The Supply Chain in Reverse—Component Remanufacturing at Rolls-Royce Corporation

‘Reverse’ and ‘Closed Loop’ Supply Chain Management
Rolls-Royce Global Repair Services: Americas
James W. Tilton, CPIM
Peter Clonts, CPIM
Jim Tilton is a thirty-plus year veteran of high-tech manufacturing operations and supply chain logistics management of power systems for civilian, military, and specialty applications for use on land at sea and in the air. This includes Commercial duty automatic transmissions and gas turbine engines.

His experiences range from shop floor operations to forecasting and data analysis to supply chain & logistics management for OEM, aftermarket, and component repair logistics and asset management.

Jim holds a bachelors degree in Business Management from Indiana Wesleyan University, is a past President of the APICS Central Indiana Chapter and currently serves on the APICS Great Lakes District staff where he is the program manager for the annual Great Lakes District Student Case Competition.

Jim is APICS certified in Production and Inventory Management, (CPIM) and is certified to instruct CPIM Classes.

He holds a Rolls-Royce Lean Six Sigma Green Belt Accreditation

Other studies: Project Management Body of Knowledge (PMBOK).
Recent activities: SME with CONEXUS Indiana to develop the Indiana high school curriculum for advanced manufacturing and Logistics.
Peter Clonts is a twenty-five year veteran of chemical and high-tech manufacturing operations and supply chain logistics management of power systems for civilian, military, and specialty applications for use on land at sea and in the air. This includes Commercial duty automatic transmissions and gas turbine engines.

His experiences range from production floor operations to forecasting/planning and data analysis to supply chain & logistics management for OEM, aftermarket, and component repair logistics and asset management.

Peter holds a bachelors degree in English from Armstrong Atlantic State University, currently serves on the APICS Central Indiana Chapter Board of Directors

He is APICS certified in Production and Inventory Management, (CPIM).

He has won several awards for inventory management and aftermarket forecasting.

He is currently completing a Rolls-Royce Lean Six Sigma Green Belt Accreditation.
What do you think of when you hear or see the words Rolls-Royce?
Rolls-Royce

Designs, develops, manufactures and supports

Power systems for -

Civil Aerospace
Defence Aerospace
Marine
Energy
Our Customers
• Definitions of featured topics
  – Remanufacturing
  – Reverse supply chain
  – Closed loop supply chain

• Overview of Rolls-Royce
  – RR PLC
  – RR North America
    • RR Corporation
      – RR Global Repair Services: Americas

• Supply Chain Models
  • Forward – a review
  • Reverse – with a look at the RR Exchange model
    – How we do what we do ...
  • Closed loop – Reverting materials

• Some Extras
  – Tour through a Rolls-Royce engine
  – Learn and share how an engine works
  – Blow up an engine

• Conclusion
  – Best practice sharing ….. ?!
  – Q&A
Professionals Need Familiarity with Remanufacturing

"Most operations management and supply chain professionals need at least some familiarity with the topic of remanufacturing?"

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<td>21.5%</td>
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<tr>
<td>9</td>
<td>12.2%</td>
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<tr>
<td>Strongly Agree</td>
<td>22.9%</td>
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Remanufacturing Visibility

In general, how visible is remanufacturing in your company?

Very Visible
- 15.0%
- 6.1%
- 5.0%
- 4.4%
- 22.2%
- 10.6%
- 10.6%
- 11.7%
- 8.9%
- 5.6%
- Not at all visible

APICS 2013
Remanufacturing Challenges - Complexity

Based on your experience, what challenges does remanufacturing pose to your organization? (Please select all that apply).

