# Latin American Geospatial Forum

**Mexico City**
**November 11, 2015**

# Trimble Airborne Mapping Solutions

**Ian Murgatroyd, Cliff Holle, Ruben James Ramos (PGPS)**

# Aerial Imaging Technology

- Picking the right tools for the job
- Doing more with those points and pixels

# Agenda

- Trimble UAS Portfolio
- Aerial Mapping Sensor Systems
- Trimble Business Center - Photogrammetry
- Applications/Software Deliverables
- Q&A

# TRIMBLE UAS PORTFOLIO

# Why UAS Aerial Imaging?

- New emerging technology well suited for geospatial professionals
- Complementary to traditional surveying technologies and to traditional photogrammetry
- Many UASs, but not many targeting the geospatial industries

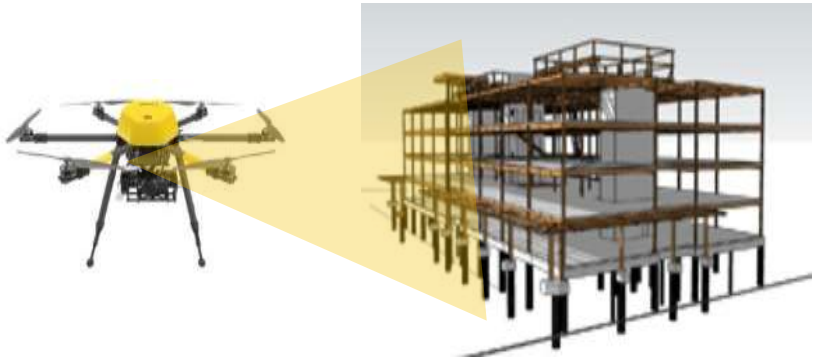
# Trimble UAS Portfolio

**Trimble UX5 HP**
High Precision
Surveying and Mapping

**Trimble UX5**
Standard in Mapping

**Trimble ZX5**
Flexible Mapping &
Inspection

# Select The Right Tool



## Fixed Wing Solutions

- Larger open areas
- Horizontal mapping
- Efficient data capture

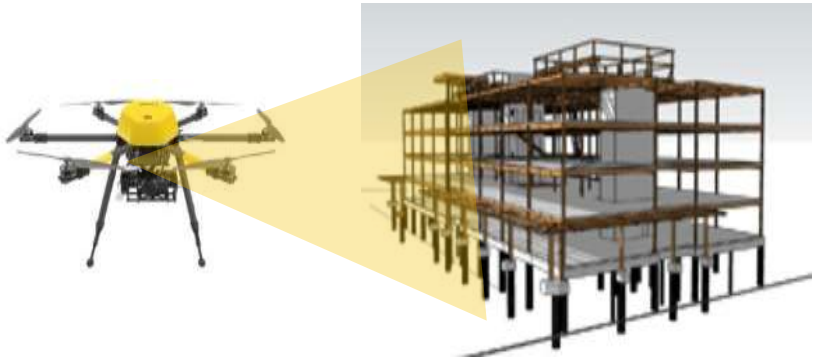
## Multirotor Solutions

- Smaller obstructed areas
- Horizontal or Vertical
- Visual Inspections

# System Overview

## Trimble UX5 Aerial Imaging Solution

# Select The Right Tool



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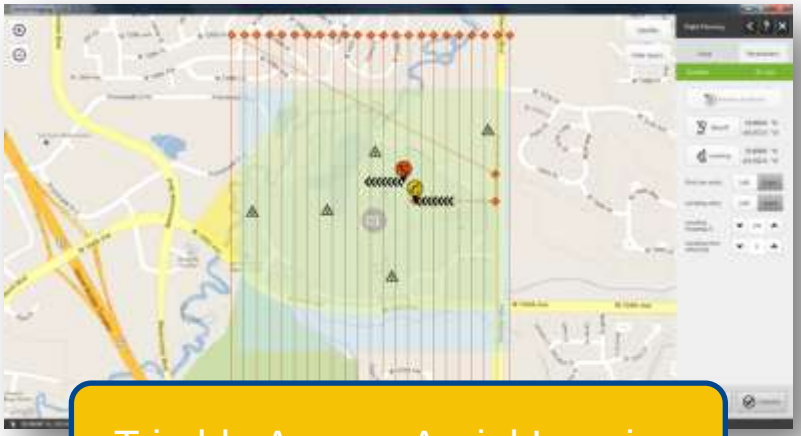
# Trimble UX5 Aerial Imaging Solution



Trimble Access Aerial Imaging

Trimble UX5 Aerial Imaging Rover & Trimble Tablet

Trimble Business Center Photogrammetry Module

# Trimble UX5 Aerial Imaging Rover

- **Airframe**
  - Internal carbon frame
  - Expanded polypropylene foam body
  - Engine & propeller
  - Servo-controlled elevons
- **Payload Bay**
  - Battery
  - Camera
  - Tracking beacon
- **eBox**
  - GPS & orientation sensors
  - 2.4 GHz radio
  - Autopilot

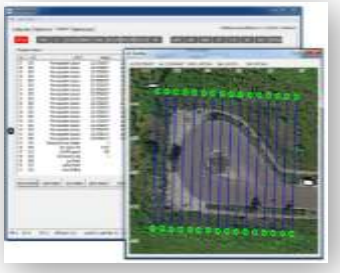
# Trimble UX5 Specifications

- Weight: 2.5 kg
- Wingspan: 100 cm
- Launch Type: Catapult
- Cruise Speed: 80 km/h
- Endurance (flight time): 50 min
- Flight Height (AGL): 75-750 m
- GSD: 1.5-15 cm
- Flight Ceiling: 5000 m
- Wind Speed: 65 km/h
- Landing Type: Belly
- Camera: Sony A5100 (24 MP)

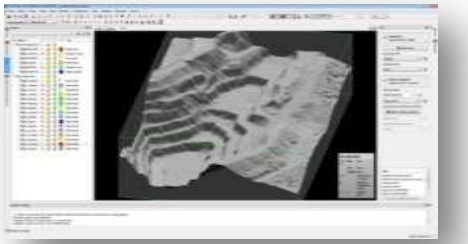
# Trimble ZX5 System Features

- Olympus 16.1MP Camera with automated triggering
- HD video capture & live video streaming
- Reliable flight controller
- Safety commands & automatic failsafe’s
- Easy deliverable workflows with Trimble Business Center & UASMaster

# Trimble ZX5 Solution



Flight Planning Software



TBC APM Software UAS Master

Ground Control

Gimbal & Sensor

Battery Packs

# Trimble ZX5 System Specs

- MULTIROTOR G4 flight controller
- Light rugged carbon structure
- Foldable arms and legs for easy transport
- Up to 20 minute flight time per mission
- Olympus E-PL7 16.1MP camera
- Brushless motorized gimbal
- Jeti DS 14 radio control station >1000m range
- Live view 5.8Ghz video (optional)
  - Jeti DS16 w/ 7“ Color monitor
- Wind stable up to 10 m/s (22mph)
- Max. airspeed 30 km/h
- Max takeoff weight 5kg
  - Max payload includes camera, batteries 2.3kg
- GSD (ground sample distance) down to 1mm

# UAS CASE STUDIES

# AIRBORNE SENSORS (AX SYSTEMS)

# Airborne Sensors (AX Systems)

- **Sensors / Components**
  - *LIDAR (polygon line scanner)*
  - *TAC Camera (mid format frame camera)*
  - *GNSS/IMU*
    - *(AP 50/ AP60)*
  - *Flight Mgt System*
  - *Power distribution Unit with UPS*
- **Platform**
  - *Fixed-wing*
  - *Helicopter*
- **Key Applications**
  - *Aerial survey and mapping*

# Airborne Sensors (AX Systems)

4500 m / 15000 ft

High

3000 m / 10000 ft

ALTITUDE

Medium

1500 m / 5000 ft

Low

Trimble AX80

Wide Area Mapping

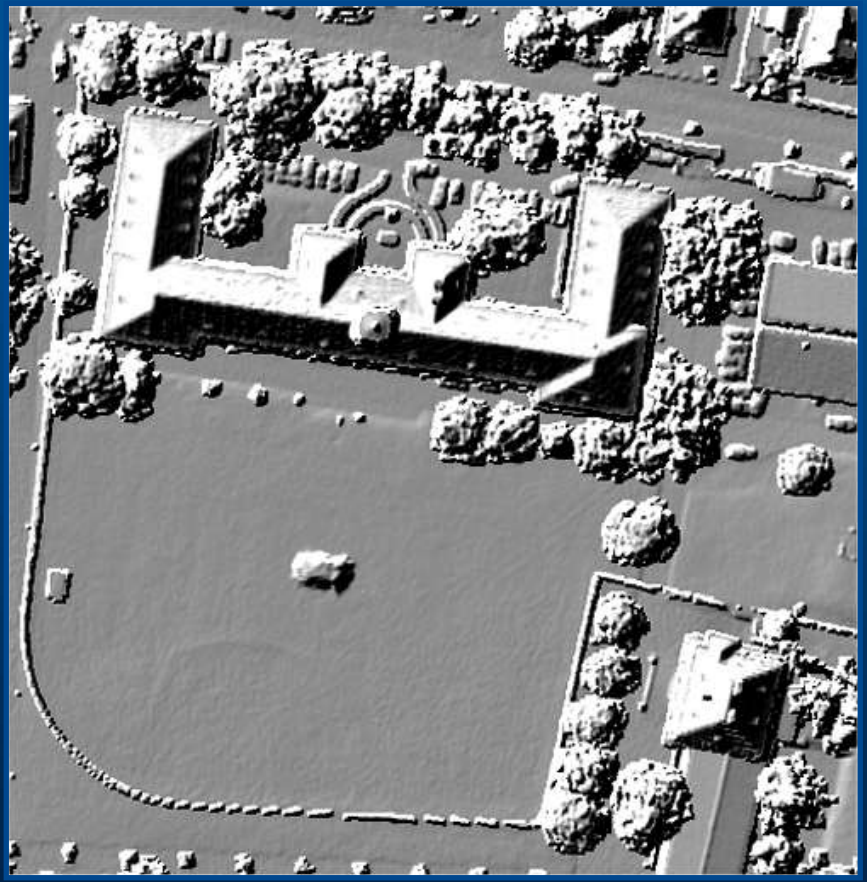
Trimble AX60

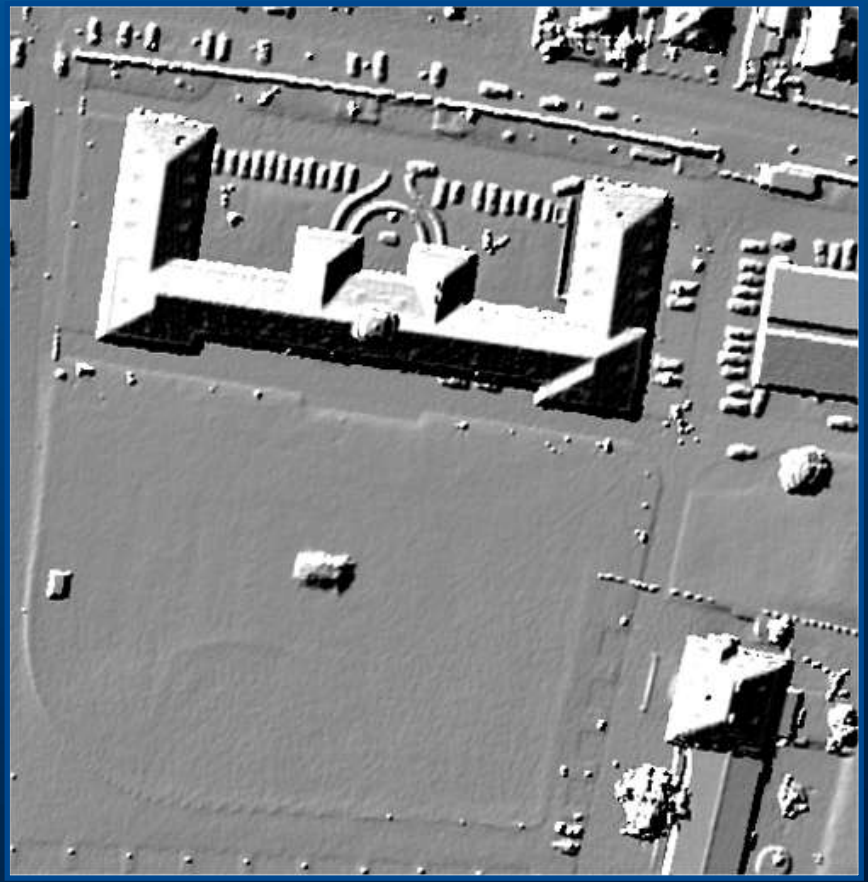
Trimble AX60i

Corridor Mapping

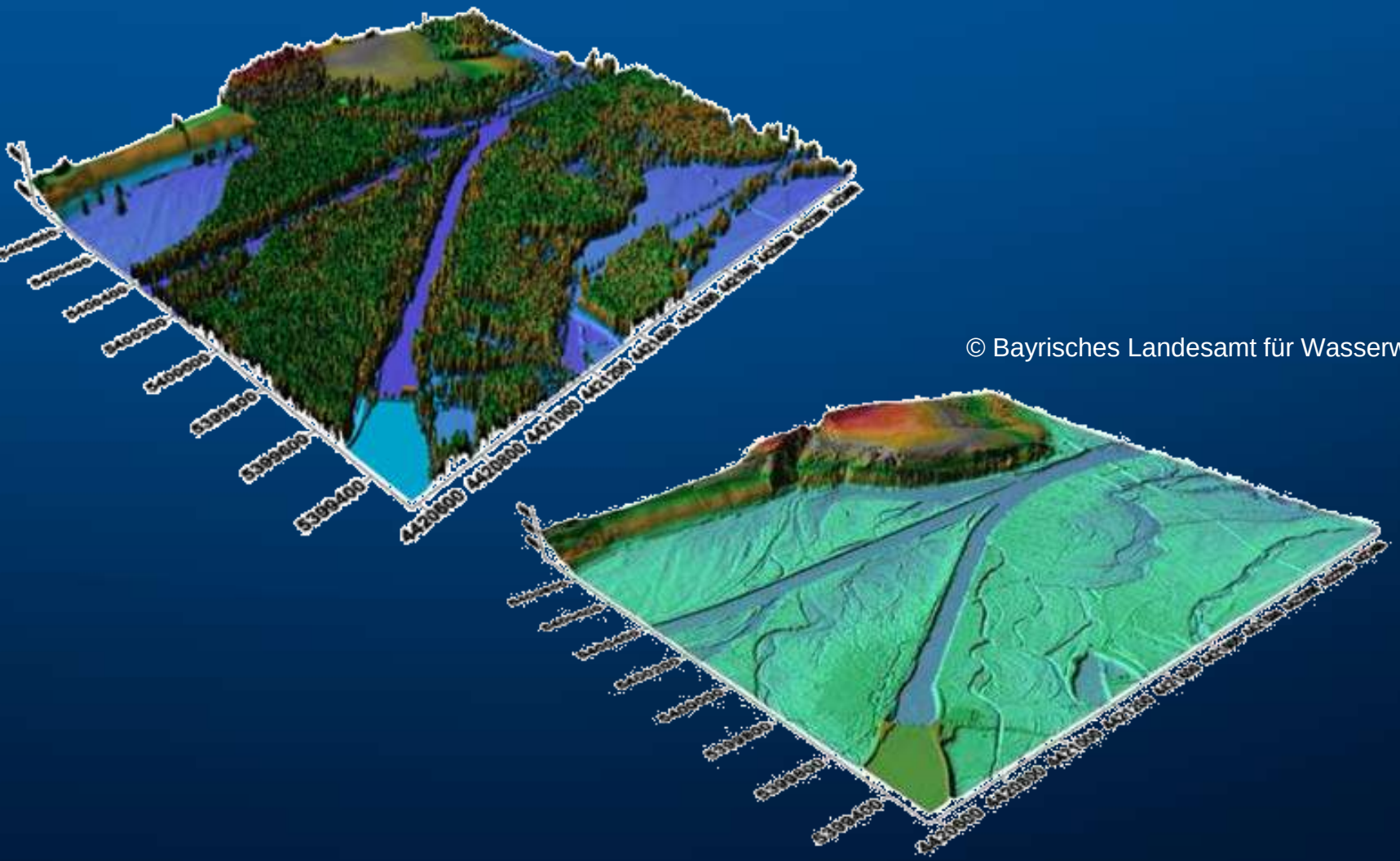
# Multiple Returns

**DEM first echo (left) and DEM last echo (right)**





# Multiple Returns



© Bayrisches Landesamt für Wasserwirtschaft

# TAC (Trimble Aerial Camera)

- **Technical Parameters**
  - mid format frame camera
  - Metric calibrated
  - RGB bayer pattern
  - 65 or 80 MPixel
  - Image release rate: < 2 sec / frame
  - Global shutter (shutter speed up to 1/1000s)
- **Optional: FMC**

Forward Motion Compensation

Without FMC

# Applications

- City modelling and mapping
- Agriculture and forestry
- Power transmission lines
- Pipelines
- Lakesides and river banks
- Glaciers and snowfields

# PICK THE RIGHT TOOLS

## Trimble's Photogrammetric Software

Inpho

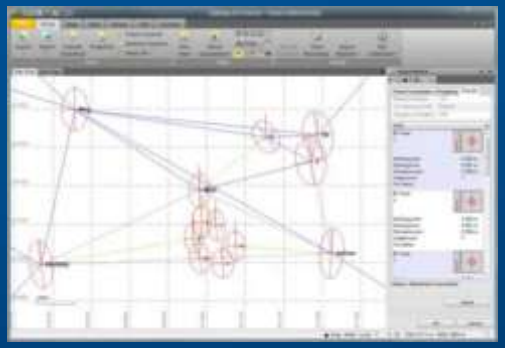
UASMaster

TBC PM

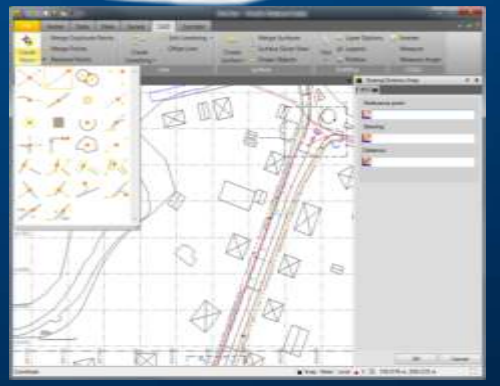
# TRIMBLE BUSINESS CENTER (TBC)

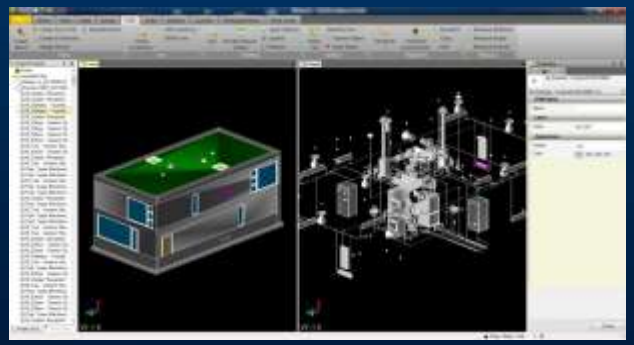
# What is TBC?

