

Airborne Lidar Sensors

This is the second Product Survey on Airborne Lidar Sensors; the last appeared under the title 'Airborne Laser-scanners' in our May 2004 issue. Seven companies were willing to co-operate by filling in the questionnaire for the present survey.

'Airborne Laser-scanners' is a term used in Europe; other parts of the world have generally adopted the term 'Airborne Lidar'. Two companies represented in our previous survey, Mosaic Mapping Systems and Terrapoint are beyond the scope of the present survey, while we welcome two newcomers. The first is Ingenieur-Gesellschaft für Interfaces (IGI) based in Kreuztal, Germany, which produces and sells the airborne Lidar Terrain Mapping system (LiteMapper) 2400. IGI is an engineering company founded in 1978 by Albrecht Grimm and specialising in the design and development of guidance positioning, attitude determination and sensor-management systems for airborne survey. The second newcomer is Fugro, a company that operates the FLI-MAP 400 system for Lidar survey. This company is positioned somewhat eccentrically in relation to other firms in that it does not put the FLI-MAP system itself on the for-sale shelf but performs only surveys. However, its system has been developed in-house and differs significantly from what other sensor operators are using in performing surveys based on Lidar systems offered by one or more manufacturers. We felt the uniqueness of the Fugro system qualified it for inclusion in this product survey. Another company standing apart from its counterparts in a similar respect is the German Toposys, which enjoys a unique position worldwide in that it combines the manufacture of Lidar systems with self-executed Lidar surveys. The company considers this dual role an advantage as it provides a broad base of expertise.

Although Optech, based in Toronto, Canada is a world leader in the development, manufacture and sale of Lidar systems, the company prefers here to present only its newest system, the Airborne Laser Terrain Mappers ALTM Gemini, able to generate 167,000 pulses per second. Precision and resolution statistics presented in these surveys are always a little tricky because the claims depend on system components taken into account. For example, does elevation precision include GPS errors or is it quoted without? Statistics on minimum detectable size of objects should also be considered with care because this factor depends on flying height and target reflectivity. At a platform altitude of 200m power-lines just 8mm in diameter may be mapped; at flying height 1000m they need to be 3cm. The maximum possible number of points detected per square metre also depends on pulse rate and rotation/rotating speed of mirror on flying height, reflectivity and platform speed. The fields of application for Lidar are very diverse and include generation of digital elevation models, 3D-city modelling, forestry management, coastline protection, disaster management, erosion studies, archaeology, monitoring of corridors such as power-lines, pipelines, railways and roads.

By Mathias Lemmens, editor-in-chief, GIM International

Manufacturer	Fugro
Type/name of Lidar sensor	FLI-MAP 400
Date of introduction/last update	Q1-2006
Dimensions	
- weight [kg] & size [cm] of laser system	30kg, 50 x 30 x 30cm
- weight [kg] & size [cm] of total system	~100kg
- power requirements	24V / 30W
Laser Pulse Characteristics	
- wavelength [nm]	1,500nm
- pulse length [ns]	4ns
- beam divergence (across/along tr.) [mrad]	0.45 mrad (radial)
- type/class laser	Fiber / Class I M
- eyesafe range [m]	0.3m
Recording Methodology	
- scanning method [1]	Rotating mirror
- rotation speed of mirror [2]	150Hz
- pulse frequency (min-max) [Hz]	250,000Hz
- max. scan angle [deg]	60 deg
- max. # of recorded echoes/pulse	4
- pulse sampling frequency [3]	0.025 ps
- pulse detection method [4]	Threshold
- dynamic range of intensity signal [bits]	11 bits
Positioning System	
- GPS system [5]	2x Trimble DB950 LI/L2, 10 Hz
- GPS precision planimetric/height (2 sigma) [cm]	5 / 10cm (2 sigma)
- INS system [6]	Applanix PosAV 410, 200 Hz
- INS precision (roll/pitch/heaving) [deg]	0.008 / 0.008 / 0.015 deg
- GPS/INS postprocessing software	GrafNav/PosProc
Precision and Resolution	
- Pointing precision (roll/pitch/heaving) [deg]	0.008 / 0.008 / 0.015 deg
- Range precision (2 sigma) [cm]	2-3 cm
- Elevation precision at 1km (2 sigma) [cm]	Depending on network quality
- Overall planimetric precision (2 sigma) [cm]	Depending on network quality
- Range precision (2 sigma) [cm]	2-3 cm (2 sigma)
- Max. # of points/m2	175 points (first return) altitude and speed-dependent
- Along-track point spacing [m] [7]	0.27m @ 150km/h
- Across-track point spacing [m] [8]	0.46m @ 400m AGL
Other System Parts	
- Cameras [9]	Forward and downward-looking 11Mpix still and video
- Data Storage Facilities [10]	Removable hard disks, 80 GB
- Power equipment	Aircraft power 24V
Operation Characteristics	
- typical platform	Helicopter/fixed wing
- flying heights (min/typical/max) [m]	50 - 400m
- max. acquisition duration [hrs]	3 - 6hrs
- air temperature (min-max) [°C]	-10 to 50 °C
- air humidity (min-max) [%]	99% non-condensing
- mission-planning software	FLIP7
- postprocessing software	FLIP7
- proven applications	Corridor mapping, DTM/DSM
Remarks	

