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ABSTRACTS


ARTICLES


Structural Analysis of the Wing of a Solar UAV Using Fuzzy Logic

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INTRODUCTION

The present work aims to implement structural and fuzzy-logic analyses of the aeroelastic wing of a medium size solar UAV. The selected UAV type is the Solar Light UAV from Marques Aviation, which provides long endurance capabilities thanks to its glider wing design and hybrid solar-hydrogen-battery energy system. The goal is to achieve structural optimization and flutter suppression for a diverse range of flight conditions. Traditionally, simplified analytical methods such as Schrenk method, Diedrich method and Fourier series have been applied to the wing structure. More modern techniques consider Fuzzy logic, a set of rules known for its inherent imprecision (or vagueness), applied to both flight condition load alleviation control and the prediction of aerodynamic characteristics of an aircraft model.

WING STRUCTURAL ANALYSIS

Past research has used structural analysis using a wide array of methods such as guides for performing analysis and optimization of wings integrating materials, aerodynamic principles, and structural analysis. Other work includes conceptual design and use of CAD and simulation software. Fuzzy logic-oriented research is diverse; some examples include a laminar flow to turbulent flow transition point detection and improvement/control with a fuzzy logic PID controller that modifies the upper flexible wing skin surface using smart materials as actuators. Fuzzy expert system (FES) development compares predicted values to the aerodynamic characteristics found using sampled wind tunnel test data, and fuzzy control architecture modules focused on Roll Control Rules and Load Alleviation Rules. Other research explores bio-inspired flapping and morphing wings from birds and dragon flies. Other wing structural analysis methods have included multi-fidelity models in which FEA or CFD is blended with numerical methods such as Fourier Series, Simpsons 1/3 Rule, double-lattice algorithm, numerical lifting-line methods, vortex-lattice methods, beam models, and response surface methods.

PROPOSED METHOD

Methods considered in this investigation include traditional aircraft design and structural analysis, aerodynamic values, structural control, numerical methods and optimization, and wing dynamic response. The study will use hand calculations (e.g., Excel) and compare these with numerical analysis and simulation design; specifically, the use of CAD (e.g., AutoCAD) and FEA software (e.g., Simscale and/or Ansys Mechanical), Matlab, Simulink, and Fuzzy logic (e.g., Fuzzy Logic Toolbox in Matlab) to address structural optimization and flutter suppression for a diverse range of flight conditions of the Solar Light UAV (Table 1).
Table 1: Speeds, loads and $C_{\text{LMAX}}$ in different flap settings and angles of bank for the SolarLight UAV

<table>
<thead>
<tr>
<th>Stall speeds &amp; loads (flaps)</th>
<th>Angle of bank (deg)</th>
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<tbody>
<tr>
<td>sea level, act W 110 kg</td>
<td>10</td>
</tr>
<tr>
<td>flap span 9.32% of wing span</td>
<td></td>
</tr>
<tr>
<td>Stall speed, $V_{S1}$ (kts)</td>
<td>31.7</td>
</tr>
<tr>
<td>Stall speed, $V_{S1}$ (m/s)</td>
<td>16.3</td>
</tr>
<tr>
<td>Stall speed, $V_{S0}$ (kts)</td>
<td>31.0</td>
</tr>
<tr>
<td>Stall speed, $V_{S0}$ (m/s)</td>
<td>16.0</td>
</tr>
<tr>
<td>Load factor n/$\tau$ turning flight</td>
<td>1.00</td>
</tr>
<tr>
<td>1g wing loading (kg/m²)</td>
<td>24.1</td>
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<tr>
<td>Turning flight wing loading (kg/m²)</td>
<td>24.1</td>
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<tr>
<td>$C_{\text{LMAX}}$ flap wing</td>
<td>1.7</td>
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<tr>
<td>Total act $C_{\text{LMAX}}$ flap up</td>
<td>1.46</td>
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<tr>
<td>Total act $C_{\text{LMAX}}$ flap down</td>
<td>1.52</td>
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<tr>
<td>$\Delta C_{\text{LMAX}}$ due to flaps</td>
<td>0.06</td>
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Steps in the structural analysis of the wing will include:

1. Evaluation of properties and selection of wing construction materials.
2. Stress and structural analyses of the wing (spars, ribs, stringers, skin).
3. Fatigue analysis of the aircraft wing.
4. Assessment of wing flutter.
5. Application of Fuzzy logic analysis to the study of the non-linear complex behavior of wing structure in different air flow and flight regimes.
6. Optimization of the wing design.

CONCLUSIONS
This ongoing research fills a gap in the area of structural wing design by investigating the loads and structural properties of a medium-size long-endurance fixed-wing solar UAV. Further, the use of Fuzzy logic to address the non-linear complex structure and aeroelastic wing behavior in UAVs is novel.

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INTRODUCTION

Advanced Air Mobility (AAM) encompasses revolutionary new aircraft and aviation systems with significant modifications to design and operation, novel propulsion concepts, development of new business models, as well as different customer experiences in air-travel and transportation[1]. New terms are widely adopted to characterize AAM, such as eVTOL and vertiport. The multi-layered nature of AAM development requires collaboration between a broad range of stakeholders to align all aspects of the ecosystem; that is, aircraft operators, aircraft developers, vertiport infrastructure designers, airspace integration specialists, and community integration experts[1,2]. This work provides an analysis of the design, specifications and performance characteristics of selected emerging AAM aircraft - Volante Vision Concept, Lilium Jet, Vertical Aerospace VA-X4, VoloConnect by Volocopter, Jobi Aviation, and Pegasus PAV of Aurora Flight Sciences.

URBAN AIR MOBILITY AIRCRAFT

Developed by Cranfield Aerospace Solutions, Cranfield University and Rolls-Royce the Volante Vision Concept is a unique icon of luxury personal air mobility that exemplifies Aston Martin’s forward-looking design ingenuity. The vehicle has room for three adults and is designed for autonomous flight using a hybrid-electric powerplant for fast, efficient and congestion free urban and inter-city air travel (Fig. 1).

Fig. 1: Airframe and aerodynamic configuration of the Volante Vision Concept by Aston Martin.

The lilium Jet features multiple unit distributed propulsion (DP) and ducted vector thrust concept (DVTC) that provides high redundancy with 36 ducted fans and Regional Air Mobility (RAM) capability[3]. The 7-seater DVTC aircraft with a maximum take-off mass of 3,175 kg can achieve a range of 261 km; noise levels are less than 60 dBA at an observer distance of 100 m, during hove. The Vertical Aerospace VA-X4 uses four tilting rotors and 4 stowable rear rotors for high efficiency, achieving noise levels 15dBA lower than helicopters. Other characteristics of the vehicle include NextGen avionics, Honeywell’s F-35 jet technology, high aspect ratio wing, Rolls-Royce electric powertrain, proprietary industry-leading battery system, high energy density, no carbon emissions, and carbon composite airframe. Voloconnect has
been designed for shorter range intra-city missions and routes of 100 km, at a cruise speed of 180 km/h, with a top speed of ~250 km/h. The airframe layout is compact for urban missions, naturally stable and highly efficient during forward flight, and with wing layout for low stall speed. The VoloIQ operations software provides real-time fleet health monitoring. The Jobi Aviation AAM aircraft is an all-electric air mobility platform with zero operating emissions. An extensive multi-year testing program with the FAA brings the aircraft close to certification for commercial operations. The aircraft is quiet and undetectable against noise background of urban environment. Range is +150 miles, and top speed 200 mph, carrying four passengers and one pilot. The Aurora Flight Sciences’ Pegasus Passenger Air Vehicle (PAV) is compact at 8.53 m wide in a three-surface wing configuration for the city environment. The aircraft is 9.14 m long and 8.53 m wide. The powerplant includes 8 propellers for vertical flight and a tail mounted pusher-prop. Maximum range is 80 km and load carrying capacity 225 kg. Maximum speed is 180 km/h. The Pegasus PAV is a two-passenger aircraft that can be piloted or flown autonomously using detect and avoid (DAA) technology.