- Additional Complexity of Reverse Supply Chains: 59.1%
- Competing For Resources With New Production: 39.0%
- Cannibalize New Product Sales: 33.8%
- Fewer Customers Want Remanufactured Products: 30.5%
- Limited Sales and Distribution Channels: 29.2%
Reverse Operations: Differences

- R-R

- IT

- Cell phones

- Auto
Reverse Operations: Differences

NEW

$ERV

CORE$

Inventory Balance$
Terms Defined…

• **Remanufacturing (Re-man)**
  
  - *The industrial process which restores worn-out or end-of-life products to like-new condition.*
  
  - CORE: the *worn-out product*
  
  - SERV: the *worn-out product that has been remanufactured and is now consider suitable for SERVICE*

• **Reverse supply chain / logistics**
  
  - All operations related to the reuse of products and materials.
  
  - It is "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information *from the point of consumption to the point of origin* for the purpose of recapturing value or proper disposal."

• **Closed loop supply chain**
  
  - An ideal in which a supply chain completely reuses, recycles or composts all wastes generated during production; at minimum “closed-loop supply chain” indicates that the company which produces a good is also responsible for its disposal
Indianapolis Overview

- **People**
  - 4,645 Employees – over 1,475 Engineers 1,739 UAW Hourly
  - Second largest manufacturer in Indianapolis
  - Sales $2.2 Billion

- **Primary Customers**
  - Embraer, Cessna, Bell Helicopter, Robinson

- **Investment**
  - Capital investment of $ 32 million in 2010
  - Research and development spend of $96 million in 2010

- **Supply Chain**
  - $1.01 Billion in spend 2010
    - ($535M – RRC, $393M – RRUK, $86M - RRD)
  - 565 NA Suppliers

- **Facilities**
  - Twelve locations in Indianapolis
Product Lines
Rolls-Royce

Global Repair Services and Repair Engineering (GRS/RE)

Provides repair and support services for engine components around the world

Our customers:
600 airlines
4,000 corporate, utility, and helicopter operators
160 armed forces
More than 2,000 marine customers including 70 navies
Energy customers in 120 countries
Let's start with what we do...
We take parts that look like this......
Do some really “cool stuff” to them........
Making them “good as new” WITHOUT......
Causing the engine Program “1 big headache”!!!
Why GRS was created

- Reduce the cost per flight hour of AE engines
- Provide development and oversight of component repair suppliers
- Provide for additional revenue opportunities for Rolls-Royce
- Provide customers a one-stop-shop for repaired serviceable components
- Provide mechanism to turn technology into revenue
Supply Chains

Forward

Reverse

Closed loop
Core “Exchange Pool” logistics map

- **SHOPS**
- **WAREHOUSE**
- **REPAIR**

- **UNSERVICEABLE**

- **LOW INVENTORY COST**

- **SERVICEABLE POOL**

- **SERVICEABLE INVENTORY COST**

- **INCREASED AVAILABILITY**

- Embody Repair vs. NEW

- $ TO FIX - COST
## GRS’ Supply Chain Model

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Inputs</th>
<th>Processes</th>
<th>Outputs</th>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL05</td>
<td>S 313 Returns</td>
<td>New Parts</td>
<td>New / *Serviceable Spares</td>
<td><em>Call Backs</em> to Plant 5, 8810</td>
</tr>
<tr>
<td>Pur New</td>
<td>8810</td>
<td>FAB / PUR</td>
<td><em>See GRSA Processes Below</em></td>
<td>Operators</td>
</tr>
<tr>
<td>Class “C” Provider (3PL)</td>
<td></td>
<td>Class “C”</td>
<td>Ship Customer Owned Material</td>
<td>AMC’s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DNA Depots</td>
</tr>
</tbody>
</table>

### Processes:
- Store / Manage Customer Owned Material
- PDC Storage
  - Pick / pack / ship

### Outputs:
- New / *Serviceable Spares
  - *See GRSA Processes Below*
- Ship Customer Owned Material

### Customers:
- Operators
- AMC’s
- DNA Depots
- Customer

### Suppliers:
- Class “C” Provider (3PL)
- Pur New
- PL05
- S 313 Returns

### Inputs:
- New Parts
  - FAB / PUR

### Outputs:
- New / *Serviceable Spares
  - *See GRSA Processes Below*
- Ship Customer Owned Material

### Customers:
- Operators
- AMC’s
- DNA Depots
- Customer

### Suppliers:
- Class “C” Provider (3PL)
- Pur New
- PL05
- S 313 Returns
## Differences in forward and reverse logistics

