If the Map Fits

Team Members:

Kiera Fulton

Esther Cho

Edmond Leahy

Academic Supervisor: Dr. Mozhdeh Shahbazi

Sponsor Supervisor: Greg Roesler, P.Eng., NovAtel Inc.

Introduction

Milestone Summary

Milestone	Components	Planned Delivery Date	Actual Delivery Date
Kick-Off Meeting	• Discuss nature of initial dataset • Discuss necessary equations for algorithm • Finalize schedule for project proposal	2018-10-05	2018-10-05
Project Proposal	• Write up proposal • Get approval from academic and corporate supervisors • Project proposal to be submitted and presented to client	2018-10-18	2018-10-18
Initial Data Collection	• Obtain data from NovAtel for calibration	2018-11-19	Ongoing
Develop algorithm/code to compute parameters and location	• Read in LiDAR, GNSS and INS data • Post-process GNSS+INS data • Perform boresight calibration to compute system parameters and location	2018-12-18	In-progress
Subsidiary data collections	• Obtain data from NovAtel to test stability of computed parameters	2019-02-06	Future work
Test code on new datasets	• Use developed code and new data to test stability of previously computed calibration parameters	2019-02-13	Future work
Compute analytics on stability of solution	• Compare parameters computed from initial and new data	2019-02-22	Future work
Create presentation material	• Compile significant results into final report, presentation, and Capstone Fair trifold	2018-03-06	Future work

Milestone Overview

Summary of Work Accomplished During this Period

The GNSS/INS and LiDAR data has not yet been obtained. This is due to ongoing discussion with Dr. Shahbazi and with experts at NovAtel to determine the desired attributes for the dataset being obtained. The specifics of the dataset have been confirmed. The following units will be used for the calibration dataset (Specifications can be seen in the Appendix attached):

- <u>GNSS Receivers</u>: NovAtel OEM719 and OEM7720
- <u>IMU Units</u>: ISA100C and OEM-IMU-STIM300
- <u>LiDAR System</u>: Velodyne Puck

The dataset obtained from NovAtel is expected to have the following characteristics:

- Static
- Long enough for the INS solution to converge to centimeter level
- At least three different planar surfaces for computation of the normal vectors instead of feature detection (due to nature of the vertical scans in LiDAR)
- Two static orientations of the same scene

It has yet to be decided whether existing NovAtel datasets are sufficient for the planned calibration, or whether it would be beneficial to have a new dataset collected that will tailored for the purposes of our calibration. Discussions are nearing an end, and we expect to have data by the new delivery date of 2018-12-7.

After meeting with our academic supervisor Dr. Shahbazi to finalize a detailed workflow for the project, the details of the dataset were better understood. Specifically, the type of GNSS, INS, LiDAR data needed, as well as the equations and algorithm required for calibration including the key parameters we will be computing. Diagrams and proposed workflow that were created during this meeting can be found in the Appendix.

Lessons Learned

Through this period of the project, we learned a great deal about LiDAR data collection and what goes into the boresight calibration. After meeting with Dr. Shahbazi, we are now more knowledgeable about the specific properties of LiDAR data and how they relate to GNSS and INS data. We also now understand the process and series of equations needed to perform the calibration, and exactly how we can test our program.

We now know the scenarios needed for the data used in a calibration; we have notified Greg of our specified data characteristics.

Changes to the Work Plan

The planned delivery date for "Initial Data Collection" has been delayed because NovAtel will be providing our data instead of us collecting our own data. Confirmation of this can be found in Figure 17 in the Appendix. We are in discussion with NovAtel about the types of data that we will need for calibration and we expect to receive date by 2018-12-7, as opposed to our previous date of 2018-11-19. Due to this delay, we are starting the WBS tasks 3.2 and onwards (developing code) later than expected. However, we still plan to finish the code before WBS Task 5 (Test code on new datasets) on 2018-02-13, as task 5 is dependent on both Task 3 and Task 4. Task 4 is not dependent on the completion of Task 3, so we are confident that we can finish developing our code while trying to obtain more datasets from NovAtel.

List of Attachments

The following documents are given in the Appendix.

- Figures 1 to 11: Specification documents for equipment used by NovAtel for data collection. The equipment are two IMU units (ISA100C and OEM-IMU-STIM300), two GNSS units (OEM719 and OEM7720), and a LiDAR unit (Velodyne LiDAR Puck).
- Figure 12: An algorithm flowchart created prior to meeting with Dr. Shahbazi to demonstrate our knowledge of the project at that time.
- Figures 13, 14, 15: Rough notes with equations and diagrams from our meeting with Dr. Shahbazi, written by Dr. Shahbazi.
- Figure 16: Meeting minutes for meeting with Dr. Shahbazi.
- Figure 17: Emails to Greg and Dr. Shahbazi in regard to nature of data collection from NovAtel.

Appendix

IMU-ISA-100C Performance

IMU-ISA-100C IMU Performance

Gyroscope Performance	
Input range	±495 °/second
In-run bias stability	≤0.05 °/hour
Scale factor repeatability	≤100 ppm
Scale factor non-linearity	≤100 ppm
Angular random walk	0.012 °/√hour
Accelerometer Performance	
Range	±10 g
In-run bias stability	≤100 μg
1 year scale factor repeatability	≥1250 μg
Scale factor non-linearity	≤100 ppm
Velocity random walk	≤100 μg/√Hz
Data Rate	
IMU Measurement	200 Hz

*Figure 1: Specifications document for **ISA100C** IMU, similar to the uIRS IMU that will be used for this project. Obtained from NovAtel website.*

OEM-IMU-STIM300 Sensor Specifications

OEM-IMU-STIM300 Performance

Gyroscope Performance	
Gyro Input Range	±400°/second
In-run Gyro Rate Bias Stability	0.5°/hour
Angular Random Walk	0.15°/√hour
Accelerometer Performance	
Accelerometer Range	±10 g
In-run Accelerometer Bias Stability	0.05 mg
Velocity Random Walk	0.07 m/s/√hour
Data rate	
IMU Measurement	125 Hz

Figure 2: First page of **OEM-IMU-STIM300** sensor specifications. Obtained from NovAtel website.

