



transforming the way the world works

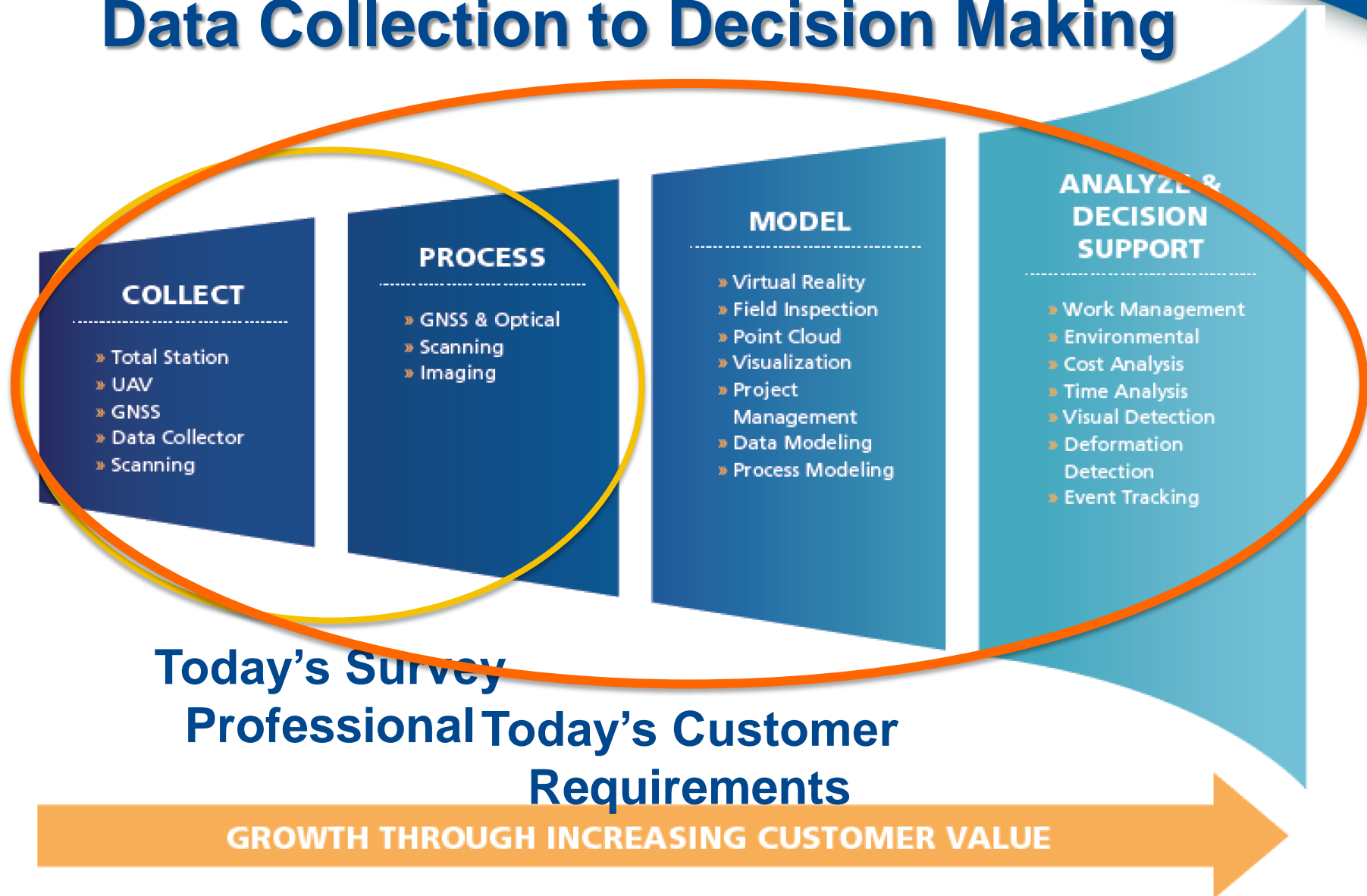


Merging Geospatial Technologies to Improve the Bottom Line

John Whitehead

Trimble Navigation Limited

Trimble: Data Collection to Decision Making



This talk will explore how the mergers of geospatial technologies provide practical, efficient solutions for today's surveyor while holding the potential to dramatically improve the bottom line.

Key Drivers of Change

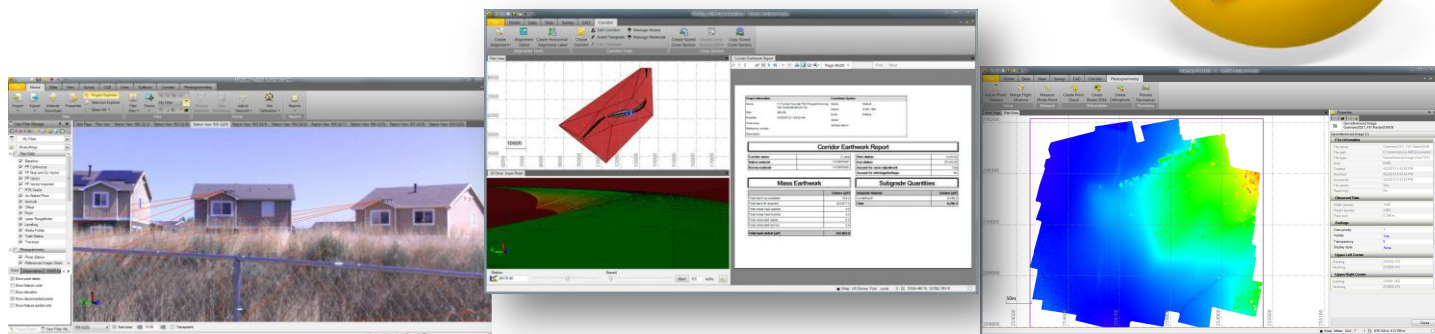
- **Customers are demanding more from their geospatial data**
- **Data Collection Solutions are rapidly changing and improving efficiency**
- **Survey Professionals are searching for ways to provide more value to their customers at multiple levels**
 - **One organization, multiple departments**
 - **One project, multiple organizations**
 - **Present and future value of collected data**



Trimble UX5 Aerial Imaging Rover



Trimble Business Center



Trimble V10 Imaging Rover

Both the V10 and UX5 combine photogrammetry principles with survey and mapping data collection workflows.....

So what can surveyors get from pictures?

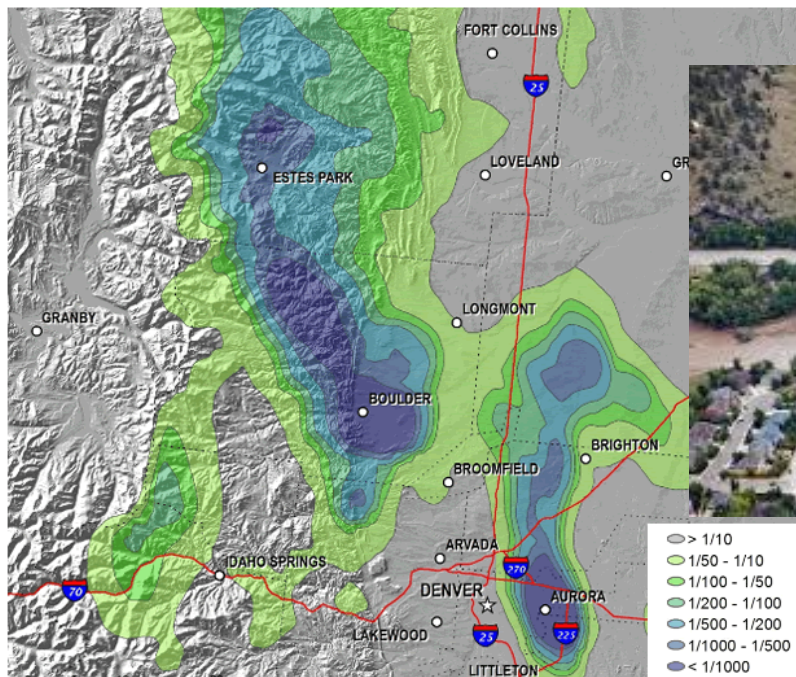
Colorado Floods

Colorado's exceedingly rare flood in 3 maps

By Jason Samenow, Published: September 19 at 1:56 pm [E-mail the writer](#)

New visuals from the National Oceanic and Atmospheric Administration reveal the exceptional nature of rainfall that flooded parts of 17 counties in Colorado last week.

The map below – as an example – shows the likelihood of the maximum 24-hour rainfall totals (in any given year) that occurred along the Colorado Front Range between September 9 and 16.



Annual exceedance probabilities for the worst case 24-hour rainfall. (NOAA)

Rain slows rescue efforts amid deadly Colorado floods

Join the conversation
CNN iReport

By David Simpson, Nick Valencia and Emma Lacey-Bordeaux, CNN
updated 12:33 AM EDT, Mon September 16, 2013

