



Global MRO Market Economic Assessment



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Submitted by:
ICF SH&E

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1 EXECUTIVE SUMMARY

The global turbine-powered civil aviation fleet is about 80,000 aircraft with over 26,000 aircraft operating in the air transport fleet. Nearly half the civil aviation fleet is domiciled in North America with 37,000 aircraft, followed by 16,000 aircraft in Europe and 11,000 aircraft in Asia Pacific. These aircraft fly over 85 million hours per year with the air transport fleet accounting for almost 80% of those hours.

The civil maintenance, preventive maintenance and alteration (MRO) market contains four distinct segments: heavy airframe, engine, component and line maintenance. The 2012 civil market is estimated at over \$65B; engine overhaul is the largest segment at \$26.1B followed by component at \$16.8B. North American-based fleet accounts for \$23.5B.

Heavy airframe maintenance accounts for \$13.0B; over 70% is provided to air transport aircraft, with 38% performed on aircraft based in North America. There are four key service providers in this segment: Type and Production Certificate holders (Original Equipment Manufacturers (OEMs)), air carriers, independents, and airline third-party. For the air transport market, operators perform 50% of the work, while in the business & general aviation (B&GA) market, independent suppliers perform 65% of the heavy airframe work. Labor represents approximately 70% of the typical cost with material and other services account for 30%.

Engine overhaul accounts for \$26.1B; over 86% is provided to air transport aircraft, with 36% performed on aircraft based in North America. For the air transport market, the engine manufacturers account for 43% of the segment's share, while for the BGA market, the OEM accounts for 50%. Material accounts for 58% of the typical cost with labor representing 22% and parts repair coming in at 10%.

Component maintenance accounts for \$16.8B; over 70% is for air transport aircraft, with 37% ultimately being installed on aircraft based in North America. Market share varies widely by component type, with manufacturers holding significant influence in the segment. Typical cost structures vary as well, with some types having a significant material investment.

Finally, line maintenance accounts for \$9.9B with almost 30% of the market for North American-based aircraft. Almost 90% of the segment is performed by the operators, with labor accounting for over 85% of the cost structure.

Every dollar spent on heavy airframe maintenance generates \$1.39 of economic activity. One dollar spent on engine overhaul generates \$1.88 and one dollar spent on component maintenance generates \$1.68 of economic activity. Line maintenance generates \$1.19 of economic activity for every dollar spent.

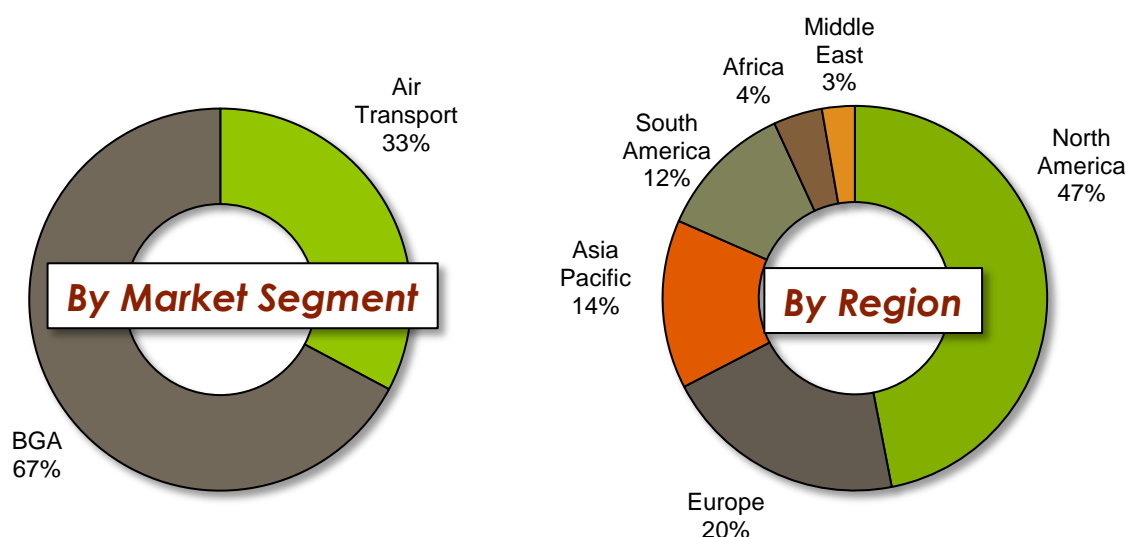
In the United States, nearly 4,100 firms with 196,000 employees operated in the civil MRO market. Small and medium-sized enterprises (SME) account for 84% of the total and 21% of all employees. There are over 143,000 technicians in the United States and approximately 36% are certificated.

2 INTRODUCTION

The global turbine-powered civil aviation fleet is about 80,000 aircraft (*Figure 1*). There are over 53,000 business and general (BGA) aircraft, which represent over two-thirds of the world civil fleet. There are over 26,000 aircraft in the air transport fleet. Nearly half of the global civil aviation fleet, 37,000 aircraft, is located in North America. Europe is the next largest market with 16,000 aircraft, followed by Asia Pacific with nearly 11,000 aircraft.

Aircraft flight hours or utilization is a key driver of MRO services. The civil aviation fleet flies approximately 85 million hours per year. Air transport aircraft, only 33% of the fleet, fly 65 million hours per year or nearly 80% of the total. On average, air transport aircraft fly 2,500 hours per year versus 370 hours per year for BGA aircraft.

Figure 1: 2012 Global Civil Aviation Fleet (79,800 Aircraft)



Source: ICF SH&E Analysis

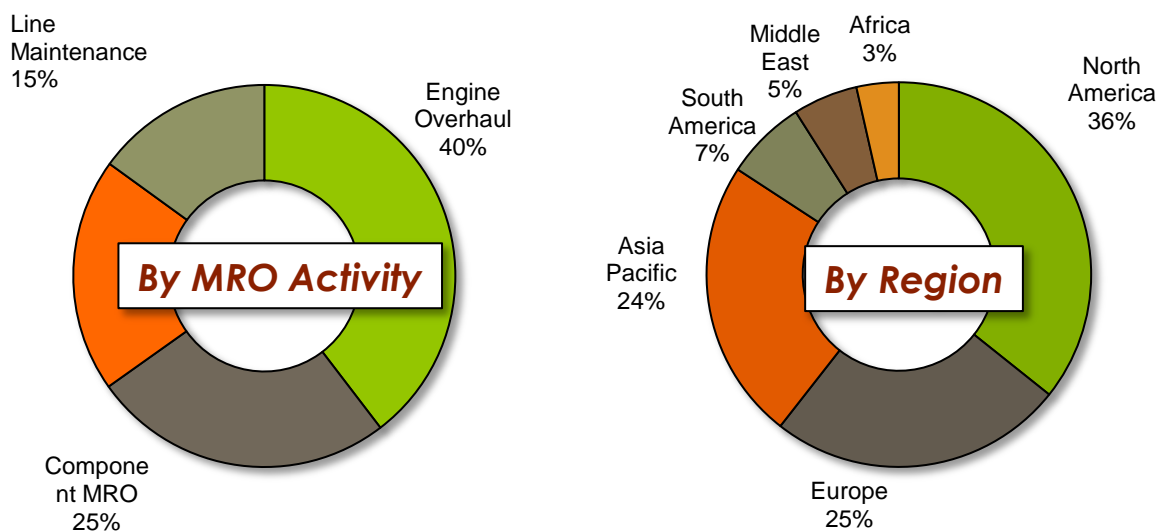
The civil MRO market consists of four distinct markets: heavy airframe, engine overhaul, component and line maintenance.

- **Heavy Airframe Maintenance** - A regularly scheduled work scope with detailed inspection, maintenance, preventive maintenance and alteration of the entire aircraft and its installed components that will place the aircraft out of service for a pre-determined period of time.
- **Engine Overhaul** - Off-wing maintenance, preventive maintenance and alteration that restores the engine to designed operational condition; by regulation the engine must be disassembled, inspected, parts are repaired or replaced as necessary, re-assembled and tested.
- **Component** - Maintenance, preventive maintenance and alteration of components that will be installed on an aircraft, airframe, engine or propeller.

- **Line Maintenance** - Maintenance checks that are carried out to ensure that the aircraft is fit for flight but that do not remove the aircraft from service.

The world civil aviation MRO market is estimated to be over \$65B (*Figure 2*). Engine overhaul is the largest segment at \$26.1B, followed by component MRO at \$16.8B. The North American MRO market is the largest geographic market – estimated to be \$23.5B. Europe and Asia Pacific are the next largest markets at \$16.3B and \$15.5B, respectively.

Figure 2: 2012 Global Civil MRO Market (\$65.8B)



Source: ICF SH&E Analysis

3 GLOBAL MRO MARKET

3.1 HEAVY AIRFRAME MAINTENANCE

Introduction

Heavy airframe maintenance is regularly schedule inspection, maintenance, preventive maintenance and alteration that will take the aircraft out of service for a pre-determined time at specified intervals. Individual airlines, in compliance with national aviation safety regulations, establish heavy maintenance schedules.

Scheduled work scopes are typically based on calendar time or a fixed number of flight hours. Generally, there are four levels for air carrier aircraft, termed “A”, “B”, “C”, and “D” checks. “A” and “B” checks are considered line maintenance, while “C” and “D” checks are classified as “heavy maintenance.”

Market	Activity	Description	Frequency*	Out of Service Time*	Man-hrs required*
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Figure 3: Heavy Airframe Maintenance Overview

Air Transport	C Check	Detailed, scheduled inspections, maintenance, preventive maintenance and alteration of the airframe, components and accessories and portions of applicable corrosion prevention programs.	2,500 to 3,000 flight hrs (or 12 to 18 months)	72 hrs to 7+ days	2,000 to 4,000 hrs
	D Check	Comprehensive maintenance, preventive maintenance and alteration of the entire aircraft, intending to return it to its original condition (to the extent possible) with interiors and components removed and replaced.	20,000 to 24,000 flight hrs (approx. 5 to 10 yrs)	30 days	10,000 (smaller jets) to 50,000+ hrs (B747)
BGA	Minor	Inspections and preventive maintenance include check of fluid levels, tire pressure, lighting, etc.	300 to 500 flight hrs	Less than one day	4 to 15 hrs
	Major	A comprehensive structural inspection, maintenance, preventive maintenance and alterations (similar to a D-check)	3,000 – 6,000 flight hrs	5 to 7 days	2,000 to 5,000 hrs

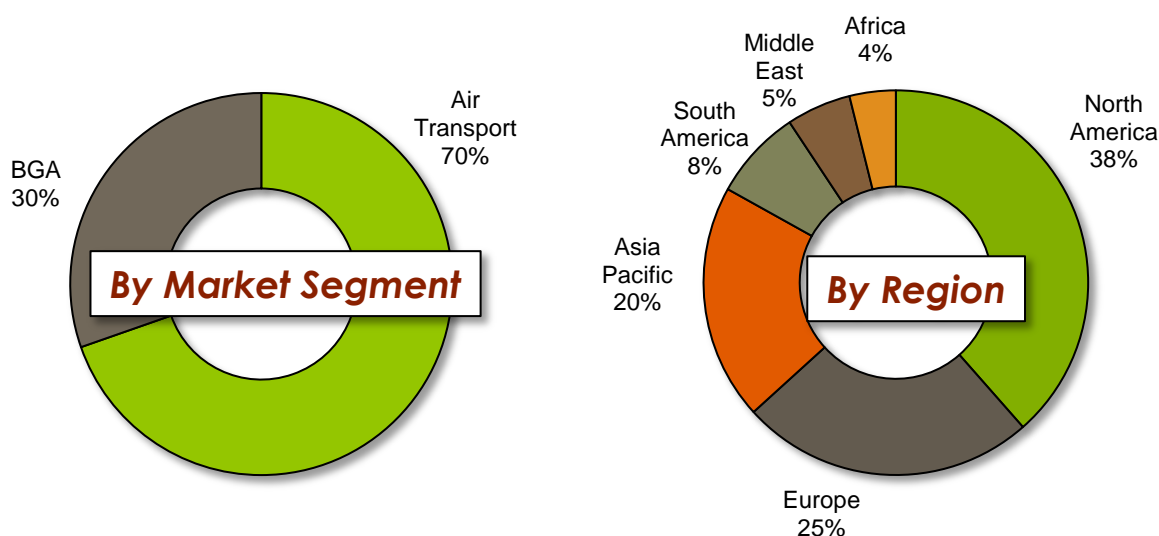
Source: ICF SH&E Analysis

* Approximate

Market Description

The civil heavy airframe maintenance market segment is estimated at \$13.0B (*Figure 4*). Air transport is the largest segment at \$9.1B or 70% of the total airframe heavy maintenance sector. BGA accounts for \$4.0B or 30% of the total. North America is the largest arena, generating \$5.0B of the total demand, followed by Europe at \$3.2B. Asia Pacific is the third, estimated at \$2.6B. Together, these three sectors represent over 80% percent of the global civil heavy airframe maintenance market.

Figure 4: 2012 Global Civil Airframe Heavy Maintenance Market (\$13.0B)



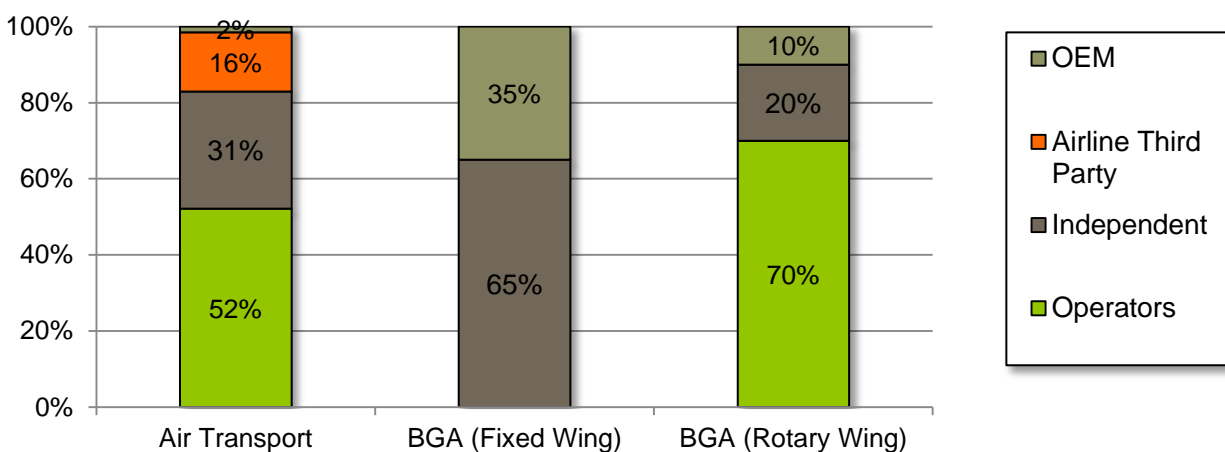
Source: ICF SH&E Analysis

There are four types of maintenance providers who perform heavy airframe maintenance (*Figure 5*):

- **OEM** – The involvement of air transport type and production certificate holders in heavy airframe maintenance is minimal. Airbus and Boeing, have a minimal role; in contrast Embraer and Bombardier, Cessna, Hawker Beechcraft, Gulfstream, Dassault, and Bombardier are actively involved in the market. The main civil rotary wing producers, Bell, Eurocopter, and Sikorsky, also make access to MRO services available to purchasers.
- **Operator** – Despite a recent trend towards contract maintenance, operators with in-house airframe maintenance capability perform the majority of their own heavy checks.
- **Independent** – MRO providers unrelated to either OEMs or airlines – are significant players in the heavy airframe maintenance market. Independents typically enjoy the lowest labor costs of any supplier group.

