Evolution of the MRO business: findings from research at the floor level

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ABSTRACT

Presently the airline business is evolving in response to a number of economic factors. While some of these factors are external, including the cost of fuel and new security measures, airlines have begun to recognize that survival may depend on their ability to control the internal factors. New or growing competitive airlines have built their enterprises on lower labor costs, higher efficiency, greater effectiveness, and the ability to adjust to customers needs. One component of these successful models is the out sourcing of work tasks that can be priced at a fixed and per unit basis. Establishing outside aircraft maintenance arrangements with large Maintenance, Repair, and Overhaul (MRO) companies is a major trend in today's airline environment. This trend appears to be gaining momentum and has the potential to play a significant role in the turnaround sought by the airlines. Purdue University's Aviation Technology Department has completed extensive research into the MRO business, both in the U.S. and overseas, including China. Much of this research has been concentrated on floor level operations, revealing many important factors for consideration as this business continues to expand. The MRO business is a complex business that must answer to a number of different stakeholders, including airline customer requirements, repair station regulations, EPA, and OSHA. Given the nature of the business, it is no surprise that interpretations of repair requirements and FAA policy differ from one station to another. Nonetheless, compliance with required and accepted maintenance procedures is of fundamental importance and of primary concern for maintaining safe and efficient airline travel. This paper will focus on the changes and support of oversight and the need for standardization as the MRO business expands in the United States and around the world.

INTRODUCTION

Preliminary findings from ongoing research conducted by Purdue University researchers both in the United States and in China are leading to some revealing observations concerning the current status of the Maintenance Repair and Overhaul (MRO) industry. Research teams from the Aviation Technology Department at Purdue University have conducted on-site analysis and collected data and support information from other studies through a review of the related literature. Observations were made at major international maintenance bases of current operational policies and procedures. As a result of collaborative efforts with the Civil Aviation University of China (CAUC), Purdue was invited to learn about international air carrier and foreign MRO maintenance operations in practice in the Peoples Republic of China. The methodology employed for the majority of these studies included an analysis of the maintenance processes required and the actual work conducted. Process mapping was then used to perform a gap analysis, revealing the shortfall between the requirements/expectations for maintenance, and the actual outcomes on the floor. A major ongoing problem results from the lack of coordinated and standardized maintenance processes between the air carriers and the MROs. Findings indicated that task card management, communication channels, operational oversight, supervisor training, and language standards are all major concerns for the industry worldwide. A new method and approach are needed to ensure that not only are high standards of commercial aviation fulfilled, but also that common standards themselves should be established to reduce the negative operational effects that these concerns may present. To accomplish this, the stakeholders should begin a dialogue on the evolution of airline maintenance, the goal of which is to unclutter and therefore improve the process flow of maintenance performed, and to provide a more standardized environment for the technicians on the floor.

New Economic Realities

The Airline industry has been under attack from the combined forces of global insecurity, market insecurity and customer insecurity. The lingering after effects of September 11 and the new security oversight regulations have added additional burdens on to an already taxed operating environment. The cost of fuel, generally computed as roughly 15% of the direct operating expense of the airlines, has skyrocketed over the past year with the cost of oil soaring past $50 a barrel. Some in the airline industry predict that long term profits are not possible until oil falls back to approximately $31 per barrel or lower (Michaels, 2004). Additionally, consumers have become more savvy about pricing, and, consequently, the high ticket revenue curves of old appear to be gone for good.

As the industry adjusts to the loss of the high yield passenger, the need for overall cost reduction has become clear. Given that it represents 40% or more of the direct expense and is the largest single cost involved in operation of the airlines, it is no surprise that labor will be among the first candidates for cost cutting (Levin, 2004). As a group, the airline pilots have already given up considerable ground in salaries and retirement packages. Within the remaining labor pools of maintenance and customer service, maintenance now finds itself a lucrative target for significant cost savings efforts and

alternative solutions. The cost of in-house maintenance has reached a level such that third party maintenance providers – MROs – are in a position to compete for the work while also paying the wages necessary to recruit the required labor pool. Figure 1 and 2 illustrates the labor cost differential; accounting for the trend in shifting maintenance to FAR Part 145 providers. 145 repair station certificates are not new to the industry, but the volume of aircraft and the nature of the customer base have begun to change significantly over the past few years. Maintenance and support that was once the domain of the major air carrier is now beginning to shift to outside vendors, due simply to the cost savings incurred.

