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Civilian UAV Deployment Framework in Qatar

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Abstract: Drone deployment in Qatar has been lagging behind that in other countries due to a wide range of reported challenges. This study developed a framework to address these operational gaps and serve as a roadmap for different stakeholders to enable drone applications for successful, safe, accountable and sustainable development. Moreover, the framework could help overcome key challenges and lay the groundwork for addressing other challenges facing UAV deployment in Qatar, thereby enabling Qatar to join the global efforts in this technological evolution. The framework was based on an analysis of the available data from previous guidelines for UAV operation and the identification of the challenges facing drone deployment in Qatar. The proposed framework was evaluated through interviews with key stakeholders in the Qatari drone steering committee. The outcomes from this evaluation supported the implementation of the framework with minor amendments and are ready to be put into practice by policymakers. In addition, it could be helpful for Gulf Cooperation Council (GCC) countries and other countries in the region to consider this framework in their efforts to facilitate drone deployment.

Keywords: drones; framework; GCC; Qatar; unmanned aerial vehicle (UAV)

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1. Introduction

In recent years, there has been an exponential increase in unmanned aerial vehicle (UAV) applications. Most civil operations currently occur in low-level uncontrolled areas or separate controlled airspaces due to safety concerns; however, the operational and technological capabilities of UAVs are expected to mature to the point where they can be deployed in both controlled and uncontrolled airspace [1]. UAVs have to meet the same safety and operational requirements as human-powered aircraft in the same national domains and must not pose greater risks to people, property, vehicles or boats than human-powered aircraft of the same class or category.

Demand for UAVs has been increasing continuously due to their enhanced flexibility and responsiveness. A distinguishing characteristic of UAVs is their ability to carry various devices, such as 3D cameras, sensors, monitors and IoT-based transceivers. UAVs are currently applied in multiple industries, including agribusiness, communications, safety and surveillance and the delivery of products and services [2,3]. The inherent advantage of UAVs is that they can gather 3D information from wider areas than intelligent road transport vehicles. They can fly at different elevations, which helps improve the quality of their wireless channels, extend the range over which they can communicate and significantly enhance their Wi-Fi signals and framework throughput and latency. However, drone operators require approval from the relevant country's radio communication channel to transmit high-resolution footage and images [4]. In addition, using UAVs rather than road-side units (RSUs), which are notoriously expensive to deploy and install, makes information technology service (ITS) operation more cost-effective [5]. UAVs can function effectively in real time, when necessary, which reduces the amounts of energy consumed and the costs of maintenance. However, the currently limited battery technology makes it difficult to use UAVs continuously as they require frequent trips back to their docking stations to recharge their batteries. Power management and optimisation strategies are needed to control the power of UAVs efficiently [6].

Researchers have investigated a number of UAV power management strategies involving various onboard hardware functionalities [7–9]. They have also investigated how to extend power management strategies in cooperation with other cyber–physical UAV networks that operate independently without human intervention. Spezzano [10] identified three categories of UAV implementation that have recently received significant attention: (1) methods for structural control and self-assembly [9,11]; (2) techniques for navigation and search functions [12,13]; (3) strategies for solving optimisation issues [14].

Despite Qatar's wealth and significant technological investments, UAV applications remain lacking compared to those in other countries. Thus, this research aimed to develop a framework to tackle current challenges and improve UAV deployment in Qatar, which could also be helpful for other countries in the region. To achieve this, we reviewed the UK and EU regulations and adapted these guidelines to satisfy Qatar's operational needs. There are many similarities between the UK and European regulations and those in North America.

2. Literature Review and Theoretical Prototype

2.1. Guidance for Unmanned Aircraft System Operation in UK Airspace

The Civil Aviation Act of 1982 regulates civil aviation in the UK under the supervision of the Department for Transport. The Civil Aviation Authority [15] is responsible for aircraft registration, air navigation, aircraft safety (including airworthiness), air traffic control, the certification of aircraft operators and airport licensing. The CAA has also developed policies, guidelines, operational authorisation, safety notifications and instructions for UAV operation. Additionally, it grants public approvals and exemptions and oversees the operation of organisations and individuals with permissions and licenses, as well as enforcement activities. The most crucial aspect of unmanned aviation is the operation being undertaken, rather than who or what is performing that operation. There are several gaps between the traditional aviation paradigm based on human-powered aircraft and this new and rapidly growing industry. Currently, in the case of adverse events or accidents, liability is mainly contextualised to the location of the incident or accident. The CAA is concerned with the risks that UAV operation poses to third parties, and authorities are now debating a proposal to amend the Air Navigation Order. This proposal aims to safeguard the public by placing operational limits on UAVs that weigh less than 7 kg, the operation of which poses a real risk of harm to the public. Operators with UAVs weighing less than 7 kg would be required to obtain CAA permission under this proposal, which is comparable to the requirement for operators with UAVs weighing 7–20 kg [16]. A visual line of sight (VLOS) is an essential aspect of flying in UK airspace. UAV pilots must always be able to see their aircraft and the surrounding airspace when the UAVs are in the air. VLOS operation allows pilots to watch their aircraft's flight path and keep it clear of obstructions, which is essential to avoid crashes. Correctional lenses are permitted, but binoculars, telescopes and other image-enhancing equipment are not. UAVs cannot fly out of sight of their remote pilots under VLOS operation.

There are no restrictions on VLOS operation at night. The basic VLOS principles still apply (i.e., remote pilots must still be able to see their aircraft and the surrounding region). Any applications for operational authorisation that incorporates VLOS operation at night must include a "night operation" section in the operational manual that outlines the operating procedures that are to be followed. Similar to human-powered aircraft, UAV pilots must have sufficient intellectual, physical and mental maturity to acquire, retain and demonstrate the essential theoretical knowledge and practical abilities that are required to learn to fly. Continuous evaluations during training and, when necessary, exams are required to show the acquisition and retention of theoretical information [17]. In the UK, the Civil Aviation (Insurance) Regulations 20054 manage the insurance requirements for UAVs.

