# The Technological, Financial, and Social Realities That Are Defining the Aircraft Mechanic of Tomorrow

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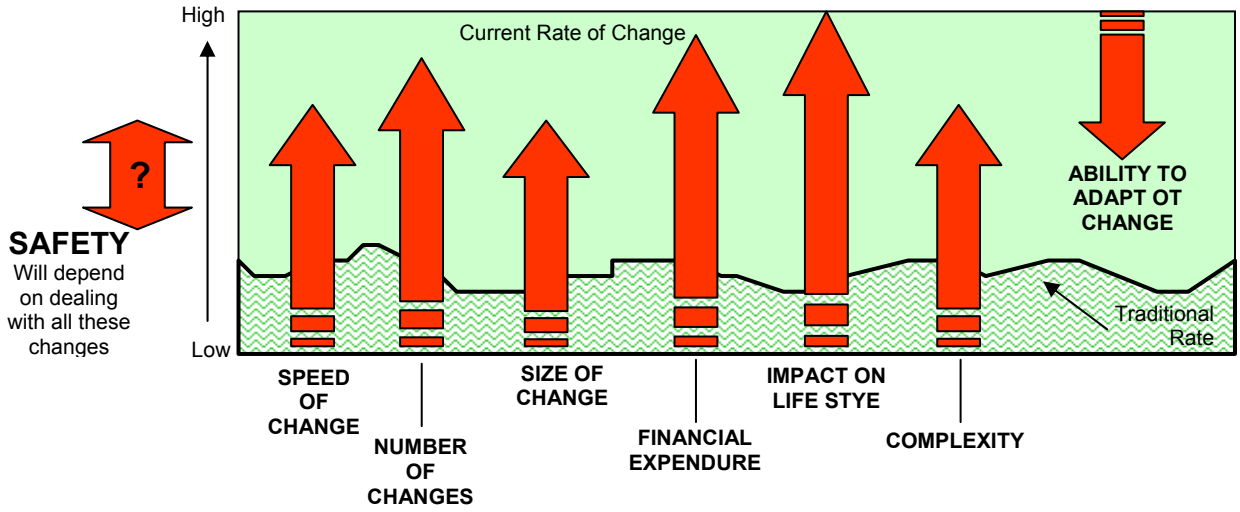
Today it is becoming increasingly difficult to describe maintenance roles because an enormous number of once stable factors affecting the maintenance person and process are changing. Technology changes like software based aircraft, air/ground/satellite/airport system integration, highly complexity systems, and other technology issues are not currently part of a maintenance person's normal skill set but are already part of aircraft maintenance needs.

Many of the change issues that are considered to be "TECHNOLOGY" initiated but usually are caused by changing financial and/or social requirements that has occurred. This is a circular result in that when technology changes occur it further drives financial and social changes. I feel that because this cycle has been going on for so long that people have accepted the spiral and failed to keep track of the state of the industry. All the changing factors must be identified and dealt with as a basis for redefining the role of "Aircraft Maintenance Person".

In the field of aircraft maintenance, major change has been occurring for years and much larger changes are on the horizon. Traditionally the changes occur in the technology aspect of aircraft maintenance and technology is definitely experiencing the most far reaching and complex changes in its history. This includes the extensive computerization of aircraft systems, major increases in the use of automation, support systems complexity, and the tightly coupling of air/ground/satellite/airport systems that is under develop as part of the NextGen (next generation) airspace initiative. [Note: This article will concentrate on computerization technologies in the maintenance task]. Accompanying these changes are some dark clouds of business issues that are making the maintenance function more of a challenge. These issues include (but are not limited to): In the labor arena there is purported to be a shortage of maintenance personnel; lack of interest in the profession because they can make more money in car dealerships; lack of interest in the work because of the inherently difficult working conditions; FAA training requirements for certification don't match the new technologies so maintenance people haven't developed the needed skills after completing authorized training; Younger people are not interested in this field partially due to the strict rule enforcement; The new technologies are driving skills and training requirements ever higher which is a cost and time issue for the potential maintenance person. Then there are substantial changes also taking place in the businesses involved with building aircraft and support systems; the airlines; and the maintenance / repair stations. These business issues include: The ever increasing cost of building, implementing, and operating new technology based aircraft; business viability due to competition, fuel cost, labor, and reduced demand. Because numerous foreign countries are able to perform aircraft maintenance at substantially lower cost than in the US, 70 % of our transport aircraft now have heavy maintenance performed off shore (reducing demand of US ma and introduces potential for problems that would be prevented in US repair centers. Add to this list of issues is the difficulty of the regulators to keep up with all these technical and sociotechnical issues and synthesize guidance for the future.

