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November 6, 2000

IT-MC-CK10-0082
Project No. 796887

Mr. Ellis Pope
U.S. Army Corps of Engineers
Mobile District
Attn: CESAM-EN-GE (Pope)
109 Saint Joseph Street
Mobile, AL 36602

Contract: **Contract No. DACA21-96-D-0018/CK10**
Fort McClellan, Alabama

Subject: **Work Plan for an Airborne Gamma Radionuclide Survey of Fort McClellan (Main Post and Pelham Range) Anniston, Alabama Prepared by Fugro Airborne Surveys Corporation**

Dear Mr. Pope:

Attached is a copy of the Work Plan for an Airborne Gamma Radionuclide Survey of Fort McClellan (Main Post and Pelham Range) Anniston, Alabama prepared by Fugro Airborne Surveys Corporation (Fugro). This work plan includes Fugro's approach to conducting the Airborne Radionuclide Survey of Fort McClellan and their health and safety plan. We have reviewed the attached document prepared by Fugro and found it to be acceptable. We have forwarded the document to you for review and approval. If you have questions, or need further information, please contact me at (770) 663-1429 or Steve Moran at (423) 694-7361.

Sincerely,

Jeanne A. Yacoub, P.E.
Project Manager

Attachments

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Central Files (1 bound, 1 original document)

Work Plan for an Airborne Gamma Radionuclide Survey of Fort McClellan (Main Post and Pelham Range) Anniston, Alabama

For

IT Corporation Knoxville, Tennessee

Submitted by

Fugro Airborne Surveys Corp.

Mississauga (Toronto), Ontario

Canada

Wednesday, 01 November 2000
IT Tracking #796887-31
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1. INTRODUCTION

Fugro Airborne Surveys has been retained by The IT Group to perform a radiological flyover of two separate areas at the former U.S. Army installation, Fort McClellan, Calhoun County, Alabama. Area one comprises 4,900 acres in the northwest portion of the Pelham Range (see figure 1) and the second area comprises 470 acres of the Main Post (See figure 2). The purpose of the survey is to identify any detectable radiological sources, what the sources are (137Cs or 60Co), and to define a source area small enough to locate the sources on the ground.

The detection limits of an airborne gamma ray spectrometer depend on many variables. The size of the area and distribution of the contamination within that area related to the 40 meter by 45-meter footprint of the system are significant variables. Interfering isotopes and background changes may also be limiting factors. Widespread contamination relative to the footprint of the system, 8" in thickness, of less than 50 pCi/g is thought to be a realistic minimum detection limit. Smaller accumulations with higher activities will be detected. For point sources, tests with the type of equipment being used at Fort McClellan have shown that 50 mCi sources at over 1 foot are detectable at 10 meter flying heights.

1.1. Scope of Work

1.1.1. Flying

For the survey areas the traverses will be flown east-west at 10 meters above ground level where tree cover and other obstacles permit, and at a separation of 10 meters. Survey height will be maintained at a mean terrain clearance of 10 meters ± 5 meters, except in areas where FAA regulations prevent flying at this height and in areas of particularly steep topography, or in the vicinity of man made obstructions, where the pilot's judgement will prevail within reason. Figure 1 below shows the survey areas and Figures 2 and 3 show the proposed flight path. Only every 10^{th} flight line is shown on these maps for clarity.

1.2. Information on the Company

On January 1, 2000, Fugro N.V. acquired the business and assets of four leading airborne geophysical survey companies, Geoterrex-Dighem and High-Sense Geophysics Limited of Canada, World Geoscience Corporation Pty. Ltd. of Australia and Geodass, a South African based geophysical company.

The new organization, known as Fugro Airborne Surveys, focuses on providing specialized airborne geophysical contracting services for clients in the mineral, petroleum and environmental management sectors. In order to provide fully integrated services for clients, the group also offers ground geophysics, data processing, interpretation and consulting services. The company offers these services on a global basis, with offices located in various parts of North and South America, Europe, Africa, Australia and Asia. The primary technologies offered by the group are airborne electromagnetics, magnetics and radiometrics. Fugro Airborne Surveys has a strong presence in the petroleum exploration sector, being able to offer the unique airborne laser flourosensor (ALF) for offshore basin exploration, as well as high resolution aeromagnetics

The combined group has available the industry's best expertise, technologies, R&D and geographic infrastructure, supported by an uncompromising commitment to the highest standards

