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Hydrographic Lidar Survey

Trégor site, France, 2006

Mesh survey 03-06-03

This project has received European Regional Development Funding through the INTERREG III B Community Initiative

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HAWKEYE II SURVEY REPORT
OF
TREGOR, FRANCE

Contract n° 06 / 2210 212

30 May – 3 June 2006

Contents

Introduction

This short report gives an overview of the survey conducted by Admiralty Coastal Surveys of the area of Tregor. The aim of the survey was to determine both the topography and bathymetry of an important environmental area on the coast of Brittany.

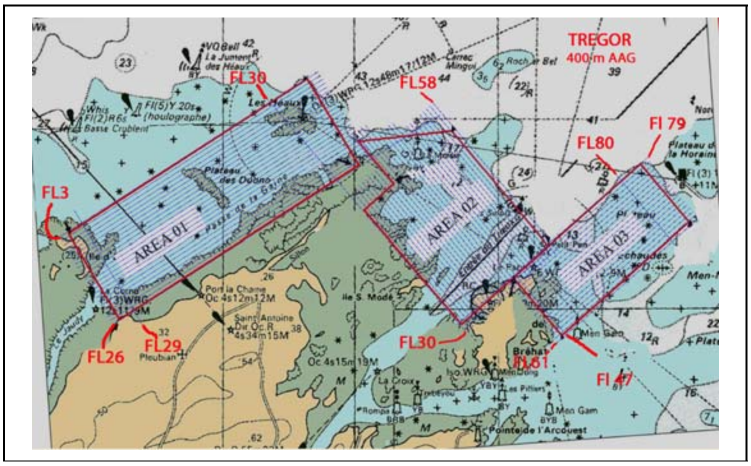

Figure 1 – Tregor Survey Area

1 Equipment

1.1 <u>Lidar System – Hawkeye II</u>

The Bathymetric Laser emits light at 2 different wavelengths – green (532 nano meters) and infrared (1064 nano meters). The infrared laser light is reflected at the water surface whereas the green laser light proceeds into the water column and reflects from the seabed. A separate topographic laser emitting 1059 nano meters is utilised to obtain the topographic data.

Associated with the Lidar system, navigation and attitude are provided by an integrated GPS and inertial reference system (POS AV 410) which delivers accurate co-ordinates in all three dimensions. The precise laser optics and measurement system translates this high precision navigation to the seabed, and the water surface and objects in or on the water are fixed in WGS 84 or similar ellipsoidal reference systems.

For this survey the WGS 84 Ellipsoid was used and the positions realised on the Universal Transverse Mercator (UTM) Zone 30N projection. For more details of the Hawkeye II system see Appendix A.

1.2 <u>Echo-Sounder System – Valeport Midas Surveyor</u>

The Midas Surveyor consists of a single beam echo sounder operating at 210kHz, a 12 channel dGPS receiver and data logger. For more information see Appendix B.

1.3 Leica SX1230 Static GPS systems

Standard Leica SX1230 GPS stations were used to record GPS phase data in order to both establish 2 new ground control stations and also to accurately position the aircraft during the survey operations.

2 Mobilisation

2.1 Hawkeye II System

The Hawkeye II system was mobilised into an Air Commander twin engine aircraft at Jönköping, Sweden on the 30 May 06. On completion of the installation static checks were conducted on the system prior to undertaking an airborne trial in and around Lake Vattern. On completion of the flight the data was downloaded and processed thus ensuring the correct operation of the system. On satisfactory completion of the processing the aircraft finally deployed to Lannion Airport, France, prior to commencement of the survey.

Figure 2 – Air Commander

2.2 Geodetic Control

Prior to the arrival of the aircraft 2 ground control points were established (30 May – 1 Jun 06) and their co-ordinates tied into the WGS 84 framework using static GPS techniques. These stations were then utilised through the course of the survey to aid in the control of the aircraft both in horizontal position and height. Before commencement of aircraft operations the ground control stations were occupied and set to record GPS data, on completion of each day’s survey the sites were dismantled and the data downloaded.

