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Timing is Everything

A software approach for a generalized profilometer

Dr. John B. Ferris

Stephen Chappell

Cameron Rainey

Timing is Everything

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Our Motivation

Systems with integrated sensors can often require very specific processing methods. This can make upgrading and expanding such a system very difficult.

Our Goals

To create a system which is able to easily incorporate new sensors with very little hardware or software modification.

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Presentation Outline

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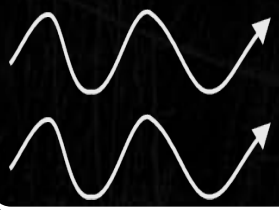
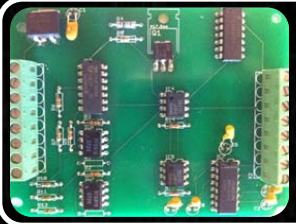
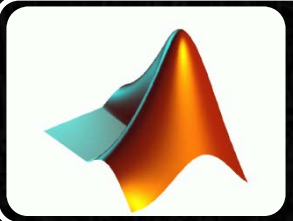
Laser Profilometer Overview



The Importance of Timing and Synchronization



Hardware Timing and Synchronization



Software Timing and Synchronization

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VTPL Laser Profilometers

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2006

2008

2011 (Current)

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Parts of a Laser Profilometer

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Scanning Lasers

INO LCMS

PSI PPS

Inertial Measurement Unit

Honeywell HG1700

GPS System

NovAtel SPAN System

GPS Antenna

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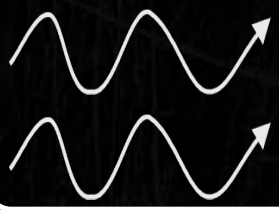

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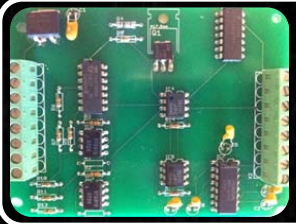

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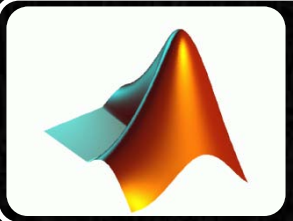

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Synchronizing Laser and INS

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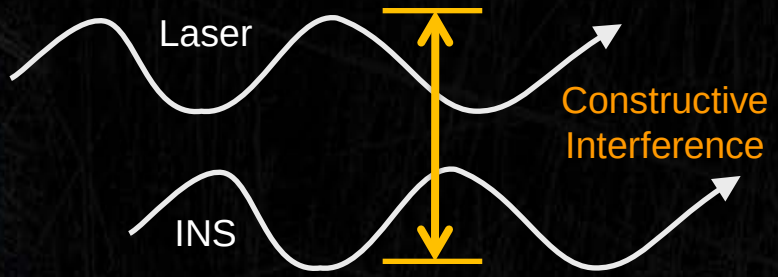
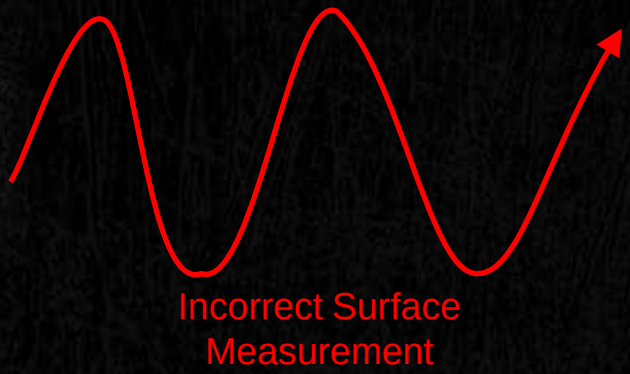
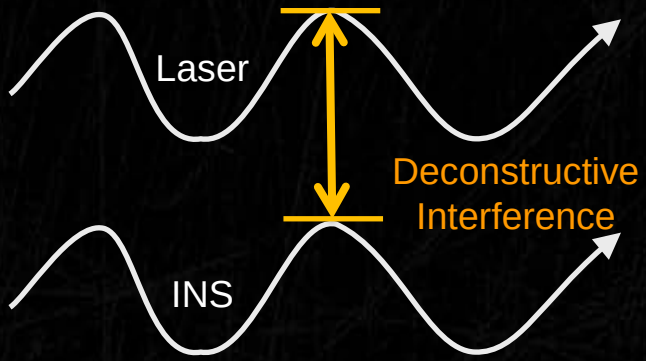
Consider an example: Vehicle bouncing on flat surface