- **Airline Third Party.** The maintenance subsidiaries of airlines which undertake work for other airlines (as well as their parent) are able to leverage operating experience and base volume to provide competitive pricing.

Figure 5: 2012 Heavy Airframe Maintenance Participants



Source: ICF SH&E Analysis

The air transport structure is fundamentally different from BGA fixed wing. In air transport, operators conduct about half of the total maintenance (\$4.7B), with the balance effectively split between independents and airline third parties.

For BGA fixed wing, however, independent providers account for almost two-thirds of the work performed, totalling some \$1.6B; the balance is performed by the OEMs.

The structure of the BGA rotary wing is more similar to air transport, where the operators perform the large majority of the work (70% or \$1.0B).

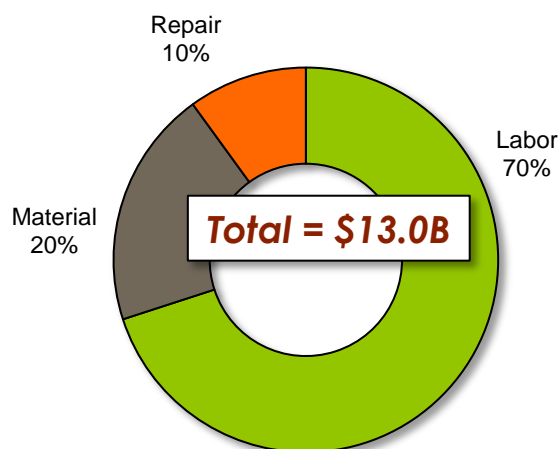
Cost Structure

There are three primary cost elements in airframe heavy maintenance (*Figure 6*). These elements are material, labor and repair/specialty services.

- **Labor** – Labor is the dominant component of aircraft maintenance cost, accounting for 70% in the air transport category. It includes direct labor required to perform the work scope, e.g., remove interiors and exterior access panels, inspection, repair (if necessary), and reassembly. These costs also include general and administrative overhead and employee benefits.
- **Material** – This is the second largest cost category at 20% of the total. This includes “consumables” such as solvents, hardware such as fasteners and standards, and airframe parts.

- **Repair/Specialty Services** – Outside repairs and services, such as non-destructive inspection, composite repairs, seat repairs, and fuel tank inspection, accounts for 10% or less of the cost.

Figure 6: Airframe Heavy Maintenance Cost Structure



Source: ICF SH&E Analysis

Supply Chain

There are three main supply sources for materials used during maintenance, preventive maintenance and alteration activities (*Figure 7*): part suppliers, distributors, and repair/specialty service suppliers. Unlike in engine overhaul, however, the material required is quite small.

- There are three primary sources for parts: OEMs, PMA (Parts Manufacturer Approval) and hardware providers, and surplus dealers.

Air transport and BGA OEMs, the source of most airframe service parts, were discussed previously.

The PMA market is rather small and focused primarily on interiors.

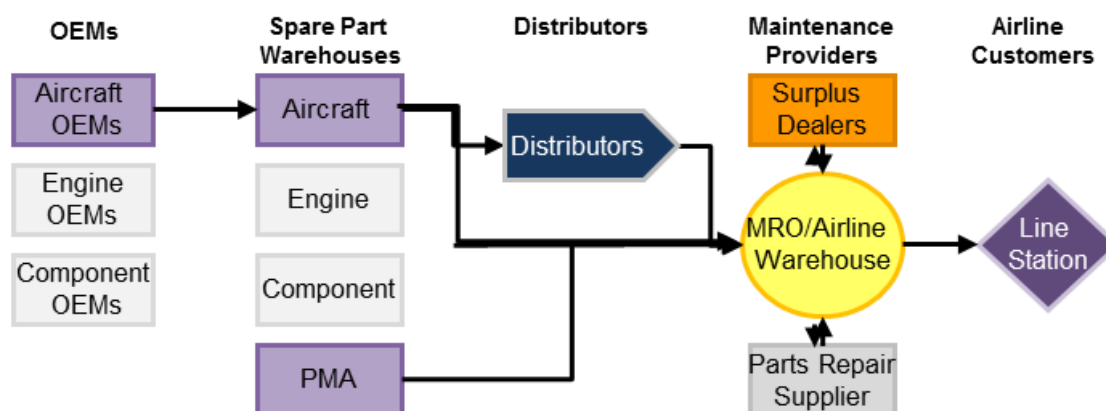
Hardware or “fasteners” are routinely replaced during MRO activities.

The last category, surplus dealers, is small in terms of material flow. The exception is for servicing older aircraft, such as the 737-200. Approximately two-thirds of surplus dealers are domiciled in the US.

On average, heavy airframe maintenance providers work with 10-15 material suppliers including OEMs, PMAs and surplus dealers; for consumables and hardware, the number of outside suppliers is in the dozens.

- Distributors are a common intermediary between parts suppliers and heavy aircraft maintenance facilities. Over 60% of distributors are domiciled in the US. On average, heavy airframe maintenance providers work primarily with 3-4 major distributors and a dozen or so smaller distributors for hardware and consumables.
- Specialty services include repairs to interiors (such as seats and galleys) as well as structural repairs to airframe parts, including both metallic and composites. Examples of the latter include composite fairings and radomes. Structural repairs to airframe parts are often completed by local machine shops. On average, airframe heavy maintenance suppliers work with between five and ten repair/specialty service suppliers.

Figure 7: Airframe Heavy Maintenance Supply Chain



Source: ICF SH&E Analysis

3.2 ENGINE OVERHAUL

Introduction

Engine overhaul services involves off-wing maintenance, preventive maintenance and alteration that restores the engine to designed operational condition; by regulation the engine must be disassembled, inspected, parts repaired or replaced as necessary, re-assembled and tested.

For air transport operators, engine overhaul is performed on an as-needed (on condition) basis, except for the replacement of life-limited parts (LLP) which occurs at a fixed time established by the national aviation authority. For business and general aviation (BGA), engine overhaul is generally performed at specified time intervals according to guidelines recommended by the engine manufacturer.

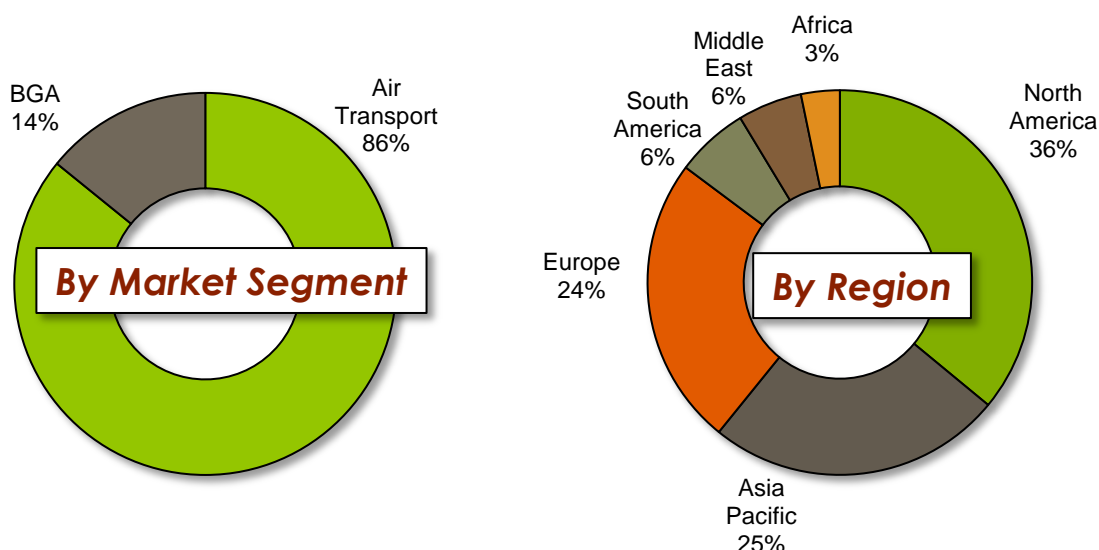
Figure 8: Engine Overhaul Definition

Market	Activity	Description	Frequency	Typical Cost
Air Transport	Overhaul	Disassembly, inspect, repair or replacement of parts, re-assembly and test	4,500 hrs to 24,000 hrs	\$450,000 to >\$5,000,000
BGA	Overhaul	Disassembly, inspect, repair or replacement of parts, re-assembly and test	3,500 hrs to 7,000 hrs	\$200,000 To \$800,000

Source: ICF SH&E Analysis

Market Description

The civil engine overhaul business is estimated at \$26.1B (*Figure 9*). Air transport is the largest segment at \$22.4B or 86% of the total engine overhaul market followed by BGA at \$3.7B, the remaining 14%. North America is the largest arena – generating \$9.4B of engine overhaul demand followed by Asia Pacific and Europe, which generate \$6.5B and \$6.3B in demand, respectively.

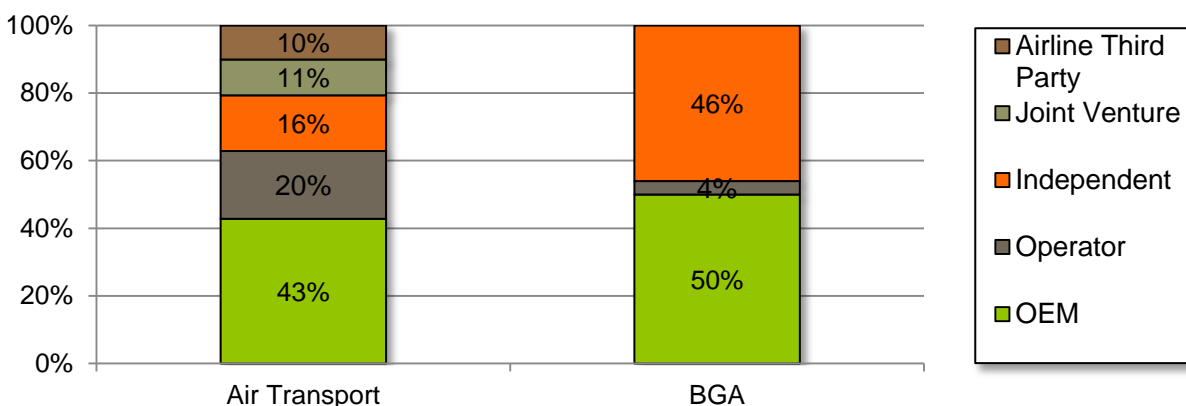
Figure 9: 2012 Global Civil Engine Overhaul Market (\$26.1B)

Source: ICF SH&E Analysis

There are four types of firms who perform engine overhaul work (*Figure 10*):

- **OEM** – The holders of the type and production certificates for engines are the largest providers of overhaul services. With the technical knowledge from the development phase of the engine and the ability to sell maintenance services during the sale of the engine.
- **Operator** – Air transport airlines with in-house engine overhaul capability, with the scale, base volume and experience to compete effectively in this sector. However, very few operators in the BGA market have the scale to overhaul their engine fleets.
- **Independent** – Independents include firms unrelated to either OEMs or airlines.
- **Airline Third Party**. Providers that are partially or fully owned by airlines and conduct overhauls for their parent company's fleet as well as third-party customers.

Operators perform approximately 18% or \$4.6B of engine overhaul work, the remaining \$21.4B or 82% of engine overhaul is performed by other maintenance providers, the largest of which are OEMs with 44% or \$11.4B of market segment.

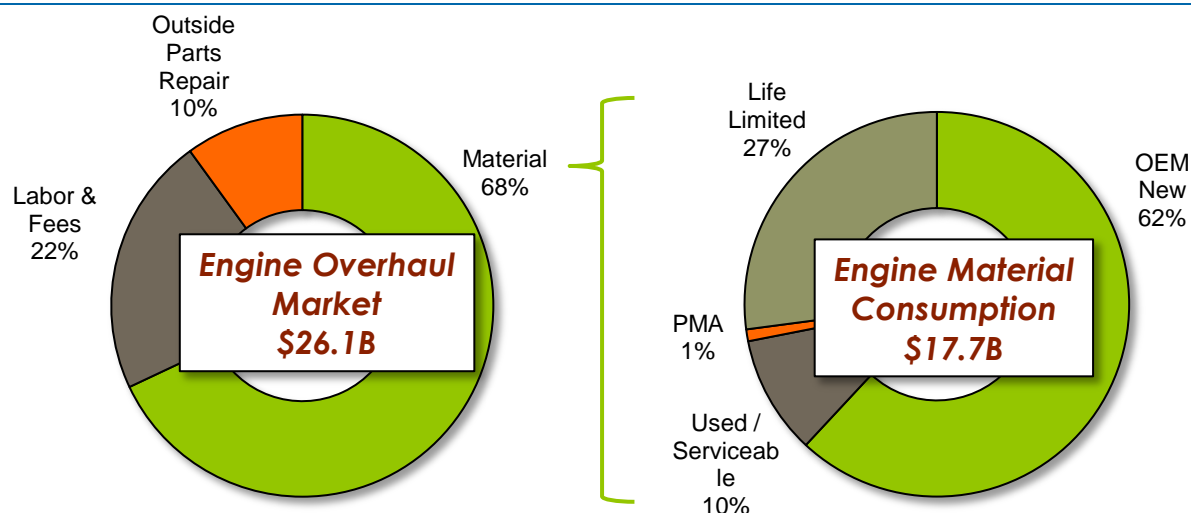
Figure 10: Engine Overhaul Participants

Source: ICF SH&E Analysis

Cost Structure

There are three primary cost elements in engine overhaul – material, labor and repair/specialty services (*Figure 11*).

- Material** - The largest driver of engine overhaul cost is material/parts, accounting for 62% of the total. Material is classified as OEM new spare parts, surplus or Part Manufacturing Approved (PMA) parts. Regardless of who performs the maintenance (operator, independent or OEM), all will use parts acquired from the OEM. In order to reduce costs, airlines may also use surplus/serviceable parts and PMA parts in-lieu of OEM parts. Hence, the material cost declines over the engine life cycle as repairs are developed and surplus material / PMAs become more available. Surplus parts have become a more popular alternative in recent years, and now account for >20% of material consumption in the air transport market.
- Labor** – Labor is the second largest cost item at 22%. Labor includes direct labor to disassemble, inspect, repair, reassemble and test the engines as well as general and administrative overhead and employee benefits. The percentage of certificated technicians varies by type of overhaul facility. For dedicated engine overhaul facilities, approximately 10% of the technicians are certificated.
- Repair/Specialty Services** – Overhaul providers, where possible, seek to refurbish articles rather than purchasing costly new parts. These repairs may be contracted to independent or specialized shops.