OEM-IMU-STIM300 Electrical and Environmental

OEM-IMU-STIM300 Electrical Specifications

Electrical	
Input Power	+4.5 to +5.5 VDC +5.0 VDC typical
Power consumption	1.5 W nominal
Connector	15 pin Micro-D, female

OEM-IMU-STIM300 Environmental Specifications

Environmental	
Temperature, operational	-40°C to +85°C
Temperature, non-operational	-55°C to +90°C

Figure 3: Second page of **OEM-IMU-STIM300** sensor specifications. Obtained from NovAtel website.

OEM719 Receiver Performance

Position Accuracy[1]	Single point L1	1.5 m RMS
	Single point L1/L2	1.2 m RMS
	SBAS[2]	60 cm RMS
	DGPS	40 cm RMS
	TerraStar-L[3, 4]	40 cm RMS
	TerraStar-C PRO[3, 4]	2.5 cm RMS
	RTK	1 cm + 1 ppm RMS

Figure 4: First section of specification sheet for NovAtel's **OEM719** GNSS receiver. Obtained from NovAtel website.

Signals Tracked	GPS	L1 C/A, L1C, L2C, L2P, L5
	GLONASS	L1 C/A, L2 C/A, L2P, L3, L5[5]
	BeiDou	B1I, B1C, B2I, B2a, B3I
	Galileo	E1, E5 AltBOC, E5a, E5b, E6
	NavIC (IRNSS)	L5
	QZSS	L1 C/A, L1C, L2C, L5, L6
	SBAS	L1, L5
	L-Band	Up to 5 channels[6]
Time to First Fix	Hot: <26 s (Almanac and recent ephemeris saved and approximate position and time entered) Cold: <46 s (No almanac or ephemeris and no approximate position or time)	

Figure 5: Second section of specification sheet for NovAtel's **OEM719** GNSS receiver. Obtained from NovAtel website.

			Code	Carrier
Measurement Precision			Code	Carrier
	GPS	L1 C/A	4 cm	0.5 mm
		L2 P(Y)	8 cm	1.0 mm
		L2C	8 cm	0.5 mm
		L5	3 cm	0.5 mm
	GLONASS	L1 C/A	8 cm	1.0 mm
		L2 P	8 cm	1.0 mm
		L2 C/A	8 cm	1.0 mm
	Galileo	E1	3 cm	0.5 mm
		E5a	3 cm	0.75 mm
		E5b	3 cm	0.75 mm
		E5 AltBOC	3 cm	0.75 mm
	BeiDou	B1I	5 cm	1.0 mm
		B2I	5 cm	1.0 mm
Velocity Limit	515 m/s[8]			

Figure 6: Third section of specification sheet for NovAtel's **OEM719** GNSS receiver. Obtained from NovAtel website.

OEM7720 Receiver Performance

Position Accuracy[1]	Single point L1	1.5 m RMS
	Single point L1/L2	1.2 m RMS
	SBAS[2]	60 cm RMS
	DGPS	40 cm RMS
	TerraStar-L[3, 4]	40 cm RMS
	TerraStar-C PRO[3, 4]	2.5 cm RMS
	RTK	1 cm + 1 ppm RMS
Signals Tracked Primary Antenna	GPS	L1 C/A, L1C, L2C, L2P, L5
	GLONASS	L1 C/A, L2 C/A, L2P, L3, L5[5]
	BeiDou	B1I, B1C, B2I, B2a
	Galileo	E1, E5 AltBOC, E5a, E5b
	NavIC (IRNSS)	L5
	QZSS	L1 C/A, L1C, L2C, L5
	SBAS	L1, L5
	L-Band	Up to 5 channels[6]

Figure 7: First section of specification sheet for NovAtel's **OEM7720** GNSS receiver. Obtained from NovAtel website.

Signals Tracked Secondary Antenna	GPS	L1 C/A, L1C, L2C, L2P, L5
	GLONASS	L1 C/A, L2 C/A, L2P, L3,L5
	BeiDou	B1I, B1C, B2I, B2a
	Galileo	E1, E5 AltBOC, E5a, E5b
	NavIC (IRNSS)	L5
	QZSS	L1 C/A, L1C, L2C, L5
Time to First Fix	Hot: <26 s (Almanac and recent ephemeris saved and approximate position and time entered) Cold: <46 s (No almanac or ephemeris and no approximate position or time)	
Signal Reacquisition	<0.5 s L1 (typical) <1.0 s L2 and L5 (typical)	
Data Rates	Measurements	up to 100 Hz
	Position	up to 100 Hz
Time Accuracy[7]	20 ns RMS	
Velocity Accuracy	<0.03 m/s RMS	

Figure 8: Second section of specification sheet for NovAtel's **OEM7720** GNSS receiver. Obtained from NovAtel website.

			Code	Carrier
Measurement Precision	GPS	L1 C/A	4 cm	0.5 mm
		L2 P(Y)	8 cm	1.0 mm
		L2C	8 cm	0.5 mm
		L5	3 cm	0.5 mm
	GLONASS	L1 C/A	8 cm	1.0 mm
		L2 P	8 cm	1.0 mm
		L2 C/A	8 cm	1.0 mm
	Galileo	E1	3 cm	0.5 mm
		E5a	3 cm	0.75 mm
		E5b	3 cm	0.75 mm
		E5 AltBOC	3 cm	0.75 mm
	BeiDou	B1I	5 cm	1.0 mm
		B2I	5 cm	1.0 mm
ALIGN Heading Accuracy	Baseline = 2 m	0.08 degrees		
	Baseline = 4 m	0.05 degrees		
Velocity Limit	515 m/s[8]			

Figure 9: Third section of specification sheet for NovAtel's **OEM7720** GNSS receiver. Obtained from NovAtel website.

