QuEST
BORN TO ENGINEER

aftermarket services - overview of repair engineering

The contents of this document are the extracts collected from various sources with the intent of how such concepts/ ideas could be viewed with respect to the Engineering service industry and how effectively could get implemented solely from the author's point of view. This may enlighten the thinking process and trigger the direction that can be considered.

Ravindra Kumar
QuEST Global

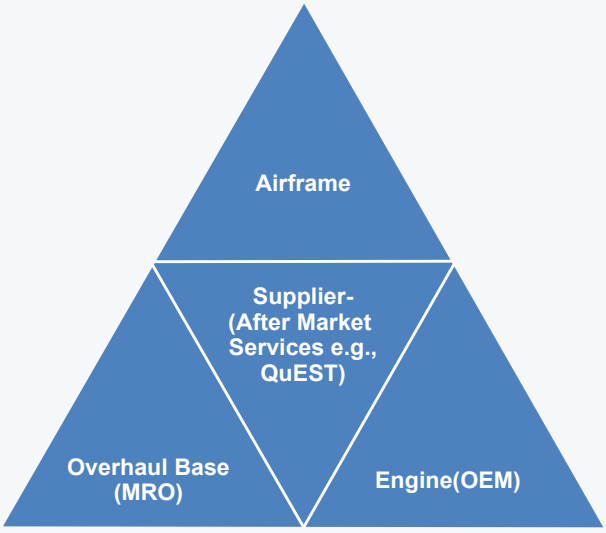
Basavaraj Patil
QuEST Global

contents

Abstract

Repair means restoring serviceability of a part or an assembly. Repair engineering service by QuEST includes providing repair solutions for individual parts or assemblies of a gas turbine, which are non-compliant with the product manual.

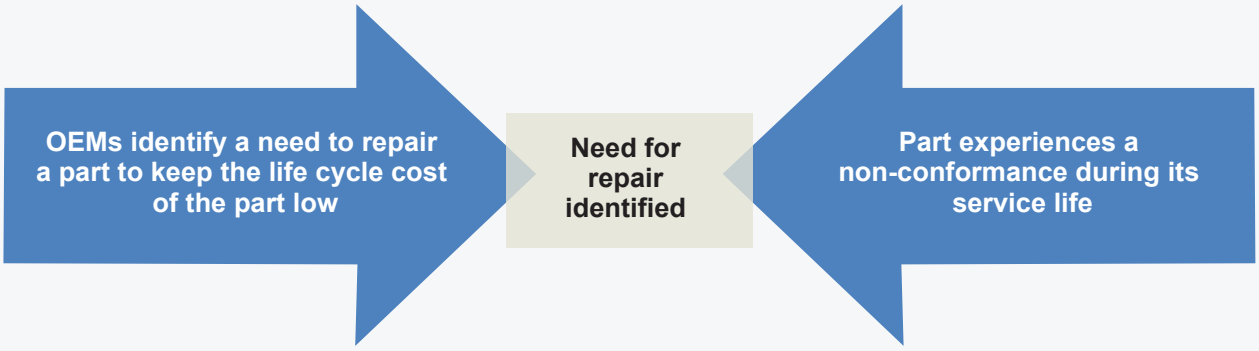
Repair Engineering is a part of maintenance engineering and is a vital function of aftermarket services. This is a complementary function of service engineering and plays an important role in deciding product replacement (product cost vs. repair cost). Repair engineering / Maintenance engineering / Service engineering are commonly used terminology in Aftermarket Services (AMS) and the current subject deals with repair engineering of aero engine components.



Overview of Aftermarket Services

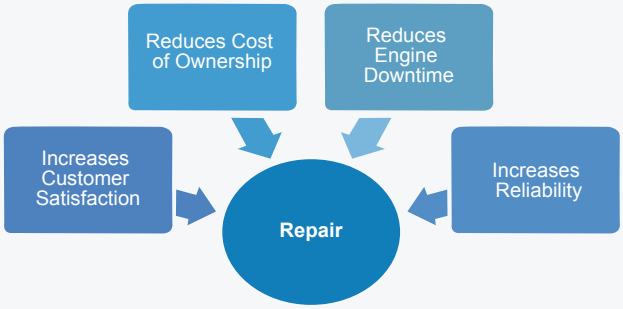
Aero-engine operational requirements demand a high-quality product with the lowest possible cost per flight hour. As the aircraft / aero engine fleet is growing rapidly, there is a growing need for the engine maintenance and repair services. An aircraft engine requires constant maintenance as it suffers the maximum wear and tear. A reliable and cost-effective Maintenance, Repair and Overhaul (MRO) solutions is a key to keep it in an airworthy operating condition. Hence there is a growing need for third party MROs / Service providers, Airline MROs and the like.

