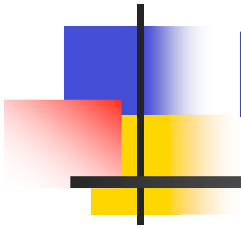
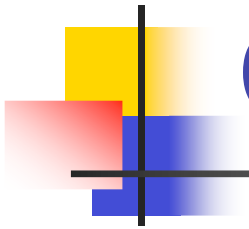


Prognostics System For Military Wheeled Vehicles

Craig Hershey

November 29, 2005



Overview

- System Description
- Goals
- Requirements Overview
- Difficulties & Benefits
- Summary

Example of Application to a Wheeled Vehicle

Reasons For Prognostics

- Maintain vehicles available for combat/missions
- Components fail from fatigue damage
  - Suspension, steering, drive train, electronics, etc…
  - Vibration and shock loading from terrain
  - Temperature, vibe, shock for electronics
- System calculates the life remaining of select components from accumulated use or damage
  - **Ability to characterize usage severity on-board in real-time**
    - **Provide commanders and maintainers with immediate feedback for deployment decision-making**
  - **Potential for failure alerts**
    - **Provide user with indicators of component failures (wheel separation, strut)**
  - **Potential for usage safety characterization**
    - **Provide user with indicators of possible unsafe usage (speed, terrain roughness)**
  - **Potential for fatigue-based prognostics**
    - **Initial efforts focusing on steering and suspension components**

Prognostics System

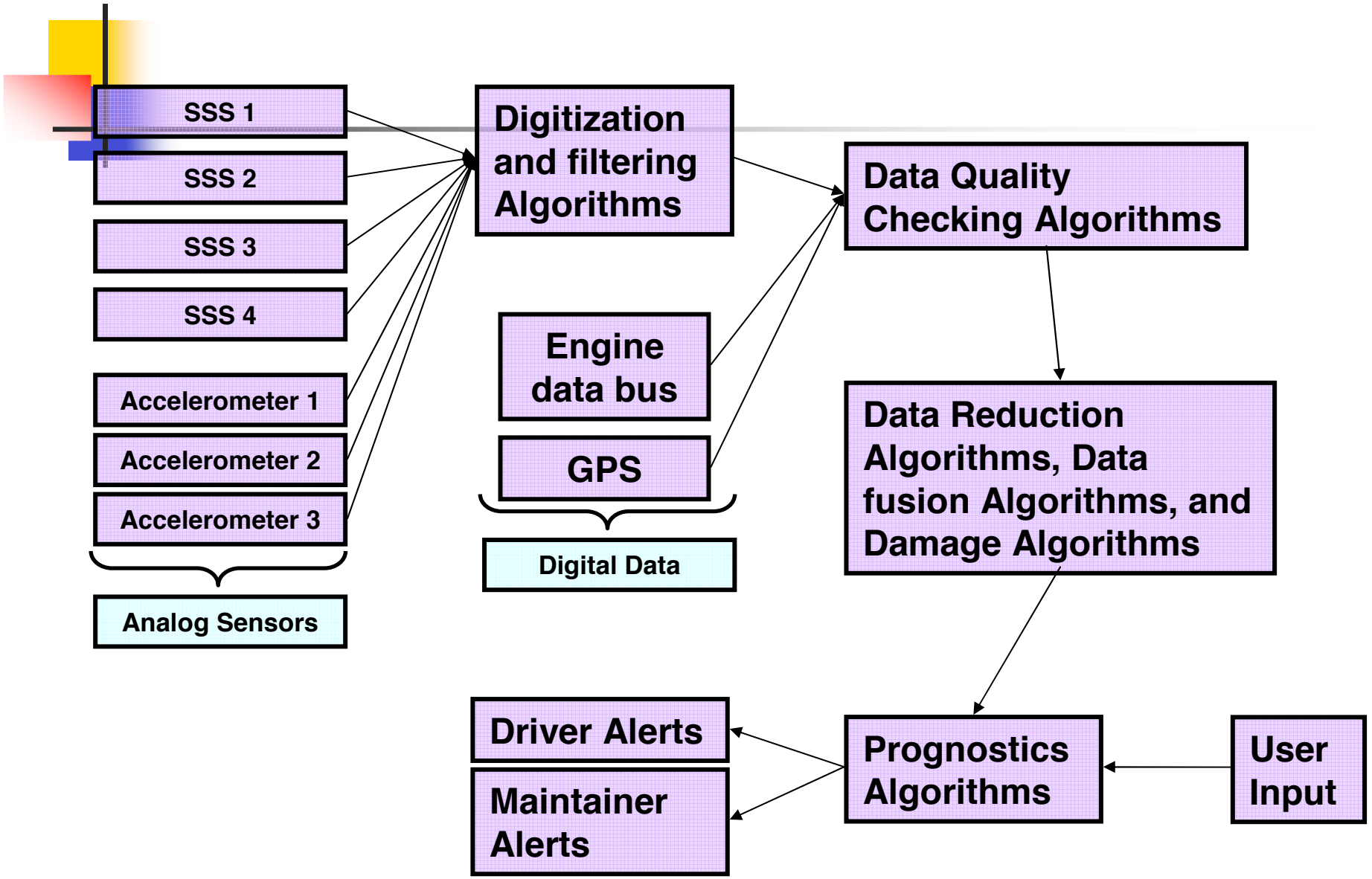
Hardware Installation:

