Lidar & Camera Sensor Solutions

Optech

Presentation Agenda

Lidar and Camera Sensor Solutions

- Sensor Overview
  - Ground-based static
  - Ground-based mobile
  - Airborne LiDAR
  - Airborne Cameras
  - Special Projects
- Key Considerations

Sensor Overview: CMS

CMS: Cavity Monitoring System

- CMS V400
  - 360° x 290° FOV
  - +/- 2 cm range accuracy
  - 1 mm range resolution
  - Subsurface Mapping

Sensor Overview: ILRIS

ILRIS: Intelligent Laser Ranging and Imaging System

- ILRIS Family of Tripod Mounted Laser Scanners
  - ILRIS-3D, ILRIS-HD and ILRIS-LR
- 1800-3000 Meter Range
- 3-7mm Accuracy
- Modular 360° Pan/Tilt Base
- Embedded Digital Camera
- External Camera Option
- Mobile Compensation Option

Sensor Overview: ILRIS Family

ILRIS-HD

- Fast data acquisition rate
- High Precision
- Measure to non-cooperative targets
- Range up to 1800 meters
- Class 1 Eye Safety

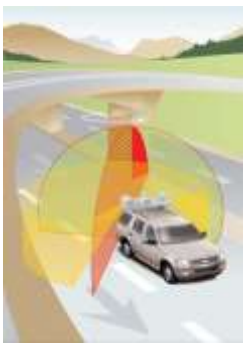
ILRIS-LR

- One of the longest range scanner on the market
- Snow, ice, and wet surface capability
- Range exceeds 3000 meters

ILRIS-MC

- Motion Compensation
- Mobile measurement to distant targets
- HD-MC or LR-MC
- Integrate with SONAR systems

Sensor Overview: Lynx Mobile Mapper



Sensor Overview: Lynx Vital Statistics

- **Accuracy**: ±5cm
- **Precision**: <7mm
- **Range**: Up to 200m
- **Field of View**: 360°
- **Laser rotates**: 4800 - 12,000 RPM
- **Measurement Rate**: Up to 500 kHz / sensor, programmable
- **Scanner Speed**: 80 – 200 Hz, programmable
- **Returns per Shot**: 4 (1st, 2nd, 3rd, last)
- Simultaneous lidar & imagery capture

Sensor Overview: Airborne Lidar Sensors

Orion H/M/C

Pegasus HA 500

CZMIL- Bathymetric

Aquarius

Sensor Overview: Orion

Ultra-compact, total solution with industry-leading data precision and accuracy

Orion C300: Low altitude, low cost sensor focused on high precision corridor mapping

- Power line surveys and vegetation encroachment studies, pipeline, transportation corridors
- Operating envelope 50 – 1000 m AGL

Orion M300: Low to mid altitude, for performing both corridor and high accuracy engineering projects

- Mine monitoring, agriculture and forestry, asset management, infrastructure modeling
- Operating envelope 100 – 2500 m AGL

Orion H300: High altitude, powerful, universal sensor, operating in all application spaces

- Wide-area topographic mapping projects
- Glacier and mountain surveying
- Operating envelope 150 – 4000 m AGL

ALTM Pegasus: HA500

High-efficiency, multi-channel wide-area mapping system capable of high-density data sets.

Features/Benefits

- Operational envelope 150 – 5000 m AGL
- Dual output laser system for maximum density capability
- High laser sampling rate for enhanced efficiency in XY point distribution
- High density at high altitude (i.e. superior area coverage rates)
- Higher accuracy and precision (powerful, narrow pulse-width lasers and state-of-the-art timing electronics)
- "Drop-in" sensor design (unrestricted FOV)
- The latest in tightly-coupled inertial and Virtual Reference System processing technology, enabling steep turns, extended GPS baselines, and the elimination of remote base stations
- Real-time point display and in-air LAS file generation
- Embedded camera options (designed for passive/active solution)

Sensor Overview: Airborne Camera Sensors

Film Replacement/
Wide Area Mapping

CS-15000

Medium Area Mapping/
Corridor Mapping

CS-10000

Oblique, Multi-spectral, Thermal

CM-MS1920, CM-LW640,
CM-6500, CM-MW640

CF-410

CC–R Camera Controller
Operates up to two digital cameras

Sensor Overview: Airborne Cameras

Medium and Large Format

- 10320 × 7752 and 15000 × 10000 pixel footprints
- True FMC & True Colour
- Lens options
- RGB & CIR options
- Kinematic mounting
- Field replaceable shutter
- Gyro stabilized mount compatible

CM-6500 – Oblique/Nadir

- 6,500× 4,300 pixel footprint
- Athermal RGB & CIR options
- Uses “universal” controller

CM-MS1920 Multispectral Camera

- 1920 × 1080 pixel footprint
- 3, 4, or 5-band configurations
- Leading multispectral camera core
- Uses “universal” controller

CM-LW640/CM-MW640

- Longwave 8-12 µm spectral band
- Midwave 3-5 µm spectral band
- 640 × 480 uncooled microbolometer
- Geometrically calibrated
- Uses “universal” controller

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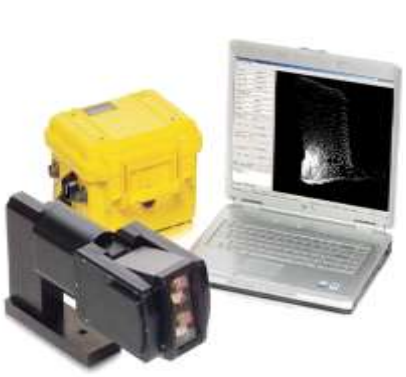
Ground-based Static



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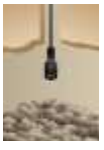
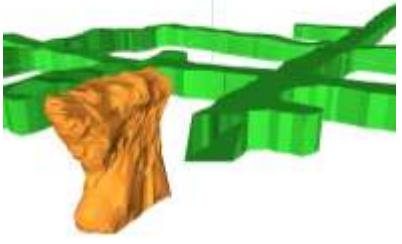
Terrestrial Platforms: CMS

Cavity Monitoring System (CMS)

- Sensor inserted into cavity attached to a tripod, boom, or vertical package
- Scanner head rotates 360° in all directions
- Create accurate underground 3D models of cavities
- Used mainly in mines for production monitoring and volume calculation

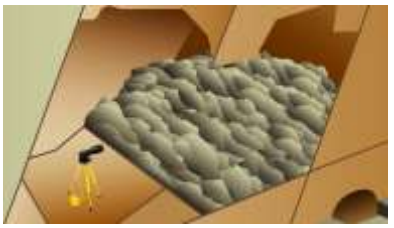




CMS – Mining Configuration Applications

Open Stope

Block Caving

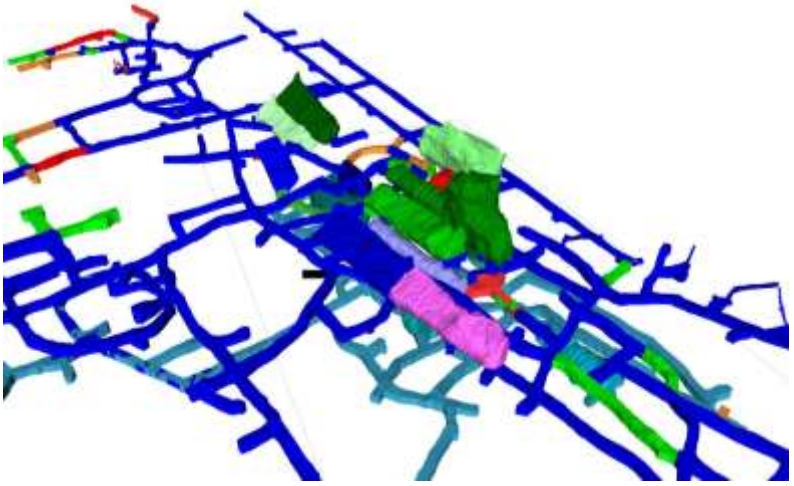


Vertical Insertion

CMS – Adaptable to Environments

CMS - Exported Data

Detailed models boosting operational efficiency

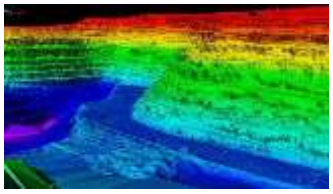


Terrestrial Platform: ILRIS

ILRIS Terrestrial Laser Scanner:

- Lidar sensor mounted on a stationary (tripod) or mobile platform
- Two mirrors scan horizontally and vertically
- Extreme detail, resolution is user defined

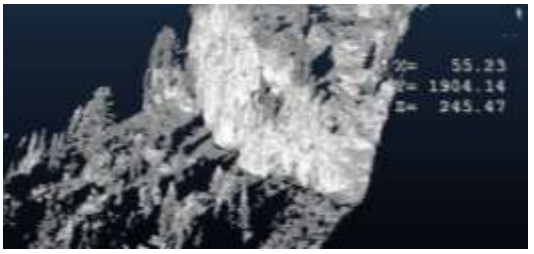
- Top Uses:
  - Open-pit mining and geology
  - Civil engineering and surveying
  - Forestry
  - Cryospheric studies (i.e. snow and ice surveying and monitoring