Velodyne LiDAR®

Puck™

REAL-TIME 3D LiDAR SENSOR

VLP-16

Automotive | Robotics | Mapping | UAV | Security | Industrial

Velodyne LiDAR PUCK™

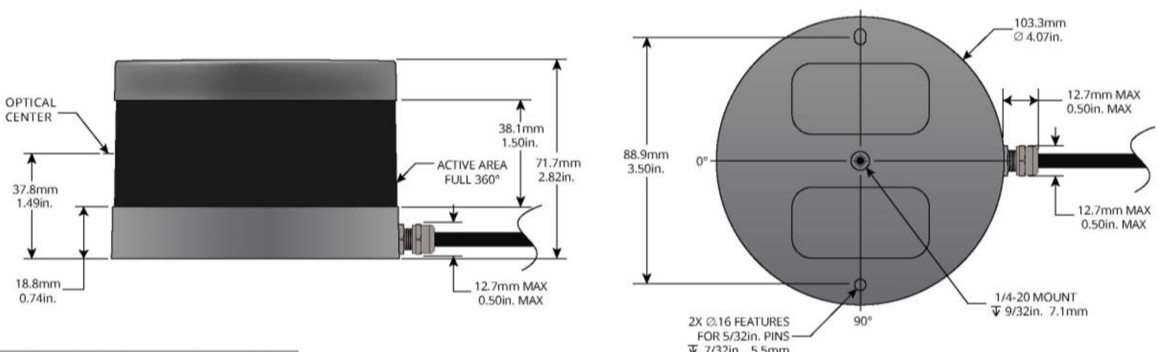
Velodyne's Puck (VLP-16) is the smallest, cost-optimized product in Velodyne's 3D LiDAR product range. Developed with mass production in mind, the Puck is far more cost-effective than comparable sensors, and it retains the key features of Velodyne's breakthroughs in LiDAR: Real-time, 360°, 3D distance and calibrated reflectivity measurements.

Real-Time 3D LiDAR

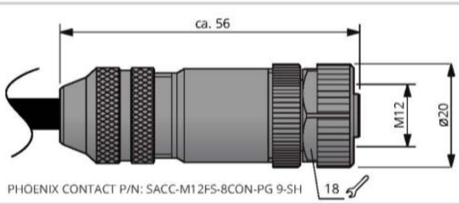
The VLP-16 has a range of 100 m, and the sensor's low power consumption, light weight, compact footprint and dual return capability make it ideal not only for autonomous vehicles but also for robotics, terrestrial 3D mapping and many other applications.

Velodyne's LiDAR Puck supports 16 channels, ~300,000 points/second, 360° horizontal field of view and a 30° vertical field of view, with ±15° up and down. The Puck does not have visible rotating parts, and is highly resilient in challenging environments while operating over a wide temperature range.

DIMENSIONS *(Subject to change)*



M12 CONNECTOR OPTION



For other connector options contact
Velodyne Sales (sales@velodyne.com)

www.velodynelidar.com

Figure 10: First page of product specification document for LiDAR unit (Velodyne LiDAR Puck Version 16). Obtained from: https://velodynelidar.com/vlp-16.html.

VLP-16

Real-Time 3D LiDAR Sensor

The VLP-16 provides high definition 3-dimensional information about the surrounding environment.

	Specifications:
Sensor:	• 16 Channels • Measurement Range: 100 m • Range Accuracy: Up to ±3 cm (Typical)[1] • Field of View (Vertical): +15.0° to -15.0° (30°) • Angular Resolution (Vertical): 2.0° • Field of View (Horizontal): 360° • Angular Resolution (Horizontal/Azimuth): 0.1° – 0.4° • Rotation Rate: 5 Hz – 20 Hz • Integrated Web Server for Easy Monitoring and Configuration
Laser:	• Laser Product Classification: Class 1 Eye-safe per IEC 60825-1:2007 & 2014 • Wavelength: 903 nm
Mechanical/ Electrical/ Operational	• Power Consumption: 8 W (Typical)[2] • Operating Voltage: 9 V – 18 V (with Interface Box and Regulated Power Supply) • Weight: ~830 g (without Cabling and Interface Box) • Dimensions: See diagram on previous page • Environmental Protection: IP67 • Operating Temperature: -10°C to +60°C[3] • Storage Temperature: -40°C to +105°C
Output:	• 3D LiDAR Data Points Generated: - Single Return Mode: ~300,000 points per second - Dual Return Mode: ~600,000 points per second • 100 Mbps Ethernet Connection • UDP Packets Contain: - Time of Flight Distance Measurement - Calibrated Reflectivity Measurement - Rotation Angles - Synchronized Time Stamps (μs resolution) • GPS: $GPRMC and $GPGGA NMEA Sentences from GPS Receiver (GPS not included)

63-9229 Rev-H

For more details and ordering information, contact Velodyne Sales (sales@velodyne.com)

1. Typical accuracy refers to ambient wall test performance across most channels and may vary based on factors including but not limited to range, temperature and target reflectivity.
2. Operating power may be affected by factors including but not limited to range, reflectivity and environmental conditions.
3. Operating temperature may be affected by factors including but not limited to air flow and sun load.

CLASS 1 LASER PRODUCT

Velodyne LiDAR, Inc. 345 Digital Drive, Morgan Hill, CA 95037 / lidar@velodyne.com / 408.465.2800 | www.velodynelidar.com

Figure 11: Second page of product specification document for LiDAR unit (Velodyne LiDAR Puck Version 16). Obtained from: https://velodynelidar.com/vlp-16.html.