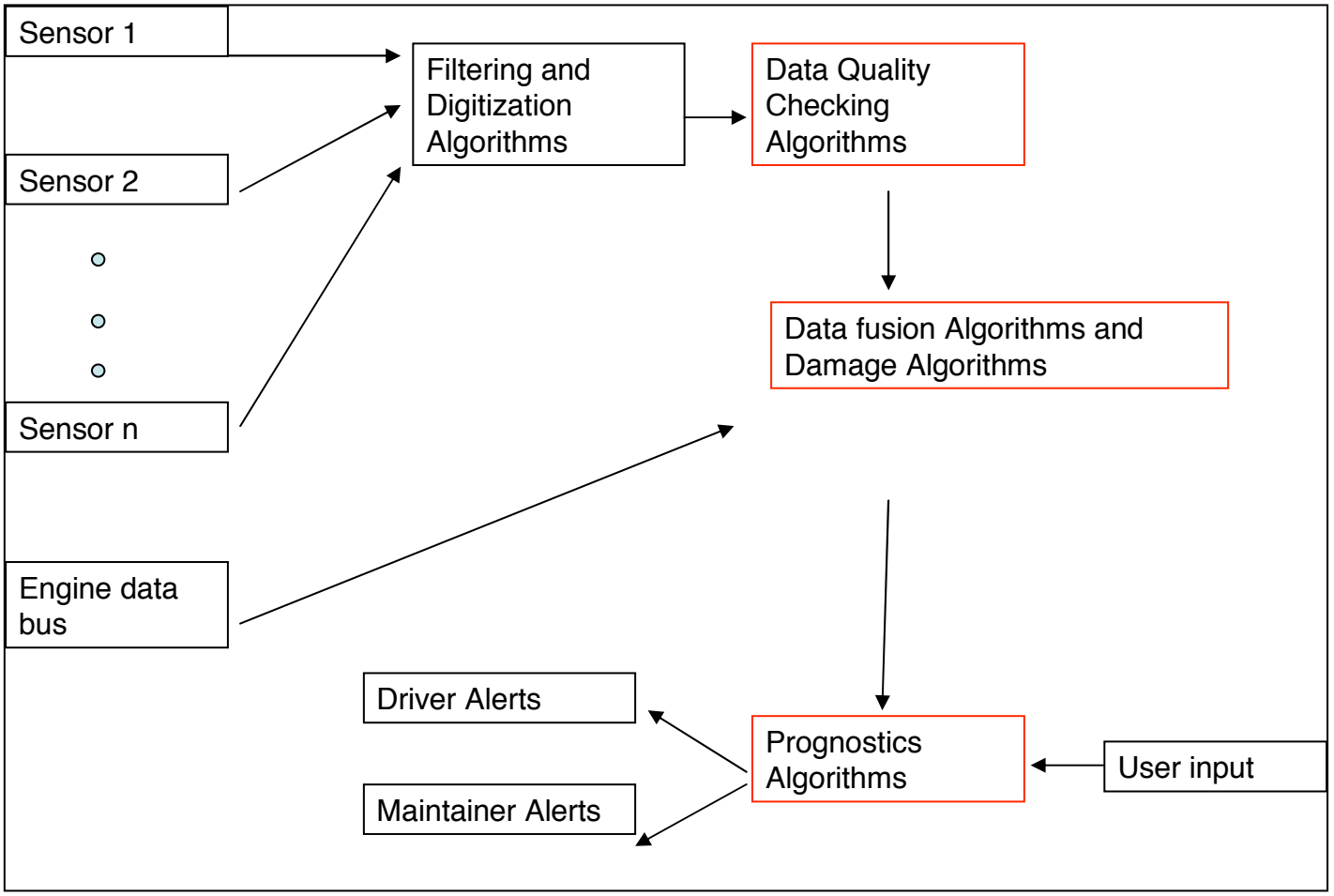
- **Small, rugged, COTS data acquisition box** - nCode eDAQ-Lite
- **Data bus –** multiple parameters (engine RPM, % load, etc)
- **GPS** (long, lat, alt, time, etc) - built into data acquisition box
- **Suspension Sensor System** – built-in to every Stryker on axles 1 and 3
- **3 accelerometers –** only added sensors - mounted on vehicle hull interior
- **About 3 hours per vehicle for installation**