United States Market – Labor Influence

Compare with Airline Pilot's mean salary of $142,110

Differences in Mean Hour Labor Rates

	MRO Provider	Air Carrier
Supervisor	$24.74	$30.15
Mechanic	$18.02	$24.19
Avionics Tech.	$18.79	$27.18

Figure 1 – Bureau of Labor Statistics (Lopp, 2004)

United States MRO Trends

- Airline Labor Rates decreasing by 13-17% however,
- MROs maintain 28-38% labor advantage

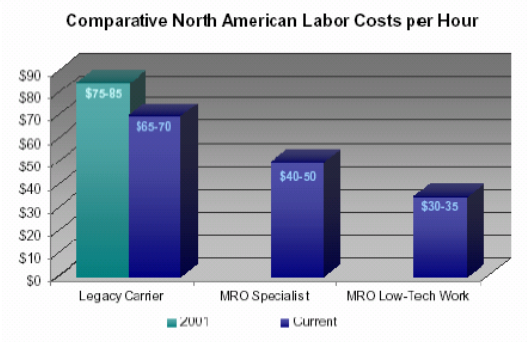

Figure 2 (Casley, 2004)

Figure 3 illustrates the forecasted growth of the MRO business in the U.S., while figure 4 reflects the economic impact and what business area may contribute to the growth (Casley, 2004)

United States MRO Trends

- Trend has been outsourcing of airframe business by air carriers
- Engine business may be more stable?
  - Higher skill requirement
  - Greater equipment and tooling demands

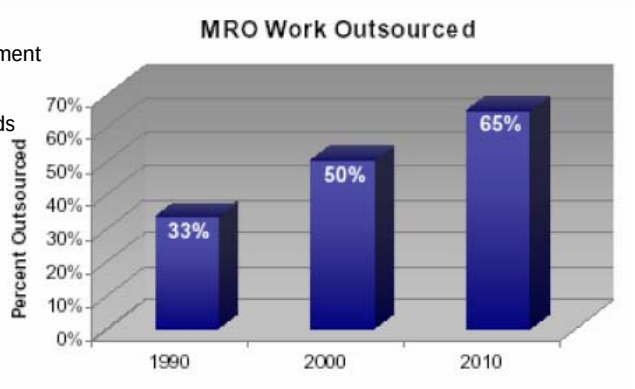

Figure 3 (Casley, 2004)

MRO World Trends

The World MRO Forecast:

- The MRO world market will grow by $4.8B USD over the next 5 years
- Regional jets and narrow body aircraft will drive the future growth in MRO services; accounting for 89% of the growth in MRO demand

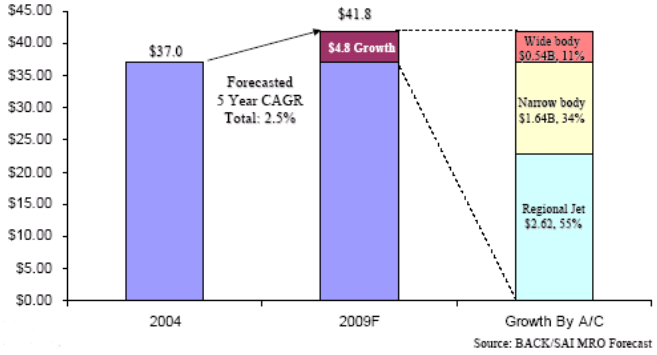

Figure 4 (Casley, 2004)