Figure 11: Engine Overhaul Cost Structure

Source: ICF SH&E Analysis / Engine Parts Repair Survey

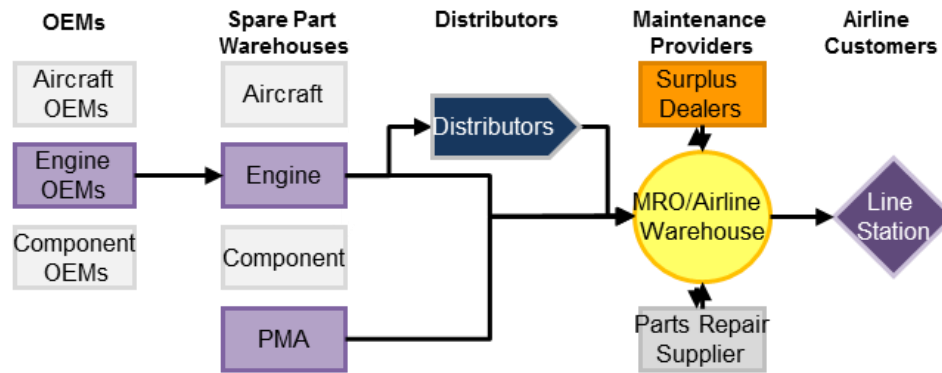
Supply Chain

There are four main sources of supply to engine overhaul shops (*Figure 12*): material/part suppliers, distributors, repair/ specialty service suppliers and labor, the latter being internal to the engine overhaul shop.

- Material suppliers include engine OEMs, PMA suppliers and surplus dealers. Approximately 60% of engine OEMs are domiciled in the US and 38% are domiciled in. The PMA suppliers that represent approximately half the market are all domiciled in the US. Approximately two-thirds of surplus dealers are domiciled in the US. On average, engine overhaul providers work with 10-20 material suppliers including OEMs, PMAs and surplus dealers.
- Material suppliers can sell parts directly to the engine overhaul shop or through a distributor. Engine OEMs typically sell directly to engine overhaul shops – the exception being for old, declining product lines. Major PMA suppliers will sell directly to engine overhaul shops; smaller PMA suppliers typically utilize distributors or major PMA holders for parts distribution. Surplus dealers tend to sell directly to engine overhaul shops. Over 60% of distributors are domiciled in the US. On average, engine overhaul providers work primarily with four to five major distributors and a dozen or so smaller distributors – mostly for hardware and consumables.
- Engine OEMs are key repair/specialty service providers, as are large third-party engine overhaul facilities. Over half of the repair/specialty service providers are domiciled in the US, although many of these providers have facilities all over the world due to the importance of turn-around time for repair/specialty services. On average, engine overhaul providers work with 20-30 certificated part 145 repair/specialty service providers for parts maintenance

Figure 12: Engine Overhaul Supply Chain

activities and four to five non-certificated services for specialty services such machining and plating. Engine overhaul providers focused on BGA utilize smaller number outside suppliers with approximately 10-12 repair / specialty service suppliers.



Source: ICF SH&E Analysis

3.3 COMPONENT MAINTENANCE

Introduction

Aircraft components provide the basic functionality for aircraft including aircraft control & navigation, communications, control surface movement, cabin air conditioning, electrical power, landing gear and braking.

A typical air transport aircraft has hundreds of components from dozens of OEMs. Accordingly, the component MRO market is extremely fragmented. *Figure 13* details the major market segments.

Figure 13: Air Transport Market Component MRO Segments

Market Segment	Maintenance Activities	% Component MRO Costs
Wheels & Brakes	Brake pad, servo valve, wheel maintenance, antiskid maintenance	25%
Avionics	Maintenance of displays, communications equipment, navigation systems, and autopilot	14%
Auxiliary Power Unit	Maintenance of the aircraft's auxiliary power unit including accessories	9%
Fuel Systems	Maintenance of engine fuel controls and aircraft fuel systems	8%
Thrust Reversers	Maintenance of aircraft thrust reversers, including actuation and surfaces	6%
Landing Gear	Maintenance of aircraft's landing gear systems	6%
Equipment/Furnishings	Maintenance of removable items of equipment and furnishings externally mounted on the aircraft or contained in the flight and passenger components	5%
Flight Controls	Maintenance of primary and secondary flight control actuators	4%
Hydraulic Power	Maintenance of hydraulic pumps and conveyance hardware	3%
Electrical	Maintenance of electrical generation and distribution systems	3%
Other	Maintenance of myriad other systems including environmental control, in-flight entertainment, safety, water & waste, and pneumatics	17%

Source: ICF SH&E Analysis

Wheels & brakes is typically the largest category of component maintenance spending on most aircraft, accounting for 25%. This is attributable to the significant wear and tear from multiple daily landings as well as the exotic materials such as carbon composite brake pads that provide light weight and heat dissipation properties.

Flight deck avionics is the second largest component MRO category. Avionics comprise several major subsystems including cockpit displays, communications equipment, navigations systems, and autopilot. Dozens of “black boxes” are required. Avionics account for 14% of a typical aircraft’s component maintenance costs, and even higher for business jets.

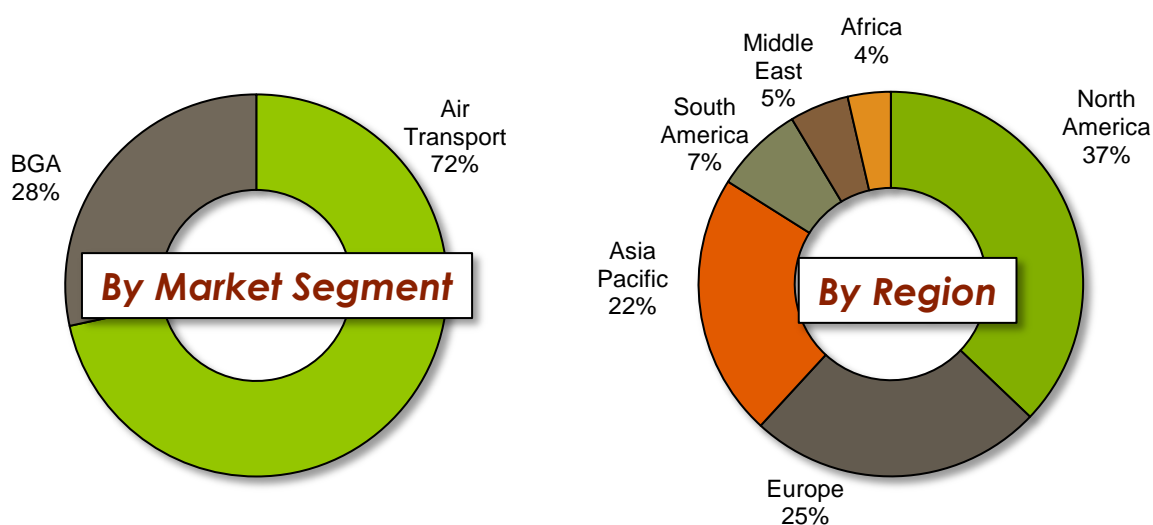
The third largest component maintenance spend category is on auxiliary power units (APU). The APU is an installed gas turbine, which provides electric power, engine starting and cabin cooling functionality.

Beyond these three major categories are several important maintenance segments: fuel systems (8% of total component maintenance spending), thrust reversers (6%), landing gear (6%), equipment and furnishings (5%), flight controls (4%), hydraulics (3%), and electrical systems (3%).

Market Description

The civil component MRO market is as estimated \$16.8B. Air transport is the largest segment at \$12.0B or 72% of the total component overhaul market with BGA comprising the remaining 28%.

Figure 14: 2012 Global Civil Component MRO Market (\$16.8B)



Source: ICF SH&E Analysis

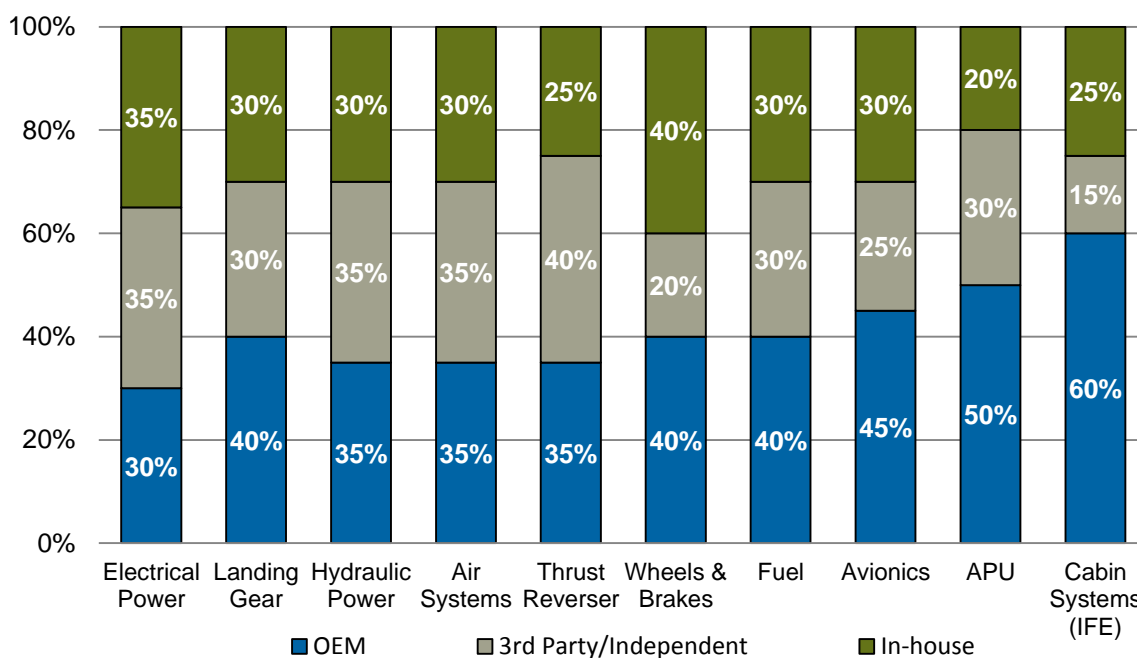
Thirty seven percent of component maintenance demand originates from aircraft operators in North America. Europe is the second largest market (25%), followed by Asia-Pacific (22%), South America (7%), Middle East (5%) and Africa (4%).

There are four types of maintenance providers in component MRO activities:

- **OEMs** – Component OEMs are major players; beyond basic repair activities, OEMs also sell service parts and refurbish piece parts. Most OEMs focus exclusively on repair of their own equipment.
- **Operator** – Airlines with in-house component maintenance capability.
- **Airline Third Party.** Often an airline's internal operations provide third-party MRO services to improve their revenues and margins.
- **Independent** – There are numerous independent providers serving the global.

MRO market shares of each component category reflect the underlying economics of repair activities as well as the competitiveness of each provider group.

Figure 15: Component Market Shares by Supplier Category



Source: ICF SH&E Analysis

Overall, operators perform approximately 30% of component maintenance; OEMs have a slightly larger share (35%), and for APUs and avionics control approximately half of the market. Airlines third party shops and independents have the remaining 35% of the market.

Airlines that perform component MRO tend to perform work on the fast moving components that require minimal capital expenditure with a relatively high proportion of labor.

Third party MROs have a larger share, by default, of the components that are suitable for broad support contracts. Independents can excel in components with high labor costs since the labor rate is often lower than OEMs and operators.

OEM's have a higher proportion of capital intensive components requiring costly testing and intellectual property. Their share of new technology components will also be relatively high until the product matures.

Cost Structure

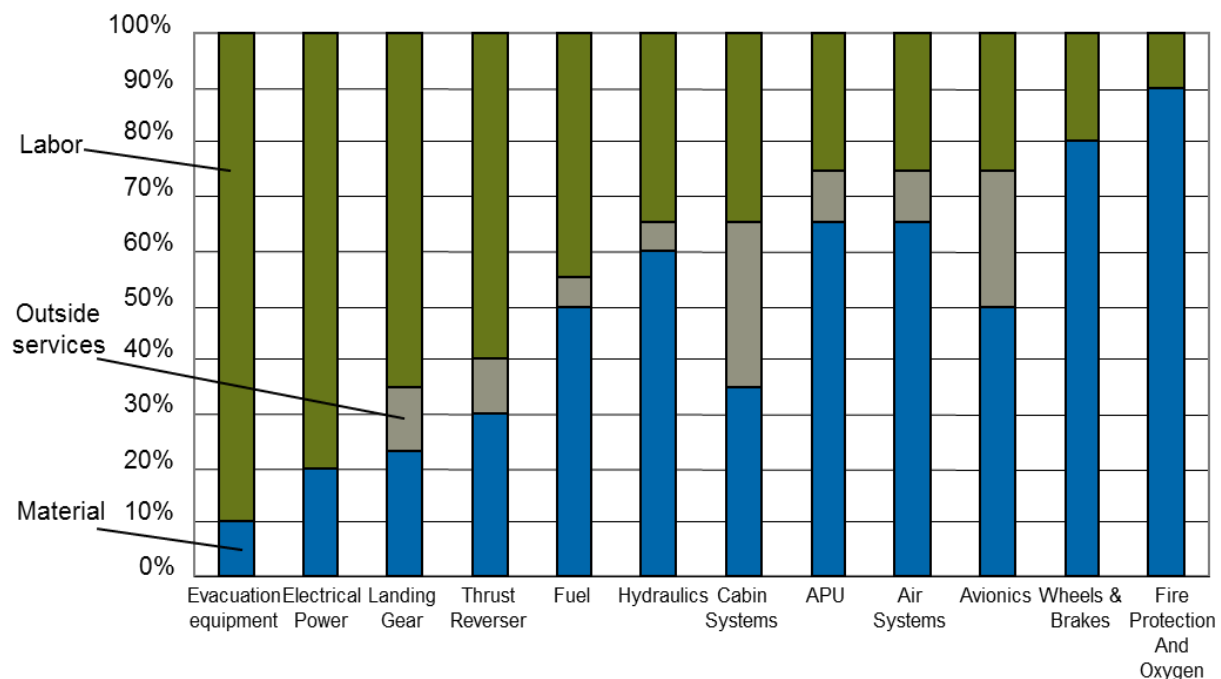
While the cost structure of component maintenance varies considerably by component type, like engine maintenance; the three major cost elements are material, labor and repair/ specialty services.

The material in component MRO comprises service parts from OEMs, surplus dealers and PMA suppliers as well as hardware obtained through distributors. OEMs generally have a very high market share for service parts – typically 90% or more – but for older, mature equipment with significant surplus parts availability, OEM market shares can be 70% or less. Usage of PMA parts for component maintenance, currently two percent overall, continues to expand.

