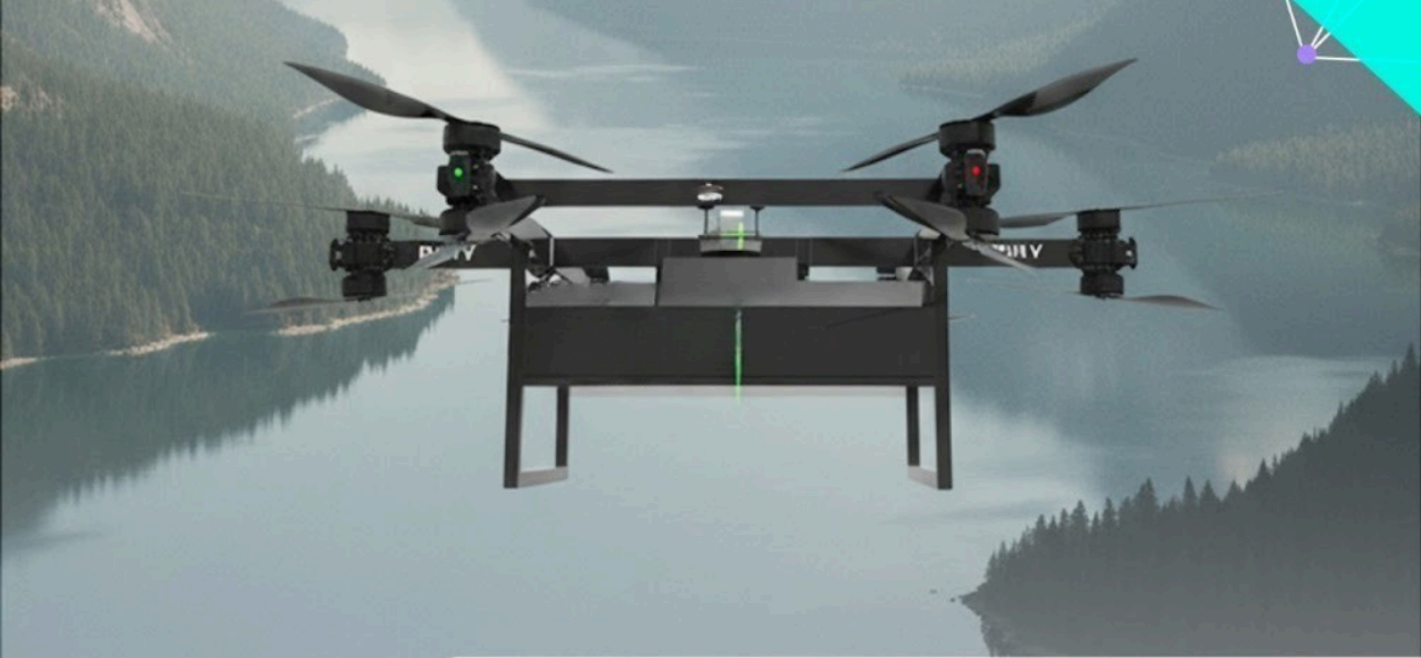
WHITE PAPER



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Unlocking India’s Low Altitude Economy

Odisha's vision for a national **UAV test** and innovation corridor at **Rangeilunda, Berhampur**

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FOREWORD

Odisha today stands at an important inflection point in its development journey. As the state continues to strengthen its foundations through ports, highways, railways, and industrial infrastructure, a new layer of opportunity is emerging, one that lies above the ground yet deeply connected to everyday governance and public service delivery. Low-altitude airspace, long viewed only through the lens of safety, is increasingly being recognised as an enabling infrastructure for the future, capable of supporting logistics, disaster response, infrastructure oversight, and technology-led growth.

The Low-Altitude Economy represents a shift in how value is created and delivered. Unlike conventional aviation, it is characterised by frequent, short-range operations conducted close to communities, assets, and frontline services. For Odisha, a state with a long coastline, diverse terrain, and a proven track record in disaster preparedness, this domain holds particular relevance. The state's emphasis on anticipatory governance, coordination, and systems-based planning provides a strong institutional foundation to engage with this emerging sector in a safe, responsible, and public-interest-oriented manner.

In this context, the Rangeilunda Airstrip in southern Odisha presents a unique strategic opportunity. As an existing aviation asset under public authority, located in relatively uncongested airspace and surrounded by varied operating environments, Rangeilunda is well positioned to evolve into a UAV testing, training, and validation ecosystem. The intent is not to create a one-off facility, but a structured institutional platform where operational procedures, safety frameworks, and emerging technologies can be tested, refined, and validated under civilian oversight and in alignment with national aviation governance.

This initiative reflects Odisha's belief that future-ready infrastructure is built not only through physical assets, but through partnerships, institutions, and shared learning. By enabling collaboration between government, industry partners, and academic and research institutions, the state seeks to create an ecosystem that supports innovation while strengthening regulatory confidence and public capacity. This white paper articulates a phased and responsible vision for this effort, one that positions Odisha as a national platform for proving, governing, and scaling India's low-altitude aviation future in a manner that is safe, inclusive, and sustainable.

Usha Padhee

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Principal Secretary
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EXECUTIVE SUMMARY

Airspace below 1,000 metres above ground level has historically been treated as a safety buffer rather than a productive resource. Today, that perception is changing rapidly. Around the world, this low-altitude layer is emerging as a new form of infrastructure that enables drones and other unmanned systems to deliver public services, improve logistics, strengthen disaster response, and support economic growth. This transformation, commonly referred to as the Low-Altitude Economy, is not driven by the number of drones in the sky, but by the ability of governments to enable safe, repeatable, and trusted operations at scale. According to the World Economic Forum's 2024 analysis of the global drone ecosystem, more than 60 percent of the long-term economic value from drones will arise from services, data, and applications rather than from manufacturing aircraft themselves. McKinsey & Company similarly estimates that drone-enabled services could generate USD 30-40 billion annually by 2030, particularly in infrastructure inspection, logistics, and public-sector use cases. These projections underscore a central message of this white paper: the future value of low-altitude aviation depends less on technology alone and more on governance, evidence, and institutional readiness.

Global aviation regulators have learned that new uses of airspace cannot be scaled safely through ad-hoc permissions or isolated pilot projects. Instead, countries such as the United States, the United Kingdom, and the European Union rely on designated UAV test sites and regulatory sandboxes where new operations can be trialled under controlled conditions, safety data can be collected, and regulators can learn what works before formal rules are finalised. The United States Federal Aviation Administration's UAS Test Site Program, the UK Civil Aviation Authority's regulatory sandbox, and the European Union Aviation Safety Agency's U-space framework all reflect the same principle: innovation must proceed through structured experimentation that strengthens regulators, de-risks industry, and builds public trust. India has already taken important steps in this direction through the Drone Rules, 2021 and the Digital Sky / National UTM Policy Framework, which emphasise trust-based regulation and digital oversight. What remains essential is operational evidence, real-world learning that allows regulators to move from experimental exemptions toward scalable, performance-based rules for beyond visual line of sight operations.

This is the context in which Rangeilunda Airstrip in Odisha assumes national relevance. Rangeilunda offers a rare convergence of attributes that make it suitable as a national-grade UAV testing, training, and validation ecosystem. It is an existing aviation asset under public authority, avoiding the need for greenfield development. It is located in low-density airspace that allows safe experimentation without interfering with commercial aviation. Its coastal and mixed-terrain environment reflects real Indian operating conditions for logistics, disaster response, surveillance, and infrastructure monitoring. Equally important, Odisha brings institutional experience in anticipatory governance. The state's disaster-management systems, frequently cited by the World Bank and United Nations agencies as global best practice, demonstrate how investment in preparedness, coordination, and systems produces disproportionate public value. The same philosophy underpins the vision for Rangeilunda.

Rangeilunda is not proposed as a commercial drone park or a defence-exclusive range. It is envisioned as a civilian-governed test ecosystem operating under national aviation oversight, where safety procedures, digital traffic management systems, operational concepts, and human factors can be validated transparently. For Odisha, the spillover benefits extend well beyond aviation activity. Test and validation ecosystems create sustained demand for high-quality jobs such as safety managers, engineers, technicians, data analysts, compliance officers, and trainers roles that are institutional in nature and grow over time. They also create steady employment pathways for licensed drone pilots, whose roles evolve from episodic flight operations to long-cycle professional careers embedded within logistics, inspection, emergency response, and public-service delivery models. The OECD's 2024 research on regional innovation clusters shows that regions hosting test and certification infrastructure experience more durable employment and higher skill retention than regions focused solely on manufacturing. Shared infrastructure also lowers entry barriers for local MSMEs and startups in electronics, composites, software, analytics, maintenance, and training, anchoring value creation locally rather than exporting it to metropolitan centres. Continuous testing activity generates recurring economic demand rather than one-time construction-led expenditure, while also producing strong local multipliers in hospitality, transport, housing, and professional services.

Beyond industry, the public-sector benefits are immediate and tangible. For a state like Odisha, which faces recurrent cyclones and floods, test-validated drone workflows strengthen disaster preparedness by ensuring that logistics, assessment, and communication capabilities are rehearsed before emergencies occur. Similar benefits accrue to infrastructure inspection, healthcare logistics, and environmental monitoring, where evidence-based scale-up is preferable to anecdotal pilots. Importantly, Rangeilunda also enables structured collaboration between industry, academia, and government. By linking the test ecosystem with universities and technical institutions, Odisha can create a living laboratory where students and researchers work with real operational data, accelerating workforce readiness, applied research, and standards literacy.

At the national level, the outcomes are equally significant. Evidence generated at Rangeilunda reduces policy risk for the Directorate General of Civil Aviation by supporting a transition from mission-by- mission approvals to scalable, performance-based regulation aligned with international practice. Domestic test capacity helps retain Indian talent, intellectual property, and investment that might otherwise flow abroad for validation. Platforms tested under regulator-supervised conditions gain credibility in international markets, supporting India's export ambitions in advanced aviation and autonomy. Early operational learning also enables India to participate more substantively in global standard-setting forums such as the International Civil Aviation Organization, moving from a rule-taker to a rule-shaper position.

This white paper does not advocate deregulation or dilution of safety standards. It proposes a phased, evidence-led approach that begins with controlled experimentation, progresses through corridor-based operations under digital oversight, and allows scale to emerge as a consequence of learning rather than assumption. Investment requirements are modest and largely shared, focused on reusable physical assets, digital infrastructure, and human capital. International experience shows that such investments are best understood as public-good infrastructure that lowers long-term regulatory and economic risk, rather than as subsidies to industry.

From an impact perspective, global evidence suggests that test-and-validation-led aviation ecosystems generate returns that significantly exceed their physical scale. The World Economic Forum (2024) notes that regions investing early in low-altitude aviation infrastructure and regulatory sandboxes often realise three to five times the downstream economic activity of the initial infrastructure investment, primarily through services, logistics efficiency, and public-sector adoption. OECD analysis from 2024 further indicates that shared test infrastructure can increase private investment density by approximately 20-30 percent over a five-to-seven-year horizon, driven by reduced regulatory uncertainty and stronger ecosystem confidence. Employment impacts are similarly skewed toward quality: such ecosystems typically support two to three times more high-skill, long-cycle jobs than comparable capital investments in conventional infrastructure. In the Indian context, analyses by

1. **Indicative Outcomes for Odisha**
   Investment: Increased private and PPP investment in drones, logistics, analytics, training, and MRO, supported by regulatory clarity and validated airspace rather than incentives alone.
2. **Employment:** Sustained creation of high-skill, higher-wage jobs across safety, engineering, data, compliance, training, and professional drone pilot roles, with longer employment cycles and stronger local retention.
3. **Network Effects:** Clustering of MSMEs, startups, academia, and service providers around shared infrastructure, generating spillovers into manufacturing quality, public services, and export readiness.

