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Pilots in the Evolving Urban Air Mobility: From Manned to Unmanned Aviation

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***Abstract*—In November 2022, the European Commission published the Drone Strategy 2.0, which includes a three-stage approach for Urban Air Mobility. Similarly, as early as 2020, the United States Federal Aviation Administration, together with the National Aeronautics and Space Administration, and industrial partners, conducted research on concepts of Urban Air Mobility operations. These regulatory initiatives addressed the evolutionary approach in the advancement of Urban Air Mobility, including operations conducted by manned aircraft, remotely piloted aircraft and autonomous aircraft successively. Pilots are an important component in the three-stage approach to the socially embraced model of Urban Air Mobility. This article will analyse relevant technical rules and social protection issues relating to pilots, in order to show how the insufficient aviation labour rules would impact the deployment and advancement of Urban Air Mobility; and what regulatory solutions are for both on-board and remote pilots.**

I. Introduction

A. The Emerging Ecosystem

Urban Air Mobility (UAM), defined as an air transportation system for passengers and cargo in and around urban environments, has the potential to mark a significant step in the evolution towards multidimensional urban mobility [1]. The increasing demands for UAM services would require more aircraft when the transportation capability per unit reaches the limitations of current technology.

Considering the expensive training cost, safety concerns about pilot fatigue, and labour tensions in the aviation industry, the rapidly increasing demand for UAM aircraft may not lead to the economically sustainable development of UAM if it is restricted to manned aviation. Unmanned Aircraft Systems (UAS) can contribute to decreasing dependence on pilots, by removing them from aircraft and, if necessary, employing them at remote stations on the ground. To this end, UAM relies on the advancement of UAS technologies, electric vertical take-off and landing (eVTOL) aircraft, and digitalised air traffic management.

B. Pilots in the Three-Stage Approach to a Socially Embraced Model of UAM

Deployment of UAS applications in UAM cannot guarantee isolation from regulatory challenges revolving around aviation labour law. In November 2022, the European Commission published its Drone Strategy 2.0 addressing the prospects of UAM. First operations are expected to be conducted with manned eVTOL aircraft which will likely be in the future remotely piloted and then fully autonomous [2]. Furthermore, the United States (US) Federal Aviation Administration (FAA) addresses the incorporation of a regulatory, operational, and technical environment for UAM within the National Airspace System. It envisioned the evolution of UAM operations and corresponding regulatory frameworks based on the key indicators in which automation levels can be identified:

- Initial UAM operations: consistent with current manned helicopter technologies;
- Concept of Operations for Urban Air Mobility (ConOps 1.0) operations: pilot-in-command actively control the aircraft with UAM-specific capabilities; and
- Mature state operations: automation improvements may lead to Human-over-the-loop (HOVTL) capabilities. [3]

The above regulatory initiatives demonstrate the common recognition of the evolutionary approach from unmanned to manned aviation in the development of UAM. Business stakeholders hold similar perspectives. Uber acknowledges that, while the autonomous operation is highly likely in the future, initial operations will require pilots [4]. Volocopter addresses the importance of pilot training in the roadmap for UAM [5]. There are a few companies planning to start operations with remotely controlled or autonomous aircraft, like EHang [6].

These plans highlight the three-stage approach as follows: firstly, manned aviation; secondly, remotely piloted operations; thirdly, fully autonomous operations. Regulatory authorities shall consider these three types of operation when drafting the rules, while there will be overlap between various rules and the work done for one type can be used for another [7].

C. Purpose of this Article

This paper is purposefully dedicated to the analysis of labour and employment issues pertaining to pilots in UAM operations. The aviation labour force would lead to concerns about technical rules, such as licensing requirements and pilot authority, on the one hand, and atypical labour relations and precarious working conditions relating to social protection, on the other.

Different categories of UAM operations are not necessarily subject to identical evolutionary changes. While passenger transport use cases expect to start operations with pilots on board, cargo transport and emergency use cases plan to fly autonomously and to be remotely controlled respectively. Moreover, societal acceptance factors relating to adjacent technologies, such as autonomous driving and smart

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home, reiterates the finding that different local conditions can influence the development patterns of UAM [8]. For example, a Chinese research paper pointed out that congested ground traffic and the considerable contribution of human factors to accidents provide an impetus to promote regulators and car manufacturers to develop autonomous driving [9]. Despite all these differences, regulatory discussions on the three-stage approach can provide a comprehensive understanding of how aviation labour regulations can promote or impede the development of UAM.