2.2. EASA Regulatory Framework for UAV Deployment

UAVs are becoming more common in European airspace and pose safety, security and integration concerns. Comprehensive legal frameworks are necessary to ensure safe UAV traffic management while facilitating the safe and harmonious operation of UAVs within the existing air traffic environments across European airspace [8]. In response to requests from the European Commission, member states and stakeholders submitted proposals to EASA, which is an operation-centric, proportional, risk- and performance-based regulatory framework for all unmanned aircraft, and competent national authorities (NCAs) were chosen by each EU member state, which are collectively responsible for overseeing and enforcing airspace laws [18].

EASA and the NCAs oversee all manned and unmanned operators and pilots, aircraft and related equipment, among other factors that are covered by the regulations. In the event of an airspace violation, they must conduct investigations and inspections and take all necessary enforcement steps to terminate the infringement. The European Union Aviation Safety Agency (EASA) is responsible for the EU-level supervision of operators who are based in non-EU member states [18].

An EASA regulatory framework [16] for the U-space that comprises rules and regulations for the use and control of UAVs in urban areas is being considered for adoption in the EU. Establishing the U-space airspace and facilities for U-space services is critical in responding to the anticipated expansion of UAV operation (particularly in low-level airspace), which is expected to exceed the current volume of human-powered aircraft traffic. Current air traffic management (ATM) systems are overburdened by UAVs.

The European legislative framework [16], allows for the harmonised implementation of U-space services and procedures and is focused on ensuring the safe control of UAV traffic. U-space enables the management of increasingly complicated and long-distance UAV operation and ensures that more complex activities, such as beyond visual line of sight (BVLOS) and urban air mobility (UAM) operation, are supported by services that improve safety, security, privacy and efficiency. The requirements for U-space airspace and U-space services are predicted to increase with UAV traffic and complexity, potentially covering all BVLOS and UAV operation with increasing levels of autonomy.

The three primary types of UAV operation that are covered by the amendments are as follows:

- UAV operation in the “open” category, which does not require prior approval by the competent authority or prior declaration by the operator.
- UAV operation in the “specific” category, which requires prior authorisation by the competent authority that considers the mitigation measures identified in operational risk assessments. Declarations by operators are sufficient in some standard scenarios, as is operators holding a light UAV operator certificate (LUC) that covers the proposed operation. The “certified” category of UAV operation requires the certification of UAVs, licenced remote pilots and competent authority-approved operators to assure a sufficient degree of safety because of the hazards involved [19].
- Currently, most national space monitoring agencies, such as the Federal Aviation Administration (FAA) in the USA and EASA in Europe, allow drones to be operated with some restrictions. As well as the restrictions on weight and sensors (such as cameras), there are restrictions on altitude, professional training and certification, drone registration and prior permission for using controlled airspace (FAA News, 2016). The most important restriction is that drones must operate within the visual line of sight (VLOS) of their operators.

2.3. Reported Challenges Facing UAV Deployment in Qatar

In a previous study [20], we identified the challenges facing the deployment of drones in Qatar using a political, economic, sociological, technological, legal and environmental (PESTLE) analysis, which was conducted to determine the different challenges perceived by various stakeholders [21]. The study’s outcomes revealed that the top five challenges facing UAV deployment in Qatar are legal, environmental, technological, political and social, as shown in Figure 1. These challenges justify the need for a framework to serve as a roadmap for UAV deployment in Qatar. The legal challenges have been reported to be the most significant, so the framework had to have the primary aim of providing a legal foundation for drone deployment in Qatar, which would in turn enable Qatar to overcome the other challenges. The other stages of the framework were modelled on the CAA's guidance and policy on unmanned aircraft system operation in UK airspace [15] and EASA's EU Regulations for UAVs [16]. Qatar follows the guideline standards that are specified by the UK and the EU.

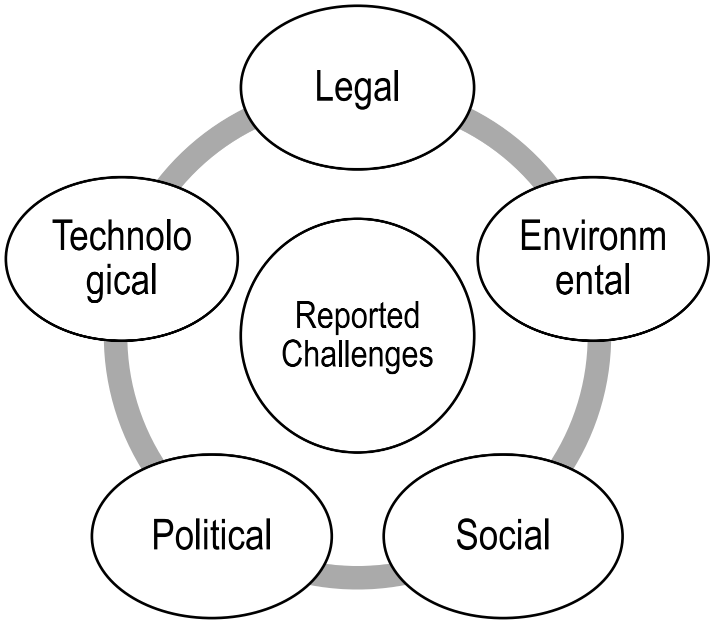

Figure 1. Top five challenges facing UAV deployment in Qatar. Source: the authors.