Rock Face Scan

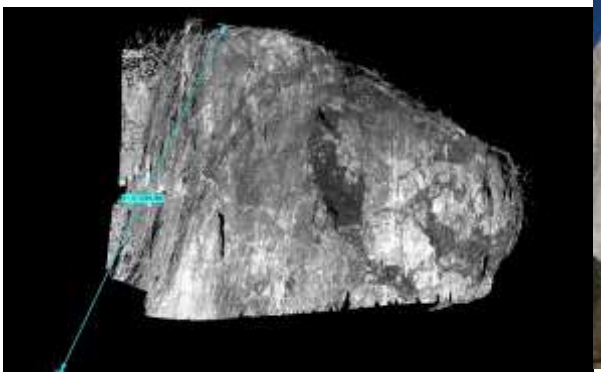
Austrian Alps

- **Rock face scan**
- **Over 1900 metres to face**

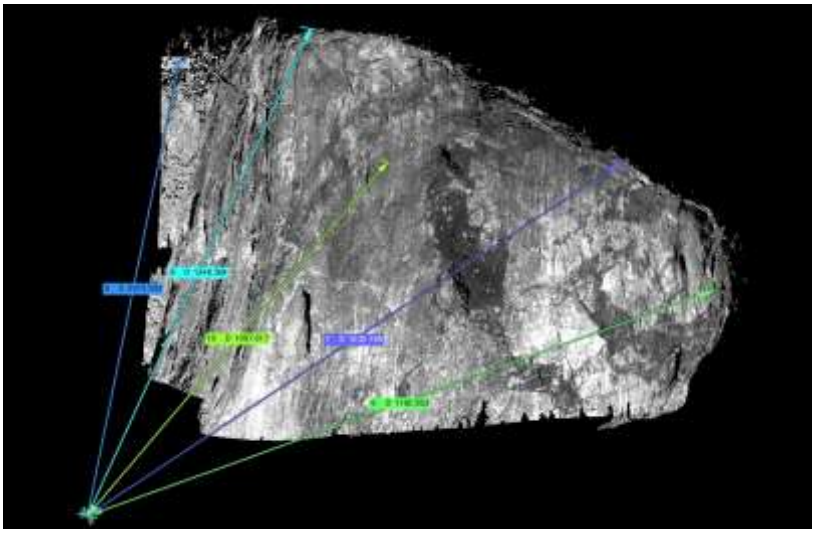


Yosemite National Park—El Capitan

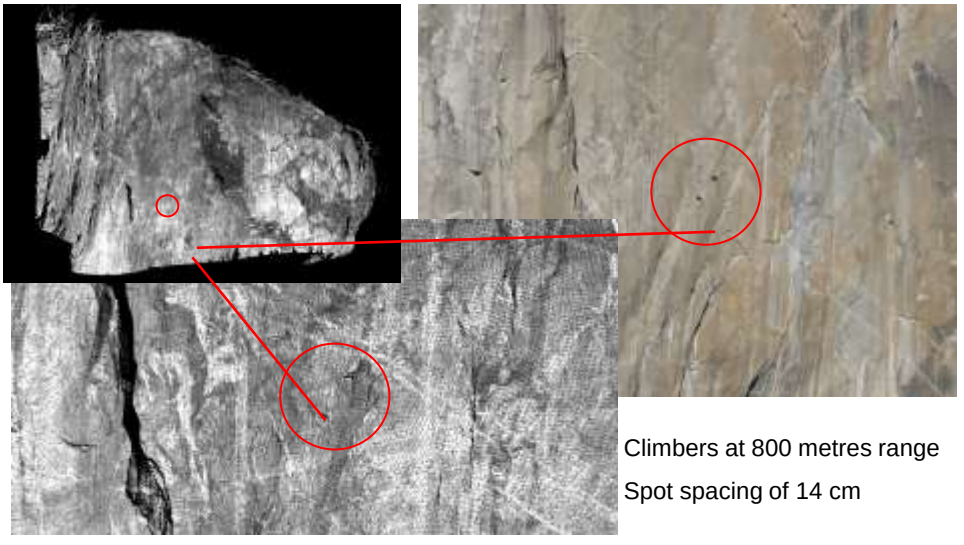
- El Capitan—Granite face/peak at 1250 metres
- Scan time under 1.5 hrs
- Controller spacing 8 / 3 pan regions
- ILRIS-LR – only known scanner to get peak data



El Capitan Continued



El Capitan—Climbers



Climbers at 800 metres range

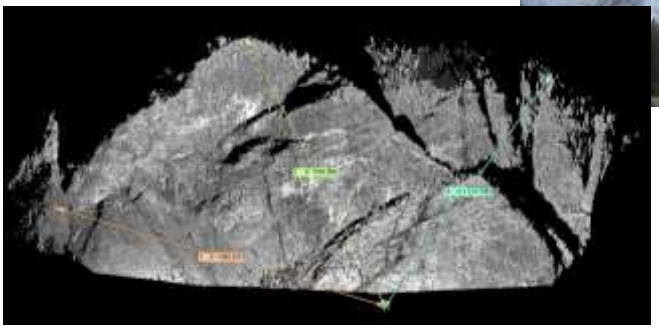
Spot spacing of 14 cm

Yosemite National Park—Sentinel Rock

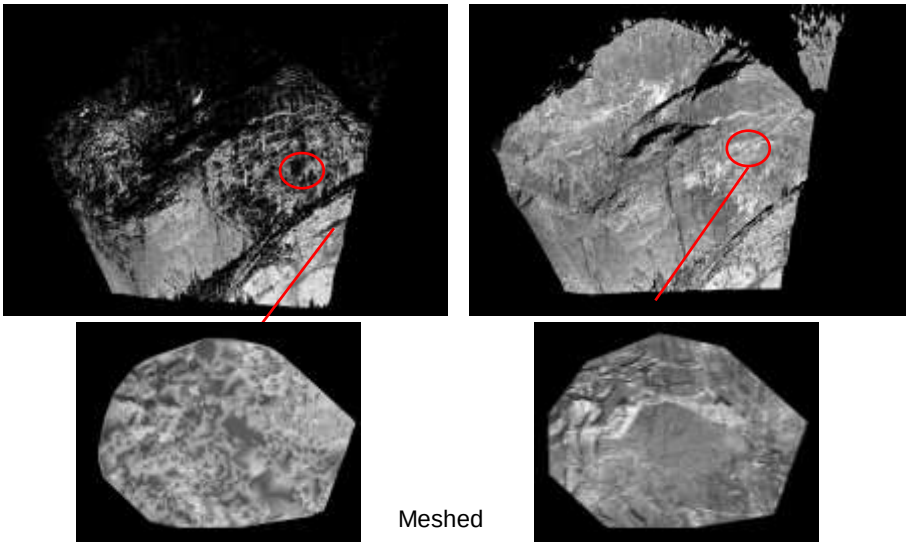
- Sentinel Rock—1250 metres to granite face
- 20 minute scan
- Controller spacing 6 / 15 cm spot spacing at peak
- Single pan region

Yosemite National Park—Glacier Point

- Glacier Point—1590 metres to Granite face
- Total scan time→ 1.5hrs
- Controller spacing 6 / 15 cm spot spacing at peak
- 3 pan regions



Glacier Point Data - continued

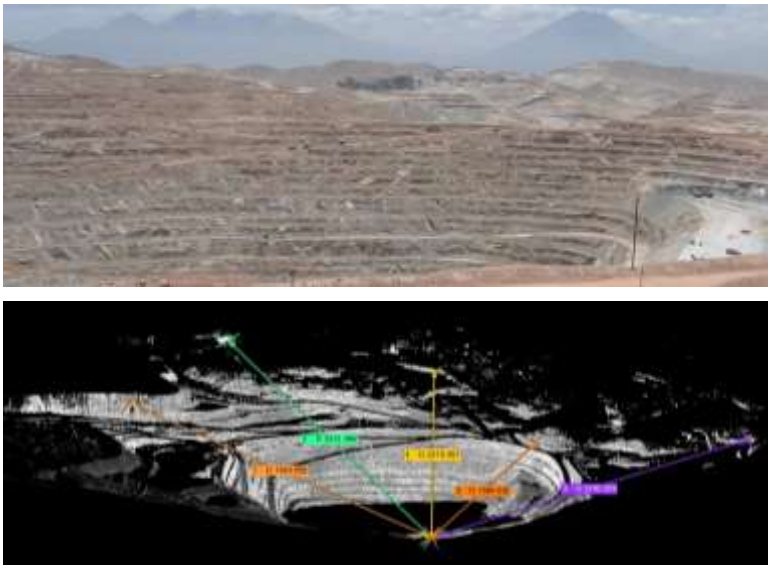


ILRIS-3D 2007

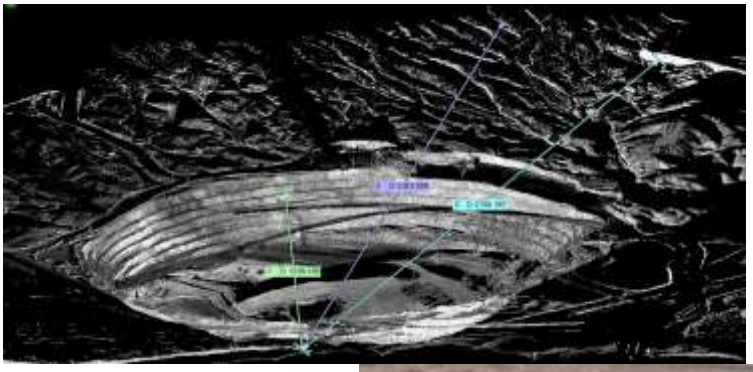
Meshed

ILRIS-LR 2011

Open Pit Mine – Peru 2010



Open Pit Mine – Chile 2010



Open Pit Mine Data

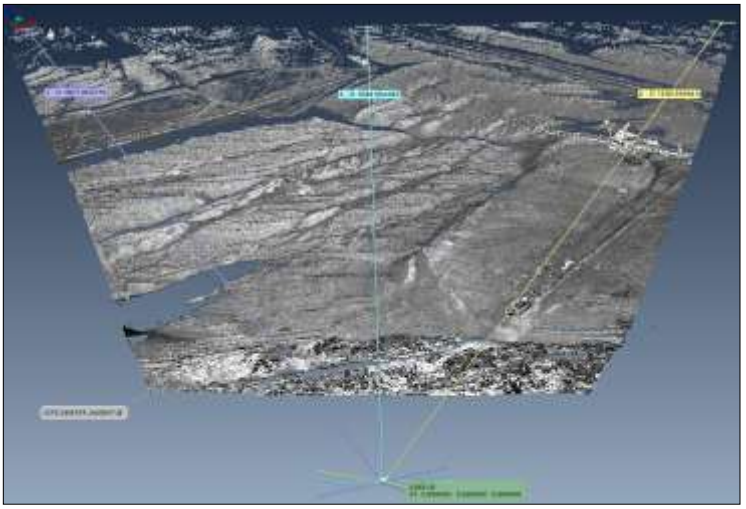
Capable of 4cm spot spacing at 2km range

