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Ultra-Long-Range Flying

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Since the dawn of aviation, the quest for longer range aircraft have been attempted by many. First, for military advantage and then for passengers' convenience. The temptation heightened with the jet age, but it was largely abandoned when the fuel prices shot up. We look at some of the challenges of operating ULR flights.

WHAT IS ULR?

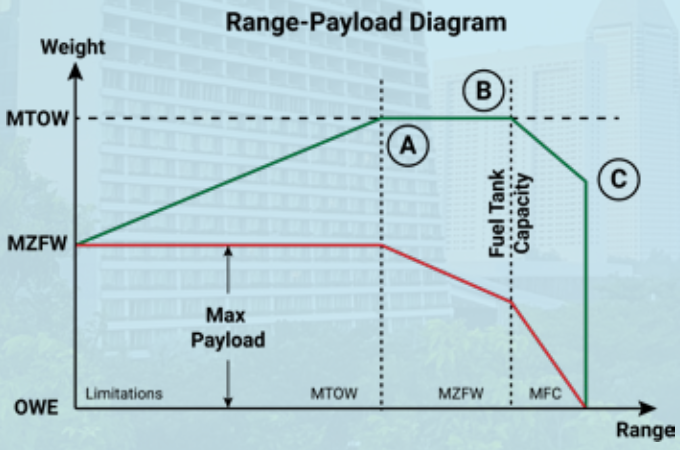
Ultra-long-range (ULR) generally refers to flights above 12 hours, but in recent years, we are looking at flights over 16 hours. At an average of 1,000 kph, 16,000 km is 40% of the Great Circle (40,000 km). That is coming close to the limit of useful range as there is no point flying beyond 50% of the Great Circle.

HISTORY OF ULR

The Boeing 747SP is one of the earliest attempts at ULR flights. With a shortened fuselage and a larger tail, the 747SP could fly 12,320 km at a cruise speed of 990 kph. But it comes with a huge price – it can carry only 276 pax compare to 452 pax on a standard 747 flying 9,000 km. Pax payload is compromised for extra fuel for the extended range (See Figure Below).

The 747-400 could be used as benchmark for long range flight. On 31 May 1989, SIA operated the first 747-400 international service on its SIN-LHR flights. SIA went on to be the launch customer for three ULR aircraft, the A380, 787-10 and A350-900.

Traditionally, only large aircraft with four engines could fly long distances. Today, twin engine aircraft with much lower MTOW are dominating ULR flights. The 777-200LR could fly 15,840 km with 317 pax while the A350-900 is flying 17,600 km with 325 pax.



This change is interesting as it represents a break with nature – only large birds with the capacity to store large amount of food and quick processing to feed the muscles could fly long distances. We have been following this trend with nature until the 787 and A350.

Three main contributors to this break are higher fuel efficiency of engines, lighter aircraft with advanced materials and improved aerodynamic efficiency. We should see this trend continuing to blur the definition of short- and long-haul aircraft.

CHALLENGES OF ULR OPERATION

MARKET

Economic flying of ULR is playing with the fine balance between MTOW, payload and fuel capacity. The cost of fuel for URL is significantly higher than a similar flight with one-stop in between. That accounts for the higher ticket prices and in some cases, no economy seats are offered on ULR flights. That was also the reason why SIA's ULR flights, started in 2004, were abandoned when the economic crises in the late 2000's could not support the yield needed to maintain a reasonable BELF (Break-even Load Factor).

ETDO - EXTENDED DIVERSION TIME OPERATION

Carrying fuel for normal operation in not sufficient. ULR flights often use polar and trans-oceanic routes where alternate airports are not in abundance. ULR aircraft need to be certified under ETDO conditions which allows an aircraft to fly beyond the 60 minutes diversion time provisioned in a normal flight.

ETDO more than 180 minutes are common in many twin engine ULR aircraft which has been made possible by the remarkable reliability of aircraft engines today. However, twin engine EDTO aircraft need to abide by special maintenance procedures to avoid single-point failures from maintenance errors.

<< This diagram shows why payload needs to be sacrificed for longer range. Up to point A, range is proportional to fuel load and payload limited by MZFW (Max Zero Fuel Weight). Once MTOW (Max Take-off Weight) is reached, range is dependent on payload. At point B where fuel tanks are full, the payload penalty becomes steeper because the aircraft is now operating under MFC (Max Fuel Capacity).

Flying beyond point B is only used in special situations like delivering or ferrying an aircraft empty for repair or maintenance.

OWE is Operating Weight Empty.

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CREW

Crew fatigue has been one of the biggest challenges of long flights. Labour regulation generally do not allow a person to work more than 12 hours a day. But on the flight deck or aircraft cabin, there is a tendency to look at work in a different sense. There is little physical activity and therefore fatigue is not apparent. Mental fatigue is hard to detect and on a flight deck, the impact of errors resulting from mental fatigue can be disastrous.

Aviation regulations requires In-flight rest facilities be available during ULR operations. Cabin crew rest facilities should be equipped with surfaces that allow for flat sleeping positions. ULR flights are to be operated with no less than four pilots, of whom two must be Captains. Airlines have various ways to comply, and more importantly to ensure that their crew do not suffer fatigue on such long flights. All these will incur additional operational costs. The problem is people tend to underestimate fatigue and overestimate their ability to handle fatigue.

PAX COMFORT & SAFETY

While we took great pains to manage fatigue in our crew, are the passengers left to fend for themselves? Not likely in this very competitive air transport market.

Airlines and aircraft manufacturers are keenly aware of problems faced by passengers on long flights. Higher risk of dehydration, deep vein thrombosis and difficult to deal with medical emergencies are some of the long-standing problems being studied and mitigations being applied in each new generation of aircraft. Recent ULR aircraft have incorporated ambiance lighting to mitigate fatigues and higher cabin pressures from 8,000 ft to 6,000 ft to improve comfort. Better humidity controls and seating position have been always been developed as part of the marketing strategy.

ULR DEVELOPMENT

Singapore - New York (SIN-EWR) flight is considered the longest route covering 15,344 km. In 2004, SIA using the A340-500 with 4 CFM engines took about 18 hours. 14 years later in 2018 the flight was relaunched with new generation A350-900ULR powered by two Rolls Royce Trent engines, taking about the same flight time.

What has changed? Is ULR a competition between aircraft types or airline marketing gimmick? The stakes are high. ULR flights have higher cost per seat-km and maintaining high yield and load factor are major challenges. The key game changer is the ability of smaller twin engine aircraft to fly long distances.

The A350-900 cruising at 38 000 ft and Mach 0.89, burned about 101 ton of fuel over the duration of the flight. That translates to 35% of MTOW of 280 tons. With equipment and furnishing, that leaves about 50 tons payload to generate revenue. Can the market sustain these operations?

Editor's Message

In early Sep 2019, Seattle became the fifth US city in Singapore Airlines' route network and the fourth non-stop flights from Singapore. While technology has enabled ULR, the decision to launch such ULR by any airline is normally based on economic considerations and the planning for such flights is by no means trivial. Our cover story brings insight into some of the challenges.