- [1] E.g. rotating mirror, oscillating mirror etc.
 [2] Also called scan frequency.
 [3] Also called sample interval per pulse.
 [4] Describe here which part of the reflected pulse is recorded.
 [5] Brand, number of channels, single or dual frequency, update frequency [Hz].
 [6] Brand, update frequency [Hz].
 [7] Number referred to flight altitude 1000m.
 [8] Number referred to a typical flying speed of 150 km/h, or other appropriate speed.
 [9] Types of camera standard to system.
 [10] Type of storage facilities (tape, disk, etc.), storage [GB], removable or not.



IGI	IGI	Leica Geosystems	Optech
LiteMapper 5600	LiteMapper 2400	ALS50-II	ALTM Gemini
2003/2006	2005/2006	February 2006	October 2006
20kg; 56 x 200 x 21.7cm	7kg; 37.4 x 18 (length x diameter)	37W x 56L x 24H cm, 30kg scanner	23.4kg, 26 x 19 x 57cm
48kg; modular	27kg; modular	45W x 47D x 36H (8U) cm, 40kg electronics	95kg, control rack size 65 x 59 x 49cm
300W	140W	28A average, 35A peak @ 28VDC	28 VDC, 35 A (maximum)
1550nm	905nm	1,064nm	1,060nm
3.5ns	-	<9ns	7ns
0.5 mrad, with 1.2 mrad option	2.7 mrad	0.22 @ 1/e ² (0.15 @ 1/e)	0.8, 0.25, 0.15 1/e
Class I	Class I	CL IV	Class IV (FDA 21 CFR)
0m	0m	200m, single pulse exposure, aiding optics	80 m +
Rotating polygon mirror	Rotating polygon mirror	Oscillating mirror, sinusoidal scan pattern	Oscillating Mirror
5 - 160 scans/sec	6 - 60 scans/s	90Hz max, full cycle	100Hz
40 - 200kHz	30kHz	150,000Hz max	167kHz
60 deg	80 deg	75 deg	50 deg
Unlimited	1	4 (1st, 2nd, 3rd, last)	4 ranges
1GHz	-	N/A	
Full waveform	First or last pulse	Leading edge CFD	Leading edge
16 bits	8 bits	8 bits plus 100:1 laser output control	12 bits
AEROcontrol, > 60 channels, L1/L2, 2Hz	AEROcontrol, > 60 channels, L1/L2, 2Hz	Leica IPAS10, 12 channel, dual-frequency, 20 Hz max	Trimble, 12 channel, dual-frequency
< 20cm	< 20cm	< 10cm	0.05cm
AEROcontrol, 256Hz	AEROcontrol, 256Hz	Leica IPAS10, 200Hz	POS 610, 200 Hz
0.004/0.004/0.01 deg	0.004/0.004/0.01 deg	0.005/0.005/0.008 deg	0.0025/0.0025/0.005 deg
AEROoffice	AEROoffice	GrafNav/IPAS Pro	POS PAC
0.004/0.004/0.01 deg	0.007/0.007/0.01 deg	0.005/0.005/ 0.008 deg with standard IPAS10 DUS5 GPS/IMU subsystem	0.0025/0.0025/0.005 deg
2cm	3cm	<10cm @ 1,000m AGL	3cm
0.06cm @ 1,000m, without GPS error	0.04cm @ 300m without GPS error	<14cm @ 1,000m AGL, including GPS error of 10cm @ 2 sigma	< 10cm
0.30cm @ 1,000m, without GPS error	0.12 @ 300m without GPS error	<24cm @ 1,000m AGL, including GPS error of 10cm @ 2 sigma	1/11000
