RIEGL®

Laserové skenery pro drony

Ing. Jan Sukup
PONYSTAR s.r.o.

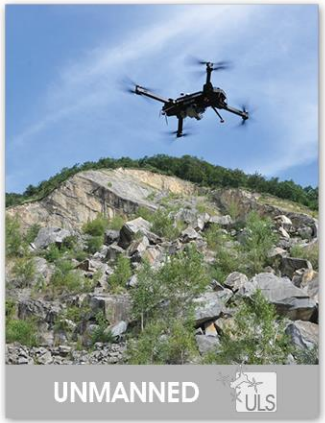
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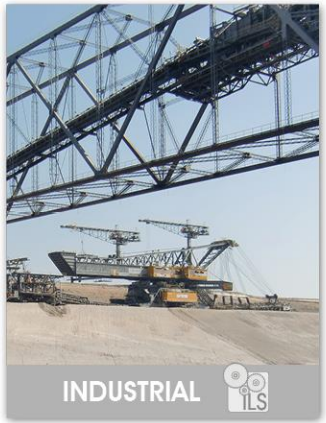
Innovation in 3D











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ULS Product Portfolio Overview



1.6 kg
360° FOV
100 /200 kHz
eff. pulse rate

extremely lightweight

3.5 kg
360° FOV
1.2 / 1.5 MHz
eff. pulse rate

powerful sensor for various applications in wide area UAV surveying

2.0 kg
100° FOV
1.5 MHz
eff. pulse rate

NFB (Nadir/Forward/ Backward) Scanning for an optimal coverage of complex and vertical targets

4.1 kg
75° FOV
1.5 MHz
eff. pulse rate

versatile scanner for use on high-speed UAVs, helicopter or small manned aeroplane

12 kg
40° FOV
(circular scan pattern)
200 kHz
eff. pulse rate
water penetration
2 Secchi depths

for topo-bathymetric LiDAR applications

efficient high resolution coastline or shallow water surveying

miniVUX-1/-2/-3UAV, -1LR	VUX-1UAV[22] /-LR[22]	VUX-120	VUX-240	VQ-840-G

for applications using low-flying small or mid-sized multi-rotor UAVs
e.g. mining, topography, forestry, landslide and avalanche monitoring

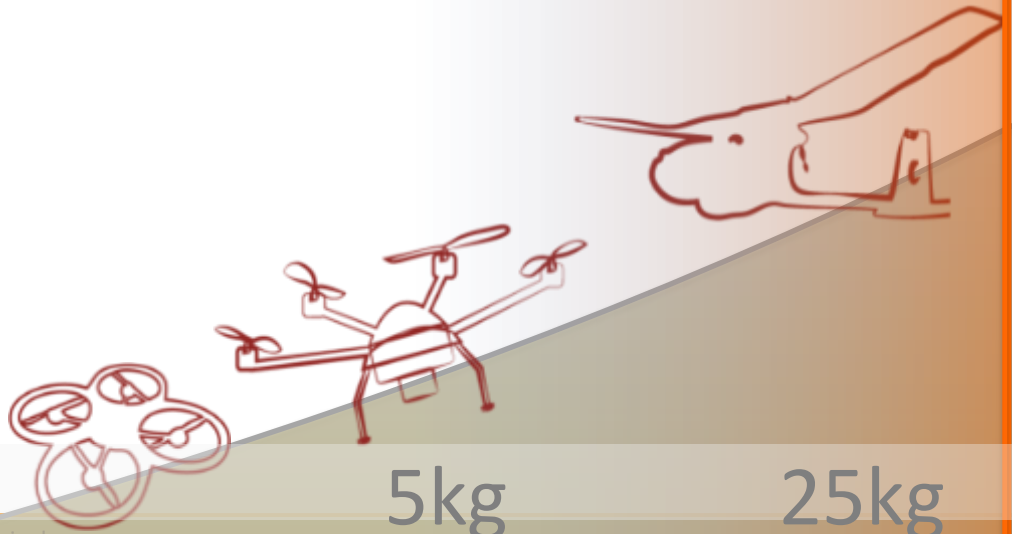
for applications using fixed-wing UAVs
e.g. corridor mapping, city modeling

for applications using higher-flying large UAVs or helicopters
e.g. mapping with the need of detailed high-resolution data

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Unmanned Laser Scanning

LIGHTWEIGHT AIRBORNE SENSOR



ALMOST ANY AIRBORNE SENSOR



5kg 25kg 50kg

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laser scanner selection guide (ULS sensors)

Application	VUX-240	VUX-120	VUX-1LR[22]	VUX-1UAV[22]	miniVUX-1UAV miniVUX-2UAV miniVUX-3UAV
PRR - Pulse Repetition Rate	1800 kHz	1800 kHz	1500 kHz	1200 kHz	up to 300 kHz
Field of View (Fov)	75°	100° (NFB)	360°	360°	up to 360°
Large Terrain Variations	●●●	●●	●●●	●●	●
Open-Cast Mining	●●	●●	●●●	●●●	●●●
Wide FoV	●	●●	●●●	●●●	●●●
Urban Environments	●●●	●●●	●●●	●●●	●●
Archaeology	●●●	●●●	●●●	●●●	●●
Corridor Mapping	●●●	●●●	●●●	●●●	●●
Agriculture & Forestry	●●●	●●●	●●●	●●●	●
Glacier & Snowfield	●●	●	●●	●	●●●

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RIEGL miniVUX Series: Update

RIEGL miniVUX-1LR
RIEGL miniVUX-3UAV



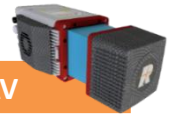
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Comparison of RIEGL miniVUX-Series

NEW







	miniVUX-1LR			miniVUX-1UAV	miniVUX-2UAV		miniVUX-3UAV	
PRR (max). eff. meas. rate	100 kHz / 100,000 pts/sec.			100 kHz / 100,000 pts/sec.	100 kHz / 100,000 pts/sec.	200 kHz / 200,000 pts/sec.	200 kHz / 100,000 pts/sec.	300 kHz / 100,000 pts/sec.
minimum range	5 m			3 m	2 m		2 m	
accuracy / precision	15 mm / 10 mm			15 mm / 10 mm	15 mm / 10 mm		15 mm / 10 mm	
FoV (Field of View)	360°			360°	360°		180°	120°
	clear sky @ 90 klx	overcast @ 10 klx	twilight @ 0.1 klx	-	-		-	
max. measuring range (20%)	210 m	240 m	260 m	170 m	170 m	150 m	170 m	
max. measuring range (60%)	350 m	400 m	440 m	290 m	290 m	250 m	290 m	
max. measuring range (80%)	400 m	460 m	**500 m**	330 m	330 m	280 m	330 m	

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NEW RIEGL miniVUX-1LR: Key Features



- **miniaturized** online waveform processing **long range** LiDAR scanner
- extremely lightweight and compact: **1.55 kg / 3.42 lbs**
- laser pulse repetition rate (PRR): **100 kHz @ 360° FoV**
- **maximum** measurement range: **500 m / 1640 ft (up to 1.5x longer)**

The **miniVUX-1LR** is an expansion of *RIEGL*'s miniaturized UAV product family:

- providing cost effective, high performance, survey-grade accuracy
- **IMPROVED longer range** performance to meet specific demands in UAV applications, such as measurements of inaccessible canyons and open-pit mines
- **more targets per laser pulse in complex target situations**
- **increased penetration capabilities**

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NEW *RIEGL Integration Kit 300 for DJI M300 RTK*





Integration **K**it **300** (**IK300**)

- IK300 (for DJI M300 RTK) similar to IK600 (for DJI M600 Pro)
- IK300 consists of:
  - mounting plate + shock absorbers
  - GNSS antenna (AV14) + cables + antenna mount
  - electrically fully integrated

supported systems:

- **miniVUX-SYS + APX-15 UAV** (2.2 kg)
- **miniVUX-SYS + APX-15 UAV + camera** (2.7 kg)



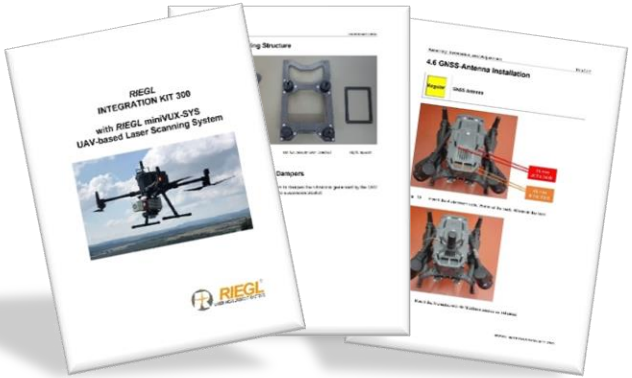
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NEW *RIEGL Integration Kit 300 for DJI M300 RTK*

Integration **K**it **300** (**IK300**)

- fast, easy and user-friendly integration
- instruction manual included
- fully autonomous operation running RiACQUIRE-Embedded from the start
- no user action required during operation
  → RXP Cutter (post-processing)
- no external battery needed (powered via UAV)
- **MTOM < 9 kg / 19.84 lbs**