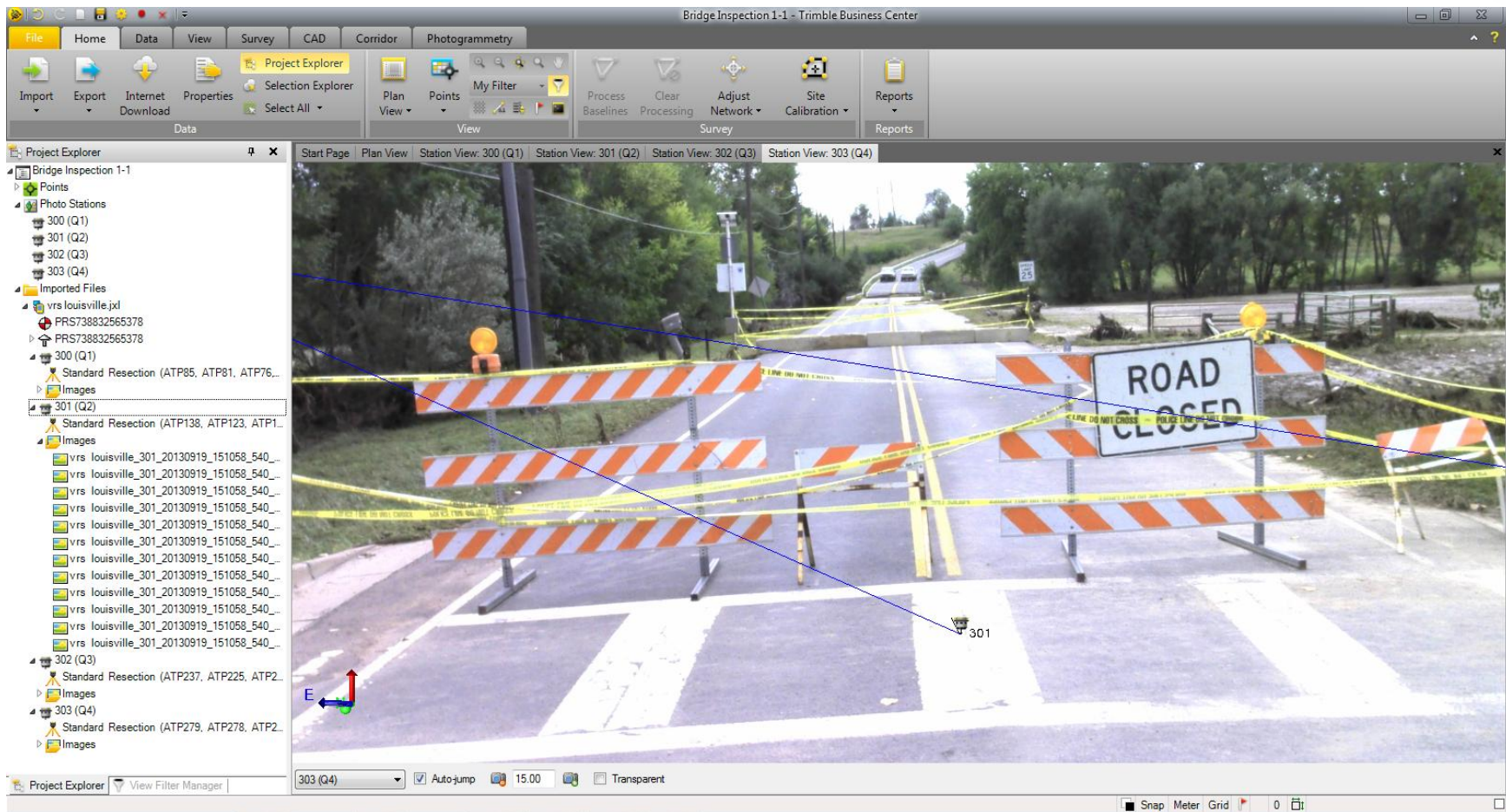


Railroad tracks washed from their path by floodwaters are seen in Longmont on Thursday, September 12. Massive flooding has left people dead and thousands of homes in state.

HIDE CAPTION

17 18 19 20 > >>





Positions from Pictures

The screenshot displays the Trimble Business Center software interface for a project named "Bridge Flood". The main window shows a 3D view of a bridge structure with various points and surfaces. The Project Explorer on the left lists the following items:

- Bridge Flood
 - Points
 - Surfaces
 - Break
 - Photo Stations
 - 400 (Q5)
 - 400-Middle 1 (P577)
 - 400-Middle 2 (P580)
 - 400-Middle 3 (P581)
 - 400-Top 1 (P584)
 - 400-Top 2 (P586)
 - 400-Top 3 (P588)
 - 400-Bottom 1 (P595)
 - 400-Bottom 2 (P599)
 - 400-Beam 1 (P602)
 - 400-Beam 2 (P605)
 - 400-Beam 3 (P606)
 - 400-Beam 4 (P611)
 - 400-Beam 5 (P614)
 - 400-Beam 6 (P615)
 - 400-Beam 7 (P620)
 - 400-Beam 8 (P621)
 - 400-Break 1 (P625)
 - 400-Break 2 (P629)
 - 400-Break 3 (P632)
 - 400-Break 4 (P634)
 - 400-Break 5 (P636)
 - 400-Break 6 (P640)
 - 400-Break 7 (P646)

The main view shows a bridge with several points labeled with ATP and elevation values. A 3D model of the bridge structure is shown below the main view, illustrating the bridge's support structure.

The Technology....

Product Vision Statement

The Trimble V10 Imaging Rover is an integrated camera system that precisely captures 360° digital panoramas used to visually document and measure the surrounding environment.



Trimble V10 – *Positions from Pictures*

Positioning Sensor

- Integrates seamlessly with R10 GNSS receiver and S-Series total station positioning sensors.
- Panoramas may also be captured standalone pre- or post- survey of occupied points



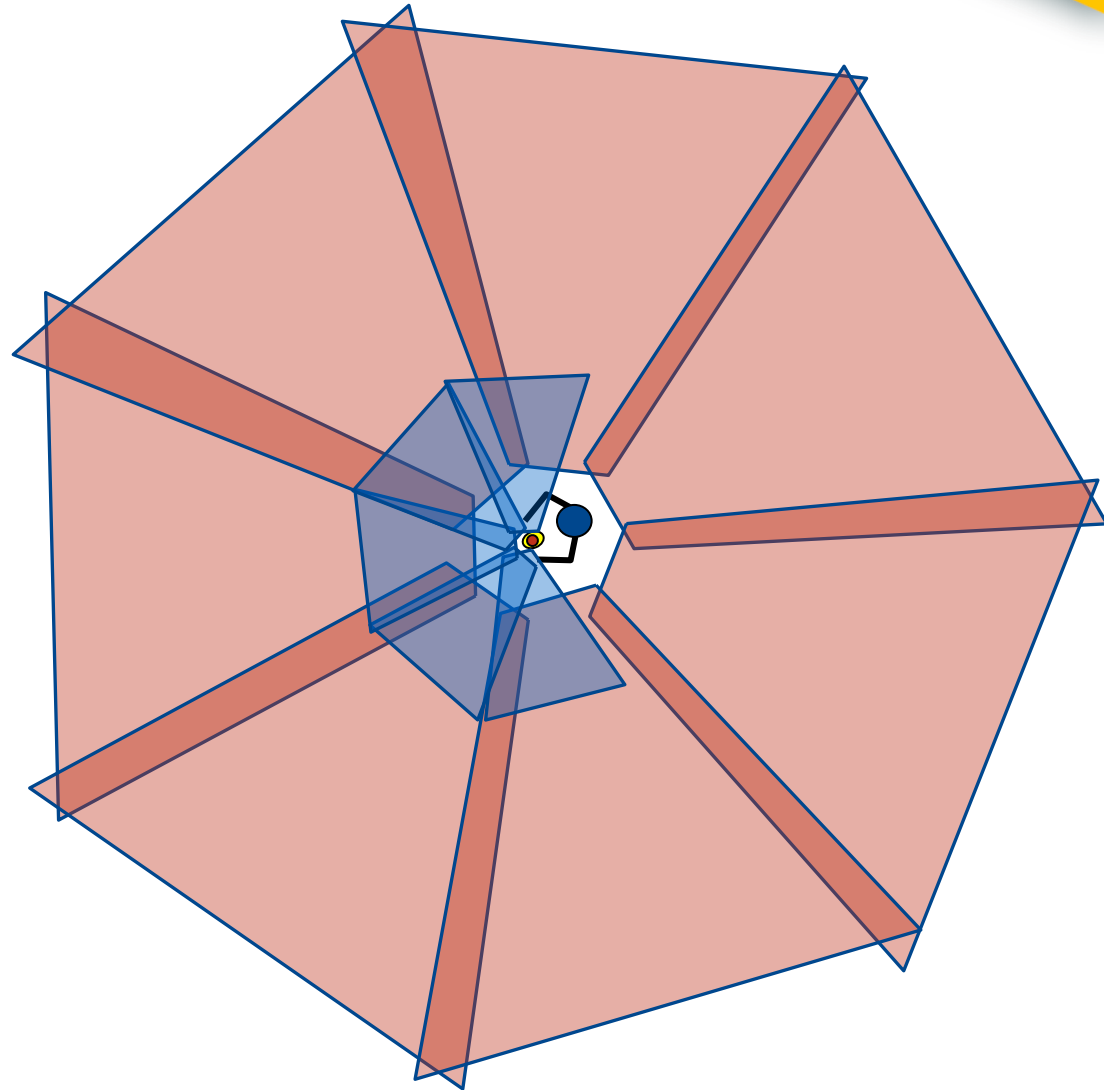
Camera System

- 12 calibrated cameras
- 60 Megapixel 360° panorama
- Sequential image capture
- Tilt sensors
- Magnetic compass
- Gyrometers and accelerometers
- On-board data storage
- USB communications
- 2m pole drop tested
- IP 54 environmentally protected

