# Magnetic Flowmeters for Primary Loop Measurements at PWRs

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# ORNL Magnetic Flowmeter Team

- **David Holcomb - conceptual design, nuclear plant requirements, thermal testing**
- **Jim Hardy - flow implementation, electrode structure, thermal testing**
- **Unknown (from metals & ceramics division) - cermet casting and fitting**

# Rationale for Improved Flow Measurement

- **Current NRC regulation calls for a 2% thermal power operating margin**
  - **Assuming a 3¢/kW-hr cost (1000MWe plant) results in $5.3M/year lost potential profit**
- **Temperature and flow measurements form the basis of thermal power information**
- **Differential pressure across Venturi nozzle most common technique for flow measurement**
  - **Nozzle fouling known ongoing problem**
  - **Differential pressure cells have had leakage problems**
  - **Nonlinear device - limited range of accuracy**

# Why Select a Magnetic Flowmeter

- Highly accurate device
  - ±1/4% under optimal conditions
- Obstructionless—consumes no pumping power
- Remote transmitters—limited electronic environmental exposure
- Linear response over full range of flow conditions
- Large knowledgebase for application in harsh environments

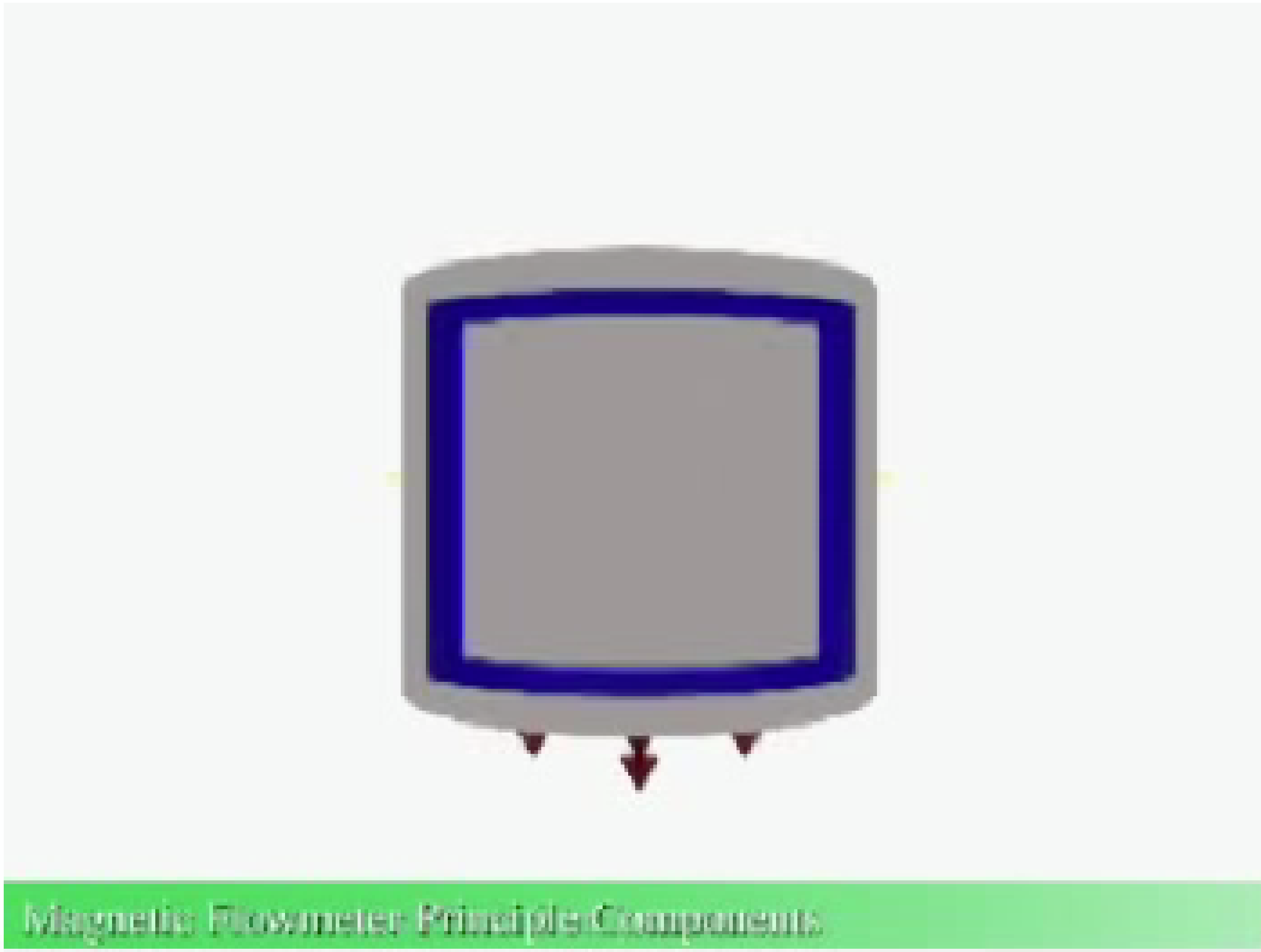
# Limitations and Concerns

- Chordal, time-of-flight, ultrasonic based flowmeters have recently won regulatory approval
  - Unclear whether either technology is superior
- High accuracy measurements require advanced signal processing
  - Uncertain regulatory approval
- Requires introduction of insulative pipe liner section
  - Demonstration of mechanical integrity of ceramic will require significant effort
- Application to conditions with potential voiding dramatically increases complexity

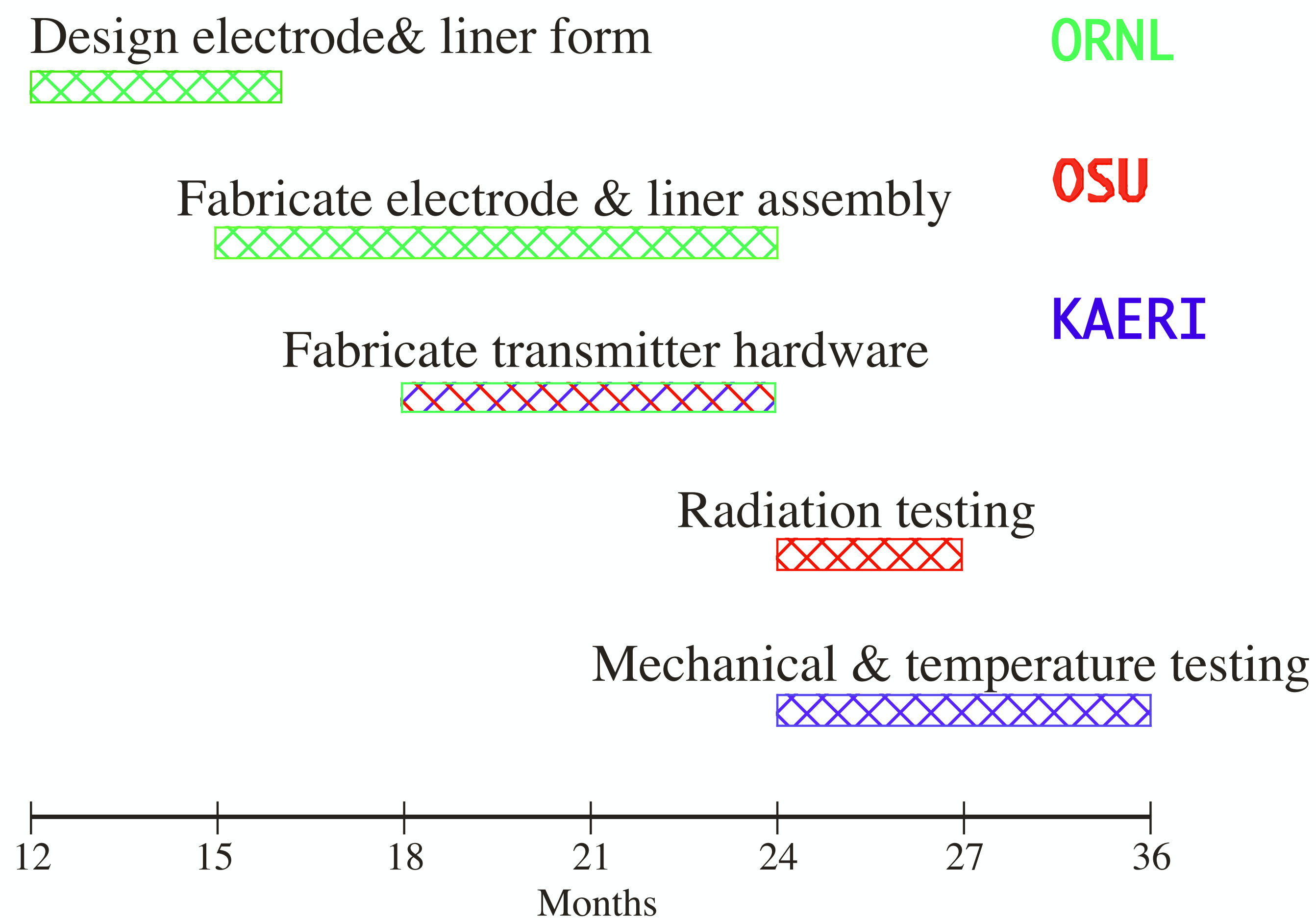
# How a Magnetic Flowmeter Works

- **Based on Faraday's Law of Magnetic Induction**
- **Any conductor moving through a magnetic field will generate a voltage across it proportional to the magnitude of the field and the velocity of motion**

$$\begin{matrix} Voltage \\ Developed \end{matrix} = \begin{bmatrix} Magnetic \\ Field \end{bmatrix} [Velocity] \begin{bmatrix} Mean \\ Conductive \\ Path \end{bmatrix}$$


