IOWA STATE UNIVERSITY

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Alternative Sources of Accurate Agriculture Topography

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1 PROBLEM STATEMENT

Problem Statement

- Bob Recker started Cedar Valley Innovation, CVI, in 2004 following his retirement from John Deere after 41 years. CVI works on many small-scale experiments to test if they can be applied in large-scale settings. CVI is a small business hoping to make a big impact on agriculture. On this project specifically, our client’s goal is to study the relative accuracy of alternative methods of data collection to create topographical data of agricultural fields for purpose of water flow and related field analysis.
- Our group understands the possible solutions for the problem of analyzing water flow are tractor-based ground units, drones, and satellite imagery. We also know relative costs for each system or method. CVI is seeking a definitive answer on which method is best and which method would be easiest for farmers to replicate. If our group tells people how we analyzed field A, would they be able to go analyze field B on their own?
- Our group has not been able to find specific examples of other companies working on analyzing the pros and cons amongst all three methods. There are plenty of companies working on improving, or trying to sell one method, but very few are attempting to determine which one of the three is the best. While determining which method is best for topographical data for water flow analysis, we will also be able to determine other areas farmers could use the

topographical data. Mapping fields, scouting crop health, monitoring weeds or need for fertilizer could all be solved with some of the same methods (Darr, 2018).

Business Case Statement

The reason for this project is to try to improve farming operations for soil conservation. By analyzing water runoff, farmers can decide the best method of action to prevent it, therefore making their fields more environmentally friendly and sustainable. Water runoff mainly occurs in tilled fields that do not have waterways or have a few locations where large amounts of water flow through on a regular basis (Kaleita, 2018). By identifying trouble areas through the use of topographical maps, farmers can implement solutions to these problems and improve their operation.

Addressing the problem above makes sense because it helps the farmer in the long run by preserving their topsoil, allowing them to continue to achieve high yields while preventing crops from getting washed out, an maintaining important characteristics of the soil. Topographical maps have an opportunity to assist because they show the big picture of the field. Using a map, the farmer can see the entire extent of the problem. Everyone, not just the farmer, should care about this because of the potential environmental and yield impact. By preventing runoff, fewer chemicals and debris will be washed into streams. Erosion and yields will also make positive changes for the farmer (Bane, et al, 2017).

2 Goal Statement

- **Main Objective(s) and Specific Objectives**
    - The main objective was to find the most accurate method for collecting topographical data to be used to assist in water management for in-field application for farmers.
    - A secondary objective was to create a 3-D print of the topographical map of a farmer's field.
- **Specific objectives include*:***
    - Comparing the differences in topography data, showing the pros and cons of each and relating the results to choose the best option for obtaining accurate topographical data.
    - Create a workflow diagram and/or decision matrix that a modern farmer or crop advisor can use to choose the best topographical data collection source for them specifically.
    - An extra add-on to our project was to be able to 3-D print the topographical data of an actual field. This way a producer can physically see and feel how the topography flows within their field (Behrens, 2018).
- **Criteria and Constraints**
    - Resolution size
    - Source of Topography data
    - Programs to analyze data
- **Rationale**

  When the project is finished, our group believes our client will be satisfied and motivated to pursue the idea, thus creating more projects in the future for Iowa State capstone students. Our client will be able to know the accuracy differences in the topographical results and be able to choose the best method to use for gathering topographical data. Our client will also be able to take that data and print a physical 3-D model of the field. Workflow diagrams will be provided to our client in addition. This way they can duplicate the processes (Recker, 2018).

3 Project Plan/Outline

A. Methods/Approach

- **Reference Materials**
    - Provided materials from client specific to what they are seeking for a solution
    - Data collected through testing of individual methods

