The Impact of Covid-19 on Human Factors in the Aircraft Maintenance Environment - Effects within Approved Aircraft Maintenance Organisations Operating in Malta

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Abstract: Since the aviation industry itself creates a risky environment, a high level of safety must be ensured during the flight of an aircraft. Aircraft maintenance up to high standards is a main requirement intended to ensure the safety of flights and has contributed to drastically reduce the number of aviation accidents. In addition, for every aviation accident the cause must be identified to prevent re-occurrence and reduce the number further down the line. Statistically, most aviation accidents occurring nowadays are due to human errors, making awareness of human factors in every area of aviation very important, including the maintenance area. With the outbreak of COVID-19 pandemic in 2020, people’s everyday life across the whole world was affected. The aviation industry was heavily impacted by this pandemic with reduction in aviation operations, affecting airports, airlines, as well as approved aircraft maintenance organisations. The effect of COVID-19 on human factors has been both physiological and psychological. Since the physiological and psychological aspects of human factors are known to have considerable effects on the human error element in aviation, it can be concluded that with COVID-19 the risk of committing errors in aviation has increased. This research is aimed to discover the element of such increased risk in aviation, particularly within the aircraft maintenance environment. Research participants are people working in the aircraft maintenance environment. Several independent variables identified from the literature review, known to affect an identified dependent variable, form an initial conceptual framework. A survey has been conducted through which exploratory statements have been set up to address the independent variables, each in a context of the impact of human factors on the required safety standards in aircraft maintenance. Data collected from a total of 75 respondents has been checked for validity using a test question inserted in the survey. This has given a total of 68 valid responses which have been analysed. Analysis has been conducted using SPSS Software. Analysis for data consistency revealed an acceptable Cronbach’s Alpha value of over 0.8. SPSS which was then used to carry out dimension reduction using Exploratory Factor Analysis (EFA). Through the EFA technique the number of independent variables has been reduced for further research from 22 to 6. Final analysis of the data shows that most of the respondents agree that in general Covid-19 has had a similar impact on human factors in aircraft maintenance, as it has had on the rest of the aviation industry. Based on this research it is suggested that measures should be taken so that a phenomenon like a pandemic situation, that would affect the physiological and psychological aspects of people, is addressed in the human factors’ element of aviation, in particular the aircraft maintenance environment. The pilot-study conducted also sets up a basis for future research in human factors in aircraft maintenance, and how they can be influenced by situations that can pose higher risks for a person to commit errors while performing work related to aviation, particularly while carrying out aircraft maintenance performance and certification activities before an aircraft can be released for further flights.

Keywords: human factors; human error; aviation accidents; aviation industry; aircraft maintenance standards; flight safety; COVID-19 pandemic; dirty dozen of human factors
Introduction

The use of civilian aircraft as means for the transportation of people and goods between countries has increased as from the second part of the twentieth century, following the end of World War II (Yiannakides and Sergiou 2020). Since aviation is inherently riskier than any other means of transport, and due to the increase in air traffic (Manarvi and Raza 2018), high levels of safety standards in aviation are set up. These standards are ensured through a strict system of regulations, which also cover the requirements for aircraft maintenance, intended to keep aircraft in continuous airworthiness (i.e. always safe to fly). On a global level, sovereign countries which are members of the International Civil Aviation Organisation (ICAO) agree to implement the minimum standards to ensure aviation safety at a national level, which includes the required maintenance standards. This creates uniformity in international aviation operational standards, with each sovereign country empowering a National Aviation Authority (NAA) to implement procedural regulations based upon the ICAO standards (Shanmugam and Robert 2015). Malta’s NAA is the Transport Malta Civil Aviation Directorate (TMCAD). Aircraft maintenance standards are ensured through the approval of a maintenance organisations (MO), as well as the licensing of maintenance-certifying crews to be able to issue the Certificate of Release to Service (CRS) after maintenance has been completed, and before the aircraft is released for the next flight/s. Approvals and licenses are issued by the NAA. Since Malta is a member state within the European Union (EU), the aviation laws enforced are those issued at a regional level by the European Parliament and the European Commission (EASA 2021). These laws are applicable to every EU member state, including Malta. The aviation regulating body representing the EU is the European Aviation Safety Agency (EASA). The aviation regulation framework applicable to Malta is illustrated in Figure 1.

The Regulating Framework for Civil Aviation, together with the improvements in aircraft design and technology, has helped so that aviation in modern times has become one of the safest means of transport. By statistics, on a yearly basis, the least number of deaths that occurs while people are travelling is during air travel (IATA 2018). However, factors like increased competition and increased demand for aircraft flying usually cause aircraft maintenance personnel to face work conditions that are not easy. Usually, they are constricted to work at the utmost of their physical and mental capabilities (Yiannakides and Sergiou 2019). Such factors and conditions have increased the risk for people operating or maintaining an aircraft to commit unintentional mistakes, something that can contribute for the occurrence of aviation accidents (Kahuho-Mwarari 2014). Statistically, approximately 70% of today’s aircraft incidents and/or accidents are attributable to the human factor element (Kansoy and Bakangolu 2021), with 15% of them resulting due to maintenance-related failures (Tsakas et al. 2014).

The outbreak of COVID-19 in December 2019, which was then declared as pandemic in March 2020 (Suk and Kim 2021), had a negative impact on the aviation industry. Isolation
and lockdown measures caused many airports to reduce operations, or even close entirely (Peter et al. 2020). This was because to block the spreading of the virus, borders had been closed, forcing airlines to cut down many routes, resulting in the grounding or even the scrapping of several aircraft (Narang and Ying Choo 2021). COVID-19 also affected the aviation industry's human resources, putting millions of jobs at risk for people employed with airlines, approved maintenance organisations, as well as aircraft manufacturers (Narang and Ying Choo 2021). According to the International Labour Organisation (ILO), the reduction in working hours due to the COVID-19 pandemic has disrupted the daily routines of workers, causing physical and mental effects like added anxiety, stress and strain, as well as financial problems. All these human factors when considered within the aviation industry would increase the risk for workers to commit errors, adding to the contribution of human factors for more accidents to happen (Rozman and Tominc 2021).

Considering the physical and psychological effects COVID-19 had on people's everyday life, this research is intended to identify at what level these human factors affect people working in the aviation industry, with a particular focus on the aircraft maintenance industry in Malta. COVID-19’s effects could enhance the risk for human-error-related accidents. By assessing such risks, suggestions can emerge as to what might contribute for the corrective actions required to be taken in attempts to eliminate or reduce such risks, as well as for preparative measures to be put in place to be ready should other pandemics break over in the future, especially since COVID-19 has become an established and ongoing health issue which no longer constitutes a public health emergency of international concern (World Health Organisation 2023).

Research Objectives

Since this research is conducted using a quantitative approach, the literature review is utilised to come up with a hypothesis that is tested through the collection and analysis of data. From the literature review it is evident that COVID-19 has had a negative influence on the human factor element in the everyday life of people. In aviation the human factor element has been shown to be of utmost importance in relation to the safety of flights.

Hypothesis

While enough existing literature confirms that the effect of COVID-19 on the human factor element in the aviation operations area, little can be found that addresses these effects on the aircraft maintenance environment. As such there is a literature gap, which allows for the hypothesis that is to be tested by this research:

*The outbreak of a pandemic such as COVID-19 negatively affects the human factor element within the aircraft maintenance environment, and if measures are not taken, the risk for aircraft maintenance people to perform mistakes would increase, posing hazards that human errors during maintenance would contribute to the increase of aviation accidents.*

Research Questions

By collecting quantitative feedback, the aim of this research is to confirm the above hypothesis. Through an online survey disseminated among personnel employed in areas within the aircraft maintenance environment, to confirm the hypothesis above, the following research questions will be answered:
• At what level has COVID-19 affected aircraft maintenance personnel physically and psychologically?
• What further measures could be put in place to enhance the safety of people working in aviation maintenance?
• What type of support could help the employee avoid performing human errors when living in pandemic situations?