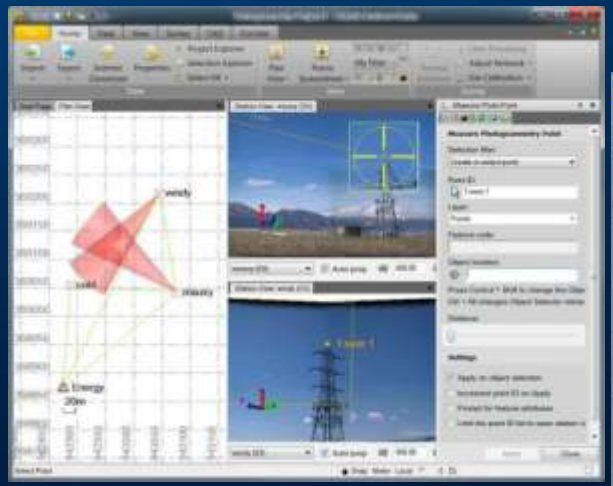
## Powerful office software for survey and mapping professionals

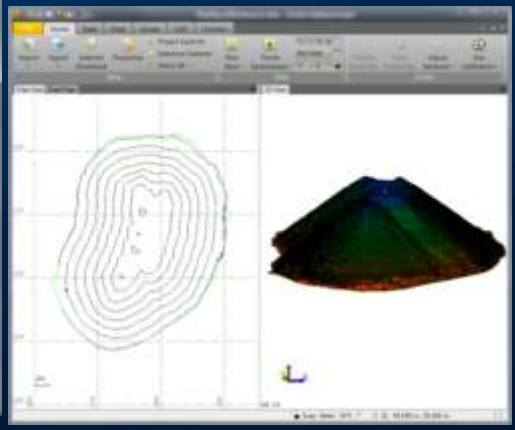


- Coordinate Geometry
- Network Adjustment
- GIS
- CAD
- Support for many types of instruments
- Support from many types of import/export
- Raw data processing
- Export of stakeout designs
- Flexible Reporting









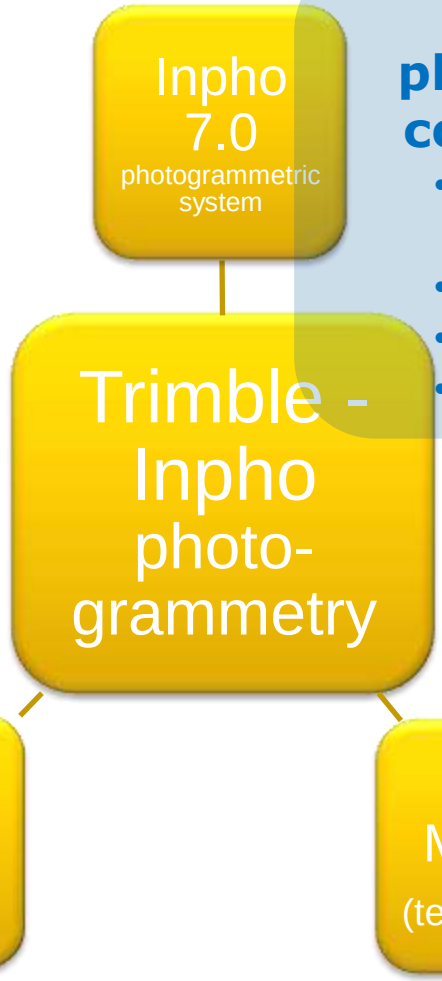
# TBC Editions & Modules

**TBC capabilities are available in different packages allowing users to purchase only what they need.**

Editions

Modules

# UAV Processing with Trimble




**Modular full-blown photogrammetry suite, complete workflow for**

- Large/medium/small format
- Frame/pushbroom
- Satellite
- Specialized UAV strategies

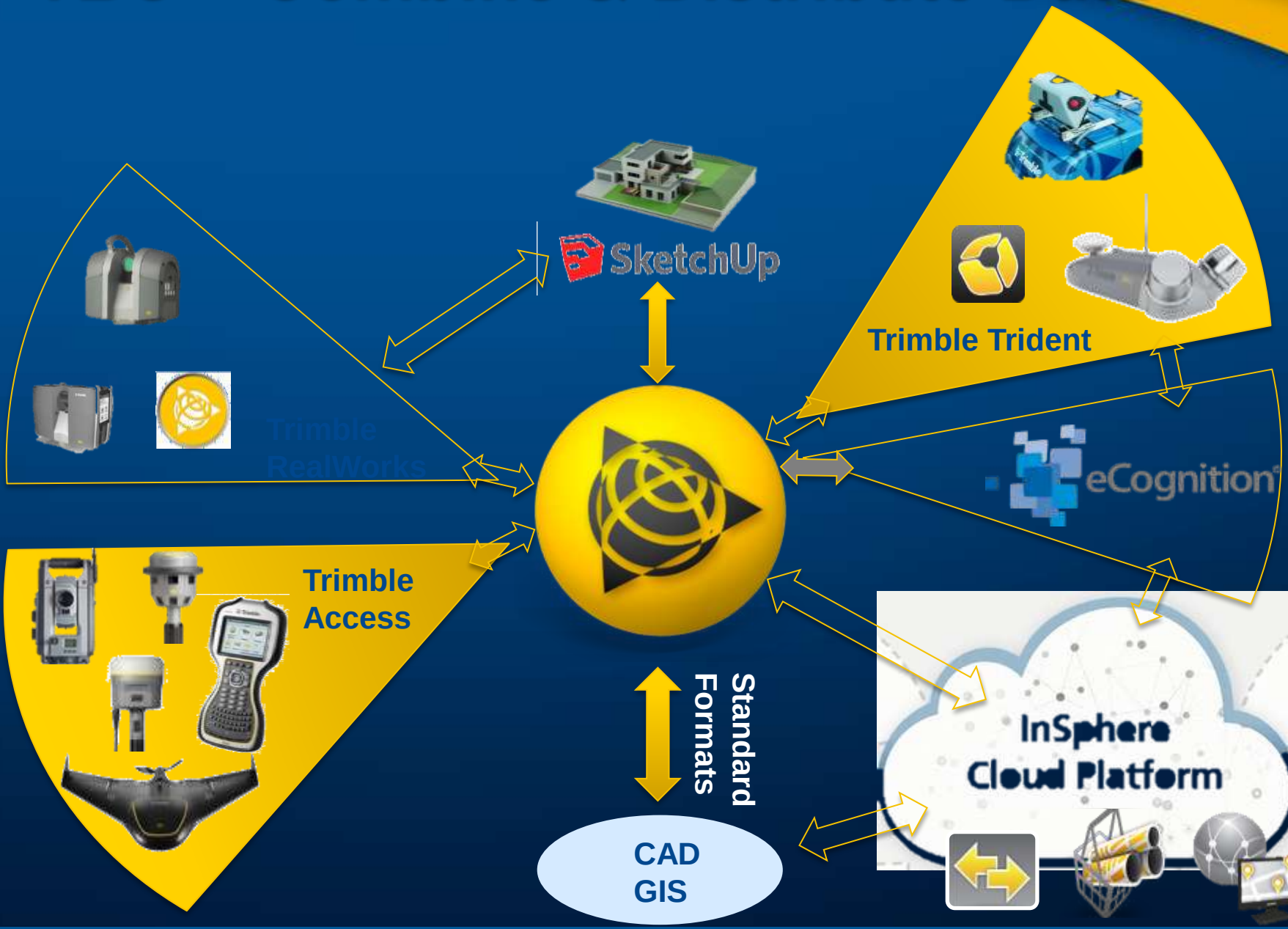
**UAV Processing in TBC**

- UAV processing for Trimble Survey
- black box batch processing
- Ease of use
- Limited to Gatewing hardware

**Specialized UAV Processing**

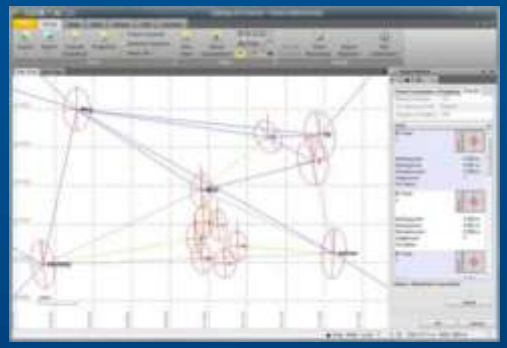
- Open for any hardware
- Streamlined batch processing
- QA/QC Tools
- Editing capabilities
- photogrammetrists and surveyors

# TBC - Combine & Distribute Data

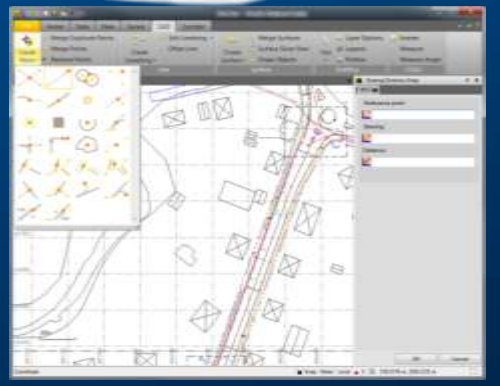


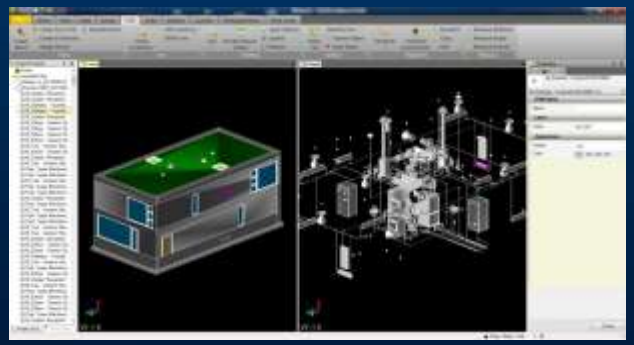
# Trimble Business Center

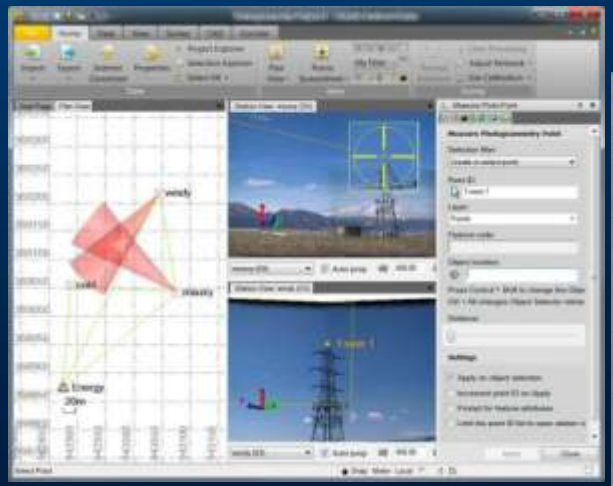
## Versatile office software for survey and mapping professionals

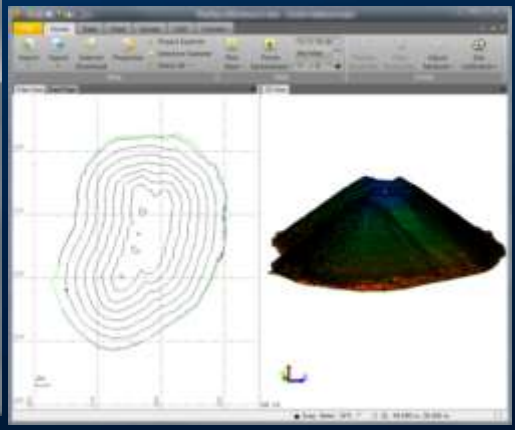


- Coordinate Geometry
- Network Adjustment
- GIS
- CAD
- Support for many types of instruments
- Support from many types of import/export
- Raw data processing
- Export of stakeout designs
- Flexible Reporting



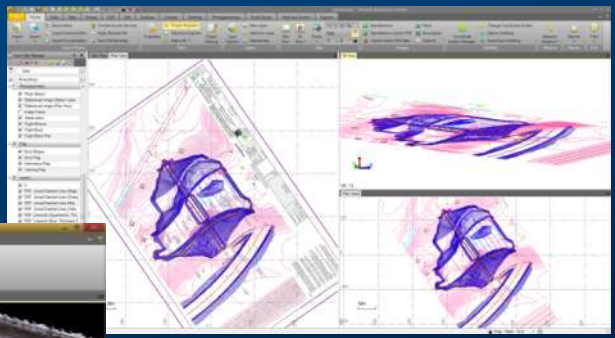


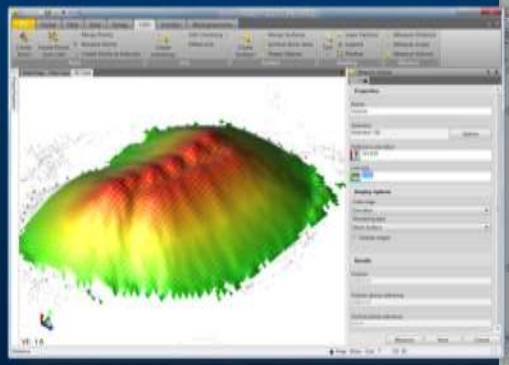


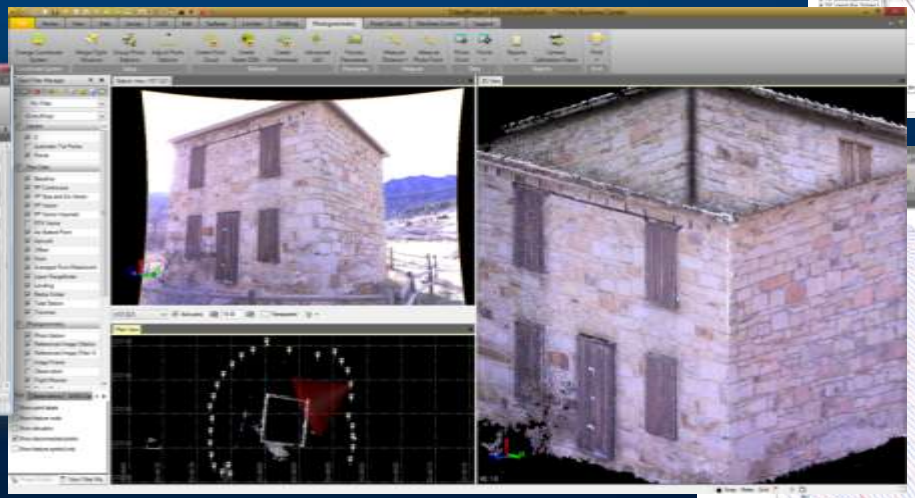


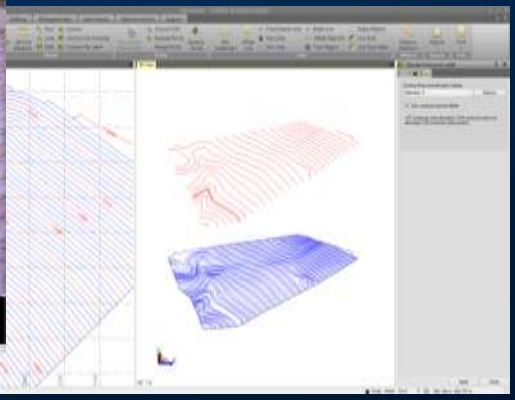
# TBC Data & Deliverables

- Drawings & Models -.dwg, .dxf, .skp, PDF, 3D PDF, IFC, iModel, Plots, DTM, DSM, Contours, corridor designs, …
- Measured Points - .txt, csv, jxl, …
- GIS - .shp, …
- Point Clouds – e57, LAS
- Images - .jpg, .bmp, KMZ, KML, Orthophotos, Panoramas, …
- Measurements – Distance, Area, Volume, …