Because so many of the technical, labor, business, and regulatory sub-fields of aircraft maintenance have traditionally operated and been managed independently of each other, it has been difficult for any one organization to grasp how the whole maintenance process works. This also means that there has been minimal knowledge developed about how changes in one sub-field have impacted others and how to adjust for change. This may be one reason that the industry as a whole has not been aware that all the changes were occurring in the individual subfield areas and therefore has not assessed the collective major negative impacts the changes were having on the industry. A number of people saw the convergence of problems coming, knew that a broad infrastructure solution was needed, but were not in a position to address more than their piece of the problem. Worse yet, the changes that were occurring in these so called independent sub-fields often were having a ripple effect economically, personnel wise, and technology wise that were only identified after the ripple has affected the next sub-field.

And to put the impact of the current changes are having in perspective, it is important to note that in the past we might only have to deal with small/slow change over long periods of time, and now we are now dealing with accelerated changes in everything. Table 1 gives us a sense of the rate of and size of changes that are occurring with a result that maybe we are not able to adapt to these changes in a way that will ensure that me meet aircraft maintenance needs now and in the future. How well these changes are managed will also impact the safety of the aircraft and related systems that must be maintained.




Seven Measurement Scales of Change

1. SPEED of CHANGE – When change occurs faster that people can understand and adapt.
2. SIZE OF CHANGE – The larger the change the larger the increased potential for problems adapting and accepting change.
3. NUMBER OF CHANGES – As number that concurrently change, the more difficult they will be to address.
4. ABILITY TO ADAPT TO CHANGE – As other measures increase, the ability and resources to deal with the changes will decrease.
5. IMPACT ON LIFE STYLE– Changes outside one's believes, interest, acceptance.
6. COMPLEXITY – Complexity and technology that is outside one's ability to understand, knowledge, or learn.
7. FINANCIAL – Aviation costs continue to climb and can quickly skyrocket with market changes like fuel costs.

Figure 1 Safety Will Rise or Fall Depending On How Well the Changes Are Addressed

**The Big Picture and Collective Impact**

Because there are so many sub-fields that make up the actual process of aircraft maintenance, the industry has had difficulty determining the collective impact of the individual sub-field changes on the process. And because of the lack of a consolidated view, it has been hard to know what the problems are, determine their magnitude, know the extent of the problem, and what action should be taken. So it is obvious that a big picture view is necessary to deal with the changing aircraft maintenance field. This means that we must look across all the changes occurring in the maintenance field and find approaches that will direct it's future. Figure 2 shows some of the sub-field areas that need to be looked at and tied together to establish the big picture of maintenance sub-fields that need to be tied together to provide the state of the industry view.