Taken together, these outcomes position Rangeilunda not as a standalone facility, but as a catalyst, one that converts Odisha's early institutional initiative into durable economic, governance, and strategic advantage for the state and for India.

ACKNOWLEDGEMENT

The authors, Baibhav Patel , A B Debasis Mohanty, and Uma Sudhindra gratefully acknowledge the support, guidance, and contributions of several individuals and institutions that made this white paper possible.

We first acknowledge the Commerce & Transport Department, Government of Odisha, for its continued support and constructive engagement under the leadership of Smt. Usha Padhee, IAS, Principal Secretary . In particular, we express our sincere gratitude to Mr. Suresh Chandra Hota, Special Advisor, Govt. of Odisha, whose constant guidance, insights, and encouragement played a critical role in shaping the direction and substance of this white paper.

We acknowledge the institutional platform, resources, and enabling ecosystem necessary to undertake this work. We especially thank Mr. Satyabrata Satapathy, for his leadership and for fostering an environment that encourages policy-oriented research and innovation in emerging aviation and drone ecosystems.

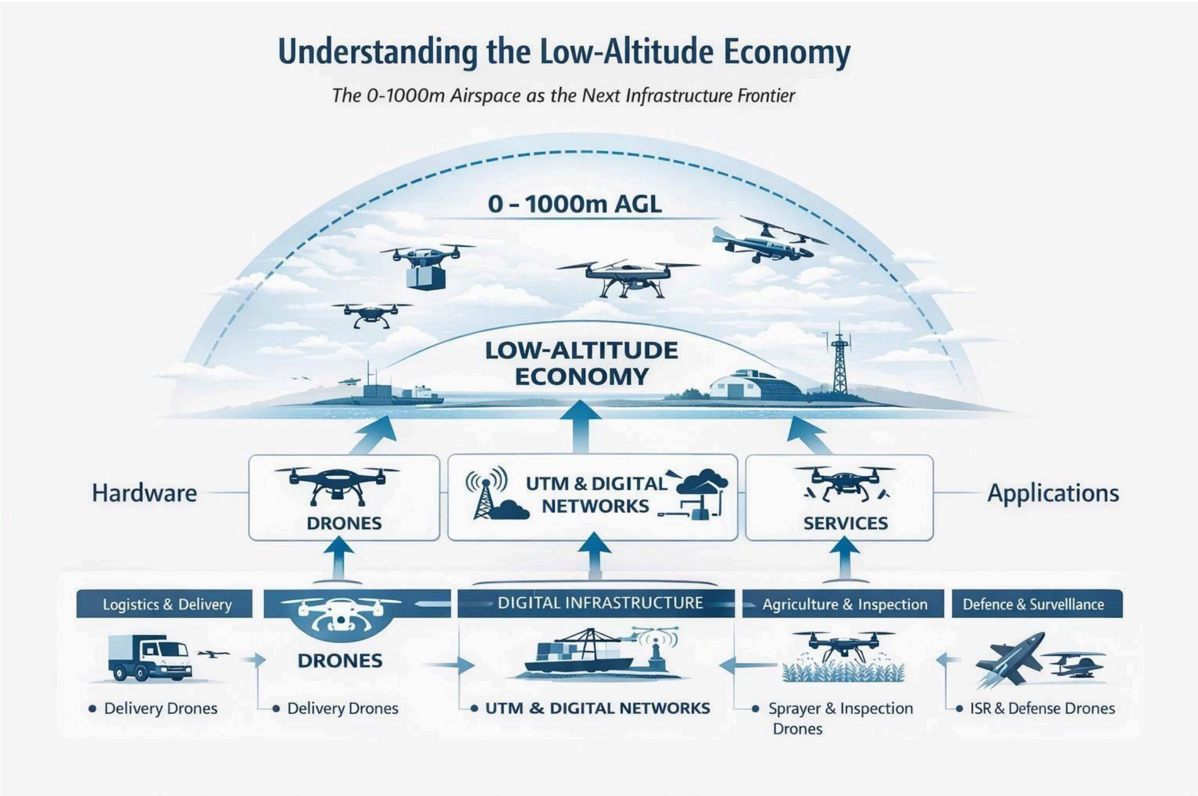
We acknowledge Archana Pasayat for her valuable contribution in coordinating and designing the infographics that enhance the clarity and accessibility of the white paper. We thank Medha and Wanda from SRGF for their thoughtful peer review and for designing the cover page, contributing significantly to both the academic rigour and visual presentation of the document.

We would also like to acknowledge Roshan Senapati for his motivation and support, which helped sustain momentum during the development of this work.

Section 1

Low-Altitude Economy (LAE) as National Infrastructure

Re-conceptualising 0–1,000 m AGL Airspace as an Economic Layer



The Low-Altitude Economy (LAE) refers to economic activity enabled in the 0-1,000 metres Above Ground Level (AGL) airspace using unmanned aircraft systems (UAS), emerging electric Vertical Take-Off and Landing (eVTOL) platforms, digital traffic management, and automation. With continuous scientific advancement and rapid technological breakthroughs, the LAE has emerged globally as a strategic, next-generation area of economic activity, playing a key role in the transformation of aerospace, logistics, and mobility systems.

Historically, low-altitude airspace was managed only as a safety buffer, not as a productive resource. Today, it is increasingly recognised as a new infrastructure layer, analogous to roads or radio spectrum, where economic value is generated through structured access, throughput, reliability, and network effects rather than individual flights.

Unlike conventional aviation, which derives value from low-frequency, high-value passenger and cargo movements at altitude, the LAE is driven by high-frequency, short-range operations conducted close to people, infrastructure, and frontline public services. These characteristics align the LAE more closely with transport, logistics, and digital infrastructure economics than with traditional aviation models.

Why this matters: McKinsey estimates that global drone-enabled services could generate USD 30-40 billion annually by 2030, with logistics, infrastructure inspection, and public services driving scale.

This underscores that low-altitude airspace is not "lower aviation," but a distinct economic layer requiring deliberate policy and infrastructure planning.

Why Low-Altitude Airspace Is a Distinct Operational Layer

Federal Aviation Administration (FAA) studies show that UTM-enabled coordination is essential once traffic density crosses low hundreds of operations per day per region. Low-altitude airspace is operationally different from manned aviation and therefore requires separate governance:

1. **High-frequency missions**: Daily inspection, emergency response, and logistics networks and not episodic flights.
2. **High platform density**: Multiple UAV classes operating simultaneously in constrained geography.
3. **Ground-risk dominant safety model**: Risk shifts from onboard passengers to people, property, and infrastructure below.
4. **Navigation & communications constraints**: GNSS degradation, multipath interference, and urban RF noise are more acute.
5. **Software-defined scalability**: Manual ATC cannot scale; automation, telemetry, and digital coordination are essential.

The LAE Stack: Hardware, Digital Infrastructure & Services

LAE industry spans manufacturing, flight operations, support services, and integrated services, with strong spillover effects across batteries, propulsion systems, software, telecom, and data analytics. Policy frameworks that focus only on drones as hardware tend to produce fragmented pilot projects. Sustained economic value emerges only when airspace itself is treated as shared infrastructure and digitally instrumented. The LAE functions as a multi-layered economic stack, encompassing the full value chain of low-altitude operations:

1. **Hardware:** UAV platforms (inspection, ISR, logistics, heavy-lift). Enables capability but not scale.
2. **Digital Infrastructure (Programmable Airspace):** UTM, Remote ID, geofencing, mission authorisation, logging, cyber resilience. Enables governance and safety at scale.
3. **Applications & Services:** Logistics, disaster response, infrastructure inspection, precision agriculture, public safety. This is where economic value is realised.

Policy that focuses only on drones (hardware) produces fragmented pilots. Economic value emerges only when airspace is treated as infrastructure and digitally instrumented.

Role of eVTOLs within the LAE

According to the Vertical Flight Society, eVTOLs represent a new mode of air transportation that is cleaner, quieter, safer, and more versatile, with applications across passenger transport, cargo logistics, and urban management. In the near term, passenger operations dominate market forecasts, while cargo and logistics applications, particularly express delivery, are already demonstrating commercial viability by alleviating ground congestion and improving distribution efficiency.

As eVTOL technologies mature, they are accelerating Urban Air Mobility (UAM) while simultaneously driving the development of low-altitude airspace management systems, standards, and regulatory frameworks. This co-evolution reinforces the case for treating low-altitude airspace as infrastructure rather than an exception-based aviation domain.

Why LAE Needs a Separate Policy Lens

Organisation for Economic Co-operation and Development (OECD) notes that absence of economic framing delays infrastructure investment even when technology is mature. Low-altitude airspace has historically been treated as residual, for five structural reasons:

1. **Manned-aviation legacy:** Airspace law evolved around crewed aircraft, airports, and corridors.
2. **Technology gap (historical):** Persistent, trackable unmanned flight was not previously feasible.
3. **Permission-centric regulation:** One-off approvals reinforced episodic use.
4. **No economic valuation:** Unlike highways or spectrum, utilisation was never monetised or measured.
5. **Institutional fragmentation:** Civil aviation, defence, telecom, and disaster management intersect without a single owner.

Consequences of Neglecting Sub-1,000 m Airspace

The European Union Aviation Safety Agency (EASA) links predictable U-space corridors (UAV corridors in low altitudes) directly to investment confidence and safety outcomes. Failure to plan low-altitude airspace as infrastructure leads to:

1. **Stalled scale:** Drone services remain stuck in pilots due to per-mission approvals.
2. **Regulatory overload:** Authorities process repetitive requests without automation or standardisation.
3. **Poor safety learning:** Non-comparable datasets prevent systematic risk reduction.
4. **Sectoral silos:** Disaster, agriculture, energy, and security build parallel systems.
5. **Strategic risk:** Advanced testing shifts outside integrated civil frameworks, increasing dependence on foreign ecosystems.

Low-altitude airspace today mirrors early radio spectrum and highway networks managed defensively rather than productively. Both unlocked economic multipliers only after segmentation, standards, and predictable access were introduced.

The economic logic of the Low-Altitude Economy ultimately depends on the ability to operate **beyond visual line of sight**. High-frequency logistics, corridor-based inspection, persistent surveillance, disaster response networks, and time-critical public services cannot be delivered at scale if aircraft must remain tethered to a human observer. BVLOS is therefore not a niche technical upgrade but the operational condition that converts low-altitude airspace from a collection of isolated flights into a continuous, networked system.