- **Data collection**
  - LIDAR data specific to the field found at http://www.geotree.uni.edu/lidar/.
  - Harvest and drone data that contains elevation points to be analyzed (Matt Darr's team)
- **Skills**
  - Matt Darr's TSM 433, Precision Agriculture
  - Amy Kaleita-Forbes' TSM 324, Soil and Water Conservation Management
  - Skills related to topographical mapping and analysis
  - Knowledge of Ag Leader and SMS systems
- **Proposed Solutions**
  - The solution was found via testing the different methods of data collection
  - Compare the accuracy of each method to actual field characteristics
  - The method that results in the least amount of cost to the landowner and provides the greatest accuracy for the farmer
  - Client input was heavily considered in developing the metric due to client's experience. Group consulted with the client to develop the metric.
  - Evaluate method in terms of cost relative to how well the method performs (accuracy)
  - Success by how well our group can define a more successful method of data collection
  - Success evaluation by our group for the means of being able to 3-D print topography field map.
- **Organization**
  - Contacted client weekly to keep him updated on the current progress of our group
  - Nominated one person to manage/delegate work for the team, make sure all members are completing required tasks
  - **Major Milestones:**
    - Collect topographical data from test field prior to testing (LIDAR data)
    - Perform on-site data collection
    - Analyze collected data to determine the best method
    - Propose group's option for best method to the client
    - Print 3-D model of the topography of client's field

B. Results/Deliverables

- Utilized an actual field in production to:
  - Compare the differences in topographical results
  - Show the differences, if any, in water flow analysis
  - Be able to 3D print topography of a field, will add to the success of the project
- Present a workflow diagram that a modern farmer or crop advisor can use to duplicate the process on his own land
- Contingency plans will vary for each step of the process
- Contact with the client for constant updates on results and timelines will be administered

4 Broader Opportunity Statement

From this project, we will determine the most effective and efficient use of drones, tractor-based data collection, and satellite imagery options to manage soil and water flow. The largest benefit will be the farmer's return for their operation.

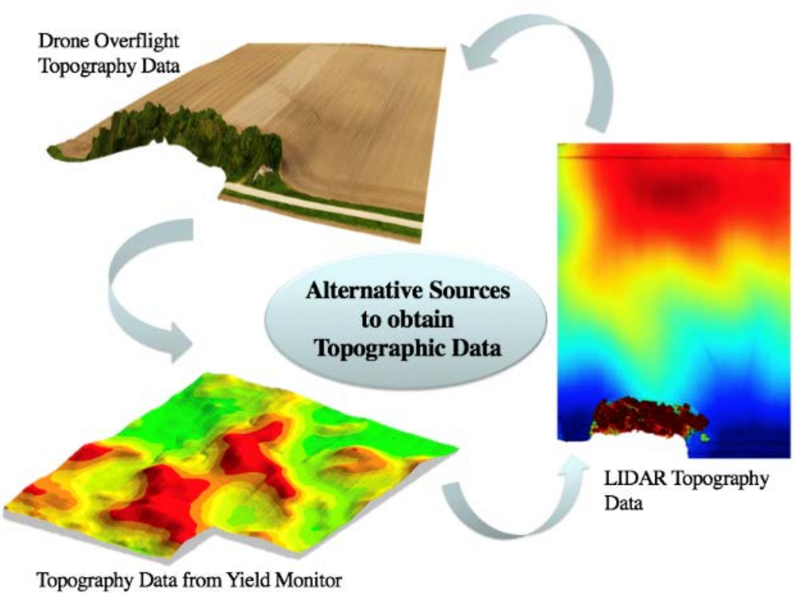
A. This project also tackles larger problems that result from agriculture such as improving soil quality, water quality and conservation, which will affect both local, state and regions outside of the project target area.
B. As agricultural production is not limited to Iowa, or even the United States, water and soil quality contamination from agricultural production are problems around the world. The results from this project can potentially have reached across national borders.

C. If this project is successful, it will be able to be applied to construction projects, landscaping projects, or any projects where water and soil may have the potential for movement to an undesired location.
D. The project is specifically located in Iowa. However, the project is tackling a large and widespread water flow management problems all over the world.
E. This project is comparing and utilizing all three data methods to see which specific data source or combination of sources will most accurately predict how water flow will move soil.

