

#### About the Authors

Dr. William Johnson is the FAA Chief Scientific and Technical Advisor for Human Factors in Aircraft Maintenance Systems. His comments are based on nearly 50 years of combined experience as a pilot, mechanic, airline engineering and MRO consultant, professor, and FAA scientific executive.

Marc Szezan is a Lecturer in International Business at the University of Oxford Saïd Business School, Oxford, United Kingdom, where he also completed the doctoral program in management studies. Previously, Marc's primary professional experience has been in leading technical and digital aviation businesses in Europe, Asia, and the U.S. Most recently, he served as Senior Vice President, Airline Operations Solutions, at Lufthansa Systems, the IT services business segment of Lufthansa Group. He led a multi-business unit flight operations support business that served a global airline customer base. He also held leadership roles at Lufthansa Technik, the MRO business segment of Lufthansa Group, and for two other German industrial companies. In 2012, Marc was recognized as one of Aviation Week & Space Technology's "40 Under Forty: Rising Stars of Aerospace and Aviation". He holds previous graduate degrees from Harvard and Duke



Dr. William Johnson



Marc Szezan

## Comparing Aircraft Maintenance for Patient Safety during Major Repair and Replacement\*

### Dr. Bill Johnson & Marc Szezan

#### Introduction

This article started when Dr. Bill Johnson (aka. Dr. Bill) was discussing his upcoming total hip replacement surgery (i.e. "major repair and replacement") with Marc Szezan, a former Lufthansa senior executive and now a Lecturer at the University of Oxford Saïd Business School. We talked about the surgery and realized that there might be similarities between performing "surgery" on Dr. Bill and on aging aircraft. Even more importantly, from Bill's point of view, there surely could be similarities in terms of what one would expect from a repair station and a hospital. So, we discussed the characteristics of an aviation maintenance service provider and a medical service provider that would be most desirable to complete respective services in an efficient, effective, and safe manner. Yes, even though the prospect of undergoing hip surgery was not all that pleasant, the discussion itself was fun. The successful surgery is now over and we look back on the pre-surgical considerations about patient safety during major repairs. Here is a short summary ...



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### Is A Repair Necessary?

First, there is the non-routine finding and the necessity to undergo repair. Too many landing cycles or hard landings on an aging airframe can result in the main landing gear attach fitting (see Figure 1) not reaching its intended Original Equipment Manufacturer (OEM) service life. Hopefully, any top-notch maintenance, repair, and overhaul (MRO) facility detects such damage, writes up a non-routine finding, and replaces the damaged or worn attach fitting. In the case of human beings, this sort of strain on the main landing gear system and its attach fittings – i.e. the legs and hips – can occur as well. Dr. Bill was fortunate that his doctor properly diagnosed failure of his right hip prior to reaching its – for lack of a better term – “OEM design life” and recommended to replace it as soon as reasonably possible. As with an aircraft, Dr. Bill had to be scheduled for a maintenance slot to accommodate the anticipated out-of-service time for repair, recovery, and new component break-in.

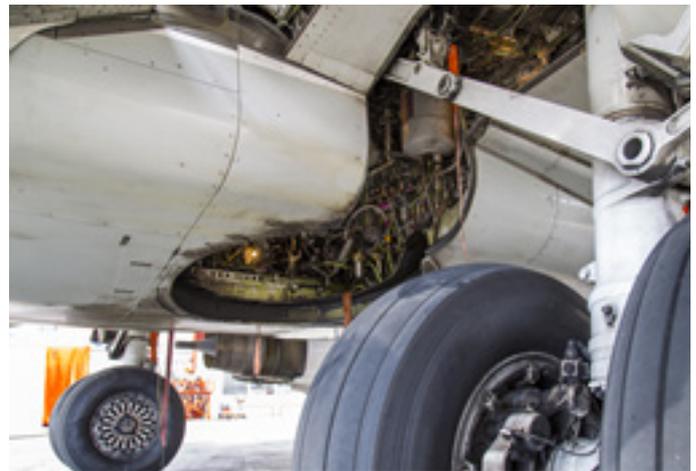
### Right Service Provider

In general, many maintenance facilities offer landing gear services. It is very important to ask around to find the very best maintenance provider. On the one hand, it is important to find a MRO that is large enough to have top-notch hangars, shops, and modern equipment. On the other hand, very busy large maintenance providers may be more focused on major airframe maintenance checks and structural repairs or full landing gear overhauls. That may mean that a mere main gear attach fitting replacement job may be squeezed in between the higher revenue big item jobs. Dr. Bill wanted a well-known provider that specializes in landing gear main attach fitting replacement and that takes pride in performing this very procedure. Also, his choice of service provider was influenced by prior family experience with the repair facility (aka. hospital) and its good track record. And repair facilities also value return and referral customers.