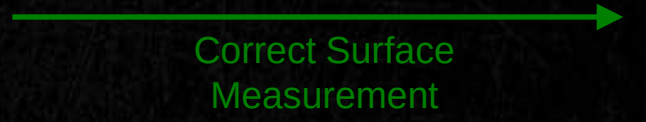
Unsynchronized





Synchronized





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Common Timing Issues

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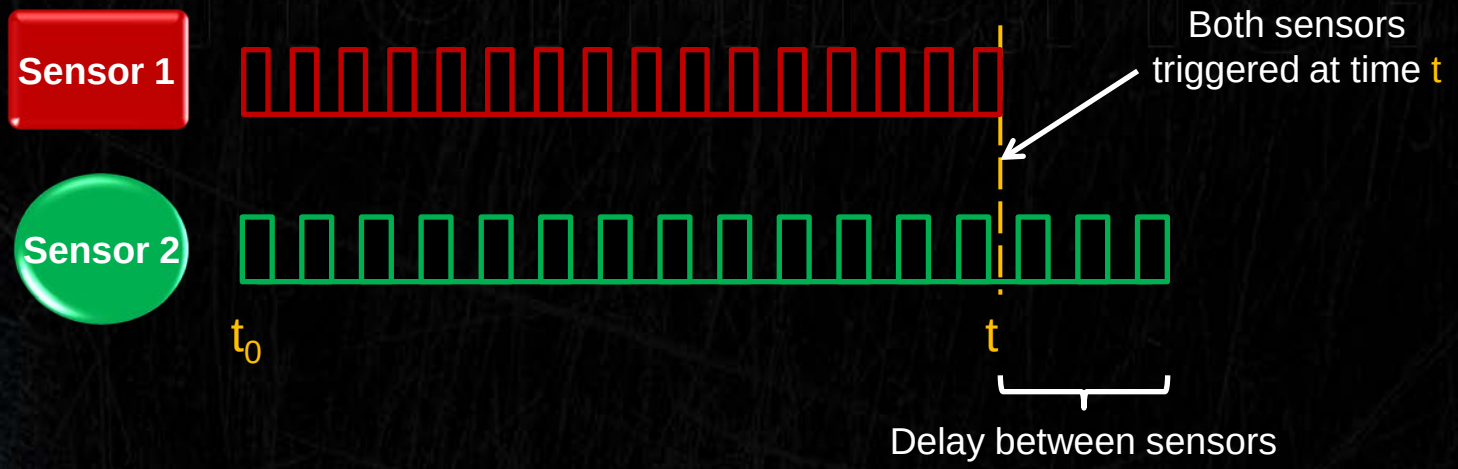
Clock Timing Mismatch



- Sensor 1 believes 16 clock cycles have passed while Sensor 2 believes only 13 clock cycles have passed.

- As time increases, clock timing mismatch increases while accuracy between each sensor decreases.

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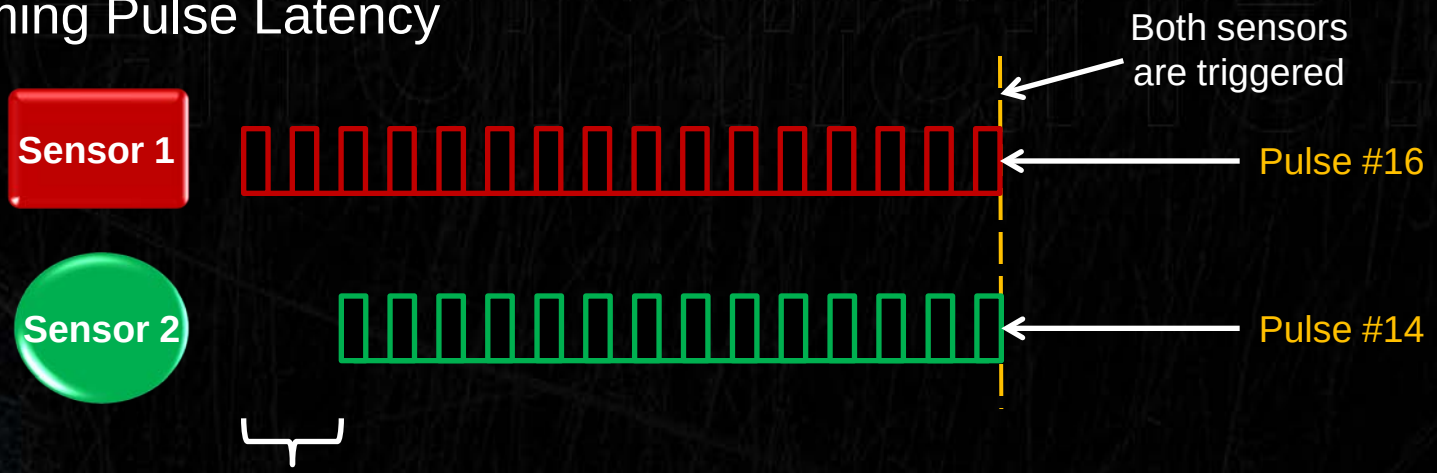
Common Timing Issues

