

International Aviation Law Library 1

Maria Piera Rizzo
Federico Franchina *Editors*

Drones in the Digital European Sky

Theoretical Foundations
and Aviation Law Perspectives

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Editors

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Contents

Introduction	1
Maria Piera Rizzo and Federico Franchina	
UAS and Aircraft	
The Aircraft	11
Simone Vernizzi	
Drones	29
Simone Vernizzi	
The Regulatory Framework of UAS	
The International Regulatory Framework on Drones	43
Francesca Pellegrino	
The Basic EU Regulation on UAS	51
Adele Marino	
Basic National Regulation on UAS: Italy and Other Countries	63
Michela Pandolfino	
UAS Operation between Legal Theory and Technological Evolution	
Operator, Pilot-In-Command and UAS Crew	79
Federico Franchina	
Urban Air Mobility; Rules of Navigation and Infrastructure	97
Cinzia Ingratoci and Adele Marino	
Air Navigation Services and U-Space Services	
Air Navigation Services	123
Silvio Magnosi and Chiara Vagaggini	

U-Space Airspaces and U-Space Services 141
Maria Piera Rizzo and Cinzia Ingratoci

Liability Matters

Civil Liability Deriving from Artificial Intelligence Used in Air Navigation 155
Stefano Pollastrelli

Liability in the Event of Collisions and Damage to Third Parties on the Surface 165
Emilia Vermiglio

UAS and Criminal Law: An Analysis from the Perspective of the Italian Legal System 177
Giuseppina Panebianco

UAS and Insurance 197
Francesca Pellegrino

UAS and Data Protection 207
Emilia Vermiglio

Innovation and Sustainability

European Union Air Navigation Services and Digitalization 221
Federico Franchina

Aviation and Sustainability 247
Francesca Salerno

Civil Liability Deriving from Artificial Intelligence Used in Air Navigation



Stefano Pollastrelli

Contents

1	Introduction.....	155
2	The Impact of New Technologies on Air Navigation.....	157
3	Various Models of Civil Liability.....	158
4	Artificial Intelligence and Civil Wrong.....	160
5	Conclusions.....	162
	References.....	162

Abstract The chapter aims to delve deeper into the topic of the civil liability deriving from Artificial Intelligence used in air navigation and to analyze the different models of responsibility. The question that lies at the centre of the debate is the source of the damage to persons or property caused by the algorithm incorporated in the device, which leads to an outcome that is unpredictable and not controllable by humans. There is a need to arrive at new forms of responsibility to guarantee adequate protection for victims of damage caused by machines equipped with artificial intelligence capable of self-learning. The issues subjected to critical examination are numerous. The work focuses on analyzing the Italian and European legislation on damages from aeronautical activities.

1 Introduction

The interrelation between artificial intelligence and law has extensively involved the navigation and transport sector, which seems increasingly characterized by the use of completely autonomous vehicles able to substitute the driver, captain and pilot of a ship or aircraft and to carry out the specific activities of the crew members.

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155

Within this context, which is symptomatically expressive of current technological innovations, is the sector that includes the use of UAV acronym for *Unmanned Aerial Vehicles* and more recently, UAS acronym for *Unmanned Aircraft System* or of drones, as they are commonly known.

The widespread use of drones in the diverse sectors of industry, agriculture, commerce, logistics, the environment, law and order and the military has led, in recent years, to a trend in the economic growth of companies of producers and suppliers that see important development opportunities, also in terms of employment.

Artificial intelligence applications which are progressively more sophisticated, evolved, technologically advanced and connected, make the products or machines that use them increasingly autonomous and increasingly less remote control.¹ We are witnessing the transition from an initial form of technological automation (in which the product was under human control), to a form of artificial autonomy in which the product develops self-learning pathways, through the implementation of algorithms capable of making autonomous decisions in order to acquire new knowledge and create actions independent of human beings (of their creators). They are therefore unpredictable or rather, as has been aptly stated, they have a sort of “unpredictable predictability” in that the algorithm developer is aware that the system could make unpredictable, ungovernable decisions (the phenomenon of *Machine Learning*).²

The technique of self-learning can also go one step further and devise new pathways using the architectures of artificial neuronal networks in its development of *Deep Learning*. These architectures have several deep, non-visible layers on a par with the human brain, and carry out nonlinear calculations originating from input signals. In giving an account of this phenomenon, it should be pointed out that the algorithms (which are an intellectual creation consisting of a mathematical formula and deemed to be intangible assets) assume a central role in the structure of artificial intelligence in that they allocate the ability to learn to the device in which they are incorporated. This is achieved through the continuous elaboration of the multiple data that they collect and the processing of a staggering amount of information (*Big Data*).