3. Research Design Methodology

The research methodology design was based on the theory of change, which dates back to the 1930s [22]. This theory explains how activities generate series of results that can contribute to achieving intended impacts. Hence, it has been widely used for interventions, events, policies, strategies and programmes because it can help establish concrete plans based on correctly identifying objectives and activities. This enables different stakeholders to make decisions and respond to emerging issues. However, the theory of change is defined by its process-level analysis, which includes inputs, outputs, outcomes and impacts and is also called a "logical framework" or "logframe" [23].

Using the theory of change as a methodology to develop the framework could support future UAV applications and development in Qatar as it could help identify series of processes that could effectively contribute to the success of both the development and evaluation phases. Rigorously analysing the causal relationships between the engagement of stakeholders in the planning process and the identification and achievement of long-term goals can uncover potential issues in reaching those goals [24]. Furthermore, utilising the theory of change to produce a causal relationship-based framework can help simplify complex issues, which can subsequently drive change because UAV operation and applications require different stakeholders from different organisations to work together in complex environments and contexts [25].

Before the construction of the research design logframe, as shown in Figure 2, it was essential to identify the fundamental purpose of the framework, which was found to be the establishment of a roadmap for UAV deployment in Qatar that is easily understood by different stakeholders. This could help enable the future deployment of civilian UAVs by addressing the existing challenges and learning from the experiences of the UK and the EU.

This process could also facilitate Qatar joining the efforts of the International Civil Aviation Organisation (ICAO) to integrate UAVs safely and efficiently into the global airspace.

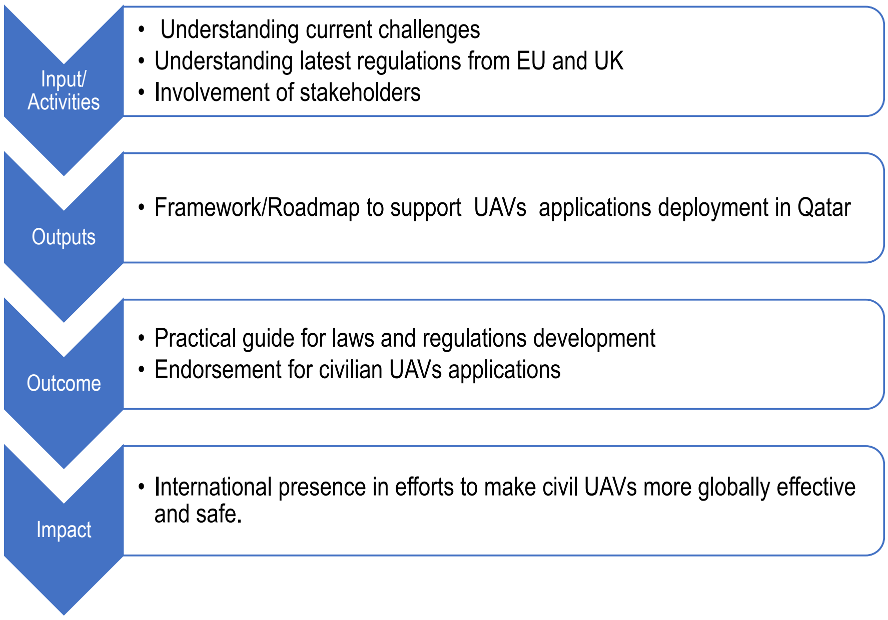

Figure 2. Research design logframe. Source: the authors.

Framework Development Method

The framework development method was established based on design science guidelines that seek to expand the boundaries of human and organisational abilities by producing novel and pioneering artefacts [26]. Figure 3 shows how the framework was developed in five stages. The critical stages were as follows: define the purpose of the framework; gather information by understanding the situation; conceptualise the framework; invite stakeholders to engage in the evaluation of the framework; develop the aligned framework.

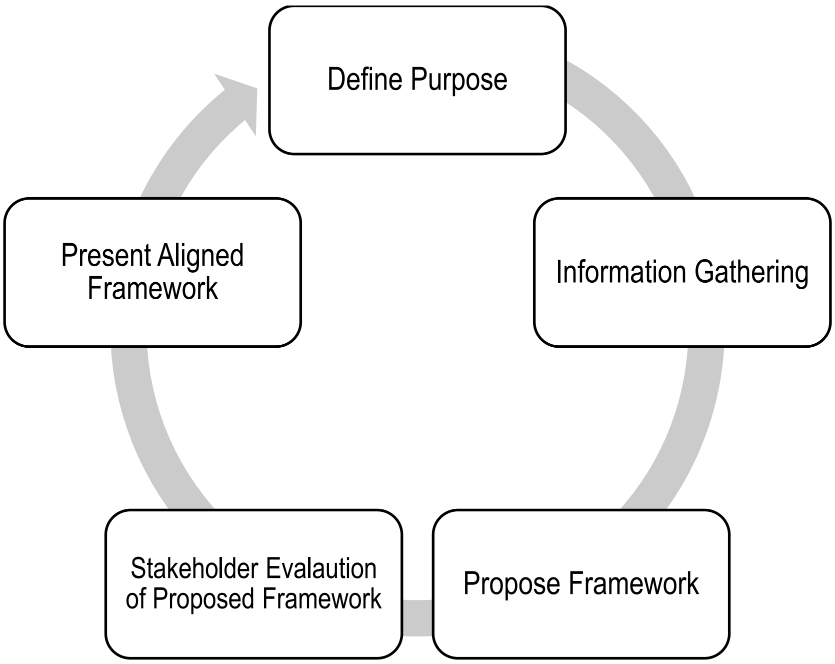

Figure 3. Framework development method. Source: the authors.