Airline maintenance is a topic of significant importance and renewed focus, for several reasons. While the dominant concern is safety, the enormous cost of airline maintenance can make or break an airline. Many airlines, faced with staggering increases in the price of fuel, heavy competition by low fare providers, and a disparity in wages across the industry, have elected to outsource much of their required maintenance in an effort to reduce costs. This is a normal evolution in a competitive environment, and a healthy one to the extent that safety is protected and cost savings are realized. As this shift has taken place, MROs operations have ramped up business in an effort to meet increasing demand, resulting, at least in many cases, in reduced maintenance expense. As the major air carriers come to the realization that financial survival requires the adoption of a lower cost model, this move to third party maintenance is accelerating. Predictably, the tension created by such change is having a stretching affect on the entire industry, creating problems that must be addressed in the near future. Since, 65% to 80% of the maintenance costs of completing an aircraft heavy service may be labor (Carey, 2005), one can make a case that the labor advantage of the MRO business will strengthen the drive towards continuing outsourcing

The history of the air transportation industry is replete with many models by which to conduct business. There have been times when both the traditional and low cost airline were successful, perennially earning profits and serving the needs and desires of their flying customers. Recently, the boundaries separating the models have begun to blur as carriers realize the importance of moving towards the lost cost model. A 'Jack-of-All-Trades' approach once enabled the major carrier to develop many facets of the company with the advantage of using each as a competitive edge. The low cost model, however, has abandoned this approach, choosing to focus support on one aspect, such as customer service, while relying on outsourcing to supplement the other facets. Low cost models utilize point-to-point route structures, fleet commonality, outsourcing beyond core competencies, and other strategies, all of which allow a carrier to focus on its niche. Maintenance, once an integral part of air carrier service, has shifted more and more to a third party competitive bid system, driving the cost lower. The extremely competitive per seat mile cost of the low cost carriers (see figure 2) has been a constant force driving the airlines away from in-house maintenance. It may be worth noting that while the majority of carriers will eventually adopt some version of the current low cost model, successful carriers will continue to find avenues by which to improve their bottom lines. What works today, may not work tomorrow.

Ranked by 2nd Quarter Domestic Unit Costs
(Domestic Operating Expenses per Available Seat Mile in cents)

2Q 2004 Rank		2nd Quarter 2003	3rd Quarter 2003	4th Quarter 2003	1st Quarter 2004	2nd Quarter 2004	2nd Quarter Operating Expenses $(Millions)
1	**Regionals**	13.54	12.99	12.94	13.61	13.53	1,651.7
2	**Network**	12.15	11.70	12.32	12.55	12.40	14,951.1
3	**Low-Cost**	7.49	7.33	7.49	7.62	7.87	3,286.9
	21-Carrier Total	**11.15**	**10.77**	**11.22**	**11.44**	**11.40**	**19,889.7**

Source: Form 41; Schedule p1.2. T100; T2 Data.

Figure 2 – Bureau of Transportation Statistics (Smallen, 2004)

Traditional Model

The new economic realities have served to drive the airline industry towards outsourcing of maintenance. Capitalizing on the situation, MROs have positioned themselves with the necessary capabilities, while continuing to remain competitive in pricing. In the meantime, growth issues for this industry are emerging, particularly with respect to oversight and process standardization. Under the traditional model, maintenance issues are directly communicated between the original equipment manufacturer (OEM) and the air carrier. As the shift towards third party maintenance takes place, oversight and process issues loom large.

Historically, critical function aircraft maintenance has been performed in-house by the major airlines. Several reasons have served as rationale for this practice. First, it allowed airlines to control the processes, a factor with input into all other considerations. Second, it enabled the oversight thought necessary for quality control and, hence, safety. Third, the major airlines alone were equipped to do all, or most of the critical work. Since the time of deregulation, these airlines have generally expanded the involvement of in-house maintenance to include more functions, including interiors, raft and emergency slides, components, LD containers, lavatories, engines, and landing gear.

The traditional model for airlines has generally been defined by the work done in-house and the route structure. Just as important in characterizing the traditional model may be the linear relationship that exists between the airline and the FAA. This direct relationship between the air carrier and the representative FAA principal inspector continues to be a fundamental part of the maintenance process, allowing for relatively efficient communication and rapid response to conditions requiring FAA input or approval. To describe the relationship between the two entities as simple or to say that it is efficient would be a mistake, but to characterize it as generally predictable and quantifiable, however, makes sense. Quality control and, to a certain extent, productivity,

are very much influenced by this relationship. When problems occur or when modifications are required, the channels through which to resolve the related issues are readily identifiable.

