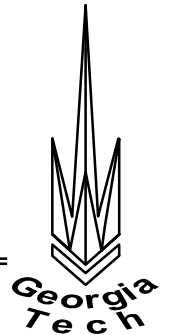


Bearing Condition Monitoring



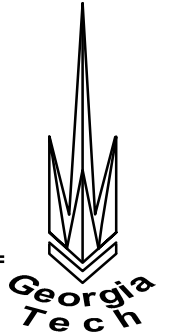
Precision Machining Research Consortium
Industrial Advisory Board
Georgia Institute of Technology
29 October 1997

Scott Billington

Yawei Li

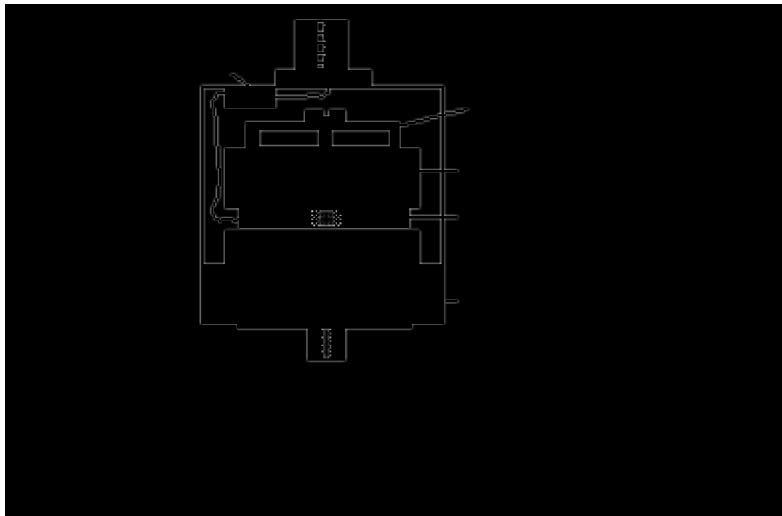
Advisors: Dr. Liang, Dr. Kurfess, Dr. Danyluk

Overview - Diagnostics and Prognostics

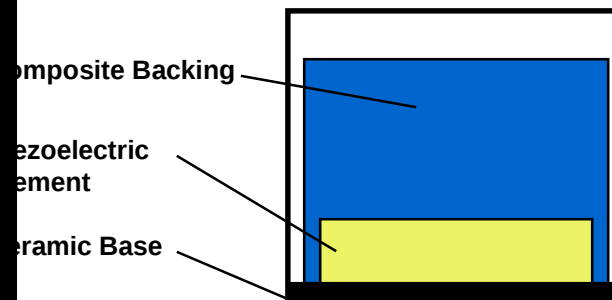


- ❖ **Diagnostics - Correlating Signals to Bearing Condition**
 - Accelerometer and Acoustic Emission Sensors
 - Signal Processing with LabVIEW interface
- ❖ **Operating Condition Effects (S. Billington)**
 - Rotational Speed
 - Radial Load Level
 - Sensor Location
- ❖ **Adaptive Prognostics (Y. Li)**
 - Crack Propagation Model
 - Rate-Calibrated Life Estimation

