

After a Rapid Unintentional Disassembly– A Study of Cross-Border Accident Investigation Framework for Commercial Space Activities

By

Chao-Ting Cheng

Institute of Air and Space Law McGill University, Montreal December 2024

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Abstract

This thesis explores the multifaceted factors involved in developing an international framework for space accident investigations. While prioritizing safety, it also considers procedural aspects, the protection of sensitive safety information, and the broader goal of preventing future accidents. Key dimensions such as the role of aerospace insurers, social and environmental impacts, and export control restrictions are examined, demonstrating that space accident investigations must extend beyond the confines of international and domestic legal rules.

International space treaties do not mandate states to investigate space accidents, but they do require states to authorize and continue to supervise their commercial space activities. In this thesis, a comparative study of the international space accident investigation model and international air law and international maritime law is presented. In addition, this thesis argues the law on state responsibility could be a basis for the obligation of investigating commercial space accidents. Moreover, the implications of international space agreements are discussed.

A comparative analysis of the legal frameworks in the United States, Australia, and the United Kingdom reveals both shared principles and distinctive approaches to space accident investigations. This analysis identifies variations in legal definitions, investigative authorities, and processes across these nations, shedding light on how each addresses space safety and regulatory responsibilities. The United States employs broad definitions and inclusive processes, reflecting its advanced space sector, while Australia adopts narrower definitions influenced by its emerging industry. The United Kingdom, inspired by Annex 13, has implemented a comprehensive and robust approach. These insights emphasize the need for a cohesive international system that harmonizes such differences while maintaining flexibility to address national priorities.

Furthermore, the thesis highlights the indispensable role of insurers in supporting independent investigations and managing financial responsibilities, as illustrated by cases like the Intelsat 708 incident. Social and environmental risks, such as those arising from Proton rocket failures, underscore the necessity of including community perspectives in investigations to enhance accountability and trust. However, national security challenges, particularly those arising from export control laws, remain a significant barrier to effective international collaboration.

The findings underscore the importance of developing a treaty or protocol specifically for space accident investigations. Such a framework would promote global cooperation, ensure consistent handling of space accidents, and address the space industry's financial, social, and political complexities. By balancing transparency with national security and enhancing datasharing mechanisms, an international framework would significantly strengthen the safety, responsibility, and sustainability of the rapidly evolving space sector.

Résumé

Cette thèse explore les multiples facteurs impliqués dans le développement d'un cadre international pour les enquêtes sur les accidents spatiaux. Tout en donnant la priorité à la sécurité, elle prend également en compte les aspects procéduraux, la protection des informations sensibles en matière de sécurité et l'objectif plus large de prévenir de futurs accidents. Des aspects clés tels que le rôle des assureurs aérospatiaux, les impacts sociaux et environnementaux et les restrictions en matière de contrôle des exportations sont examinés, démontrant que les enquêtes sur les accidents spatiaux doivent dépasser les limites des règles juridiques internationales et nationales.

Les traités internationaux sur l'espace n'obligent pas les États à enquêter sur les accidents spatiaux, mais ils leur imposent d'autoriser et de continuer à superviser leurs activités spatiales commerciales. Cette thèse présente une étude comparative du modèle international d'enquête sur les accidents spatiaux, du droit aérien international et du droit maritime international. En outre, cette thèse soutient que le droit relatif à la responsabilité de l'État pourrait servir de base à l'obligation d'enquêter sur les accidents spatiaux commerciaux. En outre, les implications des accords spatiaux internationaux sont discutées.

Une analyse comparative des cadres juridiques des États-Unis, de l'Australie et du Royaume-Uni révèle à la fois des principes communs et des approches distinctes en matière d'enquêtes sur les accidents spatiaux. Cette analyse identifie des variations dans les définitions juridiques, les pouvoirs d'enquête et les processus dans ces pays, mettant en lumière la manière dont chacun aborde les responsabilités en matière de sécurité et de réglementation de l'espace. Les États-Unis utilisent des définitions larges et des processus inclusifs, reflétant leur secteur spatial avancé, tandis que l'Australie adopte des définitions plus étroites, influencées par son industrie naissante. Le Royaume-Uni, inspiré par l'Annexe 13, a mis en œuvre une approche globale et robuste. Ces observations soulignent la nécessité d'un système international cohérent qui harmonise ces différences tout en conservant la flexibilité nécessaire pour répondre aux priorités nationales.

En outre, la thèse souligne le rôle indispensable des assureurs dans le soutien aux enquêtes indépendantes et dans la gestion des responsabilités financières, comme l'illustrent des cas tels que l'incident de l'Intelsat 708. Les risques sociaux et environnementaux, tels que ceux découlant des échecs de la fusée Proton, soulignent la nécessité d'inclure les perspectives de la communauté dans les enquêtes afin de renforcer la responsabilité et la confiance. Toutefois, les problèmes de sécurité nationale, en particulier ceux qui découlent des lois sur le contrôle des exportations, restent un obstacle important à une collaboration internationale efficace.

Les conclusions de la thèse soulignent l'importance d'élaborer un traité ou un protocole spécifique aux enquêtes sur les accidents spatiaux. Un tel cadre favoriserait la coopération mondiale, garantirait un traitement cohérent des accidents spatiaux et tiendrait compte des complexités financières, sociales et politiques de l'industrie spatiale. En conciliant transparence et sécurité nationale, et en améliorant les mécanismes de partage des données, un cadre international renforcerait considérablement la sécurité, la responsabilité et la durabilité du secteur spatial, qui évolue rapidement.

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Neihu, Taipei, Taiwan

List of Abbreviations

AAIB	Air Accidents Investigation Branch
ARSIWA	Articles on the Responsibility of States for Internationally Wrongful Acts
AST	Office of Commercial Space Transportation
ATSB	Australian Transport Safety Bureau
CGWIC	China Great Wall Industry Corporation
DOT	Department of Transportation
EAR	Export Administration Regulations
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
ICJ	International Court of Justice
IMO	International Maritime Organization
ITAR	International Traffic in Arms Regulations
MOA	Memorandum of Agreement
MTCR	Missile Technology Control Regime
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
SAIA	Space Accident Investigation Authority
SARPs	standards and recommended practices
TAA	technical assistance agreement
TSA	Technology Safeguards Agreements
TTSB	Taiwan Transportation Safety Board
UDMH	unsymmetrical dimethylhydrazine
UK	United Kingdom
UN	United Nations
US	United States
USML	United States Munitions List
VCLT	Vienna Convention on the Law of Treaties

Chapter 1: Introduction

1. Recent Space Safety Concerns and Legal Developments of Space Accident Investigation

On January 9, 2024, a Chinese Long March 2C rocket launched from Xichang Satellite Launch Center triggered a countrywide air raid alert in Taiwan.¹ The rocket was carrying the Einstein Probe, which is an X-ray astronomical satellite collaborated between the Chinese and its European partners.² The alert warns the Taiwanese public to be aware of any unidentified objects falling from the sky when the rocket flew over the southern airspace of Taiwan. The Einstein Probe was successfully delivered into orbit and, fortunately, no debris fell on Taiwanese territory in this event. This alert, however, sounded out loud the fact that today's space activities cannot be separated from public safety concerns.

As the number of commercial space launches increases, the safety concerns of the launches are no longer exclusive to those who participate in space activities. Incidents in recent years, ranging from launch failures to uncontrolled re-entries of space debris, underscore the dangers to the general public. As of 2011, around 200 humans have been killed by rocket explosions.³ The number is about ten times higher than the number of astronauts who perished during the same period.⁴ While astronauts are exposed to a greater risk of fatality than others due to the hazardous nature of their activities, the non-astronaut population exposed to the risks are extremely larger than the population of astronauts, and therefore the larger number of casualty

¹ Agencies, "China satellite triggers air raid alert", *Taipei Times* (10 January 2024), online: <<u>https://www.taipeitimes.com/News/taiwan/archives/2024/01/10/2003811888></u>.

² Xinhua, "Chinese, European scientists join hands to explore universe's mystery", *Xinhua Net* (18 January 2024), online: https://english.news.cn/20240118/25c7e9fedcc3407fb6cb059d69296d1b/c.html.

³ Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey, "Background" in Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey, eds, *The Need for an Integrated Regulatory Regime for Aviation and Space: ICAO for Space*? (Vienna: Springer Vienna, 2011) 1 at 13.

⁴ Ibid.

is not coincident. In fact, one study estimates that there could be a ten per cent risk of at least one casualty caused by rocket body reentry in ten years.⁵

Incidents in recent years, ranging from launch failures to uncontrolled re-entries of space debris, underscore the dangers to the general public. For example, in 2021, a mountain bike rider in Orcutt Hills, Santa Barbara, California, encountered space debris from Firefly Aerospace's Alpha rocket, which exploded shortly after launching from the Vandenberg Space Force Base. The debris prompted warnings from officials and led to the temporary closure of local recreational facilities for safety reasons.⁶ In one recent case, the falling debris even caused property damage. A cylindrical metal object released from the International Space Station in 2021 struck a house in Florida on March 8, 2024.⁷ The house owners have brought a claim for damages against the National Aeronautics and Space Administration ("NASA") under domestic law of the United States ("US"). Their claim includes non-insured property damage loss, business interruption damages, mental anguish damages, and other types of claims, and their insurer also submitted a subrogation claim for the damages to the property.⁸

In some cases, debris from private space objects of one country has fallen onto the territory of another country. In 2022, Australia notified the Secretary-General of the United Nations ("UN") and the US of the discovery of components of a SpaceX Dragon capsule that launched in

⁵ Michael Byers et al, "Unnecessary risks created by uncontrolled rocket reentries" (2022) 6:9 Nat Astron 1093–1097.

⁶ Janene Scully, "Mountain Biker Dodges Debris from Alpha Rocket Explosion on Orcutt Ride", *Noozhawk* (3 September 2021), online:

<http://www.noozhawk.com/vandenberg_hotline_seeks_details_about_alpha_rocket_debris/>.

⁷ NASA, "NASA Statement on Orbital Debris", (15 April 2024), online: *NASA* https://blogs.nasa.gov/spacestation/2024/04/15/nasa-completes-analysis-of-recovered-space-object/.

