Are Cross Country Courses Getting Less Hilly?

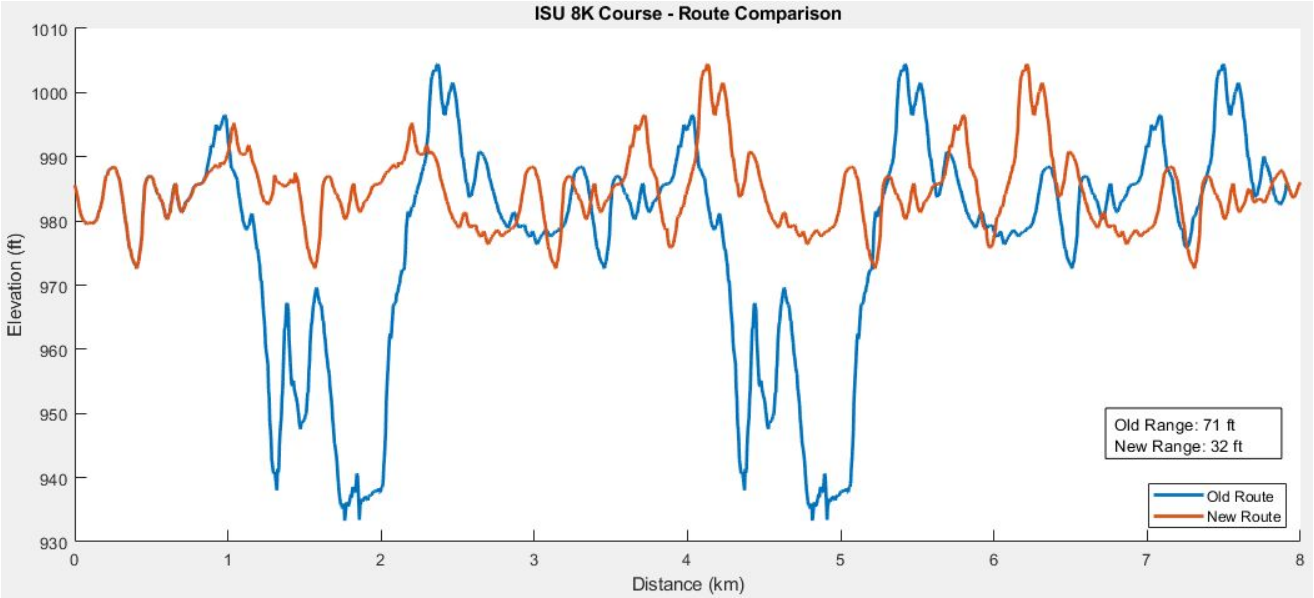
Team 37

Advisor/Client: Dr. Brian Hornbuckle

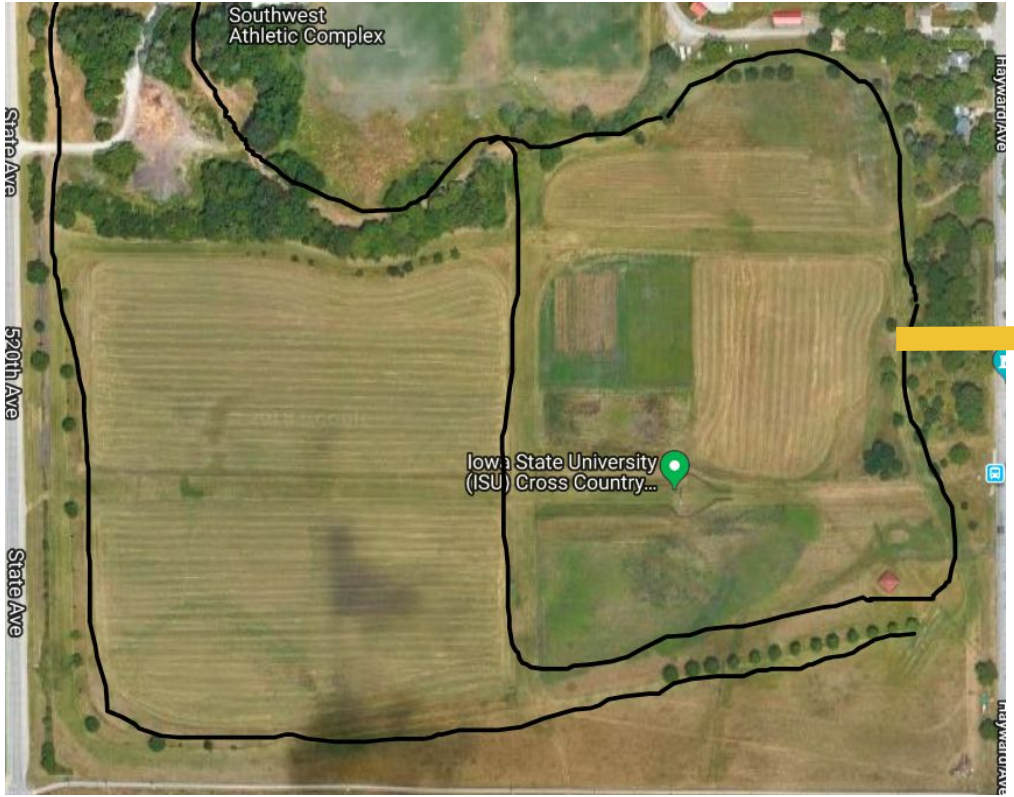
http://sdmay19-37.sd.ece.iastate.edu/

Problem Statement

- Are cross-country courses becoming easier?
- How can we compare cross-country courses?
- What data source can be used for elevation?

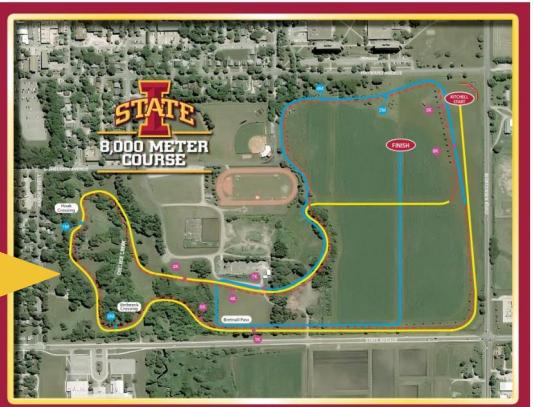


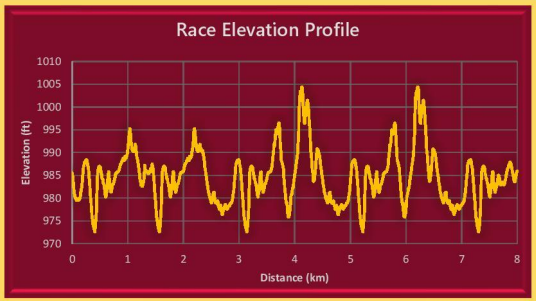
Conceptual Sketch



BIG XII CONFERENCE CROSS COUNTRY CHAMPIONSHIPS

Iowa State Cross Country Complex
October 26, 2018





5.3
Difficulty

27%
Rolling Hills

4
Big Climbs

86m
Average Hill Length

12%
Grade of Average Hill

Mile 3
Hardest Mile

Functional Requirements

- Initial ground truth studies must provide definitive information regarding accuracies of different topographic data sources
- Web app needs to be enable for communication with data source
- Web app needs to easily allow for users to upload XY route coordinates from whatever device they prefer
- Web app must be able to run classification algorithms on elevation profiles to classify hill-like topography in to subclassifications for generating rating system

Non-functional Requirements

- Elevation data source must be consistently within 3m of the USGS official elevation
  - LIDAR is only source we have found that meets this criterion
- App must generate report in under 10 seconds
- 90% of surveyed users must not report issues/confusion after using app
- 90% of users report that they comprehend the meaning of the various metrics produced by the classification
- 90% of users report that the scorecards are presented in visually appealing and easily interpretable format
- Quantitative ratings of 0-10 course score must be within ±1.5 points of average trial runners' qualitative rankings of courses.

Technical Considerations and Other Constraints

- Is our data sufficiently precise to properly document XC course topography?
  - This has been confirmed through a comparison study with USGS geodetic points
- Are phone GPS units sufficient to document X and Y data for a course?
  - This has been confirmed through a straight line test
- Will target demographic of XC coaches and high school athletic directors be technologically savvy enough to be willing to use the application?
  - Critical that UX be as straightforward and simplistic as possible to enable widespread implementation

Market Survey

- Conventional running apps will produce an elevation summary of a run if a user's phone has a barometric altimeter
  - Phone elevation data is highly inaccurate and imprecise
  - Only metric usually given is total "climb"
- Time-based XC course rating systems
  - Make use of variation in average pace from meet-to-meet to rank courses as fast or slow
- No rating system exists with a focus on physical course characteristics
  - Consulted with 2x ISU National Champion coach Bill Bergan
    - Extremely optimistic about the idea of gaining insights in to true "difficulty" of a course, not just whether or not it runs fast or slow.