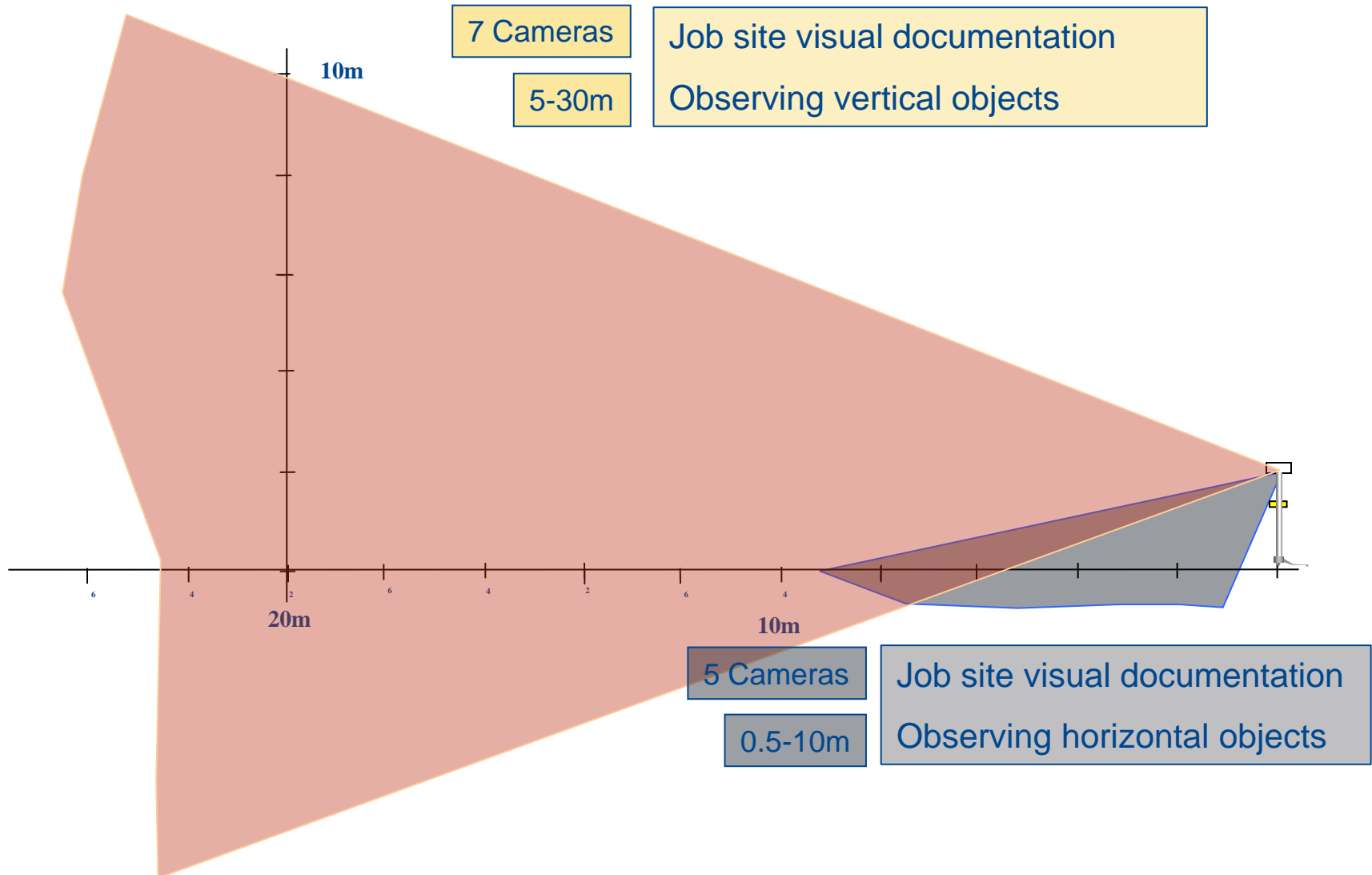


Camera System

- 7 panoramic cameras
- 5 downward-looking cameras



Camera System

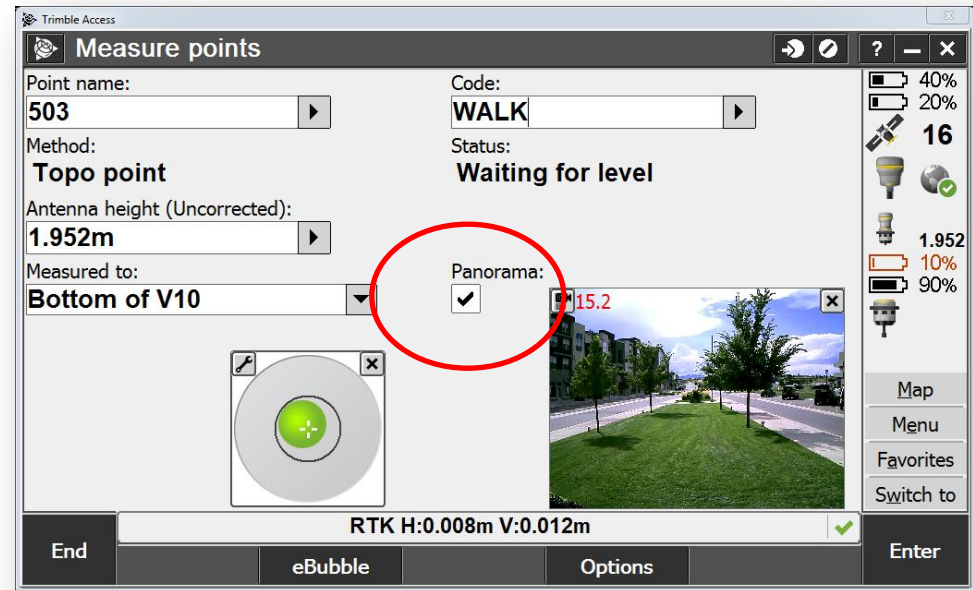


Field Software



Trimble Access

1. Streaming video
2. Capture and store panoramas simultaneously with points or standalone
3. Review thumb-nail images
4. Review Panoramas

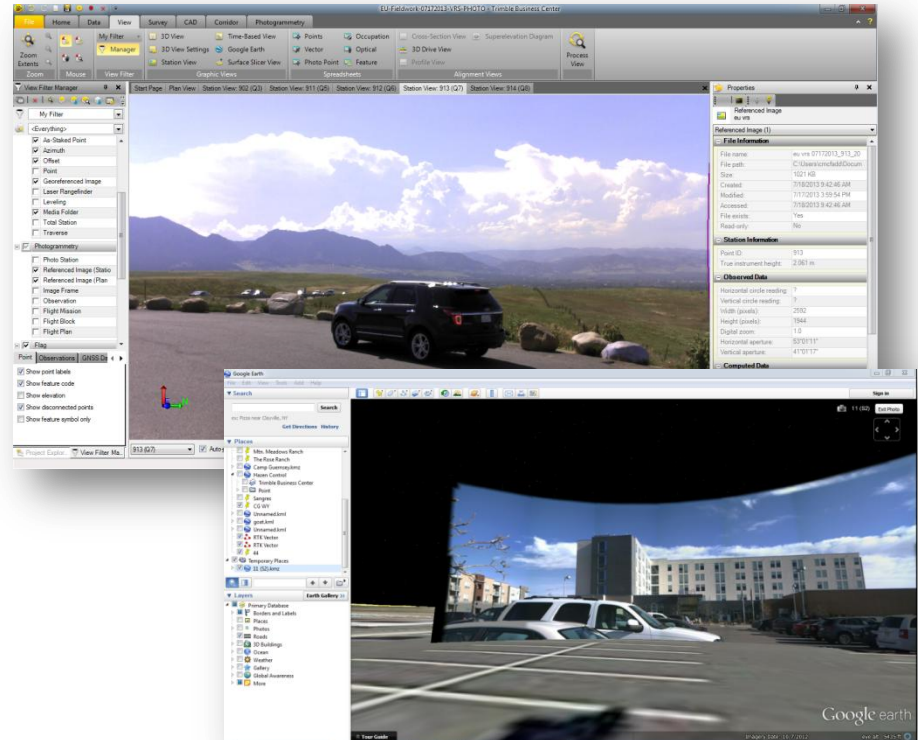


Office Software



Trimble Business Center

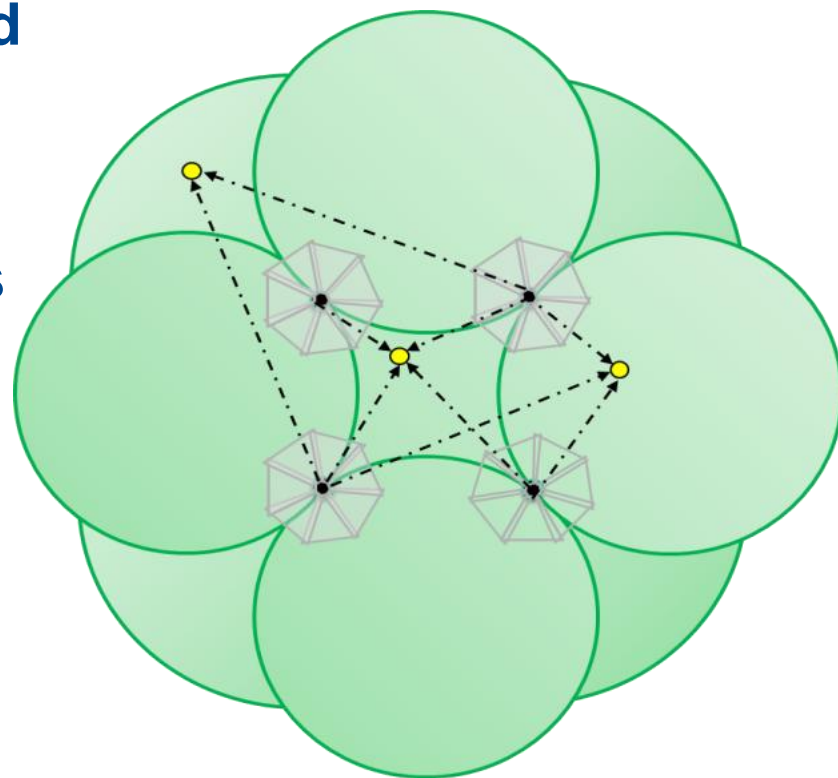
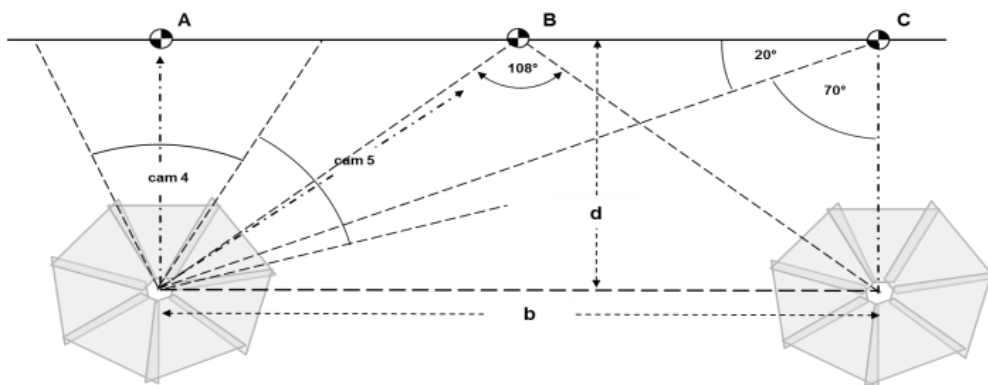
1. Network adjustment of panoramas
2. Measure photo points
3. Panoramic review with data overlay
4. Export panoramas (jpeg, html, kmz)
5. Export deliverables (CAD, GIS)



How Does It Work?

How do I get Positions from Pictures?

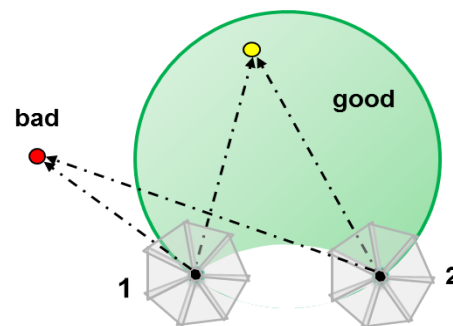
- Capture panoramas in the field using Trimble Access
- Process the data in Trimble Business Center
- Measure objects in the photos in TBC to create positions
- Prepare deliverables in TBC from the positions



How Accurate is it?

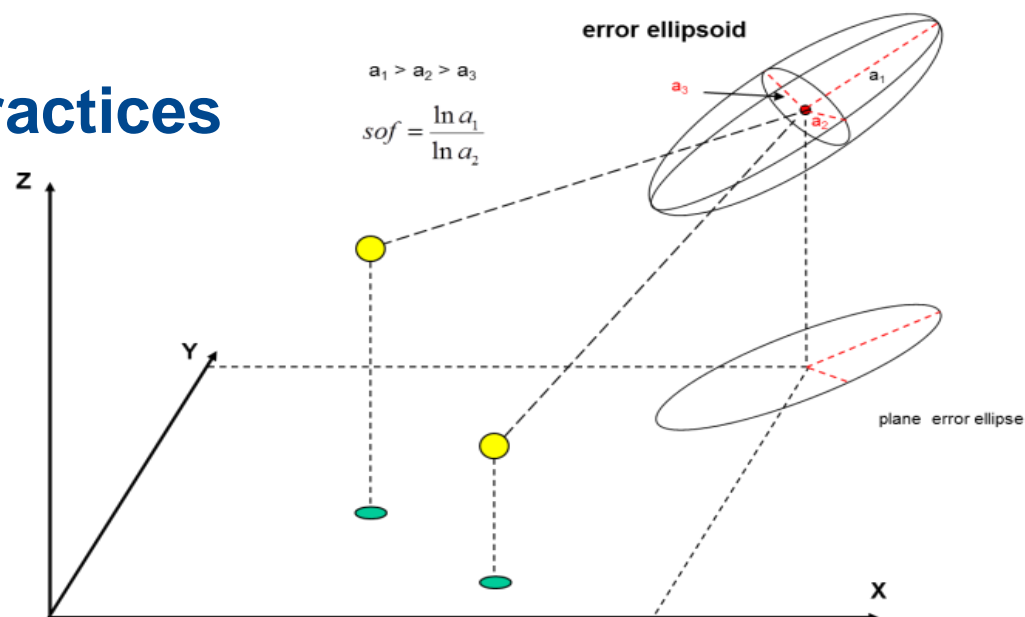
How accurate are the positions produced by the system?