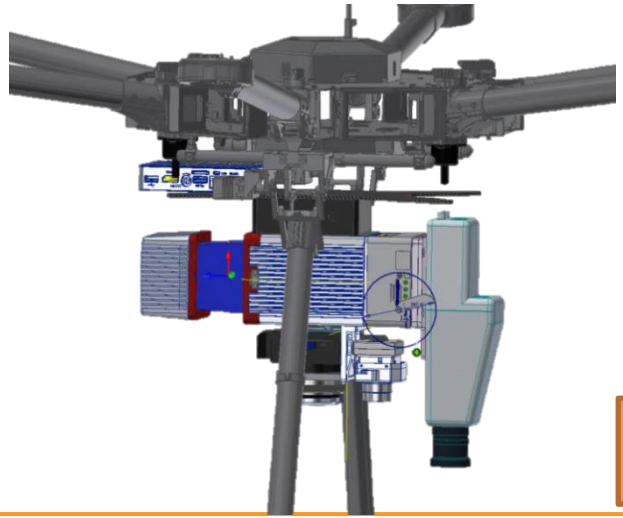


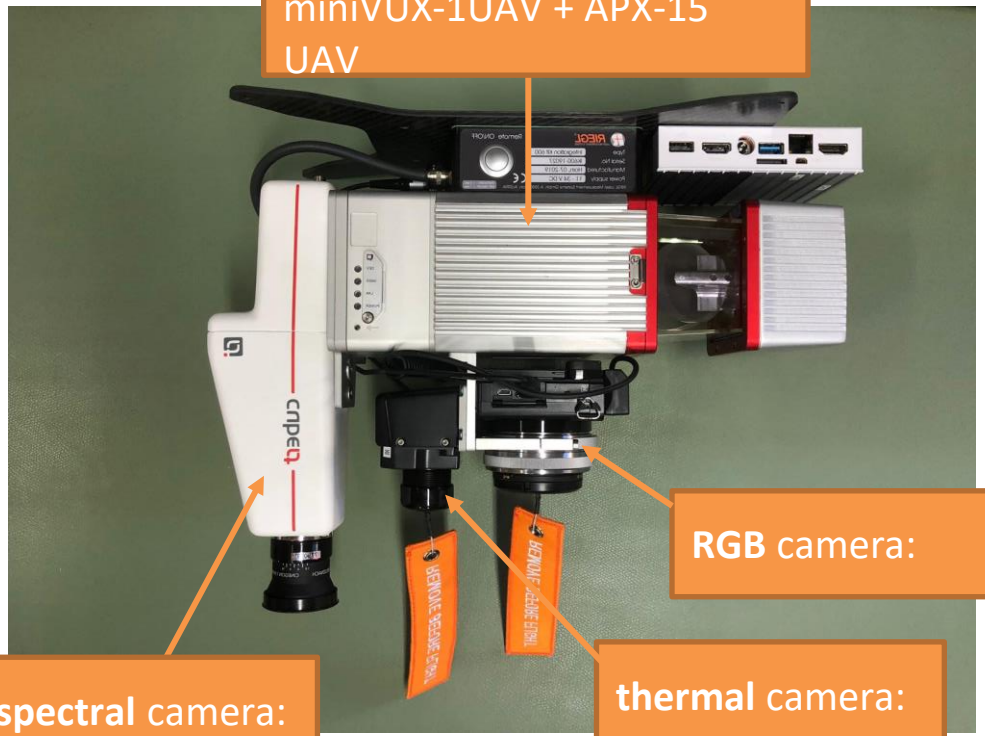


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Multi sensor integration

- multi sensor integration:
  - LiDAR, RGB, thermal, hyperspectral
  - weight: < 4 kg





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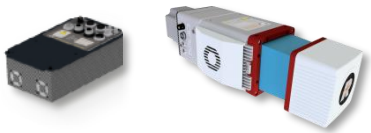
RIEGL VMY-1

- users will benefit from the multi-purpose capability to use the boresight calibrated miniVUX + INS system for MLS and ULS applications



MLS: VMY-1

available now:
miniVUX <> AP20 (DMI, GAMS)



Roadmap: miniVUX <> AP+30
- small form factor for compact UAV integration
- DMI and GAMS option for MLS



RiCOPTER: AP20 <> miniVUX



AP30+ for 3rd party UAVs

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RIEGL VUX-1 Series: Update

RIEGL VUX-1UAV^{22}

IMPROVED Specifications



IMPROVED *RIEGL VUX-1UAV^{22}: Key Features*



- **small** and **compact** online waveform processing LiDAR scanner
- lightweight: **3.5 kg / 8.42 lbs.**
- full field of view: **360°**
- very high measurement rate: **up to 1.2 MHz**
- **lower minimum range to capture even closer targets**
- **supports up to 4 cameras**

The ***RIEGL* VUX-1UAV^{22}** sets a new era for *RIEGL*'s ULS-based product portfolio:

- providing high performance and survey-grade accuracy
- **IMPROVED** efficiency and usability
- increasing flexibility in solutions for multi-purpose integrations

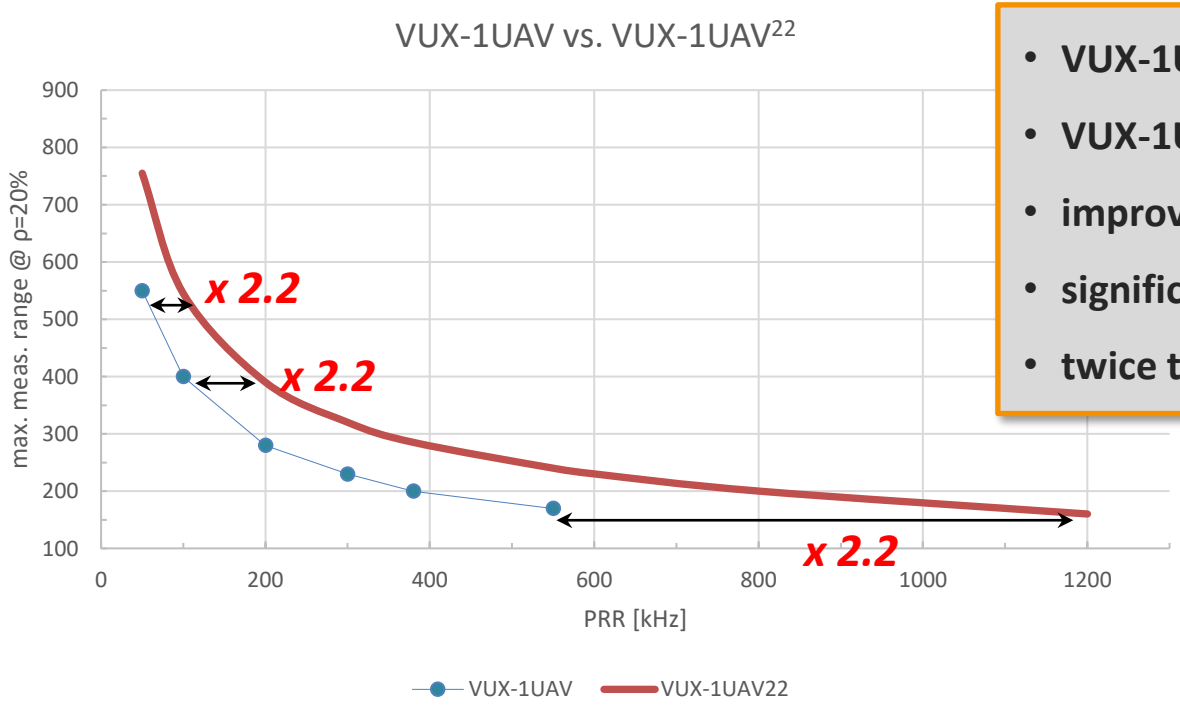
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Comparison: IMPROVED *RIEGL VUX-1UAV^{22} Updates*

	VUX-1UAV^{22}	VUX-1UAV	Performance increase
PRR (max). / eff. meas. rate	1200 kHz / 1200 kHz	550 kHz / 500 kHz	x 2.2 faster
PRR programs	50, 100, 200, 400, 600, 800, 1200 kHz	50, 100, 200, 300, 380, 550 kHz, 550 kHz (reduced)	3 more programs
max. measuring range (80%)	1415 m @ 50 kHz	1050 m @ 50 kHz	35 % - 37 % more range
	650 m @ 300 kHz	450 m @ 300 kHz	
	450 m @ 600 kHz	340 m @ 550 kHz	
	320 m @ 1200 kHz	-	
minimum range	1.5 m @ PRR ≥ 1 MHz	3 m	1.5 m lower range
laser beam divergence	0.5 mrad @ 1/e² 0.35 mrad @ 1/e	0.5 mrad @ 1/e²	additional alternative specification
FoV (Field of View)	360°	up to 330° / upgradable to 360°	unrestricted FoV
Operating temperature	-20°C - +40°C	-10°C - +40°C	lower temperature (-10°C difference)