Potential Risks and Mitigation

- Little risk with budget, involves mostly data processing
  - Free tier of software hosting
- Working with expensive GPS equipment
  - Risk: Breaking/Losing equipment
  - Mitigation: Extra care with handling equipment, no one leaves equipment unattended
- Performance and large LIDAR data files
  - Risk: File sizes over 1 GB, takes long time to get elevation points
- No risk of physical harm
  - Not working with any dangerous equipment

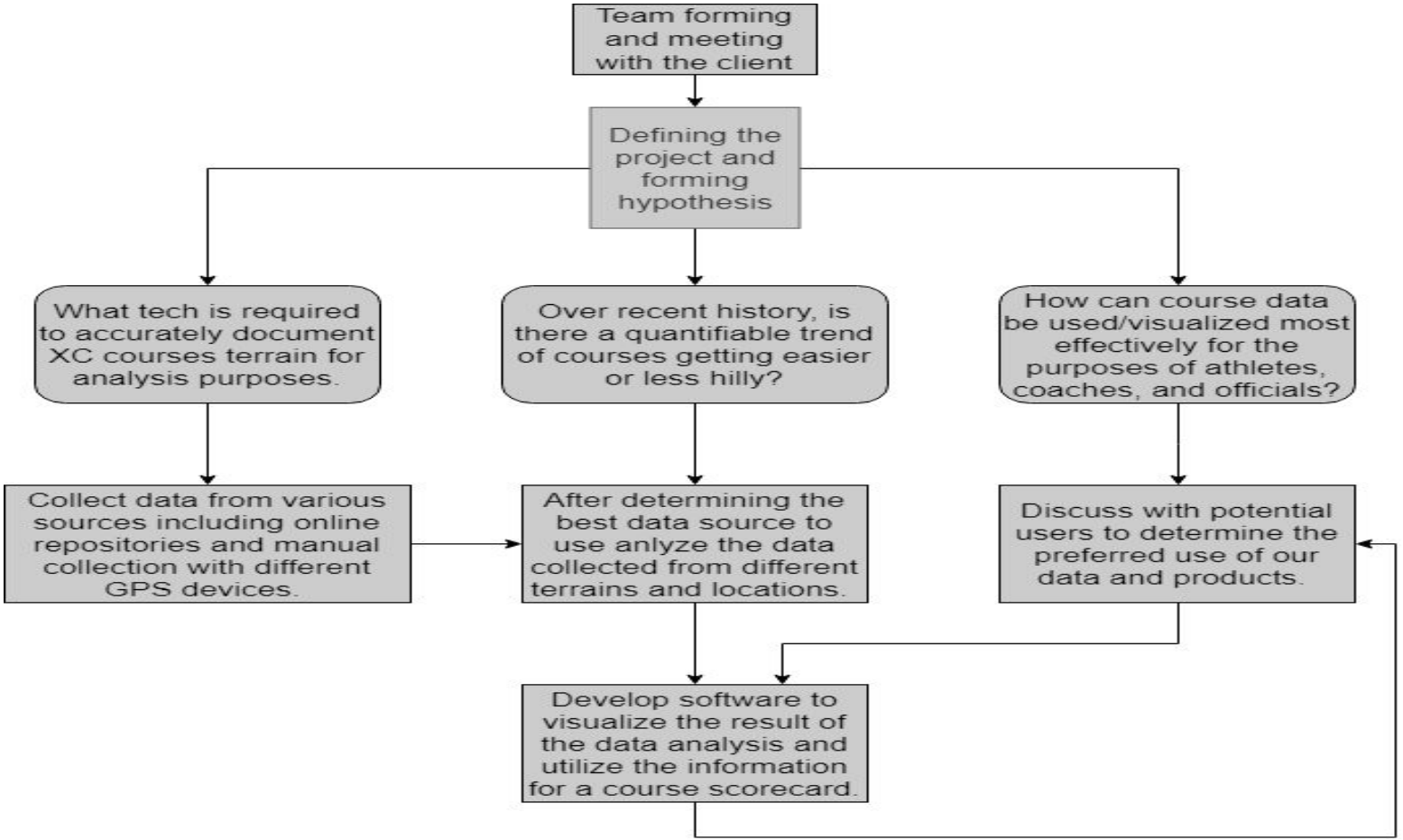
Resource/Cost Estimate

- Hardware: Borrowed GPS equipment from Dr. Bradley & Dr. Kaleita
- Software: Focusing on using open-source/free software
- LIDAR data provided free from the State of Iowa
- Physical surveys
  - Travel to 2 other XC courses out of town
  - Cost of gas to drive there
- Estimating low costs overall

