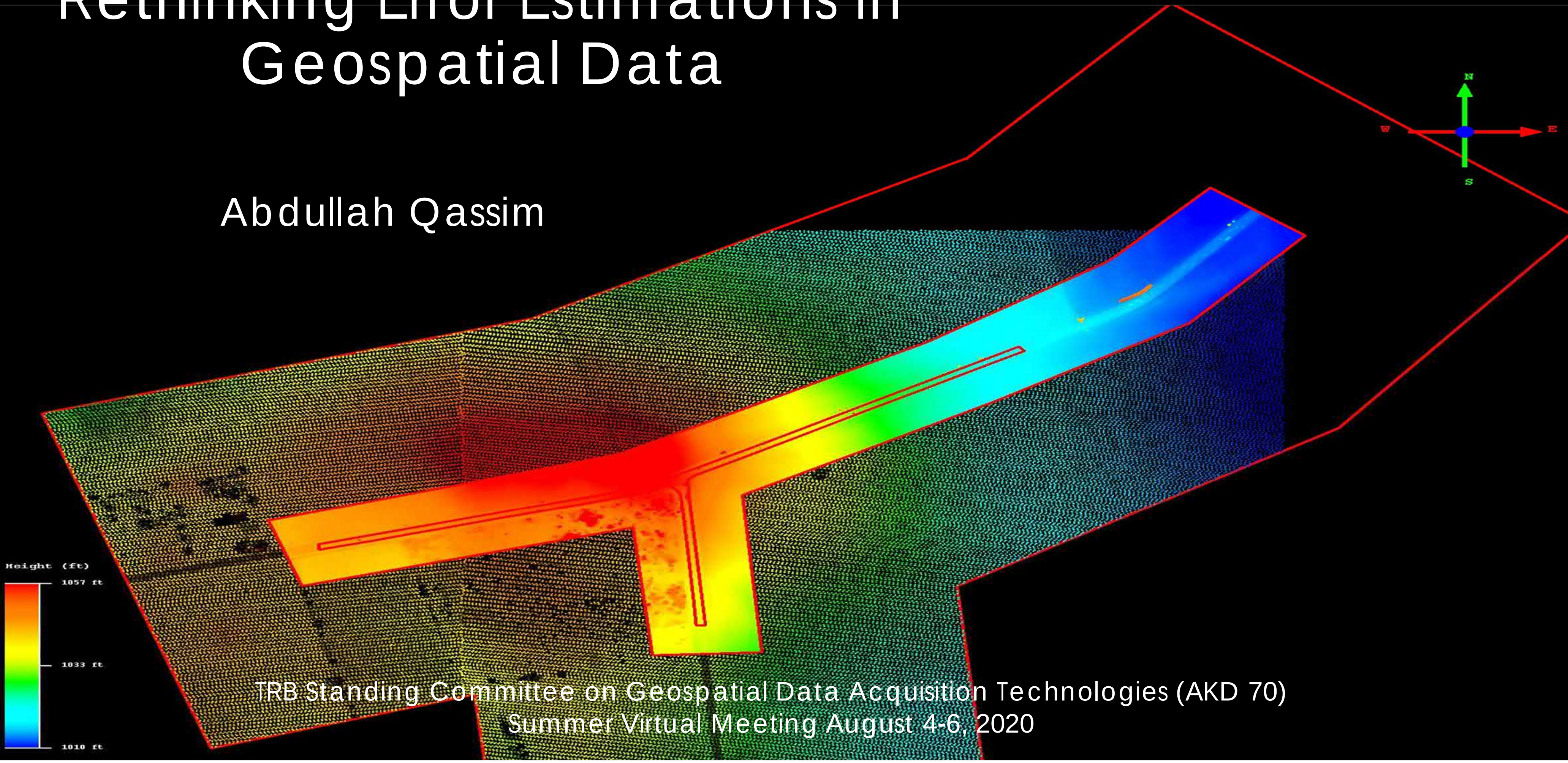
Rethinking Error Estimations in Geospatial Data

Abdullah Qassim



TRB Standing Committee on Geospatial Data Acquisition Technologies (AKD 70)
Summer Virtual Meeting August 4-6, 2020

Agenda

1. Statement of the Problem
2. Early Era of Geospatial Technologies
   - Plane Table Surveying
   - Analogue Stereo Plotters
3. Modern Era of Geospatial Technologies
   - Total Station and GPS Surveying
   - Lidar
   - Digital Camera
4. Current Practices in Computing Products Accuracy
5. The Correct Way for Computing Product Accuracy

