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ABSTRACT

This article introduces three modes of regulatory experimentation – derogation, devolution and open-texture – for regulators to respond to the challenges brought by disruptive innovation such as non-military unmanned aircraft systems (UAS). This article argues that where there is an urgency of requiring a regulatory response to a new societal challenge, and there is serious empirical uncertainty about expected technological or regulatory events and/or their consequences, experimental regulations can be a fitting approach in dealing with the new challenge – as with UAS. As the risk of failure is an intrinsic aspect of innovation, the most significant function of regulatory experimentation is to yield useful information rather than verify the validity of an innovation. Nevertheless, the setting of experimental regulation should take into account both epistemic requirements and legal values. The principles of certainty, equality and proportionality express the legal values that guide decision-making towards legitimate experimental regulation. The experimental approach demonstrated in this article also provides a model of 'future-proof' regulation. This is applied to UAS particularly by zones as experimenting by derogation and perhaps also by devolution and open texture.

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1. Introduction

Debates over emerging technologies and their proper regulation are part and parcel of modern societies. Some technological innovations are 'incremental', building upon existing knowledge, products and processes. Such incremental innovations can be deployed in an enabling environment, because they are consistent with existing regulatory systems or merely require minor amendments (Heldeweg 2015, 172). However, quite often emerging technologies have a 'disruptive' characteristic, which means they break with existing knowledge and paradigms. 'Disruptive innovations' are either inconsistent with existing regulatory systems and thus require radical changes to relevant regulations, or are unregulated while their emergence impacts legally relevant interests, and thus new regulations are needed. Examples of 'disruptive technologies' include, among others, biotechnology,

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genetically modified organisms and artificial intelligence. Such new technologies can, on the one hand, generate clean energy, alleviate the problem of starvation and improve humans' working efficiency. On the other hand, those new technologies pose serious risks to ecosystems, socio-economic stability and human health, as well as possibly causing panic over possible evil future uses, such as with robots. Facing this quandary, either the development of such 'disruptive technologies' is impeded by the existing regulatory systems, or an enabling and controlling regulatory framework needs to be established in order to promote the responsible development of novel technologies. For the sake of the continuous and prosperous development of society, the latter option appears to be sensible. Thus, regulators need to answer the question of how to modify obsolete regulations and/or make new regulatory framework with a view to promoting technological innovations while minimizing the risks created by those innovations: responsible innovation through legitimate regulation.

In practice, adapting the existing regulatory systems to emerging technologies is a major challenge. Proponents of 'disruptive technologies' long for an enabling regulatory setting for research and development. Opponents, however, contend to apply a restrictive regulatory approach, because they are worried that an enabling setting might lead to an excessively rapid and uncontrolled growth of premature technologies, which still contain a high degree of scientific uncertainty. Conceivably, debates between such proponents and opponents may well result in a stalemate, causing an even longer delay in adapting regulatory systems to new technologies.

Unmanned aircraft systems (UAS) represent such a disruptive technology, which is not harmonious with existing regulatory regimes. The term UAS refers to all types of aircraft[1] which are operated with no pilot on board, and their ancillary components, such as a control station, if applicable. There are two major modalities of UAS: remotely piloted from another place (i.e. Remotely Piloted Aircraft Systems (RPAS)), or programmed and fully autonomous UAS (ICAO 2011). UAS can also be a combination of both modalities. UAS for professional, public and recreational uses have been growing rapidly over the past five years, but effective regulations related to their functions, operation and administration of UAS still lag behind. Indeed, recently, a number of countries, such as the Netherlands, Germany, France, the US and China, have enacted their new UAS regulations,[2] which are responsive to the rapidly growing market and to the necessity of controlling and minimizing the identified potential risks arising from UAS operations. Given the rapid development of UAS technology and its related equipment, those regulations will inevitably need to be frequently modified.

When facing the legal status quo, the traditional approach of reactive regulation appears to provide neither flexibility nor stability. This article proposes an experimental regulation of non-military UAS,[3] which entails (sequential) testing of tentative and novel UAS and their regulation in a limited area, and periodically evaluate the legitimacy, effectiveness and efficiency of the experimentally tested technology and regulation in order to see the possibility of up-scaling experimental regulation to a larger area or more complex or sensitive context.[4] Under an experimental regulatory setting, stakeholders will enjoy a greater freedom that enables them to develop UAS-related technologies as well as stimulating the UAS market (i.e. as technology commercialization). Meanwhile, the experimental approach will also enable regulators to design proactive, future-proof and resilient regulations that are adaptive to UAS-related technological innovations while safeguarding vital societal and citizen interests. The experimental approach can contribute to tackling the dilemma of encouragement of the technological innovation of UAS while protecting potentially affected parties which are exposed to risks concerning their safety, security, privacy and freedom from nuisance. From a more theoretical perspective, the experimental approach could also bring insights to the co-evolution of a disruptive innovation and its innovative regulation. The experimental framework proposed in this article could also be heuristic for the designing of innovative regulation of other emerging technologies, such as driverless car and social robots.

This article attempts to answer a core question: which modes of regulatory experimentation are available to regulators facing the disruptive challenges that come with the emergence of UAS technology, and which principles are guiding the choice of when and how to apply such experiments? The main body of this paper consists of three parts: Section 2 introduces the current regulatory framework for UAS, summarizing the main problems and challenges in the regulation of UAS. Section 3 introduces the definition, elements and typology of experimental regulation. Besides, Section 3 also discusses the preconditions and the legal principles that guide the choice of when and how to apply the experimental regulatory approach. Section 4 elaborates the possibility of applying the three types of experimental regulatory approach, namely, derogation, devolution and open texture to non-military UAS.

2. Regulation of UAS – the status quo

2.1. An overview of UAS laws and regulations

The operation of UAS must comply with relevant provisions under aviation laws in general as well as specific UAS regulations enacted in recent years.

At the international level, the Convention on International Civil Aviation (Chicago Convention) is the only binding instrument which addresses unmanned aircraft (UA). In principle, existing rights and obligations apply equally to manned and unmanned civil aircraft. In particular, Article 8 of Chicago Convention regulates conditions for operating a 'pilotless aircraft'. The International Civil Aviation Organization (ICAO), a UN specialized agency managing the administration and governance of Chicago Convention, published a circular in 2011 to address UAS. This circular submits that only the remotely piloted aircraft (RPA) will be able to integrate into the international civil aviation system in the foreseeable future, because the functions and responsibilities of the remote pilot are essential to the safe and predictable operation of the aircraft. '[U]nder no circumstances will the pilot responsibility be replaced by technologies in the foreseeable future' (ICAO 2011, Glossary, para. 3.1).

At the EU level, civil UAS with an operating mass of more than 150 kg fall under Regulation (EC) No 216/2008, and the European Aviation Safety Agency (EASA) is the competent authority to regulate such UAS operations. Other categories of UAS operations fall under regulations of Member States and are regulated by national civil aviation authorities (CAAs).[5] Since 2014, the EASA has been developing a new EU RPAS regulatory framework, which is expected to replace EU Members States' regulations in a few years (2016). The EASA has proposed 'phased and gradual introduction of RPAS operations' in the Roadmap for UAS Operations in the European Union, which proposes to start from initial operations and gradually achieve the ultimate goal via evolution (2015). The latest prototype regulation published in late 2016 by the EASA provides inspiration for EU Member States to already calibrate their UAS regulation, instead of waiting until the adoption of the EU UAS regulation. EU Member States could also provide feedback to the EASA regarding the prototype regulation during their testing and calibrating process. At present, Joint Authorities for Rulemaking on Unmanned Systems (JARUS), a group of experts from national aviation authorities and regional aviation safety organizations, is closely collaborating with the EASA by providing a platform for making a unified EU UA regulation. JARUS is aimed to recommend a single set of technical, safety and operational requirements for the certification and safe integration of UAS into airspace and at aerodromes.