Project Milestones & Schedule

1. Data Accuracy
    - Comparisons of LIDAR vs Google Maps vs GPS
2. Generate Elevation Profile of XC Course
    - Trace XC course using the web app and find elevations
3. Creating Scorecards
    - Assigning scores based on hill classification, slope, length, etc.
4. Determine if XC courses are less hilly
    - Perform analysis on current and past courses

Functional Decomposition



Detailed Design

- Manual elevation analysis compared to LIDAR
- Store LIDAR data in a centralized database broken up into small manageable chunks
- Two main forms of accepting input
  - Drawing Tool
  - GPS Collection
- Extract elevation data
- Build report of course through programmatic statistical analysis

Hardware/Software Platforms

- Hardware
  - Two dedicated GPS devices
    - Garmin Montana 680t - (loaned from Dr. Miller) (~$600)
    - Thales Navigation Promark2 differential GPS (loaned by Dr. Kaleita) - (~$5000)
  - Two gps-capable smartphones
- Software
  - Django - Python based web framework
    - Built for rapid development practices
    - Multiple team members have used before
  - Angular 7 - the newest version of a popular front-end Typescript framework
    - Extensive experience with older versions
  - Webpack - Compile Angular code to Javascript

Test Plan

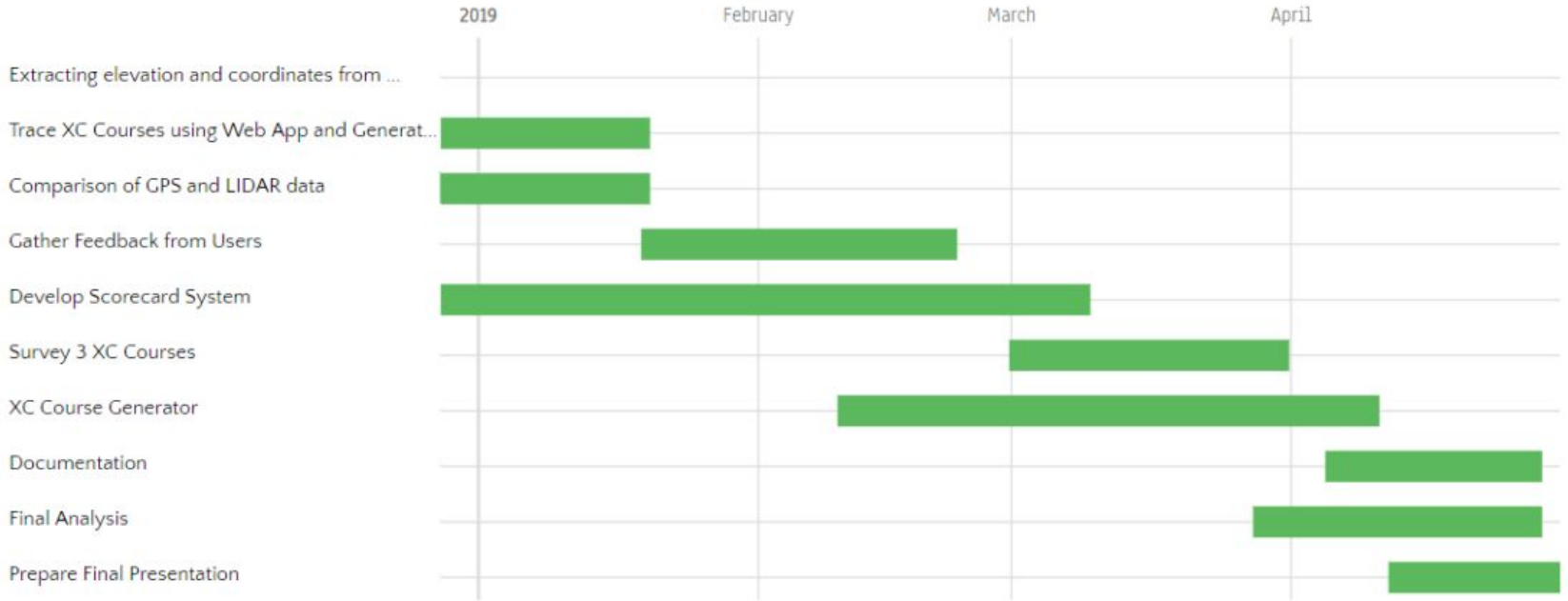
- Unit testing
  - Unittest - standard Python module
  - Karma - front-end testing framework shipped with Angular
- Functional testing
  - Run through full use case scenarios (detailed in Design Doc)
- Non-Functional testing
  - Web app accessibility
    - Survey of XC coaches
  - Accuracy
    - Course difficulty ratings
    - Elevation data
      - Geodetic markers