Literature Review

The Literature Map

The Literature map that illustrates the summary of research conducted by others is shown below. It gives an overview of the existing research related to the one conducted.

![The Literature Map](adapted from Creswell and Creswell 2018)

As illustrated in Figure 2, using a quantitative research approach, an extensive literature review was conducted to identify a literature gap which helps develop the hypothesis to be tested and the research question/s to be answered.

The Requirements of Safety in Aviation

Since aviation in and of itself is dangerous and most of the time involves the utilisation of large and/or high-speed aircraft for transporting people and cargo, the commitment to improve aviation safety is a continuous one (Sun et al. 2017). One main contributor to ensure aviation safety is the setting up of strict regulations and implementing rules. To ensure a high level of safety on a global level, the International Civil Aviation Organisation...
(ICAO) sets up a convention with articles that recommend the minimum aviation standards that are utilised as guidelines for the aviation laws set up at a national level by sovereign countries from all around the world which are members in the ICAO (Cassar 2020). Regional aviation laws based on the ICAO Convention and are issued by the European Union (EU). These laws apply to all EU member states, as well as non-members that form the European Free Trade Association (EFTA) like Switzerland (EASA 2021). These laws apply to Malta as an EU member state. Malta’s responsibility to enforce EU laws at a national level is attained through the empowerment of the Transport Malta Civil Aviation Directorate (CAD) as the Maltese National Aviation Authority (NAA) (Transport Malta 2021).

One of the measures in place to ensure flight safety is aircraft maintenance at high standards. By itself, maintenance amounts to approximately 15% of the total annual cost of an airline (Bernard et al. 2017). Hence, maintenance may be considered as not contributing to the income profit of an airline. However, there is a payback to the airline since, as argued by Tsakkos et al. (2014), “Maintenance related failures not only pose a threat to flight safety but can also impose significant costs through schedule disruptions” (PAGE NUMBER). In addition, to enhance the link between maintenance and safety, regulating bodies nowadays require the implementation of a Safety Management System (SMS) (see Figure 3) within approved Maintenance Organisations (MO) (Manarvi and Raza 2018). In simple terms, the SMS is a predictive, proactive, as well as a reactive process, where one looks for the trouble, rather than waiting for it. This is done through audits, as well as confidential reporting systems. However, when trouble arises, investigations are carried out and corrective actions are taken.

![Figure 3: The Safety Management System according to Manarvi and Raza (2018)](image)

Another element for enhancing flight safety is the integration of human factors in aircraft maintenance, which also ensures health, safety, and efficiency during maintenance (Bernard et al. 2017). Human factors define the relationship between the required airworthiness standards and the people that must attain such standards (Bhave 2021). Risky and stress-rich environments that are present in aviation could pose negative effects on the people working in the industry (Kansay and Bakanoglu 2021).
Human Factors in Aviation

Human factors may be defined as a “scientific discipline trying to understand interactions among human beings and other elements present within a system” (Kahuho-Mwarari 2014). In aviation, human factors help in understanding how people can be integrated within technology safely and efficiently. This is translated into better and safer performances when consideration to human factors is given during the design of hardware like aircraft and tools, as well as during the setup of training systems, polices, and procedures (Alam 2021).

Historically, due to the evolution of air transport, the methodologies used to ensure aviation safety have changed over time. The aftermaths of accidents and innovative investigation techniques reveal the causes and indicate corrective action requirements. Effective corrective actions enhance safety and help in the prevention of an accident from occurring again. During the first half of the twentieth century, safety occurrences were mainly related to technical failures in aircraft systems (Yiannakides and Sergiou 2020). During the second half of this century flight safety improved and occurrences related to technical failures have been reduced. However, a shift has occurred since even if the number of safety occurrences has been reduced, where the ones that occur nowadays are in the majority related to human performance (Alam 2021). That is why, nowadays, attention is given to the multiple factors that can potentially influence the behaviour of the people working in aviation (Kansay and Bakanoglu 2021). In addition, several aircraft accidents occurring during the second half of the 20th century have identified the requirement to take human factors more into account, even in the aircraft maintenance environment (UKCAA 2002).

Human factors relevant to the maintenance environment include:

- Human physiology and psychology
- Human performance and limitations
- Maintenance environment design
- Human-machine Interface
- Human anthropometrics

Human Factors in Aircraft Maintenance: Contribution to Accidents

According to Tsagkas et al. (2014), as well as Shanmugam and Robert (2015), the aircraft maintenance environment contributes to human error at the same level that the operational environment does. This is evidenced by Khahuho-Mwarari (2014) who provide examples of maintenance related errors that have contributed to accidents. Examples include improper installations of aircraft parts and components, incorrect tightening and torquing of nuts and bolts, as well as loose objects left on the aircraft after maintenance completion.

Errors, which human beings commit by nature (Kahuho-Mwarari 2014), can lead to active or latent failures. Active failures lead directly to the occurrence, while latent failures are resident pathogens whose presence can provoke an active failure. Usually, latent failures remain hidden for a period before becoming evident when the accident occurs (Drury 2000). The impact of latent failures can be reduced by preventing the error from propagating through the system, by providing barriers such as controlled procedures for aircraft maintenance (Drury 2000). Without such barriers and safety nets the slightest mistake could lead to huge and irreversible accidents occurring (Kansay Bakanoglu 2021).

In maintenance, ergonomics and human factors must be considered. While ergonomics deal with work psychology and environment design, human factors include the science based on experimental psychology, targeting human performance and system design (Kansay and Bakangolu 2021). In addition to avoiding human error in maintenance, care must be taken to avoid negative effects on the health of the aircraft maintenance personnel (Bernard et al. 2017).
The Dirty Dozen of Human Factors (HF)

Developed by Gordon Dupont in 1997, this list includes the twelve most common human error preconditions that can lead to aviation accidents (Musrani 2021). Most programmes related with HF in aircraft maintenance address the ‘Dirty Dozen’ and give examples of good practices and ‘safety nets’ that can be adopted (UKCAA 2002) to reduce errors committed during maintenance which could serve as latent errors that consequently lead to an accident (Yiannakides and Sergiou 2020). The ‘dirty dozen’ list, along with potential actions that can be taken to avoid each factor from being a contributor to error commitment, is shown in Table 1.

<table>
<thead>
<tr>
<th>Problem Example</th>
<th>Potential Solution (‘Safety Nets’)</th>
</tr>
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<tbody>
<tr>
<td>1. Lack of communication</td>
<td>Enhance communication by documented evidence. No assumptions.</td>
</tr>
<tr>
<td>2. Complacency</td>
<td>Train yourself to find a fault. Do not be overconfident.</td>
</tr>
<tr>
<td>4. Distraction</td>
<td>Mark uncompleted work. Always finish the job. Use checklists. Double inspect the work.</td>
</tr>
<tr>
<td>5. Lack of teamwork</td>
<td>Discuss how job is to be done. Be sure everyone agrees and understands.</td>
</tr>
<tr>
<td>6. Fatigue</td>
<td>Regular sleep and exercise. Avoid complex tasks at the bottom of circadian rhythm.</td>
</tr>
<tr>
<td>8. Pressure</td>
<td>Get used to say ‘NO’. Ask for extra help.</td>
</tr>
<tr>
<td>9. Lack of Assertiveness</td>
<td>Exercise your body. Discuss with others. Be aware on how stress can affect work.</td>
</tr>
<tr>
<td>10. Stress</td>
<td>Think about accident repercussions. Ask others to check your work.</td>
</tr>
<tr>
<td>11. Lack of Awareness</td>
<td>Always work in accordance with written instructions.</td>
</tr>
<tr>
<td>12. Norms</td>
<td></td>
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Table 1: Examples of Potential HF Problems from the ‘Dirty Dozen’ (UKCAA CAP 715, 2002)