Timing Pulse Latency



- Latency between sensors is always constant and time invariant
- Constant error when comparing data between multiple sensors

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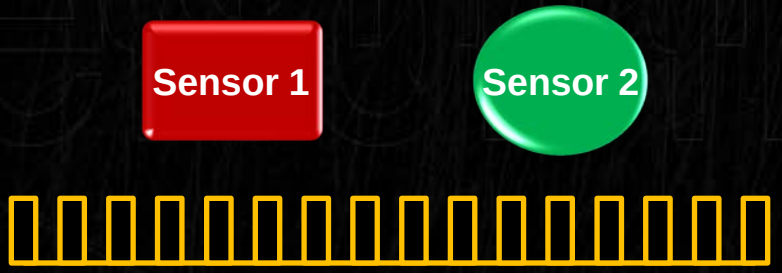
Common Timing Issues



Use ONLY one timing signal for all sensors!

How do we trigger each sensor simultaneously?

Method 1: Software Triggering

- All sensors must be connect to a common DAQ computer
- Software must be written to simultaneously control each sensor.

Method 2: Hardware Triggering

- More robust
- Does not need a common DAQ computer and software to operate.

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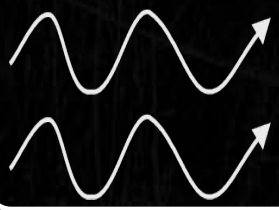

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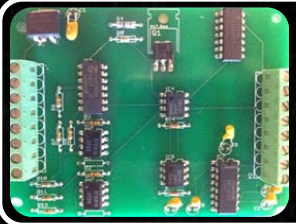

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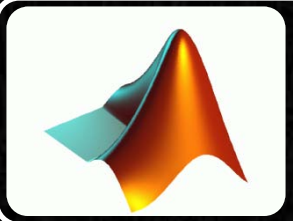

Software Timing and Synchronization

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Hardware Triggering Concerns

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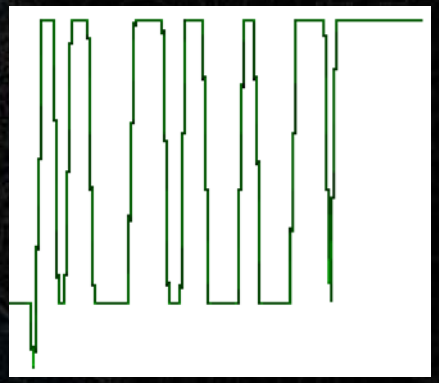
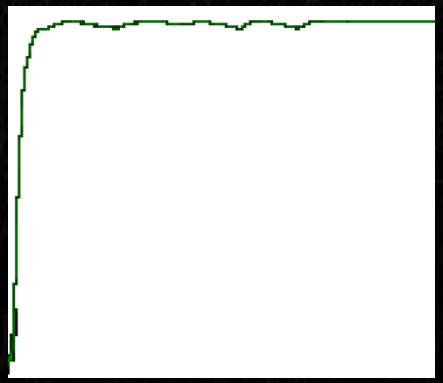


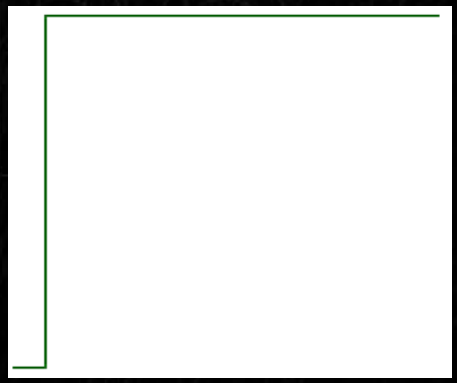
Trigger (switch) Bounce

- Will cause each sensor to trigger multiple times.
- Must be Removed!!