- **1 Centimeter sample distance @ 10 meters from object with good network geometry (2cm @ 20m, 3cm @ 30m)**



- **Dependent of field practices**

- Distance to object of interest
- Distance between stations
- Site geometry



Old Design Survey Workflow

Capture points in the field

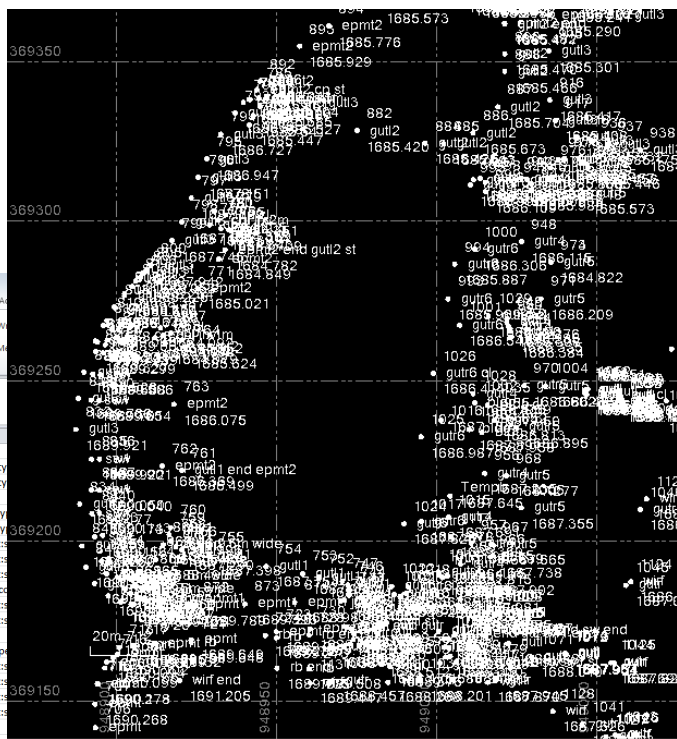
Download CSV file

Import to CAD

Connect the dots

Publish 2D+ Paper

A	B	C	D	E
Jobrtd topo	Version:12.40	Units:Metres		
1	36795.216	948984.155	1680.26	disk
2	369123.462	948831.23	1694.016	disk
3	369151.988	948910.316	1692.218	naill
4	369155.363	949005.57	1686.323	naill
5	369173.234	948993.425	1688.387	naill
6	369156.877	948895.396	1689.728	empt
7	369106.917	948896.102	1689.732	empt
8	369119.592	948895.101	1689.988	empt
9	369141.699	948896.101	1689.932	cmh
10	369141.697	948893.316	1690.259	empt
11	369149.048	948893.194	1690.268	empt
12	369149.063	948895.975	1690.203	lp
13	369146.909	948894.306	1690.209	sp
14	369155.376	948895.92	1690.274	empt
15	369162.194	948896.931	1690.165	empt
16	369164.646	948900.184	1690.102	empt
17	369166.73	948900.841	1690.06	empt
18	369155.277	948894.238	1690.178	rb
19	369160.339	948896.202	1690.1	rb
20	369163.519	948898.879	1690.095	rb
21	369166.873	948905.379	1689.89	rb
22	369167.475	948905.338	1689.996	empt
23	369166.587	948906.738	1690.005	sp
24	369167.955	948911.792	1689.791	empt
25	369168.318	948923.306	1689.648	rb
26	369169.165	948923.289	1689.649	empt
27	369171.634	948949.88	1689.204	empt
28	369170.482	948946.445	1689.238	rb
29	369169.771	948949.92	1689.273	rb



8/6/12 6011 DIA DRW WEST & SOUTH
 BASE @ 788 HI = 605
 CHECK # 5413 STORED @ 6010

STORE	DESE
6011	→ 6080 GND
100971	→ 100974 EOC2
100975	→ 100976 SIGN
100977	→ 100978 E ELECTRIC CAN
100979	→ 100980 SIGN
100981	→ 100984 EOC
100985	→ 100999 (N) RIM LIGHT
101000	(W) RIM LIGHT CUNABLE TO SELECT A RIM
101001-101010	E LIGHT (RUNWAY/FLUSH)
101011-101019	RIM (N) LIGHTS
101020-101125	E LIGHTS (RUNWAY/FLUSH)
101176-101190	RIM (N) LIGHTS
101191	RIM (W) LIGHTS
101192-101284	RIM (N) LIGHTS (END OF RUNWAY)
101285-101289	GND
101290-101299	GB
101300-101303	COR INLET
101304	E INLET (924 BOTTOM OF BOX)
101308-101323	GB 2
101323-101344	GB 3
101356-101367	WAL (TOP EDGE HEADWAL)
101368	PIPE 30" RCP (M)
101369	CHK 5360

Trimble V10 Design Survey Workflow

Mission planning

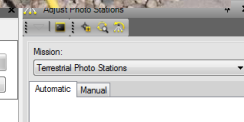
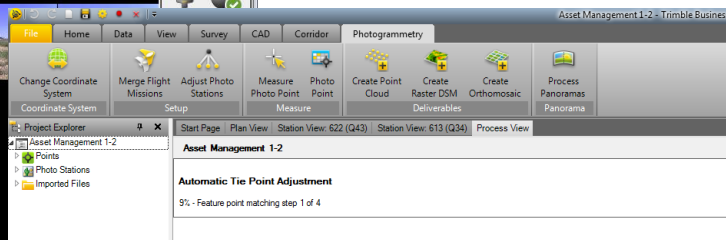
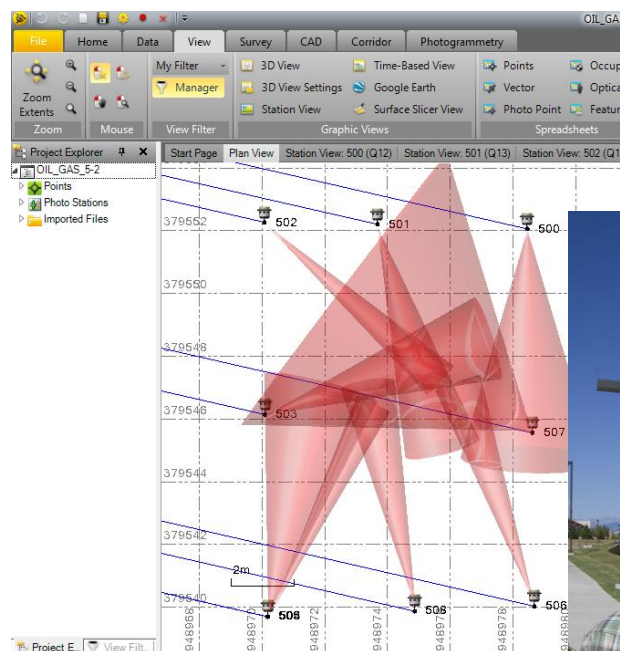
Capture panoramas

Process photo stations

Measure objects in the photos

Prepare new deliverables

Reduce field time by ~30%



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**
- **Coverage (@ 5 cm GSD): 2.19 km²**
- **Coverage (@ 10 cm GSD): 4.94 km²**
- **GSD: 2.4-24 cm**
- **Flight Ceiling: 5000 m**
- **Wind Speed: 65 km/h**
- **Landing Type: Belly**
- **Camera: Sony NEX5R (16.1 MP)**



Trimble UX5 Aerial Imaging Process

- **Mission & flight planning**
 - Trimble Access Aerial Imaging application
- **Image acquisition & flight monitoring**
 - Trimble UX5 Aerial Imaging Rover
 - Trimble Access Aerial Imaging application
- **Image processing & creating deliverables**
 - Trimble Business Center Photogrammetry Module



Defining the Project Area

The screenshot displays the Aerial Imaging V00.07.00010 software interface. The main map shows a satellite view of a residential area with a yellow mission area and a red avoidance zone. The mission area is a large yellow rectangle covering a residential block. The avoidance zone is a red-shaded area that follows the layout of a street grid, including streets like Kennedystraat, Statensstraat, and Beneluxstraat. The interface includes a sidebar on the right for Mission Planning, which contains controls for defining the mission area, adding avoidance zones, and deleting selections. It also features a list of mission parameters: GSD [cm] (3.2), Height [m] (100), Forward overlap [%] (75), Sideward overlap [%] (75), Link overlap (toggle), and Estimated flights (1). At the bottom of the sidebar are buttons for Export and Flight. The map interface includes zoom controls on the left and coordinate information at the bottom: 51.22642° N, 3.78802° E and 51.23376° N, 3.78108° E.

Defining the Flight

Aerial Imaging V00.07.00010

The screenshot displays a flight planning interface. On the left, there are map navigation controls: a plus sign for zoom in, a minus sign for zoom out, and a target icon for centering. The main map shows a satellite view of an urban area with a flight path overlaid. The path consists of a series of orange 'X' markers connected by lines, forming a rectangular perimeter. Inside this perimeter, a grid of vertical lines represents the flight lines. A yellow shaded area is visible at the top and bottom of the flight path, and a red shaded area is visible on the right side. A circular marker with the number '01' is located in the center of the flight area. On the right side, there is a 'Flight Planning' panel with a 'Satellite' button and a 'Flight 1' selection icon. Below the panel, there is a table of flight parameters.

Area	Parameters
Duration	34 min
Size	1.30 km ²
Length	1,087 m
Width	1,195 m
Forward overlap	75 %
Sideward overlap	75 %
GSD [cm]	4.8
Height [m]	150

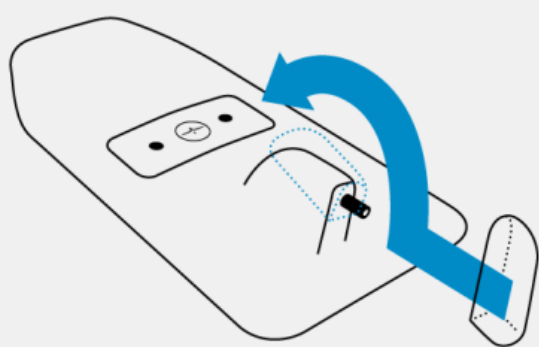
Google
Kaartgegevens ©2013 Google - Gebruiksvoorwaarden Een kaartfout rapporteren

51.22642° N, 3.77605° E 51.23376° N, 3.78108° E

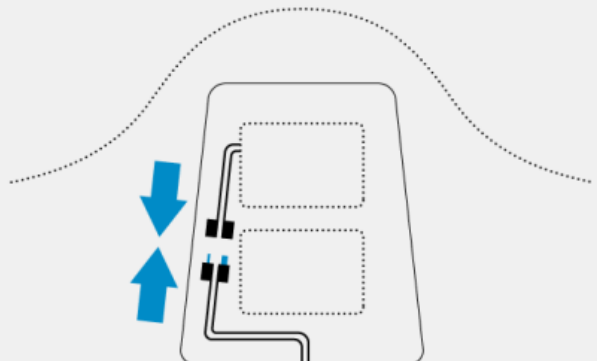
Pre-Flight Checklist

Aerial Imaging V00.07.00010

Pre-flight information



Cover pitot



Connect battery

▶ Flight

51.23652° N, 3.79982° E 51.23376° N, 3.78108° E

The image shows a software window titled "Aerial Imaging V00.07.00010" with a sub-header "Pre-flight information". It contains two instructional diagrams. The first diagram, labeled "Cover pitot", shows a top-down view of the aircraft's nose with a blue arrow indicating a cover being placed over the pitot probe. The second diagram, labeled "Connect battery", shows a side view of the aircraft's fuselage with a battery being inserted into a compartment, indicated by blue arrows. At the bottom right is a "▶ Flight" button. At the bottom left, there are two coordinate pairs: "51.23652° N, 3.79982° E" and "51.23376° N, 3.78108° E".