The paper aims to fill in the gaps and examine the *status quo* of international law, and selected national or regional regulations, which are related to aviation labour in the context of UAM. The paper firstly examines labour issues pertaining to pilots on board, including technical rules in the context of aviation safety, applicable labour and social security laws, atypical employment, and job security. It then proceeds to explain corresponding issues as regards remote pilots. In the end, this article sets the ambitious objective to discuss potential adequate regulatory solutions.

II. Pilots on Board

A. Technical Rules and Aviation Safety

1) Commercial aviation, general aviation or neither

It appears unlikely that unmanned transport of people in urban environments may take place in the near future. Before unmanned aviation becomes commonplace, UAM would account for a rapid increase in the demand for pilots. International Civil Aviation Organization (ICAO) and regulatory authorities are working on recommendations and technical rules for license and training requirements relating to eVTOL pilots, before which, however, current personnel regulations are applicable to them.

ICAO established different pilot licensing and training requirements for commercial and general aviation. The distinction is consistent with most State practices. In the US, Uber chooses to have Federal Aviation Regulation (FAR) Part 135 licenses which contain operating requirements related to commuter and on-demand operations [10], rather than helicopters or general aviation under Part 91 for its baseline proxy [11]. General aviation accounts for a large number of accidents due to pilot inexperience and poor maintenance. To facilitate societal acceptance, UAM operators require commercial pilots who must have a higher level of training, experience, flight review, and medical certification than those for private or general aviation pilots.

Commercial pilot training is a very time-intensive proposition. In the US, for example, Part 135 requires 500 hours of pilot-in-command experience for visual flight and 1200 hours for instrument flight. These training requirements and a shortage of qualified pilots will hamper UAM growth significantly when the demand for pilots rapidly increases. One possible solution lies in the amendment of licensing requirements for the type of aircraft specially designed for UAM services. While service operators have planned initially for commercial pilots, it can be anticipated that successful operation with early UAM activities can lower requirements for the pilot experience based on the reduced scope of tasks for which the pilot is responsible [12].

2) Pilot fatigue management

Pilot fatigue is of particular interest to aviation because it is an important factor in assessing personnel fitness for duty. ICAO noted that flight and duty limitations for airline pilots shall differ from those for helicopter pilots [13]. In international air transport, fatigue can arise from a large number of causes, the most common of which are attributed *inter alia* to irregular sleep and work patterns, long flying hours, long time awake, long duty-on-call pierids, early starts, night duties, and multiple sectors [14].

The pilots in UAM operations are not necessarily subject to all these technical specifications of traditional air transport. The UAM use cases would mainly include short-haul trips, including: passenger transport aircraft between a city centre and an airport, flights within a metropolitan area or flights within a city for sightseeing; cargo transport for last-mile delivery, or delivery to a hub; emergency-related use cases covering the transport of medical emergency personnel to an accident site, or the delivery of medical and emergency supplies [15].

The potential operation environments in UAM would not lead to the causes of fatigue that current aviation fatigue management rules mainly deal with. For example, Regulation (EEC) No 3922/91 contains the definition of the flight duty period which starts when the crew member is required by the operator to report for flights and finishes at the end of the last flight on which the pilot is an operating crew member. The elaborated definitions cannot accommodate the operational specifications of the UAM use cases which, as expected by industrial stakeholders, would involve multiple missions in consecutive and short-haul work periods. The UAM operations would hardly expose pilots to the negative effects of time zone differences and a change of home base. And while some of the full-scale prototypes of eVTOL being proposed have no different function than helicopters, helicopters are complex and high-maintenance machines that require skilled pilots. In UAM operations, pilot proficiency requirements can be alleviated through greater use of automation, ultimately leading to the possibility of full autonomy [16].

The increasing complexity predicted for future UAM operations, however, suggests that future research is needed to support the identification and mitigation of contributing factors to pilot fatigue. For instance, there is a danger that eVTOL pilots may conduct flight operations with several cycles of taking offs and landings within a short period. Taking in consideration that constant innovations in science and technology are brought to a higher level, the percentage of errors due to a malfunction or other system errors has been minimised. The FAA, however, pointed out that human factor participates with 68% of all of aircraft accidents, emphasising the necessity of regulating pilot fatigue in the scenarios of UAM operations with on-board pilots [17].

