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# Network-Integrated Civilian Drones: A Public Policy Framework for Smart Cities in the GCC and Egypt

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Posted Date: 10 April 2025

doi: 10.20944/preprints202504.0892.v1

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# Network-Integrated Civilian Drones: A Public Policy Framework for Smart Cities in the GCC and Egypt

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**Abstract:** Network-integrated civilian drones promise transformative benefits for smart cities by enhancing service delivery, surveillance, and transportation efficiency. This paper develops a comprehensive public policy framework for integrating drones into the urban ecosystems of GCC countries (United Arab Emirates, Saudi Arabia, Oman, Qatar, Bahrain, Kuwait) and Egypt. We examine key domains – telecommunications infrastructure (e.g. 5G networks), public safety and law enforcement, aerospace regulation, smart city infrastructure, and regional public policy – to analyze current developments and challenges. A qualitative, multi-domain review of recent (2020–2025) government strategies, regulations, and case studies in each target country is conducted. **Results** show that while Gulf states are rapidly advancing drone integration (e.g. national unmanned traffic management platforms, pilot programs for delivery and air taxis, and updated civil aviation regulations), critical challenges remain in ensuring airspace safety, security (including misuse prevention and cyber-resilience), and inter-agency coordination. **Discussion** highlights the need for harmonizing telecommunications and aviation policies to enable safe beyond-visual-line-of-sight operations via cellular networks, and balancing innovation with strict public safety measures (especially in high-risk contexts like Egypt, which currently heavily restricts drones). A strategic framework is proposed, emphasizing robust regulatory standards, technology infrastructure (UTM systems, remote identification), security protocols, privacy safeguards, and regional collaboration. The framework aims to guide policymakers in crafting balanced regulations that foster innovation (stimulating economic diversification and smart city growth) while protecting public safety and national security. We conclude with recommendations for phased implementation of drone integration in smart cities, continuous stakeholder engagement, and adaptive governance to keep pace with this evolving technology.

**Keywords:** civilian drones; unmanned aerial vehicles (UAVs); smart cities; urban air mobility; public policy; network-integrated drones; 5G communications; drone regulation; law enforcement; technology; urban surveillance; counter-UAS systems; UAV traffic management (UTM); spectrum policy; telecommunications infrastructure; public safety; GCC countries; Drone governance; smart infrastructure planning; aerospace regulation; remote identification (Remote ID)

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## 1. Network-Integrated Civilian Drones: A Public Policy Framework for Smart Cities in the GCC and Egypt

### *1.1. Abstract*

The rise of civilian drone technology is reshaping smart city development, offering new capabilities for urban management, service delivery, and surveillance. However, effective integration of drones into the urban environment requires carefully crafted public policies—especially in regions like the Gulf Cooperation Council (GCC) countries and Egypt, where security and privacy concerns are paramount. This paper presents a policy framework for **network-integrated** civilian drones in smart cities, emphasizing strategies that facilitate innovation while maintaining public safety and national security. The framework is informed by an analysis of current regulations and initiatives in GCC

 doi:10.20944/preprints202504.0892.v1



states and Egypt, as well as global best practices in unmanned aerial systems (UAS) governance. Key components include regulatory reform to permit controlled drone use, technological infrastructure for airspace management via telecommunications networks, and safeguards for privacy and cybersecurity. The results highlight how GCC cities can leverage drones for urban services under unified guidelines, and how Egypt might modernize its restrictive stance to reap smart city benefits. We discuss the implications for stakeholders—ranging from city planners to civil aviation authorities—and offer recommendations for implementing the framework. Our conclusions underscore that **network integration** of drones, supported by robust policy, can enable their safe and productive use in smart cities across the Middle East.

### *1.2. Introduction*

Smart cities rely on advanced technologies to improve governance, sustainability, and quality of life. In recent years, unmanned aerial vehicles (UAVs), commonly known as drones, have become increasingly prominent tools in urban innovation. Drones can support a range of smart city applications such as infrastructure inspection, traffic monitoring, emergency response, and delivery of goods or medical supplies (Mohamed et al., 2020). Their ability to quickly gather aerial data and reach areas inaccessible to ground vehicles makes them valuable assets for city management. At the same time, these benefits come with challenges. Authorities must ensure that drone operations do not endanger public safety, infringe on privacy, or threaten national security. This is particularly crucial in the Middle East context, where governments prioritize security and have traditionally imposed strict controls on airspace usage (Youssry Saleh & Partners, 2022).

The Gulf Cooperation Council (GCC) countries—such as the United Arab Emirates (UAE) and Saudi Arabia—have articulated ambitious smart city agendas as part of their national development visions (Alqahtany, 2025). These agendas encourage adopting cutting-edge technologies including the Internet of Things (IoT), artificial intelligence, and autonomous systems to drive economic diversification and improve public services. Civilian drones are increasingly part of this smart city vision, from Dubai's experiments with drone delivery services to Saudi Arabia's NEOM project planning drone taxis as a mobility solution. The UAE, for example, launched a "Drones for Good" initiative to promote beneficial civilian drone uses, and has developed a regulatory framework requiring drone registration and operator training (UAV Coach, 2023). Saudi Arabia has also legalized civilian drone use with regulations mandating registration of any drone over 250 grams and designating permitted flight zones (General Authority of Civil Aviation [GACA], 2020). These steps signal a regional shift toward cautiously embracing drone technology.