Flight Operation

Aerial Imaging V00.07.00010

The screenshot displays a flight planning application. The main window shows a map with a blue flight path and orange waypoints. The path starts at a yellow waypoint, moves north, then east, then south, and finally west, ending at another yellow waypoint. A black arrow indicates the current heading. The map includes street names like Valkstraat, Groenendijkstraat, and Vrijstraat. A red shaded area is visible on the right side of the map.

Flight - Scanning

COM	GPS	BAT
0	0	14

Altitude control panel showing a scale from -20 to 10 meters.

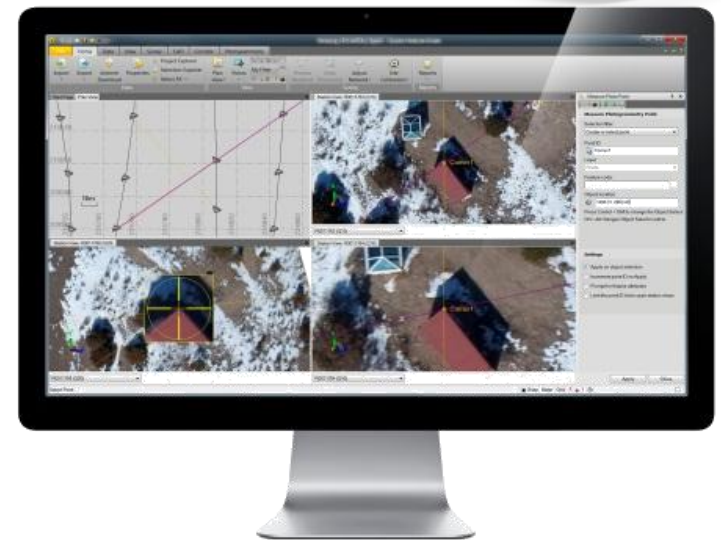
Height	150 m	Desired	150 m
Airspeed	75 km/h	Desired	75 km/h
Throttle	16%		
Time	00:30	Battery	06:38

Control buttons: Land, Fly to, Hold, Home, Right, FTS.

Coordinates: 51.22617° N, 3.79077° E | 51.23376° N, 3.78108° E | 51.23500° N, 3.78627° E, ground speed: 75 km/h

Trimble Business Center Photogrammetry Module

- Office application for processing traditional and Trimble UAS survey data
- 64-bit processor / operating system requirement
- Photogrammetry processing using technology from Inpho
- Simple workflows for importing flight data, stitching images, identifying ground control points, producing deliverables, and measuring features



Import Flight Data

The screenshot displays the Trimble Business Center software interface for importing flight data. The window title is "Guernsey - 21 March - 4 - Trimble Business Center".

Project Explorer (Left Panel):

- Guernsey - 21 March - 4
 - Points
 - Flight Missions
 - Guernsey0321_Fit1
 - Guernsey0321_Fit1
 - Flight Plan
 - R0012198 (Q1)
 - R0012199 (Q2)
 - R0012200 (Q3)
 - R0012201 (Q4)
 - R0012202 (Q5)
 - R0012203 (Q6)
 - R0012204 (Q7)
 - R0012205 (Q8)
 - R0012206 (Q9)
 - R0012207 (Q10)
 - R0012208 (Q11)
 - R0012209 (Q12)
 - R0012210 (Q13)
 - R0012211 (Q14)
 - R0012212 (Q15)
 - R0012213 (Q16)
 - R0012214 (Q17)
 - R0012215 (Q18)
 - R0012216 (Q19)
 - R0012217 (Q20)
 - R0012218 (Q21)
 - R0012219 (Q22)
 - R0012220 (Q23)
 - R0012221 (Q24)
 - R0012222 (Q25)
 - R0012223 (Q26)
 - R0012224 (Q27)
 - R0012225 (Q28)
 - R0012226 (Q29)
 - R0012227 (Q30)
 - R0012228 (Q31)
 - R0012229 (Q32)
 - R0012230 (Q33)
 - R0012231 (Q34)
 - R0012232 (Q35)
 - R0012233 (Q36)
 - R0012234 (Q37)
 - R0012235 (Q38)
 - R0012236 (Q39)
 - R0012237 (Q40)
 - R0012238 (Q41)

Main View (Plan View):

- Shows a 2D plan view of the flight area with a grid. The vertical axis (Y) ranges from 209800 to 210100, and the horizontal axis (X) ranges from 234600 to 234900.
- A central polygon represents the flight area, with a "Base" point at the bottom left.
- Points are labeled with IDs such as R0012245, R0012229, R0012213, R0012244, R0012228, R0012212, R0012246, R0012230, R0012214, R0012198, R0012243, R0012232, R0012215, R0012199, R0012247, R0012231, R0012210, R0012200, R0012248, R0012242, R0012226, R0012216, R0012240, R0012241, R0012225, R0012209, R0012249, R0012233, R0012217, R0012204, R0012250, R0012254, R0012218, R0012202, R0012251, R0012239, R0012223, R0012207, R0012252, R0012238, R0012221, R0012206, R0012253, R0012236, R0012220, R0012208, R0012237, R0012221, R0012206, R0012205.
- Blue lines connect the points, showing the flight path.
- A scale bar indicates 20m.

3D View (Right Panel):

- Shows a 3D perspective view of the flight path, with points connected by lines and a shaded ground plane.
- A north arrow and a scale of VE: 1.0 are visible.

Toolbar (Top):

- File, Home, Data, View, Survey, CAD, Corridor, Photogrammetry
- Import, Export, Internet Download, Properties, Selection Explorer, Select All
- Plan View, Points, My Filter
- Process Baselines, Clear Processing, Adjust Network, Site Calibration
- Reports

Identify Ground Control Points

The screenshot displays the Trimble Business Center software interface. The main window shows two station views: 'Station View: R0012224 (Q27)' on the left and 'Station View: R0012218 (Q21)' on the right. Both views show a grayscale aerial photograph with yellow lines representing photo station footprints and a central point labeled '15'. The 'Adjust Photo Stations' dialog box is open on the right, showing the 'Control Points' tab. Below the dialog box, the 'Process View' shows the progress of the adjustment process.

Control Points Table:

Point ID	Observations	Qu	Status
10	0	?	Enabled
11	5	?	Enabled
12	5	?	Enabled
13	5	?	Enabled
14	5	?	Enabled
15	5	?	Enabled

Photo stations seeing point 15:

Photo Station ID	Status
R0012217 (Q20)	Enab... <input checked="" type="checkbox"/>
R0012216 (Q19)	Enab... <input checked="" type="checkbox"/>
R0012208 (Q11)	Enab... <input checked="" type="checkbox"/>
R0012209 (Q12)	Enab... <input checked="" type="checkbox"/>
R0012224 (Q27)	Enab... <input checked="" type="checkbox"/>
R0012218 (Q21)	Enab... <input checked="" type="checkbox"/>
R0012215 (Q18)	<input type="checkbox"/>
R0012207 (Q10)	<input type="checkbox"/>
R0012210 (Q13)	<input type="checkbox"/>

Process View:

Guernsey - 21 March - 4

Adjustment with control points [Guernsey0321_Fit1]

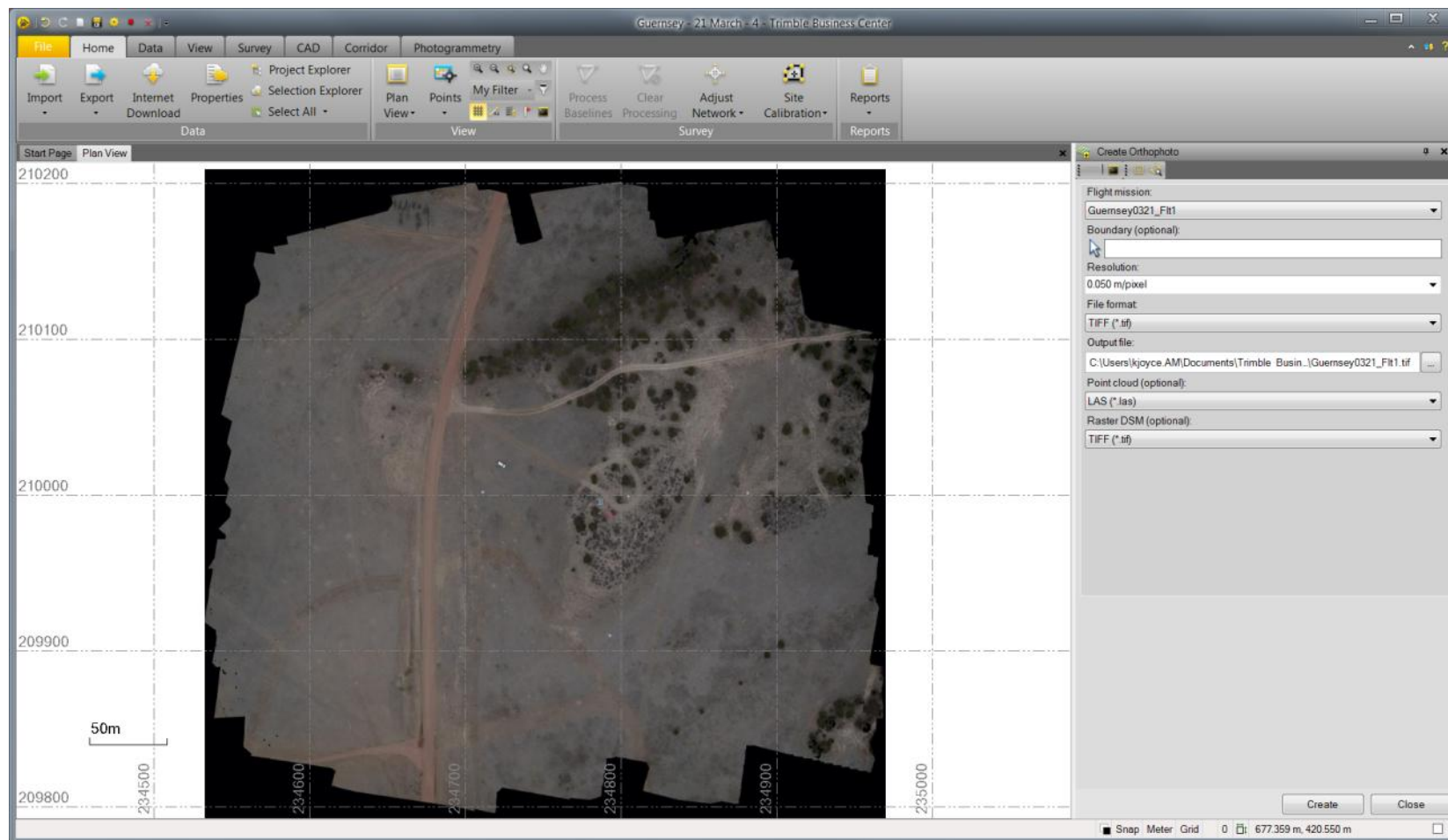
Step 9 of 33: 0% - The pre-conditions check was successful.