The AAM aircraft models under development at this time offer diverse design concepts and performance capabilities to cater for urban and regional air mobility [4].

Cruise speeds: 180 – 325 km/h (112 – 202 mph)  
Max. cruise altitude: 3,000 m (10,000 ft).  
Range: 80 – 260 km (62 - 161 miles)  
Largest MTOW: 3,175 kg (7,000 lb) of the Lilium Jet  
Carry load: 225 kg (496 lb) by Pegasus PAV  
People/seats: 2 - 6

**SUMMARY**

AAM entails new aircraft technologies, propulsion, operation & business models. The Volante Vision Concept is the most prominent example of luxury personal air mobility. The Lilium Jet propulsion system is unique using DVTC. The air platforms provide e-VTOL hybrid urban and inter-city air travel, are efficient, and achieve a very low noise signature (60 dBA).

**REFERENCES**

A Look at Cybersecurity for the Airlines

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Abstract: This document provides an overview of the cybersecurity threat in the airline industry. A simple definition of the cyber threat is offered as well as of the adversaries. Several actual incidents of breaching, ransomware, theft of data and intellectual property, domain name service hijacking, and other acts are reviewed to illustrate the complexity and diversity of the issue. Recommendations for risk mitigation and how to lessen the actual threat are provided with simple approaches. These include what to do as a flight department, an airline, and may be done by any company associated with aviation to ensure security to cyber systems.

Key words: Airlines, aviation, breach, cybersecurity, incidents.

I. INTRODUCTION

The transition to the digital era via information technology for airlines has made them prime candidates for hackers. The reason being that they collect huge amounts of data about passengers, credit cards, passports, reservations, flight schedules, and frequent flyer information. In an interview, Kelley Sheridan[1] stated, “for attackers hoping to cash in on sensitive data, the aviation industry is a gold mine.”

The deployment of technologies within the aviation industry such as electronic flight bags (EFBs) and inflight entertainment and connectivity (IFEC) systems that use Wi-Fi increases the number of attack surfaces and expands the number of opportunities for attackers to gain access to data and systems. The U.S. Department of Transportation (DOT)[2] states wireless technologies that give passengers access to wireless networks and the internet on the aircraft and the adoption of the digital devices to increase fuel efficiency and automate repairs are two factors that present new vulnerabilities to hackers.

The challenge of safeguarding aircraft and information systems can be cost prohibitive or extremely difficult to cover even after the discovery of a vulnerability. The cybersecurity talent shortage that afflicts multiple industries presents the airlines industry a real challenge and makes it problematic to hire the cybersecurity professionals needed to address exposures. Without these critical assets, the airlines are facing a growing cybersecurity threat.[3]
II. THE CYBER THREAT

The Challenge

The introduction of connected information technologies in the airline industry and the difficulties of protecting them brings a challenge. In the event of a cybersecurity incident or exposed vulnerabilities, the airlines must be able to establish assurance and rebuild the trust of the public quickly. Demonstrating effectiveness to a non-technical population will be a challenge due to the complex technical nature of the problem. This likely fragility and effort in reconstruction of trust means the industry must also pursue resilient trust with its crucial participants. [4]

Information technology is defined as “the technology involving the development, maintenance, and use of computer systems, software, and networks for the processing and distribution of data.” [5] Within the scope of this definition is a wide variety of disciplines such as software development, business technology systems, network devices, and cybersecurity, all critical elements in the operation of aviation systems.

As information technology has increased in ability and services, the benefits of the advancements have been applied across the aviation industry to provide new capabilities. These technological advances come at a cost and have resulted in vulnerabilities on airline systems which can impact the success of their operations. The vulnerabilities have amplified through a multitude of different attack vectors. Now, more than ever in the past, cybersecurity is critical to ensure the success of aerospace communication systems [6].

Aviation information systems are unique when compared to traditional information systems. Aviation systems utilize additional specialized equipment such as sensors and embedded software to meet communications and operational requirements [7]. Aviation communication systems often range widely in scope, capabilities, and size. Airline systems support communication between dispatch and their aircraft and between aircraft to Air Traffic Control. An onboard aircraft system may be used to provide satellite communications for internet access while passengers are traveling across the ocean [8]. With the multiple vectors available, attacks can come in many forms against aircraft, airports, and airlines.

The Adversaries

The adversaries are threat actors and Nation-States or anyone that intends to perform malicious actions against other cyber resources, in this case, those of the airlines. They use technology to conduct cyber-attacks to infiltrate and incapacitate targets. Typical cyber-attacks come as phishing attacks, remote worker endpoint-security breaches, ransomware, IoT device
attacks, malvertising, theft of data, and social media-based attacks. Most efforts are for economic gain; but, other incentives, including criminal intent or sabotage, are possible. Any of these are highly disrupting to the aviation industry.

**Historical Review of Aviation Cybersecurity Incidents**

A review of a variety of recent cybersecurity incidents on airlines, airports, manufacturers, and suppliers will provide a cross-sector perspective.

**TURBINE PANDA**

From 2010-2015, a Chinese state-aligned actor conducted a campaign against multiple aerospace companies that resulted in data theft and loss of intellectual property. These efforts were reportedly designed to further development of the Chinese C919 narrow body passenger jet. The perpetrators were linked to the Jiangsu Bureau of the Chinese Ministry of State Security (MSS) via US Department of Justice indictments [9]. The actors targeted aerospace firms including Capstone Turbine, General Electric, Honeywell and Safran using techniques such as strategic web compromise (SWC) or “watering hole” attacks, and domain name service (DNS) hijacking in order to extract data over the five year period. The private cybersecurity firm CrowdStrike gave this campaign the designation TURBINE PANDA [10].

**Vietnam Airports**

On July 29, 2016 a coordinated cyber-attack resulted in the disruption of operations at Vietnam’s largest airports and the national carrier, Vietnam Airlines. Chinese affiliated hacker group 1937CN took control of flight information screens at Tan Son Nhat and Noi Bai International Airports, displaying political messages regarding the South China Sea dispute between China, the Philippines, and Vietnam. The week prior, China had lost a ruling to the Philippines in The Hague Permanent Court of Arbitration regarding sovereignty issues in the region. The actors also took over the sound system at Noi Bai and broadcast pro-Chinese messages. At Da Nang International and 21 other airports across Vietnam, computer systems experienced glitches that forced the shutdown of all internet systems. Airlines were forced to revert to manual check-in procedures, resulting in flight delays across Vietnam.