⁸ Anna Hedgepeth, "Mica Nguyen Worthy Submits First-of-its-Kind Claim to NASA Seeking Recovery From Damages Sustained from Space Debris", (21 June 2024), online: *Cranfill Sumner LLP* https://www.cshlaw.com/news/mica-nguyen-worthy-submits-first-of-its-kind-claim-to-nasa-seeking-recovery-from-damages-sustained-from-space-debris/>.

November 2020 as they were found on a private property near Jindabyne, New South Wales.⁹ Recently in 2024, a large fragment from SpaceX Axiom 3 mission was found on a farm in Ituna, Saskatchewan, Canada.¹⁰ These high-profile incidents underscore that public safety should be properly addressed while commercial space activities continue to grow.

In addition to the danger posed to the general public, abnormal space activities could turn into political tensions as well. On April 24, 2023, a research rocket TEXUS-58 launched by Sweden took an unexpected turn when it veered off course during its return, landing in Norway instead of its intended target zone in Sweden. Though causing no injuries, the incident sparked diplomatic tension between the neighbouring countries. The Norwegian Foreign Ministry labelled the landing a "very serious incident" and accused Sweden of a "border violation."¹¹ The Swedish Space Corporation, which owns the launch facility, is investigating the deviation. This incident highlights the potential for space activities to escalate into international disputes, emphasizing the need for clear protocols and communication channels between countries to manage unexpected events and mitigate diplomatic fallout.

To prepare for investigating space accidents, independent investigation agencies worldwide are starting to put space accident investigations on their agenda. For instance, at the 2023 annual meeting of the International Transportation Safety Association in Taipei, a panel was dedicated to "space investigation".¹² It is worth mentioning that the Air Accidents Investigation Branch ("AAIB") of the United Kingdom ("UK") discussed their experience of investigating the

⁹ Note verbale dated 26 August 2022 from the Permanent Mission of Australia to the United Nations (Vienna) addressed to the Secretary-General, UNCOPUOS, UN Doc. A/AC.105/1281 (2022).

¹⁰ Elizabeth Howell, "Junk from a SpaceX Dragon 'trunk' may have crashed into a Canadian farmer's field (photos)", (17 May 2024), online: *Space.com* https://www.space.com/spacex-crew-dragon-trunk-space-debriscanada.

¹¹ Isabella Kwai, "A Rocket Took Off From Sweden. Part of It Landed in Norway.", *The New York Times* (26 April 2023), online: https://www.nytimes.com/2023/04/26/world/europe/sweden-norway-rocket.html.

¹² "Taipei 2023", (29 June 2023), online: ITSA <https://itsasafety.com/taipei-2023/>.

LauncherOne accident.¹³ The AAIB highlights significant investigation challenges, including jurisdictional issues over international waters and restrictions due to US export control regulations, which limit the sharing of technical data.¹⁴ Additionally, the problems of controlling the wreckage and publishing of a report may cause future disputes.¹⁵

The AAIB's competence over space accident investigation was only established in 2021, following the promulgation of the UK's new national laws and regulations on space accident investigation.¹⁶ In the new space era, countries promoting commercial spaceflight, for instance, Taiwan, Australia, the UK, and the US have enacted or intended to introduce national laws and regulations regarding space accident investigation procedures.¹⁷ These recent incidents and developments of national laws and regulations have raised the issue of the lack of an international space accident investigation framework. This thesis aims to analyze this topic in detail.

2. Definition of Space Accident

As Chapter 3 shows, space accident is defined in various ways under national laws. In terms of terminology, for example, the UK uses "accident" with two levels of seriousness;¹⁸ Australia uses "accident" and "incident" to distinguish the seriousness of the occurrences;¹⁹ and the US mainly deploys the word "mishap" to cover a wide range of occurrences.²⁰ The spatial and

¹³ See Chapter 3 for discussion about AAIB's investigation and relevant regulations.

¹⁴ AAIB, *Investigating Space Accidents* (delivered at International Transportation Safety Association Annual Meeting, Taipei, 6 June 2023) online: https://itsasafety.com/material-2023/ [unpublished].

¹⁵ *Ibid*.

¹⁶ The Spaceflight Activities (Investigation of Spaceflight Accidents) Regulations 2021 (UK), s 5 [UK Regulations 2021].

¹⁷ See, for example, Commercial Space Investigations, 86 Fed Reg 63324 (2021); Space Development Act, (Taiwan); Space Industry Act 2018 (UK), s 20; Space (Launches and Returns) Act 2018 (Commonwealth), 1998/123, ss 83-103 (Austl); UK Regulations 2021.

¹⁸ UK Regulations 2021, supra note 16, s 3.

¹⁹ Space (Launches and Returns) Act 2018 (Commonwealth), 1998/123, (Austl), ss 84–85.

²⁰ 14 CFR § 401.7 (2021).

temporal scopes of these definitions are different as well; some cover accidents in outer space, while some only cover accidents during launch and reentry. Chapter 3 analyzes the scopes in depth.

International law does not provide a functional definition of space accident. While the Outer Space Treaty and the Rescue Agreement obligated contracting states to render all possible assistance to astronauts or personnel of a spacecraft in the event of an accident,²¹ both treaties do not define what an accident is. Not to mention that the conditions of the obligation to assist under these treaties do not cover accidents that occurred to the general public and uncrewed spacecraft.

It should be noted that, although there are debates over whether "passengers" or "tourists" are covered by the terms "astronauts" and "personnel of a spacecraft" used in the Outer Space Treaty and the Rescue Agreement, these debates do not affect the discussion of this thesis. The thesis aims to answer the legal responses to space accidents that involve injury to any human, and damages to properties, and thus, the debate over the parameters of "astronauts" and "personnel of a spacecraft" will not substantively affect the outcome of the discussion provided herein. Since this thesis is concerned with the framework that mainly responds to public safety concerns over abnormal space activities, a space accident is defined as any unexpected or unintentional circumstance that happens during a space activity, whether in outer space or not. To facilitate effective writing, the terms "accident", "incident", "occurrence", and "mishap" might be used interchangeably in this thesis. Nevertheless, specific definitions will be given whenever required, particularly in the discussions of various national laws.

²¹ Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 27 January 1967, 610 UNTS 205 art V [Outer Space Treaty]; Agreement on the rescue of astronauts, the return of astronauts and the return of objects launched into outer space, 3 December 1968, 672 UNTS 119 [Rescue Agreement].

3. Research Questions

Space accident investigations lack a unified international regime. Unlike aviation accident and incident investigation, which is harmonized across different states through the implementation of Annex 13 to the Convention on International Civil Aviation ("Annex 13") into national laws.²² But little research has been done on the relevant legal bases, both international and national, and their implications for international space accident investigation. Thus, this thesis seeks to address how an international framework for space accident investigation can be justified. To answer this question, this thesis will divide it into three parts.

First, this thesis seeks to explore what international law offers in considering a framework for space accident investigation. Starting from examining whether the Annex 13 model from international air law could be effectively adapted to meet the specific requirements of the space industry. Following the *lex specialis* doctrine, if the specialized law does not govern space accident investigation, then the question will be what areas of general international law might apply to such matters. In addition, this thesis considers the implications of identifying which states are stakeholders under international space law and what obligations they hold in the context of space accident investigations.

Second, this thesis also examines how different countries approach the legal regime for space accident investigation. Specifically, it considers how national laws establish their investigation authorities, how space accident is defined within these laws, who is allowed to participate in national space accident investigations, and what practical challenges have surfaced in enforcing these national laws on space accident investigations.

²² Convention on Civil Aviation, 7 December 1944, 15 UNTS 295 art 37 [Chicago Convention]

Lastly, having in mind that safety is the priority for accident investigations, this thesis asks what broader implications space accident investigations have in the context of insurance, social and environmental impacts, and export control regulations. It examines the role of aerospace insurers in supporting independent investigations, considers how these investigations might address public concerns over the safety and environmental impacts of space activities, and assesses how states can manage export control restrictions through international agreements to enable international cooperation in space accident investigations.

4. Literature Review

As historian and philosopher of science Peter Galison has observed, aviation accident investigation is a historical inquiry of plane crash events by a legal mandate.²³ Every detail of such historical events, for example, recordings of verbal expressions in the cockpit, flight data records, various maintenance documents, interviews, and more are collected and utilized for the normative goal of reconstructing the facts and determining the causes of aviation accidents.²⁴ By determining the "probable cause" of an accident and issuing safety recommendations to the relevant parties such as regulators, manufacturers, and operators, this inquiry seeks to prevent the accident from reoccurring, and thus potentially saving thousands of lives in the future. This purpose echoes the philosophy of "Just Culture" which advocates fostering an atmosphere in which individuals are comfortable reporting mistakes, contributing to the organization's ability to glean insights from errors.²⁵ Within this framework, genuine human errors are perceived as valuable learning experiences for both the organization and its personnel. Therefore, it is emphasized that

²³ Peter Galison, "An Accident of History" in Peter Galison & Alex Roland, eds, *Atmospheric Flight in the Twentieth Century* (Dordrecht: Springer Netherlands, 2000) 3 at 3.

²⁴ Ibid.

²⁵ James Reason, *Managing the Risks of Organizational Accidents* (London: Routledge, 2016) at 195.

the purpose of an aviation accident investigation is not to apportion blame or liability.²⁶ Although the objective of Annex 13 is ideal and puts emphasis on the role of regulators, Paul Fitzgerald argued that, for the aviation industry, learning from accidents is less of a regulatory imperative, but more of a matter driven by market factors such as reputational damages and insurance premiums, making regulators less important to aviation safety.²⁷

Aviation accident investigation is unique under international law as it is the sole creation of international air law, and its principles cannot be found in general international law.²⁸ While international maritime law has adopted a similar model, international space law does not address this issue. As attention to space safety is increasing, highlighting the need for safety measures to mitigate the rapid expansion of the space industry and the increasing safety risks.²⁹ Thus, Ram Jakhu, Tommaso Sgobba and Paul Dempsey advocate extending the jurisdiction of International Civil Aviation Organization ("ICAO") to commercial space activities, emphasizing that safety culture in commercial space programs should learn from the aviation institution, and be based on best practices and technical knowledge rather than economic trade-offs. In addition, they proposed to establish an independent accident investigation board within ICAO which would be crucial for addressing space activities and potential accidents that may transcend international boundaries.³⁰ On the contrary, an investigator from the National Transportation Safety Board ("NTSB") of the

²⁶ ICAO, Annex 13 to the Convention on International Civil Aviation (2020), s 3.1.

