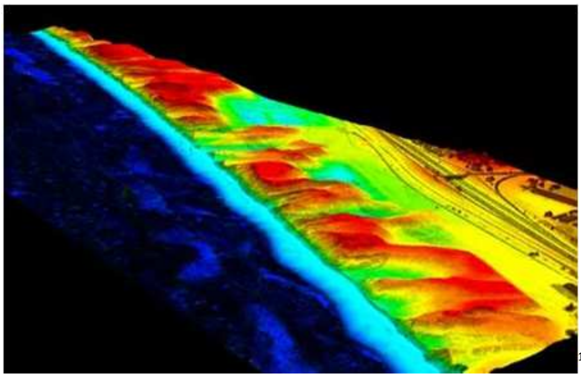
Report

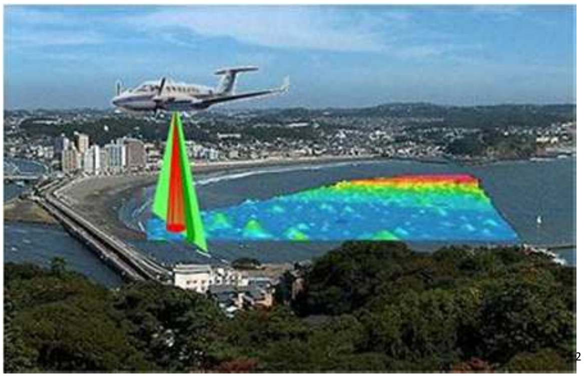
Workshop on LiDAR for Coastal Environments

25-26 March 2014,

Hosted by CSIR and DEA Oceans & Coasts

At the CSIR, 11 Jan Celliers Str, Stellenbosch

[1]

[2]

Outcomes of the CSIR and DEA Branch Oceans & Coasts-hosted workshop to establish a framework for a coordinated approach to the gathering, curating and disseminating of LiDAR data and information for use in the management of the coastal areas of South Africa.

CSIR project reference: ECCS112

CSIR Report Number: CSIR/NRE/ECOS/ER/2014/0047/A

[1] http://sanctuarysimon.org/news/wp-content/uploads/2012/07/whats_lidar_04.jpg

[2] http://www.nauticalcharts.noaa.gov/staff/news/images/headline-lidar.jpg

Prepared for:

Dr Alan Boyd
Chief Directorate: Oceans and Coastal Research
Oceans and Coasts Branch
Department of Environmental Affairs
Cape Town
South Africa

Contact details for correspondence:

Dr Melanie Lück-Vogel
Tel: +27 21 888 2412

Email: mluckvogel@csir.co.za
or
lcelliers@csir.co.za

CSIR
PO Box 320
7599 Stellenbosch
South Africa

Contributors to the report:

Ashton Maherry, CSIR

Andre Theron, CSIR

Niel Malan, DEA

Lara van Niekerk, CSIR

This report should be cited as: Lück-Vogel et al., 2014. Report: Workshop on LiDAR for Coastal Environments, DEA & CSIR, March 2014, Stellenbosch. CSIR Report No. CSIR/NRE/ECOS/ER/2014/0047/A

1. Background

Highly accurate and detailed topographic information has been identified as being crucial to addressing a wide range of coastal management issues at all three levels of government. These include, for example, determining the coastal vulnerability to sea level rise and sea storms, the definition of coastal and estuarine setback lines and the identification of coastal access routes.

Internationally, airborne LiDAR (Light Detection and Ranging) technology has been identified as a cost-effective technical solution to obtaining topographical information and is widely employed on a routine basis. LiDAR is also being increasingly used in South(ern) Africa.

However, to date, the significant costs of this technology frequently limit its application to cover small areas and for use by well-resourced clients and/or authorities (e.g. metropolitan municipalities). This results in the technology remaining largely inaccessible to others.

For the South African coast, this has resulted in a patchwork of areas covered by topographic LiDAR data, with large areas not yet covered and in certain cases probably unintentional duplication of effort due to an uncoordinated approach. Where LiDAR data have been gathered by private companies and state owned enterprises such as ESKOM and TRANSNET, its existence often remains unknown to other users, particularly government, that may benefit from the data.

The CSIR and DEA Branch Oceans & Coasts therefore hosted a workshop to establish a framework for a coordinated approach to the specification, gathering, curating and disseminating of LiDAR data and information for use in the management of the coastal areas of South Africa.

The workshop intended to facilitate:

1. A better understanding of the practicalities of gathering and using LiDAR data and information (at a strategic level); and
2. technical and practical discussions to enable better coordination of current and future activities related to the acquisition and use of LiDAR in South Africa.

The workshop was organised with the intent that both management and technical specialists would benefit from both days of the workshop.

