



*Airborne laser scanning systems for
highly efficient wide-area mapping
- technological insights*

Peter Rieger



January 29th, 2025



RIEGL Headquarters



RIEGL Subsidiaries



RIEGL Distributors

Headquarters Austria



On the roof of the building: This is also where the long-range capabilities of the terrestrial laser scanners are tested.

Auf dem Dach des Gebäudes: Hier werden auch die Messeigenschaften der terrestrischen Laserscanner bei größeren Entfernungen überprüft.

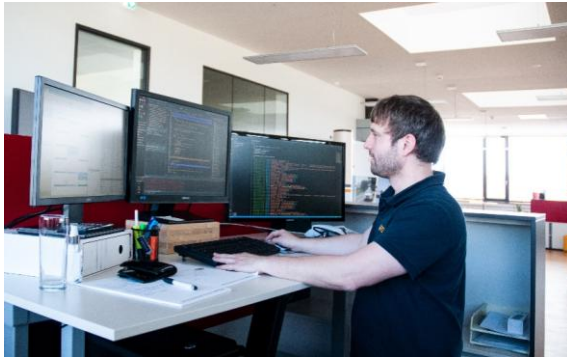
The production building in Horn has been available since 2021, doubling the available operating space. More than 26,900 square feet of additional working space expand the necessary company infrastructure to enable an efficient and up-to-date R&D and production.

2021 konnte das zusätzliche Produktionsgebäude in Horn bezogen werden. Mehr als 2.500 m² zusätzliche Arbeits- und Aufenthaltsfläche erweitern die Unternehmensinfrastruktur und ermöglichen so eine effiziente und zeitgemäße Forschung, Entwicklung und Produktion.

Headquarters Austria

In addition to the best-equipped office rooms and conference rooms, the building houses a completely new production line. The heart of the facility are two fully automatic pick-and-place machines with upstream laser-based PCB marking and following quality control by an optical diagnostic device.

Neben den bestausgestatteten Büro- und Konferenzräumen beherbergt das Gebäude eine komplett neue Fertigungsstraße. Herzstück der Anlage sind die beiden vollautomatischen Hochleistungs-Bestückungsmaschinen mit vorgelagerter laser-gestützter Platinenbeschriftung und Qualitätskontrolle durch ein optisches Diagnosegerät.



Firmware and Software department
Firmware- und Software-Abteilung



PCB (Printed Circuit Board) production
Leiterplatten-Produktion



UAV-sensor production
UAV-Sensoren-Produktion

Headquarters Austria



Directly between the buildings in Riedenburgstraße 48 and 56, the mechanical workshop is situated. Here, the CNC production is located and enables *RIEGL* to manufacture complex mechanical components for the scanners.

Direkt zwischen den Gebäuden in der Riedenburgstraße 48 und 56 befindet sich die mechanische Werkstatt. Hier ist die CNC-Fertigung untergebracht und ermöglicht es RIEGL, komplexe Mechanikteile für die Scanner herzustellen.



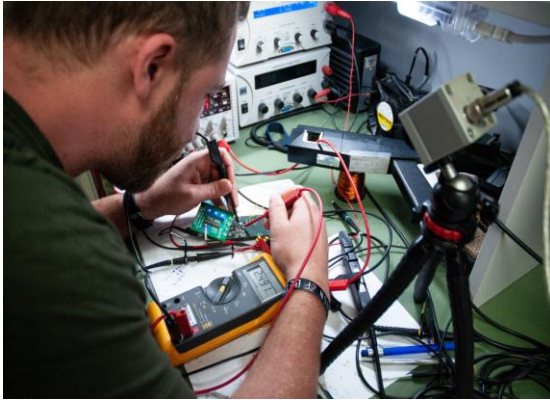
Headquarters Austria



High-quality technical equipment and facilities in the hands of highly qualified and motivated employees are the basis for the production of first-class innovative sensors.

Hochwertige technische Ausstattung und Ausrüstung in den Händen von hochqualifizierten und motivierten Mitarbeitern ist die Basis für die Herstellung erstklassiger innovativer Sensoren.

A look into scanner production | *Blick in die Scanner-Produktion*



Headquarters Austria



Marketing, sales, training, and administration are located in a marvelous building erected around 1900 in Prokschgasse 4, a cross street to Riedenburgerstraße.

Marketing, Vertrieb, Schulung und Verwaltung befinden sich in einem wunderschönen, um 1900 errichteten Gebäude in der Prokschgasse 4, einer Querstraße zur Riedenburgerstraße.



The special flair of the building is skillfully combined with the most modern equipment.

Das besondere Flair des Gebäudes verbindet sich gekonnt mit modernster Ausstattung.



RIEGL Hangar in Krems-Gneixendorf



In addition, the construction of a company hangar for the *RIEGL* surveying aircraft, which are primarily used for test and calibration flights of the airborne surveying systems manufactured in Horn, is underway at the nearby Krems-Gneixendorf airfield.

Darüber hinaus ist am nahegelegenen Flugplatz Krems-Gneixendorf der Bau eines Firmenhangars für die RIEGL Vermessungsflugzeuge im Gange, die vor allem für Test- und Kalibrationsflüge der in Horn hergestellten luftgestützten Vermessungssysteme eingesetzt werden.



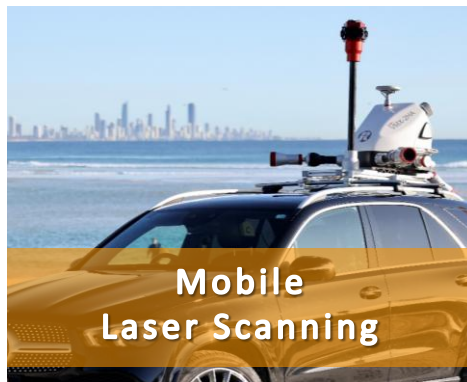
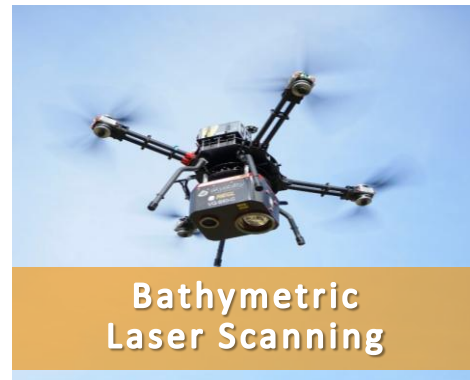
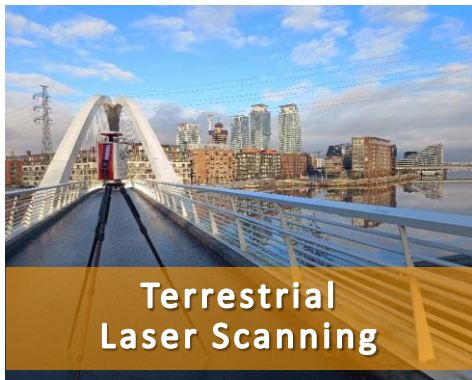
RIEGL Aircraft



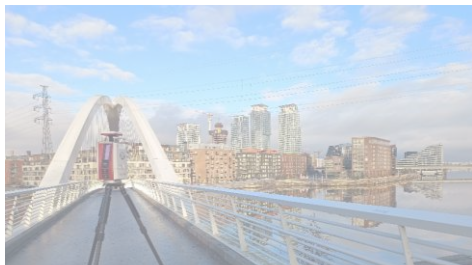
Two RIEGL planes are available for the verification of RIEGL airborne laser scanners and laser scanning systems as well as for demo flights.