 ²⁷ P Paul Fitzgerald, "Questioning the Regulation of Aviation Safety Section I: Leading Articles: Part A: Air Law"
 (2012) 37 Annals Air & Space L 1–46 at 31–5, 38–9.

²⁸ Michael Milde, "Aircraft accident investigation in international law" (1984) 9:1 Air and Space Law at 61.

²⁹ Jakhu, Sgobba & Dempsey, *supra* note 3 at 12–4.

³⁰ Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey, "Proposal for a New Regulatory Regime" in Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey, eds, *The Need for an Integrated Regulatory Regime for Aviation and Space: ICAO for Space?* (Vienna: Springer Vienna, 2011) 117 at 131.

US does not believe that an international framework is necessary because of the US national security and export control laws.³¹

The social studies of space accidents provide us a meaningful way of understanding the social meaning of space accidents. Brian Wynne used the Space Shuttle Challenger accident to illustrate that the public often perceives technology as operating according to rules. In a similar vein, accident investigations often attribute the causes of an accident to individual misconduct and a negative organizational culture.³² In reality, technology is "unruly". Influenced by its operational environments and organizational factors which generate a set of "unruly rules", technology deviates from the norm within acceptable risks.³³ Furthermore, from the perspective of "normalization of deviance", Diane Vaughan demonstrated that an engineer could not present compelling evidence to convince others that the risk of the launching the Challenger Space Shuttle has exceeded an acceptable level.³⁴ In other words, the decision of engineers not to address the issue led to a gradual deviation of the acceptable risk for the O-rings, ultimately resulting in the tragedy. Since the space shuttle is an experimental technology, all performance and risk assessments are *ad hoc* judgments made before and after takeoff. Therefore, when discussing the necessity for an international framework for space accident investigation, the intrinsic risky and experimental nature of space technology should be taken into consideration.

³¹ Joseph M Sedor, "Do We Need an Annex 13 for Commercial Space Accidents?" (2021) 54:1 ISASI Forum 4–7 at 6–7.

 ³² Brian Wynne, "Unruly Technology: Practical Rules, Impractical Discourses and Public Understanding" (1988)
 18:1 Social Studies of Science 147–167 at 150–1.

³³ *Ibid* at 154.

³⁴ Diane Vaughan, *The Challenger launch decision: risky technology, culture, and deviance at NASA* (Chicago: University of Chicago Press, 1996).

5. Methodology

The methodologies employed to study relevant international law are primarily doctrinal and policy-oriented research. The sources of international law used in this thesis are based on Article 38 of the Statute of the International Court of Justice, which includes treaties, customary international law, general principles of international law, and decisions of the International Court of Justice ("ICJ").³⁵ The methodology of doctrine interpretation is based on Articles 31 and 32 of the Vienna Convention on the Law of Treaties ("VCLT").³⁶ Although not all states are parties to the VCLT; however, since the ICJ has affirmed that Articles 31 and 32 are recognized as the codification of customary international law, it will be applied as such.³⁷

However, this thesis also has a strong policy-oriented approach. As Lung-chu Chen pointed out: "Recognizing that law is a continuing process of authoritative decision for clarifying and securing the common interest of community members, the policy-oriented approach stresses that law serves not only as a limit on effective power but also as a creative instrument in promoting both order and other values."³⁸ For a topic concerning an international framework of space accident investigations, it would be impossible to separate policy for the application of the law. For one thing, accident investigation stresses the value of safety. For another, national interest, as well as the interest of the space industry, should be acknowledged as influential in the realm of space law. Thus, in order to analyze an international framework for space accident investigation for safety, the interplay of different factors about such framework will be explored, and an evaluation of its effect will be given.

³⁵ Statute of International Court of Justice, 26 June 1945, TS 993 art 38.

³⁶ Vienna Convention on the Law of Treaties, 23 May 1969, 1155 UNTS 331 arts 31-2 [VCLT].

³⁷ See e.g. Arbitral Award of 31 July 1989 (Guinea-Bissau v Senegal), [1991] ICJ Rep 53 at para 48.

³⁸ Lung-chu Chen, "International Law in a Policy-Oriented Perspective" in *An Introduction to Contemporary International Law: A Policy-Oriented Perspective* (Oxford University Press, 2015) 3 at 14.

With regard to national laws and regulations concerning the topic, the comparative legal analysis is utilized. This thesis follows the method of functional comparison. Functional comparison is widely regarded as a foundational approach in comparative legal studies, aiming to identify how different legal systems address similar issues and fulfill analogous functions.³⁹ Kischel explains that functional comparison assumes all societies confront common problems and, consequently, that each legal system creates mechanisms to fulfill comparable functions within its unique context.⁴⁰ Therefore, this thesis compares national laws and regulations that seek to address the issues of space accident investigations. Issues of the scope of investigation, the arrangement of investigation authority, and investigational powers are carefully analyzed. Various national laws and regulations found on different countries' official websites will be compared. However, focus is given to the laws of the US, the UK, and Australia because they have comprehensive laws and regulations governing space accident investigations and have each conducted at least one investigation within their jurisdictions.

6. Thesis Outline

Chapter 2 begins by revisiting the independent safety investigation models in international air and maritime law, exploring the parallels and insights these frameworks offer for space accident investigations. The chapter then addresses the scope of such investigations, emphasizing the rights and obligations of involved states. Space activities have always fallen within the purview of international law, necessitating an examination of international space safety governance and its implications. Therefore, a significant focus will be placed on sources of public international law that govern national space activities. In particular, the responsibility for non-governmental space

³⁹ Uwe Kischel, "The Comparative Method" in *Comparative Law* (Oxford University Press, 2019) 87 at 88.

⁴⁰ *Ibid* at 88–90.

activities, along with the law on state responsibility, could be applied to cross-border space accidents, potentially forming an obligation to investigate commercial space incidents. Furthermore, international space law offers various rights and obligations for states, many are relevant to space accidents. This leads to legal questions about the implications of these norms and how they might shape a future framework. Issues on liability, rescue and return, and registration will be examined, analyzing stakeholder states in cross-border commercial space accidents. It addresses the challenges of international cooperation in such investigations, with particular attention to state liability, debris custody, and participation rights.

Chapter 3 continues with a comparative analysis of national laws governing space accident investigations, identifying the different solutions towards this matter in various legal jurisdictions. It begins by examining how space accidents are defined across three countries, establishing thresholds for initiating investigations. For example, the US has broad, multiple definitions of a space accident, while Australia employs a narrower one, with some advocating for even further restrictions. These definitions reflect each country's safety perspectives and technological progress in the space sector. The analysis then addresses the authorities responsible for space accident investigations, noting that variations often arise from each country's historical experience and resource allocation to investigative bodies. Another comparison focuses on the conduct and participation in investigations. For instance, the US Federal Aviation Administration ("FAA") generally permits operators to investigate their mishaps but oversees to ensure organizational factors are addressed. In the UK, Annex 13-style participation and protection of safety information face practical challenges without an international cooperation framework. Through this analysis, the chapter identifies areas where international harmonization, such as standardized definitions, foreign participation rights, and sensitive data-sharing standards, could benefit the space industry.

Chapter 4 opens the complex dimensions of space accident investigations, examining the entangled roles of safety, insurance, social impact, and export control. It begins with a discussion of insurance, highlighting the substantial involvement of insurers in accident investigations due to their financial stakes. By analyzing the space insurance market and referencing the case of Intelsat 708, the chapter underscores parallels and unique concerns when compared to aviation insurance practices. The social and environmental repercussions of space accidents are then addressed, with an emphasis on propellant contamination risks and the potential for including local experts or community-appointed representatives in investigations to better meet the needs of affected communities. Lastly, this chapter examines the challenge of export control, particularly US regulations, and the recent efforts to ease the export control barriers, including bilateral agreements aimed at enhancing cross-border data sharing for investigational purposes.

Chapter 2: Independent Safety Investigation for Commercial Space Accidents? Relevant International Laws and Their Implications

1. Introduction: Proposing an International Framework for Space Accident Investigation?

Unlike aviation accident and incident investigations, which are harmonized across different states through the adoption of Annex 13 to the Convention on International Civil Aviation ("Annex 13) into national laws, national laws and regulations regarding space accident investigation are not coordinated under an international regime. The international obligation to conduct a safety investigation for aviation accidents was not developed from general international law but from the creation of the Chicago Convention.⁴¹ An international legal instrument like Annex 13 unifying space accident investigation, however, is yet to be on the main agenda of international space law-making.

Ram Jakhu, Tommaso Sgobba, and Paul Dempsey argue that public acceptance of the safety of space technology may determine the fate of the business, and thus, they propose to establish an independent accident investigation board for potential space accidents within the International Civil Aviation Organization ("ICAO").⁴² They believe that borrowing the ICAO's governance experience and the safety culture of civil aviation is the best way towards this issue. On the other hand, one investigator from the NTSB of the United States argues that an international framework is not necessary because of national security reasons and export control laws.⁴³ Despite their different approach to the topic, they all pointed out the importance of international cooperation in any cross-border space accident. Section 2 of this chapter starts with revisiting the independent safety investigation model in international air law and international maritime law, focusing on the

⁴¹ Milde, *supra* note 28 at 61.

⁴² Jakhu, Sgobba & Dempsey, *supra* note 30 at 131.

⁴³ Sedor, *supra* note 31 at 7.

analogies and implications these models can provide for space accident investigation. In particular, the scope of the investigation and the rights and obligations of relevant states will be discussed.

While acknowledging the need to address public safety concerns regarding commercial spaceflight, this chapter, however, takes a step back before proposing any law-making recommendations. Space activities are not operated in a legal vacuum, and, from the very start, it has always been under the realm of international law.⁴⁴ It is crucial to explore the law that relates to the international space safety governance and its implications on this topic. Only then can we answer whether an international framework of independent safety investigation for commercial space accidents should be considered and what should be taken into consideration. Therefore, another focus will be given to sources of public international law that govern national space activities and the law of state responsibility can be applied in a scenario of cross-border accidents and be argued as a basis for the obligation of commercial space accident investigation.

