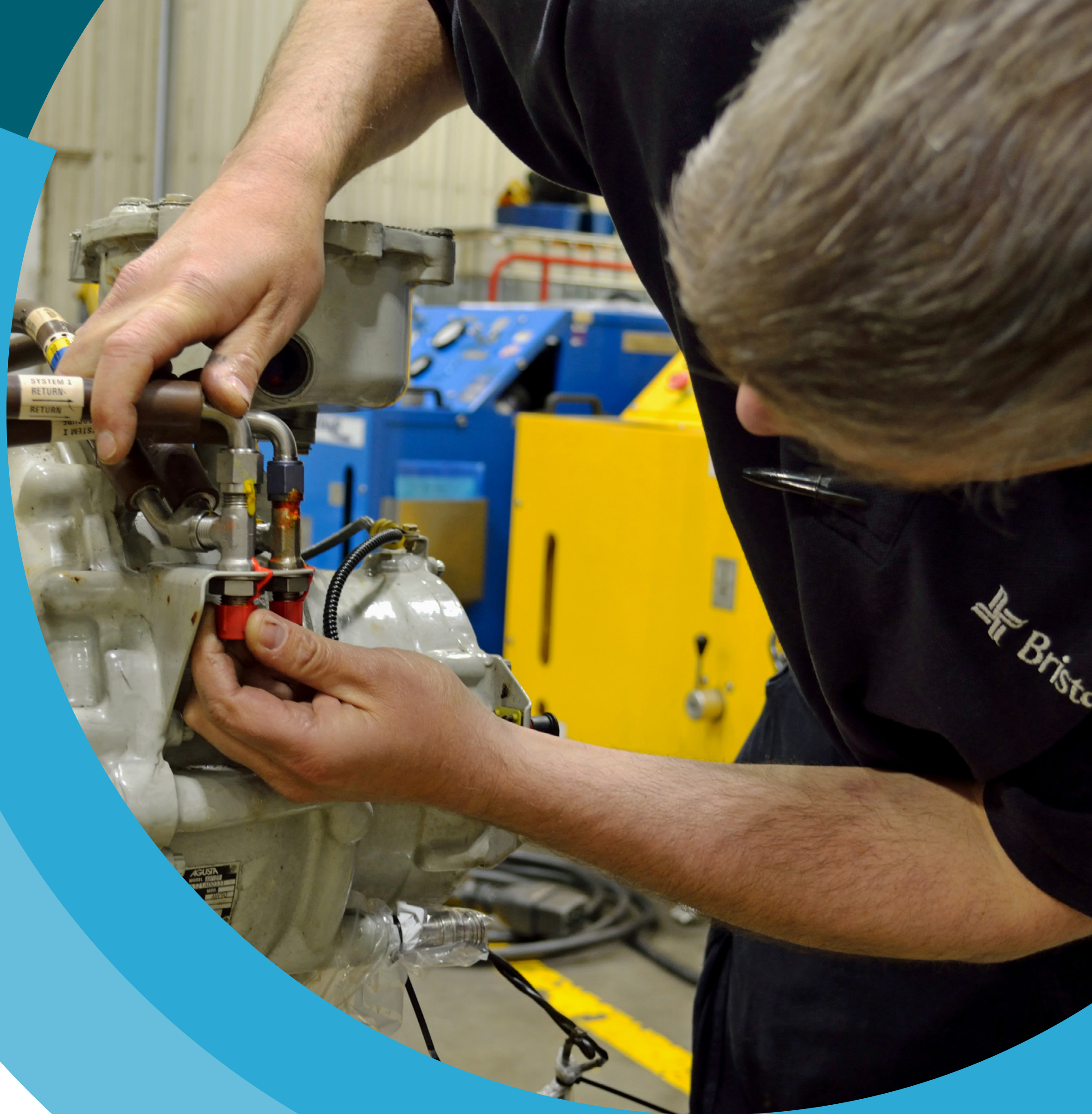
HeliOffshore
Safety Through Collaboration

Maintenance Resilience

White Paper



Critical Analysis of Offshore Helicopter Maintenance Operations

Version number: 1
Publication Date: July 2023

Safety Through Collaboration

Collaboration empowers safety and is at the very heart of HeliOffshore. This Maintenance Resilience White Paper is a great example of how our industry identifies improvement opportunities, works together and learns from each other to ensure no lives are lost in offshore aviation.

I would like to thank the industry stakeholders and every HeliOffshore member who contributed to the development and delivery of this paper. Thank you for your commitment and contribution. Together, we will implement and sustain ever-higher levels of performance so those we are responsible for travel home safely every day.

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This document is not intended to replace any contractual negotiations, agreements or requirements between helicopter operators and their customers.

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Glossary

ASB .... Alert Service Bulletin
EASA .... European Union Aviation Safety Agency
EPAS .... European Plan for Aviation Safety
FAA .... Federal Aviation Administration
HHA .... Human Hazard Awareness
HUMS .... Helicopter Usage Monitoring System
IOGP .... International Association of Oil & Gas Producers
MOP .... Maintenance Observation Programme
MRO .... Maintenance, Repair and Overhaul
MTBF .... Mean Time Between Failure
MTBUR .... Mean Time Between Unscheduled Removal
OEM .... Original Equipment Manufacturer
PBH .... Power By the Hour
PBL .... Performance Based Logistics
SB .... Service Bulletin
SCF-NP .... System Component Failure Non Powerplant
SCF-PP .... System Component Failure Powerplant
SMS .... Safety Management System
SRR .... System Reliability & Resilience
TSG .... Technical Steering Group
UK CAA .... United Kingdom Civil Aviation Authority

Executive Summary

Maintenance is an essential part of helicopter operations regardless of the role or mission the aircraft undertakes. The correct execution of this ensures that the aircraft are delivered safe, airworthy, and reliable to Flight Operations. To allow for safe technical operations it takes the work of several different technical functions operating under the jurisdiction of national and international authorities.

Regulatory bodies have legislative requirements to ensure a level of technical competency throughout the maintenance organisation and these obligations are routinely audited by the authorities and external bodies.

Due to the nature of maintenance operations, there is often a delay between the maintenance actions being carried out and the realisation of error. This delay may be days, weeks or even years dependent on the condition (Hobbs, 2008). To try to negate this it is important that all relevant technical personnel are made aware of new technical improvements, legislation, procedures and discussions about incidents and near-misses. There are many means to communicate both internally and externally so all technical employees should participate in company training as well as electing to receive information from the OEM and regulators.

The importance of a robust safety culture, management system and reporting structure is an integral part of a maintenance resilience programme whether it is MRO, Line Maintenance or OEM.