Linking UAM to the concept of multidimensional urban mobility clarifies that airborne mobility should be considered as the extension of current urban mobility to the vertical dimension *via* the creation of a complementary mobility ecosystem that will function in analogy and synergy with the current ground mobility system [18]. To this end, UAM and ground transport would deal with challenges of fatigue

management arising out of similar urban environments, such as the differentiation between peak and off-peak hours, on-demand services and standby duties, as well as emotional stress related to flying over populated commuting zone.

Safety concerns would arise out of inadequate regulation of flight and duty time limitations (FTLs) and envisaged caps of flight time, and a lack of systematic oversight of the total amount of flight hours a pilot clocks up during the UAM operations. A study conducted by the European Cockpit Association (ECA) shows that around 50% of the surveyed pilots reported falling asleep involuntarily in the cockpit or experiencing episodes of micro-sleep, when almost 80% of fatigued pilots would not file a fatigue report or consider themselves unfit to fly [19]. As manned operations would contribute to accumulated data for the autonomous control and fatigue assessment, fatigue management rules for eVTOL pilots shall be flexible enough to accommodate the new technologies [20].

B. *Atypical Employment*

Atypical employment refers to all those contractual forms of employment other than open-ended employment contracts, which are increasingly used in the aviation industry, including fixed-term work, self-employment, pay-to-fly schemes and zero-hour contracts. A recent study conducted in the European Union (EU) shows that between 9% and 19% of cabin crews and around 8% of pilots are currently employed through some form of intermediary organisations [21]. From a legal standpoint, employment *via* work agencies is established on a tripartite contractual scheme, whereby work agencies provide staff to operators in a more flexible manner. It nevertheless leads to ambiguity about how operators can ensure the compliance with some legal obligations such as health and safety, being the one entitled to supervise and direct the worker's activity. When the eVTOL pilots serve through intermediary work agencies, they would likely receive lower wages and less training opportunities compared with employees directly employed by the operators. Lower job security may result in pilots not reporting illness or making use of social rights due to the fear of not getting their contracts renewed or extended.

The employment of pilots may also be limited in duration. The unmanned aviation is expected to be involved in the major operation use cases. Such a prospect greatly reduces the willingness of operators to employ a large group of pilots under open-ended labour contracts. This has a significant impact on the safety and efficiency of air transport as precarious work brings with it variable work schedules, reduced job security, lower wages, hazards at the workplace, stressful psychological working conditions, contractual uncertainty, emotional stress, and longer shift working patterns. National laws may impose limitations on fixed-term contracts. For example, in Ireland, when an employee is employed under two or more successive fixed-term contracts, the aggregate duration thereof cannot exceed four years [22].

Last but not least, part-time employment has revealed itself as a meaningful resource for airlines to meet strategic, seasonal, and *ad hoc* needs. The fact that UAM use cases would happen in urban environments implies that operators be less likely subject to seasonal demands. The exception exists in the case of holiday operational peaks as even short holidays are influencing travel behaviour [23].

C. *Applicable Labour and Social Security Laws*

As UAM operators may receive services from pilots through intermediary companies, the question can be raised whether the law of the State of work agencies applies to a labour relationship involving the eVTOL pilots. Such a controversial issue is the primary subject matter of private international law. For example, the EU normative framework provides Regulation (EC) No 593/2008 (Rome I Regulation) and Regulation (EU) No 1215/2012 (Brussels I Regulation) to decide the jurisdiction and applicable laws. In the *Ryanair* case, the Court of Justice of the European Union (CJEU) favoured aircrew members as they would have the option of bringing proceedings before the court of the place where they perform the essential part of their duties *vis-à-vis* their employer [24]. When the majority expected UAM operations to be domestic, on-board pilots avail themselves of the virtue of certainty as regards their habitual place of work.

D. *Job Security*

UAM services are ultimately based on unmanned aviation, with, at most, remote pilots in the ground stations. At the inception of UAM, however, there will be increasing demands for on-board pilots. European Union Aviation Safety Agency (EASA) made an estimation of 3,000 to 3,500 UAM aircraft for passenger and cargo transport in 2030, when it pointed out that UAM would still be highly likely manned aviation market by then [25].

