



WD 08: CBM-A

Intelligent Vehicle Health Management System (IVHMS) for Light Tactical Vehicles

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Report Documentation Page

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Presentation Outline

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- Project Objectives and Overview
- Axle and Engine Vehicle Sensors
- Electronics Module Description
- Fuzzy Model for Diagnostics and Prognostics



Objectives

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Project

- Develop a vehicle health management system for quick installation on vehicles without existing electronic sensor networks, e.g. CAN-Bus.
- Identify a comprehensive vehicle-condition sensor array along with its wireless connection
- Develop vehicle on-board sensor data storage unit and secure sensor data transmission unit
- Develop algorithms for depot on-site diagnostics and prognostics
- Develop vehicle on-board maintenance warning capability

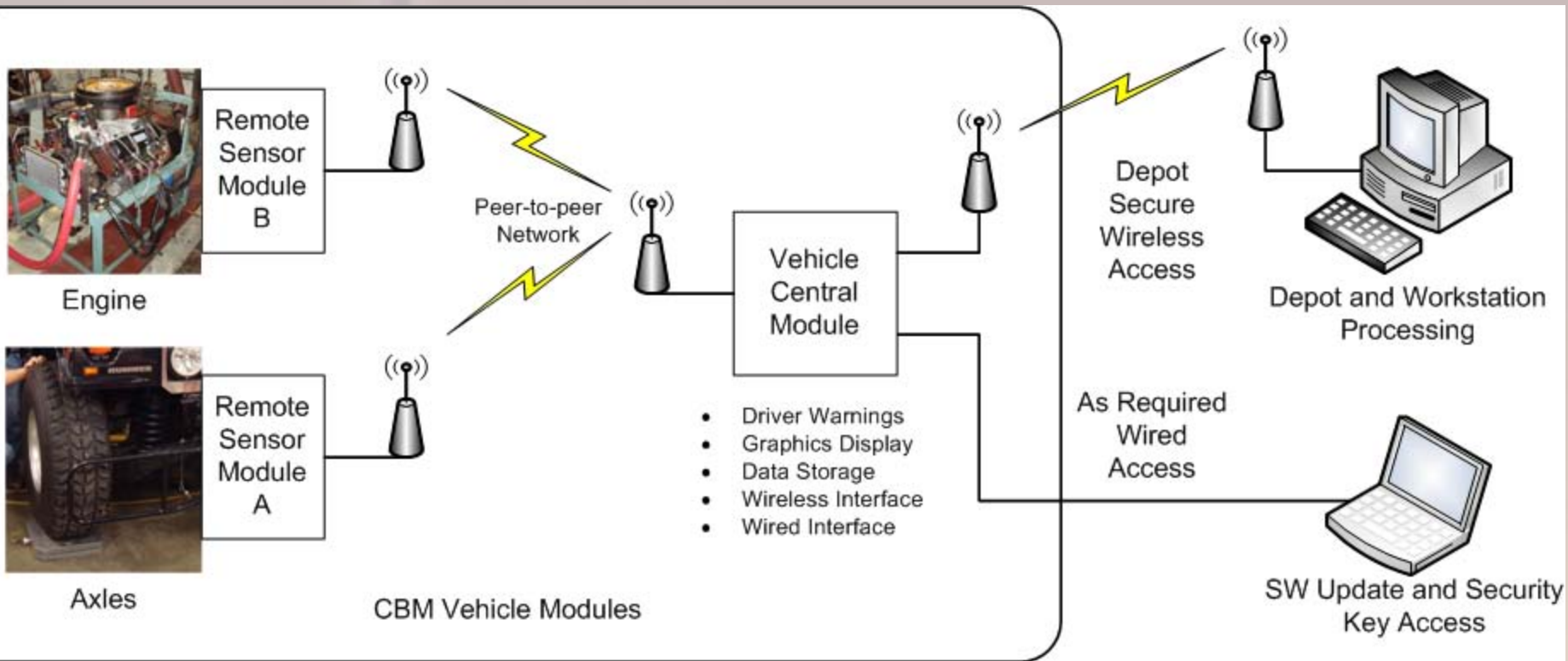
Long Term

- Significantly reduce maintenance cost through CBM for Army's current Light Tactical Vehicle Fleet
- Potentially save soldiers' lives by not allowing vehicles in need of maintenance to be deployed



System Architecture

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Workstation Software Development

