

Article

Unoccupied Aerial Systems: A Review of Regulatory and Legislative Frameworks in the Caribbean

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Abstract: Unoccupied aerial systems (UAS) have become pervasive for many small-scale and large-scale aerial operations around the world. Their implementation in small island states like those of the Caribbean is particularly useful because they are relatively cheap and versatile. Despite being used for more than a decade in this part of the world, however, many territories in this tropical region still do not have adequate regulatory and/or legislative frameworks to support UAS operations. UAS applications are varied in the Caribbean, ranging from recreational use and coral reef monitoring to public utilities and national security support. In this paper, we present the first collective assessment of existing UAS regulatory and legislative frameworks in the Caribbean region. Data on four factors that are critical to UAS operations was collected and analyzed for the fifteen full-member Caribbean Community (CARICOM) countries. Across the duration of this study, some of the countries assessed had no existing frameworks in place, while one had completely banned UAS operations within its jurisdiction. Others, including Guyana, Trinidad and Tobago, and Jamaica, had comprehensive frameworks that were continuously being updated. The outcome of a more in-depth analysis revealed that the UAS legislative framework for Guyana appeared to be the most robust amongst all CARICOM territories. Finally, some of the challenges of proper UAS regulation observed in the region are presented.

Keywords: UAS; legislation; regulations; CARICOM; drones



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1. Introduction

Unoccupied aerial systems (UASs) have been referred to as drones, robot planes, pilotless aircraft, remotely piloted vehicles (RPVs), remotely piloted aircrafts (RPAs), and various other terms, all of which describe aircraft that fly under the control of an operator, being remotely piloted or pre-programmed with a flight plan and having no person aboard [1]. They are most often called drones and when combined with ground control stations and data links, are termed unmanned aerial systems (UAS) [2]. This term is now being transformed to the more neutral unoccupied aerial system (UAS) [3]. UASs are often utilised in situations where human flight is considered too risky or difficult and is now becoming a technology which can be implemented in multiple aspects of life [4,5]. UAS technology offers spatial, temporal, and spectral advantages with the ability to fly on-demand and include multiple sensors onboard [6]. Typically, an UAS includes a remote controller and an operational screen, equipped with GPS (Global Positioning System) and INS (Inertial Navigation System) to supply location and orientation data [7]. UASs are now a highly adaptable technology which is constantly changing, and improvement in software and hardware installed in these systems has allowed for the addition of RGB cameras, depth sensors, LiDAR (light detection and ranging), event-based cameras, and waypoint orientation with front collision sensors, among many others, creating innovative ways to provide greater use [7,8].

The Caribbean experiences a generally tropical climate and has a dynamic topography among its varied landmasses, ranging from flat terrains to mountainous peaks. There are more than 7000 islands, islets, reefs, and cays belonging to a wide array of nations. The region is rich in biodiversity and contains several fragile ecosystems [9]. Such diversity, together with a complex political landscape, creates challenges for operating UASs. Many of the islands depend primarily on their marine and coastal environments [10] for their sustainability. The implementation and use of UASs can be beneficial in addressing many of the common needs of the region, as they provide a wide variety of solutions and can aid the islands in the management of various sectors [11]. The small island developing states of the Caribbean are challenged by their limited physical capacity and financial constraints, which also make them susceptible to disasters and external impacts [12]. After the explosive eruption of La Soufriere volcano in St. Vincent in April 2021, UAS technology was used to provide vital information needed by disaster management authorities. The aerial data gathered was used together with geographic information systems (GIS) for post-disaster planning [13]. Following the catastrophic earthquake in Haiti in 2021, several humanitarian aid organizations, including the US military, utilized UAS imagery to assess damage throughout the affected and inaccessible areas [14]. In the Dominican Republic, UAS technology has been applied to survey inaccessible land areas to enhance traditional archaeological methods [15]. Permits are required for both recreational and commercial use of UASs in and around Dominican Republic, along with a list of strict policies to which they must adhere. In Barbuda, a 3D robotics solo drone with a GoPro Hero 3 camera was flown at 50-m altitude to collect land cover data to identify the impacts of Hurricane Irma (2017) on the island. Drone and satellite imagery were compared, and the classification of the satellite imagery presented a challenge due to its spatial resolution. The drone imagery presented a higher classification output, which allowed the researchers to better view the impacts on the island [16]. Williams and Rolle [17] seek to implement the use of UASs in neurotrauma cases in the Bahamas. Due to the extensive geographic dispersion of the small islands which impede access and limited resources to administer urgent care in medical cases, they pursue the use of UASs to deliver intravenous access, sodium chloride infusion, hyperosmolar solutions, anti-epileptic drugs, antihypertensive drugs, pain medications, sedatives, and blood products [17]. The use of UASs for surveillance is also increasing in Caribbean nations, and it can reasonably be expected that use of the technology for other applications will rapidly escalate in the future. Other than the national security and border control uses of UASs within the Caribbean, there are several other commercial and research-oriented applications of UASs that occur. UASs are utilized for conservation, weather forecasting, mapping, and advertising tourism [18]. Raber and Schill [19] utilized the global positioning system (GPS) guided by UAS technology to create and assess a low-cost and transportable small unmanned surface vehicle (uSUS) for monitoring coral reefs and other benthic habits in shallow waters. The fast growth of UASs in the region has encouraged the islands to make the leap from recreational use of UAS to more commercial applications [20].

