Use Crow-AMSAA Reliability Growth Plots To Forecast Future System Failures

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Reliability Is?

- Reliability is concerned with avoiding failures of equipment and processes by proper design and careful operation of the equipment by trained personnel in a specified environment for a given time interval.
- The ultimate aim of reliability is a failure free environment.

MIL-HDBK-338: Reliability- 1) The duration or probability of failure-free performance under stated conditions. 2) The probability that an item can perform its intended function for a specified interval under stated conditions.
Failures are?

- Failures terminate reliability.
- Is your organization:
  1) Reliability-focused (abhor failures)?
  or
  2) Repair-focused (accept repairs)?
- How do you prove your focus based on failure data from your plant?

**MIL-HDBK-338:** Failure- The event, or inoperable state, in which any item or part of an item does not, or would not, perform as previously specified.

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Treat Repairs As Failures

- Management views repairs as failures! Why? Repairs cost money and take equipment out of service
- Too many repairs occur from accelerated consumption of life due to errors from both omission and commission
- You cannot repair yourself to happiness — avoiding failures brings happiness
Most Organizations say…

- ~2 out of 3 say “I’m reliability-focused” but they demonstrate a repair-focus. They reward fast repairs. No rewards occur for failure avoidance.
- Only ~1 out of 3 demonstrate a reliability-focus
- Line slopes on Crow-AMSAA plots tell you are:
  - $\beta < 1 \rightarrow$ reliability-focus
  - $\beta > 1 \rightarrow$ repair-focus
- What do your facts show:
  1) reliability-focus?
  2) repair focus?
- Show me, don’t tell me, how you’re doing!

A Crow-AMSAA Plot Says…?

- Beta $> 1.0$, failures accelerate & reliability declines
- Beta $= 1.0$, no change in failures
- Beta $< 1.0$, failures decelerate & reliability grows

$N(t) = \lambda t^\beta$
How To Collect Your Data

- Go to SAP. Get monthly work orders for (emergence repairs + ordinary repairs). This is monthly/weekly/daily interval data.
- Convert interval data into cumulative time (for the X-axis) and cumulative repairs (for the Y-axis).
- Plot cum data on log-log paper. Trend line slope, $\beta$, gives clues as to what you are.

Failures: For managers, every maintenance order is a failure because of money spent!

5-1/2 Years Of Corporate Data

<table>
<thead>
<tr>
<th>Raw Data</th>
<th>Cum Days</th>
<th>Cum Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Orders</td>
<td></td>
</tr>
<tr>
<td>Jan 2001</td>
<td>444</td>
<td>31</td>
</tr>
<tr>
<td>Feb 2001</td>
<td>517</td>
<td>59</td>
</tr>
<tr>
<td>Mar 2001</td>
<td>749</td>
<td>90</td>
</tr>
<tr>
<td>Apr 2001</td>
<td>786</td>
<td>120</td>
</tr>
<tr>
<td>Jun 2006</td>
<td>1490</td>
<td>2007</td>
</tr>
<tr>
<td>Jul 2006</td>
<td>1408</td>
<td>2038</td>
</tr>
<tr>
<td>Aug 2006</td>
<td>1503</td>
<td>2069</td>
</tr>
</tbody>
</table>

- Plant sites have been stable during the interval—no big expansions, acquisitions, or closures.

Plot this data on a log-log plot. The line slope is very important.
Corporate View Of Repairs

A Repair Focused Organization

Cumulative Time (days)

Forecast of coming repairs!

$\beta = 1.2$

Corporate Data:
2049 days &
109,386 orders

Forecast of coming repairs!

$\beta = 1.2$

Corporate Data:
2049 days &
109,386 orders

Mean time between repair orders has recently stabilized at ~53 orders/day

$\alpha = 1 - \beta = -0.2$

Corporate Data:
2049 days &
109,386 orders

$\alpha = 1 - \beta = -0.2$

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2049 days &
109,386 orders

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2049 days &
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$\alpha = 1 - \beta = -0.2$

Corporate Data:
2049 days &
109,386 orders
72-inch Cooling Water Line

72-inch Water Line: Repair-Focus to Reliability-Focus

\[ \beta = 2.5 \]

Cum Repairs vs Cum Time (days)

Forecasted repairs before improvements

\[ \beta = 0.3 \] and improving every day!