A sound MRO facility must strive to minimize turnaround time, effectively manage the need for engine spares and reduce the overall maintenance cost. Also, highly skilled technicians' support must be available for engines needing repair / maintenance when in service i.e. on-wing repairs or for accomplishing complex repairs.

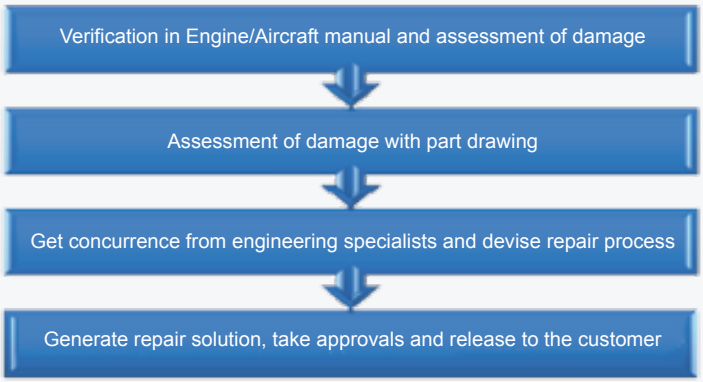


Present day expectation of an aircraft / aero engine manufacturer with respect to repair engineering is as follows:

- Cost-efficient repair solutions
- Component improvement programs
- Continuous reliability studies and modification processes
- Development of repair solutions and technical documentation pro-actively rather than reactively



Advantages of Repair Solution

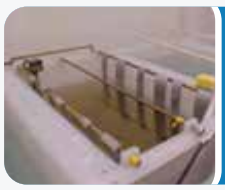


Typical Repair Process Flow for Development of Repair

Metal Spray
- Restore Location Diameter/Face/Wear
- Attrition Lining

Machining
- Remove Corrosion
- Distortion

Welding
- Crack/Material Missing/Wear



Electro Plating
- Restoring Diameter and Small Wear

Surface Treatment
- Surface Protection

Replacement Repair
- Bush Replacement
- Insert Replacement

Stop Drill
- Crack
- Low Stress

Wear Resistant Epoxy Adhesive
- Handling Damage
- Low Stress

Patch
- Composite Material
- Casing
- Sheet Metal

Shot Peening
- Rotating Components

Vibro Polishing
- Super Finishing

Types of repair practiced on Aero Engine components

Current Market Scenario

[1]The Rolls Royce Annual Report 2012 states that 54% of Civil Aerospace, 49% of defense aerospace, 43% of marine and 64% of energy revenue in the year 2012 are from services.

[2]Despite the fact that aftermarket services are perceived to rake in revenues, it is not that easy to manage after-sales support and only companies that provide services efficiently can make money from them. Recent study in the after-sales network of one of America's biggest automobile manufacturers revealed that very little coordination exists between the company's spare-parts warehouses and its dealers. Roughly 50% of consumers with problems faced unnecessary delays in getting vehicles repaired because dealers didn't have

the right parts to fix them.

Due to increase in the passenger volume, requirement for aircraft may significantly increase in coming years. The increase in aircraft demand pours in opportunities for MROs to expand their business, especially in Asia.