Coal Mine

Coal Mine

ILRIS LR for Coal mines

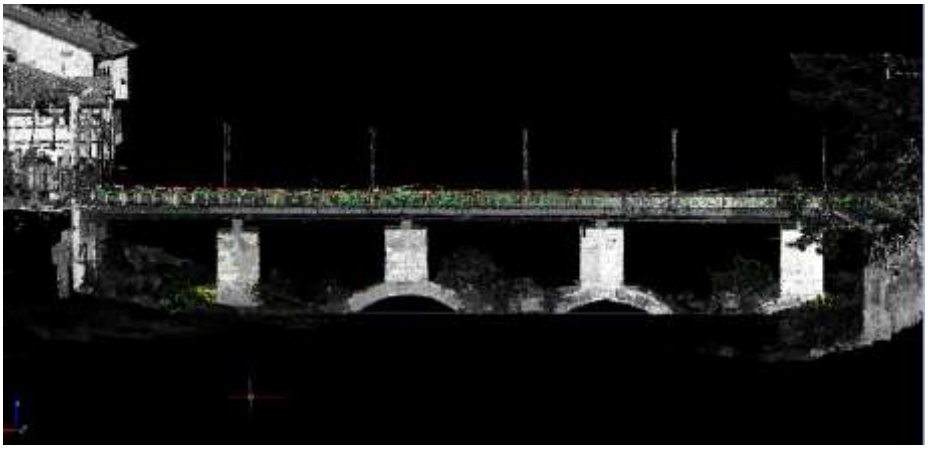
Range up to 1800 meters



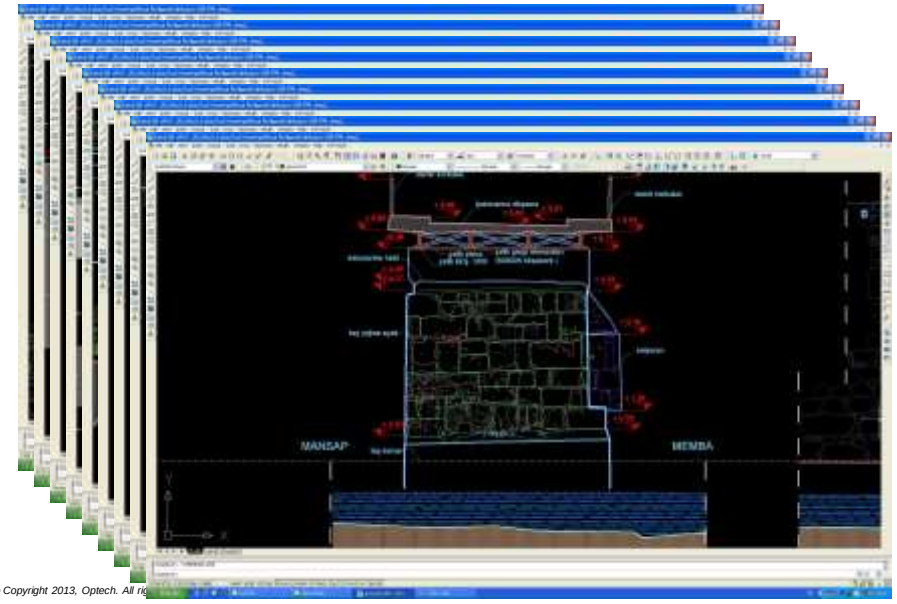
Coal Mine

Complete Modeling

Complete Modeling



Complete Modeling

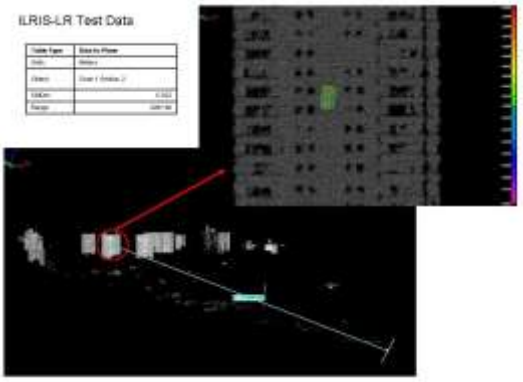


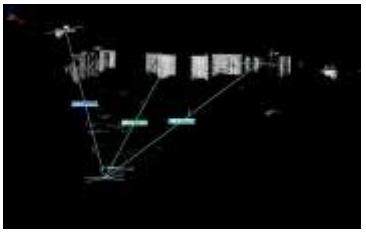
ILRIS Modeling

Civil

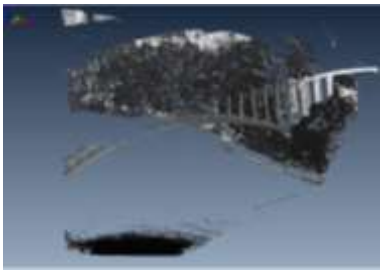
Toronto

- Building scans from office
- Testing range to concrete
- 3800 metres to buildings

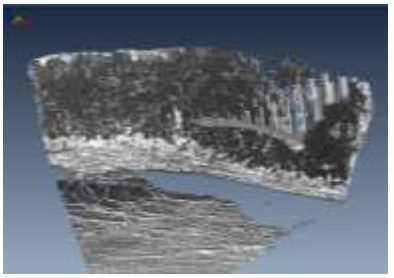




Niagara River



ILRIS HD

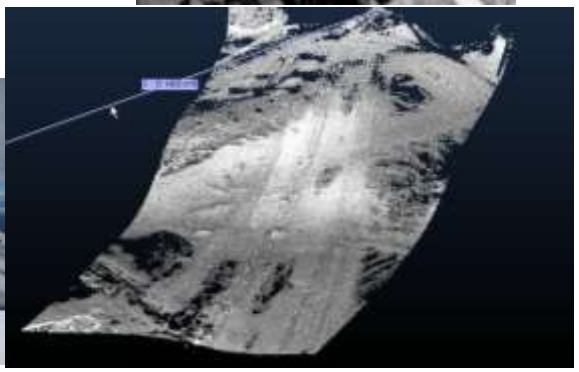


ILRIS LR

Snow and Ice Scan

Austrian Alps 2010

- Ski Hill from visitor platform
- Testing range to snow and ice
- 1872 metres across valley



Avalanche Research

2800 metres to target area

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Ground-based Mobile

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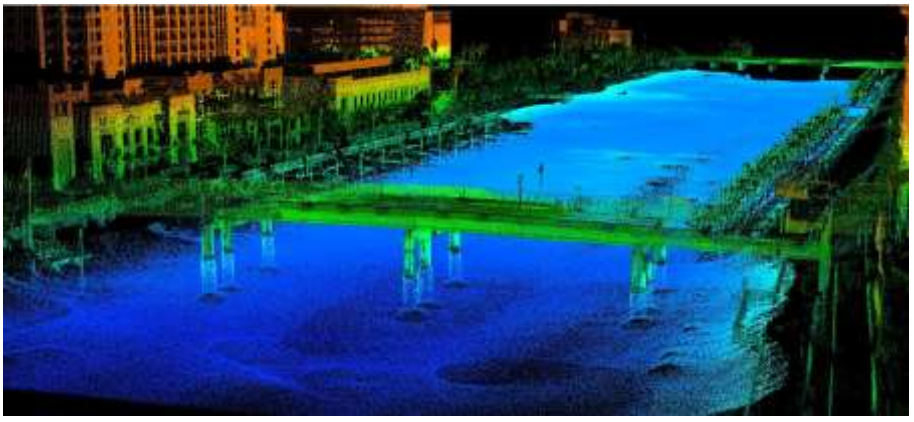
ILRIS MC

- All ILRIS models are capable of operating in conjunction with an Inertial Navigation System
- This produces georeferenced, spatially accurate points clouds of above water features

ILRIS MC



- Typically ILRIS MC scans are combined with sonar data to provide above and below water models of shallow water areas

Lynx Mobile Mapper

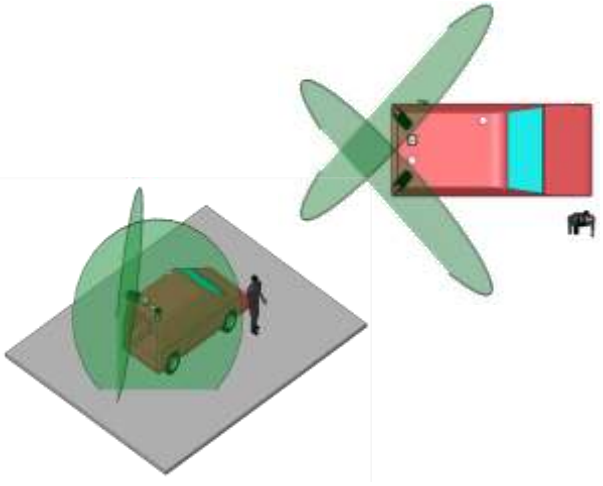
- Utility: Distribution Network Mapping, Pole Mapping
- Airport: Runway Surveys, Facilities Mapping
- Roads: Surveys, Asset Management, Bridge Assessment, Roadway Repairs
- Construction: As-Builts, Monitor Construction Progress

Lynx Mobile Mapper

System Configuration

- 2 Laser sensors
- Up to 4 camera's
- Positioning and Orientation
  - 2 GPS antennas determine vehicle's location & enhance heading accuracy with GPS Azimuth Measurement Subsystem
  - Inertial Measurement Unit records vehicle's dynamic attitude (heading, roll, pitch)
  - Distance measurement instrument attached to wheel enhances positioning ability in areas of poor GPS.