		<10cm @ 1,000m AGL	
156 points @ 50m AGL, 30 kts	8 points @ 50m AGL, 30 kts	Depends on speed, flying height, FOV; 103 points @ 200m AGL, 81 knots (150km/h), 10 degree FOV; 14 points @ 1000m AGL, 81 knots (150 km/h), 10 degree FOV	20 points - 100 Knots, 500m, 100Hz scan, +/- 10°, PRF = 167kHz.
Variable, typ. 0.6m @ 150km/h	Variable, typ. 1m @ 300m, 40 kts	Depends on speed, scan rate (not altitude); 0.23m @ nadir @ 81 knots (150km/h), 90Hz scan rate	As above 0.25m
Variable, typ. 0.6m @ 150km/h	Variable, typ. 1m @ 300 m, 40 kts	Depends on flying height, FOV, scan rate; 0.07m @ 200 m AGL, 81 knots (150km/h), 10 degree FOV, 90Hz scan rate; 0.38m @ 1000 m AGL, 81 knots (150km/h), 10 degree FOV, 72Hz scan rate	As above 0.21m
DigiCAM-H/22	DigiCAM-H/22	Standard 1.3 MP integrated digital frame camera with real-time display and annotated recording of individual frames at user selected rate; optional RCD10a 39 MP digital frame camera.	Applanix DSS, Rollei 39 Mpixel
Removable Data Recorder, 2x 320 GB	hard disk, 40GB	Removable HDD	Removable hard disk, min 70 Gbytes
Included	Included	Ground power supply	Internal to the system
Fixed-wing, helicopter	Helicopter	Fixed-wing or helicopter	Twin engine fixed-wing, rotary wing
30m / - / 1,800m	10m / - / 650m	200 - 6,000m AGL	200m / 1km to 2km / 4km max; higher available on request
10-30hrs	50hrs	~17 hrs @ max pulse rate	Unlimited
- 0°C to +40°C	-10°C to +50°C	0 - 40 °C cabin-side temperature	-10°C to 35°C
Max. 80% at 31°C	Max. 80% at 31°C	Non-condensing	0 to 95% non-condensing
WinMP	WinMP	Leica FPES	ALTM NAV
AEROoffice, GeocodeWF, TerraScan, TerraModeler	AEROoffice, Geocode, TerraScan, TerraModeler	Leica ALS Post Processor for point-cloud generation, TerraScan/TerraModeler for viewing/editing.	DASHMap
Wide-area, urban, floodplain mapping, corridors, power-lines	Corridors, power-lines	DEMs, city models, flood plain, erosion & forestry studies, forest floor; disaster management, power-lines, pipe-line and railway and roadway corridors, coastal mapping.	Power-line mapping, topographic survey, urban mapping, flood mapping, etc.
Full-waveform digitisation		Full-function system for a wide variety of applications now features highly integrated FCMS flight-management system and flexible external sensor integration.	Multipulse airborne Lidar system with the highest PRF rate of 167kHz in the industry; global 24/7 technical support.