- Fuzzy algorithm development for vehicle diagnostics and prognostics.
- Vehicle warning algorithm to be determined



Axle Sensors

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Dr. Richard Hathaway

Axle Measurements

- Strain Gages - Wheatstone Bridge
- Thermocouple Temperatures

WMU 1995 Hummer Work

- Static measurements and calculations completed
 - Weight, weight distribution, CG, tire characteristics, suspension, etc.
- Strain gage and thermocouple mounting in process
 - Gage calibration



WMU In-house Test Vehicle



College of Engineering and Applied Sciences

Engine Sensors

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Dr. Claudia Fajardo
Engine Measurements

- Throttle Position
- Crankshaft Rotational Speed
- Thermocouple Temperatures
 - Inlet, exhaust, 8 cylinders
- Differential Pressure
- Torque

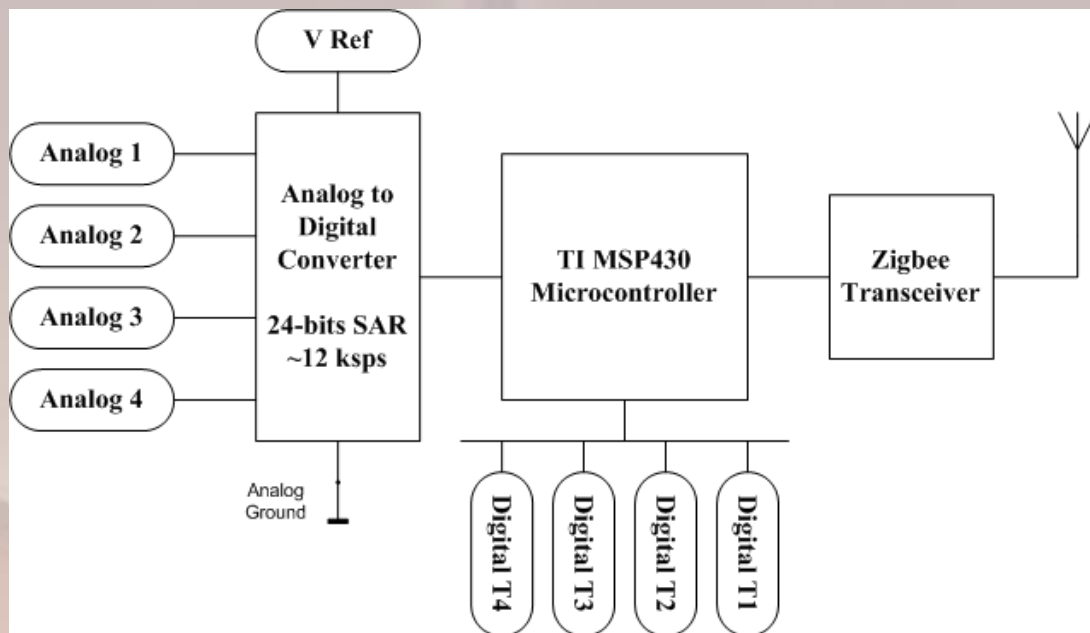


WMU Engine Test Facility



Microcontrolled Wireless Sensor

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- 24-bit 4 channel SAR Analog to Digital Converter
 - Precision Voltage Reference
 - Per channel compensation available
- TI MSP430 Microcontroller
 - Low standby power
 - TI or GCC development tools available
- Zigbee RF
 - PCB antenna
 - 2.4 GHz ISM



Custom Sensor PCB

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- In-house PCB layout and assembly
 - ORCAD layout tools
 - Vendor PCB fab
 - Solder Paste Stencil
 - Reflow Oven
 - Rework station and tools



