Project Definition Document

Aerospace Senior Projects (ASEN 4018 & 4028)
Fall 2004 and Spring 2005

1.0 Information

1.1 Project Title

Skier Location and Performance Experiment (SLOPE)

1.2 Project Customers

US Ski Team

2.0 Background and Context

The Skier LOcation and Performance Experiment (SLOPE) was organized to help USSA achieve their goal of "Best in the World" at the 2006 Olympics. To achieve this goal advances in understanding physical reactions to different technique, form, equipment, mechanics, and skier's tactics must be obtained. SLOPE is focused on the increases in on-snow velocity. Currently, athletes have basic forms of feedback: total time from start to finish, video, coach's eye, and the athlete's personal sensation during a run. There is a lack of measured knowledge of what is happening during the run. Only through the complied forms of this feedback structure can an educated guess be made to determine why one run is faster than another. And why one athlete is better than another. An integrated system of video and measured velocity changes throughout an entire training run or race would help coaches and athletes determine the optimal factors for increasing velocity, and obtaining the fastest run, therefore gaining a competitive advantage over the rest of the world.

3.0 Objectives

3.1 Overall Objective

The overall objective of the SLOPE project is to conceive, design, fabricate, integrate and verify a device that provides velocity and acceleration components accompanied with a skier in a selected training courses.

3.2 Position Measurement

3.2.1 Objective

The system should be capable of measuring the position of the skier center-of-mass to an accuracy of better than 10 cm at a sampling rate of no less than 20 Hz. Data should be provided for two axes.

3.2.2 Discussion

This measurement is the basis for most of the other measurement to be taken. The coordinate system for position, velocity, and acceleration will need to be referenced to something on the hill (start, finish,…)

3.3 Velocity Measurement

3.3.1 Objective

The system should be capable of measuring the velocity of the skier center-of-mass to an accuracy of better than 10 cm/sec in two axes.

3.3.2 Discussion

The velocity measurement is very important to the Ski Team coaches as a deliverable.

3.4 Acceleration

3.4.1 Objective

The system should be capable of measuring the acceleration of the skier center-of-mass to an accuracy of better than 30 m^2/s in two axes.

3.4.2 Discussion

From last years experimental findings, the acceleration measurement proved to be as important as the velocity measurement by providing the acceleration vector (magnitude, direction) from the skiers center-of-mass.

3.5 Timing

3.5.1 Objective

The system should provide all measurements with an absolute time tag that has an accuracy of 0.05 seconds.

3.5.2 Discussion

An absolute time tag on all measurements will make data synching possible (GPS data, IMU Data, and Video) and help provide for an extremely useful coaches tool.

3.6 Data Rates and Display

3.6.1 Objective

The system should provide all measurements with a rate of 20Hz and should be displayed using graphs or figures.

3.6.2 Discussion

Due to the length of the ski run and average velocity of a skier throughout one run, any data rate slower than 20Hz will not be fast enough to provide enough information to be meaningfully interpreted.

3.7 Thermal

3.7.1 Objective

The system should operate in the extreme temperature ranges normally encountered in ski racing (e.g. –15°C - +20°C).

3.7.2 Discussion

This is required to ensure that the system continues to operate given the environmental conditions such as extreme cold or heat.

3.8 Mass

3.8.1 Objective

The system shall have a mass of less than 1 Kg. which will not significantly affect the performance of the skier.

3.8.2 Discussion

The system must have as small of a mass as possible in order to not alter the skiers performance abilities.

3.9 Power

3.9.1 Objective

The system shall be battery powered and allow at least 1 hour running time before the batteries are recharged/replaced.

3.9.2 Discussion

An hour of running time was found to be sufficient due to the small amount of time the skier actually spends on the course.

3.10 Packaging

3.10.1 Objective

The system on the skier shall be sufficiently compact, smaller than a 1 liter box, that would fit onto the back of the skier. The packaging shall also be waterproof. The device also needs to resist impacts in the event of a fall.

3.10.2 Discussion

The packaging cannot in any way hinder the performance of the skier, or the results would not be useful. It is also necessary that the packaging protect the sensitive electronics used in the device; keep snow and water out as well as maintaining a constant thermal environment.

3.11 Angular Rates

3.11.1 Objective

In order to measure the hip movement and fore aft balance of a skier, the device needs to measure angular rates to +-50 deg/s.

3.12 Verification

3.12.1 Objective

In order to verify that the requirements have been met, a standalone device needs to be constructed that will develop position and velocity coordinates to 10 cm and at 10 cm/s respectively. Acceleration information will need to be known to 30 m^2/s. All the data from this testbed needs to be known at a data rate of 20 Hz or better.

3.13 Safety

3.13.1 Objective

The system should be designed so as to not injure the skier in the event of a fall.

3.13.2 Discussion

It is necessary that the wearing of the device does not in any way jeopardize the safety of the skier, including in the event of a fall.

4.0 Required Engineering Expertise

Technical Expertise	How Applied
GPS (Global Positioning System)	Accurate determination of position and time
IMU (Inertial Measurement Unit)	Determination of acceleration, angular rates at a high acquisition rate
Post Processing Software and Video Display	Record, process and display results with video
Packaging Design and Fabrication	Design and fabrication of the package to be worn on the skier
Data Acquisition Hardware / Software	Hardware and software to handle and record data.
Verification	Verification of the position, velocity, acceleration and data rate requirements

5.0 Resources

5.1 Facilities

GPS Lab

Electronics Lab

5.2 Additional Advisors

None

5.3 Funds

Senior projects grant and money from last year provided by the US Ski Team.