LEADING IMPROVEMENT ACROSS A COMPLEX AEROSPACE ENTERPRISE

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Presentation Contents

Key components which drive enterprise improvement
Essential tools for business improvement
Typical business improvement metrics
Improvement as a process rather than an end state
Rolls-Royce Corporation

- Founded in 1915 by James Allison
- Produced over 110,000 engines powering P38, P-51, A7, OH-6, OH-58, C-130, C-2, P-3, E-2, ERJ145, V-22
- First true multi-application engine, the AE Family: Fan, Propeller, and Shaft Driven
- Over 50 regional airline systems and hundreds of corporate operators in five continents
- Approximately 30,000 engines currently in service for civil, military, helicopter, energy, and naval applications
- Acquired by Rolls-Royce plc in 1995
Rolls-Royce Corporation
Key Statistics - 2004

4 Business Sectors
  (Civil Aerospace, Defense, Energy, Marine)
3 Major Product Families (AE, T56/501, 250)
2 Engines/day
$1M Spares/day
4,400 People, including 1950 UAW members
3,000,000 Sq. Ft. Active Floor Space
2,700 Active Machine Tools
7,000 Active Part Numbers
$1.5B Annual Sales
$250M Rolls-Royce Plant Improvement
4 Years Into Lean Journey
Rolls-Royce Stakeholders

- 1000’s of users and maintainers
- 100’s of buying customers
- 10’s of partners
- 4400 employees
- 300 suppliers
- Federal, state, and local governments
- 1000’s of shareholders
- Rolls-Royce plc leadership
- United Autoworkers Union
- Community neighbors
Improvement That Flows to the Bottom Line Requires

• Vision
• Focus on Customers and Employees
• Active Leadership Involvement and Alignment with Workforce
• Willingness to Break Established Paradigms
• Hierarchy of Trained, Empowered, and Incentivized Employees
• Constancy of Improvement Activity
• Celebrate and Reward Success
Rolls-Royce Corporation Vision

• Trusted to Deliver Excellence
  – As determined by customer satisfaction
  – And measured by a few understandable metrics
  – Supported by a workforce trained and empowered to deliver improvement
  – Across the entire business
Leadership From the Top

• Motorola - John Galvin
• GE - Jack Welsh
• Allied-Signal - Larry Bossidy
• Rockwell Collins – Clay Jones
• Southwest Airlines – Herb Kelleher
• Nucor Steel – Ken Iverson
Knowledge is Required to Deliver

• Capable, world-class processes
  and
• Streamlined, value-adding activity
Hierarchy of Knowledge

• Team and Leadership Skills

• Knowledge-based “Belts” - Yellow, Green, Black – in lean and six sigma

• Certified Mastery - ASQ

• Sensei - e.g. Mr. Ito at Pratt & Whitney
Essential Tools for Business Improvement

Define
- Charter
- Customer needs, requirements
- High-level process map

Measure
- Process flow map
- Data acquisition plan
- Plan implementation

Analyze
- Data analysis
- Process analysis
- Root cause analysis

Improve
- Solution generation
- Solution selection
- Solution implementation

Control
- Control methods
- Response plan
Essential Tools for Business Improvement

• Define
  – High level process map
  – Stakeholder values
  – Problem definition
  – Improvement goals
  – Metrics

• Measure
  – Process analysis
  – Probability and statistics
  – Data collection and analysis
  – Measurement systems
  – Process capability
Essential Tools for Business Improvement

• Analyze
  – Data analysis
  – Hypothesis testing
  – Lean concepts and tools
  – Quality function deployment
  – Fault tolerant design
  – Failure mode and effects analysis
  – Design for X

• Improve
  – Non-value added elimination
  – Kaizen
  – Design of Experiments
  – Taguchi methods
Essential Tools for Business Improvement

• Control
  – Statistical process control
  – Poka-yoke
  – 5S
  – Visual factory
  – Andon
  – Kanban
  – Muda
  – Total productive maintenance
Rolls-Royce Metrics Focus on Stakeholder Issues

• On-time delivery
• Delivered product quality
• First pass test yields
• Past due receivables
• Return on Invested Capital
Lean Initiatives at Rolls-Royce

Initial Factory Kaizen Activities
  PIF & PIL Training
  Supplier Quality Initiatives
  Single Process Initiatives
  Flow Line
  Cash Collection Team
  Supply Chain Restructuring

Systematic incremental Activity
First Year Actions

- Mobilized leadership team
- Agreed on vision
- Set priorities
- Established metrics
- Reassigned key leaders
- Streamlined process flows
- Focused on attributes data
- Invested to remove bottlenecks
First Year Results

- Significantly improved on-time delivery
- Step improvement in delivered product quality
- Increased 1st pass test yields by 4%
- Reduced cost of nonconformance by 3%
- Eliminated 500 obsolete machine tools
- Halved overage government contracts
- Eliminated 25% of chart of accounts
- Contributed significant profit and cash to Rolls-Royce plc
- Earned significant incentive compensation for all employees
Second Year Actions

• Reaffirmed prior year priorities
• Initiated cash collection team
• Began assembly flow line
• Hired third party parts supplier
• Began training workforce in lean, continuous improvement
• Increased working with suppliers
Second Year Results

- On-time delivery approached acceptable levels
- A second stepwise improvement in delivered product quality
- Reduced cost of non-conformance by 10%
- Eliminated overage government contracts
- Reduced delinquent receivables by 50%
- Initiated formal customer satisfaction measurement across business
- Delivered record profit and cash to Rolls-Royce plc
- Earned incentive compensation for all employees
Third Year Actions

