CSA Global
Mining Industry Consultants

HKND GROUP

HKND Group Ltd

Grand Canal Project

General Overview of Aerial Survey Project
Managua, Nicaragua

September 21st 2015

Presented by:
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CSA Global

CSA Global - Mining Industry Consultants 30 YEARS 1984 - 2014

About CSA Global

CSA Global is a leading geological, data, mining and management consulting company which provides high quality solutions to our clients in the natural resources and extraction industries

Our staff include geoscientists, engineers, project managers, data management professionals and technical personnel

- **30 Year History**
- **>100 Employees**
- **Global Experience**
- **Global Presence**
- **Full Project Capability**

- Initial survey to production technical services
- Project reviews, program design & management
- Operational audits and improvement strategies
- Expert reporting to various international standards
- Mineral Resource and Ore Reserve estimation
- Concept to feasibility studies.
- Gap analysis, fatal flaw studies & due diligence
- Independent reports, valuations & specialist advice

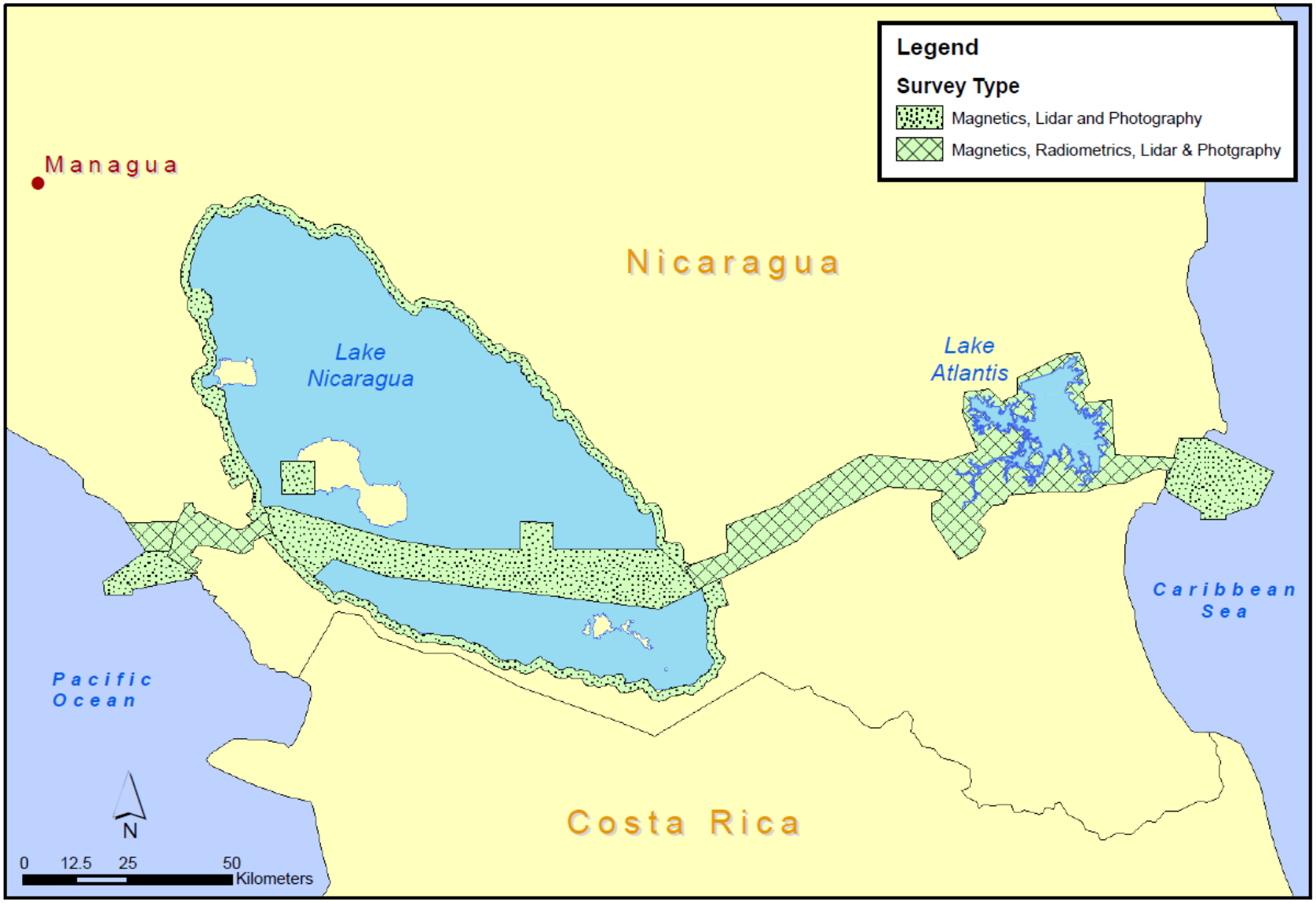
Our Offices & Projects

Aerial Survey

Summary of Project

- Detailed **topography, photography & geophysical survey** of canal route corridor, lake edges & oceanic approaches
- Objective is to collect high-resolution survey data, aerial photography & airborne geophysics **to map topography, surface infrastructure & vegetation, & interpret surface and sub-surface geology** throughout the canal corridor alignment
- The output will provide & form **baseline information** to enable construction works to be accurately engineered, estimated, sequenced and executed, along with potential fine tuning of the canal route & **capture a historical (pre-works) record of the project area**
- Survey works will be reported in UTM coordinates Zone 16N with reference to the WGS84 geographic system, & suitable for use at 1:2000 scale

Project Map


Legend
Survey Type
Magnetics, Lidar and Photography
Magnetics, Radiometrics, Lidar & Photgraphy
Managua
Nicaragua
Lake Nicaragua
Lake Atlantis
Caribbean Sea
Pacific Ocean
Costa Rica
N
0 12.5 25 50
Kilometers