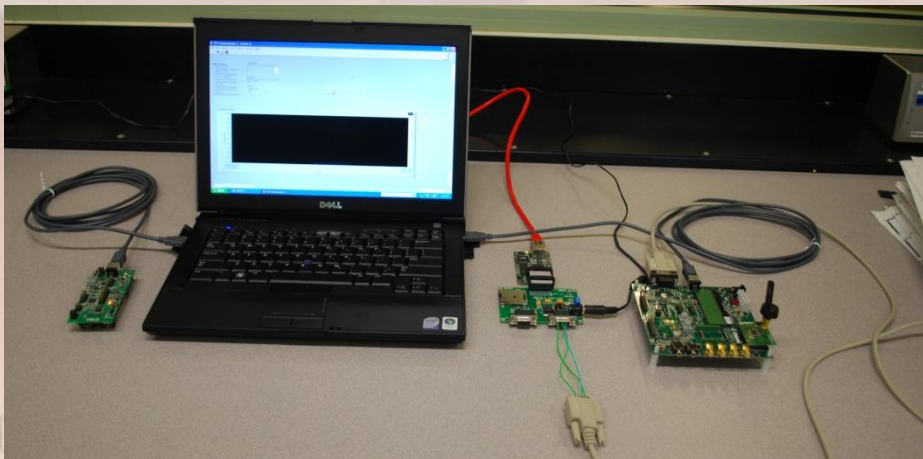
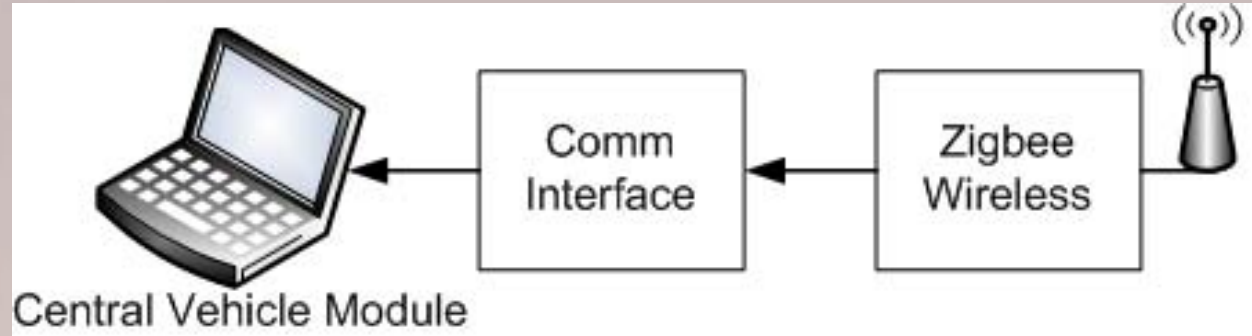


Central Module

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Design Tradeoff:

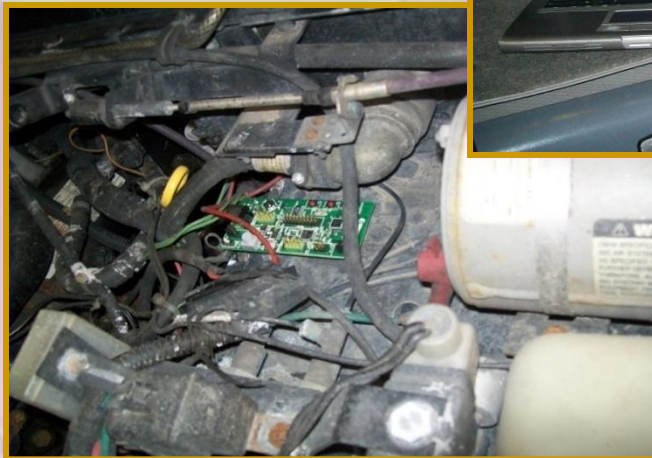
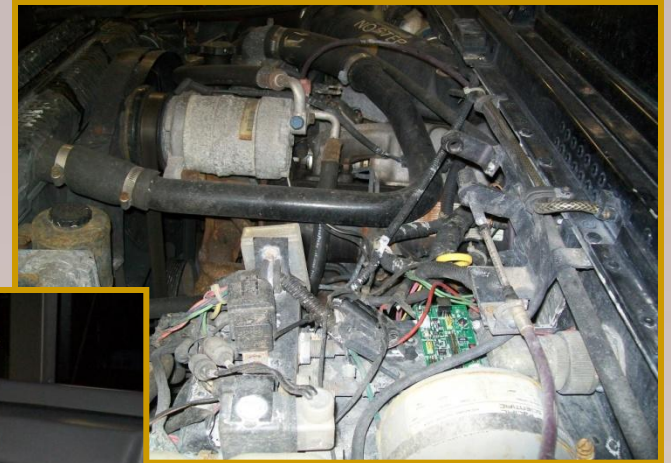
- Laptop provides a majority of module requirements
- Minimize custom PCB design and risk.