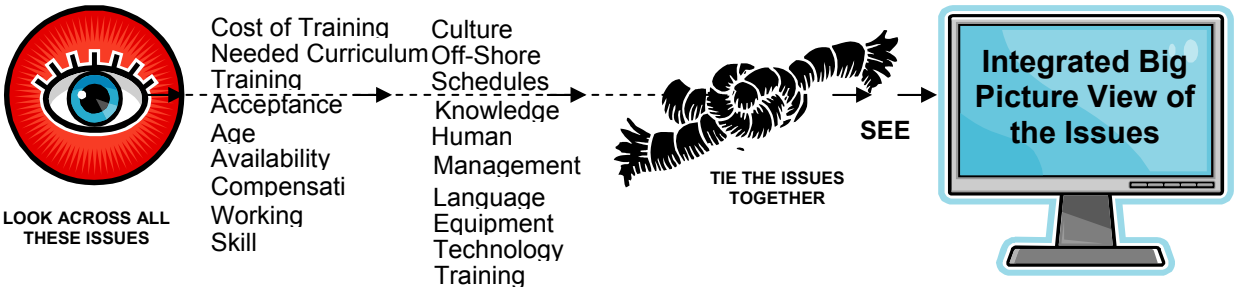



Figure 2. Integration of Issues to Create the State of the Industry View.

## Major Changes Have Occurred in Maintenance Personnel's Job

By looking at a high level history of aircraft maintenance we can see how changes in aircraft roles, technology, financial issues, and personnel both caused or altered what was thought of as the process of aircraft maintenance. As we go through this history, notice that the changes that occur are usually increasing the complexity of the process, require increasingly more skilled maintenance personnel, were trying to reduce the amount of maintenance needed, and more recently trying to use automation to eliminate large portions of the high tech maintenance process.

In the good old days an aircraft mechanic's job was well defined. Everybody knew the job was those tasks that were performed by the people with the big wrench in there hand. When something needed fixin' they would have specific procedures to perform the repairs. Over the years the wrench would not fit on all the electric parts that began to show up on aircraft. Then came electronics and the wrench was only good for tapping on those new fangled radios and guidance boxes. Although tapping sometimes worked to fix lose connections, the mechanic had to develop new skills to work on these devices. So mechanics, electronic device vendors, and device repair shops, teamed up to service and repair these devices (an increasing level of complexity to repair). These electronic devices began the process of sending electric messages through the aircraft between devices and those messages could break and had to be fixed. To this point the changes did not drastically change the maintenance job. Then some more new contraptions called computers were being used to do tasks on aircraft. Now the wrench had to be kept away from these devices because tapping a computing device might damage it. What to do. The mechanical skills and the electronic skills that the mechanic had developed were not enough to service and repair computers. Until this point the work the mechanic had to do was usually physical things that they could see, touch, measure, and replace. Although the computer has the "see and touch" component of work they now have a few new wrinkles. They had programs (software) that performed functions, but they could not directly be observed. They had to be dealt with by indirect means through things called displays, keyboards and other test equipment that may also be software based. Service and repair of these computer devices where further confounded by stuff that the programs worked on called data. The data could also break and had to be serviced and repaired. These computer contraptions where so neat (and held great potential to that people began using them for everything. The designers found that they could add many functions in one device could have many computer devices work together and pass data around to be processed and perform many aircraft functions. There were many reasons why these ideas were so attractive including provided new capabilities and at perceived cheaper cost. On the down side, the users often had more difficulty using the devices, and servicing and repairing them was becoming an increasing challenge for the mechanic and the computer specialists that were now a part of the maintenance organizations. The mechanic's dilemma was that the mechanic did not have the skills and training to deal with computer devices. So shifting the work to the computer specialist currently seems to be an appropriate solution for this changing technology.

Computers now are being used as the basic tool to introduce automation to the aircraft from the cockpit to the maintenance process. From a users view, work is supposed to be easier with automation. This is also true for maintenance people when the automation is working but introduces increased problems when the automation fails and it has to be repaired. This emerging philosophy of "automate everything" brings use to today's dilemma of understanding what should, how should, when should, why should automation be employed and how do we best use the human maintainer in the maintenance process of the future.

## Software and Automation in Maintenance Task - Make No Assumptions

The software industry has shown that automation technology is becoming increasingly more competent, but is it ready to take over large portions of the maintenance process for the next generation of aircraft and the next generation of the integrated ground/air/satellite/airport systems? Here are a few points that suggest that this may be at best a practical solution that should be cautiously applied.

