Airborne LiDAR Bathymetric Survey for Climate Change

Victorian Future Coasts Bathymetric LiDAR Survey 2008 / 2009

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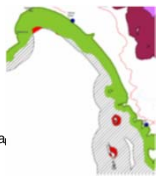
Victorian Coastline LiDAR Survey 2008 / 2009

- Bathymetric LiDAR Requirements
  - Vertical accuracy
    - IHO order 1, nominally ±50cm
  - Resolution
    - 5m average ungridded point spacing
    - 2.5m gridded DEM point spacing
  - Sounding coverage
    - Gap minimisation by managing turbidity
    - A minimum of 85% of all 100m x 100m tiles should have a minimum coverage of 320 soundings
    - Where a 5m resolution is used, 100% coverage represents at least 400 soundings per hectare (100x100m)
  - DEM coverage
    - Interpolation across "small" data gaps
  - Topographic integration points
  - Aerial photography
  - Heights relative to the GRS80 ellipsoid

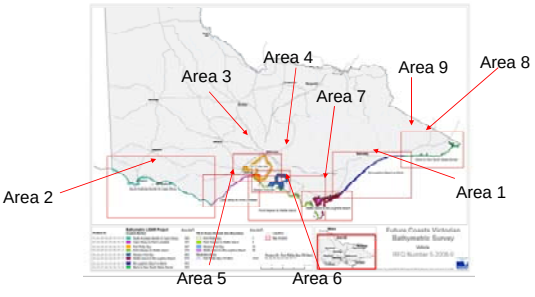
Victorian Coastline LiDAR Survey 2008 / 2009

- Survey was conducted for Vic DSE Future Coasts Program to prepare Victoria's coast for climate change
- Objectives of the program are:
  - Model the impact of extreme weather events and sea-level rise along the Victorian coast.
  - These may lead to inundation and erosion creating risks to environmental, social and economic assets
  - Aim of the project is to identify the threats and adaption strategies
  - Inform planning, decision making and strategy development by Local Government and coastal planners
- Data requirements
  - Statewide high-resolution coastal topographic elevation data
    - Coverage is at least 100m inshore of the vegetation line
  - Statewide high-resolution coastal bathymetric elevation data
    - Coverage is generally to 20m below mean sea level
    - At least 1km seaward of LAT and limited to 4km seaward of LAT
  - To produce a seamless, integrated DEM spanning the coastal zone



Victorian Coastline LiDAR Survey 2008 / 2009

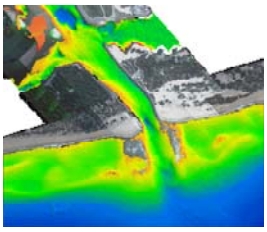
- Coastline divided up into 9 Areas:



LADS LiDAR Plan

Approach

- Three complementary LiDAR systems were used
- In general, areas were allocated to each sensor as follows:
  - LADS Mk II to survey the bulk of coastal areas including all deeper, more turbid and exposed areas.
  - Hawkeye 2 to survey shallow inter-tidal areas
  - Topographic lidar used to survey drying parts of Western Port and TIPs



- All Field work to be undertaken during 2008 / 2009 summer.
- Processing of LiDAR data and DEM generation to take place throughout 2009

Project Team Cont.

- **Cardno Lawson Treloar (CLT)**
  - Provide advice on tide gauge locations
  - Provide numeric processing of tidal data to achieve high order AHD datum
  - Provide additional tide data
- **Geomatix**
  - Provide supplementary GPS base station support
  - Conduct high order survey of selected Topographic Control Points (TIPs)
- **Tidal Princess III / Delta Tango Divers**
  - Used to install Seabed Mounted Tide Gauges