At the national level, in recent years, a number of countries, such as the Netherlands, Germany, France, the US, China and Japan, have enacted new domestic UAS regulations. Basically, those national regulations target two aspects of UAS: the design and production of UAS, and the safe operation of UAS in the common airspace with manned aerial vehicles. As regards the first aspect, main elements are the regulations relating to specifications of UAS, among others, the size, weight, type of engine and, very significantly, equipped sensors and cameras. For instance, the US Federal Aviation Administration (FAA) regulates that a small UA should not have a weight of more than 25 kg, while the Dutch RPA Regulation limits the total mass of an RPA to 150 kg. Regarding the second aspect, the main concern is how to accommodate UAS operations in the airspace shared with manned aircraft. Further, although specific regulations vary from country to country, all national UAS regulations provide for a number of safety-driven prohibitions or restrictions on flying UAS over certain zones, in particular the immediate vicinity of an airfield and densely populated areas.

In addition to government, civil society organizations are engaged in the development of UAS regulatory frameworks by expressing their concerns and providing their proposals. A number of non-profit organizations have been working on dissemination of knowledge about operational regulations of UAS in different countries, building inclusive platforms for stakeholders to communicate, discuss and propose soft regulation, such as codes of conduct and guiding principles, with a view to promoting the safe, respectful and responsible operations of UAS.[6] One common concern particularly among for-profit stakeholders relates to the possible overregulation that would restrict the growing market, which will be further addressed in Section 2.2.

Notably, there is still a host of principles, rules and regulations which are not aimed to deal with UAS specifically, but are also applicable insofar as they apply to *certain impacts* of UAS operations on individuals, society and the environment. Major concerns include the potential negative effects on safety, privacy, data protection[7] and environmental interference. Specifically, regarding safety issues, tort law[8] and insurance (framework) laws[9] apply to compensation for damages caused by operating UAS. With respect to privacy issues, human rights law in terms of the right to privacy is broadly applicable to all UAS and their operations (e.g. International Covenant on Civil and Political Rights, Art. 17 and the Charter of Fundamental Rights of the European Union, Art. 7). Similarly, data protection laws are also in general applicable to UAS and their operations, when a risk to data privacy and the legitimate and secure measures of processing data exists. The right to protect personal data is not only enshrined in human rights law (e.g. Charter of Fundamental Rights of the European Union, Art. 8), but also embedded in a wide range of legal instruments specific to data protection (e.g. EU General Data Protection Regulation, Swiss Federal Act on Data Protection and Irish Data Protection Acts). Environmental interference mainly refers to noise nuisance caused by UAS operations. National noise emission standards apply when the design or operation of UAS is carried out within the jurisdiction of a country.

2.2. Challenges in regulating UAS

Based on the overview of UAS laws and regulations addressed in Section 2.1, the first regulatory challenge is that the current national regulations of UAS and UAS operations predominantly focus on controlling and minimizing *safety risks*. Hence, the broader impacts of UAS on society and on individuals are largely overlooked, apart from some general requirements for the compliance with principles and rules laid down in privacy, security, data protection, liability, insurance and environmental protection regimes (EASA 2016, Art. 4.1). Among others, the concerns over privacy and data protection, arising from the cameras, sensors and other gadgets that some small UA are equipped with, have not been sufficiently regulated. Notably, instead of the UA per se, these sensors and other gadgets for versatile purposes are closely relevant to humans' daily life and require a distinct approach to regulating UAS. The main reason behind the unbalanced treatment of different potential risks and concerns by UAS regulations derives from the limited scope of the regulatory and administrative bodies that produce, implement and enforce rules regarding UAS' design, manufacturing and operation. Under the current regulatory framework, CAAs are the major regulatory and administrative bodies involved in the regulatory process. As the traditional scope of mandate of these CAAs lies with the safety of aeroplane operation and civil aviation, there is limited discretion in CAAs' covering of all relevant concerns surrounding UAS (Du and Heldeweg 2017). Thus the question remains to be answered how UAS regulations can better respond to *all* social implications, *inter alia*, privacy, data protection and security concerns?

Another regulatory challenge lies in the tension between the increasing demand of UAS in the market and the regulatory restrictions placed on the testing and certification of UAS as well as the validation of UAS operations. Controversies exist between regulators and key players over how to regulate UAS in the development, manufacturing and operations of UAS. On the one hand, regulators, notably CAAs, are mainly using traditional *top-down approach* to design regulations for UAS (EASA 2015).[10] On the other hand, developers, manufacturers and operators of UAS have been actively proposing to use a flexible and *bottom-up* regulatory approach to create an enabling environment for the rapid development of the UAS market (Karpowicz 2017; Snead and Seibler 2016). In their eyes, the most existing regulations reflect the overall conservative attitude of regulators towards UAS operations, and those regulations are insufficiently technology neutral and thus are likely to become a barrier to the early to middle stages of the development of UAS.

In addition, as a third challenge, given the rapid enlargement of the UAS market, the demand for *transboundary operations* of professional UAS already exists, but inter- or supranational rules on designing and operating UAS or the mutual recognition of national UAS regulations are still largely absent. Thanks to the international e-commerce, nowadays one can easily order a UA designed and manufactured in a foreign country. However, problems arise when a UA is designed in accordance with one state's regulations and cannot be operated in another state because of the inconsistencies with that state's regulations. It would be beneficial if regulators would (jointly), sooner rather than later, establish inter-, supra- or transnational standards and harmonize national regulations.

Last but not least, a fourth regulatory challenge in response to innovation lies with *uncertainty*. Uncertainty contained not only in technology itself, but also in the future regulatory framework, and in perceptions of the implications of employing UAS by the public. First of all, technological uncertainty is an intrinsic characteristic of innovation. Secondly, technological uncertainty contributes to the uncertainty over the desired future regulatory framework, which very often presents as regulatory disconnect causing innovation delays (Brownsword 2008). Regulatory uncertainty can *ex ante* affect innovation, because the incentive for stakeholders to develop new UAS technology may well decrease as it remains unclear whether the operations of a novel type of UAS will be authorized. Regulators should therefore recognize the importance of developing proactive and future-proof regulations. Thirdly, uncertainty exists in the perceptions of the public, usually defined as ambiguity, which refers to subjective judgements about particular dangers and ethical concerns (Stirling 2008, 103, Figure 4).[11] With respect to the public perception of, for example, surveillance UAS, ambiguities could occur either because of the lack or the delay of proper information delivered to the public (cognitive ambiguity), or because of biases arising from value differences between individuals, such as desirable lifestyles and visions on new technologies (values-related ambiguity).

Actually, the regulation of UAS has encountered a common challenge when regulating an emerging technology: as disruptive innovations are occurring continuously and rapidly, a central challenge is how to remove or modify obsolete regulations and/or make new regulations with a view to promoting technological innovations while minimizing the risks created by those innovations. In reality, the balance between fostering new technology and minimizing risks is complex and time-consuming. In order to best decide on the optimal, proactive and future-proof regulatory methods to deal with challenges deriving from an emerging technology, it could be useful to conduct experiments with novel technologies and ditto regulatory approaches and, by doing so, collect information and experiences for the optimal design of regulation of large-scale deployment of UAS in real life. In the case of UAS, such a 'learning by testing' approach could be applied to deal with the four challenges identified above: look beyond safety. More importantly, such an approach could provide an enabling legal environment, gaining time for the development of a novel technology without causing unacceptable negative results. The following sections will elaborate on what is and how to experiment with regulation for the design and operations of UAS.

