Reliability From A Service Provider’s Perspective
(Mark Adams, Senior Director: Reliability, Quality and Network Assets)
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For many equipment suppliers, life has been tough in telecom these past years!

• Equipment suppliers have faced many challenges (e.g.):
  – The infamous telecom bubble burst (starting 1997)
  – Mergers, acquisitions and bankruptcies
  – Legacy “bread and butter” products becoming obsolete & newer products not keeping up
  – Recession of 2008

• Many small & new international competitors are emerging in the U.S

Equipment supplier stability and performance is a concern:
• Some may not survive? What about our base?
• What is the impact of massive program, resource & cost cutting?
  – Will it impact their ability to support us?
  – What is the impact to proactive performance improvement programs?
• How will newer players perform over time?
Level Set: Service Provider Networks

• Customers expect high performance from us & have choices
• We spend a lot of time, energy and money to build and operate our networks to meet customer needs (e.g. availability):
  – Alternate power and redundant equipment to handle faults
  – Diversity: Re-routing of traffic to handle circuit faults (e.g. ring architecture & IP routing)
  – Extensive network management applications and large base of skilled operations resources

• We spend more money than we should to build and support our networks when supplier equipment reliability is not optimized:
  – Both equipment suppliers and service providers could benefit by use of reliability engineering principles to reduce reliability failures & life cycle costs
**Reliability** is the probability that an item can perform its intended function for a specified interval under stated conditions: \( R(t) = e^{-\frac{t}{MTBF}} \)

– *In a word, Reliability is Dependability.* Reliability Engineering and Design for Reliability is the discipline focused on making it happen.

**The “Bathtub Shaped” Failure Rate**

- Provides a useful construct for failure behavior within populations.

![Bathtub Shaped Failure Rate Diagram](image)

<table>
<thead>
<tr>
<th>Example Faults</th>
<th>Infant Mortality</th>
<th>Useful Life</th>
<th>Wear-out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor Design</td>
<td>Unanticipated Variation in Environment</td>
<td></td>
<td>Degradation</td>
</tr>
<tr>
<td>Poor Inspection and Quality</td>
<td>Unanticipated Variation in Application</td>
<td></td>
<td>Fatigue</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor Manufacturing Process</td>
<td>Unanticipated Variation in Materials</td>
<td></td>
<td>Corrosion</td>
</tr>
</tbody>
</table>

Some Content May be the Opinion of the Author and Not Necessarily Cox Communications
**Terminology - What is Availability?**

**Availability** is the proportion of time a system is in its operational state to perform its intended function.

**Availability** is affected by two key factors:
- The robustness of the design (mean time between failure - **MTBF**)
- The speed the repair crew can bring the product back online to provide the service (mean time to restore - **MTTR**)

\[
\text{Availability (\%)} = \left( \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}} \right) \times 100
\]

Let’s define service availability as performance from the end user perspective…Is the cable modem ready when the customer wants to connect to the Internet?
Some Basic Design Reliability Math...

• It's easy to do the math, if you have the right data for your population which is simply equipment installation and equipment failure date.

Reliability function $R(t)$
Probability an item survives up to some time, $t_1$:
- Equals one minus the unreliability
- In general, at time $t = 0$, $R(t) = 1$ and as time $t$ approaches infinity, $R(t)$ approaches 0.

\[
R(t) = 1 - F(t) = 1 - \int_0^t f(t) \, dt = \int_t^\infty f(t) \, dt
\]

• Key Finding: Many suppliers currently do not do this math or perform it inadequately or incorrectly.
Reliability is becoming more and more important to service providers:

Lower Reliability can impact:
- Customer satisfaction
- Revenue
- Life cycle costs
- Equipment and maintenance cost to maintain service
- Bottom Line Impact $$$

The balance in the market is shifting

In some segments, revenue growth is slowing – reliability can help maintain profitability

Competition is fierce:
- Customers have more choices
- Customers demand service performance
- Systems are becoming more complex
- Service provider Support costs are increasing
Example: Why is Reliability Important?

- Most service providers build networks to maintain high service availability.
- Therefore, reliability failures frequently do not result in customer impact.
- Reliability failures do increase cost and operational effort!!

