Training for the Digital Aviation Ecosystem

(Presented by JAA TO)

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1. Introduction

Soon, the International Civil Aviation Organization (ICAO) will welcome the global aviation community to its 14th Air Navigation Conference (AN-CONF/14) hosted in Montréal from 26 August to 6 September 2024, where the discussions will naturally focus on improving safety and performance of air transport, mainly from the perspective of minimising its environmental impact. However, the Conference will also consider 'hyper-connectivity' of air navigation systems – allowing connected aircraft concepts and associated challenges, specifically cybersecurity and information system resilience to be explored.

In fact, the ever-growing use of computers to support aviation (systems), businesses, computing and decision-making, and the parallel increasing availability of affordable high bandwidth telecommunication networks, enables the exchange of huge quantities of digital data in real time for operations on the ground as well as with(in) the aircraft in flight. Some experts refer to these newly-emerging environment as the 'digital ecosystem' within which several actors are interconnected and continuously exchange data, even beyond aviation. Think for instance at an Unmanned (or Uncrewed) Aircraft (UA, commonly referred to as drone) recharging its batteries at a vertiport3. The electric energy would be provided by a utility company and the quantity of energy transferred to the drone needs to be accounted and invoiced. This commercial transaction is part of the digital ecosystem, although not of aviation operations.

Without doubt will digital technologies continue to increase in traditional aviation (with the pilot on-board and therefore crewed). But, on the other side, drones were already born in the digital era and they are opening the way towards digital technologies also for the rest of aviation. The purpose of this paper is to explore what drones represent from the perspective of digital innovations, how to adopt and promote technology all while highlighting how capacity-building through training and certification can facilitate a global implementation thereof.

2. Drones and Digitalisation – Key Innovations in Aviation

An uncrewed aircraft (UA), governed through a radio signal from the ground, was first built in the UK in 1916, but it was only after the 2000s that the range of civil applications of drones initiated an exponential growth in this domain. As traditional aviation is mainly used to transport people or freight, one could coin it the 2nd industrial revolution of aviation. Today, drones catapult aviation into the 3rd industrial revolution, which means that they are mainly used to acquire, process and distribute digital information without necessarily transporting physical goods from point A to point B.

In the near future, drones are even expected to exchange digital data with the vertiport or with UAS Traffic Management (UTM) services automatically and without human intervention. Devices exchanging data without human intervention are usually considered opening the perspective towards the 4th industrial revolution, the so called 'Internet of Things' (IoT).

In this context, non-military drones have a myriad of applications and several of them require the drone to be part of a digital ecosystem, encompassing aviation and beyond. For instance, when a drone would be used to transport urgent medicines to remote locations the successful transport would need to be recorded to non-traditional stakeholders inside the digital (aviation) ecosystem, namely at the pharmacy for logistics and accountancy purposes. Flying Forward 20204, a project funded by the European Union (EU), was amongst the first to experiment the connected digital ecosystem in relation to (unmanned) medical transport.

But of course, while these developments may benefit society and generate jobs for young aviation professionals; nevertheless, aviation's top priority remains safety, without which societal acceptance would be jeopardised.

Consequently, innovators need to find solutions to the following issue: how can the community govern such innovation without detriment to safety?

Firstly, minimising the risk of security breaches remains paramount, as security incidents may soon result in an aviation safety occurrence. Taking the appropriate measures is clearly stated by Articles 4 and 88 of the EU Regulation 2018/1139 establishing the European Union Aviation Safety Agency (EASA). These 'safety evolutions' are clearly depicted in a graph from the 4th edition of the ICAO Safety Management Manual5 (Doc 9859), reproduced in Figure 1.