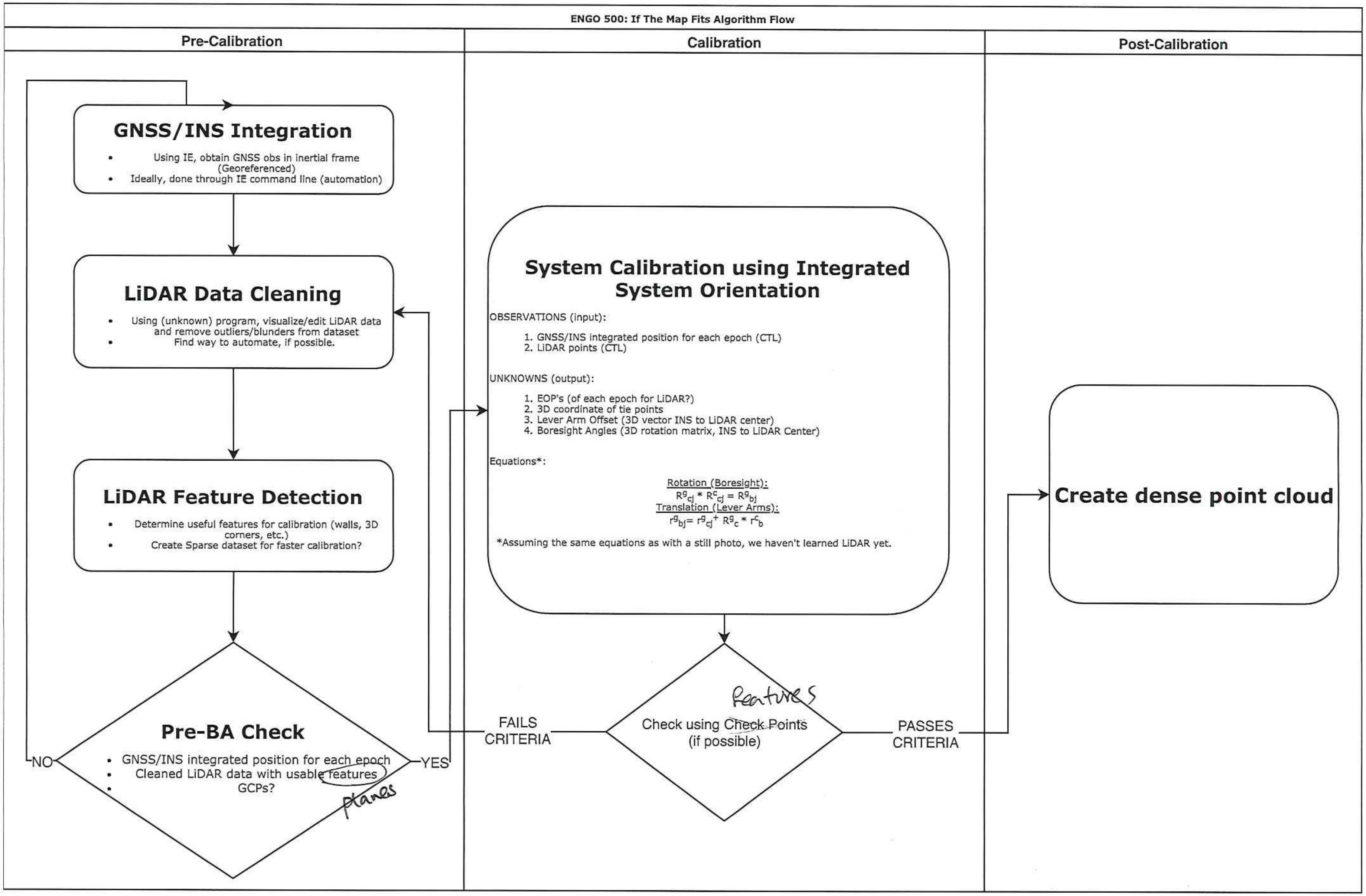


Figure 12: Algorithm flow chart created prior to meeting with Dr. Shahbazi

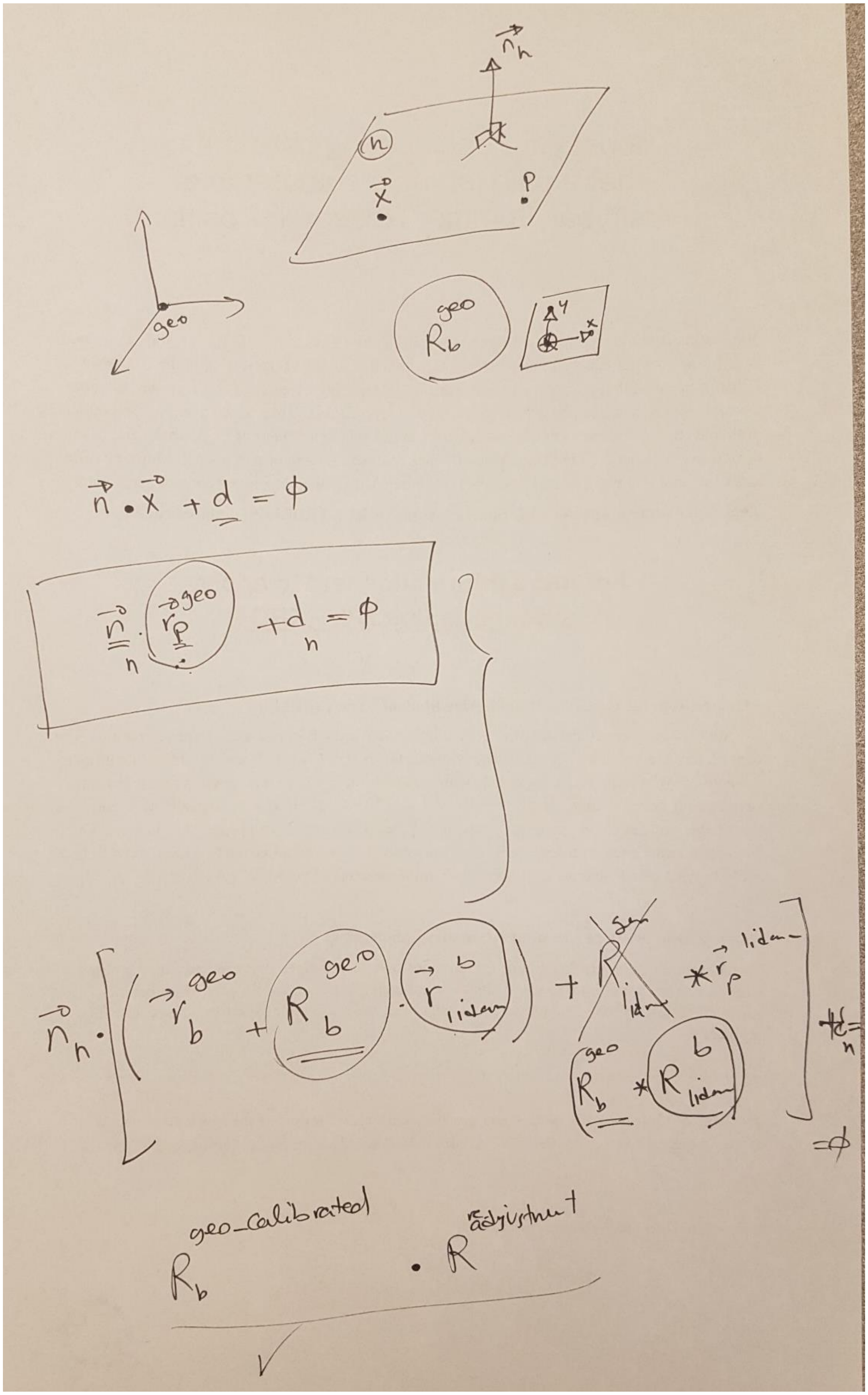


