

## Predictive Maintenance for Blade Pitch Systems

The logo consists of a circular emblem with four stylized arrows pointing in a clockwise direction, set against a light background. To the right of the emblem, the text "MLS Electrosystem" is written in a bold, white, sans-serif font.

# MLS Electrosystem

- Focused on Electric Servo Pitch Control
- Experience with Servo Pitch Since 1996
- Joint Venture Founded in 2000
- Expanding Operations to Support Growth
  - Pittsburgh, PA
  - Seneca, PA
  - Houston, TX
  - Chicago, IL
  - Madrid, Spain



# Predictive Maintenance - Value

- Schedule Resources and Materials
- Maintenance at Favorable Times
- Avoid Surprise Down Time
- Maximize Service Life of Components

Predictions are difficult,  
especially about the future!

Yogi Berra



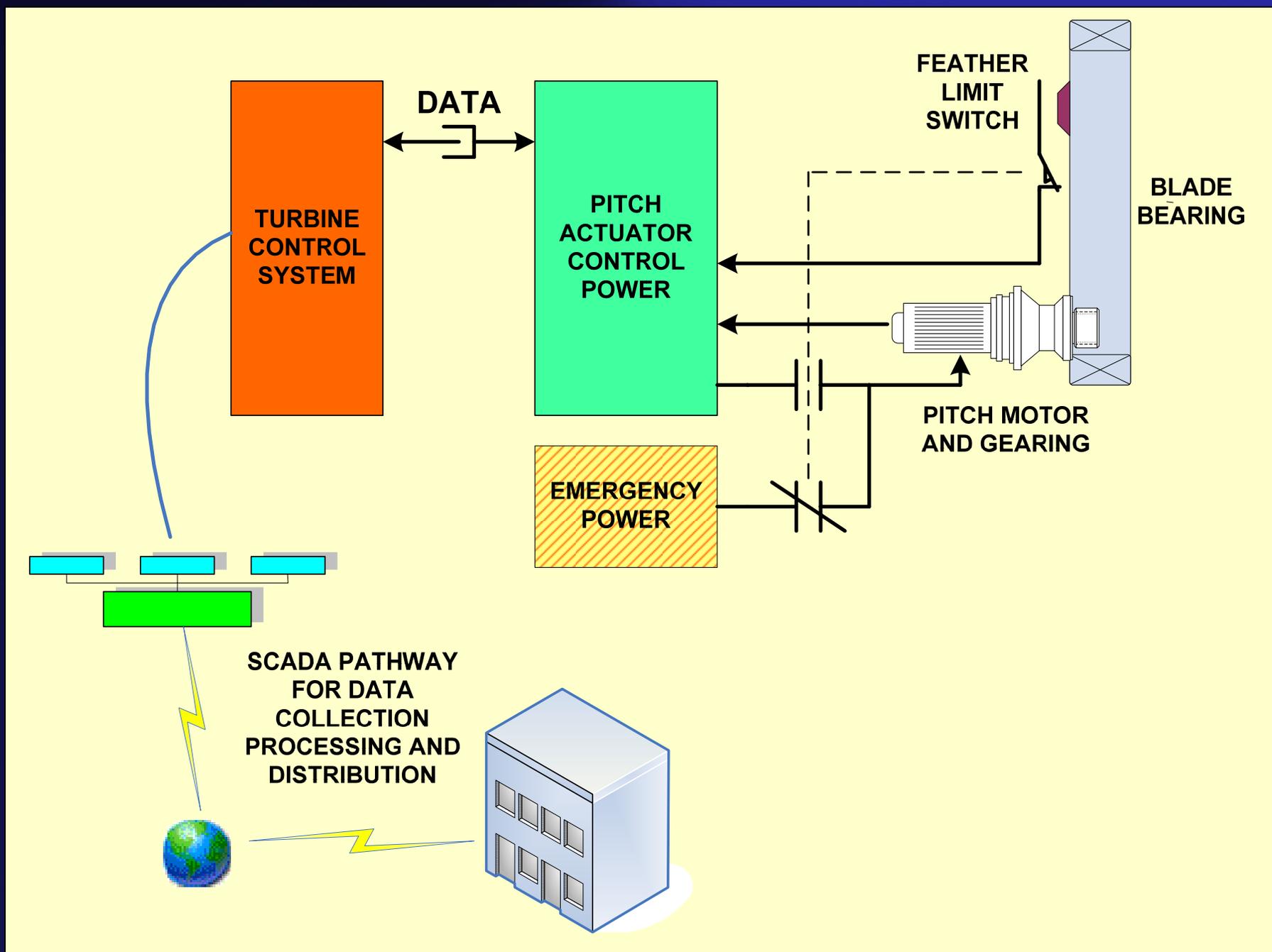
# Pitch Sub-System Basics

- Follows Blade Pitch Angle Demands from the Turbine Control System
- Provides Varying Degrees of Speed and Power Regulation
- Can Provide Load Mitigation
  - Tower
  - Drive Train
  - Blade Fatigue
- Can Provide Real-Time Blade Root and Other Load Data
- Part of Grid Loss Ride Through Strategy
- Is the Aerodynamic Brake to Stop the Turbine – Critical Safety Function