<table>
<thead>
<tr>
<th>Forward logistics</th>
<th>Reverse logistics</th>
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<tbody>
<tr>
<td><strong>Distribution</strong> is from one to many points</td>
<td><strong>Collection</strong> is from many points to one</td>
</tr>
<tr>
<td>Distribution costs are easily visible</td>
<td>Returns costs are less visible</td>
</tr>
<tr>
<td>Product packaging is uniform</td>
<td>*Product packaging is not uniform</td>
</tr>
<tr>
<td>Inventory management is consistent</td>
<td>Inconsistent inventory management</td>
</tr>
<tr>
<td>Destination and routing is clear</td>
<td>Destination / routing is unclear</td>
</tr>
<tr>
<td>Disposition options are clear / minimal</td>
<td>Disposition options are greater / and not always clearly defined</td>
</tr>
<tr>
<td>Speed is a critical factor</td>
<td>Speed is not always a priority*</td>
</tr>
<tr>
<td>Uniform product quality is a must</td>
<td>*Product quality is inconsistent</td>
</tr>
<tr>
<td>Process visibility is more transparent</td>
<td>Visibility of process is blurred</td>
</tr>
<tr>
<td>Forecasting is straightforward</td>
<td>Forecasting more difficult due to a greater number of variables / some uncontrolled</td>
</tr>
</tbody>
</table>

*Product quality is inconsistent*
Examples of packaging and product quality “uniformity” in the ‘Reman’ supply chain...
Rolls-Royce

The Core Exchange Model
Material Process Flows

Suppliers
- PL05
  - S 313 Returns
- Pur New
  - 8810

Inputs
- New Parts
  - FAB / PUR
- Class "C"

Processes
- PDC Storage
  - Pick / pack / ship
- Store / Manage
  - Customer Owned Material

Outputs
- New / "Serviceable Spares"
  - (*See GRSA Processes Below)
- Ship Customer Owned Material

Customers
- "Call Backs" to Plant 5, 8810
- Operators
- AMC’s
- DNA Depots
- Customer

Other OEM’s etc.
- Repair Suppliers
- Service Engineering / Etc.
- Operators
- AMC’s
- DNA Depots
- Recycler

Suppliers
- Class "C" Provider (3PL)
- Operators
- AMC’s
- DNA
  - US Gov’t
  - Foreign Gov’t
  - Civil Customers
- DNA depots

Inputs
- Core Returns
- Scrap
- LLP’s
- Line Replaceable Units / Drop Ship
- Customer owned Material
- Same part Repairs (EXPEDITES)
- “Investigation” Hardware

Processes
- GRS;
  - Receive
  - Inspect Documentation
  - Induct / SAP
  - Store
  - AFA Documentation
  - Scrap
  - IPT’s
  - HAZMAT Pkg’g
  - Scrap

Outputs
- Core Repairs
- Customer owned Material
- Same part Repairs
- Line Replaceable Units
- “Investigation” Hardware

Customers
- Repair Suppliers
- Other OEM’s etc.
- Service Engineering / Etc.

Suppliers
- Repair Suppliers
- Other OEM’s ie; etc.
- Service Engineering / Etc.