Many Caribbean countries have developed and implemented UAS legislation or regulations, while others have not. In places where regulations do exist, there is a lack of proper enforcement, and it is unlikely that there are police or other authorities equipped to respond to infractions [20]. Moreover, UASs present a threat when used close to airport areas and are a potential threat if used in sensitive areas where elevated security is required, such as embassies or government offices [21]. This activity has resulted in an increased number of warnings from local authorities in the region to UAS operators, noting that they could face prosecution if they are caught operating in restricted zones [20]. More stringent and proactive measures are also being taken. For instance, the government of Barbados has recently placed a ban on the importation of all UASs into the country [22]. Public safety concerns refer to the use of UASs in heavily populated/crowded areas, where malfunctions can result in injury of persons in the nearby vicinity [23]. UAS flight patterns have become an issue in recent years. The primary reason has been operational proximity

to airports and commercial aircrafts already in the air [24]. This type of occurrence has been commonly seen at the Denver International Airport in the United States of America (USA), where in one incident, a UAS flew within 500 ft of an aircraft. In response to incidents like these, the Federal Aviation Administration (FAA) implemented regulations that disallowed operation of UASs above 400ft within five miles of an airport without approval from Air Traffic Control [25].

Despite the obvious advantages, there are many issues arising out of the use of UASs in the Caribbean region with respect to not only physical and political conditions, but also the social, economic, and psychological impacts of the technology. Permits, insurance, and air regulations for the region (or lack thereof), and the associated difficulties of establishing such, are all key concerns. Like many other jurisdictions, there are limited regulatory frameworks for this type of aircraft, which has been breaking through the commercial barrier at a rapid pace [23]. For the region to fully access the benefits of the technology, a proper regional regulatory framework must be established. The aim of this study was to conduct the first regional assessment of existing UAS regulatory and legislative frameworks in the Caribbean. The review was limited to the 15 full-member countries of the Caribbean Community (CARICOM). Data on four factors that are key to UAS operations was collated and analysed.

2. Materials and Methods

The Caribbean Community (CARICOM) consists of 15 full member states (see Figure 1) that encourage a cohesive regional approach for shared economic, social, and cultural affluence [26].

