within the nominal hazard zone of the laser beam will use appropriate laser safety equipment. Optically aided devices (binoculars, etc.) should not be used to view the output window of the system during ground-based operations.

As described above, the sensor poses no realistic laser eye safety threat during nominal flight operations.

Equipment handling

The HELLAS and associated equipment will be kept in a dry environment with relative humidity less than 90%, non-condensing. The HELLAS must not be dropped, shock levels must be below 3 Gs rms, and Non-operational temperature range must be maintained between 0 to 50 degrees Celsius. The altitude range for shipping and handling must be within sea level to 7500 ft MSL, unless appropriate containers are used to provided equivalent pressure ranges

## APPENDIX E: Test Operations Plan

### GENERAL

Test Director

The Test Director is responsible for all aspects of the evaluation and is the authorized spokesperson for the test team. Circumstances may dictate that the test director designate a member of the test team as his representative. The test director will, through chain of command channels, act as the technical advisor to the Aviation and Missile Research, Development, and Engineering Command (AMRDEC) and the US Army Missile and Aviation Command (AMCOM).

Pre-test Checks and Calibrations

The aircraft will have a complete functional test flight to include vibration analysis prior to the beginning of flight test. Vibration levels will be adjusted, as necessary, to meet the desired specifications IAW the Technical Manuals. Additional vibration surveys will be conducted on the HELLAS system installation, using a HELLAS mockup, to verify the vibrations/loads being imparted on the test system and/or aircraft are within desired parameters for completion of the flight test. Vibration testing will be conducted during ground operations, run-up/shutdown, and all flight modes anticipated to occur during the flight test.

Flight Test Procedure

It is anticipated that weather and maintenance conditions will permit two flights per day. When conditions permit, additional flights will be conducted. In general, all flights will be conducted under day, VMC (1000 ft ceilings and 3 miles visibility) and smooth air. Wind conditions of 5 knots or less are desired for wire detection demonstrations. Specific test requirements may dictate flight testing in less than VMC and will be considered on a case by case basis by the test director and test crew. The flight test director will exercise configuration control. All shipboard operations will be coordinated with the Navy. Navy procedures for helicopter shipboard operations will be utilized. The test crew will be properly briefed prior to any operations on or near Naval vessels.

### TEST SUPPORT

Chase/Crash Rescue

Chase aircraft are not required for the completion of this testing. Crash rescue will be on the same alert status as is required for normal flight operations at Felker AAF, VA and the surrounding operation areas. Crash rescue for shipboard operations will be provided by the host Naval vessel or support facility.

Test Data

Test data will be collected by AATD and reduced by the FCT IPT (Dornier, NVESD and AATD). Data acquisition and signal processing equipment will be mounted onboard the test aircraft. Real time data will be monitored within the aircraft to evaluate the usefulness of the data being acquired and enable the crew to assess the viability of subsequent tests. Acquisition of pertinent data is an exit criterion for test.

Aircraft Maintenance & POL Support

All aircraft maintenance and POL support will be the responsibility of AATD at the Ft Eustis test site. All maintenance issues will be addressed to the Test Director during all phases of test. Aircraft vibration analysis will be conducted prior to testing to verify that the aircraft meets specifications IAW the Technical Manuals (TM's).

Photographic Support

**Photographic support will be provided by AATD at the direction of the test director**

## APPENDIX F: Support Requirements

**Personnel Requirements**

1. The following personnel will be supplied by Aviation Applied Technology Directorate (AATD):

   - Test Director
   - Project Engineer
   - Test Pilots
   - Photographer
   - Maintenance Personnel

2. The following personnel will be supplied by Dornier:

- Engineer support

3. The following personnel will be supplied by NVESD:

   - Test Pilots
- Engineering/Data reduction

4. The following personnel will be supplied by NAVAIRSYSCOM:

   - Project Engineer
   - Engineering/Data reduction

Facilities, Services and Equipment

**5. The following facilities and services will be provided by AATD at Felker AAF, VA as needed:**

   - Scheduled and unscheduled maintenance for test aircraft
   - Airfield crash rescue
   - Maintenance support facilities and overnight hangar.
   - POL
   - Ground power unit
   - Office space
   - Photographic equipment
   - Aircraft video recording equipment
   - Test flight areas

6. The following services will be provided by the U.S. Navy as needed:

- Coordination for use of ships
- Briefing to test crew on Navy shipboard approach procedures
- Required personnel to conduct air operations on and around the ship

Crash/search and rescue personnel and equipment

**APPENDIX G: Instrumentation**

1. A Hand held GPS receiver will be used for navigation and to monitor ground speed.

2. The cockpit is equipped with two video mini-cameras, a monitor to display the HELLAS safety line output, an obstacle warning indicator, and an IRIG display. Instrumentation, including two instrumentation pallets and a video rack are mounted in the cabin with seat fittings.

3. A detailed description of the aircraft instrumentation requirements can be found in the ASD, reference 2.

**Appendix H: Navy Deck Landing Approach Flights**

**H.1 Test Environment** Figure 1 shows the lower James River vicinity for the Navy data collection flights.

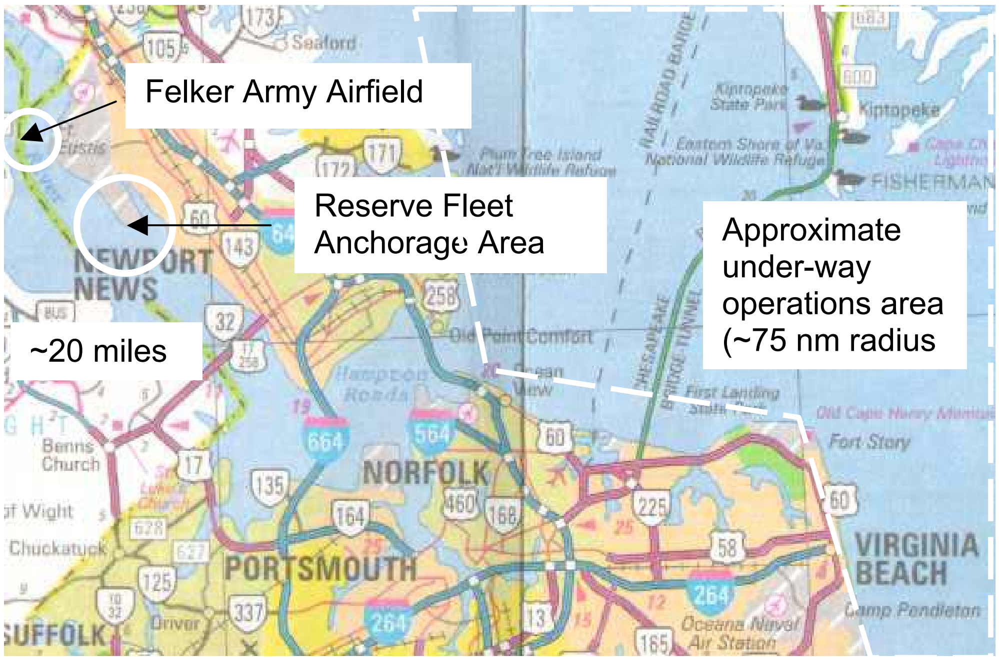


Fig. 1: Ft-Eustis-Norfolk-Hampton Roads area map

The 75-nm operational radius of the LODS UH-60 extends to about 40 nm east of Cape Henry, affording a large area in which to locate ships. Ships nearest shore will receive first consideration for deck landing approach flights.

**H.2 Test Objectives**

1. Collect HELLAS imagery during deck landing approaches to as many air-capable ship classes as possible during clear visibility conditions.

2. Operate the HELLAS system in an offshore marine environment, and collect, deck landing approach imagery to at least one ship under way.

3. Collect HELLAS imagery of multiple classes of air-capable ships.

H.3 Operational Procedures

Navy data collection flight operations are currently scheduled for Feb-March 2003. One flight per day is anticipated. One ship per flight may be a practical limit. Multiple ships per flight will be planned if experience so indicates.

Operations in the proximity of Navy ships will require close coordination with these assets and their crews. For ships under way, the Duty Officer on the bridge or quarterdeck controls landing approaches. Ship-acquired helicopter tracking data would be useful for comparison with the HELLAS data in terms of range and approach rates. Electronic interference from shore-based or ship-based radars in operation at close range may require special attention.

Pre-operations coordination with Commander, Atlantic Fleet (COMLANT) will identify air-capable ships scheduled in and around Norfolk during the test period, authorize the approach flights, and establish ship-specific operational procedures including rendezvous, communications channels, acceptable approach distances, FSO and other ship personnel requirements, and ship POCs. NAVAIR will make necessary administrative arrangements, including the requests for ship services.

**H.4. Deck Landing Approach Test Procedure:**

Fig. H-1 shows a typical deck landing stern approach, used with cruisers, frigates, and destroyers.

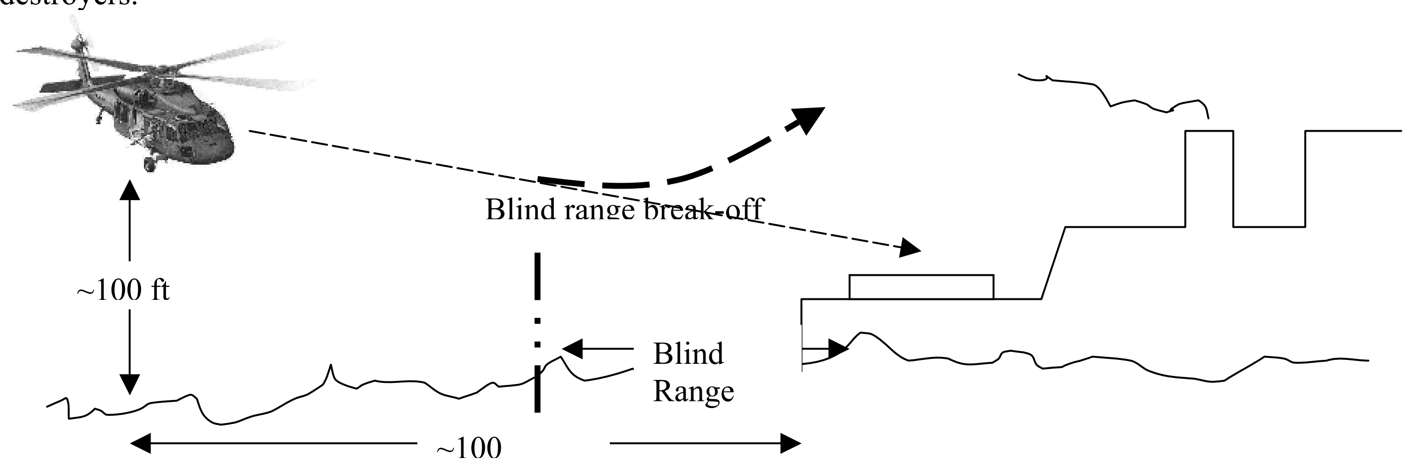


Fig H-1: Deck landing approach profile

Initially, the helicopter keeps station to the ship at ~100-ft altitude and 100-m distance astern. The helicopter approaches the ship under "fast hover" conditions to within the 50-m HELLAS blind range, then breaks off the approach and circles for another pass.

# Appendix I

# Electromagnetic Compatibility Checklist

# AVIATION APPLIED TECHNOLOGY DIRECTORATE
# QUALITATIVE ELECTROMAGNETIC COMPATIBILITY CHECKLIST

## UH-60L HELICOPTER
## WITH
## Laser Obstacle Detector System (LODS)
## INSTALLED

AIRCRAFT TAIL NUMBER _______________ DATE ________________________________

PILOT/COPILOT _________________________ TEST AREA _________________________

WEATHER ______________________________

Electromagnetic Compatibility (EMC) Checklist Procedures:

1) The purpose of this checklist is to disclose electromagnetic incompatibilities that may exist between any installed systems that would prevent safe operation of the aircraft in any of its mission configurations during a trial or one-time installation of a non-standard item/system. A detailed EMC test is required prior to use in flight.

2) This checklist constitutes the minimum checks required. Qualitative EMC checks will be conducted on the ground and in flight in accordance with the operator's manual, the pilot's checklist, and this checklist.

3) Additional EMC checks are not required for each subsequent removal/reinstallation, provided the item is installed in the same location. If configuration changes or item modifications have been made since the issuance of the original AWR, then another EMC check is required.

4) EMC Test Procedures

   a. All new components shall be powered and operating and their performance shall be monitored as the "victim" while individually powering up all existing aircraft systems in accordance with the checklists. In addition, all new components shall be tested as the "source" by monitoring all existing aircraft systems for indications (momentary or continuous) while activating the new components. Activating consists of powered operation and major modes of operation with momentary operation of any function expected to emit signals in excess of simple powered operation. Electromagnetic interference (EMI) will be recorded as either present or not present. If present, a determination will be made between the test pilot and engineer whether the interference is acceptable or not. Acceptable limits are defined as no degradation to the victim system, or the degradation is too minor to require further consideration, ie. a click in the intercom. Unacceptable would render the system non-operational or prevent it from performing its function in such a way that operation of the aircraft would be unsafe. Make a note of the source/victim relationship in the remark section. If the source cannot be determined then make a note in the remark section.

   b. Check all tunable transmitters and receivers as a source and victim at each frequency that they will be operated, or at 10-20 frequencies evenly spaced over each band. Ensure squelch is ON and volume controls are set to mid-position. Test frequency-hopping radios with a hopset that covers the full band of the radio if the use of frequency-hopping is anticipated while the test item is installed on the aircraft.

While monitoring the victim systems, operate the source transceivers in the following manner:

1. Energize and de-energize each transceiver several times to determine transient effects.
2. Tune the source transceiver to each specified frequency and mode indicated on the checklists.

Voice transmit 1-2 seconds on each frequency.

3. When testing the transponder, operate in NORMAL, mode 3/A and mode 4 without interrogation.
4. Record any interference effects and associated frequency data for each of the systems.

While operating the source systems, monitor victim transceivers under the following conditions:

1. Set all volume controls to a comfortable listening level under squelch-on conditions.
2. Aurally monitor each applicable victim transceiver's audio for noise or squelch openings on each of the frequencies called out on the checklists.
3. Visually monitor any associated transceiver displays for interference effects.
4. Monitor pulse transceivers in their normal energized mode.

c. Ensure all transponders and jammers are interrogated or simulated to cause them to transmit in all major modes required for use while the test item is installed on the aircraft.

d. During avionics checks, list the specific nomenclature of the equipment being used in the space provided i.e. UHF-ARC-164.

e. At the end of the checklist, a section is provided to list all non-standard equipment installed/operated during the test. List all non-standard items (other than the item or system that is being evaluated for EMC) that are potential source/victims and are listed in the aircraft non-standard book.

f. Record all source/victim relationships in the remark section. Mark completion of the EMC checks with the following marks. If the check is OK"[√]". If the check is unsatisfactory, "[X]". If the check was not required for the test "[NA]". All checks listed on the EMC checklist must be completed unless the system is not operational or not installed, use of the system is restricted due to environmental or flight conditions, or the checklist states, "if use is anticipated during the test". Comment on any restrictions that prevent testing in the remark section.

g. If an aircraft subsystem cannot be EMC tested, the subsystem is restricted from use until EMC testing can be performed. This restriction should also be placed in the AATD AWR.

h. Sign off the EMC check in the aircraft logbook.

5) HELLAS Operating Procedures

1. Establish aircraft ground test operation and verify all systems are functioning normally, including communication and navigation systems.
2. Verify that all HELLAS system have power and perform a HELLAS functionality check.
3. Power up all instrumentation equipment.

6) Those items marked with an "♦" indicate a task with expanded procedures in the operator's checklist.

7) Those items marked with an "♠" indicate a Maintenance Test Flight task that will be used if required by AWR or an approved test plan. If these tasks are not specifically addressed in the test plan or AWR, then perform the system check in accordance with the operator's manual requirements only.

**WARNING**

This checklist does not provide for safety margin testing of electro-explosive devices (EEDs) on the aircraft. If there is a significant potential for the newly installed item to interfere with systems utilizing EED's, AMCOM will require additional testing in the AWR. When testing aircraft having systems that include EED's, test crews should be aware that appropriate safety precautions must be taken.

## BEFORE STARTING ENGINES

1. Copilot's Collective – Extended and locked

2. Shoulder Harness Locks – Check

3. PARKING BRAKE – Release, then set

♦ 4. Circuit Breakers and Switches – Set

4a. TEST Verify test equipment is off.

4b. Note Initial Magnetic Compass Heading

## COCKPIT EQUIPMENT CHECKS

1. FUEL PUMP Switch – APU BOOST

2. APU CONTR Switch – ON

3. APU Generator Switch – ON

4. EXT PWR Switch – OFF

4a. TEST Test Equipment – ON

5. ES AUXILIARY FUEL MANAGEMENT Panel – TEST

[ ] Auxiliary Panel Lights

6. ES AUXILIARY FUEL MANAGEMENT Panel – Set fuel as required.

[ ] Jettison System Voltage Check
[ ] Jettison System Operational Check

7. EH IINS SYSTEMS SELECT Switches – DG and VG

8. EH IINS – Align

[ ] INS Alignment/Operation

9. Caution/Advisory/Warning Panels – Check

[ ] Caution Panel Lighting
[ ] CIS/MODE SEL Lights
[ ] AFCS Failure Advisory Lights
[ ] Master Caution Panel Lights
[ ] AFCS Failure Advisory Lights
[ ] Fuel Quantity Indicator Test
[ ] Fire Lights Test
[ ] Pilot/Copilot PDU Test
[ ] CDU Test
[ ] Digits ON/OFF Switch
N [ ] NVG Engine
N [ ] Dimming Functions
(Have crewchief depress WOW Switch.)
[ ] Low Rotor RPM/Engine Out Audio – Check

10. 701C DEC Engine Fault Indicator Codes – Check

11. Interior/Exterior Lighting – Set

[ ] Cockpit Utility
[ ] Cockpit Flood
[ ] Cabin Dome

N [ ] Searchlight/Searchlight Control
[ ] Landing Light/Landing Light Control
N [ ] Flight Instrument Lights (Pilot)
N [ ] Flight Instrument Lights (Copilot)
N [ ] Non-Flight Instrument Lights
N [ ] Console Lights (Upper and Lower)
[ ] Position Lights
N [ ] Formation Lights
N [ ] Console Lights (Upper and Lower)
[ ] Position Lights
N [ ] NVG Lights

12. Mission Equipment – If installed and use is anticipated while test item is installed in the aircraft.

[ ] Cargo Hook
[ ] APR-39(V)
[ ] IR Countermeasures, ALQ-144
[ ] Chaff Dispenser, M-130
[ ] Windshield Wipers
[ ] Pitot Heater
[ ] Heater
[ ] Vent Blower

13. Cold Weather Control Exercise – Check if temperature is below –17 $^{o}$C (1 $^{o}$F)

14. AFCS FAILURE ADVISORY lights - If on, POWER ON RESET

15. SAS1 – OFF, SAS2, TRIM, FPS, AND BOOST Switches – Push ON

[ ] Determine operation of each switch prior to setting the switches.