We have many enthusiastic aviation professionals who wanted to voice their perspectives in innovation in the aviation industry. In this issue, we have articles focusing on maintenance-related innovations as highlighted by our lecturers at the Aviation Safety Competition (ASC). Our members also shared innovations in MRO, which include using Drones in zonal inspection and simple innovative ideas in daily maintenance work in the RSAF.

Safety in aviation cannot be over-emphasized. We hope the pullout section on the SARPs would come in handy for our members and we look forward to your continued contribution and support in this publication.

Lim Chui Ping
Editor-in-Chief

Aviation Safety Competition 2019/2020

Leonidas Chua
Tan Chu Hiang
Lloyd Ernest Lazaro

What role does the computer play in the MRO industry in the era of globalization and Internet of Things? How should aviation professionals then ride this digital wave?

ASC 2019/20 is the fifth competition of the series and we are focusing on the theme **"Flying with Computers"**. To prepare the participants for the ASC, lectures were conducted by industry experts in Aug/Sep 2019 for the Category A participants (young students below 16 years old) to appreciate the complexity of managing safety in aviation with an industry visit to provide them direct experience in aerospace companies. The final presentation for Category A will be held in Nov 2019. Category B competition for students up to age 30 will be held in 2020.

Mr. Tan Chu Hiang, CEO of Heavy Maintenance Singapore Services Pte Ltd (HMSS), shared on emerging technologies in Aircraft Connectivity, Artificial Intelligence, Advanced Robotics, Addictive Manufacturing and Virtual and Augmented Reality and how they will play an increasingly vital role in shaping the ever-evolving landscape of the MRO industry. Of significance, digitalization of work processes has greatly enhanced workers' productivity to meet the demands of servicing and maintaining the highly sophisticated and complex systems of modern aircraft. MRO- centric ERP systems, coupled with mobility devices has integrated all the domains - ranging from supply chain and resource management, operations planning and execution to commercial and contract management, to enable quick decision making in a successful MRO business. Mobility platforms and expansive connectivity also allows onsite diagnostics, repairs and testing by engineers, supported by borderless access to expertise residing around the globe.

Technology is advancing rapidly and we can expect more interesting and exciting developments in the hangers of the future in areas such as automated inspection and work planning, collaborative robot solutions, wearable tech and augmented reality to enhance training and operations in the MRO industry.

The second speaker, Mr Llyod Ernest Lazaro, Asst Manager, Certification, CAAS, expounded on the topic of Aviation professionals in a digital landscape and raised the questions "How can we be the driving force that create the digital wave?"

Industry 4.0 brings about game-changing new technology and processes. Aviation industry has been a leader in innovation and as such, aviation professionals should embrace this new digital revolution and be ready for the paradigm shift of connectivity and automation.

While large companies are spear-heading the stride towards digital transformation due to their significantly richer resources, smaller companies could move ahead by reviewing internal processes to be more cost effective via digitalisation. Basic computer automation knowledge, Windows Task Scheduler and Microsoft Office Macros are just basics to produce tangible improvements to any process. Aviation professionals keeping hands 'on the ground', mastering data migration and refining operations of robotic systems with a strong understanding of digitalisation and automation is the start of ever more Industry 4.0 solutions. Equipping oneself with all necessary digital toolsets (knowledge) is an inherent advantage in the pursuit of operating an aircraft that is more than just controlling bit logic of ones and zeros.

It will be interesting to hear from our young aviation enthusiasts on *"How computer systems improved flight safety during the last 50 years and how else can computer systems further improve flight safety"* when they present their research in Nov 2019.

Innovation in Aerospace

An Integral Part of Daily Activities

Adrian Tan Seng Leong

Innovation - the concept of changing conventions to reap the associated additional benefits- is crucial to continuing success and has been embraced by many aviation organisations and companies. In recent times, the developments aligned to the Fourth Industrial Revolution (4IR) would often associate innovation with technological buzz words such as Big Data, Internet of Things (IoT) and Automation. However, innovation is not an abstract topic that require advanced domain knowledge beyond reach.

Innovation can be basic and is a fruit of problem solving

Innovation may be implemented through basic known methodologies. During my appointment as the Secretariat of Productivity and Innovation in Daily Efforts (PRIDE) for the Republic of Singapore Air Force (RSAF), I had seen that many top scoring projects were implemented through simple methodologies. They included ideas from the use of a modified clamp for the removal of a flight control tapered pin, to designing a simple tool for purging the hydraulic drain lines in an aircraft to determine hydraulic leaks. These simple ideas would only require small implementation capital yet they bring about huge savings.

The conception of an innovation idea would often emerge from daily problem solving in overcoming challenges faced which may include high operating costs, long and tedious tasks or unsatisfactory results from existing methods. A case in point is when I was not granted funds to procure an accelerometer test kit. As a result of the constraint, I leveraged my knowledge on the accelerometer and fabricated a test kit using existing resources, at a fraction of the commercial test kit. The innovation journey not only resulted in economic benefits, but was also satisfying as I could apply my engineering knowledge to solve problems.

Innovation relies on the application of your knowledge

While innovation does not necessary require advanced know-hows, it does require the application of your knowledge (or that of your team's). The ability to ideate requires one to fill the gap between the conventional and the desired state by leveraging the knowledge learnt. By applying what we learned from MSc in Mechanical Engineering, my team designed a tool for transporting, as well as for aiding the disassembly of the carburettor from a small aircraft engine. The tool was approved for use and was successful in preventing damage to the carburettor when it was held down for disassembly. We also applied the knowledge from other modules in the course to 3D-print the tool using Fused Deposition Modelling (FDM) method.

In short, do not think of innovation as a complex subject. It is an integral part of daily activities when engineers solve problem and does not necessarily entail complex solutions. The success of an innovation idea is not measured by the complexity of the solution but the effects it brings about. Notwithstanding, the advancement in technology does create more avenues for solving problems.

On a final note, natural that one would like to see an innovation idea being implemented quickly. While innovation is advocated, it is also important that innovative solutions are sufficiently evaluated to ensure that safety is not compromised, especially in an aviation environment.

Innovations in the Russian Helicopter

by Russian Helicopters

Russian Helicopters Holding Company (RHHC) has produced both civilian and military products that were recognised to be safe, efficient and reliable. One of the most popular Russian helicopters in history is the Mi-8/17, in particular, the civilian version – Mi-171A2 and the military version – Mi-8MTV-5-1.

The Mi-171A2 helicopter (top right) is the state-of-the-art representative of the Mi-8/17 family. It is equipped with an integrated onboard digital avionics system, which makes it possible to operate the machine without an engineer on board. This means that the new generation of helicopter operates with only two crew members. Mi-171A2 can perform search and rescue missions, medivac and cargo/passenger transportation (in both day and night), operating in harsh environments including deserts and over waters, at extreme temperatures from -50°C to +50°C.