The self-learning mechanism leads the machine towards outcomes desired by humans but the internal dynamics of the device involves the ability to self-modify and adapt to the environment, arriving at autonomous decisions that depart from the original ones employed in the algorithm and that can turn into unpredictable behaviour that is outside human control (*emergent behaviour*).³

The product and/or the machine may thus develop different pathways, deviating in an unpredictable manner from the expected purpose for which they were initially developed and put on the market. When this occurs, it means that artificial intelligence, through its automatic learning system, has made decisions about

¹ Cf. Frontoni (2024); Razzante (2024); Ruffolo and Amidei (2024); Buyers (2023).

² Piergallini (2020), p. 1745 ff.

³ Cf. Panattoni (2021), p. 317 ff.

predetermined situations. These decisions are not transparent and are difficult for humans to decipher, nor are they scientifically decryptable with the result that they remain inscrutable and obscure (the *Black Box* phenomenon).⁴

2 The Impact of New Technologies on Air Navigation

The question that lies at the centre of the debate is the source of the damage to persons or property caused by the algorithm incorporated in the device which leads to an outcome that is unpredictable and not controllable by humans. This raises new problems regarding civil liability.

The entry into the realm of aviation of products with complete autonomy, capable of self-learning and self-perfection inevitably leads to a series of reflections regarding civil liability in Aviation Law.

In this phase, marked by the fast-paced dynamic of technological and algorithmic innovation that will progressively lead to a fully automated drone market, the research to undertake should follow two paths: first to verify the validity of the traditional regulatory frameworks incorporated in the Civil and Navigation Codes, if necessary with up-to-date interpretations; second, to assess whether it is necessary to introduce new regulations to cover what we may term “algorithmic liability”.⁵

Both are affected by the impact of self-learning artificial intelligence.

Hitherto legal scholars have always dealt with systems or products controlled by humans, but such an approach is now seriously outdated. Faced with machines that self-learn and decide autonomously, we need to ask who should be liable for possible damage caused to persons and property. Likewise, we need to ask who should be considered the perpetrator in cases in which the human agent has been removed from the decision-making process which has become the responsibility of an artificial agent.

The algorithm developer (its creator), the manufacturer, the producer, the trainer, the vendor, the owner and the user are all potentially liable in the event of damage to persons or property in that they are involved in the technological development process that shaped the artificial system and which uses it for the intended purposes.

The artificial system could cause harmful events that may be attributable to construction or manufacturing defects but also as a result of unexpected outputs which the system itself elaborates and learns autonomously. The basic question is the loss of control on the part of the operator, who is transformed into a supervisor with limited possibilities to interact with the system.

The problem of attributing liability is related to the degree of autonomy attributable to the system of artificial intelligence: the more autonomous (sophisticated) the system, the more difficult it will be to identify forms of liability among the legal

⁴Cf. Scognamiglio (2023), p. 1081.

⁵Ruffolo (2019), p. 1692.

subjects mentioned above. This is especially the case in circumstances that fall the murky field of machine learning technology, in which the programmers themselves, called upon to assess complex situations, are unable to explain the algorithmic decisions made by the machine, and remain prisoners of its intelligence.

This means that liability is attributable to the thinking machine.

But this raises further questions and stumbling blocks on a probative level.

We in fact need to question whether the rules on causality are still able to provide convincing answers in the case of harmful events caused by an artificial machine capable of self-learning. An injured party will be faced with a multitude of subjects who have taken part in the machine's various planning and production phases, but who are not able to explain the aetiological pathway that has led to the damage, nor to identify the specific cause of the damage. As has been clearly pointed out, this could result in "a jumble of alternative causative factors, which, as if this was not enough, could even be linked, thus opening up the field to a web of causation".⁶

The risk is that of creating protection gaps.

3 Various Models of Civil Liability

Art. 743 of the Italian Navigation Code defines aircraft as "*every machine intended for air transport of persons or goods*". The legislator has adopted the concept of intended use as being equivalent to that of a ship, with the exclusion of the spatial reference. The second paragraph establishes that "*remotely piloted aircraft are considered aircraft and are defined as such by special laws, ENAC regulations and, for those of the military, by Ministry of Defence decrees*". The reference is to be understood as applying to drones both for civil and commercial use.

The result, in regulatory terms, is that drones are classified as equivalent to aircraft with crews on board so that liability is applied to the former under Articles 965 (liability for damage to third parties on the surface), 966 (liability for impact damage between aircraft in flight or between an aircraft and a moving ship), 941 and 952 of the Italian Navigation Code (liability regarding the contract of carriage of persons and goods).