3. Experimental regulation of disruptive technologies

After examining the available UAS regulations and the major challenges in regulating UAS, Section 3 moves on to the introduction to the experimental approach, which could bring insights into the co-evolution of a disruptive technology like UAS and its innovative regulation. The definition of experimental regulation, its main elements and categories will be elaborated in Section 3.1, and Section 3.2 will examine the preconditions of applying the experimental approach and the key principles that guide how to engage in regulatory experimentation.

3.1. Definition, elements and typology

Experimental regulation has evolved along the time, as it is not a novel approach but rather has existed for more than one century. Traced back to the late nineteenth century, it has been submitted that

> [a]ll new laws are in the nature of experiments. […] they are experiments made for a practical purpose, and they are regarded merely as provisional and tentative until experience has proved their fitness, and they are confirmed by the proof of practical success. (Williams 1889, 299)

In the 1990s, economic incentives as an alternative regulatory system to command-and-control regulation have been tested in the US to improve air quality (Selmi 1993, 1095). More recently, experimental regulation has been proposed in the field of sharing economy, such as Airbnb and Uber (Ranchordás 2015, 872). A specific example of legal experimentation at the national level can be found in the Netherlands (Lammers and Diestelmeier 2017, 212). In order to achieve the 'transition towards affordable, secure and clean energy supply', the Dutch Ministry of Economic Affairs established a 'Taskforce Smart Grids' in 2009, which resulted in the launch of 12 smart-grid pilot projects for 3–4 years.[12] Those pilot projects have encountered obstacles arising from the current Dutch Electricity Act. In response to the obstacles, the Crown Decree on Experiments in Decentralized Sustainable Electricity Generation was enacted on 1 April 2015, which entails a derogation from an existing legal constraint in the Dutch Electricity Act.[13] By the derogation, individual exemptions can be granted for experimenting with 'project grids'.

Experimental regulation can be *defined* as 'regulations that are enacted on an experimental basis […] for a previously determined duration, for a limited group of citizens or territory selected on the grounds of objective criteria, and which are subject to a periodic or final evaluation' (Ranchordás 2015, 912). In this definition, we assume that the experiment is about the regulation itself, which means to gather information by experimenting with (alternative) regulatory strategies,[14] regulatory relationships[15] and/or types of legal norms.[16] In this article, we look at experimental regulation which not only addresses such experimenting with types of regulation, but which at the same time allows or facilitates technological experimentation, *casu quo* experimenting with UAS development and use. The key thinking behind this is that experimental settings which encompass both technological and regulatory innovation are particularly well suited to address the abovementioned element of co-evolution of a disruptive innovation and its innovative regulation.

Given the above definition, experimental regulation contains three characteristic *elements*:

(a) *Temporary rules*: An experimental regulation is initially tested for a limited period of time, varying from a few months to a few years. The duration of the experiment should be defined according to the main objective and the attributes of the sector, notably the speed of technological development and the potential subjects' response to the new regulation (Ranchordás 2015, 912). The duration of an experiment should last long enough to gather sufficient results but not too long – long enough to ensure controlled (epistemic)[17] conditions and not unnecessarily prolong legal uncertainty or inequality between and with regulatees within and outside the experimental regime. Shortness in time may also relate to experimental sequencing to consecutively gather information about changing technological functions and insights. [18]

(b) *Limited areas of application*: The territorial scope of the application of experimental regulation should be limited – to special areas such as airfields, university campuses, (districts within) cities or regions. Limiting the area of application provides experiments with a focus on specific contextual characteristics. These may be relevant to epistemic purposes, such as presence, nature and density of population and of the physical environment, such as buildings, but also relevant to legal values, in that experiments are controlled not to pose a risk of causing irreparable damage. Once experimental results allow, findings may be up-scaled to larger jurisdictions.

(c) *Periodical evaluation*: Experimental regulations should be adequately evaluated on a systematic basis, to see whether the rules can be extended (i.e. above up-scaling) to the whole (relevant) population and converted into general lasting rules. Based on the result of an evaluation, the regulatory scope, objectives as well as specific provisions of the experimental regulation can be revised. In the process of periodical evaluation and re-evaluation, local authorities and scientific experts should, insofar as relevant, undertake the duty to report the performance of the experimental regulation. In addition, stakeholders and civil society should be involved to provide their feedback on the experimental regulation. The public character of this process can enhance the transparency and accountability of the enactment and implementation of experimental regulations (Ranchordás 2015, 914).

Against the backdrop of these characteristics, one may make a distinction between three *types* of experimental regulation: experimentation by derogation, by devolution and by open texture. The three types can be briefly described as follows:

(a) Experimentation *by derogation* is a type of arrangement (e.g. of experimental licences) where experimental regulation leads to the possibility of exempting from having to comply with existing restrictive laws. Two things are crucial to understanding this type. Firstly, creating a regime is to experimentally lift a rule of conduct constraint on a particular innovative praxis: a praxis that is otherwise prohibited explicitly (e.g. drone flights are not allowed) or implicitly prohibited, by a counter-command (e.g. drone flights shall be operated by certified security pilots only, i.e. an implied prohibition upon others to not do so). Secondly, the experimental permission creates a possibility to compare and evaluate experimental findings about an exceptional praxis in contrast to existing findings about the standard/normal praxis. Such comparison and evaluation fit the notion of experimenting as a practice of changing an independent variable to see how this impacts a dependent variable – 'learning by exceptional variance'. There are many subtypes of derogation, with a myriad of options to detailing the regulatory setting, with additional requirements (such as on safety) but also facilitation (such as by subsidizing) (Heldeweg 2015). Compared to ordinary permits to act, which are basically about implementing a substantive general standard (by 'normal permits'),[19] experimental permits are about an attempt to improve such a general standard.[20]

(b) Experimentation *by devolution* is a type of arrangement where a higher, (federal or supra)national government empowers multiple lower, (state, national or) local governments to, in parallel, establish new regulations in their own jurisdictions on a particular policy area or objective (e.g. experimental powers) – also known as 'experimentalist governance' (Zeitlin 2015). Crucially, this method is about applying rules of power towards 'learning by parallel variance', also named 'learning from difference' (Sabel and Zeitlin 2008, 271–327). It involves simultaneous experimental variation, as each 'local entity' chooses its own particular course of action. At the same time, it requires, both for epistemic reasons to secure proper experimentation and for reasons of upholding legal values and principles, that these experiments are part of a central or shared experimental scheme. This scheme aims to generate wisdom by bringing together information about 'local' experiments and comparing and evaluating this to draw conclusions about the overarching regulatory way forward. 'Normal devolution' is about granting powers to allow 'local' communities to determine some extent of their own political destiny – i.e. devolution as 'end in itself'.[21] Experimental devolution, however, is about a 'means to an end', by granting powers to experimentally obtain 'local' information and then aggregate this in a collective or centralized evaluation, to determine the political destiny for all.[22]

(c) Experimentation by *open texture* (Hart 1962, 120–132) is a type of arrangement where regulatory objectives are broadly described, implicitly allowing alternative lawful (collaborative) self-regulatory practices to arise, within an explicit scheme for proper comparison and evaluation. Crucially, the norm-object of an open-texture rule is not defined in terms of (not) performing a type of action as such ('action as performance', e.g. 'Do not use chemical X, as it is known this may cause health hazard Y.'), but as an action towards causing certain effects or outcomes ('action as effect', e.g. 'Do not perform any action that may incur health hazard Y.'). Experimentation by open texture is not about 'normal open texture' as an established and in principle permanent regulatory strategy favouring a fine-line/principle-based type of regulation (Black 2008). Instead, it is about a temporary strategy to obtain information about possible alternative practices under a given open standard or norm as a modus of experimentation – 'learning by interpretative variance' – towards a later evaluation and decision-making on a permanent regulatory approach.[23] Typical examples are duty of care provisions,[24] right to challenge provisions (Communities and Local Government 2011)[25] and meta-regulatory frames.[26]

The backdrop to the decision whether or not to introduce experimental regulation towards reducing uncertainty is that of 'future-proof regulation'. The tenet of future-proof regulation is a design type of regulation and of making regulation that is resilient by ensuring a regulation-to-technology connect (i.e. avoiding a disconnect) (Brownsword 2008; Butenko and Larouche 2015) as a mode of co-evolution that serves desired technological advancement and safeguards other public interests – such as by curbing undesired technologies. While it is uncertain what the future will look like and scenarios for alternative futures remain speculative, there are ways of designing resilient regulation to be adaptive while retaining its characteristic of ensuring certainty on key civil and political interests (as a matter of being resistant to undesired practices) (Heldeweg 2017). Experimental regulation is only one aside many other forms and procedures of future-proof regulation.

