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Research on the Current Status of Legal Regulation of Commercial Activities in Near Space

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ABSTRACT
The large-scale development of commercial activities in near-space poses a systemic challenge to the traditional aerospace legal framework. This study analyzes the legal challenges posed by the physical characteristics of near-space activities. It reveals three institutional shortcomings: mismatched regulatory authority, lack of behavioral regulation standards, and dysfunctional liability protection mechanisms. To address legal application conflicts and rule adaptation gaps, this study proposes the construction of a highly layered regulatory system to clarify sovereign boundaries, the formulation of technology-oriented behavioral guidelines to adapt to dynamic operational characteristics, and the innovation of multi-level liability protection mechanisms to address cross-border relief obstacles. By restructuring airspace classification rules, establishing a dynamic airworthiness framework, and creating a layered compensation system, this study aims to form an adaptive regulatory paradigm that balances technological innovation and risk management, providing theoretical support for the legal governance system in the era of aerospace integration.

KEYWORDS
Near space; Commercial activities; Current legal regulatory status

1 Introduction

As a transitional zone between aviation and space activities, the strategic value of the near-space domain has become increasingly evident with the development of new aircraft technologies. Commercial entities conducting activities such as weather monitoring and communication relay in this airspace have not only spawned new business models but also pushed beyond existing legal boundaries. The dual regulatory framework formed by aviation law and space law has created regulatory blind spots in this field, resulting in areas of legal ambiguity. Technologically, near-space aircraft possess both long-term endurance capabilities and cross-domain maneuverability. Their ultra-long endurance operational modes challenge existing certification standards for aircraft continuous operation, while their vertical airspace crossing behaviors challenge the logic of sovereign boundary demarcation. Commercial model innovations further exacerbate the difficulty of rule adaptation: pseudo-satellite spectrum usage challenges existing allocation systems, and commercial payload leasing models blur the boundaries of liability determination. The international community has fundamental disagreements over the legal attributes of these technologies. The functionalist approach faces challenges in dividing responsibilities for composite tasks, while the spatial theory standard struggles to keep pace with the iterative development of suborbital technologies. Regulatory failures are increasingly common: cross-border flight activities trigger disputes over sovereign jurisdiction, accidents involving new propulsion systems expose gaps in safety regulations, and claims for compensation for damaged high-value payloads face institutional barriers. The current system has structural contradictions: overlapping regulatory authority at the vertical level, and imbalanced regulatory capabilities among countries at the horizontal level; technical standards lag behind engineering practices, and there are rule gaps in critical safety areas; compensation liability limits are severely disconnected from commercial risks, and the insurance market lacks effective response mechanisms. These contradictions fundamentally stem from the systemic mismatch between the legal framework of the industrial era and the development of aerospace technology.

2 Legal attributes of near-space commercial activities

2.1 Conceptual definition dilemma

The conceptual definition dilemma of near-space stems from the transitional nature of its environmental characteristics. As the transitional zone between the atmosphere and outer space, its unique conditions pose fundamental challenges to legal classification: the state transitions of aircraft between atmospheric residence and space maneuvering transcend traditional classification frameworks, prolonged continuous operations disrupt aviation maintenance paradigms, and vertical airspace crossing activities undermine the principle of sovereign absoluteness. The

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unique atmospheric environment renders aviation structural standards ineffective, while spaceflight regulations at this altitude exhibit redundant contradictions. Energy transfer mechanisms under extreme temperature fluctuations undermine the foundation of traditional airworthiness standards, compelling legal frameworks to address micro-management demands such as material performance boundaries. This conflict between environmental characteristics and legal categories fundamentally stems from a systemic mismatch between regulatory paradigms and technological realities, necessitating the establishment of a multi-tiered legal attribute identification system to adapt to the dynamic utilization patterns reshaping static legal frameworks [1].

2.2 Applicability of the current legal framework

The challenges in applying the current legal framework to near-space stem from a structural mismatch between institutional design and the characteristics of space. The dual regulatory framework formed by aviation law and space law creates regulatory blind spots in this field. The underlying logic of the aviation legal system, based on airspace sovereignty, struggles to cover airspace above a certain altitude. In contrast, the principle of free exploration in the space legal framework fails to meet the demands of routine operations. Regulatory practices face contradictions in identifying legal attributes. When aircraft perform vertical maneuvers, changes in altitude trigger conflicts in classification standards, leading to repeated shifts in regulatory requirements. In terms of judicial remedies, there are obstacles in identifying liable parties. When commercial operation platforms cause cross-border damage, they neither align with the aircraft operator liability system nor fall within the jurisdiction of the country where the space object is registered. The essence of this applicability crisis lies in the systemic disconnect between traditional legal paradigms and technological development realities. This manifests as a rupture between regulatory frameworks and spatial continuity, a rupture between regulatory logic and operational dynamics, and a rupture between remedial mechanisms and risk complexity. Ultimately, this leads to the institutional failure of the current framework in near-space domains.