The ability to report incidents that may have an impact on operations whether it is a system error or human factor is key as is the confidence of a reporter to speak up whenever they feel that there is an issue or a question to be raised. This is particularly important as there is generally a lower rate of reporting than other operational branches (Teperi, et al., 2018), without this information it can lead to delays or misinformation.

There are opportunities for further research into maintenance error and resilience by the industry despite recent European Plans for Aviation Safety publications that have shown this area of research to be a low priority according to the Rotorcraft Safety Roadmap 2018 due to the work carried out by HeliOffshore.

Since the inception of HeliOffshore in 2014 we have worked with operators, energy companies, OEMs, and industry bodies such as Flight Safety Foundation and the Royal Aeronautical Society. The creation of projects such as Human Hazard Analysis and groups such as the Technical Steering Group (TSG) has allowed conversation and the flow of ideas and experience between all the stakeholders within the offshore aviation sector.

HeliOffshore is committed to working with our members with the aim to have no lives lost within offshore aviation activities.

Within this document are several discussion points that allow for constructive communication within technical aviation personnel. This paper highlights these issues and the support that HeliOffshore can offer to operators and other stakeholders.

Introduction

Why do we perform maintenance? It is simple: the maintenance of an aircraft provides assurance of flight safety, reliability, and airworthiness.

Aircraft are designed with an inherent level of serviceability and reliability in systems and as the aircraft is operated. Deterioration and degradation will increase the level of weakening within those systems. When maintenance is performed the goal is to restore systems or components to the desired level of perfection, using varied techniques and methods, for their intended use.

Maintenance operations set out to provide the flight operations department with an airworthy aircraft suitable for the intended mission, at the time the aircraft is required for flight with all necessary maintenance actions completed, or properly deferred. An unfortunate reality exists that the very nature of performing maintenance has the potential to introduce a less than desired level of perfection in a system, causing disruption to the maintenance organisations efforts in achieving its purpose.

The very nature of operations within the offshore environment it leads to complexities within maintenance.

Technical staff are often working with not only different types of aircraft but also different manufacturers regularly during the working day. In the fixed-wing world maintenance is generally carried out within a well-appointed hangar near a hub but rotary rectification also adds forward operating bases, oil rigs and drilling ships to the equation. This added diversity in maintenance locations contributes to further complications that technical staff must factor into what is already a complex operation.

These challenges are what brings about our industry's ability to either develop effective maintenance strategies anywhere from the design stage to working on the aircraft on the front line. The industry needs to overcome these challenges in a proactive manner to attain some level of resilience against obstacles put in its path, whether it is human issue or a systematic one. Whilst a proactive approach is always preferred there may be situations where organisations need to review how the system recovers from a failure and how we learn from it.

The aim of this document is to enable an open discussion on maintenance resilience between technical processionals.

By looking at current issues on maintenance, this paper acts as a catalyst for all stakeholders to review current policies and shape future HeliOffshore research. This document details the research HeliOffshore is currently undertaking, and the outcomes it will lead to.

In the five year period between 2015-19 nearly 20% of fatal accidents in our industry were attributed to System Reliability and Resilience (HeliOffshore Safety Performance Report, 2020). This includes both technical and the human-machine system. Much work has been done by regulators, industry bodies, operators, MROs, and OEMs to address the underlying issues. With this in mind, HeliOffshore are involved in several initiatives to promote with our members to research ways to understand and improve System Reliability and Resilience.

HeliOffshore has set up a Technical Steering Group (TSG) to bring together stakeholders from the across the industry to discuss, review and research current issues and look forward to where efforts should be concentrated on future projects. Through discussions with TSG stakeholders and other HeliOffshore members we have been able to identify concerns that are affecting maintenance operations whether on a global level or at the front line. This publication will be highlighting these issues as well as discussing current HeliOffshore projects.

This publication is intended to be a document that will be reviewed periodically to allow for further revisions when HeliOffshore and the stakeholders must react to changes within the industry.