Zwei RIEGL-eigene Flugzeuge stehen für die Überprüfung der Leistungsdaten von RIEGL airborne Laserscannern und Systemen - aber auch für Demoflüge - bereit.

RIEGL product fields



RIEGL product fields – Airborne Laser Scanning



**Terrestrial
Laser Scanning**



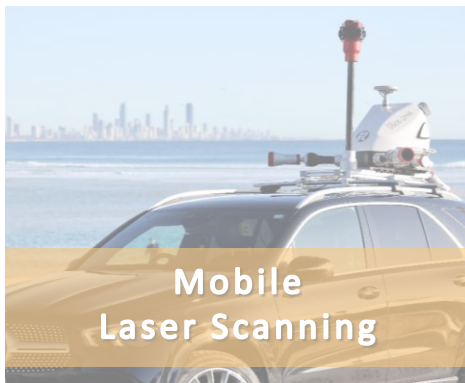
**Airborne
Laser Scanning**



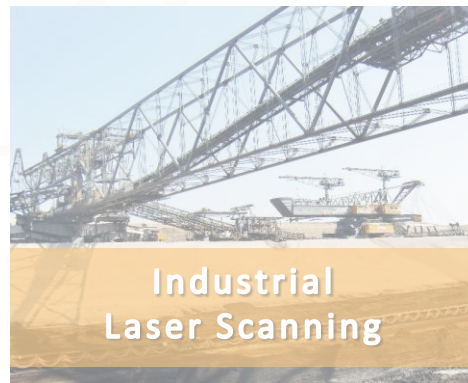
**Bathymetric
Laser Scanning**



**UAV-based
Laser Scanning**



**Mobile
Laser Scanning**



**Industrial
Laser Scanning**

RIEGL ALS product portfolio - 2024



The image displays a variety of RIEGL Airborne Laser Scanning (ALS) products, including handheld units, backpack units, and aircraft-mounted systems. The background features a 3D point cloud of a mountain range. Orange lines connect specific aircraft to their corresponding product categories: a helicopter to handheld units, a propeller plane to backpack units, and a twin-engine jet to aircraft-mounted systems. The products are arranged in a row, each with its name and specifications listed below it.

Product	Frequency	Field of View (FoV)	Altitude
VUX-160 ²³	2.4 MHz	75° FoV	885m AGL
VUX-240 ²⁴	2.4 MHz	75° FoV	885m AGL
VQ-480 II	2 MHz	75° FoV	1200m AGL
VQ-580 II-S	2 MHz	75° FoV	2200m AGL
VQ-680	2.4 MHz	60° FoV N/F/B	2300m AGL
VQ-780 II-S	2 MHz	60° FoV	3900m AGL
VQ-1260/1460	2.2 / 4.4 MHz	60° FoV	4400m AGL
VQ-1560 III-S	2 x 2.2 MHz	58° FoV	3900m AGL

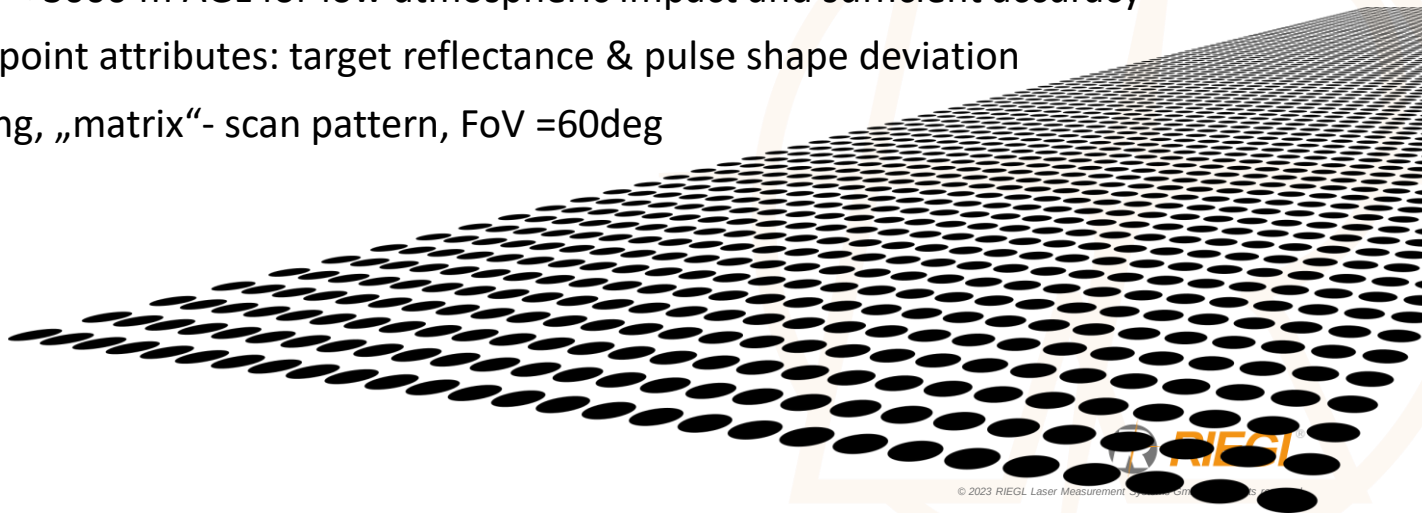
New!

RIEGL's view on wide area mapping



- USGS QL0/QL1
- area > 100km²
- length of straight flight lines of less than 20 min
- GNSS base station distance < 20 km or virtual base stations
- typ. flying altitudes < 3000 m AGL for low atmospheric impact and sufficient accuracy
- scan data contains point attributes: target reflectance & pulse shape deviation
- regular point spacing, „matrix“- scan pattern, FoV =60deg

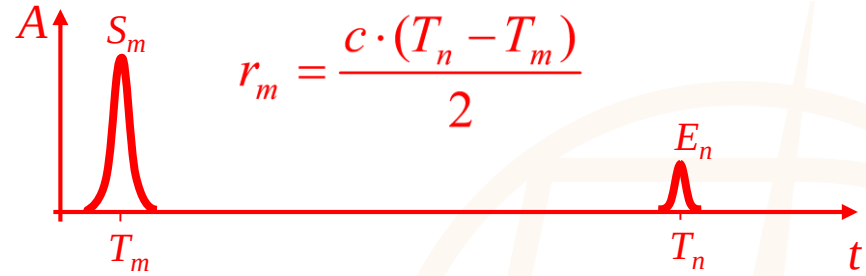
USGS QUALITY LEVEL	VERTICAL ACCURACY RMSEz (cm)	NOMINAL PULSE SPACING	NOMINAL POINT DENSITY
QL0	5 cm	<= 0.35 m	>= 8 pts/m ²
QL1	10 cm	<= 0.35 m	>= 8 pts/m ²