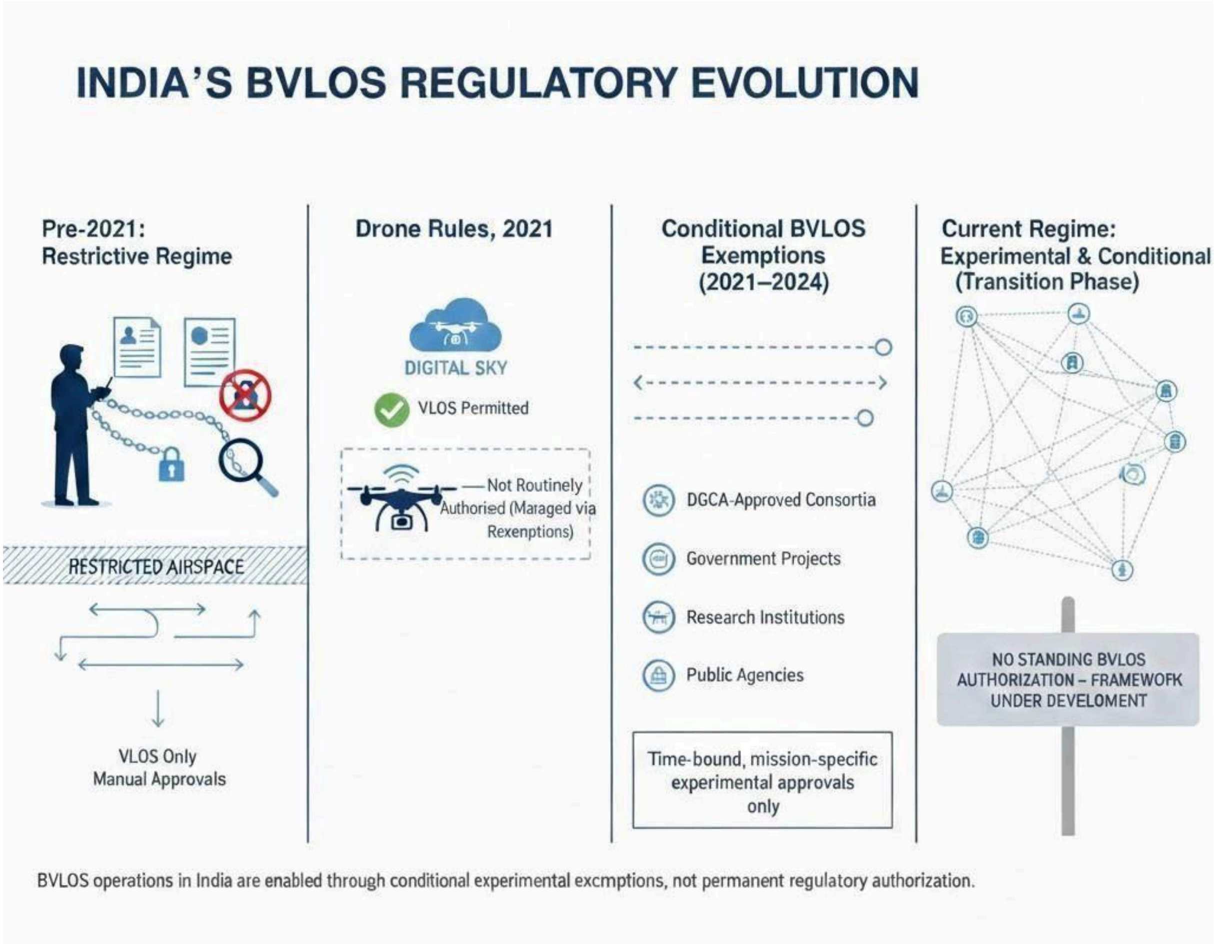
Without routine BVLOS, low-altitude airspace remains permission-bound and episodic, preventing throughput, reliability, and network effects—the very attributes that define infrastructure-driven economic value. In this sense, BVLOS is to the LAE what controlled access and signalling were to highways or what standardised spectrum allocation was to telecommunications: the enabler that transforms latent capacity into productive infrastructure. Understanding how India has approached BVLOS regulation, and why current models constrain scale, is therefore central to assessing whether the Low-Altitude Economy can move from pilots to permanence. This leads directly to an examination of India's BVLOS regulatory evolution and its implications for LAE development.

The lesson is clear: value emerges when access is structured, not merely permitted.

Section 2

India's BVLOS Constraint and the Current Regulatory Regime

Evolution of BVLOS Regulation in India: How We Got Here



India's regulatory journey on Beyond Visual Line of Sight (BVLOS) operations reflects a deliberate, safety-first progression but one that has remained structurally anchored in trial-based permissions rather than routinised operations.

The Drone Rules, 2021, issued by the Ministry of Civil Aviation, marked a decisive break from earlier, restrictive frameworks. The Rules simplified classification, reduced compliance burden, and operationalised permissions through the Digital Sky platform. However, while the Rules created a modern baseline for unmanned aircraft operations, they did not themselves enable routine BVLOS operations at scale. BVLOS continued to be treated as an exception, requiring additional approvals beyond the standard rulebook.

A significant policy signal followed, when the Ministry issued a conditional exemption order permitting selected consortia to conduct BVLOS trials under defined safety conditions and for a limited duration. This was India's first formal move toward a "test-and-learn" approach for BVLOS, recognising that evidence from controlled experimentation would be required before full-scale regulatory opening.

Subsequent developments reinforced this trial-led approach. A review of the Ministry's public order archive shows multiple conditional BVLOS exemptions granted to specific entities including government agencies, research institutions, and state-led projects (e.g., ICMR, Survey of India, IITM Pune, Telangana Government). While these exemptions enabled valuable experimentation, they also revealed a structural pattern: BVLOS permissions were being handled on an entity-specific, case-by-case basis, rather than through standing operational pathways available to all qualified operators.

Regulatory evolution has continued through amendments, notably the Drone (Amendment) Rules, 2023, which further rationalised compliance and reflected iterative learning by the regulator. Yet, even with these refinements, BVLOS remains outside the scope of routine authorisation. Dedicated operational rules, standardised safety cases, and repeatable approval pathways have yet to be fully institutionalised.

As recently as October 2025, mainstream reporting quoted senior leadership of the Directorate General of Civil Aviation indicating that BVLOS rules were in an advanced stage of finalisation. This public acknowledgement confirms that India is in a transition phase, moving from trials and exemptions toward a formal, codified BVLOS regime, but not yet fully across that threshold.

Structural Bottlenecks: Why Mission-by-Mission Approvals Do Not Scale

Despite steady progress, India's current BVLOS model exhibits structural bottlenecks that prevent scale, investment certainty, and sustained operations.

First, the heavy reliance on conditional exemptions creates high transaction costs. Each BVLOS mission or project requires bespoke documentation, review, and approval. This slows iteration, discourages repeat operations, and makes it difficult to build continuous services. In contrast, scalable infrastructure systems rely on standing authorisations zones, corridors, or standard operating envelopes rather than mission-by-mission clearance.

Second, BVLOS is fundamentally a risk-management problem, not merely a flight-permission issue. It involves airspace integration, loss-of-link scenarios, detect-and-avoid performance, ground-risk modelling, and contingency management. Global aviation practice treats such operations through structured safety cases. This is precisely why the International Civil Aviation Organization(ICAO) frames UAS Traffic Management (UTM) as an integrated system of procedures, services, information, and governance designed to enable scale while maintaining safety. Without standardised BVLOS pathways, approvals inevitably remain bespoke.

Third, India's federal structure adds an additional layer of friction. States can provide land, airstrips, and institutional support for test sites, but airspace permission and operational authorisation remain centrally governed under the MoCA/DGCA framework. In the absence of repeatable BVLOS pathways, even well-prepared state initiatives encounter binding regulatory constraints. This mismatch between state-level readiness and central approval mechanisms limits the utility of local infrastructure investments.

Fourth, scalable BVLOS operations require a digital infrastructure layer UTM-like services capable of managing constraints, deconfliction, prioritisation, and data exchange in near-real time. Without such systems, regulators are forced to rely on conservative assumptions and manual oversight. ICAO's regional reference materials explicitly identify UTM/ATM integration, corridor planning, communications protocols, and minimum safety performance requirements as core enablers of routine BVLOS.

Finally, policy uncertainty itself has become an industry bottleneck. When BVLOS remains perpetually "under finalisation," firms hesitate to invest in mature platforms, advanced autonomy, and long-term operations. Instead, they over-index on VLOS-only business models with limited scalability. Public statements in October 2025 that BVLOS rules were nearing completion underscore how long the ecosystem has been waiting for a stable regulatory regime.

Comparative Regulatory Models: What India Can Adapt

International experience demonstrates that India's challenges are not unique and that viable regulatory solutions already exist.

In the United States, the FAA convened a BVLOS Aviation Rulemaking Committee (ARC), which explicitly recommended moving away from bespoke waivers toward performance-based, risk-based regulatory pathways. The ARC's core insight was that routine BVLOS requires repeatable routes to approval, not perpetual exemptions.

The UK Civil Aviation Authority has gone further by publishing an explicit BVLOS roadmap, outlining milestones to enable routine BVLOS operations by 2027. This public, time-bound transition plan provides clarity to industry and aligns regulatory development with technological maturation.

Complementing this, the UK CAA's Regulatory Sandbox approach allows innovators to mature solutions that do not fit existing rules, under regulatory supervision. This model is particularly relevant for large test sites, where multiple use cases, platforms, and safety concepts can be evaluated simultaneously effectively functioning as regulatory sandboxes at scale.

Within the European Union, the EASA has operationalised a risk-based categorisation under Regulation (EU) 2019/947. Higher-risk operations, including many BVLOS missions, are handled under the "Specific" category through structured risk assessment and predefined authorisation logic. This reduces one-off policymaking while preserving safety oversight.

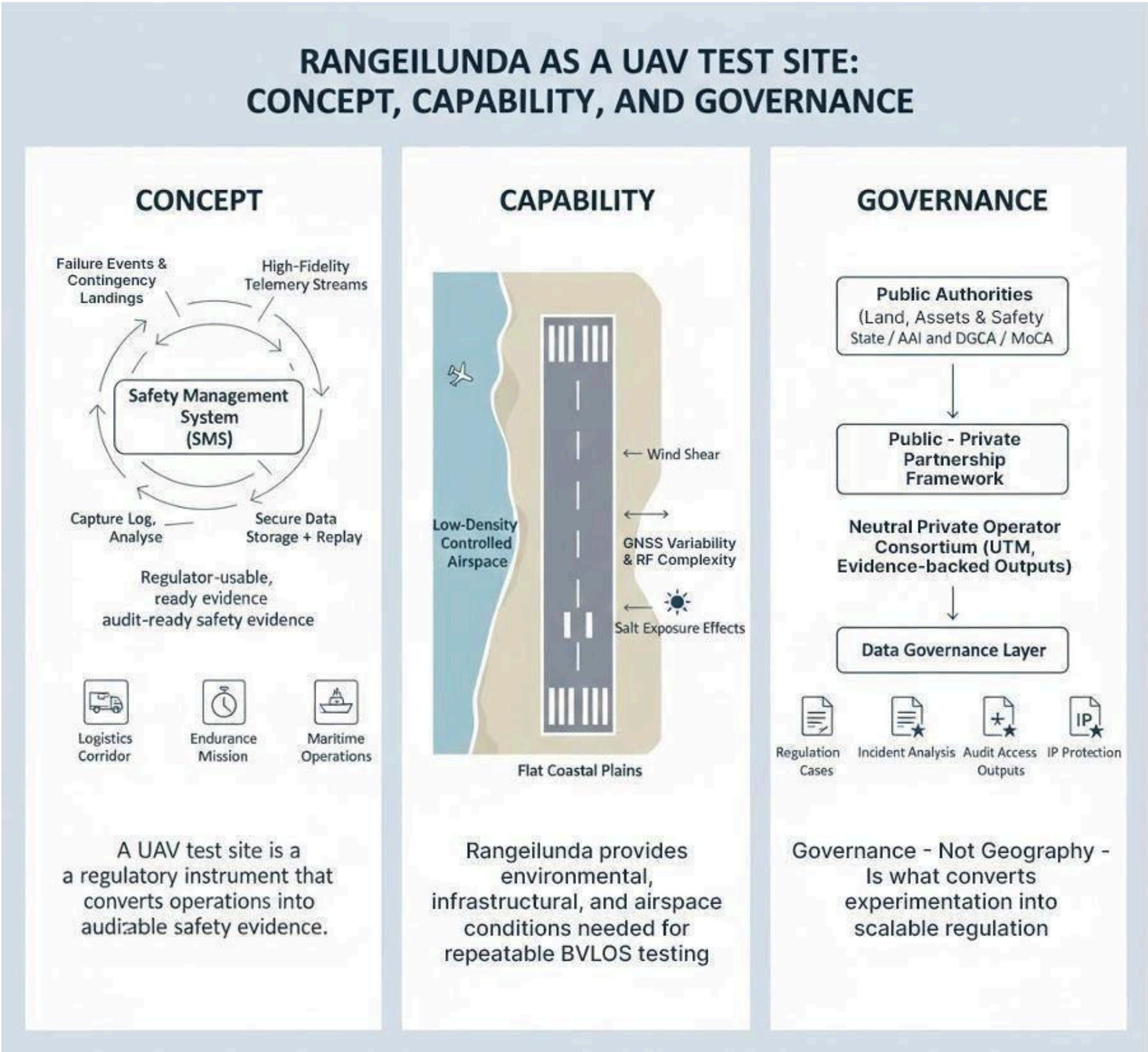
Singapore's Civil Aviation Authority of Singapore offers another instructive model. Through published Advisory Circulars, CAAS has codified the evidence and safety arguments required for BVLOS approvals. This transparency reduces uncertainty for operators and regulators alike and provides a template for how DGCA/MoCA could articulate national-scale BVLOS assessment methodologies.