Topics suggested for discussion during the workshop included:

- A general non-technical introduction to LiDAR technology and its use for coastal management;
- A comparison of LiDAR with other topographic assessment technologies;
- The identification of existing data owners (i.e. who has acquired data?) and coverage (i.e. where are existing data?) and the development of a national inventory;
- Identify priority coastal areas for which LiDAR is still required;
- Identify sources of funding for priority LiDAR coverage;
- Assess the technical and user specifications of existing data sets;
- Identify the SA LiDAR data providers;

- Consider the potential for the development of a LiDAR Consortium of public and private partner stakeholders with the intention of increasing return on data investment, improved quality control and consistency and manage frequency and coverage of LiDAR;
- Explore requirements, opportunities and constraints to access existing data;
- Consider the creation of a National Public Coastal LiDAR data pool accessible to National, Provincial and Local Authorities as well as key institutions such as the National Disaster Management Centre, SAMSA (South African Marine Safety Authority) and potentially the public, local coastal planners and other users.;
- Define minimum technical specifications for LiDAR Digital Elevation Modelling (DEM) or Digital Terrain Mapping (DTM) data for coastal applications;
- Identify value-added products for Integrated Coastal Management purposes; and
- Determine the frequency and return acquisition of LiDAR for use in the coastal zone.

2. Workshop report

1.1. Invitations and participants

Invitations for the Workshop went out to the current network of practitioners who relate to the topic's various angles. The invitees included representatives from coastal related research institutions, coastal management at National, Provincial and Municipal spheres, general environmental management and commercial LiDAR service providers.

The first invitation went out to 54 contacts, which in many cases shared the invitation within their networks, so that in the end about 75 persons were reached. This resulted in 40 registrations and when including several "guest researchers" from CSIR and the Stellenbosch University a total audience of 46 participants (see Appendix 2: Participants) was achieved.

1.2. Information sharing

After a welcome note from Mr Laurie Barwell (CSIR) and Dr Alan Boyd (DEA Oceans & Coast) and an introduction round of the participants, the focus for the first day was on general information sharing. It was decided to limit questions and comments subsequent to the respective presentations as in depth discussions were planned for Day 2.

The first block of presentations included an overview of technologies allowing the assessment of land surface topography beyond LiDAR, a general introduction into LiDAR technology and examples of local and overseas coastal LiDAR applications through the local LiDAR providers on topographic and bathymetric LiDAR (see Appendix 1: Programme).

The second block of presentations consisted of examples and experiences of local LiDAR users in South Africa. Furthermore, two LiDAR experts from the US Army Corps of Engineers ERDC presented their experience with LiDAR applications and LiDAR data sharing agreements in the USA via telephone.

The second day concluded the session on local LiDAR experiences and then delved into the national stocktaking of existing and planned coastal LiDAR coverage and in depth discussions.

1.3. Stocktaking

As opening for the discussion session on the second day, a "stock taking" exercise was undertaken to understand where the present participants already possess LiDAR data or are aware of existing LiDAR data for the South African coastal zone. This exercise was conducted using Google Earth and the plotting of the areas covered with LiDAR as lines or polygons (Figure 1). It turned out that for large parts of the coast LiDAR data do exist already or are currently being planned. Only for the major part of the Eastern Cape coast, no data seem to exist. While no systematic surveys have been done for the Northern Cape yet, the probability is high that the mining companies operating along this coast have surveyed some sections. However, the ownership of these data is in the private domain and there is some uncertainty to what extent the surveys included the area below the high water mark and the inland extension.