One legal issue leading to labour protection concerns is the bankruptcy and other business structural changes of operators. The trade unions operate primarily on the basis of seniority. Specifically, seniority governs a pilot's position as it relates to the pay scale, benefits, entitlements, and other aspects of working conditions. However, when airlines merge or fold due to bankruptcy, the seniority of pilots is often lost when they seek employment elsewhere. In the case of *Addington* v. *U.S. Airline Pilots Association*, America West and US Airways exited bankruptcy protection [26]. As a result of the seniority integration process, the US Airline Pilots Association (USAPA) was created by certain US Airways pilots. The USAPA presented a seniority proposal to the carrier based on the date of hire, with American West pilots generally at the bottom. The court held that USAPA misled the majority about its power to improve its members' seniority prospects at the expense of the American West pilots' and without an injunction, USAPA's seniority position inevitably impaired the collective bargaining process.

In the context of UAM, when there is the evolution from manned aviation to unmanned aviation, expensive labour costs would become financial obstructions to UAM operators. They may be forced to go bankrupt. In some other cases, they can also initiate strategic bankruptcy to deal with undesirable labour contracts or collective agreements concluded with labour unions before [27]. The downsizing and changes of UAM operators' business would have a negative impact on the job security of on-board pilots who may become the steppingstone to the progress of autonomous UAM operations.

III. Remote Pilots

A. Technical Rules and Aviation Safety

1) Delimitation of remote pilots

The next step relating to UAM services involves remotely piloted aircraft. ICAO has defined unmanned aircraft as the aircraft which are intended to operate with no pilot on board. An unmanned aircraft is a pilotless aircraft, in the sense of Article 8 of the Chicago Convention of 1944 [28], which is either remotely controlled from another place or programmed and fully autonomous. However, nowhere it has been determined how much manipulating of flight controls and what interval is necessary to meet the standard of piloting, for an aircraft to be recognised as a remotely piloted aircraft.

Another example of remote pilots is autonomous UAM operations. Regulation (EU) No 2019/947 has given legal meaning to autonomous operation which refers to the transportation during which an unmanned aircraft operates without the remote pilot being able to intervene. These are aircraft that do not require a pilot or act in a predetermined way; rather, they act in a pragmatic way by using the environment to make decisions. However, the transition from remotely piloted aircraft operations to autonomous ones would not be straightforward. The European Commission intends to adopt rules for the Certified Category of drone operations, addressing the initial and continued airworthiness of drones subject to certification; and operational requirements applicable to manned VTOL-capable aircraft [29]. And the FAA has addressed this process as following three aircraft automation levels:

- Human-within-the-loop (HWTL): human is always in direct control of the automation (systems);
- Human-on-the-loop (HOTL): human actively monitors the systems and can take full control when required or desired; and
- Human-over-the-loop (HOVTL): human passively monitors the systems and is engaged for exceptions when there are irreconcilable misfunction. [30]

In the context of UAM, a low number of accidents can quickly cause a deterioration of public perception. Safety is the leading acceptance factor for autonomous flying, related to both the third party on the ground and, if any, passengers on board. Thus, the highest standards should be applied to UAM [31]. A feasible application of autonomous aircraft in urban environments imposes requirements on operation personnel on the ground, who can be defined as remote pilots.

2) Remote pilot license and training requirements

In a study conducted in 2018, surveyed passengers noted potential benefits of automated flight such as: decreases in pilot fatigue, human error, and low costs for automated aircraft [32]. However, the benefits were generally outweighed by concerns over reliability, system security, lack of a human pilot, and operation under extreme conditions, such as rain, snow, and ice.

ICAO has established the Remotely Piloted Aircraft Systems Panel (PRASP) which coordinates and develops Standards and Recommended Practices (SARPs), as well as other guidance materials for remotely piloted aircraft. It has introduced the Manual on Remotely Piloted Aircraft Systems (RPAS), which contains recommendations for future regulations and represents one of the starting steps in the development of a regulatory framework for UAS operations.

The reading of the Manual on RPAS and Circular on UAS reiterates the expectation from ICAO that, unmanned aviation shall be managed in the same way as is done in manned aviation. As regards personnel licensing, Article 32 of the Chicago Convention of 1944 provides the main piece of international regulation. However, ICAO precludes the applicability of this provision on remotely piloted operations. Despite this, remote pilots must be properly trained, qualified, and hold an appropriate license or a certificate of competence to ensure the integrity and safety of the general civil aviation system [33].