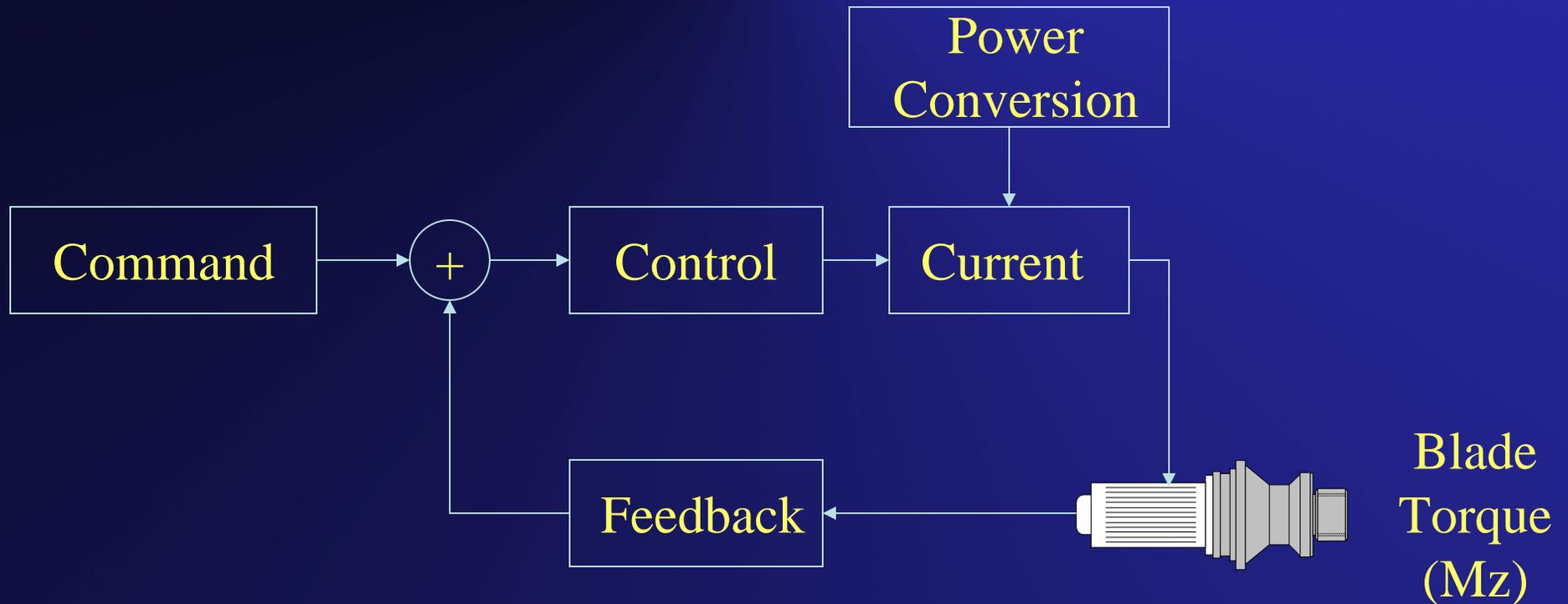


# Pitch Sub-System Basics





# Pitch Sub-System Basics



$$T = J\alpha + T_{dist}$$



# Predicting Maintenance

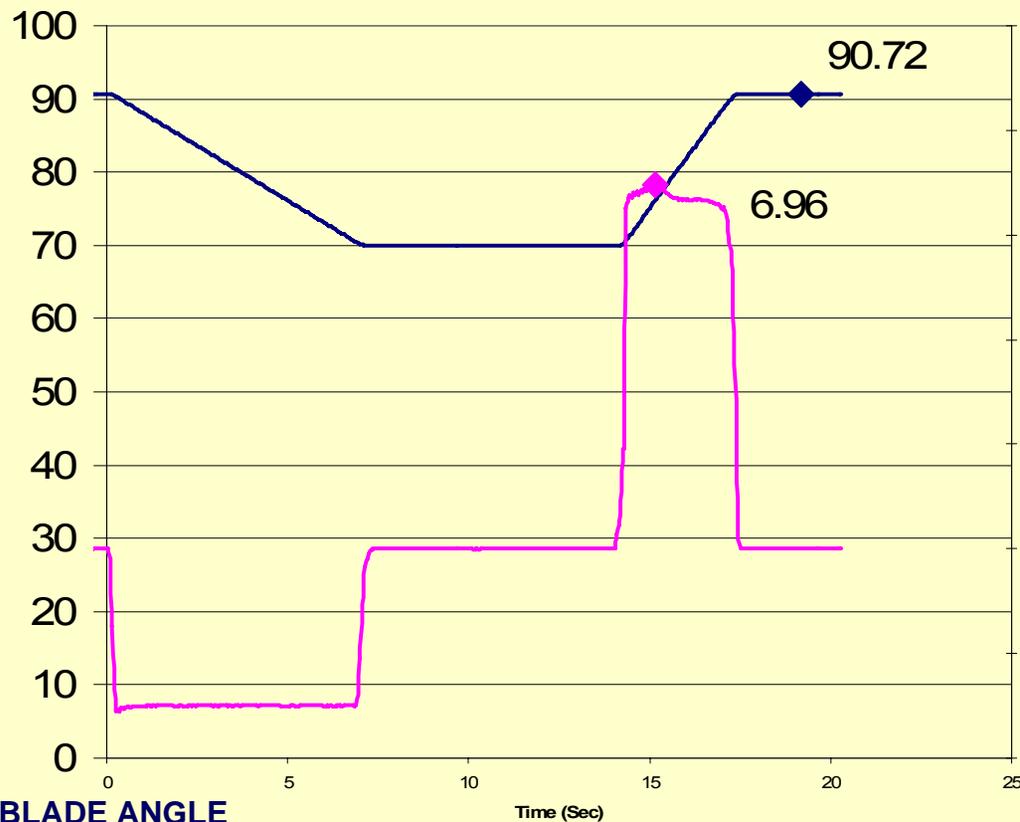
- Emergency Power – SLA Batteries
  - Useful Life 2 years? 5 Years? > 5 Years?
  - Aging Process In the Application
  - End of Life Indicator: Internal Impedance