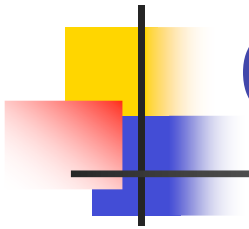
Data downloading:

- **Histogram and rainflow cycle counting data can be stored indefinitely**
- **Time history can be stored for approximately 20 days**
- **Download to laptop via wired or wireless Ethernet**

Overview of System




Sensor 1
Sensor 2
Sensor n
Engine data bus
Filtering and Digitization Algorithms
Data Quality Checking Algorithms
Data fusion Algorithms and Damage Algorithms
Prognostics Algorithms
User input
Driver Alerts
Maintainer Alerts



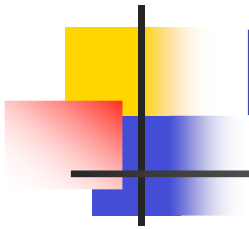
Goals

System Goals

- Logistics
- Mission Success
- Availability
- Cost Savings
- Decrease fatality
- Decrease loss of vehicles
- Maintenance Cost

Project Goals

- Organize requirements
- Verification & validation of requirements
- Visualization of requirements
- High-level representation of system
- Way to address concerns



Requirements

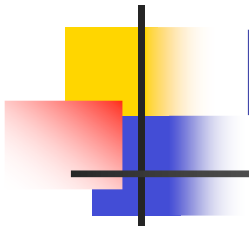
- Traceability
  - Use Case to component
  - Requirement to test/analysis and training
- Requirements Layering
- Requirements
  - Training
  - Functional
  - User
  - Performance
  - Test/Analysis (verification)
  - Design
    - Goals
    - Verification (test)

Requirements (cont'd)

- **Design Requirements (Design Goals or Needs)**
  - Component's fatigue limit is known.
  - Damage algorithms accurately predict accumulated damage
- **User Requirements**
  - Maintainer/Driver understand how to operate system
  - Driver understands course of action when an alert occurs
- **Functional Requirements (F#)**
  - System must be able to monitor components without requiring maintenance, downloading, or calibration for every mission (7 day mission).
  - System must meet all specifications that vehicle meets.

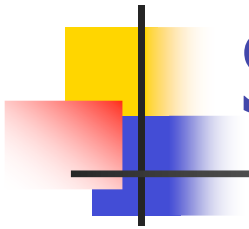
Verification of Requirements

Component's fatigue limit is known	FEA/Fatigue analysis to determine fatigue limit
System does not create EMI	Test system for EMI
System does not send false alerts	Endurance test to verify accuracy
Maintainer/Driver understand how to operate system	Operational test with crew to test system



Difficulties

- Overall Difficulties
  - Being aware of current goals vs. long term goals
  - Keeping a high level of abstraction
- Requirements
  - Developing testing, training, and analysis requirements for verification
- Optimization
  - Finding numbers for optimization



Summary

- Requirements engineering is important for this application
- Performing optimization important for ROI