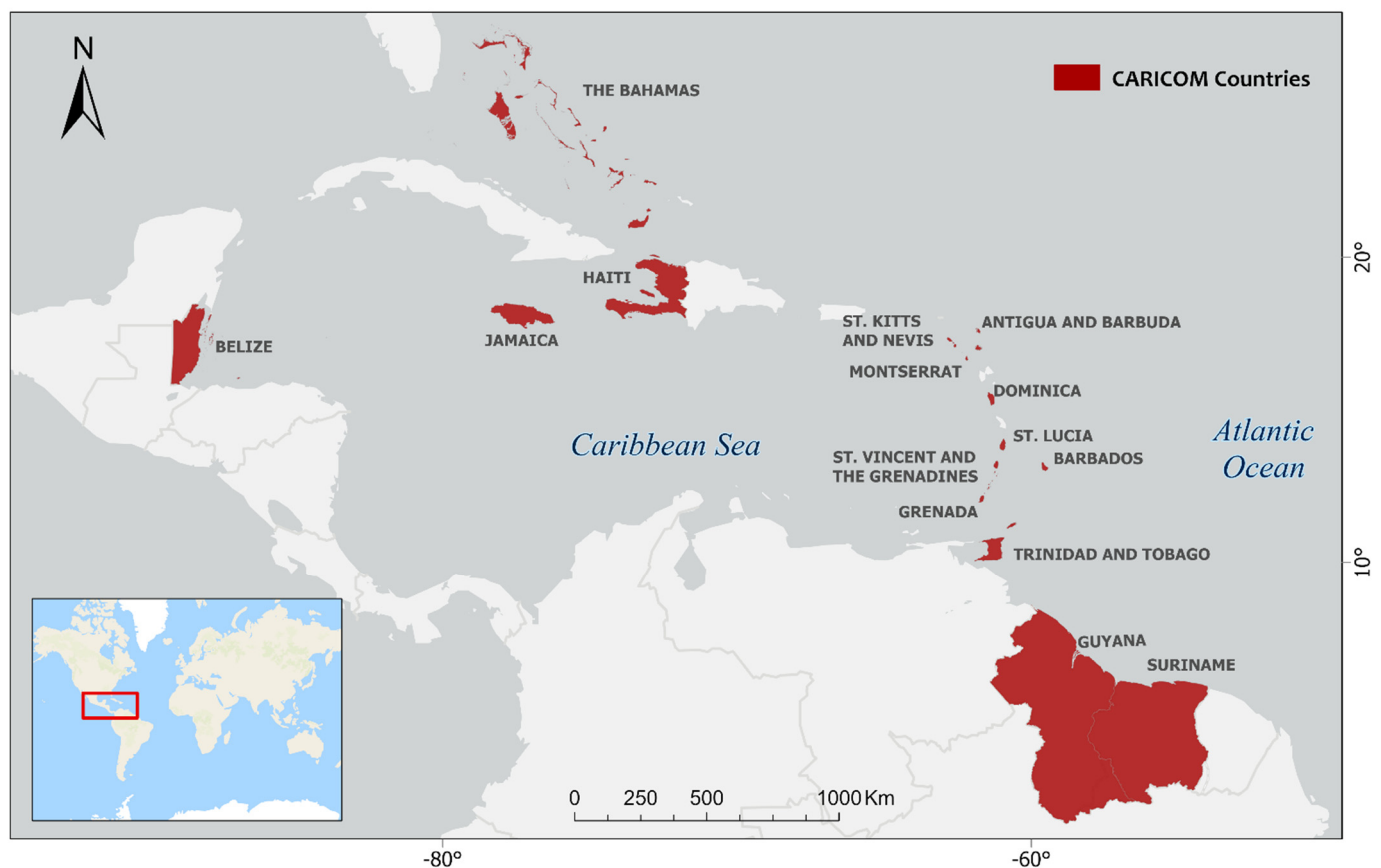


Figure 1. Study area—CARICOM Countries.

An extensive review of UAS-related legislative frameworks, guidelines, and policies of CARICOM countries was conducted based on official government information from the

respective aviation and transport authorities. A comparative analysis of these frameworks was then conducted based on the following conventional characteristics described in the documentation: weight, flight altitude, purpose, and restrictions [27]. These characteristics were further defined as follows:

1. Weight: the maximum take-off mass of the UAS
2. Flight altitude: the height of the flight above ground or sea
3. Purpose: terms for authorization of UAS use including commercial, recreational, research, or other
4. Restrictions: exclusions and boundaries on the UAS operation

3. Results

Legislative Frameworks by Country

Table 1 below illustrates a list of the full-member CARICOM countries in alphabetical order and their respective authorities in charge of UAS regulations, UAS legislative status, and URL links to official documentation sources [28]. Figure 2 portrays the spatial distribution of CARICOM countries color-coded by their UAS legislative status. A review of the documentation indicated that the Eastern Caribbean Civil Aviation Authority (ECCAA) is the leading authority that governs airspaces within the following territories: Antigua and Barbuda, Dominica, Grenada, Saint Kitts and Nevis, and Saint Vincent and the Grenadines [29]. Hereafter in this paper we refer to these territories collectively as the Eastern Caribbean (EC) territories. These EC territories along with Saint Lucia, Suriname, and Haiti had no legislative framework for UAS operations. In addition, UAS operations on the island of Barbados during the period of this study were completely banned; as a result, information for this state was not included in the findings.

Table 1. UAS Legislative status and authorities of CARICOM countries.

Country	Relevant Authority	Legislative Status	Official Source
Antigua & Barbuda	Ministry of Public Utilities, Civil Aviation, Transportation and Energy	no legal framework (only guidelines or recommendations)	[30]
The Bahamas	The Bahamas Civil Aviation Authority	legal framework	[31]
Barbados	Barbados Civil Aviation Department	operations banned	[22]
Belize	Department of Civil Aviation	legal framework	[32]
Dominica	ECCAA	no legal framework (only guidelines or recommendations)	[29]
Grenada	ECCAA	no legal framework (only guidelines or recommendations)	[29]
Guyana	Guyana Civil Aviation Authority	legal framework	[33]
Jamaica	Jamaica Civil Aviation Authority	legal framework	[34]
Haiti	Haiti Civil Aviation Steering Committee	no framework	[35]
Montserrat	Air Safety Support International	legal framework	[36]
Saint Kitts & Nevis	ECCAA	no legal framework (only guidelines or recommendations)	[29]
Saint Lucia	Ministry of Transport and Civil Aviation	no legal framework (only guidelines or recommendations)	[37]
Saint Vincent & the Grenadines	ECCAA	no legal framework (only guidelines or recommendations)	[29]
Suriname	Civil Aviation Department of Suriname	no legal framework (only guidelines or recommendations)	[38]
Trinidad & Tobago	Trinidad & Tobago Civil Aviation Authority	legal framework	[39]

Recently, many Caribbean islands have begun putting measures in place for UAS operations. Prior to this, regulation of UASs within the region had been small to non-existent throughout many of the territories. This was primarily because UAS technology was unrecognized and underutilized across many of the islands. Significant efforts to regulate and limit UAS use have emerged in recent years on many islands. Despite this, however, the popularity of recreational UAS use has increased [27], and so has the number

of UAS-related issues. Most of these issues have been related to matters such as invasion of privacy, security concerns, and public safety [40]. With respect to the use of UASs in the Caribbean region, most issues fall into two distinct categories:

1. Safety, security, and regulation and privacy
2. Analysis of legislative frameworks

In the following sections, a more in-depth analysis of the legislative criteria of CARICOM countries with comprehensive legislative frameworks was conducted. As such, only six countries were included in this analysis: The Bahamas, Belize, Guyana, Jamaica, Montserrat, and Trinidad and Tobago. Factors surrounding UAS pilots' control and accountability, etc. were considered here. In all, 13 main criteria regarding UAS operations were identified in the national legislative frameworks of these 6 CARICOM states. These criteria are presented in Table 2 below.