Under the traditional model generally followed by the major airlines, regulatory requirements for maintenance are generally not an issue of confusion, and neither are the processes followed on the floor to accomplish the work. Each airline has its set of procedures to follow, and the training and oversight are geared to accomplish the work accordingly. Nonetheless, the traditional model is struggling under the weight of its own success, as battle lines form between unions and management over wages, schedules, and duty time requirements.

Emerging Model

As the major airlines' bottom line has come under fire in recent years, attention has been focused on labor-intensive activities in support of the aircraft. The cost of maintenance labor for the major airlines has reached a level where third party providers can compete vigorously for the work while continuing to pay wages necessary to attract the required labor pool. MROs operating under Part 145 have expanded in many cases from small, 'boutique' shops specializing in interiors, components, or wheels and brakes, for instance, to operations with the capability to perform all necessary maintenance. According to Bruce Stand, chairman and CEO of TeamSAI, overhaul of airframes and engines can be performed economically only by shops of some significant scale. He fixes the minimum size of such an operation at $300 million in annual revenues. Others express concern when third party providers become too big or take on too many initiatives (Canaday, 2004). It would appear, given these seemingly conflicting statements, that appropriate MRO size and capability may be a critical factor in success. This is not something that will be dictated by regulation, but may become clear as the business evolves. Regardless, nimble independent MRO operations have responded to the needs of the airline industry, as indicated by the remarkable expansion in MRO capability over the last ten years. As MROs continue to grow from specialty operations to overhaul facilities with all the necessary heavy maintenance capabilities, however, the challenges are enormous. Among the largest challenges is oversight – who is to provide it, and the additional complexities that enter into the process when a third-party provider is involved.

Another consideration in the emerging model is the sheer number of regulations and procedures that an MRO must abide by in order to accomplish its mission. If an MRO is conducting business with five airlines flying twelve different aircraft, for instance, the variation in maintenance procedures alone is a problem of staggering proportions. Under such a scenario, the MRO is faced with set of logistical problems that airline in-house maintenance never experiences. These problems may potentially impact on management of daily operations, training requirements and cost, compliance, safety, and throughput of the product. Is there any sound rationale for the variation in maintenance procedures in evidence among the major airlines? From the MRO perspective, these problems should be addressed, and one solution that begs for consideration is the standardization of

maintenance procedures. Now is the time to begin discussion of these issues, while the opportunity remains for incremental change.

Research findings

Research into the MRO business has been underway by Purdue University students and faculty for some time. Observations and data have been collected at both domestic and international maintenance sites, including locations in the Peoples' Republic of China (PRC). The processes that are utilized to manage the relationships involved and ensure compliance with regulations and quality expectations have been the focus of this research effort. A recent study of maintenance related accidents is revealing and illuminated a pathway for additional research. In this study, the following were identified as contributory factors - note that more than one factor may apply (Eiff, 2004).

- Failure to follow procedures 74.5%,
- Inadequate inspection 19.5%,
- Organizational deficiencies 15.2%

These are issues that may plague any organization, but should be of particular interest for maintenance establishments involved with complex operations and for industries experiencing rapid growth, as is the case with current MROs. It should also be noted that each of these may be exacerbated by the great variation in maintenance procedures in evidence among the different airlines. "Failure to follow procedures" is itself a statement of non-standardization, highlighted by the fact that almost 75% of maintenance incidents or accidents can be contributed to this issue. Past research in maintenance operation has indicated that technician themselves admit that they deviate from not following procedure almost 25% of the time (Lopp, 2002). This may be driven from perception by technicians of outdated procedures or the norms in the workplace, but it does constitute the argument for strengthening the acceptance and use of standards. Standardizing procedures would certainly have a positive effect on all of these factors. Further research conducted by Purdue University students and faculty members has identified five issues related to these factors that should be considered for additional research in the MRO industry:

- Communication channels
- Operator oversight and responsibility
- Task standardization
- Supervisor key roles and education
- Language translation and understanding

All of these issues relate to practical floor operations, the magnitude of which is expected to grow dramatically as MRO operations expand. All of these issues also relate directly to training, and given that the expansion of the MRO business will rely on efficient and effective training, improvements in these areas should translate directly into better throughput, improved compliance, and safer operations.

