Implementing RCM Based Maintenance in a Large, Diverse, International Conglomerate

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United Technologies Corporation (UTC)

UTC is a diversified company whose products include:

- **Carrier**: Heating and air conditioning
- **Hamilton Sundstrand**: Aerospace systems and industrial products
- **Otis**: Elevators and escalators
- **Pratt & Whitney**: Aircraft engines
- **Sikorsky**: Helicopters
- **UTC Fire & Security**: Fire & security systems
- **UTC Power**: Fuel cells

**Ranking**

- 20th largest U.S. manufacturer (2006 list, Industry Week)
- 43rd largest U.S. corporation (2006 list, Fortune)
- 55th largest publicly held manufacturer in the world (2006 list, Industry Week)
- 126th largest in the world (2006 Global 500 list, Fortune)
- Named ‘Most Admired’ aerospace and defense company (2001-2006 lists, Fortune)

**Current Employment**

- 215,000 employees (2006)
- 47th largest employer in the world (2006 Global 500 list, Fortune)

**Revenues**

- $47.8 billion (2006)

**Sales to U.S. Government**

- $6.4 billion (2006)

**Current Business Balance (Revenues)**

- Commercial & industrial 63%
- Commercial aerospace 21%
- Military aerospace & space 16%

**International Revenues**

- 60% of total revenues (2006)

**International Presence**

- Over 4,000 locations in approximately 62 countries; UTC does business in approximately 180 countries.

**Net Income**

- $3.7 billion or $3.71 per share (2006)
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Assets

$47 billion (as of Dec. 31, 2006)

Research & Development

$3.2 billion (2006)

UTC is committed to Achieving Competitive Excellence (ACE)

- ACE is our proprietary operating system to ensure world-class quality in our products and processes. With its relentless focus on increasing efficiency and reducing waste, ACE is integral to the company's performance model. Facilities worldwide are using the operating system to improve quality and customer satisfaction while lowering cost.

- ACE is built on three main elements:
  - A philosophy based on the teaching of the late Yuzuru Ito, the company's advisor on quality methodologies. This is institutionalized in Ito University, a weeklong training session run continuously at each business unit.
  - A system that helps the organization identify and solve problems, improve processes and assist with strategic thinking.
  - The competence, commitment and involvement of the entire organization.

- ACE is implemented on the micro level, with employees who are trained and empowered to implement the standard processes across the company. Through a rigorous, data-driven process assessed by internal auditors, employees and their organizations progress through the qualifying, bronze, silver and gold levels of ACE.

Ito University

This internal “university” is a one-week course that teaches UTC managers the fundamentals of improving the quality of UTC products, services and business processes. Ito University is a living tribute to the late Yuzuru Ito, UTC’s quality advisor, who led quality efforts for Japan's Matsushita Electric (known in the U.S. as Panasonic) for decades. He was one of the world's foremost experts on quality and UTC’s quality advisor from the late 1980s until his death in 2000. Ito University plays an integral role in UTC's drive to create the most educated workforce on the planet. These training sessions allow employees to pursue continuous education in areas that affect UTC's performance. Ito University, along with UTC's Employee Scholar Program and our executive education program at the Darden School of Business at the University of Virginia, is another example of the importance we place on personal development for all employees.

Factory Team Organization

The ‘Factory Team’ is a cross-divisional organization focused on non-product commodities. It is based on leveraging spend through corporate agreements, sharing best practices and general problem-solving with representation and leadership support which is also cross-divisional in all aspects. From top to bottom, there is an Executive Council, an Advisory Council, Global General Procurement Services, and 14 specific teams, each of which has a divisional leader and champion. It is these teams where the ideas are generated, shared, and implemented, resulting in consistency and cost savings for the corporation.

The Journey to Implementing Reliability Centered Maintenance

It became evident during the regular meetings of the ‘Factory Maintenance’ teams that there was opportunity to improve the way and consistency by which we approached maintenance at UTC. Surely sharing best practices and specific project related work was having great value, but we needed to do more. Every division, without exception were doing great things, but we were not leveraging these to the level we should, to reach greater benefit. Several members were familiar with Reliability Centered Maintenance (RCM), but many of us had differing definitions of this. It was felt that RCM would be a good vehicle to bring all the good things we were already doing together, and take it to the next level. Thus, the ‘journey’ began.
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Additionally, ‘Reliability’ seemed like such a natural fit to many UTC initiatives, in addition to ‘maintenance’. UTC is very focused on safety, environmental, quality, productivity, and cost to name a few. RCM aligns with these very well, as with many of the key elements of our ACE culture (root cause, mistake proofing, standard work, TPM, process certification, etc.)