Background

HeliOffshore Safety Performance Model

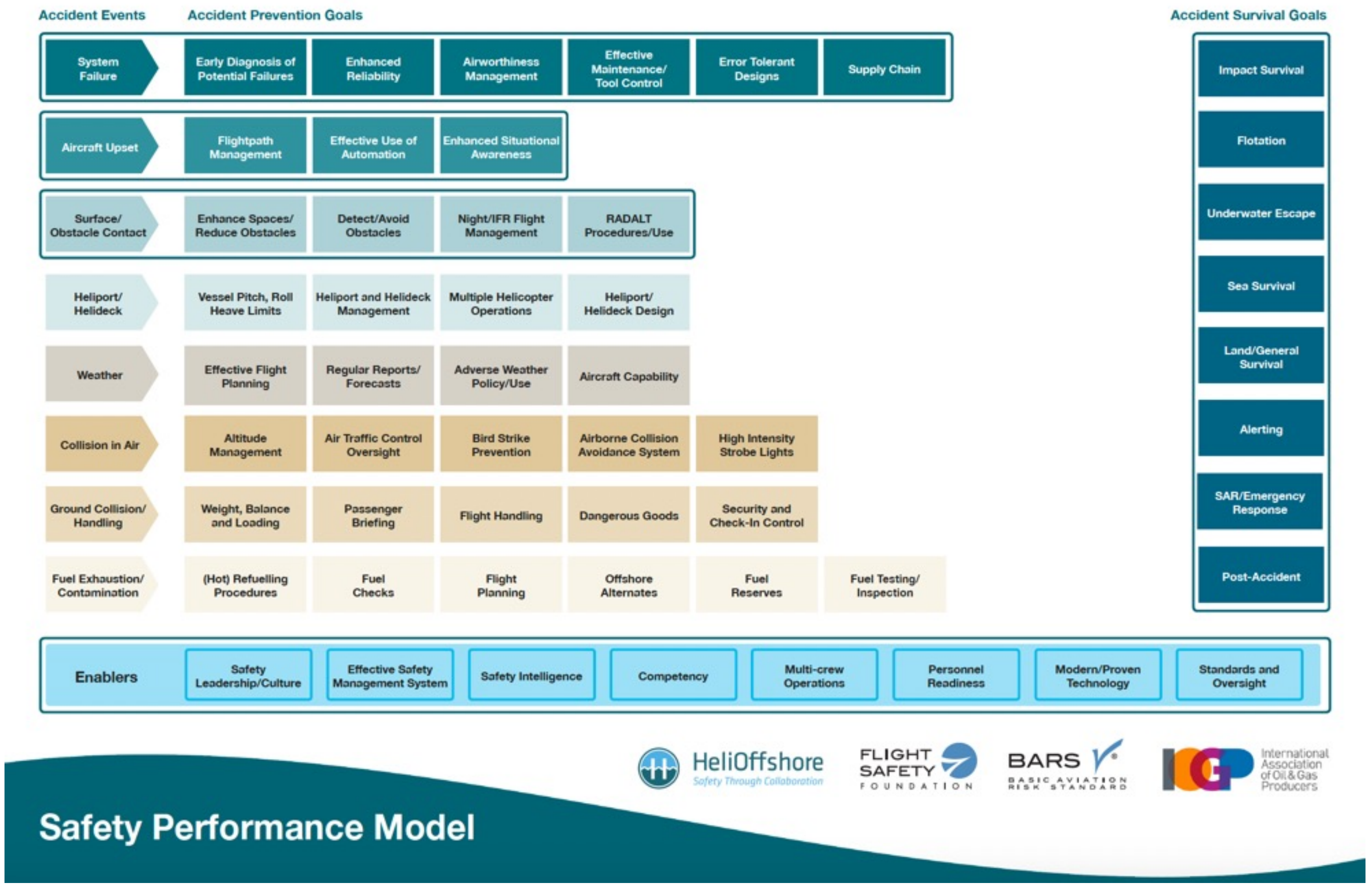

Figure One: HeliOffshore Safety Performance Model (HeliOffshore, 2020)

After a fatal helicopter accident in 2013 the seeds of HeliOffshore were sown with a mission that no lives are lost in offshore aviation. To achieve this aim, all aspects of offshore aviation must be examined. Through collaboration with its members, HeliOffshore carries out research and reviews of procedures and processes to promote the safety discussion throughout the industry.

HeliOffshore has developed a Safety Performance Model, see figure one, that looks at accident events and the performance goals that could counteract them. The System Failure element is the one of particular interest to Maintenance Resilience and these goals should form part of any maintenance or technical programme. By adopting them from design level to releasing an aircraft to service on the line it promotes a safety focussed attitude that is relevant at all levels of the industry and to all the personnel involved.

HeliOffshore has published annual Safety Performance Reports since 2019 where incidents are recorded and identified due to accident type. The two main event types that directly affect System Component Failure – Non Powerplant (SCF-NP) and System Component Failure Powerplant (SCF-PP), see figure two.

According to HeliOffshore data, between 2013-2021, the total accident occurrence rate that involved component failure was 28% (HeliOffshore, 2022). Component failure is defined by many factors and can include missing components, incorrect assembly and fitment to maintenance error and can be caused by the aforementioned conditions as well as performing out with recommended parameters.

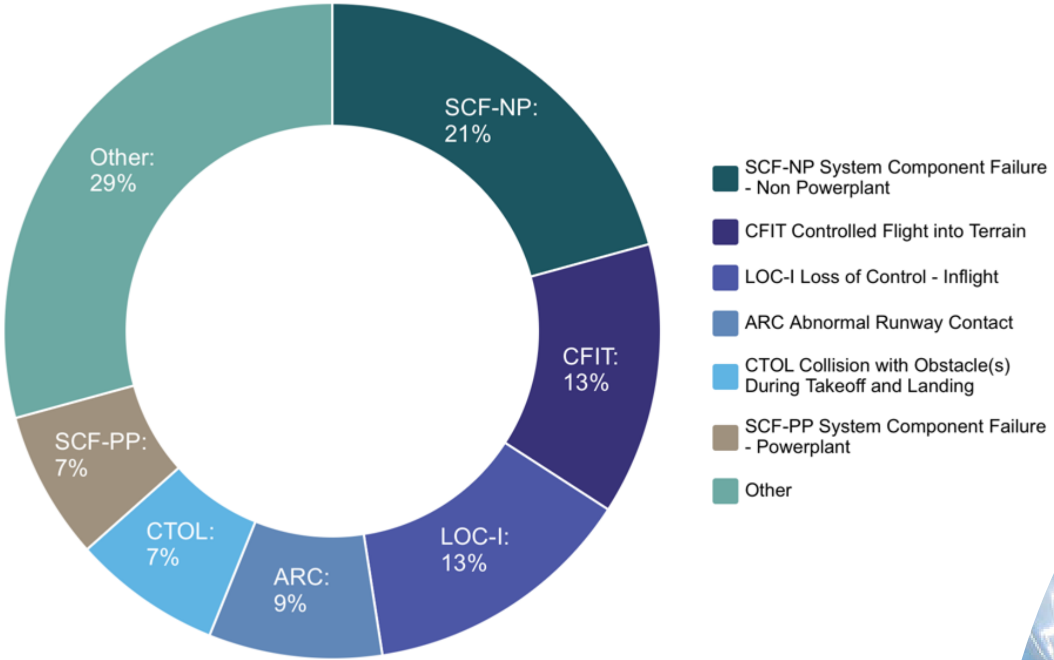

Figure Two, CICTT Occurrence Categories for All Accidents (2013-2021) (HeliOffshore, 2022)

European Risk Classification Scheme (ERCS)

In the latest EASA Annual Safety Review, they have listed the issues that they define as “key risks” for Commercial Air Transport helicopters. This data has been amassed over the period of 2017-2021, data from the UK has been excluded since 2020 due to that country leaving EASA.

Previous editions of the EASA Rotorcraft Safety Roadmap have stated that Offshore rotorcraft are a lower priority due to the work of HeliOffshore and other organisations (EASA, 2018) and whilst the risk rating remains low, see figure three, a risk remains. In the latest European Plan for Aviation Safety 2023 (EPAS) they have decided to raise helicopter maintenance related issues to “Elevated Priority” (EASA, 2023)