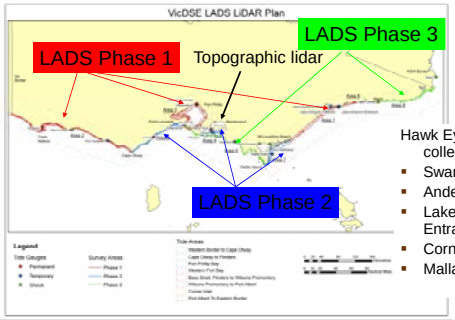
Project Team

Project Team Members

- **Fugro LADS Corporation**
  - Prime Contractor
  - Collect data using LADS MK II LiDAR system along 95% of Coastline
  - Install and recover all tide gauges
  - Process all LADS Data
  - Integrate all data and generate DEM
  - Note Tenix LADS Corporation was purchased by Fugro on 22 July 2009 and renamed Fugro LADS Corporation
- **BLOM Aerofilms UK – Hawkeye Bathymetric LiDAR**
  - Provide 2nd LiDAR system, collect data in shallow inter-tidal areas (Swan Bay, Anderson Inlet, Lakes Entrance, Corner Inlet and Mallacoota)
- **AAM Hatch Topographic LiDAR System**
  - Used to survey exposed low sand / mud flats in Western Port during Low Water Springs
  - Survey Topographic Control Areas (54 Ovals)

LiDAR Plan

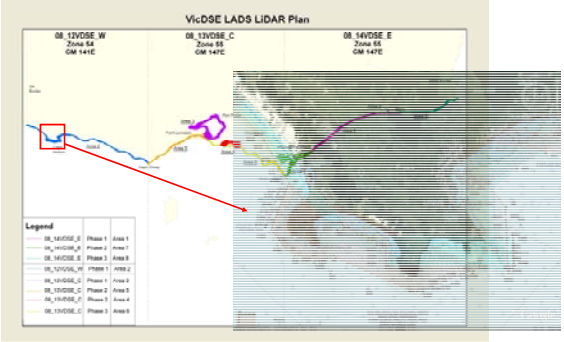
- The LADS plan divided the 9 areas up into three project data collection phases to maximise flexibility and reduce downtime due to weather



Hawk Eye 2 collected

- Swan Bay
- Anderson Inlet
- Lakes Entrance
- Corner Inlet
- Mallacoota

LiDAR Plan - 2



LADS Mk II Bathymetric LiDAR

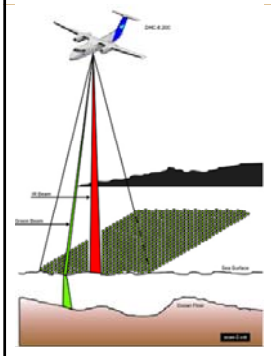
- Laser Airborne Depth Sounder (LADS)
- Hydrographic Survey / Coastal Mapping system mounted inside an aircraft
- Pulses of laser light are used to measure the depth of water and height of features (ie rocks, islands, beach gradients)

Victorian Coastline Bathymetric LiDAR Survey

Introduction

1. Introduction to the LADS Mk II Bathymetric LiDAR system
2. 2008 /2009 Survey of the Victorian Coastline
3. Processing Issues
4. Results Achieved

LADS Mk II Bathymetric LiDAR - Capabilities



- 900 soundings / second (1Khz System)
- Variable spot spacing: 2x2, 2.5x2.5, 3x3, 4x4, 5x5 or 6x6 metres
- Swath width 50 - 300 metres
- Variable altitude 1200 – 2200 feet
- Tidal and / or Ellipsoidal datum
- Maximum depth capability to 70m (subject to suitable water clarity)
- Topographic height range 0 to 50m
- Aerial Photography (0.25m Resolution)
- Relative Reflectance
- IHO Order 1 position, depth accuracy and target detection (subject to water clarity)
- Hyperspectral scanner (Apr 2010)

Survey Control and Datums

Real Time Horizontal control

- WGS 84, OmniStar Wide Area DGPS

Post Processed Horizontal control

- GDA 94, Post Processed KGPS using VicNET GPS base stations

Vertical Control – 2 Datums to be used

- AHD – through tidal reduction
- GRS 80 – through Post Processed KGPS using VicNET GPS base stations

Tidal Datum

Tidal Solution

- Use made of extensive network of permanent and project temporary tide gauges
- Gauges deployed on wharfs and on seabed brackets for duration of project
- Data exported relative to AHD Vertical datum as connected to tide gauges
- Complex Tidal Models developed along coastline to enable reductions of depths