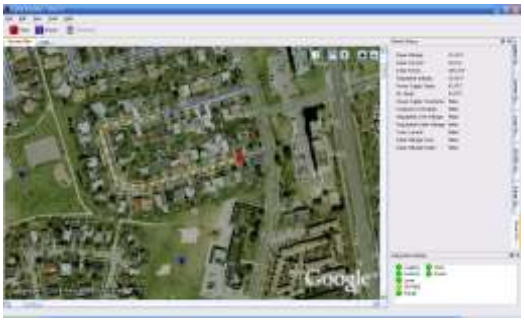
360º Collection Field of View



Configured for maximum collection efficiency

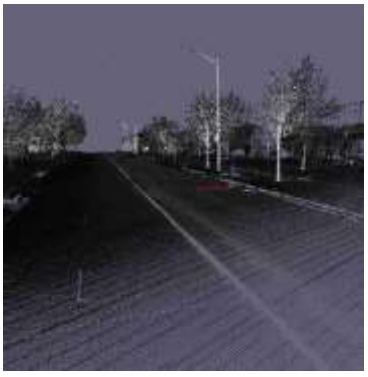
Lynx Survey: Real-time Vehicle Tracking

- Real-time system diagnostics
- Ensure good GPS coverage at all times
- GPS issues are immediately visible to the operator



Real-time Collection

- Lidar and camera real-time data display
  - Allows for in vehicle QA/QC
- Ensures complete collection



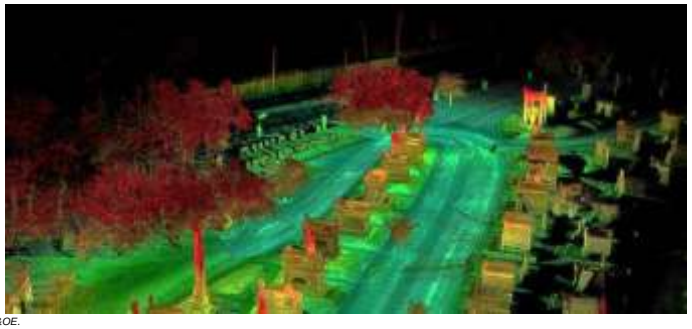
Efficient - 1 Million Points Per Second

Lynx: Mobile Platforms

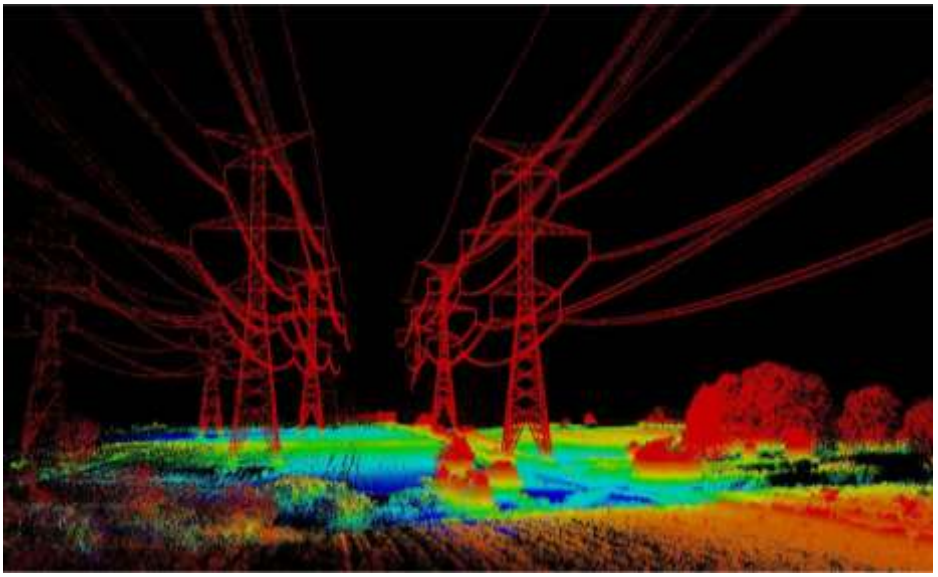
Applications

Applications include:

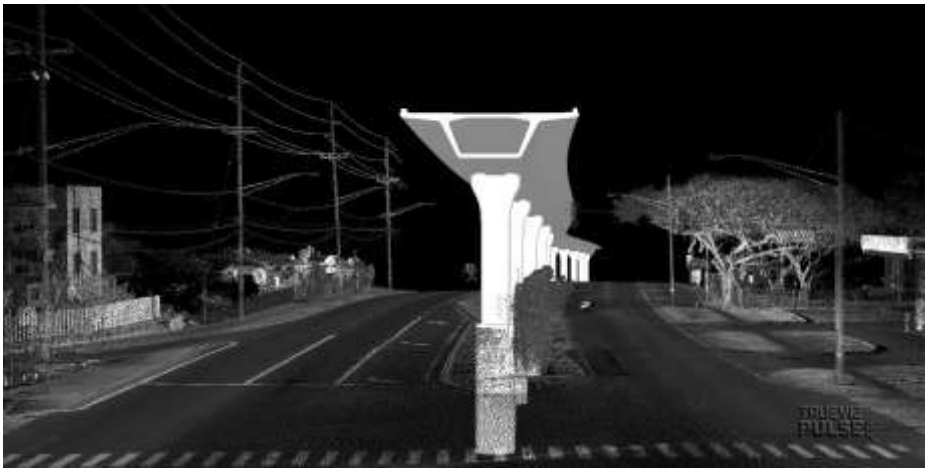
- Roads
- Construction
- Utilities (power lines, water)
- Building Information Modeling
- Airports
- Railways
- Rivers



Power Transmission Mapping



Elevated Rail Systems



Modeling for Overpass/Ramp Development

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Airborne LiDAR

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Aerial Platforms

- Airborne Platforms
  - Fixed Wing
  - Helicopters
  - Unmanned Aerial Vehicles (UAV)

Sensors

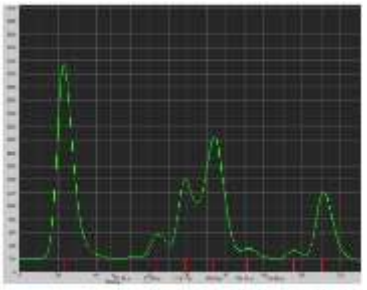
- Two core types of sensors:
  - Lidar (active)
    - Generates point clouds
  - Camera (passive)
    - Generates digital imagery
- Sensors can be operated independent or integrated
- Integrated provides data fusion options

Intelligent Waveform Digitizer - IWD-2

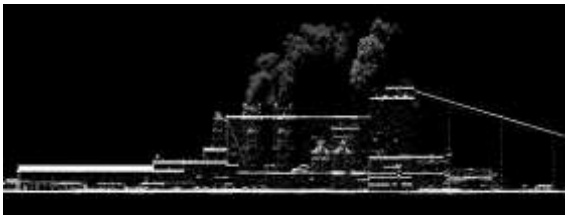
Add-on digitizer provides intelligent waveform capture on demand. Compatible with all models of ALTM

Benefits

- Increased feature classification confidence (pulse width information)
- Increased vertical density (eg. forest structure information)
- True-ground detection
- Shallow water depth mapping (Aquarius)