2.3 Valeport Midas System

A local vessel (Adventurous) was hired on the 1 Jun 06 and the Midas system deployed onboard. The transducer was connected to an over-the-side-rig whilst the GPS antenna was installed on the coach roof of the vessel. Both pieces of equipment were subsequently integrated into the Midas data logger. Line guidance was provided by the vessel’s onboard navigation system.

Once mobilised a Bar check was conducted to establish the sound velocity and confirm the echo sounder draught setting. This was further checked by lead and line readings taken whilst the vessel was stationary.

3 Field Work

The fieldwork took place between the 30 May and the 3 Jun 06.

3.1 Ground Control

Initially the 2 ground control sites (PGM1 & PGM2) were established using Static GPS techniques and tying both the stations into the WGS 84 framework. This involved the simultaneous recording of GPS data at the station and also a number of known WGS 84 control points. Once established the new stations were used to collect data during the aircraft operations.

In order to tie the Primary Stations in to the RGF-93 National Control Framework observations were made to three of the RBF points which form part of the French permanent GPS network. Observations were taken on two days (31st May and 1st June) for periods of between 6 and 8 hours.

3.2 Test Area

On 1 Jun 06 an acoustic survey was conducted using the Midas system. A small area measuring approximately 3 x 0.5 km was surveyed by running parallel lines in an area that could also be over flown by the aircraft.

3.3 Lidar survey

The Lidar data was collected over 3 sorties between the 2 – 3 Jun 06. Each sortie lasted approximately 4 hours with parallel lines being run over the designated areas at a height of 400m. On completion of each day’s sortie the data was downloaded and backed up and an area converge plot was produced to ensure no gaps were present.

A list of the start and stop times of all the lines run is at Annex A

4 Quick look of results

The survey area in and around Tregor has been surveyed within the limits of the Hawkeye 2 system resulting in a dense data set which can be used as the basis for further research in the area. A quicklook jpeg of the surveyed Lidar data can be seen in figure 8. Additionally, a set of ortho-photographs has been produced to further enhance the data set (fig. 9).