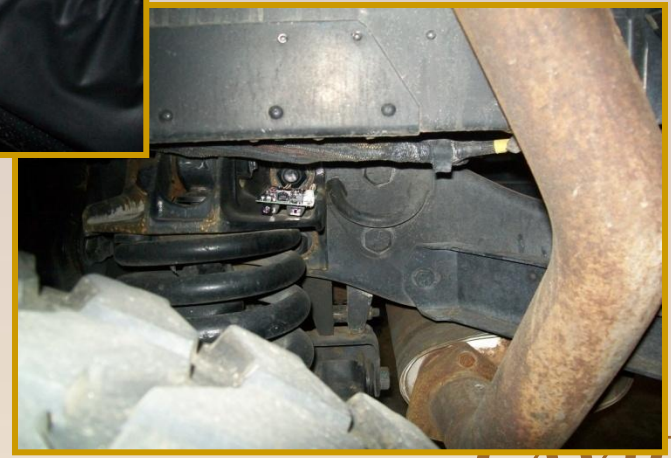


Zigbee Testing

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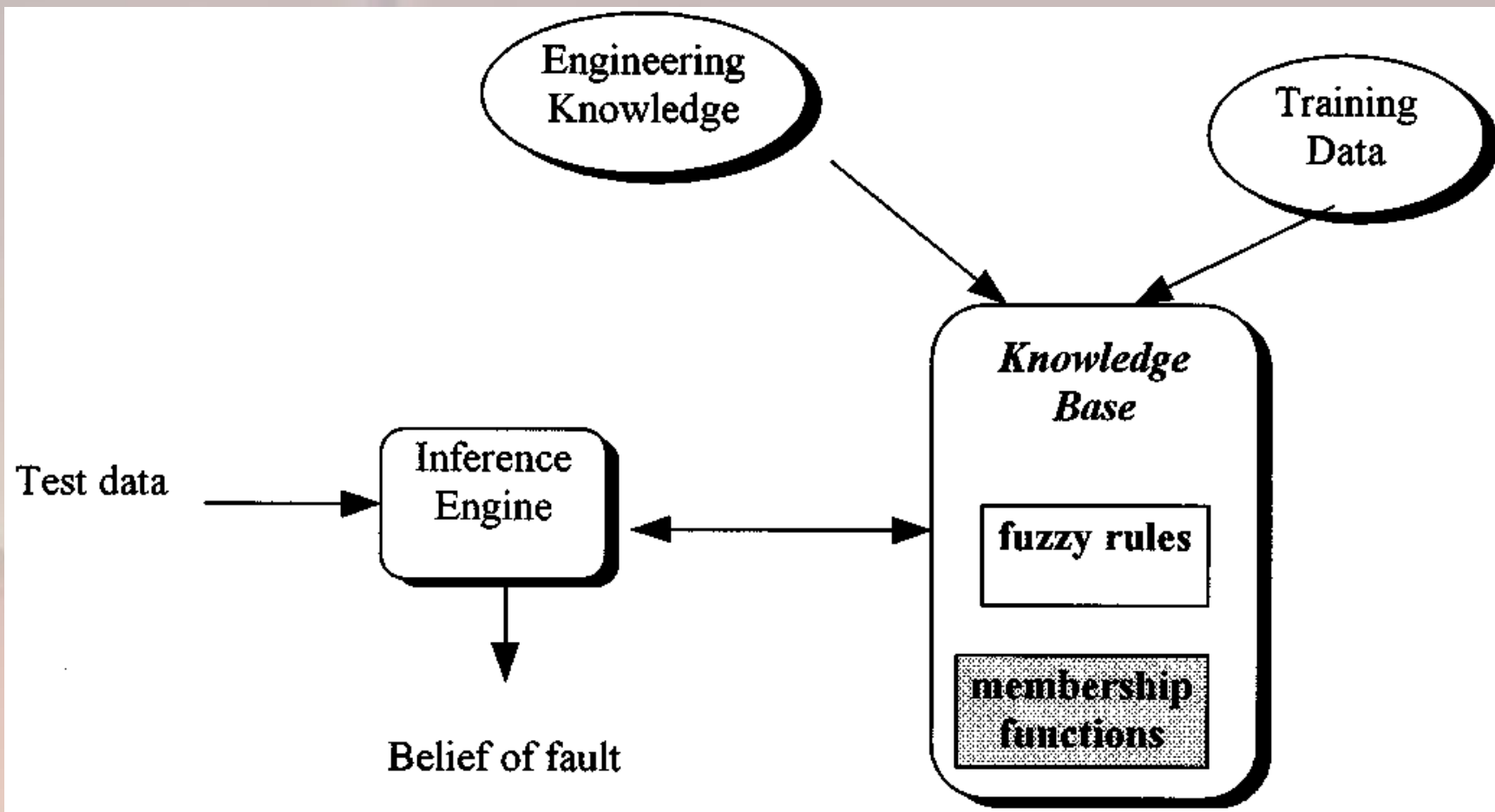
Test signals
successfully received