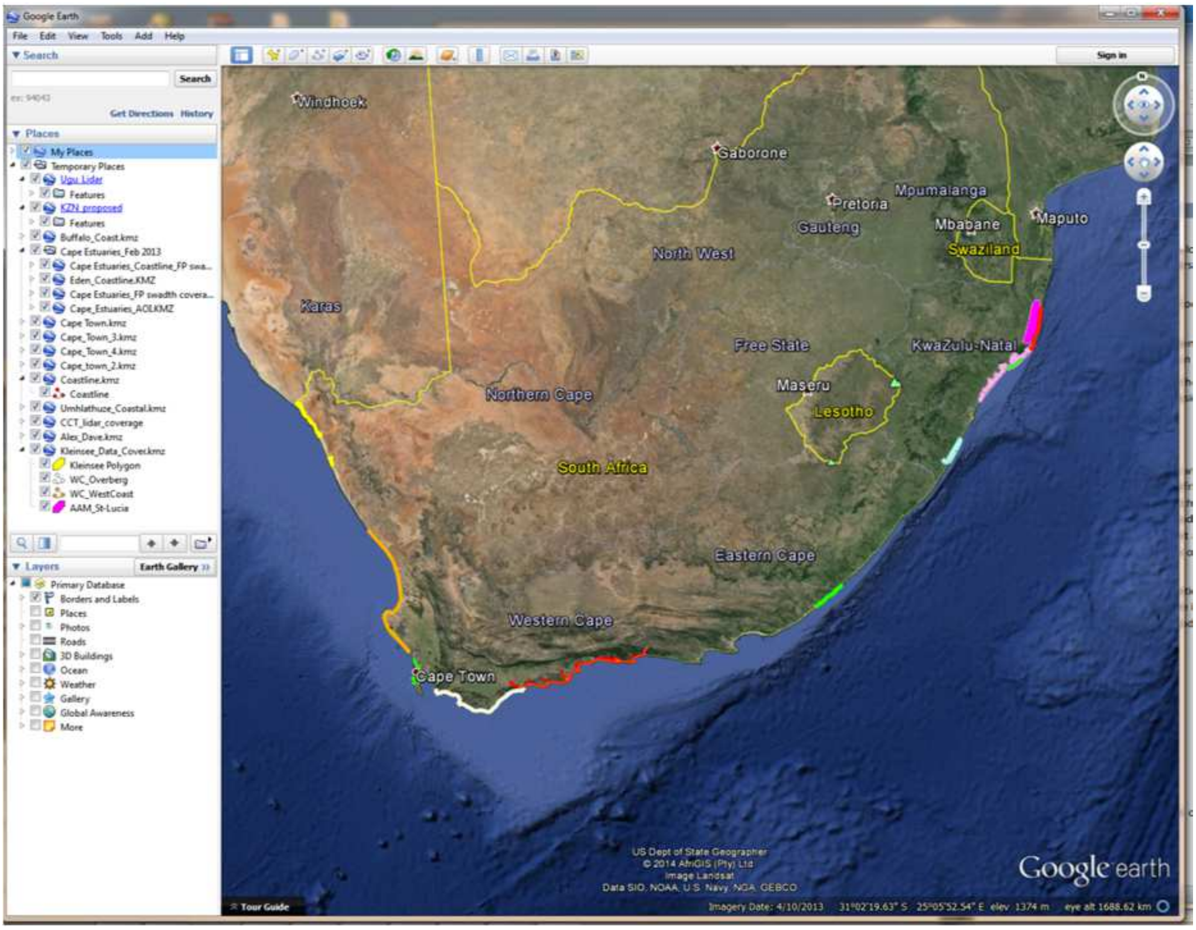


Figure 1: Coastal areas with known LiDAR coverages (coloured lines; zoom in for details).

During the stocktaking, the technical specifications of the individual data sets were not available and the participants agreed to provide the metadata with the technical specs as soon as possible after the workshop (check Section 2.6 for details). The minimum information to be included in these metadata was defined during the course of the day (Table 1).

Table 1: Suggested minimum information to be included in the metadata for LiDAR data for a national inventory

Category	Explanation
Data originator	The company who flew the LiDAR
Owner of data set	The client who tasked and paid for the data set
Accessibility of data	Restricted or freely available from the "national curator"?
Contact person for enquiries	Name, phone, email address at owner organisation
Date of acquisition	When where the "images" taken?
Geometric referencing method	e.g. based on own ground data, existing reference networks or 'relative' to a formal system such as the TrigNet beacons?
Achieved accuracies	1 sigma, 2 sigma[3]
Point density per square metre	For point clouds
Pixel size	For rasterised products
Available "value added" products	e.g. ground surface elevation, vegetation/infrastructure height, rasterised products, slope/aspect, …
Format of data files	For both, point data and rasterised data, e.g. LAS, geoTIFF
Geo-referenced footprint	e.g. GoogleEarth KML file or ESRI shape file of location of data, or position of flight lines
Flight height	Of the aircraft during acquisition
Number of flight lines	Number of flight lines
Name of full meta data report	In case that the original meta data report contains more information than the minimum information requested here.
Projection details	The following details should be provided: Projection name, horizontal geodetic Datum, Spheroid, Central Meridian, scale factors characteristic for the respective projection
Original purpose for data acquisition	If available. E.g. Mining, geology, …

Some refinements may still need to be considered after additional feedback from the data owners and data providers.

Mentioned, but not further assessed, was the list of agreed-on metadata specifications used by the US JALBTCX community. This table, which is provided in the supplementing digital appendix to this report (FederalWorkshopSpecificationsMatrix_Nov091113.xls) should be considered for further SA discussions on this topic.

3 For explanation of Sigma, please refer to Appendix 3: Accuracy versus Precision

1.4. Discussions

The main topics identified to be discussed in detail were:

1. What do we need the data for?
2. What are the standard value added products that can be produced from LiDAR data?
3. What re the minimum technical standards and specifications that need to be defined?
4. Who should be the lead agency for coordinated aspects of coastal LiDAR data?

While it was offered to have break-away sessions for people to work on the topics in parallel, the interest in all topics was so high that this idea was abandoned and all discussions took place in the plenary.

1.5. Outcomes of specific discussions

1.5.1. What do we need the data for?

The main applications for topographic information in the coastal zone are identified in Table 2 below:

Table 2: Identified application fields and purpose or features to be assessed using (LiDAR derived) topographic information. This list is preliminary and is not comprehensive, but includes the main applications.