Sensor Types

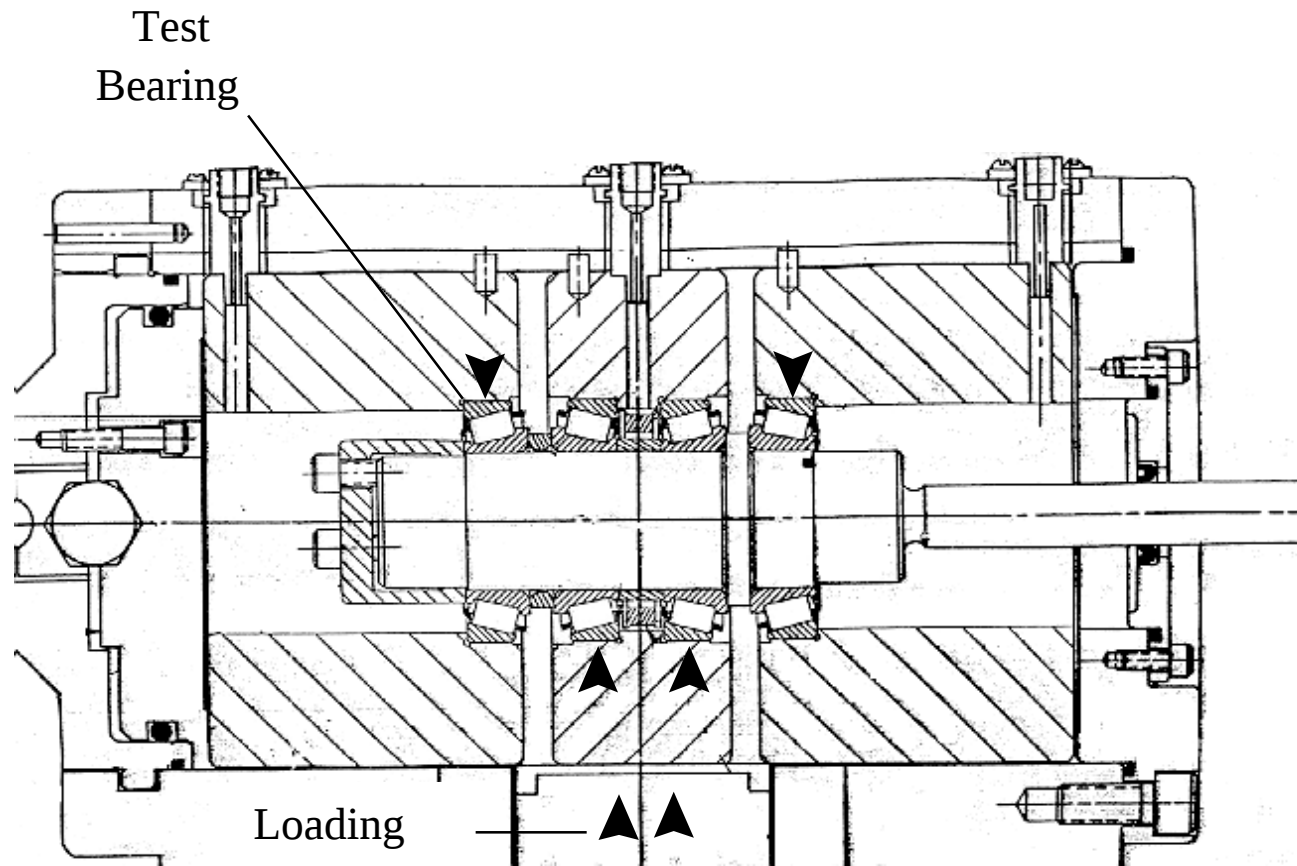


- ❖ Signal Generation Type
 - Seismic Mass
 - Force on a Piezoelectric Element
- ❖ Frequency Range Less Than 5-10 kHz