Figure 13: First page of notes from meeting with Dr. Shahbazi.

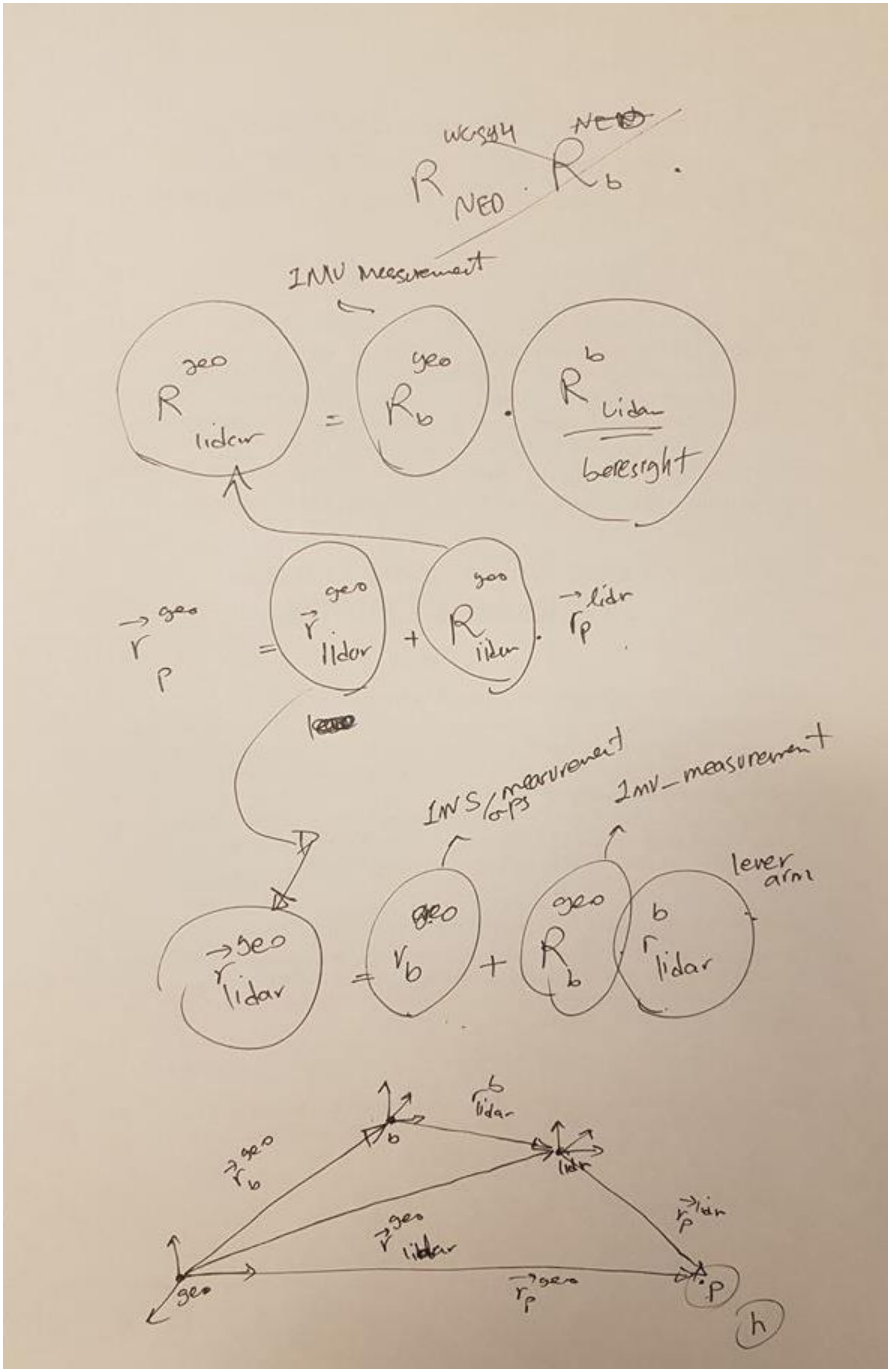


Figure 14: Second page of notes from meeting with Dr. Shahbazi.