Last but not least, as mentioned above, an international legal regime for space accident investigation does not exist. This is precisely why scholars and commentators are discussing whether there is a need to establish one by international law when facing the growing risk associated with commercial space activities. Nonetheless, international law does provide a set of rights and obligations for states that could apply to space accidents, and thus, as lawyers, one can ask what the legal effects of these norms are and what the implications these existing norms can have for a potential international framework of space accident investigation in the future. Therefore, Section 4 turns to the international space treaties on liability, rescue and return, and registration, analyzing the stakeholder states in a cross-border commercial space accident, and

⁴⁴ Ram S Jakhu, Steven Freeland & Kuan-Wei Chen, "The Sources of International Space Law: Revisited" (2018) 67:4 ZLW 606–667 at 615.

points out the challenge for international cooperation in investigating such accidents. The focus will be on the liability of states, custody of debris, and participation rights in an investigation.

2. Models of Independent Safety Investigation under International Law

In international law, the investigation of accidents in different modes of transportation has evolved to prioritize safety, transparency, and prevention of future incidents. One prominent example is the framework established for aviation accidents under Annex 13 to the Chicago Convention. Annex 13 has become a model of independent accident investigation, emphasizing a non-punitive approach to understanding accidents and issuing safety recommendations.

This section explores the independent safety investigation model in detail, examining how it harmonizes global aviation safety standards, and focusing on its procedures for accident investigations, the protection of safety information, and the ultimate goal of preventing future accidents. This discussion serves as a foundation for later comparisons with similar frameworks in other sectors, including maritime and potentially space law, as this thesis investigates the compatibility of extending such models to emerging industries.

2.1 The Annex 13 Model: States' Obligation to Conduct Independent Safety Investigation

The investigation procedure of aviation accidents and incidents established by ICAO is no doubt the most well-known model for independent safety investigation. Pursuant to Article 26 of the Convention on International Civil Aviation ("Chicago Convention"), if the event of an accident happens to an aircraft of a contracting state in the territory of another contracting state, the state of occurrence will institute an inquiry into the circumstances of the accident, per the procedure which may be recommended by ICAO.⁴⁵ Furthermore, Article 37 of the Chicago Convention provides that, to harmonized the regulations regarding, *inter alia*, investigation of accidents, ICAO shall

⁴⁵ Chicago Convention, supra note 22.

adopt international standards and recommended practices ("SARPs") and procedures to deal with such matter.⁴⁶ The standards are binding to all contracting states. If a contracting state wishes not to be bound by an amendment of the standards, it can notify ICAO of the differences between its practice and that established by the standard within sixty days of the adoption of the standard.⁴⁷

Annex 13 is the SARP which the ICAO council adopted, first in 1951, as the protocol for contracting states to conduct investigations into accidents that result in death or serious injury, established following the provisions of the Chicago Convention. In general, Annex 13 sets out the objective of the investigation, procedures for accident investigations, the protection of safety information, the production of the final reports, etc.⁴⁸ These provisions aim to harmonize the proceedings of aircraft accident and incident investigations and prevent interference with the investigation, to prevent future accidents and to cultivate a safety culture.

The sole objective of an Annex 13 investigation is to prevent accidents and incidents and is not to apportion blame or liability.⁴⁹ The latter aspect of this objective aligns with the principles of "Just Culture", which emphasizes creating an environment where individuals feel safe to report errors, enabling organizations to learn from mistakes and improve processes.⁵⁰ In this framework, unintentional human errors are regarded as important opportunities for growth and learning, benefiting the organization. To ensure this objective will not be interfered with external pressure, the contracting states are obligated to establish an independent accident investigation authority.⁵¹

⁴⁶ *Ibid* art 37.

⁴⁷ *Ibid* art 38.

⁴⁸ ICAO, *supra* note 26.

⁴⁹ *Ibid*, s 3.1.

⁵⁰ Reason, *supra* note at 195.

⁵¹ ICAO, *supra* note 26, s 3.2.

Independence of the investigation authority is the essential feature of Annex 13.⁵² However, commentators argue that states' interest might be tied to the outcome of the investigations, and thus, the independence envisaged by Annex 13 might be hard to maintain.⁵³ For instance, the State of Design or Manufacture's interest might be at risk depending on whether an accident is caused by machine failure or human factor.⁵⁴ This potential conflict of interest underscores the challenge of maintaining true independence in investigations.⁵⁵

Despite such shortcomings, Annex 13 creates a dynamic that ensures that experts from these states can be involved in facilitating an investigation by allowing states with particular interests to participate in an investigation. Generally, the State of Occurrence is obligated to investigate an accident.⁵⁶ If the location of an accident or serious incident cannot be confirmed within any state's territory, for example, on the high seas or in a non-contracting state, the State of Registry is responsible for initiating and conducting the investigation.⁵⁷ Moreover, the States of Registry, Operator, Design, and Manufacture can appoint representatives to the investigation. ⁵⁸ Participation in the investigation grants the right to engage in all aspects of the investigation, including access to the accident site, evidence, witness information, recorded media, off-scene activities, meetings, and the opportunity of submissions.⁵⁹ In addition, States Having Suffered

⁵² Chloe AS Challinor, "Accident Investigators Are the Guardians of Public Safety: The Importance of Safeguarding the Independence of Air Accident Investigations as Illustrated by Recent Accidents" (2017) Air and Space Law 43–70 at 47–9; Paul Stephen Dempsey, *Public International Air Law*, 2d ed (Montreal: Centre for Research of Air and Space Law, McGill University, 2017) at 396–7.

⁵³ Joshua C Moscow, "Independence and Liability in Civil Aviation Accident Investigations through Annex 13 and the Montreal Convention Notes" (2022) 55:3 Vand J Transnat'l L [ix]-874 at 853–4.

⁵⁴ See e.g. Galison, *supra* note 23.

⁵⁵ See also Dempsey, *supra* note 52 at 402–3.

⁵⁶ ICAO, *supra* note 26, s 5.4.

⁵⁷ *Ibid*, s 5.3.

⁵⁸ *Ibid*, s 5.18.

⁵⁹ *Ibid*, s 5.25.

Fatalities and Serious Injuries to Their Citizens are given the right to appoint expert which has limited access to the scene and information.⁶⁰

By determining the "(probable) cause" of an accident and issuing safety recommendations to the relevant parties such as regulators, manufacturers, operators and more, the investigation seeks to prevent the accident from reoccurring, thus, potentially saving thousands of lives in the future. The approach to ensure the prevention of future accidents is through the issuance of safety recommendations. Annex 13 mandates that the responsible investigating authority must promptly recommend necessary preventive actions to relevant authorities, including other states, at any stage of an accident investigation to improve aviation safety.⁶¹ In the final report, the investigating state shall issue safety recommendations to relevant authorities in other states and to ICAO if applicable.⁶² This includes a safety recommendation of global concern.⁶³ A state receiving safety recommendations is under the obligation to inform, within 90 days, the issuing state about its actions taken or under consideration, or the reason of not to act.⁶⁴

2.2 Independent Investigation Under Context of International Maritime Law: A Broader Scope of Concerns

International maritime law is another field of international law that has adopted the independent safety investigation model. In 2008, the International Maritime Organization ("IMO") adopted resolution MSC.255(84), which established International Standards and Recommended Practices for conducting safety investigations into marine casualties or incidents, also known as

⁶⁰ *Ibid*, s 5.27.

⁶¹ *Ibid*, s 6.8.

⁶² *Ibid*, s 6.9.

⁶³ *Ibid*, s 6.9.1.

⁶⁴ *Ibid*, s 6.10.

the Casualty Investigation Code.⁶⁵ Additionally, amendments were made to Chapter XI-1 of the International Convention for the Safety of Life at Sea, making parts I and II of the Casualty Investigation Code mandatory to all contracting states of the convention.⁶⁶ Its objective of casualty prevention and the emphasis on the independence of the investigation authority resonate with the ones in Annex 13.⁶⁷

One main difference between Annex 13 and the Casualty Investigation Code is the scope of an accident that demands an investigation. Annex 13's definition of an accident is aircraft-centric. It defines an accident as "[a]n occurrence associated with the operation of an aircraft ..., in which: a) a person is fatally or seriously injured ...; or b) the aircraft sustains damage or structural failure ...; or c) the aircraft is missing or is completely inaccessible."⁶⁸ On the other hand, the Casualty Investigation Code covers a broader range of casualties that includes damage to marine infrastructure and the environment brought by a ship(s).⁶⁹

In the context of space, environmental hazards resulting from space activities have been constantly discussed. One example is the threat of space debris in orbit could threaten the safety of space assets and even humanity's access to space. Another example is on Earth, population around spaceport projects have raised environmental concerns about the hazardous propellent used by launch vehicles.⁷⁰ The scope of the radioactive pollution of the Cosmos 954 incident also reminds us about the serious environmental impact space accidents can have on Earth.⁷¹ Therefore,

⁶⁵ Adoption of the Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code), IMO, 2008, Res MSC.255(84).

⁶⁶ Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974, As Amended, IMO, 2008, Res MSC.257(84).

⁶⁷ *Supra* note 65 at para 1.1, 1.2.

⁶⁸ ICAO, *supra* note 26 at 1–1.

⁶⁹ Supra note 65 at para 2.9.6, 2.9.7.

⁷⁰ David Webb, "The Environmental Effects of Space Tourism" in *Space Tourism* (Routledge India, 2024) at 118–119.

⁷¹ Canada: Claim Against the Union of Soviet Socialist Republics for Damage Caused by Soviet Cosmos 954, 23 January 1979, 18 ILM 899.

if the purpose of an international space accident investigation framework is to address public concerns related to the safety of space activities, environmental damages should be considered as one of the factors that triggers an investigation.