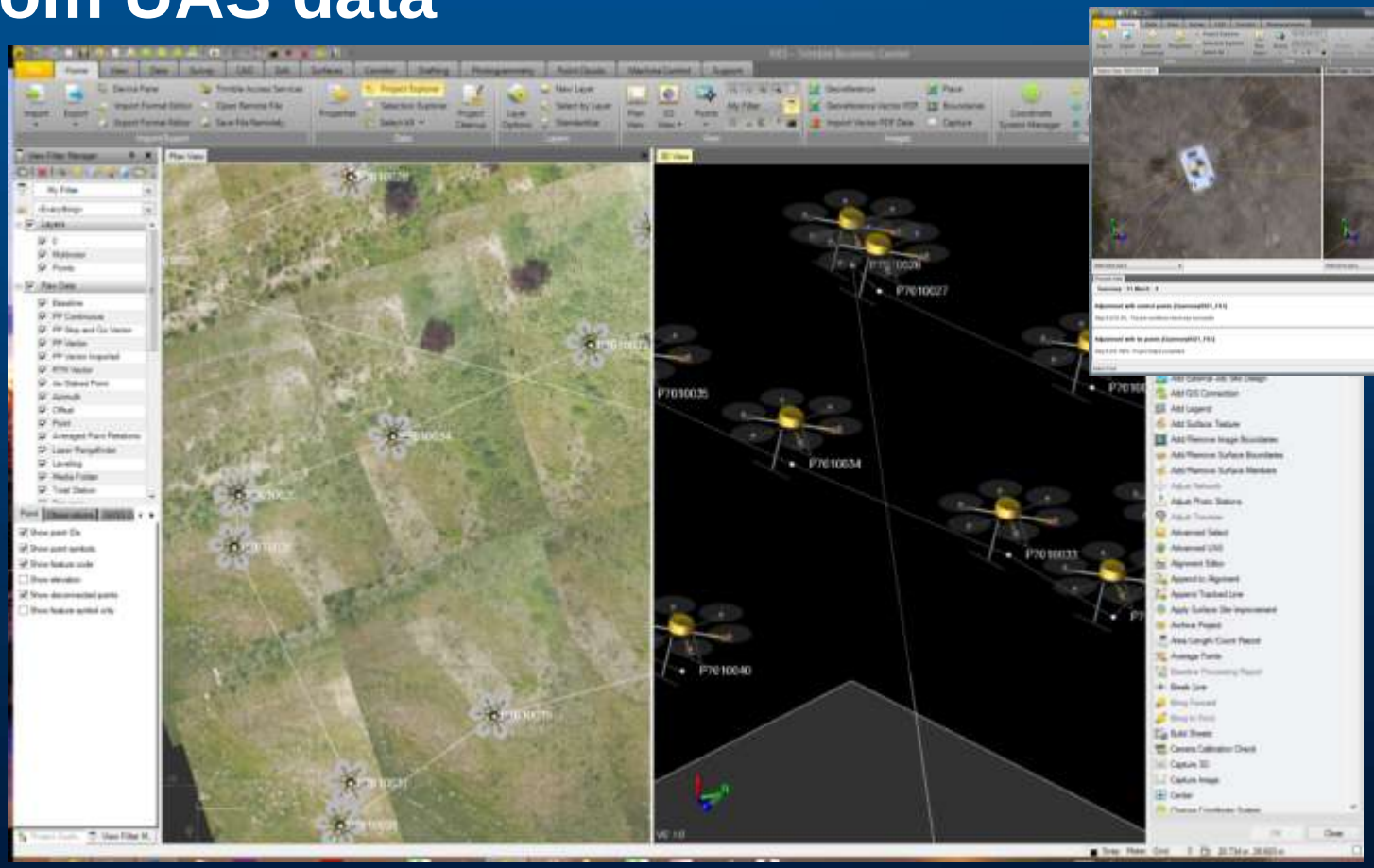


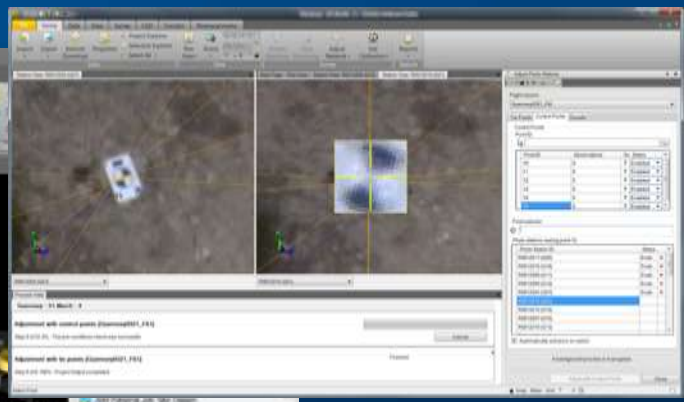




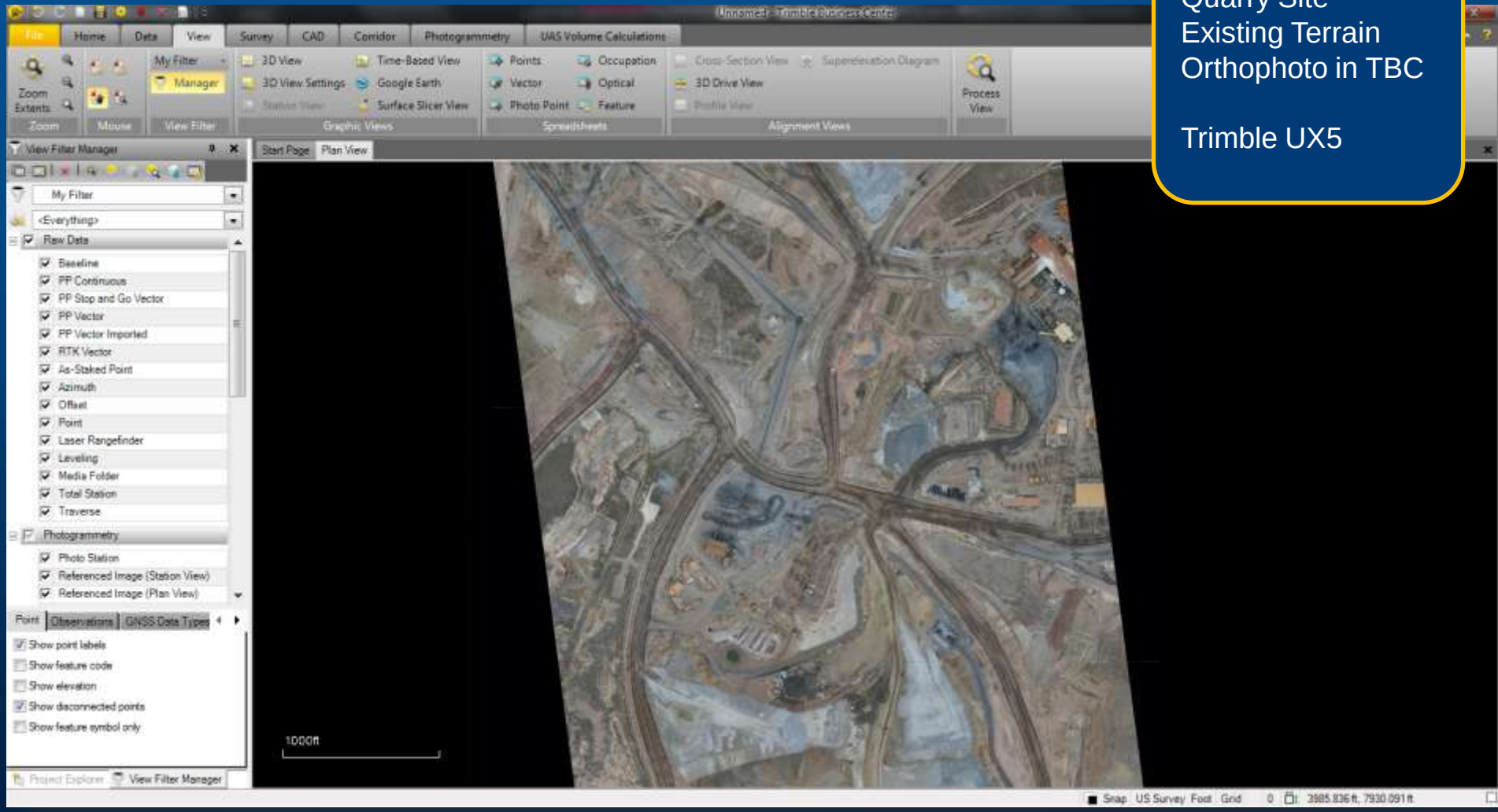
# Aerial Photogrammetry Module

## The TBC Aerial Photogrammetry Module produces a variety of high-value deliverables from UAS data





# Orthomosaics




Quarry Site
Existing Terrain
Orthophoto in TBC

Trimble UX5

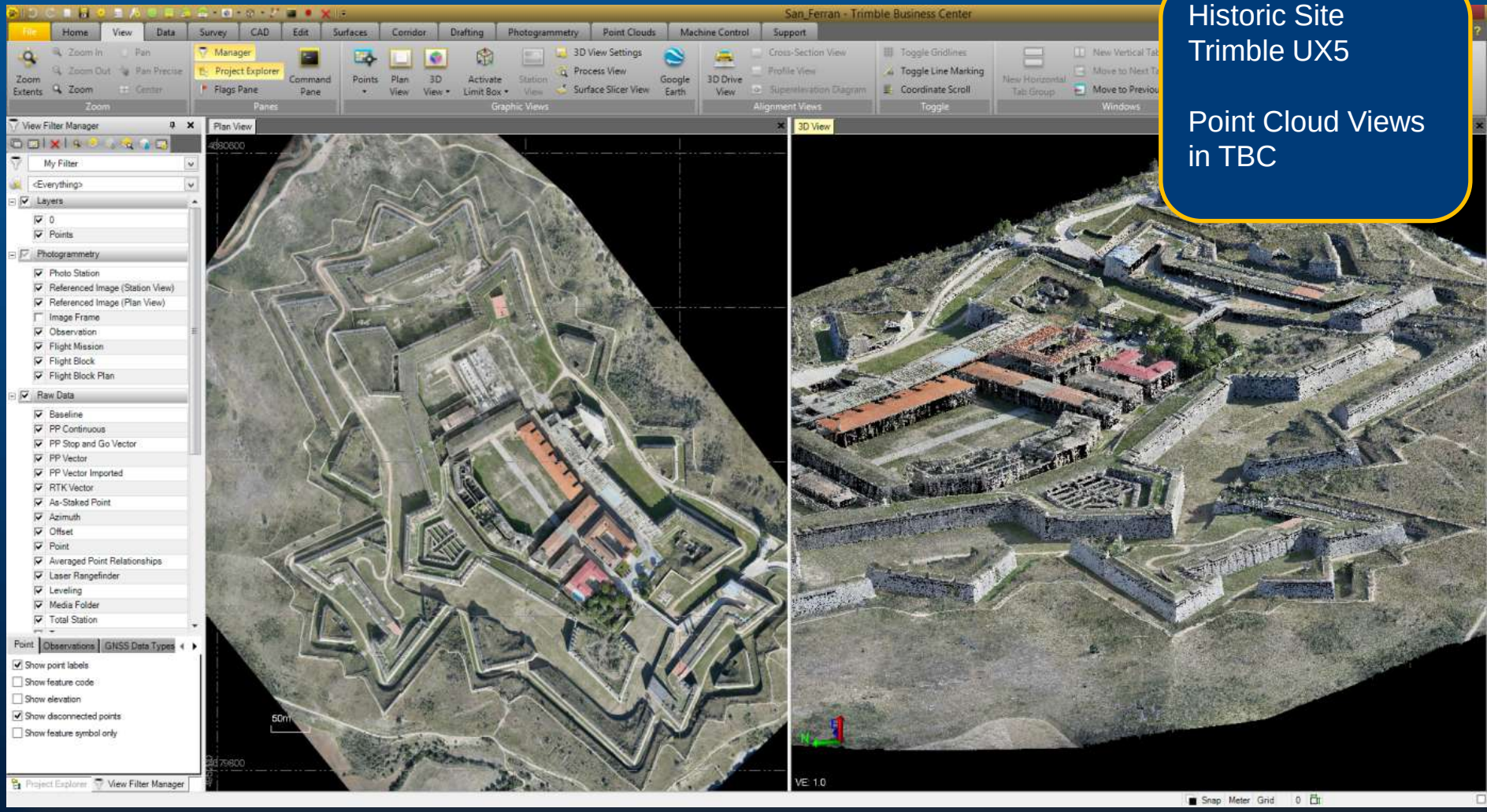
# Progress Monitoring

Construction Site
Trimble UX5
150 m Flight Height
5.7 cm GSD
2.4 $km^2$

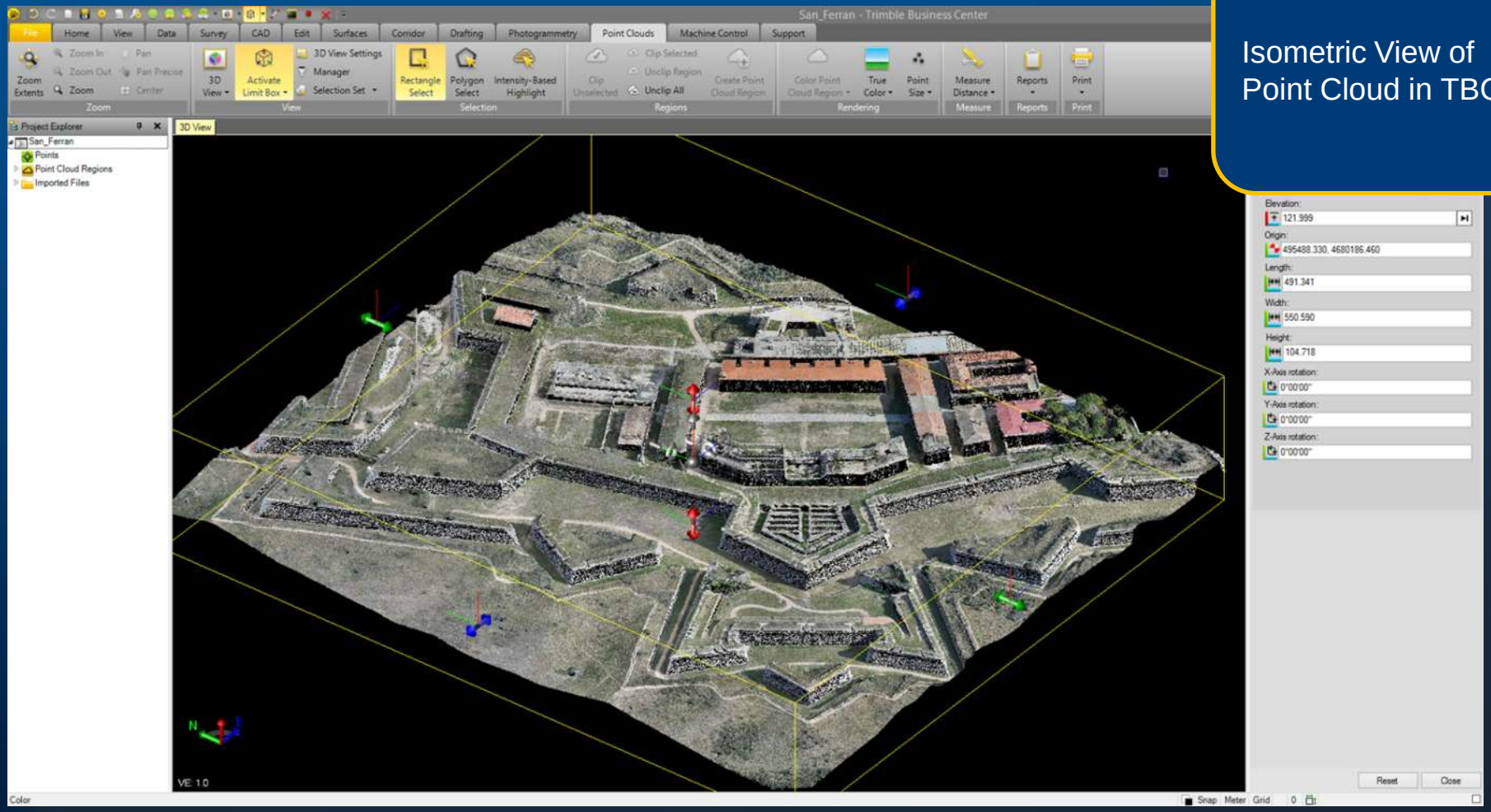
# Planning & Inspection

Interchange
Upgrade
462 Images
150 m Flight Height
5 cm GSD
0.8 $km^2$

# Point Clouds



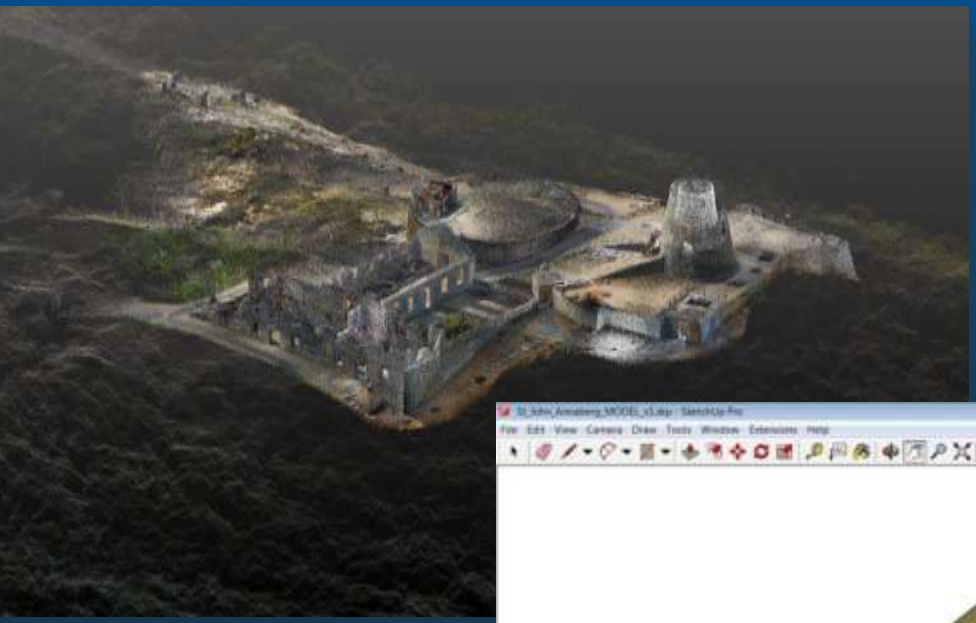
# Point Clouds

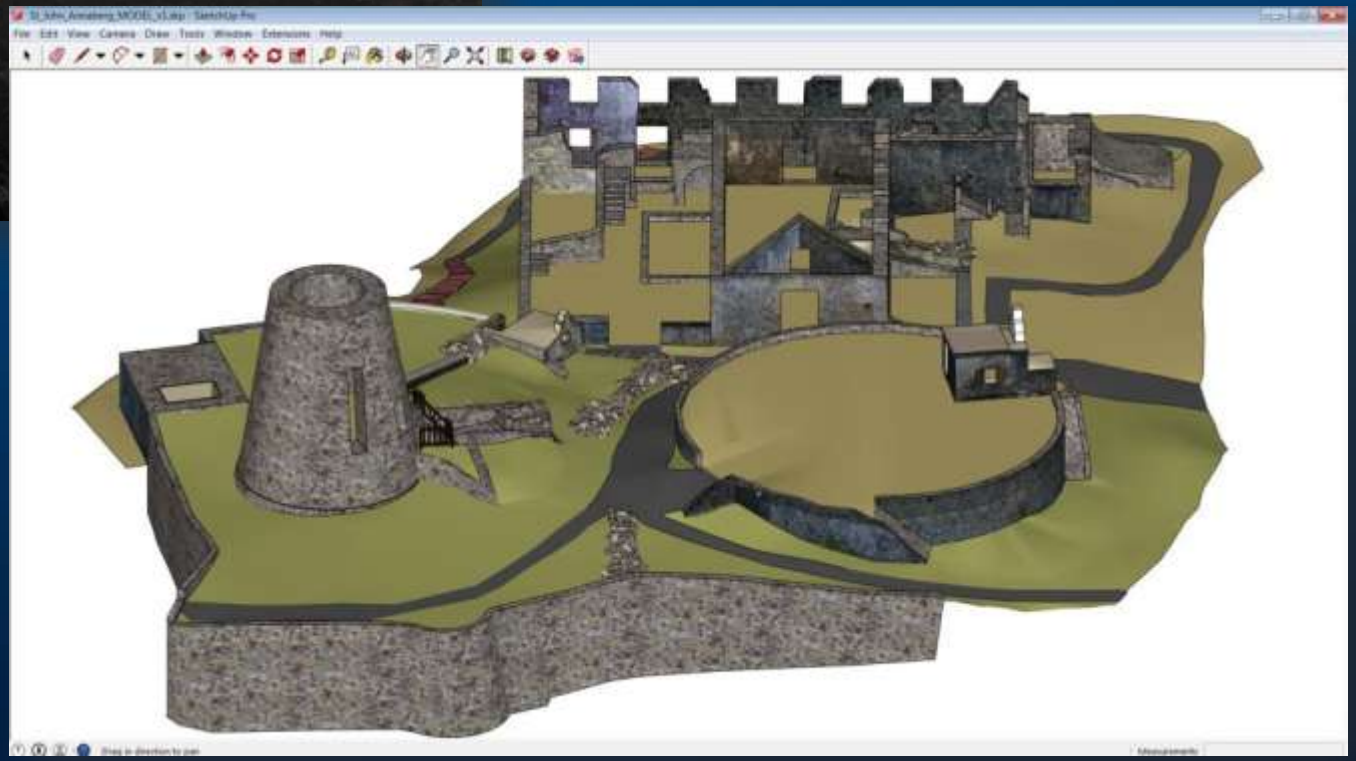



Historic Site

Isometric View of Point Cloud in TBC

# Point Clouds→Models

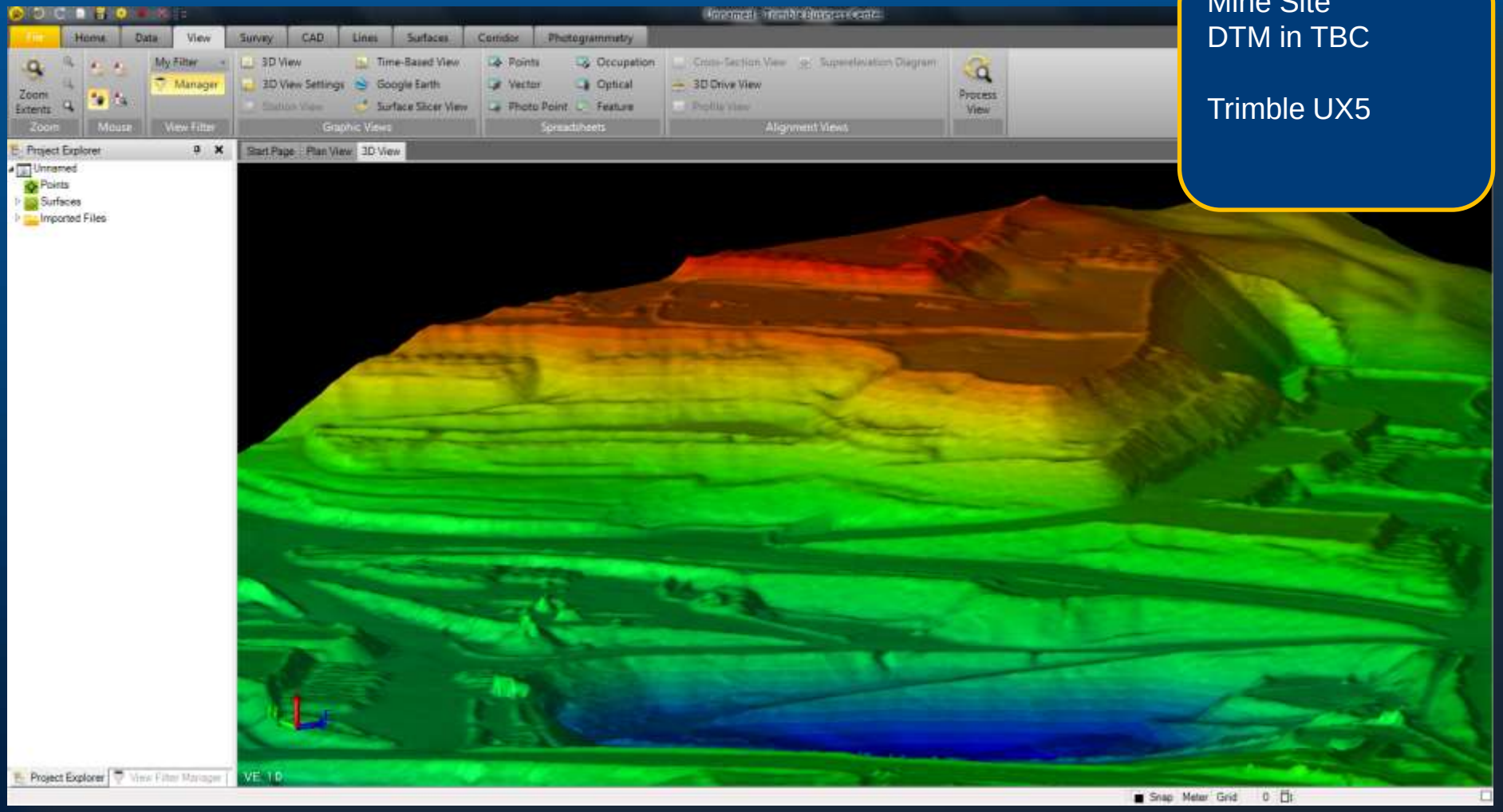




Historic Site

Point Cloud in TBC
Left
SketchUp Model
Right

# Surfaces (DSM and DTM)




Mine Site
DTM in TBC

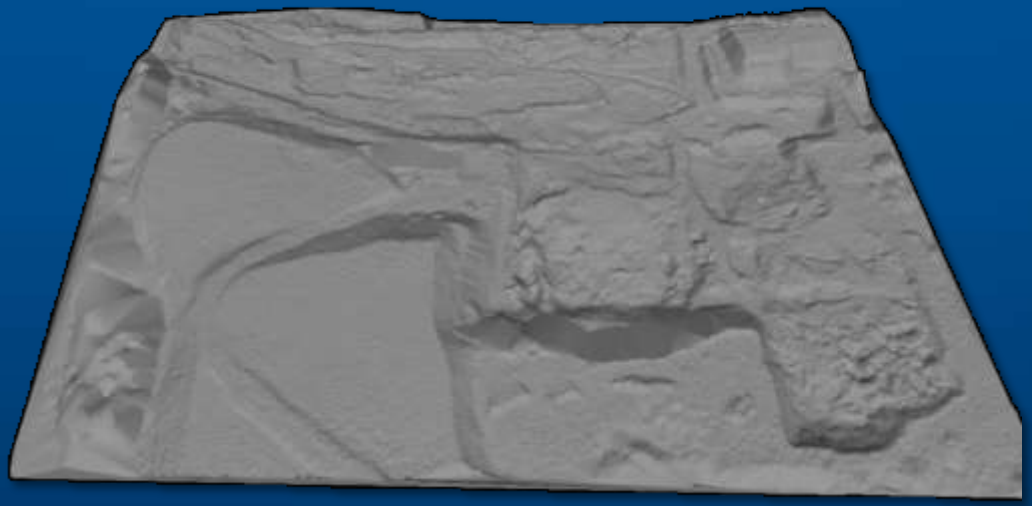
Trimble UX5

# Surfaces

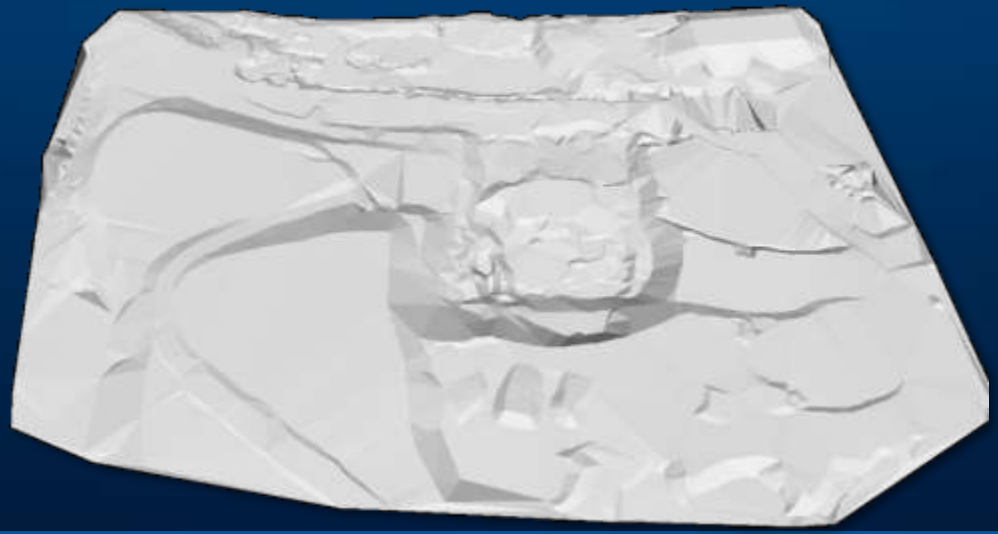
## Topographic Survey Example

Mining Site
Trimble X100

High resolution surface model

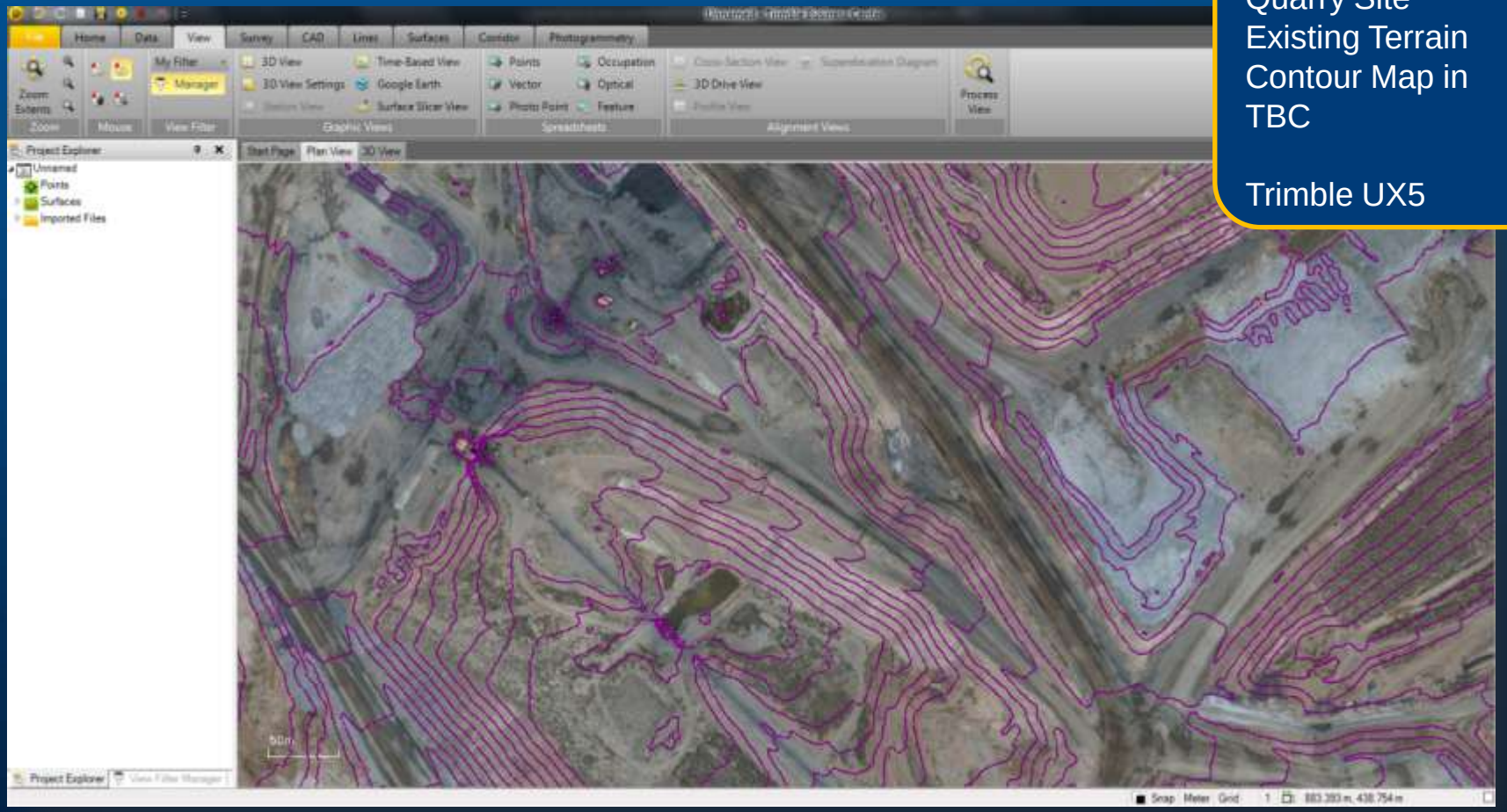


Surface model generated from UAS survey (300,000 measurements)



Surface model generated from GNSS survey (100,000 measurements)

# Contour Maps




Quarry Site
Existing Terrain
Contour Map in
TBC

Trimble UX5

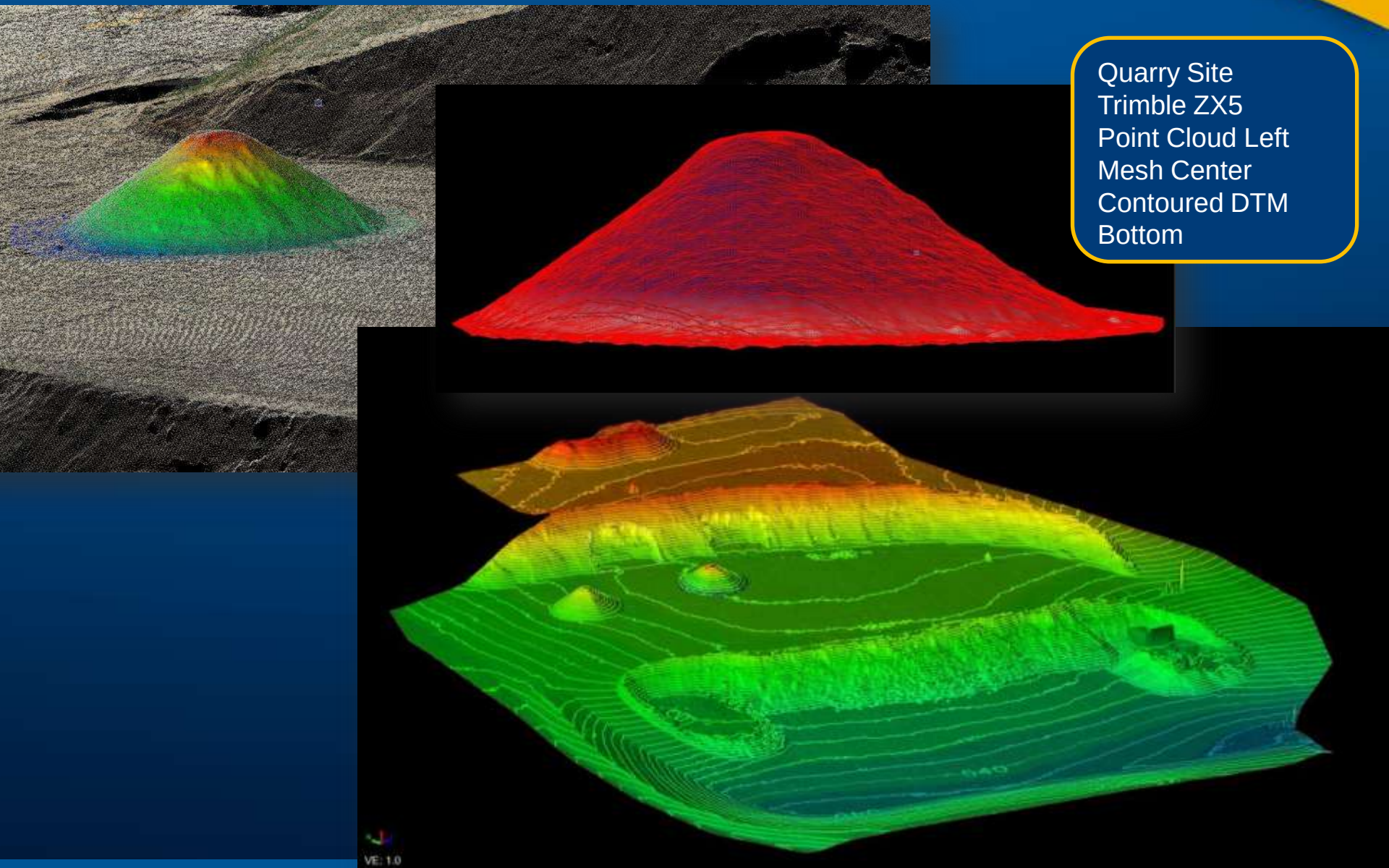
# Volumetrics

Open Pit Mine
Trimble X100
641 Images
150 m Flight Height
5.6 cm GSD
0.12 $km^2$

# Volumetrics

Quarry Site
Trimble UX5
288 Images
100 m Flight Height
5 cm GSD
1.5 $km^2$