In contrast, Egypt's policies have remained highly restrictive. Egypt's Law No. 216 of 2017 effectively bans civilian drone operations without a special military permit, reflecting deep security concerns (Youssry Saleh & Partners, 2022). While Egypt is investing in new smart cities and digital infrastructure, the outright prohibition of drones limits its ability to leverage UAVs for urban innovation. This divergence between the GCC and Egypt highlights the need for a nuanced policy approach that addresses security imperatives without stifling technological progress.

To integrate drones into smart city ecosystems, a **network-integrated** approach is proposed. *Network-integrated* refers to linking drones with existing communication networks (such as 4G/5G cellular systems and urban IoT platforms) to enable real-time tracking, data transmission, and remote management of drone operations. By using network connectivity, authorities can implement unmanned traffic management systems, enforce geofencing in sensitive areas, and respond swiftly to any incidents (Sándor, 2019). Such integration strengthens oversight and can mitigate risks associated with autonomous drones flying in urban airspaces.

This paper aims to develop a public policy framework that guides the safe and effective integration of civilian drones into smart cities in the GCC and Egypt. The framework is grounded in a comprehensive review of current regulations, technological capabilities, and urban needs in these regions. The study addresses the following key questions: How can policymakers balance the promotion of drone innovation with the necessity of safety and security? What regulatory and technical measures

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are required to incorporate drones into urban environments and existing networks? And how can regional coordination (especially among GCC states) harmonize drone policies for mutual benefit?

The remainder of this paper is structured as follows. First, we review relevant literature and global experiences in Section 2, covering smart city applications of drones, regulatory models, and challenges. Section 3 outlines the methodology used in assessing current policies and formulating the framework. In Section 4, we present the results – the proposed policy framework with its core components. Section 5 provides a discussion, examining the framework in light of stakeholder perspectives and comparing it to international best practices. Finally, Section 6 concludes with policy recommendations and suggestions for future research.

### *1.3. Literature Review*

#### 1.3.1. Drones in Smart City Applications

Numerous studies highlight the potential of drones to enhance urban services. Drones have been used for aerial mapping and infrastructure monitoring, allowing city officials to inspect roads, bridges, and power lines efficiently (Zhang et al., 2017). In traffic management, large-scale experiments have shown that fleets of drones can monitor congestion and accidents in real time, supplementing ground sensors (Barmpounakis et al., 2020). In public safety, police and emergency services deploy drones for search-and-rescue missions and disaster assessment, leveraging high-resolution cameras and thermal imaging to gather critical information from above (Valdovinos et al., 2016). These examples illustrate that UAVs can serve as integral components of a smart city's data collection and service delivery mechanisms (Mohamed et al., 2020).

However, the adoption of civilian drones in many jurisdictions has been slower than anticipated, often hindered by regulatory uncertainty and public concern (Chamata, 2017).

The GCC region has begun to pilot some of these applications. For instance, Dubai Municipality has used drones for aerial surveying and to monitor construction sites as part of its smart city program. In Saudi Arabia, planners envision drones delivering e-government services and medical supplies across futuristic developments like NEOM and other "giga-projects" aligned with Vision 2030 (Alqahtany, 2025). Such uses are still nascent but demonstrate the growing recognition of drones as enablers of urban innovation. At the same time, successful implementation depends on integrating these UAV operations with city networks and control systems to ensure they function reliably and safely in dense urban environments.

#### 1.3.2. Regulatory Frameworks and Challenges

Implementing drone applications in cities requires navigating regulatory frameworks that have historically been cautious. Aviation authorities worldwide regulate unmanned aircraft to prevent collisions, interference with manned aviation, and misuse. Two broad regulatory approaches have emerged: one that permits civilian drone operations under specified conditions (with registration, licensing, and operational limits), and another that heavily restricts or bans drones due to security concerns. The tension between innovation and regulation is well-documented. Nakamura and Kajikawa (2018) argue that overly stringent regulations can hinder technological innovation, yet lax rules may lead to accidents or public backlash, suggesting that regulators must seek a middle ground.

Global best practices show a trend toward risk-based regulation. In the United States, the Federal Aviation Administration introduced Part 107 rules to allow small drones for commercial use under altitude and visual-line-of-sight restrictions, while continuing to develop protocols for beyond-visual-line-of-sight operations (FAA, 2020).

The European Union, through the European Union Aviation Safety Agency (EASA), has implemented a unified framework classifying drone operations into Open, Specific, and Certified categories with corresponding requirements (European Union Aviation Safety Agency, 2019). These frameworks aim to enable routine drone services (like delivery or surveillance) in low-risk scenarios and require case-by-case approval for higher-risk operations, such as flights over people or autonomous missions in cities.

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Despite these advances, significant challenges remain, particularly around urban drone use. One challenge is **airspace management** in cities. Low-altitude urban airspace can become crowded if drone usage expands, raising concerns about mid-air collisions or interference with helicopters and airplanes (Sándor, 2019). Researchers have proposed Unmanned Traffic Management (UTM) systems—essentially air traffic control for drones—to organize and separate drone traffic in urban skies (Sándor, 2019). UTM systems rely on network integration: drones would continuously communicate their location and receive updates on no-fly zones or traffic advisories via networks. Pilot programs by NASA and others have tested UTM concepts, but widespread deployment requires policy support and coordination among aviation, telecom, and local authorities.

Another challenge is **privacy and public acceptance**. Drones equipped with cameras can capture imagery of private spaces, which has prompted concerns from citizens about surveillance and data protection. Public acceptance of drones tends to increase when strong privacy safeguards and transparent usage policies are in place (Clothier et al., 2015). Studies indicate that people are more receptive to civic drone applications (e.g., disaster relief) than to pervasive surveillance or commercial deliveries directly over neighborhoods (Aydin, 2019). Policymakers thus need to involve community stakeholders and establish clear rules on data usage to maintain public trust.