Field of application	Feature / purpose
Coastal zone management	Set-back lines
	Identification of illegal structures (developments, access points etc.)
	Coastal boundaries
	Land use planning
	Beach erosion/accretion
	(illegal) sand mining
Estuary management	Berm height
	Volume of estuary & floodplains
	Mouth & channel dynamics
	Biomass assessment
	Shifts in critical habitats
Risk and vulnerability	Wave run up & coastal flooding
	Foredune sizing & integrity assessment
	Vegetation (mainly structure)
Disaster response	Access to and Infrastructure location
	Topography and Surface (incl. infrastructure height)
	Erosion & inundation areas
Conservation	Detection of certain alien vegetation
	Habitat mapping

Field of application	Feature / purpose
	Coastal resilience
	Vegetation structure
Navigation	General charting
	Ports & harbours
Design	Port & coastal structures
	Harbour bathymetry
Geology	Tectonics
	Submarine sediment dynamics
	Reefs & rocky areas

During the discussion the following points were made:

- That the list of possible applications will probably grow once the standards are defined. The LiDAR users stressed the need for absolute height verification to land level versus the determination of a relative height (which is inferred from a projection system or satellite). This would require more ground truthing preparation and increased post processing time.
- That the actual need of what the data are used for should be defined in consultation with the respective Agency needs, such as SANBI, the Integrated Coastal Management Act, Set-back lines, Working for the Coast etc. While this approach is certainly valuable, it is considered to be beyond the scope of this phase of the project.
- While LiDAR's initial investment might be more costly than large scale aerial photography, it might be cheaper in the long-term. The guests from the USA mentioned that this was shown to be the case in an example where the State of North Carolina assesses their agricultural land with LiDAR annually. This approach makes change detection more cost effective.
- With regards to the bathymetric LiDAR data, it was mentioned that in any data sets, there is often a data gap between the low water and about the -10 metre line, due to the usually turbulent circumstances in the surf zone.
- Besides the above-mentioned "intended" applications, the data might actually "discover" unknown features or structures in the assessed area, such as ship wrecks, reefs or geological channels.
- Different applications such as planning and design will require different scales/accuracies of topographic data.

1.5.2. Value added products

It was understood that the original LiDAR derived point clouds are of little value to the user, with the files being too big and requiring special software for viewing/editing. Therefore, cleaned up and thinned point clouds as well as value added products such as Digital Surface Models in raster format (e.g. geoTIFF) or in the form of topographic contours (e.g. ESRI Shape file SHP) should be provided. The LiDAR companies stated that these are usually part of the standard products provided to the client anyway.

Typical standard products are listed in Table 3 below:

Table 3: Standard products usually complementing the raw LiDAR point cloud data:

Name	Description	Comments
10cm contours	Polyline shp file	Contour interval according to user specs
DSM? Digital Surface Model	Top-of-canopy/rooftop elevations?	Raster/tin?
DTM? Digital Terrain Model	Ground level elevation	???
Point clouds	Xyz text files	Thinned and cleaned up e.g. to 1 point per m^2.

It was agreed that such products will certainly suffice most of the coastal management requirements. However, certain coastal applications might benefit from other value-added products, e.g. information on the vegetation structure and/or the estimated surface area of estuaries at 10 cm intervals.

These non-standard products are currently either generated by the original data provider on request or, where capability exists, by the data owners themselves.

1.5.3. Minimum standards and specifications

1.5.3.1. Technical specifications and standards

Using the coastal applications listed in Table 2 above as context, the workshop discussed which minimum requirements should be requested in terms of absolute vertical data accuracy, spatial resolution and required repetition frequency. This resulted in the values summarised in Table 4 below.

Table 4: Technical minimum specification with regards to accuracy and resolution

Field of application	Feature / purpose	Abs. vert. accuracy	Sigma	Pixel Size	Repetition
Coastal Zone management	Setback lines	10cm	1	20cm	once off
	Illegal structures	20cm	1		
	Coastal boundaries	20cm	1		
	Land use planning	20cm	1		
	Beach erosion	10cm	1		
Estuary management	Berm height	10cm	1		6-monthly for 2 yrs, then 3-yearly
	Volumetric & floodplains	5cm	1		
	Mouth & channel dynamics	20cm	1		
	Biomass assessment	10cm	1		5-10 yrs
	Habitat shifts	20cm	1		
Risk and vulnerability	Wave run up / flooding	20cm	1		

Field of application	Feature / purpose	Abs. vert. accuracy	Sigma	Pixel Size	Repetition
	Foredune	20cm	1		
	Vegetation	20cm	1		
Disaster response	Infrastructure topography	5cm	1		
	Erosion	20cm	1		after events
Conservation	Aliens	20cm	1		
	Habitat mapping	20cm	1		
	Coastal resilience	20cm	1		
	Vegetation structure	20cm	1		
Navigation	General charting	50cm	2		
	Ports & harbours	10cm	1		
Design	Port structures	10cm	1		
Geology	Tectonics	50cm	1		3-monthly for 3 yrs
	Reefs	50cm	1		

It can be seen that for all of the features the group had clear requirements with regards to the required absolute accuracy the topographic data should have. The present LiDAR providers helped to convert these values into their "language" in the form of Sigma (i.e. 1 or 2 Standard deviations from mean value). However, for most of the features consensus could not be reached on the horizontal spatial resolution, i.e. pixel size when converting the original LiDAR point clouds into raster format. The discussion was not conclusive on the required repetition rate, i.e. how frequently new LiDAR data would be required for the respective application. While for some features specific figures were given, for most of the others agreement seemed to be that annual – or even 3-5 years – repetition would suffice.