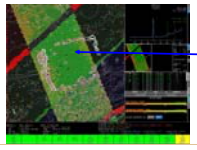
Tidal Datum vs GPS Ellipsoid (GRS 80) Vertical Datum

GPS Vertical Datum Solution

- Use made of the VicNET GPS Base Station Network
- Post Processed KGPS solution applied to all lines based on nearest station, longest base line was approximately 70km
- Data exported relative to GRS 80 vertical datum
- Advantage - Independent of tidal variation
- Disadvantage - Need multiple GPS Base Stations
  - Need GPS Base Lines
  - Need Geoid model to get AHD Dataset

Topographic Integration Points (TIPS)

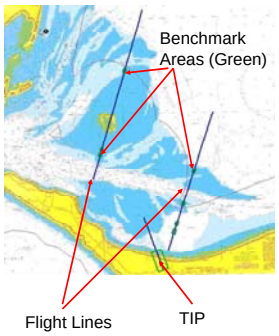
- 54 Football Ovals identified within 1 km along coastline
- Surveyed originally by Topo LiDAR
- A selection surveyed by KGPS
- All flown by LADS
- Those in inshore bays were also flown by Hawkeye
- Results used to confirm Ellipsoid model for LADS and provide a vertical reference for the Hawkeye system



Bathymetric Benchmark Areas

Bathymetric Benchmark Areas

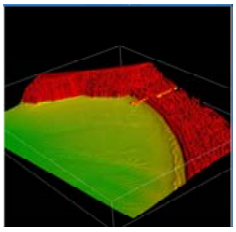
- Benchmark Areas identified from previous surveys
- LADS flew over these to as possible confirm system accuracy.
- Hawk Eye flew over these to confirm system accuracy and agreement with LADS



Advantages of the survey plan

The survey plan which was developed provided some important benefits:

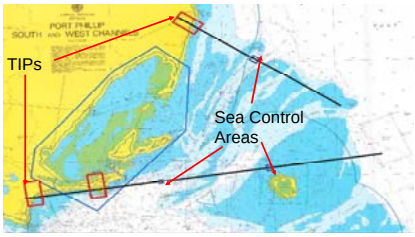
- it ensured data was collected in the priority order specified by DSE in discrete packages
- data collection was completed in one summer through provision of multiple sensors
- enabled environmental conditions to be managed through the use of an alternative areas separated geographically
- This approach ensured there was always an alternative sheltered area
- Comprehensive tidal model provided enduring benefit to the customer
- AHD and ellipsoid datasets established independent of geoid model
- Phased approach also allowed for a progressive processing and delivery of data



Sea Control Areas (SCA)

Sea Control Areas

- High Quality LADS Surveyed areas identified off each Hawkeye area ,
- Allowed checks and adjustments to be made to the Hawkeye data.



Fugro LADS LiDAR Data Collection

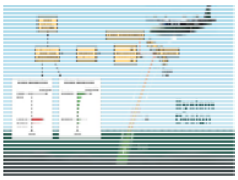
LADS Mk II Data Collection Activities

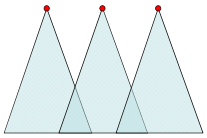
- LADS flying commenced 26 Nov 08, departed 03 April 09
- 73 flights flown of which 62 were fully effective,
- Average 4:36 on Task
- 8 Survey flights lost to bad weather
- 3 Survey flights lost to system defects
- 287 Hours of On Task time achieved
- 2271 lines flown, over 6500sqkm of data collected
- Team of 7 based in Melbourne (2 Pilots, 2 LAME, 2 Surveyors, 1 maintainer)
- Supported by Adelaide based Management, Planning, Logistics and Processing

Fugro LADS LiDAR Data Collection - Issues

Hawkeye Data Collection Activities

- Hawkeye flying commenced 17 Mar 09, aircraft departed on 07 April 09
- 17 flights flown, 15 fully effective
- Approx 22 hours on task achieved
- Average time on task of 1:13 on task
- 2.5 flights lost to Weather
- 3 Half flights lost to System Defects
- Team of 5 deployed to Victoria, supported by 1 LADS surveyor and 2 surveyors from Geomatix
- Processing of data in Cheddar, UK
- QC of data in Adelaide
- Integration into products in Adelaide