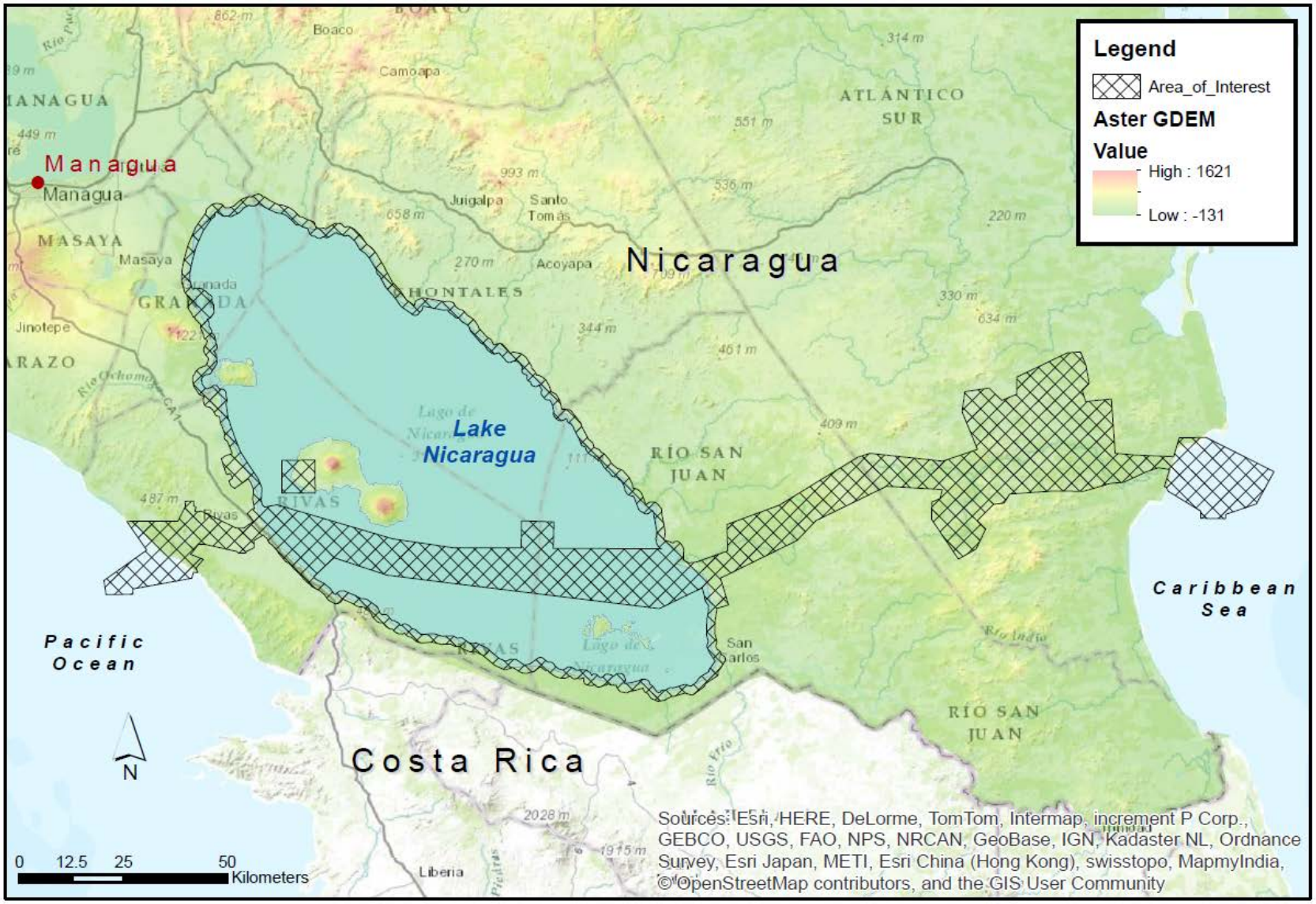
Sub-Projects Areas

- **Pacific** - 2km dredge path in the Pacific Ocean approaches
- **West Canal** - Brito Port, Brito Lock, the Pan American Highway Bridge, Pacific Resort and Pacific FTZ
- **Lake Nicaragua** - canal path, dredge disposal area & proposed artificial islands
- **Lake Perimeter** - includes the Lake Resort on Isla de Omtepe & the lake perimeter surveys (topography & photography)
- **East Canal** - canal path across the Caribbean watershed & the proposed Lake Atlanta
- **Caribbean** – 15km dredge path in the Caribbean Sea approaches & the proposed Aguila Port development

Scope – Topography

- **Topography, elevation contours & imagery** of approaches, land, canopy and lake (~4500 km^2, ~18000 line km)
- **High-resolution, airborne LiDAR** (Laser Imaging Detection & Ranging) survey & mapping
- Accuracy to <0.2m nominal & contour lines @ 1m or better via RTK GPS ground points and PPP GPS processing
- **Digital aerial photography & digital video** as pre-works catalogue of canal alignment
- **Digital terrain (DTM) & digital elevation models (DEM)** for comparison & verification of existing survey mapping data
- Also for analysis of vegetation types & surface mapping e.g. infrastructure, dwellings or archaeology