Security threats also play a central role in shaping drone policy. In conflict-prone regions or countries facing terrorism threats, drones can be used maliciously (for espionage or as weapons), which understandably makes authorities cautious. Egypt's blanket ban on drones stems from such security calculations (Youssry Saleh & Partners, 2022). Several GCC countries temporarily banned recreational drones in the past after incidents (for example, the UAE did so in early 2022 after a drone was used in an attack on critical infrastructure). Crafting a policy framework for drones in these contexts means incorporating stringent security measures—such as mandatory remote identification of drones, geofencing around sensitive sites, and empowering law enforcement with counter-drone capabilities (e.g., jamming or capture systems) for unauthorized UAVs.

#### 1.3.3. Current Policies in the GCC and Egypt

As of 2025, the regulatory landscape in the GCC is evolving. The UAE has been a regional leader in drone regulation and innovation. Its General Civil Aviation Authority (GCAA) requires all drones (regardless of size) to be registered through a centralized online platform and mandates that hobbyist and commercial pilots obtain certification from accredited training centers (UAV Coach, 2023). The UAE has designated specific areas where drones may fly freely and enforces no-fly zones near airports, military sites, and residential areas. Recent statistics reflect the impact of these policies: over 23,000 drones were officially registered in the UAE once personal drone use was re-authorized under strict conditions, showing a burgeoning interest in lawful drone operation (Emirates News Agency, 2025). Dubai's local authority, the DCAA, reported a 76% increase in registered drone pilots in a single year, along with a 53% rise in licensed drone companies, indicating rapid growth of the sector under clear regulations (Dubai Civil Aviation Authority, 2024).

Saudi Arabia's GACA has instituted a similar registration regime, albeit more recent. Drones above 250 g must be registered, and operators need approval for each flight in designated zones (GACA, 2020). Violations of these rules carry penalties, but compliant usage is growing as public awareness improves. Other GCC nations like Qatar, Kuwait, and Oman have been more restrictive initially, often handling drone permissions on a case-by-case basis through their defense or interior ministries. However, there is movement toward standardized rules; for instance, Kuwait in 2023 announced plans for a drone registry, and Qatar is exploring drone delivery services in controlled trials.

Egypt, conversely, continues to enforce one of the strictest drone laws in the world. Law 216 (2017) and its executive regulations essentially prohibit any unapproved drone activity, with harsh penalties including prison terms for offenders (Youssry Saleh & Partners, 2022). Permits for drones are extremely rare and handled by the Ministry of Defense, meaning civilian agencies or private companies have almost no practical pathway to utilize drones for smart city projects. This policy has kept Egypt's

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urban skies free of civilian drones but at a potential cost: Egyptian smart city initiatives might miss out on the efficiencies and innovation drones offer in urban management. Nonetheless, given Egypt's security environment and concerns about unauthorized surveillance, any policy shift would require robust control mechanisms to satisfy authorities.

#### 1.3.4. Network Integration and Technological Enablers

The concept of network-integrated drones is closely tied to advances in telecommunications and IoT infrastructure. Modern cellular networks (4G and emerging 5G) provide high-bandwidth, low-latency connectivity that can link drones to cloud-based control systems. This connectivity enables continuous telemetry, remote pilot intervention if needed, and even autonomous fleet coordination via cloud computing. For smart cities, leveraging existing mobile networks to manage drones is attractive because it uses established infrastructure and standards for security and quality of service. For example, 5G networks can allocate dedicated slices for drone communications to ensure reliability.

Integration with networks also facilitates **Remote ID** systems, whereby each drone broadcasts an identification code and location that law enforcement or citizens can query, analogous to a digital license plate. The United States and EU are rolling out remote ID requirements as part of their drone regulations, as a means to hold operators accountable and enhance airspace awareness. Such systems would be highly beneficial in the GCC/Egypt context, providing security services a real-time picture of all drones in the air at any given time via networked databases.

Another enabler is the development of urban drone traffic corridors – predefined routes (often following roads or unpopulated zones) where drones can fly to minimize risk. These corridors can be programmed into drones and enforced through geofencing technology. Trials in cities like Dubai have explored creating "drone highways" for deliveries, which relies on integrated navigation systems and regulatory approval of specific flight paths.

Finally, emerging technologies in automation (autonomous flight control, sense-and-avoid systems) are reducing the burden on human pilots and can improve safety if integrated properly. However, these technologies must be coupled with policy; for instance, requiring certain safety features on all drones above a weight threshold, or mandating use of network-based collision avoidance systems for any drone flying beyond visual line of sight in urban areas.

In summary, the literature and existing initiatives suggest that while drones hold great promise for smart cities, their integration requires multidimensional solutions. Effective policy frameworks will need to blend regulatory oversight with technical innovation, ensuring that drones are not only allowed in urban environments but are systematically managed and monitored. The GCC and Egypt present a compelling case study of this balance—one region cautiously opening up to drones, and another still essentially closed. Lessons from global practices and technological trends will inform the public policy framework proposed in this paper, aiming to enable network-integrated drone usage that aligns with local priorities.

### *1.4. Methodology*

This research adopts a qualitative, comparative case study methodology to develop the proposed public policy framework. The approach is two-fold: (1) an analysis of current drone regulation policies and smart city initiatives in the target region (GCC countries and Egypt), and (2) the synthesis of these findings with international best practices to formulate a context-appropriate framework.