Before the introduction of specific regulations addressing license requirements, a legal gap will exist in how States issue, render valid, or recognise such licenses. For example, the FAA established the Operation of Small Unmanned Aircraft Systems Over People (NPRM). The key test of remote pilots lies in the following two essential components:

- Remote ID: the ability of an unmanned aircraft in flight to provide identification and location information that can be received by other parties. It can help regulatory authorities find the pilot station to guarantee aviation safety and security; and
- Remote pilot knowledge test, initial training, and recurrent training. [34]

While it only addresses cargo transportation, relevant rules on pilots can provide regulatory references for UAM services with passengers on board which necessitate more stringent requirements.

3) Pilot fatigue management

Remote pilots control UAM aircraft from ground stations. They nevertheless must be able to perform their duties at an adequate level of alertness in a similar, if not the same, way as pilots on board. ICAO has addressed the importance of fatigue management in the Manual on RPAS, highlighting that RPAS operators whose organisations include operation shifts and crew scheduling schemes should establish policies and procedures for flight and duty time, operation shift schedules and crew rest periods based on scientific principles.

Through the research related to military UAS operations, the FAA has identified factors which may influence the remote pilots' ability to safely operate a UAS and perform safety-related duties. Some factors include concerns that also pertain to manned operations, such as time of day, length of duty, shift work, fitness for duty, and cumulative fatigue.

Additional considerations specific to remote pilots may include sensory isolation when operating the UAS, the workload associated with operating multiple vehicles, and risks associated with accidents [35]. Specifically, the remote pilots may experience sensory isolation, *i.e.*, a lack of vestibular and spatial cues, and thus they need to pay attention to multimodal data to assist with interpreting sensory data. Regulatory concerns associated with manned aircraft are somewhat mitigated by the fact that on-board pilots can use their natural senses to avoid hazards. Remote pilots, however, take risks of the instrument failure of the detect-and-avoid

system. Because of differences in accompanying risks and hazards between manned aircraft and remotely piloted aircraft, such as likelihood, severity, duration, and expectation, it is unreasonable to apply the technical standards for on-board pilots to their remote counterparts.

In the study on the fatigue of remote pilots, the FAA also includes research in air traffic service (ATS) providers [36]. The lessons learned from the ATS can provide guidance on shift work and fatigue management for remotely piloted aircraft operations since there are some similarities in operational specifications as regards the personnel in these two sectors. In this connection, ICAO provides a guidance document for ATS providers which described approaches to managing fatigue, including such recommendations as bio-mathematical models of fatigue, evidence-based scheduling, and recording of self-reported fatigue [37].

As regards UAM use cases, there shall be future research to support the identification and mitigation of identified contributing factors to remote pilots' fatigue. On the one hand, technology interventions may include the increasing use of automation to reduce fatigue. On the other hand, policy considerations account for unique operating conditions. For example, when one remote pilot might operate multiple vehicles, the possibility of allowing multiple crews to operate one aircraft remotely can mitigate the negative impact of polite fatigue.

4) Human factors in aviation accidents

Pilots may fail through their intentional behaviours within the system. Some accidents arose out of the suicide behaviours of pilots which require increased attention to the mental health of pilots. For example, the accident of a Germanwings flight which crashed on 24 March 2015 into the mountains of the French Alps was caused by a suicide act by the pilot [38]. For remote pilots, the fact their intentional behaviours would not endanger their health and safety increases the possibility of such human errors. EASA has adopted new safety rules on air operations to better support the mental fitness of aircrew members, by introducing amendments to Regulation (EU) No 965/2012. In the UAM use cases, technology interventions may include the use of automation which allows multiple remote pilots to operate one aircraft and creates multi-pilot operation environments.

The clash between autonomy system information and pilots' professional judgment can also lead to the failure of aircraft control. The pilot's responsibilities in relation to the use of automation devices have also been at stake in two crashes involving Boeing MAX 737 aircraft in 2018 and 2019 operated by the Indonesian air carrier Lion Air and Ethiopian Airlines respectively [39]. The pilots were not sufficiently trained and informed about the specificities of this new type of aircraft, who were not able to disconnect the Maneuvering Characteristics Augmentation System (MCAS). The issues pertaining to pilot and automation systems coupling, as well as training requirements, would be more prominent in UAM as there is higher dependence on autonomy in remote operations.