Statement of the problem

1. We quantify products accuracy ignoring the errors in the surveyed check points

2. Our surveying techniques approximates the datum, i.e. producing pseudo datum

3. Currently, we are evaluation the closeness of data to the pseudo datum and not the true datum

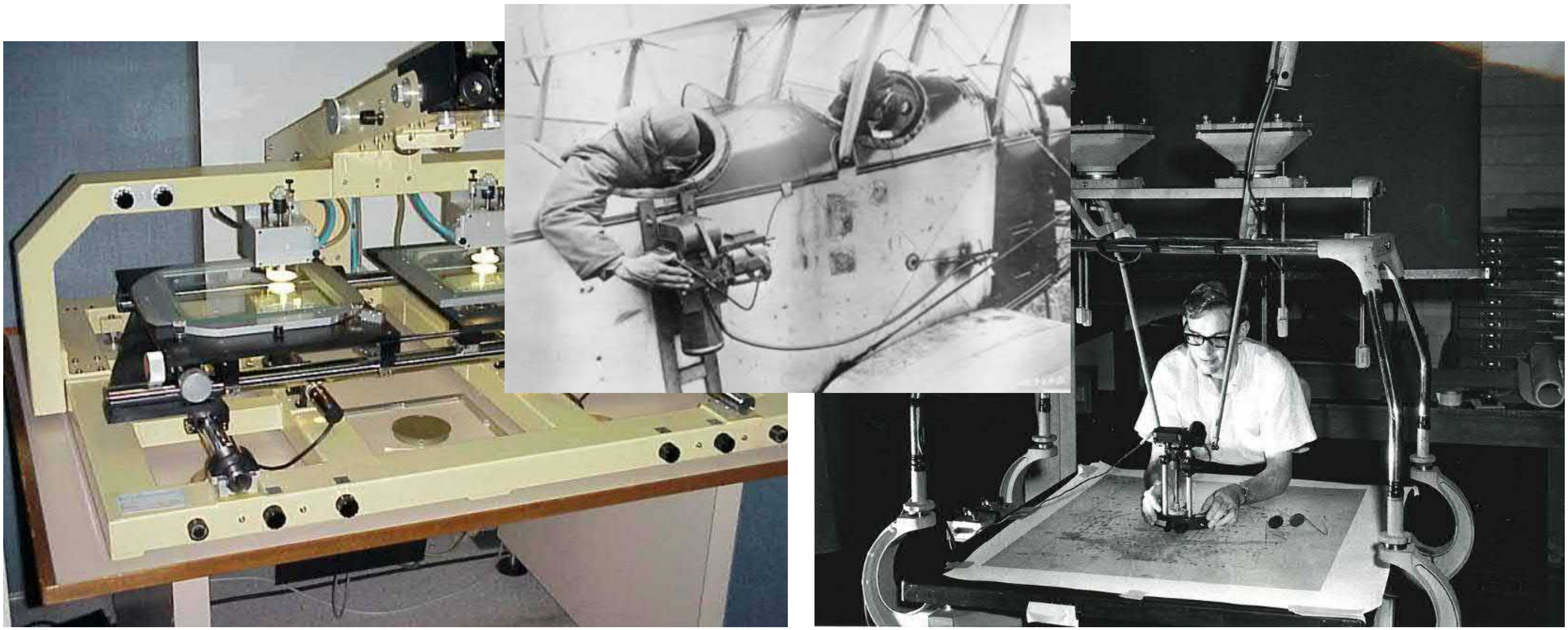

Where it was all started ….
Early Era of Geospatial Technologies

Why So

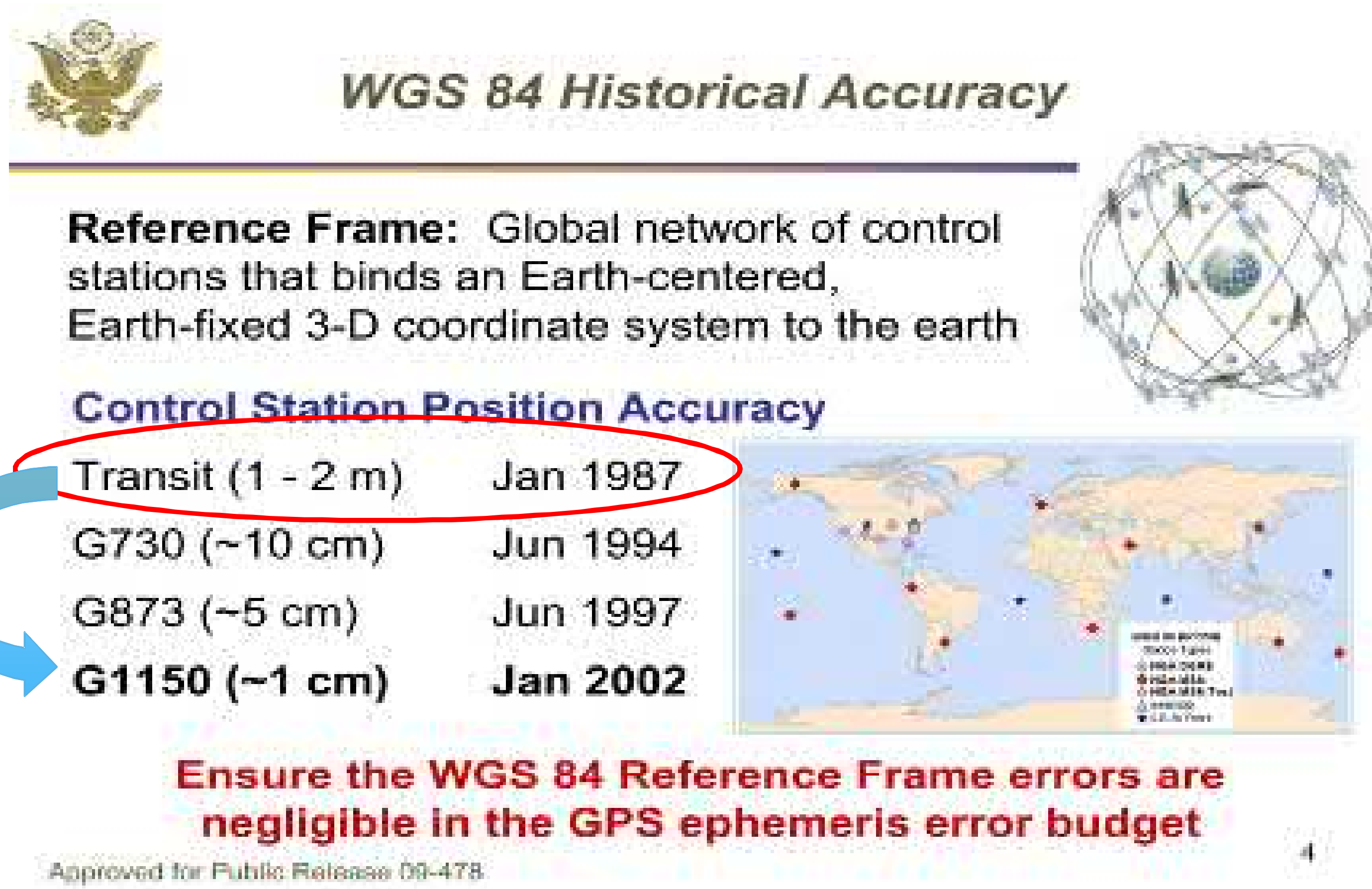
Our surveying technologies were less accurate.