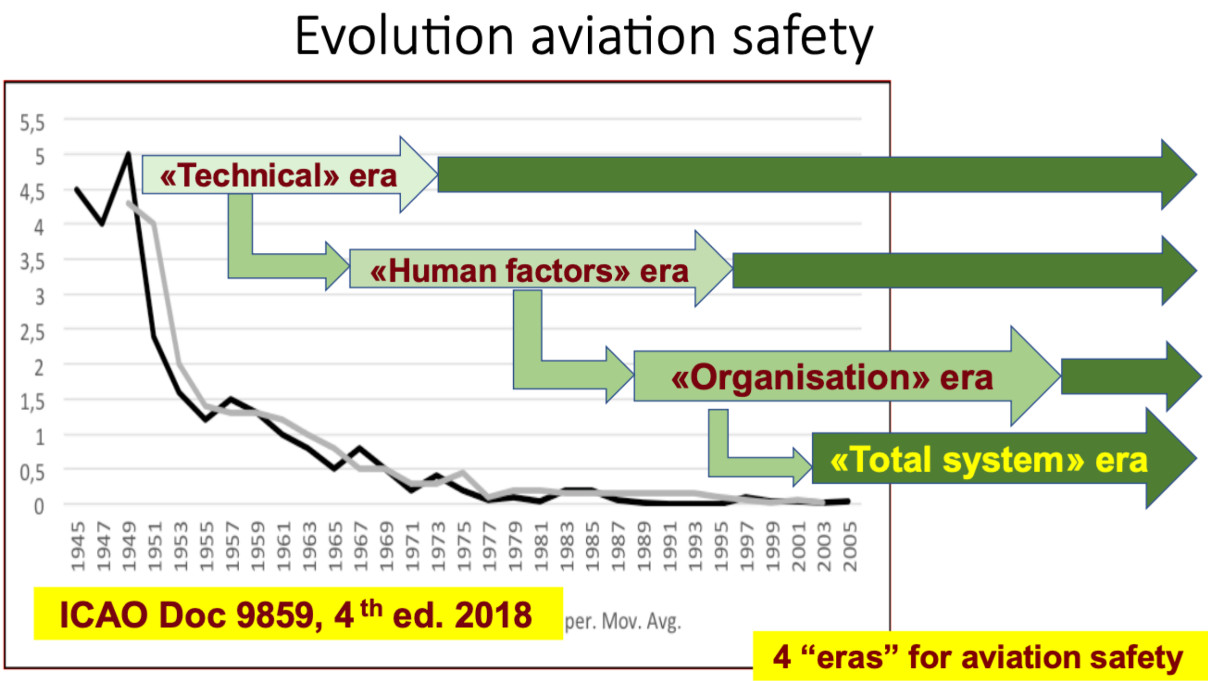

Figure 1. Source: Filippo Tomasello/private

In Doc 9859, ICAO expresses that building safety (and security) requires safe design, production and maintainance of equipment, from the drone's airworthiness to its Command Unit (CU; the station from which the Remote Pilot controls the flight), including any other training and necessary equipment (e.g. the vertiport, the command and control (C2) data link, etc.)5 Secondly, next to the 'technical safety', the aviation sector needs to minimise the probability of human errors stressing the importance of paying attention to training and qualification for UAS

Pilot Licences (UPL) and related UAS Flight Instructors (UFI), Examiners (UFE) and UAS Training
Organisations (UTO). Needless to say, that training and qualification should cover also other personnel involved in UAS operations, such as Observers, Fleet Managers and so on. As part of the qualification process, medical and mental fitness of the crews should also be tested and ensured. Finally, the Human Machine Interface (HMI) shall be appropriately designed and validated to minimise the probability of inadvertent human error.

While the above considerations feature both, the human and the system, but in independence from other humans, it is equally important to consider the organisational perspective. Through the tragic 1977 Tenerife airport disaster, aviation has learned that modern humans work in teams whose communication, culture, climate and procedures may also influence safety and human factor parameters when studying it from an inside-out organisational perspective. As result, ICAO expands beyond the system and human factor era to highlight the new frontier of safety oversight which includes also "organisations" (see Figure 1). For the purpose of this argument, safety measures on organisational level, meaning the UAS 'Operator' (i.e. the entity or commercial company employing the RPs and other personnel), is paramount.

Would this be sufficient to ensure safety and security of the digital ecosystem?

Definitely not. In fact, in the digital ecosystem, organisations continuously exchange real-time, digital data/communication (also in-flight), so the timeliness, integrity and availability of such data shall be ensured as well. ICAO concludes this as the 'total system' of aviation safety, already mentioned in Figure 1. To ensure sufficient Quality of Service (QoS) for the digital exchanges of data, three different sets of rules and related voluntary industry standards are required:
• Minimum Operational Performance Standards for each service (e.g. quality of data for UAS Geoawareness in EUROCAE ED-318) and related aircraft functions (e.g. EN 4709-003).
• Interoperability standards to reliably exchange data in a format comprehensible to both piers (e.g. emerging EUROCAE standard on Network Information Service, NIS); and
• Organisation of the service provider (e.g. ISO 23629-12 on UTM service providers).
In conclusion, ensuring safety and security of UAS operations requires much more than technical specifications to design the system.