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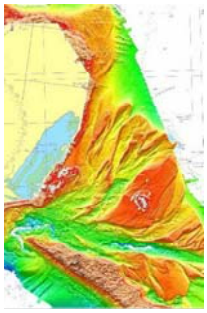
Field Processed Data

- Field Processing was returned to Adelaide for automatic processing and initial Pre-Validation to confirm system performance after each sortie
- High quality "Pre-Validated" interim LADS data available on completion of data collection
- Coverage plots generated and refly lines identified where needed
- Data then released for detailed and comprehensive validation and review in accordance with Fugro LADS quality processes



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Processing Pile Line

Data Processing

• Automated Initial Processing and depth selection

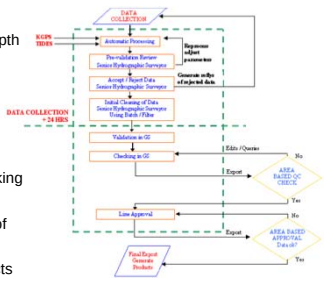
• Initial Field Check Conducted (in Adelaide for this project)

•Field cleaned pre-validated data set produced with 24 hours of last flight

•Comprehensive validation and checking process conducted in Adelaide office

•Data quality checked on completion of process

•Data then approved for use in products by Senior IHO Cat A Surveyor



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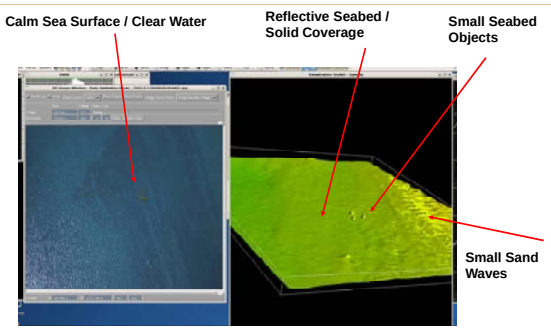
Bathy LiDAR Data Processing Issues – "a few seconds of data"



Easy data – very quick processing time line

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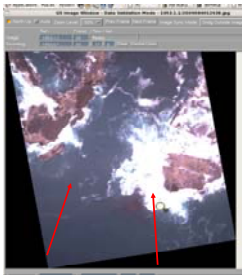
Bathy LiDAR Data Processing Issues – "a few seconds of data"

Good conditions, but a few more issues on coast – processing a little longer

Bathy LiDAR Data Processing Issues – "a few seconds of data"

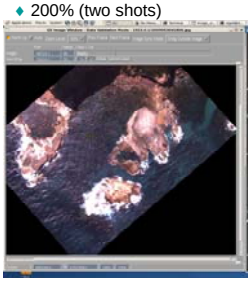
How do you survey this with light ?

- Much Easier to capture it like this?
- 200% (two shots)



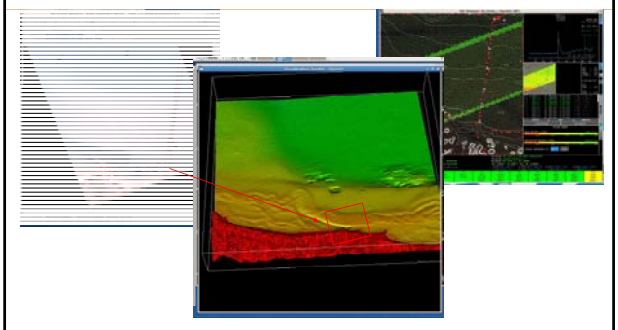
Turbidity

Swell / White Water



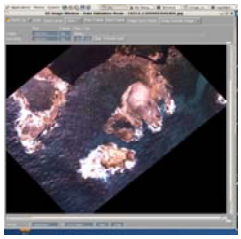
Much harder data to validate

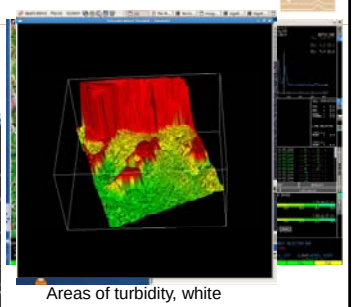
Bathy LiDAR Data Processing Issues – "a few seconds of data"