♦ 16. Flight Controls – Check

[ ] Servo OFF 1$^{st}$ Stage (Pilot and Copilot)
[ ] Servo OFF 2$^{nd}$ Stage (Pilot and Copilot)
[ ] 1$^{st}$ Stage/2$^{nd}$ Stage Interlock
[ ] Tail Rotor Servo (1$^{st}$ and 2$^{nd}$ Stage)
[ ] Backup Pump Operation
[ ] Boost Servos

*After standard flight control check*

[ ] Cyclic Trim Release (Pilot/Copilot)
[ ] Cyclic Stick Trim (Depress WOW Switch)

♦ 17. Stabilator – Check

[ ] Perform stabilator check with equipment on.
[ ] Stabilator Warning System
[ ] Pilot/Copilot Cyclic Slew Switch

18. Avionics – ON

19. COMPASS Switch – SLAVED. Set as required.

[ ] Compass Control Panel

20. Barometric Altimeters – Set

21. Cyclic and Pedals Centered – Collective raise no more than 1 inch and friction

22. BACKUP HYD PUMP Switch – OFF

♦ 23. Blade De-ice System – Test if use is anticipated while test item is installed on the aircraft.

[ ] Blade De-ice System

24. Avionics – Check

Communications Equipment (Radios frequency intervals – Page 14)

[ ] ICS _______________
[ ] VHF-FM (#1) _____________
[ ] VHF-FM (#2) _____________
[ ] VHF-AM ______________
[ ] UHF-AM _____________
[ ] Crypto (If Required) ______________
[ ] Radio Retransmission Panel
[ ] Transponder _____________
[ ] Kit-1A/TSEC IFF Computer
[ ] TEST EIS+

Navigation Equipment

[ ] ADF ___________
[ ] Magnetic Compass Variation
[ ] VOR ___________
[ ] Doppler ___________
[ ] GPS (if installed) ______________
[ ] Gyromagnetic Compass (Pilot)
[ ] Gyromagnetic Compass (Pilot/Copilot)
[ ] HSI Operation (Pilot/Copilot)
[ ] Radar Altimeter Operation
[ ] VSI Operation (Pilot/Copilot)

HSI/VSI Mode Select Panel (Pilot and Copilot)

[ ] Doppler
[ ] VOR/ILS
[ ] Back Course
[ ] FM Homing
[ ] Turn Rate Gyros
[ ] Course Heading
[ ] Vertical Gyros
[ ] Bearing #2

**STARTING ENGINES**

1. ENG FUEL SYS Selector(s) – As required (XFD) first flight of the day.

2. FUEL BOOST PUMP CONTROL Switches – ON (for all fuel types). Indicator Lights Check – On.

   [ ] Fuel Boost Pump Switch (#1/#2)

3. ENGINE IGNITION Switch – ON

4. GUST LOCK Caution Light – Off

5. Fire Guard – Posted if available

6. Rotor Blades – Check clear

   [ ] Heater Dropout – Checks (#1/#2)

♦ 7. Engine – Start

8. If single-engine start was made, repeat step 7 for the other engine.

9. Systems – Check
   - [ ] Fuel Quantity
   - [ ] XSMN Oil Temperature
   - [ ] XSMN Oil Pressure
   - [ ] Engine Oil Temperature (#1/#2)
   - [ ] Engine Oil Pressure (#1/#2)
   - [ ] TGT (#1/#2)
   - [ ] Ng Speed (#1/#2)

   <u>Pilot's/Copilot's PDU</u>
   - [ ] Engine RPM (#1/#2)
   - [ ] Torque (#1/#2)
   - [ ] Rotor RPM

10. BACKUP HYD PUMP Switch – AUTO

11. Hydraulic Leak Test System – Check
   - [ ] Hydraulic Leak Test
   - [ ] Backup Hydraulic Pump Operation

12. Tail Rotor Servo Transfer – Check
   - [ ] Tail Rotor Servo Transfer
   - [ ] Backup Hydraulic Pump Operation

13. AUX CABIN HEATER Switch – As desired
   - [ ] Auxiliary Cabin Heater

14. Engine Warm-Up – Check if temperature is below –17 $^{o}$C

**NOTE**

Make sure test equipment is off until and both Engine PCL's are at FLY and GEN #1 and GEN #2 caution lights are OFF.

N 15. Night Vision Systems – Check if use anticipated

## ENGINE RUNUP

1. Flight Controls – Hold

2. ENGINE POWER CONT Levers – FLY

3. Droop Stops – Check out 70-75% RPM R

4. #1 and #2 GEN Caution Lights – Off

4a. TEST Test Equipment – ON

**CAUTION**

Exercise caution when turning generators off while test equipment is operating. Electrical surges may cause damage to test equipment.

**NOTE**

Turn off only one generator at a time and note electrical system operation. Turn the generator back on prior to proceeding to the next generator. Evaluate the test equipment as a victim during this check.

- [ ] #1 Generator
- [ ] #2 Generator
- [ ] APU Generator

5. ECS Panel Switches – As desired

♦ 6. DEICE EOT – Check if use is anticipated.
   - [ ] Deice EOT

7. % TRQ 1 and 2 – Matched within 5%

8. EH Q/F PWR Switch – As desired

9. FUEL PUMP Switch – OFF
   - [ ] Fuel Pump Switch

10. APU CONTR Switch – OFF
    - [ ] APU Operation During Runup
    - [ ] APU Control Switch

11. AIR SOURCE HEAT/START Switch – As required
    - [ ] Air Source Heat Start Switch
    - [ ] Heater

12. ENG FUEL SYS Selectors – As required

13. SAS1 – ON

14. Collective Friction – As required

15. EH IINS NAVRDY Light Flashing – CDU Mode Select Switch to NAV

16. EH IINS SYSTEMS SELECT Switches – IINS.

17. Engine Health Indicator Test (HIT)/Anti-Icing Check – Accomplish
    - [ ] Engine Anti-Ice (#1/#2)
    - [ ] Engine Inlet Anti-Ice

    After the HIT Check is complete:
    - [ ] Engine RPM Switch
    - [ ] Windshield Anti-Ice

♦ 18. ES External Extended Range Fuel Transfer – Check
    - [ ] AUX Fuel Management Control Panel

## BEFORE TAXI

1. ES Ejector Rack Lock Levers Unlocked.

2. Chaff, Flare Electronic Modules Safety Pins – Remove

3. Chocks – Removed

4. Doors – Secured

5. PARKING BRAKE – Release

6. TAIL WHEEL Switch – As required
   - [ ] Tail Wheel Switch

7. Wheel Brakes – Check as required

**HOVER CHECK**

1. Systems – Check

2. Flight Instruments – Check

3. Power – Check

## BEFORE TAKEOFF

1. ENG POWER CONT Levers – FLY

2. Systems – Check

3. Avionics – As required

4. Crew, Passengers, and Mission Equipment – Check

   [ ] Engine Overspeed System – Test (#1/#2)

   [ ] TGT Limiter – Test (#1/#2, IAW TM 55-1520-248-23, para 1-114/114.1)

## AFTER TAKEOFF

1. ES Extended Range Fuel System Transfer – As required

   [ ] AUX Fuel Management Control Panel

2. ASE – If installed and use is anticipated while the test item is installed in the aircraft.

   [ ] APR-39(V)
   [ ] IR Countermeasures, ALQ-144
   [ ] Chaff Dispenser, M-130
   [ ] Windshield Wipers
   [ ] Pitot Heater
   [ ] Heater
   [ ] Vent Blower

<u>CDU</u>

[ ] XSMN Oil Temperature
[ ] XSMN Oil Pressure
[ ] Engine Oil Temperature (#1/#2)
[ ] Engine Oil Pressure (#1/#2)
[ ] TGT (#1/#2)
[ ] Ng Speed (#1/#2)
[ ] CDU Digits On/OFF

<u>Pilot's/Copilot's PDU</u>

[ ] Engine RPM (#1/#2)
[ ] Torque (#1/#2)
[ ] Rotor RPM

<u>Communications Equipment</u> (Radios frequency intervals – Page 14)

[ ] ICS
[ ] VHF-FM #1
[ ] VHF-FM #2
[ ] VHF-AM
[ ] UHF-AM
[ ] Crypto Equipment (If Installed)
[ ] Radio Retransmission Panel
[ ] Transponder
[ ] Kit-1A/TSEC IFF Computer(If Required)

Navigation Equipment

[ ] ADF
[ ] Magnetic Compass Variation
[ ] VOR
[ ] Doppler
[ ] GPS System (if installed)
[ ] TEST Kearfott GPS/INS System (If Installed)
[ ] Gyromagnetic Compass (Pilot)
[ ] Gyromagnetic Compass (Pilot/Copilot)
[ ] HSI Operation (Pilot/Copilot)
[ ] Radar Altimeter Operation
[ ] VSI Operation (Pilot/Copilot)

HIS/VSI Mode Select Panel (Pilot and Copilot)

[ ] Doppler
[ ] VOR/ILS
[ ] Back Course
[ ] FM Home
[ ] Turn Rate Gyros
[ ] Course Heading
[ ] Vertical Gyros
[ ] Bearing #2

Miscellaneous Systems

[ ] Engine Anti-Ice (#1/#2)
[ ] Engine Inlet Anti-Ice
[ ] Engine RPM Switch
[ ] Windshield Anti-Ice

Flight Controls

[ ] Backup Pump Operation
[ ] AFCS Control Panel Switches
[ ] Cyclic Trim Release (Pilot/Copilot)
[ ] Cyclic Stick Trim

**BEFORE LANDING**

1. TAIL WHEEL Switch – As Required
2. PARKING BRAKE – As Required
3. Crew, Passengers, and Mission Equipment – Check

## AFTER LANDING

1. TAIL WHEEL Switch – As required
2. PARKING BRAKE – Set
3. Landing Gear – Chocked

3a. ES AUXILIARY FUEL MANAGEMENT FUEL XFR MODE Switch – OFF

3b. ES AUXILIARY FUEL MANAGEMENT Panel PRESS Switch(es) – Off

4. ES Ejector Rack Locking Levers – Locked
5. Chaff, Flare Electronic Module Safety Pins – Install
6. EH IINS SYSTEMS SELECT Switches – DG/VG

7. EH IINS – OFF

8. EH ECS Panel Switches – OFF

9. SAS 1 – Off

10. DE-ICE, PITOT, ANTI-ICE, HEATER AND Q/F PWR Switches – OFF

11. AIR SOURCE HEAT/START Switch – APU

12. FUEL PUMP Switch – APU BOOST

13. APU CONTR Switch – ON

14. Collective raise no more than 1 inch.

**CAUTION**

Shut down the aircraft system if susceptible to generator transients.

15. Flight Controls – Hold

16. ENG POWER CONT Levers – IDLE

16a. TEST Test Equipment – ON. Bring the system back on line to check engine-out audio activation.

17. ENGINE IGNITION Switch – OFF

18. Cyclic – As required

19. Droop stops – Verify in, about 50% rpm R.

20. BACKUP HYD PUMP Switch – OFF

21. Stabilator – Slew to $0^{o}$ after last flight of the day.

22. BACKUP PUMP ON Advisory Light – Check off

23. ENG POWER CONT Levers – OFF after 2 minutes at Ng speed of 90% or less.

    [ ] Low Rotor RPM (Press WOW switch prior to engine shutdown..)

    [ ] Engine Out Audio (#1/#2) (WOW switch depress for #2 engine.)

24. ENG FUEL SYS Selector – OFF

25. AUX CABIN HEATER Switch – OFF

26. TGT – Monitor

27. 701C DEC Torque Indicator Fault Code – Check

28. Avionics – Off

29. FUEL BOOST PUMP CONTROL Switches – OFF

30. HUD ADJ/ON/OFF Switch – OFF

31. Overhead Switches – As required

32. TEST Test Equipment – Off

32. APU Generator Switch – OFF

33. FUEL PUMP Switch – OFF

34. APU CONTR Switch – OFF

35. BATT Switch – OFF

## NONSTANDARD EQUIPMENT

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Remarks:

______________________________________________

Pilot's Signature/Date

AIRCRAFT COMMUNICTION RADIO RECEIVER FREQUENCY TABLE

| **VHF-FM1/2** (MHz) | **VHF-AM** (MHz) | **UHF-AM** (MHz) |
|---|---|---|
| 30.500 | 108.000 | 225.000 |
| 35.500 | 110.000 | 235.000 |
| 40.500 | 112.000 | 243.000 |
| 45.500 | 114.000 | 255.000 |
| 50.500 | 116.000 | 265.000 |
| 55.500 | 121.500 | 275.000 |
| 60.500 | 125.000 | 285.000 |
| 65.500 | 130.000 | 295.000 |
| 70.500 | 135.000 | 305.000 |
| 75.500 | 140.000 | 315.000 |
| 80.500 | 145.000 | 325.000 |
| 85.500 | 150.000 | 335.000 |
| 89.500 | 151.900 | 345.000 |
| | | 355.000 |
| | | 365.000 |
| | | 375.000 |
| | | 385.000 |
| | | 395.000 |
| | | 399.000 |

**DAILY FLIGHT REPORT**

FLIGHT No. 3 and 4 Laser Obstacle Detector System Date: 12 Feb 03

| | | | |
|---|---|---|---|
| Aircraft Model:<br>EH-60L | Serial Number:<br>24468 | Project Number: | Test Location:<br>Felker AAF/ Wire sets 1,2 and 3 |
| Pilot(s): Wolons (R) / Dean(L)<br><br>FE:Craig | Engineer/ Crew :<br><br>Centolanza | Weather Condition at Test Altitude: Surface winds were 12G20 from the West. OAT +5 / PA +60. Test altitude @ 50 ft MSL winds estimated 270 @ 20 kts, OAT +5. Ceiling: None , Visibility 10+ miles.<br>Winds increased to 20G30 for flight # 4 | |
| T/O Gross Weight: 15259 LB | Landing GW: 13900 LB | T/O CG: Long: 362.8 (AFT) LAT: mid<br>Landing CG: | |
| Today's Flight time: 3.4<br>Ground : N/A | Test Pressure Altitude: 0 ft | Prod. Time: 3.0 | |
| Flight Time to Date: 7.9<br><br>Productive Time to date: 7.5 | Test Configuration: Hellas Laser installed on the LODS nose mount. LODS display on the left side of the instrument panel below the CP pedal adjustment lever. Dornier data acquisition system and AATD instrumentation system installed in the cabin | Bleed air N/A. | |

**PURPOSE OF TESTS**: Initial evaluation of LODS system capability to detect wires in the flight path.

**METHOD OF TESTS**: Data recorded by video, AATD and Dornier data acquisition systems, and on hand held data cards. Straight and level approaches were made toward wires at different speeds, angles and altitudes. Airspeeds ranged between 40 and 120 KIAS, approach path angles ranged from straight on to 45 degrees left and right, and relative altitudes ranged from level with the wires to 50 feet above the wires. Distance from the wires was estimated and compared to the Hellas raw data readout. Approaches started outside of the 1000 meter Hellas range and were broken off within 100 meters of the wires. Wire areas included the James River Bridge (wire area 1), the west bank (wire area 2) and the west area (wire area 3).

**WHAT I DID /SAW/THOUGHT:**

- **Sunlight Effects:** With the sun at approximately a 30 degree angle at 12:00, the wires on the James River Bridge were not visible to the naked eye or the Hellas system until the aircraft was within 150 meters.

- **Straight In Approaches:** In all cases, wires were visible with the naked eye before they were visible on the LODS display or the raw data on the Dornier rack. With the exception of the sun glare problems listed above, the Hellas safety line on the display appeared to accurately map the obstacles ahead. The obstacle avoidance arrows were illuminated in many cases where no obstacles were in the path and were not illuminated in a few cases where the wires were within 100 meters. The obstacle avoidance indicators would illuminate and blink rapidly as the wires got closer but in a few cases they went out before the aircraft reached the wires. In most cases, the wires were visible in the raw data before they were visible on the LODS monitor. Wire recognition distances were relatively independent of airspeed.

- **50 Foot AHO approaches:** Two straight in approaches were made 50 feet higher than the wires. In both cases, the obstacle avoidance arrows illuminated with no obstacles in the flight path.

- **45 Degree Angle Approaches:** Hellas system performance appeared not to be effected by the 45 degree approach angle.

**GENERAL COMMENTS:**

- The LODS safety line appeared to correctly map the obstacles in the flight path, however the system appeared to be highly degraded with sunlight from the front.

**Enclosure 3**

- Trees in the along the approach path to the wires on sets 2 and 3 appeared to confuse the warning indicator to illuminate almost constantly even when the aircraft was flown above all obstacles

**CONCLUSION / RECOMMENDATIONS:**

- Recommend using the hand held GPS to gage distance from the wires, RAW data distances can be used for comparison
- Begin testing with identical data cards for each wire set
- Adjust the sensitivity of the obstacle avoidance arrows.
- High wind conditions made it difficult to hold airspeed/altitude during run-ins. Recommend repeating all data points in calmer winds.

## DAILY FLIGHT REPORT

FLIGHT No. 5 Laser Obstacle Detector System Date: 4 Mar 03

| | | | |
|---|---|---|---|
| Aircraft Model:<br>EH-60L | Serial Number:<br>24468 | Project Number: | Test Location:<br>Felker AAF/ James River Bridge Wire set 1 |
| Pilot(s): Wood(R)/Wolons (L) | Engineer/ Crew :<br><br>Centolanza | Weather Condition at Test Altitude: Surface winds were 110 degrees at 7 knots, no turbulance. OAT +7 / PA –240. Test altitude @ 150-300 ft MSL. Ceiling: None , Visibility 10+ miles. | |
| T/O Gross Weight: 15259 LB | Landing GW: 13659 LB | T/O CG: Long: 362.5 (AFT) LAT: mid<br>Landing CG: | |
| Today's Flight time: 1.9<br>Ground : N/A | Test Pressure Altitude: 0 ft | Prod. Time: 1.8 | |
| Flight Time to date: 9.8<br><br>Productive Time to date: 9.3 | Test Configuration: Hellas Laser installed on the LODS nose mount. LODS display on the left side of the instrument panel below the CP pedal adjustment lever. Dornier data acquisition system and AATD instrumentation system installed in the cabin | Bleed air N/A. | |

**PURPOSE OF TESTS**: LODS system evaluation

**METHOD OF TESTS**: Data recorded by video, AATD and Dornier data acquisition systems, and on hand held data cards. Distance from the wires and bearing to the wires was measured using a Garmin 195 hand held GPS. Airspeeds tested included 40 and 60 KIAS, approach path angles of 90, 60, 45 and 20 degrees were evaluated as well as flying directly above the wires along the path of the wires. Runs were made with the wires at the pilots eye level and then repeated with the aircraft 50 feet above the wires. Approaches started outside of 2000 meters and were broken off within 100 meters of the wires. Wire set 1 was evaluated with the sun at about an 80 degree angle above the nose.