**Document Analysis:** We began by collecting and reviewing policy documents, laws, and regulatory guidelines related to drone usage in each of the GCC countries and Egypt. Sources included civil aviation authority regulations (such as the GCAA regulations in the UAE and GACA rules in Saudi Arabia), national legislation (e.g., Egypt's Law 216/2017), and official press releases or statements about drone programs. We also examined strategic documents outlining smart city visions (for example, Saudi Arabia's Vision 2030 and UAE's Centennial 2071 plans) to understand how drones are envisioned in national development agendas. This document analysis provided insight into the legal

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landscape, identifying both the enabling provisions and the restrictions that shape drone operations currently.

**Literature Review Integration:** In parallel, we integrated insights from academic literature (as reviewed in Section 2) on drone governance, technology integration, and public policy. Key themes such as risk-based regulation, privacy issues, and network-centric management of drones were extracted from the literature. These themes guided our attention to certain policy tools (like remote identification, UTM systems, etc.) during the analysis of regional cases.

**Comparative Case Study:** We treated the GCC and Egypt as two comparative contexts – one more permissive (though varied internally among GCC states) and one restrictive. Within the GCC, further comparison between the UAE and Saudi Arabia (as leading adopters) and other member states (Bahrain, Kuwait, Oman, Qatar) was conducted to note differences and commonalities in their approach. We also considered how regional cooperation (through GCC forums) might influence drone policy harmonization. The comparative lens helped in identifying which elements of a drone policy framework are universal versus which need tailoring to specific national concerns.

**Stakeholder Input (Secondary Data):** While no primary interviews were conducted for this study, we leveraged secondary sources that contain stakeholder perspectives. This included statements from government officials, public survey results where available (such as citizen attitudes toward drones), and industry reports (e.g., white papers by telecom companies on drone integration). For example, statements by UAE's DCAA officials about drone safety, or a World Bank "drone operations playbook" for regulators, enriched our understanding of practical considerations. This indirect stakeholder input ensured that the framework accounts for multiple viewpoints: regulators, city planners, security agencies, private sector operators, and the general public.

**Framework Development:** Using the information gathered, we employed an inductive approach to develop the policy framework. We first outlined common objectives that appeared across cases – such as ensuring safety, enabling innovation, protecting privacy, and coordinating stakeholders. Then, for each objective, we identified policy measures or components recommended either in practice or by literature. For instance, to ensure safety, components included mandatory registration, operator licensing, and defined operational zones; to enable innovation, components included pilot programs or sandbox testing environments; and so forth. We iteratively refined these components by checking against the case data (does a given GCC country have this measure? If not, has it been recommended by experts for similar contexts?).

The resulting framework was organized into major dimensions reflecting the areas a comprehensive drone policy should cover. These dimensions were then validated conceptually by comparing them against well-regarded frameworks from other jurisdictions (like the EU's drone regulation framework or the U.S. FAA's integration initiatives) to ensure no critical aspect was missing.

It is important to note that the methodology focuses on policy analysis and synthesis; it does not involve quantitative hypothesis testing. The strength of this approach lies in drawing detailed context-aware insights to inform policy design. There are limitations, however. The rapid pace of change in drone technology and policy means some information may become outdated quickly. Additionally, the framework is not "one-size-fits-all" – differences in political and social context (especially between GCC states and Egypt) necessitate adaptation when implementing the recommendations. Despite these caveats, the methodology provides a robust foundation for constructing a policy framework that is grounded in both current reality and forward-looking practices.

### *1.5. Results*

Based on our analysis, we propose a **Network-Integrated Drone Policy Framework** tailored to smart cities in the GCC and Egypt. This framework is composed of six interrelated components: (1) Legal and Regulatory Reform, (2) Institutional Coordination and Capacity, (3) Technology and Infrastructure Integration, (4) Security and Privacy Safeguards, (5) Public Engagement and Acceptance, and (6) Regional and International Collaboration. Each component addresses a critical dimension of integrating drones into urban environments in a safe, innovative, and publicly accepted manner.

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#### 1.5.1. 1. Legal and Regulatory Reform

**Scope of Operations:** The framework calls for clear definitions of permitted drone operations in urban settings. Laws should explicitly allow civilian drone use for defined purposes (commercial, recreational, governmental) under specified conditions. For GCC countries that already permit drones, this means expanding permissible operations gradually – for example, allowing beyond-visual-line-of-sight flights for approved services (like delivery) once certain safeguards are met. For Egypt, legal reform would involve moving from a near-blanket ban to a controlled allowance: establishing a licensing process for civilian agencies and companies to use drones for beneficial applications (e.g., infrastructure inspection, environmental monitoring) under strict oversight. Defining categories of operations (benign low-risk vs. higher-risk) will help regulators manage permissions efficiently in both contexts (Nakamura & Kajikawa, 2018).

**Registration and Licensing:** A universal element is mandatory registration of all drones and licensing of operators. Every drone must be registered in a national database, tied to an owner, and bear a unique identifier (electronically via remote ID and physically on the device). Operators (pilots) should be required to obtain a license or permit after passing knowledge tests on regulations and safety. The UAE's existing GCAA registration platform can serve as a model, having registered tens of thousands of drones (Emirates News Agency, 2025). Licensing tiers could be introduced—for instance, a basic license for hobbyists and an advanced license for commercial pilots—to differentiate training and exam requirements based on use cases.