Information gathering was undertaken in two phases. The first phase involved studying the latest UK guidance for UAV operation, as published by the Civil Aviation Authority [15] in CAP 722 (Unmanned Aircraft System Operations in UK Airspace: Guidance and Policy) and the European Union Aviation Safety Agency (EASA) (Civil Drones (Unmanned Aircraft) EU Regulations) [16]. EASA was selected as it provides guidance that has been approved by EU member states. The UK is currently undergoing a major regulatory reform following Brexit, which could provide a roadmap for emerging UAV contexts, such as the GCC. The second phase involved identifying the current challenges facing UAV deployment in Qatar, as presented in the literature review.

4. Proposed Framework

The proposed framework is divided into four key stages, as shown in Figure 4. This could help facilitate task allocation among different stakeholders and enable collaboration within complete cycles of deployment and future improvement.

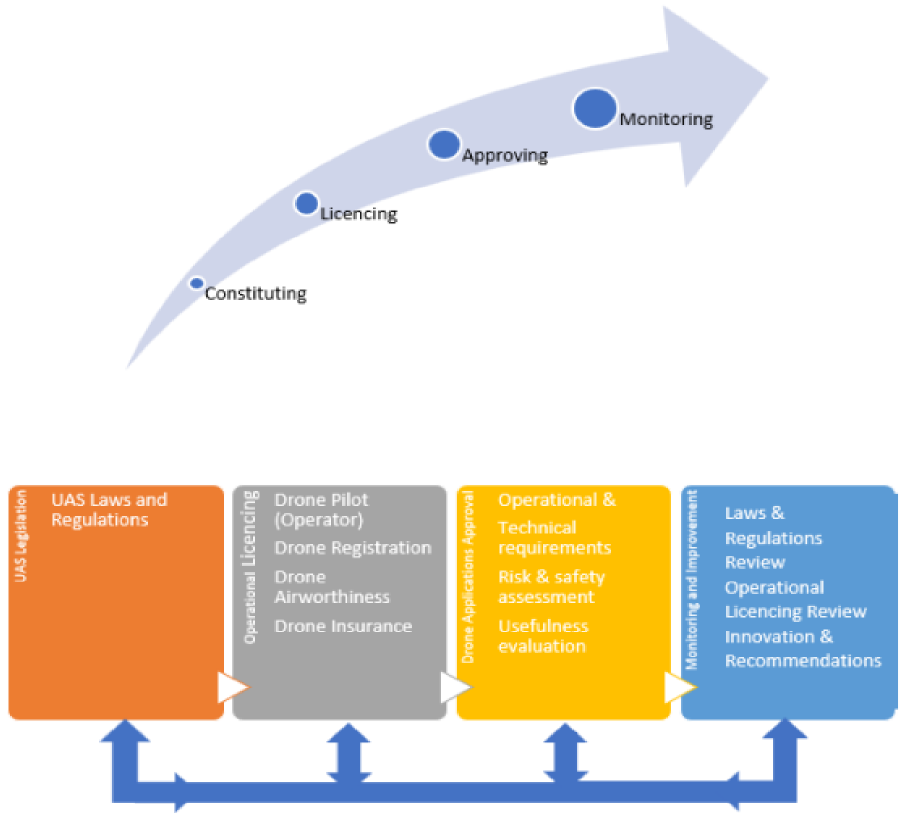

Figure 4. Proposed framework.

4.1. Framework Elements and Stages

4.1.1. Stage 1: Constituting

Qatar could benefit from various UAV applications, including (but not limited to) mapping, surveillance, construction, maintenance, inspection and firefighting. UAVs are vehicles that can serve as platforms for the different types of sensors that are required for different applications, including cameras, lasers, radars and heat sensors. Safe UAV navigation is a fundamental aspect that minimises risks to other airspace users, as well as people and property on the ground and the UAVs themselves. Therefore, each country should have clear legal frameworks to regulate UAV planning and operation [27]. Developing effective UAV regulations in Qatar is the essential first step in joining the global efforts initiated by the ICAO [28] to enable the safe and efficient integration of UAVs into the international airspace. As such, the first stage constitutes an essential and challenging theoretical and legal phase to establish laws and regulations to govern UAV use in Qatar, with the view to impact neighbouring countries and the global UAV situation. To initiate this stage, this study adopted positive regulatory examples from EASA [16] and the CAA [15].

4.1.2. Stage 2: Licensing

The second stage covers the actual enforcement of operational license requirements for the humans and systems involved in UAV operation, including the following:

- UAV pilot

Pilots remotely operate UAVs to perform surveying, filmmaking and aerial photography. Airborne surveys can be conducted, digital images and data can be gathered and maps can be created using these flight data. To obtain a pilot ID, pilots must complete a theoretical exam. All operators of UAVs and model aircraft must obtain an operator ID [15,29].

- UAV registration

In the UK, most UAVs and model aircraft must be registered before they can be flown outside [15,29].

- UAV airworthiness

Airworthiness is a measure of an aircraft's suitability for safe flight. Airworthiness certificates are issued by the civil aviation authority of the state in which the aircraft is registered. Airworthiness can be maintained by performing the required maintenance actions. The airworthiness of an aircraft or an aircraft component refers to whether it meets the requirements for safe flight, within allowable limits. There is a particular emphasis on three essential elements: safe conditions, compliance with required criteria and acceptable limitations [30,31].

- UAV insurance

UAV insurance protects against damage to UAVs and claims filed by other parties whose property has been harmed by a UAV. It is akin to conventional motor insurance. If a pilot lost control of their UAV and it crashed into someone's car, they would be covered for damage to both the UAV and the car. This insurance is mandatory to fly UAVs in UK airspace [15,29].