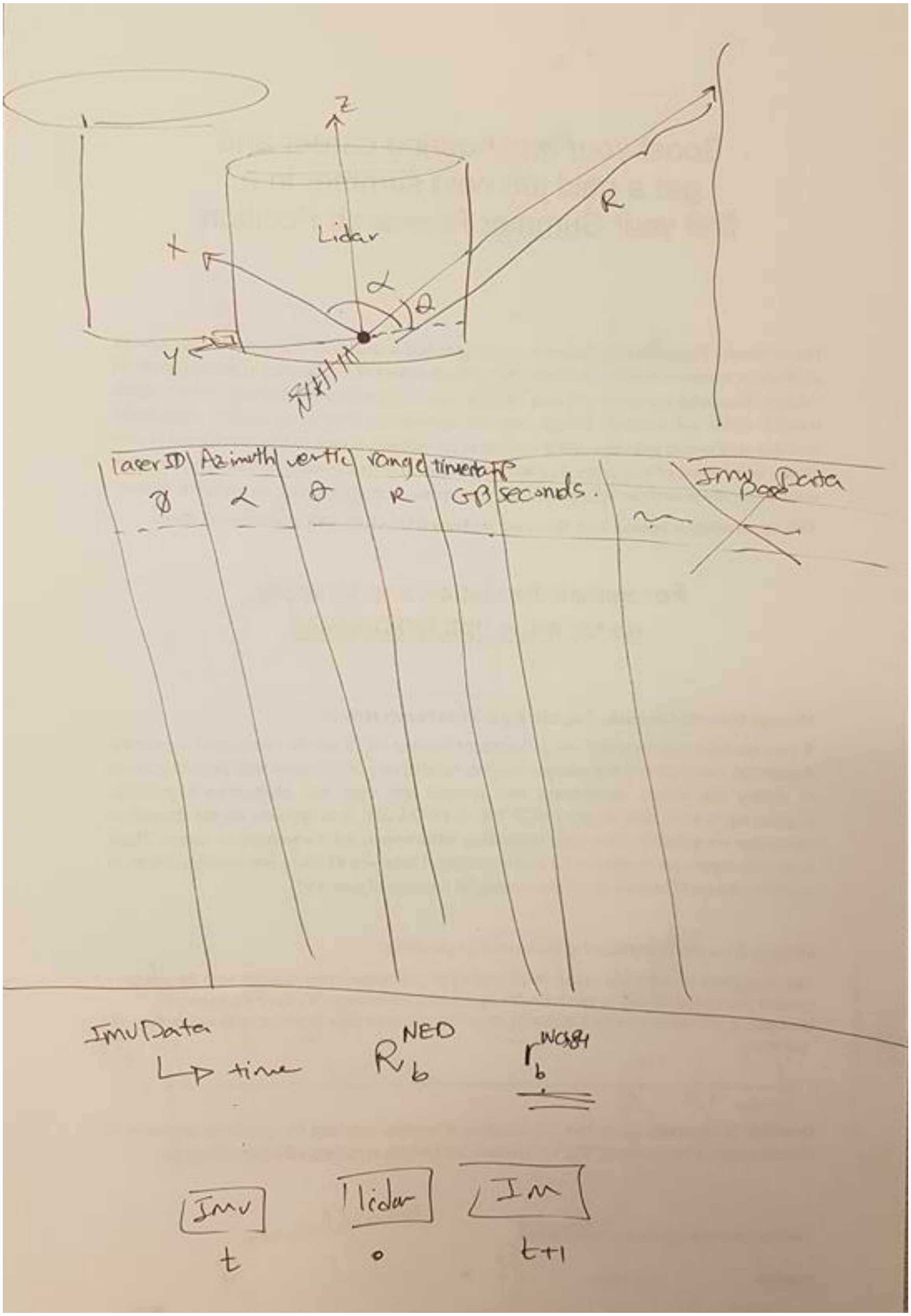
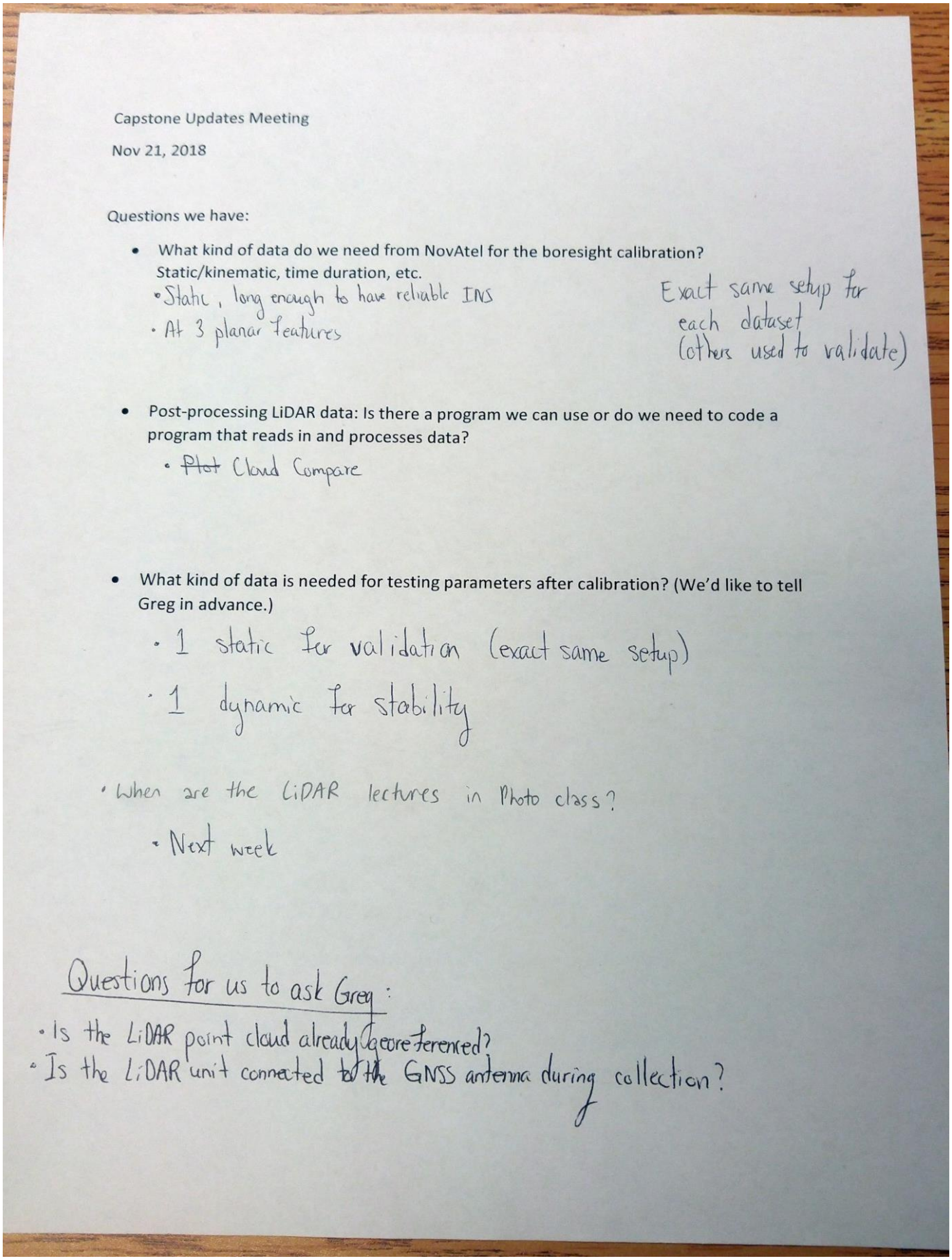