Examples of alternatives are[27] purposive standards (e.g. BAT),[28] duty of care provisions, technology neutral standards,[29] and also the right to challenge, delegation to more nimble lower legislators and decentralization, to allow room for tailoring to local conditions.[30] All of these and similar future-proof regulations should be based upon proper impact assessments and feedback mechanisms for *ex ante* and *ex post* evaluation, and upon a transparent and open regulatory process, such as *ex ante* stakeholder consultation (e.g. 'regneg'). While we cannot elaborate on the various alternatives, it is worth noting that they may be introduced either as 'normal' regulation, with permanency, but also as alternatives being 'tried out' experimentally – with or without simultaneously accommodating technological experimentation.[31] Thus one could argue that derogation, devolution and open-texture types of regulation may indeed be future-proof types of *normal* regulation, while they may also be employed *experimentally* – temporarily, locally and within a framework for evaluation, to possibly later be introduced as normal regulation, permanently and full scale. Considering our earlier remark, such would only make sense if the effects of introducing such types of regulation seem truly uncertain given their dynamic technological context, while their introduction seems urgent in hopefully securing a promise of delivering on or curbing of major societal benefits or threats, respectively – while its confined setting, e.g. purpose, time, place and evaluation, justifies the risk at failure.

Table 1 summarizes the typology used, while distinguishing normal versus experimental regulation.

In considering and arranging experimentation as a mode of regulation to reach beyond precaution, various principles express the key legal values that may guide decision-making towards responsible experimental regulation. These principles are discussed in Section 3.2.

Table 1. Typology of legal operation for normal and experimental purposes.

Characteristic legal operation	Type		
	Derogation	Devolution	Open texture
Normal purpose			
• risk averse[a]	Exempting from constraining rules of conduct (e.g. by delegation)	Granting local discretion in lawmaking upon rules of power (as decentralization)	Allowing a broad range of factual practises within a regulated purpose (e.g. technology neutral)
	Permitting to tailor a general and abstract norm	Empower local authorities for political autonomy	Secure proper regulatory connection to technology
Experimental purpose			
• risk-taking[b]	Permitting to improve on a general and abstract norm ('learning by exceptional variance')	Empower local authorities to experiment policies ('learning by parallel variance')	Spontaneous innovative lawful and specific practice ('learning by interpretative variance')

[a]Not as experimental practice (see [b]); with permanence ('end in itself')
[b]Upon urgency and uncertainty; temporary, locally, under evaluation ('means to an end': advance technology/improve regulation) – specific epistemic and legal values.

3.2. Preconditions and key principles

It follows from the key defining elements of regulatory experimentation that each subtype may only be considered truly experimentalist when the scope is limited. Time and space are limited because of the specific purpose of obtaining an improved understanding of technological opportunities and threats, and of collecting information and experiences regarding regulatory options. Such options should thus be evidence-based, permanent future-proof regulations, which only allow and facilitate responsible technological advancement. The experimental purpose requires, for reasons of epistemic rigour, some measure of controlled practice, with a unified scheme of measurement, comparison and evaluation. It merits emphasizing that experimentation is not, as pointed out in the above, about a mere matter of permitting as 'normal derogation', local politics as per 'normal devolution' or varied practice following 'normal open texture'; it is about experimentation! This is also why legal values have a particular role to play; experimental regulation, whether it combines innovation of regulation and of technology, or only involves innovation of either one, is about a different normative setting than that of 'normal' derogation, devolution or open texturedness.

This normative difference follows from the characteristics of regulatory experimentation addressed above, and relates strongly to three preconditions of applying the experimental regulatory approach: urgency, uncertainty and risk-taking. Experimental regulation can be established in a situation where there is an *urgency* of a promise or threat with societal relevance, worthy of considering a regulatory response, but with serious empirical *uncertainty* about expected technological or regulatory events and/or their consequences.[32] This uncertainty is, following the general requirement of precaution when 'regulating under uncertainty', answered by experimental regulation as a means to obtain 'certainty' to later introduce evidence-based regulation. Such experimentation does in itself involve *risk-taking*, but under limitation in time and place, in a controlled setting, to later upscale upon findings. Needless to say, this course of action requires a convincing justification in terms of being an 'abnormal' practice that is nonetheless deemed necessary for the benefit of society and that is well regulated. Such regulation of experimentation serves to secure the epistemic requirements concerning proper(ly controlled) experimentation, but also to uphold key legal values to avoid that stakeholders and third parties fall victim to frivolous experimentalism. It takes convincing reasons to argue that experimental regulation is indeed necessary, and an equally convincing arrangement should be in place to control the experiment.[33] Several legal principles play a key role in this argument about if and how to engage in regulatory experimentation.

3.2.1. Principle of legal certainty

At the first sight, the features of experimental regulations concerning the limited period of time and possible revision are at odds with the principle of legal certainty. Fuller's principles of 'internal morality of law' reflect key elements of legal certainty: laws must be promulgated to citizens; retroactive rule-making should be avoided; laws must be clear and non-contradictory; and legal implementation should be in line with the laws announced beforehand (Fuller 1969). From the perspective of 'good lawmaking', the core elements of the principle of legal certainty are the *predictability* (subjective certainty) and *accessibility* (objective certainty) of the law.[34] From the perspective of 'good government', the significance of the principle of legal certainty lies in the safeguard of citizens against arbitrary decisions and thereby securing their autonomy (Popelier 2008, 53). Legal certainty enables citizens to predict rights and duties and to be protected against sudden changes, and provides a favourable legal environment for enterprises to make decisions to invest (Popelier 2008, 66).

To conceive the principle of legal certainty as a dynamic concept, the principle of legal certainty does not preclude law from accommodating social changes, but rather steers lawmakers to accommodate changes in a legitimate way. Sometimes, legal certainty may even demand legal changes in order to retain significance of existing rights or duties (Popelier 2008, 53). Hence, to ensure that the introduction of experimental regulations does not endanger legal certainty, the accessibility of the legal text to the public and the predictability of the legal consequences of actions must be guaranteed, and no arbitrary exercise of power can be generated. Among others, information on the objective of an experimental regulation, the urgency of making such a regulation, the potential risks to citizens and measures to control such risks should be made publically available, and the process of making regulations should be transparent. Moreover, the requirement of accessibility of law under the principle of legal certainty also provides the rationale for citizens to participate in the establishment and revision of an experimental regulatory framework. It requires, in particular, that stakeholders may participate in the periodical evaluation of experimental provisions. In sum, the principle of legal certainty plays an important guiding role in the making and revising of experimental regulatory framework, and a clear, transparent, accessible and predictable experimental regulatory framework would be in line with the principle of legal certainty.