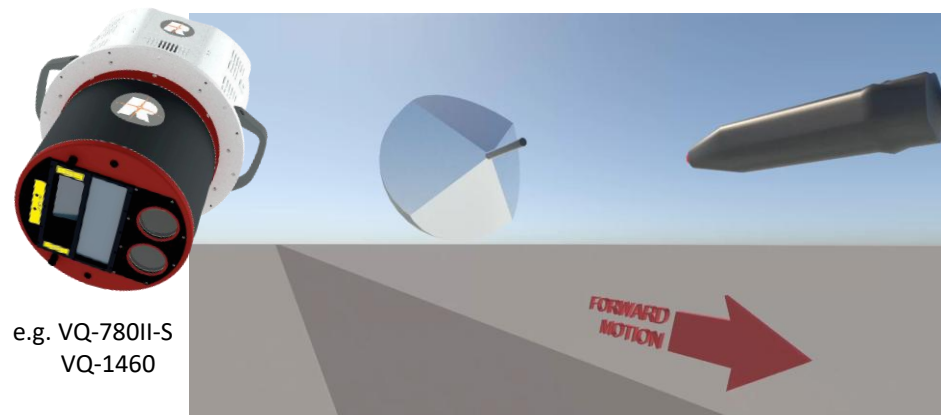
RIEGL's core technologies

- Time-of-flight measurement
- Scanning mechanisms tailored for specific applications
- Full-waveform digitization and online waveform processing
- MTA – resolving range ambiguities
- Near range target suppression – gapless data acquisition