Another famous Russian helicopter, which is operated by dozens of foreign operators, is the multipurpose, coaxial-rotor Ka-32A11BC. It is efficient in firefighting and rescue operations. At Seoul ADEX (Seoul International Aerospace and Defense Exhibition), RHHC presented a modernization program for the Ka-32 family, which included a new cabin with an avionics system, retrofitted with more powerful VK-2500PS-02 engines and a new fire extinguishing system. The modernized version of the Ka-32 helicopter was indexed as Ka-32A11M (bottom right).

The technical solutions in the avionics of the Ka-32A11M helicopter have already been tested on the civilian variants of the Ansat, Mi-38 and Ka-62. Compared to other helicopters, the new SP-32 water tank can carry four ton of water with digital control and upgraded water intake and discharge ergonomics. In addition, it can be operated at sub-zero temperatures.

New models of Russian civilian helicopters included the multipurpose Mi-38 helicopter which occupied a niche between the medium lift Mi-8 and the heavy lift Mi-26, and the medium lift multipurpose Ka-62.

The Ka-62 helicopter has an MTOW of up to 6.5 tons, translating to transportation of 15 passengers over 600 km. Cargo could be carried inside the cabin and on an external sling. The use of polymer composite materials in the helicopter's structure which accounted for up to 60% of its weight, is the machine's special feature. This increased the speed, maneuverability and load capacity of the helicopter, with a resultant improvement in fuel consumption against payload. Another distinctive feature of the helicopter is its single-rotor design with a ducted multi-bladed anti-torque rotor in the vertical tail fin. This is used on Russian helicopters for the first time.

The new Ansat light twin-engine helicopter, created by engineers from the Kazan Helicopter Plant, has the largest cabin among machines in its class. During Paris Air Show 2019, RHHC presented an upgraded Ansat concept. Besides a glass cockpit, the new generation light helicopter is equipped with weather radar, enhanced ground proximity warning module, a crash-resistant fuel system, LED lighting tools, and a wire cutter for wire strike protection. Part of the Ansat fuselage will be made of composite materials which will reduce the helicopter's weight; extending the range by 30% with a load of 8 passengers.

For the first time in Russian helicopter history, a long flight from China to Vietnam, Cambodia, Thailand and Malaysia was demonstrated. The first contract for the supply of 20 Ansat helicopters for the benefit of the Chinese Association of Emergency Medicine was signed during Airshow China 2018 in Zhuhai. The supply was to start immediately after validation of the type certificate in China.

ABOUT RUSSIAN HELICOPTERS HOLDING COMPANY

Russian Helicopters Holding Company (part of Rostec State Corporation), the only developer and manufacturer of helicopters in Russia, is one of the world leaders in the helicopter industry. Its capability spanned from design, manufacturing, testing and providing maintenance for modern civil and military helicopters.

There are over 7,950 Russian-made helicopters operating in more than 100 countries. In the heavy-lifter arena, RRHC's share accounted for 42% of the super heavy-lift helicopters (with MTOW of over 16 tons) and 80% of heavy-lift helicopters (with MTOW of 10 to 16 tons).

Mi-171A2 © Russian Helicopters

Ka-32A11M © Russian Helicopters

A Snapshot of the Urban Air Mobility Industry

Foong Zhi Yu

A potential up and coming industry which may potentially compliment and disrupt the aviation industry, has been garnering lots of media attention world-wide. Reports like "First air taxi trials to take place in Singapore in 2019" by CNA is just one of many articles which makes one wonder what the world will be like with these things flying just outside our doorstep.

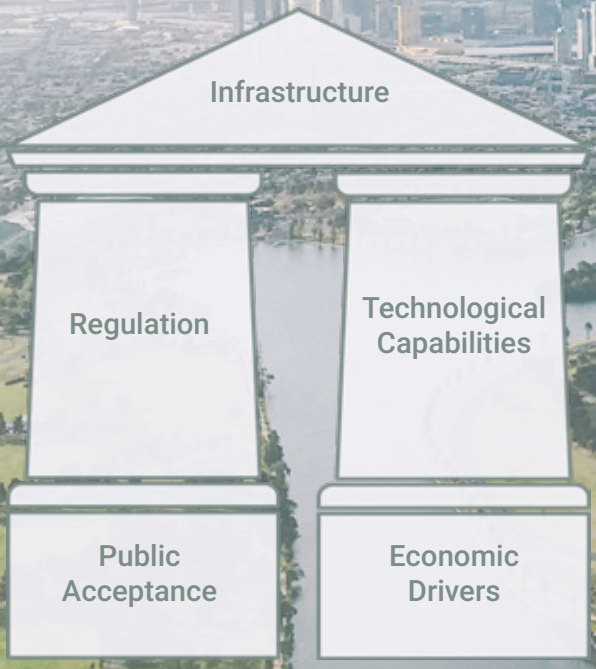
Taking a step back, there are 6 different levels of autonomy for any autonomous vehicle (AV), of which level 0 to level 4 still requires a driver while level 5 implies full automation according to the Society of Automotive Engineers (SAE). The UAM industry in particular, can only be successful if the following 5 pillars - infrastructure, regulation, technological capabilities, public acceptance and economic drivers are achieved, according to a McKinsey report (below).

Globally, the race to make the world's first, operationally viable air taxi is heating up. Uber has announced Uber Air flights in Melbourne, Dallas and Los Angeles with the aim to start demonstrator flights in 2020 and commercial operations in 2023. Volocopter has also announced test flights in cities like Singapore and Dubai. This has also triggered the race for the required infrastructure and regulations worldwide. Amazon, for instance, has recently patented a flight management system while the private sector had already attracted more than $350 million in funding to create Unmanned Aircraft System Traffic Management (UTM) and associated navigation systems. Uber Technologies has also tried to determine the costs and requirements for various infrastructure assets such as vertiports that will serve electric vertical takeoff and landing (eVTOL) aircrafts. Even large aviation firms like Airbus has increased collaborations like partnering ZF Friedrichshafen AG, a system provider for mobility, to develop highly precise end-to-end autonomous driving solutions by tapping on Airbus Ground Control Points (GCPs) and ZF's Lidar and Radar systems.

Yet, despite these advancements, there are still many hurdles that plague the UAM industry. For instance, issues on liability when an accident occurs and when an accident does occur, how should an investigation be carried out to ensure improvement of safety standards of the UAM industry has yet to be properly answered. Annex 13 Aircraft Accident and Incident Investigation to the Convention on International Civil Aviation by the ICAO has currently provided the framework for aircraft investigation and thus, a similar version of this for the UAM industry must be drafted. Even issues such as education, not only for a sustainable UAM industry talent pipeline but also key R&D challenges such as investment justification and public acceptance of the UAM industry cannot be neglected.