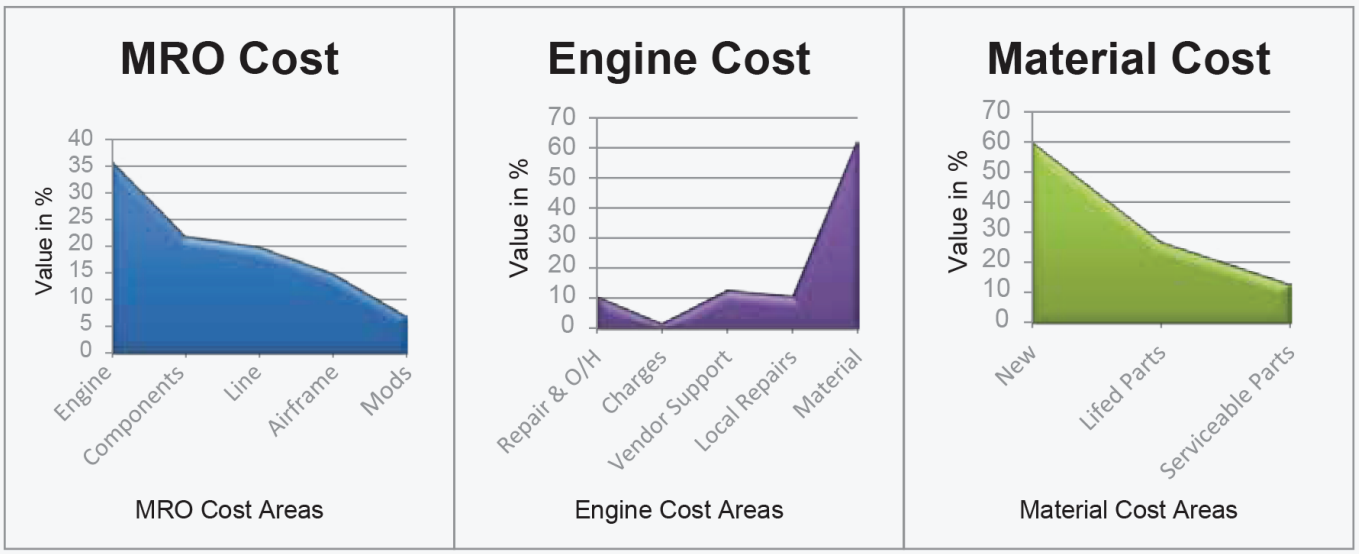
[3]North America and Western Europe account for about two-thirds of today's MRO market. It is anticipated that in the next 20 years Asia Pacific region will get a boost in the air travel and would account for about 40 percent of world air traffic and hence drive the largest MRO growth in Asia (+USD5.6 billion).

Dynamics of aircraft business are also influenced by

- Collaboration between MROs and OEMs (Original Equipment Manufacturers)
- Outsourcing MROs to third party to stay focused on core business
- Globalization in low-cost labor locations such as India, Latin America and China have now set up MRO service centers
- PMA (Part Manufacturer Approval) parts – Non-OEM parts can be manufactured to provide cost benefit and increase the competitiveness

In the early days of aviation, airlines were having their own maintenance wings. However this involved huge costs, despite the fact that this is a non-core activity. OEMs had to look at ways and means to reduce costs involving maintenance of aircrafts. To obtain cost advantage activities like MRO work were outsourced to places where there were cost reduction opportunities. This outsourcing work has increased rapidly in the last 15 years, due to the growth in aircraft sales. Thereby the OEMs get to focus on mostly towards core work such as improving design, production and quality of airframes/engines. It is expected that approximately 80% of MRO work will be outsourced by the year 2020.