The principle of time-of-flight measurements

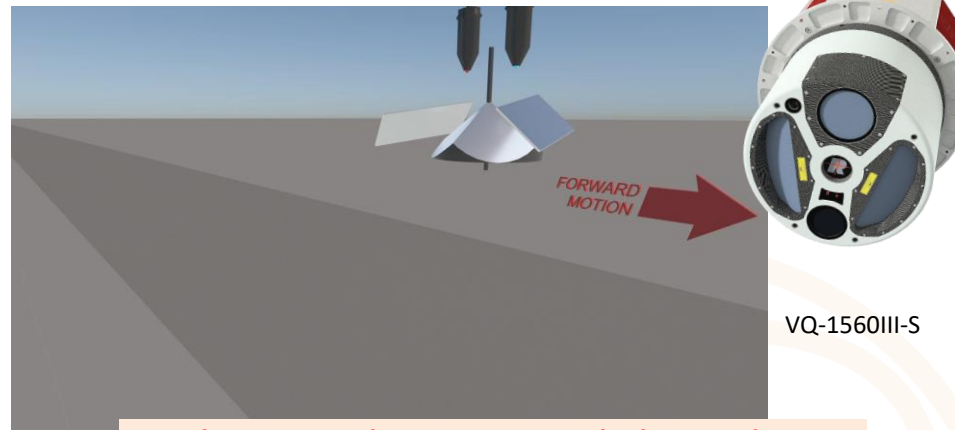


RIEGL's scanning mechanisms for ALS



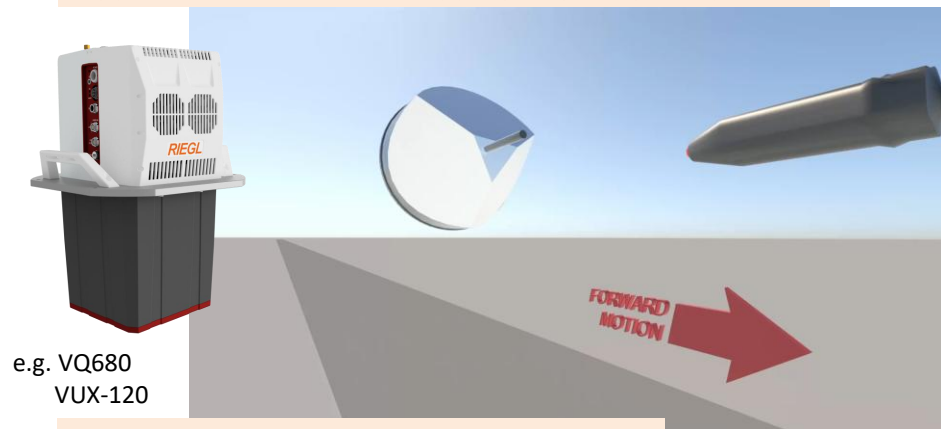
e.g. VQ-780II-S
VQ-1460

Applications: wide area mapping, regular point pattern



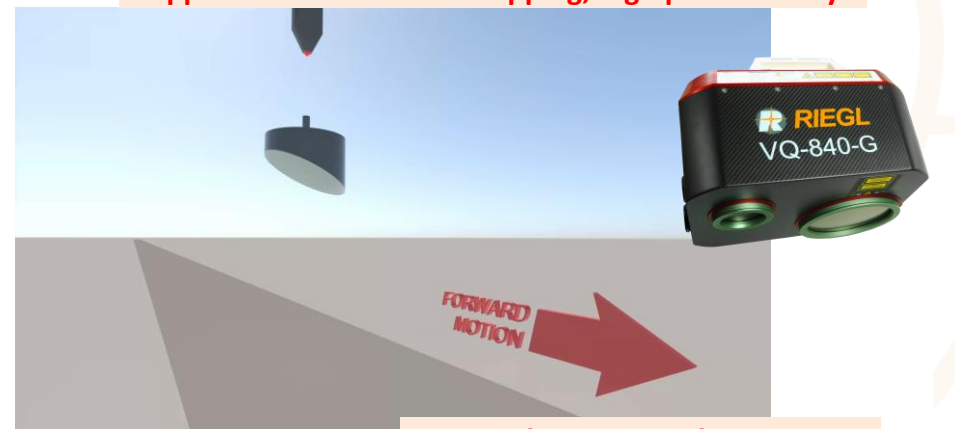
VQ-1560III-S

Applications: wide area mapping, high point density



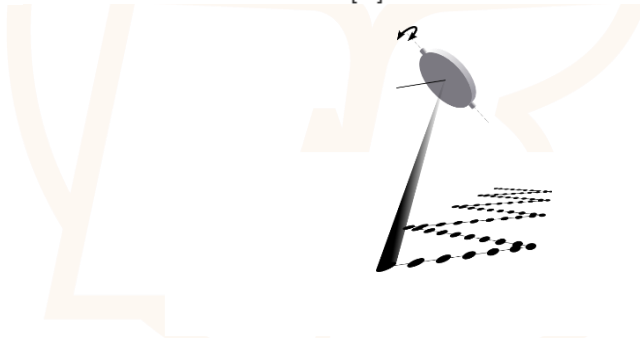
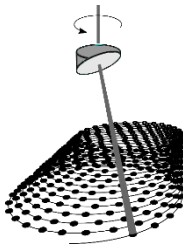
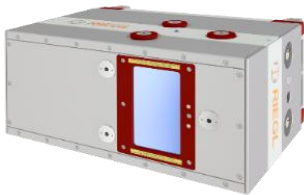
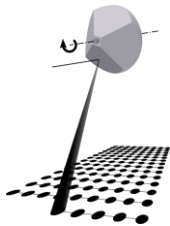
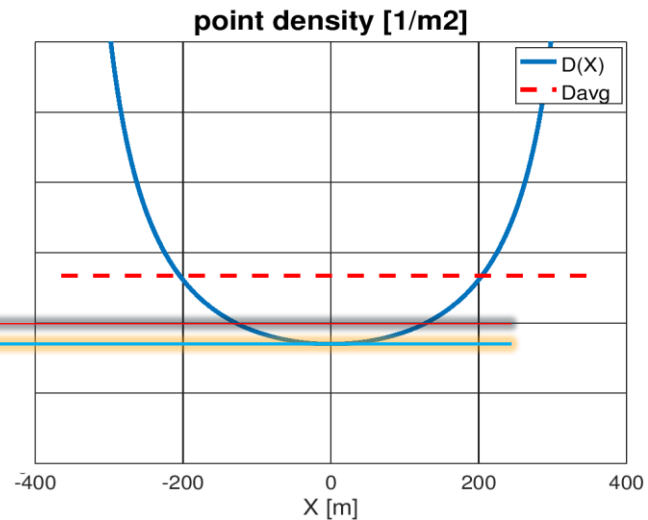
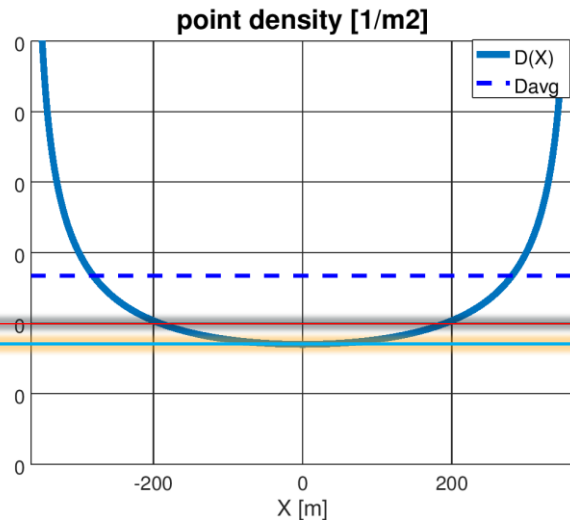
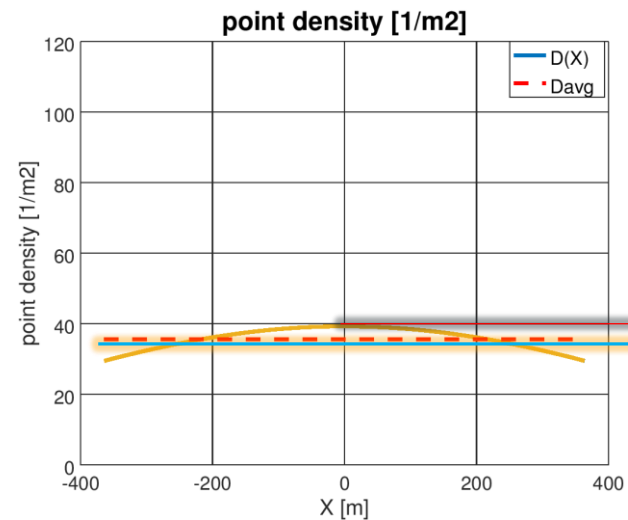
e.g. VQ680
VUX-120

Applications: city and corridor mapping

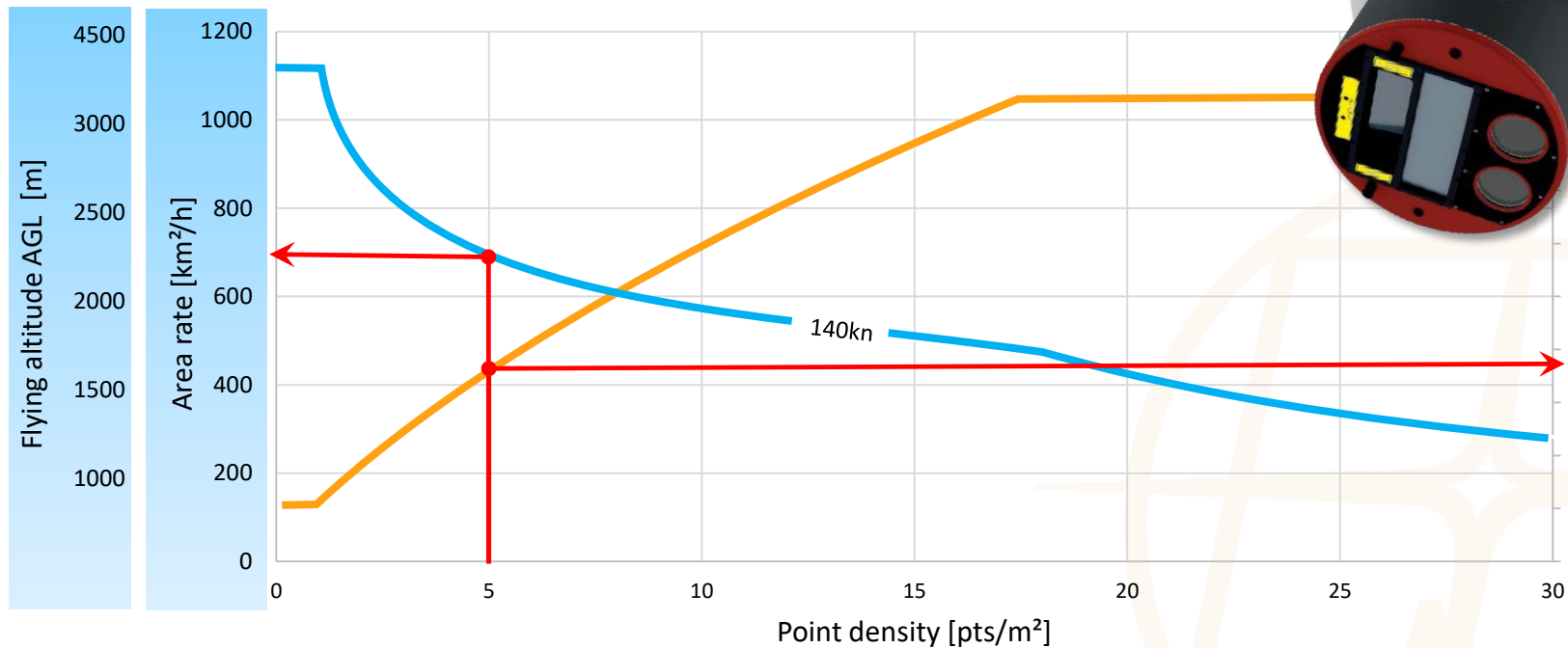


Applications: Bathymetry

Nominal point density across track



Data acquisition efficiency: VQ-1460



operational constraints: flying speed 140kn, sidelap 20%, target reflectance $\rho = 20\%$, $h_{AGL} \geq ENOHD$
effective scan time - no turns included

...supported by **RIPARAMETER**



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RiPARAMETER

<http://www.riegl.com/members-area/software-downloads/>

Scanner Type



VQ-1460 [Preliminary]

Project Requirements

Project Type:

Wide Area Mapping

Uniform Point Pattern:

ON

Total Point Density:

Avg.