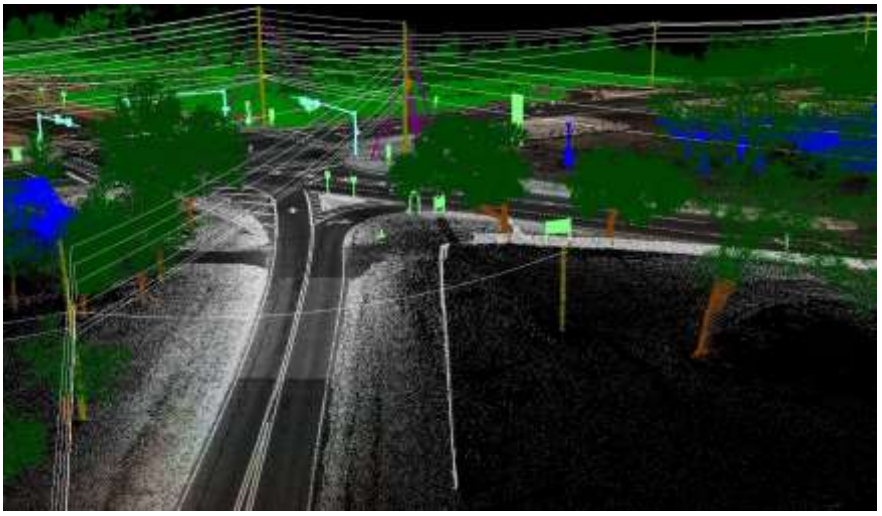


Digitized waveform showing TD pulse and multiple peaks in the return waveform



12-bit performance

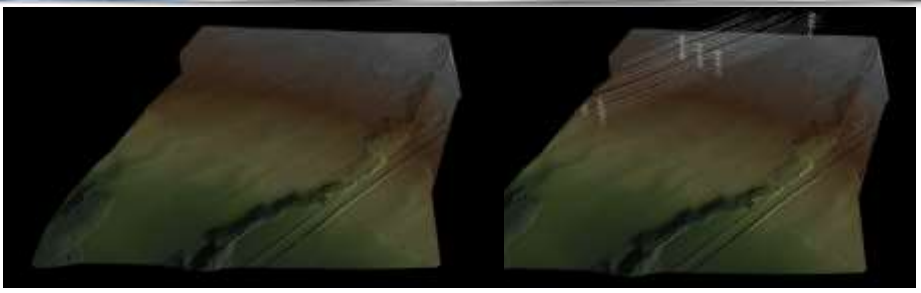
Utility Distribution Mapping



Transmission Line Surveying

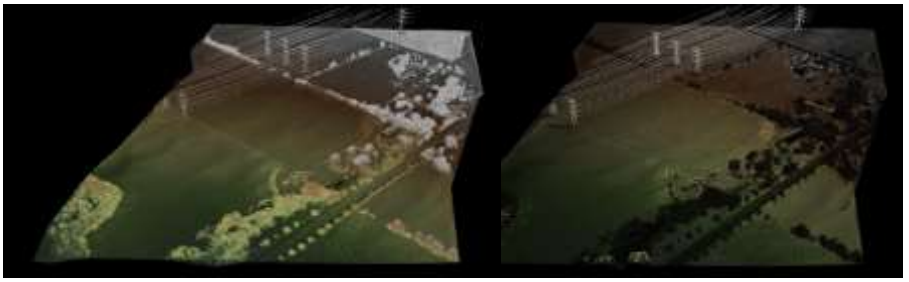
- Route planning and line construction
- Asset mapping
- Change detection and preventative modeling

Transmission Line Surveying



Bare earth lidar model

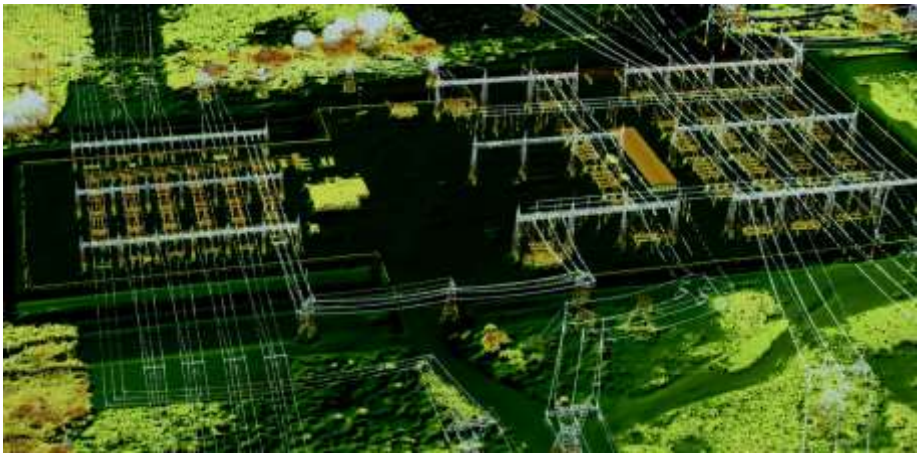
Powerline point cloud



Vegetative point cloud

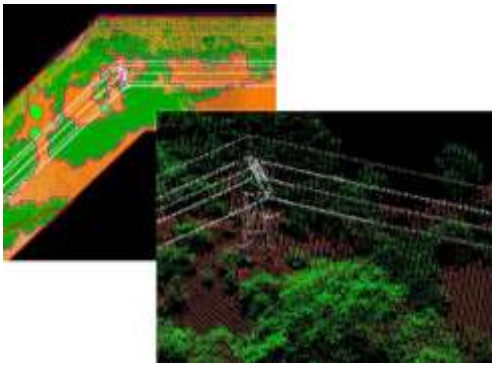
Intensity Overlay

Transmission Networks

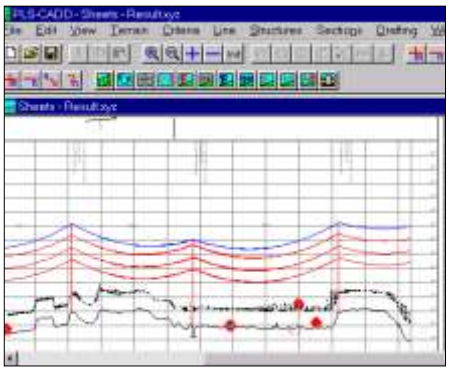


Vegetation Encroachment

- Large percentage of outages occur due to vegetation problems
- Vegetative encroachment on required clearance distances can now be determined in the office
- Crews deployed for targeted *a priori* maintenance (reduces maintenance costs)
- Difficult to access areas can be accurately assessed remotely, further reducing costs



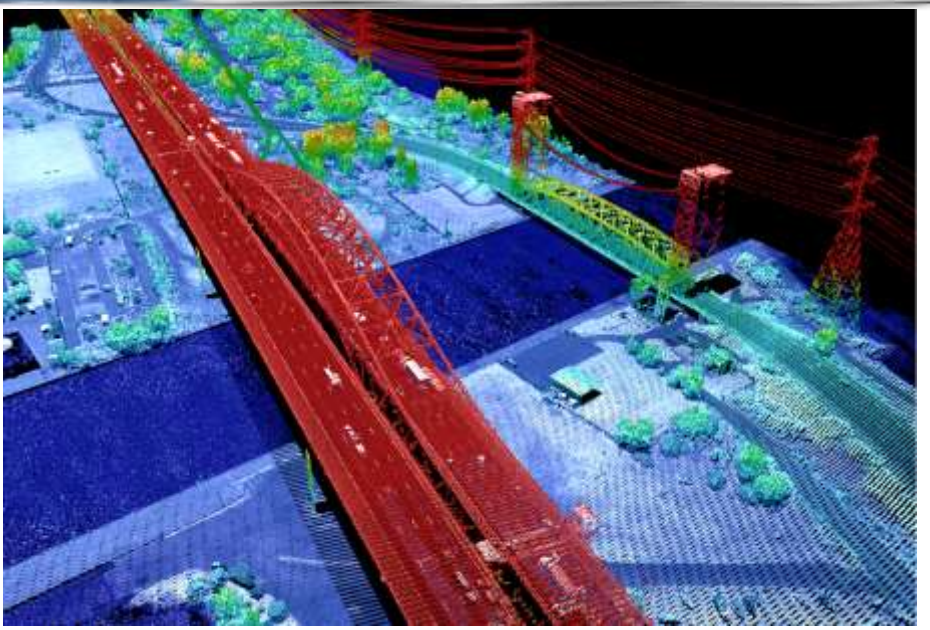
Sag Analysis



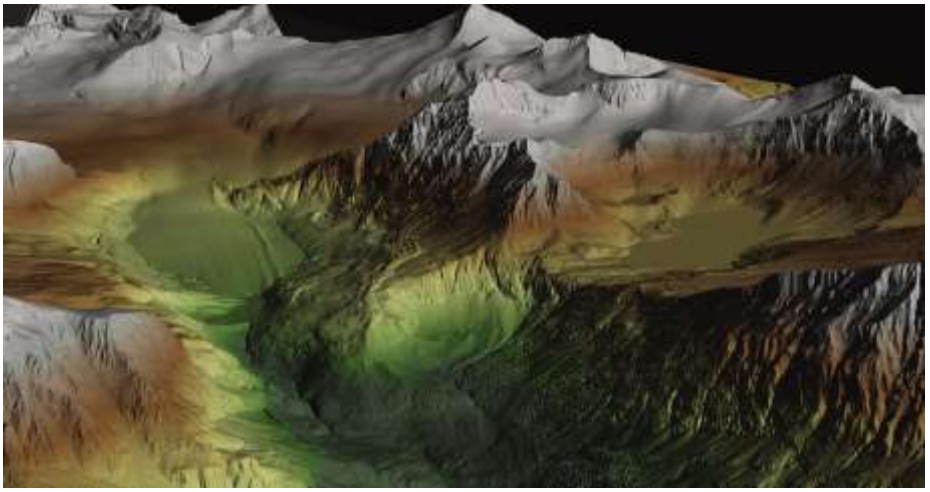
Clearance and Critical Distances

- Catenary models generated from lidar cross sections are plotted and compared to minimum distance criteria
- Actual and possible violations are flagged for further analysis

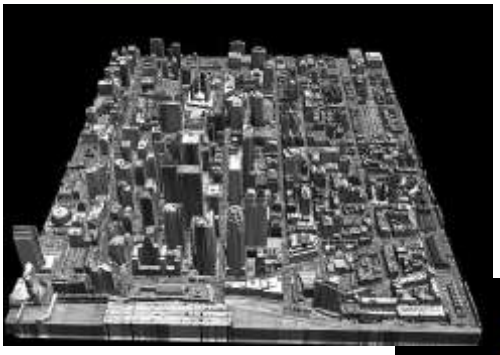
Asset Management



Wide Area Mapping



Urban Toronto



Rep Rate 50kHz
Height 850 m AGL
Area 1,400 m x 1,300 m
Time for Collection 37 min
Time for Processing 4 hrs
Spot Spacing .6m x .6m