**WHAT I DID /SAW/THOUGHT:**

- **Sunlight Effects:** With the sun at approximately a 80 degree angle at 12:00, the wires on the James River Bridge were visible with the naked eye outside of 1 km and detected by both raw data and the safety line at an average distance of 800-950 meters. The small guide wires at the top of the poles were visible at an average distance of 700 meters with the naked eye.

- **Raw Data and Safety line:** Raw data and safety line detection ranges were consistent at 40 and 60 knots. It was difficult to determine exactly when the safety line picked out the small guide wire at the top of the poles, therefore, safety line distance will have some error induced by the perception of the evaluator. Detection ranges of 900-1000 meters by raw data and the safety line were consistent up to and including the 45 degree angle of incidence points. During the 20 degree angle of incidence points, the wires were visible on the left 1/3 of the display in both raw data and the safety line. It was difficult to pick out when the safety line picked up the intended location on the wires directly to the aircraft front. Raw data and safety line identification ranges appeared to be unaffected by the change from level with the wires to 50 feet above the wires.

- **Obstacle Warning Indicator:** During the wire runs at wire level, the obstacle warning indicator (WI) illuminated at between 210 and 500 meters, however, the wires were to the front and left and the (WI) consistently indicated wires to the front and right. With the aircraft 50 feet above the wires, the warning indicator did not illuminate until the aircraft entered a right bank to complete each run.

**Enclosure 3**

**GENERAL COMMENTS:**

- The LODS Raw data and safety line appeared to be unaffected by airspeed or angles of incidence up to 45 degrees. Past 45 degrees, the wires were visible on the left 1/3 of the display and the safety line dropped off on the right hand side of the screen.

- The sun at an 80 degree angle above the nose did not seem to have a negative affect on the system.

- The WI consistently indicated obstacles on the right side of the aircraft when the wires were to the left. There was no obvious relationship between the WI distance and airspeed.

**CONCLUSION / RECOMMENDATIONS:**

- Continue testing
- Recommend analyzing the algorithm causing the WI to illuminate and matching the WI data to it.

**DAILY FLIGHT REPORT**

FLIGHT No. 6 Laser Obstacle Detector System Date: 4 March 03

| | | | |
|---|---|---|---|
| Aircraft Model: EH-60L | Serial Number: 24468 | Project Number: | Test Location: James River Bridge, wire set 1 |
| Pilot(s): Wolons(R)/ Starks(L) | Engineer/ Crew : Centolanza | Weather Condition at Test Altitude: Temp 12 C, PA –240, Clear Wind 110/7 Kts | |
| T/O Gross Weight: 15259 LB | Landing GW: 13900 LB | T/O CG: Long: XXX (AFT) LAT: mid Landing CG: | |
| Today's Flight time: 2.1 Ground : N/A | Test Pressure Altitude: 0 ft | Prod. Time: 1.9 | |
| Flight Time to Date: 11.9<br>Productive Time to date: 11.2 | Test Configuration: Hellas Laser installed on the LODS nose mount. LODS display on the left side of the instrument panel below the CP pedal adjustment lever. Dornier data acquisition system and AATD instrumentation system installed in the cabin | Bleed air N/A. | |

**PURPOSE OF TESTS**: LODS system evaluation

**METHOD OF TESTS**: Data recorded by video, AATD and Dornier data acquisition systems, and on hand held data cards. Straight and level approaches were made toward wires at different speeds, angles and altitudes. Airspeeds ranged between 80 and 120 KIAS, approach path angles were 90, 60, 45, and 20 degrees relative to the wires, and relative altitudes ranged from level with the wires to 50 feet above the wires. Set 1 wires run 235 degrees, therefore aircraft headings flown were 175, 190, 215, and 235 degrees. Distance from the wires and bearing to the wires was measured with a Garmin 195 hand held GPS. Approaches were started outside of the 2 km and broken off within 100 meters of the wires. Approaches made 50 feet above the wires were terminated upon crossing the wires. The pilot on the controls called out when he saw the large wires and then again when he saw the small guy wires at the top of the poles with the naked eye. The engineer called out when he saw the wires in the raw data, and the pilot in the left seat noted when the safety line correctly mapped the wires. The pilot in the left seat recorded all distances on hand held data cards.

**WHAT I DID /SAW/THOUGHT:**

- **Sunlight Effects:** With the sun at approximately a 30 degree angle from the horizon at the 6:00 aircraft position, the top guide wires were very difficult to see with the naked eye and in many cases could not be seen until the aircraft crossed above them. The LODS system detection ranges appeared not to be effected by sunlight from behind the aircraft.

- **Raw Data and Safety Line:** Average raw data detection of the wires including the top guide wires was 1 km. Wires were visible in the raw data and the safety line almost simultaneously. Detection ranges appeared to be independent of airspeed and independent of approach angles up to 45 degrees. Detection ranges for the 20 degree approach angle points were reduced to 700-750 meters. At this angle, the safety line followed the wires that were visible on the left half of the display, but then dropped off to the bottom right corner of the display. Detection ranges were not effected by the change in aircraft altitude from wire level to 50 feet above wire level. As the sun got lower on the horizon behind the aircraft, the wires became harder and harder to see with the naked eye, however, LODS detection ranges seemed unaffected.

- **Obstacle Warning Indicator (WI):** At wire level, the WI illumination ranged from 490-770 meters but was indicating obstacles to the right and front with the wires on the left side of the aircraft. (WI) Detection ranges appeared to increase with decreased angle of incidence to the wires. This is likely due to the relatively closer distance from the left side of the aircraft to the wires on the run in to the intended point. The obstacle warning did not illuminate on the runs that were made 50 feet above the wires.

**GENERAL COMMENTS:**

- Detection ranges appeared consistent and independent of airspeed, approach angle up to 45 degrees, and relative aircraft altitude up to 50 feet above the wires. The safety line detection ranges were almost identical to the raw data ranges.

- The obstacle warning indicator illumination appears to be independent of airspeed and indicates that the wires are on the opposite side of the aircraft.

**CONCLUSION / RECOMMENDATIONS:**

- Continue testing at wire set 2
- Adjust the WI algorithm to cause WI illumination to be a combination of speed and distance (time from the obstacle)

**DAILY FLIGHT REPORT**

| | | | |
|---|---|---|---|
| FLIGHT No. 7 (Suitability Evaluation) | | | Date: 6 March, 2003 |
| Aircraft Model: EH-60L | Serial Number: 24468 | Project Number: | Test Location: AATD / Felker AAF |
| Pilot(s): Chuck Starks (L) / JOHNSTON (R) | Engineer/ Crew : Tim Davis | Weather Condition at Test Altitude: Surface winds were 260 @ 9 Gust 22 kts, OAT +15 / PA +178. Gusting winds generated light to moderate turbulence. Clouds were FEW006 BKN250, Visibility 7 miles. | |
| T/O Gross Weight: 15259 LB | Landing GW: 13578 LB | T/O CG: Long: 362.56 (AFT) LAT: mid | |
| Today's Flight time: 2.0<br>Ground: 0.3 | Test Pressure Altitude: 328 ft | Prod. Time: 1.7 | |
| Total flight time: 13.9<br><br>Total Productive Time to date: 12.9 | Test Configuration: No external wing stores, DVMC. LODS equip installed, Bleed air off, FPS, SAS 1&2 on, Pitot heat off. Data recording equipment and test equipment operator on board. | | |

**PURPOSE OF TESTS**: Data collection for the LODS equipment. Conduct qualitative evaluation for wire warning display.

**METHOD OF TESTS**: Data recorded by hand on flight cards and automatically on LODS data recording equipment. Two flight cards were flown (set 2 and set 3). Data for set #2 was obtained at hover points over the James River using wires along the James River Bridge. Data for set #3 was obtained at wires located on the West side of the James River, abeam Felker Army Airfield.

**WHAT I DID /SAW/THOUGHT:**

- **Hover points (Data Set #2):** Weather conditions were not optimum for maintaining a precise hover position. As a result, accuracy of the hover position was +/-10 ft, +/- 10 meters, and +/- 1 degree. Hovering over the water and trying to maintain a specific location relative the wires and based upon GPS distance and bearing data was a challenge. The water did not offer visual cues to help maintain position. Additionally, gusting cross winds up to 22 knots required the pilot to maintain a constant lateral velocity relative to the wind. Essentially, flying these data points, due to winds and a lack of visual cues was difficult and the data collected could be improved in a less windy environment.

- **Guide Wires Visual Identification (Data Set #2):** The Pilots ability to see the guide wires that spanned between the top of the support structures was dependent upon the scene background. If the pilot was looking at the guide wires with water or sky in the background, there was no difficulty seeing the wires at ranges up to 1000 meters. If the pilot was looking at the guide wires with terrain or foliage filled background scene, the pilots could not see the guide wires a ranges as close as 200 meters.

- **Data Set #3:** All data for data set #3 should be re-collected. Only four data points were flown. However, due to an undefined flight test technique for recovering data, the four data points taken were not repeatable. Flight test techniques for "run in" data points need to have reference altitude (radar vs. pressure) and flight trim (ball centered or steady heading sideslip) defined based upon what type of data the engineers need. Gusting winds also caused difficulty maintaining a 40-knot airspeed. The gust variances caused the EH-60 stabilator to program randomly, which greatly affected drag and the required attitude and torque the pilot had to maintain.

- **Wire Warning Indicator:** The wire warning indicator was unusable. Over trees and in low level flight, the indicator was continuously warning the pilot of wires in all directions, even when there were none.

**Enclosure 3**

**CONCLUSION / RECOMMENDATIONS:**

- The process for flying the data point, stabilizing on condition, turning on the data recorder and completing the data recording process should be thoroughly briefed prior to take-off. Performing these events with non-school trained pilots and crew requires complete understanding to maximize and time and the quality of data collected.

- Do not conduct hover data points with high winds. Consider not flying any data flights in high winds.

- Use pressure altitude as a reference when collecting data for Set #3. Conducting runs in at the selected wire set requires flying over varying terrain, trees and water. Using radar altimeter as a reference will not provide repeatable / constant altitude.

**DAILY FLIGHT REPORT**

FLIGHT No. 8 Laser Obstacle Detector System Date: 7 Mar 03

| | | | |
|---|---|---|---|
| Aircraft Model:<br>EH-60L | Serial Number:<br>24468 | Project Number: | Test Location:<br>Felker AAF/ Wire Set 2 |
| Pilot(s): Starks(R)/Wolons (L) | Engineer/ Crew :<br><br>Bordick | Weather Condition at Test Altitude: Surface winds were 110 degrees at 10G15 knots, no turbulence. OAT +1C / PA –290. Test altitude @ 150-300 ft MSL. Ceiling: 2000 OVC , Visibility 7 Miles. | |
| T/O Gross Weight: 15259 LB | Landing GW: 13659 LB | T/O CG: Long: 362.5 (AFT) LAT: mid<br>Landing CG: | |

| | | |
|---|---|---|
| Today's Flight time: 1.9<br>Ground : N/A | Test Pressure Altitude: 0 ft | Prod. Time: 1.8 |
| Total Flight Time: 15.8<br><br>Total Productive Time: 14.7 | Test Configuration: Hellas Laser installed on the LODS nose mount. LODS display on the left side of the instrument panel below the CP pedal adjustment lever. Dornier data acquisition system and AATD instrumentation system installed in the cabin | Bleed air N/A. |

**PURPOSE OF TESTS**: LODS system evaluation

**METHOD OF TESTS**: Data recorded by video, AATD and Dornier data acquisition systems, and on hand held data cards. Straight and level approaches were made toward wires at different speeds, angles and altitudes. Data runs were made to wire set 2 from 40 to 80 knots at angles from 90 to 0 degrees relative. Wire set 2 runs 005 degrees, therefore, inbound headings were 275, 305, 320, 345, and 005 degrees. The aircraft was hovered directly over the wires to set the GPS waypoint (West Bank). The aircraft was then hovered directly in front of the wires at wire level and the altimeter was adjusted to 200 feet. Data runs were started outside of 2 kilometers. The GPS was used to determine the distance in meters from the wires. The pilot called out when he could see the main wires and the small thin wires at the top of the wire set. The engineer called out when he could see the wires in the raw data. The pilot in the left seat called out when the safety line saw the wires and when the warning indicator illuminated. All distances were recorded by the pilot in the left seat on hand held data cards. Runs were made level with the wires (200 feet on the altimeter) and then again 50 feet above the wires (250 feet on altimeter).

**WHAT I DID /SAW/THOUGHT:**

- **Raw Data and Safety Line:** The wires were consistently visible in the raw data and adjusted for by the safety line at 950-1000 meters. The pilot was able to see the larger wires at greater than 1000 meters and could see the small guide wires at the top of the poles at between 600 – 700 meters with the naked eye. At the 20 degree approach angle points, the average wire detection distances were reduced to 930-950 meters for the raw data and 870-900 meters for the safety line. The difference between raw data and safety line distance is likely due to operator interpretation of when the intended wire location reached the center of the display. Airspeed did not appear to have an effect on detection ranges.

- **Warning Indicator:** The warning indicator illuminated almost constantly during run ins to the wires and in some cases did not illuminate when the wires were within 200 meters. It was not possible to predict when the warning indicator would illuminate or to determine if the illumination was caused by the wires or by other obstacle around the wires. In many cases, the warning indicator illuminated during the runs 50 feet above the wires. Approach mode did not seem to effect the warning indicator.

**GENERAL COMMENTS:**

- Trees in the along the approach path to the wires on set 2 appeared to confuse the warning indicator to illuminate almost constantly even when the aircraft was flown above all obstacles

- Raw data and safety line detection ranges were similar to those at wire set 1 (900-1000 meters) and did not appear to be effected by the trees ahead of or behind the wires.

**CONCLUSION / RECOMMENDATIONS:**

- Complete wire set 2 testing from 80-120 knots.  Continue with wire sets 3-5

- Analyze the warning indicator data to determine if a particular obstacle can be linked to the warning indicator illumination.  Possibly adjust the sensitivity of the warning indicator.

**DAILY FLIGHT REPORT**

FLIGHT No. 9 Laser Obstacle Detector System Date: 7 Mar 03

| | | | |
|---|---|---|---|
| Aircraft Model:<br>EH-60L | Serial Number:<br>24468 | Project Number: | Test Location:<br>Felker AAF/ Wire Sets 2 and 3 |
| Pilot(s): Clark(R)/Wolons (L) | Engineer/ Crew :<br><br>Centolanza | Weather Condition at Test Altitude: Surface winds were 110 degrees at 7 knots, no turbulance. OAT +7 / PA –290. Test altitude @ 150-300 ft MSL. Ceiling: 1000 OVC , Visibility 3 Miles. Drizzle to LGT Rain and Fog. | |
| T/O Gross Weight: 15259 LB | Landing GW: 13659 LB | T/O CG: Long: 362.5 (AFT) LAT: mid<br>Landing CG: | |
| Today's Flight time: 2.2<br>Ground : N/A | Test Pressure Altitude: 0 ft | Prod. Time: 2.0 | |
| Total Flight Time: 18.0<br><br>Total Productive Time: 16.7 | Test Configuration: Hellas Laser installed on the LODS nose mount. LODS display on the left side of the instrument panel below the CP pedal adjustment lever. Dornier data acquisition system and AATD instrumentation system installed in the cabin | Bleed air N/A. | |

**PURPOSE OF TESTS**: LODS system evaluation

**METHOD OF TESTS**: Data recorded by video, AATD and Dornier data acquisition systems, and on hand held data cards. Straight and level approaches were made toward wires at different speeds, angles and altitudes. Data runs were made to wire set 2 from 80 to 120 knots at angles from 90 to 0 degrees relative. Wire set 2 runs 005 degrees, therefore, inbound headings were 275, 305, 320, 345, and 005 degrees. The aircraft was hovered directly over the wires to set the GPS waypoint (West Bank). The aircraft was then hovered directly in front of the wires at wire level and the altimeter was adjusted to 200 feet. Data runs were started outside of 2 kilometers. The GPS was used to determine the distance in meters from the wires. The pilot called out when he could see the main wires and the small thin wires at the top of the wire set. The engineer called out when he could see the wires in the raw data. The pilot in the left seat called out when the safety line saw the wires and when the warning indicator illuminated. All distances were recorded by the pilot in the left seat on hand held data cards. Runs were made level with the wires (200 feet on the altimeter) and then again 50 feet above the wires (250 feet on altimeter). Data points 1-21 were recorded at wire set 2. Data points 22 – 27 were collected at wire set 3. Wire set 3 runs 095 degrees, therefore, runs were made at 40 knots at headings of 005, 035, 050, 075 and 095 degrees.

**WHAT I DID /SAW/THOUGHT:**

- **Rain Effects:** Rain intensity ranged from light drizzle to light steady rain. The rain caused a noticeable degradation in both the raw data and the safety line output. Wire set 2 was consistently detected in both raw data and by the safety line at an average of 950 to 1000 meters during the morning flight when the ceiling was 2000 feet and the visibility was 7 miles. In the drizzle, detection ranges were reduced to 800 meters and in the light to moderate rain, they were further reduced to 400-500 meters. For the last 6 data points taken at wire set 3, it was not raining, however, the ceiling and visibility were both dropping to about 800-1000 feet and 2-3 miles. It became very difficult to determine if the wires were visible in either the raw data or the safety line output. Detection ranges ranged from 200-500 meters but there is likely more error introduced in the range data due to the noise in both the raw data and the safety line. These data points should be studied carefully to determine if the system actually detected the wires. Tower weather dropped below 1000 foot ceiling, so the flight was terminated.

- **Warning Indicator:** The warning indicator illuminated almost constantly during run ins to the wires and in some cases did not illuminate when the wires were within 200 meters. It was not possible to predict when the warning indicator would illuminate or to determine if the illumination was caused by the wires or by other obstacle around the wires. In many cases, the warning indicator illuminated during the runs 50 feet above the wires. Approach mode did not seem to effect the warning indicator.