# Volumetrics



Quarry Site
Trimble ZX5
Point Cloud Left
Mesh Center
Contoured DTM
Bottom

# Volumetrics

## Stockpile Volume Analysis

**Measured stockpile surface compared to estimated foundation surface**

| Surfaces | |
|---|---|
| **Stockpile 2** | Classification: Stockpile |

| Volumes from Surface Geometry | |
|---|---|
| **Approximate stockpile volume:** | **151.2 yd³** |
| **Approximate depression volume:** | **0.2 yd³** |

**Volumes by Depth Range**

| Elevation range | Cut (yd³) | Fill (yd³) |
|---|---|---|
| 562.213 > 564.000 | 0.1 | 14.3 |
| 564.000 > 566.000 | 0.1 | 58.2 |
| 566.000 > 568.000 | 0.0 | 39.2 |
| 568.000 > 570.000 | 0.0 | 23.0 |
| 570.000 > 572.000 | 0.0 | 11.9 |
| 572.000 > 574.000 | 0.0 | 4.4 |
| 574.000 > 574.523 | 0.0 | 0.2 |

This is a report of the volume of a stockpile, as measured between the stockpile surface and a s
constructed from the base of the stockpile.

Quarry Site
Trimble ZX5
Stockpile Volume
Reports from TBC

## Stockpile Volume Analysis

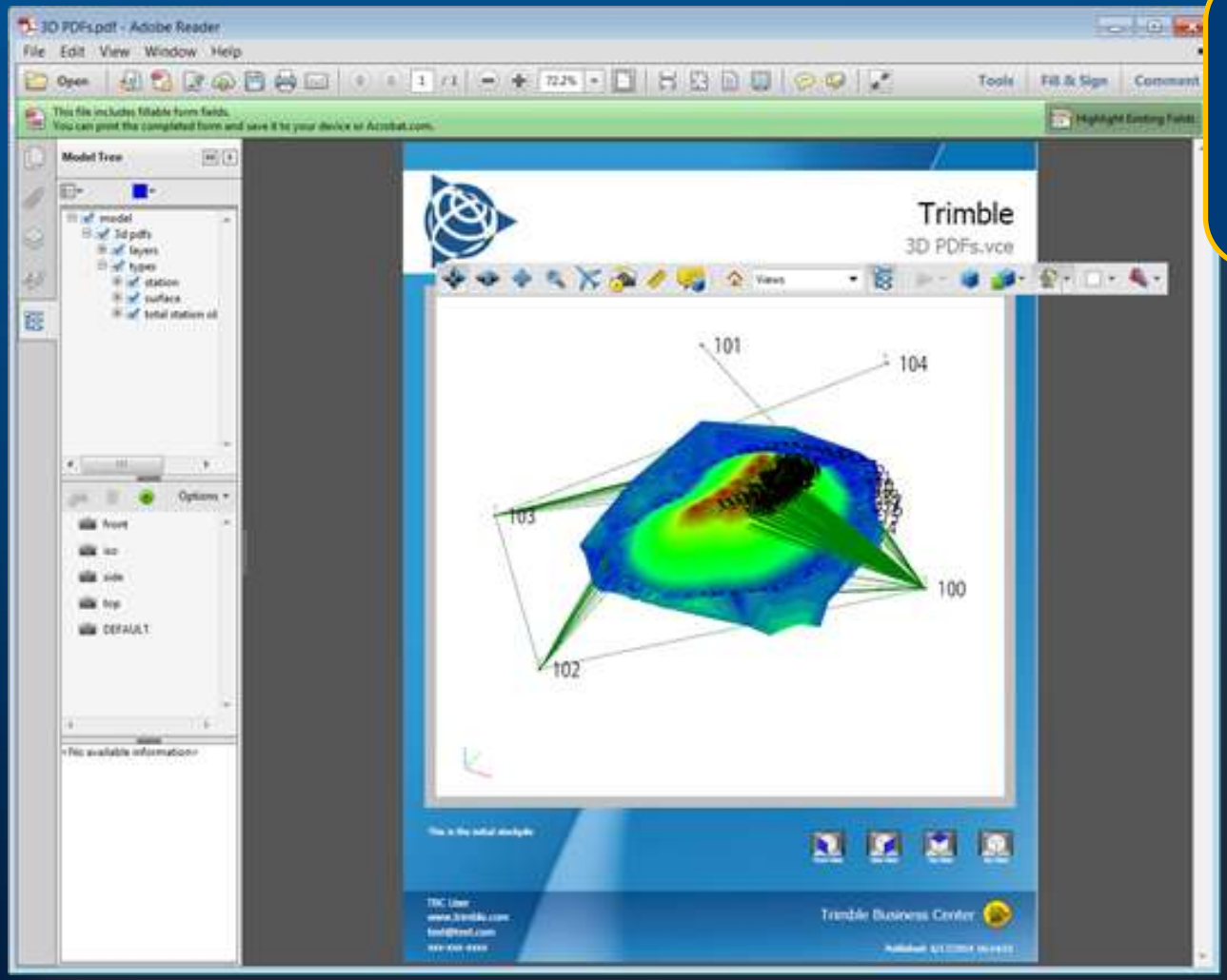
**Measured stockpile surface compared to estimated foundation surface**

| Surfaces | |
|---|---|
| **Stockpile 1** | Classification: Stockpile |

| Volumes from Surface Geometry | |
|---|---|
| **Approximate stockpile volume:** | **114.3 yd³** |
| **Approximate depression volume:** | **0.1 yd³** |

This is a report of the volume of a stockpile, as measured between the stockpile surface and a surface constructed from the base of the stockpile.

# 3D PDFs




3D PDFs allow users to measure and annotate data using only PDF-reading software

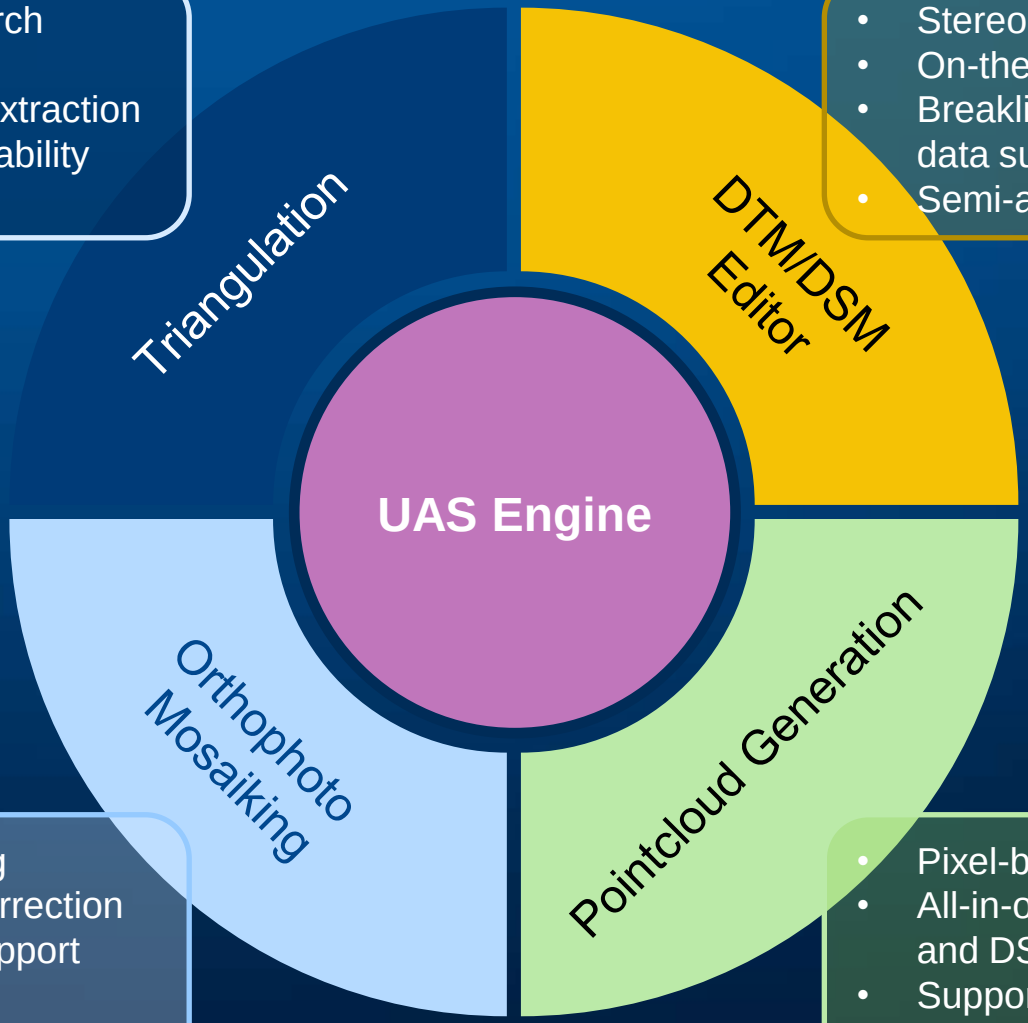
# INPHO (SUITE)

