Review of Aerial Video Survey Techniques and Recommendations of Survey Standards

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Preface

This report is submitted to the Resources Inventory Committee (RIC) by the Coastal Task Force.

The Resource Inventory Committee members are resource specialists from a wide variety of professional disciplines and represent provincial, federal, aboriginal and private sector agencies and other resource interests. RIC's objective is to develop a common set of standards and procedures for provincial resource inventories.

The Coastal Resource Task Force has identified a number of projects to develop a common set of inventory standards for the coast of British Columbia. This manual provides documentation and recommendations for aerial video mapping standards.

Funding for the RIC work including preparation of this report, is provided by the Canada-British Columbia Partnership Agreement on Forest Resources Development: FRDA II. This is a five-year (1991-1996) $200 million program cost shared equally by the federal and provincial governments.

Funding from FRDA II does not imply acceptance or approval of any statements or information contained herein by either government. This document is not official policy of Forestry Canada or any British Columbia government ministry or agency.

Abstract

This report provides a review of Aerial Video Imagery (AVI) surveys in British Columbia and was supported under contract by Coastal Task Force of the Resource Inventory Committee (RIC) and administered by the Ministry of Agriculture, Fisheries and Food (Technical Authority, Mr. Joe Truscott). The project objectives were to: (1) review existing AVI survey applications and techniques, (2) review equipment presently being used in AVI surveys and (3) provide recommendations for standardizing AVI surveys.

A review of AVI surveys currently being conducted in BC reveals a wide range of applications, although coastal biophysical inventories in support of oil spill contingency planning and stream inventory surveys in support of habitat characterization are most common. Other applications include: forestry cut-block planning, shellfish habitat inventories, powerline surveys and coastal charting. The surveys can be characterized in terms of three general categories

- ***reconnaissance surveys*** - provide a general overview for orientation surveys but imagery/tapes are not used to extract specific inventory data.
- ***planimetric surveys*** - aerial video imagery is used to map features and boundaries in a geo-referenced framework (e.g., vegetation mapping or coastal charting).
- ***inventory surveys*** - aerial video imagery is used to catalog landform or vegetation features but features are not specifically georefenced from the imagery.

A review of equipment is provided to assist potential users with identifying the most appropriate and cost-effective approach to meet their needs; commercial services are also identified. No single suite of equipment is appropriate to all applications. The listing provides a review of advantages and disadvantages of various equipment components, which will allow users to evaluate systems to match their specific requirements.

The evolution of AVI surveys over the past ten years has led to a wide variety of techniques being used, and some standardization is appropriate. A recommended standards classification for AVI is developed based on four important factors: *resolution* of the imagery, *positioning* information, *documentation* and *supplemental data*. It is also strongly recommended that AVI data be cataloged through a designated coordinating agency; the agency would maintain project data sheets initially and, if sufficient demand existed, could expand to include: GIS-based reference maps, a documentation library and tape duplication services.

Order	Criteria	Description
1^{st}	resolution	minimum sized feature that can be resolved on imagery
	positioning	position information that georefences imagery
2^{nd}	documentation	info that is publicly available and provides a basic survey report
	supplemental data	non-image data that enhances ability to interpret imagery

Acknowledgments

The Government of British Columbia provides funding of the Resources Information Standards Committee work, including the preparation of this document. The Resources Information Standards Committee supports the effective, timely and integrated use of land and resource information for planning and decision making by developing and delivering focused, cost-effective, common provincial standards and procedures for information collection, management and analysis. Representatives to the Committee and its Task Forces are drawn from the ministries and agencies of the Canadian and the British Columbia governments, including academic, industry and First Nations involvement.

The Resources Information Standards Committee evolved from the Resources Inventory Committee which received funding from the Canada-British Columbia Partnership Agreement of Forest Resource Development (FRDA II), the Corporate Resource Inventory Initiative (CRII) and by Forest Renewal BC (FRBC), and addressed concerns of the 1991 Forest Resources Commission.

For further information about the Resources Information Standards Committee, please access the RISC website at: http://ilmbwww.gov.bc.ca/risc/index.htm.

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Coastal Ecosystems Task Force

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1. Introduction

1.1 Background

This project conducted by Coastal & Ocean Resources Inc. under contract to the Ministry of Agriculture, Fisheries and Food (MAFF) on behalf of the Resource Inventory Committee (RIC), Coastal and Aquatic Task Forces, to review aerial video survey techniques and recommend standards for future aerial video surveys. The project was prompted by the use of widely varying survey techniques for different resource inventory applications. This review focused on applications related to marine and aquatic resources inventories.

Some of the first systematic aerial video surveys conducted in BC involved the use of low altitude, oblique imaging of the Saltspring Island coastline for use in coastal morphology/substrate mapping (see Owens, 1980). Since that time, most of the southern portion of the BC has been surveyed. The Ministry of Environment has used oblique aerial video imaging for stream habitat classification. Other techniques have used aerial video imaging for survey-standard planimetric mapping.

1.2 Objective of Study

The main objectives of this project are to:

- provide of review of current techniques and systems being used in aerial video resource surveys
- provide a state-of-the art review of equipment, including camera/recording systems, positioning systems and communication systems
- recommend standards to promote more uniform imagery collection and reporting.

The approach that we used was to (a) contact individuals and groups currently using aerial video imaging (AVI) as a survey tool and catalog survey objectives, (b) collect information on video, positioning and communications equipment that is potentially useful in AVI surveys, and (c) recommend standards for AVI data collection. Appendix A includes a glossary of frequently used terms related to either AVI techniques or equipment.

2. Review of Survey Techniques

2.1 Approach

Numerous interviews of individuals involved with aerial video surveys were conducted in January and February 1995. The list of summaries of the Interviews (Appendix A) and Contacts (Appendix B) are provided. Information from these interviews was used to categorize the survey techniques and identify common problems associated with the techniques.

2.2 Overview of Techniques

The basic approach of aerial video imaging surveys is to use an video camera to record land imagery from an aerial platform. The technique has gained popularity over the past ten years because of the ability of users to tailor the imagery to their particular application. In comparison to conventional aerial photography, (a) video imagery can be acquired from a wide variety of aircraft and is usually not ceiling limited (i.e., AVI flying altitude is usually much lower than that required for conventional aerial photography), (b) synchronous narrative descriptions of resources can be added, greatly enhancing the interpretative quality of the imagery and (c) the oblique imagery is similar to the view from an aircraft and easily interpreted by the lay-person. The major disadvantage in comparison to conventional aerial photography is that AVI can generally not be used for planimetric mapping without special attention to aircraft attitude during the survey.

The ease of acquisition has inspired a wide range of applications to resource mapping within BC. The technique is most suitable to mapping linear features such as rivers, coastlines or pipelines that can be centered in the image. Examples of AVI application include: coastal mapping for oil spill sensitivity assessments, inventorying stream morphology for assessing fish habitat, inventorying shellfish habitats, coastal landscape cut-block planning and general documentation of resource conditions. The coastal mapping programs have been one of the most extensive, with an estimated 25% of the BC coastline imaged. Stream classification inventories have accounted for more than 20 surveys within the Province.

Other concurrent report compilations provide a review of aerial surveillance techniques for use in watershed management (see Ham 1995).

Reconnaissance AVI Surveys

A review of the existing surveys indicates three general classes of surveys have been conducted (Table 1). The authors' reviewed hundreds of hours of overview or *Reconnaissance* AVI as part of litigation support for the *Exxon Valdez* oil spill, and although little of this type of imagery has been formally reported for BC, such imagery is routinely collected by resource managers and news agencies. The greatest weakness of this type of imagery is the lack of location information; the user is left to estimate the original flightline, based on features evident in the image. Given the general uniformity of landforms in BC (i.e., conifer forests with few distinct cultural features), this lack of position information is a severe limitation to a broader-based use of the imagery.

Table 1 - Categorization of Aerial Video Surveys in British Columbia

General Category	Description	Application	Limitations
Reconnaissance (overview)	Overview type surveys; no formal positioning information; no professional interpretation/narration attached to imagery; imagery usually suitable for single application	Overview; useful for general introduction to area	Lack of positioning makes imagery difficult to use by anyone other than initial observer
Inventory	Most common type of oblique imaging; features are inventoried but there is a postional uncertainty because of the oblique nature of the imagery; scale of features varies depending on the survey altitude and camera focal length	Resource inventories where basic morphology or character can be interpreted but spatial location and dimensions are only approximately known; specific applications: coastal mapping, stream habitat classifications; shellfish inventories; pipeline corridor surveys; landscape mapping	Feature locations and dimensions are approximate and even if mapped in conjunction with other information (GPS or air photos), resolution is generally _10m at best
Planimetric Mapping *(intensive)*	Vertical imaging can be used for planimetric mapping; with inertial navigation system corrections, surveyor-quality mapping is possible; similar to vertical aerial photos	Charting; mapping landform or vegetation areas	Significantly higher processing and interpretative costs

Inventory AVI Surveys

Inventory AVI Surveys are the most common type of aerial video survey. These are surveys where imagery is acquired of a feature or set of features for a specific application. The survey is usually pre-planned and flightline information is known such that the features can be interpreted and approximately mapped (referred to as reconnaissance mapping in aquatic resource inventories)

The imagery is typically interpreted, and landform or habitat attributes are recorded in a database and/or on a map. High resolution, planimetric mapping (e.g., 1:5,000 scale mapping) is usually not possible because imagery is oblique and uncontrolled. For example, in the coastal mapping surveys, the species of bull kelp (*Nerocystis*) can be clearly identified on the imagery but estimates in transferring the information about a kelp bed to a planimetric map base are inherently uncertain (i.e., _10m accuracy for any single boundary of the bed).

Most recent surveys provide a burned-in GPS location of the video image, assuring that the location information cannot be separated from the imagery; in some aquatic surveys there is limited data entry provided during the survey. Older surveys, including most of the coastal surveys, provide detailed flightline maps, with fixes every 30 seconds. Although this type of flightline map provides as accurate a position of the imagery as GPS, it is not physically attached to the image and subsequent copying often results in separation of the map and tape.

Planimetric Mapping AVI Surveys

Planimetric AVI mapping involves the use of vertical AVI; that is, where the camera is pointing vertically downward such that a "horizontal" image is collected. Such an image is directly analogous to a vertical photo. The scale of the image is related to the altitude of the aircraft and focal length of the camera. Resolution of features will vary, depending on the image scale (e.g., 1:5,000 or 1:20,000), the stability of the aircraft and the image resolution (in turn a function of the camera, recorder and display system).

Only two programs in BC have conducted planimetric mapping from the AVI (see Appendix A, Projects 4 and 8). The Terra/LIDAR system (see Appendix A, Summary No. 8) uses a vertically mounted camera in conjunction with a laser profiler and an inertial navigation system. The inertial navigation data allows the precise attitude of the aircraft to be known such that imagery can be corrected to _1-2m accuracy's and landscape features can be precisely mapped. The mapping requires considerable post-survey processing and is expensive; however the mapping information is very precise and is used for input to hydrographic charts.

Vertical images can be used for mapping in an uncorrected mode (no corrections for attitude fluctuation of the aircraft) and vegetation polygon mapping accuracy's of <10% are estimated (D. Campbell, 1995, pers. comm.; see additional Range and Bearing summaries in Appendix B).

Controlled and uncontrolled planimetric mapping surveys have only been conducted at two locations within BC. Although surveyor-quality maps can be produced, the processing required is expensive and for some applications, mapping from conventional, existing vertical air photos would provide a less expensive alternative (see Ham 1995).

2.3 Costs of Survey Techniques

Costs of survey techniques can only be estimated, as there are a wide range of survey objectives and variables. For example, some of the survey techniques require a specialist on-board during the overflight to provide a synchronous narration to complement the imagery. A range of survey costs are provided for a variety of survey objectives in Table 2. The costs assume private-sector charge-out rates for personal. No post-survey processing (e.g., interpretative products) is assumed such that products are (a) a videotape with inflight commentary and (b) a flightline map and/or file.

The use of a helicopter creates the major difference in survey costs, although the quality of the imagery is often more consistent. In the case of coastal surveys, for example, fixed-wing aircraft are generally too fast and tend to "straighten out" the coast, leaving long shots into embayments unsuitable for biophysical mapping.

Unit costs are likely to be reduced during longer surveys as there would be less mob/demob effort per kilometre of survey. It is expected that the relative differential between survey costs would remain approximately the same for longer surveys.

Table 2 - Comparative Costs of Survey Techniques

Objective	Aircraft	Personnel	Positioning	Camera/ Recorder	Flight Speed (km/hr)	Cost ($/km)
Reconnaissance	Fixed-Wing, Cessna $250/hr	1 professional, $ 65/hr	none or coarse flightline map	consumer	150 (80 knots)	$ 6/km
Interpretative	Fixed-Wing, Cessna $250/hr	1 professional, $65/hr 1 technician, $40/hr	GPS position burned to video image	high end consumer, SVHS or Hi8	110 (60 knots)	$ 9/km
	Helicopter Bell 206, $780/hr	1 professional, $65/hr 1 technician, $40/hr	GPS position burned to video image	high end consumer, SVHS or Hi8	110 (60 knots)	$16/km
	Helicopter Bell 206, $780/hr	1 professional, $65/hr 2 technicians, $40/hr	GPS position burned to video image; GPS logged to computer for post-survey processing (DGPS)	professional Hi8	90 (50 knots)	$21/km
Planimetric	Fixed Wing, Cessna 182	1 technicians, $50/hr	DGPS with inertial navigation	SVHS	185 (100 knots)	$26/km

Note: Cost based on 200km survey, 1 hour for non-survey flight assumed; 1 day tech time for mob/demob; products are imagery + flightline map or file

3. Review of Equipment

3.1 Video Camera Systems

In the last 10 years there has been an exponential increase in the type and availability of video equipment. The choice of equipment which is best suited for a particular AVI survey depends largely on the intended use of the images and budget limitations. Successful surveys have been completed using most of the available systems. The following discussion provides a summary of video systems, and their applicability to survey requirements.