In the context of the required repetition frequency of the data, it was mentioned that in the USA NOAA (the US National Oceanic and Atmospheric Administration) and ERDC (the US Army's Engineer Research and Development Center) task individual strips of the coast each year. This procedure is mainly due to budget constraints (Hugh). However, additional assessments usually take place e.g. for scientific purposes (Russell). In SA, CD:NGI (Chief Directorate for National Geospatial Information) follows a similar task schedule for aerial photo acquisition, also for budget reasons (Laurie).

It was mentioned that the existing standards for other countries might help to finalise the South African standards.

1.5.3.2. Safety standards

Besides the technical specification standards, safety standards relating to the actual acquisition have to be considered as well. These standards entail e.g. weather conditions under which it is safe to fly the aircraft. It is important for the client to understand these constraints as otherwise disappointment may result when flight campaigns cannot be concluded in the envisaged time frame, e.g. due to bad weather. Another safety risk for consideration in particular in the coastal and wetland context is the occurrence of hippos and crocodiles which might impede proper ground truthing, thus resulting in less absolute accuracies. It was agreed that many risks and disappointments resulting from those issues can be avoided if proper pre-scoping with the client takes place.

International Safety Standards for bathymetric and topographic mapping do exist for example for Australia. These can be assessed from http://www.icsm.gov.au/publications/#LiDAR and also in the USA (http://shoals.sam.usace.army.mil/Standards.aspx).

1.5.4. Lead agency

It was agreed that the creation of a central South African coastal LiDAR data repository in consultation with the Committee for Spatial Information (CSI) and in line with the South African Spatial Data Infrastructure (SASDI) is a good idea. Most of the present LiDAR data owners were comfortable making their data – or at least their metadata and footprints – available for this purpose. However, the expected massive data amount will require a host that is prepared for and experienced as data custodian.

The following options were discussed for potential LiDAR curators:

- Creation of a new "agency" for this purpose
- Embedded in an existing data curation structure, such as CD:NGI (Chief Directorate for National Geo-spatial Information), SANSA (SA National Space Agency), DEA (Department of Environmental Affairs), BGIS (SANBI's Biodiversity GIS), SAEON (South African Environmental Observation Network).

It was mentioned that there would be huge cost implications for the creation of a new structure.

The problem which might arise with CD:NGI on the other hand might be, that they generally limit the "warranty for accuracy" of the data provided by them to 50 cm. This, however, might be too coarse for coastal requirements (see Table 4). CD:NGI might be approachable though for negotiating these limits for the coastal LiDAR data.

Most participants felt comfortable that CD:NGI be approached for this role by a delegation of the workshop (see Section 1.6).

With regards to the role of the lead agency, it should be the curation and provision of the original point clouds as well as the basic "off-the-shelf" standard products. Further, it has to be discussed if the generation of non-standard products, e.g. vegetation structure, should reside with the curator as well or if this shall remain within the responsibility of the original data provider, owner, or data requestor.

At the end of the two-day workshop the workshop concluded that there now proudly is a

South African Coastal LiDAR Community of Practise.

All further activities in this context will subsequently be labelled "CoP Meetings". New members are welcome.

Figure 2: The founder members of the South African Coastal LiDAR Community of Practise. ☺

1.6. Agreed follow up actions

Who	What	Comments/progress
LiDAR custodians (i.e. everybody possessing LiDAR data)	Send metadata with the minimum information as requested in Table 1 to Melanie (CSIR)	To Melanie until official curator is decided on
Melanie and Roger	Explore if metadata can be put online in a geospatial portal (at AAM), get approval from custodians	
Service providers	Please summarise in your own words what you understand of what the Coastal practitioners want (1-2 pages)	
CSIR & DEA O&C Melanie & Alan Boyd?)	Approach CD:NGI to become coastal LiDAR curator, and speak to the Committee for Spatial Information	
Everybody	comment on this workshop report	
Melanie	Publish final workshop report at CSIR website and on SA-GEO Coastal & Marine Community of Practise website	Melanie is co-chair of that CoP.
Andre v.d.M., Hugh, Chris T., Melanie	Develop a Pilot project, preferably in the Langebaan area (Lagoon, Port and open coast) where our pre-defined technical specs and assumptions can be tested and calibrated.	Project should include another c-LIDAR CoP workshop/meeting/conference or should consider the CoastGIS2015 conference as platform for dissemination of results.