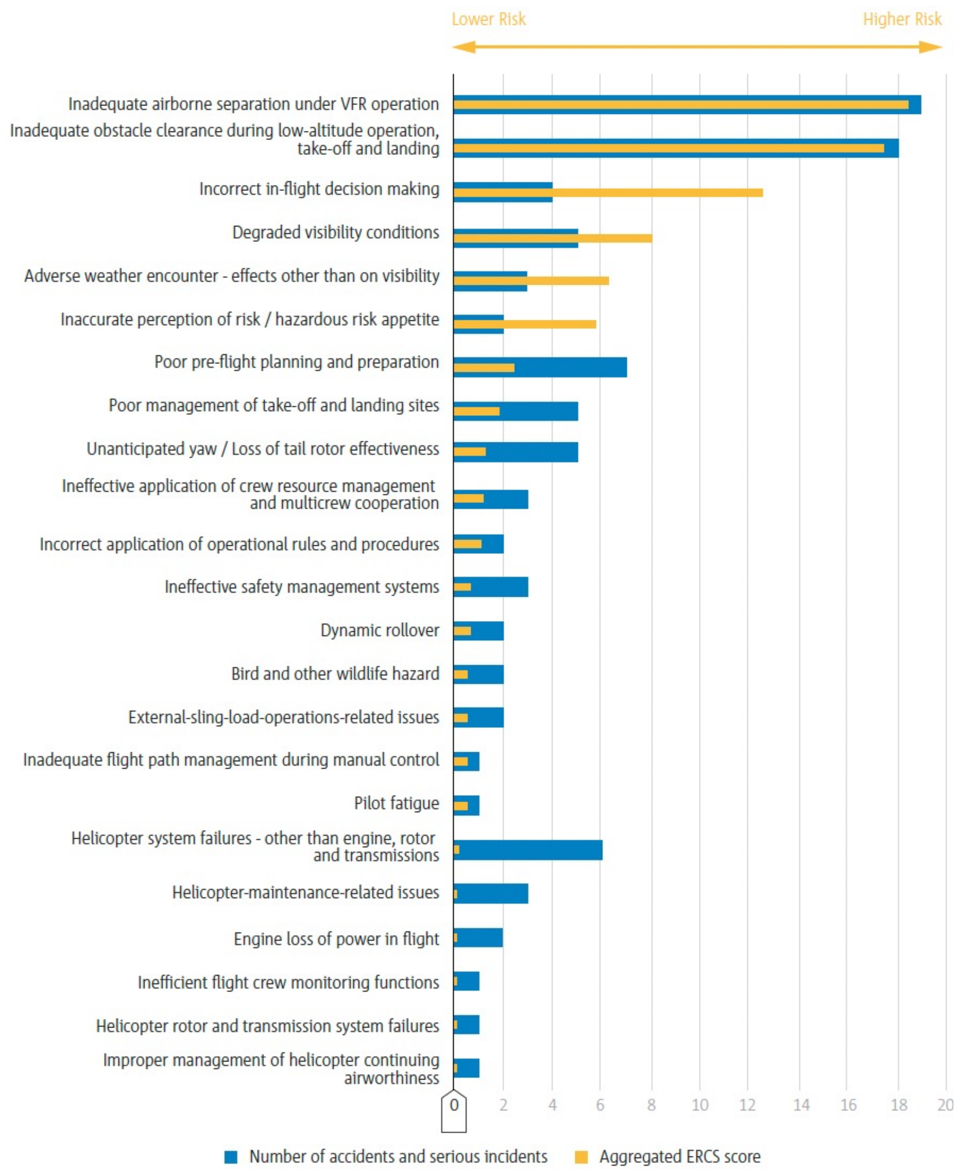

Figure Three: Safety issues by aggregated ERCS score and number of accidents and serious incidents involving commercial air transport helicopters (EASA, 2022)

Current issues with maintenance

The HeliOffshore Maintenance Resilience White Paper is intended to be a document that will be reviewed periodically to allow for regular discussion on the state of the maintenance element of the Offshore transport industry.

From the period between August 2022 to February 2023 after discussions with industry technical leaders, OEMs, customers, and frontline staff it became apparent that two recurrent topics were of primary concern:

1. **Global labour shortage**
2. **Challenges within the supply chain**

In this initial paper these topics will be discussed and reviewed. Future reviews of Maintenance Resilience will follow the same process of discussions to ascertain the greatest risks to the maintenance process. The primary source of these discussions will be the Technical Steering Group which meets every six months, but all contributions will be considered.

Global Labour Shortage

Skilled labour and its availability have always been a major issue within aviation and this problem has been further exacerbated by COVID and the subsequent downturn in flying hours and sectors.

Within the entire aviation sector Boeing are estimating a need for 626,000 new technicians within the next two decades to enter the workplace as flying rates are forecast to increase (Lampert & Ganapavaram, 2022). With the outbreak of COVID-19, a mixture of early retirements, cessation of training and technicians leaving the industry entirely it has compounded the problem. Additional complications from the UK leaving EASA have reduced the labour pool available as many UK CAA licence holders have not applied to an EASA member state for an applicable licence bring added complications to an already difficult situation. Historical events such as the downturns in flying due to low oil prices and changes in helicopter types have also contributed to reductions in labour requirements and apprenticeship programmes and this is not limited to maintenance but other various fields (OGUK, 2017) . The volatile nature of the Energy market means that there is an increased risk associated with working for an Offshore operator with the more risk averse personnel choosing to work within the aviation sectors that have been historically more stable.

The reduction in available labour has led to a rise in costs not only for permanent staff but a rise in contractor fees. The rise in contractor fees has led to another issue where permanent staff are now looking at leaving organisations to branch out as an independent. Due to other issues within the maintenance environment these contracts can last months or years.

One of the main concerns about the labour is the retirement of qualified technicians and the amount who are nearing retirement. In a survey on the age profiles within North America, they found that most FAA-certified technicians are over 40 years old with over 35% between 55 to 64 years old, see figure four, (Oliver Wyman, 2022).

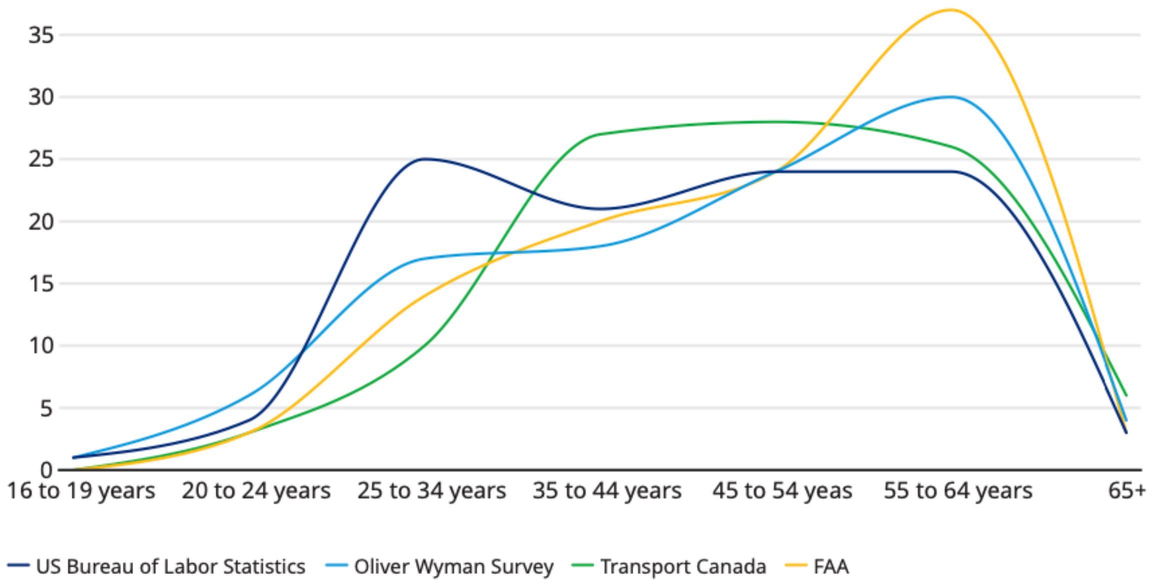

Figure Four: North American aviation maintenance technician age profiles by data source (Oliver Wyman, 2022)

The industry in general is also looking at a long-term strategy by creating or re-invigorating apprenticeship programmes within their organisations that should help to alleviate future issues. In the short term many operators are focusing on training their existing staff to grant them greater responsibility with either expanded certifying privileges and type ratings, this may be dependent on the operator's national regulator. There may be increased risks with this as staff may need extra training and lack experience in the short term.