The tables of equipment are organized in a descending order of quality (see Table 3). This list is a general guide to cameras and recorder types. The ever increasing availability of equipment in the professional, industrial, and consumer markets may shift the desirability of individual formats. For example, Sony has recently announced the release of "Prosumer" digital recording systems. It must also be recognized that equipment should be evaluated on an individual basis, as features vary widely between equipment. A more detailed evaluation of individual camera/recorder features is included in Appendix D.

The recent shift in technology have made the use of tube cameras in the field less desirable. Most modern electronic news gathering (ENG) video systems are based on some form of charged-coupled diode (CCD) technology. These are the best systems to use in a field environment due predominantly to their size and durability. This is also true for most consumer camcorders. Tube cameras, especially three tube colour systems, are susceptible to shock and image burn on bright objects. This causes considerable difficulty on aerial surveys, where sun glare off the water is a concern, and aircraft vibration a constant. They are included in this review as there is a large number of these systems still available in the rental/lease market. Their use has generally shifted to the studio or fixed position environment.

Quality of Image

The quality of the image, also commonly referred to as camera resolution, is dependent on two factors. The quality of the lenses and the capability of the pickup device to convert the "light image" to an electronic signal. The quality of lenses is a basic concept and is analogous to the differences of an inexpensive point and shoot camera to a high quality 4x5" format camera. One of the most important factors in lenses, especially in the consumer market, is their composition, plastic or glass. Glass lenses traditionally provide better light transmission and convergence properties. The conversion of the image in the camera is performed by the video tube or CCD. Three tube or chip cameras generally use one chip for each of the three primary colours, and electronically mix the results. Single tube or chip cameras use only a single composite colour device. A combination of pixel density, size of the device and number of devices will make up the final image resolution. Generally cameras with larger pickup devices and/or more devices will have a higher resolution. Multiple variations in these designs are available from different manufactures, and comparisons should be made on the specifications of each system individually.

It is important to be aware of the difference between the camera resolution and the recorder resolution. The camera resolution as discussed is the output capability of the camera. This should not be confused with the resolution of the final image on the recorded videotape. This is especially true of camcorder systems where the camera and recorder are combined. The final quality on videotape is dependent on the capability of the recorder as well as the camera. As a general rule the camera should be capable of producing "more" image than the recorder can reproduce as other factors such as the signal to noise ratio play an important part in the final result. Systems should, however be reasonably matched. For example using a professional 700 line camera on a standard VHS recorder which is capable of recording only 230 lines of information will result in a recording at only 230 lines.

Table 3 - Summary of Camera Systems

Equipment	Advantages	Disadvantages
CCD Two-Three Chip	700+ lines of resolution Stable color and light Low light capabilities Docking capabilities High quality interchangeable lens	Generally larger in size Expensive Moderate availability More susceptible to shock
CCD One Chip	300+ lines resolution Stable color and light Low light capabilities Compact in size Moderate Price Moderate lens quality	Lower resolution Fewer control features Good availability
Three Tube	600+ lines resolution Docking Capabilities Good color reproduction High quality interchangeable lens	Tubes burn on bright objects Generally large in size Expensive Susceptible to shock Decreasing availability, Studio use
One Tube	300+ lines resolution Standard docking capabilities	Lower resolution Tubes burn on bright objects Susceptible to color shift Susceptible to Shock Largely replaced by CCD cameras

Camera Features

A considerable variety of features are available on camera systems. Many of theses features are important to the usefulness of the camera and others provide varying degrees of convenience. Following is a brief discussion of the features which should be considered for aerial videotape surveys.

- Strobe Shutters - useful if clear still images are required during playback. Fast unstable camera motion can cause blurred imagery, the strobe shutter will reduce this effect. Requires higher light conditions during recording.
- Auto Iris - useful if light conditions are uniform over the survey subject. If strong variations of light are present, for example surf along a beach, manual overrides may be required.
- Auto Focus - In general almost all aerial video surveys will use the camera focused at infinity. It has been common practice to tape the camera lens open to infinity thus reducing the risk of knocking the lens during the survey. Auto focus systems on cameras are often confused in less than ideal situations, such as rain or fog and should be capable of being turned off.
- Power Zoom - The configuration of the camera in aerial surveys, whether hand held or fixed mounted make adjustments to the lens difficult. A simple finger tip or remote control of the camera zoom is preferable.
- On Screen Displays - The complexity of aerial surveys makes continuous checking of system conditions difficult. The more information which is presented on the display the better. Especially "REC".

- Auto White Balance - This is more of an convenience factor as all camera systems have some methodology of setting white balance.
- Color Bars - This is also a convenience factor. It is important to record a minute of "dead" video at the start of field tapes. This allows for editing lead time if the tape is to be used for further editing production. It also makes sure that the tape leader is properly spooled and "quality tape" is located over the heads when recording starts. If the camera generates a colour bar it provides an ideal signal to record for this initial "striping".

3.2 Video Recording Systems

Most of the video formats are available in both separate camera/recorder systems as well as varying combination of camcorders (Table 4). A separate camera/recorder system is preferable for aerial video surveys as these systems usually provide better recording features and flexibility. This type of configuration, for example, would be best suited for connection of GPS encoders. Camcorders are however usually less expensive. Considerations of quality versus cost, availability and compatibility are trade-offs. A Betacam system can exceed $20,000, whereas a standard 8mm camcorder costs under $1000. Rental and/or lease costs will vary proportionally. When making the decision of which system to use for a survey keep in mind that the price of the camera system is generally a small part of the survey costs, especially if using a helicopter.

For the purpose of this review the term "recorder" refers to both separate recorders and the recording part of camcorder systems.

Considerations must also be made for the timely use of videotapes after each survey. If an immediate analysis of the imagery is required, a duplicate system may be necessary in the office, which will increase costs. If there is time to make copies for distribution, the highest quality (on the initial recording) possible will result in less generation loss in copies, and imagery can be copied to other more compatible formats. If information response timing is important, remote transmission and satellite bounce systems are also available, at a cost!

Table 4 - Summary of Recording Systems

Equipment	Advantages	Disadvantages
Betacam SP and/or D3 Recorders	700+ lines of resolution Docking with cameras available Portable Professional features standard	Expensive Poor consumer compatibility Availability
Hi-8	450+ lines of resolution Compact size 2 hour recording	Moderate to expensive Moderate consumer compatibility
ED Beta	500+ lines of resolution 1 hour recording	Poor Availability Expensive Poor consumer compatibility
Super VHS	400+ lines of resolution 2 hour recording Good studio capabilities	Moderate to expensive Moderate consumer compatibility
3/4 Umatic	300+ lines of resolution Universal standard format Good studio capabilities Professional features standard	20 minutes per field tape Large size Expensive Poor consumer compatibility

Regular 8mm	Compact size Good consumer compatibility 2 hours recording Easy availability Low in price	Lower resolution (250 lines) Fewer professional features
Regular VHS	Good compatibility 2- 6 hour recording Easy availability Low in price	Low resolution (230 lines) Fewer professional features Susceptible to color shift Low quality copies Large in size
VHS-C Same format as VHS	Good compatibility 90 minute recording Easy availability Compact size Low in price	Low resolution (230 lines) Fewer professional features Susceptible to color shift Low quality copies
Regular Beta	Moderate in size 2 hour recording	Poor availability (discontinued) Common VCR compatibility Low resolution (240 lines) Low quality copies

Recorder Quality

The quality of the image which a video tape recorder (VTR) records is dependent on the method of magnetic storage, a combination of frequency deviation, band width, carrier frequency, colour separation and luminance signals. The technical aspects of this are not important for this discussion; however, an understanding that different formats will provide varying results is. The measure of quality is again that of horizontal lines of resolution. These are not to be confused with the horizontal scanning lines (512) on a standard North American TV (NTSC). The lines of resolution in cameras and recorders refers to a measure of individual lines which can be separately resolved by the human eye, or more simply the detail which can be observed in the image. Standard broadcast TV and most standard TV sets are capable of reproducing only 230 lines of resolution. This is the reason that the original VHS standard was set at this level. More recent TV/monitors in the market place are capable of reproducing 600+ lines.

It is important to match the components of the system to take the advantage of their capabilities. A Betacam recorder played back on a standard TV will not take advantage of the level of information available.

Tape Size and Specifications

The different formats not only have varying degrees of quality but differ in the size and nature of the recording tape. The 3/4 inch Umatic systems use large cassette tapes about the size of a good computer reference manual. The Hi8 and 8mm cassettes are close the same size as an audio cassette tape. The VHS and Betacam tapes are closer to pocket book size. In general the larger the videotape the larger the recorder. This aspect should be considered when choosing a field system. Small components are better if you have a tight recording platform. The smaller videotapes are also easier to store. This is especially important if the information is valuable and needs to be stored in a fire proof vault. Recorder size is also influenced by the number and type of features the system has. Small "palm-corders" have fewer features than full size recording decks of equal quality.

The different tape formats also support varying numbers of recordable channels beyond the basic video imagery (Fig. 1). These channels could include the audio, time code, control track, index, data and/or date stamp. For example Hi8 videotape supports two separate stereo recording channels. The AFM channels are recorded along with the video signal in the helical scan and two PCM digital audio channels are recorded on linear tracks along the tape. Betacam provides up to four linear tracks, 3/4 inch two linear tracks and SVHS provides one separable stereo track (left and right) as well as a mono dub track. Hi8 and 8mm videotape supports a timecode track, 3/4 inch Umatic only supports a control track, and VHS only records index marks. The access to these features depends on the support provided by the individual recorder system. It is important to review the specific requirements of the survey and post survey analysis to determine what features are important.

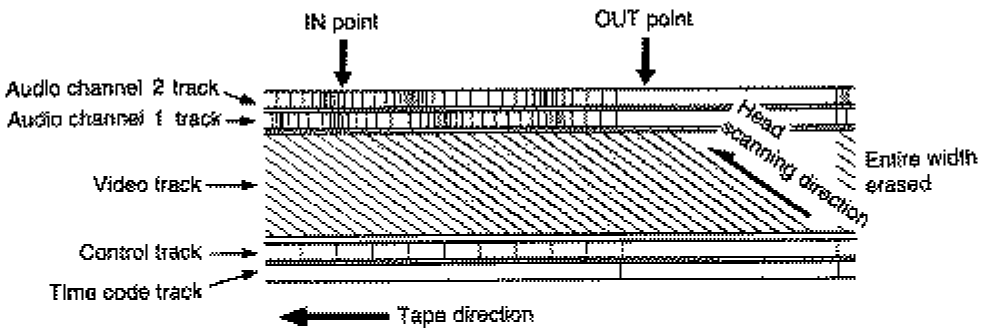

Figure 1 Typical videotape recording layout

Recorder Features

A considerable variety of features are available on recorder systems. Many of theses features are important to the usefulness of the system and others provide varying degrees of convenience. The following is a brief discussion of the features which should be considered for aerial videotape surveys.

- Audio Channels - A single audio channel is a minimum on all recorders. Two or more channels provides the ability of multiple voice commentaries and/or data logging.
- Audio mic inputs - The recorder should be capable of attaching external microphone(s) during **recording**. This should not be confused with the line input connections on many systems. Consumer systems normally use a small mini-jack, where professional systems usually have XLR connectors which are line/mic selectable.
- Audio meters - The ability to monitor the audio recording levels during the survey is **essential**, not only for quality, but to determine if the system is operating correctly.
- On Screen Time - The ability to record a data and/or time on the video image is useful if manual positing is used during the survey. It provides a direct reference between the videotape and flight line maps.
- Time Code - The ability of the system to record time code is very useful if the tape is to be edited or used with a computer based system such as a GIS. Time code is a permanent "hour:minute:second:frame" stamp recorded on the tape which allows accurate reference to any position on the tape. Recorders which are capable of "Free Run" time code can be set to "real" time and used to record the actual time of day as the reference signal. This time can be recorded in an on screen window burn during tape coping which is preferable to using a time stamp during recording.
- Monitor output - It is important to be able to view the image which is being recorded, not only to determine the integrity of the system, but for quality control. The view finders in most camera systems are still black and white and do not provide a good indication of the quality of the image.
- Docking or Camera feature cables. - The ability to Dock (directly connect) the camera to the recorder is often useful. Most professional camcorder systems are made up of separate camera and recorder sections which connect together. This offers the flexibility to use different recorders with the same camera/lens system. Separate camera and records will often

have a single cable which connects the two to carry not only the video signal but control and power. This eliminates the need of having more than one cable connected to the camera. If processing of the video signal is required, such as the "on screen burn" of GPS information, this connection will need to be capable of being patched through an external processor.