RC low pass filtered

- Removes most of switch bounce.
- Leading edge might not rise fast enough
- Different sensors might still trigger at different times!!



Schmitt Trigger

- Clean leading edge signal with high slew rate of 680 Volts per microsecond

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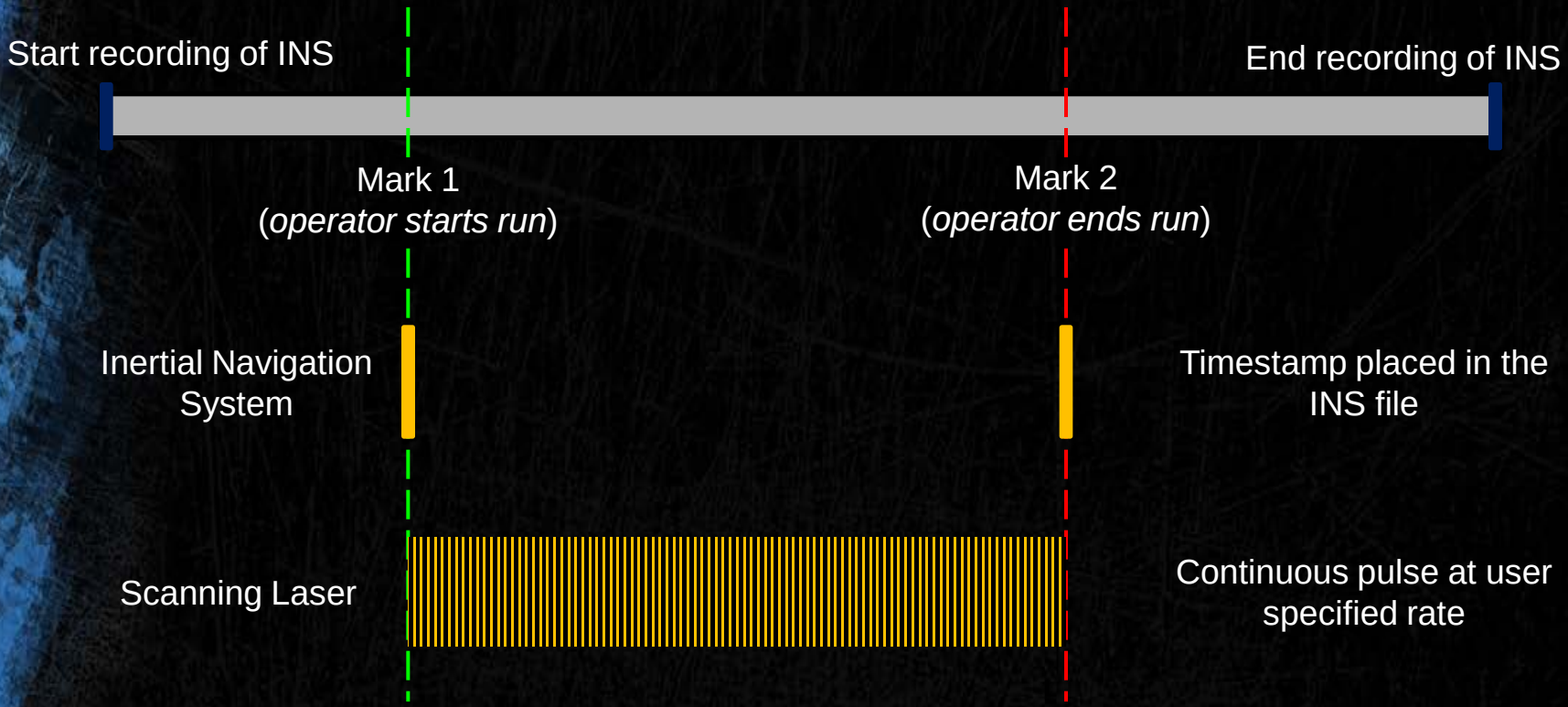
Theory - Hardware