There is a movement in the development of the next generation of aircraft and air/ground/satellite/airport integration systems maintenance to think of software and automation as the primary solution for improving effectiveness, reducing cost, and reducing direct human involvement (assumed to be a good thing for a number of reasons). A little evaluation of the viability of this concept will help us realize that we should not be in a hurry to eliminate the role of the human maintenance person.

*Software Is Never Completely Tested – All Problems Are Never Identified*

Because of the complexity and variation of the functions performed by software, data used, and users' interactions there is much of a software application's operation that never is evaluated/tested. This means that many of the problems and errors encountered in use have not been identified by the programmers and therefore have no error correction provided. The human is therefore the only resource available to resolve those issues and they are often the more obscure, difficult to understand types of errors.

*Automation Will Only Be a Particle Solution*

Some system developers think that the maintenance of aircraft computer systems (and linked devices) should be completely automated including the monitoring of operations and self correct any software or data problem and compensate for any hardware problem. These systems would also provide explicit instructions for the humans to intervene in the rare case that the computer cannot deal with the problem.

The automation solutions that are applied to aircraft systems must provide quick, accurate, and safe control and/or problem resolution. The following paraphrased statement suggests that the state-of the-art solutions of our advanced computer programs are helpful but not necessarily going to replace the aircraft maintenance person for a while. If current automation is going to depend on probability and conjecture based solutions as described below, it probably will not meet the safety levels required in the aircraft industry.

> Current traditional automation and "artificial intelligent programming techniques are in a transition from narrow, carefully defined domains to real-work situations in which systems learn to deal with complex data and adapt to uncertainty. Today, systems can perform useful work in a very large and complex world. Because these small [software] **agents don't have a complete representation of the world, they are uncertain about their actions. So they learn to understand the probabilities of various thinks happening,** they learn the preferences [of users] and costs of outcomes and, perhaps more important, they become self-aware" (Anthes, 2009).

The rest of the story about how bright these computers can be today is also suggested by Anthes in his concluding statement which follows: "We still hope that some time in the future computers will be as intelligent as we are but it's not a problem we'll solve in 10 years. It may take over 100 years." (Anthes, 2009)

With these inputs I am going to assume that the human is going to play a large role maintaining the next generation of aircraft and air/ground/satellite integration operations.

*The Place of Automation and Human in Future Aircraft Maintenance Systems*

Way back in 1983 L. Bainbridge stated the following purpose of automation. It is to replace human manual control, planning and problem solving by automatic devices and computers. But some of her colleagues pointed out: "even highly automated systems, such as electric power networks, need human beings for supervision, adjustment, maintenance, expansion and improvement." Therefore one can draw the paradoxical conclusion that automated systems still are man-machine systems, for which both technical and human factors are important.' It was suggested that the increased interest in human factors among engineers reflects the irony that the more advanced a control system is, so the more crucial may be the contribution of the human operator. (Bainbridge, 1983)

Non Automation of Maintenance for the Newly Complex Computerized Everything

There are also aircraft maintenance issues when automation is not incorporated into the highly integrated, complex computer systems.

*Limited Attempted Implementation*

There are probably only a few systems that are being designed with these goals in mind. Organizations that are making components (that may or may not work in a system environment) will not automatically implement any or the same maintenance processes as the next organization (currently no industry standard). Consequently the devices probably won't have the same service and repair process.

*No Required Implementation Means Initial Cost Lower / Operational Cost and Life Cycle Costs Much Higher / Safety will be an Issue*

With no pressure to implement "design-for-maintainability" and/or maintenance automation, many organizations that only build/sell devices/system will not be inclined to spend the money to implement. If they are directed to deal with life cycle costs, then implementation will be of great benefit. With no designed for maintenance automation, the task of maintenance requires a human solution and the labor, cost and safety problems will grow during the life cycle of the device/system.