2. Appendix 1: Programme

Tuesday, 25 March

Time	Topic	Speaker
9:30 - 10:15	Welcome coffee	
10:15 - 10:30	Welcome	Laurie Barwell, CSIR
10:30 - 10:50	Why LiDAR? Comparison of topography technologies	Melanie Lück-Vogel, CSIR
10:50 – 11:00	Opening Note	Alan Boyd, DEA
11:00 - 11:15	Tea break	
11:15 – 13:00	Technical Background on LiDAR	Norman Banks, Southern Mapping
	Examples of LiDAR Applications in the SA coastal zone	Hugh Parker, Fugro
	LiDAR for environmental management and research in St. Lucia	Chris Tanner, AAM
	LiDAR experiences in eThekwini	Andrew Mather, eThekwini Municip.
	Laser scanning for physical modelling for coastal engineering	Kishan Tulsi, CSIR
13:00 - 14:00	**Lunch**	
14:00 - 14:15	LiDAR for ESCOM	Adri de la Rey, ESCOM
14:15 – 14:40	History of US Coastal Mapping and JALBTCX	Jeff Lillycrop, ERDC (per phone)
14:40 – 15:00	Examples of coastal LiDAR applications in the USA	Jennifer Wozencraft, ERDC (per phone)
15:00 - 15:30	Tea break	
15:30	Closure Day 1	

Wednesday, 26 March

Time	Topic	Speaker
8:45 - 9:00	Welcome coffee	
9:00 - 9:15	Experiences and Challenges with LiDAR acquisition in the Western Cape Province	Ieptishaam Bekko, WC Province
9:15 - 10:00	Stocktaking of existing data	all
10:00 - 10:30	Identification of core discussion topics	all
10:30 - 11:00	Tea break	
11:00 - 13:00	Discussion Session	all
13:00 – 13:30	**Lunch**	
13:30 – 14:00	Discussion cont.	all
14:00 - 15:00	Wrap-up, conclusions and way forward.	all
15:00	Closure Day 2	

3. Appendix 2: Participants

No.	Participant	email	Phone	Affiliation	Day 1	Day 2
1	Adri de la Rey	dlreya@eskom.co.za	011 651 6908	ESKOM	x	x
2	Adriaan van Niekerk	avn@sun.ac.za	021 808 3101	Stellenbosch University	x	x
3	Alan Boyd	ajboyd@environment.gov.za	083 412 3965	DEA O&C	x	
4	Andre Theron	atheron@csir.co.za	021 888 2511	CSIR	x	x
5	André van der Merwe	andre.vandermerwe@westerncape.gov.za	021 483 3499	WC Dep. of Environmental Affairs and Development Planning	x	
6	Andrew Mather	Andrew.Mather@durban.gov.za	083 309 0233	eThekwiwi	x	x
7	Ashton Maherry	amaherry@csir.co.za	021 888 2594	CSIR	x	
8	Bronwyn Goble	bgoble@ori.org.za	031 328 8170	ORI	x	x
9	Chiedza Musekiwa	cmusekiwa@geoscience.org.za	021 943 6737	Council for Geoscience	x	
10	Chris Tanner	c.tanner@aamgroup.com	083 441 9944	AAM	x	
11	Cikizwa Mbolambi	cmbolambi@csir.co.za	021 888 2562	CSIR	x	
12	Dalene Stapelberg	andre.vandermerwe@westerncape.gov.za	021 483 3499	WC Dep. of Environmental Affairs and Development Planning	x	x
13	Dave Cochran	afsurv@mweb.co.za	012 809 4475	CAD Mapping	x	
14	Dumisani Sibande	sibanddg@escom.co.za	011 690 4076	ESKOM	x	x
15	Geoff Dekker	Geoff.Dekker@capetown.gov.za	021 487 2327	City of Cape Town	x	x
16	Heather Terrapon	H.Terrapon@sanbi.org.za	021 799 8799	SANBI Biodiversity	x	
17	Hugh Parker	H.Parker@fugro.com	+61 400 279147	Fugro LADS Corporation	x	x
18	Ieptishaam Bekko	Ieptieshaam.Bekko@westerncape.gov.za	021 483 3370	WC Province	x	x
19	Janco van der Merwe	Janco@geosense.co.za	012 643 1569	Geosense	x	x
20	Kishan Tulsi	ktulsi@csir.co.za	021 888 2539	CSIR	x	
21	Lara van Niekerk	lvnieker@csir.co.za	021 888 2491	CSIR	x	x
22	Lauren Lyn Williams	Lwilliams@environment.gov.za	021 819 2492	DEA O&C	x	x
23	Laurie Barwell	lbarwell@csir.co.za	021 888 2576	CSIR	x	x
24	Linda Harris	harris.linda.r@gmail.com	041 5044281	NMMU, Coastal and Marine Research Unit	x	x