- External Power - Normal camcorder and recorder batteries are only good for 30-45 minutes. During aerial surveys the flight times can often be hours. The ability to connect external power, either from the aircraft or larger batteries if very **essential**.

3.3 Communications Systems

The inclusion of an audio commentary on the videotape is one of the simplest techniques to add value to a final product. It is, however, the one option commonly omitted from aerial surveys. Detailed features (e.g., substrate types, species occurrence) may be easily identified by experienced observers during the overflight, but may not be discernible on the imagery. As a minimum, a good quality microphone should be used, but a proper aircraft, voice-activated, headphone/microphone communication system is preferable; the use of voice-activated microphones leaves hands free for other onboard functions such as taking photographs or camera operation.

Consideration must also be made for the intended use of the video imagery. For example, a single channel system is appropriate if only shore zone morphology is important but a two channel system is required if *both* physical and biological descriptions are desired. The communication system also provides for interactive communication between all members of the survey team, including the pilot. All topics discussed and information described is recorded onto the videotape. This could include not only shore-zone data, but location information, altitude, air speed and any other general information which any member of the team felt was important.

Table 5 summarizes the common options for videotape commentary systems.

Table 5 - Summary of Communications Systems

Equipment	Advantages	Disadvantages
Two Channel Aircraft Systems	Dual channel recording Voice activated Noise canceling mikes Noise reducing headphones Channel Selection (input) Pilot isolation/Radios	Custom made system Cost / Availability
One Channel Aircraft Systems	Voice activated Noise canceling mikes Noise reducing headphones Commercially available	Single channel recording
One Channel Audio Systems	Wireless systems available Inexpensive Commercially available	Not aircraft compatible Noisy audio recordings Generally battery only Single channel recording Poor pilot communications
Microphone Only	Better then nothing Two channel recording possible	Not aircraft compatible Noisy recordings No on line crew/pilot communications

Positioning Systems

One of the most important aspects of AVI surveys is the ability to locate a particular section of video imagery on a map. With the current satellite network and importance of linking all electronic data into compatible systems, the use of GPS is becoming an advantageous approach.

The Global Positioning System (GPS) is not a new technology, having been available for over 20 years. The use of these systems for AVI surveys has only been viable for the last few years due to the incomplete coverage of the satellite network. As recently as 1989 the satellite coverage over North America was not sufficient to use GPS as a navigation option during shoreline over flights for the *Exxon Valdez* oil spill.

General GPS Description

A general description of GPS is excepted from the U.S. Federal Navigation Plan GPS Statement:

> GPS is a space-based positioning, velocity, and time system that has three major segments: **space, control, and user**. The GPS Space Segment, when fully operational, will be composed of 24 satellites in six orbital planes. The satellites operate in circular 20,200 km (10,900 nm) orbits at an inclination angle of 55 degrees and with a 12-hour period. The spacing of satellites in orbit is arranged so that a minimum of five satellites will be in view to users world-wide. Each satellite transmits on two L band frequencies, L1 and L2. L1 carries a precise (P) code and a coarse/acquisition (C/A) code. L2 carries the P code. A navigation data message is superimposed on these codes. The same navigation data message is carried on both frequencies.
>
> The Control Segment has five monitor stations, three of which have uplink capabilities. The monitor stations use a GPS receiver to passively track all satellites in view and thus accumulate ranging data from the satellite signals. The information from the monitor stations is processed at the Master Control Station (MCS) to determine satellite orbits and to update the navigation message of each satellite. This updated information is transmitted to the satellites via the ground antennas, which are also used for transmitting and receiving satellite control information.
>
> The user segment consists of antennas and receiver-processors that provide positioning, velocity, and precise timing to the user.
>
> The GPS concept is predicated upon accurate and continuous knowledge of the spatial position of each satellite in the system with respect to time and distance from a transmitting satellite to the user. Each satellite transmits its unique ephemeral data. This data is periodically updated by the Master Control Station based upon information obtained from five widely dispersed monitor stations.

GPS Receivers

GPS receivers are available from a number of manufactures and in many different formats, capabilities and features. Prices range from under $400.00 US to over $60,000; the units that have the capabilities required for AVI surveys are in the US $1000 to $3000 dollar range.

Major features about a GPS to consider are:

- **Re-acquisition time -** This represents the length of time it takes the receiver to re-acquire a satellite when it becomes available after it has lost "sight" of it.
- **Maximum number of satellites tracked -** The more satellites tracked, the more reliable the data. With civilian single receiver GPS the best accuracy is statistically 100m to get a reliable fix for horizontal position 3 satellites are required. A reliable 3 dimensional fix (altitude) requires 4 satellites. Additional satellites provide extra position fix certainty. If the receiver loses sight of one of the satellites that it is using for calculations, it can quickly switch to another if it is tracking it. If not, then it has to acquire another one.

- **Channels and tracking mode -** Ideally the receiver will have one channel or more for each satellite it is capable of tracking. If this is not the case, the receiver is multiplexing or sequencing the selection of satellites to receive data from. This results in loss of signal strength and time delays. Most receivers today use a dedicated channel or channels for each satellite.
- **Differential capable (DGPS) -** Differential refers to the ability to use a fixed GPS station to correct data within the aircraft receiving unit. This technique improves the accuracy of position fixes from approximately _100m to _5m by removing intentional dithering of the broadcast GPS signals. The correction can be applied "realtime" during the flight or following the survey (post-processed DGPS).
- **Display of time -** it is desirable to display (record) the time on video image or to synchronize time-codes on the recorder to that recorded on the data logger. Some units do not supply the GPS time.
- **Provision for external antenna -** Reliable signals in an aircraft installation will require an external antenna mounted either external to the aircraft or internally on the aircraft windscreen, where the antenna has a clear view of the sky.
- **Voltage -** compatibility with and connection to aircraft power systems (24 to 32 v) should be considered. Battery operation on long video surveys is often a problem. At a minimum the system should be capable of external battery power input.
- **External Interfaces -** Some manufacturers list their external interface as RS232/422 etc. and some as NMEA. The first of these is an electrical/pinout specification and the second is a data protocol - e.g.. how the data passed on the interface is representing latitude, longitude information. Users must ensure that the unit is both signal, connector and data protocol compatible with any data logging equipment.
- T**ype of unit - stand alone or development.** Stand alone units are either vehicle mounted or hand held, and include display, controls and navigation (waypoint, course to steer etc.) information and often an internal antenna. Development units are typically black boxes designed to be interfaced with other equipment. For this application, the displays and navigation information in a stand alone unit may not be required. Typically the development units have more capability in terms of satellites tracked, re-acquisition time etc. for the same price as compared to stand alone units. In addition, PCMCIA units are available from several manufacturers. These cards plug into the PCMCIA slot in laptop computers. Their suitability for operation in an aircraft has not been determined.

Linking GPS Data to the Video Imagery

When examining the use of GPS in AVI surveys there are four main alternatives for linking GPS data to video imagery:

1. Providing real time GPS location data in an on screen window "burnt" onto the original videotape at the time of recording.
2. Providing real time GPS location data on the closed caption (line 21) area of the videotape at the time of recording.
3. Providing real time GPS location data on one of the supplemental audio channels provided on professional video equipment or optional data logging recorders.
4. Providing real time GPS location data on a computer disk - separate from the video recording.

Each of the GPS data and audio commentary options is diagrammed below, and discussed with their respective advantages and disadvantages.

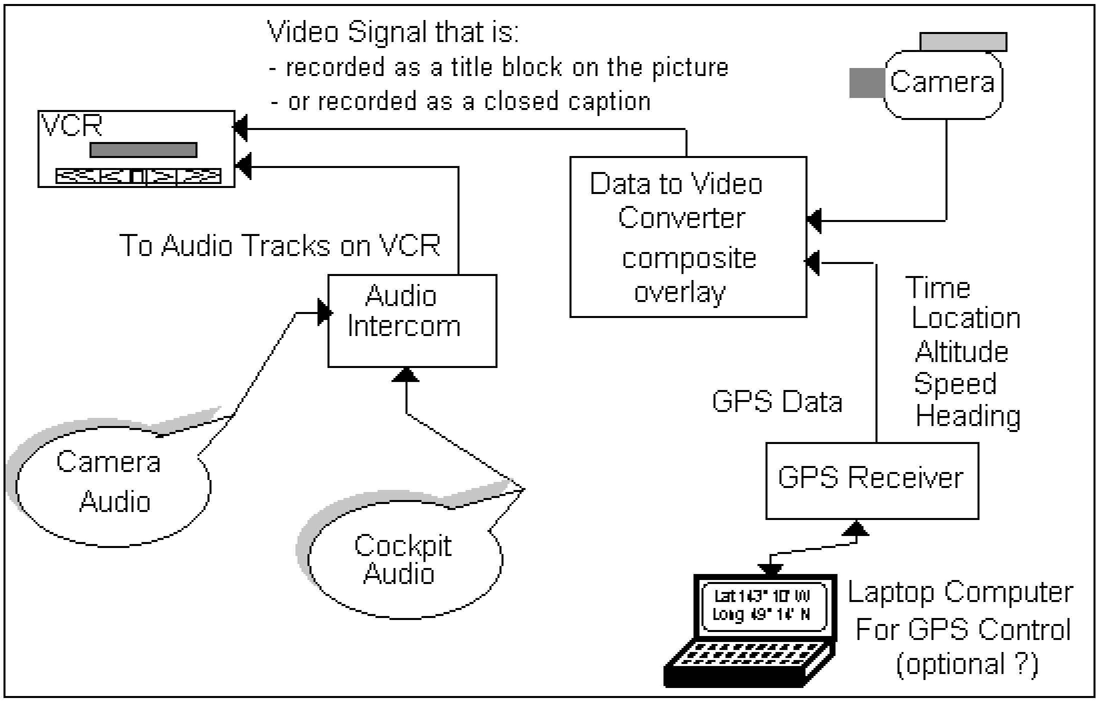

Figure 2 Schematic diagram of procedure for "burning" GPS to the video image or recording GPS to the close-captioned video track (Techniques 1 & 2)

Data to Video Converter:

- Title block burn in hardware exists off the shelf. The data is not available for data processing, so it would also have to be captured by a laptop for transfer to computer based mapping systems.
- Closed caption conversion hardware is being researched. This technique will require a separate conversion process to take the Closed Caption Data off the cassette tape for computer based plotting and data analysis. This hardware already exists in the market place .

Audio:

- Standard audio input. The use of microphone or line inputs will depend on the camera/recorder system capabilities. See section on communication systems for further information.

Video:

- Must use separate camera/recorder system as the GPS signal is overlaid on the video prior to recording. See sections on video camera systems and video recording systems for further information.

GPS Receiver:

- See Section 3 on positioning systems.

Advantages:

- All the data, video, GPS, and audio are in one place, on the video image.
- Copies of the videotape will always contain the positioning information.
- The closed caption technique potentially allows the user to selectively choose if positioning data is displayed. All standard TV sets over 21 inches, manufactured after January 1994, are required by law in the US to include closed caption decoders.

Disadvantages:

- Closed captioning requires a separate converter to get the data off the video cassette for further processing and plotting.
- The closed caption burn equipment has not been developed to our knowledge, however inquires showed that other persons are interested in the technique.

Video burn in does not allow computer access of the data off the tape for further processing. The data would also have to be independently recorded on a laptop computer or other data recorder and linked to the imagery via a time code; this step requires planning to assure time code on tape and computer are synchronized.

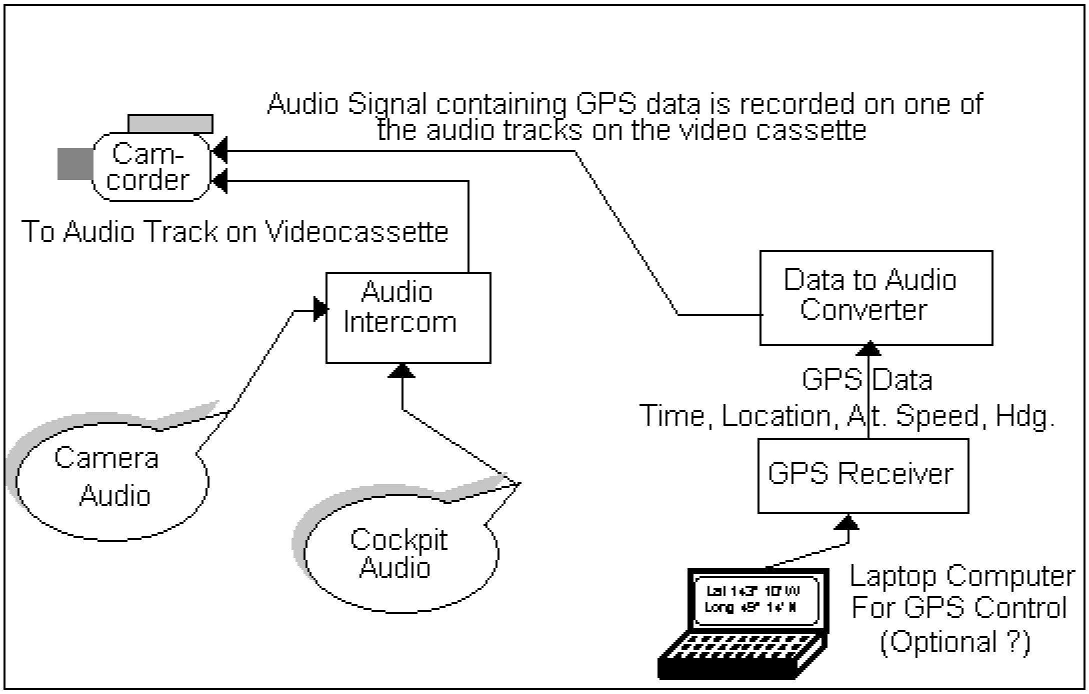

Figure 3 Schematic diagram of procedure for recording GPS data to an audio sound track on the video tape (Technique 3)

Data to Audio Converter:

- Essentially a modem to allow the data to be recorded in an audio form.
- Requires another converter to get the data off the tape for plotting and analysis.