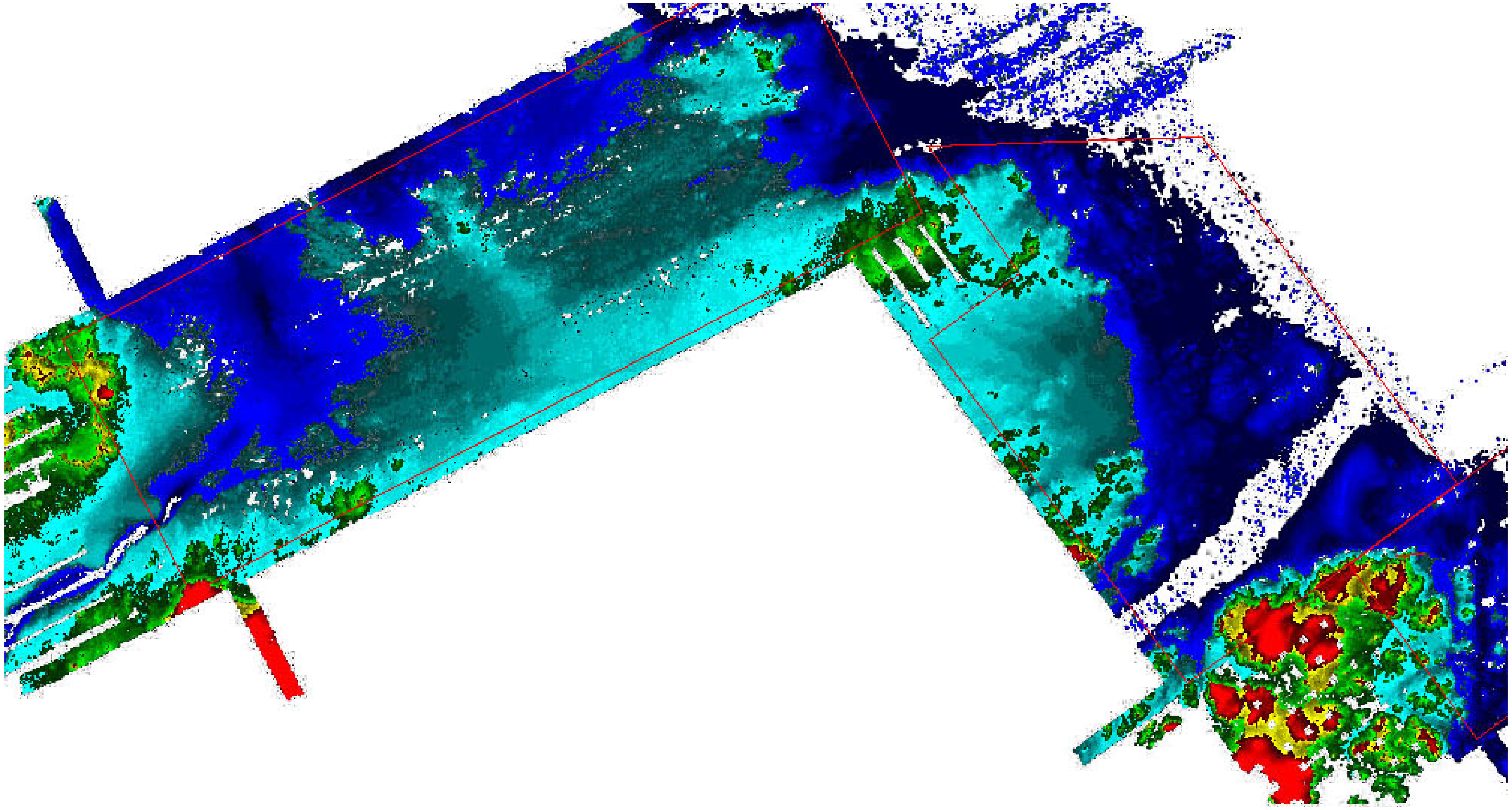

Figure 8 – Bathy Lidar of Tregor Survey Area

Figure 9 – Ortho-photograph of Tregor Survey Area

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Annex A - Tregor Mission

2006/06/02			2006/06/03					
Sortie 1	20060602_180217		Sortie 2	20060603_130023		Sortie 3	20060603_162655	
Flightline	Start time	Stop time	Flightline	Start time	Stop time	Flightline	Start time	Stop time
18	20.02	20.02	18	15.00	15.04	81	18.27	18.28
18	20.06	20.08	15	15.07	15.09	8	18.31	18.34
26	20.12	20.15	14	15.14	15.16	7	18.37	18.39
25	20.18	20.20	13	15.20	15.22	6	18.42	18.44
24	20.24	20.27	12	15.25	15.27	5	18.46	18.48
23	20.30	20.32	11	15.31	15.33	4	18.51	18.53
22	20.36	20.38	10	15.36	15.39	3	18.56	18.58
21	20.41	20.43	9	15.42	15.44	30	19.03	19.04
20	20.47	20.49	8	15.47	15.49	31	19.09	19.10
19	20.52	20.54	58	15.51	15.51	32	19.13	19.14
17	20.57	21.00	53	15.55	15.57	33	19.18	19.19
30	21.03	21.04	57	16.01	16.02	34	19.21	19.22
29	21.10	21.10	52	16.06	16.07	35	19.26	19.27
16	21.15	21.17	56	16.11	16.12	36	19.30	19.31
			51	16.16	16.17	37	19.34	19.35
			55	16.21	16.22	38	19.38	19.39
			50	16.25	16.26	39	19.42	19.43
			54	16.29	16.31	40	19.46	19.47
			49	16.34	16.35	41	19.50	19.52
			48	16.39	16.40	42	19.55	19.56
			47	16.45	16.46	79	19.59	20.01
			46	16.50	16.51	78	20.04	20.05
			45	16.56	16.58	77	20.08	20.09
			44	17.01	17.03	76	20.12	20.13
			43	17.07	17.08	75	20.16	20.17
			79	17.14	17.14	74	20.20	20.21
			29	17.17	17.18	73	20.24	20.25
			81	17.22	17.22	72	20.28	20.29
						71	20.32	20.33
						70	20.36	20.37
						69	20.40	20.41
						68	20.44	20.45
						67	20.48	20.50
						66	20.52	20.53
						65	20.57	20.58
						64	21.01	21.02
						63	21.05	21.06
						62	21.09	21.10
						47	21.13	21.14
						81	21.20	21.21