After triggering, different output signals synchronize each piece of equipment



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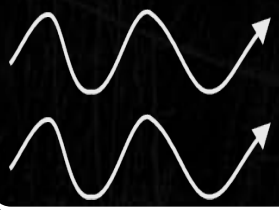

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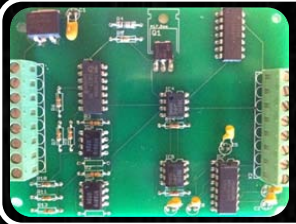

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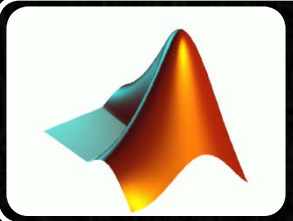

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How XYZ Data is Generated

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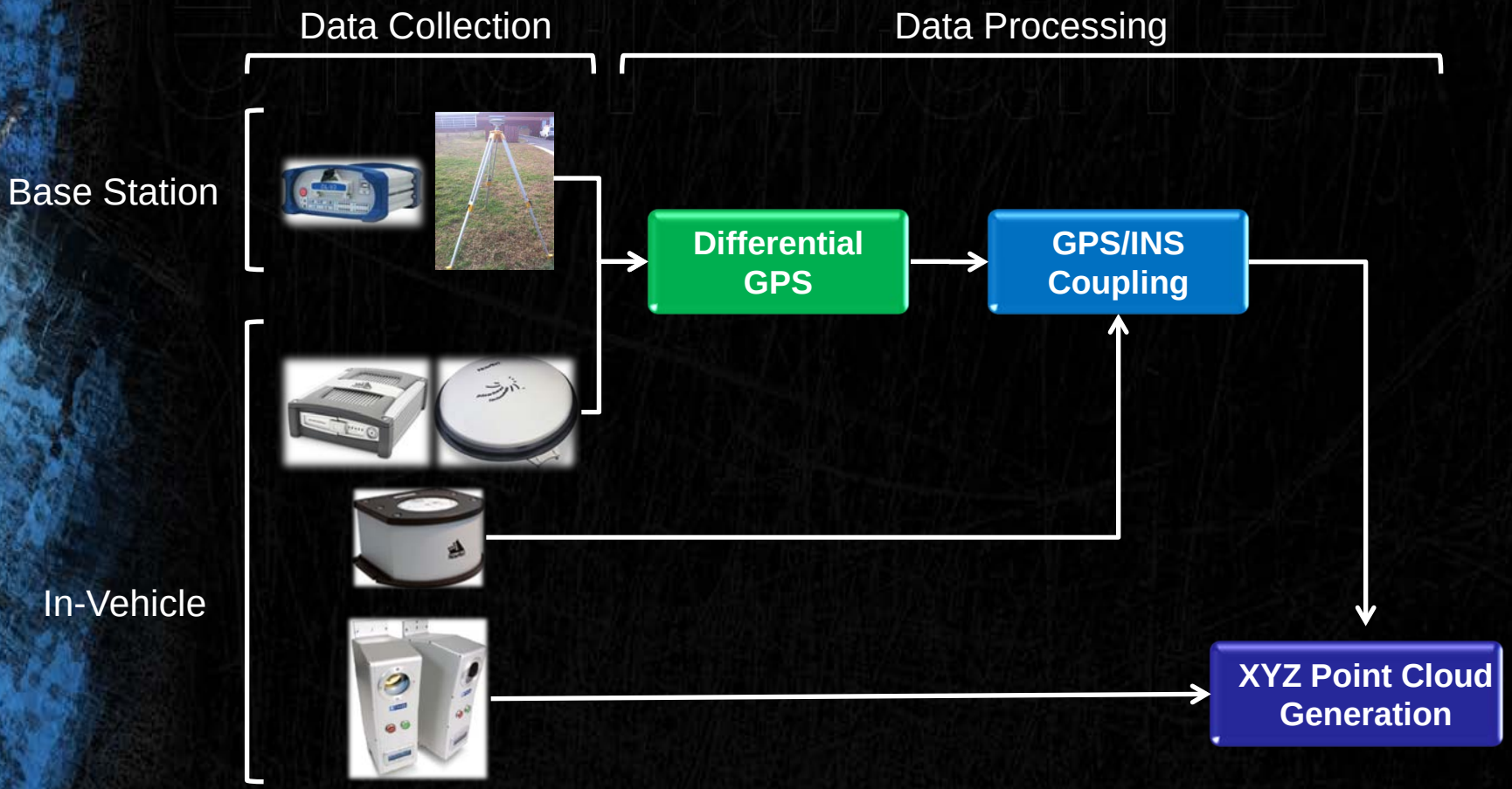