Figure 15: Third page of notes from meeting with Dr. Shahbazi.



Capstone Updates Meeting

Nov 21, 2018

Questions we have:

- What kind of data do we need from NovAtel for the boresight calibration? Static/kinematic, time duration, etc.
  - Static, long enough to have reliable INS
  - At 3 planar features

Exact same setup for each dataset (others used to validate)

- Post-processing LiDAR data: Is there a program we can use or do we need to code a program that reads in and processes data?
  - ~~Plot~~ Cloud Compare

- What kind of data is needed for testing parameters after calibration? (We'd like to tell Greg in advance.)
  - 1 static for validation (exact same setup)
  - 1 dynamic for stability

- When are the LiDAR lectures in Photo class?
  - Next week

Questions for us to ask Greg:

- Is the LiDAR point cloud already georeferenced?
- Is the LiDAR unit connected to the GNSS antenna during collection?

Figure 16: Meeting minutes from meeting with Dr. Shahbazi.

RE: Capstone Update

ROESLER Greg <greg.roesler@novatel.com>

Tue 11/27/2018 11:20 AM

To: Kiera Fulton <kiera.fulton2@ucalgary.ca>;

I believe Eunju is helping Edmond to get some data. So, I assume this should be covered.

Thanks,

Greg Roesler
Senior Manager, GNSS Algorithms
NovAtel, part of Hexagon.
T: +1 403.730.4118 M: +1 403.650.8915
E: greg.roesler@novatel.com

From: Kiera Fulton <kiera.fulton2@ucalgary.ca>
Sent: Monday, November 26, 2018 1:09 PM
To: ROESLER Greg <greg.roesler@novatel.com>
Cc: Esther Cho <esther.cho@ucalgary.ca>; Edmond Robert Leahy <erleahy@ucalgary.ca>
Subject: Fw: Capstone Update

Hi Greg,

Hope you had a great weekend!

As you can see in these past couple emails, I checked with Dr. Shahbazi regarding the vertical angle spacing. Our methodology of having three planar surfaces in the dataset does not change, for the reasons she states below.

Let me know if you have any other questions.

Thanks,

Kiera Fulton
President
Geomatics Engineering Students' Society (GESS)
Schulich School of Engineering || University of Calgary
N 51°04'46.95" W 114°07'56.99"
c: 587.888.6313 || e: kiera.fulton2@ucalgary.ca

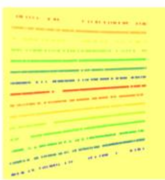
From: Mozhdeh Shahbazi
Sent: Monday, November 26, 2018 11:15 AM
To: Kiera Fulton
Cc: Edmond Robert Leahy; Esther Cho
Subject: Re: Capstone Update

Hi Kiera,

No, I am aware of the angular resolution of VLP-16 but this angular resolution within any range still translates to a large spacing in vertical direction. E.g. in the image below the lidar is maybe 1.5 m away from the wall and you can see how sparse it is in vertical direction. Finding control points in this case is very challenging. So, that does not impact your methodology.

Thanks,

M.



Mozhdeh Shahbazi, PhD, PEng

Assistant Professor

Department of Geomatics Engineering

University of Calgary

ENE 227C, 2500 University Drive NW, Calgary, Alberta, CANADA T2N 1N4

T: +1-403-210-7710

mozhdeh.shahbazi@ucalgary.ca

https://schulich.ucalgary.ca/profiles/mozhdeh-shahbazi

From: Kiera Fulton
Sent: Monday, November 26, 2018 10:32:29 AM
To: Mozhdeh Shahbazi
Cc: Edmond Robert Leahy; Esther Cho
Subject: Fw: Capstone Update

Hi Dr. Shahbazi,

Please read Greg's email regarding the spacing between scans in the vertical direction of the LiDAR unit they have.

Does this change the fact that we will need three planar surfaces in our data collection?

Thanks,

Kiera Fulton
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From: ROESLER Greg <greg.roesler@novatel.com>
Sent: Thursday, November 22, 2018 2:58 PM
To: Kiera Fulton
Cc: Edmond Robert Leahy; Esther Cho
Subject: RE: Capstone Update

Hi Kiera,

The VLP-16 has 30 deg FOV with 16 channels. So, the spacing is much less than 10 degrees, it would be closer to 2 degrees.