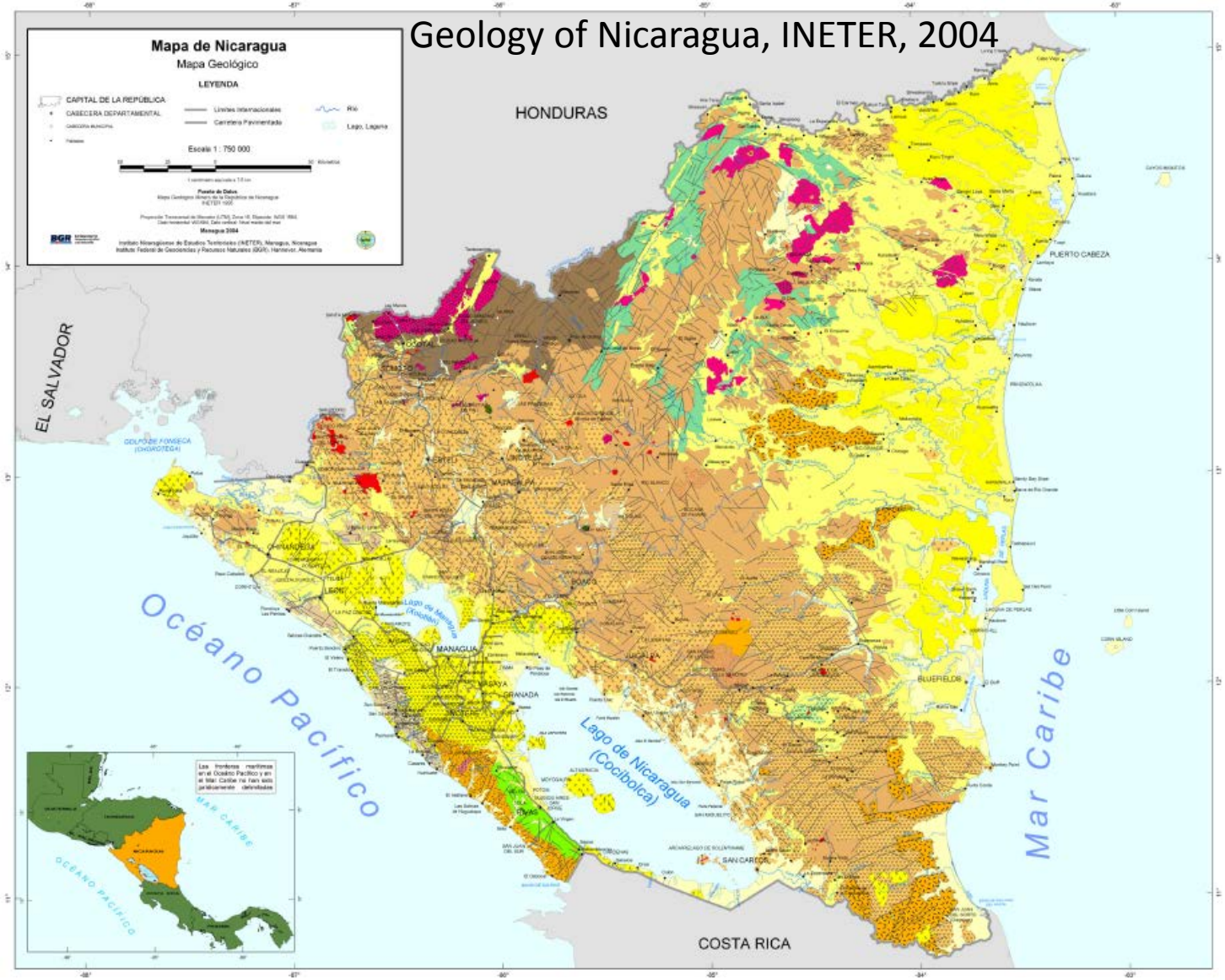
Regional Topography



Scope – Geology

- Undertake an **initial desk-top review** of publicly available geological data to allow refinement of survey if required
- Collect **airborne magnetic & radiometric** geophysical data (4000 km^2, ~34000 line km)
- Collate desk-top, geophysical & topo info into GIS database & generate **geological interpretation** of the canal route:
    - Map & interpret cover **lithology**, regolith & basement geology based on new geophysical data, LiDAR & aerial photography
    - Identify & discuss **structures** (faults, fractures, etc.) & **geohazards**
    - Assess material type & density (in terms of **excavation properties**)
    - Identify areas of interest for **construction materials** e.g. suitable for armour material, aggregate or cement manufacture
    - Comment on surface water & likely underground aquifers