However, when the UAM industry does take-off, there will also be potential spin off industries that will benefit from it too. One is the maritime logistics industry as seen from the Airbus-Wilhelmsen ship-to-shore delivery drones. Other possibilities include the tourism industry and the healthcare industry, such as using air ambulances as a potential solution to high urban road traffic.

Overall, despite the many headwinds for the UAM industry, it has a high potential to change the global transportation landscape while also potentially providing viable solutions to other industries. The Association for Unmanned Vehicles International (AUVSI), the largest trade group around Unmanned Aircraft System (UAS), estimates that by 2019 more than 70,000 jobs will be created in the US with an economic impact of more than $13.6billion and the global market for commercial applications of UAS technology will soar to around $127billion by 2020 compared to $2billion today. Countries and companies should thus start planning for this new industry to ensure their competitiveness and minimize potential disruptions.



Infrastructure
Currently in the **midst of development** for landing facilities, charging hubs.

Regulation
Most countries are **lacking behind and slow in making changes** to regulate drones in domestic airspace.

Technical Capabilities
Software such as autonomous flight are **still being developed.**

Public Accetance
NASA survey in 2018 shows **mixed results** (25% would not try UAM transportation)

Economic Drivers
Air taxi trials have been rolled out in a **few cities** such as LA and Dubai with viable customer base

DroScan

Lim Tau Fuie

One of the labor-intensive tasks during aircraft maintenance is the external zonal General Visual Inspection (GVI). Current GVI involves technicians deploying bulky ground support equipment (e.g. scissor lift) to survey the aircraft skin from top to bottom. This task is time consuming, labor intensive and put technicians at risks with working at height.

ST Engineering has developed a drone-based aircraft inspection system called DroScan and is conducting trials with various airline operators, including Air New Zealand.

DroScan uses an autonomous drone to fly along planned routes around the aircraft fuselage to capture high definition images (Figure 1). Licensed Aircraft Engineers (LAEs) would review the captured images to identify defects or areas for further inspection. Specialised algorithms are also designed to analyse the captured images and expediting LAE's review process in detection and classification of defects.

The drone used as part of the DroScan system is DrN-5, a Y-6 (6 propellers over 3 arms) configuration drone developed in-house to provide propulsion redundancy of single motor failure and a minimised overall drone footprint. The features of the new system includes precise localization system (positional accuracy of less than ±20cm) to navigate in GPS-denied environments, power tethered system for extended flight duration and restrained flight template, and multi-side sensors for collision detection and geo-fencing to prevent drone from straying out of flight template. The system is operated by 2 men; consisting of a drone operator to have line-of-sight control of the drone during flight and an LAE to supervise the image capturing process. The end-to-end solution begins with ease of use for preflight planning with flight route waypoints catered for different aircraft models. During flight, the UAV will automatically capture images of the aircraft exterior at each waypoint. Post flight, an image analytics software based on machine learning algorithm processes the captured images to automatically identify defects (Figure 2). This assists the LAE in identifying defects on the aircraft and significantly reduce the inspection effort required compared to current manual inspection methods. At the end of inspection, an inspection report will also be generated. The system is safe, flexible and provides a repeatable inspection process.

In the Air New Zealand trial, Chief Ground Operations Officer Carrie Hurihanganui shared that using DroScan for their aircraft fleet inspection has saved time - a task that normally took up to 6 hours, is shortened to between 1 to 2 hours. With the earlier completion of inspections, the commencement of required repairs could begin sooner, and in turn enable the earlier return of aircraft for operations. ANZ also highlighted an improvement in inspection quality from the results of the DroScan trial on several of their aircraft that were undergoing maintenance inspection in Singapore.

To date, DroScan has flown close to 500 sorties and ST Engineering is continuously looking to extend its capabilities. Improvements include performing size measurements of defects and application for ad hoc inspections after lightning strikes. The company's immediate plan is to engage with other airline operators and Civil Aviation Authorities towards operationalisation by the end of 2019.

Incorporating innovative technologies into aviation MRO holds great potential in enhancing the way aircrafts are serviced. Solutions such as DroScan will drive great value for the aviation industry given the huge emphasis it places on safety and efficiency.

Figure 1: DroScan is an end-to-end external general inspection system designed with automation and smart analytics capabilities and incorporated with safety protection features approved for operations within aerodromes.

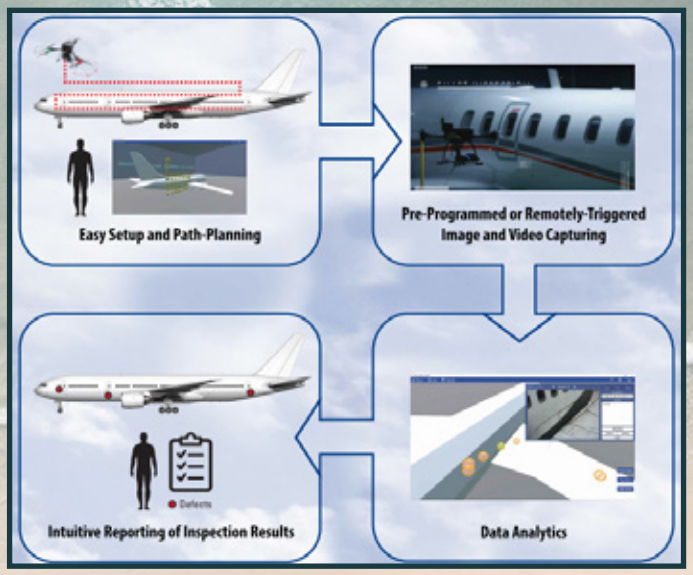


Figure 2: Machine learning algorithm diagram

Safe Air Travel Under ICAO

Jonathan Chan

2017 was the safest year ever for aviation. With 50 fatalities out of 4.1 billion passengers, the fatality rate was 12.2 per billion passengers. Although 2018 recorded the highest number of accidents in 4 years with 15 fatal accidents leading to 556 deaths out of 4.2 billion passengers, it is still well within our realm of safe air travel at 132 fatalities per billion passengers.

The fatal accident rates for 2017 and 2018 are 0.06 and 0.36 per million flights respectively. The most recent five-year average is 0.24 per million flights. Considering that we first achieved less than 3.0 in 1963 and 1.0 in 1969, we have come a long way.

The key to aviation safety is international cooperation. International Civil Aviation Organisation (ICAO) is a UN specialised agency, spawned from the 1944 Chicago Convention. It officially came into existence on 04 April 1947 - to standardise the operation of safe, regular and efficient air services which resulted in the high level of reliability and safety we are enjoying today.

ICAO works with the Convention's 191 Member States and global aviation organizations to develop international Standards And Recommended Practices (SARPs). National Civil Aviation Authorities (CAA) tailor the SARPs to develop their own Aviation Regulations with some changes to align with national priorities.

There are currently over 10,000 SARPs reflected in the 19 Annexes to the Chicago Convention which ICAO oversees. It is through these provisions – as well as ICAO's complementary policy, auditing and capacity-building efforts – that today's global air transport network is able to operate safely, efficiently and securely in every region of the world.