Current Project Status

Team Roles

Ground Truth		Determine which sources of elevation data are sufficient for documenting the topography of a cross country course route.
Connor S.	Thomas C.	
Data Handling		Handling of data inputs and outputs. Creating tools for user input, algorithms that process raw data for more useful outputs.
Ryan H.	Jacob F.	
Software Engineering		Research of programming frameworks/environments. Creation of client and server.
David K.	Andrew M.	

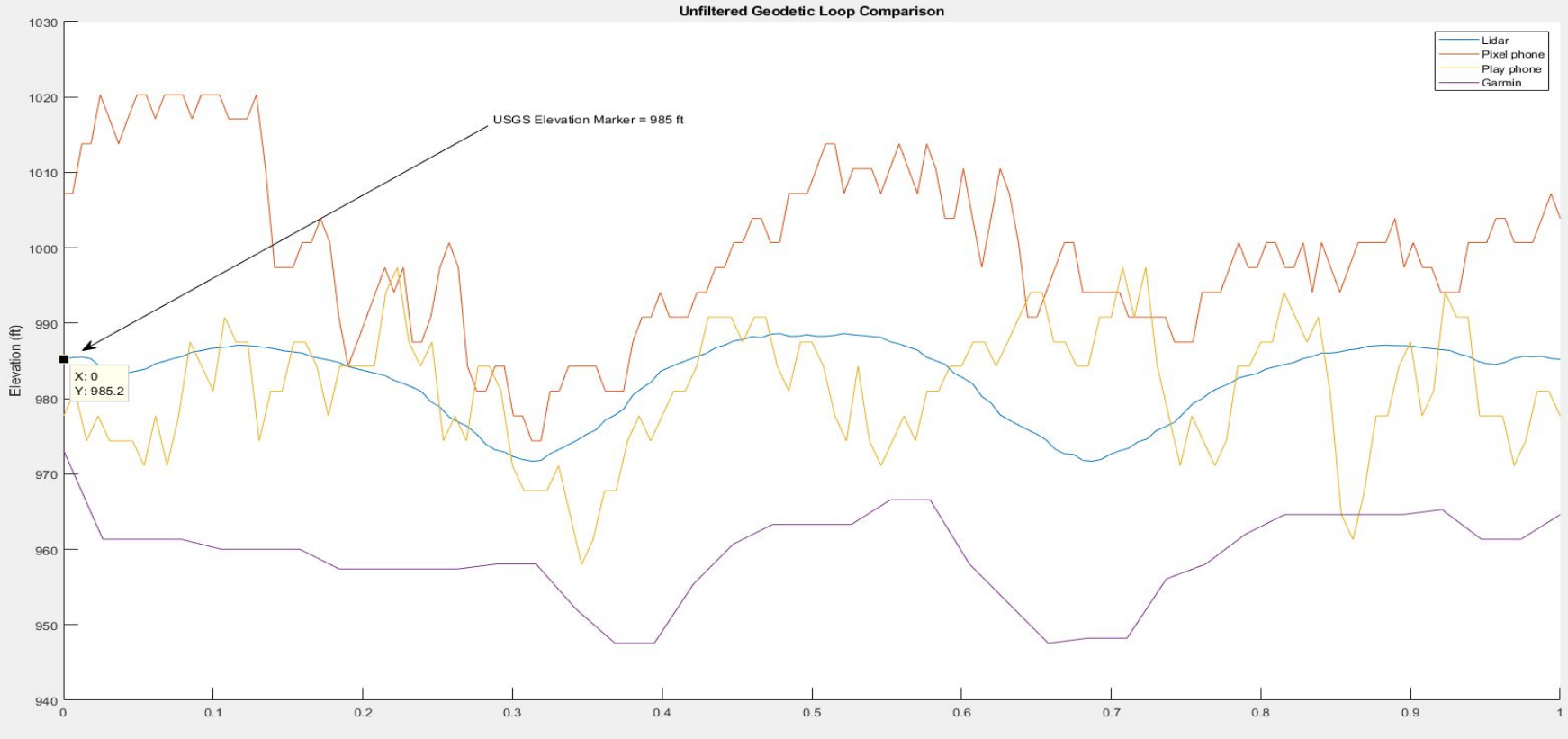
Plans for Next Semester



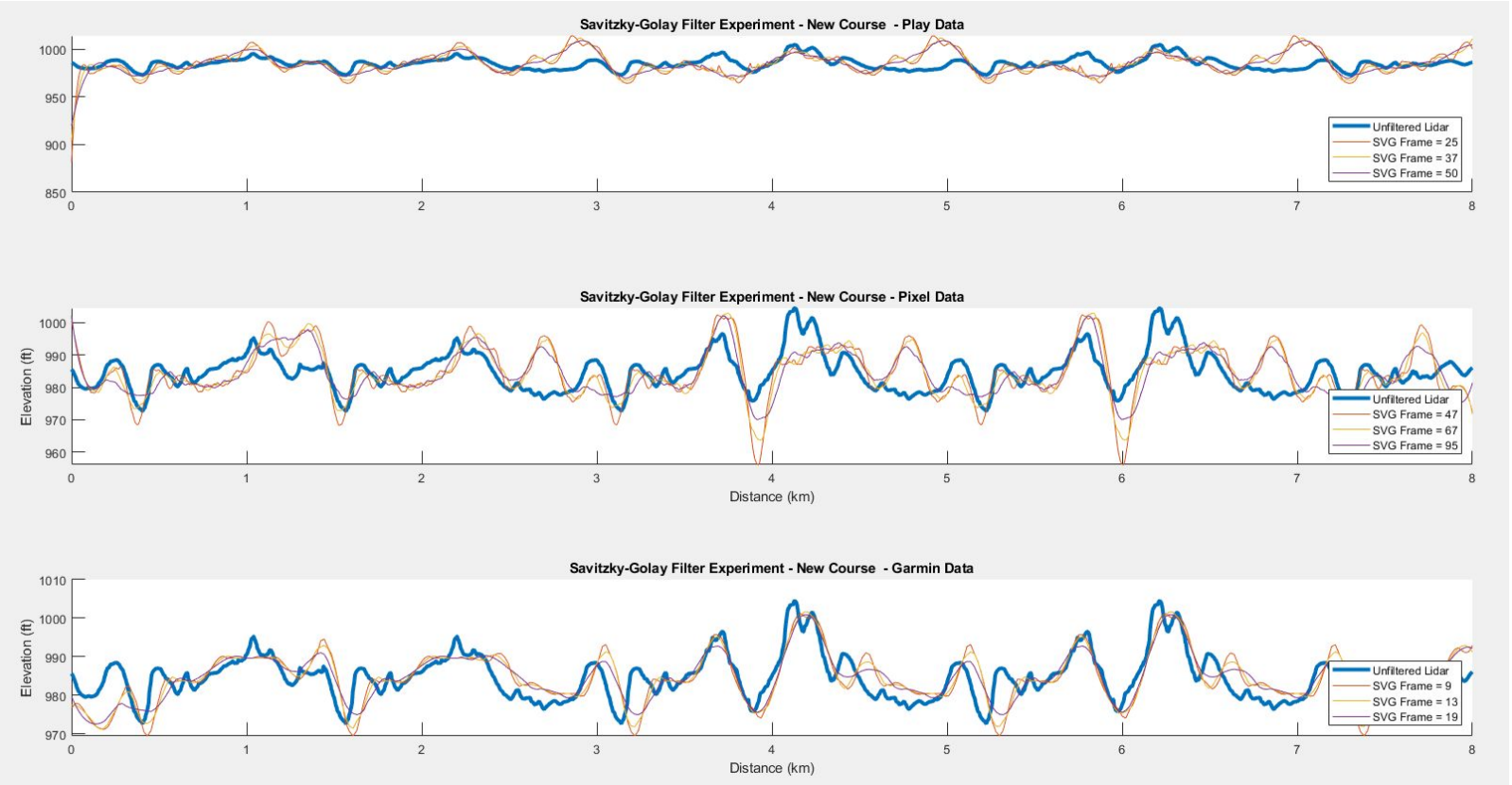
Thank you!