Key: Maintain high availability but focus suppliers on DFR!!

![Availability and Reliability Plot](image)

- Reliability
- Cost of operation

Close the gap & reduce cost & improve operational efficiency.
What Should Providers Expect From Suppliers?

Demonstrate a formal senior leadership sponsored reliability policy and comprehensive program.

• Reliability practices must begin early in the design process:
  – They must be well integrated into the product development cycle
  – Use science based methods to design reliability into products/processes
  – Understand when, what and where to use the wide variety of reliability engineering tools available

• Reliability tracking and improvement must continue after the product is released and through to retirement:
  – Implement a failure reporting, analysis and corrective action system (FRACAS). Focus on continuous improvement
  – Implement an audit & compliance system to ensure goals are met
  – Feed results to your development process for continuous improvement

Expect Suppliers to agree to contractual R(t) targets
Steps to Reliability in Design

1. State goals
2. Define the product/functional operation with functional block diagrams
3. Use reliability block diagrams to describe the relationships of the various system elements (e.g. series, parallel, etc.).
4. Develop a reliability model of the system:
   – Collect/test part and subsystem reliability data (e.g. Halt)
   – Adjust data to fit the special operating conditions of your system
   – Predict reliability using a mathematical model
   – Assign reliability allocations to system and sub-systems
5. Verify, assess risk & improve designs using reliability tools (e.g.):
   – Fault Tree Analysis (FTA) and/or Failure Mode & Effects analysis (FMEA)
   – Stress factors and parameter diagrams (P-Diagrams)
   – Field data (if available)
   – Complete reliability growth and design changes to achieve/exceed goals

Observation: Many suppliers do not have adequate programs in-place!
How Can Service Providers Drive Reliability?

1. Implement an end to end supplier performance program
2. Use formal design for reliability in your new product development process
3. Implement an operational performance tracking system
4. Analyze information to identify and prioritize opportunities
5. Implement corrective and preventive action programs
6. Validate results and ensure accountability
Step 1: Supplier Performance Program

1) Select reliable suppliers and associated products:
   • Insert reliability criteria into the vendor/product selection process as a factor
   • Validate reliability claims as stated using DFR and process

2) Formalize supplier performance agreements:
   • Contractual agreement on key performance attributes (SLA)
   • $ Liquidated damages apply

3) Implement a performance program for your suppliers:
   • Regularly measure all elements of the relationship via a formal scorecard
   • Hold regular Vendor/Cox reviews
   • Implement action plans for areas of non-compliance
   • Governance and validation

### Q3 Performance Measures

<table>
<thead>
<tr>
<th>Weight</th>
<th>Focus Area</th>
<th>Curr. Quarter</th>
<th>Status</th>
<th>Weighted Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>Purchasing</td>
<td>40</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>20%</td>
<td>Software Quality</td>
<td>70</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>10%</td>
<td>Hardware Quality</td>
<td>80</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>30%</td>
<td>System Availability</td>
<td>100</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>10%</td>
<td>Technical Support</td>
<td>90</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>5%</td>
<td>Outage Restoration</td>
<td>90</td>
<td>5</td>
<td>5</td>
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<tr>
<td>15%</td>
<td>Problem Report Fix Response Time</td>
<td>60</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

**OVERALL Quarterly Score:** 79
Step 2: New Product/Service Process

Implement formal design for reliability tasks as part of your formal new product/service/integration development process:

- Set Reliability Goals (PD/PIM lead)
- Reliability Prediction (Eng)
- Reliability Testing (Eng)
- Reliability Modeling (Eng)
- Design Document (Eng)
- Field Data Collection (Net Ops)
- Field Data Analysis (Net Ops)
- Corrective Action (Eng)
- Feedback to Design (Net Ops)