The 19 Annexes to the Convention on International Aviation are:

Annex 1	Personnel Licensing
Annex 2	Rules of the Air
Annex 3	Meteorological Services for International Air Navigation
Annex 4	Aeronautical Charts
Annex 5	Unit of Measurement to be used in Air and Ground Operations
Annex 6	Operation of Aircraft
Annex 7	Aircraft Nationality and Registration Marks
Annex 8	Airworthiness of Aircraft
Annex 9	Facilitations
Annex 10	Aeronautical Telecommunications
Annex 11	Air Traffic Services
Annex 12	Search and Rescue
Annex 13	Aircraft Accident Investigation
Annex 14	Aerodromes
Annex 15	Aeronautical Information Services
Annex 16	Environmental Protection
Annex 17	Security – Safeguarding International Civil Aviation against Act of Unlawful Interference
Annex 18	Safe Transport of Dangerous Goods by Air
Annex 19	Safety Management System

This article provides a broad description of the regulatory framework highlighting the link between CAAS and ICAO as well as other Regulatory authorities such as FAA and EASA.

The Tasks of Airworthiness Authorities are :

1. To prescribe airworthiness requirements and procedures
2. To inform the interested parties of airworthiness requirements and procedures
3. To control aeronautical material, design, and manufacturing organisations, and aircraft operators
4. To certificate aeronautical materials, organisations and personnel.

Vortex will continue to provide useful information relating to certification and airworthiness control in these pages.

– Editor.

List of common Civil Aviation authorities:

CAAS	Civil Aviation Authority of Singapore
EASA	European Union Aviation Safety Agency
FAA	Federal Aviation Administration - CAA of the United States
CAA (UK)	UK Civil Aviation Authority
CASA	Civil Aviation Safety Authority -Australian aviation safety regulates
CAAC	Civil Aviation Administration of China

Image Courtesy of ST Engineering

Singapore is a signatory to the Chicago Convention and the **Air Navigation Act** provides for the implementation of Singapore's obligations under the Chicago Convention and any other international convention, agreement, or understanding relating to safety of civil aviation to which the Government is a party.

Under the Act, the CAAS was established in 1984, and published the first issue of **Singapore Airworthiness Requirements** (SAR) in 1989.

SAR Issue 2 Rev 29 (Nov 2018)
SAR provides the minimum requirements in respect of airworthiness of aircraft. It covers basic definitions, aircraft engineering and maintenance requirements.

The document describes the certification process for various aircraft aspects, from the Registration of Aircraft and Issue of Noise Certificate, to the licensing of aircraft maintenance engineers and the approval of persons and organisations. Aircraft performance and Engineering and Maintenance administration are also covered within this document.

While defined in this document, some of the chapters such as Licensing of personnel and organisations are further elaborated within their individual parts

The SAR has the following parts:

SAR Part - 39

Airworthiness Directives

First issued in 2003, SAR-39 prescribes the requirements of Airworthiness Directives (AD) that are applicable to Singapore aircraft and components to be fitted.

The AD is a document adopted by the authority which mandates actions to be performed to restore an acceptable level of safety for aircrafts, which would otherwise be compromised. AD mandates a Service Bulletin (SB) or other maintenance action issued by aircraft manufacturers which are determined to be critical to safety.

Under SAR 39, an SB mandated by FAA or EASA are automatically considered mandatory on Singapore Registered aircraft.

SAR Part - 145

Approved Maintenance Organisations

For an aircraft to fly, it must receive a Certificate of Release to Service (CRS) issued by a SAR-145 approved organisation. Components that have undergone maintenance service must also be approved in accordance to SAR-145.

Since 1996, this part describes the requirements for approval of a maintenance organisation for operation within Singapore, from organisation and certifying staff to facility requirements.

Also stated are the requirements for an organisation that is not appropriately approved in accordance with SAR-145 to carry out certain maintenance under the quality system of an appropriately approved SAR-145 organisation.

SAR Part - 21

Certification of Products and Articles and of Design and Production Organisations

Part-21 describes the certification criteria required for products and components that are to be fitted on an aeroplane.

The Supplemental type certificates, airworthiness design standards are covered in this part.

Certification is also required for Design and Production Organisations. The requirements and procedure for approval are described in great detail.

SAR Part - 66

Aircraft Maintenance Licensing (AML)

The individual with a SAR-66 AML, operating under a SAR-145 approved organisation is permitted to issue a certificate of release to service once the maintenance on an aircraft is completed.

SAR-66 operates towards an individual level, describing the requirements that an individual must meet to obtain an AML and the conditions of its validity and use.

SAR-66 is further divided into Categories A, B and C depending on the level of maintenance, and subcategories, of Aeroplanes, Helicopters and the type of engine (Turbine or Piston).

SAR Part - 147

Approved Maintenance Training Organisations

The goal of an AMTO is to train students to be AML and Approval holders and for them to eventually work under an SAR-145 organisation.

SAR-147 prescribes the training procedures, materials, facilities, course duration, practical training and assessment criteria.

CAAS also carry out regular audits to ensure competence of lecturers and instructors.

SAR 147 organisation must maintain an exam question bank and control system acceptable to CAAS.

Image Courtesy of SIA Engineering Company

PLANELY SPEAKING

YOUR GREAT AVIATION STORY

"Aviation connects Singapore to the world. It is a key contributor to our country's success. Through this competition, we hope to inspire the next generation of aviation professionals, while deepening the appreciation of aviation's important role in transforming the lives of Singaporeans."

Mr Kevin Shum, Director-General, CAAS

For each of us, aviation may take on a different dimension. It could be the love of aircraft, fascination with technology or just a means to get far away quickly. Few people in the pioneer generation ever thought of flying in an aircraft. Yet after the formation of Singapore Airlines (SIA) in 1972 and the opening of Changi Airport in 1981, things changed rapidly. Taking an annual vacation flying thousands of km to Shanghai, London or Los Angeles seems like a routine for the younger generations.

Tell us your story. Your experience taking a flight or your first day at work as an intern in the aviation industry. Or your dream of being a Captain flying a jet aircraft or a Singapore Girl. It could be your fascination with the working of the jet engine or the landing gear after a visit to an aerospace company. It may not even need to be flying. The progress of Singapore's aviation from Seletar through Kallang and Paya Lebar to Changi is also a fascinating story to tell.

Jointly organised by the Ministry of Transport and the Civil Aviation Authority of Singapore in partnership with SIA, Scoot and Sony, the **Aviation Video Competition** is to engage our youth to increase awareness about the aviation industry.

HOW HAS AVIATION TOUCHED YOUR LIFE?

Make a two-minute personal video with the theme ***"Planely Speaking – Your Great Aviation Story"*** with a 200-word narrative and send to: ***planelyspeaking.sg/videocompetition*** by **30 Nov 2019**. There are 2 competition categories – Media Students and Open Youth. Visit the above website for more details. You can win attractive prizes from Singapore Airlines, Scoot and Sony Singapore, plus cash.