The other two elements of component MRO are labor and specialty services. Labor is required to inspect, disassemble, repair, reassemble and test components. A typical component MRO facility will have a 50:50 mix of certificated and non-certificated technicians. Specialty services include processes such as plating, coating, machining, avionics card repair, and specialty testing.

The cost structure of major component categories is shown in *Figure 16*. The most labor intensive activities are shown on the left hand side of the chart including electrical power, landing gear, thrust reverser repair, and fuel systems; the least labor intensive include wheels and brakes, avionics, and APUs; all of these categories are heavily dependent on material and outside services (e.g., card repair for avionics). Overall, labor is approximately 35% of component MRO spending; materials 60%, and outside services 5%.

Components with a higher proportion of materials may provide higher margins. High material content repairs may benefit OEMs that have greater ability to influence spares pricing and develop work scopes to minimize spares usage. However, components with high material content may be at a greater risk to PMA development especially if spares are high priced and availability is poor.

Figure 16: Typical Component MRO Cost Structure by Category

Source: ICF SH&E Analysis

The cost structure of component repair can be influenced by the provider type. OEMs generally prefer to maximize usage of their own service parts in lieu of alternate material sources and labor. In contrast, independent MRO suppliers seek to minimize purchases of service parts from OEMs and, where possible, develop repairs for parts with designated engineering representatives (DER). Most independents believe that internal parts repair capability increases margins and enhances operational control due to reduced dependence on OEM service parts availability.

Supply Chain

There are several important categories of suppliers to component maintenance facilities (see *Figure 17*): parts suppliers, distributors, and repair/specialty service suppliers.

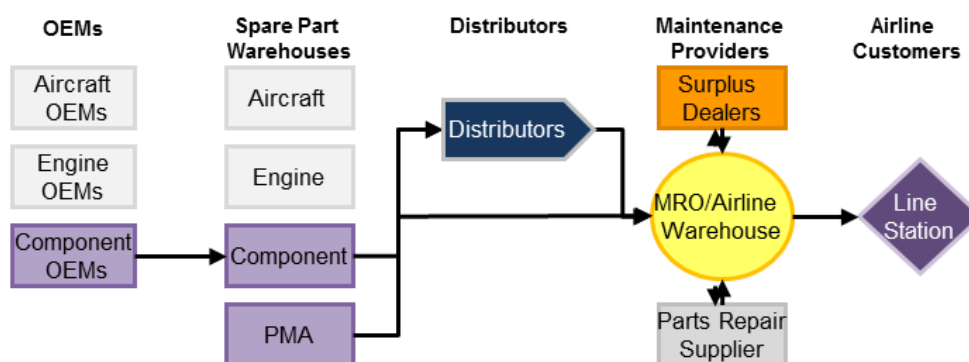
Material suppliers include component OEMs (including hardware manufacturers), PMA suppliers and surplus dealers. Approximately 60% of component OEMs listed previously are domiciled in the US. The vast majority of PMA firms are US-based. Finally, there are multiple surplus dealers supporting the component MRO supply chain; approximately two-thirds of which are domiciled in the US.

Like the engine overhaul supply chain, major material suppliers sell directly to overhaul shops while smaller suppliers typically sell through distributors. Distributors typically sell hardware, consumables and service parts made by smaller OEMs. Over 60% of distributors are domiciled in the US.

Finally there are thousands of specialty service providers that support component MRO facilities with services ranging from plating, machining, coating, parts repair, brazing, and inspection. ICF SH&E believes that 50-60% of these suppliers are based in the US.

The number of suppliers that support an individual component MRO facility varies greatly; a facility focused on a narrow product range might deal with 20-40, while a facility servicing a broad range of components will have a base in excess of 100 suppliers.

Figure 17: Engine Overhaul Cost Structure



Source: ICF SH&E Analysis

3.4 LINE MAINTENANCE

Introduction

Line Maintenance includes light checks plus day-to-day operational maintenance that is carried out to ensure that the aircraft remains in operational readiness, including trouble shooting, defect rectification, and component replacement. Technicians diagnose and correct faults on the aircraft on an ad-hoc basis and carry out minor and major aircraft checks on a scheduled interval basis. Line maintenance consists of three primary activity categories: Transit checks, Daily/Weekly checks and A-checks. For business and general aviation (BGA), line maintenance is captured in airframe heavy maintenance (Section 3.1).

Figure 18: Line Maintenance Overview

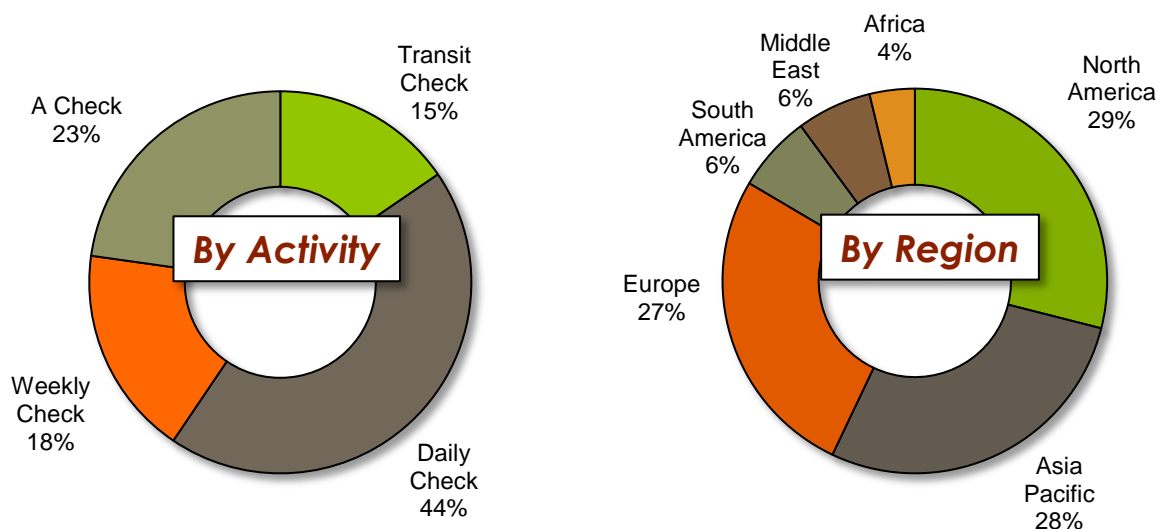
Activity	Description	Frequency	Labor Input	Typical Cost
Transit checks	<ul style="list-style-type: none"> Transit checks sometimes also described as turn-round check Consists of specific visual checks ("walk-round"), review of check log and defects, and where needed, defect rectification and trouble-shooting For long-haul operations, this also will include tasks for ETOPS clearance 	Every flight cycle	1 – 4 labor hours	\$75 to \$350 per flight cycle
Daily/Weekly checks	<ul style="list-style-type: none"> Daily checks at intervals of 24-36 hours, sometimes described as overnight checks Weekly checks include 7/8day checks and 3/4day checks Additional work may be specified for the aircraft downtime by the maintenance planners e.g., defect rectification, out-of-phase checks Increasingly this downtime is also used for IFE and cabin maintenance 	Daily: 24-36 hours (occasionally 48 hours) Weekly: 4-8 Days	Daily: 5 -10 labor hours Weekly: 10 – 30 labor hours	\$150 to \$500 per day
A-checks	<ul style="list-style-type: none"> Typically conducted at a few main bases within the airline network. Additional work may be specified for the aircraft downtime by the maintenance planners e.g., defect rectification, out-of-phase checks Increasingly this downtime is also used for IFE and cabin maintenance 	Regional: 350-500 FH Narrowbody & Widebody: 500-700 FH	Regional: 100-250 labor hours Narrowbody & Widebody: 250-500 labor hours	\$15 to \$50 per flight hours

Source: ICF SH&E Analysis

Market Description

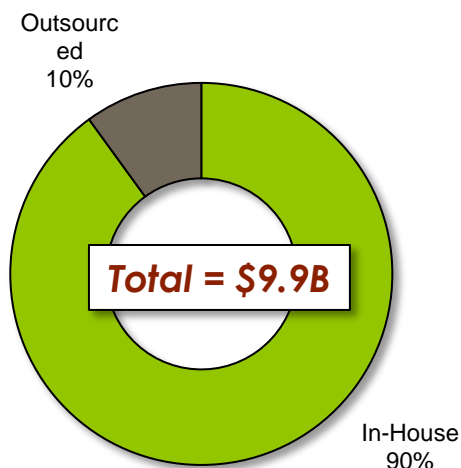
The civil line maintenance market is estimated at \$9.9B. Daily/Weekly check is the largest segment at 62% of the market, due largely to the frequency of such checks. North America is the largest market, generating \$2.9B of the total demand, followed closely by Asia Pacific, including India and China, estimated at \$2.8B. Europe is the third largest market at \$2.6B.

Figure 19: 2012 Global Civil Line Maintenance Market (\$9.9B)



Source: ICF SH&E Analysis

Line maintenance is seen as critical to on-time performance and therefore a “core business” for airlines. Hence, 85%-90% of line maintenance is performed by operators. When airlines do use contract maintenance, it is typically at airports where they do not have sufficient operations to justify a dedicated line station; high growth, low volume international airlines are more likely to use contract line maintenance in order to manage growth; this is particularly the case for new stations where they have little volume or experience or requires quick implementation.

Figure 20: 2012 Global Civil Line Maintenance Supply

Source: ICF SH&E Analysis

Given its importance to operational reliability, line maintenance provider selection is mostly focused on proven experience and expertise on type. At outstations, preferred contractors will have spares available on-site or close by to reduce the risk of long Aircraft On Ground (AOG) situations. For A-checks, man-hour rates and turn-time reliability are vital – to keep costs competitive and to ensure the aircraft is available for scheduled service at the expected time. Line maintenance effectiveness is as good as the technicians trouble shooting skills and spare parts flow.

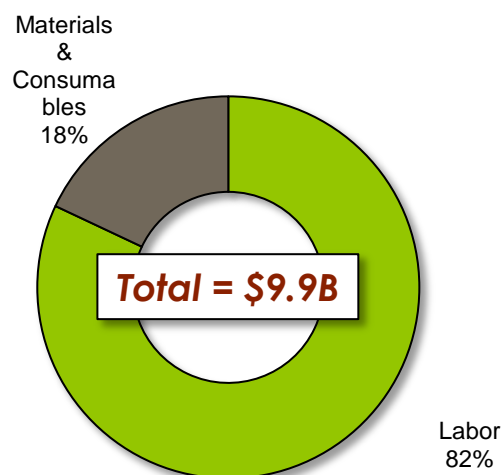
Line maintenance is a small portion of the BGA MRO market and is included in the airframe heavy maintenance figures for this analysis.

Cost Structure

There are two primary cost drivers in line maintenance (*Figure 21*) - labor and material.

Labor – Labor is the dominant component of line maintenance cost, accounting for 80-85% of the total. Labor includes direct labor required to inspect, troubleshoot, remove LRUs and engines as required, as well as general and administrative overhead and employee benefits. Over 98% of line maintenance technicians are certificated.

- **Material** – Material is typically 15-20% of the cost of line maintenance and primarily consists of expendables and consumables, such as fasteners, brackets, solvents, etc.

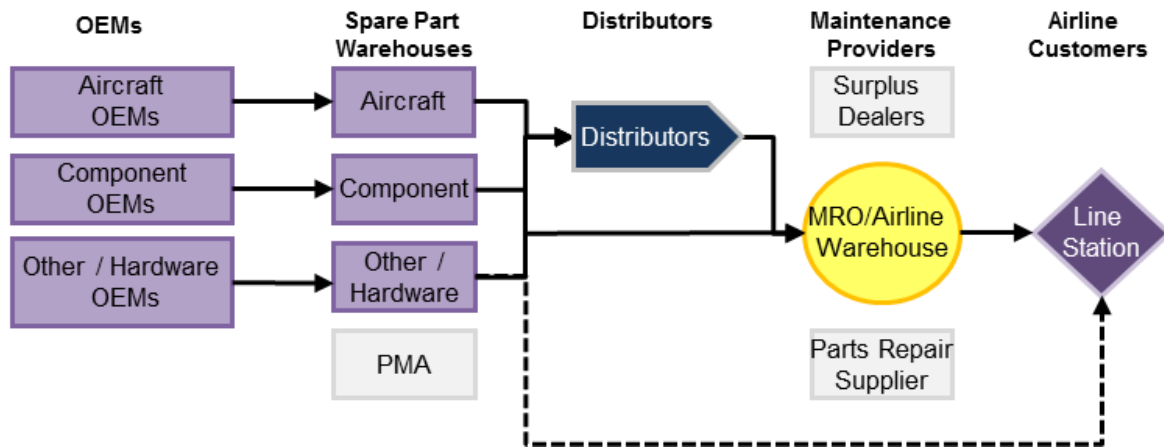
Figure 21: 2012 Global Civil Line Maintenance Supply

Source: ICF SH&E Analysis

Supply Chain

There are three main supply sources for line maintenance (*Figure 22*): part suppliers, distributors, and labor (internal to the facility itself).

- There are several primary sources for parts: Aircraft OEMs, component OEMs and other suppliers/hardware providers. "Other" material suppliers include dozens of chemical and solvent suppliers. On average, line maintenance providers work with less than five aircraft OEMs, and hundreds of component OEMs and hardware suppliers.
- Distributors are a common intermediary between parts suppliers and airline warehouses and line stations. An estimated 60% of distributors are domiciled in the US. Line maintenance providers typically work with 5-6 major distributors and a dozen or so smaller distributors for hardware and consumables.