When analysing some factors from the ‘Dirty Dozen’, one can conclude that accidents have been caused as result of inadequate HF considerations by aircraft maintenance personnel (Bhave 2021). Examples include:

- Conducting physical and mental tasks on a regular basis and in short periods of time can lead to exhaustion (fatigue)
- Complacency is one common factor found within Aircraft Maintenance Engineers (AME) having substantial amounts of experience. It can be task- or organisation-induced, or dependent upon automated systems or equipment. Complacency often overlaps with other factors like stress, fatigue, and lack of awareness. Lack of awareness can be characterised by the AME not being aware of certain aircraft system state while performing tasks, or when failing to identify certain situations, understanding associated implications, or determining related outcomes.
Overview of the COVID-19 Pandemic

The COVID-19 coronavirus emerging from Wuhan, China in December 2019 rapidly infected the whole world in such a way as to be declared a pandemic by March 2020 (Suk and Kim 2021). In such a short time, the virus forced multiple sectors to restrict or stop their daily activities, constricting individuals, and states to isolate themselves one from the other (Cassar 2020). As an effect to this, the pandemic led to severe financial crisis within different industries, including aviation (Suk and Kim 2021).

The reasons why COVID-19 has infected so many people in such a short time are intrinsic and extrinsic to the virus itself. Intrinsically, it is due to the virus’s ability to pass from one person to another very efficiently, through droplets and contact. Extrinsically, it is due to factors like travelling and globalisation (Cassar 2020).

The coronavirus has created a financial crisis, as well as affected the well-being of people. The well-being of people is defined by the World Health Organisation Constitution (WHO June/July 1946) as a “State of Complete physical, mental, social, and spiritual well-being, and not merely the absence of disease or infirmity”. This forms a model of health with four pillars, with factors within one pillar affecting the remaining pillars (Musrani 2021).

The Effects of COVID-19 on Human Factors

The COVID-19 virus may be considered both as a physical and a psychological contagion because it has affected the physical, mental, social, and financial well-being of people at different levels (Musrani 2021). The spread of the virus also affects human factors like death rate, positive results from the number of swabs taken, people’s income, and the amount of people at public places (Chhabra et al. 2021). Factors like the fear of being infected, or infecting others, symptoms like those revealed by a COVID-19 infection, as well as quarantine or hospitalisation requirements may lead to anger, anxiety, irritability, and concentrating or remembering abilities (Gilad et al. 2021). This increases the risk for a person to end up in a depression (Rozman and Tominc 2021).

The pandemic also impacted workplaces by affecting employee relationships due to social distancing, leading to higher stress levels or symptoms of other health problems. This is because a lack of social support exhibited through mutual thrust and open communication reduces the sense of stability and safe feelings (Rozman and Tominc 2021).

Additionally, the COVID pandemic influenced the relationships between management and employees. This is because less engagement between management and employees may hinder the employees’ understanding about their roles and responsibilities (Rozman and Tominc 2021), consequently enhancing stress levels (Kihara and Mugambi 2018). Some examples collected by Rozman and Tominc (2021) show how COVID-19 has affected employees:

• The pandemic period was the most stressful time of their professional life, confirmed by the increased prescriptions of anti-depressants and medication against insomnia.
• Physical, behavioural, and emotional symptoms of health problems have increased among employees.
• Employee productivity and willingness to work has been reduced by the pandemic.
• Employees felt isolated and lonely.
The Effects of COVID-19 on Aviation

The sudden outbreak of COVID-19 created unprecedented challenges on a global scale for commercial aviation due to travel restrictions imposed as a measure to combat the virus spread (Gottipati and Jinshim 2021). Several aircraft were grounded due to reduced travel demands (Suk and Kim 2021). By April 2020, with over a million cases worldwide, air travel demand went down by more than 90% compared to April 2019 (Cassar 2020). Added with airport closures, this affected the aviation industry in the form of increased debt profiles, competitive pricing, and losses of jobs (Siyan et al. 2020). Some low-cost airlines even went bankrupt (Cassar 2020). Other airlines tried to compensate for losses by seeking the government’s financial support or focusing on transporting cargo or pharmaceutical supplies (Suk and Kim 2021).

According to Cassar (2021), the pandemic triggered a time of crisis, stretching the aviation business to critical levels. This crisis will have long term effects on the industry, with firms that survive will possibly strive to innovate their services (Suk and Kim 2021). According to Boeing aircraft manufacturers it will take over 3 years for travel to return to 2019 levels and for the growth trend to resume (Narang and Choo 2021).

Aviation may have contributed to the fast spread of COVID-19 (Cassar 2020). COVID-19 is a respiratory virus transmitted through airborne droplets, increasing the risk for passengers traveling on aircraft to get infected (Suk and Kim 2021). In attempts to reduce such risks and to help aviation to restart, authorities have suggested various strategies to be taken like, screening for symptoms, use of masks and other personal protective equipment (PPE) by passengers and crews, and enhanced hygiene measures on the aircraft (Cassar 2020). Other measures have been proposed in terms of carrying blood tests on passengers at airports before embarking an aircraft, blocking middle seats, or affixing hygienic screens to isolate passengers. However, these proved to be impractical due to infringement of the right for privacy and effects on the business or safety perspectives (Cassar 2020).

In addition, COVID-19 has also influenced human factors in aviation because additional stress increases the tendency for people working in aviation to commit errors, creating higher risks for increased accidents or incidents (Musrani 2020). The design processes of aircraft products have also been affected by COVID-19 because priority has now started to be given to necessity, rather than luxury (Pathak et al. 2021). Specific plastic and coating materials are being developed which are capable of inactivating contagious viruses such as COVID-19. Such plastics are called Microbial and Antiviral Nanomaterials (Engineered Nanomaterials – ENM). However, this is just the point of departure, with the point of arrival seemingly far away. This is because the impact of such polymers on the environment, as well as their toxicological behaviour, is yet to be discovered (Pathak et al. 2021).

Research Methodology

The study is conducted using a quantitative approach, due to the nature of the research, as well as due to the researcher’s preference for a positivist philosophy (Amaratunga et al. 2002). Quantitative research uses a causal-comparative approach, where two or more variables are compared in relation to the cause of a past occurrence (Creswell and Creswell 2018). The positivism approach in quantitative research helps in explaining the cause(s) (Amaratunga et al. 2002). According to Hair et al. (2019), quantitative research influences the analytic aspect of a research and helps in the design and approach to data collection, while contributing to decision-making and problem solving.
The quantitative approach has been considered suitable for this research because the research problem calls for identifying factors influencing an outcome (Creswell and Creswell 2018). The research requires identifying how COVID-19, having an influence on human factors (HF), would affect the HF element in aircraft maintenance. The negative influence of COVID on HF in aircraft maintenance could lead to an increase in errors that may propagate more easily and serve as further contribution for more aviation accidents to happen. Using the quantitative approach, the literature review is used as a framework to deduce an alternative hypothesis with a prediction based on past studies, which is non-directional since the prediction does not specify exact forms of differences (Creswell and Creswell 2018). Past studies show that COVID-19 has influenced human factors in aviation, but due to the literature gap, the exact influence in the aircraft maintenance environment must still be identified.

According to Creswell and Creswell (2018), in quantitative research the hypothesis is tested using theories that emerge from the literature review. Using the quantitative approach, in this research tests are carried out using survey methods to find association between variables. Causality is expected since ‘variable’ COVID would be the cause for human factors degradation, which in turn would lead to an increase in human error that, if not detected and is allowed to propagate through the system, could lead to the occurrence of an event. The research is also classified as multivariate since it aims to analyse the relationship between several variables rather than analysing variables or observations by themselves (Hair et al. 2019).

