

LEADING IMPROVEMENT ACROSS A COMPLEX AEROSPACE ENTERPRISE

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Corporation 2001-2004

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

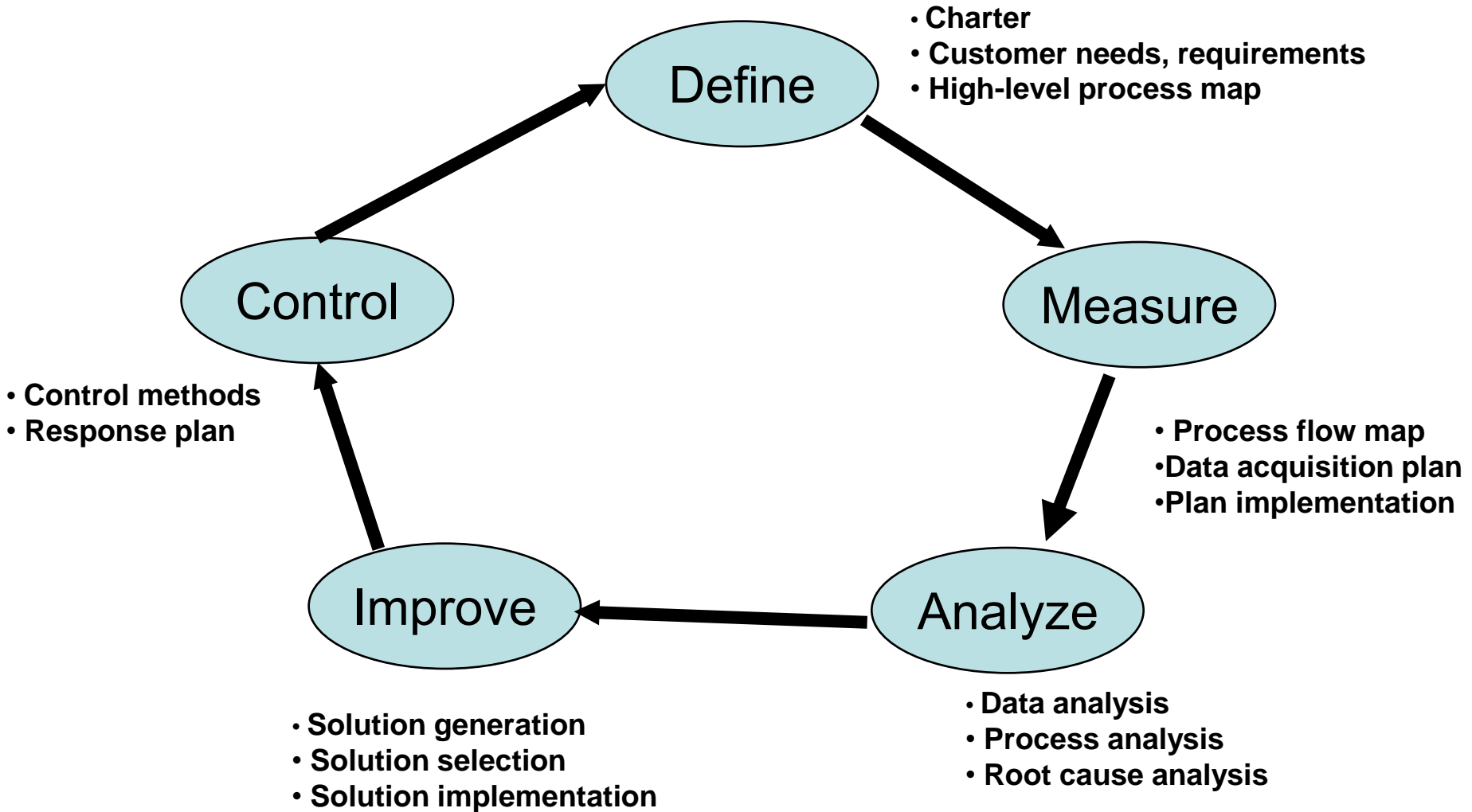
Knowledge is Required to Deliver

- 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



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

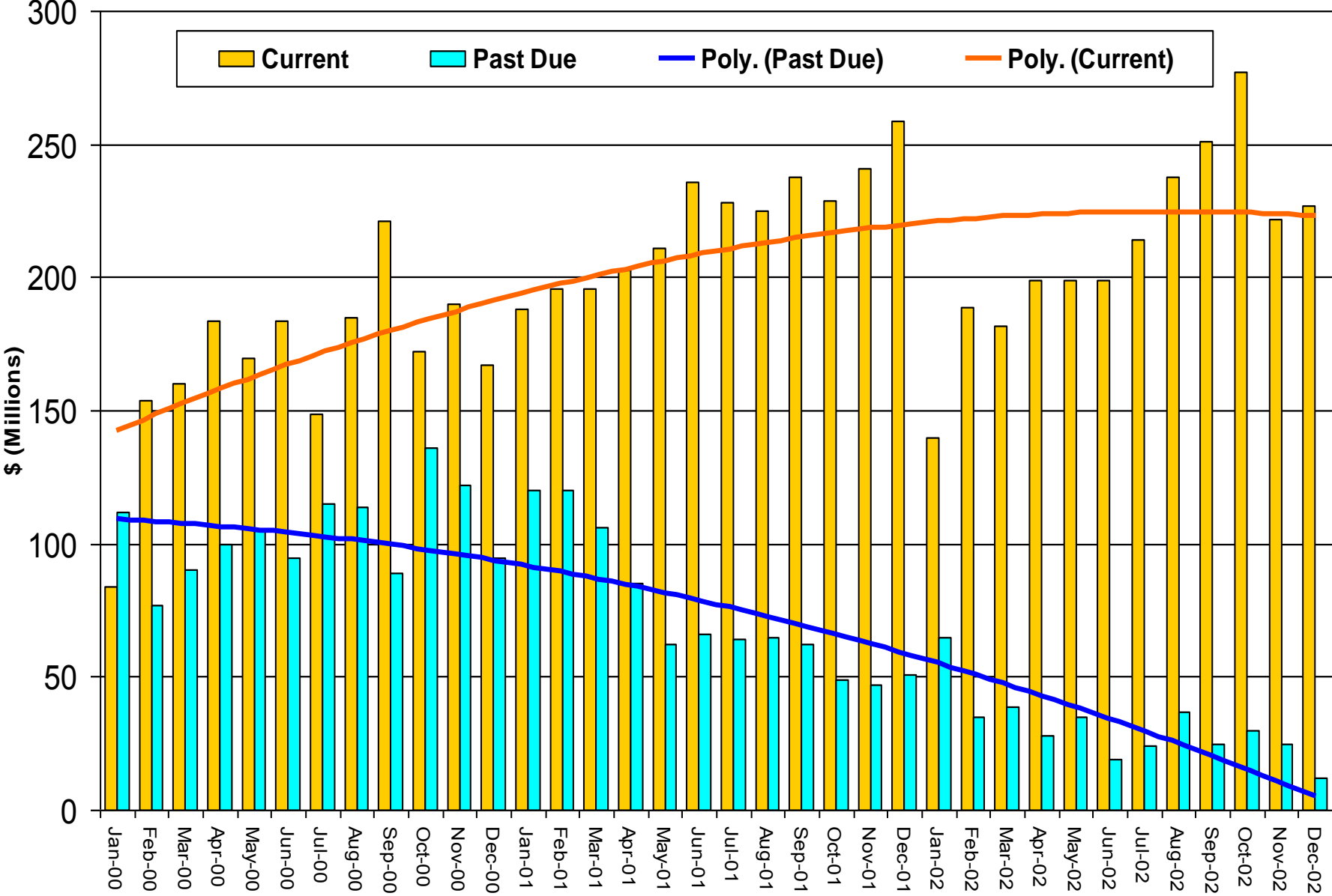
Third Year Actions

- 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

Rolls-Royce Accounts Receivable 2000-2002



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



Image: Wikimedia. Adrian Pingstone. Public Domain.

- 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



Image: Wikimedia. Adrian Pingstone. Public Domain.

- 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)



Image: Wikimedia. U.S. Coast Guard. Public Domain.

- Current and Future Operators Shown in Blue



Image: Wikimedia. ThePointblank. Public Domain.

RQ-4A Global Hawk



Image: Wikimedia. U.S. Air Force photo by Bobbi Zapka. Public Domain.

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

Osprey Engines Feature Power by the Hour™



Image: Wikimedia. U.S. Navy photo by Vernon Pugh. Public Domain.

- 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



Image: Wikimedia. AlanBarclay.CC BY-SA.

- 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
- FAA certification Oct. 25, 2010, first delivery Oct. 26

C-27J (aka Joint Cargo Aircraft)



Image: Wikimedia. Dmitry A. Mottl. Public Domain.

- 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

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16.660J / ESD.62J / 16.853 Introduction to Lean Six Sigma Methods
IAP 2012

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