Figure 22: 2012 Global Civil Line Maintenance Supply

Source: ICF SH&E Analysis

4 GLOBAL MRO ECONOMY ACTIVITY & IMPACT

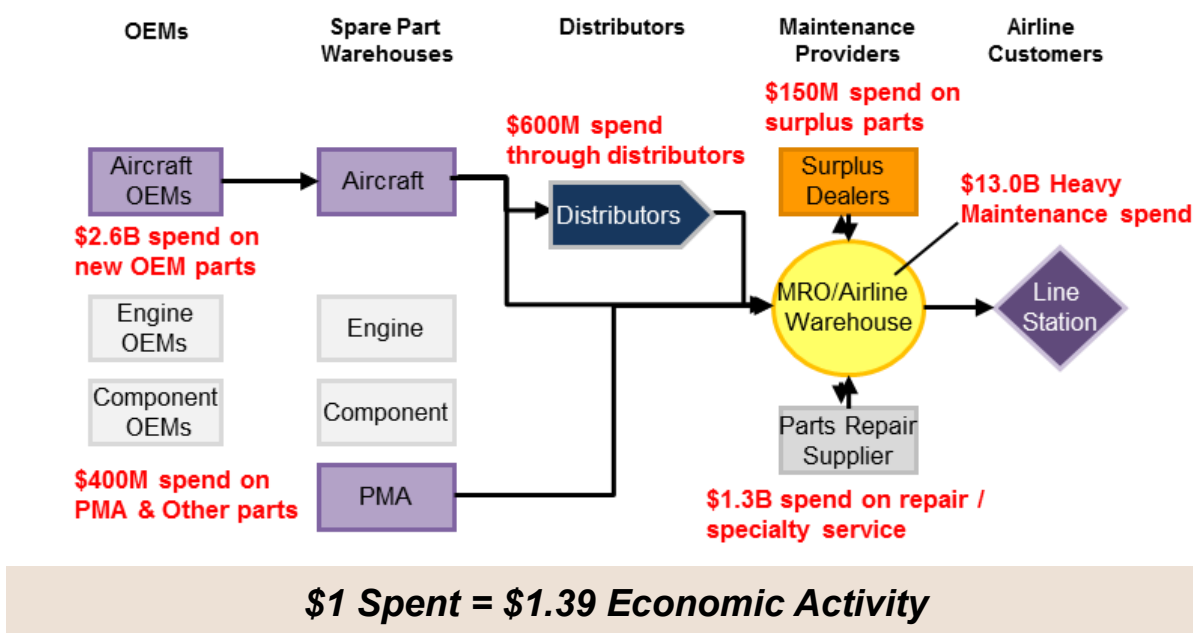
4.1 ECONOMY ACTIVITY

Heavy Airframe Maintenance

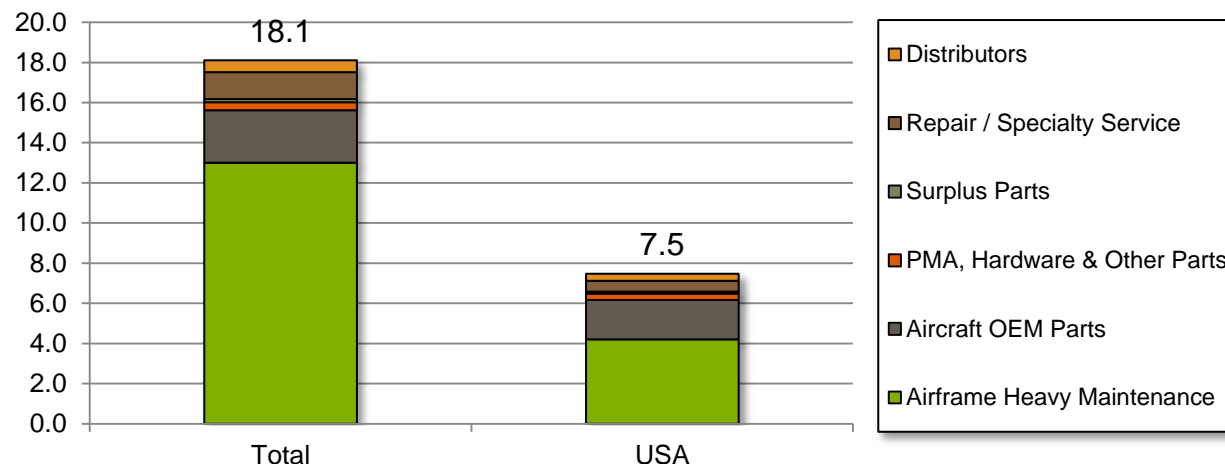
Globally, operators spend \$13.0B on heavy airframe maintenance which generates \$18.1B in overall economic activity (*Figure 23*). Every dollar spent on heavy airframe maintenance generates \$1.39 in economic activity. Of the \$18.1B of global economic activity, the US generates \$7.5B (*Figure 24*).

Heavy airframe maintenance material consumption is the largest economic activity outside of the service; approximately \$2.6B per year is spent on material globally and over 75% of this figure is with suppliers domiciled in the US, or approximately \$2.0B annually. Repair/specialty service and distribution generate \$1.3B and \$600M respectively; approximately half of the suppliers are domiciled in the US.

Figure 23: Economic Activity Generated By Airframe Heavy Maintenance



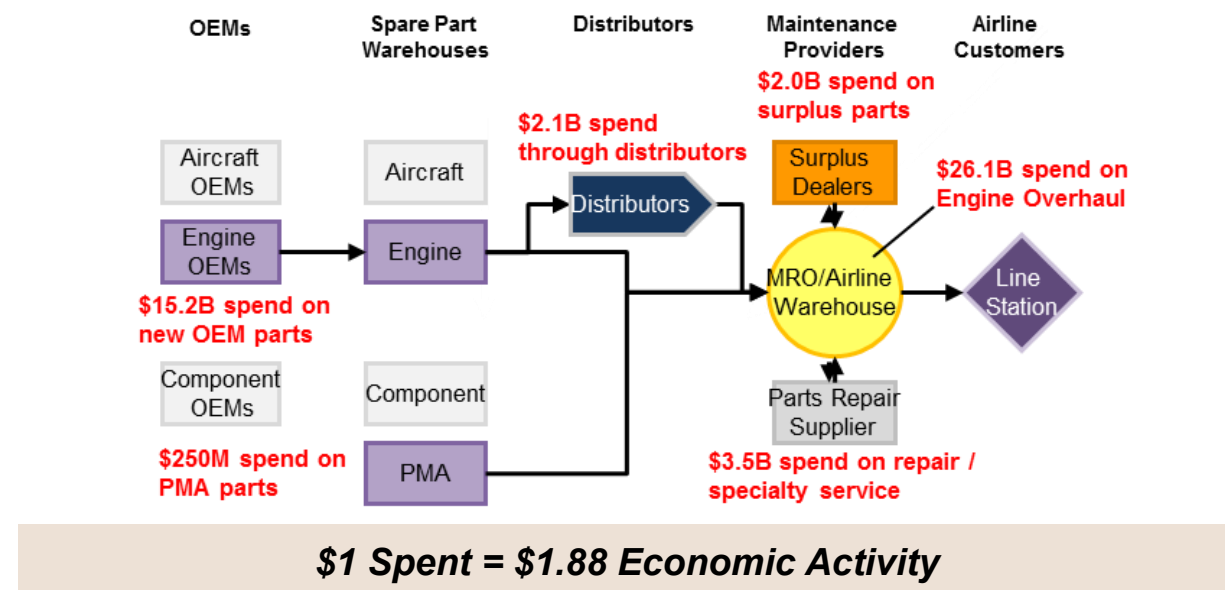
Source: ICF SH&E Analysis

Figure 24: Role of US In The Airframe Heavy Maintenance Supply Chain (\$B)

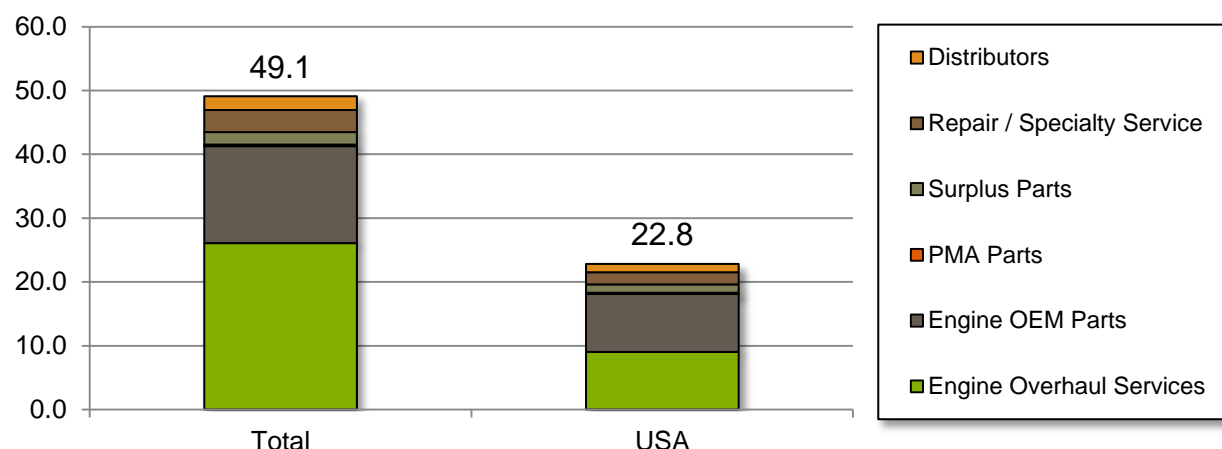
Source: ICF SH&E Analysis

Engine Overhaul

Globally, \$26.1B is spent on engine overhaul services which generates \$49.1B in overall economic activity (Figure 25). Every dollar spent on engine overhaul services generates \$1.88 in economic activity. Of the \$49.1B of global economic activity, the US generates \$22.8B (Figure 26). Engine MRO material consumption is the largest economic activity outside of the service itself; over \$17B per year is spent on material globally and over 60% of the spend is with suppliers domiciled in the US (or approximately \$10.6B annually). Repair/specialty service and distribution generate \$3.5B and \$2.1B respectively, approximately 60% with suppliers domiciled in the US.

Figure 25: Economic Activity Generated By Engine Overhaul

Source: ICF SH&E Analysis

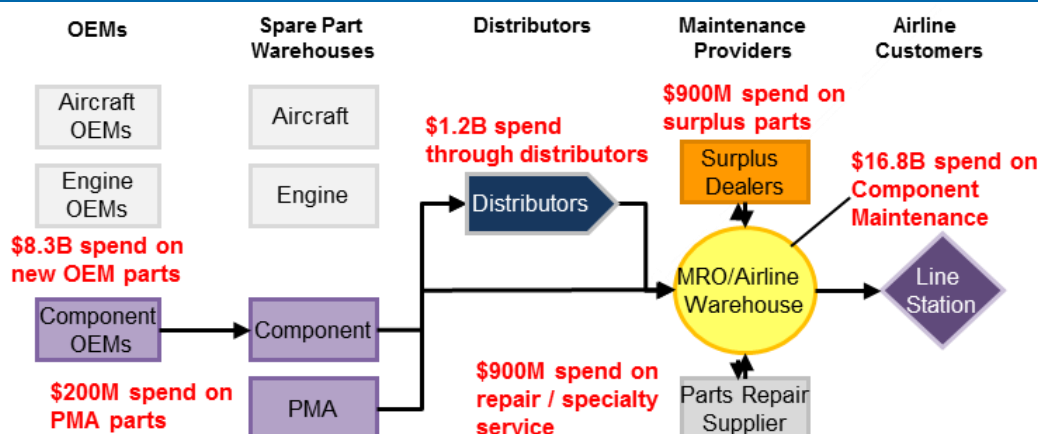
Figure 26: Role of US In The Engine Overhaul Supply Chain (\$B)

Source: ICF SH&E Analysis

Component Maintenance

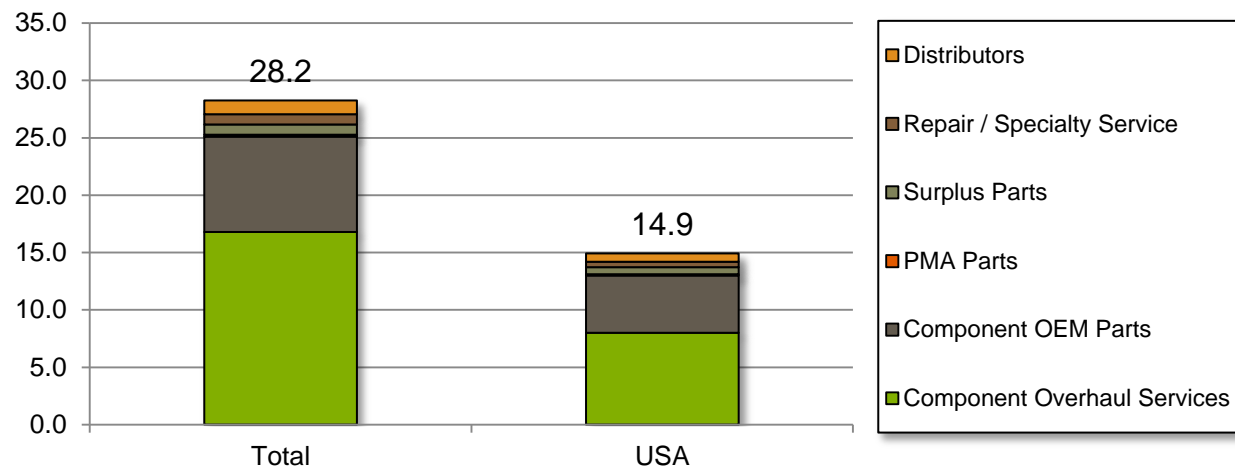
Globally, \$16.8B is spent on component MRO services which generates \$28.2B in overall economic activity. Beyond the \$16.8B accrued by MRO facilities, there is another \$8.3B spent on service parts from OEMs, \$1.2B from distributors, \$900M specialty suppliers, \$900M from surplus dealers, and \$200M from PMA parts suppliers. In aggregate, every dollar spent on component MRO services generates \$1.68 in economic activity.

The U.S. plays a prominent role in component MRO activity (*Figure 28*) as a consequence of its large air transport and BGA fleets and its high concentration of component OEMs. Overall, US suppliers account for an estimated \$14.9B of the \$28.2B in total economic activity – 50% of the total.