Greg Roesler
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NovAtel, part of Hexagon.
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From: Kiera Fulton <kiera.fulton2@ucalgary.ca>
Sent: Thursday, November 22, 2018 9:21 AM
To: ROESLER Greg <greg.roesler@novatel.com>
Cc: Edmond Robert Leahy <erleahy@ucalgary.ca>; Esther Cho <esther.cho@ucalgary.ca>
Subject: Re: Capstone Update

Because that particular unit has 10 degree spacing between scan lines in the vertical direction, it will be difficult to detect features when we are looking at the point cloud. Therefore, we are using planar features as control points in the calibration. They don't necessarily have to be orthogonal, but have different normal vectors.

We will want a good GNSS+INS solution for georeferencing the points in the lidar point cloud. We have been told that the data should be long enough to allow the INS solution to converge.

Hope this helps. Please let me know if you have any other questions.

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From: ROESLER Greg <greg.roesler@novatel.com>
Sent: Thursday, November 22, 2018 8:29:19 AM

To: Kiera Fulton
Cc: Edmond Robert Leahy; Esther Cho
Subject: RE: Capstone Update

I'm not sure if we have this in our current data. I'll have to see if this is possible or not.

How much static data? Do the planar surfaces need to be orthogonal from each other, or do they need a certain geometry? Do you need good GNSS data during the static period?

Greg Roesler

Senior Manager, GNSS Algorithms

NovAtel, part of Hexagon.

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E: greg.roesler@novatel.com

From: Kiera Fulton <kiera.fulton2@ucalgary.ca>
Sent: Wednesday, November 21, 2018 5:10 PM
To: ROESLER Greg <greg.roesler@novatel.com>
Cc: Edmond Robert Leahy <erleahy@ucalgary.ca>; Esther Cho <esther.cho@ucalgary.ca>
Subject: Re: Capstone Update

Hi Greg,

We had a discussion with Dr. Shahbazi today about the data we need.

In the data, we have been told that it should be:

- **Static**
- **Contain at least 3 planar surfaces (walls, etc.)**

The above dataset will be used to perform the calibration, and then we would need another static dataset in a different environment but with the exact same setup (IMU, antenna and LiDAR unit hasn't moved) to do validation.

Along with that, we will be ready to use an IE license very soon after receiving data.

Thank you for your help!

Cheers,

Kiera Fulton
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From: Kiera Fulton
Sent: Tuesday, November 20, 2018 6:36 PM
To: ROESLER Greg
Cc: Edmond Robert Leahy; Esther Cho
Subject: Re: Capstone Update

Thanks for the update, we will let Dr. Shahbazi know during our meeting tomorrow and use the ISA100C specs.

I will get in contact with you in the next couple days about data.

Thanks!

Kiera Fulton
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Geomatics Engineering Students' Society (GESS)
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c: 587.888.6313 || e: kiera.fulton2@ucalgary.ca

From: ROESLER Greg <greg.roesler@novatel.com>
Sent: Tuesday, November 20, 2018 4:47:25 PM
To: Kiera Fulton
Cc: Edmond Robert Leahy; Esther Cho
Subject: RE: Capstone Update

Sorry, I don't think we have a uIRS spec sheet. I'll look around a little more, but I don't we officially ever sold the uIRS.

Kiera, if needed you could use the ISA100C spec sheet and highlight that the uIRS is very similar quality.

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Senior Manager, GNSS Algorithms
NovAtel, part of Hexagon.
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From: Kiera Fulton <kiera.fulton2@ucalgary.ca>
Sent: Tuesday, November 20, 2018 3:18 PM
To: ROESLER Greg <greg.roesler@novatel.com>
Cc: Edmond Robert Leahy <erleahy@ucalgary.ca>; Esther Cho <esther.cho@ucalgary.ca>
Subject: Re: Capstone Update

Hi Greg,

I found spec sheets for all except the uIRS, is there any chance you can find us this? It's not listed on the NovAtel website.

Thanks,

Kiera Fulton
President
Geomatics Engineering Students' Society (GESS)
Schulich School of Engineering || University of Calgary
N 51°04'46.95" W 114°07'56.99"
c: 587.888.6313 || e: kiera.fulton2@ucalgary.ca

From: ROESLER Greg <greg.roesler@novatel.com>
Sent: Tuesday, November 20, 2018 11:46:57 AM
To: Kiera Fulton
Cc: Edmond Robert Leahy; Esther Cho
Subject: RE: Capstone Update

Hi Kiera,

Yes, I moved over to Algo; lots of new things now to keep me busy☺

Here is the info you requested:

IMUs used are STIM300, uIRS.
Receivers used are 7720 and 719. More recent data has the 7720 and older data has the 719.
Spec sheets for all of these are on the NovAtel website.

The LIDAR unit is the Velodyne VLP-16. https://velodynelidar.com/vlp-16.html

Hope school is going well for you.

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From: Kiera Fulton <kiera.fulton2@ucalgary.ca>
Sent: Tuesday, November 20, 2018 9:09 AM
To: ROESLER Greg <greg.roesler@novatel.com>
Cc: Edmond Robert Leahy <erleahy@ucalgary.ca>; Esther Cho <esther.cho@ucalgary.ca>
Subject: Capstone Update

Hi Greg,

First off, I heard that you moved to Algo. Congratulations!

Sorry for the delayed response about data. The last few weeks were busy with creating our proposal presentation. We are meeting with our supervisor, Dr. Shahbazi, tomorrow to discuss the nature of the data that we will need.

She is also asking that we get spec sheets on the sensors that will be in the MMS with a photo or sketch. I can manage to create a sketch based on my knowledge of the vans, but are you able to tell me which sensors (ie. which IMU, receiver and LiDAR units) would be used? Could you point me in the direction of spec sheets for them?

Thanks,

Kiera Fulton
President
Geomatics Engineering Students' Society (GESS)
Schulich School of Engineering || University of Calgary
N 51°04'46.95" W 114°07'56.99"
c: 587.888.6313 || e: kiera.fulton2@ucalgary.ca

Figure 17: Email thread between Kiera, Greg and Dr. Shahbazi