Other initiatives that have been recommended by industry experts range from greater flexibility within shift schedules to clear career progression pathways (Banglesdorf, 2023).

Due to the possibilities of the knowledge and experience drain because of the ageing workforce issue, HeliOffshore are working with Shadowbox Training to help develop training scenarios to assist with cognitive reasoning and decision making. These scenarios can be part of a Continuation Training programme that operators can tailor to their own systems that may enhance their national authority's required content.

Challenges Within the Supply Chain

Currently the aviation sector is facing an unprecedented spares and supply issue globally. This situation is affecting both the operators and OEMs as both have been exposed to worldwide issues such as COVID, political unrest and base material shortages.

The shortage of spares has increased the requirement for robberies (or cannibalization) which in turn has led to many aircraft lying dormant being used as donors. For the purposes of this discussion, it is important to differentiate between robberies to keep aircraft online with a view to replacing the part on the donor aircraft and removing a part for testing systems during maintenance. This practice is often used as the procedure of last resort as it has inherent safety implications as it means additional workload and testing as well as increasing the risk of maintenance error by removing a component from a serviceable system that would normally not require maintenance at that time.

OEMs are also facing a challenging time trying to source components and materials from their suppliers at all levels, so this is leading to difficulties fulfilling orders.

To counteract these issues in the short-term discussions are ongoing between operators, OEMs, suppliers, and customers with these issues being raised in forums such as the HeliOffshore TSG, IOGP groups and other safety bodies. Some of the solutions available are reviews of service intervals, alternative parts, and deferments. This highlights the importance of reliability data but also may cause increased maintenance due to increased inspections where a component life or its condition has come under scrutiny.

One of the directions operators are using to alleviate pressure on the supply system is using older aircraft that are no longer used operationally to harvest components. There requires a level of testing to guarantee serviceability. Removing used components introduces an element of risk into the process as well as increasing maintenance costs.

Due to the impacts that supply chain issues may have on an operator's ability to continue to operate in an efficient and safe way, it is recommended that an entry is made into the Technical Operations risk register to recognise potential risks, hazards, and safeguards. This risk register should be reviewed on a regular basis so any changes can be recognised and remedied at the earliest opportunity. An example of this can be found in the appendix.

The TSG Senior Board has requested that the TSG working groups investigate developing a survey for both operators and OEMs to ascertain the scale of the issues and to also develop a Robberies Recommended Practice.

With the ageing of current fleets, we expect more helicopters will be retired from offshore operations due to the restrictive life limitation many oil operators impose in contracts. These helicopters are prone to be part out, like we already have had in older helicopter types. This will bring yet another concern for purchasers and procurement departments that must assure they are buying the parts from a reliable, secure source.

Maintenance Optimization

Maintenance Optimization is an important part of any maintenance organisation. These models are in place to help provide the most effective use of the systems available to an organisation to achieve the aims of the department namely:

- **Improve Performance Management**
- **Reduce Downtime**
- **Optimize System Performance**
- **Improve Planning and Productivity**
- **Reduce safety compromising incidents**

To achieve these aims all possible constraints, issues and resources should be considered. By analysing these in conjunction with data, best practices, and other modelling tools it should be possible to reduce overheads and increase productivity and availability whilst maintaining a safe process of work.

There are several systems that contribute to an effective Maintenance Optimization plan, these may include a robust reliability program, an effective SMS, Workplace Observation Programme (MOP) as well as an effectual planning system. By having these in place it will allow for opportunities to provide better analysis of the maintenance data, reviewing this data means that the organisation will have a better idea of where positive experiences can be built on and where processes may need to be changed (Weerasinghe & Ahangama, 2018).

Maintenance generally falls into two categories, Reactive and Preventative and each requires a different strategy. These types of maintenance have an impact on how the optimization of the process may develop.

Reactive

- Corrective Maintenance - This is usually carried out following a report of an issue and the aim of this is to restore the aircraft to flight safe serviceability condition for whatever operation it will be involved with. This condition cannot be generally planned for but does provide several data points that can be used by Reliability systems such as Mean Time Between Unscheduled Removal (MTBUR) and Mean Time Between Failure (MTBF). Other data points for use in future planning events may include manhours, aircraft downtime and spares availability.

- Condition Based Maintenance - Modern offshore helicopters have its maintenance programs developed under the MSG-3 logic. The number of hard time components are significantly lower if compared with old generation helicopters. The maintenance program then has inspections at set intervals to assess the general condition of the components with specific criteria to determine the serviceability of the component and its system. Monitoring the component changes and failures to meet the inspection criteria is important to provide additional information for planning and the system engineering team. The modern helicopters also have the Health and Usage Monitoring System (HUMS). These systems monitor the aircraft and assess the serviceability of the components or systems within set parameters. When the deterioration breaches the levels thresholds it alerts the user that the probability of system failure may be over desired levels. The maintenance team then troubleshoot the component or system in accordance with maintenance procedures delivered by the HUMS system or engineering support.

Proactive

- Preventative Maintenance – The manufacturer maintenance program (MMP) establishes a number of tasks to be carried out at certain intervals – hour, cycles or calendar time - an operator can produce its own maintenance program (OMP), based on the MMP but with tasks set in accordance with its environment and operational conditions. For most cases the interval of a task cannot be higher than the equivalent interval on the MMP, although some authorities permit higher intervals based on a reliability program and its results. These tasks may range from simple service and cleaning to complex overhaul of significant components. The aim is to permit the operator to verify the actual status of its systems and take action to prevent a non-programmed failure or non-programmed change of a component. The data collected during these tasks are very important for future planning and for OMP revisions, making it more effective to the operator. Also, the proper data collection allows the maintenance planning to provide the information the maintenance management need for setting the correct levels of spares, labour and downtime of an aircraft. It is common to conduct Preventive checks right before the role or operating environment of a helicopter is likely to change.

By reviewing the types of maintenance and likely occurrences it should lead to improvements in estimating required labour, stock levels and length of aircraft down time (Kinnison & Siddiqui, 2014). These in turn may reduce costs as the aircraft will return to operations quicker, more likely on schedule and therefore reduced pressure on staff which may lead to less unsafe practices being carried out. By sharing some of this data with the OEM it may also lead to changes within the inspection intervals, component life or even method of executing the checks.