**Enclosure 3**

**GENERAL COMMENTS:**

- The LODS safety line appeared to correctly map the obstacles in the flight path, however the system appeared to be highly degraded in drizzle, light rain, and fog.

- Trees in the along the approach path to the wires on sets 2 and 3 appeared to confuse the warning indicator to illuminate almost constantly even when the aircraft was flown above all obstacles

**CONCLUSION / RECOMMENDATIONS:**

- Repeat all data points in clear weather for comparison.

- Adjust the sensitivity of the warning indicator.

- Conduct further testing in reduced visibility conditions and rain/fog.

**DAILY FLIGHT REPORT**

| FLIGHT No. 12 | Laser Obstacle Detector System | Date: 13 Mar 03 |
|---|---|---|

| | | | |
|---|---|---|---|
| Aircraft Model:<br>EH-60L | Serial Number:<br>24468 | Project Number: | Test Location:<br>Felker AAF/ Wire Set 3 |
| Pilot(s): Clark(R)/Starks (L) | Engineer/ Crew :<br><br>Centolanza | Weather Condition at Test Altitude: Surface winds were light and variable at 3-5 knots, no turbulance. OAT +19 / PA – 105. Test altitude @ 150-300 ft MSL. Ceiling and vis: unrestricted. | |
| T/O Gross Weight: 15259 LB | Landing GW: 13659 LB | T/O CG: Long: 362.5 (AFT) LAT: mid<br>Landing CG: | |
| Today's Flight time: 2.0<br>Ground : N/A | Test Pressure Altitude: 0 ft | Prod. Time: 2.0 | |
| Total Flight Time: 18.0<br><br>Total Productive Time: 16.7 | Test Configuration: Hellas Laser installed on the LODS nose mount. LODS display on the left side of the instrument panel below the CP pedal adjustment lever. Dornier data acquisition system and AATD instrumentation system installed in the cabin | Bleed air N/A. | |

**PURPOSE OF TESTS**: LODS system evaluation

**METHOD OF TESTS**: Data recorded by video, AATD and Dornier data acquisition systems, and on hand held data cards. Straight and level approaches were made toward wires at different speeds, angles and altitudes. Data runs were made to wire set 3 from 40 to 120 knots at angles from 90 to 0 degrees relative. Wire set 3 runs 095 degrees, therefore, inbound headings were 005, 035, 050, 075, and 095 degrees. The aircraft was hovered directly over the wires to set the GPS waypoint (3wire). The aircraft was then hovered directly in front of the wires at wire level and the altimeter was adjusted to 200 feet. Data runs were started outside of 2 kilometers. The GPS was used to determine the distance in meters from the wires. The pilot called out "pilot wires" when he could see the small, thin, target wire at the top of the wire set. The engineer called out "raw data" when he could see the wires in the raw data. The pilot in the left seat called out "safety line" when the safety line saw the wires. The timing of wire call outs precluded accurately determining when the warning indicator illuminated. All distances were recorded by the pilot in the left seat on hand held data cards. Runs were made level with the wires (200 feet on the altimeter). Data points 1-25 were recorded.

**WHAT I DID /SAW/THOUGHT:**

- **Background Sky Effects:** The background sky color and intensity greatly effects the range at which the pilot flying detects the wires through the unaided eye. An opaque background lended to an early (long range) detection, while a high intensity light blue (almost grey-white) background resulted in very short range detections. At no time was the pilot able to detect the target wire prior to either raw data determination or safety line stabilization.

- **Computer crash:** Approximately 1.5 hours into flight, the computer crashed with no prior warning of impeding failure. The reboot sequence required approximately 7 minutes to complete. No other failures were noted.

**GENERAL COMMENTS:**

- The LODS safety line appeared to correctly map the obstacles in the flight path.

- Trees in the approach path to the wires appeared to confuse the warning indicator to illuminate almost constantly even when the aircraft was flown above all obstacles.

**CONCLUSION / RECOMMENDATIONS:**

- The visual warning indicator was of little aid to the pilot. It appeared unreliable and simply does not provide enough data to the pilot to take corrective action. Consideration should be given to incorporating an aural tone to alert the pilot of wires, the pilot would then turn his/her attention to the video monitor to detect the wires. A flight path vector would greatly assist the pilot in determining if his/her intended flight path would impact the wires.
- Continue testing with new wire set.

**DAILY FLIGHT REPORT**

FLIGHT No. 12 | Laser Obstacle Detector System | Date: 13 Mar 03

| | | | |
|---|---|---|---|
| Aircraft Model:<br>EH-60L | Serial Number:<br>24468 | Project Number: | Test Location:<br>Felker AAF/ Wire Set 4 |
| Pilot(s): Clark(L)/Rombough (R) | Engineer/ Crew :<br><br>Bordick | Weather Condition at Test Altitude: Surface winds were 180 deg at 10knots, no turbulance. OAT +20 / PA –50. Test altitude @ 150-300 ft MSL. Ceiling and vis: unrestricted. | |
| T/O Gross Weight: 15259 LB | Landing GW: 14259 LB | T/O CG: Long: 362.5 (AFT) LAT: mid<br>Landing CG: | |
| Today's Flight time: 1.2<br>Ground : N/A | Test Pressure Altitude: 0 ft | Prod. Time: .5 | |
| Total Flight Time: 18.0<br><br>Total Productive Time: 16.7 | Test Configuration: Hellas Laser installed on the LODS nose mount. LODS display on the left side of the instrument panel below the CP pedal adjustment lever. Dornier data acquisition system and AATD instrumentation system installed in the cabin | Bleed air N/A. | |

**PURPOSE OF TESTS**: LODS system evaluation

**METHOD OF TESTS**: Data recorded by video, AATD and Dornier data acquisition systems, and on hand held data cards. Straight and level approaches were made toward wires at different speeds, angles and altitudes. Data runs were made to wire set 4 at 40 knots at angles from 90 to 0 degrees relative. Wire set 4 runs 070 degrees, therefore, inbound headings were 340, 010, 025, 050, and 070 degrees. The aircraft was hovered directly over the wires to set the GPS waypoint (4wire). The aircraft was then hovered directly in front of the wires at wire level (75 ft AGL) and the altimeter was adjusted to 100 feet. Data runs were started outside of 2 kilometers. The GPS was used to determine the distance in meters from the wires. The pilot called out "pilot wires" when he could see the small, thin, target wire at the top of the wire set. The engineer called out "raw data" when he could see the wires in the raw data. The pilot in the left seat called out "safety line" when the safety line saw the wires. The timing of wire call outs precluded accurately determining when the warning indicator illuminated. All distances were recorded by the pilot in the left seat on hand held data cards. Runs were made level with the wires. Data points 1-3 were recorded.

**WHAT I DID /SAW/THOUGHT:**

- Attempted data collection, however, the wooded area along the approach path were approximately 120 to 150 ft AGL, which precluded descending to wire altitude until within 300 meters of the target wire (located in a cornfield). The safety line never stabilized on the wire set during the run-in. Raw data and pilot determination both occurred as soon as the aircraft descended to wire altitude at the 300 meter range. Following 3 attempts with similar results, it was decided that the wire set location was not conducive to "good data" and data collection was abandoned. It was interesting to note that even when the aircraft was established in a hover at wire altitude from 300 meters to within 50 meters of the target wire, that the safety line never accurately mapped the wires or poles. The raw data was very difficult to identify due to the cornhusks that became airborne when hovering over the open cornfield in which the wires were located. To verify system operation, the aircraft was flown at wire set 3 with great success.

**GENERAL COMMENTS:**

- The wire set is excellent, in that the diameter is very small and nearly invisible to the unaided eye, however the location does not lend to data collection.

**Enclosure 3**

**CONCLUSION / RECOMMENDATIONS:**

- Abandon testing of wire set 4 and continue testing with new wire set.

**Enclosure 3**

**DAILY FLIGHT REPORT**

FLIGHT No. 15 Laser Obstacle Detector System Date: 18 Mar 03

| | | | |
|---|---|---|---|
| Aircraft Model:<br>EH-60L | Serial Number:<br>24468 | Project Number: | Test Location:<br>Felker AAF/ Wire Set 6 |
| Pilot(s):<br>Trang(R)/Rombough(L) | Engineer/ Crew :<br><br>Bordick | Weather Condition at Test Altitude: Surface winds were 040 degrees at 10 knots, no turbulance. OAT +19°C / PA +200. Test altitude @ 25-100 ft MSL. Ceiling: 12,000 BKN , Visibility Unrestricted. | |
| T/O Gross Weight: 15259 LB | Landing GW: 13968 LB | T/O CG: Long: 362.5 (AFT) LAT: mid<br>Landing CG: | |
| Today's Flight time: 1.4<br>Ground : N/A | Test Pressure Altitude: +200 ft | Prod. Time: 1.3 | |
| Total Flight Time:<br><br>Total Productive Time: | Test Configuration: Hellas Laser installed on the LODS nose mount. LODS display on the left side of the instrument panel below the CP pedal adjustment lever. Dornier data acquisition system and AATD instrumentation system installed in the cabin | Bleed air N/A. | |

**PURPOSE OF TESTS**: LODS system evaluation

**METHOD OF TESTS**: Data recorded by video, AATD and Dornier data acquisition systems, and on hand held data cards. Straight and level approaches were made toward wires at different speeds, angles and altitudes. Data runs were made to wire set 6 from 40 to 120 knots at angles from 90 to 0 degrees relative. Wire set 6 runs 070/250 degrees, therefore, inbound headings were 160, 130, 115, 090, and 070 degrees. The aircraft was hovered directly over the wires to set the GPS waypoint (waypoint saved as W6). The aircraft was then flown directly in front of the wires at wire level and the radar altimeter and barometric altimeter noted. Data runs were started outside of 2 kilometers where obstacles allowed. The GPS was used to determine the distance in kilometers from the wires. The pilot called out when he could see the wires. The engineer called out when he could see the wires in the raw data. The pilot in the left seat called out when the safety line saw the wires or the treeline, and when the warning indicator illuminated. All distances were recorded by the pilot in the left seat on hand held data cards. Runs were made level with the wires.

**WHAT I DID /SAW/THOUGHT:**

- **Raw Data and Safety Line:** Typically, the safety line was the first indication, but it was not outlining the wires, but outlining the treeline on either side or behind the wires. The safety line would appear on one end of the screen and work its way across slowly. Data was recorded when the safety line appeared to reach the center of the screen. Pilot eyesight was normally the next wire detection method. Raw data was the last method to detect the wires. Raw data detected the wire later (closer in) as the approach angle was reduced. Airspeed did not appear to have an effect on detection ranges. At airspeeds of 80 knots and above during the 20 degree offset angle, the pilot was starting to break from the wires for safety purposes just as the raw data was detecting the wires.

- **Warning Indicator:** The warning indicator illuminated anytime a buoy in the water, one of the reserve fleet ships, or the shoreline was nearby, making it impossible to determine actually when (or if) the warning indicator was reporting the wires. A few of the points were over water without any obstacles in the water or shoreline, which allowed for those points to have data entered on the card for the warning indicator. However, suspect the warning indicator was picking up the trees near wire set 6 and not actually the wires.

**GENERAL COMMENTS:**

- Wire set 6 was a difficult set of wires to fly due to the location of the reserve fleet on some approach angles. The 20 degree offset angle had to be flown over the top of several large ships in the reserve fleet, which were within 2 kms away from the wires, and then the aircraft was descended to wire altitude. The 20 degree offset angle from the other side of the wires was not available due to the location of the Commanding General's house and the horse stables.

- The 0 degree offset angle resulted in no raw data, so was not flown for the higher airspeeds.

**CONCLUSION / RECOMMENDATIONS:**

- If further testing is required/desired for wire size such as wire set 6, recommend locating a better set of wires without all the obstacles surrounding the wire set, and away from the airfield for traffic avoidance.

- If possible, adjust the sensitivity of the warning indicator.

## DAILY FLIGHT REPORT

| FLIGHT No. 16 | Laser Obstacle Detector System | Date: 19 Mar 03 |
|---|---|---|

| | | | |
|---|---|---|---|
| Aircraft Model:<br>EH-60L | Serial Number:<br>24468 | Project Number: | Test Location:<br>Felker AAF/ Dead Fleet |
| Pilot(s): Clark (L)/ Wood (R) | Engineer/ Crew :<br><br>Centolanza | Weather Condition at Test Altitude: Surface winds were 050 at 14G25, light to mod turb around ship structure. OAT +10°C / PA 0. Test altitude @ 150 ft MSL. Ceiling: Few 020, SCT 120, Visibility Unrestricted. | |
| T/O Gross Weight: 15059 LB | Landing GW: 14168 LB | T/O CG: Long: 362.5 (AFT) LAT: mid<br>Landing CG: | |
| Today's Flight time: 1.7<br>Ground : N/A | Test Pressure Altitude: +150 ft | Prod. Time: 1.6 | |
| Total Flight Time:<br><br>Total Productive Time: | Test Configuration: Hellas Laser installed on the LODS nose mount. LODS display on the left side of the instrument panel below the CP pedal adjustment lever. Dornier data acquisition system and AATD instrumentation system installed in the cabin | Bleed air N/A. | |

**PURPOSE OF TESTS**: LODS system evaluation

**METHOD OF TESTS**: Data recorded by video, AATD and Dornier data acquisition systems, and on hand held data cards. The flight profile consisted of maintaining constant altitude (100 ft above ship deck or 150 ft above water) and airspeed (10-12 knots) until intercepting a 10-12 deg approach angle (150 meters from stern). The ship landing deck was oriented 360/180 degrees, inbound headings were 0, 15, 30, 45, 60, 75, 90, 135, and 180 degrees. The aircraft was hovered directly over the stern of the ship to set the GPS waypoint (waypoint saved as BOAT). The aircraft was then flown directly in front of the stern and the radar altimeter and barometric altimeter noted. Data runs were started outside of 1 kilometer. The GPS was used to determine the distance in kilometers from the stern. Required data was range for visual and aural warning indicator, which was taken by the co-pilot (left seat). Although not required for the test, general comments were made on the safety line performance. Additionally, the system operator recorded qualitative data on 3D mapping of the ship structure.

**WHAT I DID /SAW/THOUGHT:**

- **Warning Indicator:** The visual warning indicator only illuminated during three of thirteen events, with a max range of 120 meters from the ship stern. The aural indicator tone only occurred during one of thirteen events, at a range of 40meters from the ship stern. It was interesting that the aural and visual warning indicators did not occur simultaneously.
- To address possible altitude effects on system performance, the aircraft altitude was adjusted to coincide with ship deck height to ensure a collision course with the ship which still resulted in no visual or aural warning indicator up to 60 meters from impact at which time the event was abandoned.
-
- **Raw Data and Safety Line:** The operator in the cabin qualitatively observed that the system properly modeled the ship structure. The safety line appeared to accurately outline the ship structure to include communication tower from 800 meters to within 60 meters of the ship stern. During one event, it was noted that the safety line experienced a transient spike that exceeded the vertical scale of the monitor. No raw data was present to substantiate an obstacle.

**GENERAL COMMENTS:**

- The ship provided an excellent target.
- The approach speed of 10-12 knots was difficult to maintain due to the pitot static system being unreliable below 40 KIAS. Such a closure rate does not seem mission representative for shipboard operations.
- Due to strong crosswinds, the aircraft was flown intentionally in a slip to ensure that the ship structure was within the laser detector's field of view. This maneuver was not mission representative of flying the aircraft "in trim" during an approach.

**CONCLUSION / RECOMMENDATIONS:**

- Gain concurrence from NAVAIR on approach speed and closure rates.
- Configure visual and aural warning indicators to actuate simultaneously.
- Incorporate a laser turret/gimbal with a suitable field of regard that would continuously adjust the laser's field of view based on the aircraft's flight path vector.  This would allow obstacle detection while "crabbing" the aircraft into the wind.

| Lods Flight # | Pilots | Date | Time | Temp | PA | | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 5 | Wood(R)/Wolons(L) | 4-Mar-03 | 1120 | 11 | -240 | | Clear, Wind 110/7 Knots |

Sun at 80 degrees above the nose

Location: Wire Set 1, James River Bridge      Wires Run 235 degrees

| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye Main Wires | Guide Wires | Wire Detection Range (km) Raw Data | Safety Ln | WI | HDG | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Set 1 | 1 | 40 | 90 | 0 | Normal | >1 | | | | | 145 | Practice Run |
| Set 1 | 2 | 40 | 90 | 0 | Normal | >1 | | 1 | 1 | 0.3 | 145 | |
| Set 1 | 3 | 40 | 60 | 0 | Normal | >1 | | 1.02 | 560 | 0.3 | 175 | |
| Set 1 | 4 | 40 | 45 | 0 | Normal | >1 | | 1 | 720 | 0.43 | 190 | WI indicated Obstacles Right |
| Set 1 | 5 | 40 | 20 | 0 | Normal | >1 | - | - | - | - | 215 | No Safety Line or Raw Data Straight Ahead |
| Set 1 | 6 | 40 | 0 | 50 | Normal | >1 | - | - | - | | 235 | Safety Line Followed Along Wires Accurately |
| Set 1 | 7 | 40 | 90 | 50 | Normal | >1 | 0.73 | 0.93 | 0.73 | - | 145 | |
| Set 1 | 8 | 40 | 60 | 50 | Normal | >1 | 0.55 | 0.98 | 0.85 | - | 185 | |
| Set 1 | 9 | 40 | 45 | 50 | Normal | >1 | 0.9 | 0.98 | 0.8 | - | 190 | |
| Set 1 | 10 | 40 | 20 | 50 | Normal | >1 | 0.93 | 0.8 | 0.68 | - | 215 | WI to right as aircraft banked right over water |
| Set 1 | 11 | 40 | 90 | 0 | Apch | >1 | 1.1 | 0.9 | 0.9 | 0.21 | 145 | |
| Set 1 | 12 | 60 | 90 | 0 | Normal | >1 | 1.1 | 0.97 | 0.92 | 0.42 | 145 | |