# Streamlining Processes

## Combining all Inpho technology into UAS Workflow

# UASMaster 7.0

- Graphical Error Search Functionality
- Automatic tie point extraction with interactive operability




- Stereo editing
- On-the-fly data control
- Breakline and morphological data support for processing
- Semi-automatic editing tools

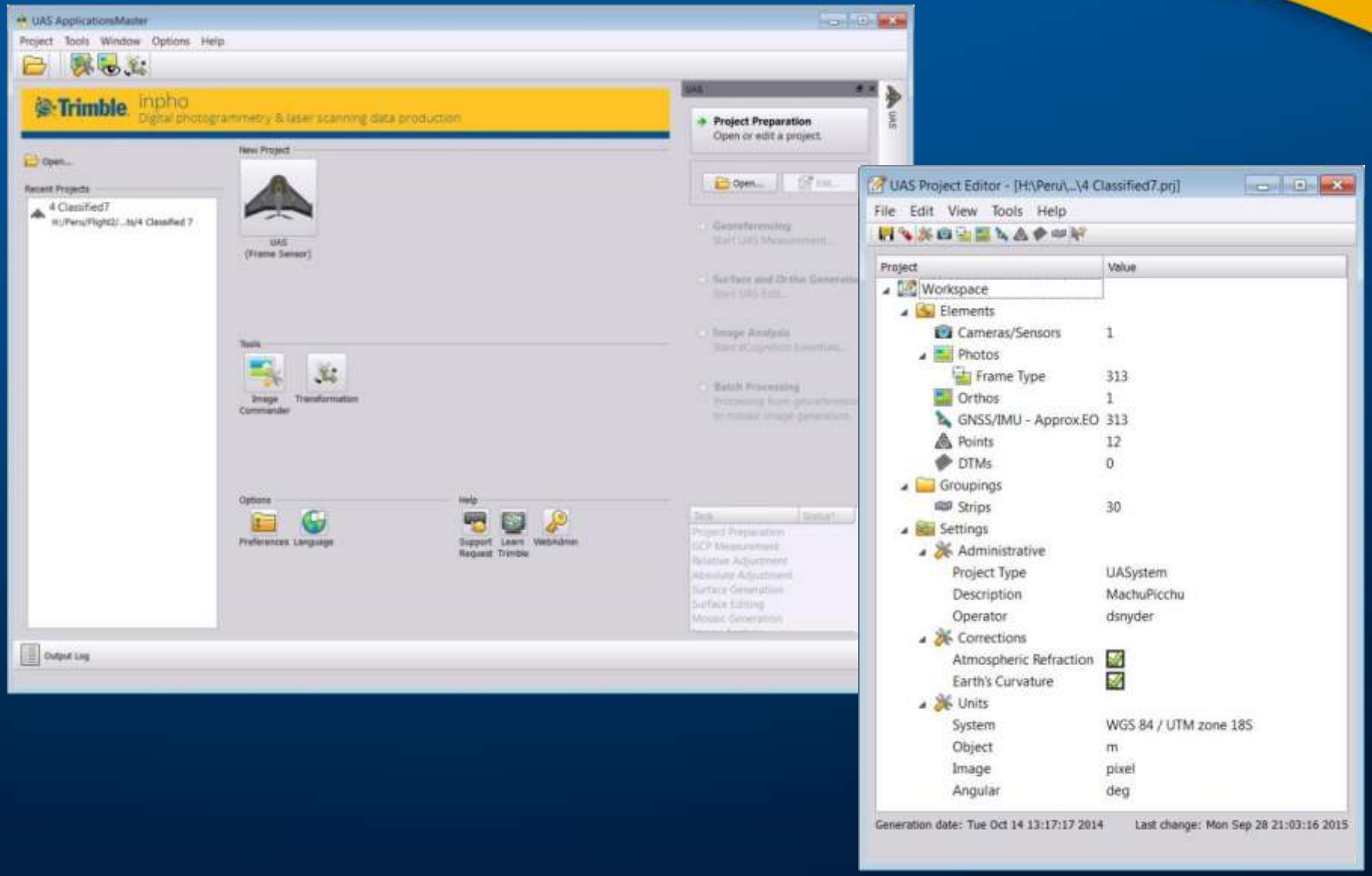
- Automatic Mosaiking
  - Radiometry correction
  - True-Ortho Support
- Automatic Seamline Generation

- Pixel-based and FB matching
- All-in-one solution for DTM and DSM generation
- Support of morphological data

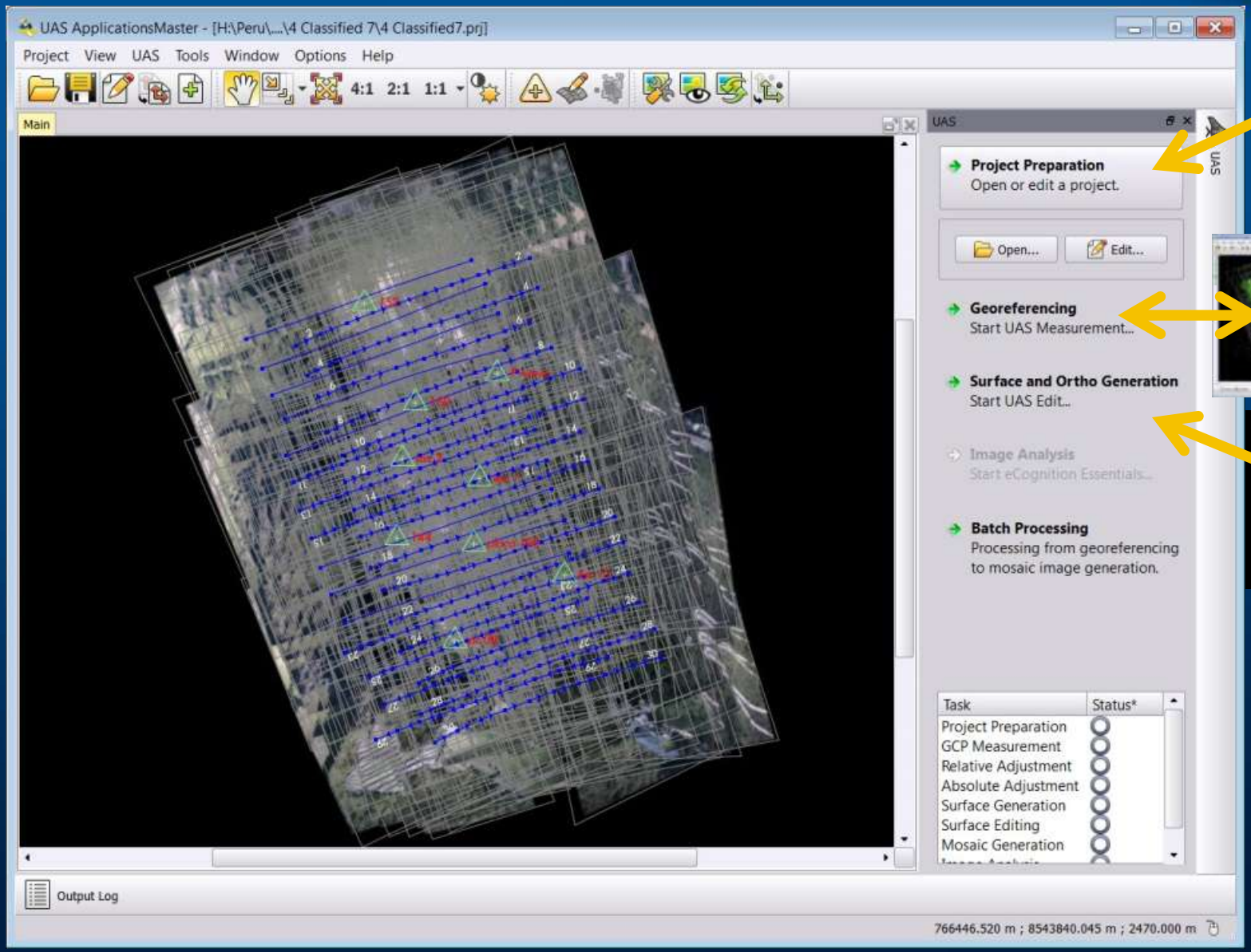
# Machu Picchu, Peru

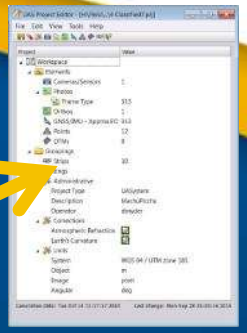
# Machu Picchu, Peru

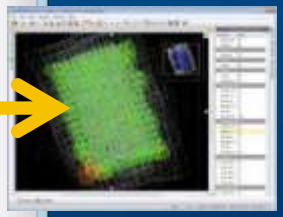
# Workflow


UAS ApplicationsMaster
Project Tools Window Options Help
Trimble inpho
Digital photogrammetry & laser scanning data production
Project Preparation
Open or edit a project.
Recent Projects
4 Classified7
UAS
(Frame Sensor)
Image Commander
Transformation
Preferences
Language
Support Request
Learn Trimble
WebAdmin
Output Log
UAS Project Editor - [H:\Peru\...\4 Classified7.prj]
File Edit View Tools Help
Project
Value
Workspace
Elements
Cameras/Sensors 1
Photos
Frame Type 313
Orthos 1
GNSS/IMU - Approx.EO 313
Points 12
DTMs 0
Groupings
Strips 30
Settings
Administrative
Project Type UASystem
Description MachuPicchu
Operator dsnyder
Corrections
Atmospheric Refraction
Earth's Curvature
Units
System WGS 84 / UTM zone 18S
Object m
Image pixel
Angular deg
Generation date: Tue Oct 14 13:17:17 2014
Last change: Mon Sep 28 21:03:16 2015

# Workflow


UAS ApplicationsMaster - [H:\Peru\....\4 Classified 7\4 Classified7.prj]
Project View UAS Tools Window Options Help
4:1 2:1 1:1
Main
UAS
Project Preparation
Open or edit a project.
Open...
Edit...
Georeferencing
Start UAS Measurement...
Surface and Ortho Generation
Start UAS Edit...
Image Analysis
Start eCognition Essentials...
Batch Processing
Processing from georeferencing to mosaic image generation.
Task
Status*
Project Preparation
GCP Measurement
Relative Adjustment
Absolute Adjustment
Surface Generation
Surface Editing
Mosaic Generation
Output Log
766446.520 m ; 8543840.045 m ; 2470.000 m





# Surface Modeling and Orthos

# TRIMBLE REMOTE SENSING SUITE (TRSS)

Trimble

**Software Bundle designed to improve, accelerate and automate the creation and interpretation of geospatial information**

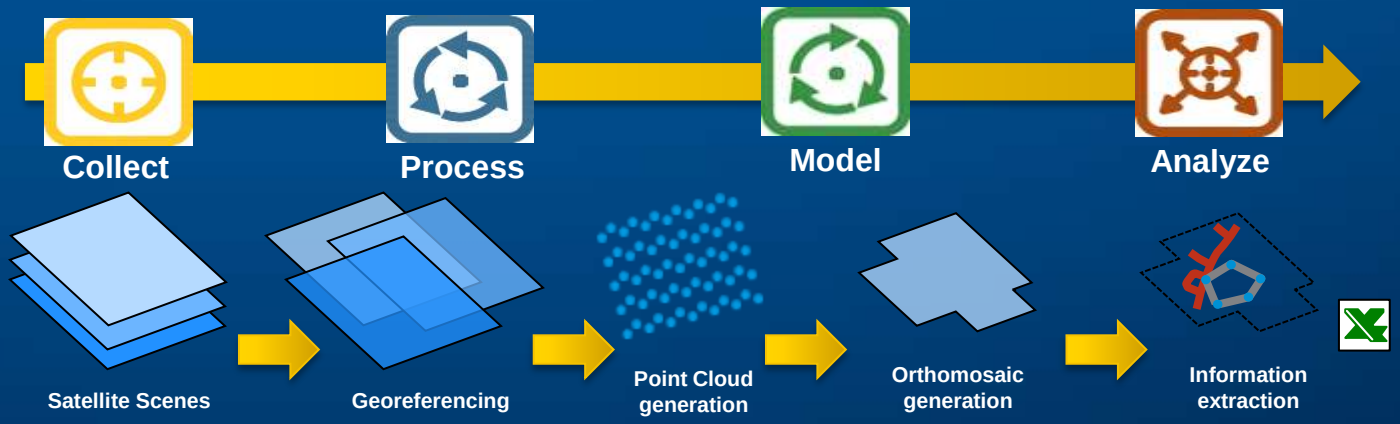
# Bundling Workflows

## Combined Inpho technology and eCognition for a complete satellite workflow

inpho & eCognition Essentials

# Introducing TRSS

## → Complete Satellite Data Processing, Modeling and Analysis Solution



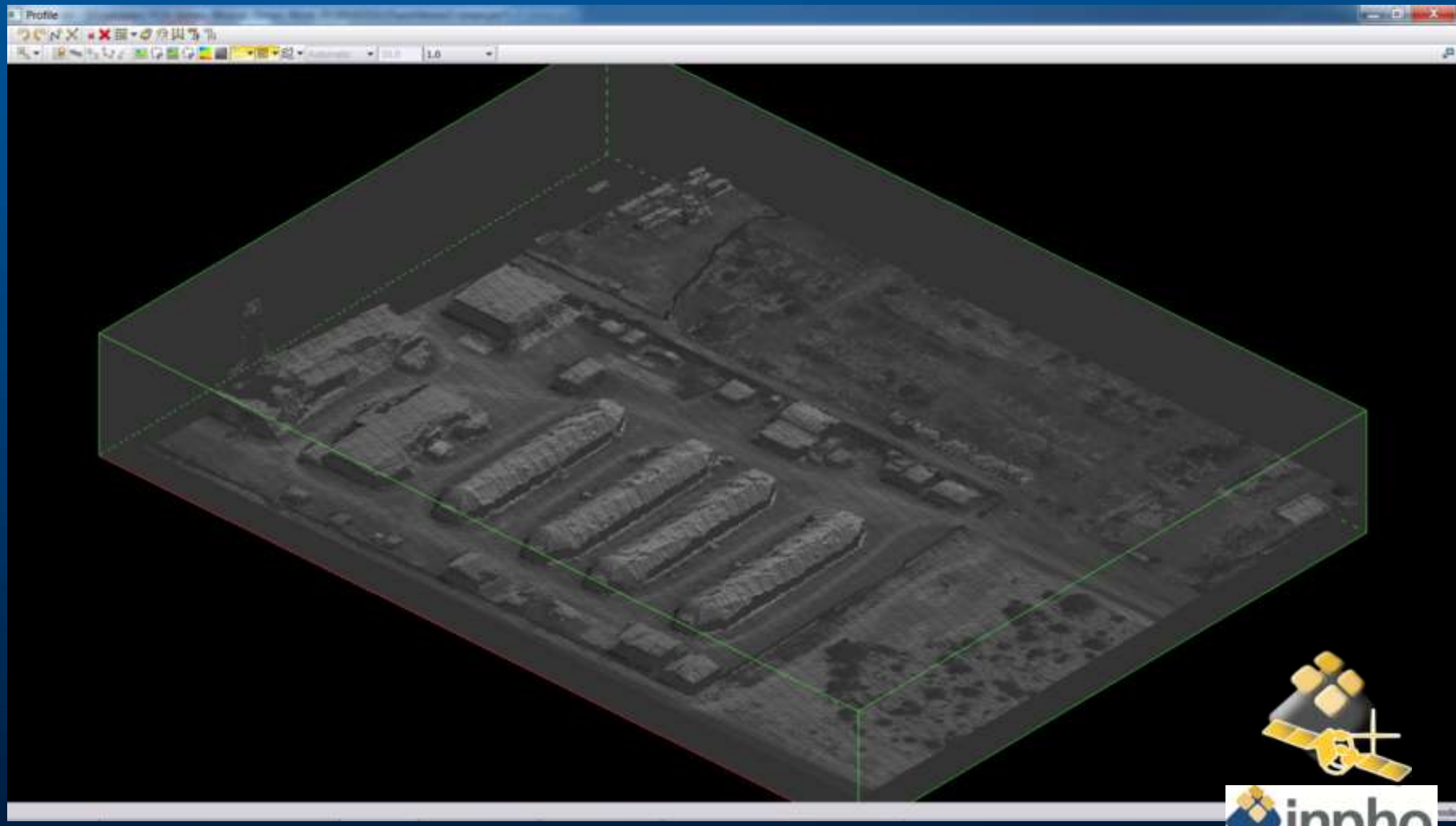

- Addressing the needs of remote sensing professionals generating high quality data, models and analytics from satellite based imagery
- Streamlined and simplified workflow to efficiently extract highly valued information
- Use Cases: geo-referencing, point cloud generation, orthorectification, mosaicking, land cover mapping, change detection
- Application fields: Environmental, urban planning, agriculture, oil and gas, forestry and mining

# Target Customers

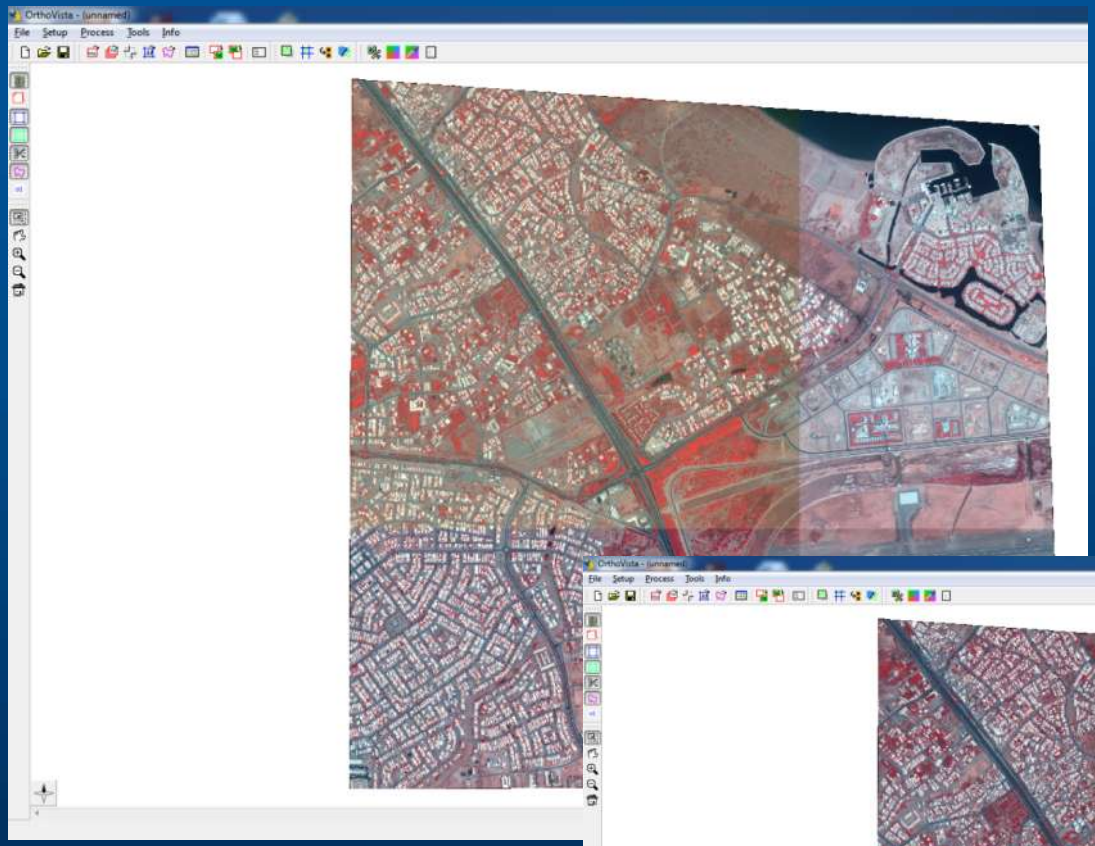
- Remote Sensing Professionals; Image Analysts; Cartographers; GIS Analysts
- Government Organizations: Environment, Agriculture, Forestry, Urban Planning
- Environmental / Climate Change Groups (REDD++ programs)