Another programme that may influence Maintenance Optimization is Performance Based Logistics (PBL), this is the generic term for service-based contracts such as Power By the Hour (PBH) amongst others. As part of these schemes then an operator or MRO must have a robust reliability programme in place as this will have an effect of costs, maintenance planning and operational planning. All items placed within a PBL programme should be subject to recording of reliability data to ensure full effectivity.

The implementation of a Maintenance Optimization scheme is an ongoing one that requires defining the organisational strategy, define the maintenance objectives and how they fit with one another. Maintenance Optimization is an ongoing project as various parameters may change so continuous monitoring of the system is necessary. This is not an easy process due to number of variables involved but key to this is the involvement of key internal stakeholders such as the MRO management, maintainers, support staff as well external parties such as the OEM and regulators. With the effective use of this programme, it can lead to an increased efficiency within the aviation engineering system that can be exploited by the operator, OEM and regulators (Rau, et al., 2011)

Current HeliOffshore research, projects and initiatives

System Reliability & Resilience Workstream

As part of the HeliOffshore SPACE site there is an area devoted to SRR. In this site it contains the documents, discussions, and posts from members. All Technical stakeholders are encouraged to register and participate in projects and conversation with other members of the technical and maintenance community.

InfoShare

InfoShare is HeliOffshore's voluntary confidential reporting system, consisting of two separate systems, Operator InfoShare and Helideck InfoShare.

Operator InfoShare is open to helicopter operators, with the request to report events which:

- Are high severity or require urgent dissemination
- Represent new risks to the operator; or
- Contain useful learning for other members

Helideck InfoShare is open to all stakeholders to submit events related to helideck operations. The system is similar to Operator InfoShare but gathers information bespoke to helideck operations.

Reports are submitted through a portal in Jive by completing fields to give a brief explanation of the event, including the option to attach images. These are then reviewed by HeliOffshore, shared with the OEM for comment if appropriate, and then released in Jive and by email to subscribed members and organisations.

InfoRate

InfoRate is a system for gathering data from helicopter operators which focusses on gathering numerical data on the number of occurrences in given categories, in a given period, which is then converted to a rate using operator flight hour data.

By only gathering the number of events, and not asking for details or narrative, we are seeking to minimise the load on operators and also allow them to report events without feeling they are 'airing dirty laundry'. By asking for all events to be included, InfoRate provides the ability to trend event rates which the voluntary reporting of InfoShare does not.

The goal is to ask for the minimum possible data to achieve effective monitoring. Then, if a trend for concern is seen, a 'deeper dive' can be carried out into a particular area, by gathering more detailed information.

For the current InfoRate categories, see figure five overleaf.

Reference	Title	Description/definition. "The number of times in the period that…"
P-Mx-001	Maintenance task or component life overrun	a life-controlled critical part remained in service past its inspection or removal interval, or a scheduled maintenance task was missed (including a task required by AD)
P-Mx-002	Premature failure of critical parts	a defect in a life-controlled critical part caused unscheduled removal
P-Mx-003	Unapproved maintenance or configuration changes	unapproved maintenance or configuration changes occurred, including: • a failure to follow an approved maintenance procedure • maintenance performed using incompatible or unapproved parts • unauthorized maintenance or repair schemes • unapproved modifications
P-Mx-004	Incomplete maintenance	an aircraft was released to service when maintenance work was not complete (whether knowingly or unknowingly) except where that release was approved in the AMM or similar (eg Maintenance Check Flight)
P-Mx-005	Unrecorded maintenance	maintenance was performed but not recorded
P-Mx-006	Tools/eqpt left on aircraft	a failure or omission of tool control procedures resulted in tools/equipment/FOD being left on an aircraft released for flight
P-Mx-007	Technical Return to Base (RTB)	an aircraft returned to base for a technical/maintenance reason *Please record operational RTBs under Op-015*
P-Mx-008	Maintenance data missing, ambiguous or in error	The number of times in the period that an error, omission or ambiguity in maintenance data was reported, or where there was no approved maintenance procedure, irrespective of whether a maintenance error occurred

Figure Five: InfoRate categories

HeliOffshore Safety Performance Model

The HeliOffshore Safety Performance Model, see figure one, has been developed to reflect the accident events and the prevention goals. Maintenance events come under System Failure and the goals are defined as:

- Early Diagnosis of Potential Failures
- Enhanced Reliability
- Airworthiness Management
- Effective Maintenance/Tool Control
- Error Tolerant Design
- Supply Chain

These prevention methods (see figure four) are derived from the Bow-Tie model and are part of the left-hand side incident avoidance mitigations.

The methods displayed in (see figure six) demonstrate that many of the mitigations suggested would benefit multiple prevention goals. Whilst this list is not definitive or exhaustive many of these and other solutions may have an impact on other areas of the maintenance operations.

Early Diagnosis of Potential Failures

- Effective HUMS programme
- Information sharing with other operators and OEM
- Incident reporting on issues
- Recording of previous component or system failures
- Recording of MTBUR

Enhanced Reliability

- Effective Reliability Programme in Place
- Review of work to record to record MTBUR and MTBF
- Review of Maintenance Records

Airworthiness Management

- Up to date maintenance data, manuals and instructions
- Work with OEM to develop effective AMP
- Embodiment of ASB & SB
- Good communication with OEM

Effective Maintenance/ Tool Control

- Tool Control Procedures in Place
- Regular Tool Serviceability Checks
- Maintenance Observation Program in Place
- Prior Planning for Base Mainte-nance
- Effective manpower plans in place for numbers and authorisations

Error Tolerant Design

- Human Hazard Awareness Projects
- Aircraft Maturity Meetings between OEM and Operator

Supply Chain

- Communication with OEMs
- Prior Planning of Tasks
- Timely Returns of Unserviceable Stock
- Suitable Stock Level Holdings at Operator and OEM

Figure Six: Possible methods for the accident prevention goals

HeliOffshore's supporting work for Maintenance Resilience

Cognitive Decision Making within Certifying Staff with Shadowbox

In association with Shadowbox, HeliOffshore started work on a project in 2022 to research cognitive reasoning and decision making within the maintenance department.

Phase one of the project commenced late 2022 the process started with Shadowbox interviewing three experienced engineers to explore their experience and look at how the problems they encountered and how they dealt with it. These decisions were analysed, and the Shadowbox were able to define a set of cognitive skills that they believe to appear critical in aviation maintenance.

Phase two is likely to start late Q1/early Q2. This research phase is looking at building upon the work done in phase one and enlarging the focus groups both in number and in geographical area to get a greater understanding of the thought process of certifying technicians.