Repair-focused with \( \beta = 2.5 \) changed to reliability-focused with \( \beta = 0.34 \)

Chemical Plant Safety Data

First Aid + Reportable Accidents + Lost Time Accidents

\[ \beta = 12.3 \]

Cum Safety Failures vs Cum Time (days)

Excellent Safety Improvement!

Injury accepting with \( \beta = 12.3 \) changed to injury prevention with \( \beta = 0.61 \)

Plant Opens 11/1/97

6/4/06

5/2/97

Forecasted Safety Events
Cum MTBF-Safety Data

Mean time between safety event is growing from a reliability-focus

Which Is More Important?

• Avoiding failures OR repairing failures?
  – You cannot repair yourself to happiness!

• Equipment OR processes/people?
  – Equipment = not as effective as working on Processes/Procedures/People = greater gains

• Trained operators OR maintainers?
  – Untrained operators and poor processes/procedures can break equipment faster than trained maintainers can make repairs
Maintenance Is?

- Maintenance is concerned with retaining function or quickly correcting failures, by use of trained employees using correct procedures.
- The ultimate aim of maintenance is minimizing maintenance costs and downtime to keep equipment operating as designed.

MIL-HDBK-338: Maintenance-All actions necessary for retaining an item in or restoring it to a specified condition.

Engineers Are---?

- **Reliability Engineers**-Strategic Assets
  – Dedicated to mainly preventing failures
- **Maintenance Engineers**-Tactical Assets
  – Dedicated to mainly correcting failures
- You need ~10 Maintenance Engineers to every 1 Reliability Engineer
  – No increase in plant head count

Need job descriptions?: [http://www.barringer1.com/jobdescriptions.htm](http://www.barringer1.com/jobdescriptions.htm)
### Business Is?

- **Business** is all about making money. This is a balance between avoiding failures, repairing failures, and keeping the process operating to make money.
- **In the end, reliability and maintenance are all about money.**
- The ultimate aim of business is satisfying customers with on-time deliveries of quality products while producing a satisfactory long-term return for stockholders.

### Get Organized

- Most managers talk about reliability but emphasize maintenance—they cross communicate!!
  - Get your organization right
  - Get your emphasis right—say the right things
  - Get your motivation right—what’s the reward?
  - Be consistent—no wishy-washy positions!
  - Work for long terms improvements
  - Work your Pareto list based on $’s—not nose counts of problems!!
  - Show your progress with Crow-AMSAA plots
Where To Improve

• Go for the **money**—not your love affair!
• Does the **system** need improvement?
• Does a **device/component** need improvement?
• Does a **process/procedure** need improvement?
• Do the **people** need improvement?
• What are your **alternatives**?—say it with money
• Correct the big $ problems by considering alternatives. Show how you’re doing with Crow-AMSSA plots.

Best Place For Gains?

• Improve **people performance**—~38% of problems
  – Make it easy for people to do right & hard to do wrong
• Improve **procedures and practices**—~34%
  – Write it down correctly and train, train, train
• Improve **hardware**—~28% of problems
  – Hardware problems may disappear if above corrected
• Engineers, by nature, think reliability issues are resolved with hardware and components and thus they often work on the wrong issues!
So You Doubt?

• Verify that people/procedures/process issues are at the heart of major problems by reading:

Summary

• Get your reliability program right
• Think about reliability issues strategically
• Look for gains first via people, second by processes and procedures, and last by way of components—many component issues disappear when people/processes/procedure issues are solved to achieve inherent component reliability!
• Show your organization how you’re doing with Crow-AMSAA plots: Show me, don’t tell me!
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- http://www.barringer1.com/nov02prb.htm
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