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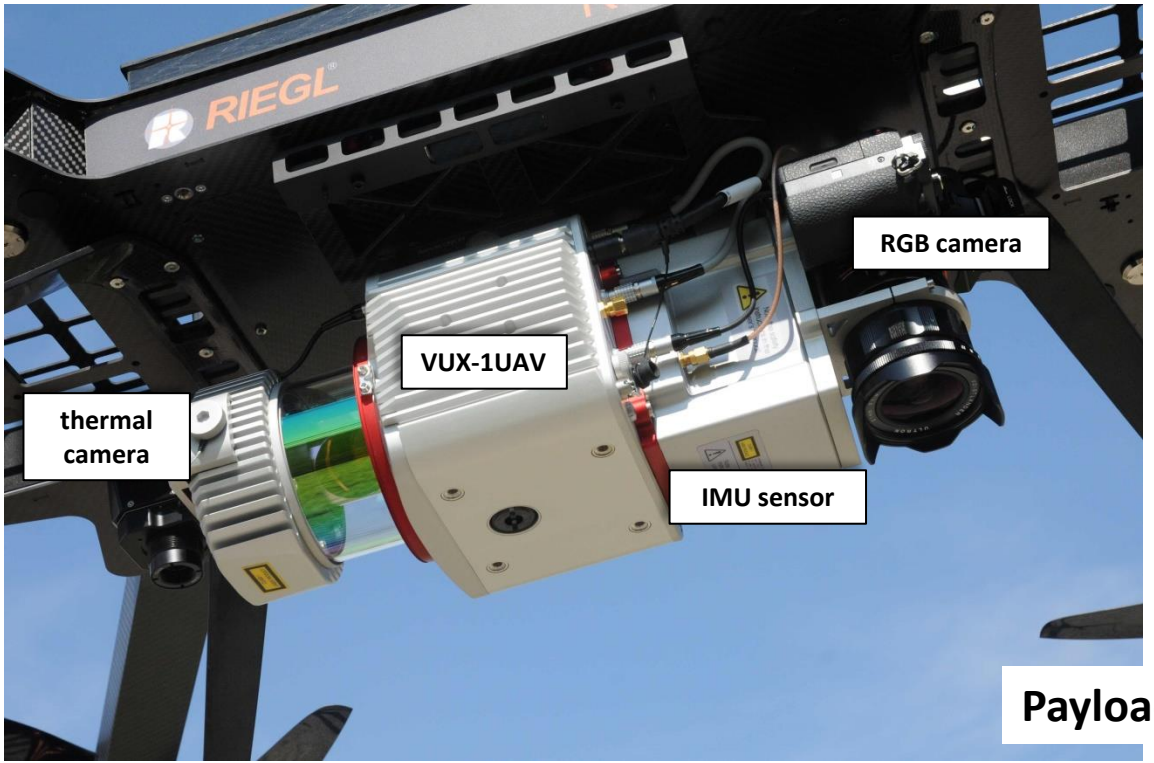
The new VUX-1UAV^{22} compared to VUX-1UAV



- VUX-1UAV: discrete PRR values
- VUX-1UAV^{22}: fine tunable PRR
- improved meas. range up to x 1.37
- significantly increased PRR by x 2.2
- twice the PRR at same meas. range

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Typical LiDAR System Setup





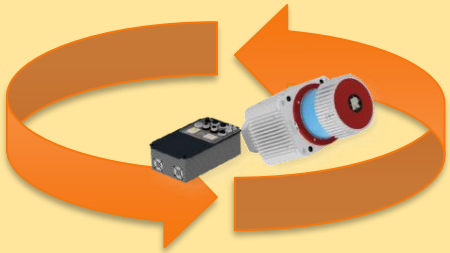
Payload 5.54 kg / 12.2 lbs

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Multi Purpose Use of VUX-SYS



MLS: VMQ





Airborne: VP-1



UAV platform

Scanner Performance (for details refer to the corresponding info sheets and data sheets)

RIEGL VUX-1 Series Sensor	VUX-1LR	VUX-1UAV	VUX-1HA [1]
Maximum Range	1,350 m [2]	920 m [2]	420 m [3]
Minimum Range	5 m	3 m	1.2 m
Accuracy / Precision	15 mm / 10 mm	10 mm / 5 mm	5 mm / 3 mm
Laser Pulse Repetition Rate	up to 750 kHz	up to 550 kHz	up to 1017 kHz
Max. Effective Measurement Rate	up to 750,000 meas./sec.	up to 500,000 meas./sec.	up to 1,000,000 meas./sec.
Field of View (selectable) [4]	up to 330°	up to 330°	up to 360°

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RIEGL VUX-120: Key Features



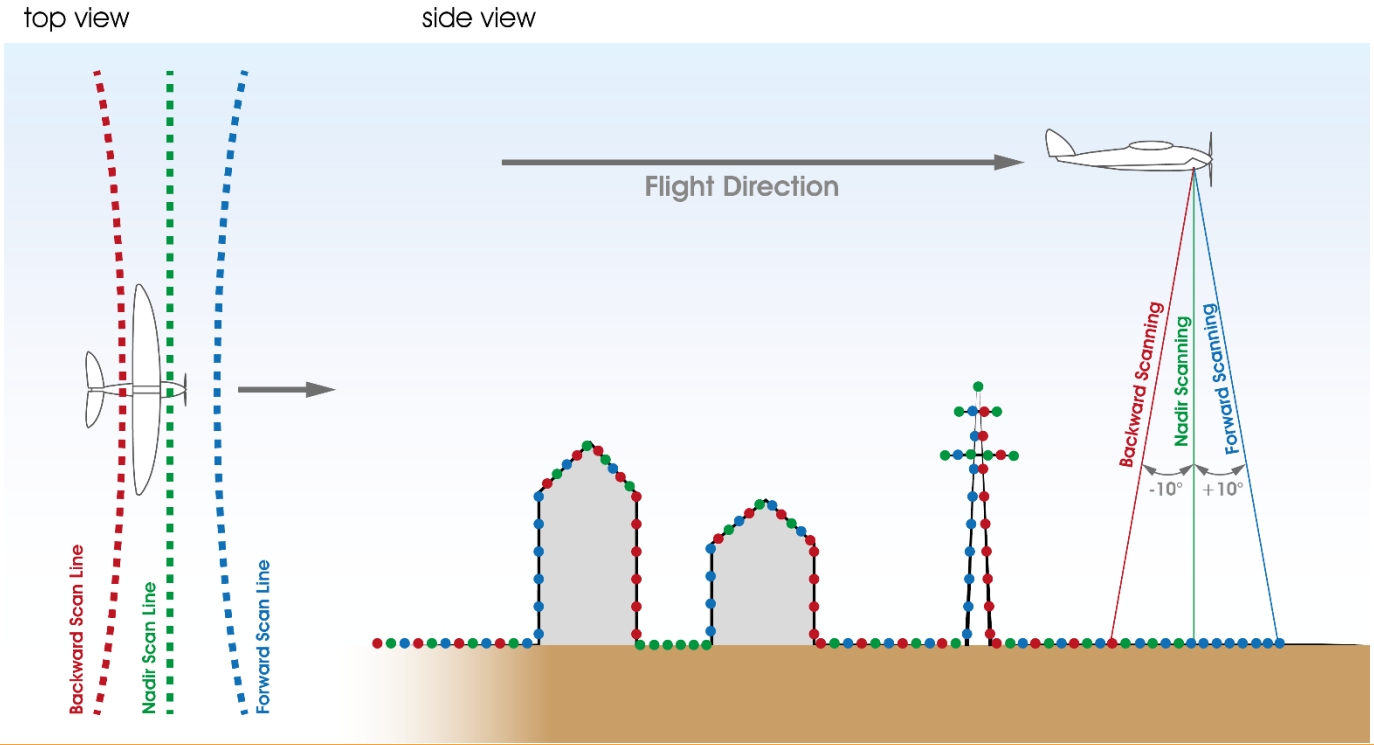
- **small** and **powerful** online waveform processing LiDAR scanner
- very lightweight: **2 kg / 4.4 lbs.**
- wide field of view: **100°**
- **Nadir-Forward-Backward** (NFB) scanning
- very high measurement rate: **1.8 MHz (eff. 1.5 MHz)**
- **supports up to 2 cameras**

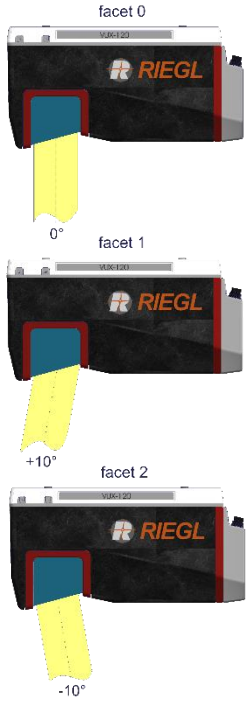
The ***RIEGL* VUX-120** sets a new era for *RIEGL*'s ULS-based product portfolio:

- to meet the specific demands of small fixed-wing UAVs
- scanner design optimized for high point density corridor mapping
- novel scanning scheme: NFB (Nadir / Forward / Backward) scanning

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RIEGL VUX-120: NFB Scanning





Nadir

Forward (+ 10°)

Backward (- 10°)

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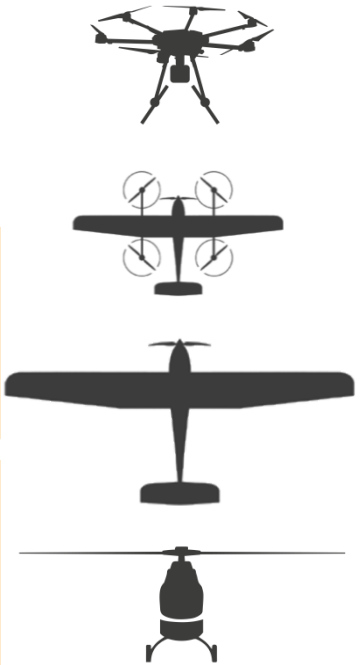
RIEGL VUX-120: Flight Parameters / Scan Pattern