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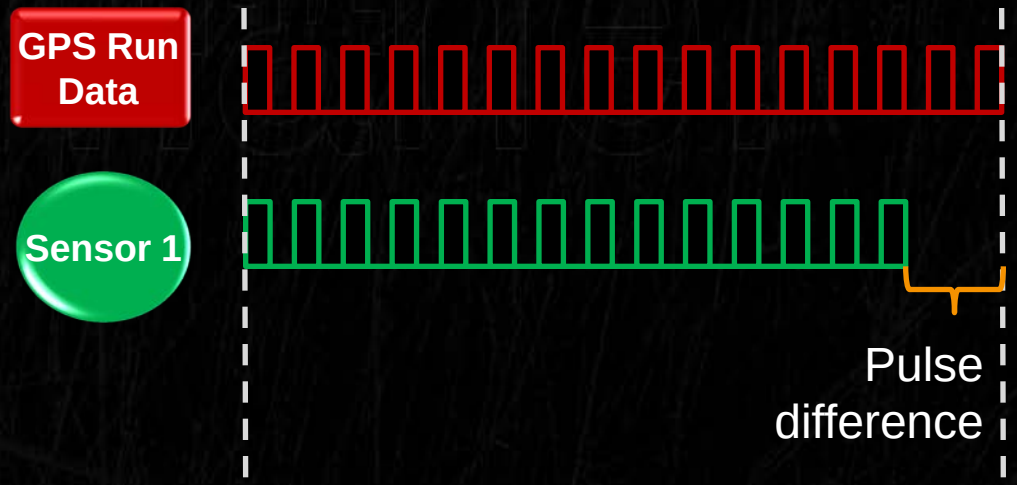
Timing Issues (Pulses)

Issues can arise when the length of sensor data is shorter than length of data collection.

Exact time offset of sensor must be determined through testing.



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Timing Issues (Internal Clock)

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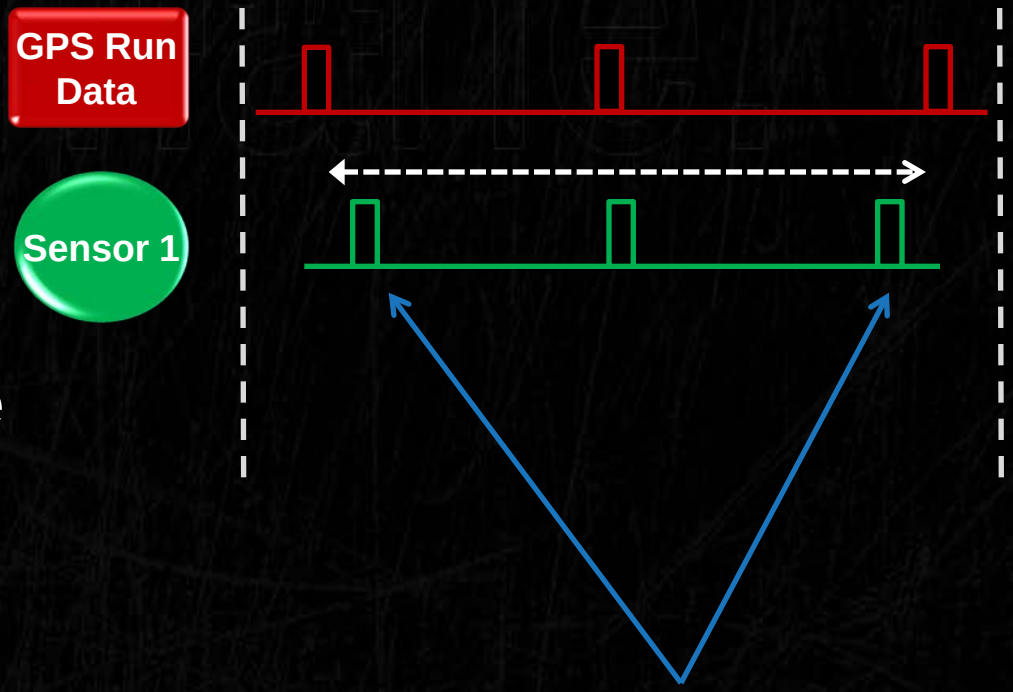
- Sometimes internal clocks are used for synchronizing
- Time differences between clocks can be problematic.
- Using time scaling can correct for the difference in internal clocks.