40.0

pts/m²

Sidelap Per Side:

20.0

%

Terrain

Min. Altitude (AMSL):

0.00

ft

0.00

m

Terrain Variation:

0.00

ft

0.00

m

Flight Height Constraints

Min. Height (AGL):

0.00

ft

0.00

m

Max. Height (AGL):

0.00

ft

0.00

m

Max. Altitude (AMSL):

0.00

ft

0.00

m

Laser Safety:

Observe ENOHD

Surface / Target / Atmosphere

Min. Reflectance:

20.0

%

Target Type:

Topography

Object Diameter:

0.1

m

Visibility:

23km Standard Clear

Aircraft

Select Aircraft:

Cessna T206H STATIONAIR

Min. Speed:

70.00

kn

129.64

km/h

Max. Speed:

140.00

kn

259.28

km/h

Max. Altitude (AMSL):

26000.00

ft

7924.80

m

Result Qualifier

SUCCESS

Scanner Settings

PRR:

2 x 2182

kHz

Laser Power:

100

%

Scan Rate:

391

lps

Angular Step Width:

0.00810

°

FOV:

60.00

°

Lag-Angle Comp. Height:

1130

m

Flight Parameters

Flying Height AGL:

3339

ft

1018

m

Flying Height AMSL:

3339

ft

1018

m

Aircraft Speed:

121

kn

225

km/h

62.4

m/s

Scan Pattern

@ Min. Terrain Altitude

Swath Width:

1175

m

Lat. Strip Separation:

940

m

Overlap Per Side:

235

m

Sidelap Per Side:

20.0

%

Line Distance:

0.159

m

Interlaced Point Distance:

Min.

0.143

m

Avg.

0.158

m

Max.

0.191

m

Total Point Density:

32.8

pts/m²

39.7

pts/m²

43.7

pts/m²

Footprint Diameter:

0.234

m

0.246

m

0.270

m

MTA Details

MTA Zone Width:

69.0

m

Show list of MTA zone transitions

MTA Zones Used:

15

18

Productivity

Net Area Rate:

211

km²/h

Typ. Data Rate:

2 x 94.3

GB/h

Max. Data Rate:

2 x 194

GB/h

Laser Safety Information

Total NOHD:

143

m

14%

50%

100%

Total ENOHD:

1001

m

98%

Auxiliary Limits

Max. Meas. Range:

1243

m

59%

100%

Scanrate-Range-Prod.:

486348

m³/lps

30%

0%

100%

SETTINGS



Flight Height= 1018m AGL

FOV= 60.00°

NOHD= 143m

ENOHD= 1001m

MTA 15

MTA 16

MTA 17

Min. Flight Height= 0m

Terrain Altitude= 0m

Swath Width= 1175m

Terrain Variation= 0m

Overview, subsampled by a factor of 368

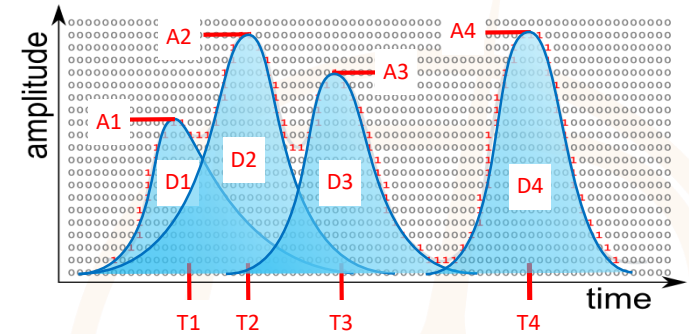
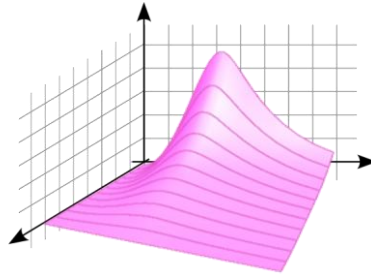
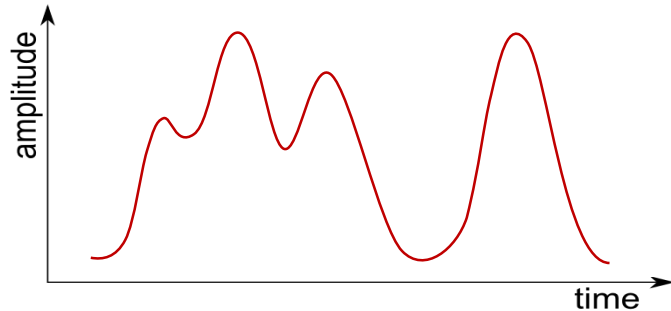
Zoom to section of max. point density

Zoom to section of min. point density

Zoom to section of avg. point density

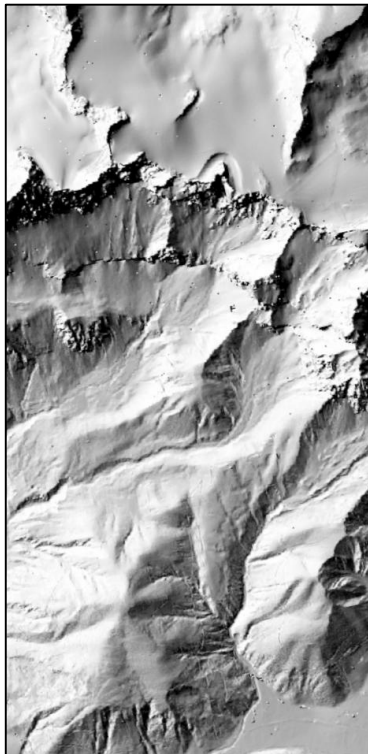
Echo digitization and (online) waveform processing

Echo reception and digitization → System response pulse fitting → Parameter estimation



- precise time stamps, distance and coordinates
- calibrated echo amplitude in [dB], relative to receiver detection limit, range dependent
- calibrated target reflectance in [dB], relative to white Lambertian diffusely reflecting target, range independent
- pulse shape deviation