Of course, Dr. Bill wanted to be able to perform an informal on-site audit himself. Unfortunately, that is not always possible. However, in our experience, nothing really beats walking around the flight line, the hangar floor, and engineering offices just to observe cleanliness, attitudes, and overall demeanor of people and to get a feel for the facility. The fact that the hospital and medical team welcomed patient safety questions before the procedure was a good sign that they were on the right track. He found the right place.

### Right People and Right Team

Maintenance work is based on highly qualified and experienced personnel, working together as a team and accomplishing the job with the highest care and resulting quality. Individual specialists must be properly trained and be current in their respective areas of work. For an individual one-time customer, it might not be feasible to check the credentials of all maintenance staff and to verify the level of recurrent training across the entire maintenance team. For MRO services one must rely on the certification agency, like the FAA. For medical services one can turn to a broad range of data sources for individual hospitals. For example, Consumer Reports, U.S. News & World Report, the U.S. Medicare website, along with numerous others provide data and, in some cases, ratings pertaining to patient safety. We all know that there is variance across different Part 145 maintenance



**Figure 1. The Main Gear Attach Fitting**

facilities but the certification agency(ies) must ensure an acceptable level of compliance to established standards. In the same spirit, Dr. Bill selected medical professionals with the right type of initial training (i.e. medical school), evidence of adequate levels of recurrent training, and appropriate certifications.

Successful maintenance work is not just a function of the excellence of an individual contributor but a true team sport. Replacement of a landing gear main attach fitting can require Airframe and Power Plant (A&P) mechanics to remove and reinstall the landing gear, avionics mechanics to work on disconnecting and reconnecting wiring, structural experts to perform the replacement of the attach fitting itself, engineers to develop or coordinate repair schemes in case of secondary findings that are out of limit, tooling and logistics specialists to ensure availability of spare parts, consumables, and tooling, facility experts to keep the hangar and shops in good condition, and – depending on an aircraft operator's standards – pilots to perform a post-maintenance test or verification flight. Similarly, Dr. Bill did not judge the hospital of his choice by the quality and reputation of the orthopedic surgeon alone. Instead, he made sure to have a good feel for all other members of his surgical team – anesthesiologists, nurses, facility managers, etc. – in their own right and, above all, in terms of their team spirit.

### Right Organizational Culture

Even the best people and the best team are likely to fail in a maintenance organization that has the wrong culture. A dedication to safety and to an appropriately configured safety culture must be a shared and non-negotiable goal throughout the entire organization. This safety culture must be lived daily reality and priority, and not just be relegated to second fiddle. Sometimes that is difficult to ascertain during a short on-site visit. But it certainly is worthwhile trying to verify this and to look for visible indications of a service provider's safety culture. For example, walk past bulletin boards and pay attention whether safety-related matters are displayed prominently, are kept up-to-date, and measure the right Key Performance Indicators (KPIs). Ask about voluntary reporting systems. Ask how the organization deals with honest errors. Ask if individual employees get sufficient rest and if teams are adequately staffed for the tasks at hand. And given Dr. Bill's background, you will not be surprised that he recommends inquiring about human factors training. Sometimes even the marketing material talks about safety. That's worth looking for! Bill checked on all of this and only settled for a

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hospital once he was reasonably sure that the hospital had the same type of safety culture that he would expect from a repair station to which he would entrust an airliner repair.

### Right Facilities, Equipment, Procedures, and Parts

The best people and best team working in the best organizational culture will struggle to produce high-quality repairs if they are forced to work without being properly resourced. If possible, check the facilities, the equipment, and the tooling that are made available to MRO employees. Good lighting, work stands for easy access, and cleanliness are important. Consider tooling and equipment-related procedures as well. Check specifics. For example, look into tool control procedures. Do mechanics perform a toolbox check upon completion of maintenance work? You don't want tools left behind inside the airframe after closing up. And you certainly don't want your doctor to leave behind a scalpel or the like after closing your personal "cowling". In the case of Dr. Bill's medical service provider, an old fashioned television in the pre-operating prep room did raise concern. However, his nurse commented that it was the oldest device in the hospital except for a couple of the other nurses and doctors. She said that all surgical equipment was state-of-the-art and in calibration.

Regarding Standard Operating Procedures (SOPs), in general, are working procedures clearly documented, sound, and consistently applied? Dr. Bill observed that his medical service provider was extremely diligent about explaining the procedure. The hospital also demanded that patients take a class, prior to the repair, to be sure that post-surgery rehabilitation was accomplished properly.