Synchronizing pulses

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How Does It Work?

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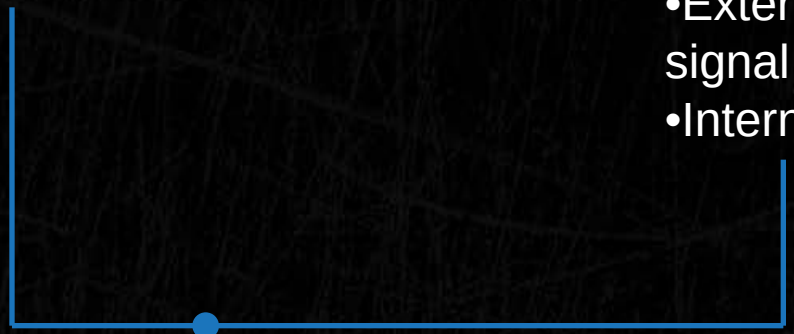
GPS Data

- Location Data
- Angular Orientation Data
- GPS Time Data

Sensor Data

- Measurements collected from sensor
- Timing data
  - External clock signal
  - Internal clock



Time Adjusted Sensor Data

- Measurements collected from sensor
- Time Data (GPS Time)

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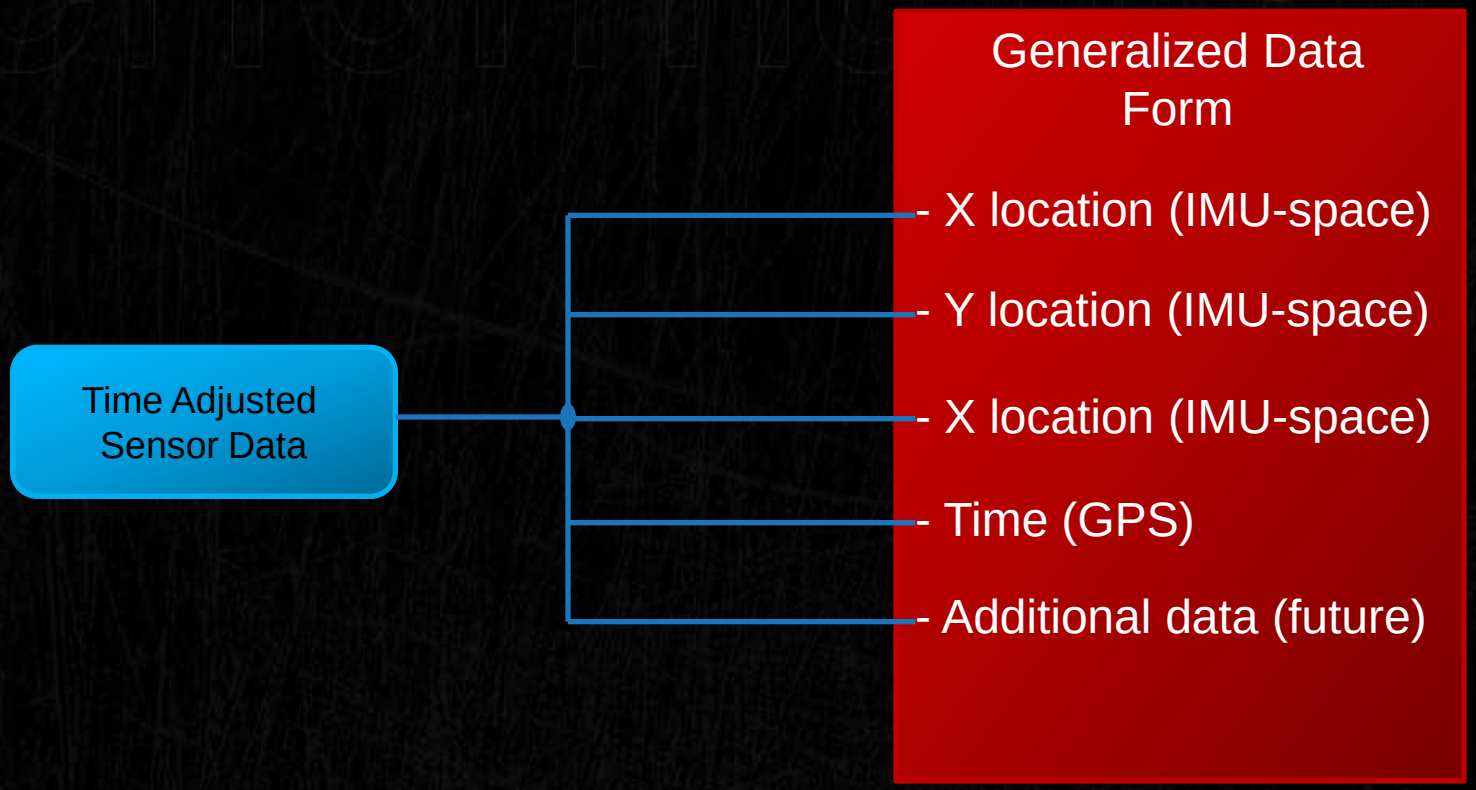
Generalized Form of Data