With UTC having engaged the services of Management Resources Group (MRG) on varying projects over the past seven years, we chose MRG to assist us in raising the awareness and benefits of a successfully implemented RCM program. Here is a list of some of the activities we have either completed or are presently engaged in:

- Business Case Workshops
- Gap Analysis & Implementation Planning for selected business units
- Divisional site visits and assessments
- RCM for Pratt & Whitney Power House and Co-Generation Plant
- ‘Reliability Game’ delivered to representatives from most divisions
- Site specific RCM / MRG overviews and awareness sessions
- Full RCM engagement by Pratt & Whitney Rocketdyne / De Soto, CA
- Funding approved to investigate content, development costs, an acceptance of a UTC Maintenance & Reliability Guidebook

Early Days of Reliability at UTC

One of the first things we did was to visit a considerable number of sites to informally observe and discuss current maintenance and reliability practices within UTC. One of the things that became evident very early on in our efforts was that the maintenance practices across UTC were very consistent. This is not to say that they were proactive...just consistent. What this also told us is that if we can establish clear definitions of what best practices are and help the organization determine what they want to look like from a maintenance and reliability standpoint and also prove the value of these practices, then we would stand a pretty good chance that these practices would be readily adopted across the enterprise.

After these visits we developed a succinct summary of the existing practices at UTC.

- Low tech maintenance practices on high-tech equipment making high tech/reliable products. There was very little use of things like Predictive Technologies, RCM/FMEA to establish reliability strategies and RCFA.
- Out dated maintenance and material management activities supporting highly coordinated production practices. Our production practices for planning and scheduling and materials management are top notch...but we didn’t apply the same level of rigor and discipline to our maintenance process.
- Calendar Based PM driven organization. Very little focus on condition based repair activities. Most of our work is time driven in handy breakdown of periods like weekly, monthly, annually. We have large PM programs that are often not current and optimized.
- Minimal Use of Predictive Tools. PdM application is limited to a few high profile pieces of equipment. PdM is looked at as an added cost and a protective tool as opposed to a robust problem identification method.
- Reactive vs Proactive. Even with our large PM programs...we were experiencing extensive “unforeseen” breakdowns...often resulting in catastrophic failures. If there was a problem our teams were very good at dropping everything to fix the problem.
- Lack of Fully Integrated Reliability Process. Operations and Maintenance were not always on the same page...Scheduling processes are not integrated.
Lack of Corporate Reliability Standards and Expectations. Lean maintenance is a term that is often used but when you ask someone what it is you get many different answers. Reliability is expected but we have not clearly defined exactly what we expect from the whole organization (not just maintenance) in the way of culture, practices and performance. Reliability is not specifically addressed in the ACE initiative.

“On Call” maintenance culture driven by operations. “Ops” is definitely in the driver’s seat and is a significant contributor to the reactive culture. Quite often a clear “just fix it” attitude exists. Planned downtime is often denied at the last minute for production needs due to previous failures or equipment issues often creating a death spiral.

Now this may seem to be a rather dim view but of course there are many good things in place such as a robust TPM program that gets a lot of visibility as part of the ACE initiative. The company has been experiencing record profits even with the issue we have so they are willing to make improvements. There is a culture of continuous improvement throughout the organization.

**Future Vision**

As you might expect...we also created a simply stated future state view of Reliability at UTC. This would be used to help paint the picture of where we wanted to go for the organization.

- Lower maintenance spend with improved asset reliability
- Asset condition-driven reliability
- All maintenance actions are based on understanding, in detail, the condition of the equipment
- Extensive use of predictive tools
- Well-planned proactive maintenance activities (labor & material)
- Well-coordinated proactive maintenance activities (maintenance & ops integration)
- Reliability generates productivity improvement
- Technology and data driven maintenance – RCM, PdM CBM, PM
- Culture – data driven, proactive, planned & scheduled maintenance fully integrated with operations – shared ownership
- Manage our maintenance like we manage our production
- Reliability is viewed as part of the culture such as Safety, ACE, EH&S

**Challenges and Enablers**

As you may surmise, just having a vision doesn’t ensure it will be achieved. There are a number of challenges associated with a company like UTC. The biggest challenge is changing the culture. Some of the things impacting the ability to change the culture are:

- **Size**: The most obvious one is the sheer size of the organization. Our plants are large, our divisions are large companies in themselves. We make a wide range of diverse products utilizing a wide range of equipment.
- **Constant Change**: Blink and then names change at least in the leadership ranks. Lots of movement and promotion so it’s touch to get consistent sponsorship. We had one project lose all momentum because the sponsoring ops and maintenance leaders got new jobs in the middle of the assessment.
- **Corporate Reliability Knowledge**: There is a wide range of understanding of what proactive reliability practices really look like. Even within the leadership level, there’s plenty of support but in reality the leaders don’t fully understand what they are really “signing up” for.
- **Short Term Focus on Improvements**: We have extensive cost cutting initiatives in place and a smaller number of long term improvement initiatives. It will be a challenge to get the organization to understand that major savings are possible but that they won’t occur overnight.
At the same time UTC has a number of things that are only found in a large organization that are significant enablers to help the organization shift to a Strategic Reliability Vision.

- **Steering and Leadership Committees:** There are a number of committees consisting of high level leaders throughout the company. Gaining approval for RCM based maintenance from these committees increases our chances of being successful and ensuring the initiative, if supported, has visibility at the highest levels.

- **Standard Methodologies and Processes:** UTC is a standards based company and once a standard is established we are very good at moving the whole organization to that standard. If we can successfully establish an official standard for maintenance and reliability practices we stand a very good chance of being successful.