B. Atypical Employment

UAM would increasingly rely upon the autonomous operation and remove pilots from the aircraft. Specifications thereof reiterate the perceived concerns pertaining to labour protection in cases of atypical employment. Deployment of remote pilot stations would increase the probability of recourse to intermediary work agencies and contractual agreements between operators to transfer the remote piloting services.

Specifically, there remains the possibility that one remote pilot controlled multiple UAS, under the contract for services as opposed to the contract of services within labour relations. It is thus difficult to recognise the *de facto* labour relations based on the personal dependence of pilots upon service operators. The essential feature of an employment relationship is that for a certain period of time a person performs services for and under the direction of another person in return for which the worker receives a salary. When remote pilots provide services for multiple UAM operators through work agencies or as self-employed workers, the absence of subordinate relationship would deprive remote pilots of any safeguards awarded to direct employees whereas it is probable that operators nevertheless impose the same restrictions and rules upon them as for a direct employee [40].

As the UAM operations are very limited, much ambiguity remains as to the impact of other forms of atypical employment, including fixed-term and part-time labour contracts. Operators would be tempted to have recourse to these types of employment which correspond to the demands for a higher degree of flexibility. Regulatory authorities need to establish a means to curb abuse and social dumping by employers *vis-à-vis* remote pilots. The possible precarious situation of remote pilots can not only have a profound impact on their labour interests, but also raise safety concerns as precariousness can lead to remote pilots flying while sick or fatigued and not reporting this to the employer.

C. Applicable Labour and Social Security Laws

Compared with manned aviation, the distributed nature of RPAS would generate new multinational aspects regarding the locations of the operator, the actual operation, and the pilot station. For example, unmanned aircraft can operate in the airspace of only one State while it is remotely operated from a station in any other State. The unmanned aircraft and pilot station can be located in two different States other than the State of the operator.

The ICAO Manual on RPAS provides that remote pilots required to be on duty should remain at the stations as necessary for the safe operation of unmanned aviation, except when their absence is necessary for the performance of duties or for physiological needs. The scenario where the pilot station is in the State different from the State of operator registry, while would lead to regulatory challenges of safety supervision, may not necessarily be problematic concerning the applicable labour and social security laws. National laws of States where remote pilot stations are based are applicable.

As precarious working conditions of remote pilots can have a negative impact on their fitness for duty, the State of the operator can include the location of remote pilot stations as a substantive consideration concerning the qualification of operators for RPAS certificates. The State of registry is responsible to guarantee the airworthiness of RPAS. In the ICAO Manual on RPAS, the indicia of the issuance of operator certificates include an adequate organisation, method

of control and supervision of flight operations, training program and maintenance arrangements 'consistent with the nature and extent of the operations specified and commensurate with the size, structure and complexity of the organization' [41]. The applicable labour and social security laws are thus of high relevance.

D. Job Security

Regulatory authorities and industrial stakeholders expect remote pilots to be a component of the three-stage approach to a socially embraced model of UAM. Similar to the situations of on-board pilots, lower job security can have a negative impact on labour protection for remote pilots. Advancement of autonomy technology reduces personnel demands as one remote pilot can operate multiple aircraft and autonomous aircraft would, if not fully dispense with human intervention, only allow for the remote control for exceptions that are not reconcilable or as part of rule set escalation. Given the possibility that one remote pilot station can provide services for multiple UAM operators, however, the business downsizing or the bankruptcy of one single operator may not cause remote pilots unemployed, resulting in legal ambiguity with respect to the issue of job security.

IV. The Need for Aviation Labour Rules

A. The Choice of the Regulatory Forum

Recognising challenges arising out of insufficient labour protection, there should be a specific set of rules to protect pilots throughout the UAM evolution from manned aviation to unmanned aviation. Regulatory authorities are supposed to accord considerable weight to both aspects of technical standards and social protection pertaining to eVTOL pilots. Then it comes to the choice of appropriate forums, *to wit*, on which regulatory level, either international, regional, or national, aviation labour rules shall be established.

The operation of pilotless aircraft is a developing area of aviation. Low-level altitude airspace over urban areas is seen as an extension of public space that municipal authorities are responsible for and UAM is the responsibility of national aviation authorities [42]. It is, therefore, necessary to have a good understanding of regulations adopted in State practices.