3.2.2. The principle of equality

The principle of equality in the context of this article refers to the equal treatment of citizens, and of states, regions or provinces, and municipalities. As described in Section 3.1, experimental regulations are to be applied to a limited area, so that only part of a state's population will be involved in the experiment(s). Hence, the choice of carrying out experiments in a certain area and among a certain group of citizens may raise concern about equal treatment. Unequal treatment might also arise due to the differentiated treatment between administrative bodies (Ranchordás 2014, 198). Such differentiation will touch upon the exercise of (fundamental) civil rights and freedoms, such as privacy, and may also touch upon fair competition, as experimentation should not favour some businesses above others – either in joining the experiment or in being excluded, other than for reasons of proper experimentation.

The NIMBY (Not In My Back Yard) phenomenon occurring in the public perceptions of UAS and their services also challenges the requirement of equal treatment. The NIMBY concept commonly describes the public opposition to new developments near homes and communities, particularly arising from renewable energy infrastructures, such as wind turbines (Devine-Wright 2009). The deployment of UAS technology is confronted with similar opposition as to the construction of renewable energy infrastructures. While everyone agrees on the usefulness of UAS services, worries about safety and privacy lead many to prefer not having the research activities and the deployment of UAS undertaken in their neighbourhood. Once an area is selected as an experimental zone for UAS services, there could be a potential infringement of the equality between citizens when the rationale behind the selection is not convincing, or when disproportionate burdens are not compensated.

Given that the impacts of experimental regulations are unclear, experiments may result in either positive or negative consequences, or a combination of both. The core question is how to justify the differentiated treatment between citizens in the experimental zone and those elsewhere within the same public jurisdiction (e.g. a state), in order to be in line with the principle of equality. In short, experimental differentiation is lawful only when it is temporary, justified by the objective of examining the validity of an experimental regulation, given urgency and uncertainty, and proportionate, given risks, to the technological challenge. In addition, it is crucial to establish mechanisms which provide reasonable compensation for the people who are exposed to experimental risks.

3.2.3. Principle of proportionality

The principle of proportionality is closely relevant to the other two principles stated above. As for the principle of legal certainty, uncertainty about future regulation throughout the limited period of time to experiment and possibly revise existing regulations should be proportionate to the need for adapting to technological developments. In other words, regulatory experimentation should not disproportionately infringe on a person's autonomy due to a lack of predictability of legal consequences attached to certain actions. In relation to the principle of equality, experimental regulation that brings a differentiated treatment of citizens is considered lawful when such a regulatory response is the most proportionate one to a technological challenge, and as long as the duration of that differentiated treatment is appropriate and necessary (Ranchordás 2014, 207). Further, where inequalities cannot be avoided and exceed normal societal risks, compensation should be offered as a matter of 'equality before public burdens' (Fairgrieve 2003, 144–150). The principle of proportionality is also relevant to the balance between ensuring an adequate protection of citizens and of the (human) environment, and the costs of actions to prevent hazards, in particular when clear proof of hazards is absent. Hence, on the one hand, the broad notion of precaution should be embedded into experimental regulations on UAS, which suggests that all stakeholders, *inter alia*, designers and developers of UAS, should accommodate the innovation process with the notion of precaution at the very early stage of designing and developing UAS – in order to minimize potential risks to safety, security, privacy and the environment rising from UAS operations. On the other hand, the costs of actions to prevent hazards should be proportionate to the likely benefits gained from the foresighted protection.

In conclusion of this third section, we emphasize that an experimental approach to regulation is not a panacea and can only be enacted and implemented within clear boundaries. These boundaries set limits to the freedom to experimentally develop new technologies and subsequent technology commercialization (Marinakis 2016), but also to the regulatory discretion to experimentally achieve regulatory fitness taking into consideration the principles and concerns discussed in the above. It should be kept in mind that the key issue about experimental regulation is to yield relevant information. Risk of failure is an intrinsic aspect of innovation – a failure does not mean that a new type of technology or regulation does not deliver on expectation, but that the experiment does not provide information that may reduce uncertainty and contribute to answering an urgent societal challenge. While this understanding makes sense in epistemic terms, regulators should never neglect that experimentation is ultimately about human interests, which may trigger but also constrain an experimental praxis.

4. Experimental regulations of non-military UAS

In response to the challenges identified in Section 2, what could the ideal future UAS regulatory framework look like? First, it should be proactive – predicting and controlling all types of potential risks to prevent any irreparable damage to individuals, to society and to the environment, and regulatory policy should be clear on remaining uncertainties and possible ambiguities. In addition to CAAs, other stakeholders, in particular, UAS developers and service providers should be well involved in the design of regulations on UAS and UAS services – without ignoring the interests of third parties – i.e. as a matter of distributive justice. Second, it should be flexible and future-proof – accommodating rules to the rapid development of UAS technology. Third, in order to legalize transboundary flights, relevant national rules between neighbouring countries need to be mutually recognized, or regional even international agreements on industrial standards or operational rules should be arranged. The final goal of regulating UAS is to allow cross-border operations in integrated airspace and over any populated territory in a safe, secure and environmental-friendly manner.

Based on the ideal-type scenario above, Section 4 elaborates on the main elements of an experimental regulation on non-military UAS, following the distinction of three types of regimes of experimental legislation as stated in Section 3.1. Most attention will go out to experimentation by derogation.

4.1. Designing an experiment by derogation – a (future) Dutch example

The design of the experimental regulation of UAS as a matter of derogation from existing regulations may be discussed upon a Dutch example. The main Dutch regulation on UA operations is that of a dedicated ministerial regulation – the regulation on remotely piloted aircraft (R-RPA).[35] It is part of a broader regulatory framework, which starts at statutory/primary legislative level with the Air-traffic Act (ATA),[36] which defines 'aircraft' including UAS.[37] Based upon the ATA, there are, at secondary legislative level, several Crown decrees that cover key air-traffic issues: personnel competence requirements (especially on pilot licenses, to exempt from the general ATA-prohibition to operate an aircraft),[38] registration and airworthiness (especially on registration and certificates of airworthiness (CoA), following a general ATA-command for Dutch aircrafts),[39] flight operations (on having an air operator certificate (AOC) to exempt from the general ATA-prohibition to operate flights as a business (service)),[40] air traffic (concerning the obligation to have a captain on board of the aircraft and follow air-traffic rules)[41] and airports (to formally designate an area as airport, or to otherwise exempt from the general ATA-prohibition to take-off or land an aircraft).[42]

The ministerial RPA Regulation tailors the above aviation rules to the use of UAS, and in doing so grants general exemptions from some of the Crown decree rules (e.g. no requirement to have a captain on board of the UA).[43] It also provides for powers to grant exemptions for individual cases, derogating from its general rules. The latter exemptions are particularly relevant when it comes to UA-specific AOCs, known as ROCs (RPA Operator Certificate for organizations offering UA services to others).[44] In the category ROCs for professional services with UAS between 4 and 150 kg,[45] such exemptions may be applied for as regards, *inter alia*, exceeding the general maximum of operations above ground/water (120 m), the minimum horizontal distance from human crowds, continuous building and major roads (150 m) and ditto from rail-tracks, civil engineering works, vessels and vehicles (50 m).