1937CN also defaced the website of Vietnam Airlines with political messages referencing the situation in the South China Sea, and uploaded a Microsoft Excel file to the internet that contained personal information of 400,000 members of the Vietnam Airlines Golden Lotus
frequent flier club, indicating that the airline’s network had been breached. [11]

**Cathay Pacific Data Breach**

On March 13, 2018, Cathay Pacific Airways discovered a breach of unauthorized access of approximately 9.4 million passengers belonging to the airline’s frequent flyer club. The passengers were from approximately 260 countries, jurisdictions, and locations. Among the data stolen were each passenger’s name, flight number and date, title, email address, membership number, address, phone number. Investigation revealed that two different groups of attackers conducted the attack. The first group (Group One) was active since at least October 2014 and used malicious software called keyloggers to capture keystrokes and credentials from authorized users. The group used the stolen credentials to access Cathay’s IT system via its restricted Virtual Private Network (VPN). They then placed further tools on the network to steal credentials and facilitate lateral movement. This group had access to Cathay’s networks through at least October 2018.

In at least August 2017 the second group (Group Two) exploited a vulnerability in an internet facing server and conducted a brute force attack that resulted in 500 users on Cathay’s staff being locked out of their accounts. The attackers planted additional malware, stole credentials and moved laterally across Cathay’s networks through May 2018. [12]

**British Airways Data Breach**

British Airways reported, on September 6, 2018, that they had been the victim of a cyber-attack that resulted in the theft of personal information, including name, travel plans, billing address, email address and payment card details for approximately 380,000 passengers. The attack was accomplished via the use of a digital skimmer, which is like physical devices criminals place on gas pumps and automated teller machines to collect credit card information. In this instance, a cybercriminal gang called Magecart gained remote access to the British Airways portal using stolen credentials from a Swissport employee in Trinidad and Tobago [13]. The actors then moved laterally across the network and gained administrative access, then inserted a bespoke script into the code of the British Airways web and mobile payment pages that allowed them to redirect customers to a fake page that allowed them to steal payment data in a similar fashion. As a result of the breach, British Airways could face £2.4 billion (approximately $3.3 billion USD) in liability as a result of a class action lawsuit [14].
Ravn Air Ransomware Attack

In December 2019 Alaskan regional carrier Ravn Air suffered a suspected ransomware attack that crippled the airline’s IT systems and caused the cancellation of all flights operating the de Havilland DHC-8-100, or Dash 8. The ransomware appeared to be specifically targeted at the Dash 8 maintenance system. The disruption was expected to last at least a month with cancellations affecting other airlines in the Ravn Air Group, PenAir and RavnAir Connect [15].

Albany New York Airport

The Albany New York International Airport, in 2019, paid to restore data access when the airport authority’s servers were disabled by Sodinokibi ransomware. The amount paid was undisclosed but was said to be five-figures. The attack was acknowledged after Schenectady-based MSP LogicalNet reported its own management services network had been breached and the ransomware virus spread to the airport authority’s servers and backup servers. The ransomware encrypted files like budget spreadsheets, but no personal or financial data was accessed, according to airport officials [16].

SITA Data Breach

In March 2021 aviation IT company SITA released a statement indicating passenger data stored on SITA Passenger Service System, Inc. (SITA PSS) servers in the United States had been stolen as the result of a cyber-attack. SITA [17], which handles a variety of digital services for about 90% of the world’s airlines, issued a statement indicating that it experienced a “serious” and “highly sophisticated” data breach on February 24. The breach appeared to include data from customers that were registered with these programs from March 2010 to June 2019, a period of nine years. The incident shaped up to be a very large example of a supply chain attack, with a number of major airlines reporting that their frequent flyer programs were compromised as a result of the breach. At least 2.1 million passengers on at least a dozen airlines had frequent flyer information compromised, including account number, status level, and traveler name, though data such as email addresses and credit card information was not part of the breach. Singapore Airlines, one of the affected carriers and member of airline code sharing agreement Star Alliance, stated that all Star Alliance member airlines provide a restricted set of frequent flyer program data to the alliance, which is then sent on to other member airlines to reside in their respective passenger service systems. Subsequently, the SITA breach resulted in the ability of the hackers to access this set of information for all 26 member airlines of the Star Alliance and
the OneWorld alliance, which uses the same system \[^{18}\].

### III. RECOMMENDATIONS

#### What to Do

A recommendation from leading experts recommends implementation of several measures to boost cybersecurity and reduce risks of data theft and hacking in general. Risk mitigation is the first step by developing and implementing cybersecurity formal policies including airline schedules, flight itineraries, ground transportation information, and personal information. Effective policies should include requirements to vet all vendors and airlines should contact service providers about their policies on data security, protection of aircraft including registration and data tracking.

Airline flight departments should establish policies regarding use of social media by individual employees and for the entire company. Aircraft tail numbers should not be posted on social media outlets or websites. \[^{19}\]

A cybersecurity policy should provide guidance for use of electronic devices such as laptops, cell phones, iPads, and other equipment that may hold sensitive information. For example, cell phones may pose security dangers to the airline if it contains a contact list for company personnel.

In addition, airlines should develop protocols related to maintenance activities. These may include how the aircraft databases, such as electronic charts, are updated, who uploads them, which devices may be uses, and methods to ensure the device used is secure. A simple USB drive may quickly transfer a virus and wreak chaos on cockpit efficiency and aircraft safety.

Airlines should consider contracting for an independent cyber audit conducted by a specialized firm that will search for vulnerabilities on the company’s network, flight department software, communications, and conduct penetration tests. Another consideration for airlines is considering obtaining cyber liability insurance. The coverage covers an organization’s liability in the event of hacking of confidential information. Accidental loss of critical information and even loss of certain paper documents can also be compensated.

Lastly, airline personnel and aircraft passengers should be informed about the improved cyber-security procedures. Company personnel should be able to identify suspicious emails and understand the severity of a network or data breach. Comprehending the possible consequence of clicking a link in a suspicious email can prevent harmful loss of data. \[^{20}\]
IV. CONCLUSION

A Call to Action

Long a target for malicious actors, the aviation industry has increased its vulnerability as it endorsed digital technology. As it connects services and systems, the potential attack surface of systems is growing larger and more complex. Increasing technology and connectivity brings news opportunities for malevolent actors targeting the aviation industry. Attacks range from actions like disrupting airport operations to state-sponsored activity such as disrupting airport video screens and audio messages for promoting propaganda. Several researchers claimed to have conducted credible attacks on both automated teller machine (ATM) systems and aircraft.

The attack surface is rapidly expanding and is owned by many stakeholders providing vulnerabilities in all systems. It is only a matter of time until they are discovered and by whom. Will they be friendly or malicious? Adversaries are always searching for what is possible and how they may benefit from it. So far, the aviation industry has experienced attacks with comparatively little impact. This may lead to a feeling of relative invulnerability. However, as other industries will confirm, such perceptions rarely last.