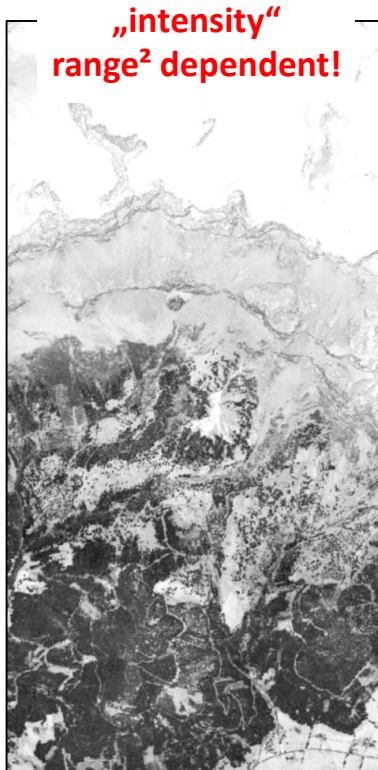
RIEGL point attributes: Amplitude, Reflectance, Deviation



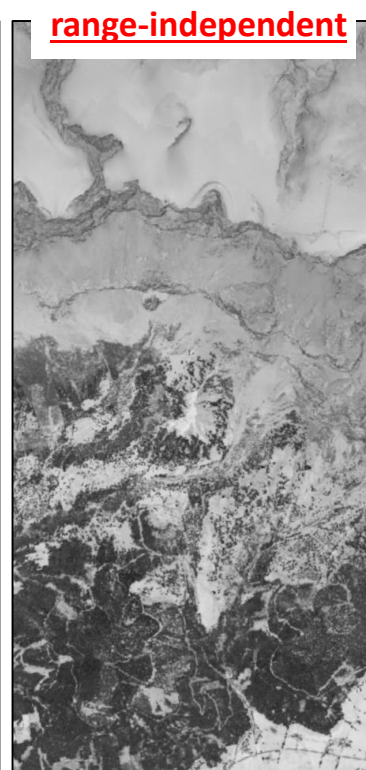
shaded relief



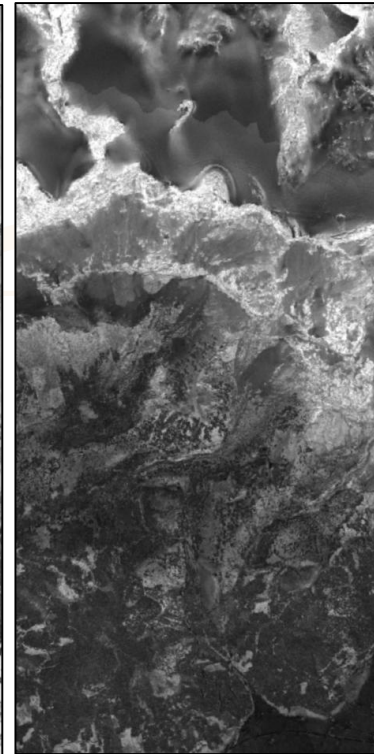
abs. height



$$A_{dB} = 10 \cdot \log\left(\frac{P_{echo}}{P_{DL}}\right)$$



$$\rho_{rel} = 10 \cdot \log\left(\frac{P_{echo}}{P_{Ref}(R)}\right)$$

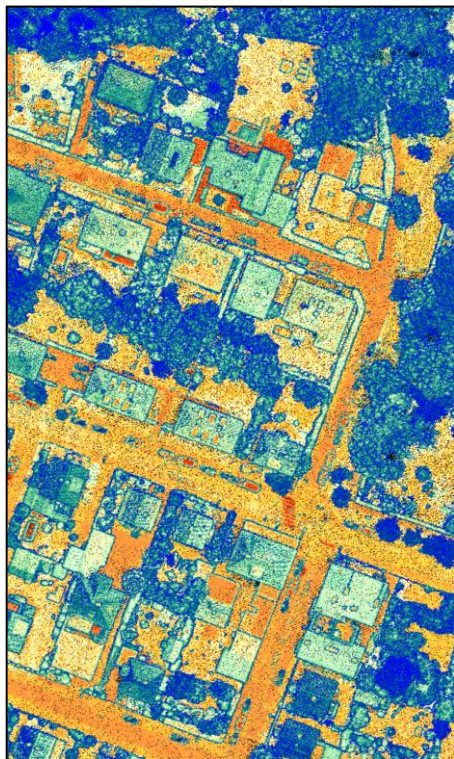


$$\delta = \sum_i^N |s_i - p_i|$$

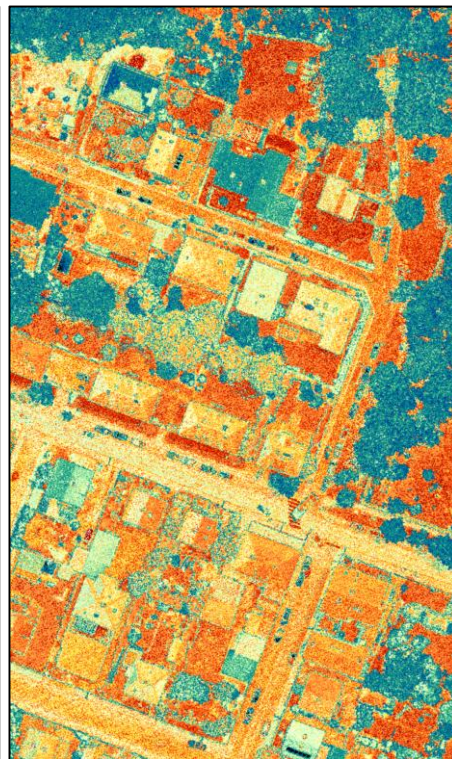
Multispectral laser scanning - Reflectance