- **Integrating With Other Initiatives:** The good news is that it is a relatively easy sell to show how RCM based maintenance supports almost all of the major initiatives underway at UTC such as ACE, EH&S, Quality, Lean and Supply Chain. This link is crucial to gaining support of the organization. If we can show how these improvements also accelerate other measured initiatives we stand a better chance at being successful.

The expected long range benefits for RCM Based Maintenance includes: High level performance at a global level, consistency of performance across the enterprise, a stable production platform and cost control.

**The First Integrated Implementation**

Over the last couple of years we have focused on awareness training, identifying and completing pilot implementations and determining and validating the business case for improvement. We are currently engaged in our first full Integrated Implementation. One of the Rocketdyne sites, which is part of Pratt & Whitney, was selected for this pilot. The first step in the implementation process was to introduce best practices to the organization. This follows the implementation sequence outlined in the presentation slides. In addition, we assessed the then current condition against the best practices and developed an implementation plan and business case for implementation. As a result of this process an implementation plan was developed that included:

- **Foundational Elements:** Master Equipment List, Master Inventory Data and Criticality Ranking
- **Technical Elements:** PdM Baseline, RCM, FMEA, PM Development, PDM Implementation and RCFA
- **Process Improvement:** Work Management, Inventory Management, Reliability Engineering, Management of Change and SAP Utilization
- **Reliability Awareness:** Reliability Game, Planning & Scheduling Training, PdM Awareness, Reliability Strategy Development Training and Mentoring
The presentation slides describe the elements of the implementation in detail and for the sake of brevity in this paper suffice it to say that this implementation touches the whole organization and has the full approval and involvement of the plant leadership. The implementation model is depicted below in Figure 1.

![UTC RCM Based Implementation Sequence](image)

**Figure 1 — UTC RCM Based Implementation Sequence.**

**The Business Case**

The business case for the Rocketdyne Implementation is very compelling. Here is some of the business case information:

**Baseline Performance**

- Replacement Asset Value = $300,000,000
- Annual Maintenance Spend = $10,300,000 (3.4% RAV)
- Inventory Value = $2,000,000 (<1% of RAV)
- Annual Energy Costs $4,713,000
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Targeted Budgetary Improvement

<table>
<thead>
<tr>
<th>Benefit Area</th>
<th>Target Improvement</th>
<th>Business Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance Overtime Reduction</td>
<td>PM Optimization, PdM Implementation, Work Management</td>
<td>$ 745,200</td>
</tr>
<tr>
<td>Operations Overtime Reduction</td>
<td>Improved Availability and Asset Performance, Integrated Scheduling</td>
<td>$ 200,000</td>
</tr>
<tr>
<td>Material Usage Reduction</td>
<td>Proactive Maintenance Strategies, Asset Health Management and Work Management Practices</td>
<td>$ 360,000</td>
</tr>
<tr>
<td>Inventory Carrying Cost Reduction</td>
<td>Optimized Inventory due to inventory standardization, RCM/FMEA Reliability Strategies, PM &amp; PdM Implementation</td>
<td>$ 162,000</td>
</tr>
</tbody>
</table>

$ 1,467,200

Long Term Potential Benefits

Total Implementation Costs Estimated at $1.95M.

<table>
<thead>
<tr>
<th>Component of Potential Benefit</th>
<th>Move Up One Quartile</th>
<th>Move to Top Quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced Maintenance Expenditures</td>
<td>42%</td>
<td>42%</td>
</tr>
<tr>
<td>Reduced Inventory Carrying Costs</td>
<td>40.0%</td>
<td>85%</td>
</tr>
<tr>
<td>Energy Cost Reduction</td>
<td>3.0%</td>
<td>14.2%</td>
</tr>
<tr>
<td>Reduced Scrap</td>
<td>04%</td>
<td>0.9%</td>
</tr>
<tr>
<td>One Time Inventory Reduction (20% on the dollar)</td>
<td>8.0%</td>
<td>17.0%</td>
</tr>
</tbody>
</table>

Implementation Duration = 1 year
Project 7 Year ROI = 5.2 to 1
Rate of Return = < 2 years
**Additional Benefits**

- The ability to support a significant increase in production capacity requirements targeted to hit in 2008
- The ability to defer or eliminate hiring of additional maintenance personnel
- Reduced Mean-Time-To-Repair (MTTR) and Mean-Time-Between-Failure (MTBF)

**Next Steps for UTC**

The next steps for UTC include:

1. The completion of the pilot implementation and tracking & validation of the targeted benefits at Rocketdyne.
2. The development and roll-out of a maintenance and reliability “Standards Manual”. This manual will create the approved/required maintenance and reliability practices and methodologies for UTC.
3. Organizational Development – We need to establish a working team structure to help support the corporate wide roll out of RCM based maintenance.
4. Identify and begin a second pilot implementation
5. Validate and refine the implementation model for use across the global organization / enterprise.
6. Continued reliability training and awareness sessions to help “market” and “sell” the initiative.