The aim of this phase is to develop 4 training scenarios that would be available to HeliOffshore member operators. These scenarios would have 5-6 decision points in each one that would allow development of cognitive skills and would be tailored to HeliOffshore's requirements. These training scenarios could be incorporated into the Continuation Training sessions that staff periodically undergo.

This part of the project is estimated to take 10-12 months.

MCBTA within Engineering Recommended Practice

Competency assessment within the aviation industry is widely used tool particularly amongst the front-line operational staff such as Aircrew, Air Traffic Control and Technical staff. There has been a large amount of work carried out on this subject concentrating on the flying and ATC aspects of the industry but proportionally little for maintenance workers.

Legislation has come into place driven by EASA and the UK CAA that has made certain assessment activities mandatory with these published as part of their Acceptable Means of Compliance and CAP 1715 respectively. ICAO Document 10098 has also been released offering guidance on the issue.

HeliOffshore has compiled various best practices from around the industry coupled with the documentation issued by the regulatory and industry bodies to publish a recommended practice. This document was published in April 2023.

Maintenance Observation Programme

Part of the standards issued in the IOGP-690/4 require operators to have a functional Maintenance Observation Programme in place. In response to this and a general interest in from the maintenance community, HeliOffshore are researching Maintenance Observation Programme (MOP) frameworks to be the subject of a Recommended Practice to be published by the end of Q4 2023.

By developing a framework that can be used as a peer-to-peer evaluation of maintenance situations, this can lead to safer work practices for maintainers. Observations of technical staff carrying out inspection or rectification are for acquiring data of behaviours both safe and unsafe whilst being confidential and without culpability. These observations can determine whether good practices, high quality procedures and required tooling and other apparatus is in place.

It is important to categorise the findings into the two types of threats, "external" and "internal" threats.

- External – These are the threats that are outside the control of the company, these may include delays caused by weather or outside agencies.
- Internal – These threats and potential opportunities are ones that are directly within the control of the company such as procedures, company strategy and leadership, maintenance planning and culture.

With the identification of good and bad observations the operators can identify threats to safety and performance and develop strategies to not only negate but, in the cases of positive actions, promote best practice.

Technical Steering Group Spares and Supply Working Group

One of the roles of the TSG is to direct its Working Groups towards researching areas that may have an impact on technical operations. At the TSG Senior Board meeting that took place in February 2023 it was decided that a group would be formed to investigate the issue of spares and the effect it is having on the industry. This group will be charged with developing a survey aimed at the operators and the OEMs. It is important to recognise that all stakeholders in the logistics are currently having issues. One of the end products requested from the TSG Senior Board is a Robberies Recommended Practices paper.

HUMS Recommended Practice and Implementation Guide

In 2020, HeliOffshore published version 2 of its HUMS Recommended Practice (RP) for offshore helicopter operations. To date, this document remains stable and is in use by operators around the globe.

The Recommended Practice was written by the HUMS workgroup, consisting of SMEs from various operator and consultant members of HeliOffshore, and aims to provide guidance to helicopter operators on HUMS processes and systems to improve airworthiness and safety standards.

The HUMS RP is heavily referenced by IOGP R690, alongside other HeliOffshore RPs, to help provide alignment across the industry and help ensure no lives are lost through offshore aviation.

HeliOffshore has since produced an Implementation Toolkit for various RPs, providing operator members with a gap analysis questionnaire comparing SOPs and operating procedures with the content within the relevant RP. This allows operators to view how aligned they are with the recommendations, give feedback to HeliOffshore on where guidance may be improved, and can share this information with their customers if they so wish to demonstrate the implementation of the RP.

Critical Parts research

HeliOffshore is currently looking into the terminology and description of critical parts on board the aircraft. We are working with OEMs and operators to discuss what constitutes a critical part and how they are treated with a view to creating a common list of components and systems affected. The aims of this programme may lead to recommendations for independent inspections criteria, storage of critical parts and recognition of what constitutes a critical part.

Maintenance Resilience Workshops

HeliOffshore has previously organised seven online workshops to investigate the challenges faced with the maintenance sector. They were attended by 126 participants representing 22 organisations (18 operators and 4 design organisations) and four open-ended questions were discussed by the industry personnel:

- Q1: Which areas of aircraft & system design and OEM documentation activity have created complications for you in performing a maintenance task? e.g.: Tooling, access to maintenance data.
- Q2: Which areas of Continuing Airworthiness Management have contributed to undesired maintenance outcomes or made maintenance more difficult for you than it needs to be? e.g.: construction of maintenance program, interpretation of service bulletins.
- Q3: Which areas of maintenance management, execution and supply chain have had a negative impact on your performance in a maintenance task? e.g.: Management, facilities, parts supply, labour.
- Q4: Which areas of compliance and Safety Management have a negative impact on your performance in a maintenance task? e.g.: poor audits, ineffective SMS.

Over 1000 comments were collected and reviewed which in turn 1364 items were created and then classified by Human Factors and maintenance specialists. The results of which can be accessed through the HeliOffshore SPACE portal. These were then grouped into various categories:

1. Quality of Instructions (n=208, 21% of all comments)
2. Company Policy & Procedures (n-145, 15% of all comments)
3. Competency Management (n=97, 10% of all comments)
4. Production Planning (n=78, 8% of all comments)
5. Supply Chain (n=77, 8% of all comments)
6. Culture (n=78, 8% of all comments)
7. Other Issues (each with <8% of all comments)

The results of analysing this data have helped shape the direction of research as well as define the areas of concern, some of which were obvious but also some were much less common. From this information HeliOffshore has instigated several initiatives such as MCBTA and the Shadowbox Cognitive Reasoning project. The other benefits of such a large-scale workshop were open and honest dialogue not only between fellow operators but giving them an opportunity to discuss situations and ideas with the OEMs.

These comments can be used to analyse the state of the industry and be used at an end user level to determine possible issues within an operation. These comments were used to produce fish tale diagrams for reference and can be found within the HeliOffshore SPACE site. Full details of the research can also be found within the HeliOffshore Maintenance Literature and Research Review 2021 also within the HeliOffshore SPACE site.

Possible future developments and projects in maintenance

Fatigue Management White Paper

Currently within the aviation environment Aircrew and Air Traffic Control operatives have restrictions on their work patterns which affect their rest periods and shifts. Numerous studies have investigated the effects of fatigue on these safety critical occupations and have led to legislation within national authorities globally.

To a lesser extent there has been some research into the effects of fatigue of engineering staff. Maintainers tend to work longer shifts (Folkard, 2002) and have less regulation controlling their rest periods. The IOGP as part of their R690 standards have introduced recommendations over rest for the engineers. Some technical staff are covered by national legislation but can opt out and this is generally not specified to cover these aviation professionals.