Why So

Our geospatial products and mapping technologies were less accurate



Why So? Surveying Datum was not accurate



Adopted from NGA presentation to the International Committee on GNSS - Working Group D, Saint Petersburg, Russia 16 September 2009

Why So? Surveying Datum was not accurate

National Spatial Reference System (NSRS) Improvements over time

NETWORK	TIME SPAN	NETWORK ACCURACY	LOCAL ACCURACY	SHIFT
NAD 27	1927-1986	10 meters	(1:100,000)	10-200 m
NAD83(86)	1986-1990	1 meter	(1:100,000)	0.3-1.0 m
NAD83(199x)* “HARN”, “FBN”	1990-2007	0.1 meter	(1:1 million) (1:10 million)	0.05 m
NAD83(NSRS2007)	2007-2011	0.01 meter	0.01 meter	0.03 m
NAD83(NSRS2011)	2011	0.01 meter	0.01 meter	0.01 m

Why did we end up that way?

- Ortho imagery were produced with low resolution, DOQQ were produced with 1 meter GSD and 33 ft. accuracy

- Maps were produced with small scale

- Therefore, errors in control/check points were ignored as it was considered negligible

Modern Era of Geospatial Technologies

Today's Surveying Technologies

Leica Nova TS60i Total Station with R1000 Reflector-less EDM

- Accuracy: sub-millimeter and sub-second
- Automatic target recognition (ATR), PowerSearch, and laser plummet
- WLAN, Bluetooth, RS232/USB interface, Radio Handle interface, and USB stick/SD card interface
- 2GB eMMC flash memory and 1GB SDRAM
- 2 keyboards with 5" WVGA color touchscreens

Source: https://www.allenprecision.com/leica-nova-ts60i-total-station-with-r1000-reflectorless-edm

Today's Surveying Technologies

GNSS Technology

A new level of productivity

8 mm H / 15 mm V	672	Integrated
Max. Precision	Channels	Antenna
Receive & Transmit		
UHF Radio		

Source: https://geospatial.trimble.com/products-and-solutions/gnss-systems

Today’s Mapping Technologies

Metric mapping cameras

UltraCAM-Eagle (courtesy Microsoft)

A3 (Courtesy Vision Map)


DMC II250 (Courtesy Intergraph)


ADS80 (courtesy Hexagon)

Phase One iXM-RS 280F

- Rigid construction
- Extreme high quality optics
- It holds to its calibration values

Today's Mapping Technologies

Non-metric mapping cameras

- – Less expensive
- – Consumer grade construction
- – It does not hold to its calibration values over time