Communication Channels and Complexity in the MRO business

Clearly, airline maintenance is undergoing a fundamental change in response to the enormous financial pressures experienced by the airlines. Policies and procedures developed and maintained by a single air carrier maintenance organization now must be translated and adopted by an outside MRO group, often one not familiar with the peculiar practices or informal communication loops of a particular carrier. When establishing an operations specification for an air carrier, the original equipment manufacturer (OEM), Federal Aviation Administration (FAA), and the air carrier itself are engaged in a well-understood and defined relationship with boundaries established by protocol, procedures, and expectations. The expectations of and limitations on Designated Engineering Representatives (DERs - air carrier engineers empowered to make FAA approved modifications of the aircraft) are clearly understood. DER function relies on clear and disciplined communication between the airline and the OEM in daily maintenance operations. When questions of maintenance practices or reference of approved and other data is needed, the air carrier organization has the authority and access to OEM networking in order to adjust and define acceptable maintenance standard practices for their technicians. Whenever questions of the correct action are needed in servicing or repairing of an air carrier's aircraft, the air carrier's engineers, technicians, and management are available for open and direct consultation. The OEM can be directly contacted for input from a manufacturer prospective, often with an established office and communication arrangement available for use at the air carrier facility.

Increasing the number of different customers at MRO operations has introduced another dimension and a level of complexity to this relationship. Organizationally, the MRO wrestles with the added layer of Part 145 regulations. From a technician's perspective, several different operational standards may come into play, resulting in increased complexity of daily tasks. When a technician arrives for work in a typical MRO operation, he or she may be confronted with twelve different aircraft from two different manufacturers operated by five different air carriers, all with different operator specifications. Adding to the level of complexity and potential confusion are the different air carrier representatives, FAA air carrier representatives, FAA Flight Standards District Offices representatives, PMA parts organizations, and parts supplies arriving from different air carriers or manufactures, each lot stored in exclusive parts areas. A decision that should be made at the floor level cascades upwards with respect to compliance for both Part 145 Repair Station regulations and the air carrier's operation specifications designed under Part 121. The technicians and their support groups must ensure that the work being conducted is supported with the appropriate illustrated manuals, task cards, and inspections procedures, all in compliance with that air carrier's specifications. Parts must be separated and verified to be appropriate for use on the aircraft, making certain that unregulated and non-authorized "swapping" does not occur. Supplemental type certificates (STCs) and other modifications that have been accomplished on the serviceable aircraft must be verified and corresponding service modifications built into the task card deck. Both support groups of the MRO and the technician must be aware of the differences and particularities to be addressed as they perform their daily functions on different aircraft operating under the different air carrier's specifications.

Compliance rules and regulations exist and are generally not in question. The problems occur as a result of increasingly complex relationships that add layers of regulations and communication to an already complicated situation. Generally, all agree that third party maintenance is here to stay, and may in fact be a key factor in the survival of the airline industry. Nonetheless, adding third party providers to the mix, certainly does add to the complexity of the recipe at the organizational level and for the technician on the floor.

Operator Oversight Roles and Responsibilities

When maintenance is conducted in-house by an air carrier, quality control, aircraft repairs specifications, task card adjustments, and other maintenance related items are monitored and controlled internally and under direct supervisory control. When business is shifted to an MRO, however, the relationship between the air carrier, FAA, OEM, and MRO operator becomes more complex. All elements of the operation, including compliance and productivity, may be negatively impacted by the increasingly complex relationships that exist. This is particularly true and problematical as the MRO business expands rapidly in response to increasing airline demands. Let there be no doubt, however, that the air carrier still holds full responsibility for maintenance compliance. Therefore, while it has shed itself of the actual maintenance workload, the air carrier still retains the responsibility for the maintenance, and must then provide the oversight required to insure that the work is done properly. The level of support required is not standardized by the industry or FAA and is open for determination between the air carrier and the MRO provider. These support and overview functions that are the responsibility of the air carrier customer often are, by their very nature, extremely complex. Typically an air carrier will provide support to the MRO business for training, definition of technical specifications, direction of inspection tasks, technical data, allocation of spare parts, and performance of continuous surveillance. The information loops that develop from these interactions in practice are not fully addressed or understood by the industry or the FAA. The air carrier's oversight responsibility can become more confusing as the procedural processes and feedback loops to the individual MRO increases exponentially, adding to the complexity of the maintenance operations, and sometimes leading to problems that impact on efficiency, production, and ultimately, safety.