Figure 1, Fort McClellan Main Post and Pelham Range Survey Areas

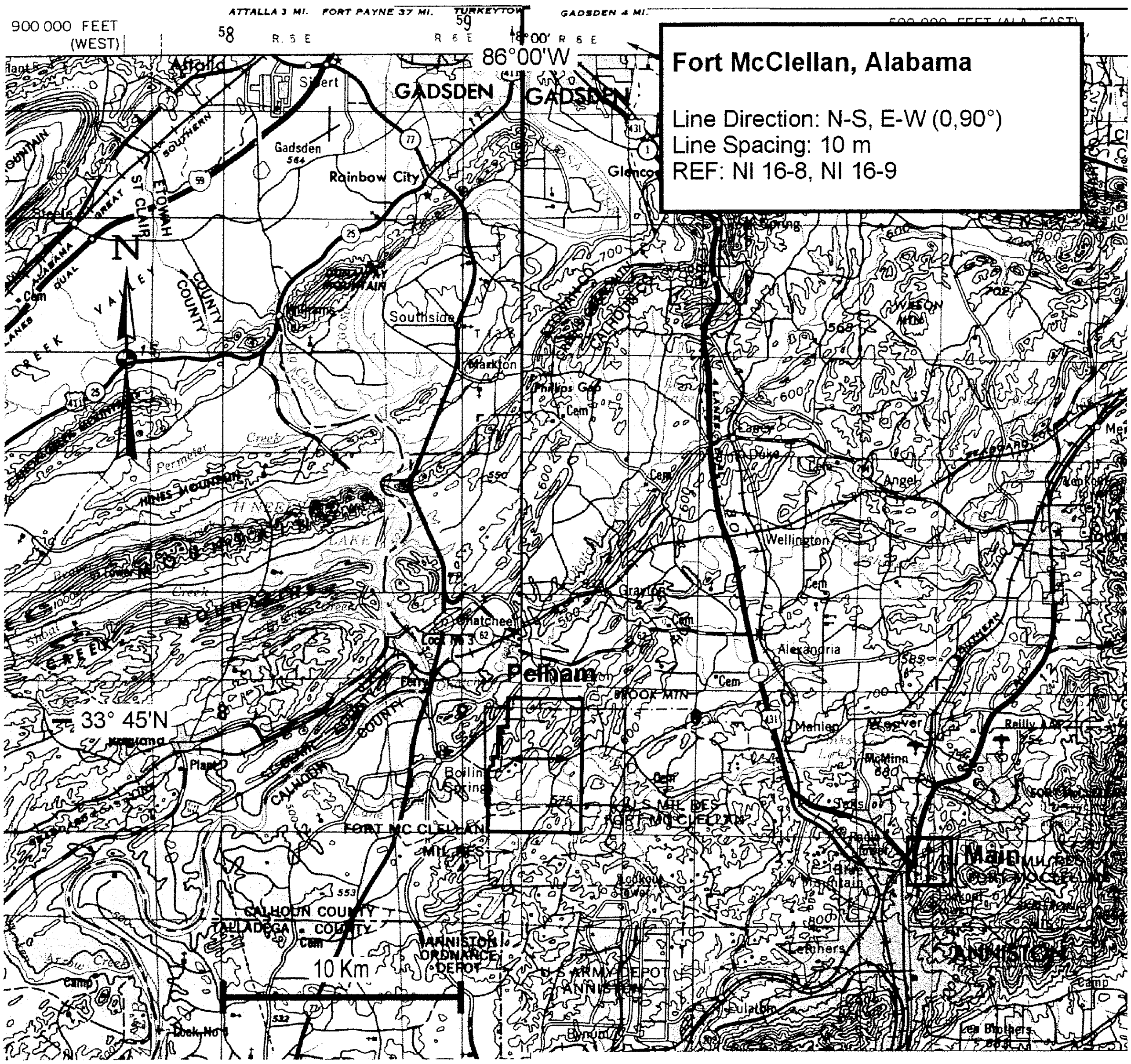


Figure 2, Main Post Flight Plan

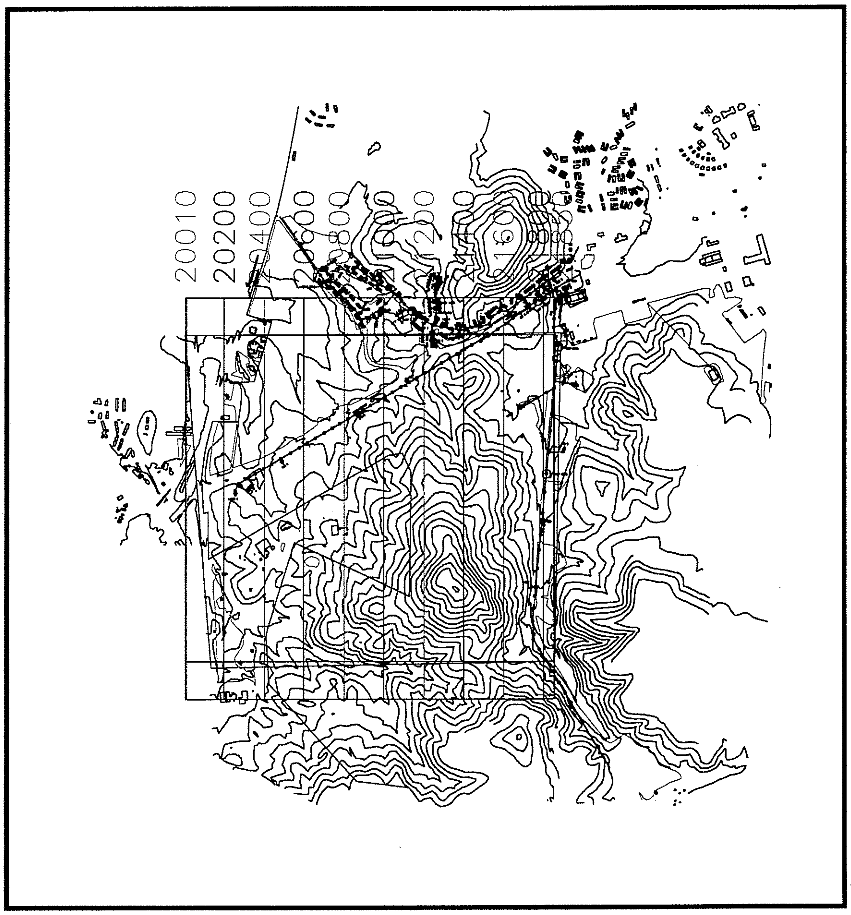
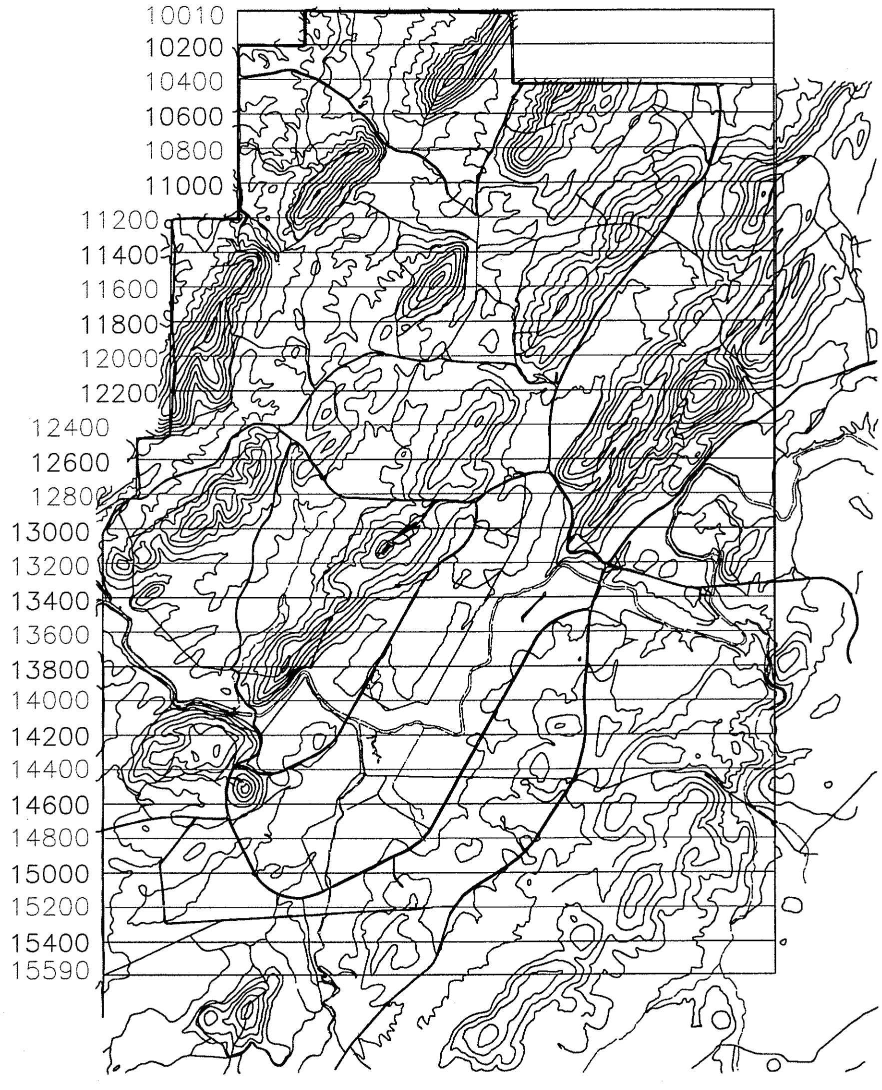


Figure 3, Pelham Range Flight Plan



in safety, quality and client service. The new company employs 300 staff worldwide, a large number of whom are highly experienced geophysicists, geologists, remote sensing specialists and field survey operators.