Bathy LiDAR Data Processing Issues – "a few seconds of data"

Complex areas of kelp, rock, sand, need to be confirmed



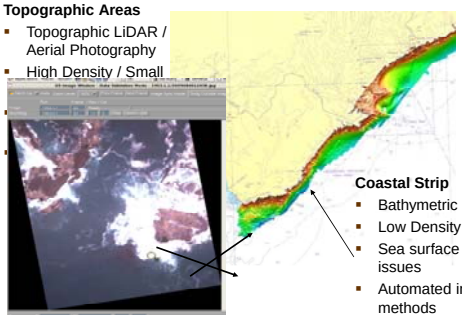


Areas of turbidity, white water, swell and surface kelp need to be removed

Data Processing Times

Topographic Areas

- Topographic LiDAR / Aerial Photography
- High Density / Small

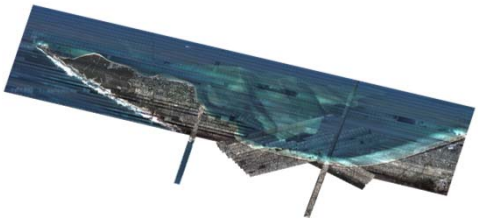


Coastal Strip

- Bathymetric LiDAR
- Low Density / Large Areas
- Sea surface / Water clarity issues
- Automated initial Processing methods
- Manual Validation of results

How Long – how much of this??

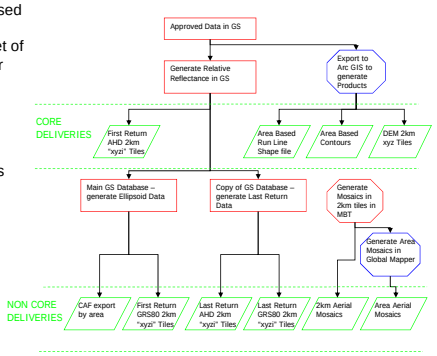
Results - Aerial Digital Mosaics



Post Data Processing Products

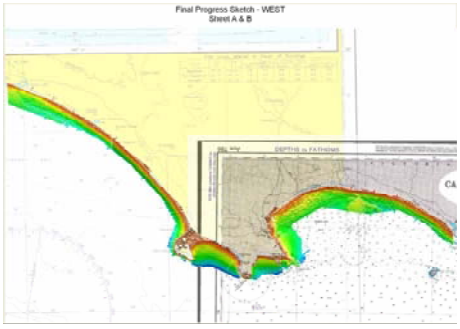
Processed data used to generate a comprehensive set of digital products for DSE such as:

- AHD xyz tiles
- DEM Tiles
- GRS 80 tiles
- Aerial Mosaics
- Relative Reflectance