Figure 27: Economic Activity Generated By Component Maintenance

\$1 Spent = \$1.68 Economic Activity

Source: ICF SH&E Analysis

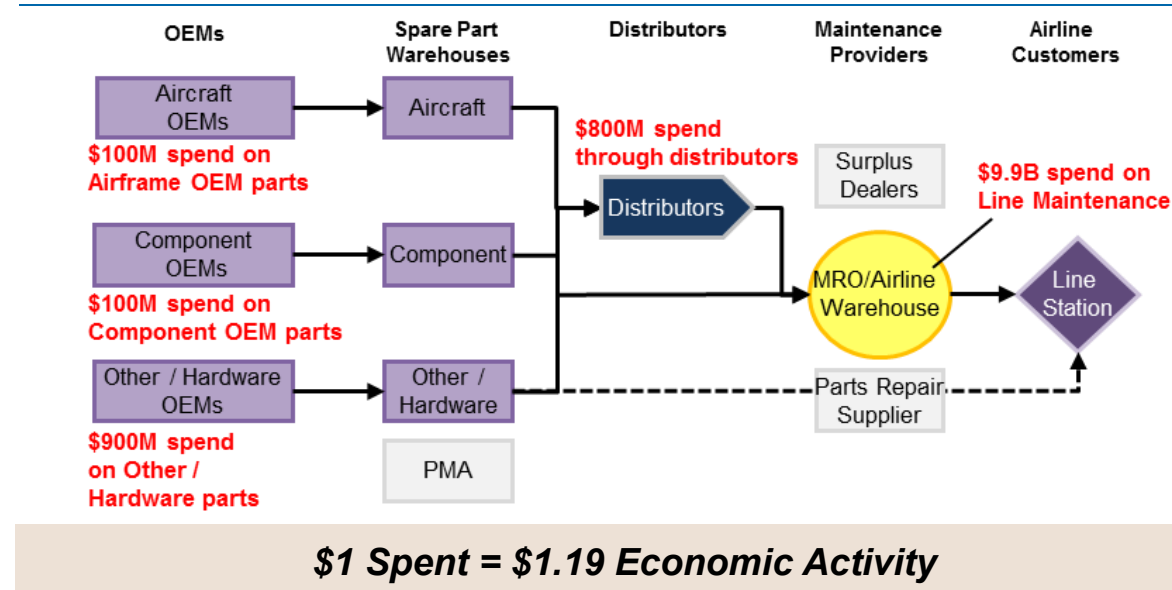
Figure 28: Role of US In The Engine Overhaul Supply Chain (\$B)

Source: ICF SH&E Analysis

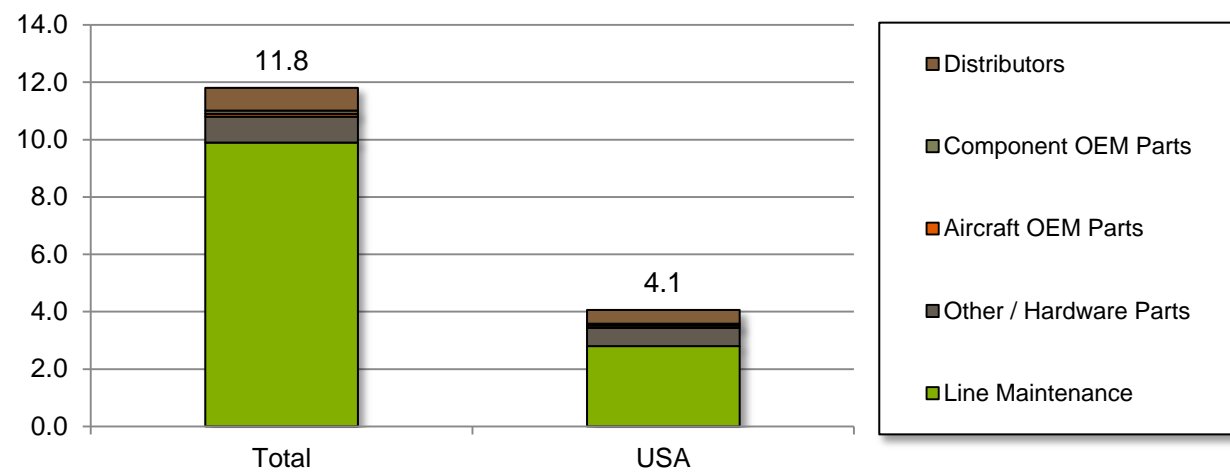
Line Maintenance

Globally, operators spend \$9.9B on line maintenance which generates \$11.8B in overall economic activity (Figure 29). Every dollar spent on line maintenance generates \$1.19 in economic activity. Of the \$11.8B of global economic activity, the US generates \$4.1B (Figure 30).

Line maintenance material consumption is the largest economic activity outside of labor; approximately \$1.1B per year is spent on material globally and approximately 70% of the spend is with suppliers domiciled in the US or approximately \$700M annually. Distribution generates \$800M; approximately 60% of suppliers are domiciled in the US.

Figure 29: Economic Activity Generated By Line Maintenance

Source: ICF SH&E Analysis

Figure 30: Economic Activity Generated By Line Maintenance

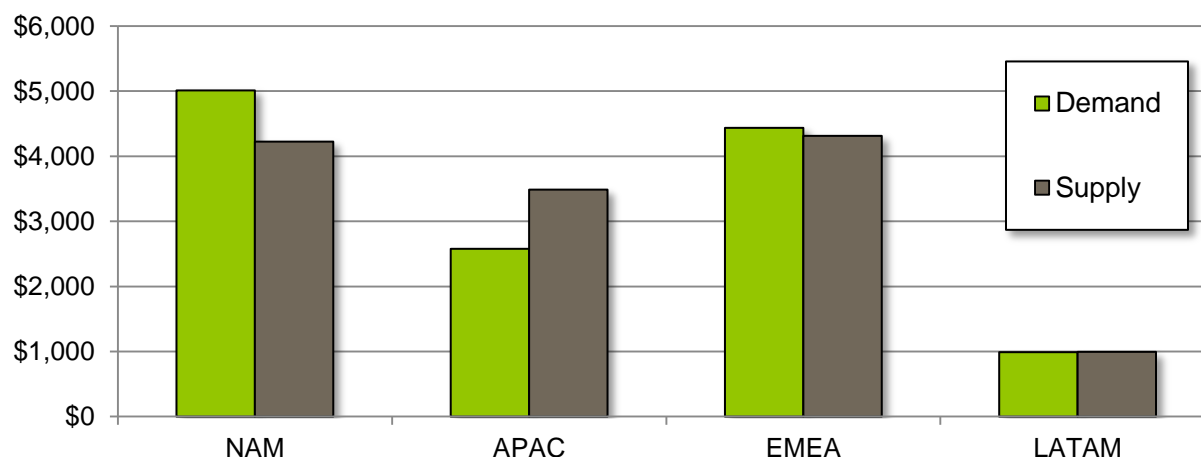
Source: ICF SH&E Analysis

4.2 BALANCE OF TRADE

Heavy Airframe Maintenance

North American (NAM) operators generate \$5.0B (Figure 31) of heavy airframe maintenance demand – over 75% is performed by providers domiciled in North America (Figure 32); Approximately \$1.1B of heavy airframe maintenance is performed in regions outside North America and an additional \$344M is conducted for other regions – resulting in a total of \$4.2B of heavy airframe maintenance performed by North American airframe heavy maintenance providers. Asia-Pacific (APAC) is a net exporter of heavy airframe maintenance; APAC operators generate \$2.6B of demand – nearly 95% of which is domiciled in APAC with an additional \$1.1B supplied to other regions.

Figure 31: Airframe Heavy Maintenance Supply & Demand (\$M)



Source: ICF SH&E Analysis

Figure 32: Heavy Airframe Maintenance Intra-Region Flow

Market Segment	Demand By Operator Region		Supplier Region			
			NAM	APAC	EMEA	LATAM
Air Transport	NAM	\$2,972	67%	24%	4%	5%
	APAC	\$2,185	1%	96%	3%	0%
	EMEA	\$3,425	1%	9%	90%	1%
	LATAM	\$498	5%	4%	2%	89%
B&G	NAM	\$2,041	93%	1%	4%	2%
	APAC	\$395	14%	80%	5%	1%
	EMEA	\$1,010	10%	1%	88%	1%
	LATAM	\$492	25%	0%	10%	65%

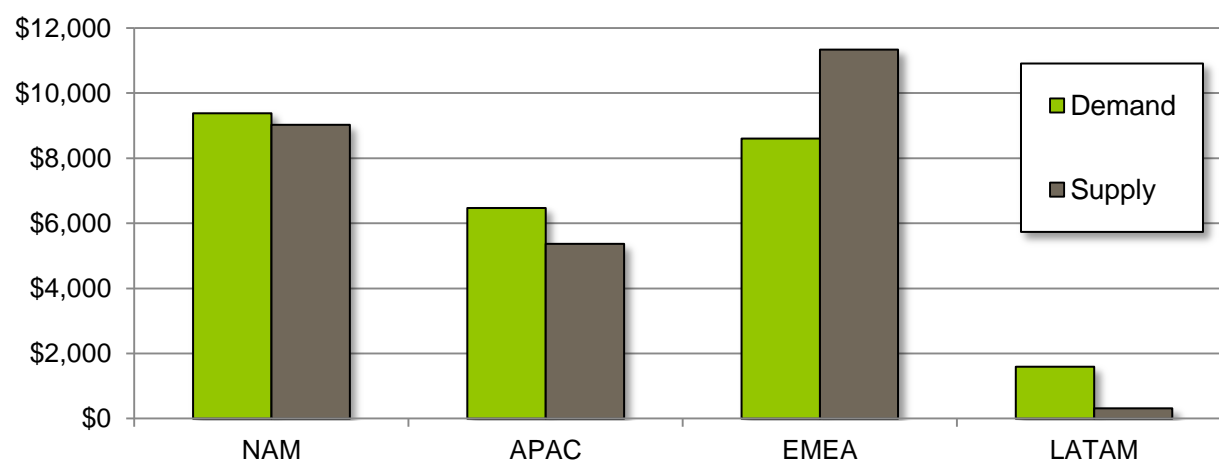
Source: ICF SH&E Analysis

Engine Overhaul

North America generate \$9.4B (*Figure 33*) of engine overhaul demand – about 70% of this work is performed by providers domiciled in North America (*Figure 34*); approximately \$2.9B of work is sent to regions outside North America and an additional \$2.6B of is performed for other regions – resulting in a total of \$9.0B of engine overhaul work performed by North American engine overhaul providers. Europe, Middle East, and Africa (EMEA) operators generate \$8.6B of engine overhaul demand – about 13% of the work or \$1.1B flows to North America.

Figure 33: Engine Overhaul Supply & Demand (\$M)

Figure 34: Engine Overhaul Intra-Region Flow



Source: ICF SH&E Analysis

Market Segment	Demand By Operator Region		Supplier Region			
			NAM	APAC	EMEA	LATAM
Air Transport	NAM	\$7,337	65%	4%	29%	1%
	APAC	\$6,163	6%	70%	23%	0%

Business & General Aviation	EMEA	\$7,705	10%	8%	81%	1%
	LATAM	\$1,164	50%	4%	42%	4%
	NAM	\$2,043	82%	1%	15%	2%
	APAC	\$309	60%	14%	25%	1%
	EMEA	\$903	37%	1%	60%	2%
	LATAM	\$435	60%	1%	25%	14%

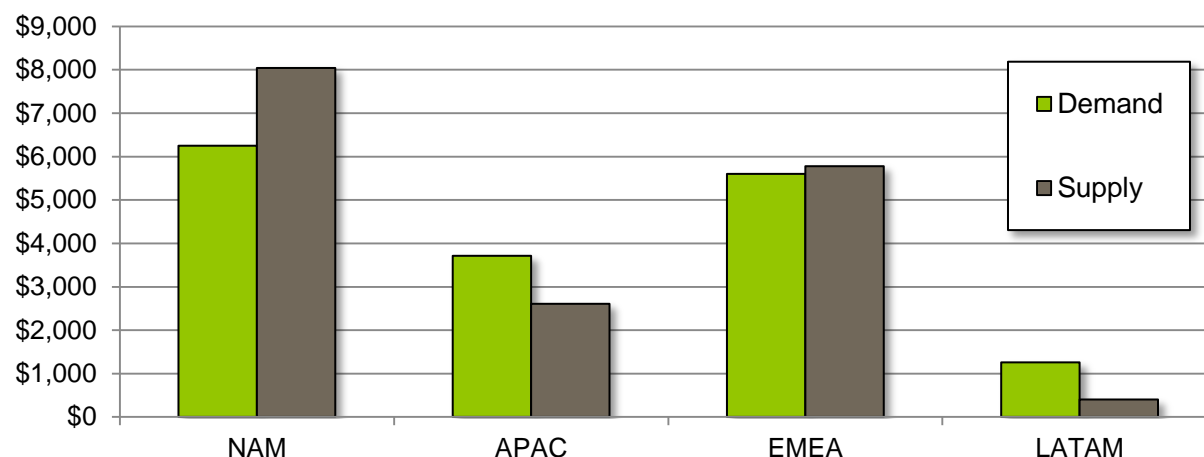
Source: ICF SH&E Analysis

Component Maintenance

The component MRO market is indeed global, as most components are relatively easy to package and ship. The intra-region flow is also shaped by the location of suppliers. The U.S. has the highest density of component OEMs and has a 50% share of the installed base. As a result, the U.S. has a deep concentration of OEM service centers. In contrast, Europe has many leading component OEMs as well as a very strong base of airline third-party and independent MROs. As a result, North American and European are net exporters of component MRO.

As *Figures 35 and 36* demonstrate, the North American market is a net exporter of \$1.8B in component maintenance work; in region operators generate an estimated \$6.2B of component MRO demand with in region providers capturing \$8.0B of revenue. APAC and Latin America (LATAM) are net importers of component maintenance.

Figure 35: Component Maintenance Supply & Demand (\$M)



Source: ICF SH&E Analysis

Figure 36: Component Maintenance Intra-Region Flow

Market Segment	Demand By Operator Region		Supplier Region			
			NAM	APAC	EMEA	LATAM
Air Transport	NAM	\$3,848	80%	4%	15%	1%
	APAC	\$3,200	20%	65%	15%	0%
	EMEA	\$4,316	15%	5%	80%	0%
	LATAM	\$681	50%	2%	15%	33%

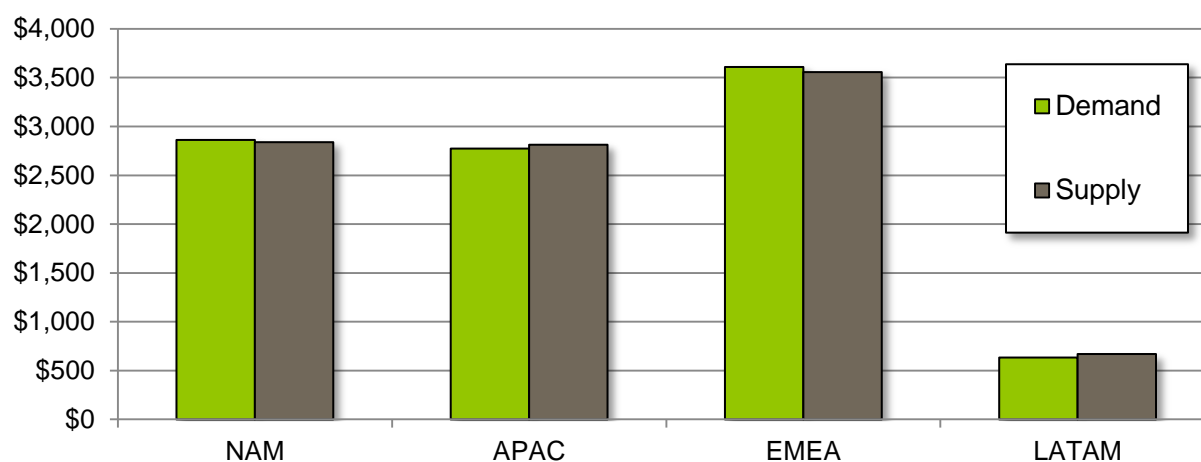
Business & General Aviation	NAM	\$2,399	93%	1%	5%	1%
	APAC	\$515	54%	20%	25%	1%
	EMEA	\$1,287	37%	1%	60%	2%
	LATAM	\$576	60%	1%	25%	14%

Source: ICF SH&E Analysis

Line Maintenance

North American operators generate \$3.36B (Figure 37) of line maintenance demand –97% is performed by providers domiciled in North America (Figure 38); Approximately \$93M of line maintenance is performed in regions outside North America and an additional \$72M is done for airlines from other regions – resulting in a total of \$2.8B for North American line maintenance providers. EMEA operators generate \$3.6B of line maintenance demand – 97% of which is domiciled in EMEA.