Fugro has conducted airborne gamma-ray spectrometry (AGS or radiometrics) since 1961. During this period we have performed work for military, government and private organizations for environmental and mineral industry work worldwide with both fixed-wing and helicopter aircraft.

During the last three years alone, Fugro has flown more than 700,000 line-km of fixed-wing and helicopter AGS surveys.

In 1997, Fugro conducted a helicopter-borne radiometric survey over a selected area of the Chicago lakefront as part of an environmental assessment project. The logistical and safety concerns of performing low-level geophysical survey operations over a built-up urban area were very similar in nature to the Fort McClellan project. The experience of Fugro in successfully dealing with these issues and in tailoring the radiometric processing to best suit the needs of this unique environment and application will be of direct benefit to the proposed project.

In 1998, the Canadian Department of National Defense selected Fugro to perform a helicopter-borne radiometric survey over selected areas in New Brunswick to locate missing radioactive sources. The high public interest in quickly locating these sources required extremely efficient and time-sensitive survey operations. This project was successful in locating a radioactive source of public interest in a Saint John area scrap yard.

The experiences detailed above coupled with the technical expertise of the Fugro personnel proposed for this radiometric survey, make Fugro uniquely qualified to meet the technical requirements of the proposed project.

2. DESCRIPTION OF AIRBORNE FLYOVER PRODUCTS AND EQUIPMENT

2.1. List of Personnel

The following personnel will be involved in carrying out this contract within the normal constraints of crew rotation and safety regulations. Fugro's senior personnel will be involved as needed throughout each phase of the contract.

Project Manager (office)	Douglas McConnell
Field Operations Manager (field)	Dave Miles
Pilot (field)	Macdonald Smith
Field Quality Controller (field)	Glen Meerburg
Electronics Engineer (field or office)	Don Ellis
Maintenance Engineer (field)	TBA
Instrument Operator (field)	Mick Drewit
Geophysical Data Processing (office)	Dak Darbha
Geophysical Data Interpretation (office)	Ruth Pritchard

Fugro has many other qualified individuals who may become involved at some stage in this contract. Curriculum vitae can be supplied as required/requested.

The proposed helicopter, pilot and engineer will be provided by Whisper Airlines, Inc. ("Whisper") under a subcontract agreement with Fugro Airborne Surveys.

2.1.1. Pilots Licenses

The survey pilots provided by Whisper all hold a valid commercial helicopter pilot license, applicable to the type of aircraft to be flown and can provide proof of this on demand to the contracting authority.

2.1.2. Maintenance Engineers

The maintenance engineers provided by Whisper all hold a valid license and can provide proof of this on demand to the contracting authority.

2.2. System Description

2.2.1. Aircraft

Fugro will fly the survey with a Eurocopter TwinStar AS355F1 twin engine turbine helicopter. This helicopter has the necessary range, flight duration and lift capabilities to efficiently fly this type of survey. All costs of the helicopter, including maintenance, fuel and fuel transportation will be the responsibility of Fugro.

The helicopter will be provided by Whisper Airlines, Inc.

2.2.2. Spectrometer

An Exploranium GR820 512-channel spectrometer with 33.4 liters (2048 cubic inches) of main downward detector crystal will be used. The 512-channel recording is necessary to provide the resolution of the low energy peaks from man-made radioactive sources. Additional processing based on spectral component analysis will be conducted post-survey to further improve the resolution in the regions of interest. No upward looking detectors will be provided since atmospheric backgrounds will be measured over a body of water. The spectrometer will be calibrated daily using cesium, uranium and thorium hand samples. One of the features of the GR820 is Automatic Gain Control based on monitoring of the thorium peak that does not require operator adjustment or maintaining the crystals at a constant temperature.

The maximum dead time for the main pulse height analyzer will not exceed 8 microseconds per pulse. The overall signal conditioning will yield a detector resolution better than 12% full width half maximum based on the 137Cs 662 keV peak.

The pulse height analysis system used will be sufficiently linear to ensure that for all peak energies between 137Cs 662 keV and 208T1 2614 keV, the relationship of energy to channel number, will remain acceptably constant.

The system will permit cosmic ray activity to be monitored. This will include all energies above 3000 keV.

The system will provide for the entire spectrum to be displayed, on a display screen, to facilitate energy calibration checks, and to assist in verifying system resolution.

2.2.3. Spectrometer Data Recording

The following data will be recorded digitally for each 1 second counting interval:

- the entire 512 channel spectrum from the main detector,
- the cosmic radiation monitor,
- the system dead-time to an accuracy of ± 0.1%.

The following windows, with limits given in keV, will be recorded for each 1-second counting interval:

Table 1, Data Recording of Windows

Element	Window (keV)
Potassium	1370 - 1570
Uranium	1660 - 1860
Thorium	2410 - 2810
Total Count	400 - 2810
Cesium-137	600 - 730
Low Energy	400 - 1370
Cobalt-60	1070 - 1410
Cosmic	3000 - ≥6000

2.2.4. Digital Recording and Configuration for the System

An RMS DGR-33 data acquisition system will be used in conjunction with an RMS GR-33 thermal graphics printer operating at a speed of 1.5 mm/sec for real-time analog chart presentation of the geophysical data (see Table 2, Airborne chart Specifications). Data will be simultaneously recorded on 100 mb disk or 50 mb flash cards at a repetition rate of 0.1 sec for post-flight computer processing. The Spectrometer is sampled at a 1.0 second repetition rate. Table 3 gives the recording specifications.

Table 2, Airborne Chart Specifications

Airborne Chart Specifications
Time
Total Count
Radar Altimeter
Barometric Altimeter
GPS Altitude
Cesium-137
Low Energy Window (dominated by man-made counts (400 to 1370 keV)
Cobalt-60

Table 3, Recording Specifications

Airborne (Digital)	Minimum Interval or Sensitivity	Sample Frequency
1. Radar altitude	1.5 meters (5 feet)	1 / sec
2. Pressure altitude	6 meters (20 feet)	1 / sec
3. Navigation output	5 meters (16 feet)	1 / sec
4. Gamma ray Spectrometer	1 count	1 / sec
5. Temperature	1 deg C.	1 / sec

2.2.5. Radar Altimeter

A Sperry AA300 series radio altimeter system, with digital output, will record the ground clearance to an accuracy of approximately 1 meter. The minimum range of the altimeter will be 0 - 2,500 feet (750 meters) with minimum accuracy of 1%.

2.2.6. *Barometric Altimeter*

A Motorola MPX4115AP pressure sensor will record air pressure and temperature, which can be converted to elevation above sea level, in units of height.

The altimeters will be interfaced to the data acquisition system with an output repetition rate of 0.1 second. Recording will be in both digital and analog form.

Additionally, the absolute elevation above sea level will be measured and recorded using the real-time differential GPS navigation.

2.2.7. *Electronic Navigation (GPS)*

A specialized GPS system will provide in-flight navigation control. The system determines the absolute position of the helicopter in three dimensions by monitoring range information of forty-eight orbiting satellites. Dual frequency Ashtech GG24 GPS receivers are used to monitor both the NAVSTAR GPS system and the GLONASS GPS system. The Ashtech GG24 uses advanced methods to blend NAVSTAR and GLONASS signals into a single position. The GG24 uses all available satellites from both systems to increase the overall accuracy of the navigation. This is extremely beneficial in obstructed operating environments. The system will yield a positional accuracy of better than 15 meters with a probability of 95% (Circular Error of Probability (CEP) of 50% is 7 meters). The positional information will be digitally recorded on the data acquisition system for subsequent flight path correction. Post-flight satellite corrections will result in positional accuracy of better than 5 meters.