Magnetic Flowmeter Principle Components

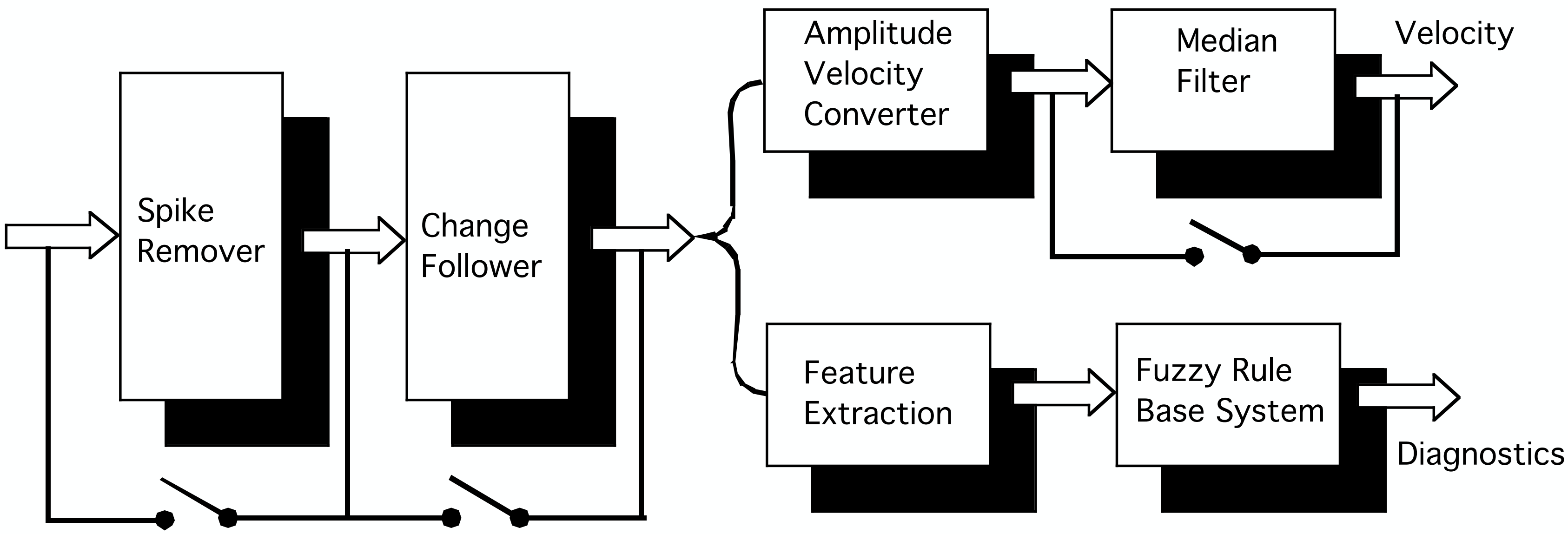
# Project Plans and Schedule




- **Based on existing flowtube hardware**

# Ongoing Work on Magnetic Flowmeters Applicable to PWRs

- **Emerson Process Management - was Fisher-Rosemount sponsored intelligent transmitter work at Purdue University Nuclear Engineering Department**
- **Schematic of Purdue Intelligent Transmitter Algorithm**



# Advanced Signal Processing and Electrode Forms Significantly Improve Performance

- Pulsed DC, multifrequency excitation coupled to a feature extraction algorithm
  - Almost no zero drift
  - High response speed
  - Large noise immunity
- Capacitive non-wetted electrodes
  - Higher mechanical integrity
  - Ability to operate with very low conductivity (0.01 µS/cm) fluids

# Initial Fabrication Technique Overview

- Concepts remain embryonic
- Initial concept metallic cermet electrode cast into alumina-zirconia ceramic liner
- Liner shrunk fit into flowtube
- Recess liner to reduce flow impingement
- CTE match liner ceramic as well as possible to steel
- Electrical feedthroughs made using standard seals