Manufacturer	Riegl LMS	Riegl LMS	Riegl LMS
Type/name of Lidar sensor	LMS-Q240i-60/LMS-Q240i-80	LMS-S560-I/ LMS-S560-A	LMS-Q560
Date of introduction/last update	Last update 09/2006	Last update 10/2006	Last update 10/2006
Dimensions			
- weight [kg] & size [cm] of laser system	7kg; 18 x 37cm [Dia x L]	20kg; 56 x 20 x 22cm [LxWxH]	20kg; 56 x 20 x 22cm [LxWxH]
- weight [kg] & size [cm] of total system	N/A	Depending on system configuration	N/A
- power requirements	43 W	120 W (laser scanner)	120 W
Laser Pulse Characteristics			
- wavelength [nm]	0.9 um	1,500nm	1,500nm
- pulse length [ns]	< 10ns	<4 ns	<4 ns
- beam divergence (across/along tr.) [mrad]	2.7 mrad	0.3 mrad with 1 mrad option	0.3 mrad with 1 mrad option
- type/class laser	Class I	Class I	Class I
- eyesafe range [m]	0m	0m	0m
Recording Methodology			
- scanning method [1]	Rotating multi-facet mirror	Rotating multi-facet mirror	Rotating multi-facet mirror
- rotation speed of mirror [2]	6 - 80Hz/ 5 - 60Hz	10 - 160Hz	10 - 160Hz
- pulse frequency (min-max) [Hz]	30,000Hz	25,000 up to 200,000Hz	25,000 up to 200,000Hz
- max. scan angle [deg]	60 deg/ 80 deg	60 deg	60 deg
- max. # of recorded echoes/pulse	First or last or alternating	Practically unlimited	Practically unlimited
- pulse sampling frequency [3]	N/A	1 GHz	1 GHz
- pulse detection method [4]	Center of gravity of echo pulse	Full waveform processing of complete echo	Full waveform processing of complete echo
- dynamic range of intensity signal [bits]	8 bits	16 bits	16 bits
Positioning System			
- GPS system [5]	N/A	Novatel/ Trimble: 12 channels, dual-frequency, up to 10Hz	
- GPS precision planimetric/height (2 sigma) [cm]	N/A	<10 / < 20cm rms / 5 - 30cm rms	
- INS system [6]	N/A	IGI AEROcontrol / Applanix POS AV 510. 256Hz / 200Hz	See LMS-S560 system
- INS precision (roll/pitch/heading) [deg]	N/A	0.004 / 0.004 / 0.01 / 0.005 / 0.005 / 0.008	
- GPS/INS postprocessing software	N/A	AEROoffice/ POSpac	
Precision and Resolution			
- Pointing precision (roll/pitch/heading) [deg]	N/A	Limited by INS/GPS specification	
- Range precision (2 sigma) [cm]	N/A	2cm	
- Elevation precision at 1km (2 sigma) [cm]	N/A	< 15cm, depending on DGPS accuracy	
- Overall planimetric precision (2 sigma) [cm]	N/A	< 10cm, depending on DGPS accuracy	See LMS-S560 system
- Range precision (2 sigma) [cm]	N/A	2cm	
- Max. # of points/m2	N/A	9 points @ 500m AGL, 90km/h ground speed	
- Along-track point spacing [m] [7]	N/A	Min. 0.16m @ 10 scans/s	
- Across-track point spacing [m] [8]	N/A	Min. 0.26m @ 160 scans/s	
Other System Parts			
- Cameras [9]	N/A	IGI DigiCAM / Applanix DSS	See LMS-S560 system
- Data Storage Facilities [10]	N/A	Hard disk RIEGL DR560, 2 x 320 Gbytes	Hard disk RIEGL DR560, 2 x 320 Gbytes
- Power equipment	N/A	Available	N/A
Operation Characteristics			
- typical platform	Helicopter	Both, complete turnkey solution with Diamond Aircraft twin-engine plane DA42MPP available.	Both
- flying heights (min/typical/max) [m]	2m / 200m / 350m	30m / 500m / 1,000m	30m / 500m / 1000m
- max. acquisition duration [hrs]	N/A	~ 8 hrs	~ 8 hrs
- air temperature (min-max) [°C]	-10 to + 50 °C	0 - 40 °C	0 - 40 °C
- air humidity (min-max) [%]	80% (at or below 31 °C)	80% (at or below 31 °C)	80% (at or below 31 °C)
- mission-planning software	N/A	IGI WinMP / TrackAir	IGI WinMP/ TrackAir
- postprocessing software	N/A	RiANALYZE 560, RiPROCESS 560, RiWORLD 560	RiANALYZE 560, RiPROCESS 560, RiWORLD 560
- proven applications	Corridor mapping, glacier mapping	All typical airborne scanning projects.	All typical airborne scanning projects.
Remarks	Small and lightweight sensor, suitable for helicopters, ultra-lights and UAVs.	Recording of digitised echo signals & subsequent full-waveform analysis, complete turnkey solution with Diamond Aircraft DA42MPP.	Recording of digitised echo signals and subsequent full-waveform analysis.

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 [6] Brand, update frequency [Hz].
 [7] Number referred to flight altitude 1000m.
 [8] Number referred to a typical flying speed of 150 km/h, or other appropriate speed.
 [9] Types of camera standard to system.
 [10] Type of storage facilities (tape, disk, etc.), storage [GB], removable or not.