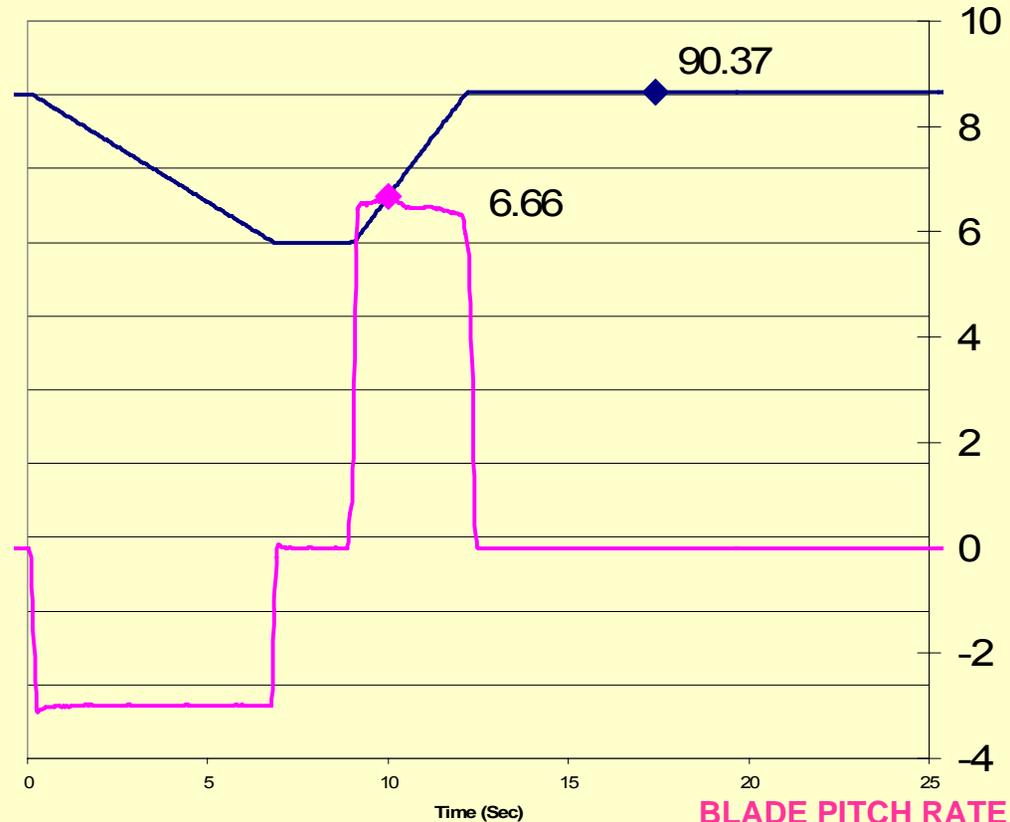
# Predicting Maintenance

- Emergency Power – SLA Batteries

EMERGENCY VELOCITY TEST A



EMERGENCY VELOCITY TEST B



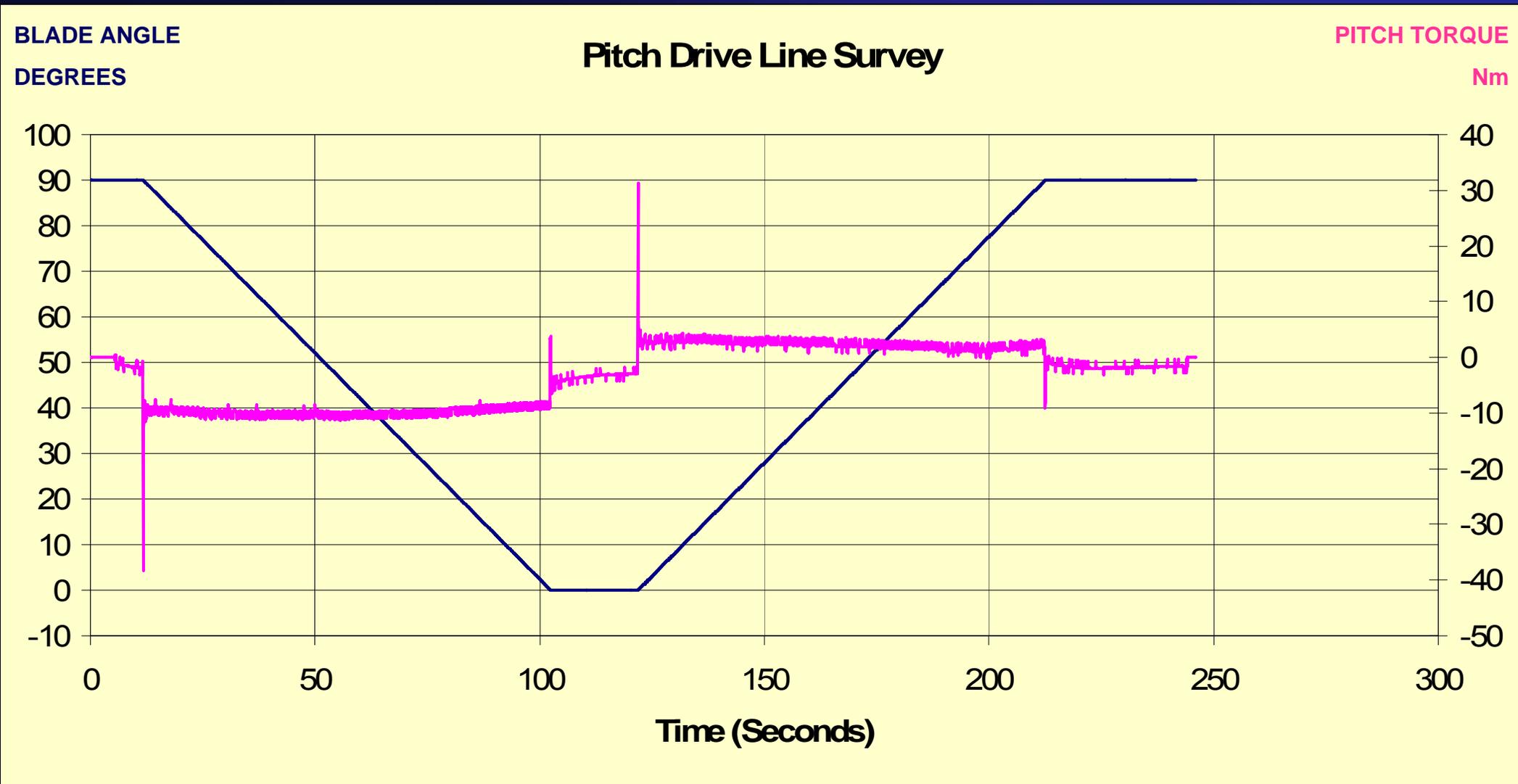
BLADE ANGLE  
DEGREES

BLADE PITCH RATE  
DEGREES/SEC



# Predicting Maintenance

- Pitch Drive Train Checking





# Predicting Maintenance

- Other Opportunities for Condition Monitoring or Prediction Analysis
  - Real-Time Pitch Torque
    - Mz RMS Loads
    - Mz Peak Loads
    - Mz Signal Analysis
  - Pitch Drive Train Backlash Checking
  - Comparison Basis for Mz Strain Measurements



# Predicting Maintenance

- Summary
  - Real-Time Data from Pitch System
  - Closed Loop Servo Control Measures Torque
  - Tests for Emergency Power Condition
  - Tests for Drive Train Condition
  - Other Opportunities