Result Qualifier	SUCCESS					
Scanner Settings						
PRR:	300	kHz				
Laser Power:	100	%				
Scanrate:	171	lps	Angular Step Width:	0.0685	°	
FOV:	100	°				
Flight Parameters						
Flying Height AGL:	984	ft	300	m		
Flying Height AMSL:	984	ft	300	m		
Aircraft Speed:	54.4	kn	101	km/h	28.0	m/s
Scan Pattern	@ Min. Terrain Altitude					
Swath Width:	715	m	Lat. Strip Separation:	357	m	
Overlap Per Side:	357	m	Sidelap Per Side:	50.0	%	
Average Line Distance:	0.164	m	Line Dist. Per Facet:	0.491	m	
	Min.		Avg.		Max.	
Point Distance:	0.359	m	0.490	m	0.868	m
Total Point Density:	7.05	pts/m²	12.5	pts/m²	17.1	pts/m²
Footprint Diameter:	0.0848	m	0.116	m	0.132	m

AGL: 120 m (~ 400 ft)
speed: 10 m/s (20 kn)
point density: ~ **525 pts/m² (avg.)**
point density: ~ **715 pts/m² (max.)**

AGL: 130 m (~ 430 ft)
speed: 20 m/s (40 kn)
point density: ~ **250 pts/m² (avg.)**
point density: ~ **330 pts/m² (max.)**

AGL: 300 m (~ 1000 ft)
speed: 28 m/s (55 kn)
point density: ~ **12.5 pts/m² (avg.)**
point density: ~ **17 pts/m² (max.)**



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Camera Preview: “Industrial-Grade” Camera Solution

RIEGL VUX-120 front-end camera:
max. payload capacity: **700 g**

“industrial-grade“ camera:

- **36 MPx** (camera body: 225 g)
- **42 MPx** (camera body: 245 g)
- **61 MPx** (camera body: 255 g)

lenses:

- **+ 21 mm** Zeiss Ventum „industrial “lens (270 g)
- **+ 21 mm** Zeiss Loxia lens (415 g)



full camera system:

- 36 MPx + 21mm Zeiss Ventum = **496 g**
- 36 MPx + 21mm Zeiss Loxia = **640 g**

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UAV Platform Integration Examples

- various UAV platforms available
- user-friendly integrations
- *RIEGL* provides assistance for integration













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RiCOPTER UAS



Fully integrated turnkey solution

- MTOM: < 25kg
- up to 6.5kg sensor payload
- foldable arms, X8
- 4 x batteries with power management and balancing system
- up to 30 minutes endurance with full payload
- fully **redundant** system (main & backup flight control)
  - *RIEGL* own development – partly based on open-source
- live video & telemetry downstream to ground station display
- customizable frequencies (433, 868, 915 MHz)
  MAVLINK-based command and control link
- powerful telemetry functions (remote control, on-screen-display, etc.)
- optimized for operation of *RIEGL* VUX-SYS with RGB cameras





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RiACQUIRE-Embedded – web application

NEW

- simple web application
- accessible via any browser (mobile phone, PC, etc.)
- user-interface provides access to execute actions
- available with latest FW of V-line scanners (~ Q4/2021)

→ **change laser/camera configuration in an easy manner**





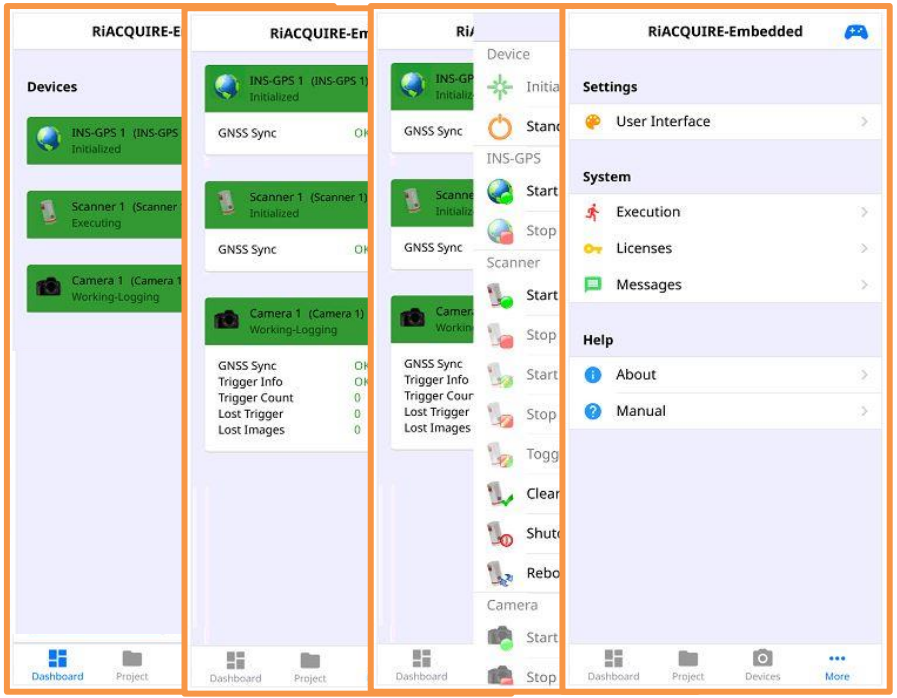


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RiACQUIRE-Embedded – web application

provides information for:

- **status information**
  initialized, executing, working-logging
- **laser configuration**
- **camera configuration**
- **project information**
  - number of records, images, files size



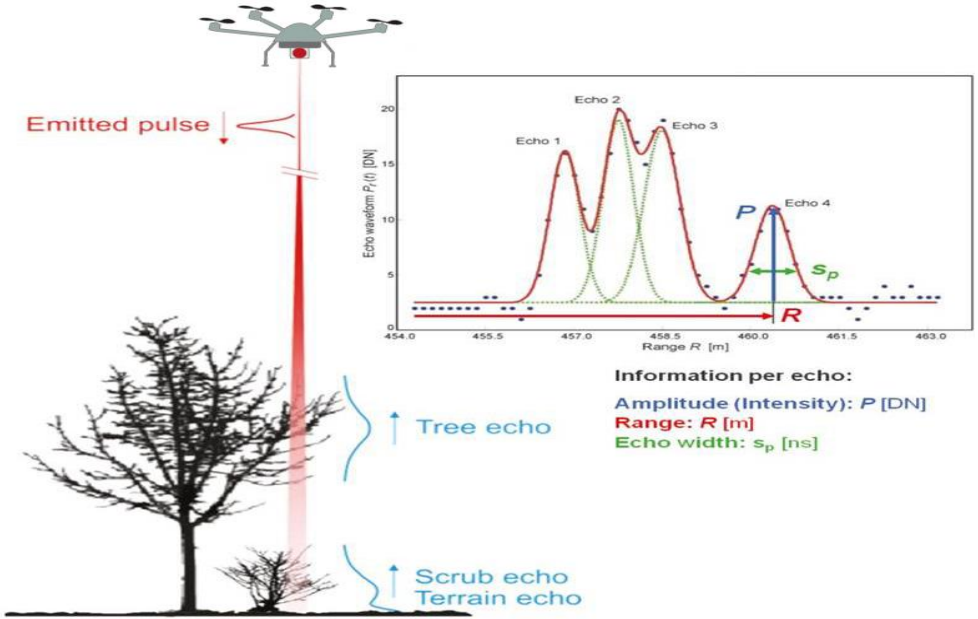
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Key Features

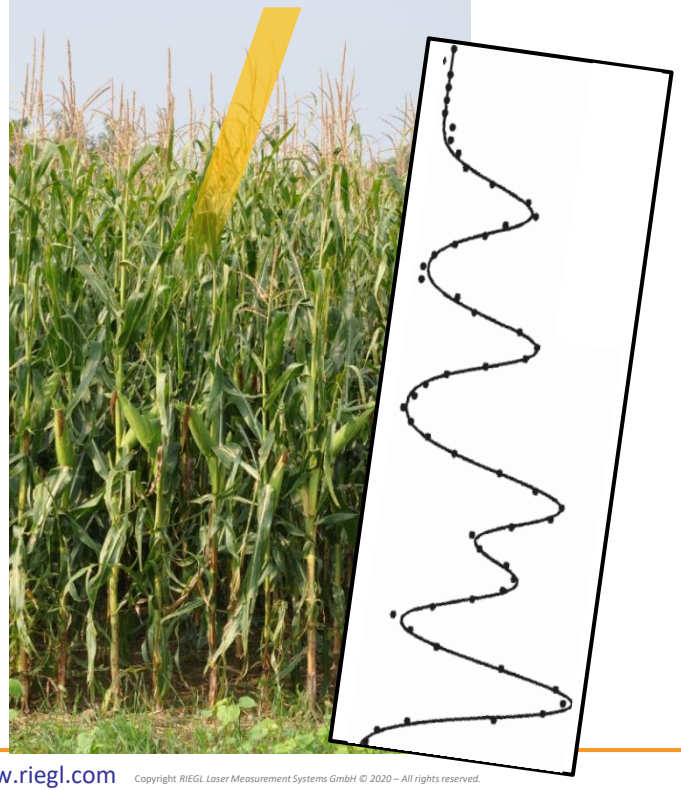
- online waveform processing technique enables
  - multiple target capability
  - high measurement accuracy
  - calibrated reflectance