Task Standardization

Why are the procedures for changing a Pratt and Whitney 4000 series engine on a 747-400 aircraft at airline 'A' different than those at airline 'B', given that all of the hardware and equipment are the same? In general, why are common and repetitive procedures not the same for all airlines? Accidents records point out the problems that can arise as a result of such issues. On May 25, 1979, for example, an American Airlines DC-10 crashed in Chicago directly as a result of an improperly performed engine change (National Transportation Safety Board, 1979). An examination of maintenance records revealed that improper procedures were followed for an engine change prior to the fatal flight. The maintenance organization, in fact, approved engine removal processes that resulted in a cracked engine pylon. On takeoff the pylon failed, the engine fell off, and the aircraft crashed, killing all 273 aboard. This non-standard process was adopted and carried out even though information in the aviation field suggested it was faulty and could lead to problems. The more recent crash of a Swissair MD-11 that resulted from

faulty wire installation of an entertainment system reflects how practices accomplished on seemly non-critical systems can have the same fatal results. The crash investigation revealed that wiring incorrectly installed in the cockpit area resulted in arching and, when coupled with the low burn threshold of the materials, an uncontrolled fire on board (Transportation Safety Board of Canda, n.d.). Reviews of numerous other incidents suggest that failure to follow procedures, unclear instructions, unclear task procedures, and the mismatch of skill level to task assignment has been a major contributor to accidents.

As 'keepers' of procedures and processes, our responsibility as aviation managers and educators should include the study of these accidents in order to learn from them, develop improved methods and procedures, and prevent accidents from occurring in the future. As the airlines moves towards the outsourcing of more work, it is our responsibility to apply the same thinking to the developments we see, anticipate problems, and act to correct them. These efforts should be at both the macro, organizational level, and at the micro, floor level, where even task card layout and illustration, for instance, come under the microscope. Standardization of process will impact the organization at many levels simultaneously. Such efforts, for instance, will improve the ability of managers and supervisors to train technicians, conduct shift briefing, and improve the work flow, in general. In order to better support the technician's understanding of the task itself, issues of compliance, clarity of signoffs, and inspections requirements, processes and procedures should be developed and implemented that are consistent for the same type aircraft, engine, component, or avionic package. Standardization, again, will be the key. Logic would seemly suggest, in the opinion of the authors, that processes **would** be standardized, helping to reduce non-compliancy and supporting the economics of process simplicity in "on-hands" task accomplishments and support functions. Until now, however, airlines identities have been indelibly imprinted on processes. Movement towards the low cost model will provide additional impetus to drive these processes towards standardization.

Supervisory Key Roles and Education

Purdue research has determined that one of the key elements required to establish a standardized process for MRO operations is the acknowledgement by the organization of the importance of direct support for the technician on the floor. The main function of support groups is to establish a seamless and continuous line of information to the technician so that he or she can complete their task in an efficient and effective manner, upholding quality as a major goal. A key strategic process identified in this process is the ability and commitment of the supervisor to ensure that tasks are assigned in accordance with technician skill level and competency. This particular process is dependent upon both the managerial ability of the supervisor and effective streamlining and standardization of the required tasks. On the human side of this issue, the supervisor must be able to assess skill level and commit to development of individual employees. On the task and process side of the matter, it is important for the supervisor to have a step by step understanding of the work the task requires. Such an understanding itself requires a level of and a commitment to process standardization.