1.0 Ideation

2.0 Concept

3.0 Requirements

4.0 Build

5.0 Test/Trial

6.0 Launch (Transition to Life Cycle)

- Business Requirements (PD/PIM Lead)
- Detail Business Case (PD/PIM lead)
- Reliability Allocations (Eng)
- Reliability Scorecard Set (Net Ops & Eng)
- Plan Life Testing (Eng)
- Risk Assessment (Eng)
- FMEA (Eng)
- Functional Requirements (Eng)
- Functional System Architectural & Service Requirements (Eng)
- Network Operations Requirements (Net Ops)
- Operations Support Model (PDPM Lead)
- Traceability Matrix (Eng)
- RFP (PDPM Lead)
- Reliability Evaluation (Eng)
- Reliability Scorecard (Eng)
- FMEA (Eng)
- Test Plan (Eng)
- Test Report (Eng)
- Verification Test Plan (Eng)
- Verification Test Report (Eng)
- Release Manifest (Eng)
- Sign-off Form (Eng)
- Engineering Deployment Plan (ENG)
Step 3: Measurement Systems

Implement comprehensive measurement systems that tracks all areas of performance:

• Supplier performance scorecards with a service level agreement compliance module @ supplier/product level:
  – Hardware return rates and true reliability measures
  – Software performance attributes
  – Service and support (time to answer, restore and resolve)

• A true reliability database to track devices (e.g.):
  – MTBF
  – Cumulative survival and failure rate functions
  – Reliability centered maintenance attributes

• Internal focused scorecards to track performance (e.g.):
  – Trouble call rates and associated measures (e.g. repeats)
  – Availability
  – Time to restore

• External scorecards published to key customers
Step 4-5-6: Analysis, Improvement & Compliance

- Analyze data and prioritize opportunities
- Implement improvement projects to address opportunities
- Implement a compliance tracking system:
  - Reviews
  - Audits
  - Accountability (e.g. vendor penalties, internal follow-up, etc.)
- Feedback mechanism to appropriate functions

Example: 7% of these nodes are causing 50% of the Alarms – why?

Table of Survival Probabilities

<table>
<thead>
<tr>
<th>Modulators</th>
<th>Probability</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPF &amp; OOA/OOS</td>
<td>95.0% Normal CI</td>
<td>0.932408</td>
<td>0.944624</td>
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<tr>
<td>Power Supply</td>
<td>3%</td>
<td>0.340865</td>
<td>0.416074</td>
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<tr>
<td>Diplex filters</td>
<td>1%</td>
<td>0.378523</td>
<td>0.416074</td>
</tr>
<tr>
<td>NE4726</td>
<td>3%</td>
<td>All others</td>
<td>51%</td>
</tr>
<tr>
<td>NE4715</td>
<td>10%</td>
<td>NE4878</td>
<td>5%</td>
</tr>
<tr>
<td>NE4822</td>
<td>7%</td>
<td>NE4705</td>
<td>4%</td>
</tr>
<tr>
<td>NE4708</td>
<td>4%</td>
<td>NE4720</td>
<td>4%</td>
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<tr>
<td>NE4713</td>
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<td>NE4787</td>
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</tr>
<tr>
<td>Capacitors</td>
<td>48%</td>
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<td>4%</td>
</tr>
<tr>
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<td>7%</td>
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<td>NE4708</td>
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<td>NE4708</td>
<td>3%</td>
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<td>Reverse Amp</td>
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<td>NPF &amp; OOA/OOS</td>
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<td>10%</td>
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<td>Other components</td>
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<td>10%</td>
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<td>3%</td>
<td>NE4726</td>
<td>3%</td>
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</tbody>
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Example: One hardware module is causing majority - why?

Example: Capacitor Overstress?
In Summary - How to Ensure Reliability

A Reliability Program: A Systematic Methodology:

1) Select Reliable Vendors
   - Use reliability as part of vendor/product selection criteria and validate claims
   - Establish contractual reliability targets/penalties

2) Design for Reliability
   - Allocate reliability goals for the solution
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3) Measurement Systems
   - Vendor scorecards with SLA compliance
   - Standard internal and external network/service performance scorecard
   - Need to track true reliability and cost performance (reliability Db module)

4) Opportunities
   - Use Reliability engineering and Quality analysis tools to identify issues
   - Prioritize issues and plan of attack

5) Improvement Plans
   - Vendor Actions
   - Internal/Ext. Actions
   - Reliability Actions
   - Use reliability & quality methods to drive continuous improvement (Six Sigma)

6) Compliance and Control
   - Validation
   - Validate performance and cost action plans for effectiveness
   - Feedback results to vendor performance, development and operational performance groups
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