A Racal real time differential system will be used to provide RTCM corrections directly to the Ashtech GG24 GPS board. The Racal system receives correctional information via a radio link from a geosynchronous satellite over the Equator. This system will yield a positional accuracy of better than 5 meters (approximately 2 to 3 meters) in real time.

The corrected positional information, including the GPS height above mean sea level, will be digitally recorded on the data acquisition system.

The recording of the electronic navigation system will be interfaced with the geophysical data acquisition system in real time.

The GPS system has the capability to record and store all parameters to permit post flight differential correction of the GPS navigational data.

2.2.8. *Flight Path Video Camera*

A Panasonic VHS color video camera and cassette recorder (i.e., closed circuit television system) operating in the NTSC format will record the flight path terrain passing beneath the helicopter. Time and fiducials will be superimposed on the video recording. The video camera will show time stamp updates displayed on the video image no less than ten (10) times per second. The time stamp numbers will show the update of each tenth of a second as part of the complete number. The displayed time stamp numbers will be in units of seconds after midnight UTC. These time numbers will be synchronized and identical to the time marks recorded by the chart records. These time stamps will be clearly visible. The combined navigation system (electronic and video) will be capable of providing the required accuracy over the entire survey area.

2.2.9. GPS Base Station

A system which is capable of operating with the GPS time standard to verify/correct the internal clock will be utilized. The timing clock of the ground monitoring station will also be synchronized with GPS time provided by the GPS base station.

2.3. Safety

2.3.1. Installation

Installation of the survey equipment in the helicopter will be done by qualified Fugro personnel. An airworthiness approval certificate is maintained for all installations.

2.3.2. Operation Guidelines

The following are operational guidelines for helicopter-borne geophysical surveying in areas with altitudes up to 3000 meters ASL. Fugro Airborne Surveys maintains comprehensive safety documentation for airborne operations and will comply with the requirements of The IT Group.

2.3.3. Aircraft Power Margin

1. The power-in-hand of the aircraft is a critical part of safety at any time, but becomes additionally important when operating near the aircraft limitations. Every effort must be made to maximize the power margin. Specific requirements:

2. No unnecessary equipment is to be carried aboard the aircraft at any time.

3. The aircraft VNE chart for density/altitude variations must be reviewed by the pilot prior to surveying in the region. Indicated airspeed must always remain comfortably below the VNE for the prevailing conditions.

4. All training and testing flights will be confined to areas of lower elevation and/or flat terrain. Operational bases will be established as close to the survey areas as is logistically feasible. On board fuel load must be carefully reviewed between pilot and survey crew prior to each flight to ensure a reasonable power margin is maintained for each survey flight.

2.3.4. Pilot Experience and Acclimatization:

1. A minimum of 3,000 hours total helicopter time is mandatory. A minimum of 500 hours helicopter time on-type is mandatory.

2. The pilot must be adequately rested before any flight.

2.3.5. Flight Planning and Search and Rescue

1. Flight plans are mandatory with ground crew or flight services prior to any flight.

2. No deviation from the flight plan is permitted mid-flight without radio confirmation with ground crew.

3. The search and rescue procedure must be reviewed and clearly understood by all personnel prior to survey flying in each survey block.

4. Emergency contact information will be procured and made available to the local aviation ground crews responsible for S&R.

2.3.6. Vehicles

1. Vehicles to be used must be equipped with a first aid kit, fire extinguisher, and suitable equipment for the weather and conditions (i.e., water, warm clothing, shovel, etc.)

2. All cargo must be properly secured.

3. Seatbelts are mandatory.

2.3.7. Additional Requirements

1. A safety meeting, involving all crew, to review the operational procedure must be completed prior to any survey flying from each base of operations. Any significant deviations from the operational safety plan must be reported to the Dighem Operations Manager prior to commencement of survey flying.

2. Helmets are mandatory for pilot and operator.

3. Protective footwear is mandatory (i.e. work boots or the like).

4. Reliable radio communications between the helicopter and a ground station is mandatory. All survey personnel must be fully trained in the operation of the radio equipment.

5. Excessive alcohol is not permitted for flight crew. Excessive is defined as two drinks in the previous twenty-four hours. No alcohol consumption is permitted in the twelve hours previous to flying.

2.4. Plan of Action

The survey equipment and personnel will mobilize to Orlando, Florida for installation of the geophysical equipment into the TwinStar helicopter supplied by Whisper Airlines, Inc. within the aircraft maintenance facilities at the hangar at the airport. The installation of the equipment in the helicopter will take one day.

Following successful installation the equipment, personnel and aircraft for the project will mobilize to Anniston to establish the field base of operations. At some convenient point during the mobilization, the over-water background tests will be performed. The base of operations will be located at the Anniston Airport. Once the base of operations has been established, the GPS base-station will be set-up and tested.

The crew will meet with Major Sellers, AL-ARNG for a briefing on communications and Range Control procedures for Pelham Range.

Following successful completion of the test procedures, the survey production flights will begin. Refueling will be conducted at the airport. Production flying will continue on a daily basis as weather permits starting with Pelham Range. Pelham will be approached from the north and west avoiding the restricted flying area over the Army Depot. Flight planning will be conducted on a daily basis at the base of operations. The helicopter crew will monitor SINGAR 3490. Flight plans will be filed daily with the Range Control. Range control will be provided with a flight plan showing the approximate location of each days flying.

The main base area flying will be done on a Friday or during Thanksgiving Holidays so as not to interfere with the USACE UXO clearance or civilian uses of the community center and museum. Flying of the main base will be co-ordinated with the TF.

All data will be downloaded and verified on a daily basis at the Fugro field-processing center established at the base of operations. The field quality controller will have primary responsibility for quality control of the field data, including calling reflights. The Technical Authority may review the field data and provide written approvals or requests in a timely fashion. In the event that a reflight is requested by the Technical Authority, this will be communicated to the field quality controller promptly to allow for proper flight planning and the set-up of logistical requirements. The Alabama Radiation Control will be informed in advance of the flight dates for the Rideout field, community center and museum areas and the data will be made available within 48 hours of flying.

2.4.1. Traverse lines

A special effort will be made to ensure that all adjacent traverses are flown at a comparable ground speed and mean terrain clearance regardless of the direction of flight.
Tolerances (traverse lines)
No flight lines may intersect a neighboring flight line.

2.4.2. Survey Speed

For the proposed 10-meter altitude, the survey speed would be restricted to 40 to 60 knots for safety and to ensure sufficient detail when sampling at 1 sample/sec so that there are no along-line gaps in the coverage.

2.5. Responsibilities of Fugro

For the field operations, Fugro will be responsible for the following:

1. The supply, maintenance and operation of a suitable helicopter, suitably equipped and FAA approved to carry out this particular type of survey, including the supply of required fuel, oil and lubricants.