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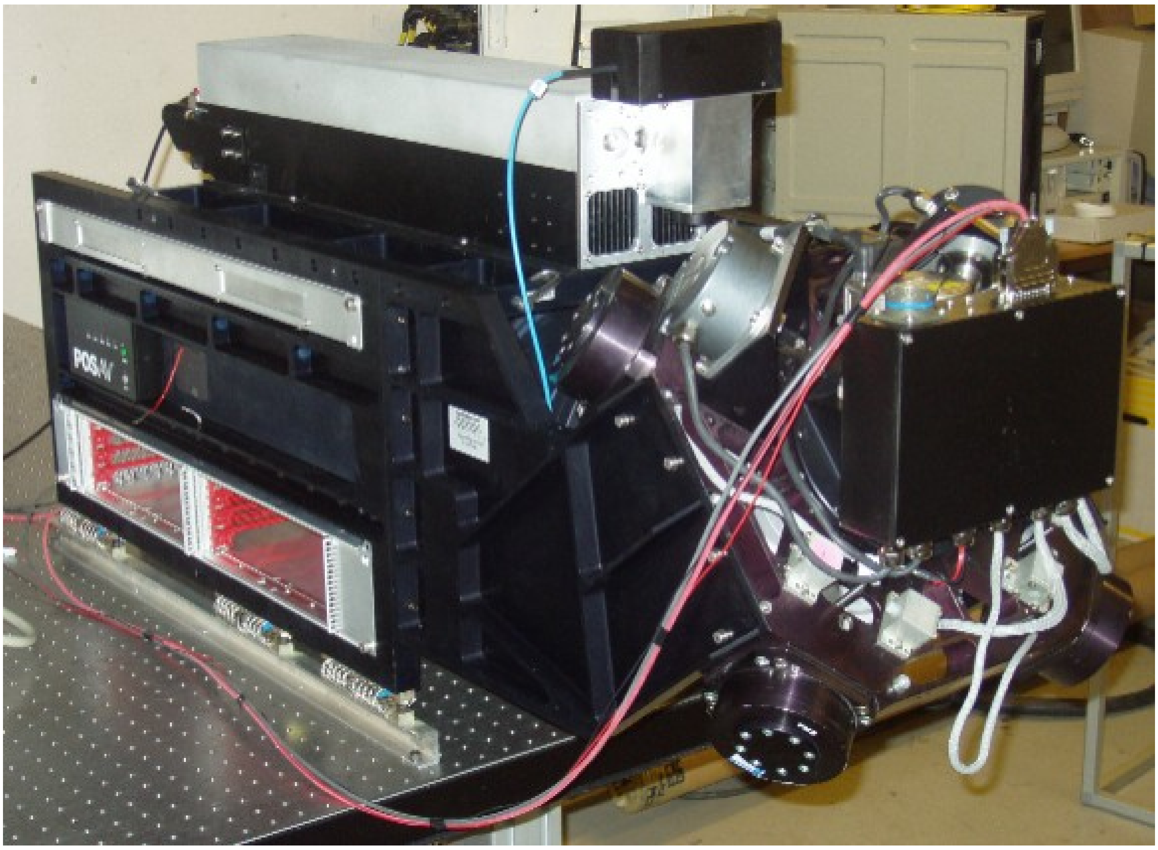
Annex B - HAWKEYE II Technical Description

General

This annexe describes the system in general terms.
The Hawk Eye Laser Bathymetry/Topography System is an airborne system using laser technology for fast and accurate surveying of shallow waters, coastlines and land. It includes ground equipment for mission planning and hydrographic/topographic processing.
The new generation Hawk Eye with improved capabilities, specifically considerable higher laser pulse repetition frequency, improved receiver technology and included topographical survey equipment, is operated by one pilot (in some cases two) and one operator in a small/medium sized helicopter/aeroplane.

The system contains two class 4 lasers - EN 60825 specification. At mission planning the planned parameter-settings are checked to secure that the mission will be operated in eye-safe conditions. The Hawk Eye system has a built in system that for each laser pulse calculates if the eye-safety requirements are fulfilled. If not the laser is immediately and automatically shut off.