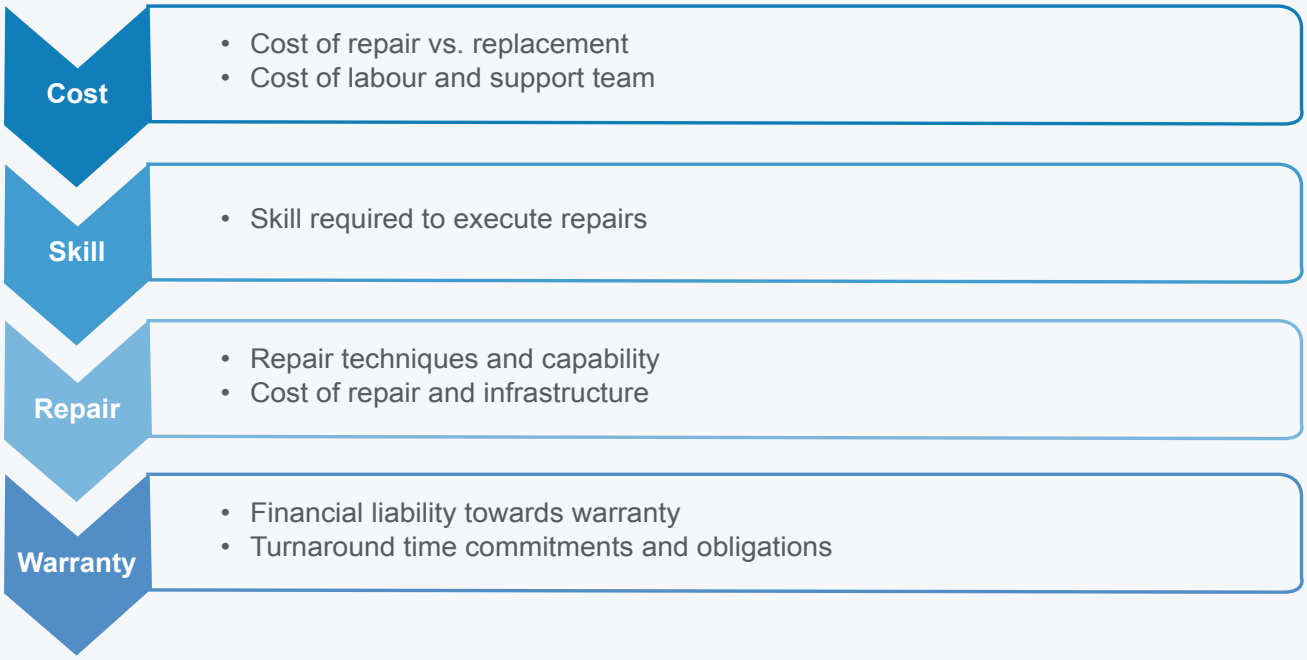
Break up of major cost incurred by MROs:



- Cost of material is key driver
- Used material and repair technology offer valuable alternatives
- Aftermarket choice is a key in lowering MRO costs – which is a key driver of residual values as engines' age

Challenges to OEM's in Handling In-service Engines

The challenges faced by OEMs are to keep the published repair solutions up-to-date to help MROs meet their turnaround time targets. Generally MROs will have difficult times in managing spares for rejected components, especially if the rejection happens during the engine build time.



About QuEST Aftermarket Services

QuEST has been offering aftermarket services over the last six years and is growing in strength, both in numbers and in service areas. QuEST has developed competency in providing repair solutions through internal training programs, on-the-job training, industrial visits, working onsite at customer locations and interacting directly with engine operators/service units to understand the details of non-conformance/concerns. QuEST currently has a competent team of 50+ repair engineers and 90+ service engineers with close to 4,00,000 project hours and experience of resources ranging from 3 to 20+ years, helping its customers by providing cost effective and high quality solutions. QuEST has also assisted customer in development activities for new engines, technical support to various service engineering functions, either onsite or offsite based on the requirement of customer at agreed time scales.

QuEST has the capability to develop repair/service engineers in a short span of time using in-house and customer supported training programs. Some QuEST engineers are even certified as first level signatories by customers (Delegated Signatory) thanks to their exceptional commitment to delivery and quality. These engineers can directly submit their deliverables to final customer review reducing turnaround time (TAT) for deliverables. QuEST has delivered more than 5000 repairs to its customers, which are being used by various MROs for in-service engines.

QuEST Experience in Various Repairs

The challenges faced by OEMs are to keep the published repair solutions up-to-date to help MROs meet their turnaround time targets. Generally MROs will have difficult times in managing spares for rejected components, especially if the rejection happens during the engine build time.