**Enclosure 4**

| | | | | | | Pilot Eye | | Wire Detection Range (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Main Wires | Guide Wires | Raw Data | Safety Ln | WI | HDG | Notes |
| Set 1 | 13 | 60 | 60 | 0 | Normal | >1 | 0.7 | 0.96 | 0.96 | 0.5 | 185 | |
| Set 1 | 14 | 60 | 45 | 0 | Normal | >1 | 0.77 | 0.61 | 0.61 | 0.37 | 190 | |
| Set 1 | 15 | 60 | 20 | 0 | Normal | >1 | 0.89 | - | - | - | 215 | |
| Set 1 | 16 | 60 | 0 | 50 | Normal | >1 | | | | | | 50 KNOTS |
| Set 1 | 17 | 60 | 90 | 50 | Normal | >1 | 0.7 | 0.9 | 0.9 | - | 145 | |
| Set 1 | 18 | 60 | 60 | 50 | Normal | >1 | 0.9 | 0.85 | 0.85 | - | 175 | |
| Set 1 | 19 | 60 | 45 | 50 | Normal | >1 | 0.75 | 0.9 | 0.85 | | 190 | 200 DEGREES ACTUAL |
| Set 1 | 20 | 60 | 20 | 50 | Normal | >1 | 0.75 | 1 | - | - | 215 | Safety Line only picked up wires in the left 1/3 of the display |
| Set 1 | 21 | 60 | 90 | 0 | Apch | >1 | 1.06 | 0.9 | 0.9 | 300 | 145 | |

**Enclosure 4**

| Lods Flight # | Pilots | Date | Time | Temp | PA | | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 6 | Wolons(R)/Starks(L) | 4-Mar-03 | 1520 | 12 | -240 | | Clear, Wind 110/7 Knots |

Sun at 30 degrees on the horizon at the tail

Location: Wire Set 1, James River Bridge　　Wires Run 235 degrees

| | | | | | | Pilot Eye | | Wire Detection Range (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Main Wires | Guide Wires | Raw Data | Safety Ln | WI | HDG | Notes |
| Set 1 | 1 | 80 | 90 | 0 | Normal | >1 | X | 1 | 1 | 0.56 | 145 | X denotes could not see |
| Set 1 | 2 | 80 | 60 | 0 | Normal | >1 | X | 1.06 | 1.06 | 0.49 | 175 | |
| Set 1 | 3 | 80 | 45 | 0 | Normal | >1 | X | 1.07 | 1.07 | 0.63 | 190 | |
| Set 1 | 4 | 80 | 20 | 0 | Normal | >1 | 0.49 | 0.67 | 1.27 | 0.49 | 215 | |
| Set 1 | 5 | 80 | 0 | 50 | Normal | >1 | - | - | - | - | 235 | |
| Set 1 | 6 | 80 | 90 | 50 | Normal | >1 | X | 0.95 | 0.98 | - | 145 | |
| Set 1 | 7 | 80 | 60 | 50 | Normal | >1 | X | 0.99 | 0.99 | - | 175 | |
| Set 1 | 8 | 80 | 45 | 50 | Normal | >1 | X | 1.02 | 1.03 | - | 190 | |
| Set 1 | 9 | 80 | 20 | 50 | Normal | >1 | 0.25 | 0.7 | 1.28 | - | 215 | |
| Set 1 | 10 | 80 | 90 | 0 | Apch | >1 | X | 1 | 1 | 0.5 | 145 | |
| Set 1 | 11 | 100 | 90 | 0 | Normal | >1 | X | 0.99 | 0.95 | 0.61 | 145 | |
| Set 1 | 12 | 100 | 60 | 0 | Normal | >1 | X | 1.02 | 1.02 | 0.68 | 175 | Consistantly Right WI with wires to the left |

**Enclosure 4**

| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye Main Wires | Guide Wires | Wire Detection Range (km) Raw Data | Safety Ln | WI | HDG | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Set 1 | 13 | 100 | 45 | 0 | Normal | >1 | X | 1.09 | 1.09 | 0.6 | 190 | |
| Set 1 | 14 | 100 | 20 | 0 | Normal | >1 | X | 0.8 | 0.8 | 0.42 | 215 | |
| Set 1 | 15 | 100 | 0 | 50 | Normal | >1 | X | | | | | |
| Set 1 | 16 | 100 | 90 | 50 | Normal | >1 | X | 0.98 | 0.98 | - | 145 | |
| Set 1 | 17 | 100 | 60 | 50 | Normal | >1 | X | 0.99 | 0.99 | - | 175 | |
| Set 1 | 18 | 100 | 45 | 50 | Normal | >1 | X | 1.02 | 1.02 | - | 190 | |
| Set 1 | 19 | 100 | 20 | 50 | Normal | >1 | X | 0.74 | 0.74 | - | 215 | |
| Set 1 | 20 | 100 | 90 | 0 | Apch | >1 | 0.45 | 0.99 | 0.99 | 0.48 | 145 | |
| Set 1 | 21 | 120 | 90 | 0 | Normal | >1 | X | 0.92 | 0.92 | 0.81 | 145 | |
| Set 1 | 22 | 120 | 60 | 0 | Normal | >1 | X | 1.01 | 1.01 | 0.77 | 175 | |
| Set 1 | 23 | 120 | 45 | 0 | Normal | >1 | X | 0.9 | 0.9 | 0.67 | 190 | |
| Set 1 | 24 | 120 | 20 | 0 | Normal | >1 | X | 0.79 | 0.79 | 0.62 | 215 | |
| Set 1 | 25 | 120 | 0 | 50 | Normal | >1 | | | | | 235 | Wire Heading |
| Set 1 | 26 | 120 | 90 | 50 | Normal | >1 | X | 0.93 | 0.93 | - | 145 | |
| Set 1 | 27 | 120 | 60 | 50 | Normal | >1 | X | 1.01 | 1.01 | - | 175 | |
| Set 1 | 28 | 120 | 45 | 50 | Normal | >1 | X | 0.97 | 0.97 | - | 190 | |
| Set 1 | 29 | 120 | 20 | 50 | Normal | >1 | X | 0.82 | 0.82 | - | 215 | |
| Set 1 | 30 | 120 | 90 | 0 | Apch | >1 | X | 0.96 | 0.96 | 0.6 | 145 | |

| Lods Flight # | Pilots | Date | Time | Temp | PA | | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 7 | Johnston(R)/Starks(L | 5-Mar-03 | 1300 | 15 | 178 | | Clear, Wind 260/9 to 22 Knots |

Location: Wire Set 1, James River Bridge      Wires Run 235 degrees

| | | | | | | | | Wire Detection Range (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Distance | Guide Wires | Raw Data | Safety Ln | WI | HDG | Notes |
| Set 1 | 1 | 0 | 90 | 0 | Normal | 1000 | X | | | | | Lost wire ~950 to 980<br>Hold event for 5 Sec |
| Set 1 | 2 | 0 | 90 | 0 | Normal | 900 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 3 | 0 | 90 | 0 | Normal | 800 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 4 | 0 | 90 | 0 | Normal | 700 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 5 | 0 | 90 | 0 | Normal | 600 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 6 | 0 | 90 | 0 | Normal | 500 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 7 | 0 | 90 | 0 | Normal | 400 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 8 | 0 | 90 | 0 | Normal | 300 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 9 | 0 | 90 | 0 | Normal | 200 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 10 | 0 | 60 | 0 | Normal | 1000 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 11 | 0 | 60 | 0 | Normal | 900 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 12 | 0 | 60 | 0 | Normal | 800 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 13 | 0 | 60 | 0 | Normal | 700 | X | X | X | | | Hold event for 5 Sec |

**Enclosure 4**

| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Distance | Wire Detection Range (km) Guide Wires | Raw Data | Safety Ln | WI | HDG | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Set 1 | 14 | 0 | 60 | 0 | Normal | 600 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 15 | 0 | 60 | 0 | Normal | 500 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 16 | 0 | 60 | 0 | Normal | 400 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 17 | 0 | 60 | 0 | Normal | 300 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 18 | 0 | 60 | 0 | Normal | 200 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 19 | 0 | 45 | 0 | Normal | 1000 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 20 | 0 | 45 | 0 | Normal | 900 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 21 | 0 | 45 | 0 | Normal | 800 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 22 | 0 | 45 | 0 | Normal | 700 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 23 | 0 | 45 | 0 | Normal | 600 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 24 | 0 | 45 | 0 | Normal | 500 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 25 | 0 | 45 | 0 | Normal | 400 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 26 | 0 | 45 | 0 | Normal | 300 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 27 | 0 | 45 | 0 | Normal | 200 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 28 | 0 | 20 | 0 | Normal | 1000 | | X | X | | | Guide wire blends into terrain Hold event for 5 Sec |
| Set 1 | 29 | 0 | 20 | 0 | Normal | 900 | | X | X | | | Guide wire blends into terrain Hold event for 5 Sec |
| Set 1 | 30 | 0 | 20 | 0 | Normal | 800 | | X | X | | | Guide wire blends into terrain Hold event for 5 Sec |
| Set 1 | 31 | 0 | 20 | 0 | Normal | 700 | | X | X | | | Guide wire blends into terrain Hold event for 5 Sec |

**Enclosure 4**

| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Distance | Guide Wires | Wire Detection Range (km) Raw Data | Safety Ln | WI | HDG | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Set 1 | 32 | 0 | 20 | 0 | Normal | 600 | | X | X | | | Guide wire blends into terrain Hold event for 5 Sec |
| Set 1 | 33 | 0 | 20 | 0 | Normal | 500 | | X | X | | | Guide wire blends into terrain Hold event for 5 Sec |
| Set 1 | 34 | 0 | 20 | 0 | Normal | 400 | | X | X | | | Guide wire blends into terrain Hold event for 5 Sec |
| Set 1 | 35 | 0 | 20 | 0 | Normal | 300 | | X | X | | | Guide wire blends into terrain Hold event for 5 Sec |
| Set 1 | 36 | 0 | 20 | 0 | Normal | 200 | | X | X | | | Guide wire blends into terrain Hold event for 5 Sec |

Notes:

Caution light on data acquisition system on continuously.

Computer crashed

| Lods Flight # | Pilots | Date | Time | Temp | PA | | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 8 | Wolons(L)/Starks(R) | 7-Mar-03 | 948 | 1 | -290 | | BKN 020, OVC 025 No Turb |
| | | | | | | | Wind 010@10G15 |

Location: Wire Set 2, West Bank    Wires Run 005 degrees

| | | | | | | Pilot Eye | | Wire Detection Range (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Main Wires | Guide Wires | Raw Data | Safety Ln | WI | HDG | Notes |
| Set 2 | 1 | 40 | 90 | 0 | Normal | >1 | 0.4 | 1 | 1 | C | 275 | C denotes constant illumination of WI |
| Set 2 | 2 | 40 | 60 | 0 | Normal | >1 | 0.7 | 1.01 | 1.01 | C | 305 | |
| Set 2 | 3 | 40 | 45 | 0 | Normal | >1 | 0.7 | 1.02 | 1.02 | C | 320 | |
| Set 2 | 4 | 40 | 20 | 0 | Normal | >1 | 0.6 | 0.93 | 0.93 | C | 345 | |
| Set 2 | 5 | 40 | 0 | 50 | Normal | - | - | - | - | - | 005 | |
| Set 2 | 6 | 40 | 90 | 50 | Normal | >1 | 0.67 | 0.95 | 0.95 | 0.3 | 275 | |
| Set 2 | 7 | 40 | 60 | 50 | Normal | >1 | 0.7 | 0.98 | 0.98 | 0.3 | 300 | |
| Set 2 | 8 | 40 | 45 | 50 | Normal | >1 | 0.75 | 0.98 | 0.98 | X | 315 | X denotes did not illuminate |
| Set 2 | 9 | 40 | 20 | 50 | Normal | >1 | 0.75 | 0.97 | 0.87 | X | 345 | |
| Set 2 | 10 | 40 | 90 | 0 | Apch | >1 | 0.6 | 0.97 | 0.97 | 0.29 | 275 | |
| Set 2 | 11 | 60 | 90 | 0 | Normal | >1 | 0.8 | 0.97 | 0.97 | C | 275 | |
| Set 2 | 12 | 60 | 60 | 0 | Normal | >1 | X | 0.99 | 0.99 | 0.53 | 305 | |

| | | | | | | Pilot Eye | Wire Detection Range (km) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Main Wires | Guide Wires | Raw Data | Safety Ln | WI | HDG | Notes |
| Set 2 | 13 | 60 | 45 | 0 | Normal | >1 | 0.79 | 0.95 | 0.95 | 0.5 | 320 | |
| Set 2 | 14 | 60 | 20 | 0 | Normal | >1 | 0.7 | 1.1 | 0.87 | 0.57 | 345 | |
| Set 2 | 15 | 60 | 0 | 50 | Normal | >1 | | | | | 005 | |
| Set 2 | 16 | 60 | 90 | 50 | Normal | >1 | 0.5 | 0.96 | 0.96 | C | 275 | |
| Set 2 | 17 | 60 | 60 | 50 | Normal | >1 | | 1 | 1 | C | 305 | |
| Set 2 | 18 | 60 | 45 | 50 | Normal | >1 | 0.7 | 0.96 | 0.96 | C | 320 | |
| Set 2 | 19 | 60 | 20 | 50 | Normal | >1 | 0.8 | 0.96 | 0.85 | C | 345 | |
| Set 2 | 20 | 60 | 90 | 0 | Apch | >1 | 0.7 | 0.95 | 0.95 | C | 275 | WI stopped illuminating at 500 meters |
| Set 2 | 21 | 80 | 90 | 0 | Normal | >1 | 0.57 | 0.95 | 0.95 | C | 275 | |
| Set 2 | 22 | 80 | 60 | 0 | Normal | >1 | X | 0.96 | 0.96 | X | 310 | |
| Set 2 | 23 | 80 | 45 | 0 | Normal | >1 | X | 0.93 | 0.93 | 0.59 | 320 | |
| Set 2 | 24 | 80 | 20 | 0 | Normal | >1 | X | 1.06 | 0.82 | C | 345 | |
| Set 2 | 25 | 80 | 0 | 50 | Normal | >1 | X | - | - | - | 005 | |
| Set 2 | 26 | 80 | 90 | 50 | Normal | >1 | 0.55 | 0.95 | 0.95 | 0.55 | 275 | |
| Set 2 | 27 | 80 | 60 | 50 | Normal | >1 | 0.7 | 1.02 | 1.02 | 0.55 | 305 | |
| Set 2 | 28 | 80 | 45 | 50 | Normal | >1 | 0.69 | 0.93 | 0.93 | C | 320 | |
| Set 2 | 29 | 80 | 20 | 50 | Normal | >1 | 0.75 | 0.87 | 0.87 | C | 345 | |
| Set 2 | 30 | 80 | 90 | 0 | Apch | >1 | X | 1.01 | 1.01 | 0.43 | 275 | |

**Enclosure 4**

| Lods Flight # | Pilots | Date | Time | Temp | PA | | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 9 | Wolons(L)/Clark(R) | 7-Mar-03 | 1307 | 7 | -290 | | OVC 010, Visibility 2-3 Miles |

Wind 010 at 7 knots

Rain varied from drizzle to light rain

Location: Wire Set 2, West Bank

Visibility and ceiling worsened as the flight progressed

Wires Run 005 degrees

to a minimum of 800 feet OVC and 2 Miles visibility

| | | | | | | Pilot Eye | | Wire Detection Range (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Main Wires | Guide Wires | Raw Data | Safety Ln | WI | HDG | Notes |
| Set 2 | 1 | 100 | 90 | 0 | Normal | >1 | X | 1 | 1 | C | 275 | Light Rain Just beginning |
| Set 2 | 2 | 100 | 60 | 0 | Normal | >1 | 0.49 | 0.78 | 0.78 | C | 305 | |
| Set 2 | 3 | 100 | 45 | 0 | Normal | >1 | 0.71 | 0.86 | 0.86 | C | 320 | |
| Set 2 | 4 | 100 | 20 | 0 | Normal | >1 | 0.7 | 0.82 | 0.82 | C | 345 | |
| Set 2 | 5 | 100 | 0 | 50 | Normal | - | - | - | - | - | 005 | |
| Set 2 | 6 | 100 | 90 | 50 | Normal | >1 | 0.4 | 0.9 | 0.78 | - | 275 | |
| Set 2 | 7 | 100 | 60 | 50 | Normal | >1 | 0.6 | 0.81 | 0.81 | C | 300 | |
| Set 2 | 8 | 100 | 45 | 50 | Normal | >1 | 0.52 | 0.83 | 0.83 | C | 315 | |
| Set 2 | 9 | 100 | 20 | 50 | Normal | >1 | 0.48 | 0.83 | 0.84 | C | 345 | Rain slowed to light drizzle |
| Set 2 | 10 | 100 | 90 | 0 | Apch | >1 | 0.54 | 0.8 | 0.8 | C | 275 | |
| Set 2 | 11 | 120 | 90 | 0 | Normal | >1 | 0.8 | 0.8 | 0.8 | C | 275 | |

**Enclosure 4**

| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye Main Wires | Guide Wires | Wire Detection Range (km) Raw Data | Safety Ln | WI | HDG | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Set 2 | 12 | 120 | 60 | 0 | Normal | >1 | X | 0.75 | 0.75 | C | 305 | Rain increased to Moderate Level |
| Set 2 | 13 | 120 | 45 | 0 | Normal | >1 | 0.7 | 0.51 | 0.51 | C | 320 | |
| Set 2 | 15 | 120 | 20 | 0 | Normal | >1 | 0.6 | 0.53 | 0.53 | C | 345 | Inadvertantly skipped point 14 on the system |
| Set 2 | 16 | 120 | 0 | 50 | Normal | >1 | - | - | - | | 005 | |
| Set 2 | 17 | 120 | 90 | 50 | Normal | >1 | 0.4 | 0.9 | 0.6 | C | 275 | |
| Set 2 | 18 | 120 | 60 | 50 | Normal | >1 | 0.3 | 0.43 | 0.43 | C | 305 | |
| Set 2 | 19 | 120 | 45 | 50 | Normal | >1 | X | 0.5 | 0.6 | X | 320 | |
| Set 2 | 20 | 120 | 20 | 50 | Normal | >1 | 0.5 | 0.5 | 0.5 | X | 345 | |
| Set 2 | 21 | 120 | 90 | 0 | Apch | >1 | 0.4 | 0.45 | 0.45 | C | 275 | |
| Set 3 | 22 | 40 | 90 | 0 | Normal | >1 | 0.3 | 0.5 | 0.3 | C | 005 | Light Drizzle/Fog Visibility Dropping 2-3 Miles |
| Set 3 | 23 | 40 | 60 | 0 | Normal | >1 | 0.59 | 0.2 | ..2 | C | 035 | Can see towers above the safety line in the video |
| Set 3 | 24 | 40 | 45 | 0 | Normal | 1 | 0.7 | 0.2 | 0.2 | C | 050 | Can see towers above the safety line in the video |
| Set 3 | 25 | 40 | 20 | 0 | Normal | 1- | 0.9 | 0.43 | 0.43 | C | 065 | |
| Set 3 | 26 | 40 | 0 | 50 | Normal | - | - | - | - | - | 095 | |
| Set 3 | 27 | 40 | 90 | 50 | Normal | 1- | 0.2 | 0.3 | 0.3 | C | 005 | |