The system is designed to be operated in a wide temperature range. At low temperatures the system has to be pre-heated before start and at high temperatures the aircraft must be equipped with a air-condition system. Heavy rain, fog, high and/or breaking waves, flat sea surface and strong wind will affect the performance for the system in different aspects.

System overview

Hawk Eye II Survey Technology

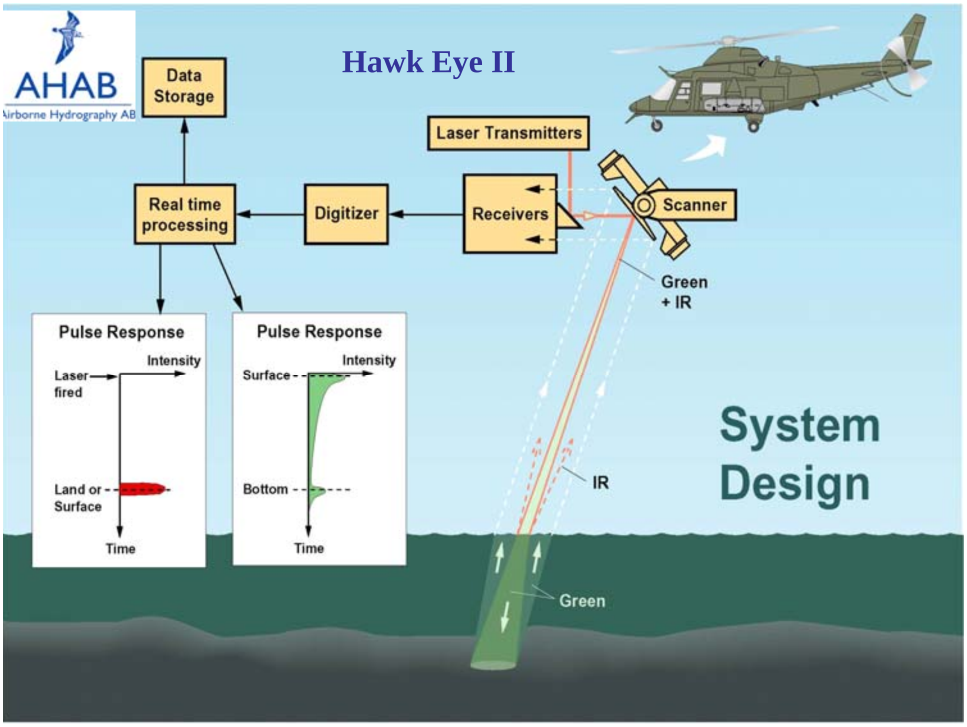


Fig 3-1. A schematic explanation of the laser pulse response.

HAWK EYE II is a helicopter or fixed wing-borne system which utilises GPS satellite technology for precise positioning.

The water depth is measured by laser pulses. Infra Red (IR) and green laser pulses are scanned in a pattern on the water surface. The green beam penetrates the water whereas the IR beam is reflected at the surface. Time difference between the green (bottom) and the IR (water surface) echoes is used to calculate the sea depth, see figure 3-1.

The land topography is measured by infrared laser pulses from a separate laser. These pulses are also scanned in a pattern,

The land topography and the water surface are scanned with a much denser pattern than the sea bottom. The footprints are much smaller and the pulse frequency is much higher.

System Architecture

The HAWK EYE II System consists of a Survey System, an Aircraft Installation Kit and a Hydrographic Studio, see figure 3-2.