Another difference between international air law and international maritime law is the parties participated in an investigation. As explained above, the Chicago Convention and its Annex 13 are clear on which state has the obligation to investigate, and which state(s) has the right to participate. The general principle is that "the flag State of a ship involved in a very serious marine casualty is responsible for ensuring that a marine safety investigation is conducted and completed in accordance with [the Casualty Investigation Code]."⁷² Note that the responsibility of the flag state is not to investigate, instead, it must ensure a qualified casualty is duly investigated. However, if the casualty occurred within the territory, including territorial sea, of a state, or involves more than one flag State, then these involving states shall consult to seek an agreement about which state(s) will be the investigating state(s).⁷³ Notably, the language includes the possibility of multiple investigating states.

As for participation, the Casualty Investigation Code also takes a non-vehicle-centric approach. A state may join an agreement regarding marine casualty investigation if the incident caused significant environmental damage within its jurisdiction, threatened serious harm to its interests or jurisdictional structures, resulted in the loss of life or serious injury to its nationals, or if it holds important information useful to the investigation.⁷⁴

⁷² Supra note 65 at para 6.2.

⁷³ *Ibid* c 7.

⁷⁴ *Ibid* at para 2.20.

2.3 Implications for Space Accident Investigation: Scope and Authority of Investigation

The Annex 13 model has been praised for establishing public trust in air travel, and independent aviation investigation authority in some countries have extended their jurisdiction beyond their international mandate into railway, highway, and other modes of transportation.⁷⁵ Now, as the new commercial space era approaches, some countries have expanded their independent investigation authority to space accidents, or at least took inspiration from the model.⁷⁶ However, international law does not specifically mandate an independent investigation for space accidents. Furthermore, international space law and national space laws have fundamental differences with air law on responsibility, national security, and other issues. The above models can nonetheless serve as inspirations for a potential international space accident investigation framework.

Drawing from the definition of marine casualty under the Casualty Investigation Code, in terms of the scope of the investigation, specific environmental impacts of an accident in outer space or on Earth should also be considered as a condition to start an investigation.⁷⁷ Moreover, for an international framework for independent safety investigation to be successful, international cooperation during the investigation and in carrying out the preventive actions are equally important. Therefore, how an international framework for space accident investigation balances the different interests of stakeholders⁷⁸ in a cross-border space accident will be a main issue that requires careful consideration.

⁷⁵ Dempsey, *supra* note 52 at 407–8.

⁷⁶ See Chapter 3 for detail.

⁷⁷ A state's environmental obligation related to outer space under international law is discussed in subsection 3.2.1.1.

⁷⁸ See Section 4 for analysis on the different interests that exist under international space law.

As mentioned in this chapter's introduction, one possible way that the Annex 13 model could be directly or indirectly deployed in the context of space accident investigation is through the expansion of ICAO's jurisdiction over the governance of space safety.⁷⁹ Public attention to space safety is increasing due to the participation from the private sector. According to Ram Jakhu, Tommaso Sgobba and Paul Dempsey, the safety risks in space missions, encompassing the safety of the general public, launch personnel, and valuable assets such as ground facilities and space systems, and also the growing risk associated with orbital debris and uncontrolled spacecraft reentry, highlighting the need for safety measures to mitigate the rapid expansion of the space industry and the increasing safety risks, emphasizing the importance of addressing safety improvements to sustain industry growth and avoid potential setbacks.⁸⁰ Despite the entry of private actors into space activities, government missions still prioritize "mission accomplishment" over safety, whereas commercial industries like aviation prioritize safety. Thus, these scholars advocate for extending the mandate of ICAO to commercial space activities to establish an internationally encompassing safety culture, emphasizing that safety in commercial space programs should be based on best practices and technical knowledge rather than economic tradeoffs. In addition, they proposed establishing an independent accident investigation board within ICAO, which would be crucial for addressing space activities and potential accidents that may transcend international boundaries.⁸¹

On the national level, it is not surprising that a state developed its national law regarding space accident investigation by referring to the Annex 13 model. For example, the UK's national law about space accident investigation is largely modelled on Annex 13. Section 20 of the Act delegates

⁷⁹ Jakhu, Sgobba & Dempsey, *supra* note 30 at 131; Bin Cheng, "From Air Law to Space Law" in Bin Cheng, ed, *Studies in International Space Law* (Oxford University Press, 1997) at 41–2.

⁸⁰ Jakhu, Sgobba & Dempsey, *supra* note 3 at 12–14.

⁸¹ Jakhu, Sgobba & Dempsey, *supra* note 30 at 131.

the power of making regulations specifically addressing the investigation of accidents related to spaceflight activities.⁸² Accordingly, the UK government introduced the Spaceflight Activities (Investigation of Spaceflight Accidents) Regulations 2021. While tailored to the needs of the space industry in the UK, these regulations are similar to the provisions in Annex 13 and share its focus on preventive measures and avoidance of blame or liability.⁸³

3. The Law of State Responsibility and the Obligation to Investigate Space Accidents

International law, non-binding soft law or self-regulating rules of the private sector are all instruments which are used to govern space activities at an international level. This section focuses on relevant international law that governs national space activities and space accidents because an international framework of independent accident investigation established by states can only be governed through international law.

Article 38, Paragraph 1 of the Statute of the International Court of Justice is the generally accepted codification of the sources of international law. It provides three authoritative sources and two law-determining sources of international law. The former include (1) international conventions; (2) international custom; and (3) general principles of law. The latter include (1) judicial decisions; and (2) the teachings of the most highly qualified publicists, both from various nations.⁸⁴ The main view is that Article 38 is not a codification of the source of international law nor does it represent a hierarchy of the sources listed.⁸⁵ Since international space law was initiated under international treaties primarily negotiated within the United Nations, it is mainly conventional.⁸⁶ Nonetheless, while the discussion below will be based mainly on the treaties,

⁸² Space Industry Act 2018 (UK), s 20.

⁸³ *UK Regulations 2021, supra* note 16, s 11(1).

⁸⁴ Statute of International Court of Justice, supra note 35 art 38(1).

⁸⁵ James Crawford, *Brownlie's Principles of Public International Law* (Oxford: Oxford University Press, 2019) at 19–20.

⁸⁶ Stephan Hobe, *Space law*, 2d ed (Baden-Baden: Nomos/Hart, 2023) at 58.

customary international law will also be taken into consideration. It should be noted that, under the doctrine of *lex specialis*, when the space treaties are insufficient to address a space accident investigation, then general international law should still be applicable to such cases.⁸⁷

The five international treaties which govern space activities are the (1) Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies ("Outer Space Treaty"); (2) Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space ("Rescue Agreement"); (3) Convention on International Liability for Damage Caused by Space Objects ("Liability Convention"); (4) Convention on Registration of Objects Launched into Outer Space ("Registration Convention"); and (5) Agreement Governing the Activities of States on the Moon and Other Celestial Bodies. These treaties set out the principles and rules of space activities. Despite that a treaty that had come into force is only binding on its contracting parties, some principles laid down in the Outer Space Treaty have been considered by scholars reflecting customary international law, and thus binds all states.⁸⁸ This section explores international law relevant to space accident, emphasising state responsibility for non-governmental space activities and the law of state responsibility.

⁸⁷ From time to time, space law is debated as a potential self-contained regime. However, most scholars agree that the *lex specialis* doctrine suggests that space law applies specifically to space activities, but it remains subject to the general international law, particularly in areas where legal *lacunae* exist. Therefore, space law is best understood as a specialized area of international law rather than a self-contained regime. See e.g. *Ibid* at 51–6.
⁸⁸ Ram S Jakhu & Steven Freeland, "The Relationship Between the Outer Space Treaty and Customary International Law" (2016) SSRN Electronic Journal, online: https://www.ssrn.com/abstract=3397145; Stephan Hobe Chen Kuan-Wei, "Legal status of outer space and celestial bodies" in *Routledge Handbook of Space Law* (Routledge, 2016) at 26.
3.1 State Responsibility for Commercial Space Activities and Space Accident Investigation under International Space Treaties

Article VI of the Outer Space Treaty lays down the foundation of state responsibility in outer space. It established that States Parties are responsible for all national activities in outer space, including the moon and other celestial bodies, regardless of whether these activities are conducted by governmental or non-governmental entities. It requires that non-governmental activities receive authorization and continuing supervision from the appropriate State Party.⁸⁹ Scholars propose that, notably, many states have implemented Article VI through their national laws, the criteria of customary international law, i.e. consistent state practice and *opinio juris*, have been satisfied, making the provisions of Article VI applicable to all states.⁹⁰ Specific responsibility of states, such as liability for damage, avoiding harmful contamination, and registering a space object, are found in other parts of the Outer Space Treaty, the Liability Convention and the Registration Convention. It should be noted that in nowhere do international space treaties explicitly obligate states to investigate space accidents.

In terms of non-governmental space activities, states are required to authorize and continuingly supervise these activities. Commercial space activities fall into this provision. Some states have national laws that require launch providers to submit a mishap plan as part of the application for a launch license. For example, in the US, all commercial space operators are mandated to report any mishap, launch anomaly, or failure immediately to the FAA, through its Office of Commercial Space Transportation.⁹¹ This includes events resulting in injury, fatality, or significant property damage. An FAA-licenced operator is obligated to investigate the mishap. ⁹² Based on

⁸⁹ Outer Space Treaty, supra note 21 art VI.

⁹⁰ Jakhu & Freeland, *supra* note 88.

⁹¹ 14 CFR § 450.173.

⁹² *Ibid*.

investigation outcomes, the FAA may mandate operators to undertake corrective measures to prevent recurrence.⁹³ An FAA investigation, however, is not an independent safety investigation. The FAA could be potentially in conflict with its dual mandate between effectively controlling the US's space activities and promoting commercial space launches in the private sector, including those with spaceflight participants, which can be seen as constraining the independence of the FAA conducting the investigation.⁹⁴ As of the time of writing, the FAA has utilized its investigative authority only once in the case of the SpaceShipTwo accident, which was collaborated with the NTSB.⁹⁵

To conclude, despite that international space treaties do not mandate states to investigate space accidents, the Outer Space Treaty does require states to authorize and continuingly supervise their commercial space activities. As an example of state practice has shown, submission of a mishap plan prior to license approval and investigation after an accident happens is a modality of fulfilling one state's responsibility under Article VI of the Outer Space Treaty. This interpretation, however, is clear when only one state has jurisdiction over an accident. As this thesis shows, in a commercial context, multiple states could be involved in an accident investigation under international law. Moreover, as the next chapter shows, state practices are not consistent with the approach of investigating a space accident, and states do not exhibit the *opinio juris* that they are obligated under Article VI to investigate space accidents. Hence, a mandatory space accident investigation has not yet become customary international law.