Purdue research in this area over the past ten years indicates that supervisors, when asked to review and write down the processes and procedures in their workplace, could not reach agreement on many issues in the workplace. As mentioned earlier, the primary contributing factor for maintenance accident and incidents was "not following procedures" (Eiff, 2004). Many of the root causes of the negative events surrounding "not following procedures" were found by the Purdue research teams to be contributed to the technician not fully acquainted with the steps or skipping steps deemed irrelevant. If confusion exists within management and support groups that oversee and support technicians on the floor, then it seems clear that technicians at the floor level, particularly those with little experience, have little chance to be properly informed and trained. Increasing process standardization to a more uniform level would improve the ability of management to align tasks appropriately with technician skill levels. Studies by Purdue University researchers turn up overwhelming evidence that many supervisors lack the so-called 'soft' or people skills to develop and implement standardization in their work zone areas.

Language Translation and Understanding

Overseas MRO operations reflect similar difficulties and concerns with respect to standardization. Additional factors contribute in developing further complications in that overseas MRO operations may contend with different air carrier customers functioning under separate regulatory rules required by the FAA, EASA, and CAA, for example. These additional factors and regulations complicate the effort to standardize. A major element of concern for safety and quality in overseas operations centers around the difficulty in translation and conversion of task cards from the original language into the country's common language. Language is by itself a barrier; technical language erects even higher barriers to understanding. For those of us experienced with the challenge of comprehending an Airworthiness Directive (AD) written in our native tongue, for instance, translation to another language appears to guarantee confusion, at best. Work on the standardization of task processes and a world wide acceptance of common methods for illustration of these processes may simplify and help eliminate confusion. Adoption of a '1000 word vocabulary', an idea under consideration in some parts of the industry, could also be beneficial. Given that aviation is written and spoken largely in English and French, language hurdles are monumental and must be addressed if the MRO business is to continue to expand effectively overseas.

RECOMMENDATIONS

The significant increase in third party maintenance provider volume, in response to the economic pressures from within the industry, has not reduced the inspection and enforcement requirements of the FAA. Two things are changing, fundamentally. As the move continues from the traditional maintenance model toward the emerging maintenance model, the operator that employs an MRO is assuming an additional oversight burden. Additionally, the staffing model for the FAA is changing as MRO operations expand.

The industry has regulatory guidance for original equipment manufacturers (OEM's) under part 25, Certificate holders under FAR part 121 & 135 and MRO's under FAR part 145. The regulatory safety net exists and has existed for a number of years. What does not exist or is under-developed is the standardization of processes. From the perspective of all stakeholders involved, consensus move towards process standardization trumps any regulatory action or enforcement criteria that may evolve in the future in response to growth issues. Simply undertaking the initiative to standardize processes demonstrates that the industry is aware of the growth issues that exist, and is working to resolve them.

Generally speaking, when needs have been identified, it pays to give thought to existing programs or initiatives that might provide a path towards the goal in mind. With this in mind, consideration should be given to two significant efforts by the FAA begun in response to the changing landscape of the air carrier industry. The Air Transportation Oversight System (ATOS) program is committed to a systems safety approach to oversight. "This program is designed to provide a common umbrella for safety oversight, using system safety methods, across all of the FAA's oversight responsibilities (FAA.GOV ATOS)." The second initiative is in the area of Maintenance Human Factors. The Human Factors Aviation Maintenance Research Program is sponsoring research into the "Development of Guidelines and Tools for Effective Implementation of an Aviation Safety Action Program (ASAP) for Aircraft Maintenance Organizations."

The second area focusing on the ASAP model appears to meet the needs of this emerging model more efficiently with quicker results. The five areas identified, communication channels, operator oversight roles and responsibilities, task standardization, supervisory roles and language barriers, all have human factor components and stand to benefit greatly from a program of this type. "The primary purpose of an Aviation Safety Action Program (ASAP) is to identify and correct adverse safety events that would otherwise not be likely to come to the attention of the FAA or company management." (Advisory Circular 120-66B). An alternative to or variation of the ASAP program for the MRO industry might be aptly titled the "Aviation Process Improvement Program" (APIP). Under such a program, the significant processes and relationships that exist among the maintenance provider, air carrier, and manufacturer would be identified, and efforts would be directed to standardize maintenance requirements across the industry. The research conducted to date has lead to the conclusion that an adequate regulatory umbrella exists for the industry. The complexity that exists with multiple carriers employing multiple techniques and customized procedures reinforces the observations that the relationships between maintenance provider, air carrier, manufacturer, and FAA are in need of process standardization.