The Research Onion

Using the research onion model (see Figure 4), a proper step-by-step design of the research methodology can be achieved (Raithatha 2017 – cited by Melinkovas 2018). In six layers, the model describes the stages to be followed in creating an effective methodology (i.e. quantitative):

- The research philosophy forming the research basis (i.e. positivism)
- The approaches to the development of theory (i.e. deductive)
- The research strategy or choice of methodology (i.e. mono-method quantitative approach)
- The methodological choice (i.e. survey)
- Time horizons in future studies which can be short term (less than 10 years), medium term (up to 25 years) or long term (over 25 years)
- Techniques and procedures, determined by choices from previous layers, including basic data collection and analysis procedures, that lead to answer research question(s).
By critically overviewing the 6 layers of the onion, an additional layer termed ‘Approach to Future Research’ is discovered, which helps forecasting future research. In quantitative forecasting, this is done through mathematical operands such as extrapolation, econometric operands, or modelling (Melinkovas 2018).

Data Collection and Analysis

Based upon the reason that surveys provide quantitative description of trends, attitudes, and opinions of a population, as well as because they help answering questions that help identifying relationships between variables, the data collection for the proposed research will be conducted through a questionnaire (Creswell and Creswell 2018).

The population for the proposed study is composed of persons having working experience within areas related with aircraft maintenance in Malta, such as:

- Aircraft maintenance training areas (e.g. MCAST Aviation Maintenance Training Centre – AMTC and Training Department within Part-145 approved Maintenance, Repair and Overhaul Organisations - MRO)
- Aircraft maintenance/repair organisation (MRO) environment, including:
  - People getting on-the-job training at the MRO (e.g. MCAST AMTC students on apprentice or sponsorship)
  - People working hands-on (employed) at the MRO (e.g. mechanics, technicians, engineers, etc.)
  - People having roles of certifying maintenance work upon completion, either inside an approved workshop, or inside an approved hangar.
  - People working at other MRO areas, including planning, quality, management, etc.
The survey is based upon an online questionnaire, with links distributed using emails and social media (i.e. Facebook). The questionnaire (see appendix B) is divided in three sections. The first section contains an introduction, explaining the main requirements to the prospective participant, as well as the consent for participation requirements. Participation in the survey is intended for persons over 18 years of age, guarantees complete anonymity, and is completely voluntary. The introduction letter is shown in Appendix A. The introduction consent for participation letter explains to potential respondents the ethical considerations followed when designing the questionnaire, as approved by the MCAST Research Ethics Committee. The second section is intended to explore the demographics of the participant, like age, area of occupation related to aircraft maintenance, and years of experience within the related area or field. The second section includes a set of Likert-Type scaled questions intended to test a set of independent variables related to a dependent variable identified from the literature review. The variables identified are listed in the Conceptual Framework shown in Figure 5. To test for validity, one of the questions, the one concerning the independent variable related with human factors training has been repeated and reworded in an opposite way to serve as a test question. For the response to be retained as valid, a match should be identified between the answers for the two questions.

To be able to collect enough data emails were sent to the major approved maintenance organisations in Malta, asking them for assistance in the dissemination of the questionnaire within the approved organisation. With the help of the MCAST Aviation Maintenance Training Centre (AMTC) administration, lecturers at the centre, as well as students at present attending MCAST courses related with aircraft maintenance and conducting on-the-job training at a MRO were contacted by email and invited to participate in the survey. In addition, the link for the online questionnaire was disseminated among people working in the aircraft maintenance environment using social media (i.e. Facebook).

Data analysis is conducted using the SPSS software, and includes statistical information about the population surveyed, as well as their response. Furthermore, the analysis of the data collected is conducted using the exploratory factor analysis (EFA) approach. Since with multivariate techniques overlapping (correlations) is likely to occur between variables, factor analysis is a very useful tool to analyse the structure of interrelationships among the variables, while effectively extracting useful information from large bodies of correlated data and grouping it in a smaller set of factors (Hair et al. 2019). Since this is a pilot study, EFA helps in the critical decision about what factors to retain for interpretation and future use. This is because EFA provides practical stopping criteria for determining which factors to retain, using a Scree Test for example (Hair et al. 2019). To easily interpret factors, and to achieve a more meaningful factor pattern, a rotation of the factor matrix is utilised (Hair et al. 2019).

Main Ethical Considerations

According to Creswell and Creswell (2018), since research involves collecting data about people, protection of research participants is required. Through ethical considerations during research, a good sense of trust is developed while promoting the integrity of the research. Main ethical issues considered during this pilot research include a consent statement that guarantees anonymous and voluntary participation in the collection of research data. Through the consent for participating statement, the 3 elements highlighted by Drew et. al (2008) are considered. Capacity is ensured by collecting data from persons of 18 years and over; information to be collected through exploratory statements is planned and presented
in an understandable manner; and voluntary participation is ensured by avoiding any form of constraint from being imposed on respondents. Using an online tool such as Google Forms for survey dissemination and as a data collection tool helps disguising identities and enhances data security (Social Research Association 2003). Online tools also eliminate the possibility of creating physical harm to the participants or the environment related with the research. According to the Social Research Association (2003), the researcher should not give the opportunity to anyone to infer identities from the data collected. To ensure this in the survey, no questions were placed that would help discovering the person’s identity, or their place of work. Avoiding the identification of the place of work would also reduce the possibility of any harm to the aircraft maintenance business. In line with what Drew et. al (2008) states, sensitivity of the data in view of the persons being studied is given consideration when designing the exploratory part of the survey. The setting in which the research is conducted might have an implication on potential invasion of privacy (Drew et al. 2008). In this research this has been avoided by using the quantitative approach and utilising an online tool to collect data. In line with what is argued by Maurice et al. (2018), attention is paid not to infringe any human rights, and any bias related to gender, groups and races is avoided. In the questionnaire designed, no questions are included that would help identifying the gender, any religious beliefs, the race, or the nationality of the participant. This is because in the aircraft maintenance industry workforce one finds a good balance between different genders, people belonging to different religious beliefs, as well as a considerable number of expatriates of different nationalities that might belong to different human races. Finally, since a researcher is obliged that, once the data is collected and analysed, measures are taken to prevent data from being published or released in a form allowing respondents and organisation identity to be disclosed (Social Research Association 2003), responses are stored on a secure online resource such as Google Forms, while SPSS analysis results are stored in soft copy format on devices dedicated only for the research, which are password-protected (password known only by researcher), with access to and use limited only to the researcher.

The Initial Conceptual Framework

Referring to figure 5, a total of 22 independent variable have been identified from the literature review, along with a dependent variable, so that an initial conceptual framework was formed. Based on the list of the independent variables identified, the survey questionnaire was designed. A statement identifying the variable is placed for every independent variable. For every statement, the respondent is asked to state the level of agreement with the statement, on a 5-point Likert-scale, starting from a strong disagreement, passing to a neutral opinion about the statement, and ending in a strong agreement with the statement.
### Independent Variables: Human Factors in the aircraft maintenance environment during a pandemic situation