Regulations contained in the Chicago Convention of 1944 show that, even though UAM operators can find opportunities to have inter-city use cases across neighbouring States, many regulatory challenges still need to be overcome to actualise sustainable operations. Article 5 restricts non-scheduled air traffic freedom and flexibility to non-numeration purposes. In very limited occasions, if any, UAM might include scheduled international air services, which would deprive its conceptual differences and advantages as opposed to traditional civil aviation or ground transportation. Moreover, Article 8 imposes the requirement of special authorisation on the operation of unmanned aircraft. To this end, the operation of UAM will be largely a domestic matter rather than an international one at this moment in time and, therefore, such operations would not fall within the remit of the Chicago Convention of 1944.

There are discussions on international solutions as regards labour protection challenges identified in traditional manned aviation, including, the introduction of international treaties on aviation labour protection, incorporation of labour protection clauses into air services agreements (ASAs), and establishment of regional aviation labour protection framework [43]. These schemes may not make sense in UAM. ICAO can nevertheless develop guidelines to standardise this operation across the globe and assist States to establish regulations based on the ICAO SARPs and guidelines.

For the EU Member States, there remains the possibility to have cross-border UAM operations considering the existence of the single aviation market. Still, it should be careful not to overestimate the impact of the EU regulations. The specific rules for the Certified Category flights have yet to be developed by EASA and any existing rules are simply not fit for purpose of UAM [44]. In addition, the fact that national regulatory authorities still need to refer to national laws for many labour issues despite some progress in harmonising labour protection rules at the EU level, implies that the labour protection for the pilots in UAM operations would largely be a national matter in the near future.

B. eVTOL Pilots: Airline Pilots or Ground Drivers

UAM operations call for new training approaches and information automation systems. While discussions about UAM mainly come from the aviation sector, ground transportation may provide referential practices as they need to deal with similar challenges arising out of the complexity inherent in the urban environments. More importantly, the goal of UAM is not to substitute the current design of urban transportation, but to complement and amplify it by providing a new dimension for multidimensional urban mobility in the context of more accessible and liveable cities for the population. The account of other modes of ground transportation can contribute to a more consistent and sustainable role of UAM within the urban mobility system.

The pilots in UAM operations do not carry with them the connotation of airline pilots. In the prospective UAM services, consequently to the above findings on technical standards, pilots hardly experience challenges arising out of acclimatisation to different time zones and long duty-on-call periods.

Besides all these different technical specifications, the pilots in UAM operations are not likely entitled to the same remuneration and conditions as those of airline pilots. On the one hand, autonomy technologies can reduce the training costs relating to pilots. Access to the profession of pilots basically includes three main steps, *to wit*, basic training, type training and line training. Young pilots probably struggle with pay-to-fly contracts whereby the pilot flies an aircraft on a regular revenue-earning flight but instead of receiving a salary the pilot pays the airline for flight hours [45]. Experienced pilots nevertheless receive attractive wages from airlines as expected by trainee pilots who may otherwise not take the financial risks of expensive training costs. As a result, such advanced autonomy technologies as sense-and-avoid systems would reduce the workload and subsequently training requirements, which is especially the case as regards remote pilots at the ground stations. The eVTOL pilots are not likely entitled to the favourable remuneration as that for airline pilots.

On the other hand, eVTOL pilots are less likely subject to operational difficulties arising out of long flight hours and acclimatisation to different time zones. With the advancement of autonomous control of UAM aircraft, the direct mechanical control workload would be greatly reduced, leaving more of the pilot's attention for situation awareness.

In general, eVTOL pilots would witness the evolution of their identification as professional operator of aircraft. The successful early UAM activities and development of autonomy technology would reduce the scope of tasks for which the pilot is responsible, contributing to less strict skill and experience requirements than those for airline pilots. The working conditions of the pilots would in this process mark a significant step in the evolution from airline pilots towards a liberalised role similar to the employment of ground drivers, within the concept of multidimensional urban mobility. The regulatory authorities shall develop a specific set of aviation labour rules geared primarily to providing appropriate and proportionate protection for pilots during UAM operations. To this end, the introduced rules would guarantee coherence with regulations imposed upon ground drivers and contribute to savings in labour costs which are necessary to encourage the innovative pace of the UAS industry.