Audio:

- Standard audio input. The use of microphone or line inputs will depend on the camera/recorder system capabilities. Consumer camcorders typically only support mic inputs. See section on communication equipment for further information.

Video:

- May use separate camera/recorder of camcorder systems. See section on cameras and recorders for further information.

GPS Receiver:

- See Section 3 on positioning systems.

Advantages:

- Data is in one place on the video cassette and no separate camera/recorder system required
- Data is automatically copied when tapes are copied.

Disadvantages:

- Requires a separate converter to get the data off the video cassette for further analysis
- Requires one audio channel for GPS data which reduces the capability of the system for audio commentary recording.
- As compared to closed caption or on screen burn, the data can not be viewed with the tape.
- Copies of the video may loose the positioning information if recording equipment or format do not allow for the additional audio channels.

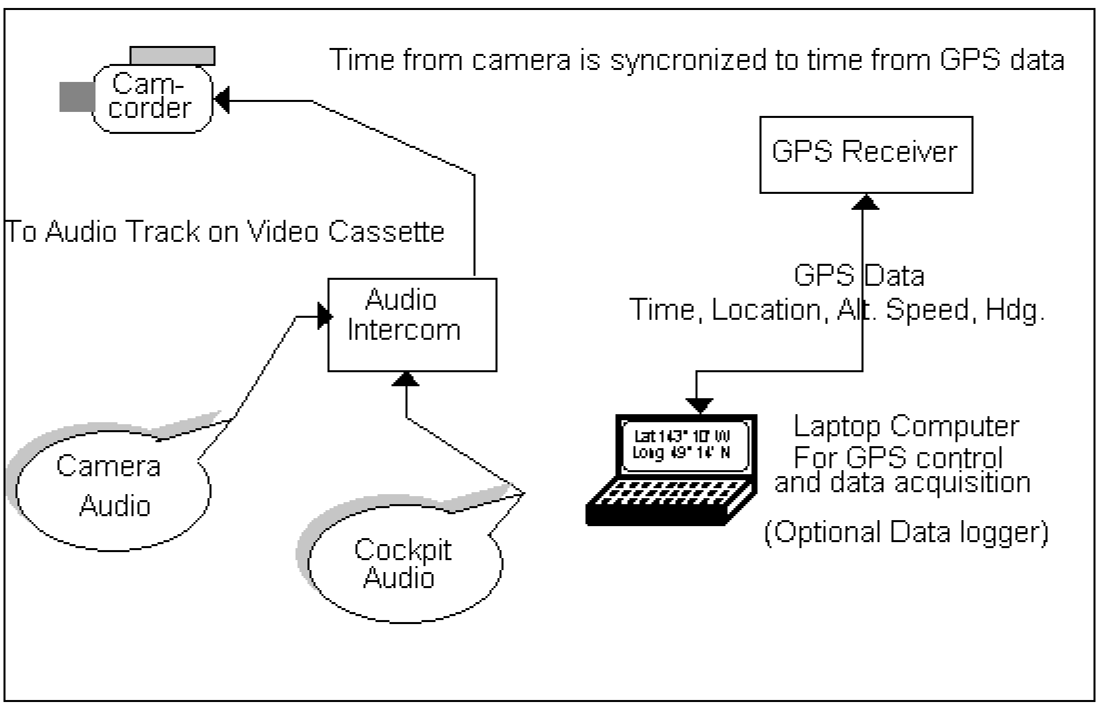

Figure 4 Schematic diagram of procedure for recording GPS data to a laptop/datalogger (Technique 4)

Audio:

- Standard audio input. The use of microphone or line inputs will depend on the camera/recorder system capabilities. Consumer camcorders typically only support mic inputs. See section on Communication equipment for further information.

Video:

- May use separate camera/recorder of camcorder systems. See section on cameras and recorders for further information.

GPS Receiver:

- See Section 3 on positioning systems.

GPS Data:

- The data from the GPS goes only to the lap top or data-logger. From there it can be transferred to other computer systems for analysis, plotting and storage with the associated video cassette.

Advantages:

- Simple, no additional conversion and or decoding equipment is required.

Disadvantages:

- The data is in two places. Attention must be given to synchronizing the time code. The only relationship between the video imagery on the tape and data file is the time track, and it's accuracy relies on the correct setting of the camera/recorder time. If the cassette and diskette become separated or mislabeled, it may be impossible to recover the data.
- Copies of the videotape will not contain the positioning data.

3.4 Aircraft

The use of different platforms for video surveys depends on a good understanding of the survey objectives. A fixed wing aircraft may be adequate if a regional overview is all that is required. For detailed shore zone analysis it is necessary to fly at lower altitudes and therefore much slower than is capable from most fixed wing aircraft. Selection of the appropriate aircraft requires an understanding of the relationship between flight altitude, flight speed, aircraft type and camera capabilities. The following discussion provides a general overview of fixed-wing and helicopter platforms.

Some aerial video survey systems are permanently mounted in aircraft whereas other approaches use chartered aircraft near the survey site. Some advantages of using dedicated aircraft include: little set-up time, avoidance of electrical/radio noise problems, permanently installed GPS antennas and ergonomically-laced controls for easy operation. The major disadvantage of using dedicated aircraft for AVI is the cost of aircraft ferry time to and from the survey site; small surveys at distance from the aircraft base become expensive.

Fixed Wing

Fixed-wing flying platforms have been widely used for AVI surveys and, with proper attention to details, can be used for reconnaissance and interpretative-type surveys. In general, the following features are desirable:

- high-wing for minimally obstructed views (Helio-Couriers have no struts), or under-carriage-mounted, tilt/pan camera pod.
- removable windows otherwise internal reflections within the aircraft reduce the image quality; windows are often scratched and difficult to clean.
- low stall speeds; best results are obtained with slower flight speeds. Although typical stall speeds of small, high wing aircraft are around 50 knots (35 knots for a Helio Courier), margin of safety considerations dictate minimum flying speeds around 70 knots (55 knots for a Helio Courier).

There are special considerations for the use of fixed-wing capabilities. If the camera is an externally-mounted camera, windows are not a problem; externally mounted equipment is subject to MOT approval, however. There are specially modified aircraft with floor ports for vertically-mounted camera systems, negating the need for opening or removable windows. One commercial video service (see Project Summary No. 4 in Appendix B) has a specially-designed Plexiglas pod in bottom of the tail-boom to allow an internally-mounted camera with wide pan and tilt capabilities.

Fixed-Wing Advantages

- low cost; typical charter rates are in the range of $150 to $250/hr
- vibration-free platform (in comparison to helicopter)

Fixed-Wing Disadvantages

- minimum flight speeds of 50-70 knots
- reduced maneuverability in comparison to helicopters resulting in best coverage of straight, linear features (e.g., pipelines) and poorer coverage of crenulated features (e.g., highly complex shoreline).
- obstructions from struts on most aircraft.

Helicopters

Helicopters have also be used extensively for AVI surveys in the Province. The superior maneuverability provides for a more flexible camera platform and their ability to land, means that surveys can be interrupted to ground-truth ambiguous features. The main features to consider in helicopter selection are:

- proximity of the base to survey area as flying time is very expensive and large quantities of fuel are required; pre-established fuel caches may be required to optimize flying time.
- for oblique, hand-held surveys, removable doors are essential to allow the camera man maximum flexibility in framing; there is no strut between the front and rear doors of the TwinStar and AeroStar models, for example, allowing even better viewing/framing capability.
- turbine-engine, twin-engine or float equipped helicopters add extra margins of safety for particular surveys.
- experience in conducting previous surveys; pilots acquire a "feel" for the survey requirements, so that a more natural flying rhythm occurs.

Advantages of Helicopters

- high maneuverability and slow flying speeds; this is especially important when features of interest are highly crenulated
- removable doors allow wide viewing areas
- ability to land at selected locations to verify field interpretations (e.g., the particular species of algae that defines an intertidal colour band

Disadvantages of Helicopters

- high cost; charter rates are typically 3-4 times that of fixed-wing aircraft
- limited range requires attention to fuel requirements and may necessitate pre-survey location of fuel caches
- vibration cause by the helicopter rotor may be transferred to the video camera and reduce the image quality

In summary, the major advantage of a helicopter of a fixed-wing aircraft is in speed and maneuverability but this advantage comes at 3-4 times the cost. If the primary survey objective is a more regional overview and the features of interest are primary linear, fixed-wing surveys would provide a more cost effective approach; however, if details are required, such as species identification, and the features of interest are crenulated, then a helicopter-based survey may be the only appropriate approach.

3.5 Special Equipment

Computer Access Systems

The increased importance of computer databases in environmental resource inventories and contingency response planning makes videotape an ideal medium for information gathering and storage. Moderately priced video playback units can be directly controlled by common desktop computer systems allowing simultaneous access to data and playback of the aerial videotape imagery. If faster response than can be provided by videotape is required, the imagery can be transferred to laser disk for direct access. This level of information presentation is fast becoming a required industry and government standard, where text, maps, visual imagery and audio descriptions are linked in an easy-to-use system. The power of small database computer systems has made the use of geographical information systems (GIS) common place (e.g., QuikMap, MapInfo, ArcView). Most systems will allow the incorporation of still pictures into the database. By adding direct access video, a still picture (freeze frame) can be accessed anywhere on the tape, taking advantage of the consistency and continuity of the media.

3.6 Approaches for Meeting Survey Objectives

This section provides an overview of alternatives for achieving a variety of survey objectives using various equipment components and survey platforms. Specific survey scenarios are outlined and alternatives approaches for meeting objectives are listed (Table 6). A discussion of each of the scenarios is provided.

Scenario 1 - Overview for Log-Dump and Stream Crossing Siting

An overview of site conditions are required for preliminary screening of the area. No previous information is available other than 1:50,000 scale topo maps, 1:80,000 scale charts and 1:20,000 air photos. The survey should document general conditions in a 2-3km section of coast and 1 km inland along a small stream. The survey should be conducted at low-tide as intertidal areas will be impacted by the log-dump. The data will serve as a preliminary basis for additional surveys and planning by the project team.

Chartering of a locally-based, fixed-wing floatplane is dictated by the short duration of the survey. Consumer-grade Hi8 or SVHS hand-held recording equipment is appropriate as this equipment is easily available but provides a higher quality than conventional VHS or 8mm video. In that a relatively small area will be covered, recording flightlines on a blown-up copy of 1:50,000 scale topographic map is an appropriate documentation as imagery will have very limited distribution. Video imaging by the operations manager is appropriate as he is familiar with the information that will be needed in future planning.

Table 6 - Examples of AVI Approaches for Meeting Survey Objectives

			Survey Approach				
Category	**No.**	**Scenario**	**Approach**	**Aircraft**	**Camera/Recorder**	**Positioning**	**Personnel**
Reconnaissance	1	overview for potential log dump and stream crossing	general shoreline, stream character and terrain overview;	fixed wing (high wing), removable or sliding window	Hi8 or SVHS handheld	flightline record on 1:50,000 scale topo map	operations manager
	2	stream surveys following heavy rains to document washouts and local failures	imagery will focus on failure areas rather than provide a systematic survey of all reaches	fixed wing (high wing), removable or sliding window	Hi8 or SVHS handheld	flightline record on air photos or using GPS to add narrative comment on tape	hydrologist or slope stability specialist
Inventory	3	land-use managers require a detailed inventory of shore structures in an operating region	imagery must be of sufficient resolution to resolve docks and moorings	fixed wing, permanent mount camera system	professional Hi8 or SVHS fixed mount	GPS burn-in and recorded	technician and land-use manager
	4	shoreline survey for oil spill contingency planning	imagery must resolve morphological features and substrate type and audio serve as supplemental data on intertidal biology and sediment type	helicopter using hand-held camera	professional Hi8 or SVHS hand-held camera with separate recorder	GPS burn-in and recorded	intertidal biologist, coastal geomorphologist, navigator
	5	stream habitat inventory	imagery resolves major features; audio necessary to identify subtle features like sediment type	helicopter with front-mount external pan-tilt	professional Hi8 or SVHS to accommodate multiple audio input	GPS data logged on lap-top; post survey processing to DGPS	stream habitat biologist; technician keys habitat breaks
Planimetric Mapping	6	estuarine habitat inventory	imagery used to map wetland types on delta	fixed wing, with fixed vertical mount	professional Hi8 or SVHS	GPS data logged on lap-top; post survey processing to DGPS	technicians; field verification program required

Scenario 2 - Overview of Washout and Slope Failures

The purpose of the survey is to inventory stream washouts and local slope failure in a Special Area watershed as a result of an exceptional rainfall. The emphasis of the survey is to concentrate on problem areas, rather than a systematic inventory of the entire watershed. Good quality imagery is required to serve as a basis for mitigative actions and potentially for litigation. Good positioning is required so that problem areas can be precisely located.