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Business Leadership in the Aviation Industry

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Abstract: This article provides an overview of leadership in the aviation industry from a Business Psychology perspective. Business Psychology is an applied science that aims to enhance effectiveness of people and organisations in the business environment and uses social scientific research methods to collect data including questionnaires, surveys, focus groups, interviews and case studies. There are different leadership styles, namely autocratic, democratic, participative, or laissez-faire which impact on team performance. Leadership typically involves teamwork, and building relationships with the team. In the challenging aviation industry, leaders rely on their teams to carry out their individual and collective roles to meet tight deadlines and stringent aviation standards. Challenges encountered by team leaders can be internal (lack of motivation or commitment, conflict or leadership challenge) or external, such as lack of resources. Leadership power fosters vision, creativity, and change in an organisation and originates from personal sources, whereas management power originates from organisational structure and supports stability, order, and problem solving within an organisation. Leadership success is closely linked to the leader’s personal traits such as intelligence, value, and appearance. Leadership styles include autocratic and democratic, and employees are likely perform as highly whether or not in the presence of the leader and experience a rewarding feeling with the democratic style of leadership. The next generation of aviation leaders require a holistic approach that combines leadership, personal and standardised qualifications throughout the industry. Technical aviation skills must be supported by soft business-related skills including communication, adaptability and listening skills for effective leadership in the aviation sector. Finally, culturally mediated values systems act as guidelines for individuals, groups and companies and shape business leadership in aviation.

Key words: Business psychology, leadership, management, soft skills, teams.

I. INTRODUCTION

Business Psychology can be described as an applied science that aims to enhance effectiveness of people and organisations in the business environment. The discipline of
Business Psychology uses social scientific research methods that allow the study of people, work venues and enterprises to optimally align multiple and competing requirements. Business Psychology plays a crucial role in creating a healthy, productive and mutually beneficial relationships between people and enterprises (The Association for Business Psychology, 2021).

“Business Psychology is the study and practice of improving working life. It combines an understanding of the science of human behaviour with experience of the world of work to attain effective and sustainable performance for both individuals and organisations” – The Association for Business Psychology (2021).

Business Psychology utilises qualitative and quantitative methods to collect data using questionnaires, surveys, focus groups, interviews and case studies. Analytical techniques typically include descriptive and inferential statistics, thematic and content analysis (The Association for Business Psychology, 2021). Domains of Business Psychology include the following:

- Coaching
- Culture
- Employee engagement
- Health and well-being at work
- Leadership development
- Learning and development
-Organisational development
- Performance management and appraisal
- Psychometric testing
- Safe and user-friendly work environments
- Selection and assessment
- Talent management

This article provides an overview of leadership in the aviation industry from a Business Psychology perspective.

**II. LEADERSHIP IN THE AVIATION INDUSTRY**

**Leadership**

It is widely recognised that there are different leadership styles impact on team performance. The approach to team leadership can be formal, informal, large, small, temporary project/task, or permanent. Leadership styles may be autocratic, democratic, participative, or laissez-faire (Lewis, 2019). The impact on team performance may be positive (e.g., increased morale, motivation, team cohesion, pride, fosters innovation, increased productivity, commitment, stretches people’s talents, raises aspirations) or negative (e.g., decreased morale, alienation, negativity, conflict, stress, reduced productivity). Effective team leadership often includes
elements of the following: adapting leadership style according to situation; delegation; clear lines of authority, accountability and responsibility, awareness of individual strengths and weaknesses; managing conflict; praise; providing resources; clear aims and objectives; acceptance of differing points of view; open and honest communication; mutual respect; empowerment; consistency in decision making; common purpose; which influence team morale, motivation, and success (Steve, Maak and Parry, 2020). Communication styles include assertive, aggressive, passive, empathetic, critical; non-verbal such as body language (open, closed), gestures, expressions; and verbal with various characteristics like voice (tone, pitch, pace), clarity, appropriate to task; listening skills. Barriers to effective team leadership are commonly determined by lack of commitment (e.g., leader, team member; poor communication); lack of appropriate skills; resource issues (financial, physical, staff); personal factors (e.g., challenges to authority, conflict between team members, inconsistency, self-interest, favouritism). Ultimately, what makes a great leader is “a person whose ideas and actions influence the thought and the behavior of others.” – Cantore and Passmore (2012).

Team Leadership

Leadership typically involves teamwork, whereby the attributes of a leader are determined by their success in building relationships with the team. In the challenging aviation industry, leaders rely on their teams to carry out their individual and collective roles effectively to meet tight deadlines and aviation standards. Employees normally work with many different stakeholders. This requires team leaders to be adaptable to effectively manage team members, encourage and support them. It is often pointed out that leadership start with one-self and that if you cannot influence yourself, you cannot influence others and thus you are not a leader (Lewis, 2019). Working in the aviation industry, typically in an airline or airport, involves teamwork where teams have to work under pressure to meet stringent schedules comply with demanding security and customer service standards. Roles include ground crew at aircraft turnaround, cabin crew servicing a flight, and hospitality teams ensuring passengers are served quickly in order to catch their flight. Team leadership plays a role in ensuring the efficiency and effectiveness of these teams. The aviation industry has had a number of high-profile leaders that demonstrate different leadership styles - Sir Richard Branson, Michael O’Leary and Sir Stelios HajiIoannou.

Team leaders often encounter challenges. These barriers may be from inside the team such as lack of motivation or commitment, conflict or leadership challenge; or they may also be
from an external source, such as lack of resources. Conflict within teams can be addressed through a group discussion. Interestingly, conflict is not always a negative occurrence, and often could have a positive effect. Of course, not all barriers can be overcome and team leaders may have to adapt their own working methods to resolve the conflict. Ultimately, leaders need to be aware of the consequences of ineffective team leadership in the aviation environment, and organisations should consider a series of team-building exercises, development of leader and employees’ interpersonal skills and team-building techniques, recognising the importance of team motivation and using encouragement and support to achieve the team’s goals.

Leadership and Management

Leadership power fosters vision, creativity, and change in an organisation and originates from personal sources, not from organisational structure. In contrast, management power comes from organisational structure and supports stability, order, and problem solving within an organization (Cantore and Passmore, 2012). Leadership success is closely linked to the leader’s personal traits such as intelligence, value, and appearance. While leadership traits are important, a true leader must refine the dynamics of the relationship between leaders and employees. The primary physical, social, and personal characteristics of a leader are identified as follows (Lewis, 2019).

Autocratic leader: The leader tends to centralize authority and uses position power (legitimate, reward, and coercive power) to manage employees. It has been proposed that employees perform highly whenever the leader is present, are not pleased with this style of leadership, and experience feelings of frequent hostility.

Democratic leader: The leader delegates authority to others, encourages participation, and relies on personal power (expert and referent power) to manage employees. In this leadership style, employees are likely perform as highly when the leader is present as when the leader is absent, and experience a positive feeling with this style of leadership.