Adjustment with tie points [Guernsey0321_Fit1]

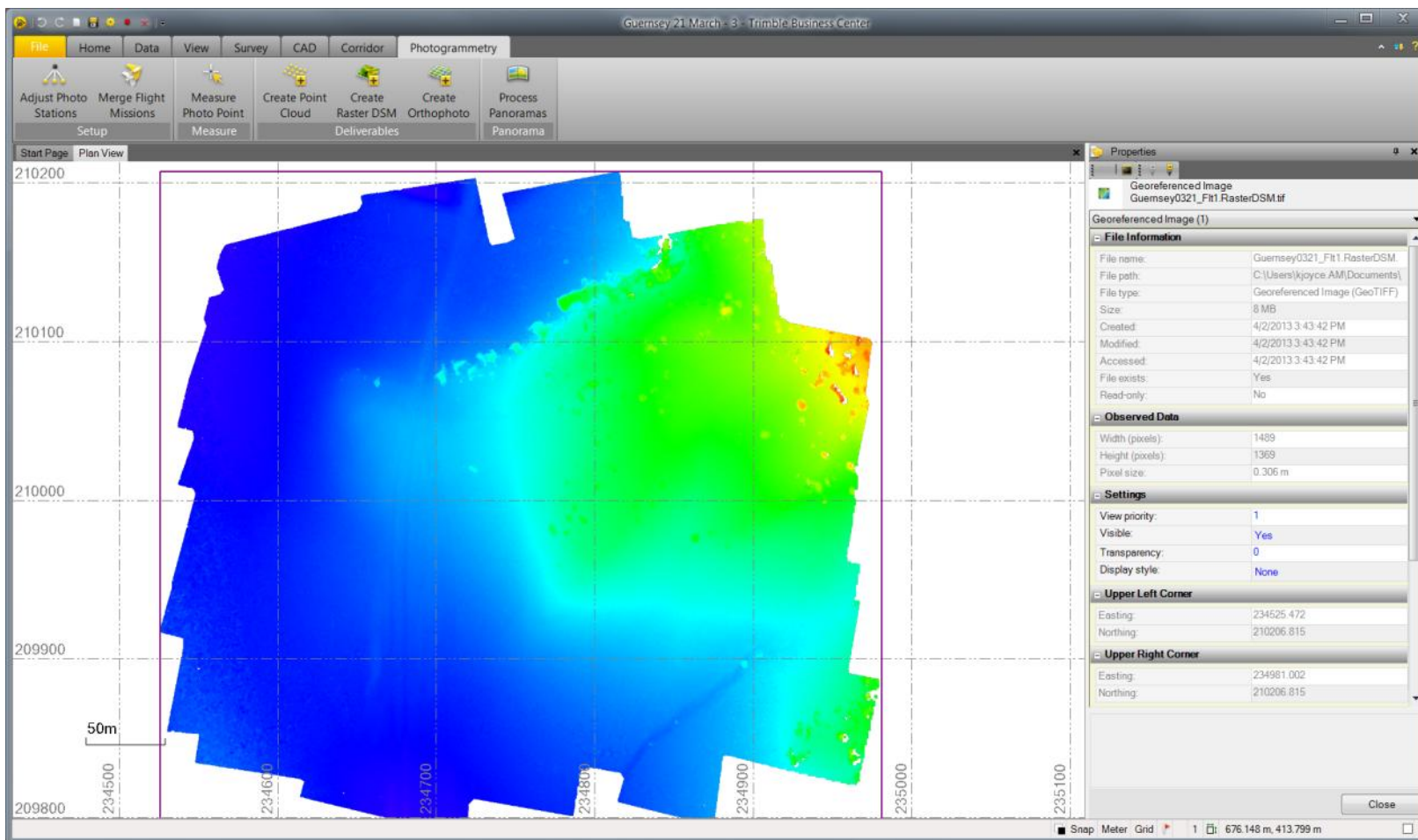
Step 9 of 9: 100% - Project Output completed.

Adjust with Control Points | Close

Create Orthophotos



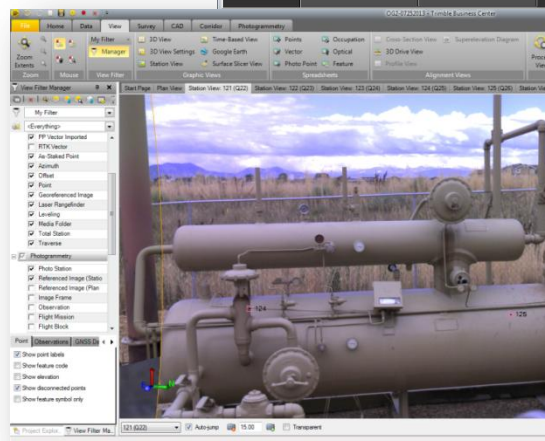
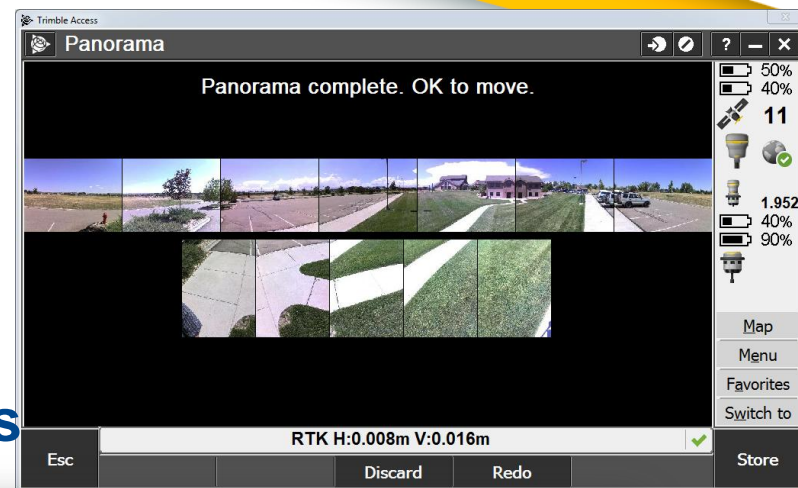
Create Digital Surface Models



Applications....

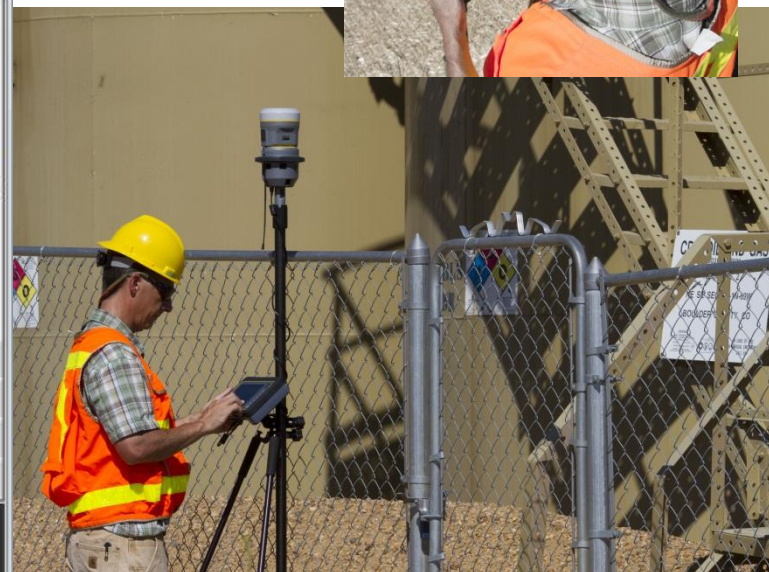
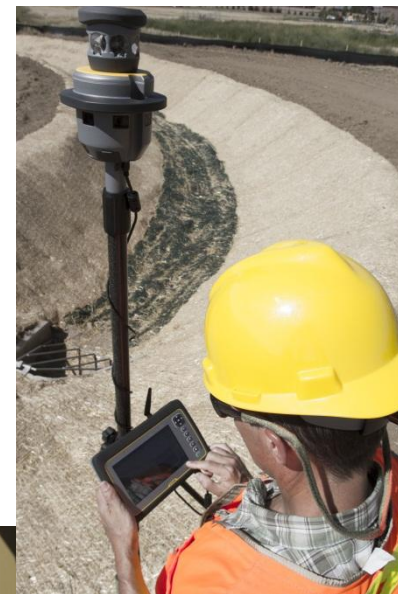
V10 Applications

- **Land Surveying**
 - Design Surveys
 - As-Builts
 - Facades
- **Geographic Information Systems**
 - 3D Cities
 - Asset Management
 - Data Inventory
- **Oil & Gas**
- **Property Management**
- **Environmental**
- **Mining**
- **Site Visualization**
 - Accident Investigation
 - Job Planning
 - Inspections



V10 Applications

- Europe – Rail (Netherlands) – Asset Management
- China – Utilities – Transformer Inspections
- North America – Oil & Gas (Texas, Global) – Facilities Management



V10 Applications continued...

Retrofit Dredging Machines - Netherlands

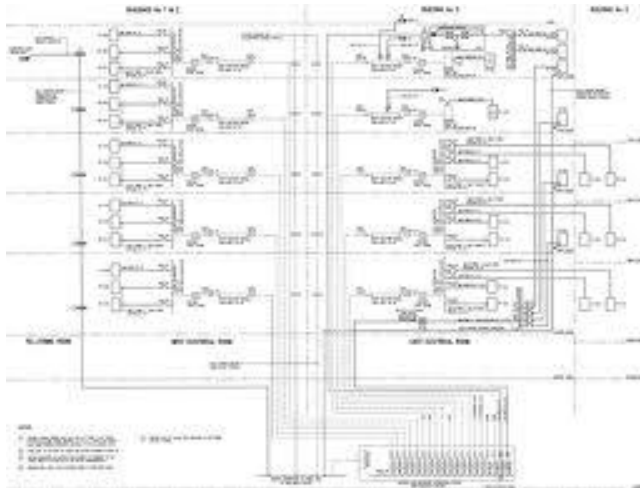
- Machines must be rebuilt or retrofitted between projects
- Estimated savings was 25% faster project completion



V10 Applications continued...