The analysed countries set operational standards that specified horizontal distances from airports and required permission to conduct flights. Among the six states investigated, five implemented flight height restrictions, required submission of operational flight plans, and prohibited flights over crowds and buildings. Four states prohibited flights in low visibility, required UAS registration, and maintained visual line of sight without aid. Three states adopted weight classifications, required pilot authorization, and prohibited dropping of objects by the UASs. Finally, two states implemented horizontal distance limitations of 1640 feet from the operator and required liability insurance for all commercial flights. These criteria were examined further in the discussion section of this paper.

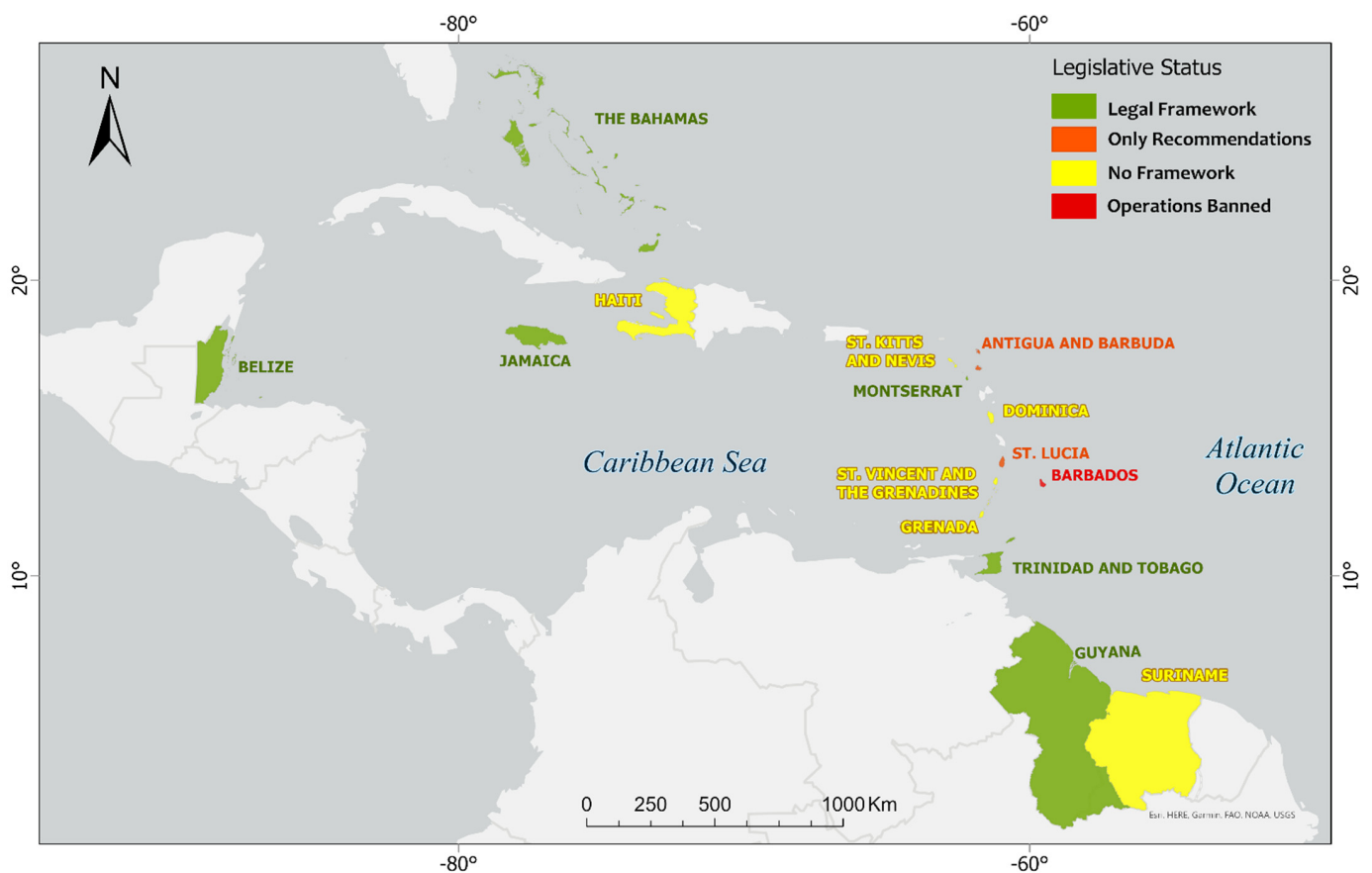
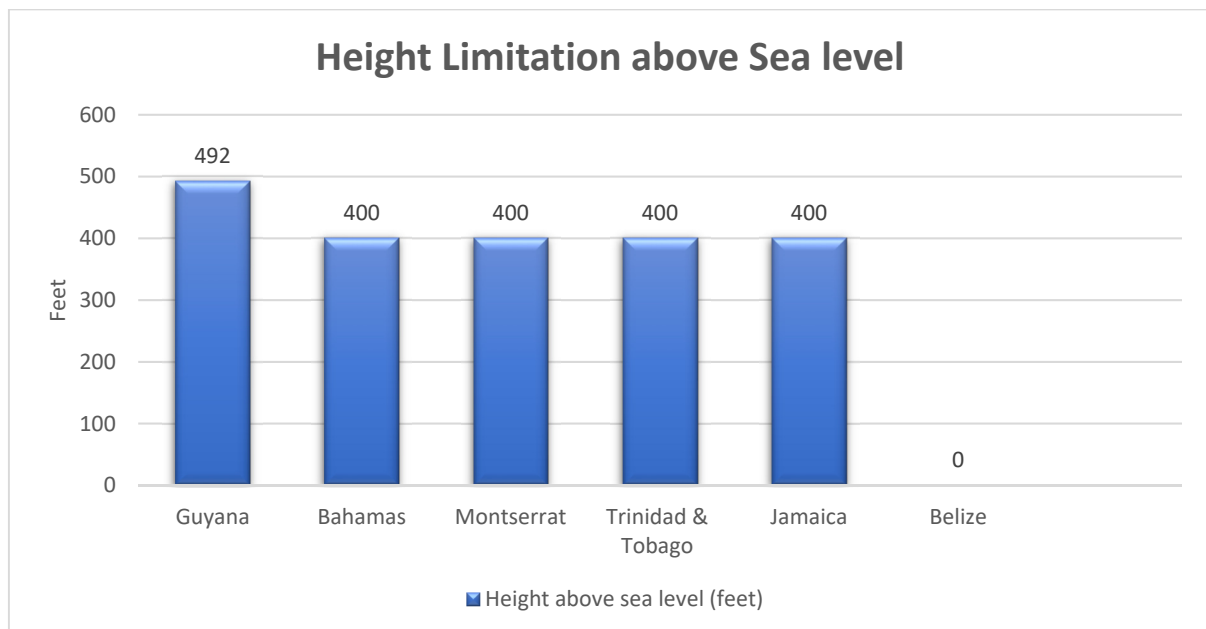