Today's Mapping Technologies

Aerial Lidar System Technology

Accuracy that we never experienced before

Today’s Mapping Technologies

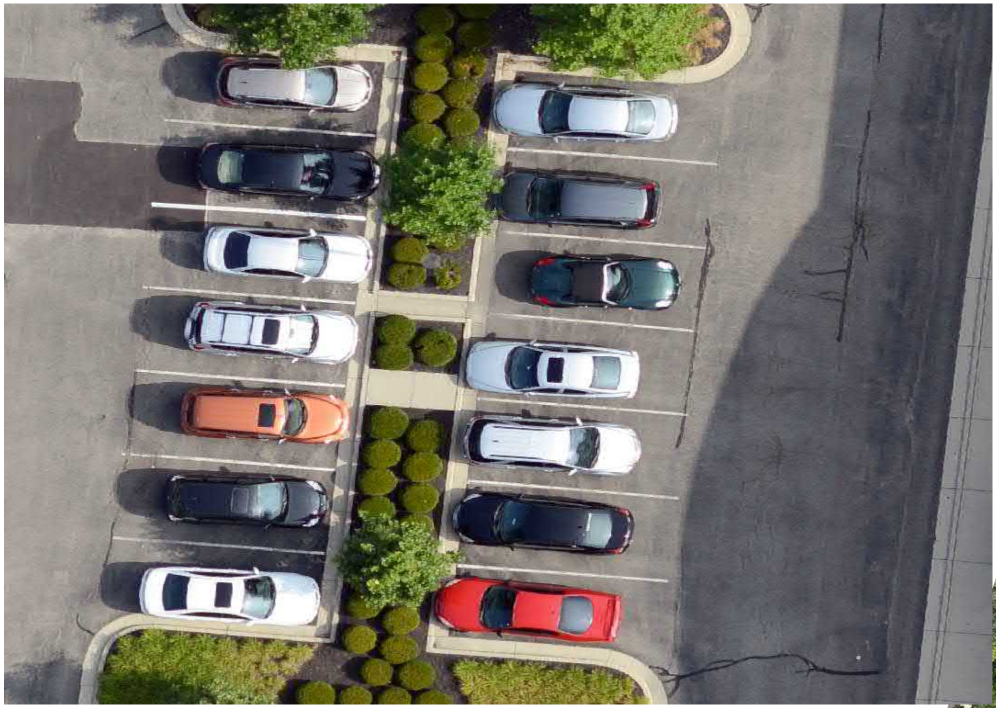
Mobile Mapping System

2,000 pts/m^2 to 6,000 pts/m^2

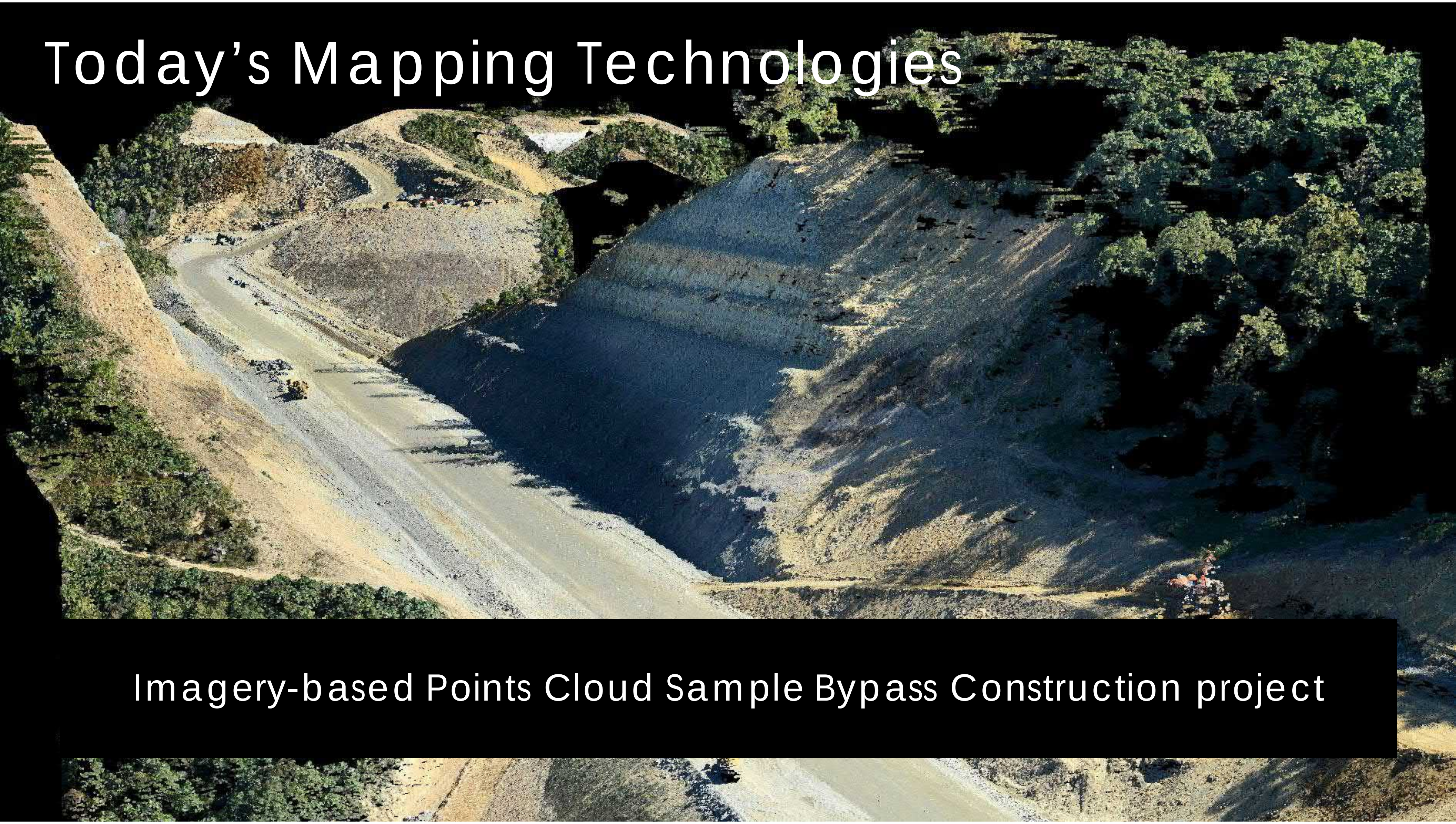
Accuracy≅1.8 cm

Today's Mapping Technologies

UAS-based Points Cloud and Imagery



Today’s Mapping Technologies



Imagery-based Points Cloud Sample Bypass Construction project

Why Now

- Geospatial products today are very accurate
- We are heading toward more accurate datum in 2022
- Drone are collecting imagery with 1-cm GSD and producing highly accurate products
- Lidar is providing accuracy in the range of 1.5 to 10 cm
- The new ASPRS standards support high accuracy
- We just can not continue our wrong practices

How should we express product accuracy?