Electrical Plants

- Virtual Site Visit
- Work Planning
 - determine the conditions
 - Allocate crews and equipment
 - Budgeting, procurement and planning



V10 Applications continued...

Cemetery Headstone Survey - USA

- The V10 could be used to inventory and locate headstones at military cemeteries.

WASHINGTON — Estimates of the number of graves that might be affected by mix-ups at Arlington National Cemetery grew from hundreds to as many as 6,600 on Thursday, as the cemetery's former superintendent blamed his staff and a lack of resources for the scandal that forced his ouster.

John Metzler, who ran the historic military burial ground for 19 years, said he accepts "full responsibility" for the problems. But he also denied some of the findings by Army investigators and **suggested cemetery employees and poor technology were to blame** for remains that may have been misidentified or misplaced. He said the system used to track grave sites relied mostly on a complicated paper trail vulnerable to error.



V10 Applications continued...

Mine Site Survey - Bulgaria

- Customer issue - Surveyors are not always available when Geologist require them



UX5 Applications

- **Engineering & Surveying**
- **Mining**
- **Civil & Heavy Earthworks Construction**
- **Oil & Gas**
- **Environmental & Landfill**
- **Public Agencies**
- **Agriculture & Forestry**

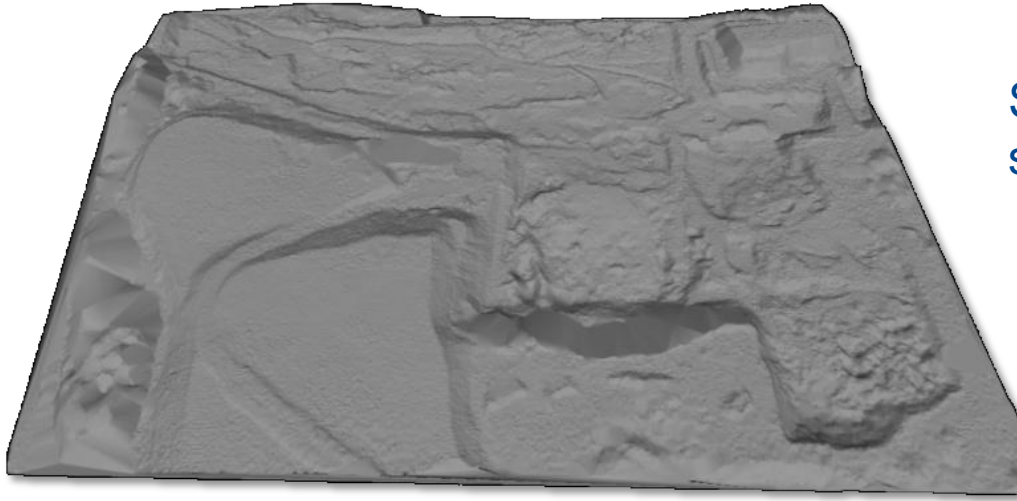


Topographic Survey Example

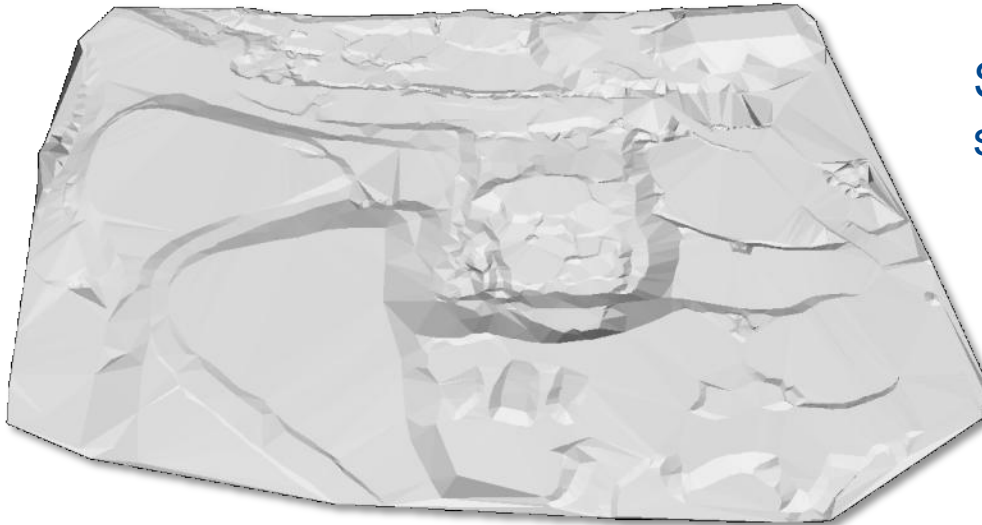


Switzerland
510 Images
400 m Flight Height
11 cm GSD
3.12 km²

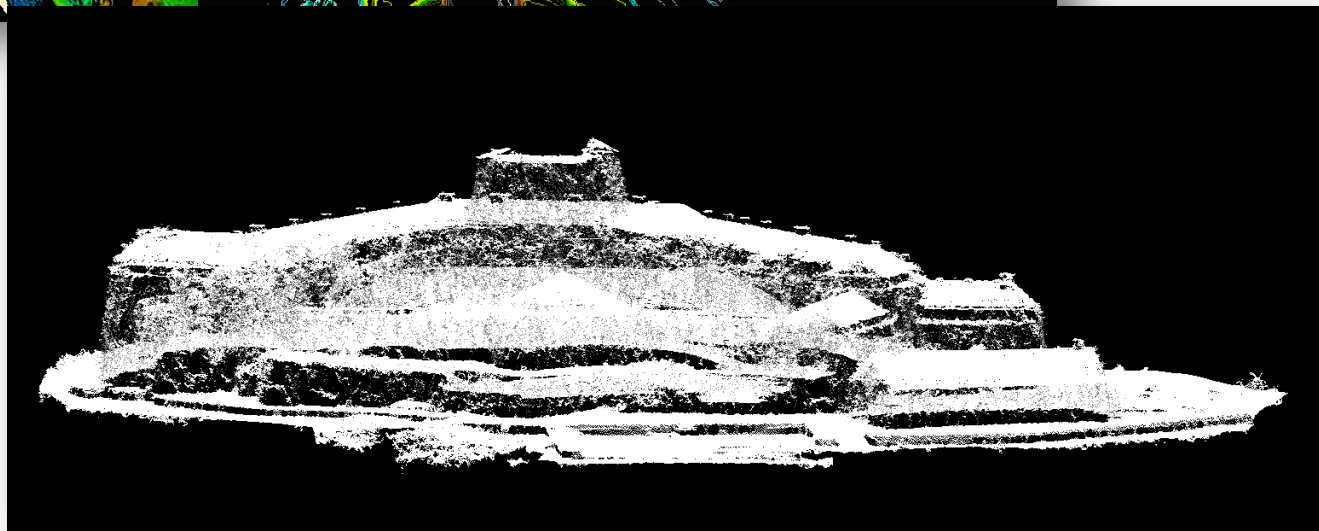
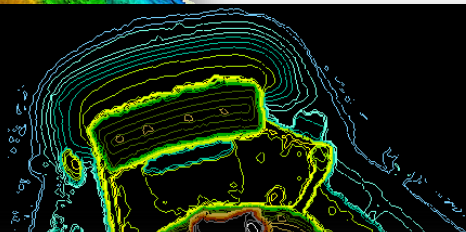
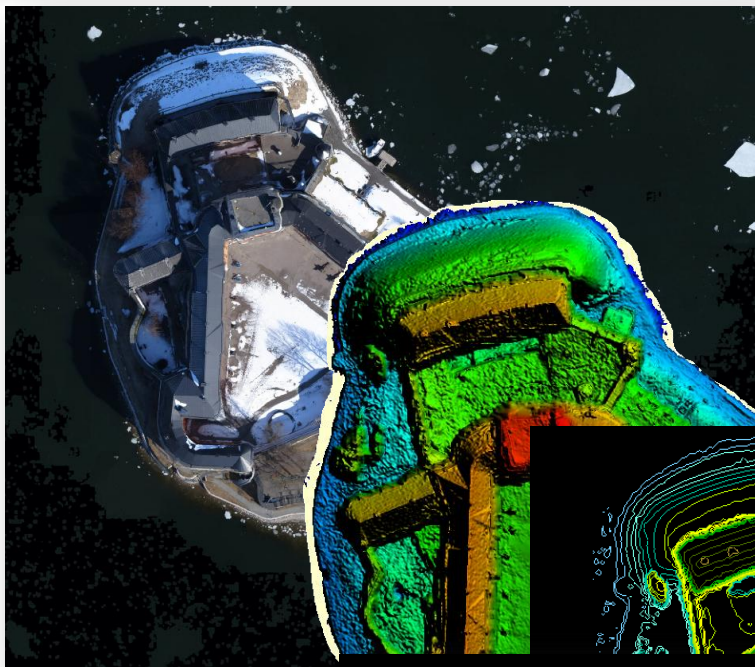
Topographic Survey Example



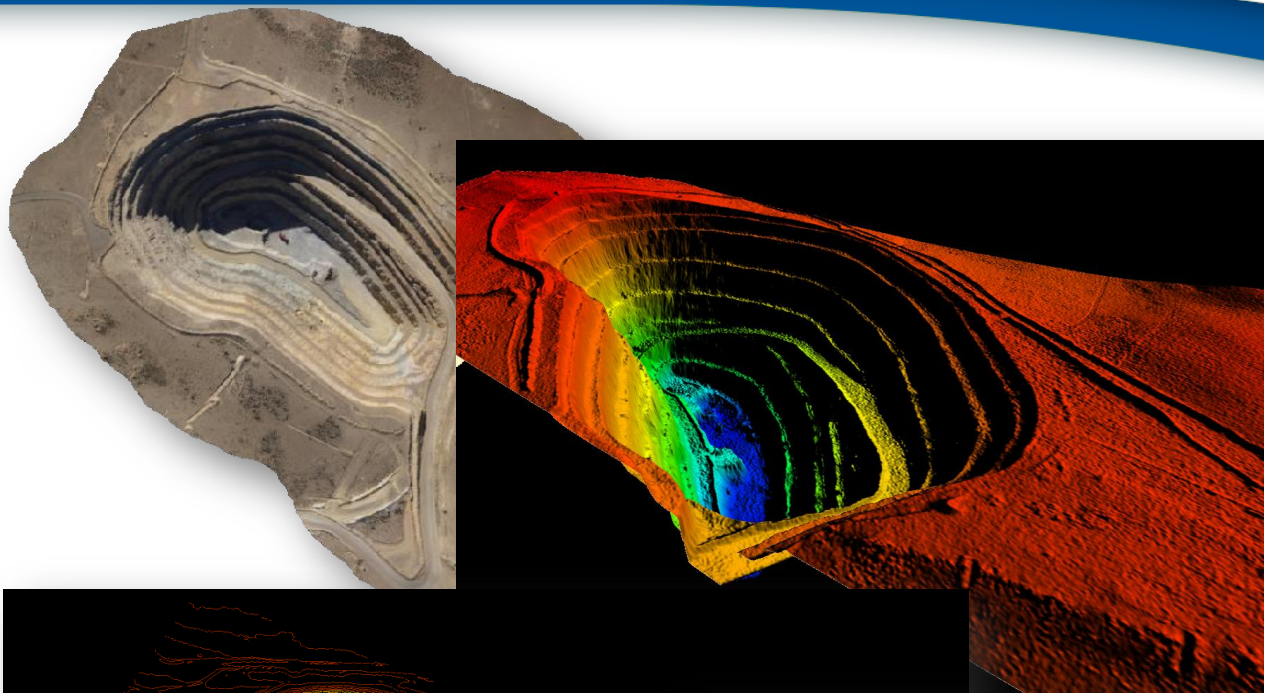
Surface model generated from UAS survey (300,000 measurements)