Authority can be misused and misunderstood. Often, authority is overused which compromises cooperation from employees; both new supervisors and experienced ones who are assigned special projects are especially vulnerable (McKenna, 2020). Newly acquired authority may influence a leader unaccustomed to directing or coordinating the efforts of employees. Power is the potential ability to influence the behavior of others and represents the
resources with which a leader effects changes in employee behavior. Sources of power may originate from a person’s position in the organisation, or may be linked to personal characteristics. The traditional manager’s power comes from the organisation, where the manager rewards or punishes subordinates in order to influence their behavior (McKenna, 2020). Forms of position power include legitimate power, reward power, and coercive power. Legitimate power arises from a formal management position in an organisation whereby workers understand that they are obligated to follow the manager’s direction in conducting work activities. Managers that have access to formal rewards, such as pay increases, promotion, praise, attention, and recognition may be able to display reward power. Coercive power is the opposite of reward power and it is based on punishment including the right to fire or demote employees, criticize, or withdraw pay increases.

Personal power typically derives from internal sources, such as a person’s special knowledge or personality characteristic. It has been suggested that personal power is the tool of the leader, since employees follow a leader because of the respect, approval, caring or consideration of their ideas they feel (Cantore and Passmore, 2012). Personal power is becoming increasingly important as teams of workers are less tolerant of authoritarian styles of management in today’s businesses environment. Expert power results from a leader’s special knowledge or skill. When the leader is a true expert, subordinates are receptive to recommendations based on superior knowledge. Nonetheless, top managers may lack expert power because employees may have greater technical knowledge than the senior management in an organisation. Referent power is due to the leader’s personality characteristic, rather than a formal title or position, that elicits identification, respect, and approval of the leader by employees (www.globaljetservices.com).

The Next Generation of Aviation Leaders

The aviation sector needs good leadership to direct the industry and operations, from customer services, ground operations, training, facilitation and aviation security. Leadership in aviation necessitates a holistic approach to secure appropriate sources of talent (Steinhouse, 2018). Aviation leadership and personal development are closely inter-twinne and requires qualifications standardised throughout the industry to produce global leaders for the future of aviation. The aviation industry has three key organisation in its global network, ICAO, IATA and ACI. This points to the need for a global education system with qualifications recognised throughout the world. It has been suggested that ICAO, IATA and ACI introduce a collective apprenticeship scheme and provide opportunities for individuals at the point when they leave
school or university.

**Essential Soft Skills for Aviation Leadership**

Technical proficiency and other qualifications are essential, however soft skills are also the attributes of an effective leader particularly those that mitigate interpersonal issues and communications disconnects in the workplace (Lewis, 2019). It is crucial that aviation leaders are able to effectively communicate with others in an environment where there are internal personnel to the airline or airport organisation, as well as passengers and other external parties.

“It can be a challenge getting the message across to people outside of the airport industry so that they see both the opportunities you’re bringing forward and the reality that sometimes in an airport, you have to do things a little bit differently than you would in other businesses or industries.”

Aviation leaders must be able to communicate in a concise and clear manner without using technical aviation terms.

“The language of aviation needs to be secondary to the language of business.” - Brechter.

Adaptability and flexibility are essential qualities of an effective aviation leader. According to Brechter, “An effective aviation director needs to be as comfortable in the halls of the company headquarters as they are walking across the hangar.”

Aviation leaders must be good listeners in order to place themselves in a position of meaningful collaboration with their team. Attentive listening provides opportunities for constructive criticism and feedback; Neville Hay in International Airport Review writes:

“A great quality in a leader is the ability to listen to others and not be afraid to change one’s mind or acknowledge the superiority of another’s.”

Aviation leadership is best accomplished by a combination of technical aviation skills and soft business skills. According to Mike Nichols, NBAA’s VP of Operational Excellence and Professional Development.
“An effective aviation director must have these business-related skills in order to effectively work with headquarters, but he or she also must maintain technical skills in order to maintain safety in the organisation and credibility with the flight department staff.”

Value Systems Model and Leadership

Dobbelstein and Krumm (2016) explain the 9 levels for value systems, where culturally mediated values act as guidelines for individuals, groups and companies and also shape business leadership (Fig. 1). Value systems shape corporate cultures, drive people to accomplish objectives, and contribute to success of an organization. Corporate entities are not static and the value systems are prone to development (Dobbelstein and Krumm, 2016).

III. SUMMARY

Business Psychology plays an important role in shaping leadership in the aviation industry. In the challenging aviation industry, leaders rely on their teams to meet tight deadlines and stringent aviation standards, and must enhance their leadership style to accomplish effective teamwork and building relationships with the team. Leadership power from personal sources must be in synergy with management power from the organisational structure to achieve
stability, order, and problem solving within an organisation. Democratic styles of leadership are favored by employees, resulting in greater employee independent performance and job satisfaction. Future aviation leaders need a holistic approach that combines leadership and personal development, and standardised qualifications throughout the industry. Technical aviation skills should be complemented with the soft business-related skills of communication, adaptability and listening skills for effective leadership in the aviation sector. Culturally mediated values systems provide guidelines that shape business leadership in aviation.

IV. REFERENCES

Positioning of an Unmanned Aerial System UAS for Spatial Measurements on the Electromagnetic Field

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Company: www.mobilis.dz

Abstract: The unmanned aircraft systems (UASs) are commonly used for aerial photography, express delivery for packets, or video monitoring. Accurate geo-referring for the measurements of the electromagnetic field is one of the most important applications of these systems in order to obtain centimeter-level accuracy measurements. The main objective of this work focuses on the practical assessment of the methods used for positioning a low-cost UAS quadrotor for antenna measurement. In this contribution, a UAS quadrotor runs in a centralized way 3D fix, based on two main structures namely, an Altitude fix mode using a barometer to hold the vehicle leveled at the same altitude, even if it's pushed away from its position when flying, and a GPS control in order to maintain the quadrotor flying horizontally at the same GPS Coordinates. Here, we report on the design and the methods used for positioning a low-cost UAS quadrotor prototype for antenna measurement flying in open areas.

Key words: Autonomous flight, accurate geo-referring, Antenna measurement, PID controller, unmanned aircraft system.

I. INTRODUCTION

During its operation, industrial installations generate mutual disturbances and emit a powerful electromagnetic field permanently or intermittently, which can interfere with the operation of devices in terms of electromagnetic compatibility (EMC) and also endanger the health and safety of people. Spatial antenna measurements have gained attention in the last years, thanks to recent developments in UASs hardware allowing accurate positioning and geo-referring. National authorities in many countries are interested in using UASs for example in performing Radio Frequency Interference (RFI) measurements or the localization of jamming sources [1], they were interested in the UASs ability to perform RFI measurements in hard-to-reach places. Iterative techniques based on acquiring the near field (NF) at two or more acquisition surfaces enable the use of simple, low-cost hardware.

The NF scanning technique with a UAV drone equipped with an electromagnetic probe is one of these tools. Current advances in airborne-based antenna measurements have made it possible to measure the NF radiated by the Antenna using cm-level positioning and geo-referring systems such as Real-Time Kinematic systems (RTK), enabling in-situ measurements up to 5 GHz [2], with the potential application at K-band [3-4].
II. DESCRIPTION OF THE SYSTEM

The prototype used in this contribution is shown in (Fig. 1). A scheme of the main prototype subsystems together with the connections is depicted in (Fig. 2).