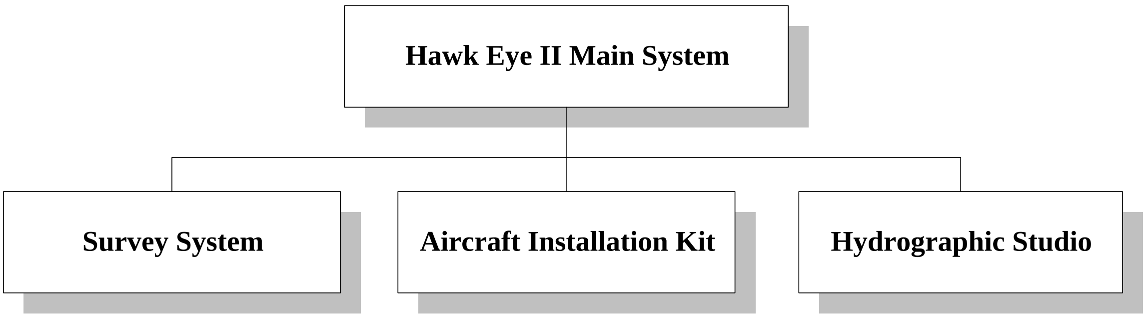
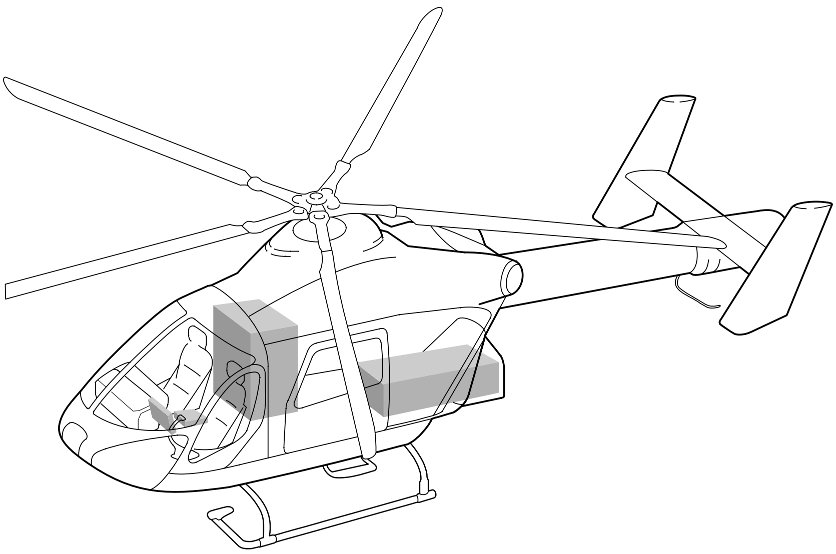


Fig 3-2 The three main blocks of the Hawk Eye main system

Survey System



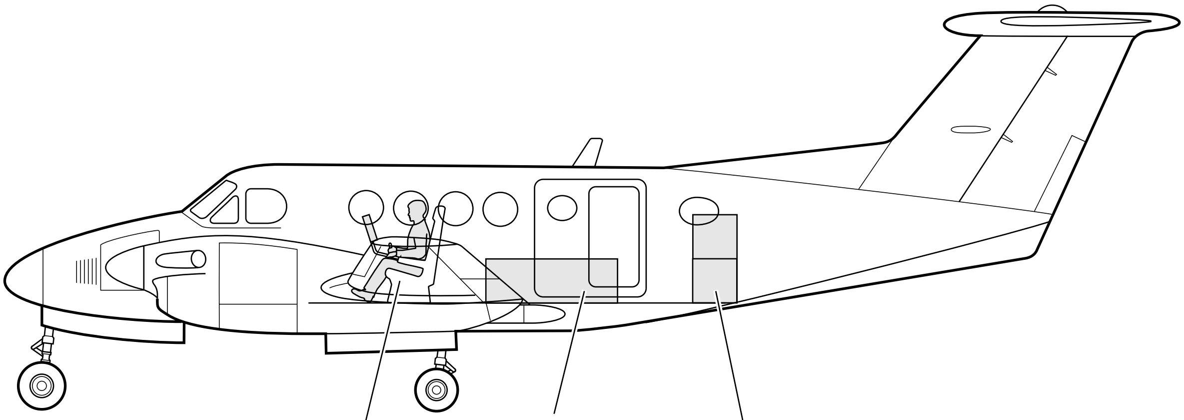


Fig 3-3 Example of Hawk Eye installation in a helicopter and aeroplane

Functions for the Survey System are Surveying, Control, Monitoring and Data storage. Figure 3-3 shows the Sensor Subsystems and distributed parts from the Control, Operator, Pilot and Positioning Subsystems in a medium light helicopter.