**Operational Rules:** Regulations should establish when, where, and how drones can fly in cities. Key rules include altitude limits (commonly 120 meters or 400 feet to avoid manned aircraft paths), no-fly zones (around airports, strategic installations, and possibly around sensitive public venues), and conditions for flight (daytime, good weather, line-of-sight unless special approval for beyond). The framework suggests formalizing designated "drone zones" in cities—areas or corridors where drone activity is pre-approved (e.g., certain parks, industrial areas, or along specific routes)—to encourage utilization while containing risk. Conversely, clear penalties for illegal flights (as Egypt already prescribes, with severe fines and jail terms for unauthorized use) should remain as a deterrent, though applied proportionately to the offense risk.

**Dynamic Policy Mechanisms:** Given the fast evolution of drone tech, the legal framework should be adaptable. One mechanism is to use temporary pilot programs or sandbox environments: regulators can issue time-bound exemptions for trials of new drone services (such as aerial taxi tests in a city) to gather data before wider legalization. This approach has been used in the U.S. (the FAA's Integration Pilot Program) and can be replicated. Additionally, the law might empower civil aviation authorities to update technical standards (like remote ID requirements or communications standards) via secondary legislation or directives without needing full parliamentary processes for minor adjustments.

#### 1.5.2. 2. Institutional Coordination and Capacity

**Central Regulatory Body:** Effective implementation requires a competent authority to oversee drone integration. The framework recommends establishing a dedicated unit or department within the civil aviation authority (or equivalent) focusing on UAS integration. For example, the UAE's DCAA already plays this role for Dubai, and a national UAS program office exists in the GCAA. This body will handle licensing, monitor compliance, and coordinate with security agencies. In countries with multiple jurisdictions (federal vs local), clear delineation of responsibilities is needed to avoid overlaps or gaps.

**Inter-agency Coordination:** Drones intersect with various sectors—aviation, security, telecommunications, transportation, and city governance. Regular coordination mechanisms (such as a national committee on drones or task force) should be instituted. In the GCC, this could mean involving interior ministries (for security enforcement), municipal authorities (for local airspace permissions and city infrastructure integration), telecom regulators (for spectrum and network aspects), and defense (for high-security risk assessment). Egypt would similarly need to coordinate between its Ministry of

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Defense (currently the permit authority) and civil agencies like the Ministry of Civil Aviation and Ministry of Communication for a coherent policy shift. Joint protocols for incident response (e.g., how police and aviation authorities handle a rogue drone sighting) would stem from this cooperation.

**Capacity Building:** A critical often-overlooked aspect is building human and technical capacity to manage and utilize drones. The framework advises investment in training programs for regulators and first responders. Aviation inspectors and air traffic controllers may need new training to handle UTM systems or investigate drone incidents. Urban planners and city officials should be educated on how to incorporate drones in their planning (for instance, designing rooftops that can serve as drone landing pads in the future). The government can also facilitate capacity building in the private sector by certifying training academies (as the UAE has done with drone pilot training centers) to ensure a pipeline of qualified drone operators.

**Public-Private Partnerships:** Encourage partnerships with private technology firms and startups specializing in drones. Such collaboration can help governments access cutting-edge UAS technology and expertise without bearing the full cost. For instance, telecom companies in the region might partner to provide the infrastructure for drone tracking and communication; local tech startups could develop urban drone services under the guidance of city authorities. PPP models could be used to deploy drone networks for public services (like a city contracting a company to perform regular drone surveillance of traffic, under agreed privacy terms).

#### 1.5.3. 3. Technology and Infrastructure Integration

**Unmanned Traffic Management (UTM):** At the core of network integration is implementing a UTM system. The framework proposes that GCC states (perhaps collaboratively) develop a UTM platform that integrates with national air traffic control but is tailored for low-altitude drone operations. This platform would ingest flight plans from drone operators, de-conflict routes, and provide dynamic instructions or restrictions. It would likely rely on cloud services and mobile network connectivity. Governments should set technical standards for UTM interoperability; for example, requiring drones to have GPS tracking and the ability to communicate over LTE/5G to the UTM. Pilot projects can test UTM in a limited urban area before scaling up. Notably, a shared UTM across multiple cities or countries in the GCC could promote regional consistency. Egypt, should it open up, could join such an effort or create its own integrated with its air defense radar to appease security needs.

**Telecom Network Support:** Working closely with telecom providers, authorities should ensure that the cellular network coverage and quality in urban areas extends upward to typical drone flight altitudes. This may involve tuning antennas or deploying network repeaters that cover low-altitude airspace (since networks traditionally focus on ground users). Additionally, reserving or prioritizing certain frequencies for drone control links can enhance reliability. The recent allocation of parts of the C-band (5 GHz spectrum) for drone communications in some jurisdictions is an example (FCC, 2024). GCC regulators (many of which are already investing in 5G rollout for smart cities) have an opportunity to incorporate drone connectivity requirements into their telecom infrastructure plans.

**Geospatial Infrastructure:** Smart cities should map out their digital airspace. This includes maintaining updated maps of restricted zones (no-fly areas), altitude ceilings, and approved drone corridors. The framework suggests creating a publicly accessible map portal that drone users must consult or that can feed directly into drones' navigation software. This geospatial data needs constant updating (e.g., adding temporary restrictions for events or emergencies), which again ties back to the need for a capable central authority or UTM system.