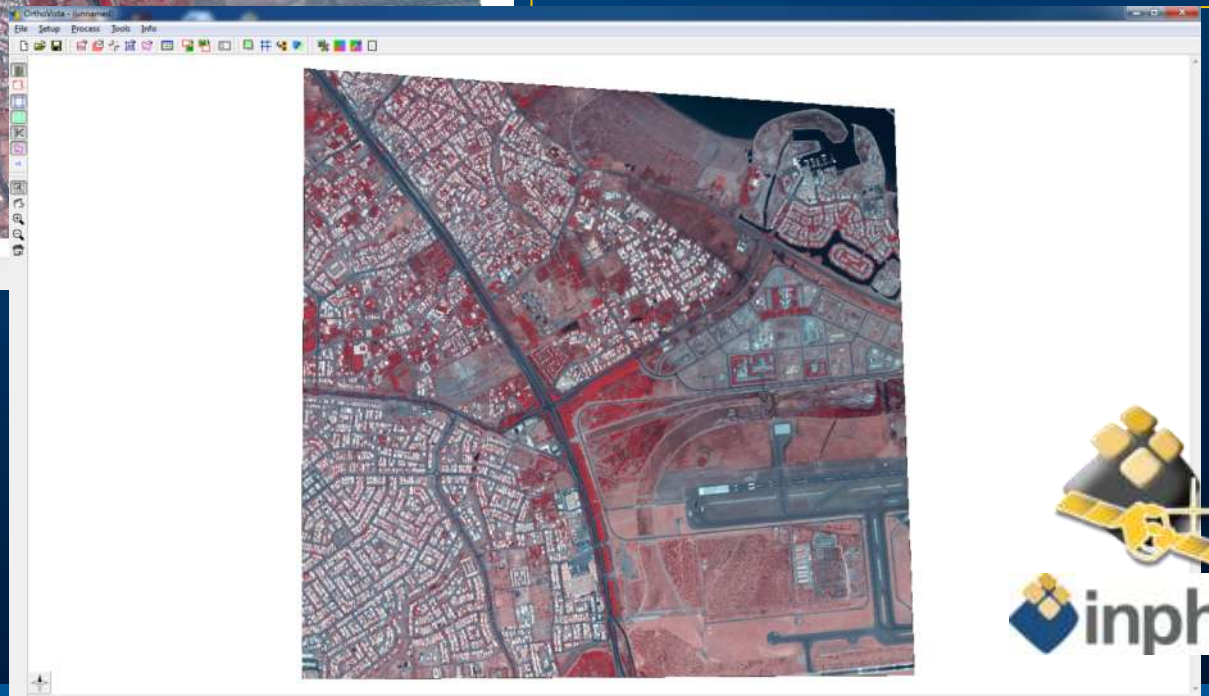
- Photogrammetric companies expanding to include satellite based deliverables like elevation models derived from overlapping satellite scenes.
- Existing eCognition customers working with satellite imagery needing to increase geospatial accuracy; generate DTM/DSM's; create quality orthomosaics

# Dense Point cloud from WorldView 3



# Orthomosaic generation



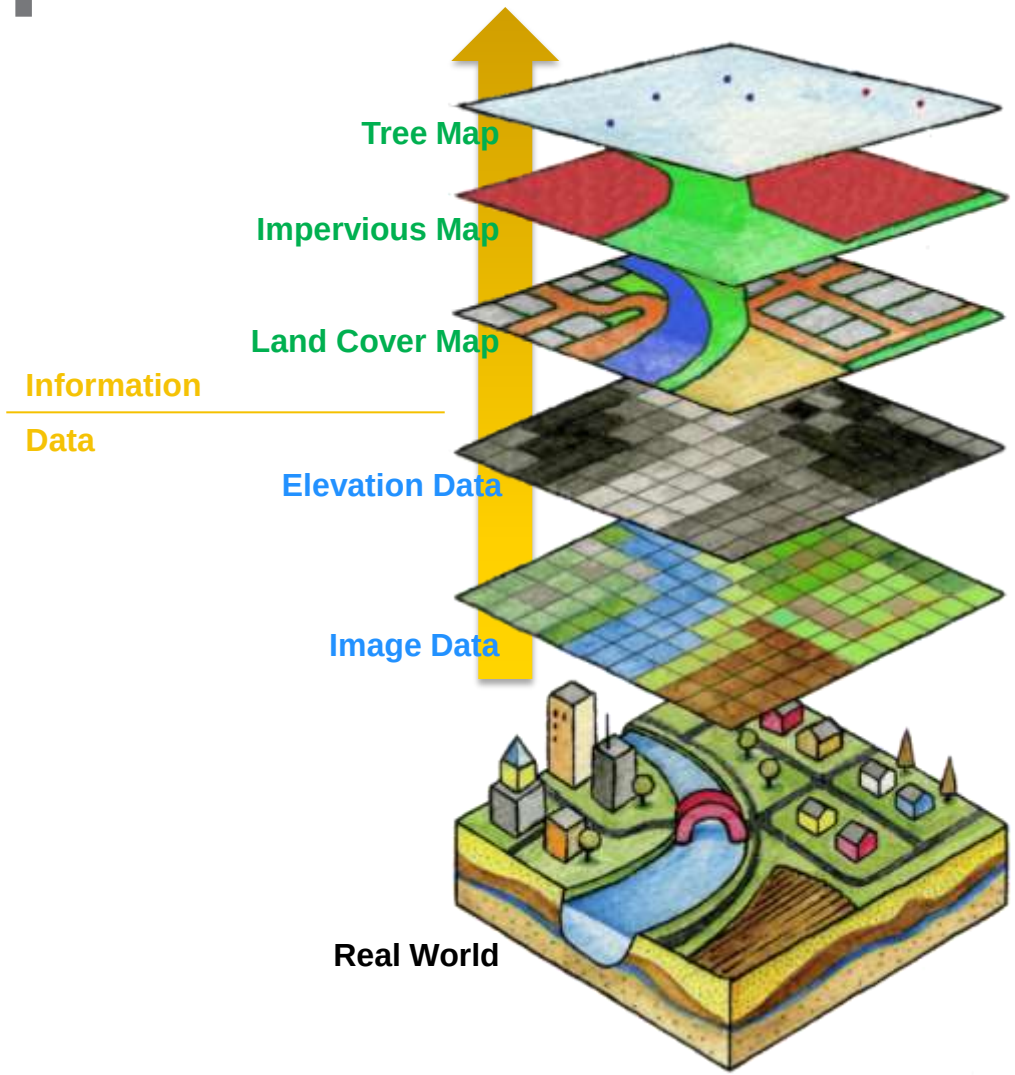




- Perfect balancing for homogeneous mosaics
- Automatic seam detection
- Adaptive blending through image texture analysis
- Interactive seam editing and color grading
- Multichannel support

# ECOGNITION
# (SUITE AND ESSENTIALS)

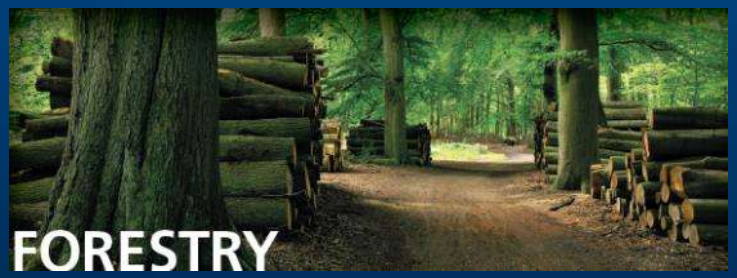
# eCognition®

- **Analysis software for geospatial applications**
- **Enables users to automate the interpretation of geospatial data**

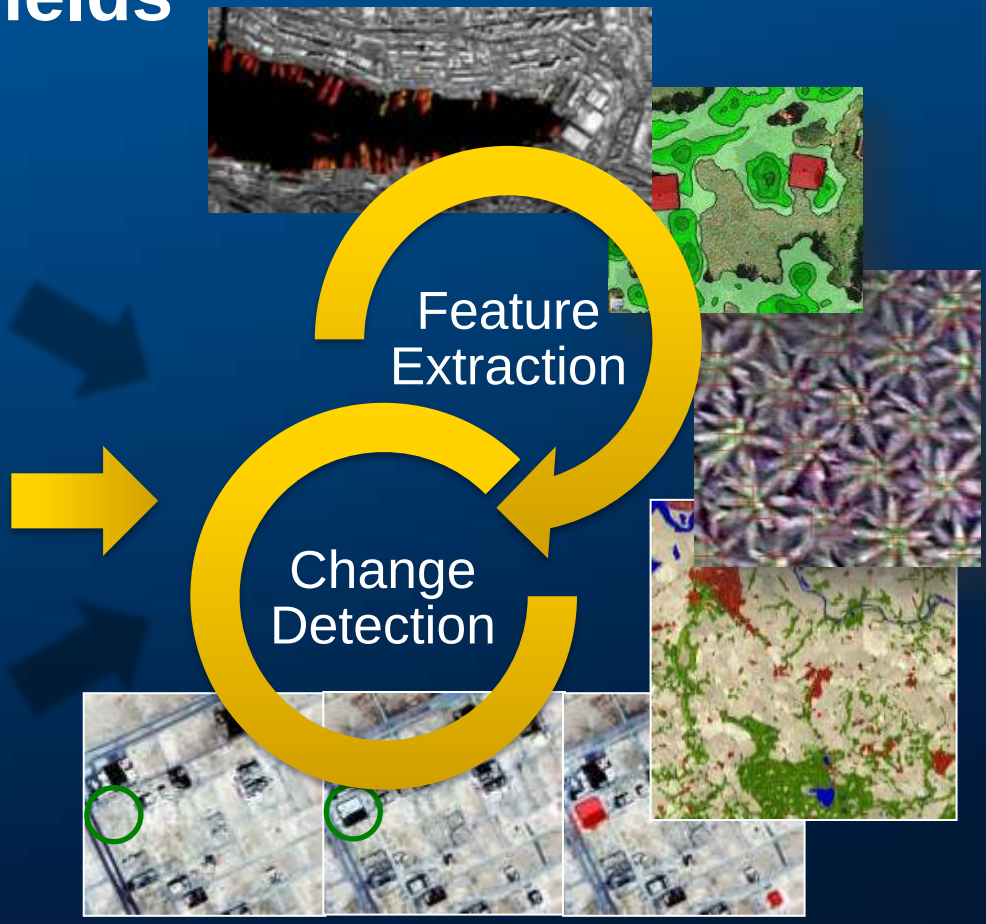


# Application Fields & Use Cases

- eCognition software offers capabilities for different application fields



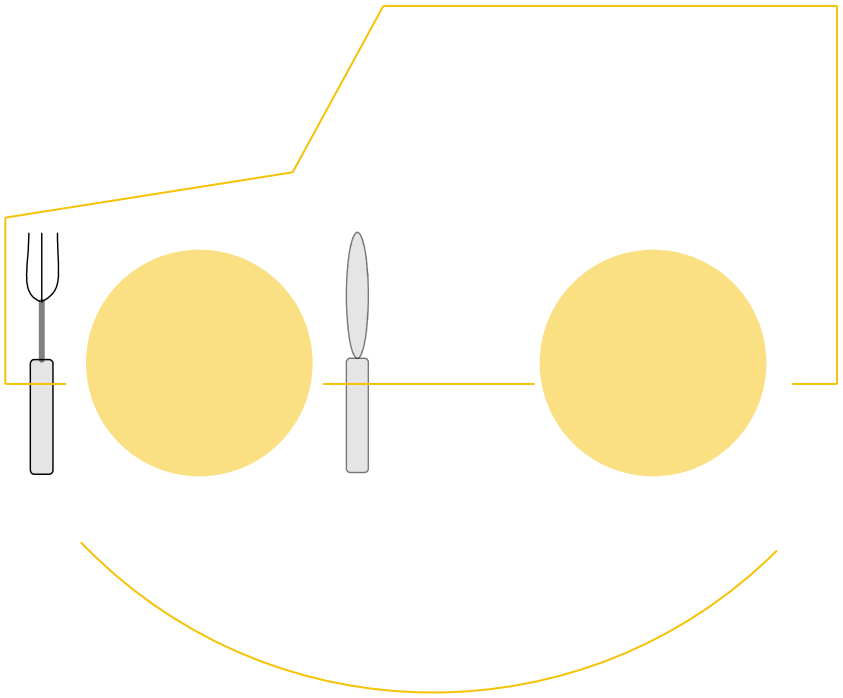
Application Fields




Use Cases

# Technology Principles

- **Object Based Image Analysis (OBIA)**
  - Examines pixels not in isolation: uses color, shape, texture and size of objects as well as their context and relationships → Better results than pixel based approaches (Emulates the human mind's cognitive power)



# eCognition Products

eCognition® Suite

Developing & Analysis Platform

→ Enables users to develop and execute solutions to transform geospatial data into geo-information

eCognition® Essentials

Out-of-the-box Application

→ Allows users at any skill level to quickly produce GIS-ready land cover information from imagery

# ECOGNITION ESSENTIALS

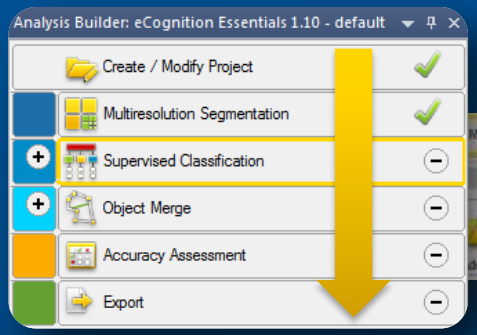
# eCognition Essentials

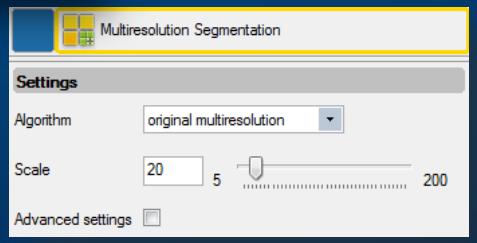
- **Powerful out-of-the-box Land Cover and Change Detection Mapping solution**
- **Enables users at any skill level to quickly produce high-quality, GIS-ready deliverables from imagery**

# eCognition Essentials

## Key Features

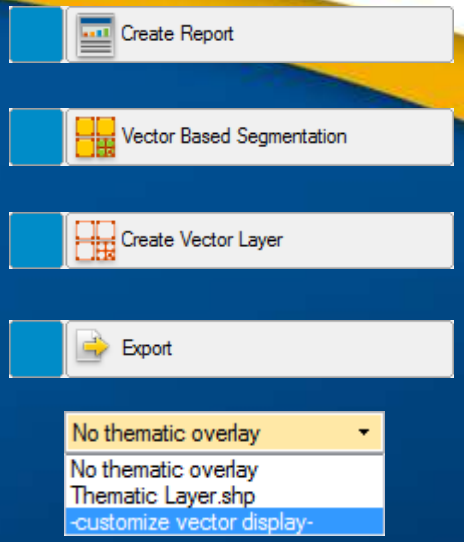
- **Efficient Mapping**
  - Intuitive and easy-to-use mapping UI
  - Covers all mapping steps so that no additional analysis tools needed
  - → Little ramp-up time
  - → Rapid discovery and easy access to geospatial data via InSphere Data Marketplace
- **Guided Analysis**
  - Predefined and structured workflow blocks streamlines the efforts of imagery-based mapping tasks
  - The available components are specifically designed for the particular purpose, and their sequence is predefined as well
  - → Reduce complexity and focuses users on their specific tasks
  - → Increase productivity by UI guidance



# Customer Benefits

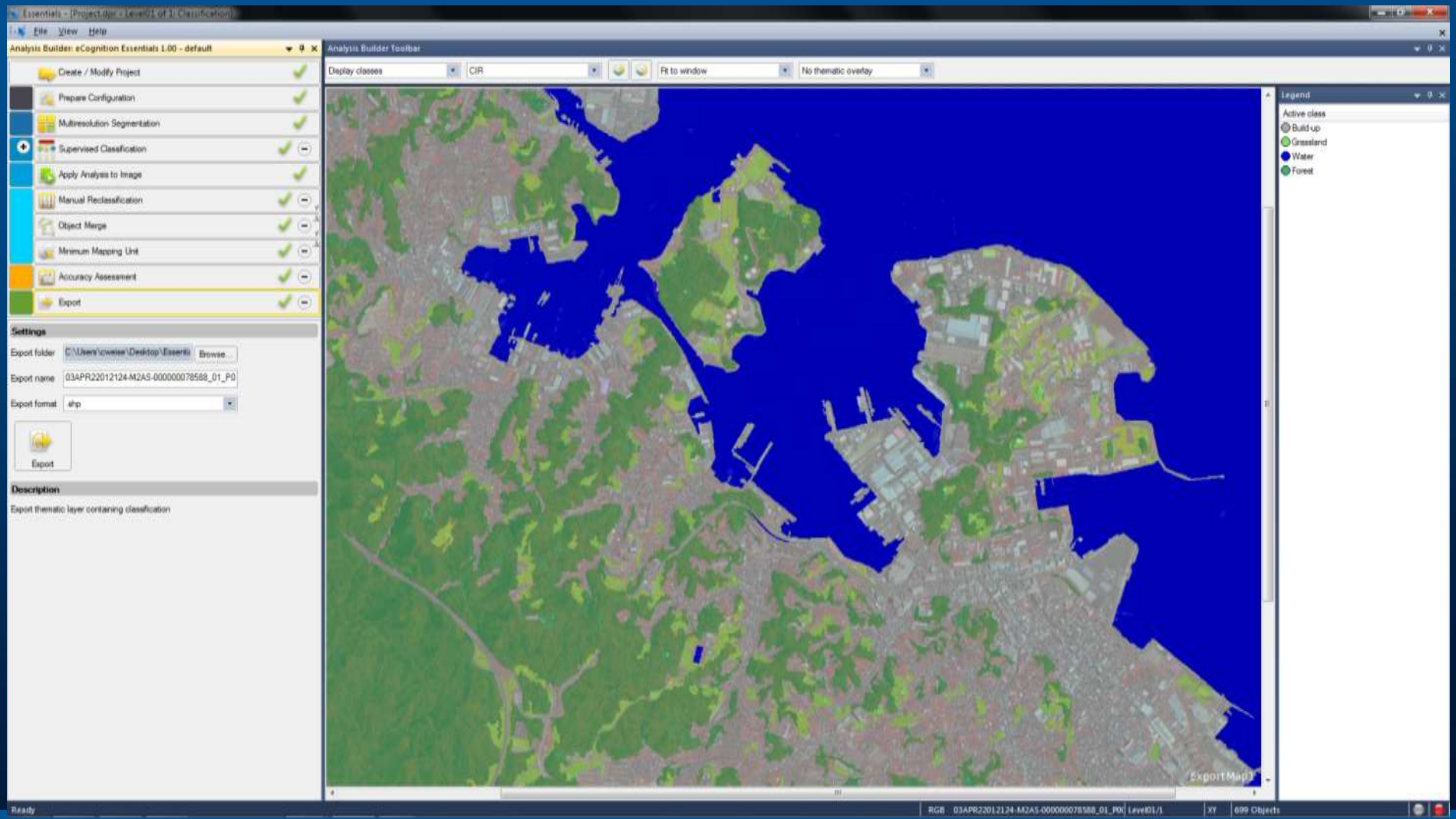
- **Low Ramp-up Time** → Intuitive graphical user interface to perform land cover mapping and change detection on imagery
- **Get work done faster** → Guided and automated workflows for effectively transforming image data into actionable intelligence
- **InSphere Data Marketplace** →Rapid discovery and easy access to geospatial data