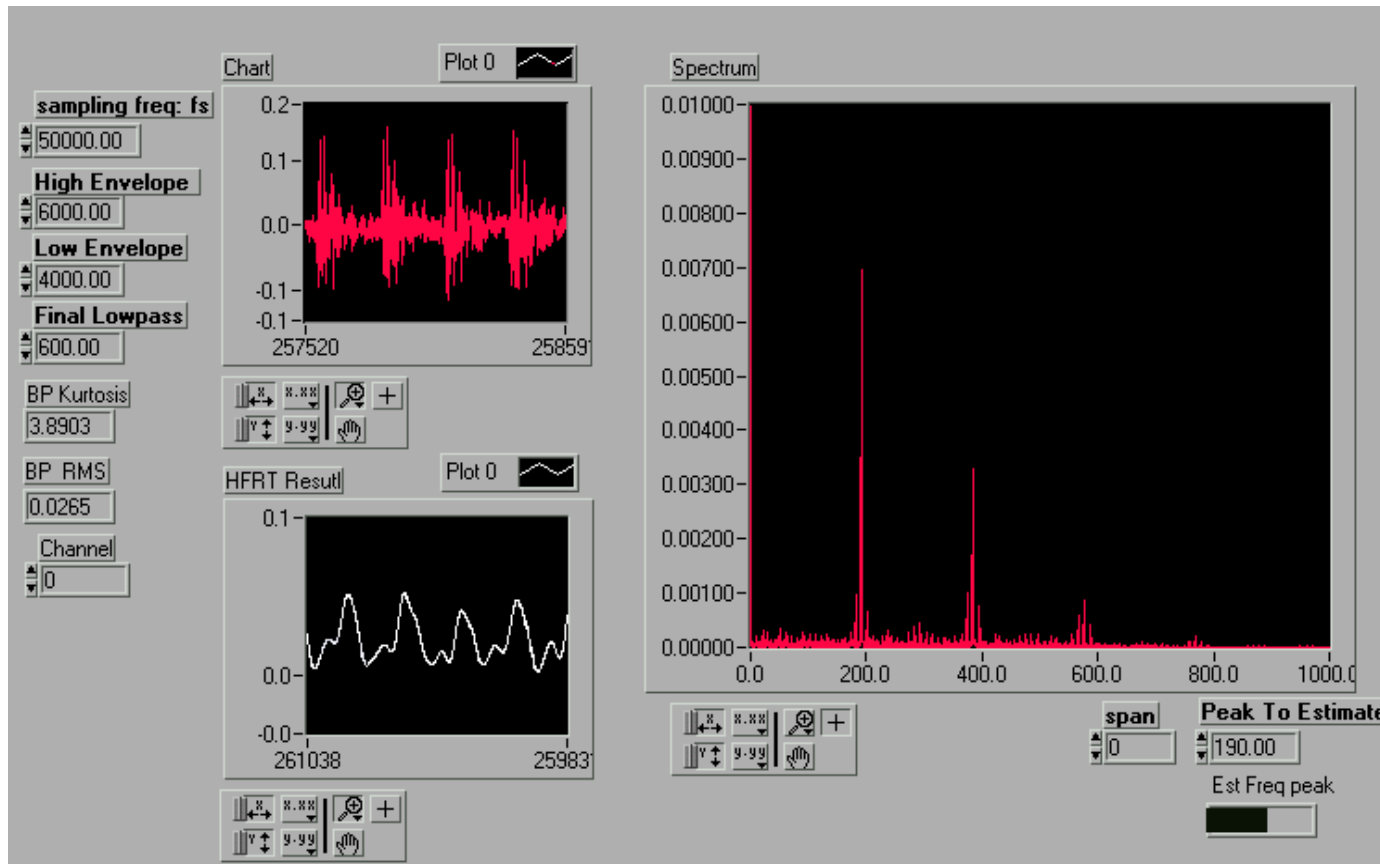


- ❖ ACOUSTIC EMISSION
- ❖ Signal Generation Type
 - Elastic Stress Waves
 - Stress Wave Propagation through a Piezoelectric Element
- ❖ Frequency Range Greater Than 100 kHz