Again, because the survey is of limited duration, chartering of a local fixed-wing aircraft is most appropriate; however if on-the-ground inspections are necessary, a helicopter may be required. High quality, consumer-grade video equipment is appropriate as it is available locally and easy to use. A detailed airphoto (1:10,000 scale) could be used to locate failures or alternatively a hand-held GPS used to locate the site and position added to the narration. A stream hydrologist or slope stability specialist is the most appropriate individual to be imaging as they can provide an inflight commentary and know most critical features to document in the imagery.

Scenario 3 - Shore-Structure Survey

The Lands Department requires a detailed, synoptic record of shore structures located within the regional land district. The purpose of the survey is to document un-permitted structures in the foreshore. The region contains about 2,000 km of shoreline. Low tide surveys are not required so the time of the survey is not constrained.

A fixed wing aircraft with an external pan-tilt camera mount is probably appropriate due to the length of the survey - an estimated 15 hours of survey time. A fixed wing aircraft offers extended flight time between refueling stops and ergonomically-positioned controls to permit extended surveys (est. 5 hours of survey per day). Professional quality Hi8 or SVHS systems are recommended to facilitate GPS burn-in and synchronous GPS data recording on the audio tracks. A GPS burn-in system is recommended because of the potential use of the imagery in litigation, and a GPS recording system is recommended to facilitate flightline plotting and data management. A near-vertical imaging mode should be sufficient to resolve shore structures. The camera system would be operated by a technician and the land manager would accompany the flight as a client observer.

Scenario 4 - Shoreline Survey for Oil Spill Planning

This data is required for interpretative purposes and to develop oil spill sensitivity maps. In particular, intertidal sediment size determines potential residence of stranded oil and biological zonation contributes to sensitivity. Because it is not possible to resolve the sediment size characteristics or intertidal biota from the imagery alone, specialist narrations and 35mm photos provide important supplementary data. Surveys must be conducted at low tide only so are limited to a 3hr/day tide window.

A helicopter survey platform is recommended to increase maneuverability along the highly crenulated coast and to provide low-altitude (100m), slow-speed (<100km/hr) overflights. A hand-held camera system is recommended because the aircraft undergoes considerable attitude variations while flying along the crenulated coast. The professional quality Hi8 or SVHS system is recommended to provide dual channel audio-recording capability and to provide GPS burn-in capability; the GPS burn-in is recommended as tapes are likely to be used by a wide range of agencies and the positioning data is then permanently linked to the imagery. GPS data will be continually recorded to facilitate flight line recording and data management.

Scenario 5 - Stream Habitat Characterization

A standard aquatic habitat inventory program requires stream habitat characterization mapping to 1:20,000 scale maps. Stream courses are highly sinuous and terrain very steep. Inventory data provides the most detailed record of habitat so positioning critical.

Because of the sinuous nature of the streams and the steep terrain, a helicopter is recommended. The stream inventory program requires inventory of both banks of the stream as well as the stream channel; to avoid "shadowing" problems that occur with oblique, hand-held video, the use of a near vertical pan-tilt camera system is recommended. GPS data is logged to a lap-top computer for post-survey differential correction to DGPS standard as detailed positioning is required; DGPS data is linked to the video-imagery through the burned-in time code on the video image. Standard DGPS flightline files are maintained and the flightlines can be easily imported into GIS systems for data management purposes.

Scenario 6 - Estuarine Habitat Mapping

An inventory program of estuary habitat types requires planimetric mapping at 1:5,000 scale mapping. Planimetric video imaging was chosen over vertical aerial photography because of the limited duration of the survey and the need to fly during early morning, low tide windows (i.e., less weather dependency).

A vertical format video image is required to facilitate mapping so a fix mounted system is recommended. Resolution requirements of the mapping program will dictate the need for inertial navigation systems in the aircraft. Professional video equipment is recommended to allow time code to be recorded and linked to GPS datafiles on the laptop. Post-survey processing of GPS to DGPS recommended to improve location information to <5m accuracy. Screen captures of individual video frames will provide the basis for mapping within a desktop GIS system. Some ground-truthing required to verify aerial mapping interpretation.

4. Recommendations of Survey Standards

4.1 Factors Affecting Survey Quality

A wide variety of aerial video imaging (AVI) is being conducted in British Columbia. Applications include: coastal resource inventories, fisheries habitat mapping for both coastal and river systems, shellfish habitat inventories, landscape feature mapping for use in forest cut-block planning and charting shoreline positions for hydrographic chart preparation. The wide range of applications has resulted in a wide variety of AVI platforms and collection techniques being used, with little standardization.

The flexibility of AVI has resulted in the independent development of numerous survey techniques. These range from the simple acquisition of oblique aerial imagery collected on an *ad hoc* reconnaissance basis with consumer-grade equipment to sophisticated systems using differential GPS (DGPS) positioning and inertial navigation systems. A single standard for AVI collection was not appropriate because of the wide range of survey objectives.

Table 7 provides a summary of user-controllable factors that control the overall quality of the AVI survey results. The table lists the various factors that influence the quality of imagery and associated interpretive value of the flight data. Users can evaluate various trade-offs between quality and cost in terms of their survey objectives.

4.2 Recommended Standards Criteria

It is not possible to simply combine all the factors listed in Table 7 into a simple standard. Survey quality will also be affected by weather conditions during the overflight; for example, turbulence can affect aircraft stability, precipitation may degrade the image and bright sunlight may cause reflection problems off water surfaces. The recommended standards are based on the actual quality of the imagery and associated data rather than the intended quality.

Four key components of the survey data were selected for standardization:

- **resolution**, which is a function of the scale of the imagery (i.e., altitude and camera focal length), equipment resolution, aircraft stability and ground speed of the aircraft
- **positioning**, which presently range from rudimentary flightline maps to DGPS with inertial navigation systems.
- **documentation**, which varies from simple data sheets to comprehensive reporting.
- **supplemental data,** which can include: synchronous photography which is of a higher resolution than the imagery, synchronous narrative descriptions of features in the image that may not be resolvable in the imagery and synchronously recorded databases that involve data logged onboard during the overflight

Table 7 - Factors Affecting Aerial Video Imaging Survey Quality

		Survey Variables						
Survey Quality	**Cost**	**Camera**	**Recorder**	**Communications**	**Positioning**	**Aircraft**	**Inflight Interpretation**	**Data Logger**
low	*low*	CCD, 1 composite chip or tube*	VHS	none	manual reconstruction of flightline	low-wing	none	none
↓	↓		8mm	single channel, mic	inflight 1 min fix marks	high wing, struts		
↓	↓				GPS w video burn-in	high-wing, strutless	single, on-board interpreter	
↓	↓	CCD, 2 chip or 2 tube*	SVHS		GPS w burn-in and logging	high-wing, strutless, STOL		
↓	↓		Hi8		DGPS			
↓	↓		3/4"Umatic		GPS w on-board GIS			on-board computer
high	*high*	CCD, 3 chip or 3 tube*	Betacam	multi-channel; voice-activated mic's	DGPS & inertial navigation	helicopter	multiple, on-board interpreters	on-board computer w GIS

*chips less shock & light "burn" sensitive than tubes

Image Resolution

For the purposes of this discussion, image resolution is defined as:

> *the smallest, consistently resolvable feature on the imagery, usually defined on the basis of a natural feature, such as a cobble or boulder.*

This standard essentially addresses the composite affect of camera, recorder, aircraft speed and stability that affect image quality. Slow, low altitude overflights using a hand-held, consumer-grade cam-corder may have the same image resolution of a faster, higher overflight with professional-grade camera and recorder systems.

Positioning

Positioning is a critical component of AVI surveys in that there are often few distinct landscape features that can be used to reference the imagery. The advent of inexpensive, widely available GPS systems, which provide geographic positions within _100m of the true position, puts positioning within reach of all users. For the purposes of this project, we define positioning as:

> *the ability to relocate imagery in terms of a geographic coordinate system such as UTM coordinates or latitude and longitude.*

Prior to the use of GPS, detailed flightline maps with frequent fixes were used to locate imagery; this process required an intermediate interpretation of an experienced navigator and is partially dependent of the scale of the maps used to plot the flight line. Many surveys have no or rudimentary flightline positioning, making the imagery difficult to locate for all but the original, inflight personnel.

Documentation

There is no standard of documentation for aerial video surveys. Often only a single version of flightline maps are available from the original project investigator, if at all, and there is no centralized repository of aerial video information. For the purposes of defining an AVI standard, we define documentation as:

> *supporting written, map or electronic information that documents the date and time of overflights, the survey coordinator, survey objectives, flight data (such as speed and altitude), geographic extent of survey, flightlines (either as maps or files) and standards (resolution, positioning, documentation and supplemental data standards as defined in this report)*

A minimum documentation could be in the form of a data sheet, archived by a designated AVI coordinating agency and cross-referenced by NTS sheets. A more formal documentation might include a survey report and associated data files of the flightline.

The advantage of establishing a central clearing house for the aerial video survey data, is that some type of copying system could be established for the videotapes. At the present time, tape copies are obtained on a completely informal basis, and there is no quality control.

In view of the substantial, *albeit* dispersed, annual expenditure on aerial video surveys, the documentation needs improvement and a central clearing house should facilitate distribution.

Supplemental Data

Supplemental data collected during the overflight may greatly enhance the use of the imagery. For example, specialist commentary is critical to identifying features that may not be visible on the imagery but are visible during the survey (e.g., species distribution). Another example is where data may be logged directly into a laptop computer during the overflight. Supplemental data is:

> *information other than the imagery itself that enhances the interpretations that can be made from the video survey data.*

It is our own experience and that of other users of AVI that the value of the imagery is considerably enhanced by having the end-user or interpreter (e.g., the stream hydrologist that will be classifying the stream habitats) in the aircraft providing a synchronous commentary, concentrating on features that may be marginally discernible on the imagery. In our coastal surveys (see Section 5, References), the coastal geomorphologist operates the camera at the same time as providing an inflight commentary; the commentary focuses on beach sediment composition, which is often difficult to resolve on the imagery.

4.3 Recommended Classification of Standards Criteria

Because of the extremely wide range of survey objectives (i.e., reconnaissance, inventory and mapping) addressed by AVI surveys, we recommend that AVI be *classified* in terms of the four above-outlined criteria, rather than specifying standards (Table 8). Details of the ratings are summarized in Table 9.

It is envisaged that the imagery classification will be included on AVI datasheet (see next section) that catalogs basic information of the survey (e.g., location, custodial agency, contact, date, survey objective, etc) would include a classification designation (Table 10). The AVI classification will be included in associated documentation and labeled on the videotapes.

Table 8 - Summary AVI Classification Standard

Order	Criteria	Rating
1st	Resolution	1 = highest resolution (<0.5m2) 2 = moderate resolution(0.5-2m2) 3 = lower resolution(>2m2)
	Positioning	1 = GPS or better (DGPS) 2 = <1:50,000 flightline maps 3 = >1:50,000 flightline maps
2nd	Documentation	1 = detailed survey report 2 = survey report 3 = data sheets on survey7
	Supplemental data	1 = extensive supplemental data 2 = some supplemental data 3 = no supplemental data

Table 9 - Explanation of Rating Criteria for AVI Survey Classification

Component	Class	Description	Rationale
Resolution	1	Possible to resolve objects $0.5m^2$ in diameter or smaller	Small features can be resolved on the image
	2	Possible to resolve objects $2.0m^2$ in diameter or smaller	Individuals can be resolved on the image
	3	Objects smaller than $2.0m^2$ cannot be resolved	Individuals or smaller features cannot be resoled on the image
Positioning	1	Positions are GPS standards or better (e.g., DGPS) and positions are permanently tied to the imagery, either as a burned in time code that can be linked to a database or a burned in GPS position; ASCII format electronic files are available	Positioning is more or less permanently linked to the image and will survive various copy formats and is independent of playback machines.
	2	Flightline maps on 1:50,000-scale maps or better with fix points of not more than 1 minute are linked to the imagery by either a time code or audio-commentary	Positioning is independent of playback machines and should be of sufficient resolution to approximately fix image location
	3	Flightline maps on 1:50,000 to 1:100,000-scale maps with fix points of not more than 1 minute are linked to the imagery by either a time code or audio-commentary	Bare minimum positioning information; image location will be only approximately known without additional position information (e.g., Air photos, maps)

Documentation	1	A report indicating survey crew, survey date, associated flight data (general flightline paths, available documentation such as files, tapes, etc.) Must be publicly available (maps bc?); Tapes must be systematically archived and copies available	Potential users can review information on the imagery from a central source, decide if will meet their survey objectives and order imagery
	2	A report with flight data and must be publicly available from the collecting agency/ Institution; tapes should be archived and available for copying	Potential users can review information from local offices and/or contacts and order imagery
	3	Data sheets and flightline maps are available; the survey coordinator is identified and the imagery is available, albeit on an *ad hoc* basis	Documentation is available although it is highly dependent on identifying the survey coordinator; tapes are available but copying is not conducted on a routine basis
Supplemental Data	1	Supplemental data is available that significantly complements the stand-alone imagery. This may include: gis compatible maps with flightline maps and index electronically to the videotapes; professional, synchronous inflight commentary on features that may not be resolvable in the imagery; synchronous 35mm photographs that are linked to the imagery; data files that were logged during the overflight and which provide an additional level of information not captured by the imagery	Data that may significantly enhance the interpretations from the imagery
	3	No supplemental information is available	

Table 10 - Example of AVI Classification of West Coast Shoreline Surveys

Survey	Resolution	Positioning	Documentation	Supplemental
Barkely Sound (1983)	2	2	2	2
Barkely Sound (1986)	3	3	3	2
Claoquot Sound (1993)	1	2	1	1
Nootka Sound (1994)	1	2	1	1
Johnstone Strait (1995)	1	1	1	1

Until such time as a lead agency is designated for AVI data, it is recommended that project managers be responsible for (a) classification of imagery and (b) submission of project data sheet to the coordination agency.