As explained previously, UAVs have a wide range of applications, including (but not limited to) surveillance, inspection, monitoring, mapping, mining, construction, agriculture, energy, firefighting, healthcare and logistics. Hence, different challenges, including weather conditions and human factors, can influence optimum UAV performance and impair safety and security. Therefore, the right pilot competency levels, registration systems, airworthiness mechanisms and insurance requirements are necessary safeguards for this new UAV revolution [6].

4.1.3. Stage 3: Application Approval

The third stage involves approving UAV applications, which is advanced and requires that applications are designed according to the best standards in order to enable effective deployment without imposing any risks to the safety of the public or those involved in the device operation. It is essential to follow systematic approaches to investigate the effectiveness of drone applications to serve their intended purposes. Various approaches have been developed, such as the well-known engineering system development life cycle (SDLC) [32], which comprises five stages: inception, which defines user requirements; design, which needs to serve the intended goal; implementation, which involves establishing a prototype and testing it; maintenance; audit or disposal, which evaluates whether to continue to refine and improve the prototype, considering risk analyses. A similar five-point framework based on the design thinking methodology was proposed by Mollá [33]. Their five stages were as follows: empathise, i.e., better understand user needs; define, i.e., state user needs and problems; ideate, i.e., test assumptions and generate ideas; create a prototype, i.e., present real examples; test, i.e., evaluate performance in actual trials.

Application approval ensures that the correct procedures are followed and that the best possible outcomes are achieved from the design, prototyping and evaluation stages. The most critical aspect is the assessment of UAV operational risks, which indicates the safety levels associated with applications under actual circumstances. Hence, evaluating UAV operational risks is the first significant step towards establishing safe flight missions for specific applications via the due consideration of the reasonable and acceptable levels of risk, as UAV operation involves different agencies or organisations [27]. However, it is essential to balance the various complex factors and data from public, technological, political and commercial perspectives [19]. The proposed framework splits this stage into three phases: defining the technical requirements, assessing the risks and safety levels and evaluating the usefulness of new applications. These phases were developed to help both operators and regulators.

4.1.4. Stage 4: Monitoring

As UAV technology is evolving rapidly, monitoring is essential to learn lessons from real experiences as quickly and efficiently as possible to ensure that the regulations are fit for the purpose and to re-evaluate all aspects related to UAV deployment and operation. All stakeholders involved in the preceding three stages must actively follow the monitoring and evaluation stage to maximise the efficiency of UAV deployment and ensure that guidelines are followed. An excellent example in this regard is the EASA regulatory framework for drone service delivery [16]. This stage identifies technological problems and potential disruptions, ensures the timely alignment of business models and incorporates new UAV technologies to sustain competitive advantages [34]. In this way, Qatar could help commercial parties become more competitive and productive.

4.2. Framework Evaluation

To evaluate the proposed framework, we decided that interviews were the most effective method to gather feedback from key stakeholders who participated in a grievance study with the aim of identifying challenges related to UAV deployment applications in Qatar. Semi-structured interviews constitute a well-known qualitative data collection method and are highly advantageous for both interviewers/researchers and participants as they allow interviews to remain focused on the phenomena of concern while allowing participants to disclose contextually rich data based on their own in-depth knowledge and perspectives [35,36]. The interview form used in this study was adapted from that of Al-Yafei [37], who successfully proposed a similar framework for another context. The interview form included closed questions and open questions to allow the participants to discuss their opinions about framework elements and offer suggestions for improvement based on their professional perspectives relating to the drone industry. Following the construction and validation of the interview form, in which three professionals made sure that it was correct and could be understood by stakeholders from different professional backgrounds [38], interviews were conducted with 27 stakeholders and their answers were digitised to enable better data analysis. The 27 interviewees were selected to participate in the evaluation based on their previous involvement as members of the Qatari stakeholder's advisory committee (known as the "Remote Aircraft Regulation Committee"), which has 40 members, meaning that they had a good understanding of issues related to drone deployment and the need to development a regulation framework.

4.3. Data Analysis

Our data analysis was conducted using SPSS [39]. The analysis began by evaluating the reliability of the responses, followed by a descriptive comparison between the responses from different stakeholders. Finally, the suggestions provided by the participants were collated and analysed.

4.3.1. Statistical Analysis

Our statistical analysis included a descriptive analysis of the mean, standard deviation (SD), frequency, percentage and degree values, with length of period scores that were calculated based on the following formula:

$$Length\ of\ period = \frac{Upper\ Bound - Lower\ Bound}{Number\ of\ levels} = \frac{5-1}{3} = 1.33$$

Consequently, the number of period levels was categorised as follows: low (1–2.33); medium (2.34–3.67); high (3.68–5). Cronbach's alpha was used to determine the stability of the study instrument and one-way ANOVA testing was used to compare the results from different groups [39].

4.3.2. Sample Reliability

For the responses to be reliable, they had to have a Cronbach's alpha coefficient of at least 0.6, indicating that the questions in the questionnaire measured the variables that they were supposed to and thereby demonstrating that the questionnaire was a consistent and dependable instrument. The Cronbach alpha coefficient in this study reached (0.87), indicating that the tool was valid for the study purposes [40].

4.3.3. Demographic Characteristics

Figure 5 and Table 1 shows that the participants worked in diverse sectors. The largest cohort worked in the fire service (n = 4; 14.8%), followed by research and higher education (n = 3; 11.1%) and military aviation (n = 3; 11.1%). The remainder of the participants worked in other sectors in equal proportions (n = 2; 7.4%), except for one participant (3.7%) who was employed in the civil aviation sector.