A Fuzzy Diagnostic Model³

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Reference³

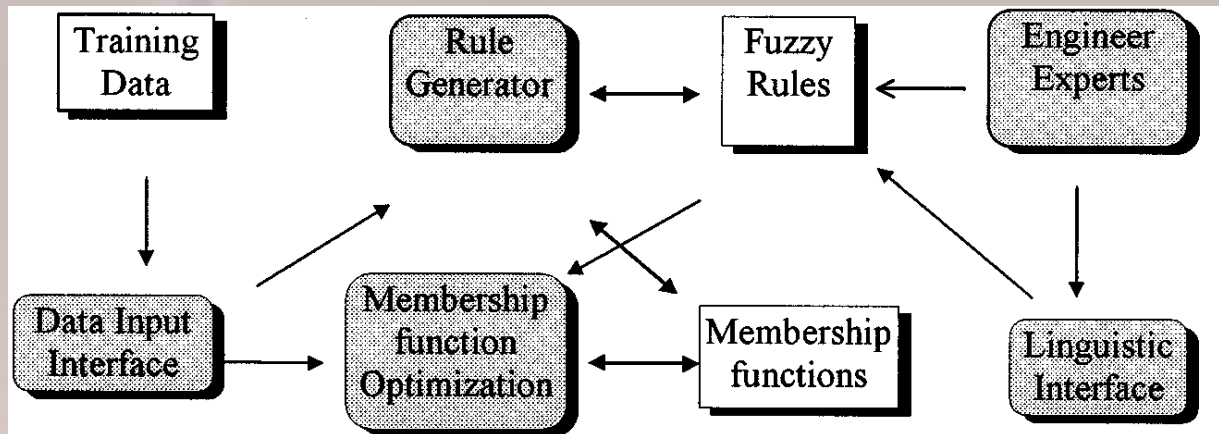
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- Yi Lu, Tie Qi Chen, and Brennan Hamilton, A Fuzzy System for Automotive Fault Diagnosis: Fast Rule Generation and Self-Tuning, IEEE Transaction on Vehicular Technology, VOL. 49, NO. 2, March 2000

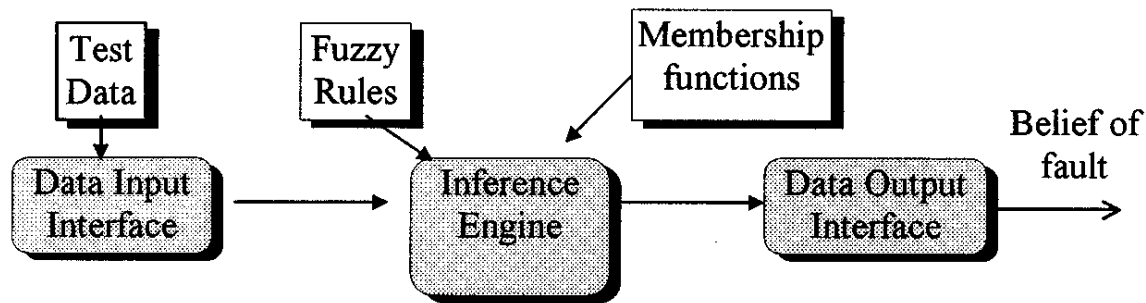


Implementation of a Fuzzy Model³

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(a) Learning fuzzy knowledge



(b) Fuzzy inference.