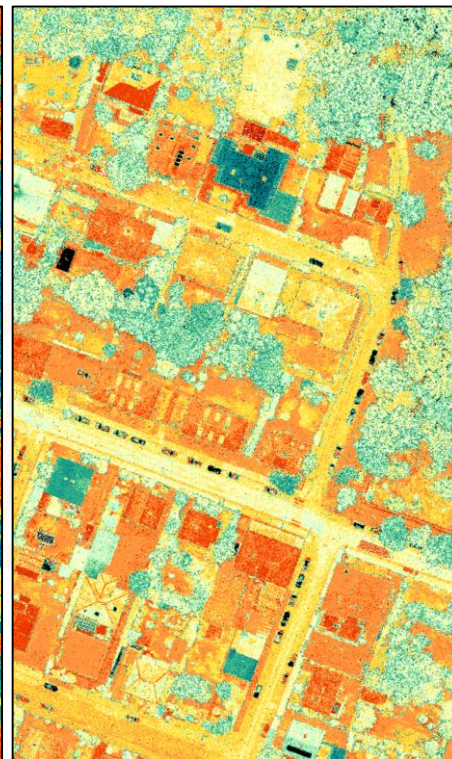
RGB



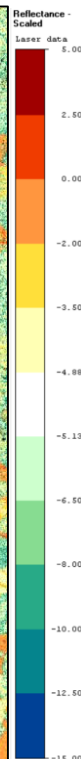
532nm



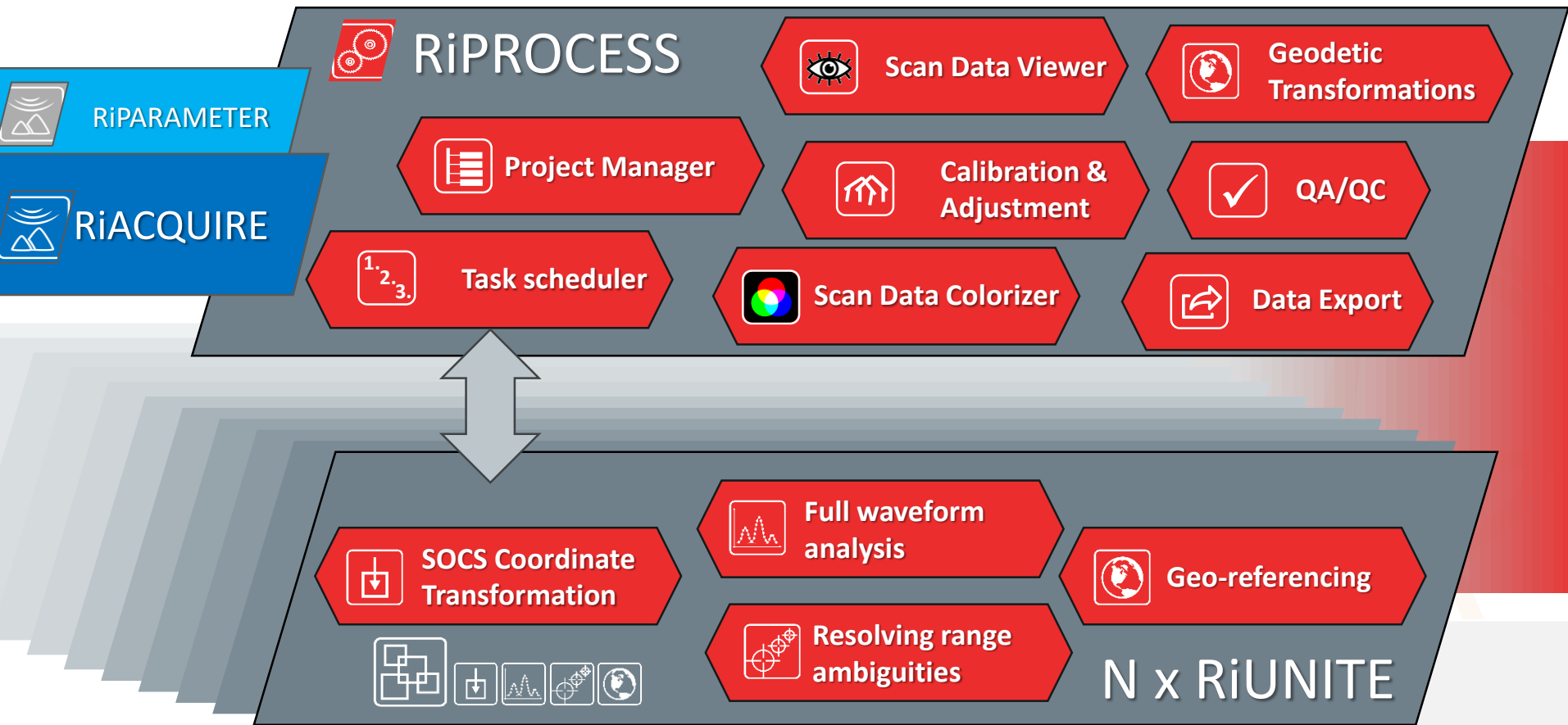
1064nm



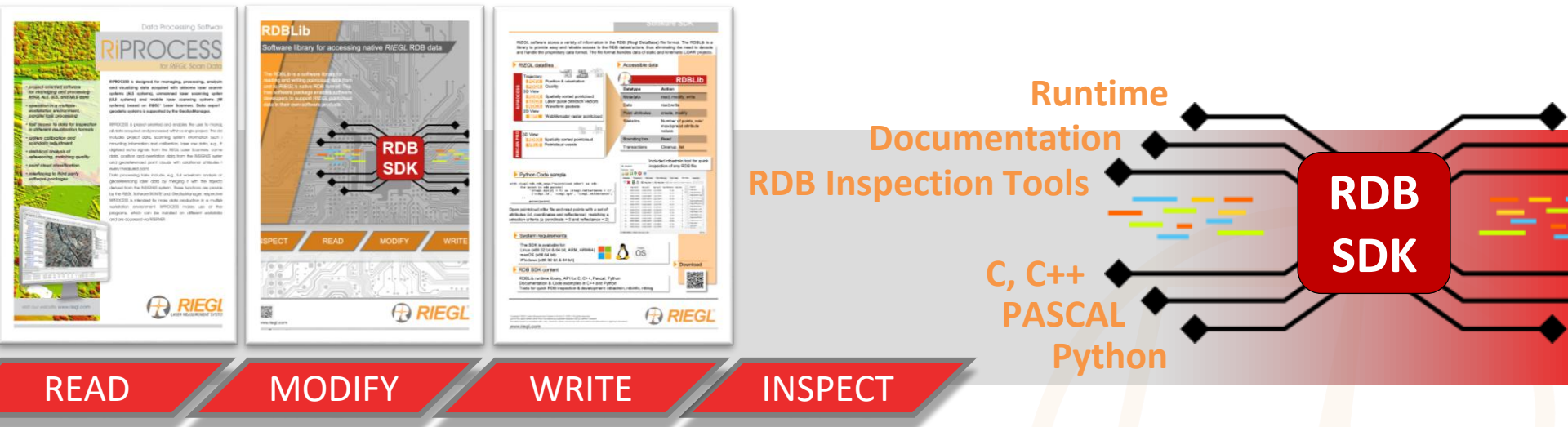
1550nm



The *RIEGL* kinematic software suite



Accessing the *RIEGL* point cloud data base – the RDBLib



- secure signature of serial number as basis for licensing *RIEGL* post-processing software
- 3rd party software can natively **read, modify, and write** RDB data
- digital signature of transactions to recognize modifications of data base

<http://www.riegl.com/members-area/software-downloads/>

The *new* VQ-680 city and corridor airborne laser scanner

- nadir/forward/backward scanning (NFB) at +20 / +10 / 0 / -10 / -20 degrees
- wide total field of view 60° across track, 40° along track
- high PRR up to 2.4MHz, 500 lps
- measurement ranges ($\rho \geq 20\%$)
3000m @ 300kHz
1300m @ 2400kHz



VQ-680



VQ-680 OEM
(system integrator edition)

The *new* VQ-680 city and corridor airborne laser scanner

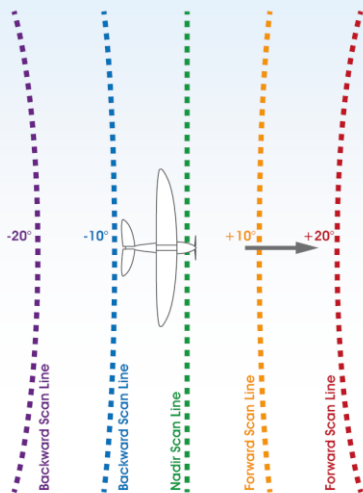
- nadir/forward/backward scanning (NFB) at +20 / +10 / 0 / -10 / -20 degrees
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- high PRR up to 2.4MHz, 500 lps
- measurement ranges ($\rho \geq 20\%$)
3000m @ 300kHz
1300m @ 2400kHz
- **VQ-680 OEM** integrated in the new hybrid camera/LiDAR system **UltraCam Dragon 4.1 by VEXCEL**