4.4 Other Recommendations

There is a great deal of aerial video imagery available in the Province but sources are very difficult to locate, documentation is almost non-existent and tapes are filed on an helter-skelter basis. Some centralization would address these problems.

1. It is recommended that initially a Provincial agency be designated to maintain data sheets on AVI surveys. This coordinating agency would maintain a database of AVI surveys and small-scale location maps of flightline coverage within the province.
2. It is recommended that a standard datasheet be developed to summarize information on individual AVI surveys. A suggested format is provided in Table 11.
3. Should sufficient demand develop, videotapes could be archived with the coordinating agency to facilitate copying and distribution of the imagery.

Table 11 - Suggested Format for AVI Datasheet or Data Fields

Project Name: ______________________ Project ID: ______________

Sponsoring Agency/Institution: ______________________________

Contact Name: ______________________ Phone: ______________

Contact Address: ____________________ Fax:

____________________ E-Mail: ______________

____

Survey Objective: ______________________________

Date(s): __________ General Location:

(show approximate flightlines on attached 1:1,000,000 map)

Description: ______________________________

____

____

____

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1. Imagery	**1. Resolution**	**1. Positioning**	**1. Documentation**	**1. Supplemental Data**
2. Classification:	2.	2.	2.	2.

(see AVI Classification Standard)

Resolution (minimum resolvable object): ______________________

Positioning (state type of positioning used): ______________________

Documentation (type, reference): ______________________

Supplemental Data (type[s], description): ______________________

Other (e.g., post-survey processing): ______________________

____

Appendix A: Project Summaries

Technique: MELP/CORO-EML

Project I.D. No. 1

Survey Data	**Objective:** Biophysical shore-zone mapping **Location:** Vancouver Is; Gwaii Haanas/South Moresby **Period of Surveys:** 1991-1994 **Altitude (m):** 100-200 **Other:** obliques imagery collected from helicopter, bio & geo commentaries
Equipment	**Camera:** Sony, H18 consumer **Tape Format:** H18 **Audio Record:** 2 channel audio; bio and geo **Positioning:** 30 sec fixes, manual recording on maps **35mm Photos:** slide; located on basemaps, audio **Aircraft:** Bell 206; rear door removed
Reporting	**Tape Archive System:** yes **Location Maps:** yes; hard copy w 30 sec fix marks **Tape Location:** MELP-Victoria **Reference:** Harper, J.R., M. Morris, P.D. Reimer 1994. Flightline log, aerial video survey of West Coast Vancouver Island, 23-26 June 1994. Technical Report by Coastal & Ocean Resources Inc for Land Use Coordination Office, MELP, Victoria, B.C., 13p. w appendices.
Post-Survey Editing	**Edits:** yes, 1995 **Copies:** VHS **Edit Format:** ¾"
Contact	Howes, Don Phone: (250)356-7721 Land-Use Coordination Office Fax: (250)953-3481 Ministry of Environment Lands and Parks E-Mail: dhowes@luco.env.gov.bc.ca
Description	This aerial video imaging technique relies on obliquely collected imagery from low altitude aircraft. Most surveys have been conducted from helicopters, with the door removed, shooting an oblique image of the shoreline. With typical imaging altitudes of 100-200m, features of the size of cobbles can be resolved in the imagery. Synchronous audio commentary on shoreline biota and shorelines morphology substrate are recorded on separate audio tracks. Cost of imagery collection and production of draft flightline maps has averaged about $30/km of shoreline imaged over the past three years.

Technique: MELP/Waberski-Darrow

Project I.D. No. 3

Survey Data	**Objective:** River habitat surveys and classification **Location:** Fort St. John District, MELP **Period of Surveys:** Altitude (m): 50-100
Equipment	**Camera:** remote pan-tilt mount external pod **Tape Format:** SVHS **Audio Record:** Yes, 1 audio channel; 2 possible **Positioning:** DGPS; GPS burned to video image **35mm Photos:** not usually; vertical mount possible **Aircraft:** helicopter, Bell 206
Reporting	**Tape Archive System:** no formal system **Location Maps:** yes; hardcopy; digital files; attribute database **Tape Location:** MELP-Fort St. John **Reference:** Downs, T., J. Robertson 1995.Aerial Video Survey Techniques for Stream Habitat Classification. Technical Report by District Office, MELP, Fort St. John, BC, (in prep).
Post-Survey Editing	Edits: yes; cleanup tapes to remove overlap, add labels Copies: Edit Format: SVHS
Contact	Down, Ted Phone: (250) 787-3289 Fish & Wildlife Branch, MELP Fax: (250) 787-3507 10003 110th Ave E Mail: Fort St. John BC V1S 6M7
Description	This system has been used for mapping stream morphology in support of MELP fisheries programs from the Fort St. John district office. Habitat ;types are characterized at mapping scales of 1:10,000, are georeferenced to DGPS standards, are plotted on hard-copy maps and are logged in digital databases. The system has been used on about 9 surveys in the northeastern area of BC. Approximately 800km of surveys have been flown using this system. Imagery is acquired using a variable orientation camera system mounted on a helicopter. Typical flying altitudes are 100-300' and flight speeds are 20-30 knots. The stream channel and riparian zones are framed in the image; imagery is usually collected obliquely, although vertical shots are possible. A habitat ecologist describes the river habitats in terms of a regionally standardized MELP classification during the overflight. This audio commentary is logged on the audio channel of the videotape. The habitat ecologist also indicates break points between habitats which are digitally logged by the navigator using an event marker on the on-board laptop computer. GPS positions (latitude and longitude) are "burned" on the video image during the overflight, along with date, time, aircraft heading and utm coordinates while simultaneously being logged to the computer with the event information. (Continued...) SVHS recording decks are used to record the imagery and audio channel data. Post survey processing includes: differential correction of the GPS positional data, "cleaning" of the trackline data (e.g., removing turns, or overlaps), plotting the flightline, river channels and associated habitat data onto 24x36" plots, developing a DXF-file format of the map data and spreadsheet files of the habitat data. Video imagery is edited to remove

	overlaps and turns and to insert labels. Acquisition and processing (as described above) costs are estimated at about $70/km.

Technique: Range & Bearing

Project I.D. No. 4

Survey Data	**Objective:** various - river and coastal habitat; shellfish habitats **Location:** arctic; many BC rivers; coastal areas of Queen Charlotte Islands **Period of Surveys: Altitude (m):** 150-200 **Other:** use permanently mounted fixed-nose camera and operator-tilt cameras in tail pod.
Equipment	**Camera:** 2; fixed in nose and tilt-mounted in tail pad; gyro stabilized **Tape Format:** SVHS; Hi8 **Audio Record:** yes; one standard, two possible **Positioning:** GPS and DGPS **35mm Photos:** yes, oblique **Aircraft:** twin-engine, low-wing; Piper Navajo or Hughes 500
Reporting	**Tape Archive system:** tapes provided to clients **Location Maps:** yes; hard-copy; digital files **Tape Location:** various **Reference:** Nass, Bryan, 1994. Fisheries habitat assessment of the Ishkeemickh River, B.C. using aerial video imagery, 1993. Technical Report by LGL Ltd for Nisga'a Tribal Council, New Aiyansh, B.C., 12p. w appendices.
Post-Survey Editing	**Edits: yes** **Copies:** VHS, SVHS, Hi8, 8 **Edit Format:**
Contact	Campbell, Doug Phone: (604) 541-2634; Range & Bearing Environmental (800) 670-3880 Resource Mapping Corporation Fax: (604) 541-2828 200-1678 128th St E Mail dcampbel@direct.ca South Surrey BC V4A 3V3
Description	This technique has been used in a variety of applications ranging from coastal resource surveys, shellfish habitat inventories to river channel surveys. Applications of the imagery include: shellfish habitat characterization (Environment Canada) and river morphology (Environment Canada) characterization. Two camera systems are used: (1) a fixed, forward-looking, wide-angle, nose-mounted camera and (2) an operator-controlled, gyro-stabilized tilt camera which can shoot in either an oblique or vertical mode. The tilt-camera is permanently mounted in a Plexiglas pod on the tail of a twin-engine, fixed-wing aircraft. Typical flight altitudes are 300 to 750' at 100 knots. Imagery and audio signals are recorded onto Super VHS (SVHS) recording decks (Hi8 optional). Two on-board GPS systems are typically used: (1) an aircraft Trimble Navigation System that supplies uncorrected GPS positions and (2) a Trimble Pathfinder System with a time stamp that can be post-survey processed to provide DGPS. (Continued...) Navigation data is logged on a laptop computer and recorded on an audio track of the videotape. The navigation system has the capability of using digitized maps through a QuikMap GIS System to provide real-time, inflight

	map data and to pre-plot flightlines. The minimum flying configuration is with a pilot and a camera-operator/navigator. The aircraft can accommodate four, including the pilot, although the low-wing configuration limits visibility of the observers. Post-survey processing varies depending on client needs. The simplest processing would involve supplying the videotapes with a hard-copy flightline map. Plotting of the flightline tracks on digital maps is routinely conducted. Image processing to map habitats or other map features is possible, especially using vertical-mode imagery Typical data acquisition costs are $6-17/km. In the Ishkeenickh River survey, video acquisition costs were $66/km (2 passes over the 37 km survey area; costs with interpretation were $193/km; Nass 1993). Prices vary depending on the amount of pre and post-survey processing. Mobilization of the aircraft to the survey base is an additional cost.

Technique: MOF-Queen Charlotte Island Coastal Landscape Inventory

Project I.D. No. 5

Survey Data	**Objective:** provide inventory data for mapping landscape and recreational features and designing cutbacks to minimize visual impacts **Location:** coastal areas of Queen Charlotte Islands **Period of Surveys:** 1993, 1994 **Altitude (m):** 75-100 **Other:** oblique imagery from hand-held camera
Equipment	**Camera:** Sony Hi8 camcorder, high-end consumer, Sony CDDXX3 **Tape Format:** Hi8 **Audio Record:** yes; one standard; 2 possible **Positioning:** GPS burned on image **35mm Photos:** yes; selected locations **Aircraft:** helicopter, Bell a206 on floats; rear door removed
Reporting	**Tape Archive System:** no formal system **Location Maps:** yes; hard-copy 1:150,000 hand plotted **Tape Location:** MOF Queen Charlotte (Recreation Section) **Reference:**
Post-Survey Editing	**Edits:** no **Copies:** VHS **Edit Format:** n/a
Contact	Eccles, Brian Phone: (250) 559-6223 Ministry of Forests Fax: 250) 559-8342 Box 39 E Mail: Queen Charlotte BC V0T 1S0
Description	This system was developed to inventory coastal forest areas for use in landscape inventories, recreational inventories and cut-block planning by the Ministry of Forests (MOF). Oblique aerial video imagery is reviewed to inventory various landscape and recreational features, which are summarized on base maps. Selected video frames are digitally captured and processed to review cut-block alternatives and to view landscapes from different view points. The entire coastal area of the QCI Forest District has been surveyed using this technique since 1993. Oblique video imagery is acquired from a helicopter equipped with floats; the camera is hand-held with the cameraman located in the rear seat with

	the door removed. The cameraman and navigator provide a continuous narrative commentary, which is recorded on one audio channel; this channel also records intercom audio from the aircraft. Consumer grade Hi8 camcorder systems are used to collect the imagery (SONY D5000). (Continued...) GPS from the aircraft is burned onto the video image for selected locations; GPS data is not recorded with the tape. The navigator also keeps a flightline track on 1:150,000 scale maps; annotations are added to these maps. Tapes are re-dubbed following the survey with original commentary is over-written. No additional editing is usually conducted. Tapes are copied to long-play (6 hr) VHS tapes for general use. No formal reports have been prepared and there is no formal archiving system. Imagery acquisition costs are estimated at about $30/km to produce the above described products.