⁹³ *Ibid*.

⁹⁴ Josef S Koller et al, *Commercial Human Spaceflight Safety Regulatory Framework* (The Aerospace Corporation, 2022) at 25.

⁹⁵ Ibid.

3.2 Potential Basis for Space Accident Investigation under General International Law: The Law of State Responsibility

International space treaties do not directly obligate contracting states to investigate a space accident and, as argued above, institutionalizing independent investigation for space accidents as a means of authorization and continuing supervision of non-governmental space activities has yet not reached the status of customary international law. This is, however, not the end of our inquiry into international law's effect towards space accident investigation. International space treaties are specialized international instruments on space governance, which means national space activities are also governed by general international law. Article III of the Outer Space Treaty also reaffirms that space activities shall be carried out in accordance with international law. According to the doctrine of *lex specialis*, since the specific law governing space matter does not address space accident investigation, we should then approach this matter from the *lex generalis*. As to whether a state is responsible for investigating a space accident, the law of international responsibility may be proper to address this question.

The law of states' international responsibility is codified in the International Law Commission's Articles on the Responsibility of States for Internationally Wrongful Acts of 2001 (ARSIWA), which is widely accepted as reflecting customary international law on this subject.⁹⁶ According to Article 1 of ARSIWA, "[e]very internationally wrongful act of a State entails the international responsibility of that State." International responsibility is a state's answerability towards acts or omissions which can be attributed to it and breaches its international obligations.⁹⁷ An act of a non-governmental entity cannot traditionally be attributed to a state unless the conduct

⁹⁶ Crawford, *supra* note 85 at 524.

⁹⁷ Articles on Responsibility of States for Internationally Wrongful Acts, UNGA, UN Doc A/RES/56/83 (2001) art 2 [ARSIWA].

is directed or controlled by a state, the conduct is exercising elements of the governmental authority in the absence or default of the official authorities, the conduct is an insurrectional or another movement, or the conduct is acknowledged and adopted by a state as its own.⁹⁸ On the contrary, as mentioned above, states are responsible for their non-governmental space activities under Article VI of the Outer Space Treaty, and scholars argue that Article VI has reached the status of customary international law.⁹⁹ Then it follows that if a non-governmental space activities of one state violates the international obligation of that state, that state is internationally responsible for such violation.

The following subsections examine probable bases where an accident caused by a space object belonging to a non-governmental entity can breach the international obligations of the state concerned and argue whether that state should be internationally responsible for conducting an accident investigation. Two scenarios of breach are of particular interest, namely a lack of due diligence, and intrusion of the airspace and territory of another state.

3.2.1 Obligations towards protecting the Environment

Environmental concern related to space activities, especially space debris mitigation, is one of the topics that has attracted many space lawyer's attention in recent years. Outer space is indeed a fragile environment that can be easily contaminated and difficult to recover from even the slightest alteration. As we have seen above, environmental damage is one of the events that could trigger an independent investigation under IMO's Casualty Investigation Code. This section argues that space accident has links to the environment and the international obligations to protect the related environment as well.

⁹⁸ *Ibid* arts 8–11.

⁹⁹ Jakhu & Freeland, *supra* note 88; Chen, *supra* note 88 at 26.

3.2.1.1 Due Regard and the Obligation to Avoid Harmful Contamination under Outer Space Treaty

The drafters of the Outer Space Treaty share the view of environmental protection and put in Article IX that states " ... shall conduct all their activities in outer space, including the moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty."¹⁰⁰ The second sentence of Article IX provides that when conducting exploration in outer space, state parties have the obligation to avoid harmful contamination to the outer space environment. In addition, the same provision also requires states to avoid "... adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter"¹⁰¹ Thus, the protection of the outer space environment extends back to Earth as well.

Space debris is well-known to cause harm to satellites and humans in orbit and larger debris can cause damage on Earth when re-entering the atmosphere.¹⁰² However, there is a debate over whether the risk of space debris falls within the language of harmful contamination. Some argued that the ordinary meaning of harmful contamination does not exclude the damages that could be caused by space debris.¹⁰³ While others argued that according to the preparatory work of the Outer Space Treaty, harmful contamination contains only biological, chemical and nuclear contamination.¹⁰⁴ This thesis finds that the first interpretation to be correct. According to Article 32 of the Vienna Convention on the Law of Treaties, preparatory work is a supplementary means of treaty interpretation and can only be used when interpretation by the ordinary meaning and the

¹⁰⁰ Supra note 21 art IX.

¹⁰¹ *Ibid*.

¹⁰² The Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space, *Technical report on space debris*, UNCOPUOS, 1999, UN Doc A/AC.105/720 at 79–94.

¹⁰³ Jan Helge Mey, "Space Debris Remediation" (2012) 61:2 ZLW 251–272 at 259; Stephan Hobe, Bernhard Schmidt-Tedd, & Kai-Uwe Schrogl, eds, *Cologne Commentary on Space Law: Volume 1 - Outer Space Treaty* (Cologne: Carl Heymanns Verlag, 2009) at 176–177.

¹⁰⁴ Gershon Hasin, "Confronting Space Debris through the Regime Evolution Approach" (2021) 97 Int'l L Stud Ser US Naval War Col 1073–1159 at 1084.

treaty's object and purpose is leaves ambiguous or obscure or leads to a result which is manifestly absurd or unreasonable.¹⁰⁵ Interpreting space debris as harmful contamination does not create ambiguous or obscure results, and it is in line with the Outer Space Treaty's purpose is promote to explore and use outer space for peaceful purposes.¹⁰⁶ Moreover, the French, Russian, and Chinese texts of the Outer Space Treaty, which are equally authentic,¹⁰⁷ denote and indicate pollution in outer space.¹⁰⁸ Therefore, depending on whether the pollution of space debris is harmful on the *ad-hoc* basis, space debris might fall within the purview of harmful contamination under Article IX.¹⁰⁹

Despite that Article IX obligates states to avoid harmful contamination of outer space, the consequence of non-compliance would only trigger a potential consultation request from a concerned party. A consultation could not be argued as a possible basis for a space accident investigation. Moreover, debris and launching vehicles are not extraterrestrial matters, and thus the obligation to avoid contamination on Earth does to extend to contamination caused by re-entry debris accident or launch failure. Space accident investigation, therefore, must be based on other international environmental obligations.

3.2.1.2 International Environmental Law

This missing link nevertheless between space accidents on Earth and the obligation of due diligence can still be established under general international law and other provisions in the Outer Space Treaty. As per Article III of the Outer Space Treaty, space activities shall be carried out in

¹⁰⁵ *VCLT*, *supra* note 36 art 32.

¹⁰⁶ Supra note 21 Preamble.

¹⁰⁷ *Ibid* art XVII.

¹⁰⁸ Peter Stubbe, *State Accountability for Space Debris: A Legal Study of Responsibility for Polluting the Space Environment and Liability for Damage Caused by Space Debris* (Brill Nijhoff, 2017) at 156. The Chinese text speaks of "有害之染污", which also contains, in ordinary use, meaning of pollutive effect of the environment. ¹⁰⁹ *Ibid* at 166.

accordance with international law including environmental international law as many argued.¹¹⁰ In the Gabčikovo-Nagymaros case, the ICJ reaffirmed its finding in Nuclear Weapons that there exists a general obligation of states "to ensure that activities within their jurisdiction and control respect the environment of other States or of areas beyond national control"¹¹¹ Some argued that this "prohibition of the causation of transboundary harm" is not tailored to the space environment and remains highly debatable in the real world scenario.¹¹² Nevertheless, most scholars view this obligation as either customary international law¹¹³ or the general principle of international law.¹¹⁴ This thesis agrees with the latter opinion because Article IX and Article III stipulate the obligation to protect the space environment and the compliance with international law. The space environment is beyond national control as Article II of the Outer Space Treaty declares the non-appropriation principle. In addition, space debris that falls onto foreign territory and pollutes the environment of other states falls within the meaning of ICJ's language cited above. Accordingly, states are under the obligation to exercise due diligence over their national space activities, both governmental and non-governmental, concerning the environment of outer space and other states.

The collision of the Russian Satellite Cosmos 2251 and the US Satellite Iridium 33 can illustrate this argument. Before the collision occurred on February 10, 2009, Russia had abandoned Cosmos 2251 in orbit and was non-operational for approximately 10 years. Russia has violated its duty of due regard under Article IX of the Outer Space Treaty by abandoning Cosmos 2251 in

¹¹⁰ Supra note 21 art III.

¹¹¹ Gabčíkovo-Nagymaros Project (Hungary v Slovakia), [1997] ICJ Rep 7 at para 53 [Gabčíkovo-Nagymaros]; Legality of the Threat or Use of Nuclear Weapons, [1996] ICJ Rep 226 at para 29 [Nuclear Weapons].

¹¹² Timothy G Nelson, "Regulating the Void: In-Orbit Collisions and Space Debris" 40 J Space L 105–130 at 129.

¹¹³ Hobe, *supra* note 86 at 55, 102; Lotta Viikari, *The Environmental Element in Space Law: Assessing the Present and Charting the Future* (Brill Nijhoff, 2008) at 150.

¹¹⁴ Stubbe, *supra* note 108 at 216–221.

orbit.¹¹⁵ On the other hand, Iridium 33 was functioning normally and capable of making manoeuvres to avoid the collision. The US was not free from its inaction or inability to prevent the collision either, especially under the obligation of due diligence and considering that the US knows about the potential collision from regularly monitoring space debris.¹¹⁶ Both parties never filed a claim under Article III of the Liability Convention regarding the Iridium-Cosmos collision. From a legal point of view, this case seems to imply that both states have realized that they may be partially at fault for the collision.¹¹⁷

It is important to note that, since outer space is a *res communis omnium*, some have argued that the obligation under Article IX of the Outer Space Treaty is *erga omnes partes*.¹¹⁸ Following this view, state responsibility of violating the obligations under Article IX can entitle any state other than the injured state to seek certain reparation under Article 48 of ARSIWA.¹¹⁹ It should also be noted that, however, there is no judicial decision or article of the most highly qualified publicists that has determined Article IX as *erga omnes partes*, and thus a state other than the injured state might not seek remedy under Article 48 of ARSIWA.