2.3 Legal attribute disputes

Disputes over the legal attributes of near-space focus on structural conflicts, with differences in spatial demarcation standards manifesting as a normative opposition between functionalism (defining legal applicability based on the technical characteristics of aircraft) and spatialism (insisting on physical altitude thresholds). The dilemma of object classification arises from the same platform switching between aircraft and space object identities due to vertical maneuvering, leading to a breakdown in regulatory responsibility attribution. Sovereignty claims conflict stems from the tension between coastal states' claims to airspace jurisdiction and the principle of international freedom of passage. Additionally, technological continuity challenges legal classification frameworks, sovereign exclusivity constrains resource utilization, and risk uncertainty challenges the logic of liability determination, reflecting the collision between the governance paradigms of sovereign nation-states and borderless technological ecosystems.

3 Challenges in implementing regulatory systems

3.1 Deficiencies in authority allocation

Deficiencies in authority allocation are primarily manifested in the multi-level structural contradictions within the regulatory system. The civil aviation administration and space regulatory agencies have overlapping functions in the near-space domain, leading to bottlenecks in the approval process. Stratospheric flight platforms must simultaneously meet the requirements for aircraft airworthiness certification and space object registration, resulting in conflicting demands from two systems on the same entity, creating a self-negating administrative loop. National sovereignty claims and internationally recognized rules clash fundamentally in vertical airspace. Coastal states assert traffic control authority over a particular kilometer of airspace above their exclusive economic zones. At the same time, the Outer Space Treaty① advocates insist that the principle of free passage applies to this region, creating an irreconcilable legal conflict. Commercial entities are increasingly dominating constellation-level projects, with private capital leveraging technological advantages to effectively control the allocation of space resources, marginalizing national regulatory bodies in critical decision-making processes [2].

① Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205, art. IV.

3.2 Logical discontinuity in behavioral regulation

The current behavioral regulation system suffers from structural logical discontinuity, posing risks of regulatory failure for commercial activities in near-space. The enforcement effectiveness of the approval system has weakened, with companies circumventing sovereign jurisdiction through technical design and selectively applying regulatory standards based on vertical airspace stratification. Safety certification standards lag behind technological innovation, with high-dynamic flight modes exceeding traditional maintenance cycles, rendering rapid technological iterations ineffective for review. Frequency resource allocation is imbalanced, with private entities monopolizing core frequency bands through first-mover advantages, creating market barriers. Liability determination rules are inadequate, with shared operational models blurring the lines of responsibility, and cross-border service chains triggering multiple jurisdictional conflicts.

3.3 Insufficient coverage of liability mechanisms

Liability mechanisms suffer from systemic gaps in coverage, making it challenging to address the unique risk profiles associated with commercial activities in near-space environments. The failure of entity identification rules leads to challenges in assigning liability. At the same time, the blurred boundaries of responsibility among platform owners, technology providers, and service users under shared operational models further complicate the issue. Traditional registration systems are unable to identify the ultimate liable party. Technical compatibility defects create obstacles to liability attribution. When intelligent systems make autonomous decisions that cause harm, the black-box nature of algorithms prevents the determination of fault, rendering existing causality assessment standards inapplicable. Cross-border damage compensation mechanisms are dysfunctional. When high-speed aircraft cause harm across multiple countries, conflicts in compensation standards and overlapping jurisdictional authority for enforcement coexist. Imbalances in resource allocation exacerbate compensation obstacles. The prioritization of commercialization leads to insufficient safety investments, shifting risk prevention responsibilities to the public sector. These defects stem from the contradiction between the rapid pace of technological iteration and the rigidity of liability frameworks, the contradiction between globalized risks and localized compensation mechanisms, and the contradiction between commercial self-interest and public safety interests, ultimately resulting in the substantive paralysis of liability mechanisms [3].

3.4 Structural disorder in traffic management

Near-space traffic management faces systemic disorder, leading to unresolved contradictions such as the failure of traditional aviation collision avoidance rules in the thin atmosphere, the inability of space object monitoring systems to cover transitional airspace, and the resulting regulatory vacuum; the lack of dynamic coordination mechanisms in areas where military and civilian activities overlap, resulting in frequent airspace resource conflicts; and cross-border high-speed flights causing collision avoidance command conflicts due to differences in trajectory prediction standards, exacerbating the risk of misjudgment in sovereignty-sensitive areas; Insufficient high-dynamic target tracking technology and the lack of legal certification for autonomous collision avoidance systems. Vertical maneuvering characteristics challenge the logic of horizontal layered governance. At the same time, the large-scale deployment of commercial constellations exacerbates conflicts over spectrum and airspace resources, ultimately triggering a vicious cycle of rule failure and risk accumulation.