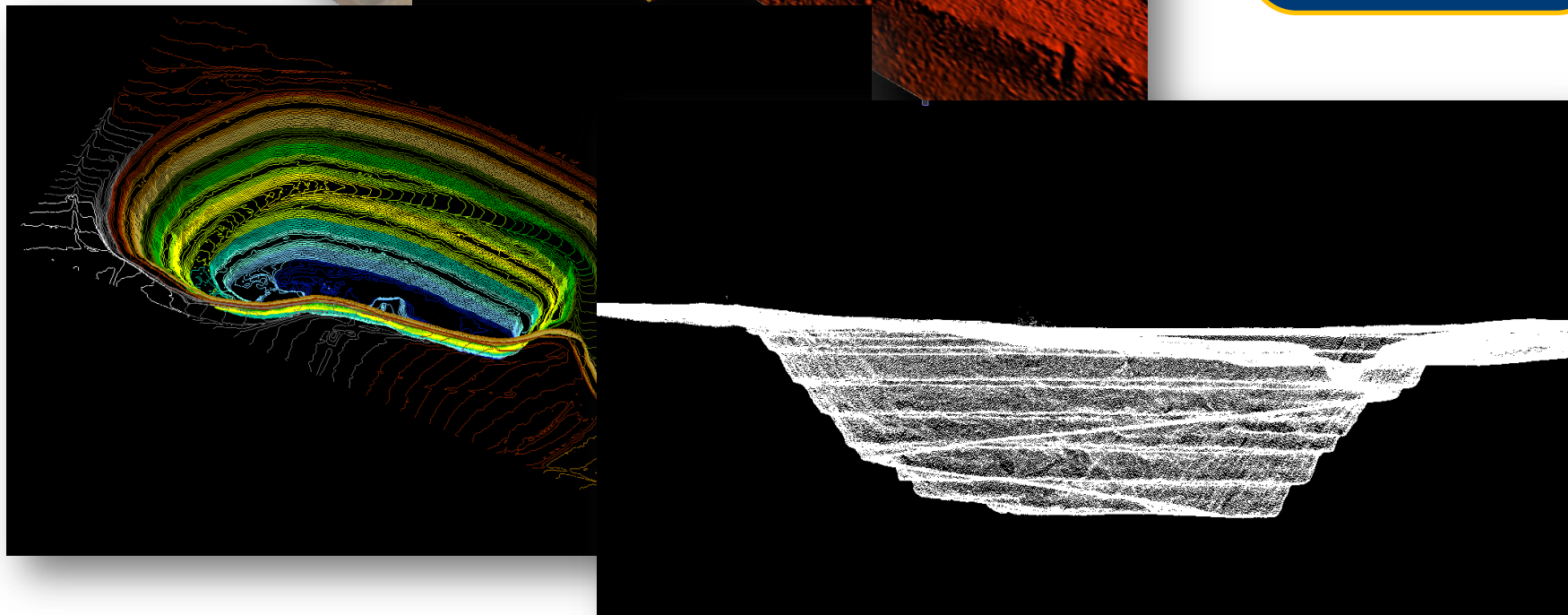
Surface model generated from GNSS survey (1,000 measurements)



Vaxholm Castle,
Sweden
126 Images
120 m Flight Height
3.8 cm GSD
550 x 600 m



Pit Mine, Argentina
362 Images
200 m Flight Height
6.4 cm GSD
500 x 900 m



Route Planning Example



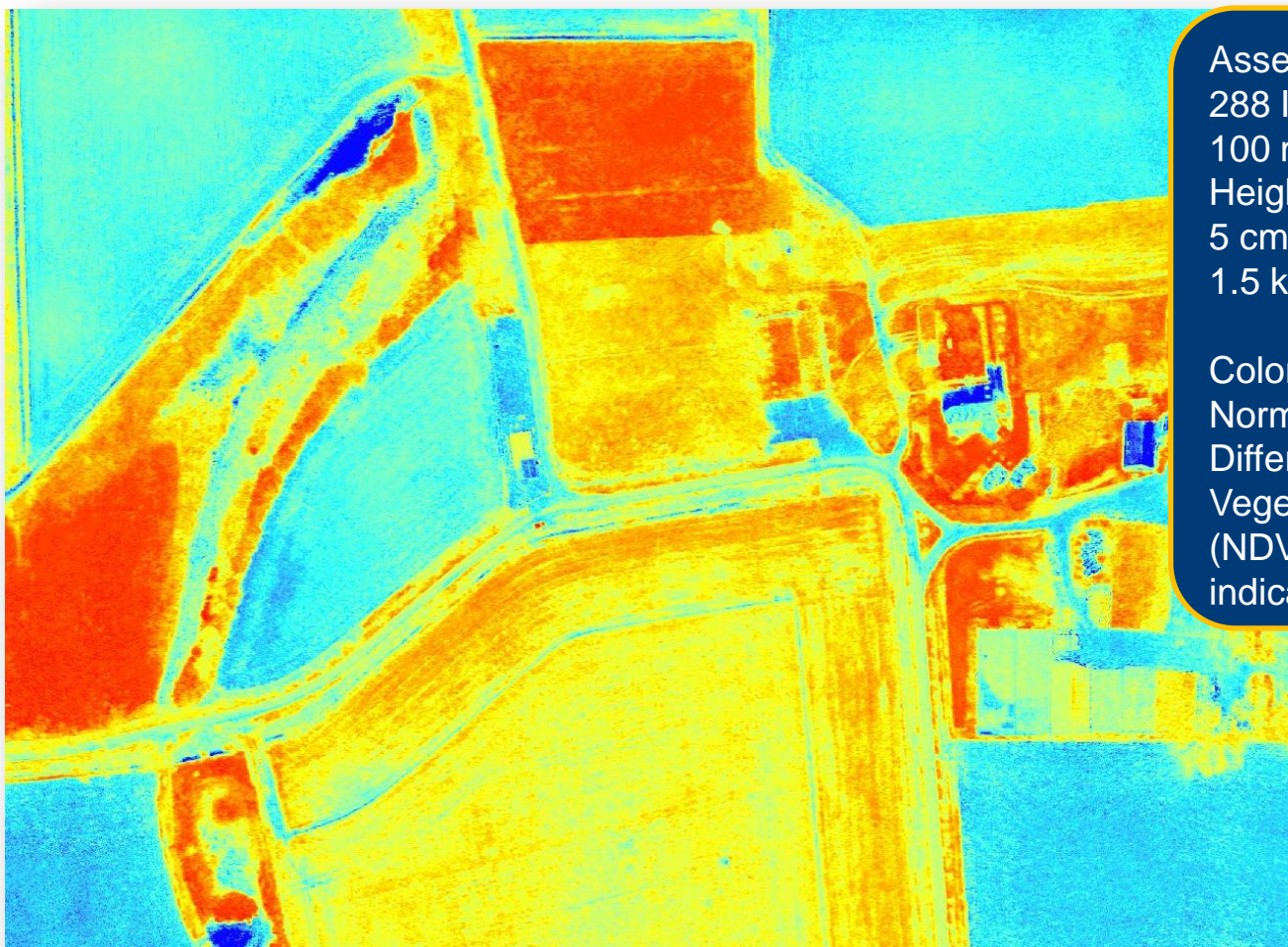
Belgium
462 Images
150 m Flight Height
5 cm GSD
0.8 km²

Progress Monitoring Example



United Kingdom
150 m Flight Height
5.7 cm GSD
2.4 km²

Vegetation Health Example



Assenede
288 Images
100 m Flight
Height
5 cm GSD
1.5 km²

Color relates to
Normalized
Difference
Vegetation Index
(NDVI) value -
indication of health

Return on Investment....

V10 Customer ROI

Cost Estimate for 5 day survey project with 2-man field crew, 1 draftsman and 1 professional land surveyor working on the project.

Traditional Survey Workflow			Trimble V10 Imaging Rover Workflow		
Item	Cost	Fee	Item	Cost	Fee
Setting Control	\$ 180	\$ 600	Setting Control	\$ 180	\$ 600
Boundary Solution (Office and Field)	\$ 1,180	\$ 2,200	Boundary Solution (Office and Field)	\$ 860	\$ 2,200
Locate Improvements	\$ 1,800	\$ 2,400	Locate Improvements	\$ 720	\$ 2,400
Capture Topography	\$ 1,080	\$ 1,800	Capture Topography	\$ 720	\$ 1,800
Drafting	\$ 1,200	\$ 1,920	Drafting	\$ 1,200	\$ 1,920
Deliverables	\$ 400	\$ 640	Deliverables	\$ 400	\$ 1,640
Total	\$ 5,840	\$ 9,560		\$ 4,080	\$ 10,560

UX5 Topographic Survey ROI

	UAS	GNSS	Comments
Area	1.5 km ²	1.5 km ²	
Ground control setup & measurement	1 ¼ hr	---	Ground control not required for all applications
Setup time	15 min	15 min (per day)	
Survey time	45 min	30 ½ hr (4 days)	
Tear-down time	15 min	15 min (per day)	
Data processing time	4 hrs	---	Data can be processed overnight
Total time	6 hr 30 min	32 hr 30 min	5x faster than GNSS
Measurement sampling	3.8 cm (at 120 m flight altitude)	15 m	Minimum sampling size is 2.4 cm
Horizontal accuracy	2 cm	1 cm	
Vertical accuracy	4 cm	2 cm	

But there is more hidden value...

- **Economic solution** – multiple data sets extracted from one trip to the field, reduces repeat trips. Different parties have interest in different data, so users can capitalize on multiple deliverables from one trip to the field
- **Safety**
- **Efficient process** – in addition to reduced field time, data processing time is cut down
- **Workflow dependent** – the workflow dictates everything, so as long as the user follows a well planned work flow, strong results will follow
- **Versatility** – a technology that can be used to serve numerous professional markets and applications
- **Diversification** – opens up new applications and new business opportunities for users



transforming the way the world works



Thank You!

Terima Kasih!