Do employees have easy access to and perform maintenance work in accordance with authorized and up-to-date and controlled documentation such as Aircraft Maintenance Manuals (AMMs) or Structural Repair Manuals (SRMs)? Replacing the main attach fitting of a landing gear is a complicated procedure. First, the gear must be removed from the airframe (see Figure 1). Then the main attach fitting must be replaced. In case of finding secondary corrosion, that must be removed. The gear must be mechanically reinstalled and all electrical and hydraulic lines must be reconnected. Hip replacement is similarly complicated (see Figure 2). You want your surgeon to work in accordance with proper procedures. You surely don't want your surgeon to – no pun intended – just "wing it".

When undergoing parts replacement – i.e. a new hip – you want to make sure that the replacement part itself is of acceptable quality. Both in the case of "surgery" on human beings and on aircraft you want to beware of Suspected Unapproved Parts (SUPs). Ask about the procedures your maintenance provider – i.e. hospital – has in place to control the risk of SUPs. Ask about procedures designed to ensure that consumables have not expired.

Dr. Bill looked into all of this before feeling at ease with his choice of hospital!

### Aircraft Maintenance vs. Medicine

As aviation safety professionals, we all appreciate the direct comparison between aircraft maintenance and surgery. Our maintenance processes, particularly our

Safety Management Systems, ensure continuing safety worldwide. Our industry strives to identify hazards thus seizing every opportunity to manage safety.

Especially before his surgery, Bill did not want to ponder medical patient safety statistics. They are not positively impressive. While the worldwide commercial airline total accident fatality rate has been about 500 lives lost per year during the past ten years, a recent study suggests more than 250,000 deaths per year due to medical error in the U.S. alone; that is, a rate more than 500 times as high! The good news is that medical professionals and hospitals are seeking advice from aviation safety risk experts. Some aviation safety consultancies have even reduced their aviation workload in favor of medical patient safety consulting, where the help is most certainly needed. Medical schools are increasing their offerings related to patient safety as well. Insurance companies have stepped up to incentivize with lower rates for patient safety initiatives.

After having tried to do his homework of checking on people and teams, the organizational culture, and facilities, equipment, procedures, and parts at the hospital of his choice, Dr. Bill was ready for his major repair and replacement. His total hospital turn-around-time was less than six hours and he was hobbling around by the end of the day. He is looking forward to returning to walking and running his favorite trails. Better yet, to doing more "walk-arounds" at your MRO.

\* This article is a slightly edited version of an article that was published in the August-September 2017 issue of *AMT Magazine* and is reprinted with the publisher's permission.



Figure 2. Simplified Front View of Human Gear Attachment Fitting

## MAINTENANCE HUMAN FACTORS RECENT AND UPCOMING EVENTS

Human Factors & Ergonomics Society Conference  
Dr. Michelle Bryant

October 9-13, 2017  
Austin, TX

Airlines4America MX Safety Council Meeting  
Dr. Michelle Bryant

October 17, 2017  
San Diego, CA

Aviation Safety InfoShare  
Dr. Michelle Bryant

October 18-20, 2017  
San Diego, CA

Flight Safety Foundation International Air Safety Summit, Session Chair and Panelist on Fatigue Risk Management in MX  
Dr. Bill Johnson

October 24-26, 2017  
Dublin, Ireland  
<https://flightsafety.org/summit-seminar/iass-2017-home/program/>

Royal Aeronautical Society, Human Factors in Aircraft MX, Lessons Learnt from Recent Accidents & Incidents - Summary Panelist  
Dr. Bill Johnson

November 1-2, 2017  
London, England  
<https://www.aerosociety.com/events-calendar/human-factors-in-aircraft-maintenance/>

Talent Solutions Coalition - Integrating Soft Skills into Technical Training, Session Chair and Panelist  
Dr. Bill Johnson

November 7-8, 2017  
Indianapolis, IN  
<https://talentsolutionscoalition.org/event/talent-solutions-coalition-forum-ii/>

Boeing/A4A Safety Conference on MX Procedure Complexity  
Dr. Bill Johnson & Dr. Michelle Bryant

November 15-16, 2017  
Seal Beach, CA

European Human Factors Analytics Group, Group Member  
Dr. Bill Johnson

November 28-29, 2017  
Cologne, Germany

## SEE SOMETHING MISSING?

Are you a regular reader of our Mx HF Newsletter? Do you see something we're missing? As always, please let us know! If you have ideas for future articles or would like to contribute, please contact our newsletter staff at:

crystal.rowley@faa.gov

## OPERATOR'S MANUAL: HUMAN FACTORS IN AVIATION MAINTENANCE (PDF LINK)