C. UAS and Aviation Labour: From the Doctrine of Labour Monopsony

From a purely legal perspective, labour conditions and atypical contractual forms of employment may not necessarily be unlawful. These negative consequences nevertheless give a convincing explanation for the increasing tension between airlines and pilots. Beginning around late June 2022, several European airlines have been facing backlash and repercussions from their employees. Pilots from Brussels Airlines held a three-day strike on June 23 [46]. Scandinavian Airlines filed for bankruptcy protection in July 2022 in the US facing strike action by its pilots and financial problems [47]. Without a specific set of aviation labour rules, the tension related to pilots can also exert a negative influence on the sustainable development of the UAM.

The doctrine of labour monopsony can provide the context to propose labour protection rules for the pilots in UAM operations. When the aviation product market is confounded by the monopoly of power and a lack of sufficient competition between airlines, consumers may find it difficult to get access to lower prices, a choice as to air services that they buy, and air operation efficiency [48]. However, the regulatory scope of competition law in one specific jurisdiction goes beyond the product market.

The US Department of the Treasury has defined labour monopsony as:

> A firm's power to reduce the compensation it pays to its workers, paying less than an equivalent job would in a hypothetical perfectly competitive market […] where compensation refers not just wages, but also benefits, job quality and working conditions. [49]

In the context of UAM, operators have their common objective of reducing the dependence on manned aviation. Operators may have agreements, whether in written forms or implicitly, to provide atypical employment to pilots. In 2014, China Air Transport Association worked with China Airline Pilot Association and industry groups to reach the Pilot Movement Consensus on the issue of pilot mobility between airlines [50]. They introduced a pilot movement quota of 1% per year. As an industry agreement, the consensus has no legally binding effect. It rather reveals the conservative attitudes of industry governing groups about the free movement of pilots. Should UAM operators have the conspiracy of adopting labour conditions favourable to the business prospects, both on-board and remote pilots would find it difficult to improve the quality of working conditions. The increased tension can allow such possibilities as strikes which impede the development of autonomy technologies.

National authorities shall promote the social dialogue between pilots and operators through which labour disputes can be solved and avoided. For example, labour protection for remote pilots would require attention paid to the possibility to convert their experience to flight hours required for on-board pilot licenses. ICAO has addressed the license of remote pilots in the Manual on RPAS and expects to develop a single remote pilot license which covers all types of scenarios [51]. The European Commission also plans to adopt new training and competencies requirements for remote pilots and pilots of eVTOL aircraft. Such a design can help accommodate the technical specifications of remotely piloted aircraft. However, it influences the career development and job security of these pilots in the aviation labour market.

The Joint Authorities for Rulemaking of Unmanned Systems (JARUS) is a group of experts gathering regulatory expertise from all around the world and providing consensus recommendations to Member States and stakeholders, including ICAO. JARUS specifically recommends to credit military remote pilots and previous knowledge in the application for a remote pilot license [52]. As a step forward, reciprocal recognition of the qualifications and experience of eVTOL pilots, at least on-board ones, to obtain commercial pilot licenses, can address regulatory challenges arising out of the future reduced demands for pilots and contribute to the sustainable development of UAM. The participation and involvement of stakeholders would help to bring about collective agreements with a specific consensus on the evolution of UAM from manned to unmanned aviation, in which pilot unions have more bargaining power than those individual pilots.

V. CONCLUSION

The analysis conducted in the previous sections had the primary objective of examining the current legal systems and sources in place. The paper has enlightened two crucial points: on the one hand, the evolutionary approach of advancing UAM entails manned aviation as the interim form of operation. Technical specifications of UAM and urban environments suggest that regulatory authorities shall introduce amendments or additions to existing regulations on personnel licensing and fatigue management; on the other hand, there is a possibility that the development of UAM would witness regulatory challenges arising out of inadequate labour protection for pilots therein.

These perceived areas of concern would not only lead to precarious working conditions of pilots and negatively impact

aviation safety, but also increase the tension in the labour market and impede the advancement of necessary autonomy technologies. As regards technical rules, ICAO, EASA, and the FAA have recognised the necessity to introduce new regulations on the eVTOL pilots. Stakeholders in the field of UAM nevertheless overlook the social protection. A tripartite social dialogue, involving regulatory authorities, UAM operators, and pilots can help contribute to a sustainable labour framework which would not only meet operational demands and enhance autonomic controls, but also mitigate the negative impact of inadequate labour protection on aviation safety and working conditions of pilots. For successful assimilation and commercially viable UAM operations, specific and comprehensive aviation labour rules for eVTOL pilots are desirable.

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