International practice shows a clear direction of travel: from exemptions to pathways, from permissions to infrastructure, and from manual oversight to digitally mediated governance. India's ongoing BVLOS rule-finalisation process represents a critical inflection point. The choices made now particularly around corridors, UTM integration, and test-site-enabled evidence generation will determine whether BVLOS becomes a constrained niche capability or a foundational component of India's low-altitude economy.

Section 3

Rangeilunda as a UAV Test Site: Concept, Capability, and Governance

What Qualifies as a UAV Test Site (Beyond a Flying Area)



A UAV test site is not merely a location where drones operate; it is a regulatory and safety instrument designed to generate evidence usable by regulators—including safety data, failure-mode learning, operational procedures, and integration pathways.

The FAA UAS Test Site Program, reaffirmed in its 2024 UAS Integration Strategy Update, explicitly positions test sites as mechanisms to support rulemaking, certification, and scalable integration into the National Airspace System (NAS). As of 2024, FAA test sites have collectively supported over 30,000 documented BVLOS and advanced operations, feeding data into Remote ID enforcement, BVLOS rulemaking, and UTM validation efforts.

FAA guidance makes a clear distinction: sites that only host demonstrations or pilots do not qualify as test sites unless they generate structured safety outputs that regulators can audit, reproduce, and rely upon.

Accordingly, a credible UAV test site must include:

1. A formal **Safety Management System (SMS)**: Treated as the backbone of experimentation. FAA and EASA both emphasise SMS-driven testing to ensure failures are anticipated, contained, and converted into learning rather than suppressed.
2. **Segregated or conditionally reserved airspace**: The UK CAA Innovation Sandbox (expanded in 2024) confirms that early-stage autonomy and BVLOS operations require airspace where systems can fail safely without interacting with commercial manned aviation.
3. **High-fidelity telemetry and data capture**: The U.S. National UAS Test Plan (2024 revision) highlights sub-second telemetry, secure storage, and replay capability as prerequisites for regulator-usable evidence.
4. **Defined Concepts of Operations (CONOPS)**: FAA and EASA now assess sites based on their ability to test specific operational concepts like logistics corridors, endurance missions, maritime operations, and urban BVLOS, not generic flying.
5. **Multi-stakeholder collaboration**: The UK CAA and EASA (2024 U-space implementation reviews) show that meaningful regulatory learning occurs when regulators, academia, and OEMs co-develop metrics and procedures in shared environments.

In this sense, a UAV test site functions as a “laboratory of the sky”, not a flying field.

Site Suitability: Why Rangeilunda Is Test-Site-Grade

Against this definition, Rangeilunda can be credibly positioned as a test-site-grade aviation asset, not a drone park.

Anchor aviation infrastructure
Rangeilunda's 3,000-foot paved airstrip, under public authority and documented by the Airports Authority of India, aligns with global test-site norms that prioritise persistent access, controlled entry, and formal aviation oversight. In 2024-25, FAA and EASA reviews increasingly emphasised that serious BVLOS and logistics testing requires runway-based infrastructure, not ad-hoc launch zones.

Coastal operational complexity
Coastal UAV operations are now explicitly recognised as a priority validation domain. The EASA 2024 U-space Deployment Status Report identifies salt corrosion, wind shear, GNSS variability, and RF interference as among the most common contributors to UAV incident reports in maritime and coastal trials. Rangeilunda's coastal environment therefore enables testing that inland sites cannot replicate, particularly for logistics, ISR, disaster response, and maritime surveillance.

Low surrounding traffic density
Digital Sky and MoCA airspace assessments indicate low commercial traffic density around Rangeilunda. Internationally, both FAA and EASA now treat low-density airspace as an advantage during early BVLOS and autonomy testing, allowing regulators to observe loss-of-link behaviour, contingency management, and emergency recovery without systemic risk.

Terrain diversity
The site's proximity to flat coastal plains and nearby hilly terrain aligns with global best practice. The FAA 2025 BVLOS ARC findings emphasise that terrain variation is essential for validating detect-and-avoid systems, terrain-following sensors, and communications resilience.

Climatic suitability
Regional meteorological data indicates a high proportion of VFR (Visual Flight Rules) -compatible days, supporting persistent testing cycles. Persistence is now explicitly cited by FAA and EASA (2024-25) as a key differentiator between demonstration sites and true test sites.

Collectively, these factors allow Rangeilunda to be framed as a "green-zone" for high-frequency UAV experimentation, consistent with global test-site selection logic.

Governance and PPP Model: Ensuring Regulatory Trust

By 2024-25, global consensus has converged on one principle: geography enables testing, but governance enables trust.

The NASA-FAA UTM CONOPS and EASA U-space implementation guidance (2025) both describe low-altitude airspace management as a cooperative system: regulators set policy, industry delivers digital services, and operators comply within defined constraints. This directly supports a public-private partnership (PPP) model.

Under a regulator-trusted PPP structure:

1. The State / AAI provides land and aviation assets
2. DGCA / MoCA retain airspace and safety authority
3. A neutral private operator consortium manages day-to-day operations, UTM services, and data infrastructure

The World Bank (2024 Infrastructure Governance Update) and OECD (2025 Infrastructure PPP Review) both emphasise that experimental aviation PPPs must include explicit risk-sharing, indemnity, and insurance frameworks to protect public assets during testing.

Critically, governance must mandate policy outputs, not utilisation metrics. FAA test sites are evaluated based on rulemaking contributions, not flight hours. For Rangeilunda, mandated outputs should include:

1. BVLOS safety cases and reliability benchmarks
2. Incident and near-miss taxonomies
3. Corridor performance and availability metrics
4. Interoperability and UTM validation reports

The UK CAA Sandbox (2024 expansion) and EASA U-space model demonstrate how temporary airspace reservations, supervised CONOPS trials, and evidence-based escalation allow learning without premature rule changes. A standing Safety and Airspace Review Board at Rangeilunda would align directly with this practice.

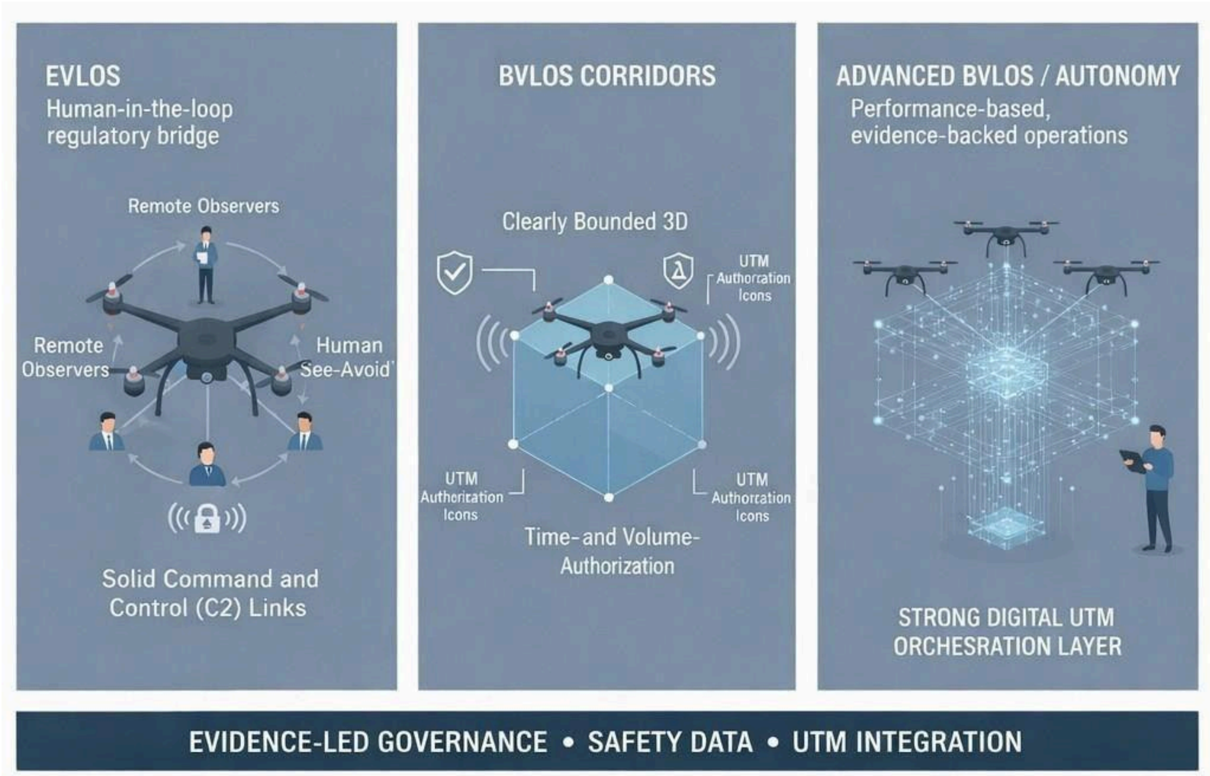
Data governance is now non-negotiable. FAA and EASA 2024 guidance stress clear protocols for data ownership, anonymisation, audit rights, and regulator access, ensuring private IP protection while preserving full safety visibility. Transparent slotting and fee structures are essential to prevent vendor lock-in and preserve national utility.

In light of 2024-25 global regulatory practice, Rangeilunda can be positioned as more than a UAV facility. It can function as a regulatory laboratory where India resolves BVLOS uncertainty, validates digital airspace systems, and generates evidence.

By treating Rangeilunda as a test site in the strict regulatory sense, India can move from exemption-led experimentation to structured, scalable UAV operations, anchoring the low-altitude economy in evidence, trust, and international credibility.

Section 4

Phased Operational Roadmap: EVLOS to Advanced BVLOS



A DGCA-friendly, risk-based, evidence-led pathway to scale

The transition from Visual Line of Sight (VLOS) to routine Beyond Visual Line of Sight (BVLOS) operations is not a regulatory switch, but a governance journey. Global regulators now converge on a core principle: scale must follow evidence, not precede it.

As of 2024-2025, leading aviation authorities including the ICAO, FAA, and EASA explicitly endorse phased, performance-based progression from human-observed operations to digitally managed BVLOS environments. A phased roadmap: EVLOS → corridor-based BVLOS → advanced autonomy designed to reduce regulatory risk, generate auditable safety evidence, and align Indian practice with international norms. Rather than treating EVLOS and BVLOS as binary permissions, they are framed here as progressive safety and governance instruments.

EVLOS Safety: EVLOS as the Regulatory Bridge to BVLOS

Extended Visual Line of Sight (EVLOS) is not merely an incremental relaxation of VLOS. In regulatory practice, EVLOS functions as the primary risk-decomposition layer between direct visual oversight and fully remote BVLOS operations.

Human-in-the-loop safety buffer

EVLOS preserves a distributed "see-and-avoid" capability through trained remote observers while extending operational range. The ICAO UTM Framework (2024 update) explicitly recognises stepwise human-to-digital transition as the safest integration pathway for low-altitude operations.

Command and Control (C2) link validation under operational stress

EVLOS is the first environment where command-and-control (C2) reliability, latency, handover, and partial degradation can be tested in real conditions. FAA test-site data released in 2024 shows that communication-related anomalies remain among the top three contributors to BVLOS incident reports, reinforcing the need to validate links before visual oversight is fully removed.

Disciplined evidence generation

EVLOS allows regulators to standardise and audit:

1. lost-link and recovery drills,
2. emergency procedures,
3. telemetry, logging, and post-flight analysis.