Repair Type	Defense Engines	Large Civil Engine	Small and Medium Civil Engines	Industrial Engines
Metal Spray	Y	Y	Y	Y
Welding	Y	Y	Y	Y
Surface Treatment	Y	Y	Y	Y
Stop Drill	Y	Y	Y	Y
Patch Repair	N	Y	Y	N
Vibro Polishing	Y	Y	Y	Y
Machining	Y	Y	Y	Y
Electro Plating	Y	Y	Y	Y
Replacement Repair	Y	Y	Y	Y
Wear Resistant Epoxy Adhesive	Y	Y	Y	Y
Shot Peening	N	Y	Y	N

Y - Considerable experience; N - No experience to limited experience

Examples of a few QuEST projects

- Analysis of gaps between required and existing standards / repair limitations of repair documents / solutions and providing proactive amendments to repair solutions. This has reduced volume of non-conformances raised by customers, thereby reduced cost to OEMs and improved engine turnaround time
- Implemented process and productivity improvement initiatives through DMAIC projects to benefit customers and improve internal productivity. These projects have saved close to 6000 man hours to customers annually and reduced the OEM's response timeto customer issues by 2-5 days
- Support the customer with local global model or onsite-offshore model. QuEST leverages local talent and expertise at customer location; at the same time offsets cost by executing the work at cheaper locations without compromising in quality and schedule

Case Study on Non-conformance Support

Background: Service run engines are periodically stripped and components are cleaned and examined using engine manual. Any non-conformance of engine component to the engine manual is referred to OEMs for possible acceptance/repair.

Customer scenario and business impact: The Engine overhaul units operate at stringent timelines to meet the requirements of airlines, which is to keep the fleet running without any delays or with minimum service disruption.The OEM was operating at an agreed SLA to provide at least 85% definitive solution of acceptance / repair / rejection within 3 weeks.

The project was given to QuEST with an objective of

1) Increasing the solution delivery rate to 85% within 3 weeks
2) Reduce the turnaround time from 3 weeks
3) Improve permanent solutions in manuals (update service manuals) rather than offer a one-time solution.

Challenges for QuEST

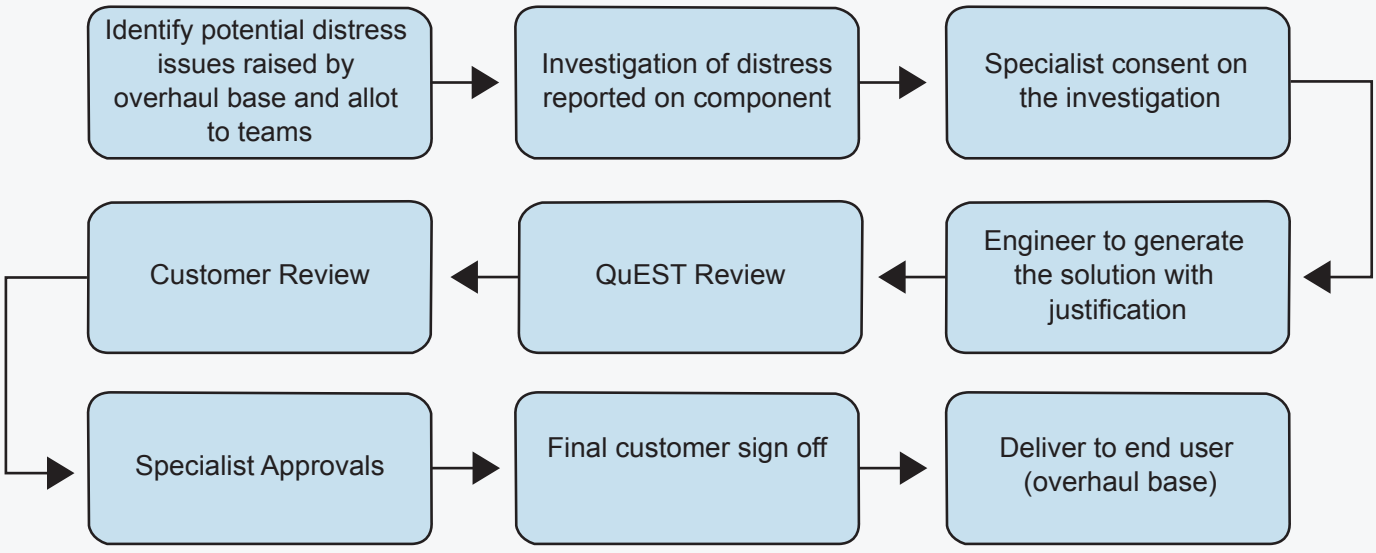
- Recruiting new engineers to support customer objectives
- Training to meet the required competency to execute the tasks
- Creation of robust process map, understanding the work breakdown and estimate of efforts involved
- Succeed in the project and win customer confidence

QuEST methodology

QuEST used existing capability and experience in Repair engineering and devised a plan to recruit engineers from campus/off campus, followed by training them to customer requirements for a certain period including exposure to engine hardware, repair techniques and visit to aero workshops. Also QuEST placed experienced repair engineers to interface with customers, capture the customer voice and develop suitable process for meeting customer objectives.