Evaluation Criteria: Relevance to Theme, Emotive Impact, Originality and Execution

The video should tell *"Your Great Aviation Story"* in a creative story telling manner to engage your audience to reflect on your message. Effective technical execution to produce quality visual and audio integration to deliver a positive viewing experience.

AWARDS AND PRIZES

Award	Awards Prize Package for Open Category and Media Category
Best Video Award	• Singapore Airlines Flight Simulator Experience • Singapore Airlines Economy Class Return Air Tickets to Anywhere on the Singapore Airlines Network • SONY a7III (ILCE-7M3K) Camera • $1,500 Cash Prize
Audience Choice Award	• Scoot Economy Class Return Air Tickets to Anywhere on the Scoot Network • SONY a6500M (ILCE-6500M) Camera • $1,000 Cash Prize
Merit Award	• SONY a6400L (ILCE-6400L) Camera • $500 Cash Prize

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Human Factors Training in Aircraft Maintenance

The Dirty Dozen

Prof Lim Yeow Khee, BBM, Hon F.SIAE, FRAeS

Anyone who has worked in aircraft maintenance within the last 20 years, will not fail to recognise the Dirty Dozen – a set of 12 posters displayed in hangars and workshops across the world. These posters were the outcome of a study by Transport Canada to reduce maintenance error, known as Human Performance in Maintenance (HPIM) workshop. And the man behind the creation of these 12 posters is Gordon Dupont.

Gordon started his aviation career as a missionary pilot in New Guinea in 1961. He became involved in human factors while working for Transport Canada as Special Programs Coordinator from 1993 to 1999.

Gordon Dupont

At that time, the world was bracing for the phenomenal growth of air travel and its impact on air safety. Three things stood up in the effort to assess the situation:

1. Fatal accident rates have dropped drastically from 35 per million departures (pmd) in 1960 to less than 5 pmd and the introduction of jet aircraft has contributed much to this.
2. At this rate, multiplying by the expected growth, we can expect to have one crash every week by 2010.
3. The number of accidents attributed to machine failures has dropped while those attributed to human errors have increased.

While working as a Technical Investigator for the Canadian Transportation Safety Board, Gordon saw first-hand the tragic results of maintenance and human error.

He discovered that safety investigation work may be interesting but reactive. The same things seemed to crop up in every accident. *"Sometimes all I had to do was change the date, names, locations and aircraft registration of the last accident and it was the same accident all over again"* Gordon once said.

HOW HUMAN FACTORS' DIRTY DOZEN WERE CONCEIVED

Gordon conceived the Dirty Dozen (Title of a famous movie) after going through thousands of records on maintenance errors. From those records identified as careless, Gordon saw 12 common preconditions to human errors.

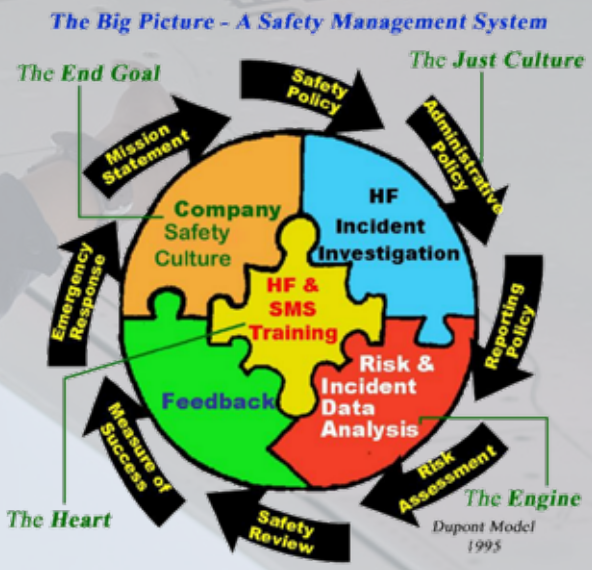
Lack of
- **Communication**
- **Knowledge**
- **Teamwork**
- **Resources**
- **Assertiveness**
- **Awareness**

In the state of
- **Complacency**
- **Distraction**
- **Fatigue**
- **Pressure**
- **Stress**
- **Norm**

Gordon retired from Transport Canada in 1999 and found System Safety Services focusing on Human Factors training to make our industry safer. He has provided Human Factors training to over 10,000 persons around the world, including Singapore, Australia, Sweden, China, Portugal, Holland, USA, UK and Ireland.

In Singapore, Gordon was very supportive of SIAE mission and has conducted many courses with ATTC. I had the privilege of learning from Gordon in Singapore and is now certified to conduct HFEM and SMS using materials from Systems Safety Services. As a fellow aircraft maintenance engineer, we shared the same passion to reduce maintenance errors to make flying safe.

Gordon has always emphasised on HF Training as the central element in a Safety Management System, as seen by the Dupont Model created in 1995 (below).



The Dupont Model 1995 © Systems Safety Services

As a strong believer of hand-on training, he developed many interesting case studies for Problem Based Learning (PBL) and made videos on air accident investigation for his training programs.

"Many times over the years, I have discovered that too many companies have the 12 Dirty Dozen Maintenance posters hanging in their hangers, but not one of their employees has had the HF training!"

"You need to have the training to understand exactly what each of the posters means and how each of the Safety Nets provided on the posters prepares the AMEs to avoid making the errors they never intended to make" said Gordon.

National Airfix Aeronautical Model Engineering Competition

Peter Chiang

There was huge enthusiasm at 13th annual National Airfix Aeronautical Model Engineering Competition. Held at the Air Force Museum from 20 - 22 June 2019, the competition aims to bring together an avid and talented group of Airfix Modellers and provide them with an avenue where they can share their work with others in this community.

The event mission statement ***"Fostering enjoyment of scale modelling as a hobby. Encouraging participation of newcomers and recognising achievements of enthusiasts of all levels and ages."*** was unveiled. It serves as a stark reminder that this craft can be suitable for anyone.

The guest-of-honour was Senior Parliamentary Secretary Associate Professor Muhammed Faishal Ibrahim from the Ministry of Education and Ministry of Social & Family Affairs. He had been an Airfix Modeller in the past.

The event also held "make & take" sessions on 20 & 21 June for students to try out this craft for themsleves. It gave them the opporunity to fine-tune their motor skills and learn a craftmanship that is not taught in their classrooms. The craft of scale aircraft modelling requies one to read technical instructions, picturing the model in a full 360 degree angle and then build a 3D replica. These sessions help the students develop patience and focus which are important practical and problem-solving skills that can be valuable and useful in their future.

The competition saw an entry of 105 models which included 70 entries in the Master, Senior and Inter-School class. The prizes were provided by the event sponsor Hobby Bounties & Morgan Hobbycraft Center. The youngest winner was Rafael Lim, age 8, with his Percival Jet Provost (the real Singapore Air Force aircraft which is displayed on site). The best Airfix prize went to the oldest Modeller, George Gauron at 81 years, with his Airfix 24th F6-F Hellcat which had its worldwide launch on 21st June 2019.