Test Stand

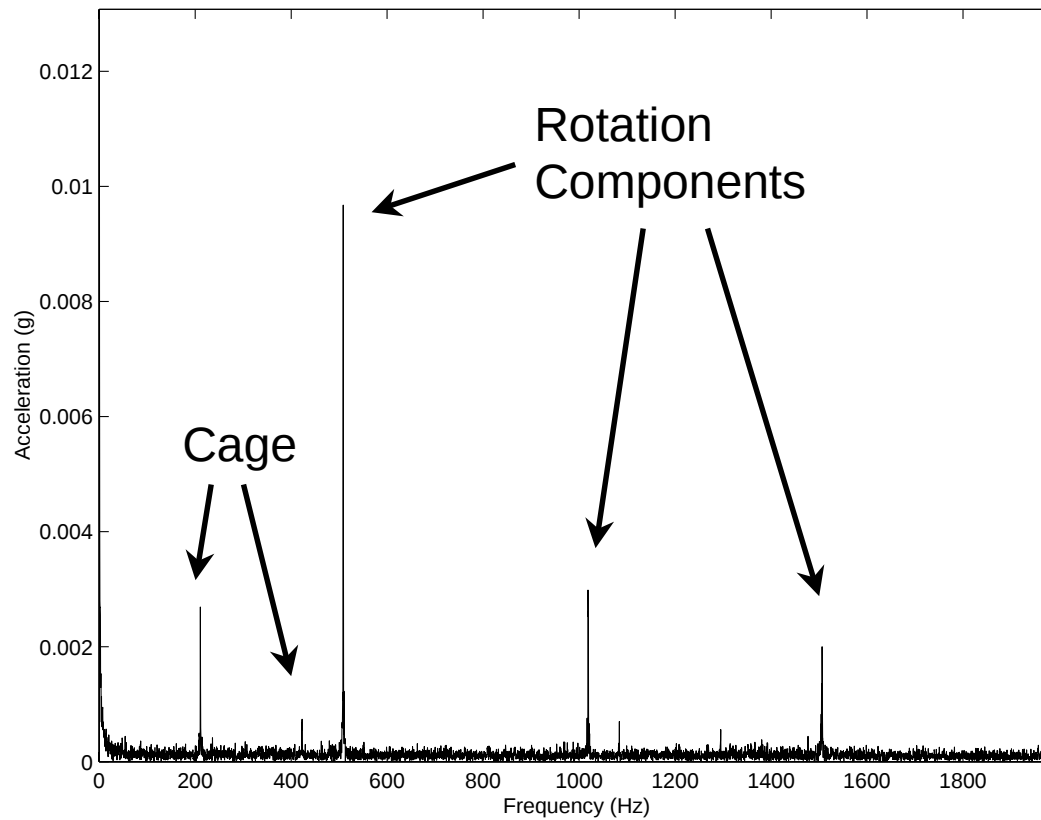
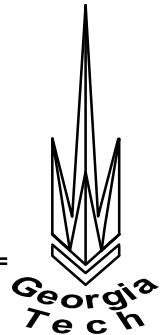