At this stage, it seems that the grounds and possibilities for these exemptions, which could potentially be relevant to experimental development and use of UAS, do not offer much leeway. Exemptions apply only to performing aerial work concerning a vessel, vehicle, building or civil engineering work, provided that the relevant type of flight is allowed under the ROC.[46] Thus it seems that the currently existing exemptions are merely about normal derogation, which does not preclude some liberty space for more minor, de facto experimental technological practices, within the normal range of acceptable risk – where normal derogation and normal open texture overlap.[47] It does, however, not come with any explicit experimental intent or set-up, neither on technological applications nor on regulatory refine- or improvement. So, when it comes to major, disruptive experimentation, such as on fully autonomous UA-flights and BVLOS (beyond visual line of sight) flights, the Dutch UA regulation does not currently allow experimental derogation.[48]

What developers are also looking for[49] is the establishment of geographically defined experimental zones, whereby derogations would be granted in bundle, particularly on the above maximum distance and minimum proximity requirements, for a particular area (van der Veen 2017). Such area could be an airfield, for initial experiments, particularly on safety, to later be extended to other or the same but expanded areas, either for safety BVLOS, but also privacy *etc.*, in more vulnerable natural and/or human environments (i.e. living labs, such as university campuses). Ultimately, upon several consecutive steps over time, experimenting with in-between evaluations and across different scales or environments would move to increasingly more life-like experimental zones, in order to finally be able to upscale experimental findings to normalized use under normal rules. Ideally, such experimental zones would be accompanied with stakeholder involvement (including third parties) in preparation, execution and evaluation of the experiment, as a matter of proper experimental precaution, and perhaps support, but also to learn about related regulatory options. Thus, the public law permission to operate within an experimental zone would be meta-regulation to private or public-private regulation for experimental practices within. Again, ideally to experimenters the public law regime-permission for each zone would be mostly principle-based, whereas they themselves could, together with other stakeholders, dynamically set (real-time) rule-based experimental operation rules, to secure a proper and controlled execution.

While currently such smart experimental zones as geographically bundles of derogations do not exist in the Netherlands, recently a draft proposal for a 'Crown decree on test locations for drones' was made public for internet consultation.[50] While the consultation is now closed, we await its evaluation and follow-up (proposed) decisions. The key characteristic of the Crown decree is that test and experimentation locations would indeed function as experimental zones, and would, on the basis of one location safety certificate, exempt from the requirement of a pilot license and certification of the drone that is being tested. Clearly, the Dutch government seeks to move beyond the normal exemptions that currently exist. It remains to be seen how the definitive proposal will relate to concerns over the principles discussed in Section 3.2, but at this stage they are not considered prohibitive to the creation of experimental zones in terms of infringing (too much) on legal certainty, equality and proportionality, at least not from the perspective of safety concerns.

Meanwhile, the timing of the proposal for this new Crown decree is not coincidental, because the Dutch government is clearly inspired by and anticipating upon the EASA Notice of Proposed Amendment 2017-05 (A): Introduction of a regulatory framework for the operation of drones. This proposed amendment is in turn triggered by the proposed change of the EU 'Basic Regulation' (Regulation (EC) No 216/2008), whereby the competence of the EU will be extended, in the 'New Basic Regulation', to all UAS regardless of their maximum take-off mass (COM (2015) 613 final-2015/0277(COD)). Article 12 of the EASA proposed amendment elaborates upon this future broader regulatory scope, by regulating, under this new EU regime, the possibility of Member States to establish two types of zones: (1) zones where UAS operations are prohibited or restricted and (2) zones that alleviate certain requirements in the open or specified category of UAS. 'The first type of zones may be established for safety, security, privacy or environmental reasons, whereas the second one, for example, to facilitate flight testing of new designs or operations' (see entry 2.3.1.3 of the EASA proposed amendment). The consultation on the proposed amendment closed on 4 May 2017, and a final EASA proposal to the Commission was completed in the end of 2017; a decision by the Commission is expected to be made in the second quarter of 2018. Should all of this work out well, then the Dutch proposed Crown decree would indeed fit with Article 12, and meanwhile the proposed Crown decree sends out a message that this is indeed the desired way forward.

4.2. Designing an experiment by devolution – a Swiss and future EU example?

To experiment by devolution is to allow decentralized policy undertakings in one particular societal challenge where uncertainty abounds as regards the best policy way forward. By instituting powers towards parallel variance, it becomes possible to, in time, evaluate results and decide on a future policy approach, which may be centralized (as 'one size fits all') or indeed decentralized as a matter of normal devolution.

Take, for example, Switzerland, where Article 51, section 3 of the Aviation Statute[51] empowers the federal government to authorize the Swiss cantons to take measures to reduce environmental pollution and danger to persons and property on the ground for certain categories of UA. On this basis, the Swiss federal government has indeed issued a federal decree/ordinance on aircraft of special categories,[52] stating in Article 19 that the cantons can issue rules for unmanned aerial vehicles weighing less than 30 kg to reduce environmental pollution and danger to persons or property on the ground. Clearly, this approach may, by virtue of the legal discretion left to the cantons, lead to an interesting difference in policy, regulatory and legal practice, from which one could learn about how to achieve a proper regulatory balance between the 'pros' and (some of the) 'cons' of UAS below 30 kg. It is, however, worth emphasizing that both the statute and the ordinance do not hold any provision suggesting that indeed cantons shall introduce rules, so that a variation will develop, nor that there is any temporality, duty to report and evaluation of results. For all intents and purposes, this is normal devolution rather than experimental devolution.[53]

Still, one can well imagine a government to apply devolution in an experimental way.[54] Nevertheless, the approach of multiple, decentralized experimentation seems attractive only when the uncertainties are highly complex and the urgency of clarification outweighs the costs of a proper experimental scheme across many 'cases', with large numbers of stakeholders, and much more elaborate than experimentation by derogation. By devolution, issues may rise over inequalities and proportionality, plus the expectations that may rise on future policies allowing devolved policies, instead of devolution merely using communities as 'living labs' (Bergvall-Kåreborn et al. 2009, see also the website of the European Network of Living Labs). On that balance, applied to UAS, and particularly to the whole spectrum of UAS, not only to the 'below 30 kg' category, the method of experimentation by devolution seems one that is a more likely choice when: (a) there is, indeed, a high complexity and overall compelling urgency for many simultaneous experiments; (b) there is, due to complexity, not one single key constraining norm against which to undertake experiments by derogation and (c) while uncertainties relate to socio-cultural/ethical concerns that may vary strongly across the overall jurisdiction (i.e. ambiguity).[55] The overall urgency and jurisdictional concern could, for example, be one of securing the responsible functioning of (an 'internal market' for) transboundary UA operations – being one of the reasons behind the proposed introduction of a New (EU) Basic Regulation as mentioned in Section 4.1. Given socio-cultural/ethical differences, to experiment may not only be to allow for differentiated decentralized pathways towards a (minimum) standard norm for all, as a matter of combining experimentation (to determine such a standard), but also as a means of enhancing acceptance – acting, together with (local) stakeholders, upon an overall regulatory responsibility, without prejudice about whether experimental findings will in future allow for a measure of normal devolution.

The prospect of a New Basic Regulation in the EU and the proposed EASA amendment introducing a regulatory framework for the operation of drones and the notion of zones for drone testing and experimenting has meanwhile given rise to informal comments that perhaps Member State zones for experimenting by derogation could become part of a broader scheme of experimenting by devolution. Upon such a scheme information about the set-up and results from such experimentation would be shared among the Member States and with the EASA and the EU Commission to further joint learning about new UAS technology and its regulation.[56] At this point in time, it is impossible to predict whether this idea will be picked up by the EASA and/or the Commission. In the light of the technological advancements that lie ahead, such as of new UA-types and applications, for example, UA-swarms acting autonomously upon collective artificial intelligence, and also as regards the use of designed-in techno-regulation (such as geofencing), shared learning by devolution may be a sensible way forward.[57]

Finally, should experimentation by devolution be pursued as regards UAS regulation, then clearly the concern over Section 3.2 on principles, particularly of equality, participation and transparency, will be essential. Therefore, when communities act as living labs, such as across Member States, it is essential that members of communities are well involved in the setting-up, execution and evaluation of these experiments.