**Integration with City Systems:** Drones, as part of smart city IoT, should feed into and draw from other urban systems. For example, a drone's live video feed during a traffic incident should interface with the city's traffic management center software. Similarly, emergency dispatch systems should have the ability to launch and control city-owned drones directly when needed. The framework encourages investment in open APIs and data standards to allow such cross-system communication. By integrating drones with existing smart city dashboards and control rooms, cities can maximize the utility of drones as just another sensor/actor in the urban landscape, rather than an isolated tool.

 doi:10.20944/preprints202504.0892.v1



#### 1.5.4. 4. Security and Privacy Safeguards

**Remote Identification and Tracking:** As mentioned, requiring every drone to broadcast its identity and location is pivotal for security. The framework mandates remote ID technology on all but the smallest toy drones. Law enforcement agencies should have access to systems that can track drones in real time and cross-reference identities with registration databases. This measure acts as a deterrent to misuse (operators know they can be identified) and allows rapid intervention if a suspicious drone is detected. The network-integration aspect means this identification data would typically be transmitted over cellular networks to authorities. In high-security contexts like Egypt, authorities might insist on having the capability to commandeer the control link of any drone in their airspace—technically feasible if drones are networked, but it requires legal backing (for instance, a law permitting security forces to override control of a drone during a security alert).

**Geofencing Critical Sites:** Regulators should enforce that all drones sold or operated have geofencing software that prevents entry into designated high-risk zones. These would include military bases, presidential palaces, critical infrastructure (power plants, etc.), and potentially certain border areas. The list of these protected coordinates can be maintained by the authority and updated in drones' firmware or through the network. Modern drones already come with pre-defined no-fly zones (e.g., around airports); expanding and customizing this for local security needs is recommended. Violations—if a drone tries to enter despite geofence (which could only happen if someone hacks or uses a custom drone)—would immediately trigger alerts in the UTM/security system.

**Counter-UAS Measures:** Despite preventive measures, the framework acknowledges the importance of having counter-drone capabilities. Police and security services in GCC cities and Egypt should be equipped and trained with technologies to safely disable or capture rogue drones. These range from radio frequency jammers that can disrupt control signals, to more sophisticated drone-catching drones or nets. Policies must clarify under what circumstances these can be deployed (for instance, any unidentified drone in a no-fly zone can be subject to neutralization). Developing standard operating procedures here is crucial to avoid, say, interference with legitimate drones. It's also a matter of public safety – disabling a drone must be done in a way that minimizes risk of injury from a falling UAV.

**Data Privacy:** The framework also addresses the data privacy concerns. It proposes that legislation include clauses on responsible use of data collected by drones. For government-operated drones, data should be handled according to privacy laws, with limitations on surveillance of private property without cause. For private operators, misuse of drone-captured imagery (such as publishing images of individuals without consent) should be penalized under privacy or harassment laws. In a smart city context, plenty of CCTV and sensors exist; drones add an aerial dimension, but should be subject to similar governance as street cameras when used for monitoring. Public transparency can help—for example, if a city uses drones for routine monitoring, they might publish reports or dashboards so citizens know what is being monitored (Nelson & Gorichanaz, 2019). Building public trust through such measures is essential for long-term acceptance.

#### 1.5.5. 5. Public Engagement and Acceptance

**Awareness Campaigns:** Introducing or expanding drones in urban areas requires public buy-in. The framework emphasizes conducting public awareness campaigns about the rules for drone usage and the societal benefits of drones. In the UAE and Saudi Arabia, where adoption is growing, authorities have periodically used media to educate people about how to register drones and the do's/don'ts of flying. Continuing and expanding these efforts—workshops, online portals, and integration into driving/license education systems—will ensure more users know their responsibilities. In Egypt, if a policy shift happens, public outreach would be even more critical to explain the change and reassure citizens that drones will be used responsibly to improve services, not to violate privacy.

**Community Reporting Mechanisms:** To engage the public in monitoring, authorities can set up easy channels for citizens to report rogue or nuisance drones. A mobile app or hotline could allow people to note sightings of unregistered drones or unsafe behavior. This crowdsourcing of enforcement

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can help overstretched regulators and also gives the public a sense of involvement in keeping the system safe. Of course, this should be coupled with the formal tracking systems noted earlier.

**Demonstration Projects:** One way to increase acceptance is to visibly demonstrate the positive use cases. The framework encourages cities to carry out pilot projects that citizens can see or even participate in. For example, a municipality might run a pilot where drones deliver defibrillators in response to emergency calls for cardiac arrest, or use drones to monitor beach safety. Publicizing successful outcomes (like lives saved or costs reduced) will build support and counteract the fear of drones as only "eyes in the sky." The "Drones for Good" competition in the UAE, which showcased humanitarian and civic uses of drones, is a good practice that could be replicated by others (Khan et al., 2018).

**Feedback and Iteration:** Finally, policy-makers should treat the drone integration process as iterative, seeking public feedback. Surveys could gauge public comfort levels with various drone activities over time, and regulations can be adjusted accordingly. For instance, if residents express high concern about noise from delivery drones, rules might be tightened to limit hours of operation or require quieter models. Demonstrating responsiveness to public concerns will help maintain a social license for drone operations in the long run (Clothier et al., 2015).

#### 1.5.6. 6. Regional and International Collaboration

**GCC Cooperation:** Given the geographic proximity and similar governance styles among GCC states, a unified or at least interoperable approach to drone policy is advantageous. The framework suggests that GCC governments work towards common standards—potentially through a GCC working group on drones. This could lead to mutual recognition of drone pilot licenses across countries, standardized technical requirements (so a drone approved in UAE would automatically meet standards in Saudi Arabia, for example), and even shared resources like a regional training center or UTM information sharing. Joint exercises or cross-border pilot projects (imagine a scenario where a drone might travel from one city in the GCC to another for a delivery, with seamless regulatory transition) could be long-term goals. Aligning policies also strengthens the region's stance when engaging with global industry players or international aviation bodies.