Data Acquisition Interface



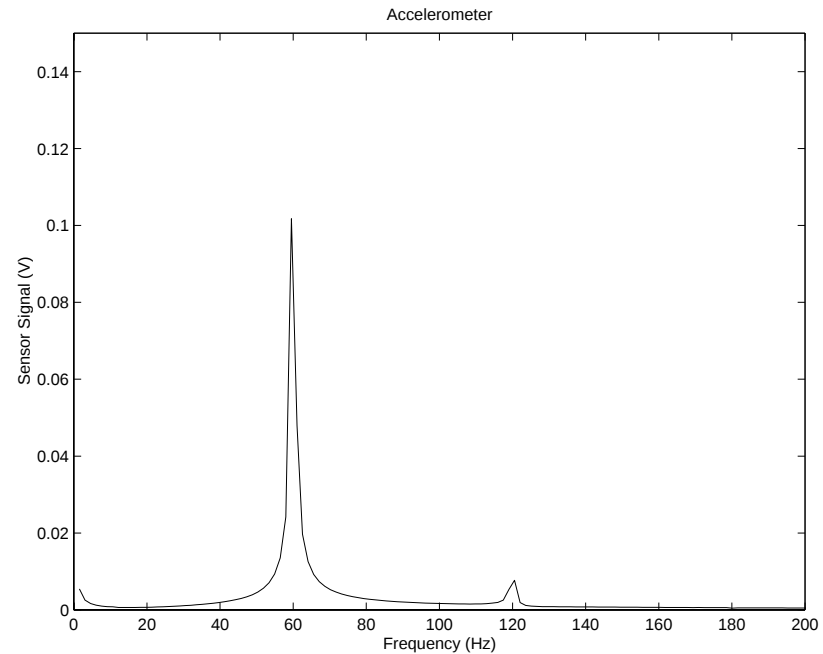
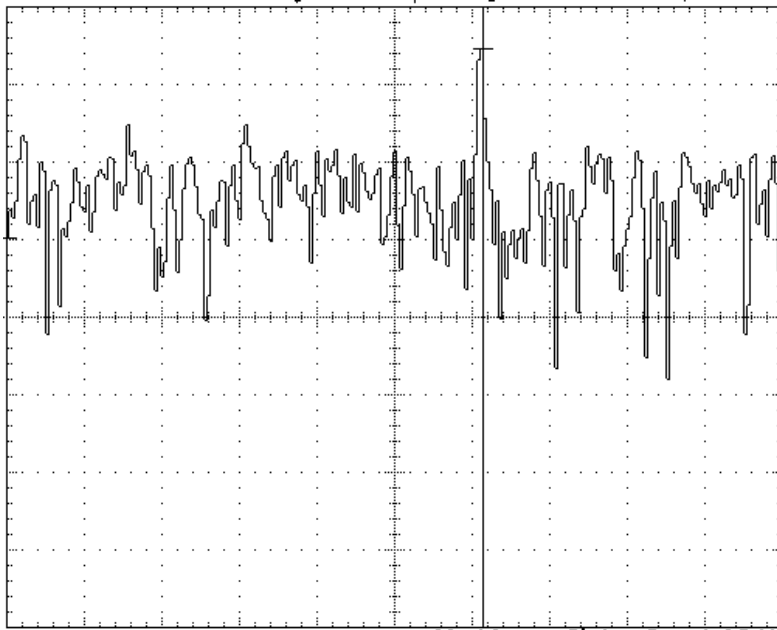
❖ LabVIEW Based Virtual Instrument - HFRT Pictured

High Speed Grinding Spindle



- ❖ ~30,000 RPM
- ❖ 262,144 Data Points, 2 MB ASCII file
- ❖ Excellent Noise Rejection
- ❖ Excellent Repeatability

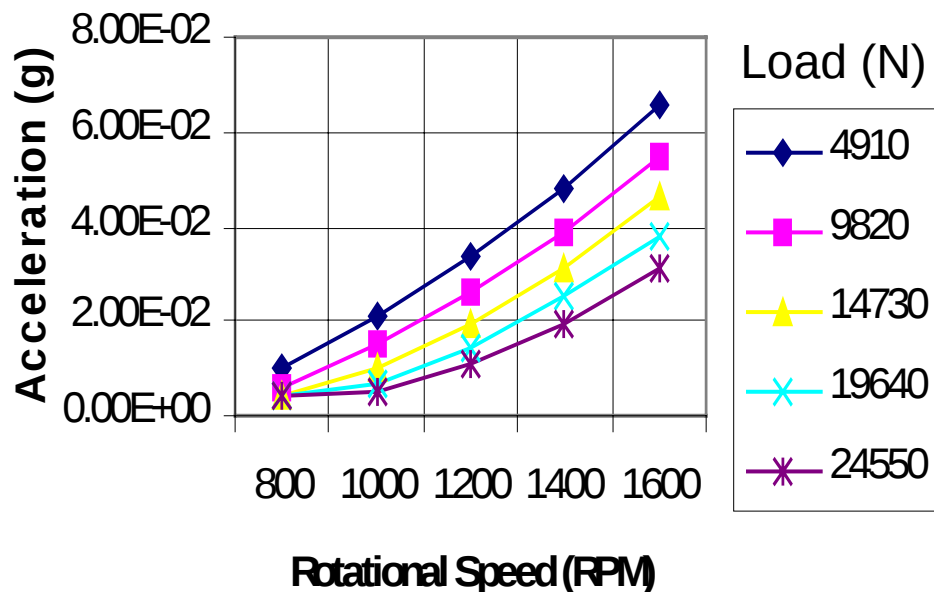
Comparing Instrumentation



- ❖ Comparing Instrumentation : TEK FFT Oscilloscope and Virtual Instrumentation

Speed-Load Effects (1)