Generating and Refining the Fuzzy Model

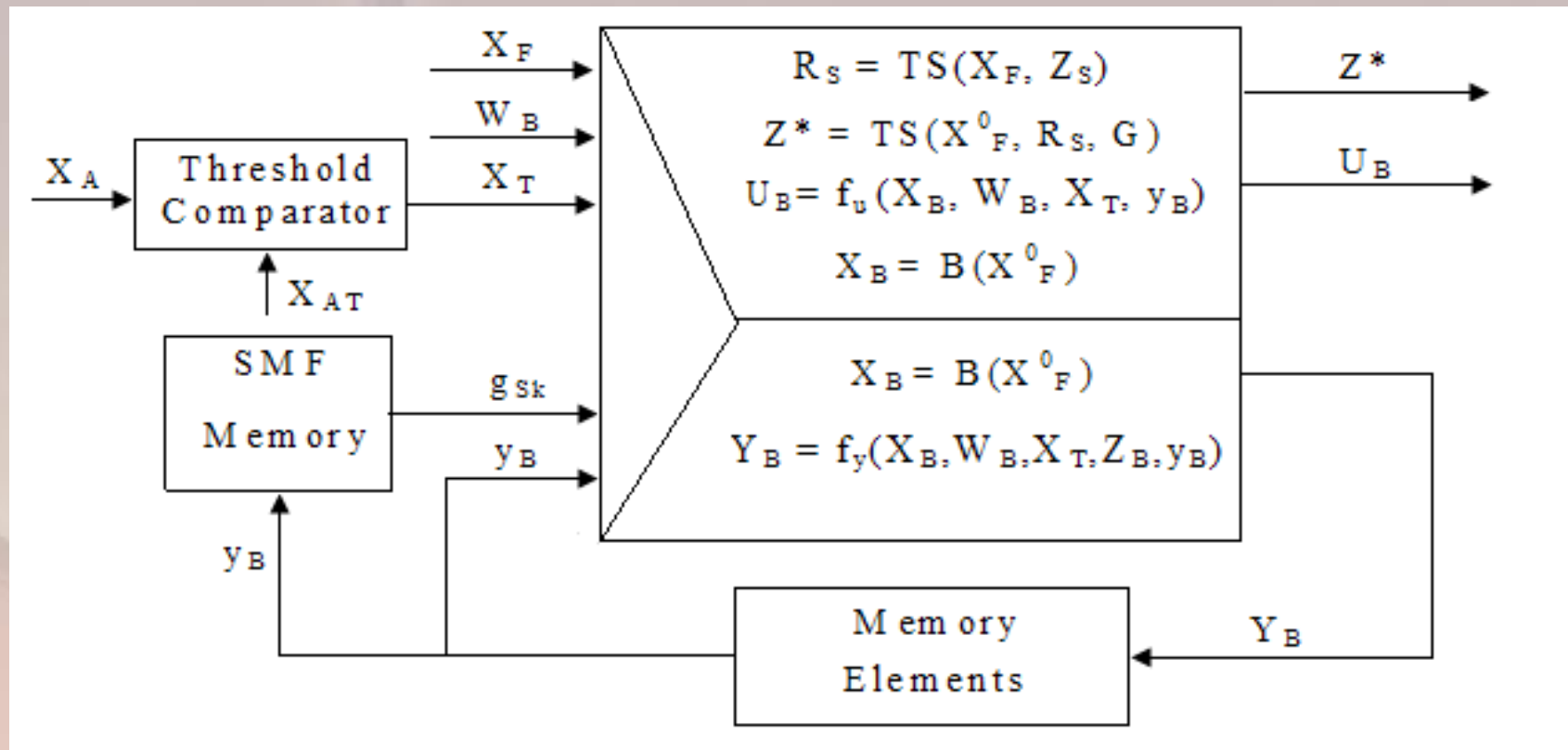
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- Each membership function is uniquely defined by a set of critical parameters (e.g., 2 for triangles and 4 for trapezoids)
- The rule generator can start with assigning arbitrary initial values to the critical parameters of the membership functions
- Then the input data set is separated into clusters using a cluster-extraction procedure
- After all data have been clustered the locations of cluster centers are calculated. If the locations of the cluster centers don't properly agree with the critical parameters of the corresponding membership functions, the critical parameters are updated



Takagi-Sugeno Type Fuzzy Automaton Block Diagram

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Current Status

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- Engine and WMU Hummer H-1 truck sensor preparation and installation work continuing
- Analog electronics, axle sensors, digital electronics and wireless communication systems have been bread boarded and tested
- Prototype Sensor PCBs
 - axle sensors being populated and tested
 - wireless communications board being populated and tested
 - engine sensing PCB in design phase, awaiting axle PCB results
- Central Module
 - Zigbee to microcontroller to Ethernet to PC path testing completed
- Intelligent diagnostics/prognostics methods
 - Fuzzy logic based approaches being researched
 - Initial fuzzy model for axle being developed