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General Data Processing Overview

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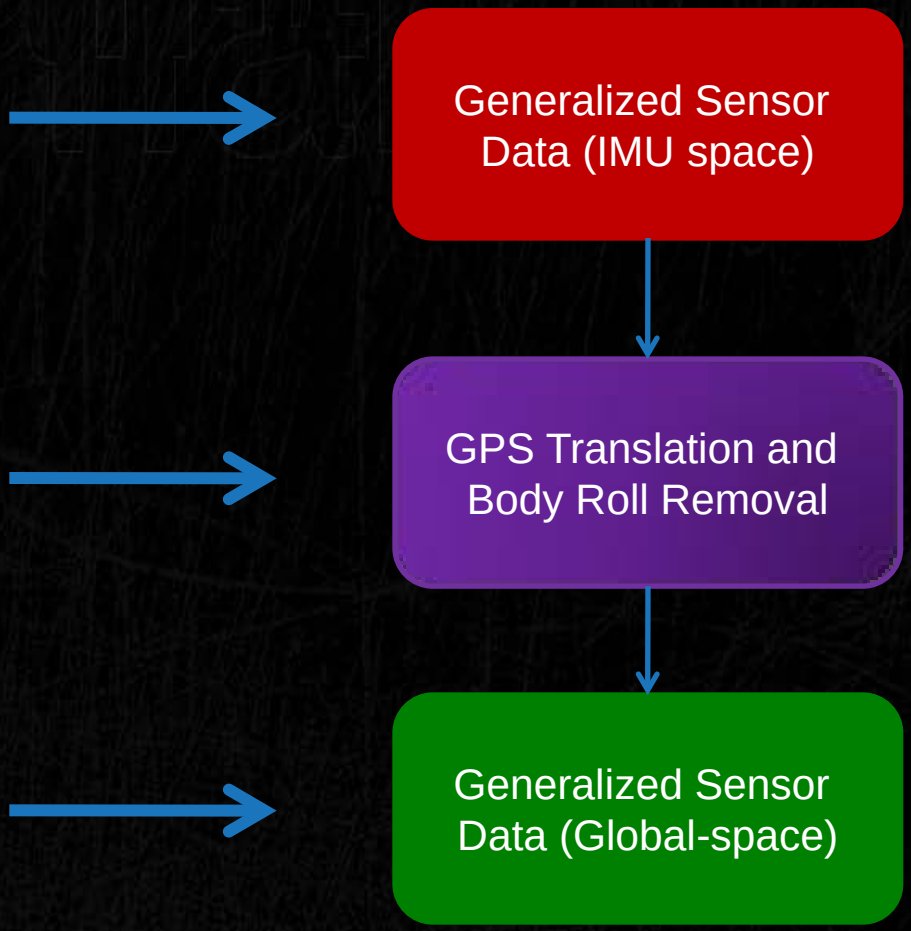
- Data in IMU-Space with GPS timestamps
- Generalized Sensor then Translated to locate it in GPS space.
- Sensor Data is then rotated to remove body roll
- Output is then placed back in the generalized Sensor Data format but now the locations are in Global-space.



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Summary

Hardware:

- Designed to allow for simultaneous triggering of many different types of systems
- Modular, expandable, and robust

Software:

- Processing flow does not need to be modified for new sensors
- Very little new code is needed when system is expanded

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Thank you!

- Questions and Comments?

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