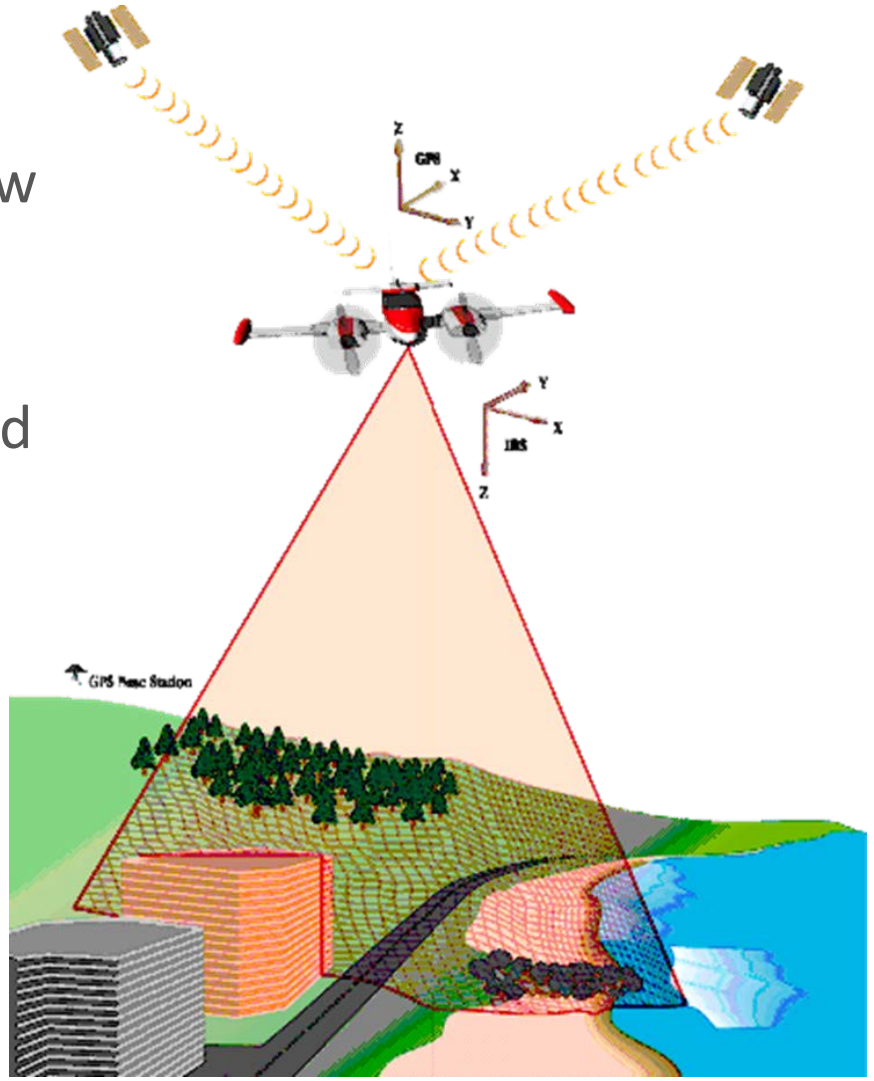
Regional Geology



Geology of Nicaragua, INETER, 2004

LiDAR - Process

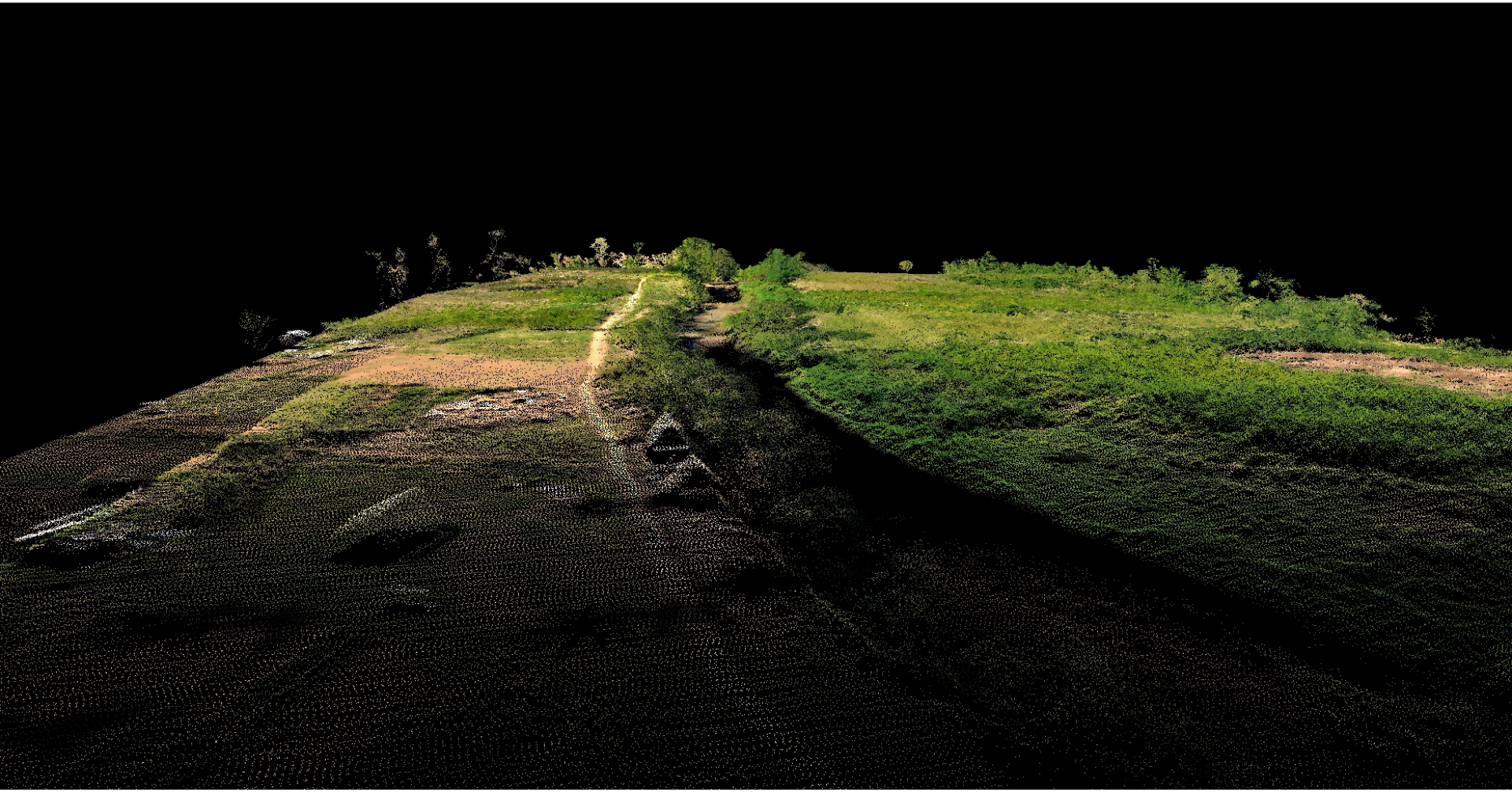
- Pulses of light sent out, time until echo comes back is measured to accuracy of a few trillionth's of a second
- Distance to target can be calculated based on the speed of light
- Laser – distance to ground
- GPS - aircraft position
- IMU - roll, pitch & heading
- Scanner – pointing direction beneath aircraft