No.	Participant	email	Phone	Affiliation	Day 1	Day 2
25	Liwa Madikiza	Lmadikiza@environment.gov.za	021 402 3624	DEA O&C	x	
26	M.Q. Mquibi	Qmqubi@environment.gov.za		DEA O&C	x	
27	Mbongeni Tyesi	mbongeni@environment.gov.za	072 252 4192	DEA O&C		x
28	Melanie Luck-Vogel	mluckvogel@csir.co.za	021 888 2412	CSIR	x	x
29	Michael Machutchon	michael@geoscience.org.za	021 943 6718	Council for Geoscience	x	
30	Michelle Denner	Mdenner@ruraldevelopment.gov.za	021 658 4399	CD:NGI	x	
31	Monde Hashe	mondeh@telkomsa.net	011 868 1832	CAD Mapping	x	
32	Niel Malan	dmalan@environment.gov.za	021 405 9495	DEA O&C	x	x
33	Norman Banks	norman@southernmapping.com	011 467 2609	Southern Mapping	x	x
34	Ntomboruyo Madlokazi	nmadlokazi@environment.gov.za	021 819 2495	DEA O&C	x	
35	Omar Parak	Omar.Parak@kzndae.gov.za	033 355 9438	KZN Province	x	x
36	Potlako Khati	PKhati@environment.gov.za	021 819 2495	DEA O&C	x	
37	Prevlan Chetty	prevlan@southernmapping.com	084 607 8690	Southern Mapping	x	x
38	Riaan Brink	r.brink@fugro.com	082 558 8455	Fugro Geospatial	x	x
39	Roger Blewett	R.Blewett@aamgroup.com	011 260 4900	AAM	x	x
40	Russell Harmon	russell.s.harmon.civ@mail.mil	+44 (0)1895 616 192	ERDC	x	x
41	Sandiso Zide	sandiso.zide@deaet.ecape.gov.za	043 605 7256	Eastern Cape Dept. of Ec. Development, Env. Affairs & Tourism	x	x
42	Tebogo Senoge	tebogo@cadmapping.co.za		CAD Mapping	x	x
43	Thabo Tyholweni	dayzathabo@gmail.com		CSIR	x	
44	Thomas Reiner	Thomas.Reiner@capetown.gov.za	021 487 2394	City of Cape Town	x	x
45	Wilhelm van Zyl	wvzyl@geoscience.org.za	021 943 6700	Council for Geoscience	x	x
46	Xolani Nikelo	xolani.nikelo@deaet.ecape.gov.za	043 605 7105	Eastern Cape Dept. of Ec. Development, Env. Affairs & Tourism	x	x
47	Zain Jumat	Zain.Jumat@westerncape.gov.za	021 483 2889	WC Province	x	x

4. Appendix 3: Accuracy versus Precision

Source of Document:

OPTRON

Accuracy versus Precision

Accuracy versus Precision

Products

- All instruments and software where accuracy and precision apply

Summary

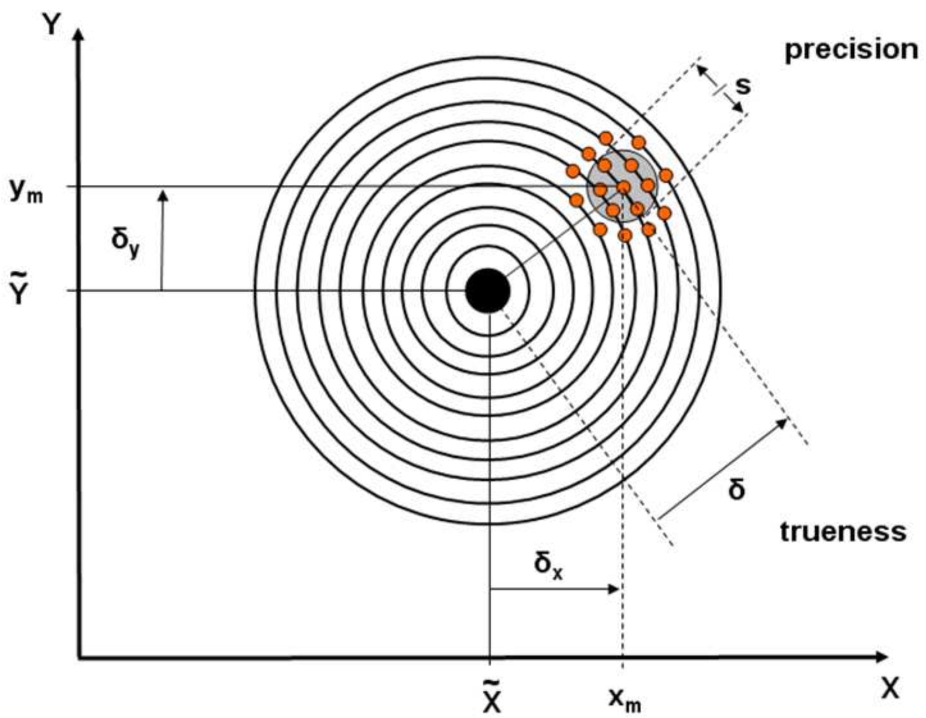
This TechTip describes the difference between "accuracy" and "precision".

Description

Although the terms "accuracy" and "precision" are commonly used as synonyms, in reality the meaning is very different and is governed by the applicable discipline. The descriptions in this document relate specifically to survey and construction.

- ***Accuracy*** is a qualitative expression of how close a measuring result is to the true value. Precision is one element of accuracy.
- ***Precision*** is the closeness of measured points. It contributes to the accuracy of a measurement.