Photogrammetry:

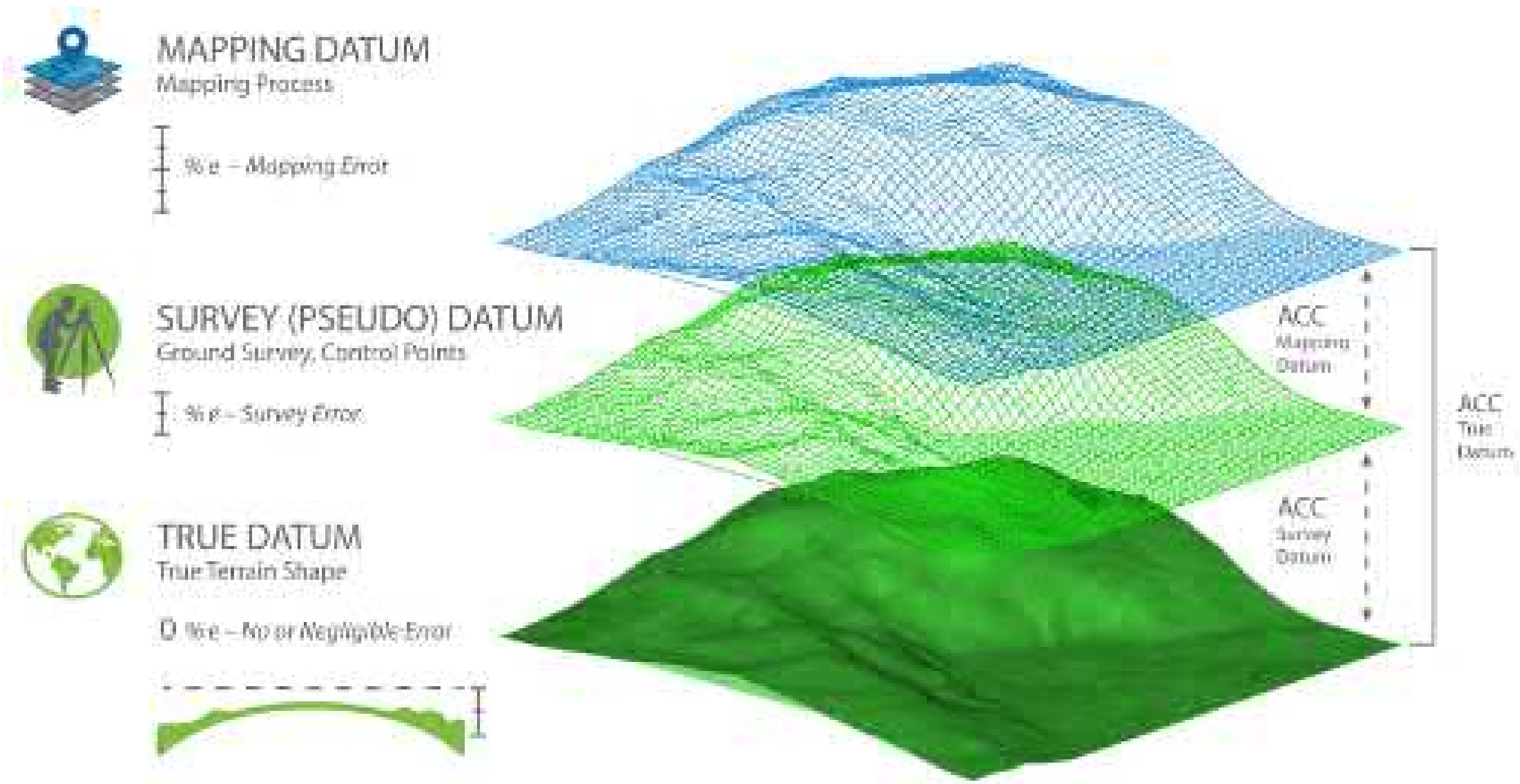
Aerial Triangulation Accuracy should consider the fit to the GCPs & the accuracy of the GCPs

Ortho Accuracy = should consider the fit to check points & the accuracy of the check points

Lidar:

Lidar Accuracy = should consider the fit to check points & the accuracy of the check points

How should we express product accuracy?