Accelerometer Signals
Band-Passed RMS

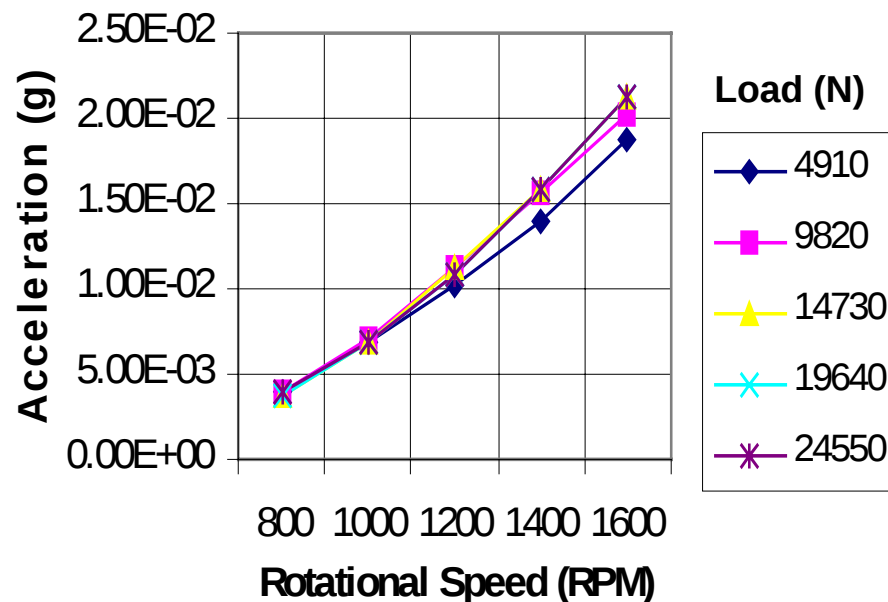


- ❖ Increasing Speed, Increases RMS
 - Linear Increase in number of Outer Race Impacts
 - Similar increase over all Loads
- ❖ Increasing Load, Decreasing RMS
 - Increasing Load Reduces Signal Levels of Statistical Indicators
 - ~50% Error in Diagnostic Metric

Accelerometer Positioned Directly Over the Bearing on the Housing

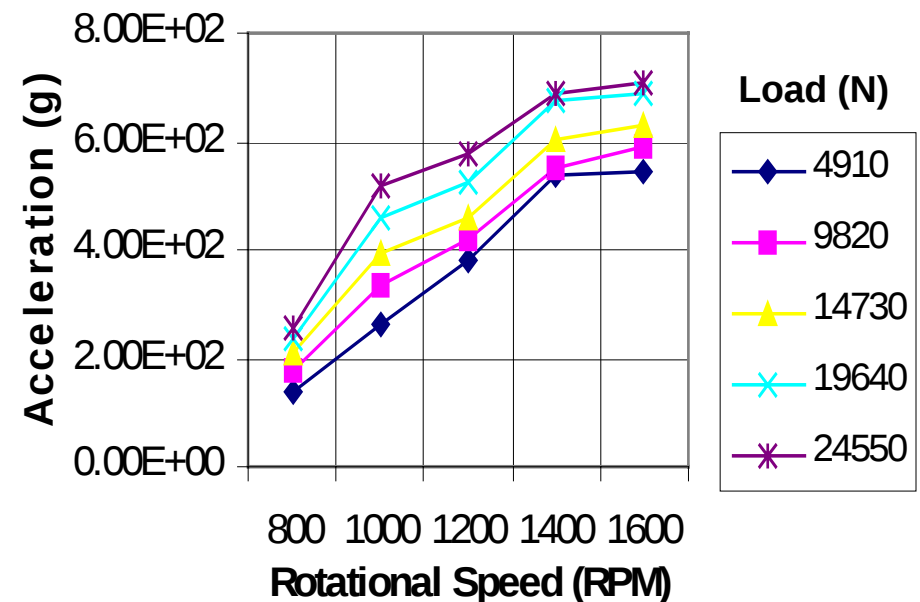
Speed-Load Effects (2)