![Image of prototype](image)

**Fig. 1: Picture of the implemented prototype.**

The prototype system is composed of the following subsystems:

- The flight controller, which is a professional double-sided printed circuit board (PCB) that contains the 32-bit ARM microcontroller, and the usual positioning sensors. These sensors are MPU6050 Gyroscopic Inertial Measurement Units (IMU), the MS5611 barometer, and a GPS (GNSS) M8N with an HMC5883L compass integrated on its PCB.
- Ground telemetry system, which allows to check various parameters before and during flight like flight mode, Battery voltage, flight time, Altitude, Heading, Roll and Pitch angles, number of satellites connected to GPS, and the total flight time, these parameters are managed by the rangefinder algorithm of the flight controller and then

![Diagram of prototype](diagram)
transferred by the APC220 transceiver module to the ground station.

- RC transmitter/Receiver 2.4 GHz, based on NRF24L01 radio module to control the movements of the vehicle referring to the pilot orders.
- The 3D printing makes it easy to combine all modules and sensors and attach them to our system. The RC transmitter and flight controller frames are 3D designed using an organic looking outer shell method with Archicad 23 and then printed with Polylactic Acid (PLA).

III. The PID controller (Proportional-Integral-Derivative)

In the flight controller program the PID controller calculates the necessary corrections for the three axes of movement (Pitch, Roll and Yaw) continuously every 4ms (the flight controller refresh rate), the setpoints for the PID controller are the input signals of the receiver and the angular movement variables measured by the gyroscope, and then the outputs of the PID controller are intended to control the speed of the quadrotor motors to ensure balance. The use of mathematical operators (Proportional, Integrator, and Derivative) (Fig. 3), allows to produce an adequate command output for the system. The mathematical model of the PID controller is described as follows: 

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{de(t)}{dt} \quad eq. 1$$

$$e(t) = \text{Gyro input data - Receiver input data} \quad eq. 2$$

Such as:
- $e(t)$: The system error
- $K_i$: Integration gain
- $u(t)$: PID output variable
- $K_d$: Derivation gain
- $K_p$: Proportional gain

The PID controller gains $K_p$, $K_i$ and $K_d$ are determined experimentally by acting on these gains in a way to stabilize the quadrotor angular motions during flight tests, and therefore a quick convergence of the error $e(t)$ towards zero, the values of the PID gains of the quadrotor for the 3 axes of movement Pitch, Roll and Yaw are represented in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>Pitch</th>
<th>Roll</th>
<th>Yaw</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K_p$</td>
<td>1.3</td>
<td>1.3</td>
<td>4</td>
</tr>
<tr>
<td>$K_i$</td>
<td>0.04</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>$K_d$</td>
<td>18</td>
<td>18</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1. PID gains introduced into the main program of the UAV flight controller
IV. ALTITUDE FIX

Altitude fix as the name implies is a flight controller mode that will keep the quadcopter leveled at the same altitude, even if it's fluctuated up or down of its position when flying. The sensor used to measure the altitude is a very sensitive pressure sensor, when the vehicle is gaining altitude the air pressure surrounding it will slightly drop as the air pressure is higher close to the ground. Mathematically, close to the earth’s surface the atmospheric pressure decreases almost linear with the increasing altitude. With every meter $\Delta h = 1m$ in altitude change the air pressure changes $\Delta p = 0.117 \text{mbar}$ (Fig. 4).

The pressure sensor that we use for this contribution is the MS5611 module, which can detect pressure differences within a 10cm accuracy. This sensor is really sensitive, and it’s great to use it when we need a high precision measurements as measuring the altitude, but the high sensitivity also has quite some disadvantages. One of the main downsides is that this sensor is light-sensitive. Meaning that when the sunlight falls on the pressure sensor the signal coming out of the sensor becomes random and the altitude data will change significantly compared to the total darkness, so in that case we can't get the real Altitude.

In order to resolve this problem, we have to ensure darkness by putting the sensor in a special housing that contains several holes on the outside where air can flow in and out, and on the inside, it contains a border that helps to absorb the sunlight by the black paint of the housing (Fig. 5). This way, the sensor reacts very fast to changes in height, but it will not be sensitive to light. Changes in atmospheric pressure are related to variations in temperature, so the temperature readings from the MS5611 sensor are parts of the pressure calculations. When we plot 200 of the calculated values, in every period of 20 output the pressure spikes and slowly decreases (Fig. 6). This is because after every temperature reading, the next pressure output results in a higher value and then decreases, which is undesirable for the flight. So this data need further preprocessing before being used.
Fig. 6: MS5611 pressure output values for 200 readings (blue line), and its calculated average every 20 outputs (red line) displayed on an Excel sheet.

Therefore, when we take the average of 20 readings it becomes a smooth and usable line, this is because in every average there is only one pressure spike. However, when we feed this data into a serial plotter (Fig. 7) and after applying complementary filter instructions that use the 20 points calculated data average as a base, we can see the fast reaction to changes in altitude. Finally, to create a stable altitude fix for the quadcopter, basically these data are introduced as inputs variables for the PID controller (Fig. 8). This prevents the quadcopter of reacting jumpy when flying.

Fig. 7: Pressure data signal on a serial plotter.

Fig. 8: Flowchart of PID output of the altitude fix flight mode subroutine.
V. CONCLUSION

Programming a UAV equals a lot of field testing and tuning, especially when adding new features to the program and try new open source algorithms that require new settings. In this contribution, an improvement of the UAV prototype has been presented. It enables the simultaneous measurement and acquisition of the EM field radiated in space. In this system, the UAV quadrotor flight controller uses the IMU to extract the angular data rates of the drone in space, in order to control the tilt angles of the quadrotor. In order to prevent the quadrotor of fluctuating up and down, and aiming to achieve a low cost and low complexity framework, the high-resolution barometer sensor is used for programming the Altitude fix function instead of using a coherent RTK positioning system. Therefore, an electronic compass and a GPS module are implemented so that the quadcopter knows in which direction is the magnetic north and to prevent the drone from declination so that it can hovers at the same GPS coordinates.

Thanks to this simple setup, measurement errors due to positioning and geo-referring uncertain are minimized to centimeter-level and then the quadcopter can fly autonomously so we get a 3D fixed flight.

VI. ACKNOWLEDGMENT

This work has been partially supported by the Electrical Equipment Characterization and Diagnostic Laboratory of USTHB, it represents the engineering part of my Ph.D. thesis which consists of the practical implementation of an autonomous UAS for EM field measurement applications. We offer special thanks to Mr. Yahia Almouboudi for his great support.

VII. REFERENCES

LUCA Air: Airline Operation Requirements and National Airspace (NAS) Integration

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Abstract: The FAA has decades of experience regulating the safety of manned aircraft but less than a decade regulating the safety aspects of unmanned aircraft in the NAS. This has caused the FAA to take a cautious approach to integrating unmanned aircraft into the NAS by integrating small unmanned aerial vehicles (sUAV) before large unmanned aircraft. The aim of this research is twofold: To investigate requirements for large unmanned cargo aircraft (LUCA) airline operations and to evaluate the anticipated needs of the FAA to support integration of LUCA airline flights into NAS. Stakeholders must weigh the costs of transportation with the time and make a decision how they will ship their cargo. If the air cargo costs can be reduced by 30-40% then it will drive the LUCA market to expand. The traditional freight industry made up of airplanes, trucks, trains, and ships is ripe for disruption. The transportation costs for $USD / Ton KM has a potential to be less than truck transport which would make a LUCA operator quite profitable.