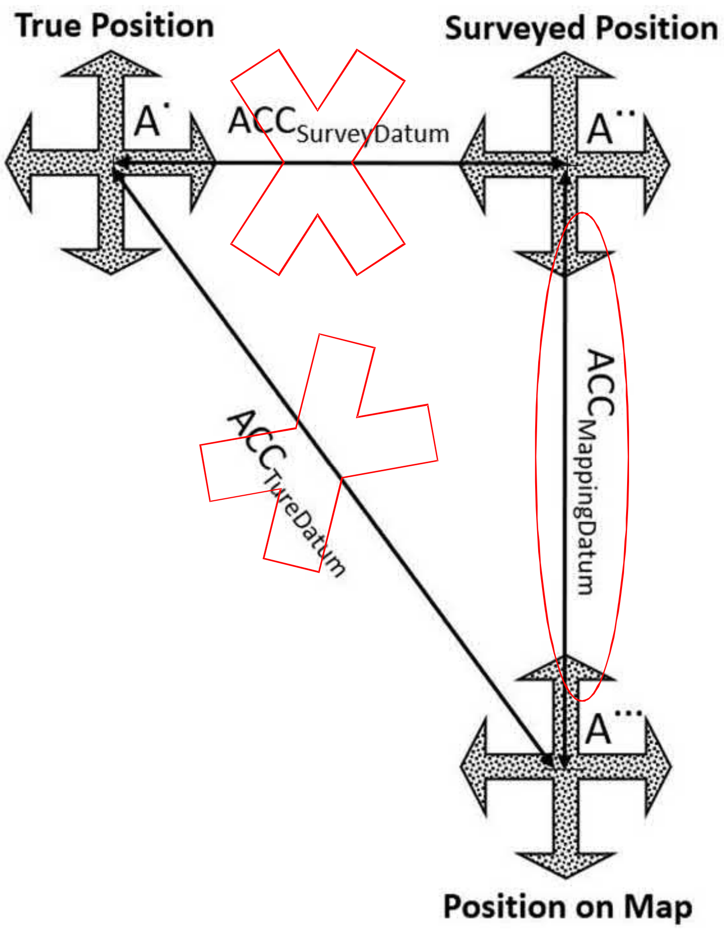


How should we express product accuracy?

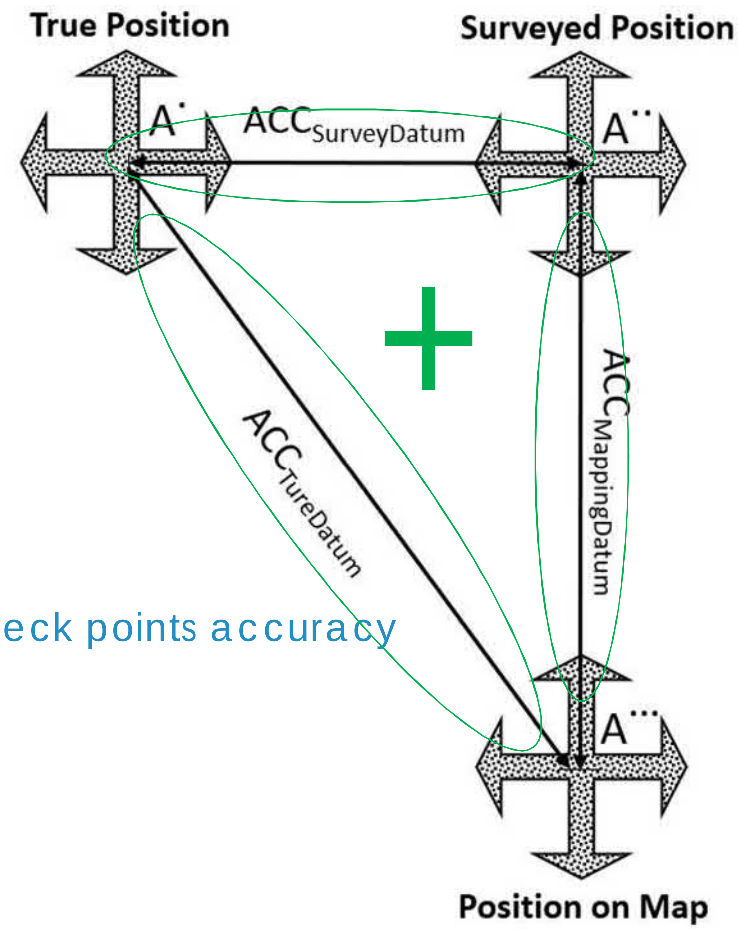
Current practice:

Product accuracy = Errors in fitting products to check points

$ACC_{TrueDatum} = ACC_{MappingDatum}$



How should we express product accuracy?



Correct practice:

Product accuracy = Errors in fitting products to check points + check points accuracy

$$ACC_{TrueDatum} = \sqrt{ACC_{MappingDatum^2} + ACC_{SurveyDatum^2}}$$

** Using vector algebra and error propagation

How should we express product accuracy?

Lidar vertical accuracy

Current practice:

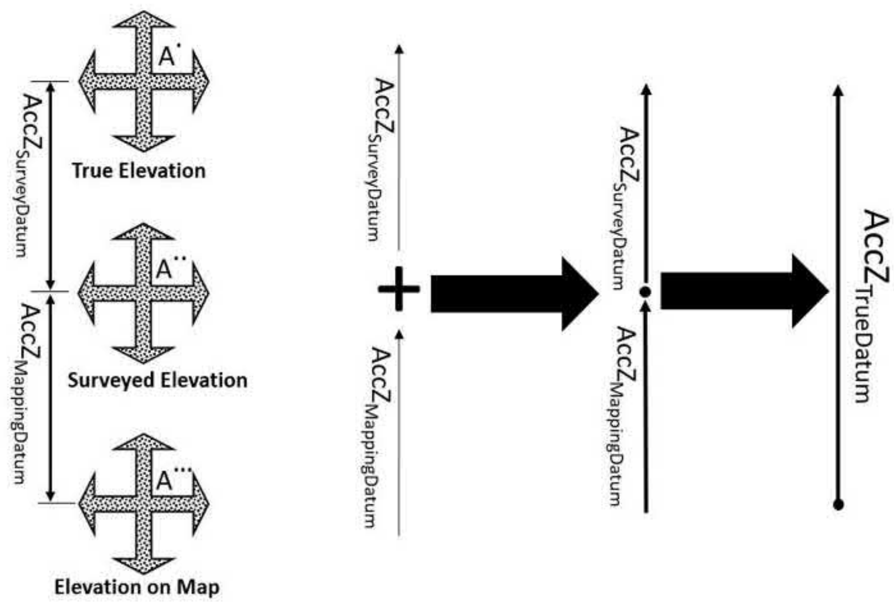
Product accuracy = Errors in fitting products to check points