3.2.2 Intrusion of The Airspace and Territory of Another State

One of the fundamental principles of international law is that states are sovereign over their territories and in the airspaces above their territories. Article 1 of the Chicago Convention reaffirms this principle by declaring that "... every State has complete and exclusive sovereignty over the airspace above its territory." The ICJ also found this principle as customary international law. In *Nicaragua (Merits)*, the Court held that,

¹¹⁵ Ram S Jakhu, "Iridium-Cosmos collision and its implications for space operations" in Kai-Uwe Schrogl et al, eds, *Yearbook on Space Policy 2008/2009: Setting New Trends* (Vienna: Springer, 2010) 254 at 259.

¹¹⁶ *Ibid* at 258.

¹¹⁷ *Ibid* at 259.

¹¹⁸ Stephan Hobe, Bernhard Schmidt-Tedd, & Kai-Uwe Schrogl, *supra* note 103 at 181.

¹¹⁹ ARSIWA, supra note 97 art 48.

The basic legal concept of State sovereignty in customary international law, expressed in, *inter alia*, Article 2. paragraph 1, of the United Nations Charter, extends to the internal waters and territorial sea of every State and to the air space above its territory. As to superjacent air space, the 1944 Chicago Convention on International Civil Aviation (Art. 1) reproduces the established principle of the complete and exclusive sovereignty of a State over the air space above its territory. ... The Court has no doubt that these prescriptions of treaty-law merely respond to firmly established and longstanding tenets of customary international law.¹²⁰

A space object re-enters the atmosphere and intrudes into a foreign state's airspace, thus, violating without doubt the sovereignty of the intruded state and the customary international law to respect such territorial sovereignty. In the incident of Cosmos 954, Canada claimed that the Soviet satellite impact on Canadian soil was an intrusion of Canada's airspace and a violation of Canada's sovereignty.¹²¹

Cosmos 954 was a Soviet satellite powered by a nuclear reactor that crashed in Canada on January 24, 1978, because it had not been completely burned during the re-entry. The debris of the satellite scattered along a path mainly in Canada's Northwest Territories, and its radioactive materials contaminated Canadian land.¹²² Canada filed a claim for compensation of around 6 million Canadian Dollars under the Liability Convention against the Soviet Union for damages incurred by the clean-up operation and other costs.¹²³ Both states eventually agreed on compensation of 3 million Canadian Dollars.¹²⁴

A reentry-satellite's intrusion of other states' airspace itself, however, may not be enough to constitute a breach of international obligation. In *Nicaragua (Merits)*, ICJ held that the obligation to respect the territorial sovereignty of other states should be judged depending upon the facts

¹²⁰ Military and Paramilitary Activities in and against Nicaragua (Nicaragua v United States of America), [1986] ICJ Rep 14 at para 212 [Nicaragua (Merits)].

¹²¹ Supra note 71 at 905–907.

¹²² *Ibid* at 902.

¹²³ *Ibid* at 904.

¹²⁴ Protocol between the Government of Canada and the Government of the Union of Soviet Socialist Republics, Canada and USSR, 2 April 1981, arts 1–2.

relating to the accused actions.¹²⁵ In Canada's claim against the Soviet Union, Canada alleged that the Soviet violated its sovereignty by not only intruding its airspace but depositing radioactive materials on its territory, which "the interference with the sovereign right of Canada to determine the acts that will be performed on its territory."¹²⁶ Therefore, to claim that a satellite's intrusion has violated the responsible state's international obligation to respect the territorial sovereignty of other states, the claimant would have to provide facts on the consequences or interference of the intrusion with its sovereign right. This can be damage to its property, injury to its nationals, damage incurred for the clean-up, and more.

3.2.3 Space Accident Investigation as a Possible Way to Fulfill a State's Obligation for an Internationally Wrongful Act

Under the law of international responsibility, the consequences of an internationally wrongful act may entitle an injured state or even a non-injured state to respond. The forms of response include seeking cessation and assurances of non-reparation, seeking reparation, and taking countermeasures.¹²⁷ For this thesis, the following discussion focuses on assurances and guarantees of non-reparation and satisfaction (a form of reparation) as possible bases for claiming against the responsible state to conduct a space accident investigation.

Article 30 of ARSIWA stipulates that "[t]he State responsible for the internationally wrongful act is under an obligation: (a) To cease that act, if it is continuing; (b) To offer appropriate assurances and guarantees of non-repetition, if circumstances so require."¹²⁸ Both cessation and assurances and guarantees of non-repetition are concerned with the future performance of the breach of an international obligation, whereas the cessation is the negative of future performance,

¹²⁵ Nicaragua (Merits), supra note 120 at para 213.

¹²⁶ Supra note 71 at 907.

¹²⁷ ARSIWA, supra note 97.

¹²⁸ *Ibid* art 30.

assurances and guarantees serves as a prevention of repeating the breach in the future.¹²⁹ The forward-looking and preventive aspect resonates with the purpose of an independent safety investigation. The objective of an aviation accident investigation is to prevent accidents and incidents of the same causes from reoccurring. Although an aviation accident itself does not often constitute a breach of an international obligation of a state and the obligation to investigate an aviation accident is a standalone obligation of the state of occurrence under the Chicago Convention, however, as mentioned in sections 3.2.1 to 3.2.2, space accident could constitute an internationally wrong act and thus obligates the responsible state for providing assurances and guarantees of non-repetition.

As the condition of "if circumstances so require" in Article 30 (b) implies, unlike cessation, assurances and guarantees of non-repetition are not always required. It is usually claimed when the injured state believes that simply restoring the previous situation is insufficient to protect its interests adequately. For instance, immediately after a protest at the US Embassy in Moscow in 1965, the US government stated that the Soviet government had violated its obligation to protect foreign diplomatic missions and asked for not only apology and compensation but also "adequate protection" in the future.¹³⁰

In the case of *LaGrand* between Germany and the US, the ICJ further developed the content of assurances of non-repetition. When adjudicating Germany's submission of asking the court to declare that the US shall provide Germany an assurance that it will not repeat the wrongful act of not complying with Article 36, paragraph 1, of the Vienna Convention on Consular Relations, the

¹²⁹ Commentary to ARSIWA, in Yearbook of The International Law Commission 2001, vol 2, part 2 (New York: UN 2007) at 88 (UNDOC. A/CN.4/SER.A/2001/Add.1 (Part 2)).

¹³⁰ Damages to U.S. Government Buildings Overseas, 3 May 1965, 4 ILM 696 at 698.

Court affirmed that the submission for a general assurance of non-repetition is appropriate. The

Court held that:

an apology is not sufficient in this case, as it would not be in other cases where foreign nationals have not been advised without delay of their rights under Article 36, paragraph 1, of the Vienna Convention and have been subjected to prolonged detention or sentenced to severe penalties.¹³¹

The Commentary of ARSIWA noted that guarantees of non-repetition are more than verbal assurances. Guarantees can be e.g. preventive measures implemented by the responsible State to prevent the recurrence of the breach.¹³² An injured state can seek any form of guarantee, in the *LaGrand* case, however, the ICJ refrained from declaring any specific assurances sought by Germany. In its submission, Germany asked the Court to declare that the US shall provide Germany an assurance that,

... in any future cases of detention of or criminal proceedings against German nationals, the United States will ensure in law and practice the effective exercise of the rights under Article 36 of the Vienna Convention on Consular Relations. In particular in cases involving the death penalty, this requires the United States to provide effective review of and remedies for criminal convictions impaired by a violation of the rights under Article 36.¹³³

The Court ruled that whereas the US has an obligation to ensure its compliance with the Vienna

Convention on Consular Relations in the future, the "obligation can be carried out in various ways [,]" and "[t]he choice of means must be left to the United States."¹³⁴ Therefore, although an injured state could demand specific measures as a guarantee of non-repetition, whether it should be granted depends on a case-by-case basis, and the nature of the obligation and the breach should be taken into consideration.¹³⁵

¹³¹ LaGrand (Germany v United States of America), [2001] ICJ Rep 466 at para 123 [LaGrand].

¹³² *Supra* note 129 at 90.

¹³³ LaGrand, supra note 131 at para 117.

¹³⁴ *Ibid* at para 125.

¹³⁵ *Supra* note 129 at 90.

In addition to Article 30 of ARSIWA, Article 37 provides satisfaction as a remedy for the injured state when the damage cannot be restituted or compensated which could also be a basis to seek assurances and guarantees of non-repetition.¹³⁶ In practice, the main difference between Article 30 and Article 37 is that, according to Article 48, Article 30 may be sought by a state other than an injured state. Thus, if one argued that obligation under Article IX of the Outer Space Treaty is *erga omnes partes* and a space accident was caused by the responsible state because it has violated Article IX, then any state could, in theory, seek assurances and guarantees of non-repetition per Article 48 of ARSIWA.

Turning to the previous scenarios in which a space accident constitutes a breach of the appropriate state's international obligations. In such a case, an injured state may be entitled to seek an investigation as a guarantee of non-repetition under Article 30 (b) of ARSIWA. An apology and compensation for the damage caused by the intrusion of airspace and violation of due diligence would only deal with the wrong in the past and would not prevent the same accident from happening again. To prevent an accident of the same cause from reoccurring, it is crucial to discover what went wrong to learn a lesson from the accident. Since the obligation to offer a guarantee of non-repetition also has a preventive nature, it is appropriate and reasonable for an injured state to seek the responsible state for an investigation of the accident as a guarantee of non-repetition. Despite that Article 30 (b) of ARSIWA could be argued as a basis for the obligation to investigate a space accident involving a non-governmental entity, it does not go as far as in what kind of procedure should the investigation be performed. If the domestic investigation procedure of the responsible state does not violate any of its international obligations, following ICJ's opinion

¹³⁶ *Ibid*.

in *LaGrand*, the responsible state shall have the right to choose whatever investigation it deems fit.