TopEye	TopoSys GmbH	TopoSys GmbH	TopoSys GmbH
TopEye Mk II	Falcon III	Harrier 56	Harrier 24
January 2006	February 2000/July 2006	October 2005/September 2006	October 2005
25kg	> 20kg customised due to options	> 15kg customised due to options	> 10kg customised due to options
250kg	2 boxes, < 95kg total	2 boxes, > 45kg total	2 boxes, > 30kg total
500 W	28 V DC, 15 A max.	28 V DC, 17 A max.	28 V DC, 13 A max.
1,064nm	1,550nm	1,550nm	900nm
4 ns	5 ns	< 4 ns	< 10ns
1 mrad	0.7 mrad	0.3 mrad with up to 1mrad option	2.7mrad
3B	Class IM	Class I	Class I
40m at low effect	0.27m	0m	0m
Plamer Scanner	Fibre scanner	Rotating multi-facet mirror	Rotating multi-facet mirror
0-75Hz	Up to 415Hz	10 - 160Hz	6 - 80Hz / 5 - 60Hz
1-50,000	50,000 - 125,000	25,000 - 200,000	30,000
+/- 20 deg 14 deg BWD/FWD	28 deg fixed	45 deg. or 60 deg	60 deg / 80 deg
Unlimited	8 or full waveform	Practically unlimited	First or last or alternating
2 GigaSamples	Analogue	1GHz	N/A
Full Waveform logic	Rising edge detection or full wave form	Full waveform processing of complete echo	Center of gravity of echo pulse
10 bits	8 bits	16 bits	8 bits
Trimble 5700 L1/L2	Applanix POSAV 510	Applanix POSAV 410	Applanix POSAV 310
	5 - 30cm	5 - 30cm	5 - 30cm
Honeywell 764	Applanix POSAV 510	Applanix POSAV 410	Applanix POSAV 310
< 0.005 deg	0.005/0.005/0.008 deg	0.008/0.008/0.015 deg	0.015/0.015/0.035 deg
POS GPS TopEye PP	Applanix Pos/Pac	Applanix Pos/Pac	Applanix Pos/Pac
< 0.25 mrad 2 sigma	INS precision	INS precision	INS precision
1cm - Range indepenent	1cm	3cm	3cm
N/A	7cm	15cm	15cm
	10cm	15cm	N.A.
	1	2	3
Std Product 30 points	50 points	40 points	10 points
N/A	0.1 (@1000m, 150km/h)	0.6 (@ 1000m, 150km/h)	0.5 (@150m, 150km/h)
N/A	0.3m (@1000m, 150km/h)	0.6m (@ 1000m, 150km/h)	0.7m (@150m, 150km/h)
Rollei AIC	RGB/CIR line scanner or frame cameras	RGB/CIR line scanner or frame cameras	RGB/CIR line scanner or frame cameras
Removable HDD	Removeable disc, 500GB	Removeable disc, 500GB	Removeable disc, 200GB
-	UPS	UPS	UPS
RW Honeywell 764	Both + high speed aircrafts	Both	Helicopter
60m / 300m / 750m	30m / 1,500m / 2,000m	30m / 800m / 1,000m	(60°) 3/280/430 (80°) 3/250/380
3 hrs	> 8 hrs	> 8 hrs	> 8 hrs
-10°C to + 35°C	-10°C to + 50°C	0° to + 40°C	0 to + 50°C
Non-condensing	Non-condensing, <95%	80% (at or below 31°C)	80% (at or below 31°C)
TopEye MPS	TrackAir	TrackAir	TrackAir
TopEye PP & TASQ	TopPIT	TopPIT	TopPIT
Corridor, 3D City, PowerLines, etc.	All kinds of applications which require high point density and error free data, such as city models, corridor / river / coastal / flood plain / wide area / forest mapping, deposits and mining, contruction and engineering, ortho and true-ortho images.	Corridor mapping such as pipelines or power-lines or motorways, construction and engineering, forest, city, target classification, ortho and true-ortho images.	Low-altitude corridor mapping and surveying for construction and engineering, snow, ice and glacier mapping, ortho and true-ortho images.
The Palmer scanner means that a Laser Echo is extracted from each 'sub area' twice with a 4-8 sec time difference by a single mechanical system and with full receiver apperture.	High-end system, turnkey solution, stable scanner geometry avoids any data error, no repetitive calibration required, extremely high survey speed possible > 400km/h, very long flight lines possible.	Turnkey solution, additional sensors such as temperature, oblique or video available, customised housing possible, stable frame camera also for photogrammetric work, very easy to handle, no operator required.	Entry level system, low-cost turnkey solution, additional sensors such as temperature, oblique or video available, customised housing possible, very easy to handle, no operator required.