# Use Case Examples

## Basic Land Cover Mapping

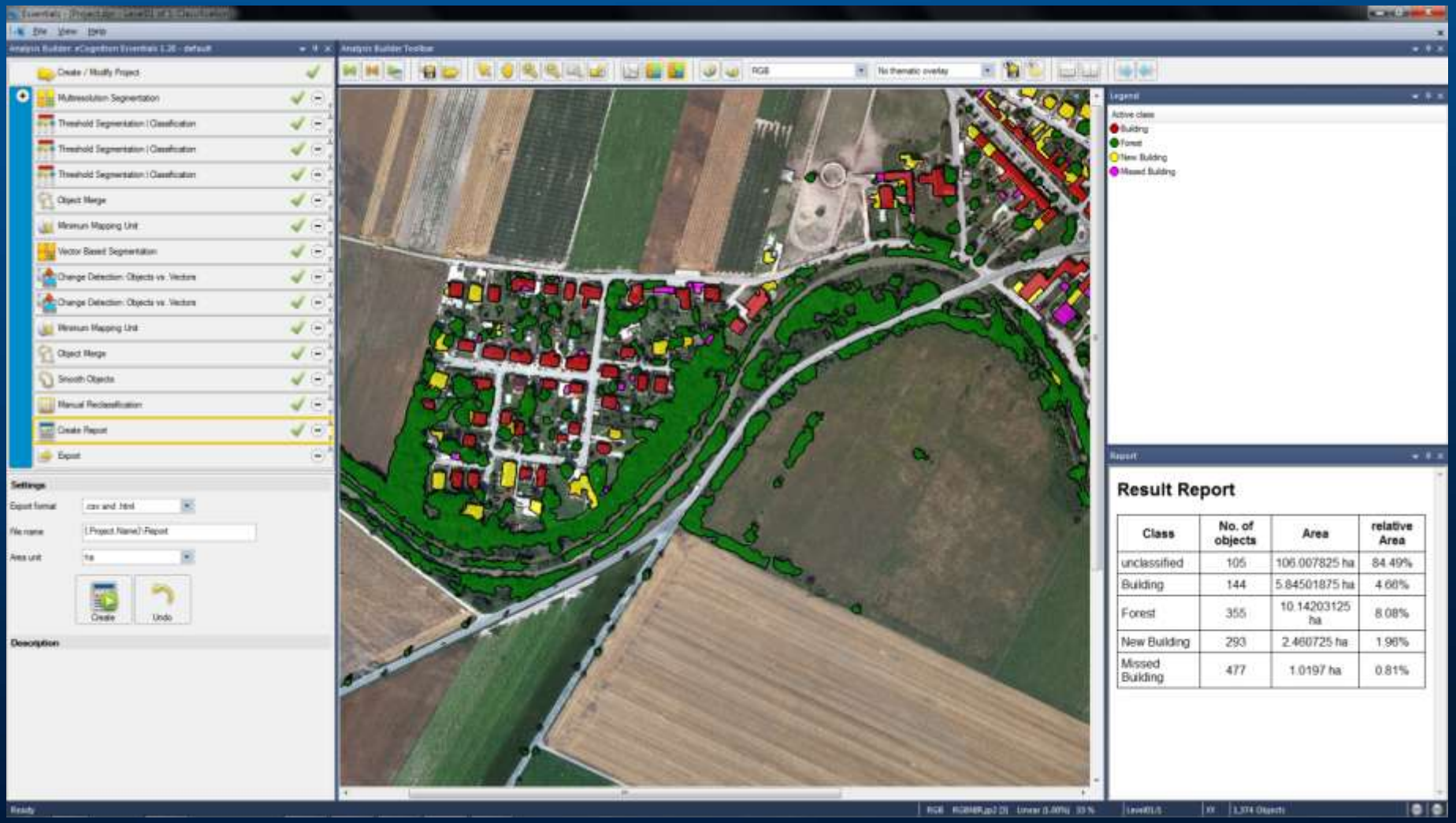
(1) Import Data (2) Create & Classify Objects (3) Edit & Check Results (4) Export Results



# Use Case Examples

## Thematic Change Detection (i.e. Buildings)

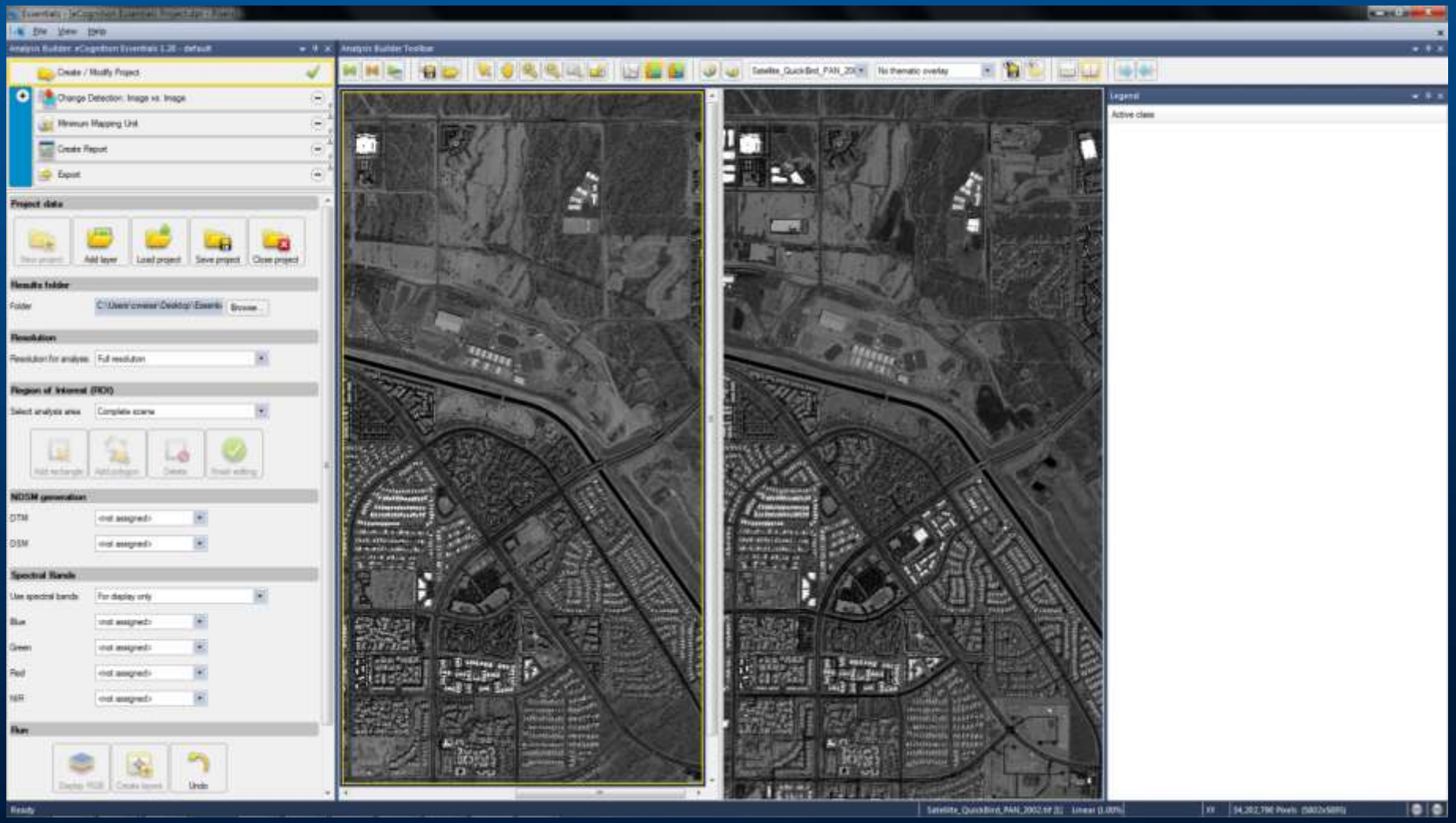
(1) Load Image and GIS layers (2) Classify Image Data (3) Compare Classification with GIS Layer (4) Export Results



# Use Case Examples

## Image Change Detection

(1) Load Images (2) Create Difference Layer(s) (3) Classify Changes (4) Export Results



# ECOGNITION SUITE

# eCognition Developer & Server

- **Advanced Analysis Software Suite available for geospatial applications**
- **Designed to improve, accelerate and automate the interpretation of geospatial data**
- **Enables users to create feature extraction or change detection solutions to transform geospatial data into geo-information**

**eCognition Developer:**
development & analysis environment for applications

**eCognition Server:**
processing environment

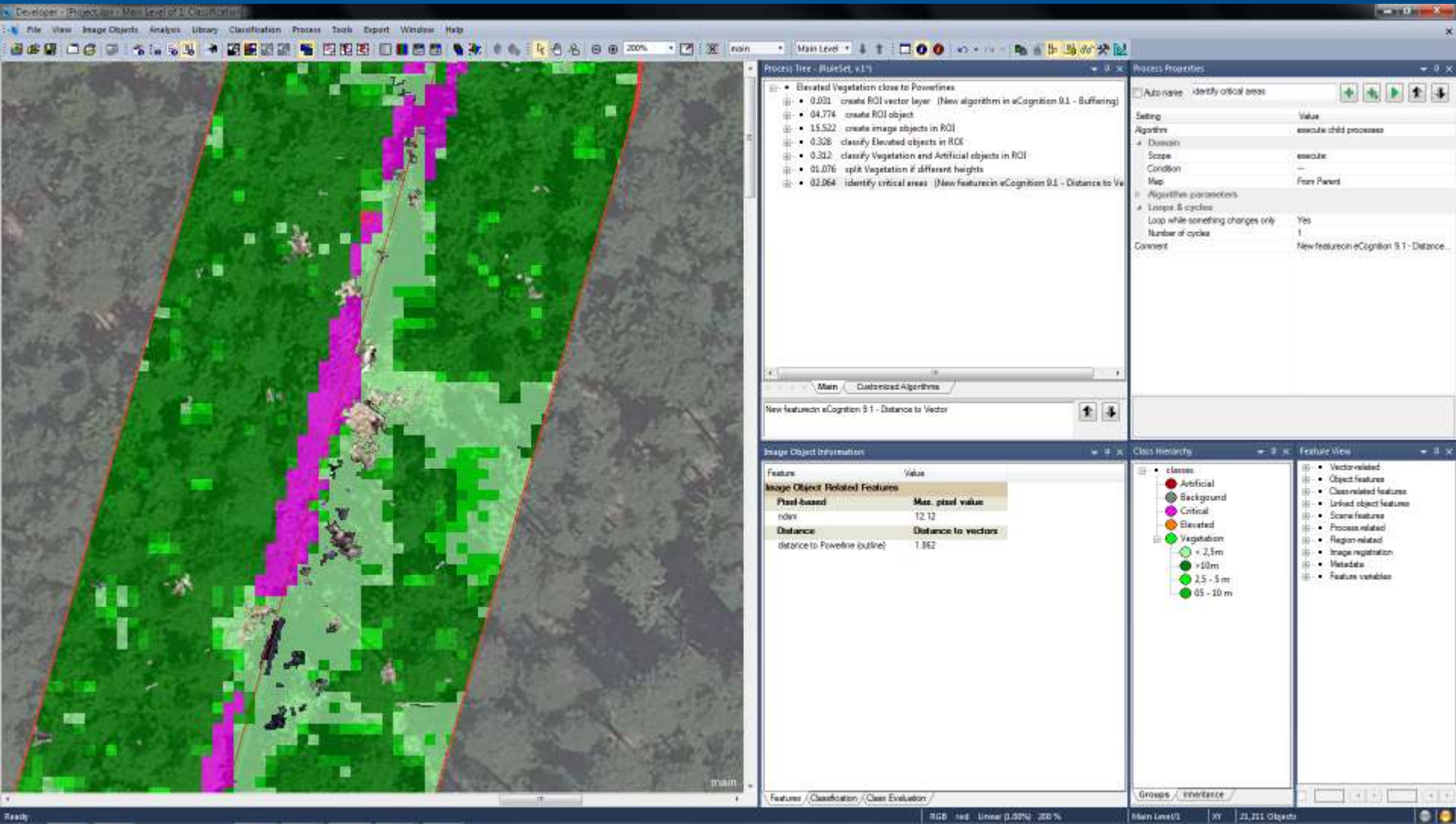
www.eCognition.com

# PROJECT EXAMPLES (RESULTS)

# Use Case Examples

## Vegetation Analysis closed to Powerlines

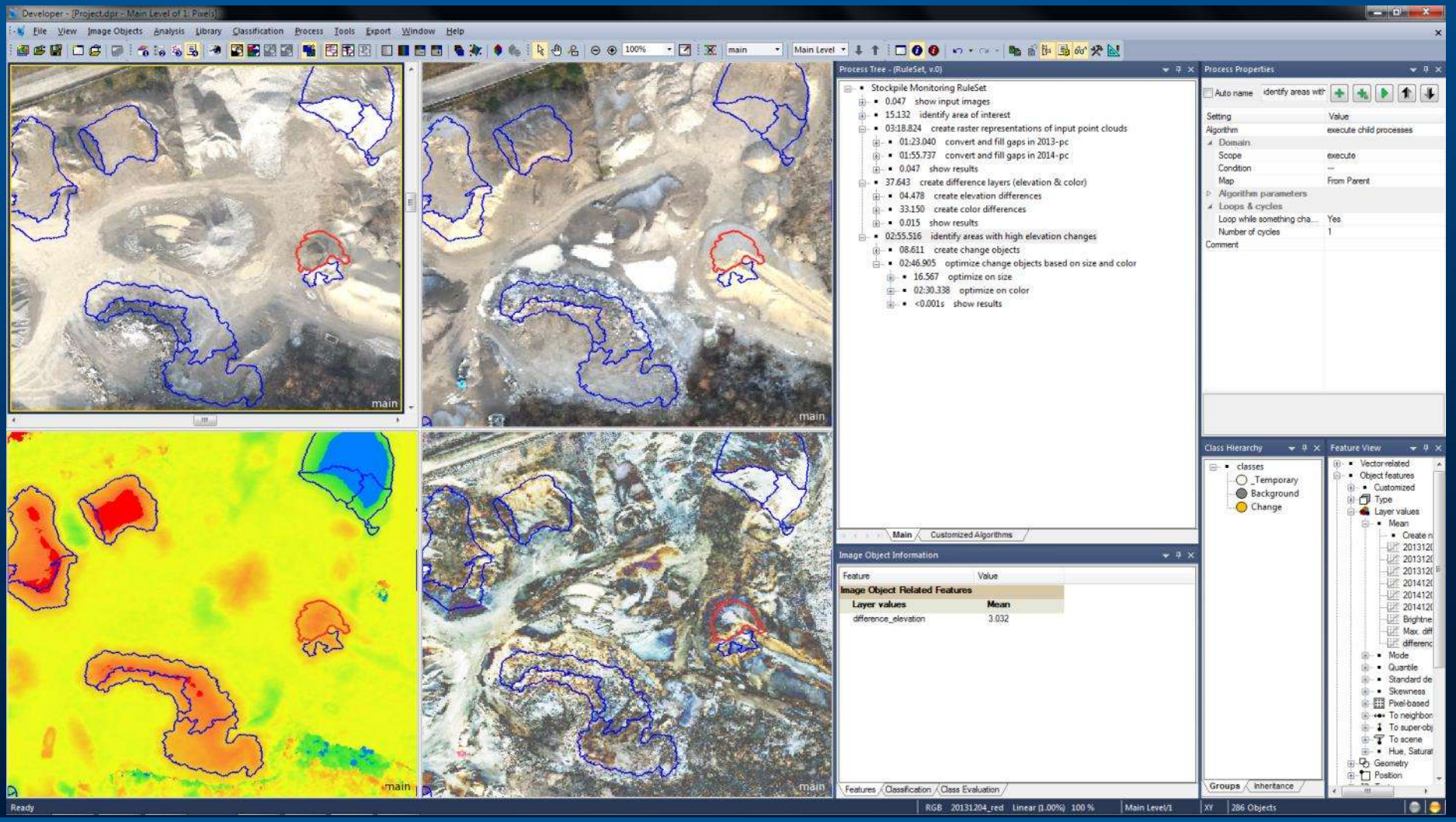
(1) Load Data (2) Buffer Powerline (3) Restrict Analysis (4) Using LiDAR (5) Using Images (6) Using Context



# Use Case Examples

## Change Detection Analysis on UAV data

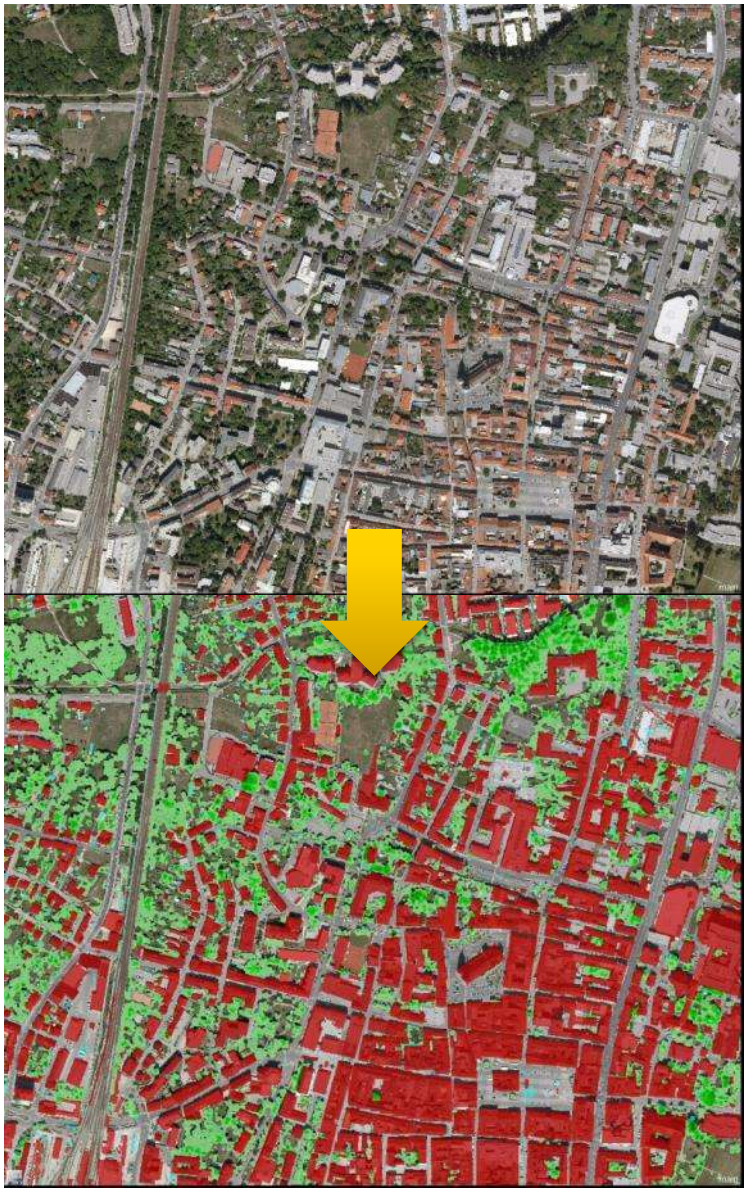
**(1) Load Project** **(2) Find ROI** **(3) Convert Point Clouds** **(4) Compute Differences** **(5) Classify Change Objects**

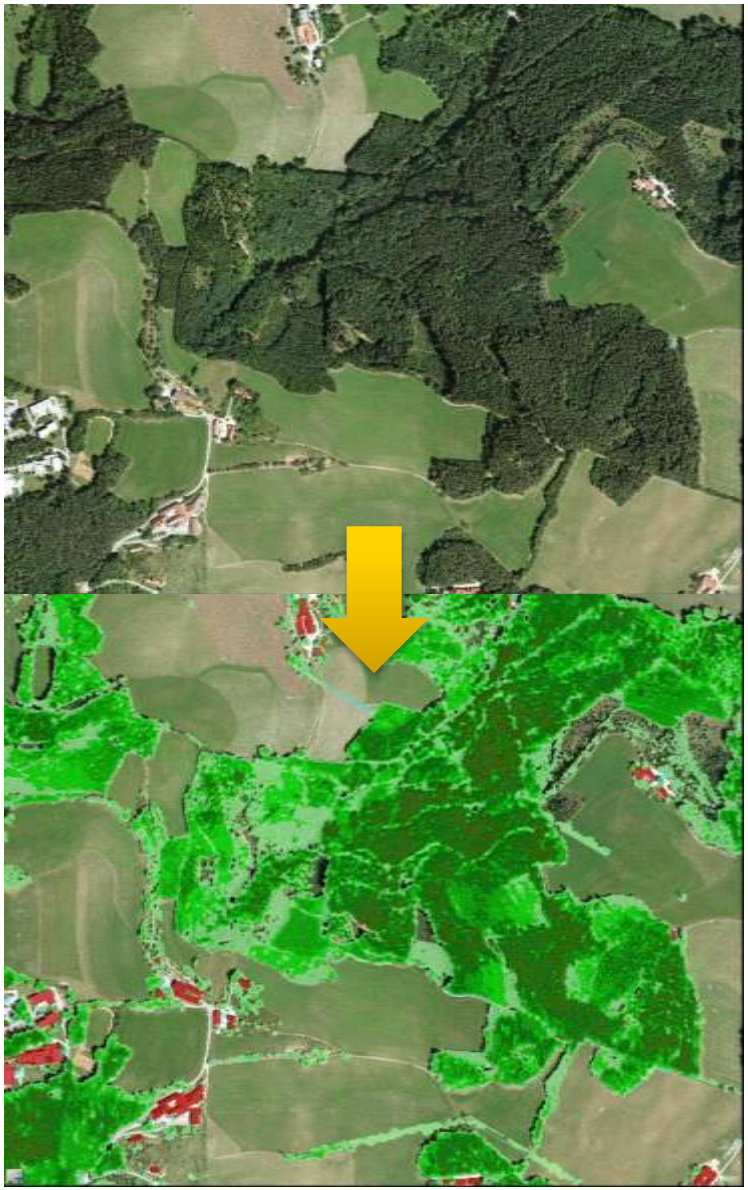


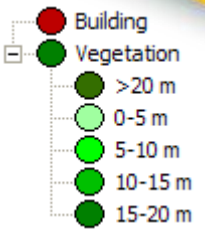
# Building & Vegetation Extraction

- **Customer**
  - The Department of Surveying and Geo Information of the State Government of Lower Austria
- **Task**
  - Automatic extraction of buildings and elevated vegetation (Urban Tree Canopy Assessment)
- **Input Data**
  - Ortho photos
    - RGB & NIR (0.15 m)
  - DSM + DTM (1 m)
- **Output**
  - Building rooftops (Shapefile)
  - Elevated vegetation in height classes (Shapefile)
  - Processed area: 20,000 km²