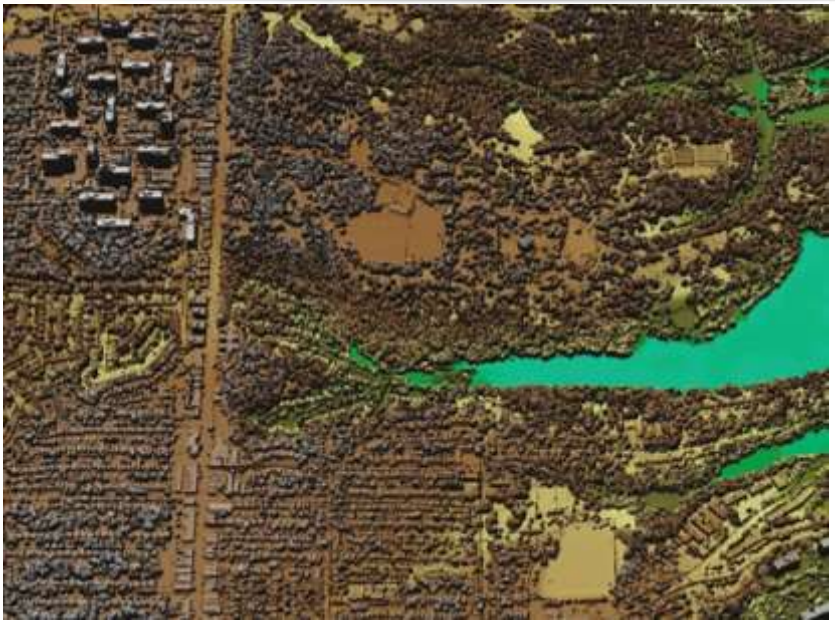
Above - active laser photo
or “laser intensity”

Right - Digital Surface Model

Pegasus: Urban Modeling

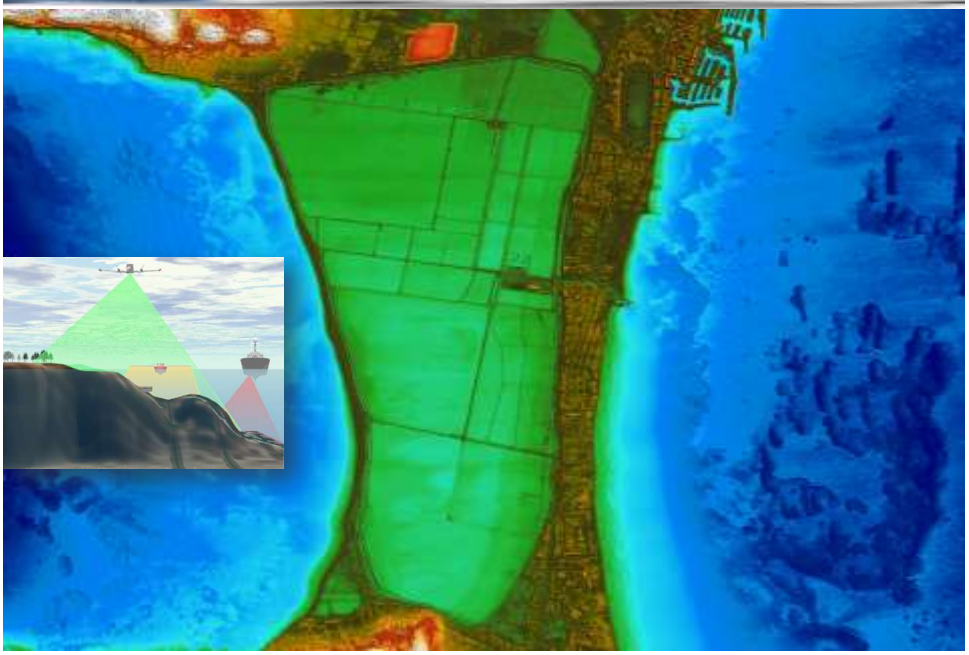
Pegasus: Asset Management

Pegasus: Topographic Mapping



Optech

Bathymetry



Optech

Aquarius

Shallow Water Depth Mapping

Optech

Aquarius

Collects high-density water depth information in areas that may otherwise be inaccessible from water-based vessels.

Applications

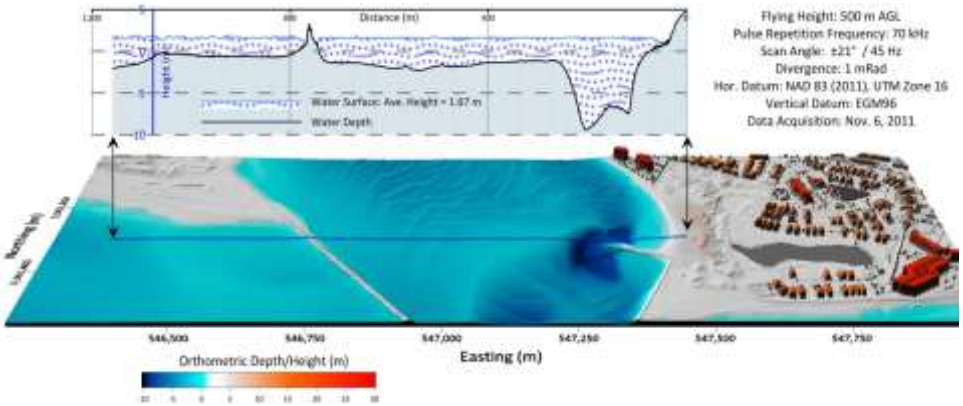
- Shallow water depth mapping
- Riverbed profiling
- Erosion monitoring
- Riparian zone variation and structure
- Flood plain analysis
- Reservoir sedimentation
- Water flow and water level dynamics

Optech

Aquarius

Benefits

- Simultaneous bathymetric/topographic mapping capability
- Depth penetration capability = one Secchi depth
  - >10m depth penetration when water clarity k = <0.1/m
- “Drop-in” sensor design (unrestricted FOV)

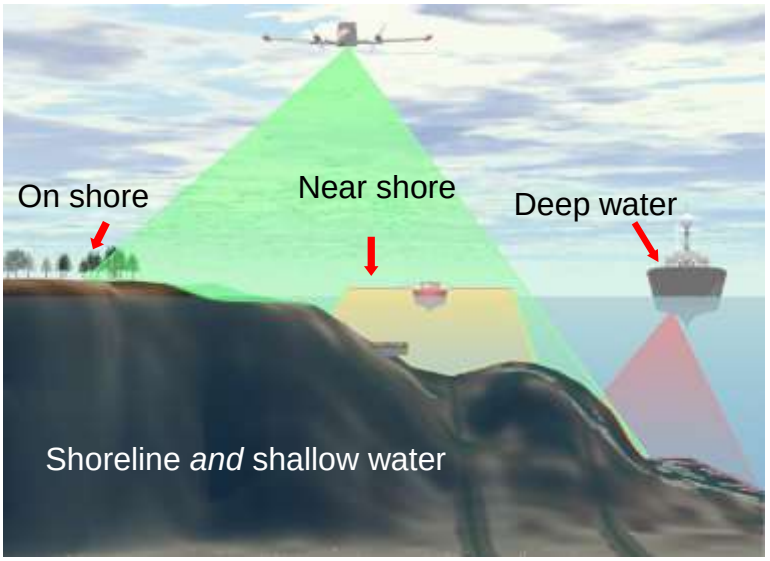


Coastal Zone Mapping and Imaging Lidar (CZMIL)

- Developed with Multi-Agency U.S. Government Support
- Game-changing Technologies
  - Combines active (green IR) and passive (hyperspectral, RGB) sensors with data fusion software
  - High performance in shallow, medium depth or turbid water
  - Wide performance envelope - Depth penetration up to 50 m
  - Simultaneous high-resolution topographic and bathymetric imaging

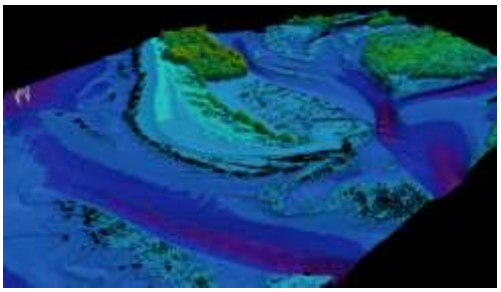
CZMIL Technology

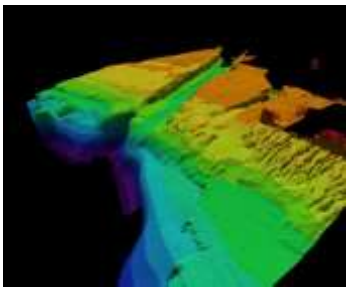
Lidar goes where sonar does not



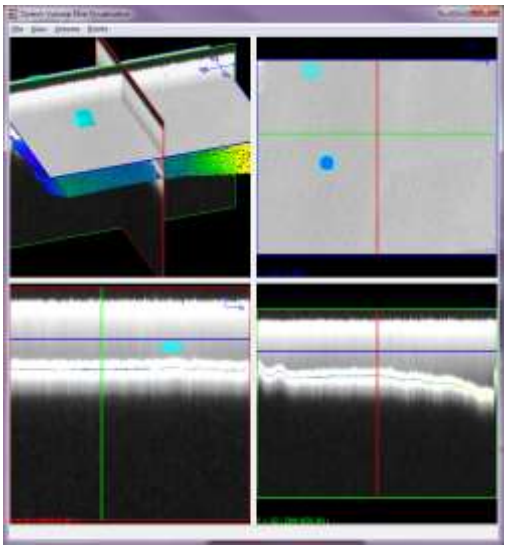
CZMIL Applications

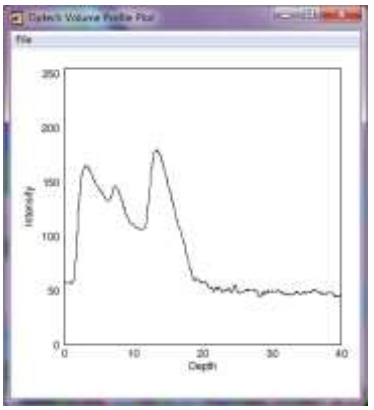
- Shoreline mapping and coastal management
- Harbor and navigation channel inspection
- Beach/coastal erosion monitoring
- Nautical charting
- Aquatic ecosystems
- Rapid environmental assessment
- Underwater object detection