Tsagkas et al. (2014); Bernard et al. (2017); Yarmaravi and Raza (2018)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
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</table>
| Var. 1   | Errors and mistakes  
Sun et al. (2017) |
| Var. 2   | Aviation Regulations  
ICAO, EASA (2021); Cassar (2020) |
| Var. 3   | Safety Management System (SMS)  
Manarvi and Raza (2018) |
| Var. 4   | Human Factors Training  
Alom (2021) |
| Var. 5   | Setting up of Policies and Procedures  
Alom (2021) |
| Var. 6   | Human-Machine Interface  
UKCAA (2002); Shanthnagam and Robert (2015) |
| Var. 7   | Maintenance Environment Design  
UKCAA (2002); Shanthnagam and Robert (2015) |
| Var. 8   | Relationships between employees  
Rozman and Tominec (2021) |
| Var. 9   | Relationship between Management and Employees  
Rozman and Tominec (2021) |
| Var. 10  | Productivity and Willingness to work  
Rozman and Tominec (2021) |
| Var. 11  | Communication  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |
| Var. 12  | Stress, depression, and anxiety  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002); Rozman and Tominec (2021) |
| Var. 13  | Complacency  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |
| Var. 14  | Lack of Knowledge  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |
| Var. 15  | Distraction  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |
| Var. 16  | Teamwork  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |
| Var. 17  | Fatigue  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |
| Var. 18  | Resources (Parts, Manuals, Tools, etc)  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |
| Var. 19  | Pressure  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |
| Var. 20  | Awareness  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |
| Var. 21  | Assertiveness  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |
| Var. 22  | Norms  
The Dirty Dozen – Dupont (1997); Musrani (2021); UKCAA (2002) |

### Dependent Variable

High Aircraft Maintenance Standards  
Requirements to ensure flight safety  
Bernard et al. (2017); Tsaklas et al. (2014); Yarmaravi and Raza (2018)

---

**Figure 5:** The Initial Conceptual Framework
Analysis of Results

Following the dissemination of the survey and until the date planned for the start of data analysis, a total of 75 responses were posted online on Google Forms. The first part of the analysis consists of a check for the validity of the responses. Analysing the test questions included in the questionnaire, it was concluded that 7 responses were not answered truthfully. Hence, the data related with these 7 responses was discarded and removed from the data set. This means that a final dataset for this pilot study consisted of 68 responses.

Reliability Test

The data collected in the 68 valid responses is converted into a numerical value, according to codes assigned for the descriptive questions of the Survey Part 1, and for the Likert-scale related for the exploratory questions of part 2. The data related with the independent variables was coded according to Table 2 using Excel software, and then loaded onto SPSS software, with every variable identified on a metric scale.

| Strongly Disagree | 1 |
| Disagree          | 2 |
| Neither Agree nor Disagree | 3 |
| Agree             | 4 |
| Strongly Agree    | 5 |

Table 2: Coding for responses collected

Using SPSS software, testing for reliability was carried out and the Cronbach’s Alpha value was obtained for that data collected in relation to the independent variables. According to Hair et al. (2019), for a dataset to be retained reliable and consistent, the alpha value should be at a minimum of 0.7. With all 22 variables included, the Coefficient Alpha value resulted to be at a very good level of 0.862. It was also noted that by removing variable 3 (SMS), a better value would even be achieved, as shown in Table 3.

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s Alpha</td>
</tr>
<tr>
<td>.864</td>
</tr>
</tbody>
</table>

Table 3: SPSS Reliability Test - Cronbach’s Alpha Value using 21 independent Variables

Survey Respondents

The descriptive section of the survey is intended to form general demographic data related to the participants, including age, area within the aircraft maintenance environment, role in aircraft maintenance, and the years of experience in the aircraft maintenance environment in general. The pie charts that follow give an indication about the demographics of the people that responded with valid information.

Age Distribution: Figure 6 shows that most responses originate from people aged between
26 and 40 years. Similar percentages cover people having age brackets covering 18 to 25 years, and 41 to 61 years. Only one respondent was more than 61 years old.

**Figure 6: Distribution of respondents’ age**

**The Area within the Aircraft Maintenance Environment:** Most of the participants work hands-on either in the hangar directly on aircraft, or in the approved workshop performing maintenance on components removed from the aircraft. Around 23% of the respondents come from a training department, either of a Part-145 approved MO, or a Part-147 approved training organisation like the MCAST AMTC. Around 17% of the participants work in other areas of the maintenance organisation, as indicated in Figure 7.

**Figure 7: Areas of the Maintenance Environment where Respondents are employed**

**What are the roles within the aircraft maintenance environment of the participants?** Almost an equal numbers of participants work either as trainers or instructors, or as maintenance people in the roles of mechanics, technicians, supporting or certifying staff in the hangar. A smaller percentage covers similar roles, but in the workshop. This is understandable, since a larger number of people is required in the hangar to perform maintenance on a large aircraft. A lesser amount is required in a workshop. As depicted from Figure 8, there are several responses originating from people covering roles in other areas of aircraft maintenance like the planning and quality departments of MOs. This
would help having a reliable dataset covering as many areas of the aircraft maintenance environment as possible.

![Pie chart showing present role within the aircraft maintenance environment of the respondents.](image)

**Figure 8: The role within the aircraft maintenance environment of the respondents**

**Years of experience in aircraft maintenance related work:** Figure 9 shows that there is a good distribution of experience related with aircraft maintenance among the respondents, with most people having experience of over 20 years. However, comparable percentages cover other important experience brackets, ranging from 1 year, up till 20 years.

![Pie chart showing years of experience related with aircraft maintenance of the participants.](image)

**Figure 9: Years of experience related with aircraft maintenance of the participants**

**The Exploratory Factor Analysis**

In this quantitative multivariate research, following an in-depth review of the literature, a total of 22 independent variables were identified. This number was reduced to 21 to achieve the best Cronbach’s Alpha value for data reliability. Since the number of variables identified is considerable, overlapping or correlations is likely to occur (Hair et al. 2019). Exploratory factor analysis is a technique very useful in analysing the structure of the interrelationship among many variables (Hair et al. 2019). Using such an analytic technique, the number of variables can be reduced, and the appropriate variables can be selected and included in further multivariate analysis (Hair et al 2019). According to Watson (2018), exploratory factor analysis (EFA) is one of a family of multivariate statistical methods that attempts to identify the smallest number of hypothetical constructs known as factors that can explain the covariation observed among a set of measured variables. This identifies common factors explaining the structure among observed variables. EFA is used to simplify...
interrelated measures, to discover patterns in the set of independent variables identified from the literature review, and to analyse which of these variables ‘go together’ (Gie Yong and Pearce 2013).

Factor analysis for this pilot research has been carried out using SPSS Software (version: 28.0.1.0 (142) – licensed to MCAST). The coded data collected through the online questionnaire, and related to the 22 independent variables identified, was uploaded to SPSS. After analysing the data for reliability, the number of variables was reduced to 21 for factor analysis.

Identification of Factor Components

The number of factors that were used to subsequently investigate in a Common Factor Analysis were estimated by the eigenvalues produced during the analysis (Watkins 2018). In addition, the magnitudes of these values were plotted in a visual scree against the number of components so that the true factors could be detected by an elbow or a distinct break in the slope of the Scree plot (Watson 2018).

An initial analysis set to identify factors for components having eigenvalues greater than 1 identified a total of 7 factors. However, analysing the Scree Plot, it is assumed that the scree (i.e. lowering of gradient value) occurs from component 6 onwards. Hence, the SPSS factor analysis was repeated to identify the extraction and rotation of sums square loading for a total of 6 components. The scree plot is shown in Figure 10, and the table for total variance is given in Table 4.