4.3. Designing an experiment by open texture

The aforementioned Chicago Convention holds an example, in Article 8, of what may be named an open-texture provision on UAS safety: 'Each contracting State undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft.' The key standard is only defined by pointing at a particular interest ('obviation of danger'), while leaving it to contracting States to decide how to go about achieving this, as long as it is through some form of 'control'. One may say this is an example of normal open-texture regulation, as there is no overarching experimental framework. As UAS technology is still very much in motion and it is uncertain which new drone types and types of uses will be developed and practised in future, normal open-texture clauses are likely to be of use in any body of UAS aimed regulations – as regulatory safety net. Specifications would only make more or less explicit references to reasonable efforts being made in avoidance of and, if unavoidable, mitigation of infringements upon safety, privacy, autonomy, dignity and other vital interest that may be at stake in UAS development and use – while applying a broad definition of UAS (development and use).[58] Ideally, such a provision will come with a scheme for systematic collection of information about novel UAS applications, particularly when these fall outside existing 'closed' and within such 'open-texture' provisions. The information gathered could be part of an institutionalized experimentalist scheme that also provides periodical regulatory evaluation – whether as experimentation by derogation and/or by devolution.

A more elaborate scheme would regard such provisions as meta-regulation in order to trigger private or public-private regulatory endeavours (Sabel, Herrigel, and Kristensen 2017), for example, by involving the JARUS. Clearly, such types of experimentation are of a more open structure than in experimentation by devolution and (certainly) more than in experimentation by derogation. Openness relates to stakeholder involvement, particularly in co-regulation, but one should carefully weigh where co- or (delegated) private regulation may kick-in, introducing 'closed texture', and where 'open texture' should remain to first allow interpretative praxis to develop a (further) variety of regulatory approaches. Public regulators, such as the EASA, should orchestrate this type of open-texture experimentation to secure a proper co-evolution of technology and regulation. This article will not further elaborate on this type of experimentation as regards UAS, but apparently it makes sense to keep an eye on opportunities for open-texture provisions, possibly linked to risk/impact assessment requirements, to experimentally improve and secure responsible co-evolution of UAS regulation and technology.

Needless to say, with open-texture (experimentation) the key concern on principles is that of legal certainty, with equality and proportion in its wake. The less clear the desired course of action is, given the prescriptive focus on the (un)desired result, the more variance such actions would have, and the less guidance on equality and proportionality would be generated. In case of grave uncertainty combined with huge urgency, such legal trade-offs may be acceptable. However, if conditions allow, a proper and confined experimental setting would probably be preferred.[59]

5. Conclusion

The leading question to this article is which modes of regulatory experimentation are available to regulators facing the disruptive challenges that come with the emergence of UAS technology, and which principles are guiding the choice of when, where and how to apply such experiments.

Where there is an urgency of considering a regulatory response to a new social challenge, and there is serious empirical uncertainty about expected technological or regulatory events and/or their consequences, experimental regulations can be introduced to deal with the new challenge. Taking into account the risk of failure as an intrinsic aspect of innovation, it is important to understand that the most significant function of regulatory experimentation is to yield useful information. Hence, a failure cannot preclude the potential usefulness of an innovation, but merely shows that an experiment fails to contribute to answering an urgent societal challenge.

However, such an understanding above should not be used as the excuse for framing an experimental regulation frivolously. The setting of experimental regulation should take into account both epistemic and legal values. As for the former, many factors could affect the legitimacy of the experimental result: the duration of an experiment, the area of application, the composition of population, the selection of empowered entities, etc. As for the latter, the legal values such as certainty, equality and proportionality must be secured; they are the overarching guidance for the choice of when, where and how to apply one or more regulatory experiments.

To date, no experimental regulation on UAS is available. The exploration of the possible design of UAS experimental regulations in this article is mostly based on the existing examples of 'normal' derogation, devolution and open texture and the prospect of feasible entry point for UAS experimental regulations in future. It resonates with newly proposed regulation, both at the national level (EU Member States) and at the EU level (by the EASA), indicating that there is political willingness to move forward by experimentation. Hopefully, the design proposed in this article will bring inspiration for regulators when facing the challenges coming with disruptive innovations and provides a model of 'future-proof' regulation.

Notes

1. Different types of aircraft include aeroplanes (fixed wing), airships (lighter than air) and helicopters (rotary wing).
2. The Netherlands: Regeling op afstand bestuurde luchtvaartuigen; Germany: Gemeinsame Grundsätze des Bundes und der Länder für die Erteilung der Erlaubnis zum Aufstieg von unbemannten Luftfahrtsystemen gemäß § 16 Absatz 1 Nummer 7 Luftverkehrs-Ordnung; France: Relatif à la conception des aéronefs civils qui circulent sans personne à bord, aux conditions de leur emploi et aux capacités requises des personnes qui les utilisent; Relatif à l'utilisation de l'espace aérien par les aéronefs qui circulent sans personne à bord; US: FAA (2016). Operation and certification of small unmanned aircraft systems. China: 轻小型无人机运行规定 [Provisions on the Administration of the Operation of Small Unmanned Aircraft System].
3. This article prefers to use the term 'non-military' instead of 'civil', because the former covers not only civil uses but also some types of state uses. According to Art. 3.1 (b) of the Convention on International Civil Aviation (Chicago Convention), '[a]ircraft used in military, customs and police services

shall be deemed to be state aircraft'. Hence, 'non-military uses' of UAS embrace law enforcement uses as well as professional and recreational uses.

4. Complexity or sensitivity, such as of numbers and categories of exposed citizens, types of buildings or natural surrounding, and of (more or less vital) socio-economic or socio-technological activity, will often, but not always, involve a large experimental geography.
5. Member States regulate military and state operations as well as civil UAS with an operating mass of no more than 150 kg and model aircraft.
6. For instance, UAViators, which is a humanitarian UAV network, has published its Humanitarian UAV Code of Conduct & Guidelines. Retrieved from http://uaviators.org/docs; see also, UVS International. Retrieved from https://uvs-international.org/.
7. For a detailed research on privacy and data protection in civil RPAS, see Finn et al. (2014).
8. The tort of negligence, for instance, imposes a duty to all parties on the causal chain to exercise a reasonable level of prudence in order to minimize any foreseeable harm.
9. For instance, under the EU law, the current insurance framework under the Regulation EC/785/2004 on minimum insurance requirements for air carriers and aircraft operators applies to UAS. Regulation (EC) No 785/2004 of the European Parliament and of the Council of 21 April 2004 on insurance requirements for air carriers and aircraft operators, Art. 2(g).
10. The top-down approach can be found, for instance, in the EU drone regulation-making by the European Commission and the EASA: it starts from the highest conceptual level and an overall structure, and then works down to details.
11. In this figure, Stirling categorizes four forms of incertitude: risk, uncertainty, ignorance and ambiguity.
12. Besluit van de Minister van Economische Zaken van 16 oktober 2009, nr. WJZ/9182801, houdende de instelling van een Taskforce Intelligente Netten.
13. According to Article 16, paragraph 3 of the Dutch Electricity Act, only the designated network operators are allowed to carry out grid operations.
14. Such as hierarchy-based, competition-based, community-based and architecture-based regulatory approaches (see Murray and Scott 2002, 502).
15. Such as first-, second- and/or third-party regulation (see Levi-Faur 2011, 8).
16. Such as *ex ante* or *ex post* public versus private law norms (see Smith 2016, 571–587). Regarding the modes of permissions with(out) reservations or facilitation, see Heldeweg (2015).
17. For the distinction between epistemic and legal values (the former are on achieving proper experimental results, the latter on securing values such as precaution, certainty, proportionality and equality), see Heldeweg (2016).
18. While the temporary experiment may involve temporary legislation, it may also follow upon legal acts based upon a provision to experiment within a permanent legislative framework. The above example of Dutch Decentralized Sustainable Electricity Generation is of this type.
19. This substantive general standard is not so much expressed by the general prohibition (or command) that lies behind the permit (or dispensation), as this is merely a 'rule of closure', to enable permitting (exempting); behind that rule, but rather through the policy purpose upon which there is discretion to tailor permission on a case-to-case basis.
20. Which may be that the permanent regulatory strategy will be one of permitting, but equally it could be that upon evaluation one abstract and general rule is introduced (for all).
21. Federalism is a less likely frame, as it does not agree well with the concept of using states within the federation as living labs for federal-level decisions about future regulatory approach – which implies that the power as such is a federal power.
22. Which may (then) be to continue devolution in the former ('end in itself') meaning of the word.
23. The element of evaluation should be clear from the outset to regard this as true experimentalism. Non-regulation, which could be seen to allow the maximum of experimenting space, would be hard to understand as such by lack of a normative frame for comparison, if only by setting a date to perform comparison and evaluation – well-argued 'eloquent

silence' would be the least necessary arrangement to speak of experimentation (see Heldeweg 2015).

