Health and Maintenance Through the Lens of Dynamic Scheduling

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The diagram illustrates the relationship between Failure Rate, Time, and various stages of machine degradation. It shows three phases:

1. **Decreasing Failure Rate**:
   - Early “Infant” Mortality Failure
   - Observed Failure Rate
   - Constant (Random) Failures

2. **Constant Failure Rate**
   - Wear Out Failures

3. **Increasing Failure Rate**

The diagram also highlights different maintenance strategies:

- **ALARM ANNUNCIATION**
- **MACHINE DEGRADATION**
- **MACHINE DOWN**
- **PREVENTATIVE MAINTENANCE**
- **MACHINE PROGNOSTICS**

This categorization helps in planning maintenance activities, from preventive to predictive, ensuring that maintenance actions are tailored to the specific phase of machine degradation.
CAPABILITY CENTRIC

- Machines have capabilities
- Capabilities degrade due to use
- Ex: Tooling, Motion, Tolerance, Torque, Enclosure, Coolant, Max Weight, ...
SCHEDULING

• Jobs are Sent to Machines when they have capability
• Maintain when the machine can not service the current job queue
MILLING MACHINE

• 1996 Okuma H-Mill
• 3 Axes of Motion X, Y, Z
• Spec’d to 0.0001”
• Actual 0.005
• Can’t Finish Parts
• Good for Roughing
BORING MILL

• 1995 Toshiba Horizontal Boring Mill
• 4 Axis of Motion X, Y, Z, B
• B Spec’d to 0.0001°
• B axis Rotation Doesn’t Repeat Accurately
• Not Capable of 4 Axis motion
• Still good 3 Axis
SELF-AWARE/INTELLIGENT DEVICES
PRESCRIPTIVE ANALYTICS

![Graph showing capability over time for processes 1, 2, and 3 with maintenance level marked as well.](image-url)