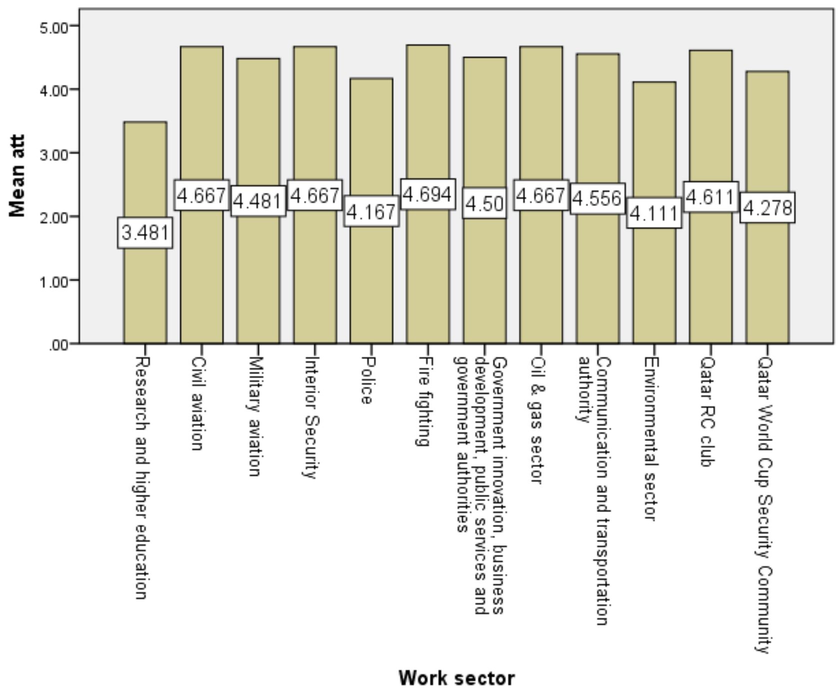

Figure 5. The degree of satisfaction with the DFQ by work sector. Source: the authors.

Table 1. One-way ANOVA testing for the degree of satisfaction with the DFQ by work sector.

Work Sector	N	Mean	SD	df	Mean Square	F	Sig.
Research and higher education	3	3.48	1.957	11	0.337	0.542	0.845
Civil aviation	1	4.67					
Military aviation	3	4.48	0.339				
Interior security	2	4.67	0.157				
Police	2	4.17	0.236				
Fire service	4	4.69	0.229				
Government innovation, business development, public services and government authorities	2	4.50	0.236				
Oil and gas	2	4.67	0.000				
Communication and transportation authorities	2	4.56	0.314				
Environmental services	2	4.11	0.943				
Qatar RC Club	2	4.61	0.079				
Qatar World Cup Security Community	2	4.28	0.393				
Total	27	4.39	0.708				

Source: the authors.

4.4. Satisfaction with Current Civilian UAV Deployment Framework in Qatar

Satisfaction with the current civilian UAV deployment framework in Qatar (i.e., the "DFQ") was measured by participant agreement with various aspects of satisfaction, as shown Table 2. Table 3 shows the mean scores of all responses representing participant degree of satisfaction with the DFQ. It can be seen that all items achieved a high degree of agreement (ranging between 4.04 and 4.63) and that the "Framework is clear and easy to understand" item earned the highest degree of agreement. By contrast, the "Framework is comprehensive (includes all essential aspects)" achieved the lowest degree of agreement. The averages indicated a high degree of satisfaction with the DFQ (4.39). Table 3 and Figure 4 show the degree of satisfaction with the DFQ by work sector. A one-way analysis of variance (ANOVA) was conducted to determine whether work sector affected the degree of satisfaction with the DFQ. The results are shown in Table 4 and indicate that the F-value was not statistically significant at $\alpha \leq 0.05$. Therefore, we could conclude that work sector did not significantly affect the degree of satisfaction with the DFQ. In summary, this study found that the degree of satisfaction with the DFQ was high, with no significant differences between work sectors.

Table 2. Demographic information.

Work Sector	N	%
Fire service	4	14.8
Research and higher education	3	11.1
Military aviation	3	11.1
Interior security	2	7.4
Police	2	7.4
Government innovation, business development, public services and government authorities	2	7.4
Oil and gas	2	7.4
Communication and transportation authorities	2	7.4
Environmental services	2	7.4
Qatar RC club	2	7.4
Qatar World Cup Security Community	2	7.4
Civil aviation	1	3.7
Total	27	100.0

Source: the authors.

Table 3. The degree of satisfaction with DFQ.

	Mean	SD	%	Degree
Framework is clear and easy to understand	4.63	0.688	92.6	High
Framework is efficient	4.59	0.888	91.9	High
Framework is practical	4.41	0.888	88.1	High
Framework is applicable	4.41	0.844	88.1	High
Framework is systematic and well structured	4.41	0.888	88.1	High
Framework is appropriate for Qatar	4.37	0.884	87.4	High
Framework is easy to implement	4.33	0.784	86.7	High
Framework helps stakeholders to understand civilian UAV deployment needs	4.30	0.993	85.9	High
Framework is comprehensive (includes all essential aspects)	4.04	0.940	80.7	High
Average	4.39	0.866	87.7	High

Source: the authors.

Table 4. The degree of satisfaction with DFQ by work sector.