Accelerometer Signals
Band Passed RMS



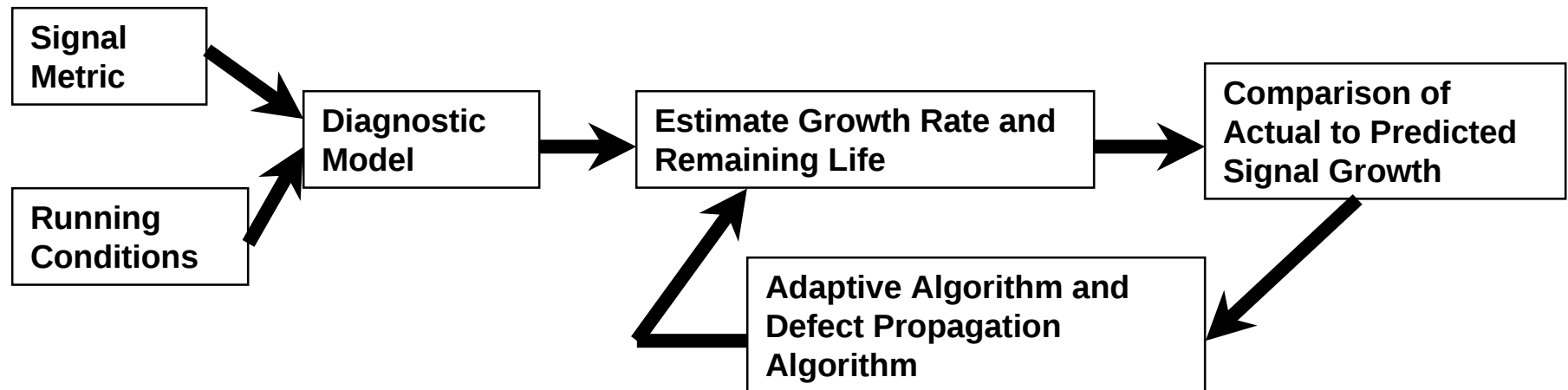
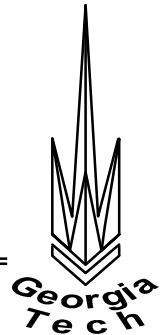
- ❖ Accelerometer Location In Unloaded Zone of Housing
- ❖ Relationship is Explained by Dynamic Model

Acoustic Emission
RMS



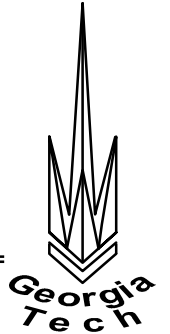
- ❖ Acoustic Emission Sensor Directly Over Bearing on Housing
- ❖ Contact-Area Sensitive

Adaptive Prognostics



- ❖ Estimates Damage Level with Diagnostic Model
- ❖ Estimates Bearing Damage Growth According to Signal Growth Rate

Conclusions



- ❖ Sensor Placement and Type Has Drastically Different Effects for Changes in Rotational Speed and Load
- ❖ Speed and Load Relationships can be Explained by Dynamic Models
- ❖ Signal Processing Techniques are Effected Differently by Speed and Load Changes
- ❖ Adaptive Prognostics are Calibrated on Signal Growth Rate