Inputs
- SERV (repaired cores)
  - Repaired Customer owned Material
  - Same part Repairs
  - Unrepairable
  - SCRAP
  - Repaired LRU’s
  - “Investigation” Hardware

Processes
- GRS;
  - Receive
  - Inspect
  - Induct / SAP
  - Store
  - Scrap
  - IPT’s
  - HAZMAT Pkg’g
  - Scrap

Outputs
- SERV (repaired cores)
  - Repaired Customer owned Material
  - Same part Repairs
  - "Investigation" Hardware Maybe held / returned
  - Repaired LRU’s
  - Unrepairable / Shelve Hold
  - SCRAP

Customers
- Operators
- AMC’s
- DNA Depots
- Recycler
Core exchange logistics map

SHOPS → WAREHOUSE

UNSERVICEABLE

Energy
Defense
Civil
Marine

GRSA

SERVICEABLE POOL

SHOPS ← WAREHOUSE

Embody Repair vs. NEW

INCREASED AVAILABILITY

~ 2300 P/N- SKUs
88,800 Pieces

~ 40 Storage Locations
Condition
Engine / Customer
DEV / INV

~ $10M Inventory

APICS 2013
The Reverse Supply Chain Processes

• Covered activities
  – Return
  – Collection,
  – Inspection,
  – Reprocessing
  – Remanufacture
  – Redistribution
  – Recycling.

• Supply chain :
  – Remanufacturing vs. traditional
    • Strategy is the same
    • Tactics differ
    • More complex

It has been said that while Fred Astaire was a great dancer...
We cannot forget that Ginger Rogers did everything he did,...
backwards, and in high heels...
How we are grouped....

Repair engineering

Program management

Aftermarket supply chain

Scheduling

Logistics

Quality

Finance
How Do We Do That Thing We Do?

It begins with planning – SORB (sales and operations review board)

APICS Dictionary, 13\textsuperscript{th} Edition defines sales and operations planning as:

“... The process brings together all the plans for the business (sales, marketing, development, manufacturing, sourcing, and financial) into one integrated set of plans... The process must reconcile all supply, demand, and new product plans at both the detail and aggregate levels to tie to the business plan...”
Business Case:

Cost of new

Cost of repair

Technical feasibility

Available cores

Projected volume
<table>
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<tr>
<th>Forecasting</th>
<th>Quantity per engine</th>
<th>10</th>
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<tbody>
<tr>
<td>Shop visit rate</td>
<td>10</td>
<td>= 100</td>
</tr>
<tr>
<td>Touch rate</td>
<td>80%</td>
<td>= 80</td>
</tr>
<tr>
<td>Reject rate</td>
<td>50%</td>
<td>= 40</td>
</tr>
<tr>
<td>Scrap rate</td>
<td>10%</td>
<td>= 4</td>
</tr>
<tr>
<td>Return rate</td>
<td></td>
<td>= 36</td>
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</tbody>
</table>
Customer (CFBU)

Total demand
New/repair balance
Supplier (new) performance
New inventory
Repaired inventory
Core (raw material) inventory

Opposing Viewpoints
Justin
Case
Betty
Won’t use it
Supplier performance:

- Quality
- Cost
- Delivery
- Responsiveness
- WIP
- Yield Rate
Manufacturing

- Repair options
- Repair capacity
- Repair commitment
- Repair yield
New product design
Service limit changes
Repair history
Business case
... In short

... It’s a balancing act
Repair SORB Outputs

Change/establish:
- Demand balance between new and repair
- Serviceable stock target
- Core disposition
- Core stock target

Repair commitment
Clear cores via technical variance
Yield serviceable from existing core stock
Hardware review
Business case
1.0 PurReg
- RULE: Cores must be available prior to Requisition creation.