3. Implementing Innovation
To develop, deploy and apply non-military drones for applications beneficial to society, we need four key enablers:
a) Developed, mature and available technologies on the market for UAS, UTM and Advanced (alias Innovative) Air Mobility (A/IAM) including but not limited to the aircraft;
b) A comprehensive set of rules protecting society on one side, giving certainty to investors on the regulatory processes, the achievable approvals and associated privileges and accountabilities on the other side;
c) Related voluntary industry standards supporting the rules as Means of Compliance (MoC); and
d) Capacity-building including training and certification of aviation professional and therefore related instructors and examiners, but also inspectors in the Civil Aviation Authorities (CAAs) able to identify, understand, consult and apply the relevant rules and industry standards.6

For initial development of technology innovations public funding is indeed an asset. That is why, the European Commission (EC) has funded almost 800 research projects7 in the mobility sector, several of which dealing with digital technologies for various modes of transportation and several specifically aiming at development of technologies and services for non-military drone applications.

After initial spin-off, which public funding significantly contributes to, the market should take over promoting clear rules for end-users to fly drones without disproportionate administrative burden. Market- and product-driven competition among manufacturers should open up the widest possible level playing field to further promote innovation implementation.

For small UA, typically encompassing airframes with a total maximum take-off mass (MTOM) not above 25 kg, the EU has opened the way for a global market entry. Consequently, the market autonomously produces ever-frequent innovations because the customer base is now sufficiently wide for industry to invest part of its income in new developments. A good illustration on the successful implementation on EU level is the purchase and operation of a very small drone of less than 250 grams. In this case in fact, by lowering the administrative barriers the involved person may only need to register and, without any mandatory training and without any additional approval, s/he may start flying, based on the limitations and conditions in European Commission Regulation (EU) 2019/947.

Furthermore, manufacturers from all over the world, complying with the rules in EU Regulation 2019/945 can put their products on the EU market, accompanied by a Declaration of Conformity, CE mark and class label based on series 4709 of European Norms (EN) developed by CEN. Several of such Declarations are already available8.

However, to fly drones Beyond Visual Line-of-Sight (BVLOS) we still need to develop vertiports9 and UTM services10. Additional EC funding initiatives should hence be undertaken to continue developing these key aspects aiming at creating the proper digital ecosystem around the operation of a drone.

In addition to technology, mentioned EU Regulations 945 and 947 of 2019 provide a comprehensive regulatory framework, still absent in several other States outside the EU, offering certainty to investors who are deciding to develop a technology or to establish a company that commercially operates drones – which will offer even more societal benefits and could generate sustainable job growth. To this argument, comprehensive regulatory frameworks provide a societal and economic anchor to innovation and technology implementation on State level. These rules are already backed by several industry standards developed e.g. by ISO, by ASTM, by CEN, by EUROCAE and by other Standard Development Organisations (SDOs). This work is however far from being completed and therefore, EU calls for tenders for newly funded projects should include the requirements to link research, demonstrations and development with inputs for the SDOs.

Finally, capacity-building for aviation professionals, including but not limited to Remote Pilots and inspectors in the CAAs, should accompany all developments highlighted in this paragraph. For this purpose, EC/EASA are committed through several Aviation Partnership Projects (APP)11 In its comprehensive approach to UAS training activities, JAA TO has contributed to several of such Projects in relation to UAS/UTM/IAM e.g. in Central and Southern America, Zambia and

South Asia.

4. Avoiding Pitfalls in the Financial Business Plan

A big limit of European funded projects is that historically, EU financial support was capped at the Technology Readiness Level (TRL) 7 which encompasses demonstrations in an operational environment through systems at, or near scale of the operational system with most functions available. However, at TRL 7 limited documentation is available. For instance, necessary industry standards may not be mature, manuals may not be ready, and personnel may not have been trained appropriately to use the new system. In fact, these aspects are completed at subsequent step TRL 8, which completes validation and verification providing most user, training and maintenance documentation as necessary for actual implementation. Finally, TRL 9 implements the innovation in the operational environment, and leads to accruing concrete experience on the operational use gaining confidence in the market implementation/launch. However, in the EU, TRL 8 and 9 are left to individual EU Member States or to private investors. This may often result in gaps between achieved TRL 7 objectives (or limits) and actual implementation. This evident funding mechanism disconnect oftentimes turns the results of EU funded projects into a series of mere reports doomed to dust on the shelf, without any investor actually committing to implementation.