Figure 37: Line Maintenance Supply & Demand (\$M)



Source: ICF SH&E Analysis

Figure 38: Line Maintenance Intra-Region Flow

Market Segment	Demand By Operator Region		Supplier Region			
			NAM	APAC	EMEA	LATAM
Air Transport	NAM	\$2,861	96.7%	1.0%	1.6%	0.7%
	APAC	\$2,775	0.9%	98.2%	0.9%	0.0%
	EMEA	\$3,609	1.2%	1.7%	96.5%	0.6%
	LATAM	\$634	0.6%	0.1%	0.5%	98.8%

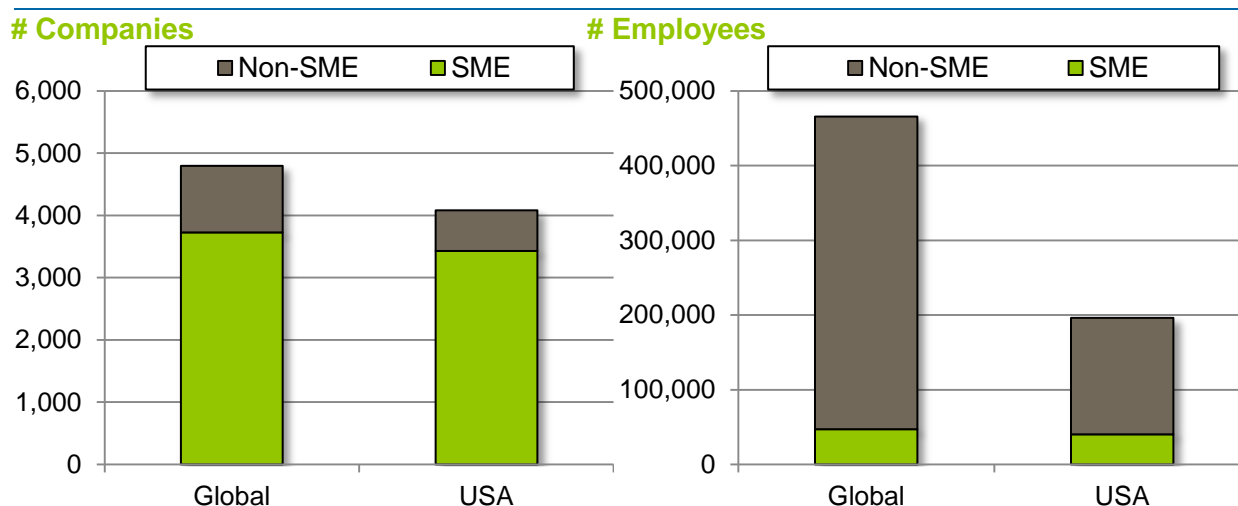
Source: ICF SH&E Analysis

5 AVIATION MAINTENANCE INDUSTRY EMPLOYMENT & ECONOMIC IMPACT

5.1 GLOBAL CIVIL AVIATION MRO EMPLOYMENT

There are approximately 466,000 employees from some 4,800 firms worldwide participating in the civil MRO market. Nearly 80% of firms are SMEs. Globally, there are about 277,000 technicians – 22% of which are certificated. In the USA, there are nearly 4,100 firms with 196,000 employees in the civil MRO market. SMEs comprise 84% of all firms and account for 21% of all employees. There are over 143,000 technicians in the USA and approximately 36% are certificated.

Figure 39: Civil Aviation MRO Companies & Employment

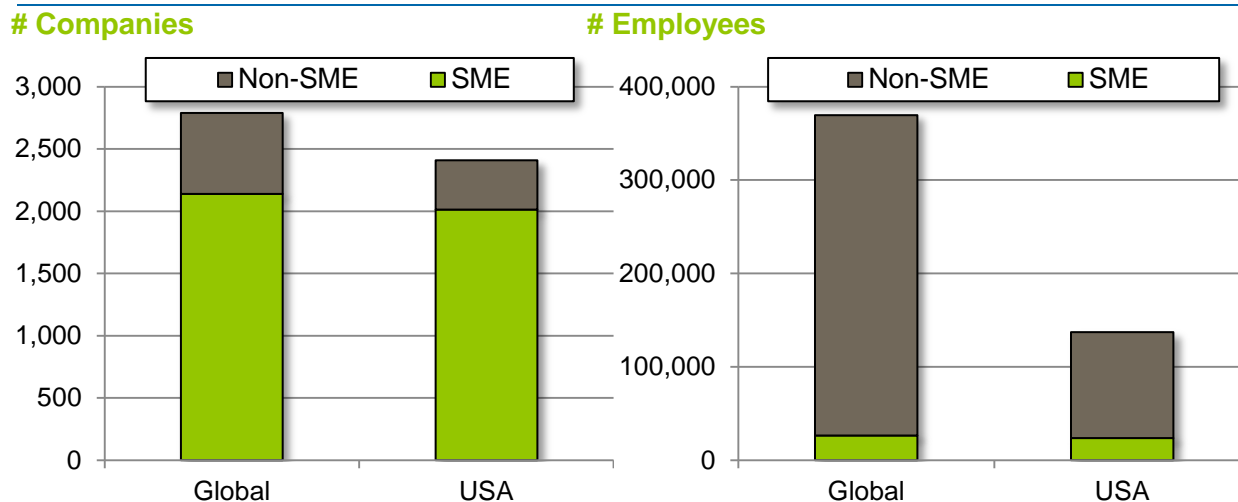


Source: FAA / ICF SH&E Analysis

Heavy Airframe Maintenance

Heavy airframe maintenance facilities employ 369,000 employees within 2,788 companies (Figure 40); nearly 80% are SMEs, which employ over 26,000 people worldwide. In the US, there are 137,124 employees in the heavy airframe maintenance supply chain within 2,406 companies; nearly 85% of the providers in the US are SMEs – employing nearly 24,000 people.

According to the FAA, there are 217,971 technicians engaged in heavy airframe maintenance, with nearly 30% being FAA certificated individuals. In the US, there are 102,857 technicians – approximately 57% or 58,561 are FAA certificated.

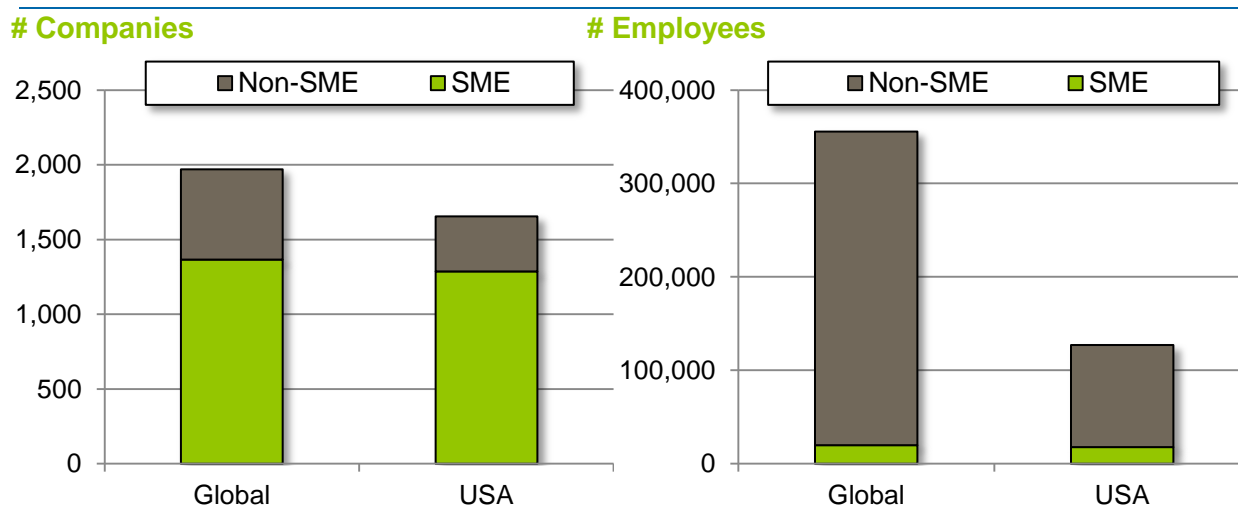
Figure 40: Airframe Heavy Maintenance Employment

Source: FAA / ICF SH&E Analysis

Engine Overhaul

The global engine overhaul supply chain employs 355,648 employees within 1,970 companies (Figure 41); approximately 70% are SMEs, employing nearly 19,738 people worldwide. In the US, there are 127,298 employees in the engine overhaul supply chain within 1,656 entities; nearly 80% are SMEs – employing nearly 18,000 people.

Globally, there are 208,966 technicians in the engine overhaul supply chain, around 30% of whom are FAA certificated. In the US there are 95,701 technicians – approximately 57% or 54,600 are FAA certificated.

Figure 41: Engine Overhaul Employment

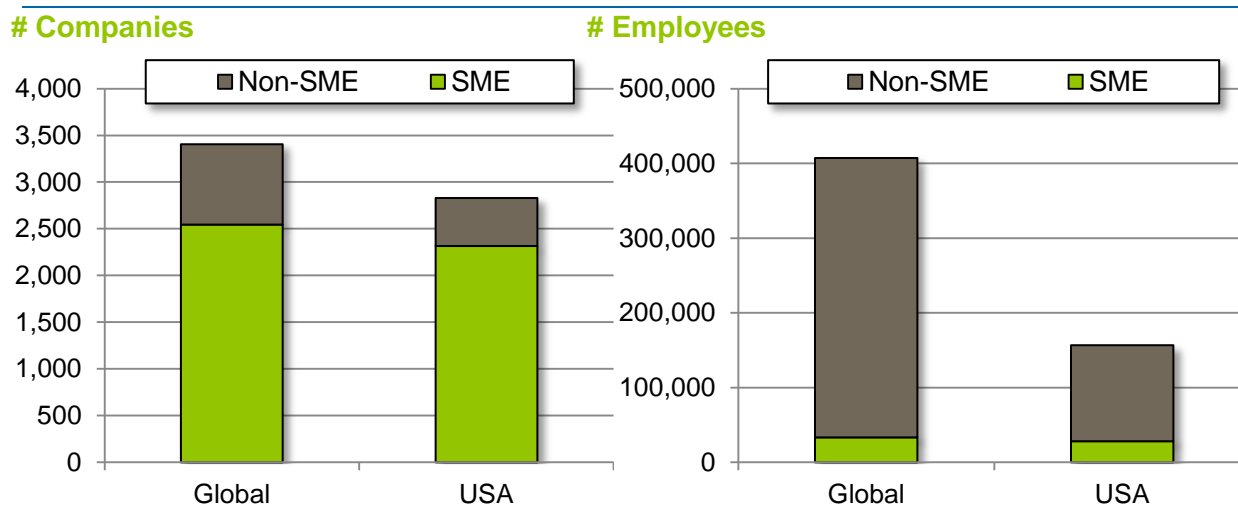
Source: FAA / ICF SH&E Analysis

Component Maintenance

The global component maintenance supply chain employs 407,524 employees within 3,405 companies (*Figure 42*); approximately 75% are SMEs, employing nearly 33,342 people worldwide. In the US, there are 156,971 employees in the component maintenance supply chain within 2,829 entities; about 80% are SMEs – employing 28,119 people.

Globally, there are 236,171 technicians in the component maintenance supply chain; around 30% are FAA certificated. In the US there are 113,635 technicians – approximately 51% or 58,137 are FAA certificated.

Figure 42: Component Maintenance Employment



Source: FAA / ICF SH&E Analysis

Line Maintenance

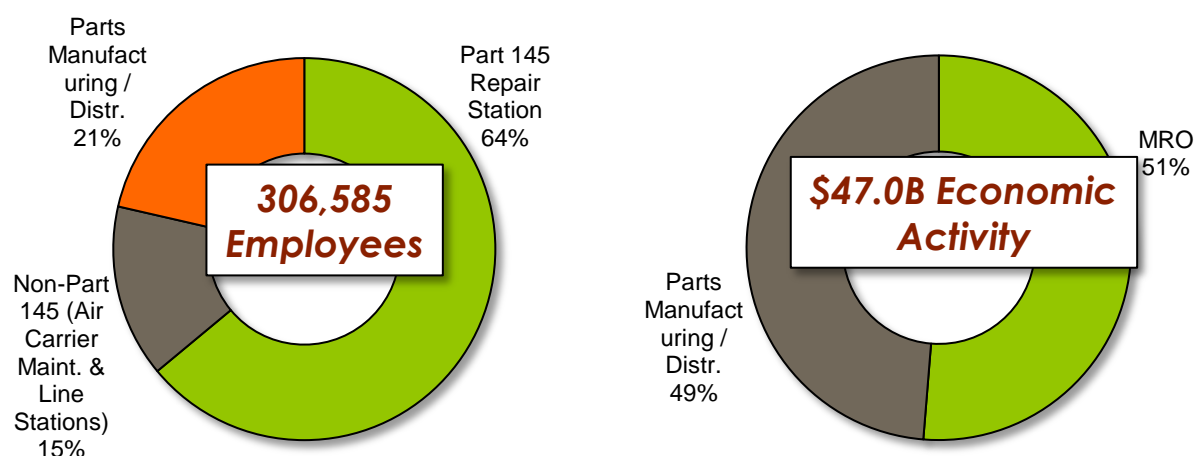
Labor, which is internal to the line maintenance facility, accounts for approximately 116,500 employees; an additional 12,700 employees support work in other parts of the line maintenance supply chain. In the US, it is estimated that approximately 41,000 employees are in line maintenance supply chain.

5.2 US EMPLOYMENT & ECONOMIC IMPACT BY STATE

Overview

The US civil aviation maintenance industry employs over 306,000 people and generates \$47B in economic activity (*Figure 43*). MRO accounts for 80% of the total employment in the US with 240,000 employees; within the MRO industry, companies that are certificated by the FAA under part 145 are the largest employers with nearly 200,000 employees. The remaining 45,000 are employed by other companies involved in civil aviation. Parts manufacturing and distribution accounts for the remaining 20% of employment with 66,000 employees. MRO generates over 50% of the economic activity or \$24.1B. With 20% of the total employment, parts manufacturing and distribution accounts for 49% of the total economic activity or \$22.9B.