Keywords: Large Unmanned Cargo Aircraft (LUCA), Small Unmanned Cargo Aircraft (sUCA), Optionally Piloted Aircraft (OPA), National Airspace System (NAS), Federal Aviation Administration (FAA), Unmanned Aircraft System (NAS), Code of Federal Regulations (CFR)

I. INTRODUCTION

This article is being written in advance of a dissertation the author is completing. The contents of which are a summary of literature and previous research the author has completed. On Oct. 5, 2018, President Trump signed into law the FAA Reauthorization Act of 2018 (Public Law 115-254), which reauthorizes funding for the FAA through Sept. 30, 2023. This is the first long-term FAA reauthorization since 2012 that has been signed into law. The new reauthorization takes significant steps forward in the continuing integration of unmanned aircraft systems (UAS), or drones, into the National Airspace System (NAS) (Roberson, 2018). Just like the FAA Modernization and Reform Act of 2012 mandated the integration of UAS in the NAS, the FAA Modernization of 2018 takes it one step further by mandating that the FAA start to authorize drone deliveries in the NAS. Since this time, we have seen two commercial cargo drone carriers receive FAA 14 CFR Part 135 Air Carrier and Operator certification for small < 55 lbs unmanned cargo aircraft (sUCA). Wing a subsidiary of Alphabet and United Parcel Service (UPS) are now operating under Part 135 small cargo drones in uncontrolled
Class G airspace under 55 lbs below 400 above ground level (AGL) to delivery small parcels for the final delivery mile. This is just a small incremental step towards integrating larger unmanned cargo aircraft in altitudes where manned aircraft operate.

In order to simplify the classification of unmanned cargo aircraft (UCA) The Platform for Unmanned Cargo Aircraft (PUCA) classified UCA in two categories. The first category is for short distance small to medium sized UCA that deliver specialized items like medicines and packages. The acronym used for this classification is sUCA. The payloads for these types of sUCA are typically 1-55 lbs (0.43-24.9 kg) and would operate in an urban environment for delivering packages 9-19 km from a central distribution point. In rural areas, these sUCA would be traveling 20-50 km to deliver their cargo by using delivery trucks to launch and recovery sUCA in conjunction with central distribution points. This is similar to the Amazon Prime Air multirotor package delivery system. As defined by PUCA, the second category is for long distance unmanned cargo transport. These long distance large unmanned cargo aircraft (LUCA) have the potential of carrying 100-25,000 lbs. (45-11,340 kg) and with a range of 200-10,000 miles (321–16,000 Km) (Collins, 2017).

The aftermath of the Hurricane Maria in 2017 left Puerto Rico and its residents’ cutoff from food, fresh water, and medical supplies. Many of its residents died from these experiences. The bridges, airports, harbors, roads, and communications systems were all destroyed, making it next to impossible for many people to find access to these resources (Huber, 2018). FAA approved LUCA operations would have helped the residents of Puerto Rico receive the resources they needed to survive. For example, LUCA could have transported food, medical supplies, and water from ports in the United States or ships directly to the affected residents. This could have saved lives and prevented further escalation of the situation. In an effort to prevent this type of humanitarian crisis from happening again, further research is needed to evaluate the feasibility of commercial LUCA operations.

II. LIMITATIONS FACING LUCA TO NAS INTEGRATION

Assuming that FAA regulations allow remotely piloted passenger aircraft in the NAS, convincing the public that integration is safe is a major limitation facing integration. Other limitations include safety, liability, over flying populated areas, and technology constraints (Collins, 2017). Another significant limitation is that the FAA has decades of experience regulating the safety of manned aircraft but less than a decade regulating the safety aspects of unmanned aircraft in the NAS. This has caused the FAA to take a cautious approach to integrating unmanned aircraft into the NAS by integrating small unmanned aerial vehicles
(sUAV) before large unmanned aircraft. In the fall of 2019, the FAA certified Wing Aviation LLC, a subsidiary of Alphabet and UPS Flight Forward Inc, to operate sUCAs under 14 CFR Part 135 in urban environments below 400 ft. Under the Part 135 certification, Wing and UPS can provide commercial non-scheduled small cargo delivery using sUCA. The Wing drone is a vertical takeoff fixed wing UAV that is being used to deliver FedEx Express packages in the Christiansburg, Virginia area, while UPS has partnered with Matternet to deliver medical samples via a Matternet quad-copter drone across the WakeMed Raleigh, North Carolina medical campus. Both companies plan on rolling out their approved drone service nationwide in the coming years (FAA, 2021).

Thus far, no air carrier has been approved by the FAA to commercially operate LUCA or remotely piloted passenger aircraft in the NAS. This problem shows the need for researching the future FAA operational requirements for an air carrier certificate to operate LUCA in the NAS. This includes identifying differences between commercial manned Part 135 air carrier cargo flights and those for LUCA flights in the NAS. Further research should identify safety characteristics and reliability for LUCA NAS integration.

III. LUCA RESEARCH AIMS AND OBJECTIVES

To further the advancement of the LUCA industry and as parts and the requirements to complete a dissertation on this subject the author is conducting interviews and a survey with experts in the air carrier cargo airline industry and UAS experts. The aim of this research is twofold: To investigate requirements for LUCA airline operations and to evaluate the anticipated needs of the FAA to support integration of LUCA airline flights into NAS.

The research objectives of the study are as follows:
1. To design, pilot and validate a questionnaire and an interview for the enquiry into requirements for LUCA airline operations.
2. To design, pilot and validate a questionnaire and an interview for the study of needs of the FAA to support integration of LUCA airline operations into NAS.
3. To carry out interviews using manned air carrier cargo airline experts and unmanned aircraft systems experts.
4. To develop a model of LUCA airline operations.
5. To develop a model of integration of LUCA airline operations guided by research, the results from the expert interviews and the results from the questionnaire.
IV. ECONOMICS OF LUCA

Before looking at LUCA operations in the NAS it is important to evaluate the current state of the U.S. transportation systems to help determine potential markets for LUCA air carrier operations. Such as areas where there is a need for cargo but no airports, no roadways, no railways, or waterways to delivery cargo. Examples could include remote areas of Alaska, Nevada, or other remote areas in the United States. Also, as part of the research looking at trucking delays and congestion areas and determining if LUCA air carrier operations should be considered as an alternate mode of transportation for those areas. Another benefit of this research is that it could reveal LUCA air carrier niche markets and find potential lucrative LUCA air carrier supply chain routes. Any disruptions in the transportation supply chain caused by weather, no infrastructure, poor infrastructure, trucking delays, congestion, or driver shortages could be possible market opportunities for LUCA air carrier operations.