$$AccZTrueDatum = AccZMappingDatum$$

Correct practice**:

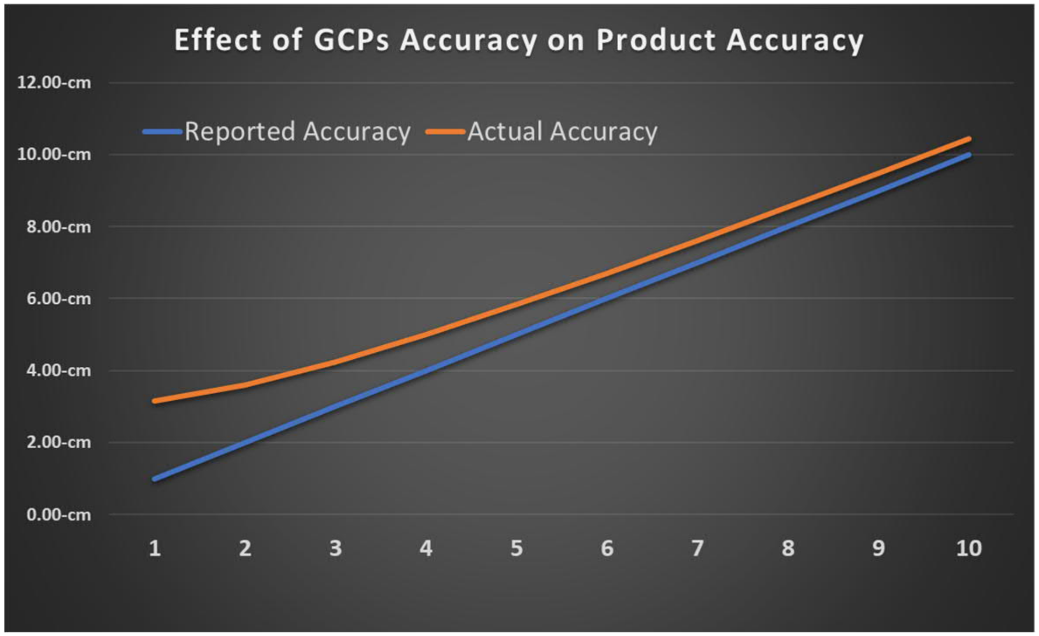
Product accuracy = Errors in fitting products to check points & check points accuracy

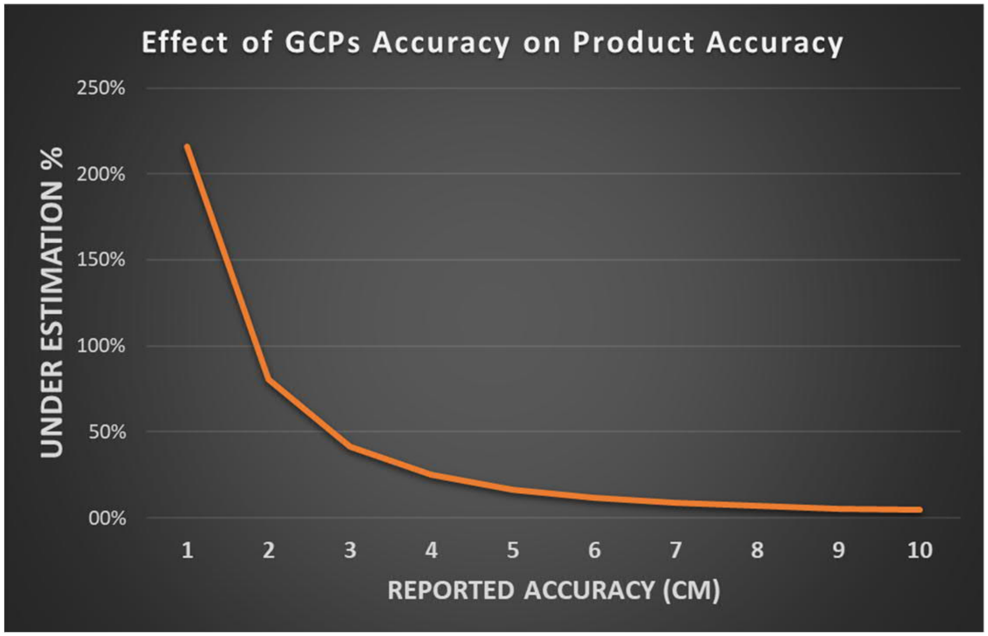
$$AccZTrueDatum = \sqrt{AccZMappingDatum^2 + AccZSurveyDatum^2}$$