(Below) Winners and participants of the National Airfix Aeronautical Model Engineering Competition 2019
Images courtesy of Airfix Cup

(From Top) A few prize-winning Airfix Models: Best Airfix Model - Yak-9D by George Gauron; Masterclass 1st Place - Seafire FR47 by Kevin Khoo; Most Creative Model - Ki-61 Hien by Ng Keng Leong

Paris Air Show 2019

Robin Viva Thevathasan

The Paris Air Show, Salon International de L'Aeronautique et de L'Espace, Paris Le Bourget, was held from 17 to 23 June 2019. First held in 1909 (110 years ago!), the 53rd edition of the airshow is widely regarded as the premier and largest aerospace industry event.

2019 marked the 50th anniversaries of several important aerospace events which invariably drove some of the focus in this year's Paris Air Show. The events included:

- Apollo 11 Moon Landing
- First flights of the Boeing 747 and Concorde
- Launch of the A300 and the Airbus Consortium
- Formation of Embraer

Some of the show's highlights are summarised as follows:

Eclipsed by its ongoing B737MAX issues, Boeing has placed emphasis on safety, re-establishing the trust that had taken a beating with the recent B737MAX incidents. During this show, Boeing managed to secure a large order from IAG (in which airline group British Airways, Iberia and Aer Lingus belong). In the IAG announcement (as well as that from an earlier Ryanair announcement), the more traditional Boeing numeric designation (737-8) nomenclature was used.

Paris Air Show 2019 is the first show without the charismatic lead Airbus salesman John Leahy. In this year's show, Airbus has emphasized quality of orders rather than sheer numbers, with its A220 gaining momentum (with 85 orders) and A321XLR the most significant new aircraft type (an upgraded version of an existing type with ability to travel from Delhi-London non-stop). Orders for these aircraft from Asia-Pacific included Air Asia, Qantas, China Air Lines and Korean Air Lines.

At the military front, the 6th Generation Fighter project was also mooted. This is announced as a joint Franco-German-Spanish project to replace the Rafale & Eurofighter in a decade or more. It highlighted the use of AI and the use of force-multiplying Remote Drone Carriers in swarms rather than being restricted to what could be carried on its own platform.

In a significant industry consolidation, the merger of United Technologies Corporation's Aerospace arm (comprising Collins Aerospace and Pratt & Whitney) with Raytheon Company was announced. The combined company will be named Raytheon Technologies Corporation and will have approximately US$74Billion in revenue.

Next show - the 54th will be held on 21-27 June 2021

A quick comparison of the recent Singapore Air Show in Feb 2018* with that of Paris and Farnborough, provided the following interesting facts:

While the Paris show is the largest, the Farnborough and Singapore shows could clearly attract comparable exhibitor countries and official delegations.

	Paris Air Show (2019)	Farnborough Air Show (2018)	Singapore Air Show (2018)
Number of Exhibitors	2,453	1,500	1,062
Exhibitor Countries Represented	49	48	50
Trade Visitors	139,840	80,000	54,151
Official Delegations (Countries)	304 (98)	156 (66)	287 (91)
Journalists	2,700	1,800	816

** The next Singapore Air Show will commence on 12 Feb 2020. During Paris Air Show 2019, the delegation from Singapore also presented Singapore Airshow 2020 in the ST Engineering Chalet.*

Images by SIAE Salon du Bourget

Finding your way out by knowing who is I

Carol Cheng

Since time immemorial, man has struggled to find meaning to the simple word "I". Easily translated without distortion by all languages, yet illusive. Descartes said, "I think, therefore I am" and RD Laing defining, "Awareness is what do I think, you think I think". Let's stay away from the confusion and put "Me, myself and I" to work for us in our everyday life.

KNOWING ME, MYSELF AND I

In my work as a therapist, I discovered an interesting phenomenon among my clients. Most have difficulty answering directly to this question: "How do you feel?". Answers were either unrelated to their emotions, or they have no idea how they feel. It is normal to feel "nothing" when one is devastated or traumatised. But in most cases, it is the limitation in vocabulary of emotion words.

Perhaps it is rooted in our collective Confucian culture that we are perceived as "reserved", "inexpressive" or "inscrutable" by western society. We are brought up to confine ourselves to say things that are socially or culturally appropriate. Hence, words associated with individual feelings are limited.

The most common emotion words I have encountered are "angry', "sad", "scared", "happy" and "guilt". Only one out of the five is positive. It is not surprising as those who came to seek help are troubled.

The key question is, why is there a need to know more emotion words? Before we come to this question, remember: We often cannot control what is happening in our environment, but we do have some control of ourselves.

Being able to control oneself requires skills. The first step is awareness or understanding yourself. One must be aware of what is happening in our inner world. It is equivalent to knowing what the problem is before we try and find a solution. Knowing how one feels and finding the right word to describe helps to understand oneself better.

In fact, it is this process of going through "how you feel" that increases the awareness of oneself which may eventually give rise to awakening. On the right are some of the words associated with the most common emotions of angry and sad.

Whenever you are feeling angry or sad, take a deep breath and go through the list on the right. Once you have identified one or more of the emotions you have, think about what has prompted you to feel this way. Write it down according to the two questions below:

1. What things "It is" now
2. What things "Should be"

You will soon realised the problem lies with believing things "should be" rather than "it is". This gap contributes significantly to the unpleasant emotions. The ability to see things as "it is" and not "should be" will help ease your unpleasant feelings.

EXPRESSING EMOTIONS

Why is there a need to express emotions? Penned-up emotions will eventually affect daily functioning and one's relationships with people. In the worst case it may develop into mental health issues. The goal of expressing emotions is not to get rid of it but finding an avenue for it to "park', so that it will not "get in your way" while trying to move on.

There are many ways of expressing emotions, some can be quite detrimental. What I am suggesting is something more subdue and yet can be effective for some people.

Drawings - draw what your emotion looks like. Give it a form, for example if you feel "crushed, draw what "crushed" is like. Make use of colours to express it more thoroughly. After completion, give it a title and you may decide what to do with this drawing. You may like to put up somewhere visible to you. The idea is to "be-friend" with it since you can't get rid of it. It takes twice the effort to get rid than to let it be there.

If you are feeling angry and a strong need to vent your anger physically, try tearing the drawing into smallest possible pieces and threw it in the air. Repeat this whole drawing and tearing process if needed. Try it. You will be surprised at how this simple trick can make your day.