2. Compliance with all provisions of the National Transportation Act and directives, orders, rules and or regulations pursuant to those Acts.

3. All technical equipment and instrumentation, with spares, necessary to execute the airborne geophysical survey in an expeditious manner.

4. Provision of the necessary qualified personnel and their office accommodation required to complete the project work.

5. Transportation, mobilization, demobilization, and subsistence, while in transit, as well as shipping between company headquarters and the respective points of arrival and departure of the aircraft, personnel, technical equipment, materials and supplies necessary for the effective performance of the work, including aviation fuel and lubricants.

6. Arranging and paying for its own accommodation, meals and incidental expenses such as airport fees.

2.6. Compilation of the Survey Data

Fugro maintains a modern, efficient processing center that is capable of the required processing and preparation of the final products. Final digital data will be provided in the standard archive tape format. Positional data will be in latitudes and longitudes in decimal degrees and NAD83 Alabama State Plane east zone, (feet). Fugro will establish a system for providing such data expeditiously when requested.

2.6.1. Base Maps

The flight path is derived from post-processed GPS navigation data at 0.5-second intervals and plotted on the topographic base maps. The base maps are produced from digital planimetry supplied by IT.

2.6.2. Flight Path Format

Each flight line will have a unique line number with the segment number incorporated as the last digit of the line number.

The flight lines with their respective fiducial number and identification will be plotted on stable base material separate from the contour / color information.

2.6.3. Digital Data

Digital line data can be supplied in ASCII XYZ format or binary formats such as Geosoft GDB or GBN. Contours and other line-work can be supplied in AutoCAD (dxf, dgn or DWG) format. Gridded data can be supplied as Geosoft grids, located or geo-referenced tiffs or a variety of image formats such as jpeg or bitmap. Complete images of map products can be provided as HPGLII or PostScript plotter ready files or as image formats such as bitmap, tiff or jpeg, which can be imported into AutoCAD or GIS (ESRI) format. Other formats may be provided as specified by IT.

2.6.4. Gamma Ray Processing

Fugro's radiometric processing rigorously for natural radiation potassium, uranium and thorium follows the IAEA Technical Report 323 specifications. Standard corrections as detailed in that report will be applied during processing of the radiometric data.

The specialized processing for man-made radionuclides to produce maps to locate $cesium^{137}$ and $cobalt^{60}$ sources is discussed below. All units for radiometric products will be Special units unless requested in SI (or International) units by IT.

Cosmic, Radon and Aircraft Background

These backgrounds will be determined from flights over a body of water.

Calculation of Exposure Rate

The exposure rate (E) in uR/hr from natural background radiation will be calculated from the ground concentration of K%, equivalent U ppm and equivalent Th ppm. This is used as an interpretation tool during the evaluation of the $cesium^{137}$ and $cobalt^{60}$ parameter maps. The exposure rate is calculated using the expression:

$$E=1.505 \times K + 0.653 \times Eu + 0.287 \times eTh$$

Man-made Radiation and 512 Channel Processing

Man-made sources of $cesium^{137}$ and $cobalt^{60}$ isotopes are the target of the survey. Processing of the entire 512-channel spectrum will be employed to enhance spectral peaks from these sources. Background removal, filtering, ratios of selected energy windows and/or spectral component analysis are techniques that can be used to enhance anomalous peaks due to man-made radionuclides.

The spectral component technique can be used to reduce the statistical error associated with each measurement point (one second of flying time) which results in improved precision and accuracy. This method effectively improves the resolution and the signal to noise characteristics of the data, which equates to increasing the number of channels or detector volume. The Hovgaard and Grasty NASVD method[1] can be used directly to improve the $cesium^{137}$ window, or a more specialized approach can be used. In the specific case of improving the resolution of the $cesium^{137}$ and $cobalt^{60}$ peaks, the principle components of the 512 channel spectrum will be determined and examined to identify components that contain the $cesium^{137}$ and $cobalt^{60}$ peaks and those containing noise, natural radiation and background radiation. The components containing the contributions from $cesium^{137}$ and $cobalt^{60}$ will be re-windowed to produce improved channels for $cesium^{137}$ and $cobalt^{60}$ isotopes. These channels can be gridded or analyzed as profile data.

Background removal can be applied if a typical background spectrum can be defined for the survey area from flights over a non-contaminated location with natural radioactive properties similar to the site for investigation. The average background spectrum is removed from the survey data. This helps to isolate peaks from man-made contamination that are localized within the survey area.

A ratio of the low energy portion of the spectrum (400 - 1370 keV) to the high energy portion of the spectrum (1370 - 2780 keV) helps to isolate gamma-rays from man-made radionuclides. Terrestrial radiation dominates the high-energy window. A ratio of the two windows yields useful information regarding man-made sources of radiation and helps to isolate sources of $cesium^{137}$ and $cobalt^{60}$.

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1 Hovgaard, J. and Grasty, R. L.; "Reducing statistical noise in airborne gamma-ray data through spectral component analysis"; in Proceeding of Exploration 97, 1997; p.753-764

Hovgaard, J. ; "A new processing technique for airborne gamma-ray data (noise adjusted single value decomposition); Am. Nucl. Soc. Symp. on Emergency Preparedness and Response; San Francisco 1997.

These methods will be applied to the data and evaluated to determine which methods produce the best results in identifying areas with anomalous $cesium^{137}$ and $cobalt^{60}$ levels with respect to natural varying radiation levels. The 512 channel data can be extracted according to any window or windows after processing in the 512-channel domain.

2.6.5. Gridding and Contouring

The geophysical data are interpolated onto a regular grid using a modified Akima spline technique or minimum curvature gridding will be employed. Fugro will employ the method that best represents the data. The resulting grid is suitable for generating contour maps of excellent quality. The grid cell size will be one quarter of the line spacing.

Interpolating the grid down to the pixel size produces color maps. The parameter is then incremented with respect to specific amplitude ranges to provide color "contour" maps.

2.6.6. Technical Inspection of Final Compilation

Fugro will submit for approval before preparation of the final products, one (1) copy of each of the following for each survey area:

- All gamma ray spectrometer maps at a scale of 1:10,000.
- The flight line maps at a scale of 1:10,000.
- The report and interpretation map

2.7. Products to be delivered by Fugro

2.7.1. Color Maps

Three (3) sets of the following color maps at a scale of 1:10,000. A base map will be superimposed on each map to relate the airborne data to ground location.

$Cesium^{137}$ (counts or pCi/g)
$Cobalt^{60}$ (counts or pCi/g)
Exposure rate (uR/hr)
Ratio map (low energy to high energy windows)

2.7.2. Digital Data

The final maps will be archived on a suitable medium such as a CD. Vector information will be in *.dxf format, and raster information will be in geo-referenced tiff or ArcView binary raster format (.flt and *.hdr). The digital data will be delivered as Geosoft binary data base files containing the 512 channel data and ASCII XYZ files containing location information but only the windowed radiometric data including: $Cesium^{137}$, $Cobalt^{60}$, K, Th, U, Exposure rate, ratios of the natural radiation parameters (U/Th, Th/K, U/Th) and ratio of high energy to low energy portions of the spectrum.