**Enclosure 4**

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 10 | Capobianco/Starks | 3/12/2003 | 1011 | | | |

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 2 | 1 | 100 | 90 | 0 | Normal | 0.79 | 0.98 | 0.98 | on | |
| Set 2 | 2 | 100 | 60 | 0 | Normal | 0.62 | 0.98 | 0.97 | on | |
| Set 2 | 3 | 100 | 45 | 0 | Normal | 0.54 | 0.99 | 1 | on | |
| Set 2 | 4 | 100 | 20 | 0 | Normal | 0.75 | 1.09 | 1.09 | on | |
| Set 2 | 5 | 100 | 0 | 50 | Normal | - | - | - | - | |
| Set 2 | 6 | 100 | 90 | 50 | Normal | 0.57 | 0.89 | 0.89 | - | |
| Set 2 | 7 | 100 | 60 | 50 | Normal | 0.68 | 1.02 | 1.02 | - | |
| Set 2 | 8 | 100 | 45 | 50 | Normal | 0.72 | 1.03 | 1.03 | - | |
| Set 2 | 9 | 100 | 20 | 50 | Normal | 0.57 | 0.9 | 0.9 | - | |
| Set 2 | 10 | 100 | 90 | 0 | Apch | 0.54 | 0.9 | 0.9 | - | |
| Set 2 | 11 | 120 | 90 | 0 | Normal | 0.67 | 0.91 | 0.91 | | |
| Set 2 | 12 | 120 | 60 | 0 | Normal | 0.67 | 1.1 | 1.1 | | |
| Set 2 | 13 | 120 | 45 | 0 | Normal | 0.5 | 1.19 | 1.15 | | |
| Set 2 | 14 | 120 | 20 | 0 | Normal | 0.3 | 0.3 | 0.9 | | |
| Set 2 | 15 | 120 | 0 | 50 | Normal | - | - | - | | |

**Enclosure 4**

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 2 | 16 | 120 | 90 | 50 | Normal | 0.72 | 0.99 | 0.99 | - | |
| Set 2 | 17 | 120 | 60 | 50 | Normal | 0.58 | 0.91 | 0.91 | - | |
| Set 2 | 18 | 120 | 45 | 50 | Normal | 0.74 | 0.98 | 0.98 | - | |
| Set 2 | 19 | 120 | 20 | 50 | Normal | 0.65 | 0.48 | 0.5 | - | |
| Set 2 | 20 | 120 | 90 | 0 | Apch | 0.68 | 0.91 | 0.91 | - | |

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 12 | Clark/Starks | 13-Mar | 1030 | 19 | -105 | Unrestricted, Light wind, No Turb |

| | | | | | | Wire Detection | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 3 | 1 | 40 | 90 | 0 | Normal | 0.56 | 0.81 | 0.81 | Not noted | |
| Set 3 | 2 | 40 | 60 | 0 | Normal | 0.86 | 0.89 | 0.89 | | |
| Set 3 | 3 | 40 | 45 | 0 | Normal | 0.7 | 0.86 | 0.88 | | |
| Set 3 | 4 | 40 | 20 | 0 | Normal | 0.47 | 0.83 | 0.83 | | |
| Set 3 | 5 | 40 | 0 | 50 | Normal | | | | | **Flying along wires** |
| Set 3 | 6 | 60 | 90 | 0 | Normal | 0.4 | 0.91 | 0.91 | | |
| Set 3 | 7 | 60 | 60 | 0 | Normal | 0.8 | 0.99 | 0.99 | | |
| Set 3 | 8 | 60 | 45 | 0 | Normal | 0.8 | 0.81 | 0.81 | | |
| Set 3 | 9 | 60 | 20 | 0 | Normal | 0.26 | 0.62 | 0.62 | | |
| Set 3 | 10 | 60 | 0 | 50 | Normal | | | | | Flying along wires |
| Set 3 | 11 | 80 | 90 | 0 | Normal | 0.73 | 0.99 | 0.99 | | |
| Set 3 | 12 | 80 | 60 | 0 | Normal | 0.61 | 0.94 | 0.94 | | |
| Set 3 | 13 | 80 | 45 | 0 | Normal | 0.47 | 0.79 | 0.79 | | |
| Set 3 | 14 | 80 | 20 | 0 | Normal | 0.26 | 0.52 | 0.52 | | |
| Set 3 | 15 | 80 | 0 | 50 | Normal | | | | | Flying along wires. Also, computer crashed 1.5 hours into |

**Enclosure 4**

| | | | | | | Wire Detection | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 3 | 16 | 100 | 90 | 0 | Normal | 0.96 | 0.96 | 0.96 | | |
| Set 3 | 17 | 100 | 60 | 0 | Normal | 0.73 | 0.97 | 0.97 | | |
| Set 3 | 18 | 100 | 45 | 0 | Normal | 0.39 | 0.68 | 0.68 | | |
| Set 3 | 19 | 100 | 20 | 0 | Normal | 0.23 | 0.4 | 0.74 | | |
| Set 3 | 20 | 100 | 0 | 50 | Normal | | | | | Flying along wires |
| Set 3 | 21 | 120 | 90 | 0 | Normal | 0.71 | 0.93 | 0.93 | | |
| Set 3 | 22 | 120 | 60 | 0 | Normal | 0.95 | 0.95 | 0.95 | | |
| Set 3 | 23 | 120 | 45 | 0 | Normal | 0.68 | 0.76 | 0.77 | | |
| Set 3 | 24 | 120 | 20 | 0 | Normal | 0.3 | 0.5 | 0.58 | | |
| Set 3 | 25 | 120 | 0 | 50 | Normal | | | | | Flying along wires |
| | | | | | | | | | | |

**Enclosure 4**

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 13 | Clark/Rombough | 13-Mar | 1330 | 20 | -50 | Unrestricted, light southern winds, no turb |

| | | | | | | Wire Detection | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 4 | 1 | 40 | 90 | 0 | Normal | 0.3 | 0.15 | 0.66 | Not noted | Flight path obstacles prevented aircraft from maintaining desired altitude until within 300 meters of wires. |
| Set 4 | 2 | 40 | 60 | 0 | Normal | 0.27 | 0.27 | Never stabilized | | |
| Set 4 | 3 | 40 | 45 | 0 | Normal | 0.28 | 0.32 | | | |
| Set 4 | 4 | 40 | 20 | 0 | Normal | Discontinued test due to decision that wire set was not conducive to gaining good test data. | | | | |
| Set 4 | 5 | 40 | 0 | 50 | Normal | | | | | |

**Enclosure 4**

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 15 | Trang/Rombough | 3/18/2003 | 1355 | 18C | 200 | 05 Few 30 SCT 120 BKN |

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 6 | 1 | 40 | 90 | 0 | Normal | 1.01 | 0.43 | 0.9 | | Recorder on 1405 |
| Set 6 | 2 | 40 | 60 | 0 | Normal | 1.1 | 0.41 | 1.1 | | |
| Set 6 | 3 | 40 | 45 | 0 | Normal | 1 | 0.37 | 1.05 | | |
| Set 6 | 4 | 40 | 20 | 0 | Normal | 0.86 | 0.17 | 1.05 | | |
| Set 6 | 5 | 40 | 0 | 50 | Normal | 0.3 | - | 0.07 | | |
| Set 6 | 6 | 60 | 90 | 0 | Normal | 1 | 0.45 | 1.07 | 0.55 | |
| Set 6 | 7 | 60 | 60 | 0 | Normal | 0.85 | 0.37 | 1 | 0.55 | |
| Set 6 | 8 | 60 | 45 | 0 | Normal | 0.9 | 0.35 | 1 | 0.51 | |
| Set 6 | 9 | 60 | 20 | 0 | Normal | 0.65 | 0.2 | 0.9 | 0.5 | |
| Set 6 | 10 | 60 | 0 | 50 | Normal | 0.32 | - | 1.1 | | |
| Set 6 | 11 | 80 | 90 | 0 | Normal | 0.9 | 0.44 | 1 | 0.6 | |
| Set 6 | 12 | 80 | 60 | 0 | Normal | 1.14 | 0.4 | 1 | 0.6 | |
| Set 6 | 13 | 80 | 45 | 0 | Normal | 0.9 | 0.34 | 0.98 | 0.63 | |
| Set 6 | 14 | 80 | 20 | 0 | Normal | 0.4 | 0.2 | 1 | | |
| Set 6 | 15 | 100 | 90 | 0 | Normal | 0.8 | 0.45 | 1 | 0.7 | |

**Enclosure 4**

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 6 | 16 | 100 | 60 | 0 | Normal | 0.75 | 0.37 | 0.97 | 0.7 | |
| Set 6 | 17 | 100 | 45 | 0 | Normal | 0.73 | 0.37 | 0.9 | | |
| Set 6 | 18 | 100 | 20 | 0 | Normal | 0.5 | 0.16 | 0.9 | | |
| Set 6 | 19 | 120 | 90 | 0 | Normal | 1.1 | 0.41 | 1 | | |
| Set 6 | 20 | 120 | 60 | 0 | Normal | 0.85 | 0.39 | 0.9 | | |
| Set 6 | 21 | 120 | 45 | 0 | Normal | 1 | 0.31 | 0.95 | | |
| Set 6 | 22 | 120 | 20 | 0 | Normal | 0.6 | 0.17 | 0.9 | | |

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 16 | Wood/Clark | 19-Mar | 1000 | 10 | -150 | Few 020, SCT 120, OVC 200, Lt to Mod Turb SFC - 080, Wind 050 14G25 |

| Test Location | Event # | A/S | Angle | Rel Alt | Glide Slope | Switch | Min Range | WI Range | Notes |
|---|---|---|---|---|---|---|---|---|---|
| Ship #1 | 1 | 10-15 | 0 | 100 | 10-12 | Normal | 800 | 120m | Visual WI correctly lit up the center and right arrow indicators representative of ship |
| Ship #1 | 2 | 10-15 | 15 | 100 | 10-12 | Normal | 800 | No ind | No aural or visual warning indicator |
| Ship #1 | 3 | 10-15 | 30 | 100 | 10-12 | Normal | 800 | No ind | No aural or visual warning indicator |
| Ship #1 | 4 | 10-15 | 45 | 100 | 10-12 | Normal | 800 | 100 | No aural indicator |
| Ship #1 | 5 | 10-15 | 60 | 100 | 10-12 | Normal | 800 | 85 | No aural indicator; mod turb experienced within 300m of ship |
| Ship #1 | 6 | 10-15 | 75 | 100 | 10-12 | Normal | 800 | No ind | No aural or visual warning indicator |
| Ship #1 | 7 | 10-15 | 90 | 100 | 10-12 | Normal | 800 | No ind | No aural or visual warning indicator |
| Ship #1 | 8 | 10-15 | 135 | 100 | 10-12 | Normal | 800 | No ind | No aural or visual warning indicator |
| Ship #1 | 9 | 10-15 | 180 | 100 | 10-12 | Normal | 800 | No ind | No aural or visual warning indicator |
| Ship #1 | 10 | 10-15 | 0 | 100 | 10-12 | Appr | 800 | No ind | No aural or visual warning indicator |
| Ship #1 | 11 | 10-15 | 15 | 100 | 10-12 | Appr | 800 | No ind | No aural or visual warning indicator |
| Ship #1 | 12 | 10-15 | 30 | 100 | 10-12 | Appr | 800 | No ind | No aural or visual warning indicator |
| Ship #1 | 13 | 10-15 | 45 | 100 | 10-12 | Appr | 800 | No ind | No aural or visual warning indicator |
| Ship #1 | 14 | 10-15 | 60 | 100 | 10-12 | Appr | 800 | | Discontinued testing. Appr mode resembled normal mode. Event 14 was used to map |

**Enclosure 4**

| Lods Flight # | Pilots | Date | Time | Temp | | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 17 | Rombough/Clark | 3/28/2003 | 1007 | +16 | | -200 | 12 BKN 250 OVC light Turb SFC-60, Wind N @5 |

| Test Location | Event # | A/S | Angle | Rel Alt | Glide Slope | | Switch | Min Range | WI Range | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| Ship #1 | 1 | 60 initial 10-15 final | 0 | 100 | 10-12 | 140m | Normal | 800 | <.1 | no tone |
| Ship #1 | 2 | 60 initial 10-15 final | 45 | 100 | 10-12 | 140m | Normal | 800 | none | no tone |
| Ship #1 | 3 | 60 initial 10-15 final | 90 | 100 | 10-12 | 140m | Normal | 800 | none | no tone |
| Ship #1 | 4 | 60 initial 10-15 final | 0 | 100 | 8 | 220m | Normal | 800 | 0.3 | tone on break away, 75m |
| Ship #1 | 5 | 60 initial 10-15 final | 45 | 100 | 8 | 220m | Normal | 800 | 0.1 | no tone, lights at break off |
| Ship #1 | 6 | 60 initial 10-15 final | 90 | 100 | 8 | 220m | Normal | 800 | none | no tone |
| Ship #1 | 7 | 60 initial 10-15 final | 0 | 100 | 20 | 85m | Normal | 800 | none | no tone |
| Ship #1 | 8 | 60 initial 10-15 final | 45 | 100 | 20 | 85m | Normal | 800 | none | no tone |
| Ship #1 | 9 | 60 initial 10-15 final | 90 | 100 | 20 | 85m | Normal | 800 | none | no tone |
| Ship #1 | 10 | Sideways hover R to L | 90 | 80' AGL | | | Normal | | | 140m, 80-85' AGL |
| Ship #1 | 11 | Sideways hover L to R | 90 | 80' AGL | | | Normal | | | 130 m 80' AGL |
| Airfield Runway | 12 | Sideways hover | | 30' AGL | | | Normal | | | |
| North Sod / Combat Sod | 13 | Normal walk | | 30' AGL | | | Normal | | | |

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 5 | Wood/Wolons | 3/4/2003 | 1120 | 11 | -240 | Clear, Wind 110/7 Knots |

**Operator's card**

Warnings: INU Align & BAT warnings on MSU, BAT warning on CDU

HELLAS caution light came on for a few seconds at takeoff

Note: Distances are approximate -- based on HELLAS raw data colors

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 1 | 1 | 40 | 90 | 0 | Normal | >1 | | | | practice run |
| Set 1 | 2 | 40 | 90 | 0 | Normal | >1 | 1 | 1 | 0.35 | sun washing out camera image |
| Set 1 | 3 | 40 | 60 | 0 | Normal | >1 | 0.95 | 0.9 | 0.3 | |
| Set 1 | 4 | 40 | 45 | 0 | Normal | >1 | 0.9 | 0.9 | 0.35 | |
| Set 1 | 5 | 40 | 20 | 0 | Normal | >1 | 0.7 | | | |
| Set 1 | 6 | 40 | 0 | 50 | Normal | >1 | towers: 1 | | | events 6 & 7 switched? |
| Set 1 | 7 | 40 | 90 | 50 | Normal | >1 | 1 | 1 | 0.35 | events 6 & 7 switched? |
| Set 1 | 8 | 40 | 60 | 50 | Normal | >1 | 1 | 1 | none | |
| Set 1 | 9 | 40 | 45 | 50 | Normal | >1 | 0.9 | 0.8 | none | |
| Set 1 | 10 | 40 | 20 | 50 | Normal | >1 | 0.8 | 0.8 | none | |
| Set 1 | 11 | 40 | 90 | 0 | Apch | >1 | 1 | 1 | 0.2 | |

**Enclosure 5**

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 1 | 12 | 60 | 90 | 0 | Normal | >1 | 1 | 0.9 | 0.4 | |
| Set 1 | 13 | 60 | 60 | 0 | Normal | >1 | 0.9 | 0.9 | 0.4 | |
| Set 1 | 14 | 60 | 45 | 0 | Normal | >1 | 0.8 | 0.8 | | |
| Set 1 | 15 | 60 | 20 | 0 | Normal | >1 | 0.7 | | | |
| Set 1 | 16 | 60 | 0 | 50 | Normal | >1 | towers: .9 | | | |
| Set 1 | 17 | 60 | 90 | 50 | Normal | >1 | 1 | 1 | none | |
| Set 1 | 18 | 60 | 60 | 50 | Normal | >1 | 0.9 | 0.9 | none | |
| Set 1 | 19 | 60 | 45 | 50 | Normal | >1 | 0.8 | 0.8 | none | |
| Set 1 | 20 | 60 | 20 | 50 | Normal | >1 | 0.6 | | none | |
| Set 1 | 21 | 60 | 90 | 0 | Apch | >1 | 1 | 1 | 0.3 | |
| Set 1 | 22 | 80 | 90 | 0 | Normal | >1 | 1 | 1 | 0.4 | |

**Enclosure 5**

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 6 | Wolons/Starks | 3/4/2003 | 1520 | 12 | -240 | Clear, Wind 110/7 Knots |

**Operator's card**

Warnings: INU Align warning on MSU, BAT warning on CDU

Note: Distances are approximate -- based on HELLAS raw data colors

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 1 | 1 | 80 | 90 | 0 | Normal | >1 | 1 | 1 | 0.55 | pilots cannot see guide wires |
| Set 1 | 2 | 80 | 60 | 0 | Normal | >1 | 0.95 | 0.95 | 0.35 | |
| Set 1 | 3 | 80 | 45 | 0 | Normal | >1 | 1 | 1 | 0.6 | |
| Set 1 | 4 | 80 | 20 | 0 | Normal | >1 | 0.6 - 0.7 | | 0.5 | |
| Set 1 | 5 | 80 | 0 | 50 | Normal | >1 | tower: .95 | | | |
| Set 1 | 6 | 80 | 90 | 50 | Normal | >1 | 1 | 1 | none | |
| Set 1 | 7 | 80 | 60 | 50 | Normal | >1 | 1 | 1 | none | |
| Set 1 | 8 | 80 | 45 | 50 | Normal | >1 | 0.9 | 0.9 | | |
| Set 1 | 9 | 80 | 20 | 50 | Normal | >1 | 0.7 | | | SL had wires but RD did not |
| Set 1 | 10 | 80 | 90 | 0 | Apch | >1 | 1 | 1 | 0.5 | |
| Set 1 | 11 | 100 | 90 | 0 | Normal | >1 | 1 | 1 | 0.7 | |
| Set 1 | 12 | 100 | 60 | 0 | Normal | >1 | 1 | 1 | 0.7 | |