Figure 2. UAS Legislative status of CARICOM countries.

Table 2. Comparison of the main requirements of regulatory frameworks in countries with more comprehensive UAS legislation.

	The Bahamas	Belize	Guyana	Jamaica	Montserrat	Trinidad & Tobago
Maintain specified distance from airports	✓	✓	✓	✓	✓	✓
Flight permission required	✓	✓	✓	✓	✓	✓
Flight height limitation	✓		✓	✓	✓	✓
Prohibited flights over crowds and buildings	✓		✓	✓	✓	✓
Operation plan required		✓	✓	✓	✓	✓
Flights prohibited in low visibility	✓		✓	✓		✓
UAS registration required	✓		✓	✓		✓
Maintain visual line of sight			✓	✓	✓	✓
Pilot authorization required			✓		✓	✓
UAS weight classed			✓		✓	✓
UAS dropping objects prohibited			✓	✓	✓	
Insurance required					✓	✓
Horizontal distance limitation			✓	✓		
Totals	6	3	12	10	10	11

As indicated in Figure 3, a standard flight limitation in most of the studied states was the maximum flight altitude above sea level. A comparison of height limitation requirements above sea level for the specified nations revealed a constant of 400 feet for The Bahamas, Montserrat, Jamaica and Trinidad and Tobago. Guyana had a limitation of 492 feet and Belize had no specified altitude restriction.

**Figure 3.** Height Limitation from Sea level.

All six states had set operational standards that maintained specified horizontal distances from airports. However, this distance varied among them. The horizontal limitations from airports for the specific states were also examined, as portrayed by Figure 4. While most states required a minimum distance of 3.4 miles from airports, Jamaica and Belize stipulated 3 miles, whereas The Bahamas required a minimum of 5 miles. A spatial

graphic of both height and horizontal distance from airport limitations is presented in Figure 5.