Engineering staff work a variety of different shifts, different lengths of shifts and within a diverse range of environments, so research is required to ascertain fatigue levels and the possible effects on safety, human performance, and the human condition.

HHA Engine OEMs

In 2018 HeliOffshore carried out, in association with Drs Hazel Courteney and Simon Gill, several Human Hazard Awareness programmes on different aircraft platforms with frontline aviation technical professionals from the operators meeting with OEM design representatives. In 2020 and 2021 this programme was continued online due to various COVID restrictions. These sessions provided valuable amounts of data, knowledge, and practical opinions on the aircraft for further use on OEM projects.

It is proposed that HeliOffshore continue this programme but with engine manufacturers, HeliOffshore is currently in discussions with engine OEMs to take this research onto the next stage.

Consideration for Further Reading

FAA Aviation Safety Workforce Plan 2021-2030

SINTEF Helicopter Safety Study 4

CAA CAP 1715 Competency Assessment Guidance Document

EASA Acceptable Means of Compliance (AMC) and Guidance Material (GM)

RAeS Development of a Strategy to Enhance Human-Centred Design for Maintenance

EASA Annual Safety Review 2022

HeliOffshore Safety Performance Report 2022

HeliOffshore Maintenance Literature and Research Review 2021

Appendix One

Supply Issues Risk Register Example

Item No	Hazard	Threats	Hazard Related Consequences	Initial			Existing Defences to Control Safety Risks	Residual			Additional Controls / Actions Required
				Severity	Likelihood	Risk		Severity	Likelihood	Risk	
1	Spares Availability (Operator)	Poor availability of spares	1. Increased risk of robberies 2. Availability of Aircraft 3. Increased workload due to robberies (double work) 4. Increased risk of maintenance error due to duplicity of work 5. Possibility of penalties/ damage to relationship with customer. 6. Possible reputational damage 7. Possible damage to relationship with OEM 8. Possible issues with lease handbacks 9. Problems with forward planning 10. Increased maintenance manhours leading to increased costs or fatigue of existing staff				1. Robberies from other aircraft 2. Component life extensions from OEM 3. PBH/SBH programmes 4. Reliability programmes in place to help predict failure rates 5. Maintenance programs in place to allow better planning				1. Reviews of reliability data between Operator and OEM 2. Third party supply options 3. Lease extensions to allow for sourcing parts 4. Better returns of unserviceable parts.
2	Spares Issues (OEM)	1. Lack of raw Materials 2. Increased pressure on supply system	1. Reputational damage with operators 2. Possible litigation regarding PBH/SBH 3. Increased costs with acquiring from other sources 4. Reduction in revenue				1. Communication with operators 2. Reliability data reviews 3. Ability to grant component life extensions				1. Source other suppliers 2. Increased stock holding 3. Change terms of PBH/SBH 4. Further reviews of reliability data
3	Spares Issues (Lessor)	1. Delays on aircraft handbacks 2. Robbing aircraft from operators to service contracts elsewhere	1. Reputational damage 2. Relationship strains with operators. 3. Litigation with operators 4. Increased costs				1. Parts and labour only in leases.				1. Extensions to leases 2. Changes to contract that might consider payment in lieu of goods 3. Changes to replacement of lifed parts limits

Bibliography

Banglesdorf, R., 2023. *Viewpoint: What Leadership Should Know About The Mechanic Shortage.* [Online]
Available at: https://aviationweek.com/business-aviation/maintenance-training/viewpoint-what-leadership-should-know-about-mechanic [Accessed 11 April 2023].

EASA, 2018. *Rotorcraft Safety Roadmap,* Cologne: EASA.

EASA, 2021. *FAQ n.19013.* [Online]

Available at: https://www.easa.europa.eu/en/faq/19013 [Accessed 28 February 2023].

EASA, 2022. *Annual Safety Review 2022,* Cologne: EASA.

EASA, 2023. *European Plan for Aviation Safety (EPAS) | VOLUME III,* Cologne: EASA.

FAA, 2010. *Airworthiness Certification of Aircraft and Related Products,*
Washington D.C>: FAA.

Folkard, S., 2002. *Paper2002_6 Work Hours of Aircraft Maintenance Personnel,*
Crawley: CAA.

HeliOffshore, 2020. *System Reliability and Resilience.* [Online]
Available at: https://www.helioffshore.org/activity/system reliability-and-resilience-workstream [Accessed 28 February 2023].

HeliOffshore, 2022. *HeliOffshore Safety Performance Report 2021,* London: HeliOffshore.

HeliOffshore, 2022. *HeliOffshore Safety Performance Report 2021,* London: HeliOffshore.

Hobbs, A., 2008. *An Overview of Human Factors in Aviation Maintenance,* Canberra: ATSB.

Kinnison, H. & Siddiqui, T., 2014. *Aviation Maintenance Management.*
New York: McGraw Hill.

Lampert, A. & Ganapavaram, A., 2022. *Aviation sector faces hiring headache as mechanics shortage looms.* [Online]
Available at: https://www.reuters.com/business/aerospace-defense/aviation-sector-faces-hiring-headache-mechanics-shortagelooms-2022-07-15/ [Accessed 1 March 2023].

Lavri, 2022. *Employee and skills shortages in the aviation industry: How can SWP help prevent and fight it?* [Online]
Available at: https://hrforecast.com/employee-and-skills-shortages-in-the-aviation-industry-how-can-strategic-workforce-planning-prevent-and-fight-them/ [Accessed February 2023].

Marais, K. & Robichaud, M., 2012. Analysis of trends in aviation maintenance risk: An empirical approach. *Reliability Engineering & System Safety,* Volume 106, pp. 104-118.

OGUK, 2017. *Economic report,* London: OGUK.

Oliver Wyman, 2022. *Not enough aviation mechanics,* s.l.: Oliver Wyman.

Rau, C., Necas, P. & Boscoianu, 2011. REVIEW OF MAINTAINABILITY AND MAINTENANCE OPTIMIZATION METHODS FOR AVIATION ENGINEERING SYSTEMS. *Science & Military,* 2(11), pp. 54 - 58.

Teperi, A. et al., 2018. *Modeling Safety Criticality in Aviation Maintenance Operations to Support Mastery of Human Factors.* New York, Springer Cham.

Weerasinghe, S. & Ahangama, S., 2018. *Predictive Maintenance and Performance Optimisation in Aircrafts using Data Analytics.* Moratuwa, IEEE.

Maintenance Specialists are encouraged to participate in our online, secure collaboration tool: HeliOffshore Space.

You can find out more about HeliOffshore, our safety plan, and the workstreams at:

www.helioffshore.org

This guidance will be updated regularly. If you have comments or suggested amendments, please email: info@helioffshore.org

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Safety Through Collaboration