**Enclosure 5**

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 1 | 13 | 100 | 45 | 0 | Normal | >1 | 1 | 1 | 0.7 | |
| Set 1 | 14 | 100 | 20 | 0 | Normal | >1 | 0.7 | 0.7 | none | |
| Set 1 | 15 | 100 | 0 | 50 | Normal | >1 | tower: 1 | | | |
| Set 1 | 16 | 100 | 90 | 50 | Normal | >1 | 1 | 1 | none | |
| Set 1 | 17 | 100 | 60 | 50 | Normal | >1 | 1 | 1 | none | |
| Set 1 | 18 | 100 | 45 | 50 | Normal | >1 | 0.9 - 1 | 0.9 - 1 | none | |
| Set 1 | 19 | 100 | 20 | 50 | Normal | >1 | 0.75 | 0.75 | | |
| Set 1 | 20 | 100 | 90 | 0 | Apch | >1 | 1 | 1 | 0.4 | |
| Set 1 | 21 | 120 | 90 | 0 | Normal | >1 | 1 | 1 | 0.8 | |
| Set 1 | 22 | 120 | 60 | 0 | Normal | >1 | 0.9 | 0.9 | 0.75 | |
| Set 1 | 23 | 120 | 45 | 0 | Normal | >1 | 0.95 | 0.95 | | |
| Set 1 | 24 | 120 | 20 | 0 | Normal | >1 | 0.8 | 0.8 | | |
| Set 1 | 25 | 120 | 0 | 50 | Normal | >1 | tower: 1 | | | |
| Set 1 | 26 | 120 | 90 | 50 | Normal | >1 | 1 | 1 | none | |
| Set 1 | 27 | 120 | 60 | 50 | Normal | >1 | 1 | 1 | none | |
| Set 1 | 28 | 120 | 45 | 50 | Normal | >1 | 0.9 | 0.9 | none | |
| Set 1 | 29 | 120 | 20 | 50 | Normal | >1 | 0.6 | 0.6 | none | |
| Set 1 | 30 | 120 | 90 | 0 | Apch | >1 | 1 | 1 | 0.7 | |

| Lods Flight # | Pilots | Date | Time | Temp | PA | | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 7 | Johnston(R)/Starks(L) | 5-Mar-03 | 1300 | 15 | 178 | | Clear, Wind 260/9 to 22 Knots |

| Operator's Card |
|---|

Location: Wire Set 1, James River Bridge        Wires Run 235 degrees

| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Distance | Wire Detection Range (km) Guide Wires | Raw Data | Safety Ln | WI | HDG | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Set 1 | 1 | 0 | 90 | 0 | Normal | 1000 | X | | | | | Lost wire ~950 to 980<br>Hold event for 5 Sec |
| Set 1 | 2 | 0 | 90 | 0 | Normal | 900 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 3 | 0 | 90 | 0 | Normal | 800 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 4 | 0 | 90 | 0 | Normal | 700 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 5 | 0 | 90 | 0 | Normal | 600 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 6 | 0 | 90 | 0 | Normal | 500 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 7 | 0 | 90 | 0 | Normal | 400 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 8 | 0 | 90 | 0 | Normal | 300 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 9 | 0 | 90 | 0 | Normal | 200 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 10 | 0 | 60 | 0 | Normal | 1000 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 11 | 0 | 60 | 0 | Normal | 900 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 12 | 0 | 60 | 0 | Normal | 800 | X | X | X | | | Hold event for 5 Sec |

| | | | | | | | Wire Detection Range (km) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Distance | Guide Wires | Raw Data | Safety Ln | WI | HDG | Notes |
| Set 1 | 13 | 0 | 60 | 0 | Normal | 700 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 14 | 0 | 60 | 0 | Normal | 600 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 15 | 0 | 60 | 0 | Normal | 500 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 16 | 0 | 60 | 0 | Normal | 400 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 17 | 0 | 60 | 0 | Normal | 300 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 18 | 0 | 60 | 0 | Normal | 200 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 19 | 0 | 45 | 0 | Normal | 1000 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 20 | 0 | 45 | 0 | Normal | 900 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 21 | 0 | 45 | 0 | Normal | 800 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 22 | 0 | 45 | 0 | Normal | 700 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 23 | 0 | 45 | 0 | Normal | 600 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 24 | 0 | 45 | 0 | Normal | 500 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 25 | 0 | 45 | 0 | Normal | 400 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 26 | 0 | 45 | 0 | Normal | 300 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 27 | 0 | 45 | 0 | Normal | 200 | X | X | X | | | Hold event for 5 Sec |
| Set 1 | 28 | 0 | 20 | 0 | Normal | 1000 | | X | X | | | Guide wire blends into terrain<br>Hold event for 5 Sec |
| Set 1 | 29 | 0 | 20 | 0 | Normal | 900 | | X | X | | | Guide wire blends into terrain<br>Hold event for 5 Sec |
| Set 1 | 30 | 0 | 20 | 0 | Normal | 800 | | X | X | | | Guide wire blends into terrain<br>Hold event for 5 Sec |

**Enclosure 5**

| | | | | | | | Wire Detection Range (km) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Distance | Guide Wires | Raw Data | Safety Ln | WI | HDG | Notes |
| Set 1 | 31 | 0 | 20 | 0 | Normal | 700 | | X | X | | | Guide wire blends into terrain<br>Hold event for 5 Sec |
| Set 1 | 32 | 0 | 20 | 0 | Normal | 600 | | X | X | | | Guide wire blends into terrain<br>Hold event for 5 Sec |
| Set 1 | 33 | 0 | 20 | 0 | Normal | 500 | | X | X | | | Guide wire blends into terrain<br>Hold event for 5 Sec |
| Set 1 | 34 | 0 | 20 | 0 | Normal | 400 | | X | X | | | Guide wire blends into terrain<br>Hold event for 5 Sec |
| Set 1 | 35 | 0 | 20 | 0 | Normal | 300 | | X | X | | | Guide wire blends into terrain<br>Hold event for 5 Sec |
| Set 1 | 36 | 0 | 20 | 0 | Normal | 200 | | X | X | | | Guide wire blends into terrain<br>Hold event for 5 Sec |

Notes:

Caution light on data acquisition system on continuously.

Computer crashed

**Enclosure 5**

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 8 | Wolons/Starks | 3/7/2003 | 948 | 1 | -290 | BKN 020, OVC 025 No Turb |
| | | | | | | Wind 010@10G15 |

**Operator's card**

Warnings: INU Align warning on MSU, BAT warning on CDU

Initially tape would not record then started working

Note: Distances are approximate -- based on HELLAS raw data colors

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 2 | 1 | 40 | 90 | 0 | Normal | >1 | 1 | 0.5 | | trees interferred |
| Set 2 | 2 | 40 | 60 | 0 | Normal | >1 | 1 | 0.7 | | |
| Set 2 | 3 | 40 | 45 | 0 | Normal | >1 | 0.9 | 0.8 | | |
| Set 2 | 4 | 40 | 20 | 0 | Normal | >1 | 0.8 | 0.8 | | SL drops off at near end |
| Set 2 | 5 | 40 | 0 | 50 | Normal | >1 | 0.9 | | | |
| Set 2 | 6 | 40 | 90 | 50 | Normal | >1 | 1 | 1 | | |
| Set 2 | 7 | 40 | 60 | 50 | Normal | >1 | 1 | 0.8 | | saved raw data |
| Set 2 | 8 | 40 | 45 | 50 | Normal | >1 | 0.9 | 0.6 | | |
| Set 2 | 9 | 40 | 20 | 50 | Normal | >1 | 0.7 | 0.7 | | |
| Set 2 | 10 | 40 | 90 | 0 | Apch | >1 | 1 | 0.9 | | |
| Set 2 | 11 | 60 | 90 | 0 | Normal | >1 | 1 | 0.7 | | |

**Enclosure 5**

|  |  |  |  |  |  | Wire Detection (km) |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 2 | 12 | 60 | 60 | 0 | Normal | >1 | 0.95 | 0.9 |  |  |
| Set 2 | 13 | 60 | 45 | 0 | Normal | >1 | 0.9 | 0.9 |  |  |
| Set 2 | 14 | 60 | 20 | 0 | Normal | >1 | 0.8 | 0.9 |  |  |
| Set 2 | 15 | 60 | 0 | 50 | Normal | >1 | 0.6 |  |  |  |
| Set 2 | 16 | 60 | 90 | 50 | Normal | >1 | 1 | 0.7 |  |  |
| Set 2 | 17 | 60 | 60 | 50 | Normal | >1 | 1 | 0.7 |  | saved raw data |
| Set 2 | 18 | 60 | 45 | 50 | Normal | >1 | 0.9 | 0.7 |  |  |
| Set 2 | 19 | 60 | 20 | 50 | Normal | >1 | 0.6 | 0.5 |  |  |
| Set 2 | 20 | 60 | 90 | 0 | Apch | >1 | 1 | 0.8 |  | tape switch |
| Set 2 | 21 | 80 | 90 | 0 | Normal | >1 | 0.95 | 0.9 |  |  |
| Set 2 | 22 | 80 | 60 | 0 | Normal | >1 | 0.9 | 0.7 |  |  |
| Set 2 | 23 | 80 | 45 | 0 | Normal | >1 | 0.9 | 0.9 |  |  |
| Set 2 | 24 | 80 | 20 | 0 | Normal | >1 | 0.8 | 0.6 |  |  |
| Set 2 | 25 | 80 | 0 | 50 | Normal | >1 | 0.6 |  |  |  |
| Set 2 | 26 | 80 | 90 | 50 | Normal | >1 | 1 | 0.7 |  |  |
| Set 2 | 27 | 80 | 60 | 50 | Normal | >1 | 0.9 | 0.75 |  |  |
| Set 2 | 28 | 80 | 45 | 50 | Normal | >1 | 0.95 | 0.95 |  | saved raw data |
| Set 2 | 29 | 80 | 20 | 50 | Normal | >1 | 0.8 | 0.8 |  |  |

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 2 | 30 | 80 | 90 | 0 | Apch | >1 | 0.9 | 0.9 | | |

Enclosure 5

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 9 | Wolons/Clark | 3/7/2003 | 1307 | 7 | -290 | see pilots flight card for detailed weather |

**Operator's card**

Warnings: INU Align warning on MSU, BAT warning on CDU

HELLAS caution light came on for a few seconds at takeoff

Note: Distances are approximate -- based on HELLAS raw data colors

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 2 | 1 | 100 | 90 | 0 | Normal | | 1 | 1 | | practice run before Event #1, light rain, short break after |
| | | | | | | | | | | event #1 - returned to AF, saved raw data |
| Set 2 | 2 | 100 | 60 | 0 | Normal | | 0.7 | 0.8 | | event repeated three times |
| Set 2 | 3 | 100 | 45 | 0 | Normal | | 0.8 | | | black bars on LHS of raw data |
| Set 2 | 4 | 100 | 20 | 0 | Normal | | 0.7 | | | hard to see entire wire in RD |
| Set 2 | 5 | 100 | 0 | 50 | Normal | | 0.75 | | | |
| Set 2 | 6 | 100 | 90 | 50 | Normal | | 0.9 | | | guide wires hard to see in RD |
| Set 2 | 7 | 100 | 60 | 50 | Normal | | 0.8 | 0.8 | | |
| Set 2 | 8 | 100 | 45 | 50 | Normal | | 0.8 | 0.8 | | |
| Set 2 | 9 | 100 | 20 | 50 | Normal | | 0.8 | 0.8 | | |
| Set 2 | 10 | 100 | 90 | 0 | Apch | | 0.8 | 0.8 | | rain slowed to drizzle, save RD |

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 2 | 11 | 120 | 90 | 0 | Normal | | 0.8 | 0.8 | | |
| Set 2 | 12 | 120 | 60 | 0 | Normal | | 0.7 | | | |
| Set 2 | 13 | 120 | 45 | 0 | Normal | | 0.6 | 0.6 | | rain increasing to moderate |
| Set 2 | 15 | 120 | 20 | 0 | Normal | | 0.5 | 0.5 | | Fog, event 14 skipped |
| Set 2 | 16 | 120 | 0 | 50 | Normal | | | | | |
| Set 2 | 17 | 120 | 90 | 50 | Normal | | 0.8 | 0.7 | | |
| Set 2 | 18 | 120 | 60 | 50 | Normal | | 0.5 | | | |
| Set 2 | 19 | 120 | 45 | 50 | Normal | | 0.6 | | | |
| Set 2 | 20 | 120 | 20 | 50 | Normal | | 0.5 | | | |
| Set 2 | 21 | 120 | 90 | 0 | Apch | | 0.7 | | | HELSIM crash when tried to save RD-- See note below** |
| Set 3 | 22 | 40 | 90 | 0 | Normal | | 0.5 | 0.3 | | new tape before event, light rain, fog |
| Set 3 | 23 | 40 | 60 | 0 | Normal | | 0.2 | 0.15 | | |
| Set 3 | 24 | 40 | 45 | 0 | Normal | | 0.2 | 0.15 | | |
| Set 3 | 25 | 40 | 20 | 0 | Normal | | 0.2 | 0.5 | | |
| Set 3 | 26 | 40 | 0 | 50 | Normal | | tower: .4 | | | |
| Set 3 | 27 | 40 | 90 | 50 | Normal | | 0.35 | 0.35 | | |
| Set 3 | 28 | 40 | 60 | 50 | Normal | | 0.4 | 0.4 | | saved raw data |

**Enclosure 5**

| | | | | | | Wire Detection (km) | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |

**HELSIM CRASH NOTE - HELSIM crashed when tried to save raw data after event #21, probable that lost raw data for

event #s 11 to 21, after crash, closed and reopned HELSIM program, still did not work so had to reboot computer

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 10 | Capobianco/Starks | 3/12/2003 | 1011 | | | |

**Operator's card**

Warnings: INU Align warning on MSU, BAT warning on CDU

HELLAS caution light came on for a few seconds at takeoff

KVM Switch problem - no laptop display -- opened gray box to start laptop

Mouse from Dornier computer froze, had to reboot machine

INU alignment restarted due to bump of INU

Note: Distances are approximate -- based on HELLAS raw data colors

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 2 | 1 | 100 | 90 | 0 | Normal | | 1 | 1 | C | test run before event 1 |
| Set 2 | 2 | 100 | 60 | 0 | Normal | | 1 | 1 | C | redo |
| Set 2 | 3 | 100 | 45 | 0 | Normal | | 1 | | C | |
| Set 2 | 4 | 100 | 20 | 0 | Normal | | 0.85 - 0.9 | | C | |
| Set 2 | 5 | 100 | 0 | 50 | Normal | | tower: .95 | | | |
| Set 2 | 6 | 100 | 90 | 50 | Normal | | 1 | 0.9 - 1 | C | redo 2X |
| Set 2 | 7 | 100 | 60 | 50 | Normal | | 1 | 1 | C | |
| Set 2 | 8 | 100 | 45 | 50 | Normal | | 1 | 1 | C | |

**Enclosure 5**

| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Wire Detection (km) | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Pilot Eye | Raw Data | Safety Ln | WI | |
| Set 2 | 9 | 100 | 20 | 50 | Normal | | 0.7 | | C | posts visible, wires hard to see |
| Set 2 | 10 | 100 | 90 | 0 | Apch | | 1 | 1 | C | saved data after event |
| Set 2 | 11 | 120 | 90 | 0 | Normal | | 1 | 1 | C | |
| Set 2 | 12 | 120 | 60 | 0 | Normal | | 1 | 1 | C | redo2X |
| Set 2 | 13 | 120 | 45 | 0 | Normal | | 1 | 1 | C | |
| Set 2 | 14 | 120 | 20 | 0 | Normal | | 0.3 | | | |
| Set 2 | 15 | 120 | 0 | 50 | Normal | | tower .95 | | | |
| Set 2 | 16 | 120 | 90 | 50 | Normal | | 1 | | C | |
| Set 2 | 17 | 120 | 60 | 50 | Normal | | 1 | | C | |
| Set 2 | 18 | 120 | 45 | 50 | Normal | | 1 | | C | |
| Set 2 | 19 | 120 | 20 | 50 | Normal | | 0.5 | | C | |
| Set 2 | 20 | 120 | 90 | 0 | Apch | | 1 | | C | saved RD after event |

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 11 | Capobianco/Starks | 3/12/2003 | 1510 | 20 | -150 | Few 20 |

**Operator's card**

Warnings: INU Align warning on MSU, BAT warning on CDU

Set Location LAT 3704530 LON -7647073

Streaks notice in raw data

Note: Distances are approximate -- based on HELLAS raw data colors

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 3 | 1 | 100 | 60 | 0 | Normal | | 0.9 | | C | |
| Set 3 | 2 | 100 | 45 | 0 | Normal | | 0.9 | | C | Caution Light |
| Set 3 | 3 | 100 | 20 | 0 | Normal | | 0.8 | | C | Caution Light |
| Set 3 | 4 | 100 | 0 | 50 | Normal | | 1 | | C | |
| Set 3 | 5 | 100 | 90 | 50 | Normal | | 0.95 | | C | |
| Set 3 | 6 | 100 | 60 | 50 | Normal | | 0.95 | | C | |
| Set 3 | 7 | 100 | 45 | 50 | Normal | | 0.9 | | C | |
| Set 3 | 8 | 100 | 20 | 50 | Normal | | 0.8 | | C | |
| Set 3 | 9 | 100 | 90 | 0 | Apch | | 1 | | C | |
| Set 3 | 10 | 120 | 90 | 0 | Normal | | 1 | | C | |

**Enclosure 5**

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 3 | 11 | 120 | 60 | 0 | Normal | | 0.95 | | C | |
| Set 3 | 12 | 120 | 45 | 0 | Normal | | 0.9 | | C | |
| Set 3 | 13 | 120 | 20 | 0 | Normal | | 1 | | C | |
| Set 3 | 14 | 120 | 0 | 50 | Normal | | 1 | | C | |
| Set 3 | 15 | 120 | 90 | 50 | Normal | | 1 | | C | |
| Set 3 | 16 | 120 | 60 | 50 | Normal | | 0.9 | | C | |
| Set 3 | 17 | 120 | 45 | 50 | Normal | | 0.75 | | C | |
| Set 3 | 18 | 120 | 20 | 50 | Normal | | 1 | | C | |
| Set 3 | 19 | 120 | 90 | 0 | Apch | | 0.9 | | C | RD Saved |
| Set 3 | 20 | 40 | 90 | 0 | Normal | 0.24 | 0.75 | | C | Never locked on tower |
| Set 3 | 21 | 40 | 60 | 0 | Normal | 0.32 | 0.7 | 0.76 | C | Locked on single tower |
| Set 3 | 22 | 40 | 45 | 0 | Normal | 0.2 | 0.52 | | C | Never locked on tower |
| Set 3 | 23 | 40 | 20 | 0 | Normal | 0.39 | 0.75 | 0.38 | C | |