Accuracy contains two criteria: the precision and the trueness (exactness of the mean). This can easily be explained with shots to a target. However, the dots can also represent some polar measurements with a total station:



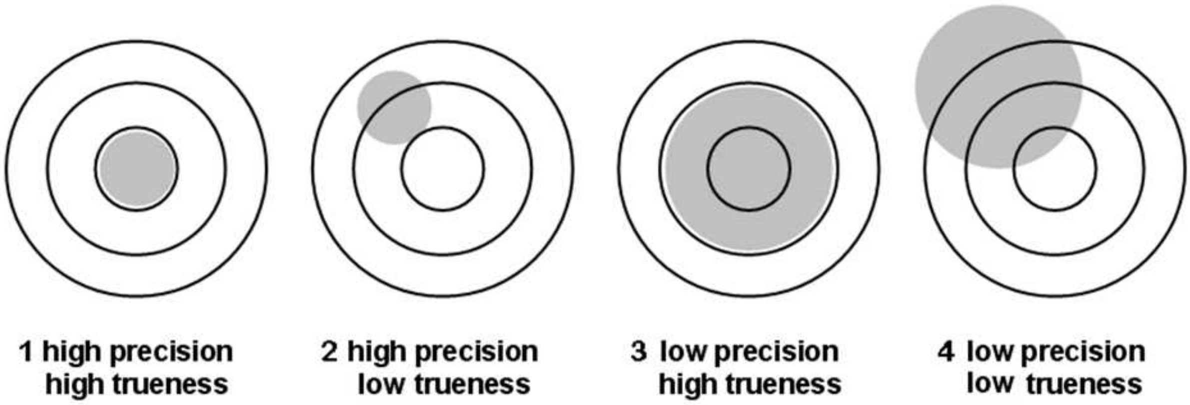
- The center of the target represents the true value (position) of the measured point. The true value is normally not known.

- Several measurements from the same station point in a short period of time will result in the measured positions, indicated with the red dots. The mean value (xm, ym) can be calculated.
- The precision says how close all the measured points are. This can be expressed by the standard deviation s.

In general, the mean value does not match the true value: The systematical measuring deviation between the mean value and true value is called the trueness or bias δ. With total station measurements, it could be caused by an error in the orientation and a wrong prism constant or an additional constant for the distance meter.

The trueness cannot be explained by a standard deviation. Trueness is an element of accuracy, so in general, the accuracy also cannot be expressed by a standard deviation.

The following diagram shows the possible relationship between trueness and precision, from left to right:



1. Where the trueness δ equals zero, that is, when all systematical deviations are excluded, precision is the sole criterion of accuracy. In this example, the grey area represents the point cloud and is centered to the true value. This means that the trueness is very high. The area size is small, so the precision is also high.

2. This example shows a high precision and low trueness.

3. This example shoes a low precision without any systematical deviations. As a result, the trueness is high.

4. This example shows a low precision and a low trueness.

Notes

- *The accuracy of a measuring result is determined by the precision and by the care taken in excluding known systematical measuring deviations.*
- *The accuracy is not specified by a quantitative value like a standard deviation.*

Examples from surveying practice

- A distance is measured 10 times over a short period. The precision can be expressed by a standard deviation and is a measure of the repeatability, which is a characteristic of the used distance meter.
  The atmospheric parameters may be constant within the measuring time. But there may be a systematical deviation, when the measured temperature does not represent the temperature along the distance. The accuracy of the distance result can be low, although the precision may be high.
- Angles are measured within 2 faces to eliminate remaining collimation and trunnion axis errors. The measuring values in both faces have different expectation values, caused by the axis errors. Standard deviations calculated, including the differences between face 1 and face 2, would contain systematical deviations. Therefore, the ISO 17123-3 norm states to average both faces before calculating the precision.
- Plumbing with an optical plummet in the tribrach results in a centering error when the plummet is not correctly adjusted. This leads to systematical errors of all the distances and angles measured from this station, whereas the standard deviation may indicate a high precision.
- Trimble datasheets provide some specifications. For example, the "distance accuracy" for a Trimble® S8 total station is specified with a standard deviation of 1 mm + 1ppm. This sounds wrong with respect to the statement above (that only a precision can be expressed by a standard deviation), however, distance meters are manufactured so that no systematic errors remain, for example an additional constant or a scale factor. The measured distances are checked against the known true (nominal) values, as on calibration lines. The true values for the different distances to measure are known; no bias or systematic deviations remain. In this case, the accuracy is represented by the precision.

The standard deviation for measurements with a known "true value" is calculated by

$$s = \sqrt{\frac{\sum (x_i - x_m)^2}{n}}$$

Where n is the degree of freedom.

The standard deviation is usually calculated with n-1; this is why the mean value must be calculated so that the degree of freedom is reduced by 1. If the true value is known, the mean value does not need to be calculated. So the degree of freedom equals the number of measurements.

Related information

- For definitions of accuracy and precision, see also ISO 3534-1977, *Statistics - Vocabulary and Symbols.* These definitions apply generally to both science and engineering applications.

Contact

Optron Geomatics
Block C
Lakefield Office Park
272 West Avenue
Centurion
South Africa
0157

Email: helpdesk@optron.com
Tel: +2712 683 4504
0860 999 007