	Sector																							
	A		B		C		D		E		F		G		H		I		J		K		L	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
I	4.00	1.732	5.00		5.00	0.000	5.00	0.000	4.00	0.000	4.75	0.500	4.50	0.707	5.00	0.000	4.50	0.707	4.50	0.707	4.50	0.707	5.00	0.000
II	3.33	2.082	4.00		4.67	0.577	4.50	0.707	4.50	0.707	4.75	0.500	4.50	0.707	5.00	0.000	4.50	0.707	4.00	1.414	4.50	0.707	4.50	0.707
III	3.33	2.082	5.00		4.00	0.000	4.50	0.707	3.50	0.707	4.50	0.577	4.50	0.707	4.50	0.707	4.00	0.000	3.00	1.414	4.50	0.707	3.50	0.707
IV	3.33	2.082	5.00		4.67	0.577	4.50	0.707	5.00	0.000	4.50	0.577	4.50	0.707	4.50	0.707	5.00	0.000	4.00	0.000	4.50	0.707	4.00	0.000
V	3.67	2.309	5.00		4.67	0.577	5.00	0.000	4.50	0.707	5.00	0.000	5.00	0.000	4.50	0.707	5.00	0.000	4.50	0.707	4.50	0.707	4.00	1.414
VI	3.67	2.309	5.00		4.33	0.577	4.00	0.000	4.00	1.414	4.75	0.500	4.50	0.707	5.00	0.000	4.50	0.707	4.50	0.707	5.00	0.000	4.00	0.000
VII	3.33	2.082	4.00		4.00	0.000	5.00	0.000	3.50	0.707	4.75	0.500	5.00	0.000	4.50	0.707	4.50	0.707	4.50	0.707	5.00	0.000	4.50	0.707
VIII	3.33	2.082	4.00		4.33	0.577	4.50	0.707	4.00	1.414	4.75	0.500	4.00	0.000	4.50	0.707	5.00	0.000	3.50	2.121	4.50	0.707	5.00	0.000
IX	3.33	1.528	5.00		4.67	0.577	5.00	0.000	4.50	0.707	4.50	0.577	4.00	0.000	4.50	0.707	4.00	1.414	4.50	0.707	4.50	0.707	4.00	0.000
Av.	3.48	1.957	4.67		4.48	0.339	4.67	0.157	4.17	0.236	4.69	0.229	4.50	0.236	4.67	0.000	4.56	0.314	4.11	0.943	4.61	0.079	4.28	0.393

Findings from evaluation

I. Clear and easy to understand
II. Systematic and well structured
III. Comprehensive
IV. Applicable
V. Efficient
VI. Practical
VII. Appropriate for Qatar
VIII. Helps stakeholders to understand needs
IX Easy to implement

M: Mean
SD: Standard deviation

A. Research and higher education
B. Civil aviation
C. Military aviation
D. Interior security
E. Police
F. Fire service
G. Government innovation, business development, public services and government authorities
H. Oil and gas
I. Communication and transportation authorities
J. Environmental services
K. Qatar RC Club
L. Qatar World Cup Security Community

Source: the authors.

4.5. Stakeholder Suggestions (Recommendations and Limitations)

Tables 5 and 6 illustrate the suggestions that were provided by the stakeholders and the limitations that were identified by different stakeholders with the actions that were taken to address them, respectively.

Table 5. Stakeholder suggestions.

Stakeholder Suggestion	Comment
Focus more on the regulations since there are no regulations for drones in Qatar so far	Addressed in Stage 1
Fostering the capabilities of UAVs can most easily be accomplished by removing the technical and regulatory barriers to civilian drone deployment, so Qatar must endeavour to develop its current low-level technologies into technologies that can be readily produced commercially (then, the costs would have lower impacts on market development) and develop technologies and policies that facilitate UAV deployment in the national air space of Qatar; when this occurs, innovation and entrepreneurship could drive down the costs of UAVs and increase their safety, reliability and operability	Addressed in Stages 1, 3 and 4
Some technical modifications could improve the framework	Not clear
Drones offer numerous benefits and have vast potential in academic communities, both in terms of deploying new programs of study and augmenting existing research; however, the proposed framework should accommodate challenges and manage UAV use on computers	Addressed in Stage 3
The short flying times should be enhanced through this framework	Outside scope of research
Areas of study should be elaborated	Addressed in all stages
The internal structures of UAVs should be shown	Outside scope of research
Conceptual sketches of UAVs should be shown	Outside scope of research
The framework is very generic and needs to be more detailed	Not clear
The framework has many flaws and is a generic model without experimental designs; it should be developed based on experimental designs that ultimately prove the existence of UAVs (Stadium Security Office workers do not think that this framework would help design security measures)	Addressed in Stage 3
Drone flight times need to be improved	Outside scope of research
The graphics should be reformatted to be more professional	Addressed in all stages
The framework should be engaged in stadium security measures	Addressed in Stage 3
Other vehicles could offer some helpful information	Not clear

Source: the authors.

Table 6. Limitations of the proposed framework that were identified by the stakeholders.

Weaknesses/Limitations	Comment
The terminologies are weak and should be more accurate and professional	Addressed in all stages
The framework handling process and its practical implications are weak	Not clear
It is useless in mortal combat	Not clear
The systematic procedures to enhance battery life are under-researched	Outside scope of research
Time frame	Addressed in all stages
It is limited to technical and operational skills; human resources and the influence of stakeholders need to be addressed	Addressed in all stages
Areas should be specified in each country	Not clear
Lack of practical and experimental designs	Addressed in Stage 3
Needs longer battery life	Addressed in all stages

Source: the authors.

5. Aligned Framework

The aligned framework is shown in Figure 6, including the improvements that were suggested by the participants and the timeframe of each stage. It should be noted that these timeframes are merely estimations to provide some guidance; however, policymakers should be able to identify a realistic timeframe for each step. Developing the human capacity that is needed to propel Qatar towards the objectives of the Qatar National Vision 2030 requires the nation's most talented and brightest stakeholders to be encouraged to pursue education in STEM (science, technology, engineering and mathematics) fields. This study aimed to inspire stakeholders to achieve their academic goals and raise their awareness of the numerous ways in which they could contribute to the development of Qatar by pursuing education in technological or scientific fields.