Figure 10: Factor Analysis: Scree Plot
<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>1</td>
<td>5.839</td>
<td>27.804</td>
<td>27.804</td>
</tr>
<tr>
<td>2</td>
<td>2.581</td>
<td>12.289</td>
<td>40.094</td>
</tr>
<tr>
<td>3</td>
<td>1.471</td>
<td>7.004</td>
<td>47.097</td>
</tr>
<tr>
<td>4</td>
<td>1.350</td>
<td>6.431</td>
<td>53.528</td>
</tr>
<tr>
<td>5</td>
<td>1.229</td>
<td>5.854</td>
<td>59.383</td>
</tr>
<tr>
<td>6</td>
<td>1.200</td>
<td>5.713</td>
<td>65.096</td>
</tr>
<tr>
<td>7</td>
<td>1.020</td>
<td>4.855</td>
<td>69.951</td>
</tr>
<tr>
<td>8</td>
<td>.831</td>
<td>3.955</td>
<td>73.906</td>
</tr>
<tr>
<td>9</td>
<td>.746</td>
<td>3.552</td>
<td>77.458</td>
</tr>
<tr>
<td>10</td>
<td>.701</td>
<td>3.338</td>
<td>80.795</td>
</tr>
<tr>
<td>11</td>
<td>.621</td>
<td>2.959</td>
<td>83.755</td>
</tr>
<tr>
<td>12</td>
<td>.586</td>
<td>2.790</td>
<td>86.545</td>
</tr>
<tr>
<td>13</td>
<td>.493</td>
<td>2.346</td>
<td>88.891</td>
</tr>
<tr>
<td>14</td>
<td>.432</td>
<td>2.059</td>
<td>90.950</td>
</tr>
<tr>
<td>15</td>
<td>.401</td>
<td>1.912</td>
<td>92.861</td>
</tr>
<tr>
<td>16</td>
<td>.345</td>
<td>1.643</td>
<td>94.505</td>
</tr>
<tr>
<td>17</td>
<td>.318</td>
<td>1.513</td>
<td>96.018</td>
</tr>
<tr>
<td>18</td>
<td>.251</td>
<td>1.197</td>
<td>97.215</td>
</tr>
<tr>
<td>19</td>
<td>.243</td>
<td>1.158</td>
<td>98.373</td>
</tr>
<tr>
<td>20</td>
<td>.190</td>
<td>.905</td>
<td>99.278</td>
</tr>
<tr>
<td>21</td>
<td>.152</td>
<td>.722</td>
<td>100.000</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.

Table 4: Factor Analysis: Total Variance Explained

Dimension Reduction

According to Gie Yong and Pearce (2013), datasets consisting of several variables can be reduced by observing groups of variables or factors and then assembling common variables into descriptive categories, using factor analysis. In factor analysis, factor rotation helps to achieve a simpler and more meaningful solution. Through rotation the axes within factor space are brought nearer to the location of the variables (Watkins 2018). Using SPSS for EFA analysis, the Rotated Component Matrix was produced, which for this pilot study is shown in Table 5. Through Varimax Rotation, the matrix gave the maximization
component value for every variable. In Table 5 it is shown that SPSS obtained the required data convergence using 13 iterations from a maximum of 25 defined. The maximum component value is defined for each variable, as shown by the highlighting in the matrix (Table 5). Following that, variable grouping according to the correlation was determined for every component to be able to reduce the number of variables from 21 to 6. For every group a new multiple item scale variable was created as listed in the dimension reduction table shown in Table 6.

<table>
<thead>
<tr>
<th>Variable Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Errors and Mistakes</td>
<td>0.725</td>
<td>0.055</td>
<td>0.188</td>
<td>-0.036</td>
<td>0.032</td>
</tr>
<tr>
<td>2</td>
<td>Aviation Regulations</td>
<td>0.007</td>
<td>-0.187</td>
<td>0.109</td>
<td>0.745</td>
<td>0.224</td>
</tr>
<tr>
<td>4</td>
<td>Human Factors Training</td>
<td>0.278</td>
<td>0.256</td>
<td>0.305</td>
<td>0.461</td>
<td>0.290</td>
</tr>
<tr>
<td>5</td>
<td>Policies and Procedures</td>
<td>0.040</td>
<td>0.078</td>
<td>0.030</td>
<td>0.742</td>
<td>0.277</td>
</tr>
<tr>
<td>6</td>
<td>Human-Machine Interface</td>
<td>0.071</td>
<td>0.043</td>
<td>0.049</td>
<td>0.257</td>
<td>0.853</td>
</tr>
<tr>
<td>7</td>
<td>Design of the Working Environment</td>
<td>-0.090</td>
<td>0.034</td>
<td>0.252</td>
<td>0.211</td>
<td>0.815</td>
</tr>
<tr>
<td>8</td>
<td>Relationship between employees</td>
<td>0.263</td>
<td>0.545</td>
<td>0.206</td>
<td>-0.067</td>
<td>-0.155</td>
</tr>
<tr>
<td>9</td>
<td>Relationship between Management and Employees</td>
<td>-0.294</td>
<td>0.569</td>
<td>0.381</td>
<td>0.271</td>
<td>-0.311</td>
</tr>
<tr>
<td>10</td>
<td>Productivity and Willingness to work</td>
<td>-0.001</td>
<td>0.349</td>
<td>0.567</td>
<td>0.073</td>
<td>0.090</td>
</tr>
<tr>
<td>11</td>
<td>Communication</td>
<td>0.113</td>
<td>0.178</td>
<td>0.699</td>
<td>0.220</td>
<td>0.219</td>
</tr>
<tr>
<td>12</td>
<td>Stress, depression, and anxiety</td>
<td>0.351</td>
<td>-0.183</td>
<td>0.787</td>
<td>0.004</td>
<td>0.057</td>
</tr>
<tr>
<td>13</td>
<td>Complacency</td>
<td>0.538</td>
<td>0.270</td>
<td>-0.232</td>
<td>0.217</td>
<td>-0.062</td>
</tr>
<tr>
<td>14</td>
<td>Lack of Knowledge</td>
<td>0.441</td>
<td>0.390</td>
<td>0.143</td>
<td>0.443</td>
<td>-0.170</td>
</tr>
<tr>
<td>15</td>
<td>Distraction</td>
<td>0.706</td>
<td>0.390</td>
<td>-0.047</td>
<td>0.222</td>
<td>0.092</td>
</tr>
</tbody>
</table>

Rotated Component Matrix

Rotated Component Matrix*
<table>
<thead>
<tr>
<th>Variable Number</th>
<th>Original Independent Variable for Multiple Item Scaling</th>
<th>New Multiple Item Scaled Independent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Errors and Mistakes</td>
<td>Physiological and psychological factors affecting errors and mistakes</td>
</tr>
<tr>
<td></td>
<td>Complacency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distraction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fatigue</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assertiveness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Norms</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Relationship between employees</td>
<td>Good relationships between aircraft maintenance personnel improves safety awareness</td>
</tr>
<tr>
<td></td>
<td>Relationships between management and employees</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teamwork</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Awareness</td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Rotated Component Matrix for Dimension Reduction
Productivity and willingness to work
Communication
Stress, depression and anxiety

Aviation Regulations
Human factors training
Policies and procedures
Lack of knowledge

Human machine interface
Design of the working environment

Resources (parts, tools, manuals, etc.)
Peer pressure and time pressure (Deadlines)

Table 6: Dimension reduction and identification of New Multiple Item Scaled Independent Variables

The Updated Conceptual Framework

Following dimension reduction using the Exploratory Factor Analysis, the initial conceptual framework was updated and a new conceptual framework was the result, as illustrated in Figure 11.

Figure 11: The Updated Conceptual Framework
Analysis of Responses

A graphical analysis of how the participants in this study replied to the statements regarding the effect of COVID-19 on the safety standards requirements in aircraft maintenance is given in Table 7. The level of agreement or disagreement of respondents in relation to every statement exploring each independent variable is illustrated.