Figure 43: US Civil MRO Employment and Economic Activity

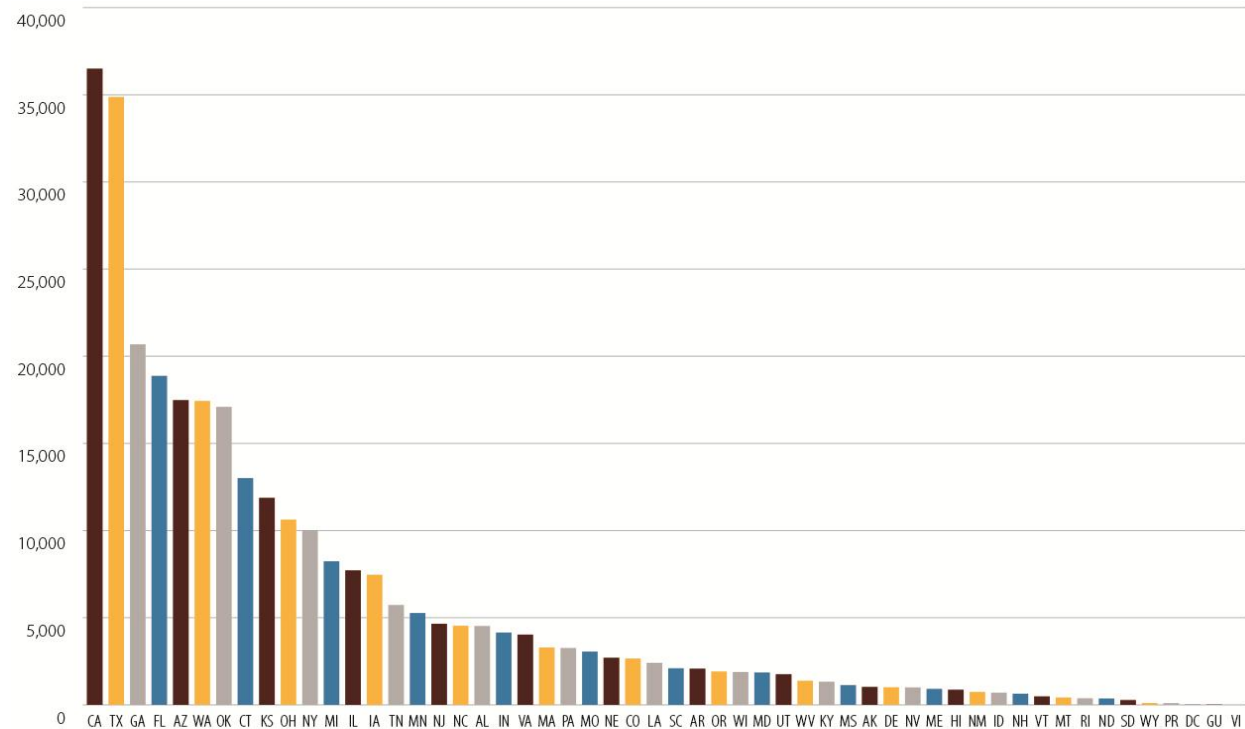


Source: FAA / RITA / WAD / ICF SH&E Analysis

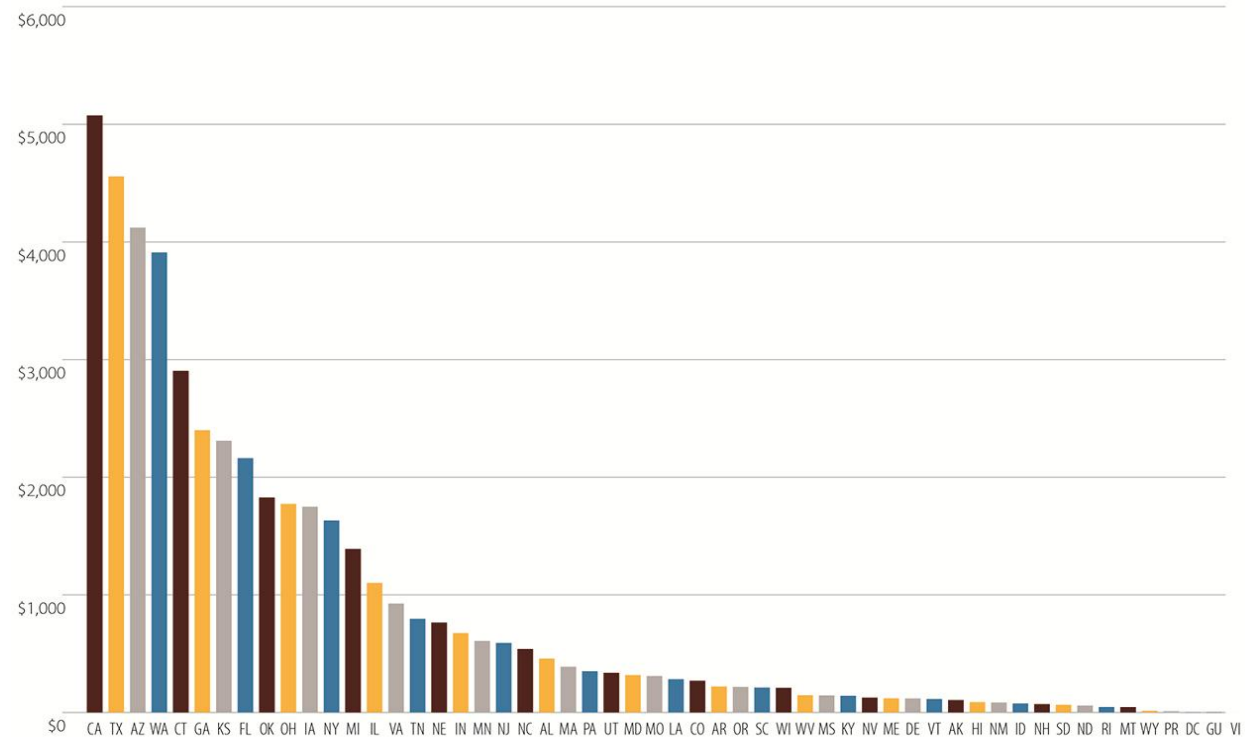
Analyzing the MRO industry at the state level, ICF SH&E estimates that California, Texas, Georgia, and Florida combined represent more than a third of the total US civil aviation maintenance employment with an estimated 111,000 employees (*Figure 44*); the top ten states represent nearly two-thirds of the total employment in the US.

California and Texas also generate the most economic activity followed by Arizona, Washington, Georgia and Connecticut; together, these six states generate almost half of the total economic activity (*Figure 45*).

Figure 46 presents the detailed employment and economic impact at the state level.

Figure 44: 2012 US Employment Ranking by State (# Employees)

Source: FAA / RITA / WAD / ICF SH&E Analysis

Figure 45: 2012 US Economy Activity Ranking by State (\$M)

Source: FAA / RITA / WAD / ICF SH&E Analysis

Figure 46: 2012 US Aviation Maintenance Industry Employment and Economic Impact

State	Aviation Maintenance Industry Employment			Aviation Maintenance Industry Economic Activity (\$M USD)	
	Maintenance, Repair and Overhaul (MRO)		Total Employment (MRO plus Parts Manufacturing/Distribution)	MRO	Total Economic Activity (MRO plus Parts Manufacturing/ Distribution)
	FAA-Certificated Repair Station	Air Carrier (Base and Line Maintenance)			
AK	541	478	1,028	\$101.9	\$104.7
AL	4,400	96	4,523	\$449.6	\$458.4
AR	2,000	15	2,074	\$201.5	\$220.8
AZ	5,529	2,311	17,480	\$784.0	\$4,122.5
CA	28,408	2,744	36,497	\$3,115.2	\$5,074.5
CO	1,183	1,461	2,659	\$264.4	\$269.2
CT	6,084	48	13,008	\$613.2	\$2,904.4
DC	18	0	18	\$1.8	\$1.8
DE	925	0	1,006	\$92.5	\$119.2
FL	16,488	1,435	18,873	\$1,792.3	\$2,161.8
GA	16,001	3,286	20,683	\$1,928.7	\$2,399.5
GU	11	0	11	\$1.1	\$1.1
HI	138	718	864	\$85.6	\$88.3
IA	3,042	98	7,463	\$314.0	\$1,749.0
ID	569	96	697	\$66.5	\$77.0
IL	3,620	2,690	7,712	\$631.0	\$1,101.6
IN	2,785	225	4,143	\$301.0	\$674.9
KS	6,932	141	11,872	\$707.3	\$2,310.3
KY	518	765	1,326	\$128.3	\$142.4
LA	2,047	182	2,411	\$222.9	\$282.9
MA	1,961	1,071	3,293	\$303.2	\$389.4
MD	1,003	275	1,855	\$127.8	\$318.0
ME	752	36	914	\$78.8	\$120.5
MI	4,007	1,765	8,235	\$577.2	\$1,390.0
MN	3,192	1,725	5,267	\$491.7	\$608.6
MO	1,494	1,537	3,053	\$303.1	\$310.3
MS	931	65	1,132	\$99.6	\$144.6
MT	380	20	418	\$40.0	\$45.8
NC	3,206	957	4,537	\$416.3	\$539.9
ND	244	24	364	\$26.8	\$58.5
NE	1,339	99	2,700	\$143.8	\$764.4
NH	556	49	637	\$60.5	\$71.0
NJ	3,931	281	4,649	\$421.2	\$590.7
NM	600	96	742	\$69.6	\$84.8
NV	529	360	1,002	\$88.9	\$126.1
NY	5,265	2,094	10,028	\$735.9	\$1,631.9
OH	5,623	1,913	10,624	\$753.6	\$1,772.6
OK	13,096	3,492	17,097	\$1,658.8	\$1,826.7
OR	1,788	15	1,916	\$180.3	\$217.6
PA	2,494	654	3,259	\$314.8	\$351.4
PR	100	0	100	\$10.0	\$10.0
RI	334	0	377	\$33.4	\$47.5
SC	1,944	144	2,098	\$208.8	\$212.3
SD	73	34	272	\$10.7	\$65.2
TN	1,970	3,172	5,727	\$514.2	\$796.5
TX	25,090	5,979	34,873	\$3,106.9	\$4,556.7
UT	292	1,012	1,750	\$130.4	\$337.1
VA	1,162	593	4,028	\$175.5	\$925.7
VI	2	0	2	\$0.2	\$0.2
VT	161	32	482	\$19.3	\$114.8
WA	8,267	404	17,437	\$867.1	\$3,911.3
WI	1,692	101	1,884	\$179.3	\$209.5
WV	1,345	0	1,382	\$134.5	\$146.7
WY	68	20	105	\$8.8	\$14.4
Total	196,130	44,808	306,585	\$24,094	\$46,975

Source: FAA / RITA / WAD / ICF SH&E Analysis

6 CONCLUSION

The global turbine-powered civil aviation fleet is about 80,000 aircraft with over 26,000 aircraft operating in the air transport fleet. Nearly half the civil aviation fleet is domiciled in North America with 37,000 aircraft, followed by 16,000 aircraft in Europe and 11,000 aircraft in Asia Pacific. These aircraft fly over 85 million hours per year with the air transport fleet accounting for almost 80% of those hours.

The civil MRO market contains four distinct segments: heavy airframe maintenance, engine overhaul, component maintenance and line maintenance. The 2012 civil MRO market is estimated at over \$65B. Engine overhaul is the largest segment at \$26.1B followed by component MRO at \$16.8B. North American-based aircraft account for \$23.5B.

Heavy airframe maintenance accounts for \$13.0B. Over 70% is in air transport aircraft and 38% for aircraft based in North America. Four key providers exist in the heavy airframe maintenance market: OEMs, operators, independents, and airline third party. For the air transport market, operators account for over 50% of the market share, while for the BGA market, independent providers account for 65%. Labor makes up approximately 70% of the typical cost for heavy airframe maintenance while material and other repairs account for 30%.

Engine overhaul accounts for \$26.1B. Over 86% of this market is in air transport aircraft and 36% for aircraft based in North America. For the air transport market, the engine OEM accounts for 43% of the market share, while for the BGA market, the OEM accounts for 50%. Material accounts for 68% of the typical cost for engine overhaul while labor takes up 22%. Parts repair accounts for 10%.

Component maintenance accounts for \$16.8B. Over 70% of this market is in air transport aircraft and 37% for aircraft based in North America. Supplier market share varies widely by component type, but OEMs are significant providers. The typical cost structure for components varies as well, with some component such as wheels and brakes and fire protection having a significant material cost.

Finally, line maintenance accounts for \$9.9B with almost 30% of the market for North American-based aircraft. Almost 90% of the market is done in-house by operators and labor accounts for over 85% of the cost structure.

For every dollar spent on heavy airframe maintenance, \$1.39 dollars of economic activity are generated. One dollar spent on engine overhaul generates \$1.88 of economic activity and one dollar spent on component maintenance generates \$1.68 of economic activity. Line maintenance generates \$1.19 of economic activity for every dollar spent.

In the United States, there are nearly 4,100 firms with 196,000 employees in the civil MRO market. SMEs account for 84% of the total and 21% of all employees. There are over 143,000 technicians in the United States and approximately 36% are certificated.



Appendix A:

US Aviation Maintenance Employment & Economic Activity Methodology

Employment

Employment can be segmented into three primary groups: MRO, Service Parts and Distribution.

- **MRO** – The employment to support the maintenance, preventative maintenance and alteration of aircraft; this includes airframe heavy maintenance, engine overhaul, component maintenance and line maintenance. MRO employment includes technicians as well as employees engaged in sales, general and administrative activities.
- **Service Parts** – There are three primary sources for service parts: OEMs, PMA holders and hardware manufacturers. Service parts employment includes persons engaged in distribution, administrative and manufacturing activities.
- **Distribution** – Distributors are a common intermediary between parts manufacturers and suppliers and MRO facilities. Distribution employment includes employees supporting distribution center operations as well as sales, general and administrative activities.

The main source of employment for the MRO industry are facilities certificated by a national aviation authority under part 145 (repair stations). Part 145 employment estimates are based in part on 2012 FAA repair station data. Part 145 facilities account for approximately 80% of the total MRO employment, but do not capture employment for non-certificated activities. To capture and identify the 20% of employment represented by non-certificated companies, maintenance employment and base locations are identified for the airlines in the US. Employment for non-Part 145 firms is allocated based on the following assumptions:

- 80% of line maintenance/base maintenance personnel are at hub or key airports
- 20% are at tertiary line stations
- For low cost carriers which fly point-to-point, 40% of line maintenance personnel are at tertiary line stations

Sources of data for non-Part 145 firms include: company 10Ks, RITA Database and general internet search.

Service parts employment is estimated by identifying the key commercial OEMs and associated employment by state using data from the World Aerospace Database; the results are then aggregated to reflect the pro-rata employment contribution by state.

Overall, US service parts suppliers generate \$19.5B in revenue. ICF SH&E research suggests that for every \$1M in service parts revenue, a company typically employs three people (2.5 manufacturing plus 0.5 administrative). Overall, ICF SH&E estimates that there are 58,483 employees to support \$19.5B in service parts revenue in the US; these 58,483 employees are allocated based on the pro-rata employment contribution by state developed previously.

Finally, distribution employment is based on employment data from World Aerospace Database for US-based distributors and re-distributors. There are approximately 7,164 employees participating in the distribution of service parts.

Economic Activity

Economic activity by state is developed by multiplying the employment at the state level by the following revenue per employee assumptions (*Figure 47*):

Figure 47: US Civil MRO Employment and Economic Activity

MRO	Service Parts	Distribution
\$100K/employee	\$330K/employee	\$500K/employee

Source: ICF SH&E Analysis