A program of this type would not require official status in order to have legitimacy. In fact, a non-regulatory home for such an APIP program might well foster the user-friendly environment necessary for success. The principle participants would be representatives of the MRO segment, an air carrier or air carrier trade group such as the Air Transport Association (ATA), and the manufacturing sector (OEMs). A similar structure to the ASAP program as outlined in Advisory circular 120-66B is envisioned. The FAA has sufficient regulatory guidance and their role in the safety arena is clearly defined with

established roles and responsibilities. It is within this regulated operating environment that MRO's, air carriers and manufacturers find themselves and the industry as a whole. Adjustments through collaborative efforts are needed in order to facilitate more efficient operation and maintain the safety net as the industry moves through an evolutionary period of time.

CONCLUSIONS

The initial research effort was to identify issues within the domestic MRO industry to improve productivity. When the opportunity to conduct field research on a global scale presented itself, the research observations took on a more global perspective. It became apparent to the research team that issues relating to management of the process and floor level supervisory issues were similar on both sides of the ocean. Issues of concern for management included the oversight process which has become increasingly complex with the growth of the MRO business. Adding a third party provider to the interwoven relationship that before was limited to the OEM, air carrier, and FAA, has complicated the process, and deserves careful consideration. Affecting both management and floor level supervision is the lack of process standardization among the different airlines and MROs already struggling to adapt to the needs of a growing industry are stretched by this problem. Given that the MRO business is predicted to expand considerably as the new order emerges for the airline industry, these issues left unaddressed will likely become significant barriers to effective growth, productivity, and quality control. The authors recommend that consideration be given to the development of a new program with the suggested title "Aviation Process Improvement Program (APIP). This program, mirroring the basic format and philosophy of the Aviation Safety Action Program, would include membership from MROs, FAA, OEM, and air carriers. Members under this program would collaborate in an effort to standardize procedures for maintenance. All stakeholders would benefit, including the airline industry in general. Furthermore, it is incumbent upon the industry and all involved in air transportation to take whatever measures are necessary to eliminate preventable problems - problems that left unattended can lead to catastrophic consequences.

While both oversight and standardization are issues that should be addressed, other factors deserving additional research have been uncovered, as well. Purdue University researchers investigating operations at the floor level found the following to be specific problem areas, each of which should be investigated on a global scale: communication channels, operator oversight and responsibility, task standardization, supervisor key roles and education, language translation and understanding. Note that lack of standardization, this time at the task level, is again mentioned as an issue of considerable importance. Research indicates that each of these factors is now a problem of some consequence for MROs. Given the expected growth in the industry, floor level problems of this nature are bound to become larger issues demanding attention in the future.

The MRO business is in the process of expanding in response to economic pressures experienced by the airlines. In order for the third party providers to operate effectively and safely, it is incumbent upon us to carefully observe the business, anticipate the

problems that may occur as this industry develops and expands, and develop mechanisms that remove obstacles to sound operating principles. Oversight and standardization of processes are large topic concerns that deserve careful thought and attention. The five factors put forward as deserving of further research will be under discussion at Purdue University. If a dialogue across the industry begins partly as a result of these efforts, then positive results have occurred.

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Prior to his time at Purdue University, Mr. Lopp managed the Cargo Methods, Standards and Budgets Department at Pan American World Airways. This included setting standards and determining operational and expansion financial requirements for the world’s largest airfreight operation. He was also a major team member in developing a new department in corporate finance that developed budgeting and evaluation systems for passenger service, ramp service, catering, and reservations. Preceding this, Mr. Lopp held various management positions, including supervision of 747/727 heavy maintenance. Mr. Lopp, a pilot, has owned several aircraft, assisted in building a

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