4 Pathways for optimizing legal regulatory systems

4.1 Building a tiered regulatory system

The core of a tiered regulatory system lies in establishing a vertical governance structure that aligns authority and responsibility, addressing deficiencies in the allocation of authority through systematic institutional design. First, the authority allocation mechanism must be restructured by establishing a national-level interdepartmental coordination body to integrate aviation and space regulatory functions, formulate clear lists of responsibilities and authorities to define approval boundaries, and eliminate institutional conflicts between airworthiness certification and space object registration. Second, a scientific airspace classification governance model should be established, dividing regulatory intensity into three tiers based on the operational altitude and mission nature of aircraft: implementing state-led enhanced management in low-altitude activity zones, promoting an international organization-coordinated regulatory mechanism in mid-altitude transition zones, and incorporating high-altitude space zones into the existing space governance framework for unified regulation. To address the risks associated with the expansion of commercial capital, a dynamic response rule system should be established. When the operational scale of a commercial project reaches a predefined threshold, a special regulatory procedure should be automatically triggered to prevent the dilution of

regulatory functions through mandatory technical reviews [4].

4.2 Innovative behavioral regulation paradigm

Innovative behavioral regulation paradigms require the establishment of an adaptive framework that dynamically responds to technological changes and commercial practices. First, a technology-inclusive certification system should be established, with a segmented certification process for high-dynamic aircraft designs. The traditional centralized review process should be broken down into three stages: design pre-review, prototype testing, and operational monitoring. Real-time data transmission should replace fixed-cycle maintenance requirements. Concurrently, reform spectrum management models by establishing dedicated shared frequency bands for near-space operations and implementing a priority-use system based on declarations. Operators must dynamically report their frequency usage needs to eliminate monopolistic control by private entities from the source. The key is to develop intelligent regulatory tool systems and deploy a distributed evidence-recording node network to continuously record flight decision parameters, thereby establishing a traceable evidence chain for liability determination in cases of algorithm-induced damage [5].

4.3 Improving the liability protection system

The key to improving the liability protection system lies in establishing a comprehensive, multi-level risk allocation system to systematically address issues such as unclear responsibility, technical compatibility, and cross-border relief deficiencies. The primary task is to innovate the mechanism for identifying responsible parties, implement a digital identity binding system to forcefully link technology developers, platform operators, and end users, and establish a traceable, multi-dimensional liability network. To address issues of oversight in intelligent system decision-making, establish presumption rules for algorithmic liability, requiring all autonomous devices to be pre-equipped with decision-recording modules that automatically trigger liability determinations against technical parties when systems deviate from design parameters. Cross-border remedies require breakthroughs through multilateral collaboration, including the signing of mutual recognition agreements for judicial rulings to establish a unified enforcement list, and leveraging the Bank for International Settlements to establish cross-border compensation fund transfer channels to resolve enforcement obstacles caused by overlapping jurisdictions. Concurrently, a socialized risk dispersion mechanism should be established, implementing a mandatory tiered insurance system: the basic tier covers routine operational risks, the special tier addresses catastrophic damages, and the international tier establishes a public compensation fund to underpin ultimate liability.

4.4 Innovative strategies for near-space traffic management

To address the issue of disordered operations in the near-space domain, it is necessary to establish a tiered governance framework. This framework can draw inspiration from the U.S. Class E airspace management system to develop dynamic airspace rules, such as incorporating low-altitude stationary activities into an autonomous collision avoidance system, implementing coordinated trajectory control for high-dynamic flights at mid-altitude, and integrating sub-orbital mission operations with air traffic scheduling at high altitude. Additionally, the risk threshold mechanism outlined in the European "Higher Airspace Management Concept" ②can be integrated to enable adaptive adjustments to regulatory intensity. Airspace resource allocation should adopt a dual-track shared architecture, with the civilian layer introducing a spectrum time-slot rotation system and developing weather-responsive elastic isolation zones. In contrast, the dedicated layer retains rigid protective spaces for military and high-risk experiments. Conflict resolution can be achieved through integrated isolation and coordination strategies, such as enhancing situational awareness through military-civilian data relay stations, resolving cross-border jurisdictional disputes through unified navigation standards and border buffer zones, and coordinating high-speed and low-speed mixed traffic through speed corridor systems and three-dimensional separation layers. The intelligent prevention and control system should establish a three-tier response mechanism, from navigation warnings and collaborative avoidance to emergency takeover by automatic collision avoidance modules, to achieve rapid adjudication of cross-border damages and form a governance closed loop enabled by institutional rules and technology [6].

5 Conclusion

The regulatory challenges in the near-space domain stem from a mismatch between its physical characteristics and the

②European Union Aviation Safety Agency. *Higher Airspace Management Concept* [R]. Opinion No 03/2023. Cologne: EASA, 2023: 41.

legal framework. Deficiencies in authority allocation lead to overlapping domestic functions and international sovereignty conflicts. Regulatory gaps result in lagging technical standards and ineffective liability determination. Insufficient liability mechanisms exacerbate cross-border redress obstacles and imbalanced risk allocation. Therefore, an adaptive governance approach is proposed: reconstructing authority allocation by establishing a vertically layered airspace system; bridging behavioral gaps by establishing a technology-inclusive regulatory framework; and innovating multi-level liability protection mechanisms to achieve socialized risk allocation. Ultimately, this will form a regulatory paradigm of synergistic evolution between law and technology, providing institutional support for the era of aerospace integration.

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