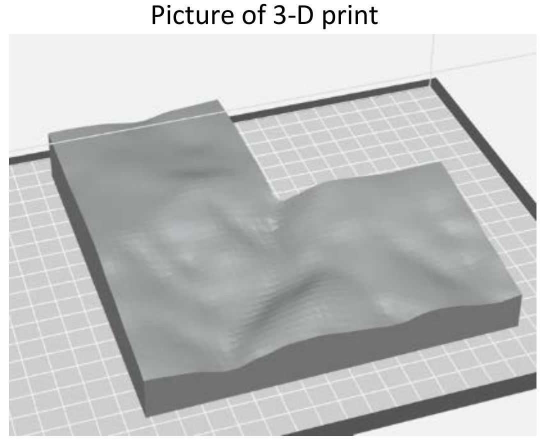
5 Project Scope

A. The scope of this project with CVI is to understand and measure the relative accuracy of alternative methods to create topographical maps of agriculture fields, and find which method is the most accurate compared to the cost involved. The purpose of finding an accurate method to create topographical data for agriculture fields is for water flow analysis to reduce soil erosion, and aid in soil relocation work. This deliverable is driven by our client because this type of analyses is important to CVI's work with farmers and the results are data they strive for.
B. The client shared his past experiences with John Deere and precision agriculture with us immediately after we met. His company, Cedar Valley Innovations LCC, is a start-up company. They determine new ways to give back and benefit farmer's bottom line. The client shared his vision of finding and further understanding accurate topographical data from LIDAR data, public domain sources, drone over-flights, and data gathered by tractor-based yield monitoring systems. CVI's goal, like our group's, is to compare the accuracy, logistics, and cost of methods of gathering topographic data.

6 Graphical Abstract



Picture of 3-D print



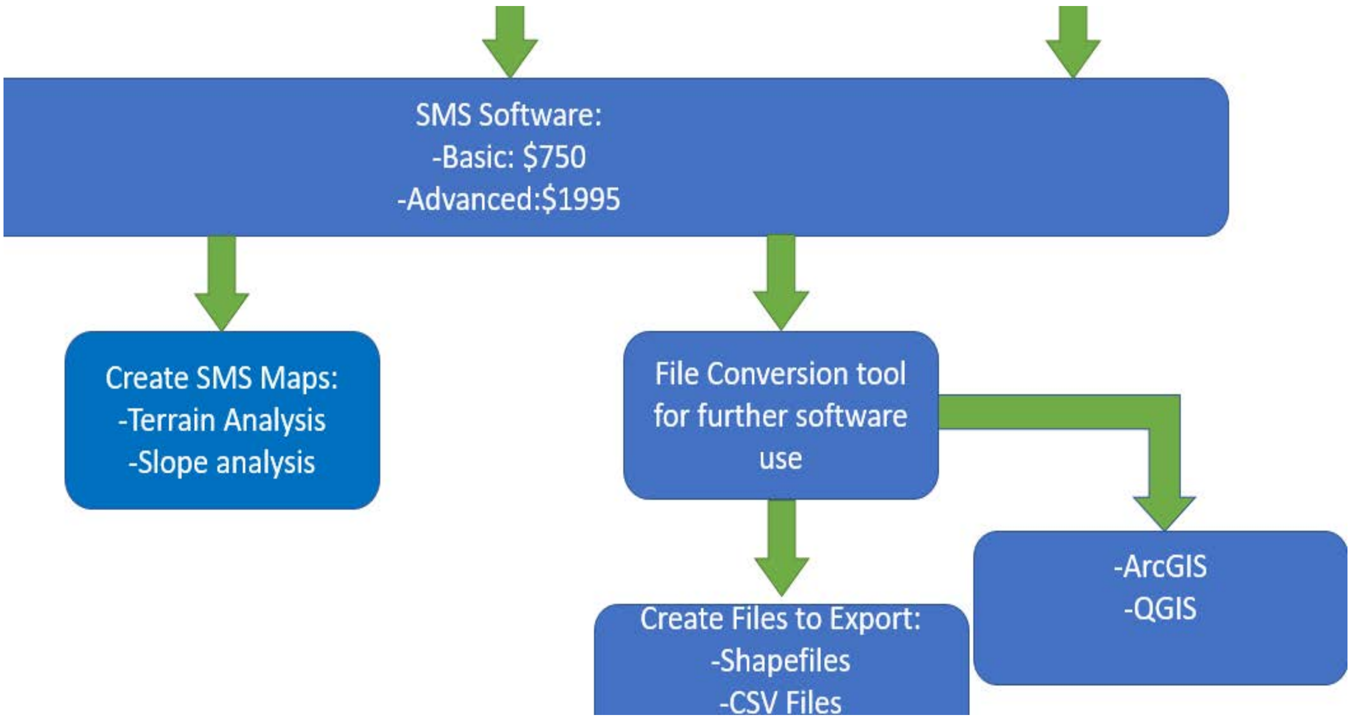
7 References

Comparative Study of Topographical Analysis Tools for Farmland (Cedar Valley Innovation)