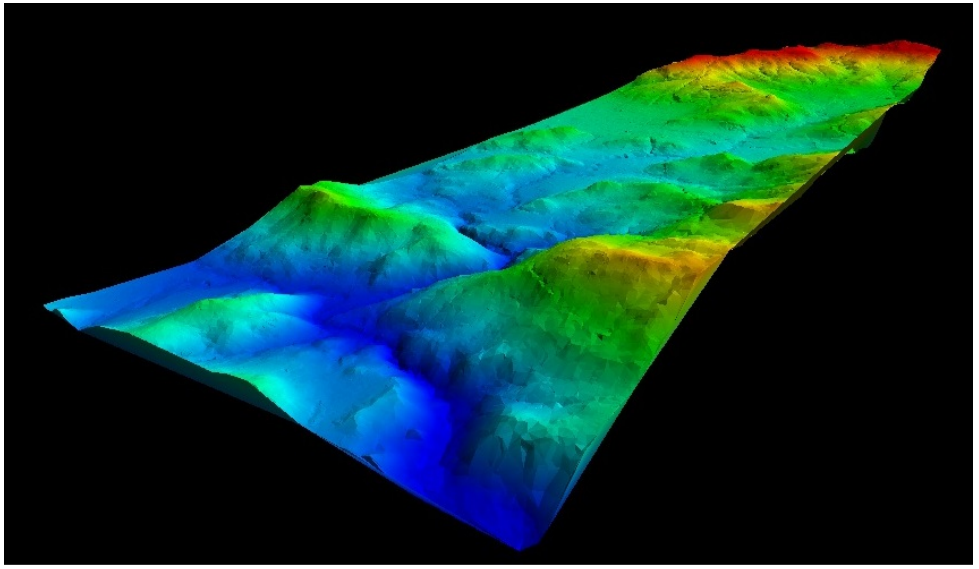
LiDAR - Equipment

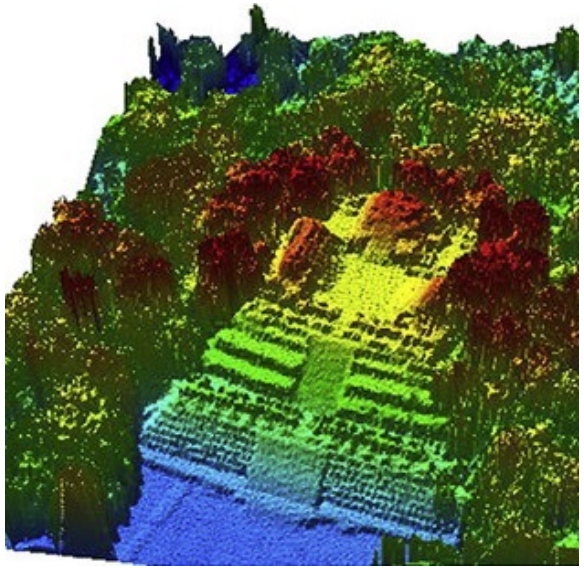
- Fixed-wing, Cessna 206, turbo-prop
- **Dual Optech LiDAR systems employed**; Topo: Gemini (infrared) & Bathymetric: Aquarius (green)
- Multi-haz echo sounder collects **300,000 points per second**
- Opening lens of +/- 50°, **200-400m survey width per line**
- Average density of 4-12 points/m²
- Number of points depends on vegetation & reflectivity of surfaces
- Due to huge amount of data the digital products are presented as 1 km x 1 km tiles

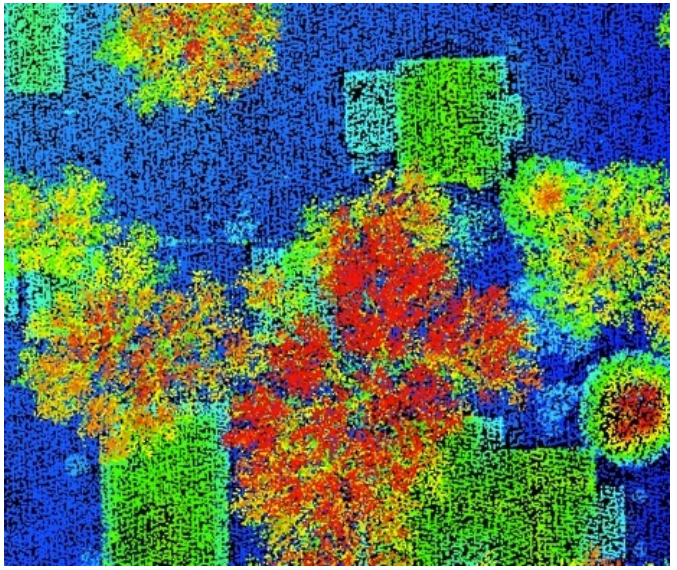
LiDAR examples



LiDAR examples







Aerial Photography

- Acquisition of digital **colour photography is planned for end of wet season** (October / November) when lighting is best to improve colour balance & minimise cloud shading
- A Nikon D810 industrial aerial digital camera (36MP) will be used for photogrammetry with Resolution of 10 - 20 cm pixels
- Velocity of the camera is 30 seconds per take
- **Photographs will be ortho-rectified by integrating with the LiDAR survey & control points**
- The mosaiced photography will be draped on the DTM to create a **3D image** of the route
- The geo-referenced (GeoTIF) imagery will be used to provide a **digital video flythrough** of the project area with input from HKND

Geophysics - Equipment

- Fixed-wing, Piper Navajo PA-31-310 twin-engine aircraft with fixed stinger
- Caesium vapour magnetometer, 20 Hz (0.05 sec) sampling rate, 0.001 nT res.
- RS-500 gamma ray spectrometer, 2Hz (0.5 sec) sampling rate in 256 channels
- KRA405B radar altimeter, 0.3m resolution, ± 5% accuracy at 500' to 2500‘ elevation
- Novatel 14 channel DGPS system, Thomson survey navigation and guidance system
- A base station magnetometer will be setup to monitor diurnal variations to correct the aeromagnetic data

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