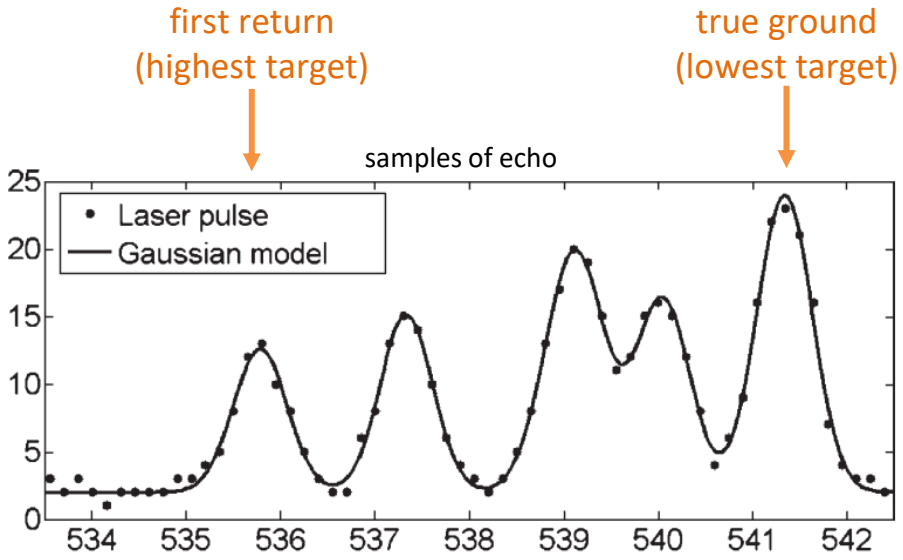




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Time of flight - multitarget

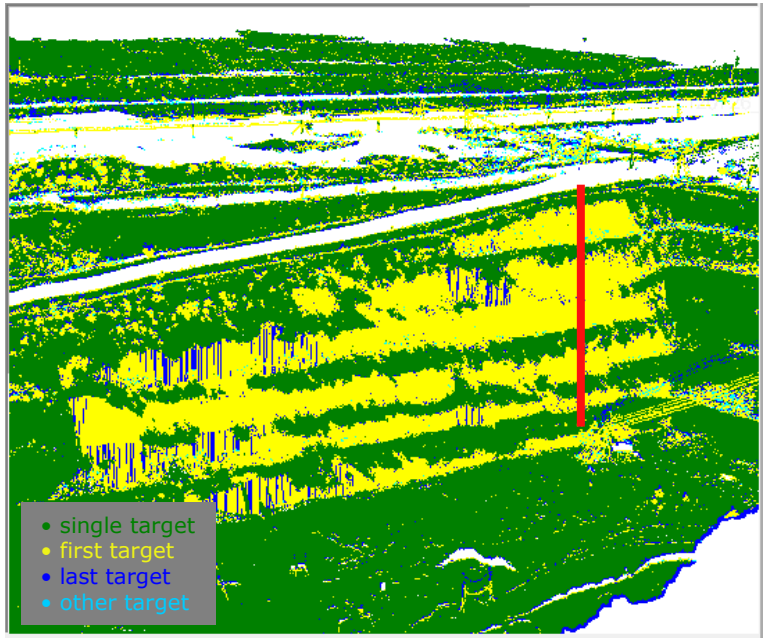




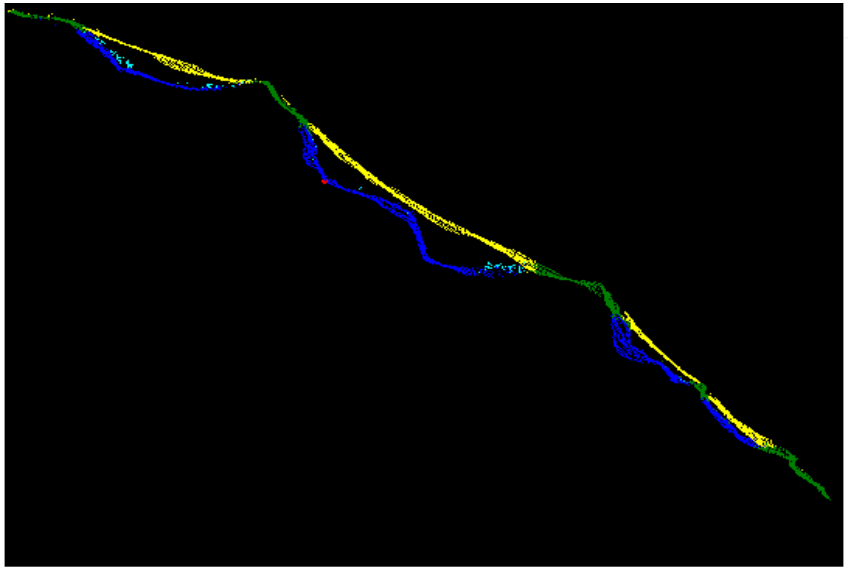
clear separation of target returns

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multiple target capability



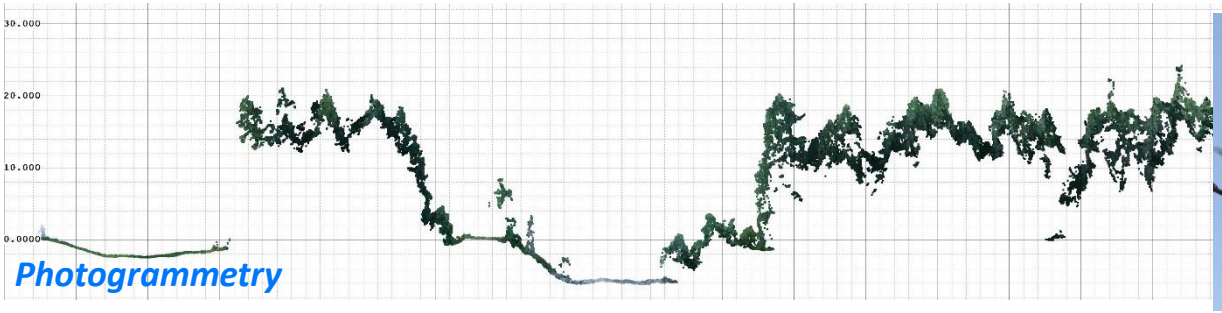
enables penetration of fine meshes



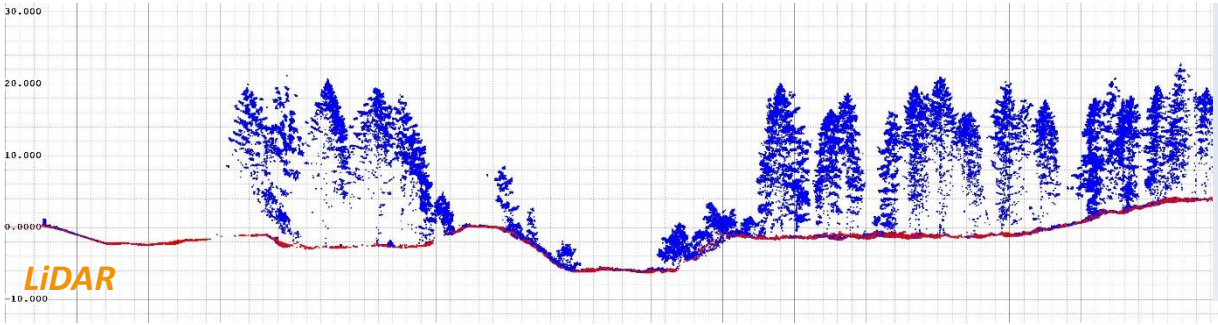
fine meshes are classified showing target reflectance values