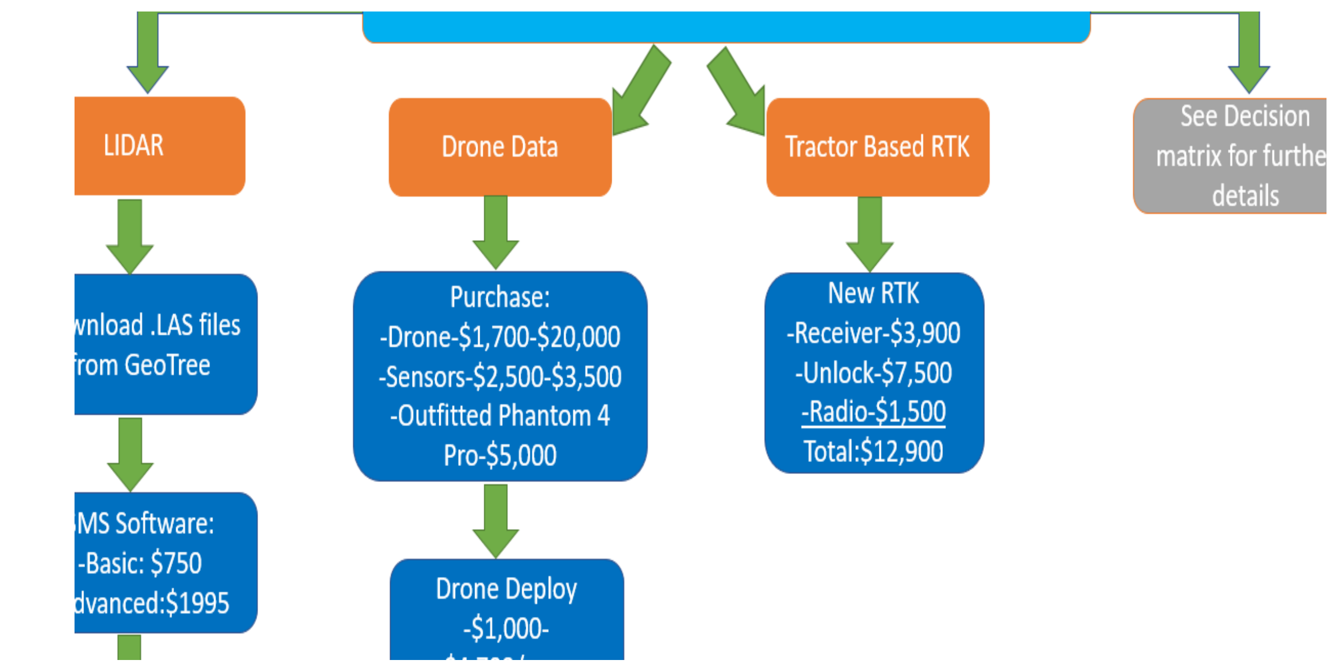
- Chandler Bane, Mitchell Hora, Gabe Lorack, Nick Lane, Joseph R. Vanstrom and Jacek A. Koziel. Harvest the Sun, Build the Soil. Final Report. TSM 416 Technology Capstone Project, April 28, 2017.
- Robert Recker, *Owner of Cedar Valley Innovation, Personal Communication, March* 18, 2018.
- Matt Darr, *Professor in Agricultural & Biosystems Engineering, Personal Communication, March* 18, 2018.
- Amy Kaleita, *Associate Professor in Agricultural & Biosystems Engineering, Personal Communication, March* 18, 2018.
- Chris Murphy, *Precision Agriculture Program Coordinator in Agricultural & Biosystems Engineering, Personal Communication, March* 18, 2018.
- Jake Behrens*, Teaching Laboratory Coordinator, Personal Communication, March* 18, 2018.

8 APPENDIXES

Current Access for Data Collection



No Access to Data Collection



Decision Matrix

	Accuracy	** Cost-Effectiveness	Access to Required Software	User Friendliness	Compatibility	**TOTAL**
Weight	5	4	3	2	1	Σ (weight x score)
LIDAR	4	5	5	4	3	**66**
Tractor-Based RTK	5	2	2	3	2	**47**
Drone	3	2	2	1	3	**34**

Based on a rating of 1-5, 5 being the best rating

Client's 3-D Print Model