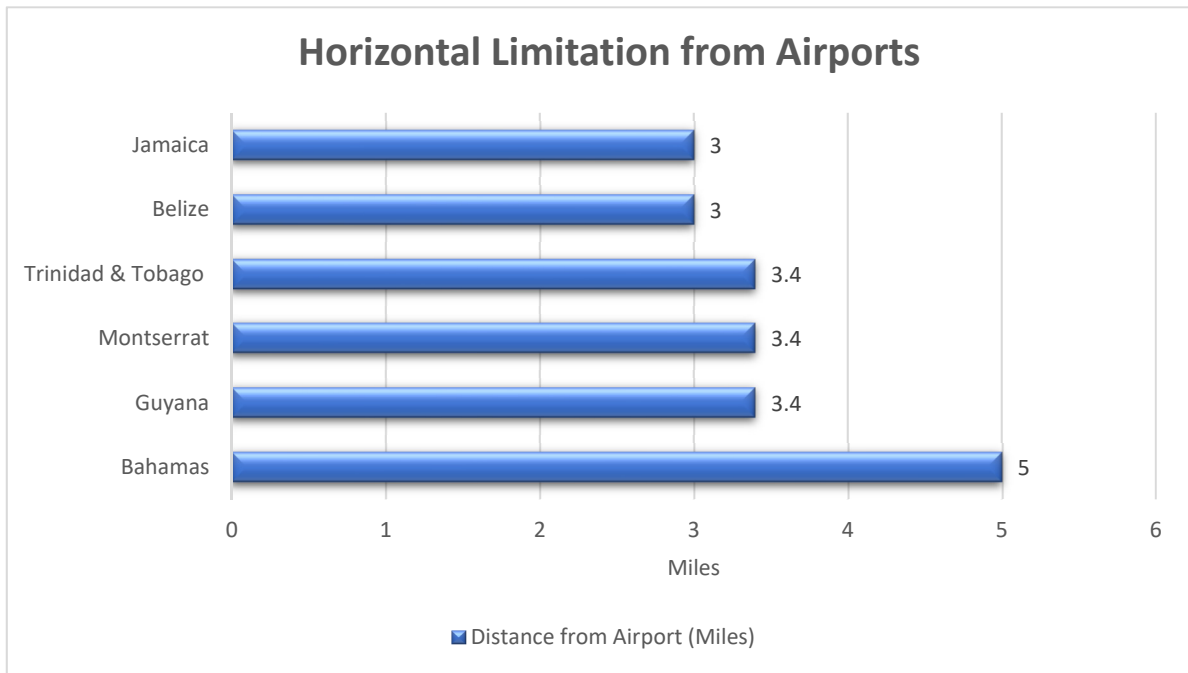


Figure 4. Horizontal limitation from airports.

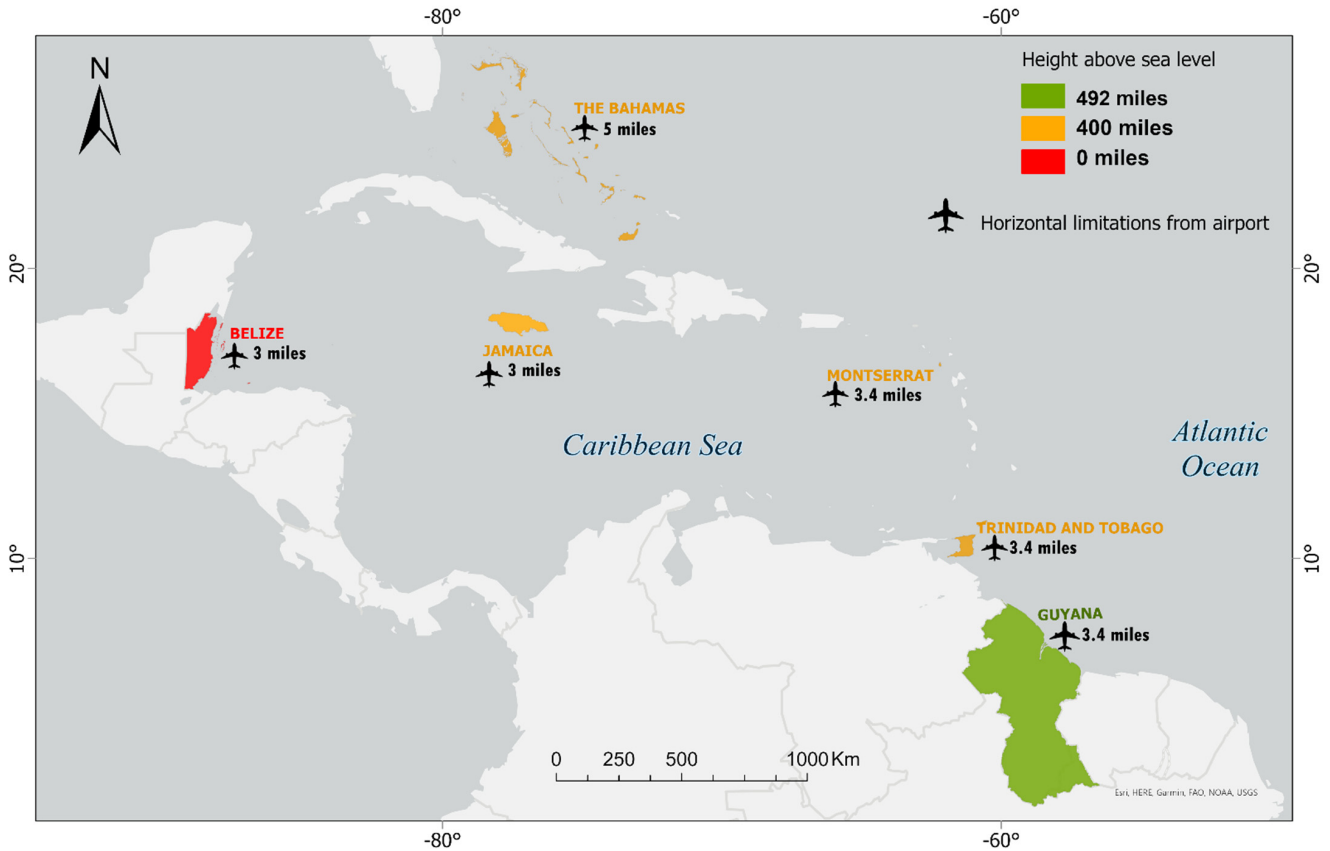


Figure 5. UAS Height and Horizontal distance restrictions for selected CARICOM states.