2.7.3. *Project Report*

The Project Manager will prepare three copies of the project report. This report will include:

- Maps showing the results of the analysis to identify locations of anomalous activity of cesium^{137} and cobalt^{60} will be included with the report. Anomalous areas selected by a geophysicist will be identified as annotated symbols on the base maps.
- A description of the field operations including a list of the dates of the survey, the flight numbers, the personnel, the aircraft and the instruments.
- The technical specifications of the survey, flying height, line spacing, etc. and a list of the end products of the survey.
- Documentation of the format of the digital data recorded on the CD / tape.

A draft copy of the Project Report will be submitted to the Project Leader and approved by the Scientific Authority prior to its finalization.

2.7.4. *Chart Records and Video-Cassettes*

All annotated chart records, films or videocassettes will be delivered to the Project Leader.

3. DATA QUALITY OBJECTIVES

3.1. Field Quality Control

Fugro will provide sufficient verification information to establish the integrity of the digital data. The system has the capability to perform the following items:

1. The digital data tapes will be verified on a daily basis with an in-field system to prevent unnecessary reflights if faulty recording has taken place.
2. The digital verification system will be capable of plotting the recorded values back at scales suitable for detecting any problems and to ensure that all data are within specifications.
3. The system will be capable of calculating differentially corrected GPS flight path and differentially corrected GPS altitude. The system will also be capable of plotting the navigation data in true x-y format and produce contour plots of the gridded GPS altitude data.
4. After every day's flying the contents of the day's production of digital data and videos will be verified using the verification system.
5. The flight path derived from electronic navigation (differentially corrected using the base station GPS unit) will be verified by comparison with navigator's fiducial and picked points utilizing the color video data as well as through the generation of speed check plots.

The following list details the standard data quality checks that are performed by the field geophysicist during the course of data acquisition:

1. Check raw digital flight file for proper sampling rates and valid data strings.
2. Load the raw data file into a flight database format. Verify the channel statistics.
3. Review and annotate flight analogs to verify data quality.
4. View selected data channels, particularly altimeter, in profile form.
5. Check base and mobile GPS files for completeness and valid data sampling rates.
6. Post-process the GPS data and generate raw and corrected flight path maps to compare with intended flight lines. Use program DBGPSCOR to calculate the percentage of corrected positional data to ensure that full coverage exists for each survey line. Check for gaps and poorly flown sections in the flight path.
7. Verify video status, if possible, and ensure proper labeling (digital and external label) with flight number, date and job number.

A dedicated PC-based field computer workstation developed by Fugro will be used at the technical base in the field for purposes of displaying geophysical data for quality control, calculating and displaying the navigation, producing preliminary maps and copying/verifying the digital data.

3.2. Field procedures to ensure data integrity

To facilitate inspections, which will be carried out in the field after each day of flying, the field data quality controller will maintain an up-to-date log of the survey progress and production. A list of planned re-flights with annotations of flight data quality with specific details on any problems, which would potentially have adverse effects on data quality.

The field quality controller will demonstrate that all survey calibrations have been completed as required according to specifications, that all digital flight, video records, flight analog charts are systematically annotated, and verified to be complete.

The field quality controller will demonstrate that all airborne radiometric data collected since the start of the survey have been evaluated, that all data which do not meet specifications have been identified and recorded and available for review.

3.2.1. Gamma-Ray Spectrometer Calibration

Prior to commencing the survey, the system will be calibrated on an approved set of calibration pads to enable stripping ratios to be determined. At the survey site, or at a convenient location during mobilization, a calibration will be carried out with the detectors installed in the survey aircraft. At this time, a series of test flights will be conducted to determine the attenuation coefficients for the system. The flights will be made at intervals of 25 meters from 75 - 200 meters. Backgrounds at the same altitude will also be made over a body of water. The results from these test flights will be used to determine the attenuation coefficients. No cosmic calibration flights will be conducted since the cosmic ray background will be measured over a body of water.

To calibrate the system sensitivities to cesium^{137} and cobalt^{60}, a test range containing known quantities of contamination is required. If such a site is available in the vicinity of Anniston, Alabama, arrangements can be made between IT and Fugro to conduct the sensitivity calibration. Additionally, a clean site with similar background characteristics to the investigation site will be overflown to determine cesium^{137} and cobalt^{60} backgrounds. An average 512-channel spectrum from the background test can be subtracted from the survey data to isolate the peaks of interest.

3.2.2. Gamma-Ray Spectrometer Verification Tests

During the course of the survey, tests will be carried out periodically to ensure that the spectrometry system is functioning correctly. These include weekly and daily tests.

The energy resolution will be confirmed using the 662 keV photopeak of 137Cs weekly. The total system resolution will never exceed 12%. If there is a substantial change in the resolution, a post season re-calibration will be conducted.

Each day, Cesium, Thorium and Uranium source tests will be done. These tests will confirm the stability of the system sensitivity and stripping ratios. Sources will be placed at precisely repeatable locations for the tests. Counting time will be sufficient to obtain 10,000 counts in each of the K, U, and Th windows. A background count with no sources will also be recorded. The background corrected thorium window count rates will not differ by more than 5% from the average of all previous measurements.

3.2.3. *Precipitation Limitations*

Since varying ground moisture conditions affect the airborne radioactivity measurements, no radiometric survey flying will be undertaken during or for 3 hours after measurable precipitation. In the event of heavy precipitation yielding more than 2 centimeters of snow or ground soaking rain, flying will be suspended for at least 12 hours after the end of the precipitation or until soil returns to its "normal" moisture level.

3.2.4. *Radar altimeter*

Pre- and post survey calibration records will be submitted for the radar altimeter, as determined from flights at barometric altitudes of 15', 30', 50', 100', 200', 300', 400' and 500' above the base air strip, flat level area of known height or large lake.

This calibration will be performed at the start and at the end of the survey project. A re-calibration will be performed if any one of the heights measuring equipment (including components of the GPS system) is changed.

3.2.5. *Electronic navigation*

A calibration check on the accuracy of the electronic navigation system will be carried out prior to the commencement of survey.

3.2.6. *Daily calibration*

All recording and time synchronization systems will be calibrated daily during each flight. The data recorded during these calibrations will be part of the raw data. True atmospheric pressure will be available for the entire survey. The pressure will be recorded in flight. External air temperature for each flight line will be recorded in flight.

3.2.7. *Ground Calibration*

The radiometric system and ancillary equipment will be operating for one hour prior to survey flying to allow for sufficient warm-up of the equipment. All of these ground calibrations will be completed before commencement of each flight.

3.3. *Technical Inspection*

Work will be performed to the satisfaction and subject to the acceptance of the Scientific Authority. Copies of the Technical Specifications (Section B) will be in the possession of the Field Operations Manager during the field operations and the Chief Compiler during the compilation phase.

The Scientific Authority will be available for consultation on technical problems that may arise during the course of the field operations, and have the authority to approve changes to the Technical Specifications that will not affect the general scope of the work.

Any changes entailing reductions or additional charges to IT will be referred to the Project Manager.

Notwithstanding the foregoing provisions, Fugro will be solely responsible for the quality of the work.