An overall plan was agreed with the customer to develop capability offshore and start delivering to the customer objectives. Trained recruits and experienced repair engineers started working in process groups interacting closely with the customer and to the process devised.

Process adopted by QuEST



Within a reasonable time of project allotment, the offshore team in tandem with the onsite QuEST team was successful in managing the complete process from induction to approvals.

Key benefits for customers

- The solution delivery rate was increased to 90% within three weeks and was sustained for a period of one year
- Turnaround time was reduced by few days as well, some engineers were awarded signatory status which enables them to review and submit the tasks to customer without any reviews, thereby reducing turnaround time for tasks. This also increased customer confidence in QuEST capability and process maturity
- QuEST has demonstrated ability to manage the process with limited customer support, which has enabled customer to focus in other areas of their business

References

1) Rolls-Royce annual report (Page 2 and 3)

2) HBR report 'Winning in the Aftermarket' (Page 130)

3) IBM report 'Keep them flying' (Page 1,4,5)

4) Report 'Aircraft Maintenance Repair and Overhaul Market Study. Glasgow International Airport'

5) MTU website and International Air Transport Association Website (http://www.iata.org/whatwedo/workgroups/Documents/MCC-2012-ATL/Day1/1400-1440-mtu-serviceable-parts-vs-newparts.pdf) (Slide 7)

Author Profile

Ravindra Kumar

Ravindra Kumar specializes in repair process design and development for in-service aero engine components.

Ravindra Kumar has about 17 years of experience in the field of process planning, repair development and technical publication of in-service aero engine components. He has previously worked in Hindustan Aeronautics Limited (H.A.L), Engine Division specializing in process planning (Overhaul Support) of aero engine components used in defense services. He also has 2 years experience in Technical publications of Aircraft manuals. He is currently the Technical Manager and in charge of capability development / competency building of repair engineering team. Ravindra Kumar has a Bachelor's degree in Industrial Engineering from IIIE, Navi Mumbai.

He can be reached through
ravindra.kumar@quest-global.com

Author Profile

Basavaraj Patil

Basavaraj Patil (BP) specializes in repair process design and development for in-service / development aero engine components. He has been working with QuEST for the last 5+ years at Rolls-Royce CoE, Bangalore. BP has 10+ years of experience in Aero-engine repair services and assembly inspection domain. Prior to joining QuEST, BP has worked with Hindustan Aeronautics Ltd., Engine Division, Bangalore and Infotech Enterprises Ltd, Bangalore.

BP has Bachelor of Engineering (Mechanical) from B.V. Bhoomaraddi College of Engineering and Technology, Hubli. Karnataka University, Dharwad (2000) and has done his Master of Business Administration (International Business) from Annamalai University, Annamalai nagar (2009).

At QuEST, BP's currently working as a Project Leader.

He can be reached through
basavaraj.patil@quest-global.com

About QuEST Global

QuEST Global is a focused global engineering solutions provider with a proven track record of over 17 years serving the product development & production engineering needs of high technology companies. A pioneer in global engineering services, QuEST is a trusted, strategic and long term partner for many Fortune 500 companies in the Aero Engines, Aerospace & Defence, Transportation, Oil & Gas, Power, Healthcare and other high tech industries. The company offers mechanical, electrical, electronics, embedded, engineering software, engineering analytics, manufacturing engineering and supply chain transformative solutions across the complete engineering lifecycle.

QuEST partners with customers to continuously create value through customer-centric culture, continuous improvement mind-set, as well as domain specific engineering capability. Through its local-global model, QuEST provides maximum value engineering interactions locally, along with high quality deliveries at optimal cost from global locations. The company comprises of more than 7,000 passionate engineers of nine different nationalities intent on making a positive impact to the business of world class customers, transforming the way they do engineering.

QUEST

BORN TO ENGINEER

http://quest-global.com