Some projects, to which EuroUSC Italia12 has contributed, strove to turn results into standards, such as ICARUS13 which initially developed the Vertical Conversion Service (VCS), and is now included in ISO 23629-12; CERTIFLIGHT14 which developed the Authenticated Tracking services is now mentioned in ISO 23629-9; and Flying Forward 202015 further defines the role of the Fleet Manager. Such new job profile is already necessary to prepare the UAS mission of today but it will remain essential for all UAS missions in the future when fully autonomous operations would no longer require a RP. The ideas developed by this latter project are now being embedded in subsequent editions of ISO 21384-3 on UAS operations and ISO 23665 on training of UAS personnel.

In addition to the abovementioned TRL discrepancy, one common investment pitfall yet still remains and addresses the defiance of not including costs and efforts for regulatory compliance in respective business plans. This early negligence may later result in costly corrective actions or unfeasibility due to poor documentation in a product launching process that is compliance dependent. Therefore, it is strongly recommended to include such costs and activities in new projects from the beginning, pathing the smoothest way towards the shortest possible time-to-market.

5. Training for the Digital Aviation Ecosystem

EuroUSC Italia supports the aviation industry for participation to EU-funded projects, in relation to safety evaluations and regulatory compliance. In addition it supports the industry in preparing the documentation and obtaining any approval in the aviation sector and in particular for non-military applications of drones. These Subject-Matter-Expert environments facilitate the knowledge transfer and implementation process of innovations to the objective of a safe and sustainable digital ecosystem. Further, regulatory compliance, education, hands-on experience and know-how is mediated through proper UAS training, capacity-building and the correct reference materials and standards ensuring that regulatory frameworks and training activity evolve in tandem with technological advancements. Continuous training and skill development are essential equipping the workforce to implement these innovative solutions effectively. Regular training programs, workshops, and certification courses can ensure that aviation professionals stay abreast of the latest technological advancements and regulatory changes. For instance, specialised training in drone technology, AI-driven air traffic management, and more can prepare the workforce to handle new developments confidently. Engaging in continuous dialogue and feedback loops between innovators and regulators, along with robust training initiatives, ensures that innovation is implemented safely and efficiently, ultimately leading to a more dynamic and forward-thinking aviation industry.

6. Conclusion

To summarise the transformative potential of digital technologies in aviation, particularly focusing on the integration of drones and the associated challenges of cybersecurity and system resilience, the concept of a digital ecosystem, where various actors continuously exchange data, is central to this transformation. Today, drones spearhead the third industrial revolution in aviation by primarily handling digital information rather than physical goods. EU funding has been crucial in developing these technologies, but further efforts are needed to promote market-driven competition and lower administrative barriers for drone operations. Safety remains a top priority, necessitating robust solutions to security risks and human error. ICAO's Safety Management Manual emphasizes the importance of safe design, production, and maintenance of equipment, as well as comprehensive training and qualification for UAS operators and related personnel/organisations manifesting the ‘total system’ era of today’s aviation safety culture and operationalisation.

To support innovation, remind us of the four key enablers: mature technologies, comprehensive regulations, voluntary industry standards, and capacity-building through training and certification which can significantly enhance the mastery of the digital aviation world by fostering a culture of continuous learning and adaptability. Implementing modular and scenario-based training programs can simulate real-world challenges, equipping professionals with practical skills to handle emerging technologies. Additionally, integrating AI and virtual reality into training modules can provide immersive and interactive learning experiences, making complex concepts more accessible and engaging.

By emphasising cross-disciplinary training, aviation professionals can develop a broader understanding of interconnected systems, promoting a holistic approach to safety and innovation. Ultimately, a robust and dynamic training framework can ensure that the workforce remains agile and proficient, ready to navigate the complexities of the digital aviation ecosystem.

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3 The term vertiport is defined in ISO 21384-4:2020 https://www.iso.org/standard/76785.html?browse=tc

4 https://www.ff2020.eu/

5 https://www.icao.int/SAM/Documents/2017-SSP-GUY/Doc%209859%20SMM%20Third%20edition%20en.pdf

6 https://jaato.com/uas-diploma/

7 https://cordis.europa.eu/search?q=(%2Farticle%2Frelations%2Fcategories%2Fcollection%2Fcode%3D%27resultsPack%27%2C%27projectsInfoPack%27%2C%27brief%27%2C%27news%27%2C%27video%27)%20AND%20(%2Farticle%2Frelations%2Fcategories%2FapplicationDomain%2Fcode%3D%27trans%27)%20AND%20language%3D%27en%27&p=1&num=10&srt=/article/contentUpdateDate:decreasing

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