The FAA's UTM Concept of Operations v2.0 and subsequent 2025 integration updates emphasise that shared situational awareness must be proven under EVLOS before it is trusted for BVLOS scale.

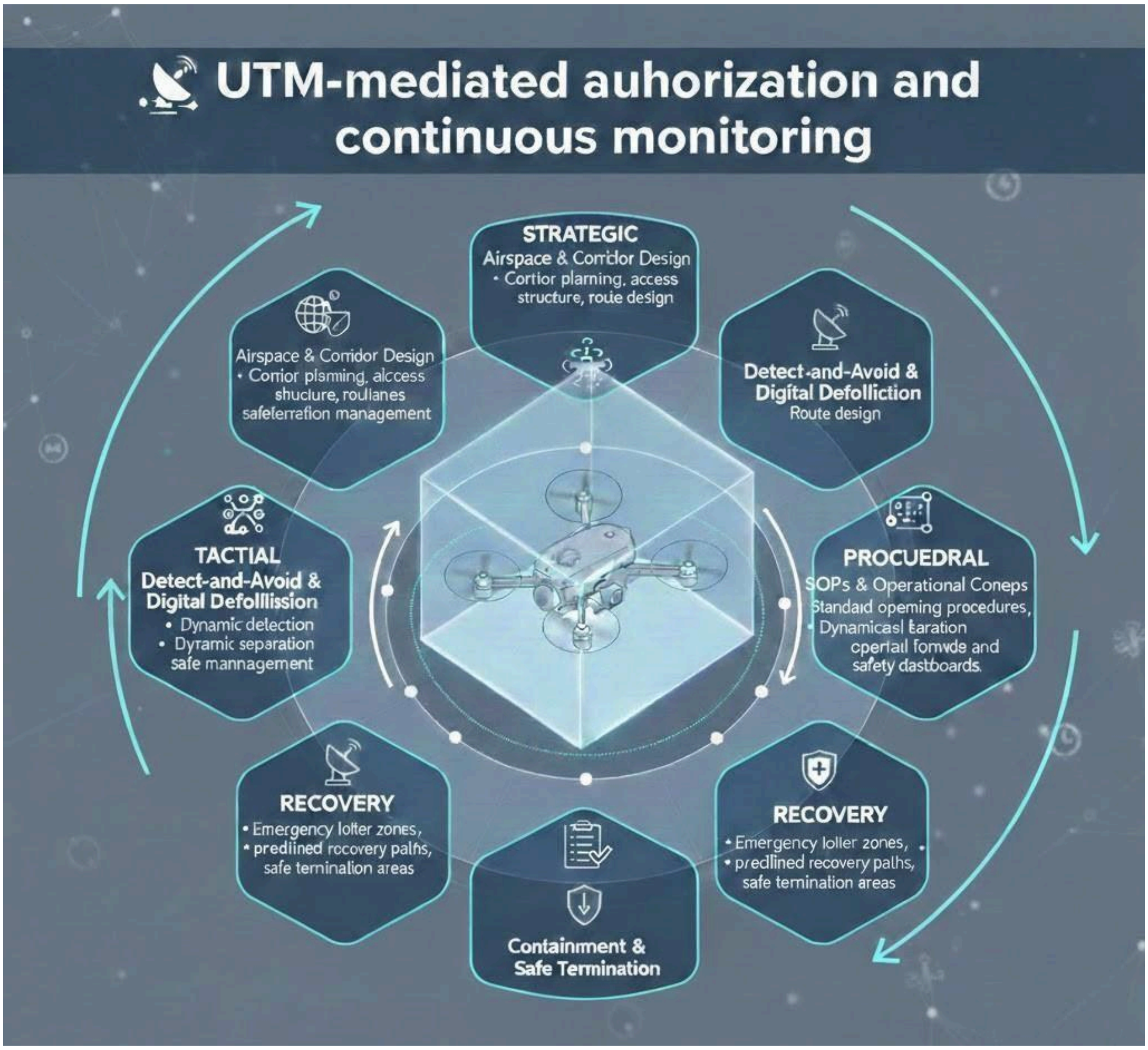
Human factors under load

FAA and EASA human-factors reviews (2024) highlight that crew coordination, alert interpretation, and SOP adherence account for a significant share of operational risk. EVLOS allows these dynamics to be observed under real workload conditions.

Policy implication

EVLOS should be formalised as a standardised experimental envelope, with measurable performance gates such as incident-free hours, successful contingency drills, and C2 reliability thresholds replacing subjective, case-by-case approvals. EVLOS is the bridge from sight to scale: where human observation is systematically replaced by data-driven safety.

BVLOS Risk Mitigation: From Bespoke Permissions to Repeatable Pathways



BVLOS introduces compounded risks: loss of visual separation, increased ground exposure, and dependence on digital systems. The global response has been consistent BVLOS must be enabled through structured, risk-based methodologies, not ad-hoc exemptions.

Risk-based decision architecture

The Joint Authorities for Rulemaking on Unmanned Systems (JARUS) SORA framework, updated through Edition 2.5 (2024), remains the global reference for assessing ground and air risk through layered mitigations. While India need not adopt SORA wholesale, its logic graduated mitigations instead of binary approvals aligns closely with DGCA's safety philosophy.

Performance-based regulation

The FAA's BVLOS Aviation Rulemaking Committee (ARC) Final Recommendations (2024) explicitly advise moving away from waiver-heavy systems toward repeatable, performance-based pathways. This approach reduces regulatory load, improves consistency, and increases investor confidence.

DAA and C2 as outcomes, not prescriptions
Recent FAA and EASA guidance (2024-25) treats Detect-and-Avoid (DAA) and C2 links as performance outcomes defined by "well-clear" criteria, latency, and reliability thresholds rather than mandating specific sensors or vendors. This avoids technology lock-in while preserving safety intent.

Layered mitigation logic
ICAO and JARUS frameworks converge on a four-layer safety narrative:

1. **Strategic:** airspace design and corridor planning
2. **Tactical:** DAA and digital deconfliction
3. **Procedural:** SOPs and contingency handling
4. **Recovery:** fail-safe and containment mechanisms

This layered approach provides regulators with a defensible safety case for BVLOS scale.

Indian alignment
India already recognises UTM as national digital infrastructure through the Digital Sky platform. Positioning BVLOS trials as implementations of national UTM policy, rather than exceptions, reduces institutional friction and accelerates acceptance.

BVLOS is not about removing the pilot; it is about replacing human sight with verifiable digital situational awareness.

Corridor Design: Operationalising EVLOS → BVLOS at Rangeilunda

BVLOS corridors are not mere airspace allocations; they are governance instruments that convert policy intent into controlled operational reality.

Corridors as managed volumes
ICAO's UTM Implementation Guidance (2024) defines corridors as three-dimensional, time-bound volumes with mandatory services: flight-intent submission, authorisation, geofencing, and constraint dissemination.

Progressive complexity
Global best practice (FAA and EASA, 2024-25) shows that corridors should evolve gradually starting with low-density, predictable routes and expanding only after safety evidence is accumulated.

Containment and contingency
Corridor design must hard-code containment logic: emergency loiter zones, recovery routes, and safe termination areas. SORA-aligned containment concepts make operations audit-ready and regulator-defensible.

Mandatory telemetry and safety reporting
Every corridor flight should generate standardised artefacts:

1. incident and near-miss reports,
2. C2 and navigation performance data,
3. procedural compliance metrics.

This converts corridor flying from permissioned activity into continuous safety research the primary input regulators need for durable rulemaking.

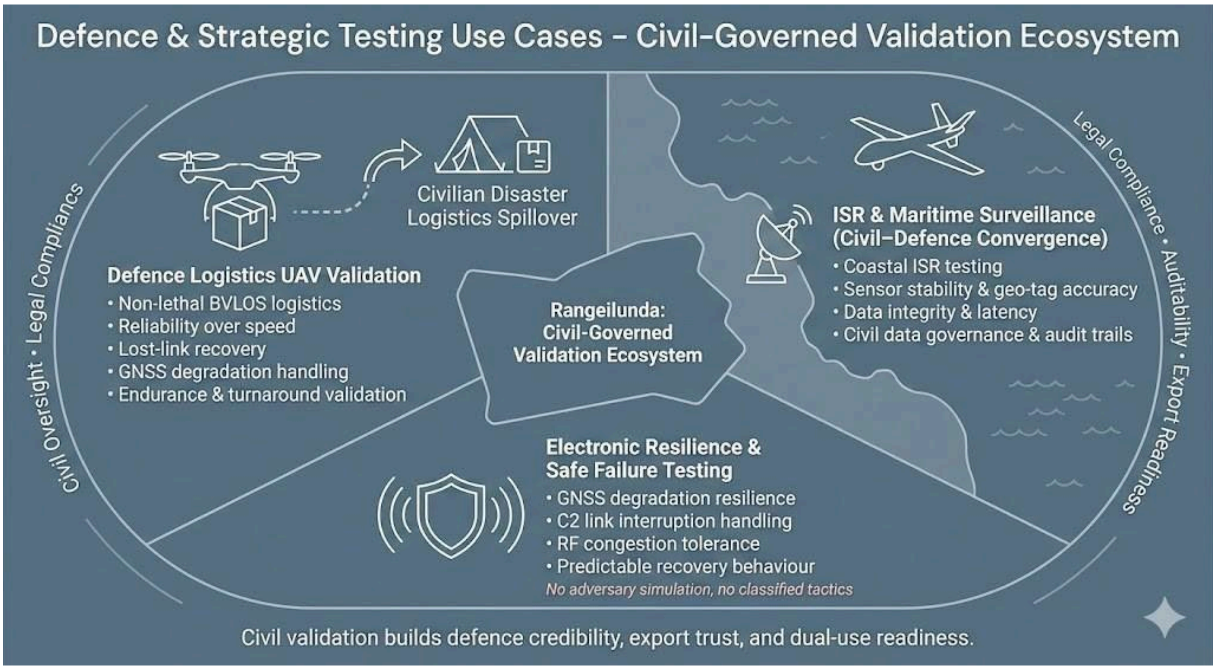
Governance alignment

Clear role definition, operator, UTM service provider, site authority, regulator is essential. Alignment with national UTM ensures Rangeilunda is seen as executing policy, not inventing parallel regimes. A drone corridor is the digital equivalent of a high-speed rail line: structure enables speed without sacrificing safety.

The EVLOS → BVLOS corridor → advanced autonomy pathway is not an industry convenience, it is a regulatory confidence-building architecture. Each phase decomposes risk, generates auditable evidence, and conditions both operators and regulators for the next level of complexity. By adopting this phased, evidence-led roadmap at Rangeilunda, India can move from mission-by-mission approvals to system-level governance, ensuring BVLOS scale emerges as a consequence of learning not as a leap of faith.

Section 5

Defence & Strategic Testing Use Cases



Rangeilunda as a Controlled Validation Ecosystem

Defence applications have historically driven early adoption of advanced aviation technologies. However, by 2024-25, global practice has shifted decisively: the credibility, scalability, and exportability of defence unmanned systems now depend on civil-compatible testing environments that generate auditable evidence, respect legal boundaries, and enable dual-use spillovers.

Leading regulators and defence buyers increasingly favour platforms validated in civilian-governed test ecosystems, rather than isolated military ranges. Rangeilunda can therefore be positioned not as a defence range, but as a civil test site producing defence-relevant validation, a distinction critical for regulatory trust, international acceptance, and long-term ecosystem growth.

Defence Logistics UAVs: The Strategic Entry Point

Among defence UAV applications, logistics is globally recognised as the lowest-risk, highest-value gateway for BVLOS-scale operations.

Global trend (2024-25):

1. The NATO 2024 Defence Innovation Accelerator (DIANA) report identifies autonomous aerial logistics as one of the top three priority adoption areas, ahead of kinetic roles.
2. The U.S. Department of Defense reported in 2024 that over 65% of operational UAV sorties in non-combat zones were logistics, resupply, or ISR-related, reflecting a shift away from strike-centric use.