24. Only detailing a desired or undesired result/outcome or interest to be served – possibly as meta-regulation, to inspire or trigger private rule-making – although this would by experimentalist only if accompanied with a sunset-clause (setting an 'end date', upon which to evaluate) (see Coglianese and Mendelson 2010).
25.

    The Right [to Challenge] will hand the initiative to communities and the bodies that represent them who have innovative ideas about how services could be shaped to better meet local needs, or could be run more cost effectively. It will ensure these ideas get a fair hearing and give them the time they need to organise themselves and develop their ideas to be able to bid to run the service.

26. The meta-regulatory framework may be of a public law nature, to be followed by private law regulation, e.g. standardization and certification (see Coglianese and Mendelson 2010).
27. Taken from a Dutch national government report (of July 2016): Kamerbrief Werken aan toekomstbestendige wetgeving en een toekomstbestendig wetgevingsproces. https://www.rijksoverheid.nl/documenten/kamerstukken/2016/07/06/kamerbrief-werken-aan-toekomstbestendige-wetgeving-en-een-toekomstbestendig-wetgevingsproces. Also see: Opinion of the European Economic and Social Committee on Future Proof Regulation (Exploratory opinion). 2016/C 487/07. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C_.2016.487.01.0051.01.ENG&toc=OJ:C:2016:487: TOC and summarizing: http://www.eesc.europa.eu/?i=portal.en.int-opinions.39287.
28. That is, Best Available Techniques – comparable to setting standards at ALARA levels: As Low As Reasonably Achievable.
29. All of these three may lead to (more flexible) sub-legislative/self-regulatory arrangements, such as policy guidelines, covenants and contracts – effectively as meta-regulation.
30. Note that open texture by delegation or decentralization may involve the power to derogate – not only to regulate *ab initio* or to regulate more specifically – whereby both regulatory modes, 'by derogation' and 'by open texture', are overlapping. This applies especially, but not only, when the higher or centralized standard is a rule of closure; having no other '*raison d'être*' than to facilitate lower/decentralized tailored regulation.
31. Theoretically, it may make sense to say that, alike other modes of future-proof regulation, one could also experiment with experimental regulation; but practically speaking that has little added value.
32. Even beyond the stochastic certainty of risk, where the chance of a certain outcome of events at a certain time and place is calculable.
33. An opposite frivolity is to consider any kind of regulation as an experimental affair that may or may not be successful, thus taking regulatees as guinea pigs in a grand societal living lab; to say nothing of framing this as a variation of Foucauldian governmentality, in which humans are to adjust to government policy aims.
34. The two aspects of legal certainty – accessibility and predictability – have been acknowledged by Belgian and German constitutional courts as well as the European Court of Justice and the European Court of Human Rights (see Popelier 2008, 54–55).
35. Regeling op afstand bestuurde luchtvaartuigen.
36. Wet luchtvaart.
37. Article 1.1 ATA defines aircraft as (in authors' translation): 'A vehicle that may be retained in the atmosphere as a result of forces, exercised upon the vehicle by the air, other than forces of the air against the earth's surface.' Definitions of aircraft subtypes, such as 'airplanes', 'helicopters', 'RPA' and 'RPAS' are listed in the ATA-based Crown decrees.
38. Besluit bewijzen van bevoegdheid voor de luchtvaart.
39. Besluit luchtvaartuigen.
40. Besluit vluchtuitvoering.

41. Besluit luchtverkeer.
42. Besluit burgerluchthavens.
43. Art. 15b R-RPA exempts RPA from the obligation of Art. 5.7 ATA to have a captain on board of the aircraft; the obligation to appoint a captain for each flight, in Art. 5.6 ATSA, remains in place.
44. Non-professional, recreational use of UAS does not fall within this scope, as Art. 1 R-RPA excludes these (an RPA: 'A remotely piloted aircraft, unmanned, not being a model aircraft.'). These model aircrafts fall within the scope of the ministerial regulation on model aircraft: Regeling modelvliegen.
45. With RPA-licensed pilots, registered UAs with a CoA, flying only at daytime, within 500 m from the pilot (i.e. only as (E)VLOS operation – i.e. within (Extended) Visual Line of Sight – see: Article 1 jo 3, para. 6, sub b. of the Crown decree on pilot licensing). With no flights above human crowns, continuous building, civil engineering works, industrial and harbour zones, including railways and major road; a requirement following from limitations in the remote pilot license (Art. 2 R-RPA) or a special RPA CoA (Art. 7 and Annex 3 R-RPA).
46. See Arts. 14-15 R-RPA. Also see the relevant Explanatory Memorandum (also in Dutch). https://zoek.officielebekendmakingen.nl/stcrt-2015-12034.html.
47. Without regulated, experimental arrangements, as regards temporariness, local placing, evaluation and experimental purpose. As regards overlap see *supra* note 30.
48. Only VFR flights (following Visual Flight Rules; at daylight, within (Extended) Line of Sight) are allowed. Also see the Explanatory Memorandum to R-RPA (Art. 13-15).
49. This broadly formulated assumption is based upon informal talks with stakeholders in the course of the Responsible Design of Drones and Drone Services project (Du and Heldeweg 2017).
50. Besluit testlocatie drones. The proposal was published on 26 September 2017 and the consultation closed on 24 October 2017.
51. Bundesgesetz über die Luftfahrt (LFG).
52. Verordnung des UVEK über Luftfahrzeuge besondere Kategorien (VLK).
53. *Nota bene*, we believe this to be a case of devolution, not of federalism: it is the federal government that decides that some legal policies can best be left to the cantons, given that aviation law is a matter of federal power; it does not follow from the constitution itself, as inalienable powers of the cantons.
54. While it is possible to be quite formal about the distinction between 'normal' and 'experimental devolution', particularly as regards protecting citizens' rights and related principles (e.g. equality and proportion) and as regards epistemic requirements of proper experimentation, of course there may be 'shades of grey' on a spectrum between both, and there is scope for policy learning also outside if 'experimental devolution' *stricto sensu*.
55. Experimentation by devolution may be about technology advancement, but in this view, are less particularly relevant when it comes to uncertainties about the appraisal of novel technology applications.
56. As in the Missing Link Conference in October 2017 (Regulating the Development of Unmanned Systems). https://www.dronesconference2017.eu/ (Accessed on 14 November 2017). Whether the same comments came up in the internet consultation on the EASA proposed amendment on the Introduction of a regulatory framework for the operation of drones is not yet known.
57. For an example of experimentation by devolution at EU level, in the area of renewable energy, within the renewable energy directive, see Heldeweg (2016).
58. Even broader formulations would speak merely of avoidance/mitigation of harm or damage caused to others by such development and/or use.
59. This is not to rule out open texture as a normal provision, but a stable setting, away from high and unexpected dynamics and with considerable (ability of) foresight, particularly among regulatees, would be preferred.

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