A comparative analysis of the UAS regulations within the specified CARICOM countries indicated that, although there were some similarities among them, each state adopted a different approach with respect to UAS legislation. In terms of the number of criteria included in its UAS legislative frameworks, the data indicated that Guyana (12 criteria) and Trinidad and Tobago (11 criteria) were numbers 1 and 2, respectively, when compared to the other states that were assessed. Figure 6 illustrates the 6 countries mapped against number of regulatory framework criteria for UAS operations.

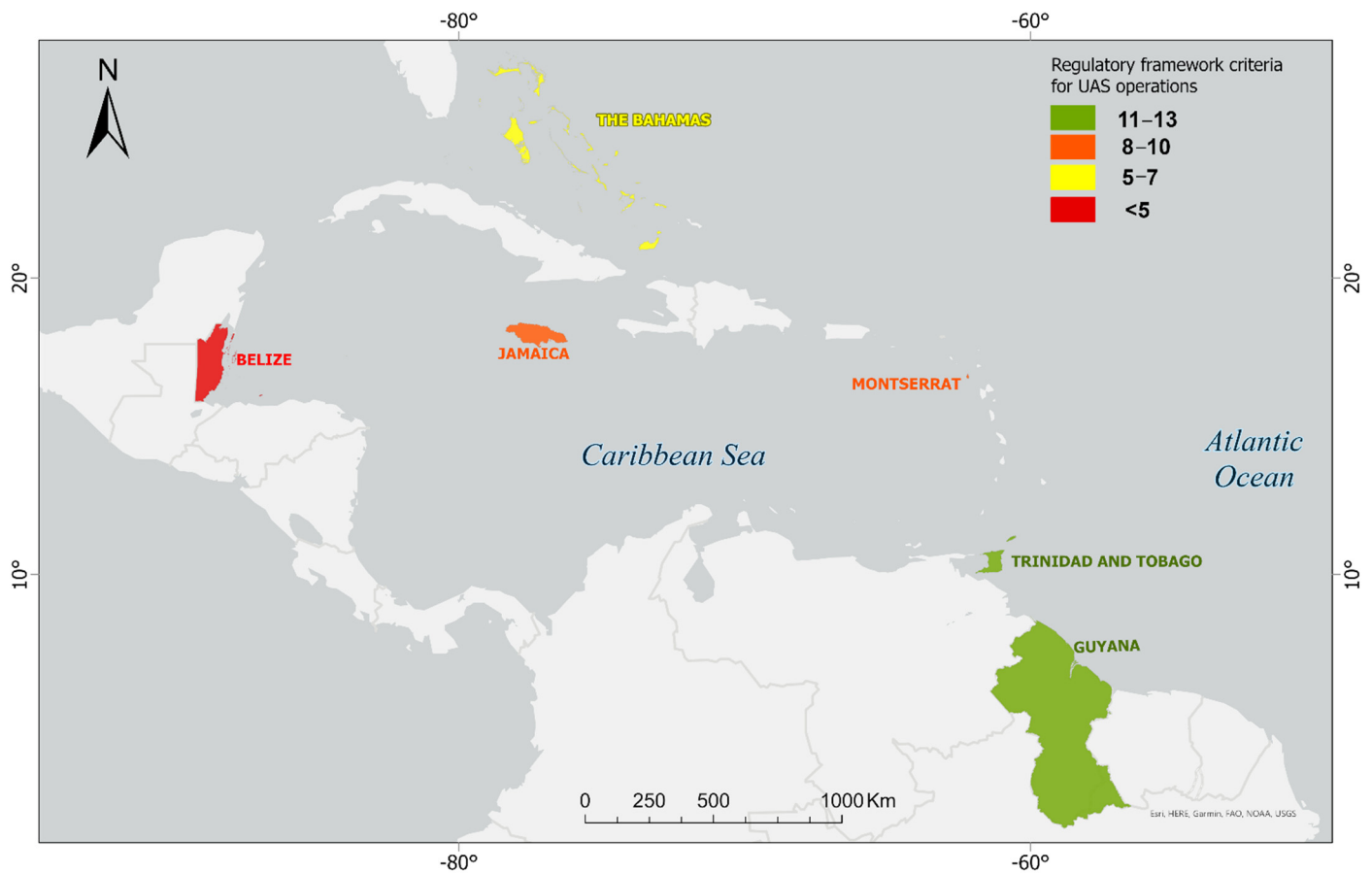


Figure 6. Number of criteria incorporated in UAS regulatory framework.