The subjects held accountable are the operator, pursuant to Art. 878 Italian Navigation Code, and in cases of liability regarding carriage, the air carrier (which often coincides with the operator). It also appears that the operator is held accountable, jointly and severally, both with the tortious user, in the case of use of an aircraft without his/her consent, when he/she has not exercised due diligence to avoid the damage (Art. 879 Italian Navigation Code), and with the occasional user, who has acquired the right of use of the aircraft for a duration of not more than a fortnight, when he/she causes damage to third parties (Art. 939 *ter* Italian Navigation Code).

⁶See, Piergallini (2020), p. 1762.

It should be pointed out from the above framework that the Rome Convention of 7 October 1952 on the subject of damage caused to third parties on the surface, which is also applied to damage caused on the national territory by aircraft registered in Italy, by rule of the extension made by Art. 965 Italian Navigation Code, attributes the liability to the pilot in command, i.e. the person using the aircraft who is in control of navigation; it should be understood that this is not the same person as the operator, namely the entity responsible for the management of the navigation, and therefore engages in a business organized with the aim of economic gain (Art. 878 Italian Navigation Code).⁷

The regulatory system described above is founded on the regulation of the operator's liability which forms part of the general legal principles regarding civil liability.⁸

The operator is liable to third parties for acts committed by members of the crew and for the obligations assumed by the captain regarding the aircraft and shipping of goods. Based on the above-stated criterion, the operator, in virtue of their supervisory role, is liable for lawful and unlawful acts committed by his/her employees or people in charge "*in the exercise of the tasks to which they are assigned*" (Art. 2049 and Art. 1228 Italian Civil Code, regarding contracts). It is a matter of strict liability for the actions of others (or *vicarious liability*)⁹ without any provision of exculpatory evidence for the operator. Even if it is not absolute, it is rigorous, marked by the existence of a relationship of "*occasional necessity*", in the sense that the performance of the assigned tasks must be such as to define a situation that facilitates or makes possible commission of the offence.¹⁰

The "acts of the crew" insofar as they were committed in the performance of the duties assigned to them, must be considered, as regards third parties, as acts committed by the operator, who is liable for all damage, which is the concrete expression of the increased risk typically created by the process of navigation.

Art. 879 Italian Navigation Code establishes therefore a special rule and as such it prevails over that established under Art. 2049 of the Italian Civil Code. However, it does not deal exhaustively with the topic of the regulations on tort with which the operator, as legal subject and entrepreneur, must comply in the same way as with the attribution criterion. Art. 878 Italian Navigation Code attributes to the operator the legal consequences of the lawful and unlawful acts of the people in charge but gives no provision in relation to the act generating liability which remains governed by other regulations of the Civil Code among which those laid down in Arts. 2050 and 2051 Italian Civil Code applicable in the field of navigation.¹¹

⁷Masutti (2016): "Therefore, considering the complexity of drones, it is vitally important to make a clear distinction between the person who has the authority to direct a flight (pilot in command) and is responsible for the operations of the aircraft in accordance with the rules of the air, and the legal entity operating a drone (operator)".

⁸Cf. Busnelli (1991).

⁹Ruffolo (1976); Bonvicini (1976).

¹⁰Cass. 10 ottobre 2014, n. 21408, in *Resp. civ. prev.*, 2015, 292

¹¹Cass. 14 novembre 2014, n. 24347, in *Resp. civ. prev.*, 2015, 452 ff.

4 Artificial Intelligence and Civil Wrong

At this point, based on the attribution criterion described above, the aeronautical activities carried out by unmanned automated aerial vehicles with human operators, that cause damage to third parties, both in the case of damage to third parties on the surface and impact damage, fall within the criteria of the liability mentioned above, and may be viewed as occurring during the performance of duties of the people in charge and employees.

What is more debatable and difficult to pinpoint is the liability for damage to third parties by completely autonomous drones, where there is no remote pilot, but whose manoeuvres and behaviour are entrusted to artificial intelligence and its learning capacities (*Machine Learning*).

It is in this context questions arise regarding the concept of autonomous algorithmic liability where the subject to be held liable is the algorithm developer, who interacts with the operator and has liability under tort towards the damaged third parties. The algorithm developer is distinct from the person who incorporates the algorithm in the product or in one of its components, but also distinct from the producer, software supplier and trainer. We are dealing with distinct and autonomous liabilities that should be integrated by the traditional forms.¹²

This new awareness marks significant progress on the subject of liability in the air law sector, although problems remain. First, the operator or user may be held liable as the result of an earlier error made by the person who created the mathematical formula from which the algorithm originated. Alternatively, an algorithm capable of self-expanding and self-learning from various experiences may cause an malfunction in the product, leading to unpredictable behaviour that is the root cause of damage to persons and property.