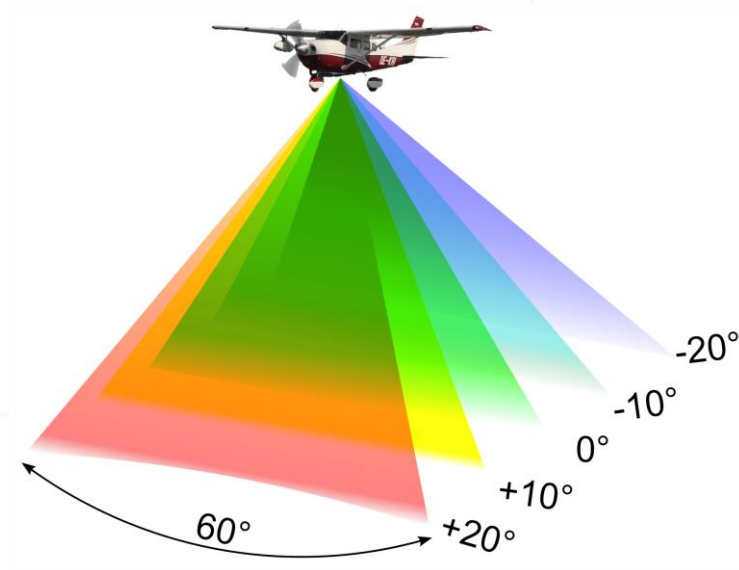
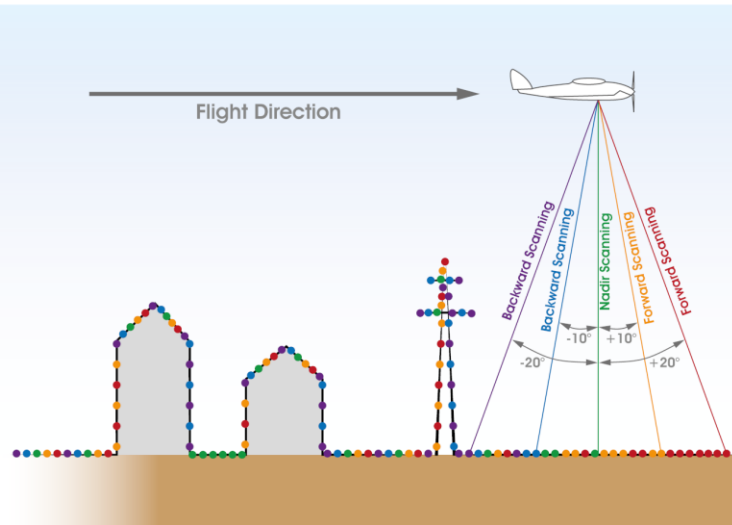
VQ-680 OEM
(system integrator edition)

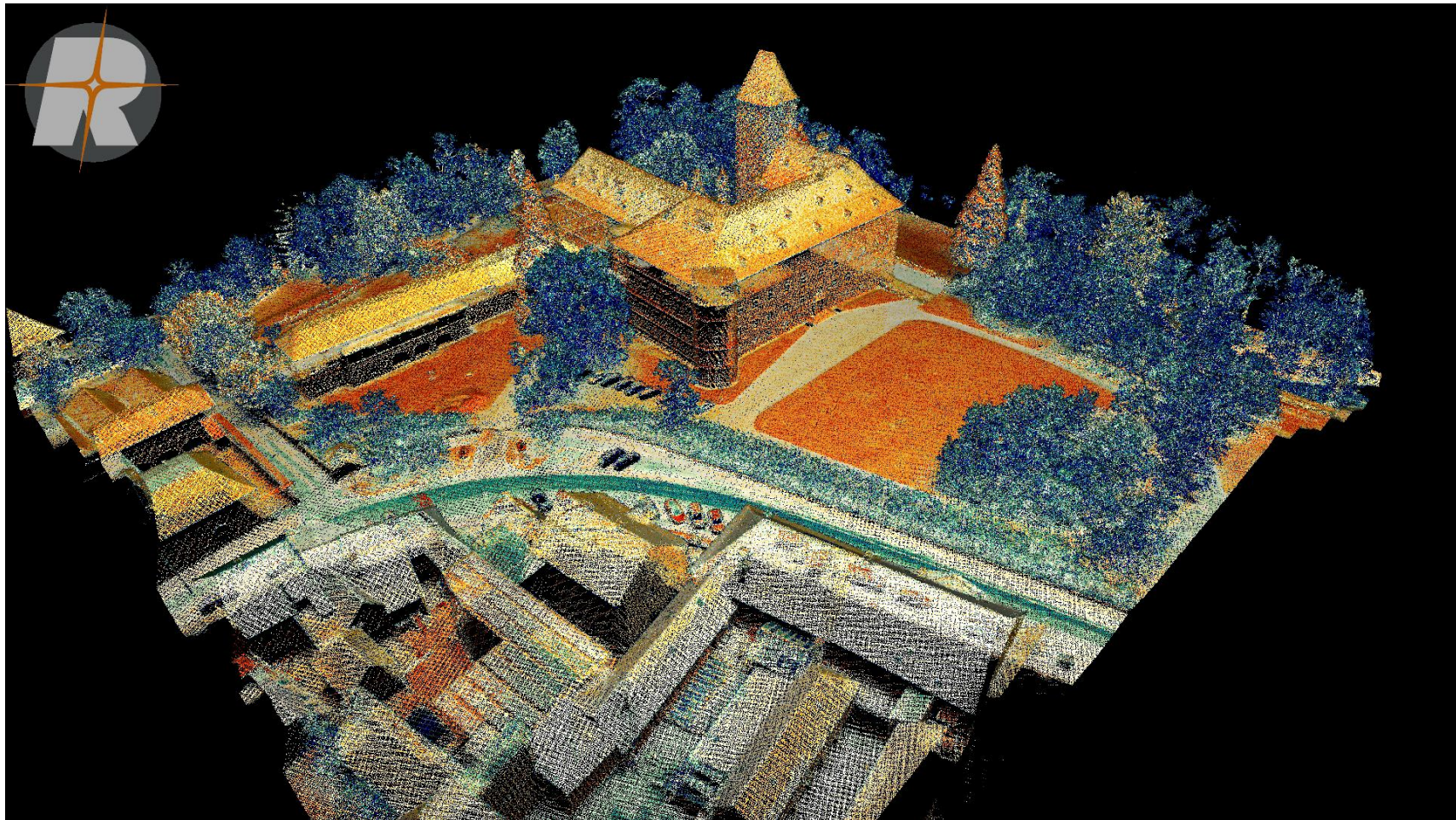
The *new* VQ-680 OEM: scanning mechanism

top view



side view







Thank you for your interest!

Peter Rieger



May 23rd, 2024