The Project Manager will ensure that adequate quality control procedures are in place and are being strictly followed.

The Project Manager will sign off each report and each product submitted for inspection, thereby certifying that the work was carried out in accordance with the Technical Specifications.

3.4. Verification of In-Flight Data

All digital data will be verified after each flight by a suitable process using equipment at the operation-flying base. Fugro will describe in detail the process intended to be used.

3.5. Incomplete Survey Data

Fugro will re-survey, lines or segments of lines for which the required digital data are missing or are not in accordance with the Technical Specifications. Isolated errors or spikes and short, non-sequential gaps consisting of a few points that can be corrected by interpolation may be provided.

3.6. Reflights - Lost Data

Digital data which are lost in transit or in processing (if no digital copies have been made) or are rejected by the Scientific Authority will be re-acquired under the same conditions including flying services, at no additional cost. Any re-flights to replace lost digital data will be at Fugro's sole expense.

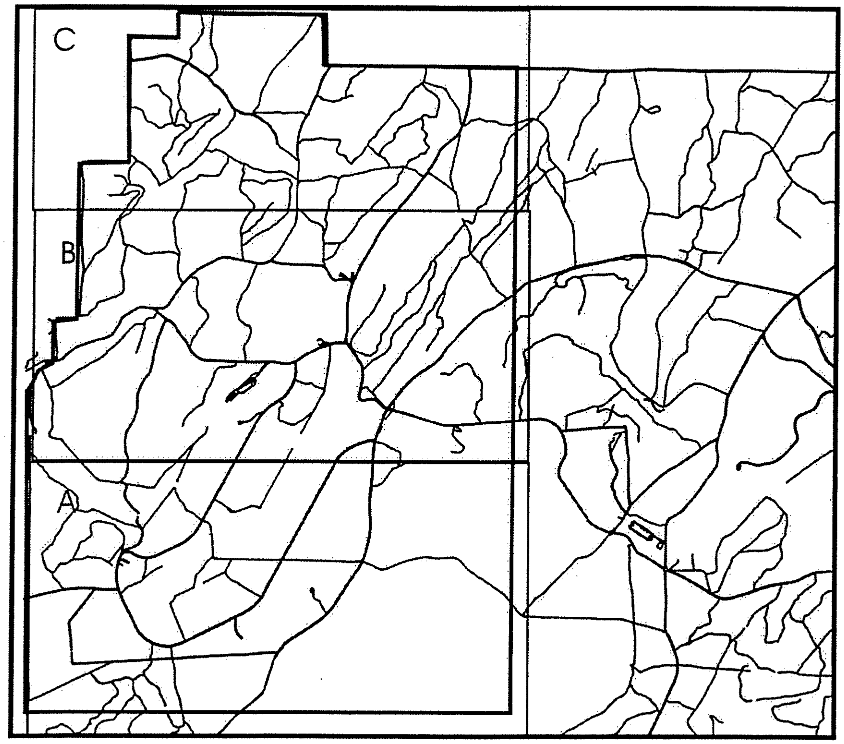
4. SCHEDULE

Flying will commence during the week of November 13th, 2000. Flying will extend during daylight hours for seven days a week. Estimated completion is December 15th. The flying will consist of 4 or 5, 2-hour flights over the survey area per day, with ferry flights back and forth to the Anniston airport for re-fueling and rest.

The following outline map of the northwest corner of Pelham Range (Figure 4) shows rectangles reflecting the approximate locations of the flying during specific time periods. These locations are tentative and subject to change due to unforeseen logistical or weather conditions. Rectangle A will be the area of flying Starting November 13th to about November 30th. During this period the Main Post area will be flown during the week of November 19, but is estimated to only take 2 or 3 days. Rectangle B will be flown from December 1st to December 8th and rectangle B from December 9th to December 15th.

Figure 4

Pelham Flying Schedule



Appendix A Job Safety Analysis

The greatest potential hazards to airborne geophysical survey operations with low level flying are problems due to:

- fuel errors
- engine failure
- obstacles
- pilot error
- deteriorating weather

With regard to pilot error, conditions should be continually reassessed by the pilot whilst flying. By continually mentally revising potential hazard situations and rehearsing the required response action. In this JSA, the Response Visualization Process is referred to as RVP.

The most effective method for minimizing accidents or near misses is graphic training to increase awareness, knowing the capabilities of the aircraft with respect to local conditions and terrain, and being prepared for the unexpected using RVP and development and knowledge of the Job Emergency Response.

Contract: Job:	Team Members: Reviewed By:	Date: Date:

Step	Description of Task	Potential Incidents and Hazards	Precautions to Minimize/Eliminate Risk	Responsible Person
1	Mobilization	1.1 Manual handling injury from lifting equipment	*1.1.1 Pack smaller size loads if possible* *1.1.2 Utilize mechanical aids where possible* *1.1.3 Use team lifts where no aid available* *1.1.4 Use correct lifting techniques*	All
		1.2 Inadequate modes of transfer to site	*1.2.1 Pre-planning to evaluate available transport and make best selection* *1.2.2 Preferred mode of transfer -International Standard airline -company aircraft*	Ops Mgr/CL/Tech
2	Establish camp and communication facilities	2.1 Electric Shock	*2.1.1. Wear insulated shoes* *2.1.2 Stand in dry area* *2.1.3 Keep leads and plugs dry* *2.1.4 Inspect all leads, cables, plugs etc daily for wear or damage* *2.1.5 Disconnect mains power while connecting equipment* *2.1.6 Ensure sufficient distance between electrical components to avoid arcing or voltage differences*	All
		2.2 Fall from height	*2.2.1 Use experienced local staff, ie hotel engineer* *2.2.2 Use ladder, inspect before use* *2.2.3 Place ladder with secure footing and support* *2.2.4 Choose safest access point to installation point for aerial*	Team Leader / Operator
		2.3 Manual handling injury	*As 1.1.1* *As 1.1.2* *As 1.1.3* *As 1.1.4*	All

Step	Description of Task	Potential Incidents and Hazards	Precautions to Minimize/Eliminate Risk	Responsible Person
		2.4 Snake / Insect bite	*2.4.1 Wear long pants* *2.4.2 Fully enclosed shoes to be worn with socks* *2.4.3 Check area, using paths wherever possible* *2.4.4 Avoid long grass or overhanging branches* *2.4.5 Walk noisily* *2.4.6 Avoid outside areas between dusk and dawn* *2.4.7 Use correct strength DEET based insect repellent* *2.4.8 Comply with specialist medical advice on anti-malarial drug use*	All
		2.5 Contaminated fuel	*2.5.1 Test for water with syringe or paste* *2.5.2 Use go / no go filter on any drum fuel and paste test* *2.5.3 Check aircraft fuel, drain test on each tank* *2.5.4 Mechanical filter to remove any particulate contamination ie rust*	Pilot
		2.6 Fire or explosion	*2.6.1 Use correct earthing procedure – aircraft to truck, truck to ground, refueller to ground, aircraft to ground, nozzle to aircraft* *2.6.2 Filled and checked extinguisher available at the refueling point* *2.6.3 Only airport personnel trained in refueling and use of extinguisher are to refuel aircraft*	Pilot
		2.7 Fuel spillage	*2.7.1 Authorized airport staff to refuel aircraft* *2.7.2 Above person to avoid distraction and take care while refueling aircraft*	Pilot