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LiDAR / Photogrammetry







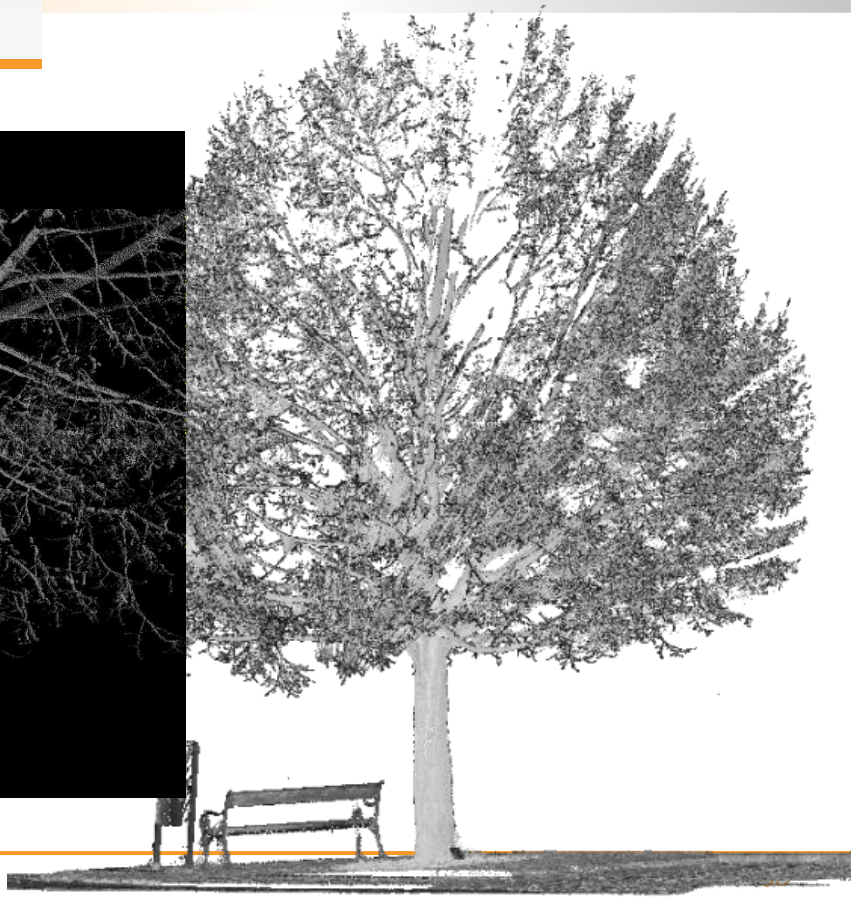


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Pulse shape deviation

cleaned-up point cloud





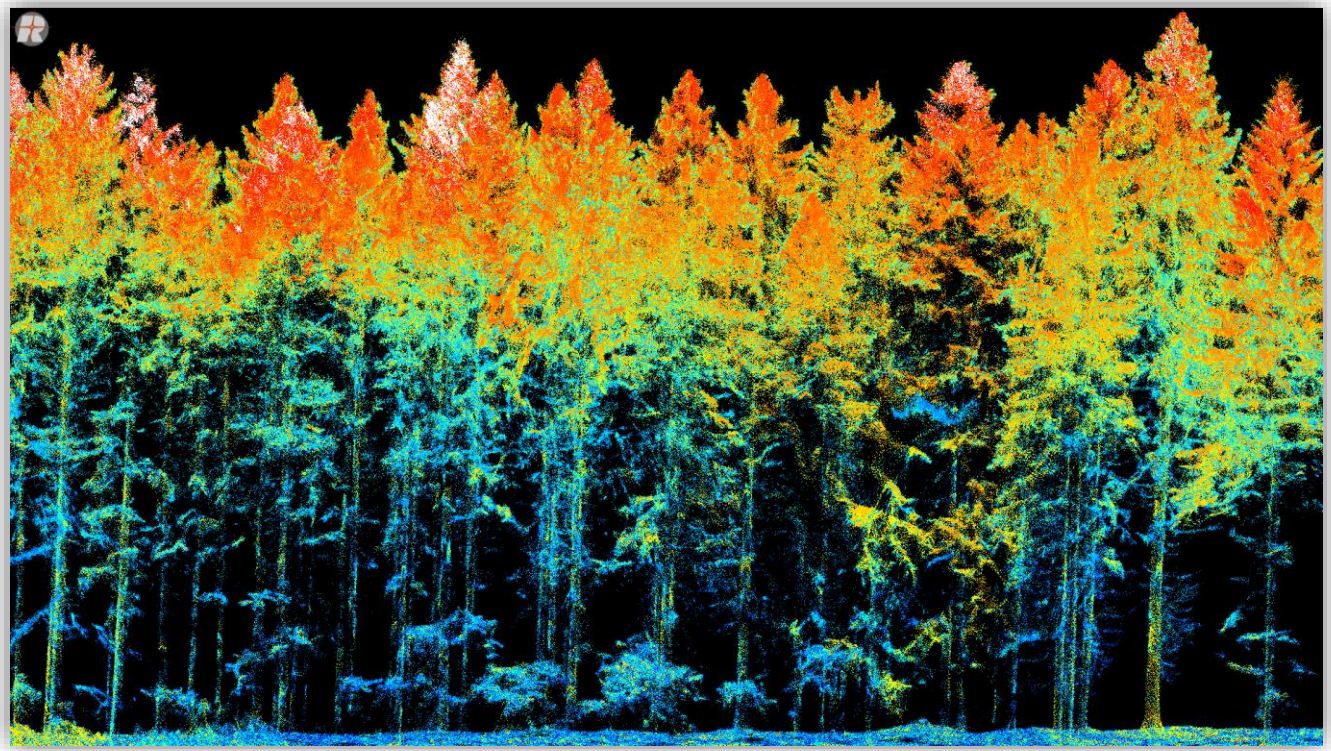
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Intensity vs Reflectance



Usage Application: Forestry



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Vegetation Analysis



RIEGL VUX-1UAV on RiCOPTER

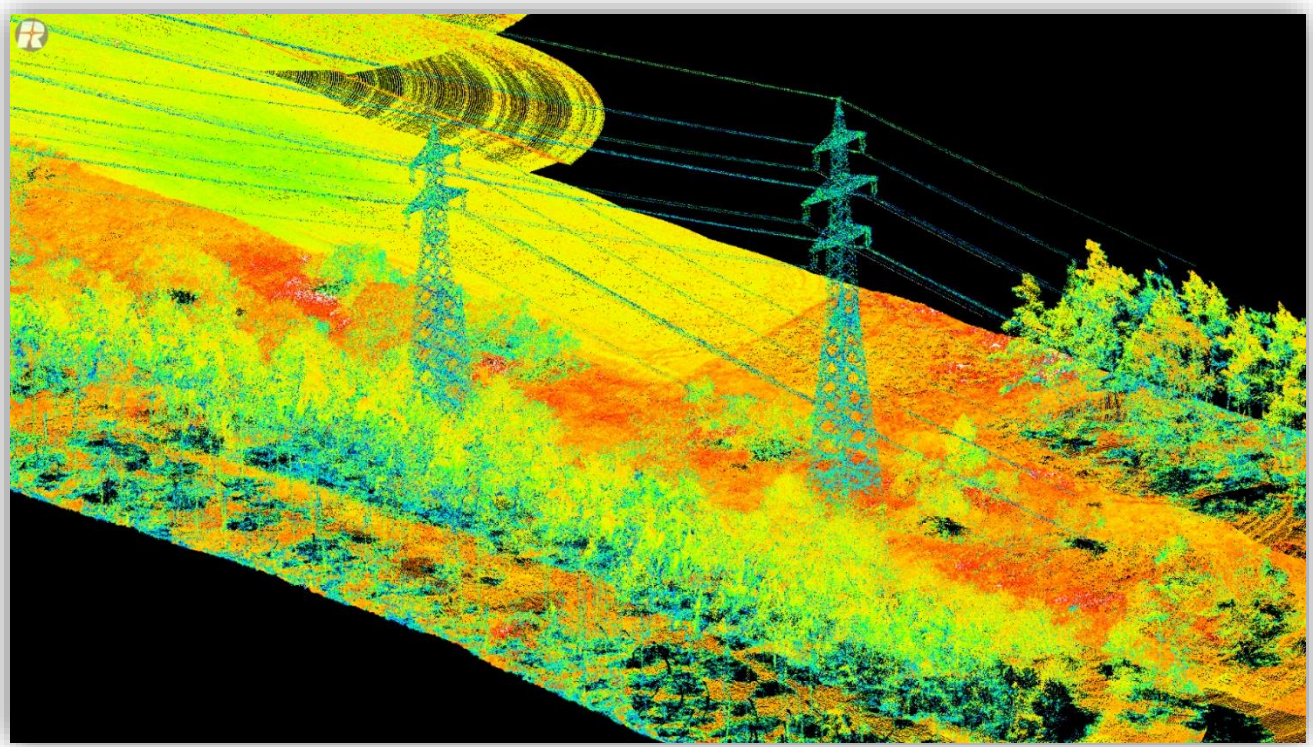
• AGL	50 m
• speed	7 m/s
• PRR	550 kHz
• LPS	125
• density	250 meas/m²
• acq. area	15 acres
• acq. time	29 min
• acq. pts	280 millions

sample data

• area	720 m²
• tree height	35 m
• points	4.6 millions

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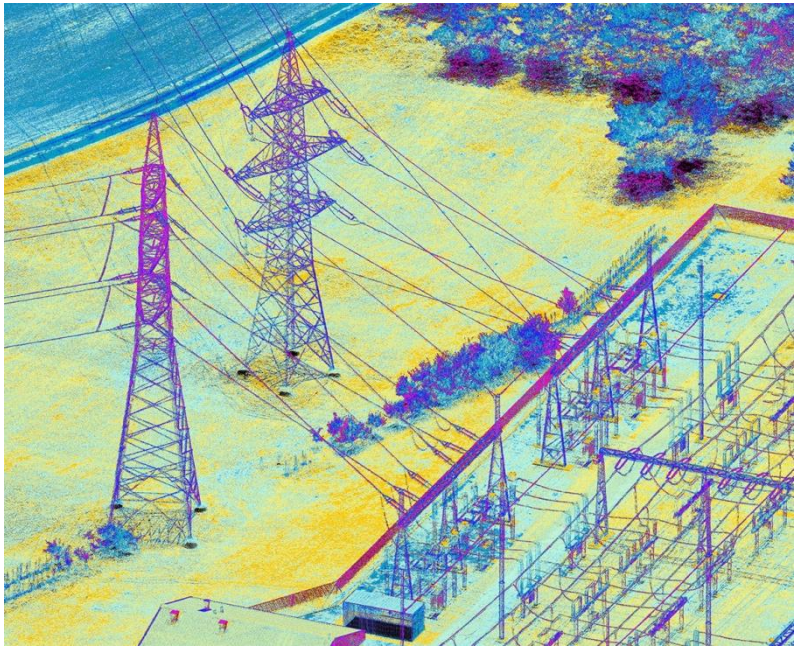
Usage Application: Powerlines / Utilities



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LiDAR pointclouds – power line survey