Why logistics first ?:
Logistics UAVs perform **non-lethal functions** like resupply, sustainment, emergency delivery making them politically and regulatorily acceptable while still stress-testing autonomy, communications, navigation, and reliability.

Reliability over speed:
Defence logistics prioritises **repeatability under stress**, not raw speed. Test-site validation focuses on:

1. lost-link recovery rates,
2. GNSS degradation handling,
3. battery endurance across sortie cycles,
4. maintenance and turnaround reliability.

These metrics closely mirror humanitarian and disaster-response logistics, creating immediate civilian spillovers.

Interoperability with supply chains:
2024 studies by the RAND Corporation highlight that the primary failure point in military UAV logistics is workflow integration, not flight performance. Rangeilunda enables end-to-end validation, that is dispatch, transit, delivery, recovery under civilian oversight. Positioning Rangeilunda as a coastal-to-hinterland logistics validation zone, with proximity to Army training infrastructure in the Ganjam–Gopalpur region, allows joint evaluation without militarising the site.

"In modern operations, logistics is the target; autonomous resupply is the shield."

ISR & Maritime Surveillance: Civil-Defence Convergence

Intelligence, Surveillance, and Reconnaissance (ISR) is the clearest domain of convergence between civil and defence requirements particularly in coastal environments.

Strategic context (2024-25):

1. India has over 7,500 km of coastline, with increasing demands for fisheries monitoring, environmental compliance, SAR, and maritime domain awareness.
2. The International Maritime Organization and EASA both highlight UAV-enabled maritime surveillance as a core civil-defence crossover capability in their 2024 guidance.

Why Rangeilunda matters:
Coastal ISR testing exposes systems to salt corrosion, haze, glare, humidity, RF variability, and moving maritime backgrounds underrepresented in inland test sites.

ISR as a data system, not an aircraft:
By 2025, regulators increasingly treat ISR as an end-to-end data problem. Performance depends on sensor stability, geo-tagging accuracy, downlink integrity, processing latency, and dissemination, not just payload resolution. A controlled test site enables repeatable, scenario-based validation using standardized test cards, producing comparable performance baselines across OEMs which is essential for fair evaluation and regulatory confidence.

Data governance:
Civilian governance enables strict role-based access, dataset segregation, and audit trails, allowing defence relevance while preserving transparency and compliance. ISR testing at Rangeilunda should be framed explicitly as airworthiness, safety, and data-governance validation, not intelligence operations, preserving civil aviation primacy.

"Strategic ISR is no longer about seeing more, it is about processing reliably, at scale."

Electronic Resilience & Counter-UAS: Testing the Inevitable

As unmanned traffic grows, navigation degradation and electromagnetic interference are no longer edge cases.

2024-25 operational reality:

1. ICAO reports a year-on-year rise in GNSS interference events, affecting both civil and unmanned aviation.
2. EASA's 2024 Safety Review identifies loss of navigation integrity and C2 disruption as among the fastest-growing UAV risk categories.

Focus on defensive resilience:
Rangeilunda enables controlled degradation testing, that is, how systems behave under partial GNSS loss, intermittent links, or RF congestion without simulating adversary tactics or exposing classified doctrine.

Civil spillover benefits:
EW-resilient design directly improves civilian safety: fewer fly-aways, safer operations near critical infrastructure, and greater reliability during disasters where spectrum congestion is common. All such testing must remain within strict legal and ethical envelopes, with predefined conditions and regulatory oversight. The objective is not interference, but safe failure and predictable recovery.

Dual-Use Doctrine & Export Readiness

By 2026, export credibility increasingly begins at the test site, not the sales pitch.

Civil validation as defence credibility:
International defence buyers now prefer platforms validated under civil regulatory frameworks, viewing this as evidence of maturity, reliability, and governance discipline.

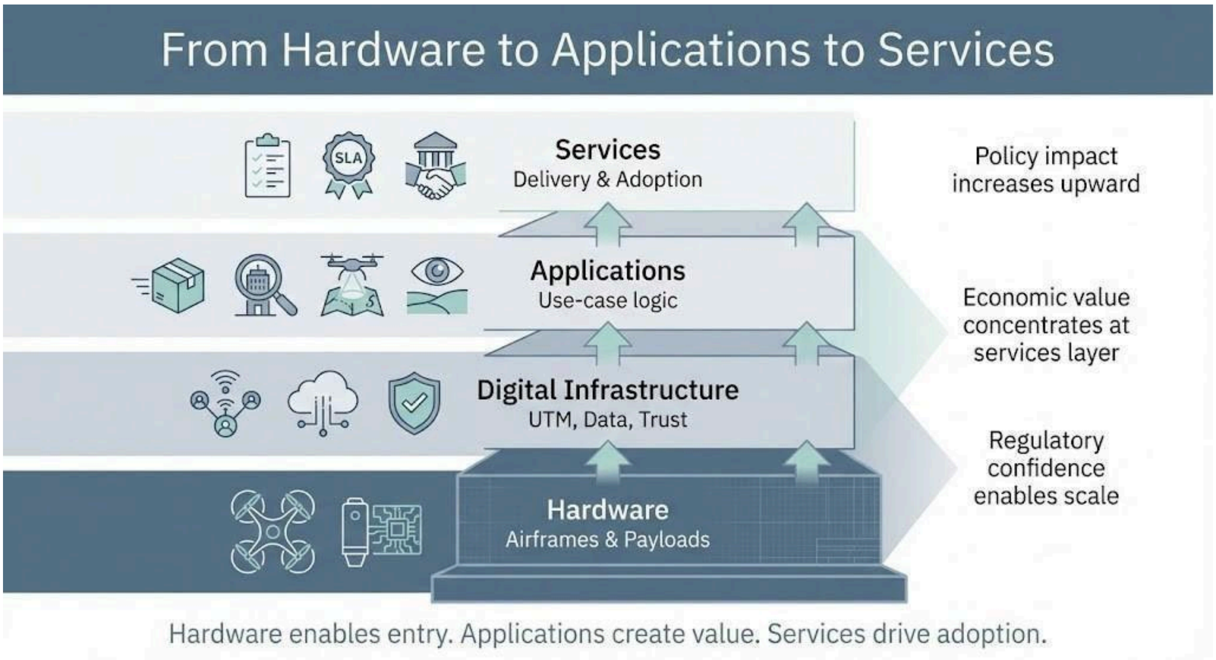
Managing dual-use sensitivities:
Testing within a transparent, state-enabled civilian framework strengthens compliance narratives under export-control regimes and reduces downstream friction.

Strategic signalling:
A recognised test site signals that India is not merely producing hardware, but institutionalising safety, accountability, and interoperability, which is a critical differentiator in competitive defence markets.

"Rangeilunda is where startup agility meets national security discipline."

Section 6

From Hardware to Applications to Services



Policy and Industry Friendly Framing Aligned to Value Migration

"The real value in technology shifts from hardware, to platforms, and finally to applications and services."
_Arvind Krishna, IBM leadership commentary on value migration

India's drone ecosystem is at an inflection point. Considerable progress has been made in airframe manufacturing, indigenous payloads, and pilot training, yet large-scale economic and societal value remains constrained. This pattern is not unique to aviation. Every major technology sector, from computing and telecom to semiconductors has followed the same trajectory: hardware enables entry, but applications and services capture durable value.

By 2024-25, global drone leaders and regulators have converged on this understanding. The Low-Altitude Economy must therefore be framed not as a hardware industry, but as a four-layer stack:

1. Hardware (airframes & payloads)
2. Digital infrastructure (UTM, data, trust)
3. Applications (use-case logic)
4. Services (delivery & adoption)

Policy that remains concentrated on the first layer risks stalling the ecosystem precisely when it is ready to scale.

Hardware Layer: Necessary, but Not the End-Game

Hardware is the entry ticket, not the destination.

Globally, as drone manufacturing capacity has expanded, margins have compressed and differentiation has weakened, mirroring patterns seen earlier in consumer electronics. A 2024 market review by McKinsey & Company notes that OEM margins in mature drone segments are declining, while value is shifting to software-enabled operations and services. From a regulatory perspective, hardware matters primarily for safety and compliance: airworthiness, EMI/EMC behaviour, fail-safe logic, propulsion reliability, and operating envelopes. These are necessary conditions, but not sufficient ones, for scale.

This is where test sites such as Rangeilunda become strategically important. They allow:

1. One-time, high-quality validation of airframes under regulator-visible conditions
2. Reusable evidence generation (reliability curves, incident data, performance envelopes)
3. Reduced dependence on repeated exemptions and bespoke approvals

Internationally, the FAA UAS Test Site Program continues to serve precisely this function. As of 2024, FAA test sites have supported tens of thousands of advanced operations, feeding data directly into BVLOS rulemaking and Remote ID enforcement.

From an Indian policy lens, indigenous hardware capability remains essential, particularly for defence, critical infrastructure, and strategic autonomy. However, hardware alone does not unlock employment, exports, or productivity unless it feeds into scalable operations and services. This aligns with India's shift from *"Make in India"* toward *"Make for the World."*

Rangeilunda's role at this layer should therefore be framed as certification-adjacent validation systematically producing evidence that strengthens DGCA processes and future rulemaking.

Digital Infrastructure Layer: Where Policy Meets Scale

Value migration becomes most visible at the digital infrastructure layer.

Once hardware exists, value shifts to platforms that coordinate, optimise, and govern operations at scale. In low-altitude aviation, this layer is UTM, managing flight intent, constraints, deconfliction, priority, identity, and data exchange. UTM is not a private convenience, it is public-interest infrastructure. The ICAO UTM Framework and FAA guidance both define UTM as a cooperative system in which:

1. regulators define rules and performance expectations, and
2. industry provides interoperable services under oversight.

India has already acknowledged this reality through the Digital Sky platform, positioning it as the backbone for national low-altitude airspace governance. What remains limited is operational execution under real conditions.

This is where Rangeilunda's strategic value deepens:

1. validating UTM workflows (authorisation, tracking, incident reporting),

2. stress-testing communications, GNSS behaviour, and redundancy,
3. demonstrating that BVLOS scale can be digitally managed, not manually supervised.

For regulators, this converts abstract policy into observable performance. For industry, it converts pilots into repeatable operating models. Without this layer, applications remain demonstrations. With it, they become markets.

Applications Layer: Where Public and Economic Value Converge

Applications, not airframes are where policy objectives and market demand intersect. Governments prioritise outcomes: disaster response, connectivity, security, efficiency. Industry seeks predictable demand. Applications sit precisely at this intersection. By 2025, global data shows that the fastest-scaling drone segments are logistics, infrastructure inspection, and public-sector services, not platform sales. A 2024 analysis by the World Economic Forum highlights that over 60% of projected drone economic value by 2030 lies in application-driven services, not manufacturing. Critically, applications depend on predictable operating conditions, not bespoke permissions. Scheduled logistics, inspection, emergency response, and surveillance all require corridor-based BVLOS and UTM-enabled workflows. Rangeilunda should therefore be positioned not merely as a test range, but as an application-validation zone, where:

1. multiple sectors trial end-to-end workflows (flight + data + service delivery),
2. policymakers observe which use cases merit national scale-up, and
3. regulators gain evidence on safety, reliability, and societal benefit.

This reduces market uncertainty for industry and policy risk for the government.

Services Layer: The Political Economy of Adoption

Services are where adoption becomes irreversible. We have seen in the past that services, not hardware sales, generate durable economic value. IBM's own transition from hardware manufacturing to platforms and services offers a useful analogy for policymakers navigating the drone economy.

Drone-enabled services align naturally with public procurement and PPP models:

1. governments act as anchor customers for disaster response, infrastructure monitoring, and security;
2. private players innovate on delivery, efficiency, and reliability.