The United States Department of Transportation (USDOT) produces an annual report each year. This report represents an overview of the U.S. Transportation system and includes statistics on cargo movement, economics of transportation, transportation safety, environmental impacts on transportation, and other data on the U.S. transportation system. The report shows that in 2018, the total truck shipments represented 61% or 11.5 billion of the total value of all the U.S. shipments. This high value for truck shipping is increased to over 72% when you include those cargo shipments that went by multiple transportation modes such as those shipments that went by water/truck, train/truck, pipeline/truck, and those that go by mail.

The American Transportation Research Institute (ATRI) collects and processes truck GPS data in support of numerous USDOT freight mobility initiatives. Using truck GPS data from over 1 million freight trucks, ATRI develops and monitors a series of key performance measures on the nation’s freight transportation system. Among many GPS analyses, ATRI converts its truck GPS dataset into an ongoing truck bottleneck analysis that is used to quantify the impact of traffic congestion on truck-borne freight at over 300 specific locations in the national highway system.

According to research by ATRI, traffic congestion on the U.S. highway system added nearly $74.5 billion in operational costs to the trucking industry, a 0.5 percent increase over 2015. This is nearly 1.2 billion hours of lost productivity and equates to 425,533 commercial truck drivers sitting idle for a working year. These congestion costs are concentrated on a relatively small proportion of the national highway system (NHS). 86.7 percent of total nationwide congestion costs occurred on just 17.2 percent of NHS segment miles. ATRI’s analysis also documented the states, metropolitan areas, and counties that were most impacted by these
delays and subsequent cost increases. As listed in Table 1 the top 10 states experienced trucking congestion costs of more than $2.4 billion each. This was led by Texas at $6.5 billion, Florida with over $5.5 billion, California with $5 billion, New York at $4.3 billion, New Jersey at $3.3 billion, and Illinois at $2.9 billion in cost due to congestion. These 10 states combined accounted for 51.8 percent of the congestion costs nationwide (Hooper, 2018). It is well known that the trucking industry is facing unprecedented driver shortages. These shortages are caused by low pay, lack of respect for drivers, poor working conditions, trucking companies paying drivers on mileage not time, and the stressful demands of the job. ATRI reports that the driver shortage increased to 60,800 in 2018 and is expected to double to 160,000 over the next decade.

Table 1 ATRI Top Ten States Total Cost of Trucking Congestion (Brewster, 2018)

<table>
<thead>
<tr>
<th>Rank</th>
<th>State</th>
<th>Total Cost in Billions of $</th>
<th>State Share of Total Cost</th>
<th>2015 Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Texas</td>
<td>$6,370</td>
<td>8.6%</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Florida</td>
<td>$5,637</td>
<td>7.6%</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>California</td>
<td>$5,059</td>
<td>6.8%</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>New York</td>
<td>$4,347</td>
<td>5.8%</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>New Jersey</td>
<td>$3,350</td>
<td>4.5%</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Illinois</td>
<td>$2,903</td>
<td>3.9%</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>Pennsylvania</td>
<td>$2,885</td>
<td>3.9%</td>
<td>6</td>
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<tr>
<td>8</td>
<td>Tennessee</td>
<td>$2,838</td>
<td>3.8%</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>Ohio</td>
<td>$2,769</td>
<td>3.7%</td>
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<tr>
<td>10</td>
<td>North Carolina</td>
<td>$2,429</td>
<td>3.3%</td>
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</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>$38,587</strong></td>
<td><strong>51.9%</strong></td>
<td></td>
</tr>
</tbody>
</table>

When comparing the economic potential of LUCA air carrier operations to other shipping modes stakeholders should consider both transportation time and costs. Based on previous research performed by Collins (2017) and PUCA the operating costs for LUCA will be lower than current air cargo transportation but more than other transportation shipping modes like trucking, water, train, or pipeline. However, the shipping time LUCA takes for the cargo to reach its destination is forecasted to be less than any other shipping modes. In today’s market without considering LUCA as one of the shipping modes, transporting cargo by air is the costliest but the fastest way to get your cargo to its destination. Stakeholders must weigh the costs of transportation with the time and make a decision how they will ship their cargo. If the air cargo costs can be reduced by 30-40% then it will drive the LUCA market to expand. For example, stakeholders will have the ability to use LUCA instead of manned air cargo or in situations where trucking takes too much time. Figure 1 details transportation mode trade-
offs for transportation time versus its cost. The size of the oval shown for the transportation modes in Figure 1 represent the proportional dollar value of the cargo shipped in United States in 2018.

![Transportation Mode Trade-offs](image)

*Figure 1: Transportation Mode Trade-Off Time vs. Cost*

V. CONVERTING MANNED AIRCRAFT TO LUCA

Only those companies that are seeking FAA type, production, and airworthiness certification under 14 CFR Part 21 & Part 23 were considered for this research. There are less than a dozen of different LUCA companies working with the FAA for aircraft and part certification. Only a few of them will be explored. They are all at different stages of completion. Some of them are converting manned aircraft to LUCA while others are designing, testing, and engineering them separately without any humans onboard. Both company approaches to LUCA has limitations and its advantages. For example, LUCA designers starting from scratch do not need those systems for manned aircraft. Some of the companies starting off by converting manned aircraft to cargo aircraft. These include companies like Reliable Robotics, Xwing, Merlin Labs Inc., Dorsal Aircraft Corporation & Romaris Corporation. In order to test the systems in the NAS they are using a pilot to monitor the systems from the air while the aircraft are being controlled by a remote pilot on the ground.

Reliable Robotics is one of the leaders developing and testing systems that will result in planes taxiing, taking off, maneuvering in the air, and landing without a pilot. Reliable was co-founded in 2017 by Robert W. Rose and Juerg Frefel from SpaceX. Robert Rose
previously worked as the Senior Director of Autopilot at Tesla Motors and was responsible for developing the autopilot systems for Tesla. Reliable is headquartered in Mountain View, California where engineers write software, develop actuators, test prototypes, and the machinery needed for their autonomous aircraft (Vance, 2021). Reliable Robotics completed a series of remotely operated test flights directed by a pilot stationed in its Mountain View headquarters over fifty miles away. The remote pilot in the control center instructed an upgraded Cessna 208 Caravan to taxi, takeoff, maneuver over a populated region, and land while communicating with nearby air traffic through the aircraft’s onboard radios. A picture of the converted Cessna Caravan is shown in Figure 2.

![Figure 2 Reliable Robotics Cessna Caravan converted LUCA (Thurber, 2020)](image)

**VI. CONCLUSION**

The most common mode of cargo shipping is by truck using the national highway system (NHS). The costs are going up and the delays are getting worse. Billions of dollars are required to improve access and throughput otherwise disruptions in shipping will continue. However, this doesn’t mean that trucking shipping mode will be the best solution. It is predictable from looking at the cost of highway congestion by state in Table 1 that LUCA air carrier operations would be a commercially viable transportation mode starting in states with the highest costs due to congestion. Another great motivator in starting LUCA air carrier operations in the NAS is that it would not have any direct competition. So, the traditional freight industry made up of airplanes, trucks, trains, and ships is ripe for disruption. The transportation costs for $USD / Ton KM has a potential to be less than truck transport which would make a LUCA operator quite profitable.
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