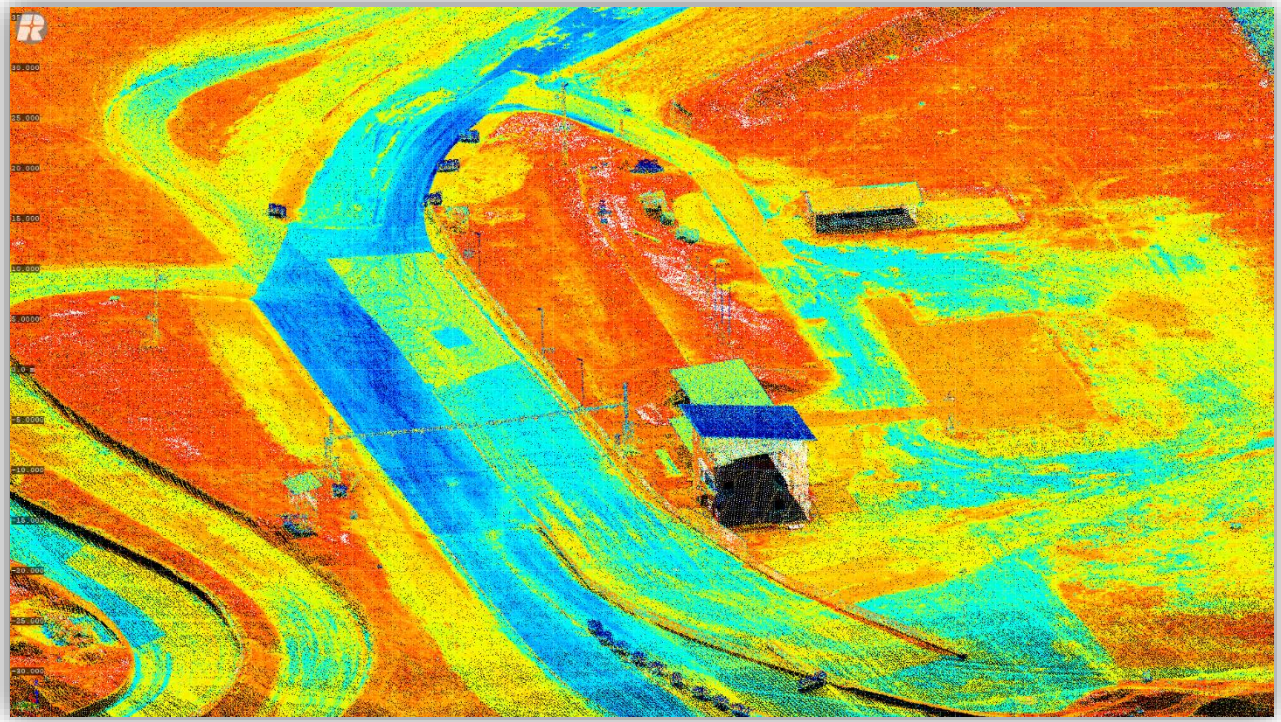
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Usage Application: Transportation



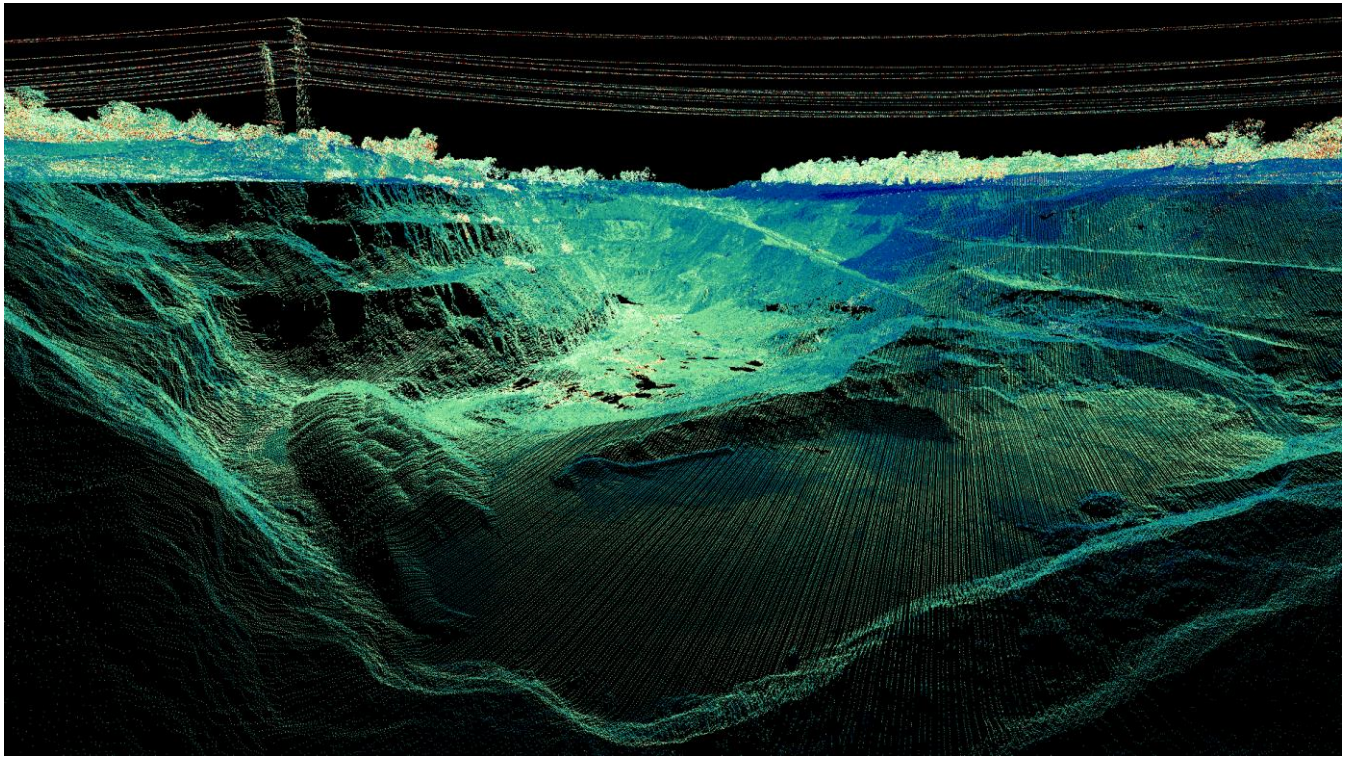
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Usage Application: Pavement Assessment



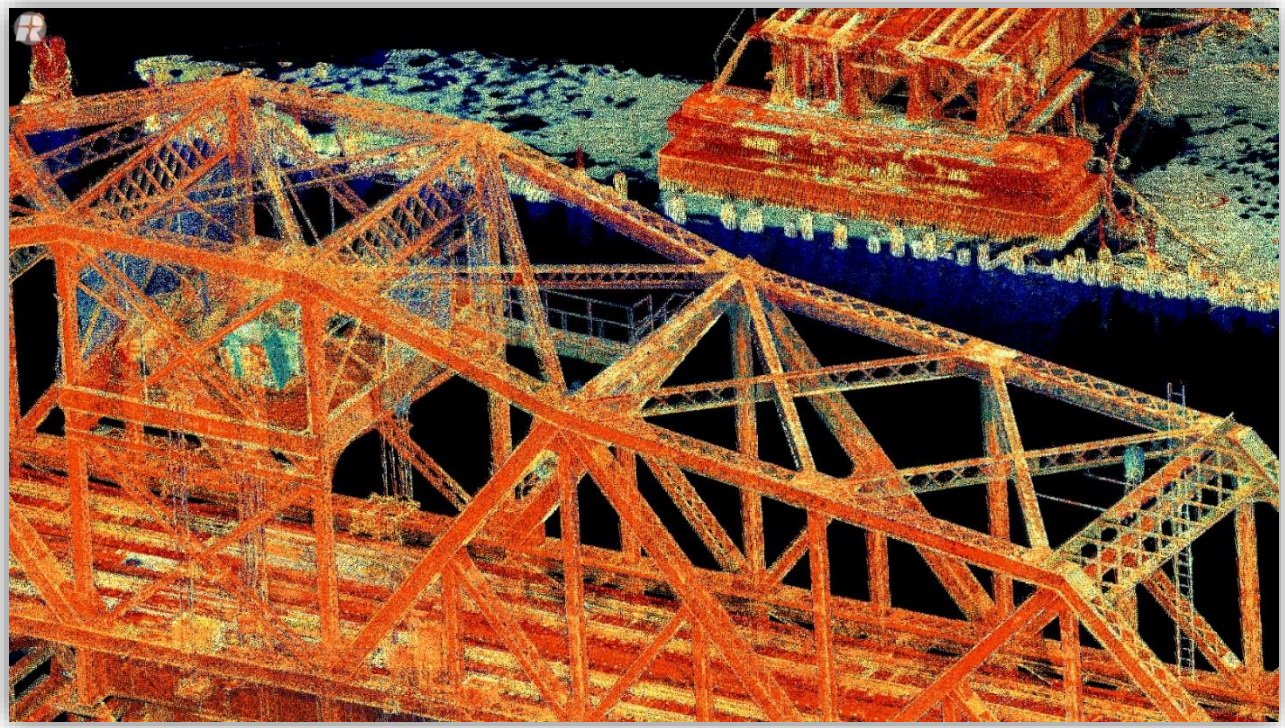
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Usage Application: Open Cast Mining



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Usage Application: Bridge Inspection / Critical Infrastructure



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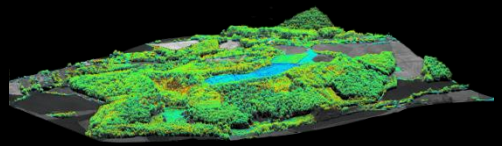
Usage Application: Geophysical Risk Assessment & Management



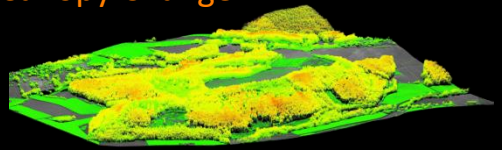
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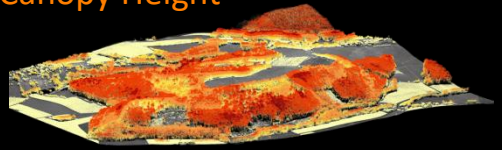
Environmental Monitoring / Multi-Target-Capability