The Man Machine Interface (MMI) contains all information needed to control the system. The surveyed area is displayed for the operator on a monitor as colour coded depths in real time. The single operator, sitting in the co-pilot seat, runs the system via the Operator Console.

During normal operation the laser system is eye-safe. The Hawk Eye system has a built in function that automatically shuts off the laser if it is not in an eye-safe mode.

Aircraft Installation Kit

The aircraft installation kit is the interface between the survey system and the actual aircraft.

The kit consists of electrical interfaces like connectors and cables, mechanical interfaces like mounting beams and trays. The kit also includes modified parts of the aircraft hood like replacements for cargo doors.

A version of the installation kit has to be specified and procured for each type of craft.

Hydrographic Studio

The hydrographic studio is a hardware and software environment for planning surveys and handling survey data on ground after completion of a survey.

The hardware is computer systems capable of handling and storing large amounts of data. The selection of equipment will be dependent on the availability and compatibility of the systems available at the time of procurement.

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A software toolbox for hydrographic/topographic processing will be available in the studio.

Examples of functions are:

- Planning of flight lines from map data.
- Adding position data from GPS reference stations.
- Use of both inertial and GPS data to establish aircraft position.
- Correcting depth data due to tide and sea level values.
- Classifying survey data and adding "Metadata" to survey data.
- Converting survey data format according to specified formulas.

The equipment is located in a Base Station, mobile or at an aircraft port, together with field level support equipment and space for spares.

Operational Sequence

The operational sequence consists of three steps, see fig 3-4, (1) mission planning where the extent and purpose of the missions are transformed to flight line patterns and system parameters settings (2) airborne operation where data is collected and (3) the hydrographic processing where survey data are enhanced and converted into specified formats.

Mission Planning
- Import/create map.
- System parameters
- Flight-line parameters