# Building & Vegetation Extraction

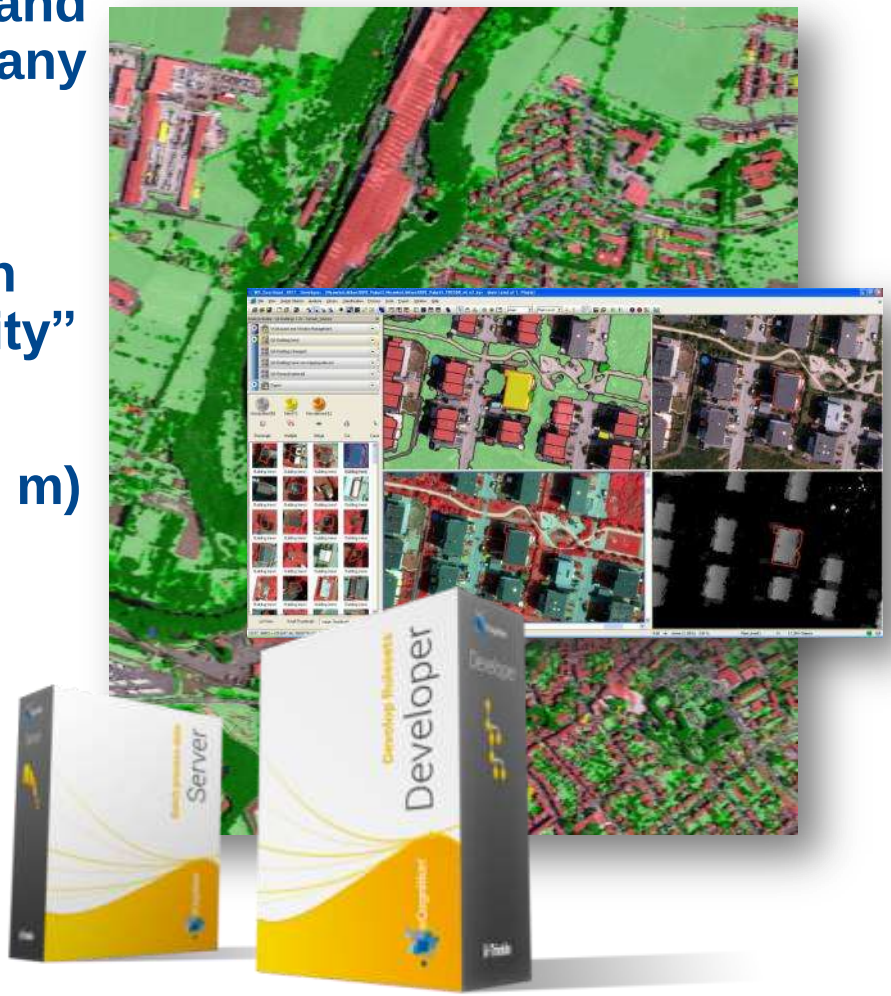






# Cadastral Change Detection

- **Customer**
  - Rhineland-Palatinate Survey and Land Register Office in Germany
- **Task**
  - Automatic detection of differences/ changes between cadastral buildings and “reality”
- **Input Data**
  - Ortho photos (RGB + NIR, 0.2 m)
  - DSM + DTM (1 m)
  - Building outlines
- **Output**
  - New buildings (Shapefile)
  - Disappeared buildings (Shapefile)



# Cadastral Change Detection

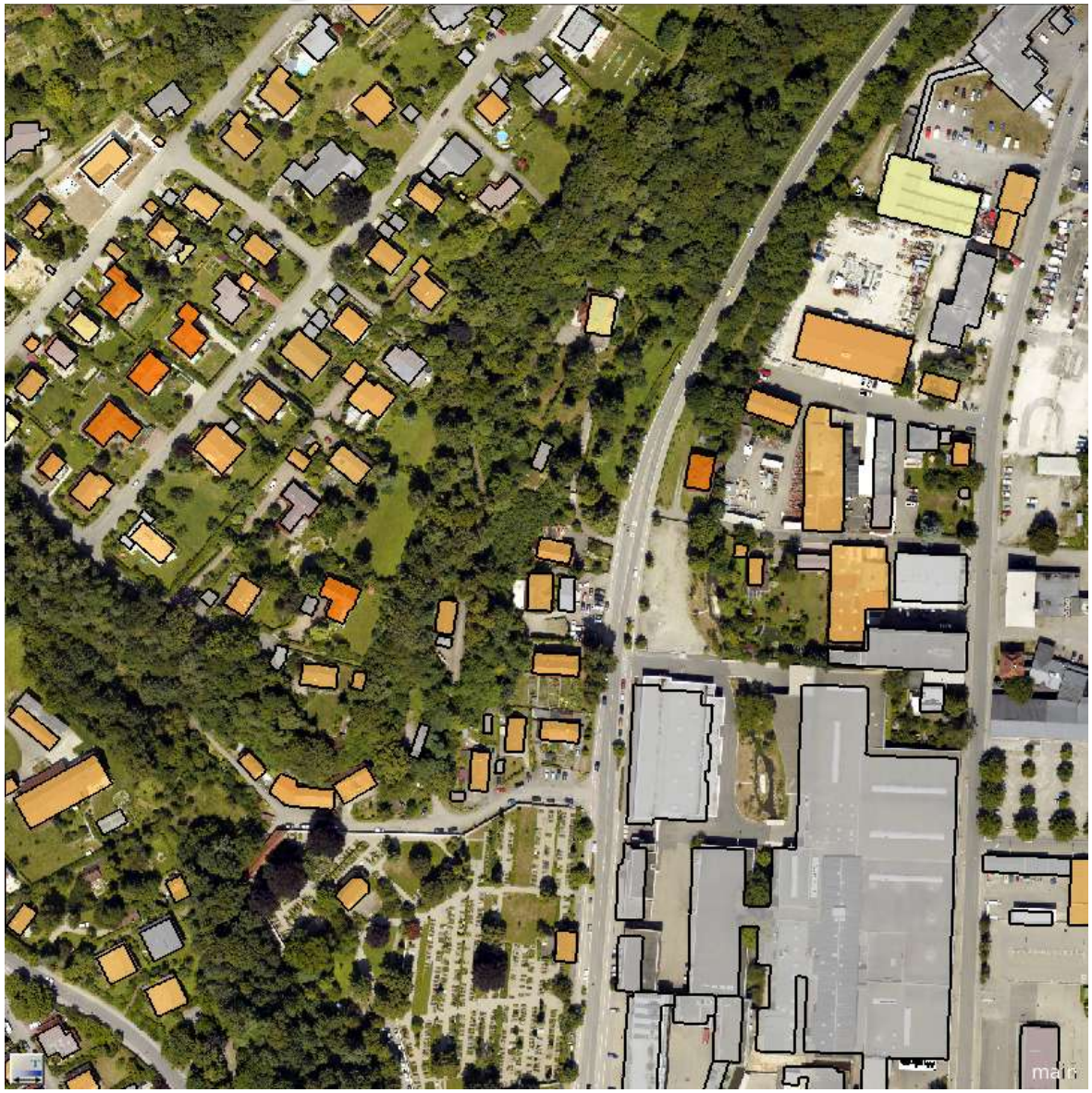
## Change Detection

- classes
  - Building
    - Building (changed)
    - Building (new)
    - Building (unchanged)
  - Vegetation
    - Forest
    - Low Vegetation
    - Shrubs

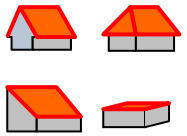
# Roof Type Extraction

- **Customer**
  - NBB – Utility Network Operator Berlin, Germany
- **Task**
  - Automatic generation of a roof type map
- **Data**
  - RGB & NIR Images (0.20 m)
  - LiDAR (> 4 pts/m²)
- **Output**
  - Roof types
  - Roof part suitability (slope, orientation)
  - 469 ha

# Roof Type Extraction



- classes
  - Building Roof Subarea Direction
    - East
    - Flat
    - North
    - South
    - West
  - Building Roof Type
    - Flat Roof
    - Gable Roof (2 sloping sides)
    - Hip Roof (>= 4 sloping sides)
    - Pitched Roof (1 sloping side)

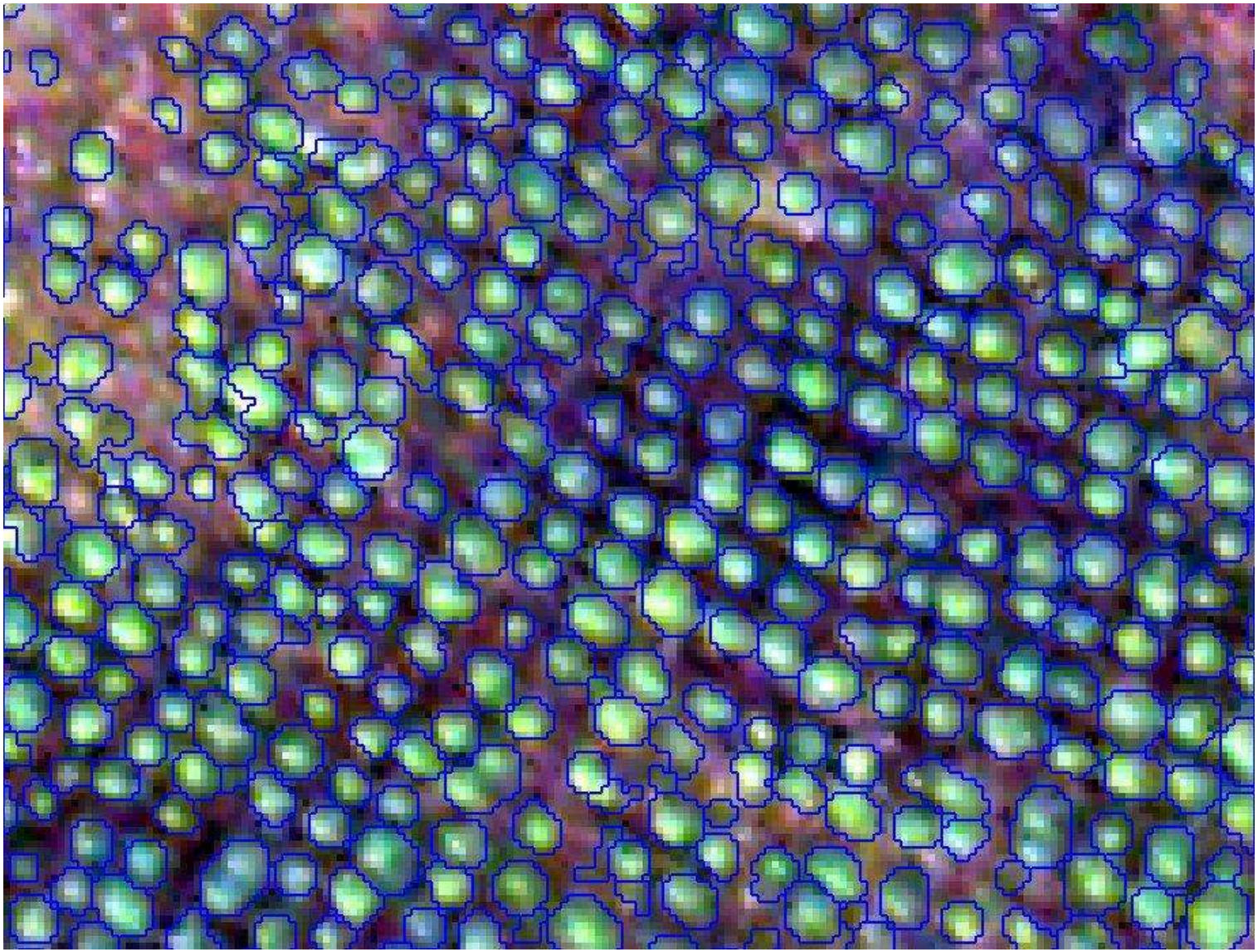


# Counting of Tree Crowns

- Customer
  - Forestry Commission, Great Britain
- Task
  - Automatic counting of tree crowns
- Input Data
  - RGB (0.2 m)
- Output
  - Tree center (Shapefile)
  - Single tree attributes
    - Diameter
    - Area
    - Perimeter
    - Width, Length

Forestry Commission

# Counting of Tree Crowns

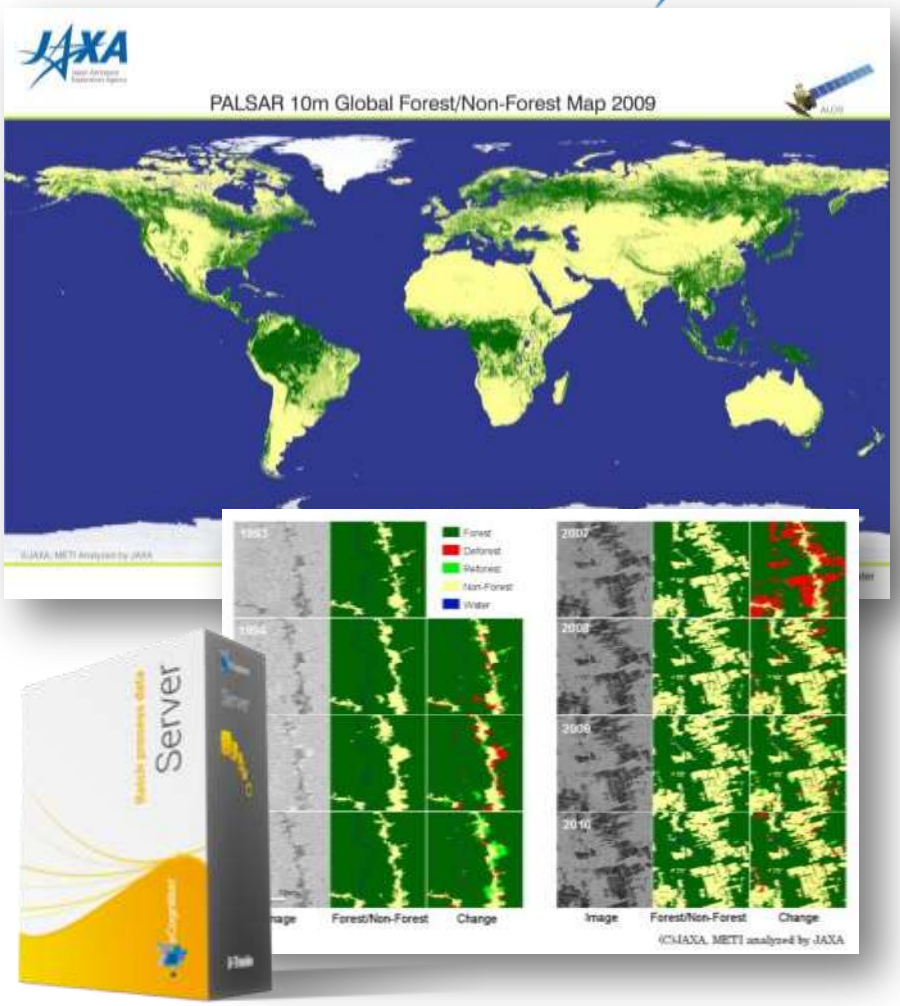


Forestry Commission

# Global Forest Map

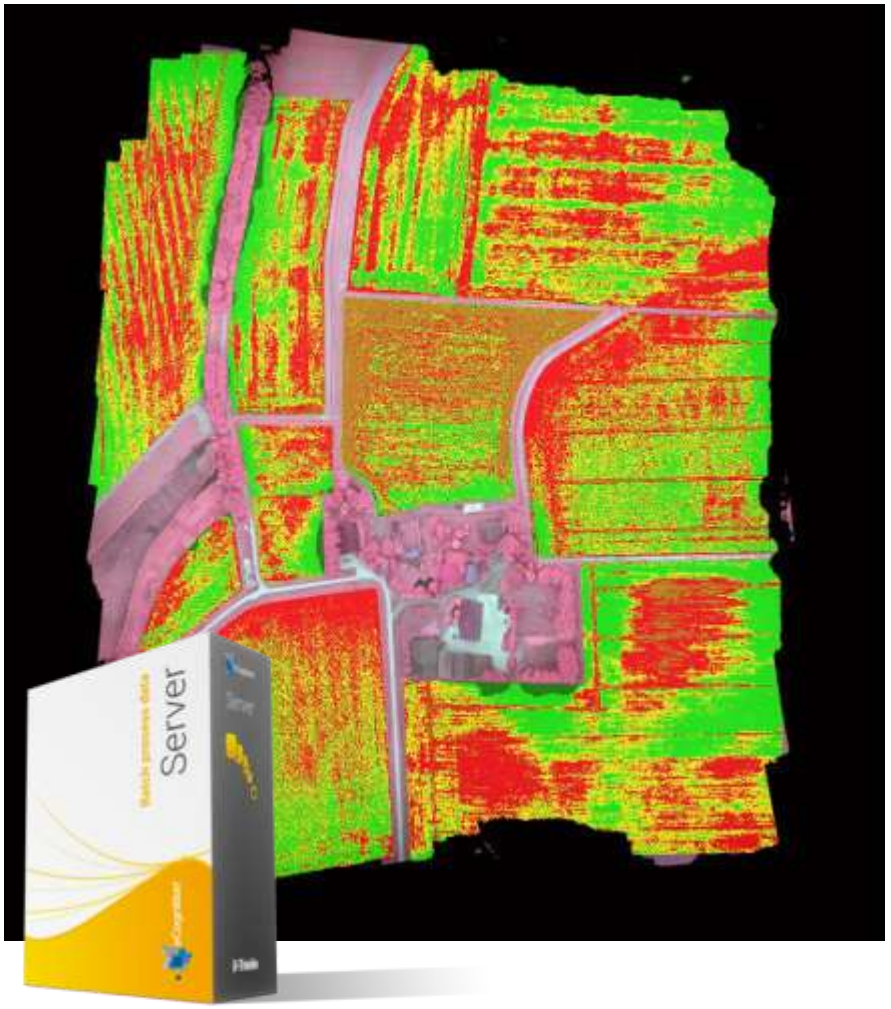
- **Customer**
  - Japan Aerospace Exploration Agency (JAXA)
- **Task**
  - Automatic forest/non-forest classification
- **Data**
  - ALOS PALSAR (L-band, 10 m)
- **Output**
  - Forest (Raster Map)
  - Non-Forest (Raster Map)

- **Customer Outcome**
  - World wide forest map of 2009 (86,000 scenes covering the globe)
  - Forest carbon tracking to monitor increases and decreases in forested area around the world
  - Monitor forest mass to prevent deforestation



# Vegetation Vitality Mapping

- Task
  - Automatic vegetation/non-vegetation classification
  - Automatic extraction of 3 vitality/productivity classes per field
- Input Data
  - Trimble UX5
    - Orthophoto mosaic (CIR)
    - DSM
- Output
  - Vegetation Density Map
  - Vitality/Productivity Map



# ONE TRIMBLE!

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# THANK YOU