CZMIL Object Detection

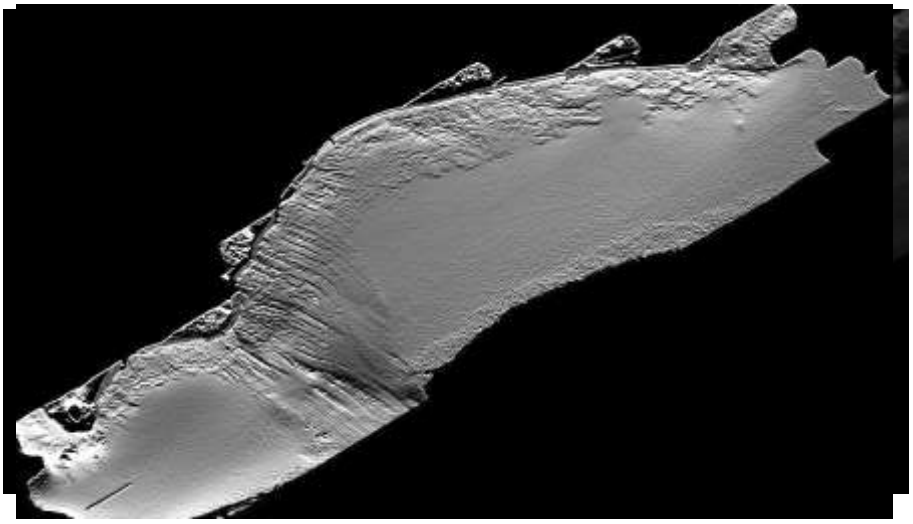




Optech

Malibu, CA

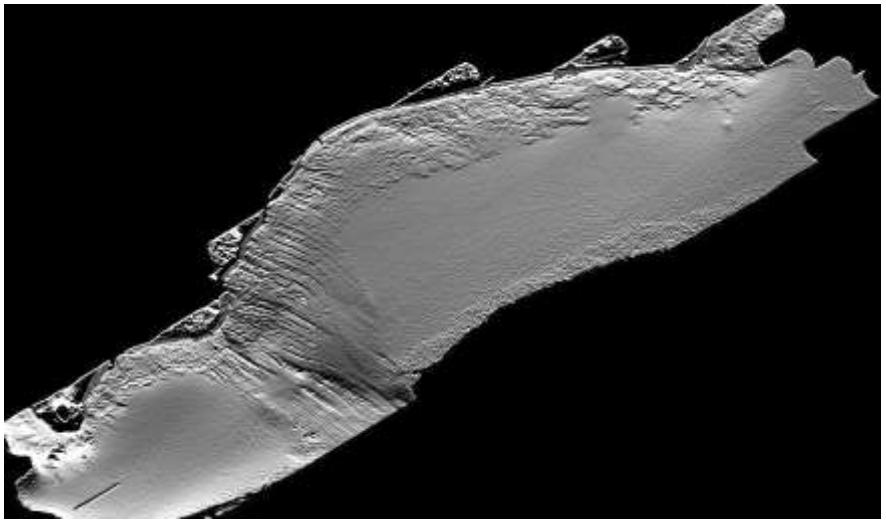
Seafloor reflectance image



Optech

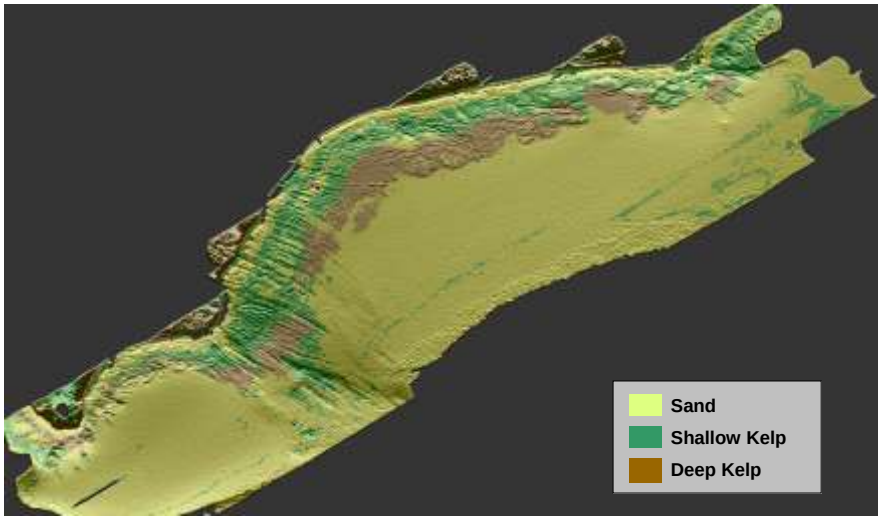
Malibu, CA

Shaded relief map

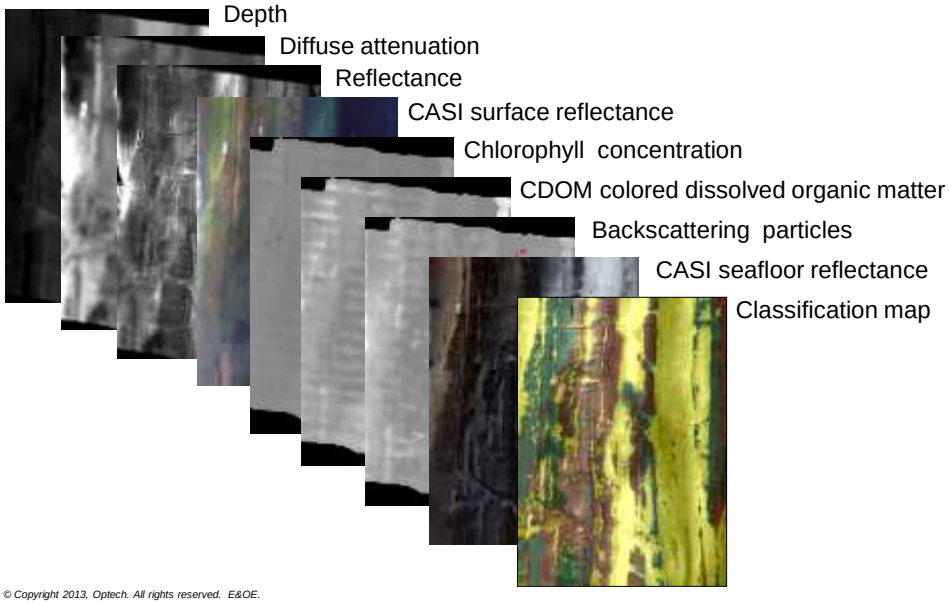


Malibu, CA

kNN classification (with shape features)



CZMIL Deliverables



Optech

Airborne Cameras

Optech

Integrated, Interchangeable Camera Systems

Film Replacement / Wide-Area Mapping

CM-15000

CF-410
Camera Frame

Small- to Medium-Area
Mapping / Corridor Mapping

CM-10000

CC–R
Universal Controller

Medium and Large Format Camera's

80 Mpix

- True FMC & True Color
- Lens options
- RGB & CIR options
- Kinematic mounting
- Field replaceable shutter
- Gyro stabilized mount compatible

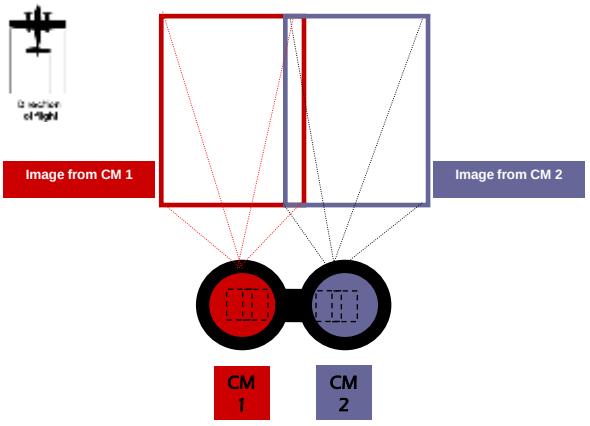
10320 × 7752 pixel footprint

Applications

- Corridor mapping
- Wide area mapping
- Ortho-imagery
- Stereo Images
- Contours and digital elevation models
- Lidar augmentation