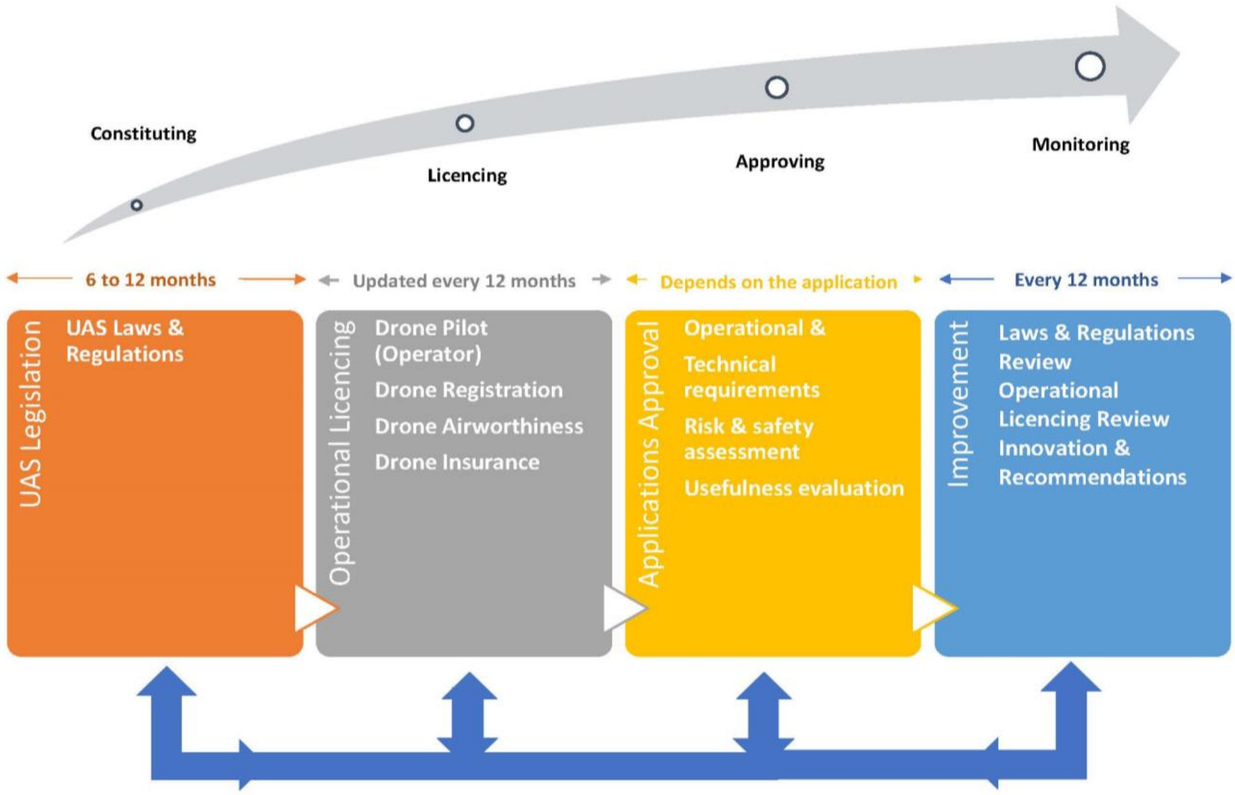

Figure 6. Aligned framework. Source: the authors.

6. Conclusions

To support the country's efforts to become a modern state with state-of-the-art technologies, including the safe operation and application of civilian UAVs so as to achieve economic and technological benefits, Qatar needs to join the global efforts endorsed by the ICAO to integrate UAVs into the global airspace in a safe and effective manner. This aligns with the push for public and private organisations to achieve digital transformation in line with the Qatar National Vision 2030. The proposed framework in this study was constructed based on the theory of change and involved a wide range of stakeholders from different backgrounds. Inspired by the efforts of EASA and the CAA, our framework was evaluated by a wide range of stakeholders, including 27 members of a previously formed national committee, who provided advisory support for the government during the development of laws and regulations to govern UAV deployment in Qatar. These stakeholders had an in-depth understanding of civilian UAV technological advancements in other countries, as well as the UAV regulatory journeys of those countries.

It was clear from our analysis that the proposed framework obtained a high degree of acceptance among the participants, with no statistical differences between groups. The results from the first part of the questionnaire (with structured, closed questions) demonstrated that the participants had high levels of confidence that each part of the framework would satisfy the mission of improving the deployment of drones in Qatar, thereby enabling Qatar to catch up with other countries that have made significant progress in UAV technologies and infrastructures. The second part of the questionnaire elicited insightful suggestions and highlighted some shortcomings of the original framework, which were addressed in the aligned version. Nevertheless, there were some suggestions and identified weaknesses that were either unclear or beyond the scope of framework, which was to initiate and establish the application and operation of drones in Qatar. Hence, it is essential to highlight that the theory of change emphasises that once a framework or policy is established, it should be revised regularly to accommodate new and emerging dynamic changes and remain responsive to changing internal and external factors.

This framework could serve as an excellent road map to enable different stakeholders to contribute to the development of the UAV industry and supporting facilities in Qatar, thereby allowing the country to establish an international presence in the global efforts to make civilian drones effective and safe. The next stage is to put this framework into practice and regularly conduct validation and assessment studies in order to continuously monitor and improve the framework according to emerging data and stakeholder requirements and continue to provide sustainable support for the UAV industry in Qatar. In addition, this study's results could contribute to filling the gaps in the literature on the specific subject of civilian UAV deployment, particularly in Qatar but also in other countries, as well as supporting future research agendas.

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