** Using vector algebra and error propagation

Where it hurts the most is in accurate products





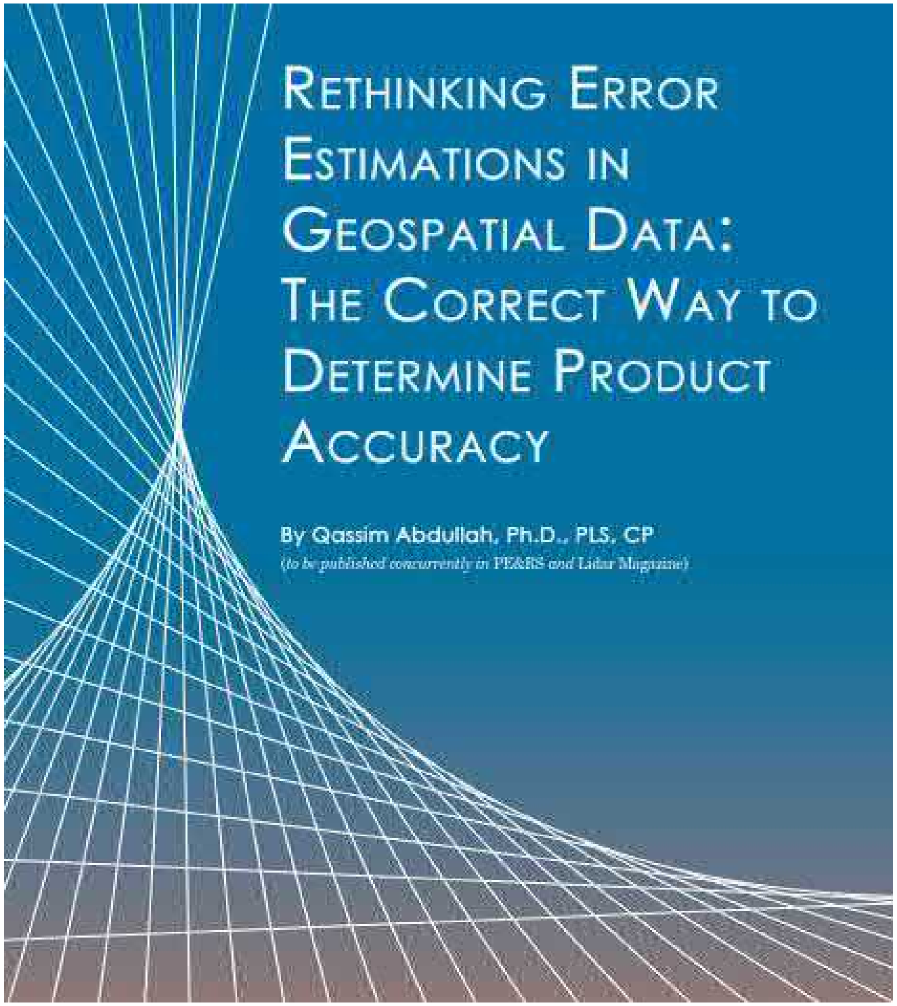
Product Accuracy	Ground Survey Accuracy	Current Designated Accuracy	Correct Product Accuracy	Under Estimation
1.00-cm	3.00-cm	1.00-cm	3.16-cm	216%
2.00-cm	3.00-cm	2.00-cm	3.61-cm	80%
3.00-cm	3.00-cm	3.00-cm	4.24-cm	41%
4.00-cm	3.00-cm	4.00-cm	5.00-cm	25%
5.00-cm	3.00-cm	5.00-cm	5.83-cm	17%
6.00-cm	3.00-cm	6.00-cm	6.71-cm	12%
7.00-cm	3.00-cm	7.00-cm	7.62-cm	09%
8.00-cm	3.00-cm	8.00-cm	8.54-cm	07%
9.00-cm	3.00-cm	9.00-cm	9.49-cm	05%
10.00-cm	3.00-cm	10.00-cm	10.44-cm	04%

Concluding Remarks

1. The mapping community needs to start incorporating the accuracy of field surveying ground control points or checkpoints into their product accuracy computations when reporting final product accuracy

2. Similar actions need to be considered in the next version of the ASPRS Positional Accuracy Standards of Digital Geospatial Data. These standards need to be amended to introduce the correct way to compute product accuracy and to provide practical examples like the ones outlined in this article.

3. Private and public agencies need to mandate that future product accuracy should be expressed according to the new concept introduced in this presentation. By not doing so, the stated product accuracy according to the current practices will be incorrect and misleading.



Good reading on the topic, my highlight article in:

- The ASPRS PE&RS journal, July 2020

  https://lidarmag.com/2020/07/12/rethinking-error-estimations-in-geospatial-data-the-correct-way-to-determine-product-accuracy/

- Lidar Magazine

  https://woolpert.com/resource/rethinking-error-estimations-in-geospatial-data-the-correct-way-to-determine-product-accuracy/?utm_content=133088073&utm_medium=social&utm_source=linkedin&hss_channel=lcp-166967

Questions?

Thank you!

Qassim Abdullah

qassim.abdullah@woolpert.com

Mapping_matters@asprs.org

www.woolpert.com | www.asprs.org/Mapping-Matters.html