<table>
<thead>
<tr>
<th>Independent Variable Exploratory Statement</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>In a pandemic situation the risk of committing errors or mistakes tend to increase whilst doing maintenance on aircraft</td>
<td><img src="chart1.png" alt="" /></td>
</tr>
<tr>
<td>Aviation regulations should address pandemic situations to ensure the same level of safety in such situations</td>
<td><img src="chart2.png" alt="" /></td>
</tr>
<tr>
<td>Safety Management System (SMS) in the aircraft maintenance environment would reduce maintenance errors</td>
<td><img src="chart3.png" alt="" /></td>
</tr>
<tr>
<td>Human factors (HF) training must be done as soon as there is an official pandemic alert, even if training is still valid (i.e. less than 2 years have passed from last HF training) in order to address the effects of such unusual situations on aviation maintenance standards</td>
<td><img src="chart4.png" alt="" /></td>
</tr>
<tr>
<td>Policies and procedures for the aircraft maintenance environment must also address pandemic situations</td>
<td><img src="chart5.png" alt="" /></td>
</tr>
<tr>
<td>Following the COVID-19 experience, designers should take into consideration the human-to-human transmission of viruses when working on the aspect of human-machine interface (i.e. interaction of people with hardware like aircraft, tools, etc)</td>
<td><img src="chart6.png" alt="" /></td>
</tr>
<tr>
<td>Special measures could be taken when designing the working environment to be prepared when the outbreak of a pandemic occurs</td>
<td><img src="chart7.png" alt="" /></td>
</tr>
<tr>
<td>Independent Variable Exploratory Statement</td>
<td>Response</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>The relationship between colleagues during the COVID-19 situation has drastically changed</td>
<td></td>
</tr>
<tr>
<td>Relationships between management (including supervisors or leaders) have changed following the COVID-19 outbreak (e.g. online meeting procedures have been introduced)</td>
<td></td>
</tr>
<tr>
<td>Productivity and willingness to work in the aircraft maintenance environment diminished during the COVID-19 pandemic situation</td>
<td></td>
</tr>
<tr>
<td>During a pandemic situation like COVID-19, the importance of ensuring proper communication between people working in the aircraft maintenance environment becomes more important. This includes the requirement of retaining documented evidence and refraining from assumptions</td>
<td></td>
</tr>
<tr>
<td>COVID-19 has increased the level of stress and anxiety among people working in the aircraft maintenance environment (Possible reasons: during the peak of the pandemic workload has decreased; at present, a reduction in the availability of staff is being experienced).</td>
<td></td>
</tr>
<tr>
<td>A pandemic situation would increase the risk of complacency (overconfidence) within the aircraft maintenance environment</td>
<td></td>
</tr>
<tr>
<td>A pandemic situation may affect the level of knowledge, should less training be provided, and the possibility of working with more experienced people is reduced</td>
<td></td>
</tr>
<tr>
<td>A person tends to be more distracted when working in the aircraft maintenance environment during a pandemic situation</td>
<td></td>
</tr>
<tr>
<td>Independent Variable Exploratory Statement</td>
<td>Response</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>COVID-19 has had a negative effect on teamwork during Covid-19</td>
<td></td>
</tr>
<tr>
<td>COVID-19 has caused people working in the aircraft maintenance environment to feel more fatigued (i.e. more physically tired)</td>
<td></td>
</tr>
<tr>
<td>Human-to-human transmissible diseases would lead to bad use of resources (i.e. tools, manuals, parts, etc.)</td>
<td></td>
</tr>
<tr>
<td>Forms of pressure (e.g. peer or time) are being felt more as result of the COVID-19 situation</td>
<td></td>
</tr>
<tr>
<td>Preventive measures related to the spread of COVID-19 might compromise the awareness of maintenance personnel about accident repercussions</td>
<td></td>
</tr>
<tr>
<td>Maintenance standards might be compromised by lower levels of assertiveness during COVID-19</td>
<td></td>
</tr>
<tr>
<td>The tendency of following norms instead of written and approved procedures or instructions has increased during COVID-19</td>
<td></td>
</tr>
</tbody>
</table>

*Table 7: Graphical analysis of responses (source of analysis - Google Forms)*
Conclusion

From the responses collected it seems that, in general, apart for some minor exceptions, what has been defined through the literature review in relation to the effect of the COVID-19 pandemic on the human factors in the aviation industry around the world, also applies to the aviation industry in Malta, including the aircraft maintenance industry.

Most of the respondents agree that a pandemic situation increases the risk of committing errors and mistakes during aircraft maintenance. As such, most of the respondents agree with has been argued by Cassar (2020), Manarvi and Raza (2018), and Alam (2021). This indicates that the human factor element within the aircraft maintenance industry must be given further importance during situations like pandemic ones. The authors mentioned highlight the importance of addressing pandemic situations when regulating bodies such as ICAO and EASA set up the aviation regulations and related policies, and when approved organisations set up required procedures, as well as the safety management system (SMS) required by the Implementing Regulations for Continuing Airworthiness, that address approved organisations like Continuing Airworthiness Management Organisations (CAMO) and Maintenance Organisations (MO) (EASA 2021). Having pandemic situations addressed by legislative requirements would serve as a safety net to prevent a further increase in the risks for committing errors and mistakes when the outbreak of a pandemic situation occurs. As a further preventive measure, the majority of the respondents agree that human factors (HF) continuation training should be organised when a pandemic situation develops, even if the 2-year period required by regulations for HF continuation training to be organised by the Approved Organisation for its employees still has time remaining until it expires. This confirms what has been stated by Alam (2021). The approved organisation may update its policy or procedure so that even if the legislative requirement will still be that of providing continuation training in HF and procedures every two years, an update in human factor training is given to the staff when there is a risk of a pandemic situation outbreak.

Most of the respondents also believe that, having experienced Covid-19 pandemic, ergonomics within the aircraft maintenance environment should address necessities particularly related with dangers arising from easily transmissible diseases classified as a pandemic. Example ergonomics highlighted in this study were the human-machine interface (i.e. interaction of humans with hardware such as tools, parts and the aircraft), as well as the design of the working environment (e.g. climate control, space requirements, etc.). This is in agreement with what has been stated by Shanmugam and Robert (2015), as well as the UKCAA (2002). In relation to this, approved organisations may suggest such factors to the providers and design organisations of hardware when they provide the necessary feedback.

Other factors addressed by the study were the relationships between people at places of work where maintenance on aircraft is performed. Most of the respondents agree that COVID-19 has affected relationships between the aircraft maintenance human resources and the management as well. This confirms what has been argued by Rozman and Tominc (2021) in relation with the rest of the aviation industry. While one must accept the fact that social distancing was a necessity during the peaks of COVID-19, when such measures are eased out, the approved organisation should refrain from organising meetings using virtual means as much as possible, and staff meeting activities like social and team building ones, as well as break-times should return as they were before the pandemic.

In relation to the Dirty Dozen of Human Factors (Dupont 1997) in aircraft maintenance, most of the respondents agreed that it has become more useful during the COVID-19 situation, except for complacency and norms. While most of the respondents feel that risks of complacency and norms remained the same during the COVID-19 period, they agree
that the remaining 10 risks have increased during this period. A final factor with which the majority of respondents did not agree with is the possible reduction of willingness for work and productivity during COVID-19. This does not match with what was stated by Rozman and Tominc (2021) when it comes to the rest of the aviation industry.

**Limitations encountered**

While conducting this pilot study, limitations that were encountered included the changes experienced during the COVID-19 pandemic, in the form of new variants that developed and were developing, the effects of vaccination, as well as the continuous changing of the restrictive measures taken against the spreading of COVID-19. This might have had an influence on the collection of the data, as well as the way participants responded to the survey questions. For example, the fact that the data was collected during a time when almost all measures were lifted and when almost everything had returned to normal might have influenced the view of a person about the impact of the pandemic situation on human factors.

Another limitation that might have influenced this pilot study is the absence of several years of the researcher from the ‘hands-on’ environment of aircraft maintenance. This might have created difficulties to get an acceptable level of responses for the survey. For future research, more effort would be required in getting a better diffusion of the research tool within the aircraft maintenance environment. In addition to the use of emails and social media as disseminating tools, visits to approved organisations, or other forms of meetings (i.e. online) could be organised by the researcher so that the aims and requirements of the research can be better explained to potential participants.