*Maintenance Systems Need Maintenance and Automated Systems May Be Unable To Do the Job*

A key point is that the when the self maintenance automation doesn't work or the guided service and repair systems have problems (which they will) they will have to be serviced by another smarter computer and/or a human. Now we have added another level of complexity. The complexity of the problems that will be turned over to the human could make it very difficult and time consuming to make corrections.

## The Challenge – Preparing for the Future

Most of this paper has discussed both the state of the aircraft maintenance industry and about the thinking about replacing people maintainers with automation of one type or another. I have suggested that it is highly unlikely that our very sophisticated computer systems located in aircraft, aircraft support systems, airport systems, air traffic control systems, and all the other related systems will be able to eliminate the human maintainer in the near future. It is projected that the traditional description of the maintenance function probably will have to drastically change. Many tasks not traditionally attributed to the current maintenance person's job (including dealing with complex computer functions, configuration management, software/hardware version updating and control, data management, data repair, security or maintenance systems and data, interfacing with electro mechanic systems and traditional maintenance, etc., etc.) may become part of this job. Someone is already doing these functions on modern aircraft but not under the traditional maintenance job classification.

*The Rest of the Story – Financial and Social Realities That Are Defining the Aircraft Mechanic of Today and Tomorrow*

As you were reading about the changes occurring in the maintenance process and industry, how often did you translate the technology drivers into the underlying financial, personnel, and social underpinnings of those technologies? If like many people, you seldom or never thought about the causation of change which is often a result of financial, personnel, social, or other practical reasons that result in technology and process change. This is a circular argument in that when financial, personnel, and social changes drive technology changes, these technology changes further drive additional financial and social changes. Because this cycle has been going on for so long people have accepted the spiral and pay little attention to the causal issues and the cumulative state of the industry caused by the changes.

*Financial and Social Drivers to Develop a State of the Industry*

There are numerous issues that will bring substantial financial pressure to our industry to identify the state of the industry and to develop solutions to resolve those issues. Among those issues are: Technological complexity may be advancing faster than the maintenance process can address it with the financial impact it will be difficult to economically maintain aircraft from a life cycle view. There may not be enough people being trained with the skills that will be needed for new technology and there will be a great shortfall of trained maintenance personnel with new and traditional skills. This shortage could impact maintaining the market or limit its expansion. Automation will be employed to reduce some costs but from a systems view in a life cycle environment it could actually be more costly to maintain highly automated systems.

As the aging maintenance workforce retires the work ethic, objectives, and style is changing. This change is having far ranging impact on accomplishing safe, effective repair. Because of salary pressures on airlines, maintenance personnel can find much better salaries at auto dealerships so the airlines are not competing. Work conditions and schedules are issues that were accepted by older workers but are not tolerated by younger works. A huge number additional social issues have developed over the years and many will have to be resolved before the social aspect of the maintenance job will be seen as a desirable.

## What Needs to be Done?

Traditional thinking would suggest that we identify the problems and fix them so they work as well as they used to. But the "used to" has gone away. This realization should lead the industry to think of the maintenance process needing a new beginning. By evaluating the needs of the customer (system, devices, airlines, repair stations, maintenance people, etc.) (Gallaway, 2006, 2007) a picture of the maintenance industry role for the future can be built. This would then be followed buy specific action plans to deliver what was needed. By openly addressing the financial, personnel, and social requirements through the development of the new process, the new process can meet the industry *need.*

## Working on the Future

The maintenance industry no longer has the option to continue on it's lassie fair path any longer if the maintenance industry wants to provide aircraft maintenance services in the future. The conclusion is that this industry must benchmark its state, identify the current and future needs for maintenance, determine what the maintenance person will need to know and be able to do, develop standards for work sharing between automation and humans, look at alternatives to meeting maintenance service, and begin the shaping and resolving of issues to meet safety and business needs, and identify how the process should be managed

The FAA Flight Standards Division has initiated a research program to start the process. This work will be supported by representatives from industry, government, academia, labor. It will also be well grounded in financial, social and regulator requirements of the industry.

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