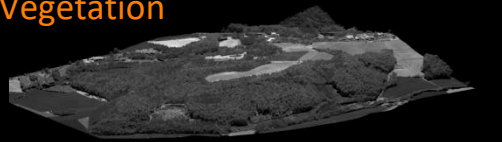
Canopy Change



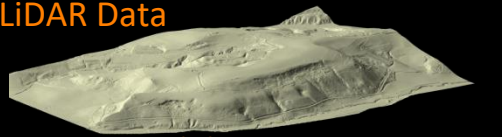
Canopy Height



Vegetation

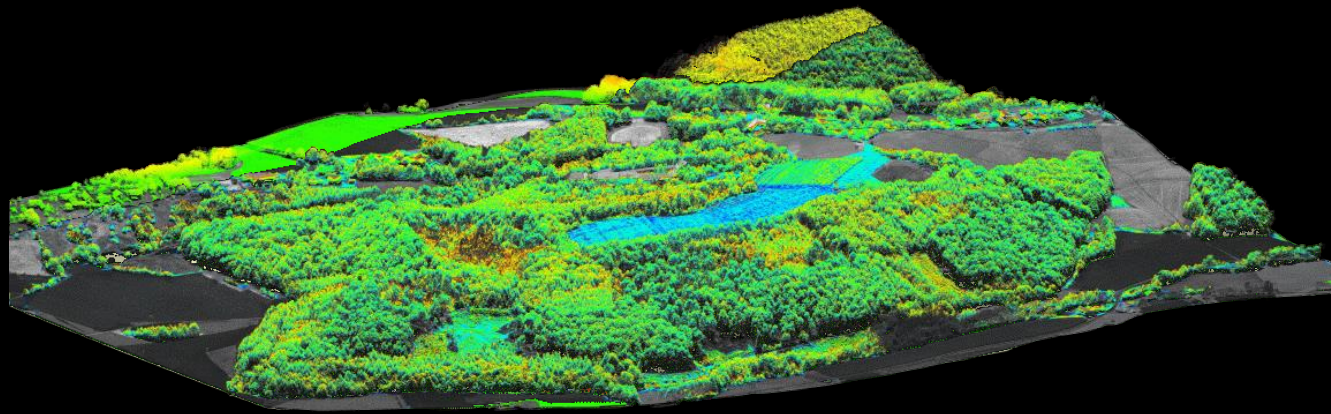


LiDAR Data

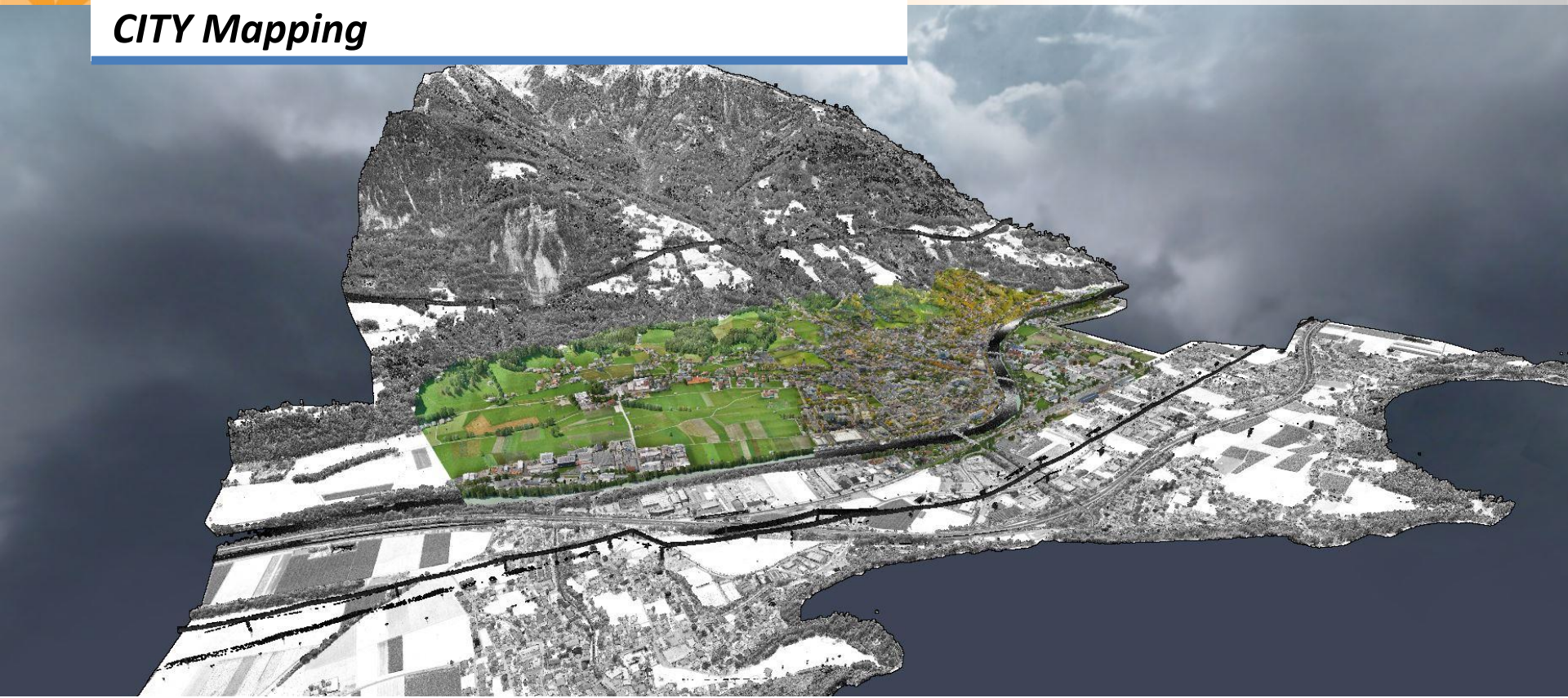


Terrain Model

Layers of Information



CITY Mapping

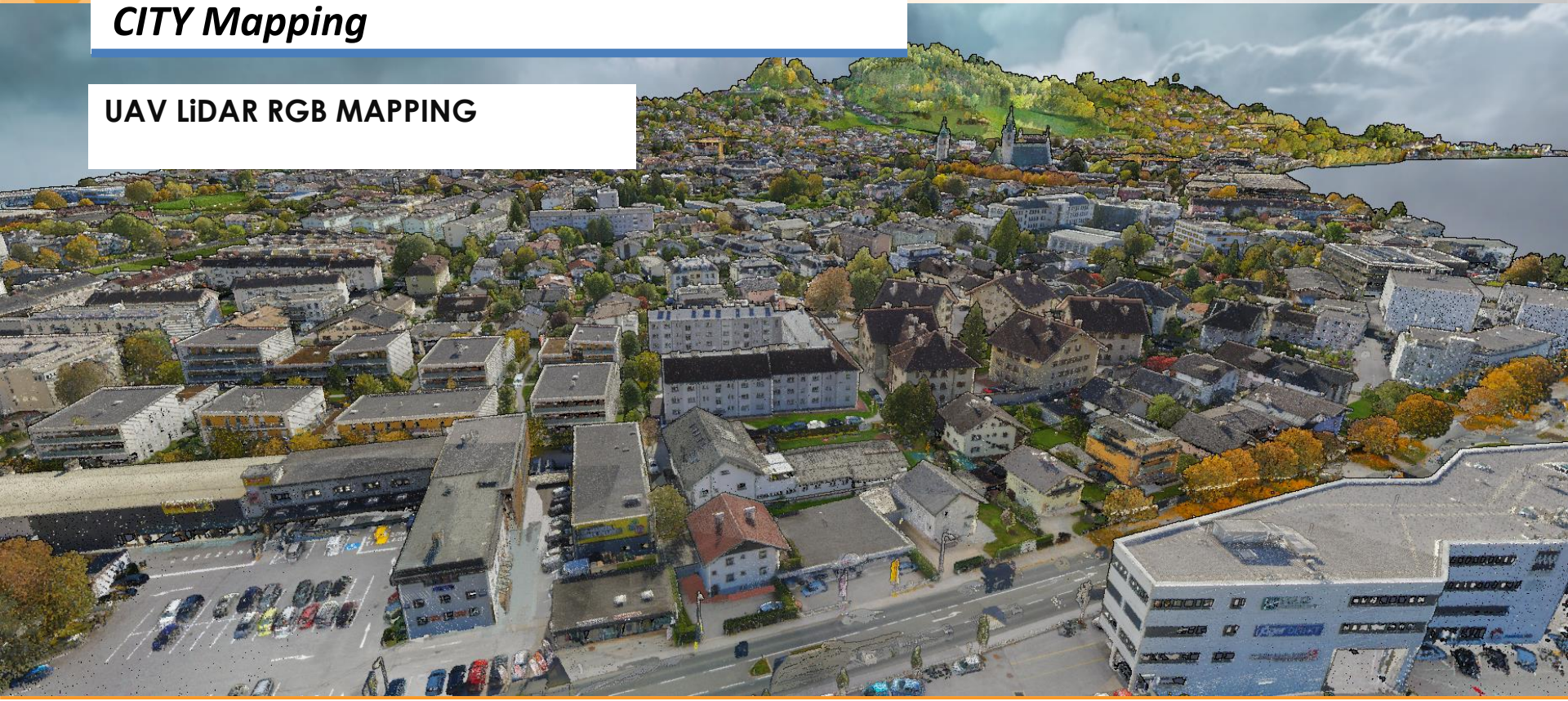


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CITY Mapping

UAV LiDAR RGB MAPPING



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