1.2 Req. List
- ME5A
- Batch Consolidation
- Multiple S/N’s
- Req Date
- Need date (< 10 days)

2.0 Core Pull
2.1 Core Pulled
- Excel File
- Emailed to GRS Logistics

2.3 Cores Ready
- LS e-mails MRPC Buy

3.0 Create PO
- ME21n
- Adsubcon

3.1 ADSUBCON

4.0 Pick Ticket
- Cores Picked, packed

SHIP To Vendor
- Cores Shipped to GRS Vendor
- Run VL03N to see ship history

5.0 Send PO To Vendor
- May need to negotiate repair Costs
- SPR, Etc...

5.1 Repair Process @ Vendor
- PO Lines to be correct
- SERV
- Scrap
- UNREP

5.2 Ship Back To PDC
- Investigation
- Call-Offs

6.0 Receipt into PDC
- SAP 101 SERV
- HOT SHEET
- SCRAP
- UNREP
- CORE?
- Issues? - See Problem Resolution Dept.

10.0 Common Issues
- Deficit of Stock
- Equip Record
- SPR S/O
- S/N Issues
- PO Mgmt...

10.1 PO Mgmt Issues
- SPEC 2K
- PN (Change?)
- Storloc
- VAL Type
- Pricing
Rolls Royce Corporation
Global Repair Services: Americas

• 2012 Statistics:
  – $30M annual component repair spend
  – 7,000 PO’s created & maintained
    • (external suppliers for component repair)
  – 50,000 pieces of inventory managed
  – 400+ unique repair part numbers managed
Key benefits for the CFBU and engine build shops

- Customer satisfaction due to predictable parts delivery to shops
  ✓ Currently enabling the customer facing business units (CFBU) to meet >95% on time parts delivery and their benchmarked shop total replenishment time (TRT) at reduced cost versus new part replacement

- Inventory managed to optimum levels
  ✓ Reduced administration needs for expedited or one-off repairs
  ✓ Allows RR to leverage economies of scale to reduce supplier repair cost
  ✓ Inventory levels optimized through part exchange model
  ✓ Inventory managed by R-R rather than invisible cost burden in the external supply chain
  ✓ SAP plant structure has the potential to provide visibility to CFBU of new and core parts for better demand signal management
  ✓ Allows engineering to look for repair opportunities in a single warehouse
  ✓ Increased visibility of CORE/ SERV opportunities
  ✓ Core availability proactively manages the risks of supply chain shortage
A Returns Management System (RMS)
Requirements, Functions, Success Factors

• Before an item can be refurbished, repaired, repackaged, recycled, or sold, …
  – It has to be properly received (identified and recorded) into the processing facility’s inventory.

• The receiving process of an RMS should accomplish two primary functions.
  1. Identify and credit the “sender” for the assets they shipped to the processing facility.
  2. Ensure the returned asset, and its value, is “visible inventory” in the system.

• Success starts at the front end of your RMS.
The RMS should immediately answer the following questions as goods are received:
  – When did the item arrive at the facility?
  – Where did the item come from?
  – Who was the shipper?
  – What is the RMA; i.e. PO / AFA
  – What is the part number / serial number or other identifying number for item identification?
  – What is the condition of the item? (CORE, SCRAP, SERV, UNREP, INVESTIGATION.)
  – What is the total “inventory” of the shipment that has been received?
  – Quantity’s received?

Source: State of the Art Reverse Logistics System  November 25th, 2010 | Author: Curtis Greve |
Closing The Loop
“Closed Loop Revert”

New Bar/Billet For R-R & R-R Supply Chains

New Parts Manufactured

Global “scrap” Collections from R-R facilities, Supply Chains, Airline Customers etc

Revert returned to mills for re-melting

Revert Processed

Alloys Sorted / Certified Destruction

Material Forms Collected

Turnings

Unserviceable Engine Parts

Foundry Scrap (PCF/PFB)
Component Remanufacturing at Rolls-Royce Corporation

‘Reverse’ and ‘closed loop’ supply chain management

Rolls-Royce Global Repair Services: Americas

Some notes on becoming successful ……
Key Enablers:

• Ensure that the parts forecast is accurate 🌞

• Influence the field centers to return unserviceable material to the warehouse to ensure inventory pool can be built

• Identify candidate parts for induction into process

• Commit appropriate level of resources to support the program

• Agree estimated budget for build-up of exchange pool
Now that we’ve come full circle...

...Answers?, Comments?, Questions?
Contact Us !!

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    • (317) 230-6252