Service models are also regulation-friendly. They standardise responsibility, accountability, and oversight, far easier to govern than thousands of ad-hoc pilots. Rangeilunda can catalyse this layer by allowing firms to test not only aircraft, but business models: uptime guarantees, redundancy planning, workforce training, MRO cycles, and pricing, under regulator visibility.

A service-first ecosystem also:

1. enables MSME participation across operations, analytics, MRO, and training,
2. reduces export friction compared to pure hardware sales, and
3. prevents monopolisation through neutral, time-bound access.

By treating validation infrastructure as a public good, applications as the justification for reform, and services as the unit of adoption, policymakers can align regulation with value creation. In this model, airspace reform is not granted to technology. It is earned by outcomes.

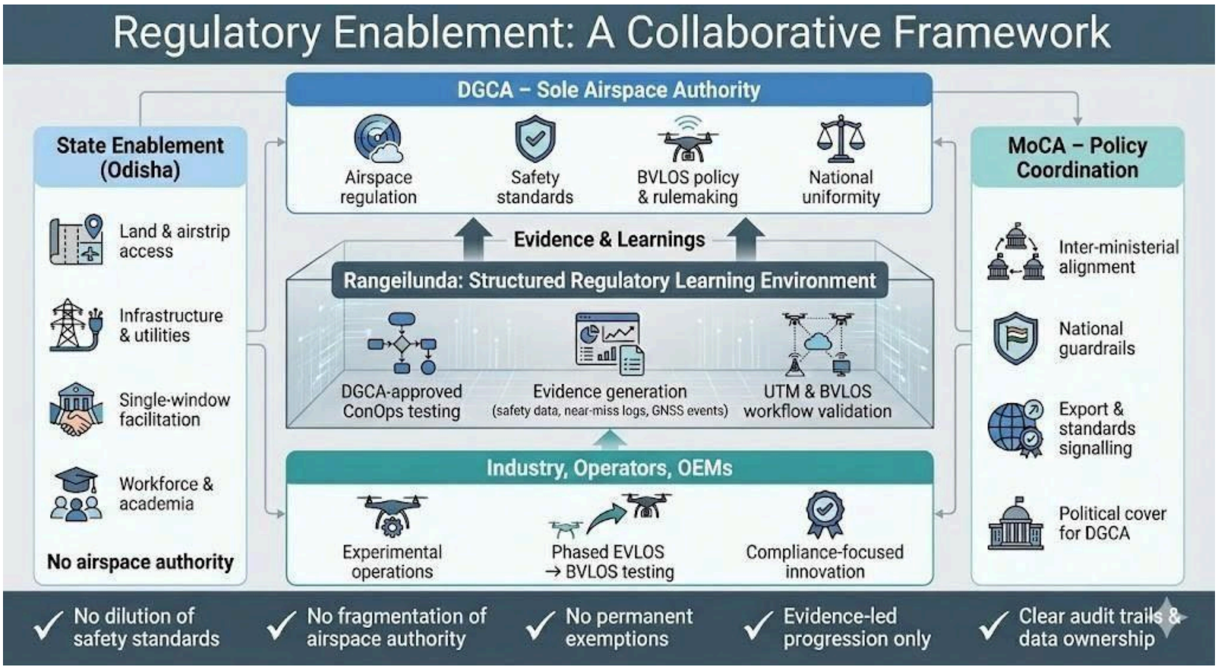
Section 7

Regulatory Enablement: A Collaborative Framework

Federal-friendly, DGCA-centric, and politically safe

India's Low-Altitude Economy (LAE) will not scale through regulatory relaxation. It will scale through regulatory design where safety oversight is preserved, learning is institutionalised, and uncertainty is systematically reduced. Global regulators now converge on this principle: experimentation must be enabled without fragmenting national airspace authority.

As of 2024-25, leading aviation authorities have adopted evidence-led, sandbox-style approaches to integrate BVLOS operations while retaining central control. This section outlines a framework that is conservative in law, ambitious in process, and aligned with global best practice positioning Rangeilunda as a regulatory instrument, not an exception.



Federal Aviation Context: Clear Roles, No Dilution of Authority

India's aviation governance is constitutionally unambiguous. Airspace regulation is a Union subject, exercised under the Aircraft Act, 1934 through the Directorate General of Civil Aviation (DGCA). States control land, airstrips, and ground infrastructure. This division is not a constraint, it is a designed complementarity.

The Drone Rules, 2021 already reflect a modern regulatory philosophy: digital authorisation, self-certification, and post-operation accountability. A state-facilitated test site does not weaken this approach; it operationalises it under controlled conditions.

Critically:

1. States do not regulate airspace
2. DGCA remains the sole aviation regulator
3. Test sites are structured learning environments, not carve-outs

This mirrors global precedent. In the United States, the FAA retains exclusive authority over airspace while designating test sites operated by state entities and universities. In 2024, FAA reaffirmed that its test sites exist to inform rulemaking and certification, not to bypass them. Similarly, the UK Civil Aviation Authority expanded its regulatory sandbox in 2024 with Department for Transport backing, without devolving regulatory power.

Positioning principle: Rangeilunda is required to be framed as a place where DGCA-approved Concepts of Operations are tested, observed, and refined before national adoption, preserving uniformity while accelerating evidence.

DGCA-Level Enablement: What Is Being Asked (and What Is Not)

This proposal does not ask DGCA to amend the law, dilute safety standards, or pre-empt BVLOS rulemaking. It asks for process enablement within existing powers, consistent with international practice.

Formal recognition of UAV test sites
DGCA may recognise state-facilitated UAV test sites through CARs, guidance notes, or experimental permissions mirroring the FAA's test-site framework, without creating a new statutory category.

Standing experimental permissions (EVLOS to phased BVLOS)
Within designated corridors and pre-approved ConOps, DGCA could allow standing experimental permissions, moving from flight-by-flight approvals to site- and operator-based oversight. This aligns with the FAA BVLOS Aviation Rulemaking Committee (ARC) 2024 recommendations to shift away from bespoke waivers toward repeatable pathways.

Data as a regulatory output
Test-site operations must generate standardised safety data, near-misses, lost-link events, GNSS anomalies creating a structured evidence base for DGCA rulemaking. This is consistent with the ICAO UTM Framework.

Clear demarcation of authority
Participation at Rangeilunda confers no operational rights elsewhere. National rollout remains DGCA's prerogative. The site reduces uncertainty, it does not grant entitlement. This is regulation becoming systemic, not permissive.

Ministry of Civil Aviation: Policy Alignment and Political Cover

The role of the Ministry of Civil Aviation (MoCA) is policy signalling and coordination, not operational micromanagement.

Avoiding fragmentation
As states innovate, MoCA ensures national guardrails so India does not drift into incompatible regional regimes.

Inter-ministerial convergence
BVLOS intersects defence logistics, telecom spectrum, internal security, and digital infrastructure. MoCA is uniquely placed to convene Defence, Home, Telecom, and IT, preventing siloed clearances. This mirrors the UK DfT-CAA model expanded in 2024.

Institutional backing for DGCA
Explicit MoCA endorsement of test-site-led learning provides DGCA political cover to innovate the process without being perceived as compromising safety.

Export and standards signalling
By framing sites like Rangeilunda as part of India's export-readiness and standards-setting ambition, MoCA links domestic experimentation with international credibility, an approach increasingly used by EASA in its U-space rollout (2024-25).

Importantly, no rule change is required on Day One. Notifications, guidance notes, and pilot frameworks are sufficient to begin.

Government of Odisha: Legitimate State Commitments

The Government of Odisha does not regulate airspace, but it determines whether safe experimentation is feasible.

Key commitments include:

1. Long-term asset stewardship: assured access to land and airstrip infrastructure
2. Single-window facilitation: power, data connectivity, buildings, and local coordination
3. Neutral institutional anchoring: avoiding single-OEM capture
4. Workforce and academic integration: DGCA-aligned pilot training, MRO, and analytics
5. Upward transparency: learnings flow to DGCA and MoCA, strengthening national policy

As a principle: *"While the Centre provides the rules of the sky, the State provides the ground upon which innovation takes flight."*

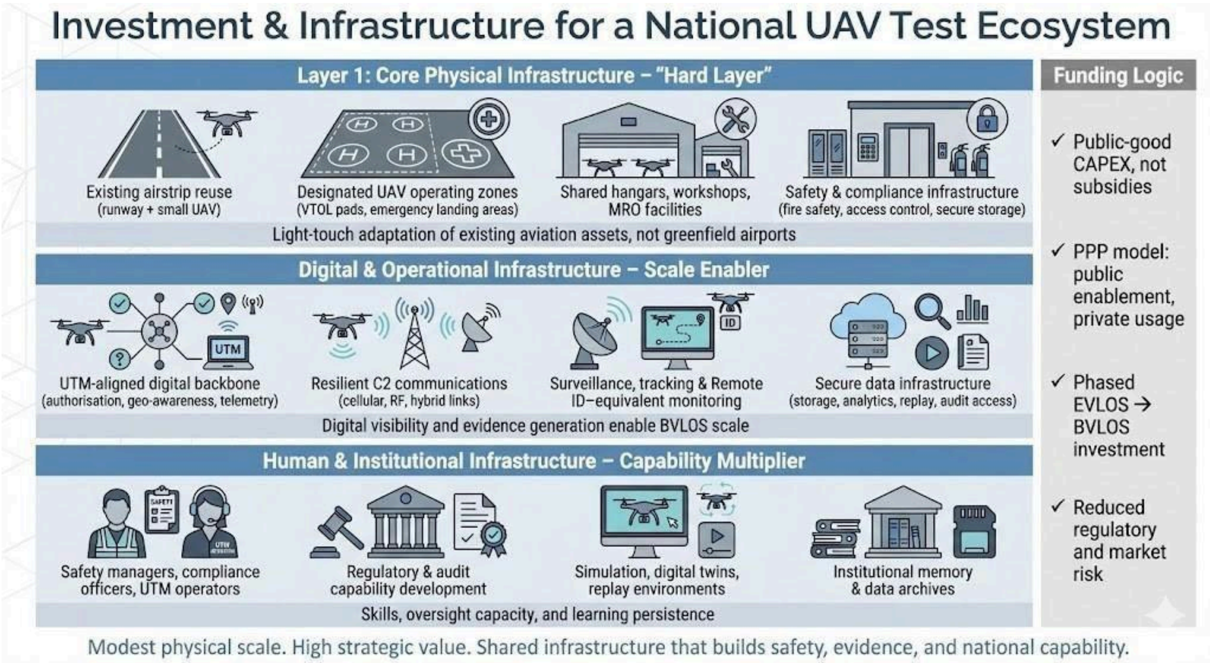
Why This Is a "Green-Flag" Proposal

1. No dilution of safety standards, only structured experimentation
2. No fragmentation of airspace governance, DGCA remains sole authority
3. No permanent exemptions, only evidence-led progression
4. Clear audit trails and data ownership, regulator confidence increases
5. Alignment with global best practice, FAA, ICAO, EASA, UK CAA (2024-25)

Section 8

Investment & Infrastructure Requirements

The section outlines the types of shared infrastructure required for a national-grade UAV test ecosystem, how such infrastructure is built globally, and why these investments are best understood as sovereign capability creation, not subsidies.



Core Physical Infrastructure: The "Hard Layer"

Low-altitude aviation does not require airport-scale capital expenditure. Global experience shows that UAV test sites are light-touch adaptations of existing aviation assets, not greenfield airports.

Airstrip and airfield adaptations
Most operational test sites reuse existing runways or airstrips with modest upgrades: resurfacing where needed, apron space, basic lighting, fencing, and coordination protocols with manned aviation. As of 2024, the FAA reaffirmed that all UAS Test Sites in the U.S. rely on existing public aviation assets, prioritising reuse over new construction to limit fiscal and safety risk.