**Recommendations for Future Research**

In addition to analysing responses in relation to the impact of COVID-19 on human factors within the aircraft maintenance industry in Malta, this pilot study was also aimed as a preparation for future work and further research studying by using dimension reduction to reduce the number of variables forming the initial conceptual framework. With the aid of SPSS software, it was found that the dataset created was rather consistent, obtaining a Coefficient Alpha value of over 0.8. Using Exploratory Factor Analysis, from an initial amount of 22 independent variables, by dimension reduction, the initial conceptual framework was converted into a final framework consisting of 6 variables. With the number of variables reduced, future work can now be concentrated to determine what measures could be taken now that the world seems to be returning back to some sort of ‘pre-Covid normality’, with measures taken within the aircraft maintenance industry so that, should there be another pandemic outbreak, the industry will be well prepared and the impact COVID-19 has had on the industry will be different in any future iteration, with no or less repercussions. This can be done by enhancing the dataset through the re-distribution of the survey among a larger population so as to get a better sample for analysis. Given that the number of independent variables was a considerable one, the dependent variable was not explored in the survey during this pilot study. Now since the number of independent variables has been reduced from 22 to 6, the dependent variable would be better explored on a multiple-item scaled variable. Indications for a further study would be achieved on a more advanced quantitative level, using SPSS Multiple Regression Analysis. As stated by Moore and Wong (2006), multiple regression is a statistical technique that is ideal to study the relationship between a single dependent variable and several independent variables, with the objective of predicting the value of the single dependent variable using the independent variables having known values. This is why it is important that, in a future study, the dependent variable is also explored in the survey that is distributed.
Appendices

Appendix A - Survey Covering Letter

“The Impact of COVID-19 on Human Factors in the Aircraft Maintenance Environment: A Study about the Effects within the Approved Maintenance Organisations in Malta”

My name is Alfred Galea, at present conducting a research study as part of the MCAST Post Graduate Certificate in Research Methods. This research focuses on identifying the effects COVID-19 pandemic might have on the human factors within the aircraft maintenance environment. As a research conducting tool, the following survey is being distributed among people having a role related with the aircraft maintenance environment, particularly in the areas of Aircraft Maintenance related training departments, Aircraft Maintenance Environment (i.e. Approved hangars and Workshops), and other areas (departments) within the Approved Maintenance Environment, including planning, quality and management.

If you have a role (as identified above) within any of the areas identified above, your participation in my research would be highly appreciated. Your participation would involve answering the following questionnaire, that should not take more than 15 minutes to complete.

Your participation in this survey is completely voluntary, and you are free to either accept or refuse to participate. Should you decide not to participate, there is no need to submit any reason. Should you decide to participate, you are free to withdraw from the study at any time, without the requirement to explain why. Any questions that have been answered before deciding to withdraw will be erased.

If you agree to participate in this survey, please note that you will not be asked to submit your name, or any other information that could lead to your identification. This means that your participation is completely anonymous. Finally, should you decide to participate, please note the following:

- Once your answers have been submitted, there are no means to retrieve, modify, or delete them.
- All the data collected from the survey will be erased within 2 years of completion of the study. This is because this is a pre-test study, with intention to further develop the research.
- When the data collected is analysed and conclusions are drawn in accordance with the findings identified, by no means will information be given which can directly link yourself to the area you work within, the role you hold, and the organisation you are employed with.

Should there be any questions, queries, or concerns, please feel free to contact me.
I thank you in advance for your interest and participation in this survey.

Sincerely,

Alfred Galea

Appendix B - Online Questionnaire Statements

Part 1: Demographic Information:
Please indicate your age:

- 18 to 25 years
- 26 to 40 years
The Impact of Covid-19 on Human Factors in the Aircraft Maintenance Environment - Effects within Approved Aircraft Maintenance Organisations Operating in Malta

- 41 to 50 years
- 51 to 61 years
- Over 61 years old

Please indicate your area of involvement within the aircraft maintenance environment:
- Part-145 Maintenance Organisation Training Department
- Part-147 approved Maintenance Training Organisation
- Approved Part-145 Maintenance Organisation Hangar or Workshop
- Other department of the Part-145 Maintenance Organisation (e.g. Planning, Quality, Management, etc.)

Please indicate your role within the organisation:
- Trainer, instructor, lecturer, or practical assessor
- Conducting On-the-Job Training (OJT)
- Full-time aircraft licenced mechanic, or workshop technician
- Workshop Certifying Staff
- Support Staff at the Part-145 MO Hangar (e.g. Team Leader or Cat B authorised)
- Certifying Staff at the Part-145 Hangar (e.g. Line Leader, Bay Manager or Cat C authorised)
- Planning staff at the approved Part-145 MO
- Staff at the Part-145 Approved MO planning department
- Staff at the Part-145 Approved MO quality department

Please indicate the years of work experience that you have:
- Less than 1 year
- Between 1 year and 5 years
- Between 6 years and 10 years
- Between 11 and 20 years
- More than 20 years

Part 2: Exploratory Statements

1. In a pandemic situation the risk of committing errors or mistakes tend to increase whilst doing maintenance on aircraft.
2. Aviation regulations should address pandemic situations to ensure the same level of safety in such situations.
3. Safety Management System (SMS) in the aircraft maintenance environment would reduce maintenance errors.
4. Human factors (HF) training must be done as soon as there is an official pandemic alert, even if training is still valid (i.e., less than 2 years have passed from last HF training) in order to address the effects of such unusual situations on aviation maintenance standards.
5. Policies and procedures for the aircraft maintenance environment must also address pandemic situations.
6. Following the COVID-19 experience, designers should take into consideration the human-to-human transmission of viruses when working on the aspect of human-machine interface (i.e. interaction of people with hardware like aircraft, tools, etc.).
7. Special measures could be taken when designing the working environment to be prepared when the outbreak of a pandemic occurs.
8. The relationship between colleagues during the COVID-19 situation has drastically changed.
9. Relationships between management (including supervisors or leaders) have changed following the COVID-19 outbreak (e.g. online meeting procedures have been introduced).

11. During a pandemic situation like COVID-19, the importance of ensuring proper communication between people working in the aircraft maintenance environment becomes more important. This includes the requirement of retaining documented evidence and refraining from assumptions.

12. COVID-19 has increased the level of stress and anxiety among people working in the aircraft maintenance environment (Possible reasons: during the peak of the pandemic workload has decreased; at present, a reduction in the availability of staff is being experienced).

13. A pandemic situation would increase the risk of complacency (overconfidence) within the aircraft maintenance environment.

14. A pandemic situation may affect the level of knowledge, should less training be provided and the possibility of working with more experienced people is reduced.

15. A person tends to be more distracted when working in the aircraft maintenance environment during a pandemic situation.

16. COVID-19 has had a negative effect on teamwork during COVID-19.

17. COVID-19 has caused people working in the aircraft maintenance environment to feel more fatigued (i.e. more physically tired).

18. Human-to-human transmissible diseases would lead to bad use of resources (i.e., tools, manuals, parts, etc.).

19. Forms of pressure (e.g., peer or time) are being felt more as a result of the COVID-19 situation.

20. Preventive measures related to the spread of COVID-19 might compromise the awareness of maintenance personnel about accident repercussions.

21. Maintenance standards might be compromised by lower levels of assertiveness during COVID-19.

22. The tendency of following norms instead of written and approved procedures or instructions has increased during COVID-19.

References


IATA 2018. ‘Aviation Safety [International Air Transport Association]’. Available at: https://www.iata.org/en/youandiata/travelers/aviation-safety/#:-text=Flying%20is%20the%20safest%20form,for%20every%204.2%20million%20flights (accessed 10 August 2022).