Questions?

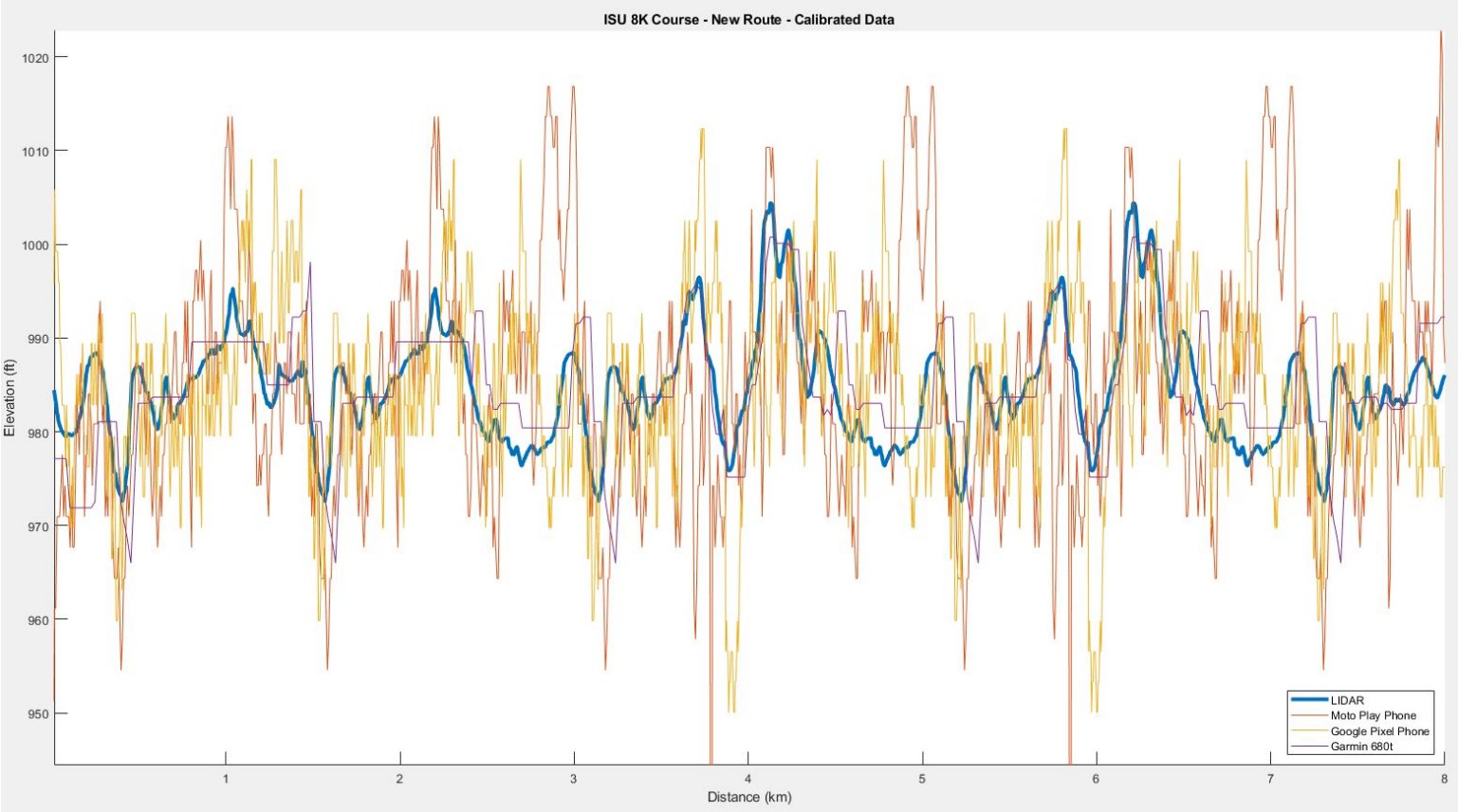
Geodetic Loop Comparison



Savitzky-Golay Filtering Testing



Unsmoothed Raw Elevation Data



Smoothed Elevation Data