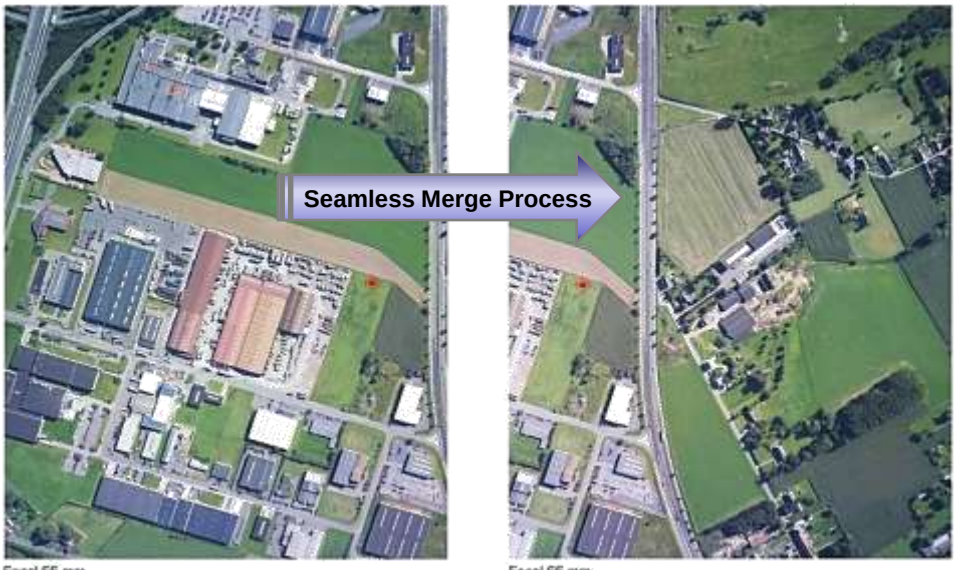
15000 × 10000 pixel footprint

CS-15000 – Image Merge



- 2 x 80 MP CCDs horizontally-opposed (i.e. CCDs are offset relative to focal principle points)
- Results in common overlap area
- Overlap area used to merge the two independent images and create a single image

CS-15000 – Image Merge



Focal 55 mm Image 1

Focal 55 mm Image 2

CS-15000 – Image Merge

- ***Large-format*** photogrammetric image product

CS-15000 – Data Products

- Seamless & tonally-balanced RGB mosaics

Colour-balanced 2,000-image mosaic (10cm GSD; 60% sidelap)
Brest, west coast of France

CS-15000 – Data Products

- RGB and CIR geotiff

Optech

Camera Efficiency

Field-Replaceable Shutter

- Shutter can be changed in minutes in the field
- Does not require re-calibration or new boresight alignment
- Proven concept / Patented

Maximum Operational Efficiency

Optech

Camera Efficiency

Interchangeable Lenses

- No flight re-calibration needed
- Proven concept / Patented
- Coming soon to an airport near you

Kinematic lens mounting system maintains geometric alignment when changing lenses

High return on your camera investment

Optech

Camera Data Quality

Forward Motion Compensation

- Increased productivity through higher aircraft speed and superior image quality
- Longer integration times (improved dynamic range & signal/noise ratio)
- Better visibility in shadow conditions
- Compensation during acquisition (no post-processing, saving time/money)

Eliminates motion smear

FMC On

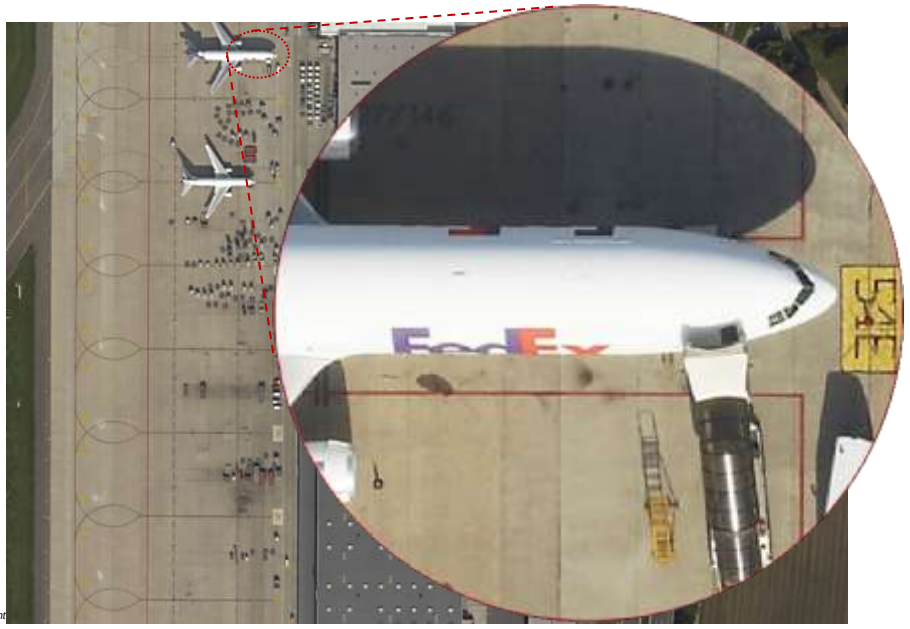
FMC Off

Optech

10-cm GSD

Optech

5 cm GSD



Optech

5 cm GSD

Additional Camera Options

CM-6500

CM-MS1920

CM-MW640

CM-LW640

- Compact nadir and oblique cameras (RGB, CIR, IR)
- Multi-spectral cameras (3-5 bands)
- Thermal imaging cameras (medium and long wave IR)

CM-6500 – Oblique/Nadir

CM-6500

- 6,500× 4,300 pixel footprint
- Athermal RGB & CIR options
- Uses “universal” controller

Applications

- Corridor mapping
- Lidar augmentation
- Orthophotography
- Oblique applications

Transmission Line Surveying

Oblique Imagery (CM-6500)

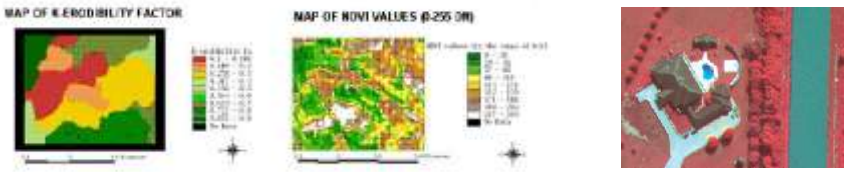
CM-MS1920 Multi-spectral

CM-MS1920 Multispectral Camera

- 1920 × 1080 pixel footprint
- 3, 4, or 5-band configurations
- Leading multispectral camera core
- Uses “universal” controller

Multispectral Applications

- Forestry & Agriculture
- Invasive species
- Submerged vegetation
- ISR



Up to 5 Spectral Bands for automated classification

CM-MS1920 Images - NIR

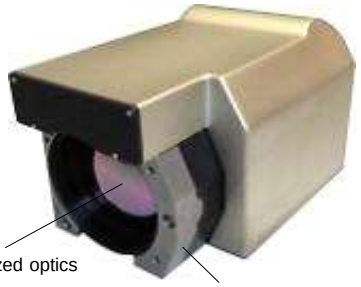
CM- MW640 Midwave IR

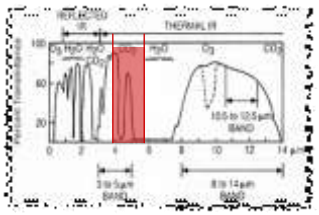
CM-MW640 Midwave IR Thermal (3-5 µm)

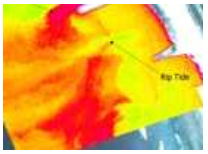
- 640 × 480 cooled microbolometer
- Geometrically calibrated
- Uses “universal” controller

Midwave Sensor Applications

- Fire
- Natural Resources
- Defense, homeland security, ISR







ITAR restricted
Export controlled

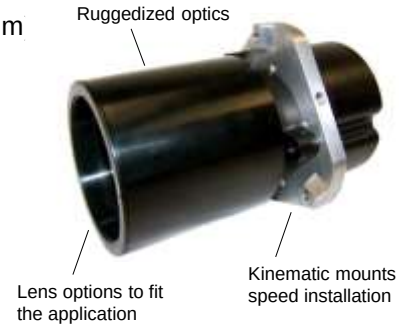
CM-LW640 Longwave IR

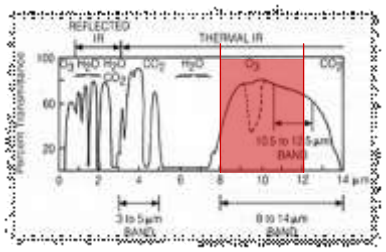
CM-LW640 Longwave IR Thermal (8-12 µm

- 640 × 480 uncooled microbolometer
- Geometrically calibrated
- Uses “universal” controller

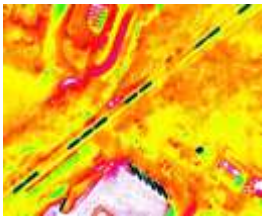
Applications

- Power transmission
- Building heat-loss mapping
- Corona discharge detection
- Wildfire mapping & management
- Defense, homeland security, ISR



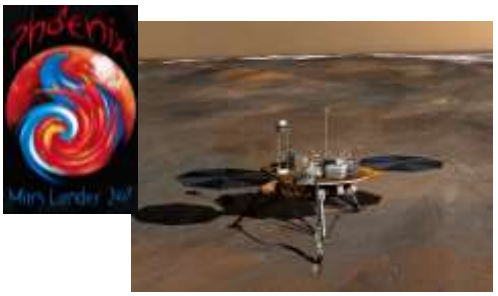


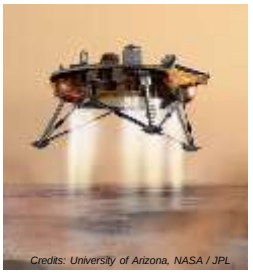
ITAR restricted
Export controlled



Mission:
NASA Phoenix Mars Lander 2007

- Flight Hardware: Meteorological Station Lidar Sensor
  - Launch in August 2007.
  - Landed on Mars in May 2008.





- Landing site in the region of 65° to 75° N latitude.
- Surface mission duration of approximately 90 sols.