4. Discussion

The assessment conducted in this study examined the UAS legislative frameworks, guidelines, and policies of CARICOM states based on data from national authoritative websites. Each member state of CARICOM has its own regulatory framework and guidelines for UAS operations. An initial review revealed that only six of the fifteen CARICOM states had legal regulatory frameworks for UASs in place during the period of this study. These were The Bahamas, Belize, Guyana, Jamaica, Montserrat, and Trinidad and Tobago. Thirteen criteria including UAS weight, flight altitude, purpose, and restrictions were used to compare the frameworks of these six states against each other. The wide variability among the legislative frameworks of these six states (Table 2) is notable. The scores w.r.t. the total number of criteria achieved by each state were as follows: Belize (3), The Bahamas (6), Jamaica (10), Montserrat (10), Trinidad & Tobago (11), and Guyana (12). With a total score of 12, Guyana's framework was the most robust within the studied group while the framework for Belize was the least robust since it only implemented three of the listed criteria. The differences among criteria are noteworthy as this study did not weigh the values of each. Of the thirteen criteria that were used to assess the six states with UAS legislative frameworks, only two of these criteria were present across all six jurisdictions.

These included the requirements for (i) maintaining a specified distance from airports and (ii) having advance flight permissions.

Some UAS operations (particularly border patrols and national security response), may require flights within the airspaces of adjacent CARICOM states. In such cases, differing and conflicting legislation may prove to be a severe impediment. Although a single-use policy may be difficult to determine and implement based on the dynamic political and economic environments, it may be an initiative worth exploring in all CARICOM jurisdictions. We propose that a singular legislative framework for UAS operations be developed for the CARICOM member states. We also suggest some minimum requirements for such a policy based on elements of existing frameworks that formed part of this study, in addition to proposed policy papers in other regional jurisdictions. These requirements include flight permission from the local regulatory authority, maintaining a minimum distance of 3.4 miles from airports, maximum altitude restriction of 120 m, UAS being registered in a national database with a unique registration number maintained by the local regulatory authority, flight plan and further details being registered before each flight, and insurance coverage being obtained prior to each flight. In addition, when drafting such a regional framework, it may be prudent to consider the U.S. Department of Transportation's Federal Aviation Administration (FAA) recommendations for UAS operations [41] due to its success. The FAA has established two methods by which a commercial operation may be authorized to use UAS. They may apply for a Section 44,807 Exemption "to perform commercial operations in low-risk, controlled environments," or they may file for a Special Airworthiness Certificate that requires details on the UAS design, software, and purpose [42]. One regulation requires that, as of December 21, 2015, all commercial and personal UAS between 0.55 and 55 lbs must be registered with the FAA (larger UAS must use the Aircraft Registry). Persons who are not citizens or permanent residents are not allowed to register or use UASs in the United States [43]. Additionally, The FAA has partnered with several industry associations to promote "Know Before You Fly," a campaign to educate the public about using unmanned aircraft safely and responsibly [44]. A similar public awareness and education initiative can be implemented in the CARICOM region.

5. Conclusions

Unlike other regions of the world where UASs are utilized in armed conflicts, Caribbean territories presently have little to no military use for UASs. Regarding law enforcement applications, UASs are primarily used for border patrols and monitoring of marine spaces for illegal trade. While UASs have also been used to meet environmental mapping and surveying needs, the largest users of UASs in the region are the recreational and commercial groups. Capturing aerial imagery from manned aircrafts and/or satellites has proven to be problematic and ineffective for this tropical region for several reasons, including high acquisition costs and obstructing cloud cover. UAS technology offers a method of staying below the impeding atmosphere and capturing on-demand imagery for a variety of applications in a cost-effective manner. In addition, high resolution sensors are becoming more affordable as the industry expands, making the technology an increasingly attractive prospect for commercial applications. Due to the rapid growth within the last decade, however, this still-emerging technology must be properly regulated. This study performed the first known assessment of UAS legislation among CARICOM member states. States were first grouped into four categories based on the status of their UAS legislative frameworks and were classified as follows: operations banned, no framework, no legal framework (only guidelines or recommendations), and legal framework. Of the fifteen CARICOM member states assessed only six had legal regulatory frameworks in place for UAS operations within their jurisdictions. Thirteen criteria from these frameworks compiled during the study were used to compare these six legislative frameworks against each other. There was a wide variation in the number of criteria contained in each framework reviewed, ranging from 3 (Belize) to 12 (Guyana). While we did not investigate the reasons for this variation,

the most apparent ones appeared to be: the extent of UAS usage in the country, in addition to the rate at which its legislature moved to enact the relevant laws. We suggest a more unified approach in UAS legislation for the CARICOM member states and recommend some core criteria to be included. A more detailed analysis is required, however, to determine how to incorporate other criteria into this regional framework in a more equitable manner. This study may provide the foundation for such future work. Standardized regulations and drone certification processes can aid in integrating UASs safely into territorial airspaces among the CARICOM nations. A proposed unified/standardized framework can help to ensure that drones are operated safely without harming public and national security of the territories involved. In addition, such a framework would enable more robust accountability for any incidents which place lives at serious risk, or for any security breaches by drone operators. Regulations that are too rigid, however, have the potential of negatively impacting drone operators and associated downstream businesses. It is hoped that some measure of stakeholder consultations will occur and a level of flexibility in the guidelines, which maintain a safe system of work, may be attained. This will likely benefit the individual territories, associated businesses, and drone operators within. Finally, it is important to note that there are no approved set of standards for UAS pilot certification and training for the region, and to date, UAS pilots have had to travel to Europe and/or the United States to become certified. As the technology expands it will also be worthwhile to establish a regional center specifically designated for training and certifying UAS pilots.

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