INDIGNATION
OUTRAGE
ANNOYANCE
FURY
BITTERNESS
FRUSTRATION
GRUMPINESS
HOSTILITY
VENGEANCE
WRATH
AGITATION
FEROCITY
EXASPERATION
RAGE
GROUCHINESS
IRRITATION
AGGRAVATION

PITY
WOE
GRIEF
HURT
AGONY
DEFEAT
DISMAY
GLOOM
ALONE

LONELINESS
INSECURITY
SUFFERING
DISAPPOINTMENT
DESPAIR
HOMESICKNESS
ALIENATION
UNHAPPINESS
CRUSHED
DISCONTENTMENT
DEJECTION
MELANCHOLY
SORROW
DISPLEASURE
REJECTION
DEPRESSION
ANGUISH
INSECURITY
NEGLECT
DISTRAUGHT
GLUMNESS
MISERY

Importance of Engineering Ethics – Bicycles to Aircraft

Doing the Rights Things vs Doing Things Right

Prof Lim Yeow Khee, BBM, Hon F.SIAE, FRAeS

In the 1950s each bicycle had a licence plate and riding a bicycle without a bell was an offence. Bicycles, like aircraft are unstable vehicles which can be controlled with practice by a skilled driver. The only requirement for a cyclist was, he must ride with both hands on the handlebar. But pilots need go through rigorous training and be licensed.

The difference is the consequences of failure. An aircraft flying at 500 kph can do a lot more damage compared to a bicycle moving at 15 kph. The law changes over time. Today, bicycles are no longer licensed and nobody gets charged for riding without a bell. The regulations for pilots changed too. We have VFR and IFR and categories of automatic landing for pilots together with rules for operating and maintaining the aircraft.

Changes to the law take a long time and often after some catastrophic events. In the meantime, people involved in operation have to take responsibility to ensure safety. That's is where ethics and morals are important.

Ethics and morals are sometimes lumped together because the outcomes are often similar. But there are important differences when it comes to professional ethics.

As a professional engineer, society expects you to make decisions based on your specialist knowledge. Hence it is difficult to take guidance from the general public or some invisible sources. It has to come from yourself, but you can draw guidance from your profession. This often comes in the form of Code of Ethics from professional associations.

Engineers often take the American National Society of Professional Engineers (NSPE) code as a reference to develop their own code. It has 6 points:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves responsibly, so as to enhance the reputation of the profession.

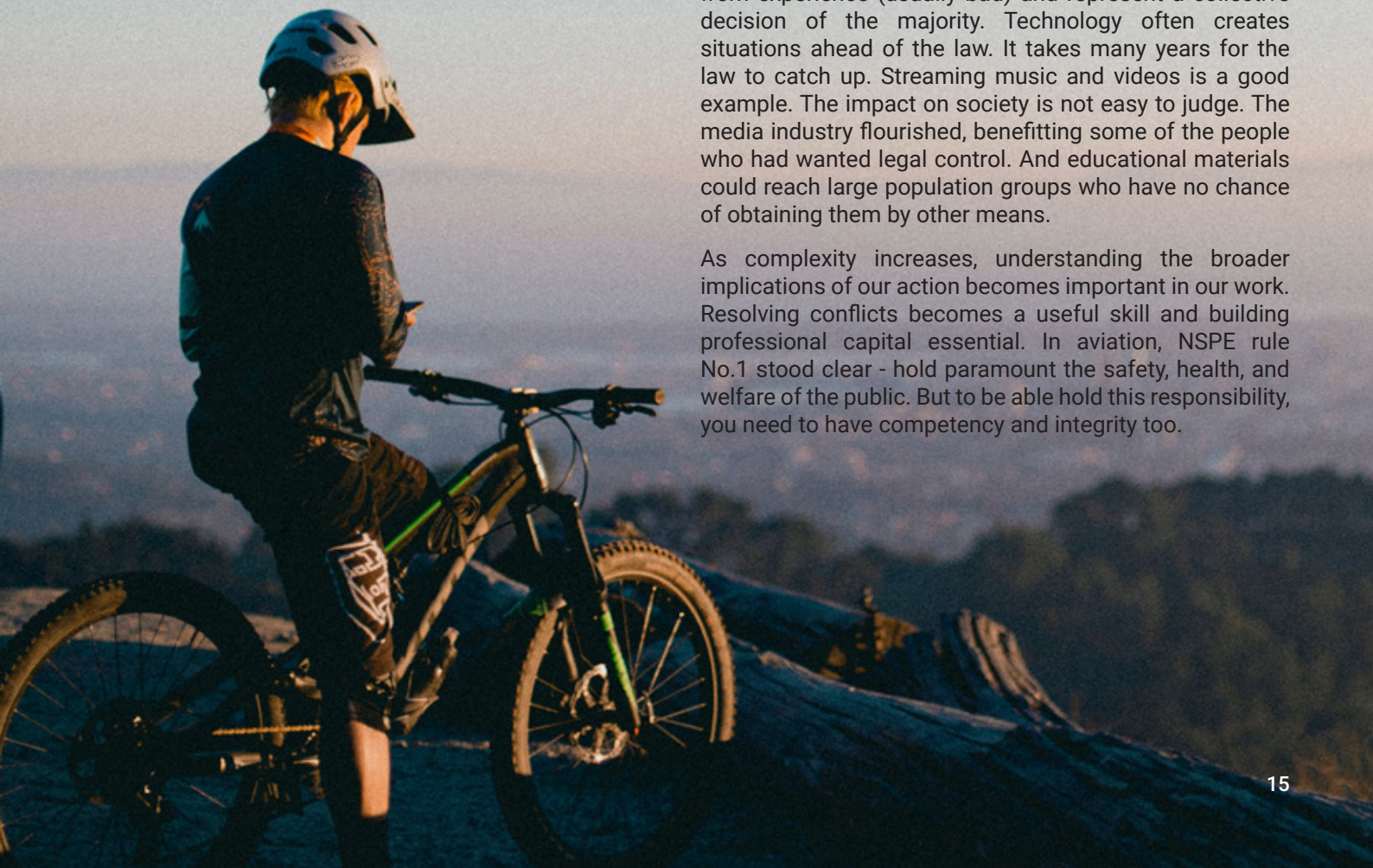
Morals is how society expects you to behave. Ethics is doing the right things based on your specialist knowledge and experience on the situation at hand.

Conflict will arise because we will always be influenced by our culture and the way we were brought up. To add to the complexity, we have the Law to conform to. Laws are things society agreed that one must do or should not do.

On the lighter side, we have etiquette to define what you shouldn't wear for an occasion and how you should eat your food. Breaking a law may land you in jail, but bad etiquette may just reduce the number of invitations you will get in future.

Does legal meant ethical? Think about it. Laws are enacted from experience (usually bad) and represent a collective decision of the majority. Technology often creates situations ahead of the law. It takes many years for the law to catch up. Streaming music and videos is a good example. The impact on society is not easy to judge. The media industry flourished, benefitting some of the people who had wanted legal control. And educational materials could reach large population groups who have no chance of obtaining them by other means.

As complexity increases, understanding the broader implications of our action becomes important in our work. Resolving conflicts becomes a useful skill and building professional capital essential. In aviation, NSPE rule No.1 stood clear - hold paramount the safety, health, and welfare of the public. But to be able hold this responsibility, you need to have competency and integrity too.



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Student	100	50	No	No

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