• Fine tuned priorities
• Multi-skill training for 50% of shop floor employees
• Completed assembly flow line
• Razed 800,000 sq ft of obsolete facilities
• Began third party logistics efforts
• Trained transactional (office) black belts
Third Year Results

- Significant volume reduction post 9/11
- On-time delivery and delivered product quality stalled
- Cost of non-quality reduced by 18%
- Customer satisfaction index improved by 2%
- Halved engine assembly cycle time
- Achieved world class cash collection results
- Delivered significant profit and cash to Rolls-Royce plc
- Earned significant incentive compensation for all employees
Fourth Year Actions

• Increased emphasis on quality
• Completed shop floor multi-skill training
• Began third party logistics implementation
• Completed majority of factory renovation
• Changed COO but not vision
Fourth Year Results

- On-time deliveries improved
- Delivered product quality and cost of non-quality static
- Customer satisfaction improved
- Profit and cash generation ahead of targets
- Earned significant incentive compensation for all employees
Fifth Year Actions

• Negotiated breakthrough contract with UAW
  – But this distracted leadership from many components of enterprise business improvement

• Leadership team changes – planned and unplanned
  – Loss of momentum in key areas of Operations, Manufacturing and Quality
Fifth Year Results

• Implemented new labor contract which increases competitiveness within aerospace industry
• Sustained improvements in business metrics and customer satisfaction with new leadership team
• Awarded multi-billion contract for Joint Strike Fighter
• Earned incentive compensation for all employees
Other Beneficial Results

- Active Charge Numbers from 22,930 to 6,593
- Monthly Aircraft on Ground Claims from 701 to 153
- Open Material Review Board Folders from 390 to 195
- Monthly Financial Report Pages from 630 to 120
- SAP Exception Messages from 18,000 to <6,000
- Part Numbers in SAP from 42,087 to 25,390
- Cost centers from 544 to 442
- Eliminated over 500 procedures by adopting Rolls-Royce Quality Management System
- Reduced accounts payable transactions from 80,000 to 50,000 per year
## More Beneficial Results – A 5-year Journey

### Inputs
- Annual employee training increased 10%
- Transitioned to a multi-skilled hourly workforce
- Modernized over 50% of facility
- Employees empowered to earn significant incentive compensation

### Outputs
- Cycle times reduced by >2/3
- Inventory turns improved 40%
- Cost of non-quality halved
- On-time deliveries reach benchmark levels
- Customer satisfaction improved 50%
Benefits to Rolls-Royce

• Eliminated chronic customer dissatisfaction
• Reversed pattern of mediocre financial performance and generated record cash and profit
• Secured future lines of business
• Contributed several “best practices” which have been deployed world-wide
Barriers to Change

- Underground resistance
- Skepticism
- “Just another initiative”
- “It will pass”
- Upsets the status quo
- Takes people out of their comfort zone
Breaking Down the Barriers

• Define the “burning platform”

• Work to obtain buy-in from key stakeholders

• Communicate, communicate, communicate

• Dispatch the resistance

• Reward results
Robust Repeatable Processes Are Key to Sustained Excellence

• At Rolls-Royce these included:
  – Standardized design tools
  – Lean manufacturing techniques
  – Supplier partnerships
  – Kaizen throughout the company
  – Respect for all employees
Since 2004 ..

• On-time delivery ✓
• Delivered product quality ✓
• First pass test yields ✓
• Past due receivables - Financial Data not Reported Separately
• Return on Invested Capital - Financial Data not Reported Separately
Embraer ERJ Family

- Over 1100 built (1000 in service as of Aug 2010)
- 30M engine hours
- No material related crashes or fatalities (as of June 2010)
Legacy 600 and 650 Business Jet

- 200 Legacy 600’s in operation as of 6/2011
- First Legacy 650 delivered 12/2010
- Least expensive bizjet with comparable cabin volume and 3800 nmi nonstop range

218 C-130J’s Delivered – 66 on Order (>1100 engines)

- Current and Future Operators Shown in Blue


RQ-4A Global Hawk

- Over 1500 combat sorties and 30,000 combat hours (as of Feb. 2010)
- Deployed around the globe

Osprey Engines Feature Power by the Hour™

- Guaranteed hourly operating cost provides value to users and incentive to Rolls-Royce to maximize reliability and availability
- First use on military aircraft program
- 112 in service as of May 2010

Model 300 Engine Powers Robinson R66 Helicopter

- The Model 300 features a simplified single-stage centrifugal compressor that, along with a lower acquisition cost, is expected to result in lower maintenance costs
C-27J (aka Joint Cargo Aircraft)

- 34 delivered to 8 countries, 10,000 flight hours as of fall 2010
- 45 on order including 21 for US Army and US Air Force

Customers Expect Affordable Cost, Product Quality, and Timely Delivery

• Rolls-Royce Corporation’s Lean Journey has contributed to:
  – Improved customer satisfaction (Embraer, US Govt, Lockheed, Northrop Grumman, Bell/Boeing)
  – Increased orders (C-130J, Global Hawk)
  – New Products (Model 300 and Model 500)
  – New Customers (Robinson Helicopters)
  – More credible partnerships (GE, P&W)
Concluding Observations

• Improvement is a journey – not a destination
• Business conditions will change along the way
• Constancy of leadership intent is key
• The better you get – the more there is to do
16.660J / ESD.62J / 16.853 Introduction to Lean Six Sigma Methods
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