**Learning from Abroad:** The GCC and Egypt should maintain dialogue with countries that are at the forefront of drone integration. This can be through participation in ICAO (International Civil Aviation Organization) UAS panels, bilateral agreements or information exchanges, and academic collaborations. Keeping abreast of how other smart cities around the world are dealing with drones (in Asia, Europe, North America) will help local policy avoid pitfalls and adopt proven solutions. For Egypt in particular, observing how a strongly security-conscious state can still enable drones (Israel, for instance, heavily regulates drones but allows civilian use to a degree) might provide a blueprint that decision-makers find acceptable.

**Global Standards and Compliance:** Drones and their components (hardware, software protocols) are produced globally. The policy framework should thus ensure local regulations are not in isolation. Embracing international standards (for communication, remote ID, etc.) means devices and systems in the GCC/Egypt will be compatible and up-to-date. Also, aligning with global norms can boost local drone industries' ability to export or participate in international projects. It also helps manage transnational issues: e.g., a drone straying across a border will be easier to handle if both sides have similar rules (important for neighbors like Saudi and UAE, or GCC states and nearby countries like Jordan or Iraq).

In summary, the results of this study—the Network-Integrated Drone Policy Framework—provide a comprehensive set of measures. These measures, when implemented together, aim to create an environment where drones can be safely woven into the fabric of smart cities. Table 1 provides an overview of the framework components and example actions for GCC states and Egypt (see below).

*[Table 1: Proposed Network-Integrated Drone Policy Framework for Smart Cities in GCC and Egypt]*

*(The table would outline each component and list key actions or policies under GCC example and Egypt example.)*

 doi:10.20944/preprints202504.0892.v1



### *1.6. Discussion*

The proposed framework is intended to strike a balance that reflects the nuanced needs of the GCC and Egypt. In discussing its implications, it is useful to compare back to the challenges identified and assess how the framework's components address them, as well as to consider the feasibility and potential impact of implementation.

#### 1.6.1. Balancing Innovation and Security

One of the core tensions was how to encourage drone innovation for smart city benefits while ensuring security. The framework tackles this by not leaving any side unattended: legal reforms open the door for legitimate use (thus encouraging innovation), but simultaneously robust security safeguards (remote ID, geofencing, counter-measures) are put in place. This dual strategy is in line with recommendations by technology governance scholars who argue that trust in an emerging technology is built by proactively addressing risks (Nelson & Gorichanaz, 2019). If authorities in Egypt adopt even a moderated version of this framework, it could, for example, allow drone mapping in new city construction projects while still having the Ministry of Defense maintain control through tracking systems. In GCC states, where the door is already open, the framework's additions (like a more formal UTM or enhanced privacy rules) will fine-tune the balance and may placate any remaining public or political concerns about drones.

It is worth noting that implementing these measures requires investment—financial and political. Security agencies must be convinced that network-integration can actually improve, not reduce, their ability to control drones. The evidence from places like the UAE is encouraging: by 2024, authorities could report growth in drone usage with apparently no major security incidents, suggesting that careful regulation works (Dubai Civil Aviation Authority, 2024). Egypt's context is different (higher baseline threat perception), but over time, success stories from neighbors might build confidence to try a controlled liberalization. For GCC states, a forward-looking approach is important as the technology evolves. The framework's adaptability (through pilot programs and periodic reviews) ensures innovation is not stifled by outdated rules—a key risk that Nakamura & Kajikawa (2018) warned against.

#### 1.6.2. Integration into Smart City Ecosystems

Integrating drones via networks and data systems means they could become just another component of the smart city, rather than an outlier technology. This integration has many advantages: data collected by drones can enhance city analytics, and conversely city data (like traffic or weather info) can make drone operations safer and more efficient. The framework's technology integration component envisions a synergy where, for instance, a city's air quality sensors and drone-based air sampling work together to map pollution (a possible scenario for a city like Riyadh that faces dust and pollution issues).

However, integration also brings complexity. Cities will need technical expertise to manage these interconnected systems. There could be interoperability issues at first—say, if different cities use different UTM software that don't communicate. This is where setting common standards (via regional collaboration) is vital. The discussion among GCC policymakers should include whether to pursue a centralized UTM for the whole region or at least ensure national systems can exchange data. Perhaps an existing regional entity or a new public-private consortium could take up building such infrastructure, given the cost and expertise required.

Another aspect is redundancy and reliability: relying on networks for drone control implies the need for extremely reliable communications (a dropped network signal could lead to a lost drone). 5G technology promises high reliability and low latency; implementing network slicing specifically for drones (as being tested in Europe) could be an area GCC telecom regulators push, leveraging the fact that several GCC countries are early adopters of 5G. Discussion with telecom operators will be necessary to guarantee quality-of-service for drone operations.

 doi:10.20944/preprints202504.0892.v1



#### 1.6.3. Public Reception and Ethical Considerations

The social dimension is critical. Even a perfectly crafted technical and legal system can falter if public opinion turns sour due to a privacy scandal or a dramatic accident. The framework's emphasis on public engagement reflects this concern. GCC societies and Egypt each have unique social contexts. In some GCC states, there is high public trust in government-led technology (for example, residents of Dubai often express pride in the city's tech innovations). This can facilitate drone acceptance if framed as part of national progress. Yet, incidents like hobbyist drones causing scares or the memory of misuse (e.g., drones used in regional conflicts) can also create fear. Thus, authorities need to communicate clearly what drones will and will not be used for.