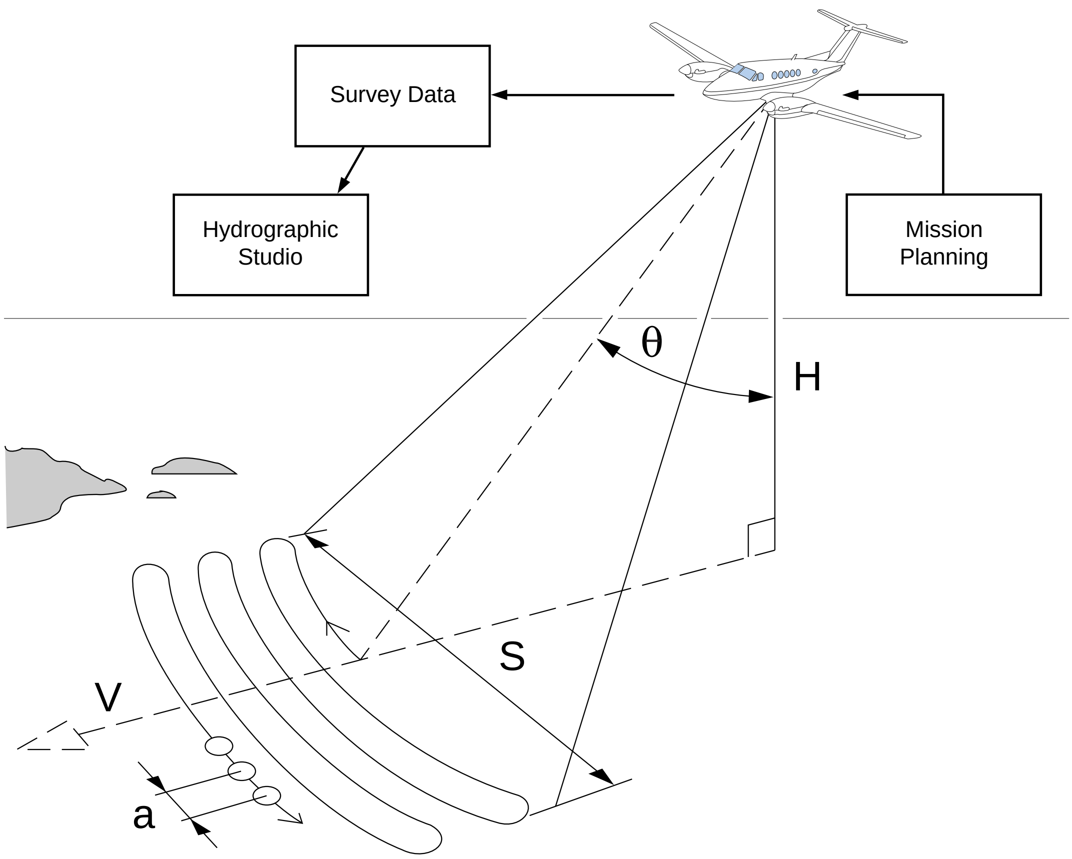
→

Airborne Operation
- Reading mission planning data
- Send and receive laser pulses.
- Real-time data processing
- Real-time presentation
- Recording of survey data
- Video

→

Hydrographic Processing
- Reading survey data
- Processing of raw data.
- Data enhancement.
- Quality control of data
- Data format conversion.

During mission planning maps over the planned survey areas are imported and stored. For the areas optimal system parameters are set and stored. The survey areas are divided into strips, called flight lines. Fig 3-5 Laser soundings on the water surface.



In the figure 3-5 the pattern of the laser soundings on the water surface is shown. The parameters have the following meanings: a is the distance between the centre of two adjacent laser spots on the water surface. V is the aircraft speed over ground. S is the swath width. H is the flight altitude and θ is the off nadir angle. The same parameters are used for the topographic soundings.

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System Operation

The Man Machine Interface (MMI) contains information needed to control the system. The single operator, sitting in the co-pilot seat, runs the system via the Operator's Console. On the operator monitor several windows for different type of information can be shown. On the operator window showed below the colour coded depth of the surveyed area is displayed in the upper right corner, an analysis window is shown in the upper left corner, the waveform window is shown under the survey area window and in the bottom the base information window is shown. All necessary information is shown in real-time, including Quality Control parameters for both the laser system and the positioning system.

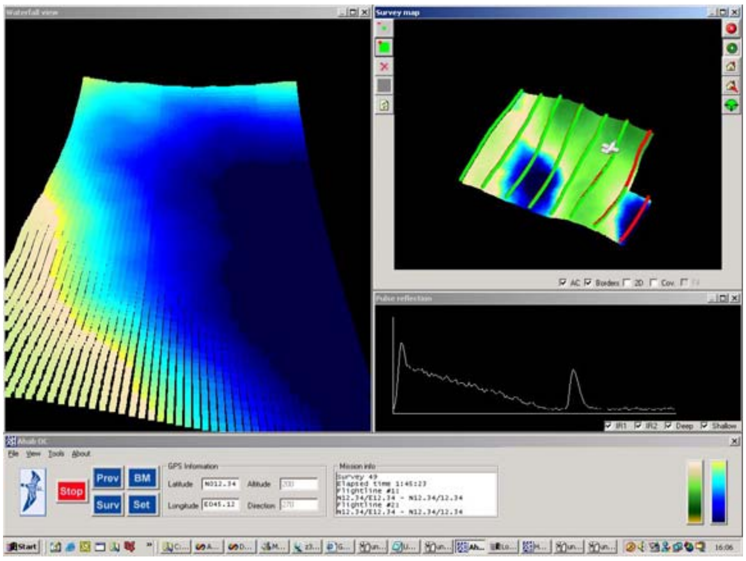

Fig 3-6 The MMI showing the operations windows in the Hawk Eye II system.

The pilot has a monitor that graphically shows flight line guidance.

Capabilities

The maximum depth capability is dependent on the water turbidity. A Secchi disk can be used to approximately determine the vertical visibility in the water.

For flat bottoms (reflectivity greater than 5 %) the maximum depth capability (D_{max}) under normal operating conditions is a function of K, where K is the green light diffuse attenuation coefficient for the water. For water with good visibility the depth capability is expected to be up to 60-70 meters for a flat bottom (not Order 1).

The water surface is separately discriminated.

Within the limit of the depth range the system will easily fulfil the requirements of IHO S44 Order 1-3.

IHO Special Order requirements can be met in shallow clear water using the precision of RTK GPS combined with HAWKEYE II's beam splitting and patented statistical resolution techniques.