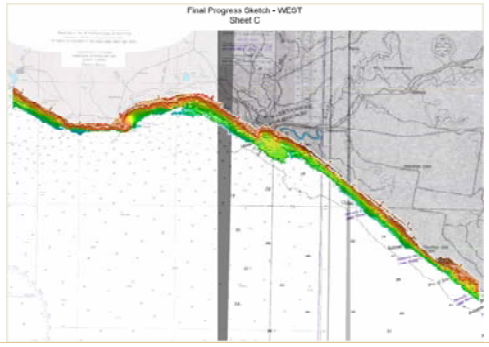
Results – LADS Areas West to East

Area 2 – SA Border to Cape Otway – Part 1



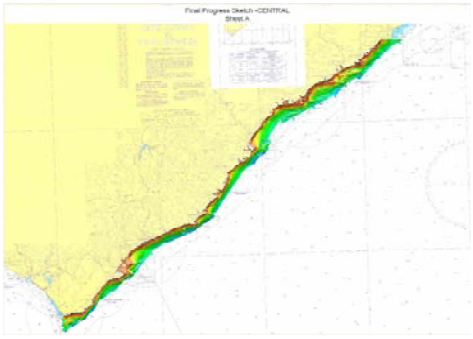
Results - West to East

Area 2 – SA Border to Cape Otway – Part 2



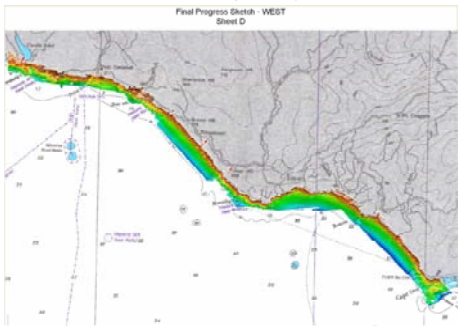
Results – LADS Areas West to East

Area 5 –Cape Otway to Point Lonsdale



Results – LADS Areas West to East

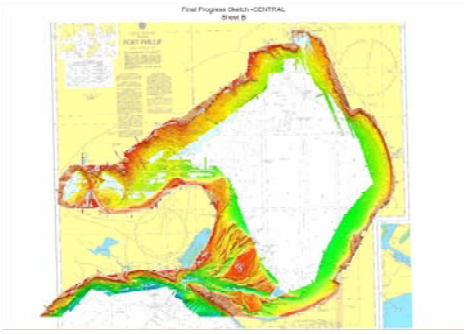
Area 2 – SA Border to Cape Otway – Part 3



Results – LADS Areas West to East

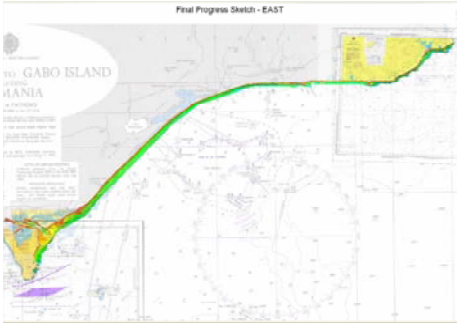
Results – LADS Areas West to East

Area 3 – Port Phillip



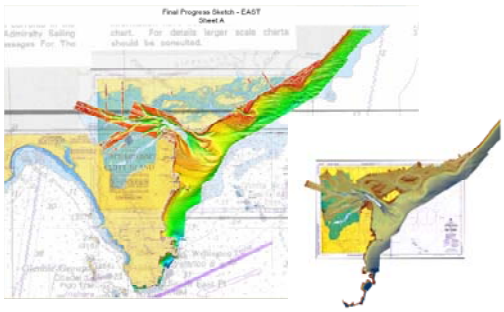
Results – LADS Areas West to East

Area 7, 1, 8 – Wilsons Prom to NSW Border



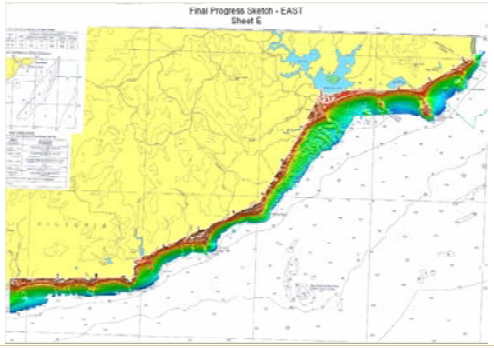
Results - West to East

Area 7 – Wilsons Prom to McLoughlins Beach (including Corner Inlet)



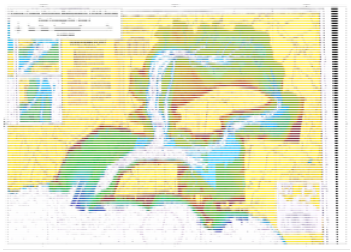
Results – LADS Areas West to East

Area 8 – Marlo to NSW Border



Conclusions

- Multiple ALB and topographic lidar sensors were employed and the data was collected in one season as planned
- Data was successfully integrated to produce > 15,000 files of 2 x 2 km tiles
- Data quality exceeded customer expectations in terms of coverage and vertical accuracy agreement
- A seamless topographic / bathymetric data set has been produced



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