Technique: MELP-Victoria Stream Survey

Project I.D. No. 6

Survey Data	**Objective:**Stream morphology surveys for fisheries habitat monitoring **Location:** All areas **Period of Surveys:** Altitude (m): 100-200 **Other:** oblique aerial video imagery with synchronous morphology classification
Equipment	**Camera:** Sony TR-101 Camcorder **Tape Format:** Hi8 **Audio Record:** yes; 1 channel; two possible **Positioning:** 1:50,000 topo maps tied to index **35mm Photos:** not usually **Aircraft:** helicopter; Bell 206
Reporting	**Tape Archive System** nothing formal; in file cabinet **Location Maps:** none **Tape Location:** MELP-Victoria **Reference:**
Post-Survey Editing	**Edits:** yes; labeling, remove overlap C**opies:** VHS **Edit Format:** Hi8 masters; VHS copies
Contact	Norris, Gary Phone: (250) 387-9560 Fisheries Branch, MELP Fax: (250) 3879750 2nd Floor, 780 Blanshard St E Mail: Victoria BC V8V 1X4
Description	This survey program collects imagery for stream habitat classification. Oblique aerial imagery is collected, along with an audio narration, of the streams and riparian zones on each side of the stream. Following collection the imagery with audio is used to classify various reaches of the rivers and stream in terms of a standard classification system of the branch. Approximately 12 separate surveys have been conducted covering an estimated 1,000 km of river. Oblique aerial imagery is collected from a helicopter using hand-held camera. The cameraman sits in the rear seat with the door removed; an observer sits in front of the cameraman and provides a running commentary on the stream morphology; this commentary is recorded on

	one of the audio soundtracks. A Sony TR 101 Hi8 camcorder is used. Flight altitudes are typically 100-200m with flight speeds of 50-80 knots. No flightline data is recorded during the overflight; positions are reconstructed following the survey by recording time from various confluences. A backup Sony Video Walkman is used to display the imagery for the forward observer and to provide a backup tape copy (8mm tape format). (Continued...) The tapes are edited by MELP to remove overlaps and turns, and to add labels on the tapes. The tapes are edited in a Hi8 format to produce Hi8 masters. Working copies on VHS are provided to client departments. The original imagery and edited masters are maintained in the MELP-Victoria office. The surveys tapes are interpreted following the survey to map habitat characteristics. 1:50,000 Aquatic Biophysical maps are produced associated data files (morphology/FIS summary).

Technique: MELP Cranbrook Pilot Comparative Survey

Project I.D. No. 7

Survey Data	**Objective:** pilot project of detailed stream havitat mapping **Location:** Cranbrook District **Period of Surveys: 1994 Altitude:** 30-50 **Other:** The pilot project compared aerial video habitat data to GPS-fixed ground surveys in 1 of 7 assessments
Equipment	**Camera:** fixed mount, remote pan, tilt **Tape Format:** SVHS **Audio Record:** Yes, 1 audio channel **Positioning:** DGPS, GPS burned on image **35mm Photos:** no **Aircraft:** helicopter, Bell 206
Reporting	**Tape Archive System:** no formal system; single survey **Location Maps:** yes; hardcopy; digital files **Tape Location:** MELP, Cranbrook District **Reference:** Downs, T., J. Robertson 1995. Aerial Video Survey Techniques for Stream Habitat Classification. Technical Report by District Office, MELP, Fort St. John, BC, (in prep).
Post-Survey Editing	**Edits:** no **Copies: Edit Format:** n/a
Contact	Oliver, Gerry Phone: (250) 489-8556 MELP - Kootenay Region Fax: (250) 489-8506 205 Industrial Road G E Mail: Goliver@cranbrook.env.gov.bc.ca Cranbrook BC V1C 6H3

Description	This pilot project was conducted to test the use of aerial video imagery and GPS of stream attributes as a prerequisite of fish habitat assessment under Watershed Restoration Program. It was intended to reduce the amount of time normally required in a ground survey. A reconnaissance overflight was conducted using the technique developed by the Fort St. John MELP office, then detailed habitat characterization was conducted from the helicopter during a slow, low-altitude over pass of the watershed. On one stream, a ground survey using GPS-positioned personnel was conducted to map habitat. Oblique aerial video imagery was collected using a fixed-mount camera with pan and tilt (see Project Description No. 3). Flight altitudes were about 75m. Positioning was by GPS, which was burned on to the image of the video. SVHS recording decks were used. (Continued...) Imagery and follow-up overflight GPS data were compared to ground survey GPS data. Comparison of the data indicate that the video imagery/audio is of sufficient resolution to resolve 50-100m habitat units for 4^{th} and 5^{th} order streams; GPS-positioned ground surveys resolve features in the order of 1-5m and are more appropriate to categorizing 1^{st}, 2^{nd} and 3^{rd} order streams. The video imagery was useful in classifying reach-breaks at the watershed scale as well as providing a record of riparian habitat (vegetation type, distribution and density).

Technique: Terra Survey LIDAR/Coastal Charting Surveys

Project I.D. No. 8

Survey Data	**Objective:** mapping high and low tide lines for coastal hydrographic charting **Location:** Strait of Georgia; arctic **Period of Surveys:** 1990-1995 **Altitude (m)**: 500 **Other:** vertical imagery with DGPS and inertial navigation can be used to plot feature 1m accuracy
Equipment	**Camera:** fixed mount; fixed oblique possible **Tape Format:** SVHS **Audio Record:** no; two channels possible **Positioning:** DGPS; millisecond time code burned on image **35mm Photos:** no **Aircraft:** fixed wing (Cessna 182 & up); helicopter
Reporting	**Tape Archive System:** no formal system **Location Maps:** yes **Tape Location:** Terra Surveys **Reference:**
Post-Survey Editing	**Edits:** no **Copies: Edit Format:** n/a
Contact	Onyschtshuk, Peter Phone: (250) 656-0931 Terra Survey Ltd. Fax: (250) d;d656-4604 1962 Mills Rd E Mail: Sidney BC V3L 3R9
Description	Vertical aerial imagery is collected during LIDAR bathymetric surveys (water depth is measured using a laser) in coastal waters to delineate shore features, in particular, the high water line, the low water lines and other intertidal. The information is used as base data for the development of hydrographic charts. The imagery is collected from fixed-wing aircraft, usually a Twin Otter or Beaver, at the same time LIDAR data is collected. The instrument package incorporates an inertial navigation system and DGPS positioning equipment. The camera system is mounted vertically, such that imagery very similar to a vertical aerial photo is obtained. The scale of the image varies depending on the altitude but is typically in the order of a 1:10,000 when displayed on a monitor, features the size of a few metres can usually be resolved in the imagery. A time code is burned onto the video image and simultaneously recorded on the on-board computer. Flightline paths can be reconstructed following the survey using the inertial navigation data (removes pitch, roll, and heave aircraft motion) and survey-quality DGPS, resulting in track line positions with 1-2m accuracy. (Continued...) Features on the imagery are digitized on the screen (e.g., high water line) and navigational data used to correct the positions; the digitized features are then plotted to a base file for eventual reconstruction into chart. No post-survey editing of the imagery is normally conducted.

Appendix B: Contacts

Campbell, Doug
Range & Bearing Environmental Resource Mapping Corporation
200-1678 128th St
South Surrey BC V4A 3V3
Phone: (604) 541-2634; (800) 670-3880
Fax: (604) 541-2828
E Mail: dcampbel@direct.ca

Carigan, Wayne
MATRIX Professional Video Systems
123 W 7th Ave
Vancouver BC V5Y 1L8
Phone: (604) 875-6301
Fax: (604) 875-0543
E Mail:

Down, Ted
Fish & Wildlife Branch, MELP
10003 110th Ave
Fort St. John BC V1S 6M7
Phone: (250) 787-3289
Fax: (250) 787-3507
E Mail:

Eccles, Brian
Ministry of Forests
Box 39
Queen Charlotte BC V0T 1S0
Phone: (250) 559-6223
Fax: (250) 559-8342
E Mail:

Fairhurst, Ken
Ministry of Forests
2100 Labieux Rd
Nanaimo BC V9T 6E9
Phone: (250) 751-7112
Fax: (250) 751-7198
E Mail:

Froebel, Dave
Atlantic Geoscience Centre
Bedford Institute of Oceanography
Dartmouth NS B2Y 4A2
Phone: (902) 426-7736
Fax: (902) 426-4104
E Mail:

Gillie, Rick
AXYS Consulting Ltd.
2045 Mills Rd
Sidney BC V8L 3S1
Phone: (250) 656-0881
Fax: (250) 655-4789
E Mail:

Harper, John
Coastal & Ocean Resources Inc
107-9865 W Saanich Rd
Sidney BC V8L 3S1
Phone: (250) 655-4035
Fax: (250) 655-1290
E Mail: cori@islandnet.com

Reid, Stafford
Enforcement & Emergency Planning
Ministry of Environment Lands and Parks
3-1106 Cook St
Victoria BC V8V 1X4
Phone: (250) 356-?
Fax: (250) 356-0742
E Mail:

Reimer, Doug
EML Environmental Mapping Ltd.
273 Portsmouth Ave
Victoria BC V9C 1S1
Phone: (250) 478-9727
Fax: (250) 478-5307
E Mail: eml@islandnet.com

Robertson, Jeff
Waberski-Darrow Survey Group
10720 100th Ave
Fort St John BC V1J 1Z3
Phone: (604) 787 0300
Fax: (604) 787-1611
E Mail:

Williams, Ian
Pacific Biological Station
Hammond Bay Rd
Nanaimo BC V9R 5K6
Phone: (250) 756-7095
Fax: (250) 756-7053
E Mail:

Appendix C: Video Equipment Database

EQUIP 08-Mar-95

Manufacturer	Model	Format	Image device	Resolution	System weight	Audio tracks	Audio input	Audmeters
JVC	GREZ1	VHS	¼" CCD		630g	1	0	0
JVC	GR-SV3	VHS	¼" CCD		820g	1	0	0
JVC	GR-SZ7	S-VHS	CCD	570K-PIXEL	820g	1	0	0
SONY	CCD-TR400	Hi8 8mm	1/3" CCD	470K PIXELS	910g	2	-1	0
SONY	CCD-VX3	Hi8 8mm	1/3" CCDx3	530 HORIZ LN	1.5kg	2	-1	0
SONY	CCD-FX730V	8mm	1/3" CCD	270K PIXELS	1.5kg	2	-1	0
SONY	CCD-TR700	Hi8 8mm	1/3"PR CCD*	410K PIXELS	930g	2	-1	0
SONY	EVW-300	Hi8 8mm	½" IT CCD*	700 LINES	5.6kg	2	-1	-1
SONY	EVO-150TR	Hi8 8mm	1/3" CCD	400 LINES	1.25kg	2	-1	0
SONY	UVW-100	BETACAM SP	½" IT CCD*	700 TV LINES	6.9kg	2	-1	-1
PANASONIC	AG-195U	VHS	1/3" CCD	230 LINES	2.6kg	1	-1	0
PANASONIC	PV-IQ604-K	VHS	1/3" CCD	270K PIXELS	920g	1	0	0
PANASONIC	PV-54-K	VHS	1/3" CCD	270K PIXELS	980g	1	0	0
PANASONIC	PV-S64-K	S-VHS	1/3" CCD	400 LINES	990g	1	0	0
PANASONIC	AG-455U	S-VHS	1/3" CCD	400 LINES	2.7kg	2	-1	0
PANASONIC	AG-DP800	S-VHS	3 FIT 1./2" CCD	700 LINES	4.5kg	4	-1	-1
PANASONIC	AJ-D310	D-3 ½" DVC	3 FIT 2/3" CCD	750 LINES	6.7kg	4	-1	-1
PANASONIC	AJ-D320	VTR ONLY			7.7kg	4	-1	-1
SONY	DXC-537A	CAMERA ONLY	3 2/3" IT CCD	750 LINES	3.6kg	1	-1	0
SONY	EVV-9000	Hi8		400 LINES	1.8kg	2	-1	-1
JVC	GY-X2BU	S-VHS	½"	750 LINES	6.0kg	2	-1	0

			CCD					
JVC	KY-19U	CAMERA ONLY	½" IT CCD X 3	750 LINES	2kg	4	-1	-1
JVC	GY-XITCAULI	S-VHS	½" CCD X 3	600 LINES	5.2kg	3	-1	-1

Appendix D: Commercial Suppliers and Services

Note: This listing provides only a partial selection of potential suppliers and services and does not necessarily imply endorsement or recommendation of the authors or sponsoring agencies.