One ethical consideration is the potential for increased surveillance. Smart cities are often critiqued for encroaching on civil liberties with omnipresent cameras. Drones could exacerbate that if not properly regulated. The framework's privacy safeguards must thus be taken seriously in implementation—clear guidelines on when police can use drones for surveillance, whether they need warrants, how long data is stored, etc. Engaging legal experts and civil society in drafting these rules would strengthen legitimacy. While such discussions are still nascent in the GCC, the global discourse on AI ethics and privacy is growing and will likely influence expectations in these countries too, especially among younger, tech-savvy citizens.

For Egypt, public skepticism might be higher initially, given that drones have been mostly seen as military or dangerous devices. Early use cases there would need to be very transparent and obviously beneficial (like disaster relief or archaeological surveys in remote areas) to shift perceptions. Egypt could also learn from Rwanda's example in Africa, where drones for medical supply delivery changed public perception positively due to clear life-saving value.

#### 1.6.4. Regional Alignment and Future Prospects

If GCC countries successfully align their drone policies, they could collectively become a global hub for urban drone innovation. The region's mix of wealthy smart city testbeds (like Dubai, NEOM) and relatively controlled airspace provides an attractive environment for companies to develop new drone-based services. This has economic implications: fostering a drone industry (manufacturing, software, operations) can create jobs and diversify the economy in line with visions like Saudi's 2030. Already, we see companies in UAE developing drone taxi services in partnership with global firms (Volocopter in NEOM, for example). A supportive framework will accelerate these projects reaching commercial viability.

On the flip side, divergent regulations would slow progress. If, say, each GCC country had entirely different requirements, companies would hesitate or have to customize too much. Fortunately, the current trend seems to be convergence rather than divergence – likely because early movers like UAE set a template others can adapt. The discussion at the GCC level could even consider a unified drone law or mutual agreements akin to how they handle cross-border driver's licenses or other transport issues.

Internationally, aligning with standards can also position GCC and Egypt as responsible players influencing global norms. By participating in international forums and showcasing their approaches, they can contribute to evolving standards. For instance, if the GCC has a functional regional UTM, that could inform ICAO guidelines for multi-country UTM integration.

One must also discuss limits: drones are not a panacea for all smart city challenges. There is a risk of over-promising their impact. The framework is comprehensive, but prioritization is necessary. Some applications will prove economically or technically unfeasible (e.g., routine drone food delivery has struggled even in advanced markets due to cost and regulation). The recommended pilot projects will help determine which use cases are truly useful and scalable in this region. It's possible that government and industrial uses (infrastructure, surveying, emergency response) will dominate over flashy consumer services, and policy should be ready for that outcome as well.

 doi:10.20944/preprints202504.0892.v1



Finally, the framework's security measures, while important, should be periodically reviewed to ensure they do not become unnecessarily burdensome. If, over time, trust in drone operations grows and capabilities like sense-and-avoid improve, regulators might relax some restrictions (like permitting night operations or flights over people with the right tech). Thus, the discussion should emphasize that this framework is not static. It is a blueprint that requires continuous improvement—a living policy framework that evolves with the technology and societal values.

### *1.7. Conclusion*

Civilian drones offer significant opportunities for enhancing smart city functions in the GCC and Egypt, from efficient service delivery to improved urban monitoring. Yet, realizing these benefits requires careful navigation of regulatory, technical, and societal challenges. In this paper, we presented a comprehensive public policy framework designed to integrate drones into urban environments in a manner that leverages modern network connectivity and addresses regional security and governance concerns.

The framework covers legal reforms to permit and regulate drone use, establishment of institutional capacities to manage drone integration, deployment of technological infrastructure like UTM systems through telecom networks, enforcement of stringent security and privacy safeguards, strategies for engaging the public and building acceptance, and the pursuit of regional collaboration for standardization. By retaining critical controls (such as mandatory registration, remote identification, and geofencing) while opening channels for innovation (such as pilot programs and defined drone zones), the framework aims to balance two imperatives: **fostering innovation** in smart cities and **ensuring safety and security** in the air and on the ground.

For the GCC countries, adopting this framework can accelerate the incorporation of drones into their smart city projects and economic diversification plans. It provides a pathway to harmonize policies across the Gulf, which will benefit not only national governance but also private sector growth in the drone industry. For Egypt, the framework offers a blueprint to cautiously transition from a prohibitive stance to a regulated environment where drones can contribute to its urban development goals (for example, managing its new administrative capital city) without compromising security.

Implementing the framework will require political will, inter-agency coordination, and investment in new systems. Stakeholders should approach this as a phased journey: immediate steps may include creating the legal basis and registration systems, followed by medium-term steps like launching UTM pilot projects and training programs, and long-term steps like full integration of autonomous drone services into city operations. It is also essential to involve international partners and learn from global experiences as the policy environment evolves.

In conclusion, network-integrated civilian drones, governed by thoughtful public policy, can become a cornerstone of smart cities in the Middle East. The road to that future necessitates bridging the gap between traditional security approaches and the boldness to experiment with innovative technology. The framework in this paper is a step in that direction, offering policymakers a structured approach to enable drones to fly safely over our cities and contribute positively to society. With prudent implementation, GCC cities and even a security-conscious Egypt can transform drones from sporadic tools into trusted, ubiquitous elements of the urban landscape, driving progress in the digital age.

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