Dedicated UAV operating zones
Safe experimentation depends on segregation, not expansion. Launch/recovery zones, VTOL pads, emergency landing areas, and ground safety buffers can be created through marking, access control, and zoning. The ICAO UTM Framework (2024 update) explicitly treats designated operating environments as governance tools, not heavy infrastructure projects.

Hangars, workshops, and shared MRO
Repeated testing requires on-site inspection, repair, payload integration, and turnaround capability. The Organisation for Economic Co-operation and Development (2024 Infrastructure Review)

classifies shared hangars and workshops as productive public infrastructure when multi-user, as they prevent duplication and lower barriers for MSMEs.

Safety and compliance facilities
Fire safety, emergency response equipment, controlled access, and secure storage are baseline regulatory and insurance requirements across all global test sites.

Digital & Operational Infrastructure: The True Enabler of BVLOS

If physical infrastructure enables flight, digital infrastructure enables scale. This is where long-term value and regulatory confidence reside.

UTM-aligned digital backbone
The most critical investment is not concrete but code. UTM-aligned systems, authorisation workflows, geo-awareness, telemetry ingestion, constraint dissemination, and incident reporting are essential for EVLOS-to-BVLOS progression.
The EASA U-space implementation review (2024-25) concludes that no jurisdiction has achieved routine BVLOS scale without a functioning digital backbone.

Resilient communications (C2)
BVLOS risk is dominated by command-and-control resilience. Multi-link architectures (cellular, RF, hybrid, fallback) are therefore essential. The state's role is to ensure availability, redundancy, and auditability, not to replace private networks.

Surveillance, tracking, and monitoring
Regulatory confidence depends on visibility. Cooperative tracking and Remote ID-equivalent capabilities allow near-real-time auditability, shifting oversight from manual policing to systemic assurance. FAA 2024 safety briefs highlight that digital visibility reduces regulator workload as traffic density increases.

Data infrastructure as the primary output
A test site's real product is evidence. Secure storage, analytics, replay, and controlled access are core infrastructure. The UK Civil Aviation Authority sandbox reports (2024) emphasise that data quality, not flight hours, is what ultimately informs rulemaking.

Human Capital & Institutional Infrastructure: The Hidden Multiplier

The most underestimated requirement in aviation innovation is institutional human capacity.

Beyond pilot training
A functional test ecosystem requires safety managers, UTM operators, compliance officers, data analysts, and incident investigators. OECD 2024 research on innovation clusters shows that institutional skills are as decisive as physical assets.

Regulatory and audit capability
Modern oversight relies on interpreting telemetry and trends, not manual inspection. Test sites therefore become training grounds for regulators and auditors, strengthening oversight rather than weakening it.

Simulation, digital twins, and replay
ICAO's 2024 guidance recognises simulation as a primary risk-reduction and standardisation tool. EVLOS/BVLOS simulators and replay environments enable stress-testing, consistent training, and post-incident analysis without additional flight risk.

Institutional memory
Data archives and replay systems preserve learning even as personnel rotate mirroring how traditional aviation safety matured.

Funding Logic: Public-Good CAPEX, Not a Subsidy

UAV test ecosystems display classic public-good characteristics:

1. reduced information asymmetry,
2. de-risked private investment,
3. faster evidence-based rulemaking.

No single firm can internalise these benefits, justifying public enablement.

Global precedent (2024-25):
FAA test sites and UK regulatory sandboxes follow a mixed funding model:

1. baseline infrastructure enabled publicly,
2. operators pay usage fees and bring their own equipment.

PPP as the natural model
Public Private Partnerships allow:

1. states to provide land and anchor assets,
2. industry to pay for access and services,
3. Private Partners bring their own equipment for testing..

Phased investment reduces fiscal risk
Crucially, no large upfront allocation is required. Phased investments aligned to EVLOS→BVLOS milestones allow learning before scaling, providing strong fiscal and political cover.

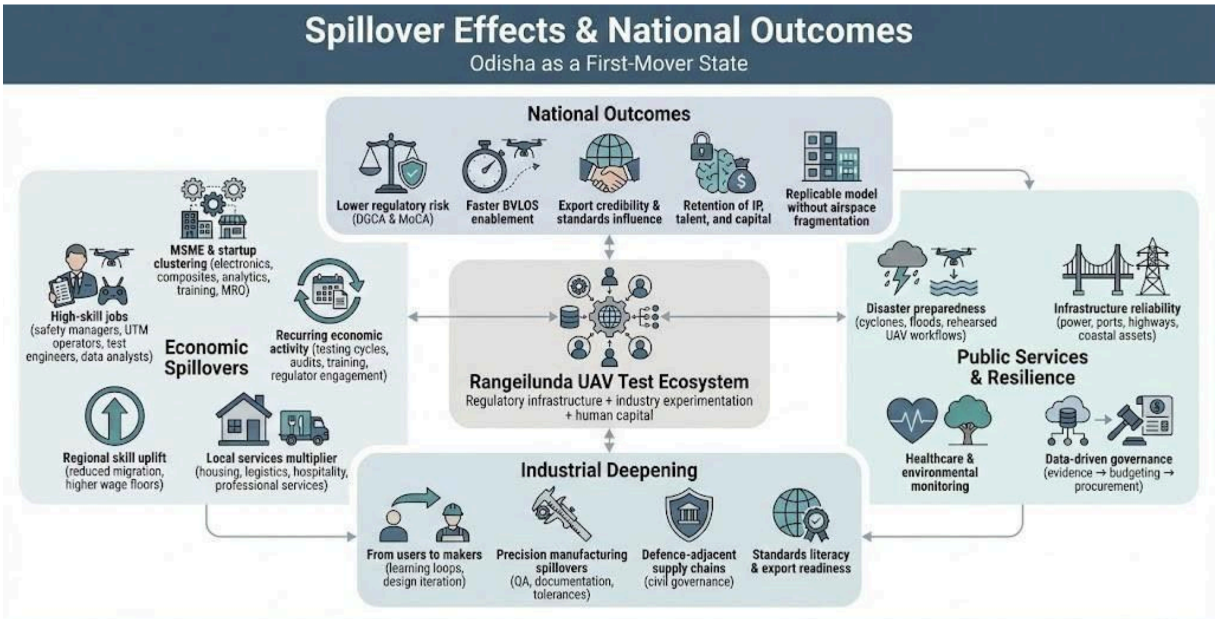
"The infrastructure required for a UAV test site like Rangeilunda is modest in physical scale but high in strategic value. Most investments are shared, reusable, and directly tied to safety assurance, regulatory learning, and skill development. These are not subsidies, but nation-building assets that reduce long-term regulatory and economic risk." The cost of building this capacity is visible. The cost of not building it will surface only when options have already narrowed.

Section 9

Spillover Effects & National Outcomes

Odisha as a First-Mover State

The real value of a UAV test ecosystem such as Rangeilunda is not measured by flight counts or pilots conducted, but by spillover effects, the durable economic, institutional, and strategic capabilities that emerge when regulatory infrastructure, industry experimentation, and human capital are deliberately aligned. Globally, jurisdictions that treat test sites as policy instruments, not facilities, capture outsized returns in jobs, industrial depth, and governance capacity.



As of 2024-25, this approach is increasingly explicit in global policy. The World Economic Forum notes that over 60% of projected drone-sector value by 2030 will come from services, data, and applications, not hardware manufacturing alone implying that spillovers, not sorties, determine national outcomes.

Economic Spillovers for Odisha: Jobs, MSMEs, and Local Value

High-quality, durable jobs

A functioning UAV test ecosystem creates a different employment profile from conventional infrastructure. Beyond pilots, sustained demand arises for safety managers, UTM operators, flight-test engineers, MRO technicians, data analysts, compliance officers, and incident investigators. The OECD highlights that test-and-certification ecosystems generate higher skill multipliers than manufacturing-only clusters, with longer job tenures and wage premiums.

MSME and startup clustering

Shared access to airspace, SOPs, telemetry, and validation services lowers entry barriers for MSMEs. Global experience shows that proximity to test infrastructure accelerates supplier clustering in composites, electronics, batteries, software, analytics, and training. For Odisha, this anchors value locally rather than exporting it to Tier-1 metros.

Recurring economic activity
Unlike construction-led capex, test-site operations generate continuous demand, testing slots, audits, training cycles, safety reviews, and regulator engagements. This produces predictable revenue streams and employment stability, particularly valuable for regional economies.

Skill-premium uplift outside metros
Hosting advanced validation in southern Odisha raises local wage floors and reduces migration. The International Labour Organization links such regional tech anchors to inclusive growth by retaining skilled workers outside major cities.

Local services multiplier
Hospitality, transport, housing, logistics, and professional services benefit from visiting OEM teams, regulators, academics, and defence users broadening the economic base beyond the drone sector.

Industrial Deepening: From Users to Makers

From usage to creation
Test infrastructure enables regions to move from technology usage to technology creation. Repeated testing accelerates learning loops for airframes, propulsion, avionics, payloads, autonomy software, and communications, capabilities that procurement alone cannot build.

Precision manufacturing spillovers
UAV ecosystems demand tight tolerances, QA discipline, and documentation. These spill over into aerospace, defence, renewables, electronics, and mobility manufacturing, raising the overall industrial quality bar. The McKinsey & Company observes that regions with test-and-validation infrastructure advance faster up the value chain than those focused solely on assembly.

Defence-adjacent supply chains under civil governance
Controlled validation allows suppliers of logistics UAVs, ISR payloads, and resilient communications to co-develop under civil oversight, preserving airspace primacy while enabling authorised defence participation.

Standards literacy and export readiness
Routine engagement with DGCA-aligned processes builds a compliance culture, documentation, safety cases, audit readiness, an essential prerequisite for exports. Platforms validated under regulator-supervised conditions are easier to place internationally.

Public Services & State Capacity: Resilience by Design

Disaster preparedness
For Odisha, exposed to cyclones and floods, test-validated UAV workflows for assessment, logistics, and communications replace improvisation with rehearsed capability. The World Bank underscores that pre-validated response systems materially reduce disaster losses.

Infrastructure reliability
Once BVLOS corridors and UTM services are proven, frequent inspection of power lines, ports,

highways, coastal assets, and industrial facilities become feasible, improving reliability while reducing lifecycle costs.

Healthcare and environmental monitoring
Repeatable trials for medical logistics and environmental monitoring (coastal erosion, wetlands, emissions) generate evidence for scale-up where value is proven, replacing anecdotal pilots.

Data-driven governance
Standardised data capture and reporting convert pilots into evidence, informing budgeting, procurement, and policy design, an outcome the UK Civil Aviation Authority (2024 sandbox reviews) identifies as central to regulatory learning.

National Outcomes: Why Odisha's First Move Matters

Lower policy risk for regulators
Evidence generated at Rangeilunda reduces uncertainty for the Directorate General of Civil Aviation and MoCA, supporting a shift from exemption-led approvals to performance-based regulation, consistent with latest global practice.

Retention of Indian innovation
Domestic test capacity keeps IP, talent, and capital in India, reducing the need to test abroad and strengthening strategic autonomy.

Export credibility and standards influence
Regulator-supervised validation improves exportability and allows India to contribute substantively to international forums (e.g. ICAO), moving from rule-taker to standards shaper.

Replicable without fragmentation
Odisha's model is replicable by other states under DGCA oversight, scaling national capacity while preserving uniform airspace governance.

"By investing early in low-altitude aviation infrastructure, Odisha is not merely hosting drone activity, it is building institutional capacity in regulation, safety, skills, and innovation. This positions the state as a national testbed where India's low-altitude economy can be proven safely, scaled responsibly, and exported globally."

1. **For Odisha:** sustained jobs, MSME clustering, industrial depth, and governance capacity
2. **For India:** safer and faster BVLOS enablement, export credibility, and strategic autonomy
3. **For regulators:** evidence, not pressure
4. **For industry:** predictability, not permissions

Rangeilunda demonstrates how state initiative, national oversight, and industry responsibility can converge to deliver national outcomes, without compromising safety, sovereignty, or institutional integrity.

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