Step	Description of Task	Potential Incidents and Hazards	Precautions to Minimize/Eliminate Risk	Responsible Person
3	Fly Survey Reconnaissance	3.1 Entering restricted airspace	*3.1.1 Identify restricted airspace by studying charts and maps and contacting local authorities* *3.1.2 Obtain necessary permits and comply with all local controls and requirements*	Pilot / Operator
		3.2 Collision with powerlines, towers, etc	*3.2.1 Check maps and visually identify all height hazards, verify all sighted hazards are recorded on the maps* *3.2.2 Mark additional sightings on map* *3.2.3 Log way points on GPS*	Pilot / Op'tors
		3.3 Poor weather / visibility	*3.3.1 Check local forecasts and avoid storm cells* *3.3.2 Adjust flight operations accordingly* *3.3.3 Any team member may call for the abandonment of a flight*	Pilot / Team Leader All
		3.4 Collision with ground in steep or mountainous terrain	*3.4.1 Carefully check maps and identify high points and hazards* *3.4.2 Plan to do the most difficult terrain in optimal weather conditions regardless of sequence* *3.4.3 Note minimum safe elevations* *3.4.4 Any crew member may call for flight to be abandoned if in their opinion conditions warrant* *No debate on the issue is to take place until the aircraft is on the ground*	Pilot All
		3.5 Collision with another aircraft	*3.5.1 Maintain contact with air traffic control, and follow instructions* *3.5.2 Monitor radio traffic* *3.5.3 Maintain visual observation of area*	Pilot / Crew
		3.6 Pilot illness or incapacity	*3.6.1 Pre-employment and periodical medical examinations of pilot* *3.6.2 Compliance by pilot and crew with alcohol policy and legislative requirements* *3.6.3 Daily pre-flight checks of pilot by Team Leader* *3.6.4 Pilot to self report illness or incapacity and* ***NOT FLY UNLESS FIT***	Pilot All Team Leader Pilot

Step	Description of Task	Potential Incidents and Hazards	Precautions to Minimize/Eliminate Risk	Responsible Person
		3.7 Aircraft failure	*3.7.1 AS IN SECTION 5*	
		3.8 Ditching into sea	*3.8.1 AS IN SECTION 5*	
4	Living and working in camp	4.1 Inadequate local facilities and / or accommodation	*4.1.1 Select most suitable, adequate, clean accommodation*	All
			4.1.2 Eat at identified safe, clean location or provide a cook	
			4.1.3 Avoid mosquito and other insect bites by use of DEET repellent, covered clothing, nets and avoiding dawn / dusk exposure	
			4.1.4 Crew comfort to be given high consideration, ie air conditioning preferable, fans otherwise, accommodation clean and serviced	Team Leader
5	Daily Survey flying	5.1 Forced landing	*5.1.1 Pre flight planning and identification of alternate landing sites and flight routes if weather changes*	Pilot
			5.1.2 Adequate maintenance and preparation of aircraft	Engineers
			5.1.3 Pre flight checks correctly carried out	Pilot
			5.1.4 Calculation and carrying of correct fuel reserves for flight and emergency	
		5.2 Engine Failure	*5.2.1 Knowledge of emergency landing areas*	Pilot
			5.2.2 Knowledge of direction to turn to increase ground clearance	
			5.2.3 Pre flight engine checks	
			5.2.4 RVP during flight	
			5.2.5 Awareness and use of INMARSAT emergency button	
			5.2.6 Operator to also monitor key gauges and / or own instrumentation for any abnormalities that may indicate engine irregularities or impending failure	Operator
		5.3 Engine or electrical fire	*5.3.1 As in 5.2.1 to 5.2.6*	
			5.3.2 Knowledge of use fire extinguishing system	Pilot / Operator
			5.3.3 Trained and practiced in fire emergency drill	Pilot
			5.3.4 Assess consequences of electrical fire	
			5.3.5 Ensure additional power requirements to operate survey equipment DO NOT DECREASE SAFETY OF AIRCRAFT POWER SUPPLY SYSTEMS	

Step	Description of Task	Potential Incidents and Hazards	Precautions to Minimize/Eliminate Risk	Responsible Person
		5.4 Aircraft hydraulics failure	*5.4.1 Daily pre flight reservoir checks* *5.4.2 Daily checks of gas cylinders in alternate system*	Pilot
		5.5 Increased hazards of low level flying	*5.5.1 Use maps marked up on reconnaissance flight* *5.5.2 Set altimeter alarms and GPS Way Points and alarms or warning systems* *5.5.3 Operator to verbally remind pilot of approaching hazards*	Pilot Operator
		5.6 Run out of fuel – forced landing	*5.6.1 Pre flight fuel calculations and checks and flight plan checks* *5.6.2 As in 5.2.1 to 5.2.6*	Pilot
		5.7 Down-draft due to turbulence associated with low level flying	*5.7.1 Knowledge of "danger areas", eg ridges, cliffs etc as determined from the reconnaissance flight*	
		5.8 Turbulence generally	*5.8.1 Seat belts to be worn at all times when seated*	Operator
		5.9 Turbulence when deploying or retrieving bird	*5.9 Operator to wear helmet at all times*	
6	Conducting SAR for missing aircraft	6.1 SAR not initiated in a timely manner	*6.1.1 Set SAR time and strictly adhere to the time* *6.1.2 Activate response at specified time* *6.1.3 Return early rather than exceed SAR time*	Pilot / Team Leader Pilot
		6.2 Lack of external response for SAR	*6.2.1 Utilize Company resources wherever possible* *6.2.2 Develop and maintain relationships with other operators for mutual aid during SAR*	
		6.3 Aircraft congestion during SAR	*6.3.1 Maintain communication with all parties involved in SAR*	Team Leader
		6.4 Local authorities lack experience handling SAR	*6.4.1 Use own resources, systems, contacts* *6.4.2 Make Emergency Response Plan as independent of local authorities as possible, while complying with local laws*	Tech / Ops Field Team

Step	Description of Task	Potential Incidents and Hazards	Precautions to Minimize/Eliminate Risk	Responsible Person
		6.5 Access to accident site	*6.5.1 Use local knowledge and support*	Team Leader
		6.6 Inadequate local medivac response	*6.6.1 Have two crew members in each operational unit trained in first aid*	All teams
			6.6.2 Take advice from EVAC Provider (IMAN/SOS) on appropriate action and follow that advice	Team Leader
		6.7 Inadequate local facilities	*6.7.1 Take advice from SOS/IMAN* *6.7.2 Medivac to nearest major approved location usually Singapore or Australia at earliest opportunity*	Team Leader
		6.8 Unable to communicate critical information in an emergency due to language difficulties	*6.8.1 Ensure at least one crew member from each operational unit understands the local language in areas where English is not readily understood*	All teams
		6.9 Local customs and religious beliefs not compatible with good medical or first aid response	*6.9.1 Understand local values and address in work plans and inductions*	
			6.9.2 Ensure emergency response is as independent as possible from local personnel and customs	