Video Rental Equipment

Canadian Helicopters
Sea Island Base
4391 Agar Rd
Richmond, BC V7B 1A5
Phone: (604) 276-7672
Fax: (604) 276-7644
Services: fixed-mount, video camera and GPS package

Matrix Video Professional Video Systems
123 W 7th Ave
Vancouver, BC V5Y 1L8
Phone: (604) 875-6301
Fax: (604) 875-0543
Contact: W;ayne Carigan
Services: rental of video cameras, video recorders, batteries, communications systems

Vancouver Island Helicopter (VIH)1-9600 Canora Rd
Sidney, BC V8L 5V5
Phone: (604) 656-3987
Fax: (604) 656-1180
Contact: Gavin Miller
Services: fixed mount, video camera and GPS package

Aerial Video Services

Coastal & Ocean Resources Inc.
107-9865 West Saanich Rd.
Sidney, BC V8L 3S1
Phone: (604) 655-4035
Fax: (604) 655-1290
Contact: John Harper
Services: coastal biophysical video surveys; interpretation, mapping

EML Environmental Mapping Ltd.
273 Portsmouth Dr
Victoria, BC V9C 1S1
Phone: (604) 478-9727
Fax: (604) 478-5307
Services: video surveys, communication systems, post-survey editing, interpretation, mapping

Range and Bearing Environmental Resource Mapping
200-1678 128th St
South Surrey, BC V4A 3V3
Phone: (604) 541-2634
Fax: (604) 541-2828
Contact: Doug Campbell
Services: complete video survey capability, camera systems, GPS, DGPS, GIS interpretation

Waberski-Darrow Survey Group
10720 100 Ave
Fort St. John, BC V1J 1Z3
Phone: (604) 787-1611
Contact: Jeff Robertson
Services: stream video surveys, GPS/DGPS GIS, interpretation and mapping

Specialized Equipment Suppliers

Cansel Survey Equipment
3751 Napier St
Vancouver, BC V5C 3E4
Phone: (604) 299-4794
Fax: (604) 299-1998
Services: rental of GPS and DGPS systems and software

Van Isle Avionics Ltd.
15-22 Kitty Hawk
Sidney, BC V8L 3S1
Phone: (604) 655-1371
Fax: (604) 655-1371
Services: Communications system

VPL Vision Processing Ltd.
1225-18th Ave. NW
Calgary, AB T2M 0W3
Phone: (403) 650-1719
Fax: (403) 282-9431
Services: GPS to video burn-in module (BPC-100-Stand alone unit; VPC-200- User configurable unit)

GIS Software with GPS Input Capabilities

Axys Environmental Consulting Ltd.
PO Box 2219, 2045 Mills Road
Sidney, BC V8L 3S8
Phone: (604) 656-0881
Fax: (604) 656-4511
Services: QuikMap software that is compatible with GPS inputs

Environmental Systems Research Institute Inc.
ESRI Canada Ltd.
12 Water Street, Suite 201
Vancouver, BC V6B 1A5
Phone: (604) 682-4652
Fax: (604) 682-5692
Services: ARC/INFO and ARCVIEW GIS software that is compatible with GPS inputs

Glossary

A-B roll edit	An edit in which two or more players are used to create special effects such as dissolve and wipe, and one recorder is used to record the results of the edit. Using an editing controller allows efficient control of the VTRs and very precise editing.
AFM recording	Abbreviation of Audio Frequency Modulation recording. The recording of frequency modulated audio signals together with frequency modulated video signals in video tracks
AGC	Automatic Gain Control. Sets proper video gain control for low light shooting situations. video sensitivity gain is increased when the iris F-stop reaches a pre-determined minimum value.
Assemble edit	An edit mode for adding new scenes to the end of the existing recorded scenes. Continuity of CTL signals at the edit points is maintained electrically. In this mode, inserting new scenes into the middle of the existing recorded scenes causes noise to appear on the picture at the end of the inserted scenes
AVI	aerial video imaging or imagery - refers to the general technique of acquiring aerial imagery in a video format.
B-Y signal	One of the color difference signals, the B signal minus the Y signal.
Chroma Detail	Compensates for poor resolution in the high chroma (colour) areas of the picture.
Chrominance signal	Signal which carries information about hue and color. Also called C signal.
Color frame	The color subcarrier phase whose one cycle consists of two frames (four fields).
Color framing	A method to maintain continuity of color subcarrier phase from one two-field frame to the next, for the purpose of avoiding noise on the picture at the edit points.
Component signal	A video signal consisting of a luminance signal (Y) and two chrominance signals (R-Y, B-Y).
Composite signal	A composite video signal containing video. burst and sync signals
Condensation	Water which has condensed on tape transport mechanisms. Videotape tends to adhere to and be damaged by condensation on the head drum
CTDM	Abbreviation of Compressed Time Division Multiplex. A processing method employed to record color difference signals. When composite video signals are recorded, the narrow bandwidth color difference signals (R-Y, B-Y) are compressed by time division, multiplexed, and recorded in a single track. CDTM video is characterized by its broad bandwidth and high picture quality.

CTL signal	Abbreviation of Control signal. in VTRs, regular pulses used to synchronize tape movement and the scanning position of the video heads. Recorded in a special track so that the video heads can scan the playback tape accurately.
Dark Detail	This circuit determines the optimum degree of contour enhancements to the dark areas of the picture, to deliver crisper, cleaner, more natural looking images under challenging lighting conditions.
Data Code	Allows the user to store date and time information on the videotape. Information is automatically encoded. Indicates the date (year, month and day) and time (hour, minute and second).
DGPS or Differential Global Positioning System	normal GPS data has an inherent error intentionally introduced in the satellite signals; this error is typically around _100m. However, the error can be corrected either during the survey (real time DGPS) or after the survey (post-survey corrected DGPS) to produce positions typically accurate to _5-10m. For survey data to be DGPS corrected, special handling of the data is required.
Digital Signal	Using digital circuitry to process the video image brings benefits in: 1) higher performance, 2) fine adjustment of a variety of video parameters, 3) flexible and higher quality image processing. Includes such parameters as (see) Chroma Detail, Dark Detail, Highlight Compression and Flare Correction Circuits.
Drop frame mode	In NTSC format, the actual number of frames per second is approximately 29.97, while that for the time code is specified as 30. Drop frame mode is a mode in which the time code is advanced in such a way that the difference in frame value between real time and the time codes is corrected. In this mode, two frames are skipped at the beginning of each minute, except for every tenth minute, so that the frame value for time codes matches that for real time.
EE mode	Abbreviation of Electric to Electric mode. Video and audio signals are supplied to the VTRs internal circuits, but not to the recording heads.
External synchronization	Synchronization of the signals and tape transport of a VTR with those of a reference VTR.
FIT Processing	Frame Interline Transfer. CCD type image sensors.
Flare Correction Circuit	Compensates for unsteady black caused by light or by a subject's movements
Genlock	Abbreviation of Generator Lock. The pulse generator built into video equipment is adjusted to synchronize it with an external reference signal.
GPS or Global Positioning System	the Global Positioning System is a satellite positioning system that typically provides positional accuracy of _100m with the use of an appropriate receiving system, some of which are hand-held. The GPS data can be corrected to produce accuracies as good as _5-10m (see DGPS) with minimal processing. With special survey-grade processing, accuracies of _1-2m are possible.

Highlight Compression	This circuit expands the dynamic range of the highlighted areas and prevents halation. Provides detailed images even against bright backlight or daylight.
Hyper HAD	Hole Accumulated Diode. CCD type image sensor. HAD type CCD offers high resolution (600 lines).
Insert edit	An edit mode for inserting new scenes into the middle of existing recorded scenes. The recorder uses the CTL signals already recorded on the recorder tape to control tape movement. Before editing, VBS signals must be recorded over the entire length of the recorder tape.
Intelligent Auto Iris	Automatic control of the camera's iris. Very practical when there is an extreme difference in the brightness of an object and the background. The iris automatically adjusts to compensate for this difference.
LANC	Local Application Control Bus System (Sony). Allows connection of a Handycam to another VCR or editor.
LTC	Abbreviation of Longitudinal Time Code. A time code recorded in a separate track at the edge of the tape.
Luminance	The signal which carries information about brightness. Also called the Y signal.
Lux	A measure of light usually in foot candles.
Metal tape	Magnetic tape coated with a fine metallic powder of needle-like spines mixed with a binder. Metal tape is noted for its high recording density.
Non-drop-frame mode	A mode of advancing the time code in such a way that the difference in frame values between real time and the time code is neglected. Using this mode produces a difference of approximately 86 seconds per day between real time and time code, which causes problems when editing programs in units of seconds using the number of frames as a reference.
Oxide tape	Magnetic tape coated with needle-like spines of ferrous oxide mixed with a binder.
Phase synchronization	When editing with two VTRs, adjustment of the movement and position of the recording and playback tapes, carried out while the tapes run from the pre-roll position to the edit in point, in order to increase editing precision.
Program AE	Programmed Auto Exposure. The shutter speed automatically adjusts to match lighting conditions. Some cameras offer several modes for differing situations.
Record Review	Playback of the last recorded scene.
Reference video signal	A video signal consisting of a sync signal or sync and burst signals, used as a reference.

RC Time Code	Re-writeable Consumer Time Code Generator. Indicates the absolute position of the tape with hour, minute, second and frame
R-Y signal	One of the color difference signals, the R signal minus the Y signal.
Search mode	A VTR mode used when searching for specific scenes by viewing the video picture or time codes while rewinding or playing the tape fast forward.
Servolock	The mechanisms which control the phase of the head drum and the speed of tape transport during recording or playback are called servo mechanisms. Servolock is synchronization of drum rotation and tape speed with a reference signal
Scene File	Customized digital parameter settings. Digital processing of the video signal (e.g. colour correction, background lighting, dark detail). See Digital Signal Processing.
Shutter	Electronic shutter works in conjunction with the iris setting (F-stop)and, in higher shutter speeds, eliminates the blurred image of fast-moving subjects. See Program AE.
S/N	Signal-to-Noise ratio. The higher the signal-to-noise ratio, the better is picture quality.
SMPTE	Society of Motion Picture and Television Engineers.
SteadyShot	Optical Image Stabilizer (Sony). Compensates for camera shake.
Superimpose	To superimpose two or more video images in layers.
S-VHS	Super VHS. Format which offers higher video performance than regular VHS. Horizontal resolution is improved (often over 400 Lines).
Sync signal	A reference signal consisting of vertical and horizontal sync signals used for synchronizing the scanning patterns of the video camera and the monitor.
TBC	Abbreviation of Time Base Corrector. Electronic circuits to electrically stabilize the playback signals by removing color variation and roll in the playback picture caused by irregularity in drum rotation and tape movement. Time base correction reduces deterioration of picture quality when transmitting or copying playback signals.
Time code	A digital code recorded on the videotape to supply information such as the hour, minute, second and frame of each frame. LTC and VITC are time code formats.
Tracking	Control of playback tape speed in such a way that video heads are able to scan the recorded signals correctly.
User bits	Sections of the digital time code signal left open so that the user can record any information which may be necessary, for example the actual clock time.

VITC	Abbreviation of Vertical Interval Time Code. A time code inserted during the vertical blanking interval between two fields. Unlike LTC codes, VITC codes are stored in the same tracks as the video information, so they can be read even while the tape is not moving.
V-blanking	The portion of the video signal that occurs between the end of one field and the beginning of the next. During this time, the electron beams in the cameras and monitors are turned off so that they can return from the bottom of the screen to the top without showing traces of movement on the screen. When the position of Vblanking is not adjusted correctly, a horizontal black bar appears on the screen.
VBS	Abbreviation of Video, Burst and Sync. A composite signal consisting of video signal, burst signal and sync signal.
Video gain	Amplification of video signals, expressed in decibels (dB).

References

Coastal & Ocean Resources Inc. 1991. Aerial video survey of South Moresby/Gwaii Haanas National Park Reserve, July, 1991. Technical Report by Coastal & Ocean Resources Inc., Sidney, BC for the Canadian Park Service, Calgary, AB, 6p w appendices.

Coastal & Ocean Resources Inc. 1992. Aerial video survey of Gwaii Haanas, Queen Charlotte Islands, June, 1992. Technical Report by Coastal & Ocean Resources Inc., Sidney, BC for the Canadian Park Service, Calgary, AB, 47p.

Frobel, D., R.B. Taylor and D.L. Forbes 1987. Video applications in coastal research. Proceedings of the 1987 Canadian Coastal Conference, National Research Council of Canada, p. 429-436.

Ham, D. 1995. Stream channel monitoring methods: Technical Review and Evaluation. Technical Report by the Department of Geography, University of British Columbia, Vancouver, BC for the Watershed Restoration Program, Ministry of Forests, Victoria, BC, 67p.

Harper, J.R., M. Morris and P.D. Reimer, 1993. Western Vancouver Island aerial video survey (1993). Unpublished Report by Coastal and Ocean Resources Inc., Sidney, BC for the Ministry of Environment, Lands and Parks, Victoria, BC,11p. w appendices.

Harper, J.R., M. Morris and P.D. Reimer, 1994. Flightline log and aerial video survey of West Coast Vancouver Island, 23-26 June 1994. Technical Report by Coastal and Ocean Resources Inc., Sidney, BC for the Ministry of Environment, Lands and Parks, Victoria, BC, 13p. w appendices.

Harper., J.R. and P.D. Reimer, 1995. Review of aerial video imagery (AVI) applications and development of AVI standards for the Province of British Columbia. *In* Proceedings of the Third Thematic Conference on Remote Sensing for Marine and Coastal Environments, Seattle WA, p. 700-709.

Owens, E.H., 1980. Physical shore-zone analysis, Saltspring Island, BC. Technical Report by Woodward-Clyde Consultants, Victoria, BC for the Lands Directorate, Pacific and Yukon Region, Environment Canada, Vancouver, BC, 155p.

Owens, E.H., 1983. The application of videotape recording (VTR) techniques for coastal studies. Shore and Beach 51(1): 29-33.

Owens, E.H. and G.A. Robilliard, 1980. Shoreline aerial videotape surveys for spill countermeasures. Spill Technology Newsletter, Environment Canada, 5(5):126-130.

Reimer, P.D., 1995. British Columbia coastal video imagery catalog: reference maps for Phases I and II. Technical Report by EML Environmental Mapping Ltd., Victoria, BC for the Ministry of Environment, Lands and Parks, Victoria, BC, in preparation.