**Enclosure 5**

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 12 | Clark/Starks | 3/13/2003 | 1030 | 19 | -105 | Unrestricted, Light Wind, No Turb |

**Operator's card**

Warnings: INU Align warning on MSU, BAT warning on CDU

KVM Switch problem - no laptop display -- opened gray box to start laptop

Operator monitor too dark to evaluate safety line, pilots monitor not affected

Note: Distances are approximate -- based on HELLAS raw data colors

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes -** save of rd before #1 |
| Set 3 | 1 | 40 | 90 | 0 | Normal | | 0.95 | | C | practice run before event |
| Set 3 | 2 | 40 | 60 | 0 | Normal | | 0.85 | | C | |
| Set 3 | 3 | 40 | 45 | 0 | Normal | | 0.75 | | C | |
| Set 3 | 4 | 40 | 20 | 0 | Normal | | 0.8 | | C | towers visible, hard to see wires |
| Set 3 | 5 | 40 | 0 | 50 | Normal | | tower 1 | | C | saved RD after event |
| Set 3 | 6 | 60 | 90 | 0 | Normal | | 1 | | C | |
| Set 3 | 7 | 60 | 60 | 0 | Normal | | 1 | | C | |
| Set 3 | 8 | 60 | 45 | 0 | Normal | | 0.9 | | C | |
| Set 3 | 9 | 60 | 20 | 0 | Normal | | 0.7 | | C | |
| Set 3 | 10 | 60 | 0 | 50 | Normal | | tower .8-.9 | | C | saved data after event |
| Set 3 | 11 | 80 | 90 | 0 | Normal | | 0.95 | | C | |

**Enclosure 5**

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes -** save of rd before #1 |
| Set 3 | 12 | 80 | 60 | 0 | Normal | | 0.9 | | C | |
| Set 3 | 13 | 80 | 45 | 0 | Normal | | 0.8 | | C | |
| Set 3 | 14 | 80 | 20 | 0 | Normal | | 0.5 | | C | |
| Set 3 | 15 | 80 | 0 | 50 | Normal | | tower .9 | | C | changed tape, tried to save RD, **see note below** |
| Set 3 | 16 | 100 | 90 | 0 | Normal | | 1 | | C | redo |
| Set 3 | 17 | 100 | 60 | 0 | Normal | | 0.9 | | C | |
| Set 3 | 18 | 100 | 45 | 0 | Normal | | 0.7 - 0.8 | | C | |
| Set 3 | 19 | 100 | 20 | 0 | Normal | | 0.45 | | C | |
| Set 3 | 20 | 100 | 0 | 50 | Normal | | tower .95 | | C | saved rd after event |
| Set 3 | 21 | 120 | 90 | 0 | Normal | | 1 | | C | |
| Set 3 | 22 | 120 | 60 | 0 | Normal | | 1 | | C | |
| Set 3 | 23 | 120 | 45 | 0 | Normal | | 0.7 | | C | |
| Set 3 | 24 | 120 | 20 | 0 | Normal | | 0.55 | | C | |
| Set 3 | 25 | 120 | 0 | 50 | Normal | | tower .9 | | C | saved rd after event |
| Set 3 | 26 | 120 | 60 | 0 | Normal | | 0.95 | | C | redo of event 17, rd also includes search for wire set #4 |

**NOTE: Dornier computer crash when tried to save data after event 15 (blue screen with "dump of physical memory", had to reboot computer, data from events 11 to 15 probably lost, conducted a few "practice data saves" before continuing to event 11

**Enclosure 5**

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 13 | Clark/Rombough | 3/13/2003 | 1330 | 20 | -50 | see pilot card |

Operator's Card

| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Wire Detection (km) | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Pilot Eye | Raw Data | Safety Ln | WI | |
| Set 4 | 1 | 40 | 90 | 0 | Normal | | 0.25 | 0.25 | | |
| Set 4 | 2 | 40 | 60 | 0 | Normal | | 0.3 | 0.3 | | |
| Set 4 | 3 | 40 | 45 | 0 | Normal | | 0.35 | 0.3 | | Stopped Test |

Picks up corn & dust - specs everywhere - safety line at top only in hover

Review of RD: partial wire at 400 m - more complete at 350m

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 14 | Wolons/Starks | 3/14/2003 | 930 | | | |

**Operator's Card**

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 5 | 1 | 40 | 90 | 0 | Normal | | 0.6 | 0.65 | | |
| Set 5 | 2 | 40 | 60 | 0 | Normal | | 0.5 | 0.55 | | |
| Set 5 | 3 | 40 | 45 | 0 | Normal | | 0.55 | | | |
| Set 5 | 4 | 40 | 20 | 0 | Normal | | 0.3 | | | Trees in way |
| Set 5 | 5 | 40 | 0 | 50 | Normal | | 0.4 | | | |
| Set 5 | 6 | 40 | see note | | Normal | | 0.5 | | | Angle: Down Runway |
| Set 5 | 7 | 60 | 90 | 0 | Normal | | 0.4 | | | |
| Set 5 | 8 | 60 | 60 | 0 | Normal | | 0.5 | | | |
| Set 5 | 9 | 60 | 45 | 0 | Normal | | 0.3 | | | |
| Set 5 | 10 | 60 | 20 | 0 | Normal | | 0.3 | | | |
| Set 5 | 11 | 60 | 0 | 50 | Normal | | 0.3 | | | Saved |
| Set 5 | 12 | 60 | see note | | Normal | | 0.45 | | | Angle: Down Runway |
| Set 5 | 13 | 80 | 90 | 0 | Normal | | 0.5 | | | |
| Set 5 | 14 | 80 | 60 | 0 | Normal | | 0.45 | | | |

**Enclosure 5**

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 5 | 15 | 80 | 45 | 0 | Normal | | 0.4 | | | |
| Set 5 | 16 | 80 | 20 | 0 | Normal | | 0.3 | | | |
| Set 5 | 17 | 80 | 0 | 50 | Normal | | 0.4 | | | |
| Set 5 | 18 | 100 | 90 | 0 | Normal | | 0.5 | | | |
| Set 5 | 19 | 100 | 60 | 0 | Normal | | 0.4 | | | |
| Set 5 | 20 | 100 | 45 | 0 | Normal | | 0.45 | | | |
| Set 5 | 21 | 100 | 20 | 0 | Normal | | 0.4 | | | |
| Set 5 | 22 | 100 | see note | | Normal | | 0.45 | | | Angle: Down Runway, saved |
| Set 5 | 23 | 120 | 90 | 0 | Normal | | 0.5 | | | |
| Set 5 | 24 | 120 | 60 | 0 | Normal | | 0.45 | | | |
| Set 5 | 25 | 120 | 45 | 0 | Normal | | 0.4 | | | |
| Set 5 | 26 | 120 | 20 | 0 | Normal | | 0.35 | | | |
| Set 5 | 27 | 120 | see note | | Normal | | 0.4 | | | Angle: Down Runway, tape change |
| Set 6 | 28 | 40 | 90 | 0 | Normal | | 0.35 | | | *See note below - events 28-31 |
| Set 6 | 29 | 40 | 60 | 0 | Normal | | 0.5 | | | |
| Set 6 | 30 | 40 | 45 | 0 | Normal | | 0.4 | | | saved |
| Set 6 | 31 | 40 | 20 | 0 | Normal | | 0.4 | | | |

* Note for Events 28-31: Safety Line Up & Down, Specs in raw data and video, wires blend in w/ tree background

**Enclosure 5**

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 15 | Trang/Rombough | 3/18/2003 | 1400 | 19C | 200 | 10 kt @ 40 deg, no turb |

**Operator's Card**

Notes: Specs on screen but less than previous flight

Caution light on until event 2

Pilots video not on but fixed

Tape 1 2:00

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Location** | **Event #** | **A/S** | **Angle** | **Rel Alt** | **Switch** | **Pilot Eye** | **Raw Data** | **Safety Ln** | **WI** | **Notes** |
| Set 6 | 1 | 40 | 90 | 0 | Normal | >1 | 0.45 | | | Safety Line sees trees behind wires |
| Set 6 | 2 | 40 | 60 | 0 | Normal | >1 | 0.4 | | | caution light off |
| Set 6 | 3 | 40 | 45 | 0 | Normal | >1 | 0.35 | | | saved |
| Set 6 | 4 | 40 | 20 | 0 | Normal | 0.85 | 0.15 | | | |
| Set 6 | 5 | 40 | 0 | 50 | Normal | | | | | |
| Set 6 | 6 | 60 | 90 | 0 | Normal | 0.85 | 0.5 | | | |
| Set 6 | 7 | 60 | 60 | 0 | Normal | 0.85 | 0.35 | | | |
| Set 6 | 8 | 60 | 45 | 0 | Normal | 0.9 | 0.35 | | | |
| Set 6 | 9 | 60 | 20 | 0 | Normal | 0.65 | 0.2 | | | |
| Set 6 | 10 | 60 | 0 | 50 | Normal | | | | | |
| Set 6 | 11 | 80 | 90 | 0 | Normal | 0.9 | 0.45 | | | |

**Enclosure 5**

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 6 | 12 | 80 | 60 | 0 | Normal | >1 | 0.4 | | | |
| Set 6 | 13 | 80 | 45 | 0 | Normal | | 0.35 | | | |
| Set 6 | 14 | 80 | 20 | 0 | Normal | | 0.15 | | | |
| Set 6 | 15 | 80 | 0 | 50 | Normal | | | | | saved |
| Set 6 | 16 | 100 | 90 | 0 | Normal | 0.85 | 0.45 | | | |
| Set 6 | 17 | 100 | 60 | 0 | Normal | | 0.35 | | | |
| Set 6 | 18 | 100 | 45 | 0 | Normal | | 0.35 | | | |
| Set 6 | 19 | 100 | 20 | 0 | Normal | | 0.2 | | | |
| Set 6 | 20 | 100 | 0 | 50 | Normal | | | | | |
| Set 6 | 21 | 120 | 90 | 0 | Normal | | 0.45 | | | |
| Set 6 | 22 | 120 | 60 | 0 | Normal | | 0.4 | | | |
| Set 6 | 23 | 120 | 45 | 0 | Normal | | 0.35 | | | |
| Set 6 | 24 | 120 | 20 | 0 | Normal | | 0.15 | | | |
| Set 6 | 25 | 120 | 0 | 50 | Normal | | | | | |

| Lods Flight # | Pilots | Date | Time | Temp | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|
| 16 | Clark/Wood | 3/19/2003 | 1000 | 10 | -150 | see pilot's flight card |

**Operator's card**

Warnings: INU Align warning on MSU, BAT warning on CDU

HELLAS caution light came on for a few seconds at takeoff

Labview program problems could not be fixed --- no acc or GPS data recorded

Safety Line mapped ship at 800-900m

| Test Location | Event # | A/S | Angle | Rel Alt | Glide Slope | Switch | Min Range | WI / AW (m) | **Notes --** hover & practice run before #1 |
|---|---|---|---|---|---|---|---|---|---|
| Ship #1 | 1 | 10-15 | 0 | 100 | 10-12 | Normal | 800 | 150/33 | Mast, chains visible in RD |
| Ship #1 | 2 | 10-15 | 15 | 100 | 10-12 | Normal | 800 | X | Masts, chains, wires (partial) visible |
| Ship #1 | 3 | 10-15 | 30 | 100 | 10-12 | Normal | 800 | X | Masts, chains, wires (partial) visible |
| Ship #1 | 4 | 10-15 | 45 | 100 | 10-12 | Normal | 800 | 100/X | Masts and wires visible |
| Ship #1 | 5 | 10-15 | 60 | 100 | 10-12 | Normal | 800 | 85/X | Masts and wires visible |
| Ship #1 | 6 | 10-15 | 75 | 100 | 10-12 | Normal | 800 | X | Masts and wires visible |
| Ship #1 | 7 | 10-15 | 90 | 100 | 10-12 | Normal | 800 | X | post visible |
| Ship #1 | 8 | 10-15 | 135 | 100 | 10-12 | Normal | 800 | X | |
| Ship #1 | 9 | 10-15 | 180 | 100 | 10-12 | Normal | 800 | X | Mast, chains visible, Save RD |
| Ship #1 | 10 | 10-15 | 0 | 100 | 10-12 | Appr | 800 | X | Mast, chain (partial) visible |
| Ship #1 | 11 | 10-15 | 15 | 100 | 10-12 | Appr | 800 | X | Mast, chain, wire (partial) visible |

**Enclosure 5**

| Test Location | Event # | A/S | Angle | Rel Alt | Glide Slope | Switch | Min Range | WI / AW (m) | **Notes -- ** hover & practice run before #1 |
|---|---|---|---|---|---|---|---|---|---|
| Ship #1 | 12 | 10-15 | 30 | 100 | 10-12 | Appr | 800 | X | Mast, chain, wire (partial) visible |
| Ship #1 | 13 | 10-15 | 45 | 100 | 10-12 | Appr | 800 | X | Masts and wires visible, tape ran out |
| Landing | 14 | | | | | Normal | | | Save RD |

| Lods Flight # | Pilots | Date | Time | Temp | | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 17 | Rombough/Clark | 3/28/2003 | 1007 | +16 | | -200 | 12 BKN 250 OVC light Turb SFC-60, Wind N @5 |

| Operator's Card | |
|---|---|
| | Problem with Labview software - couldn't stop acquisition or close program, event counter at 300+ |

| Test Location | Event # | A/S | Angle | Rel Alt | Glide Slope | | Switch | Min Range | WI Range | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| Ship #1 | 1 | 60 initial 10-15 final | 0 | 100 | 10-12 | 140m | Normal | 800 | break off | hover pt before #1 / mast visible in RD |
| Ship #1 | 2 | 60 initial 10-15 final | 45 | 100 | 10-12 | 140m | Normal | 800 | X | mast and small post at stern visible in RD |
| Ship #1 | 3 | 60 initial 10-15 final | 90 | 100 | 10-12 | 140m | Normal | 800 | X | small post at stern visible in RD |
| Ship #1 | 4 | 60 initial 10-15 final | 0 | 100 | 8 | 220m | Normal | 800 | 0.3 | mast visible in RD |
| Ship #1 | 5 | 60 initial 10-15 final | 45 | 100 | 8 | 220m | Normal | 800 | 0.1 | mast w/ wires & small post visible in RD, saved RD after event |
| Ship #1 | 6 | 60 initial 10-15 final | 90 | 100 | 8 | 220m | Normal | 800 | X | small post at stern visible in RD |
| Ship #1 | 7 | 60 initial 10-15 final | 0 | 100 | 20 | 85m | Normal | 800 | X | mast w/ wires visible in RD |
| Ship #1 | 8 | 60 initial 10-15 final | 45 | 100 | 20 | 85m | Normal | 800 | X | mast visible in RD |
| Ship #1 | 9 | 60 initial 10-15 final | 90 | 100 | 20 | 85m | Normal | 800 | X | small post at stern visible in RD, saved RD after event |
| Ship #1 | 10 | Sideways hover R to L | 90 | 80' AGL | | | Normal | | | Sideslip to map ship -- 140 m from ship |
| Ship #1 | 11 | Sideways hover L to R | 90 | 80' AGL | | | Normal | | | Sideslip to map ship -- 130 m from ship |
| rfield Runw | 12 | Sideways hover | | 30' AGL | | | Normal | | | Sideslip to map runway, hangers, a/c, etc. |
| North Sod / Combat | 13 | Normal walk | | 30' AGL | | | Normal | | | Sideslip to map runway, hangers, a/c, etc., saved RD after event |

| Lods Flight # | Pilots | Date | Time | Temp | | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 18 | Grinsell/Wolons | 5/21/2003 | 1130 | | | | |

| Operator's Card |
|---|

Set Location LAT 37°15'00.1" LON -76°54'05.9"

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 7 | 1 | 40 | 90 | 50 | Normal | | 0.5 | | N/A | |
| Set 7 | 2 | 60 | 90 | 50 | Normal | | 0.5 | | N/A | |
| Set 7 | 3 | 80 | 90 | 50 | Normal | | 0.5 | | N/A | |
| Set 7 | 4 | 100 | 90 | 50 | Normal | | 0.5 | | N/A | |
| Set 7 | 5 | 120 | 90 | 50 | Normal | | 0.5 | | N/A | |

Enclosure 5

| Lods Flight # | Pilots | Date | Time | Temp | | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 19 | Grinsell/Wolons | 6/6/2003 | 1000 | | | | Good |

| Operator's Card |
|---|

Set Location LAT 36.01095 LON -75.68636

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Shore Line | 1 | 100 | 0 | 200 | Normal | | N/A | | N/A | Observed water to sand transition |
| Set 8 | 2 | 90 | 90 | 50 | Normal | | 0.85 | | C | |
| Set 8 | 3 | 90 | 90 | 50 | Normal | | 0.9 | | C | |
| Sand Dune Survey | 4 | Hover | 90 | 50 | Normal | | | | | Observed sand contours |
| Set 8 | 5 | 100 | 90 | 50 | Normal | | 0.95 | | C | |
| Sand Dune Survey | 6 | Hover | 90 | 50 | Normal | | | | | Observed sand contours |
| Set 8 | 7 | 100 | 45 | 50 | Normal | | 0.95 | | C | |
| Set 8 | 8 | 110 | 45 | 50 | Normal | | 0.85 | | C | |

| Lods Flight # | Pilots | Date | Time | Temp | | PA | Weather, wind, turbulence |
|---|---|---|---|---|---|---|---|
| 20 | Wood/Wolons | 7/7/2003 | 2000 | | | | |

| Operator's Card |
|---|

Problem with Labview software - Aircraft data not recorded

Set Location LAT 37.07800 LON -76.79461

| | | | | | | Wire Detection (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Location | Event # | A/S | Angle | Rel Alt | Switch | Pilot Eye | Raw Data | Safety Ln | WI | Notes |
| Set 2 | 1 | 80 | 90 | 50 | Normal | N/A | 0.95 | N/A | C | Daytime scout of wire set Set #2 not good candidate due to towers |
| Set 3 | 2 | 80 | 90 | 50 | Normal | N/A | 0.95 | N/A | C | Daytime scout of wire set Set #3 chosen for night time flight |
| Set 3 | 3 | 80 | 90 | 50 | Normal | N/A | 0.65 | N/A | C | |
| Set 3 | 4 | 80 | 90 | 50 | Normal | N/A | 0.75 | N/A | C | |
| Set 3 | 5 | 80 | 90 | 50 | Normal | N/A | 0.8 | N/A | C | Test aborted due to thunderstorms |

**Enclosure 5**