When considering this approach, we should bear in mind the rule of causation in order to establish the scope of compensable damage.

On the level of adequate causality, in fact, the damage caused by the use of artificial intelligence would be attributable to the original programmer. However, the black box phenomenon should not be forgotten, as it produces unexpected outputs not desired by humans. Therefore, the action is not adequate to produce the expected event. In this sense, it could constitute a supervening factor capable of breaking the causal link, since it is beyond the subject's control and ability to predict. However, this must be considered an abnormal occurrence (Art. 41, paragraph 2, Italian criminal code). Whereas with reference to the theory of human causality,¹³ the final unexpected outcome should not be attributable to the programmer of the original algorithm, since its ability to self-learn could lead the machine to engage in unpredictable and unusual behaviour which differs from its initial programmed instructions, thus resulting in final outcomes that humans cannot control.

¹² Cf. Ruffolo (2019), p. 1693.

¹³ Cf. Antolisei (2003), p. 245 ff.

The verification of the causal link is therefore problematic, in that the action that produced the damage may derive from a programming or information error, or manufacturing defect, but also from external environmental agents or distorting phenomena that are not easy to decipher. This makes it impossible to attribute liability for damage caused by algorithms in the use of drones.¹⁴

In view of the perspective that we have attempted to outline, navigation law permits the application of Art. 2050 Italian Civil Code to the liability for damage caused by the exercise of hazardous activity.¹⁵ The Italian Court of Cassation has established that the legislator does not consider aviation a hazardous activity, nor can it be deemed possible to define it as objectively hazardous. However, in reality, this danger exists every time the activity does not fall within the normal expected conditions (safety conditions, atmospheric conditions), which involve hazardous abnormal situations, and the consequent applicability of the provision of Art. 2050 Italian Civil Code to air navigation.¹⁶

Consequently, caselaw extends the meaning of hazardousness to encompass activities which are normally not dangerous (air navigation) but that can have dangerous aspects that exceed the normal level of risk. The notion of risk is thus extended to include aeronautical activities carried out by drones equipped with artificial intelligence. In fact, it is precisely the precondition of risk, that is intrinsic to the methods of use of products equipped with artificial intelligence self-learning, that permits civil law scholarship to suggest a criterion of attribution based on Art. 2050 Italian Civil Code which refers to the riskiness intrinsic to products of artificial intelligence.¹⁷

Therefore, Art. 2050 of the Italian Civil Code would appear to be the most suitable approach for regulating aeronautical activities carried out with totally autonomous drones which use self-learning artificial intelligence-systems, since they are highly likely to cause harmful events.

EU law, specifically EU Regulation 2024/1689 of 13 June 2024 on artificial intelligence classifies artificial intelligence systems based on risk. More specifically, for high-risk systems that pose significant risks for health, safety and people's fundamental rights, it establishes strict liability for operators.

Furthermore, it should be born in mind that damage may derive not only from construction flaws or production defects, but also from design flaws in the onboard software and the settings of basic algorithms (software producer) and also from communication defects in a technological and IT system of correlation and interoperability, which would not appear ascribable to the software developer nor to the owner or operator.

¹⁴ Cf. Piergallini (2020), p. 1762.

¹⁵ Cf. Querci and Pollastrelli (2023), p. 61 ff.

¹⁶ Cass. 10 novembre 2010, n. 22822, in *Riv. dir. nav.*, 2011, 397 ff.; Cass. 18 marzo 2005, n. 5971, in *Dir. maritt.*, 2007, 1127 ff.; Cass. 19 luglio 2002, n. 10551, in *Danno e resp.*, 2002, 1215 ff.

¹⁷ On this point, cf. Costanza (2019), p. 1688; Trimarchi (2021), p. 429 ff.; Comporti (2009), p. 172 ff.

With reference to liability for defective products, Directive (EU) 2024/2853 of the European Parliament and of the Council of 23 October 2024 on liability for defective products and repealing Council Directive 85/374/EEC, extends liability for defective digital products and the use of artificial intelligence that does not conflict with EU law in the field of artificial intelligence.¹⁸

5 Conclusions

The scenario outlined above, while on the one hand raising interesting points, on the other, presents inevitable application-related uncertainties regarding the allocation of liability, the identification of liable subjects and causality. In this process of technological development, increasingly propelled towards more evolved forms of artificial intelligence, it is necessary to cover modern protection needs and to redefine the boundaries of traditional civil liability frameworks established to safeguard people's fundamental rights, which might no longer be sufficient to address the unacceptable risks inherently linked with the use of machines equipped with artificial intelligence.

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¹⁸ Ponzanelli (2025), p. 153 ff.

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