While the investigation procedure in Annex 13 serves as a model for independent safety investigation (see section 2.1 for discussion), it is one way to determine the root cause of an accident. Investigations come in different forms and procedures, such as an internal investigation within a private entity, an administrative and oversight investigation, a judicial investigation and even an investigation initiated by the victims. To fulfill their obligation of continuing supervision of non-governmental space activities under Article VI of the Outer Space Treaty, states have frequently included inspection and investigation powers in their legislations.¹³⁷ In addition, some states require authorized space operators to file a plan in case of a mishap or to report a failure.¹³⁸ Considering the states' obligations and practices, therefore, investigation of a space accident can be argued as a guarantee of non-repetition. Nonetheless, without an explicit international obligation to perform an independent safety investigation such as in the case of an aviation accident, how a space accident investigation should be performed is still at the will of the responsible state.

4. The Implications of International Space Treaties for Space Accident Investigation

The last section focuses on the law of state responsibility looking for the basis of space accident investigation under international law. While the obligation to investigate a space accident investigation may be established through the law on state responsibility given above, the broader aspects of international space law will influence the dynamic of such framework as well. Hence, this section dives into various aspects of liability, notification, and involvement in the event of a

¹³⁷ See e.g. *Outer Space Act 1986* (UK) s 5(1)(c); Law of the Russian Federation on Space Activities (Russia) art 23; *Space (Launches and Returns) Act 2018* (Commonwealth), 1998/123, s 83 (Austl); Space Development Act (Taiwan) art 18; Space Development Promotion Act (Republic of Korea) art 16; *LOI n° 2008-518 du 3 juin 2008 relative aux opérations spatiales (1)*, JO, 11 September 2024, no 129.

¹³⁸ See e.g. 14 CFR § 450.173; Act on Launching of Spacecraft, etc. and Control of Spacecraft (Japan) art 25.

space accident, outlining the legal obligations of states and analysing potential stakeholders under the frameworks established by international treaties such as the Outer Space Treaty, the Liability Convention, and the Rescue Agreement.

4.1 Liability for Damage Caused by Space Accident

Since the start of the space era, space exploration has been inherently high-risk and ultrahazardous to its participants and third parties that it can injure in the event of a mishap. The drafters of the Outer Space Treaty, therefore, introduced the concept of international liability for damage resulting from a space object incident. According to Article VII of the Outer Space Treaty, any state party that launches or procures the launch of an object, as well as any state party from whose territory or facility an object is launched, is liable for damage caused by its space objects.¹³⁹

This principle of liability is further developed in the Liability Convention, the *lex specialis* of this subject matter. The third paragraph of the Preamble of the Liability Convention highlights the intrinsic risks of outer space activities, especially during launches, necessitating that states implement preventive safety measures to ensure maximum operational safety.¹⁴⁰ It acknowledges that despite all precautions, accidents and damage may still occur during launches. It is the risky nature of space operations that justifies the treaty obligation of a state, even for its non-governmental space activities, to compensate the victims of a space accident. Articles II and III of the Liability Convention further divide the liability into absolute liability and fault liability. The former applies to damage caused by their space objects on the surface of the Earth or to aircraft in

¹³⁹ Supra note 21 art VII.

¹⁴⁰ Convention on the international liability for damage caused by space objects, 29 March 1972, 961 UNTS 187 Preamble [Liability Convention].

flight.¹⁴¹ Whereas the latter covers the events which are not covered by Article II, for instance, damage in outer space.¹⁴²

These legal principles provide the basis of stake that a state takes as the liable party in the event of a space accident. While the purpose of an independent safety investigation is to prevent accidents of the same cause from reoccurring and not to apportion blame or liability, however, at least in the context of aviation liability dispute, the findings of an investigation report are still the most influential evidence.¹⁴³ Therefore, the liability regime for damages caused by space objects still provides implications for a potential international space accident investigation framework.

In the context of Article II, a launching state is absolutely liable for damage caused by its space objects on the surface of the Earth. Since an injured party does not need to prove that a launching state is at fault, and it does not operate the same type of launching vehicle, there is almost no incentive for the injured party to put any resources into an investigation of the cause of the accident. On the other hand, a launching state will have every incentive to investigate such an accident, whether independent or not, because it bears absolute liability for its commercial space activities under the Liability Convention and would want to make sure that the accident does not reoccur.

It is a different story when it comes to damage in outer space. In this circumstance, the launching state is only liable when it or its responsible person is at fault. To evaluate whether a launching state is at fault under Article III of the Liability Convention, we should ask what are the rules which create a legal obligation for a launching state to avoid damages caused by its space object. Article IX of the Outer Space Treaty, *inter alia*, provides that states shall conduct all their activities in outer space with due regard to the corresponding interests of all other state parties to

¹⁴¹ *Ibid* art II.

¹⁴² *Ibid* art III.

¹⁴³ Lisa J Savitt, "Admissibility and Use of Government Aviation Accident Investigation Reports" in Andrew J Harakas, ed, *Litigating the Aviation Case*, fourth edition ed (Chicago: American Bar Association, 2017) 479 at 500.

the Outer Space Treaty.¹⁴⁴ Therefore, from a purely legal perspective, both a launching state and an injured state involved in an accident in outer space seems to have equal stakes to investigate an accident based on their due regard obligations and to prove fault of the other party. This argument can also be supported by the *Corfu Channel*, in which the ICJ ruled that "nothing was attempted by the Albanian authorities to prevent the disaster. These grave omissions involve the international responsibility of Albania."¹⁴⁵ Accordingly, Albania's defence of being unable to prevent the damage due to its unawareness of the mines in its territorial waters was dismissed.

The international liability regime for damage caused by space objects creates a unique liability regime in which states are directly liable. When considering a potential international framework for space accident investigation, it is inevitable to delegate the investigation powers to states which may have a stake in the accident in terms of liability and compensation. As discussed above, a state where the injury of a space accident happens can have no interest in investigating the accident that caused damage on its territory; and states can conflict with interest in an investigation to find the cause as well as the fault of a collision in space.

4.2 Custody of Debris: Notification and Return of Foreign Space Object

While the state suffered from a space accident could have no interest to investigate, it is still obligated to notify the launching state and return, upon request, the space object under international space law. Article V of the Rescue Agreement establishes the framework for an international response when a space object or its components re-enter Earth's atmosphere and land within a contracting party's jurisdiction, the high seas, or any unclaimed areas.¹⁴⁶ This provision delineates the obligations regarding notification, return, etc.

¹⁴⁴ Supra note 21 art IX.

¹⁴⁵ Corfu Channel Case (United Kingdom of Great Britain and Northern Ireland v Albania), [1949] ICJ Rep 4 at 23 [Corfu Channel].

^{25 [}Corju Channel]

¹⁴⁶ *Rescue Agreement, supra* note 21 art V.

The initial responsibility of a contracting party upon discovering a returned space object is to notify both the launching authority and the Secretary-General of the United Nations. According to the United Nations Office for Outer Space Affairs, more than 160 notifications have been made since the Rescue Agreement came into force on December 3, 1968.¹⁴⁷ Contracting parties are also required to assist in the recovery and the return of space objects or their components upon the request of the launching authority.

To conduct a comprehensive accident investigation, the investigation agency needs to have custody of the object under investigation. Annex 13 shares this view and stipulates that the state of occurrence shall have safety custody of aircraft for investigation.¹⁴⁸ Therefore, Article V of the Rescue Agreement seems to imply that in an accident caused by a foreign space object, the state of launching authority should be the one that investigates the accident.

4.3 Parties Which Could Be Involved in The Investigation

The previous subsections cover the obligations and the stakes a state may have when an international space accident occurs. This subsection turns to the question of which states could be involved in the investigation. For this purpose, an analysis of the concepts of "appropriate state", "launching state", and "the state of registry" is crucial.

As mentioned in 3.1, Article VI of the Outer Space Treaty requires non-governmental activities to be authorized and continuingly supervised by the appropriate state. The most accepted view is that an appropriate state is the state that has jurisdiction under the general principles of public international law – personal, territorial or registrational – over the space activities in question.¹⁴⁹ Judging from this provision, for a launch accident, the state of the launching site, the state of the

¹⁴⁷ "Recovery and Return of Objects Launched into Outer Space", online: https://www.unoosa.org/oosa/en/treatyimplementation/arra-art-v/unlfd.html.

¹⁴⁸ ICAO, *supra* note 26, s 3.3.

¹⁴⁹ Stephan Hobe, Bernhard Schmidt-Tedd, & Kai-Uwe Schrogl, *supra* note 103 at 117.

launch service provider, and the state of registry for the launching vehicle could become parties to the investigation of a potential space accident, for satellite collision, the state of the operator of the space object and the state of registry for such object could become parties.

As for the liability regime, discussed in subsection 4.1, the liable entity for the damages is a "launching state". Article I (c) of the Liability Convention defines a launching state as "(i) [a] State which launches or procures the launching of a space object; (ii) [a] State from whose territory or facility a space object is launched [.]"¹⁵⁰ This provision further shows that the state which procures the launching of a space object ("state of procurement") can also become a party to the investigation. Besides being liable, the state of procurement could also have an interest in the investigation because it or its non-governmental entity may have an enormous financial interest in a destroyed space asset.

The Registration Convention adopts the same definition of launching state.¹⁵¹ Pursuant to Article II of the Registration Convention, if there is more than one launching state, only one state shall be the state of registry.¹⁵² To avoid the situation in which a state of the launch provider would also be the state of registry of a foreign payload, it is a common practice to individually register the upper stage of the launch vehicle and the payload.¹⁵³ Therefore, this practice together with the Registration Convention give the state of procurement more stake in an accident investigation.

In conclusion, drawing from the procedures and practices in civil aviation, the collaborative involvement of various states in accident investigations ensures a comprehensive and transparent process. In space activities, the concepts of "appropriate state," "launching state," and "state of

¹⁵⁰ Supra note 140 art I(c).

¹⁵¹ Convention on Registration of Objects Launched into Outer Space, 15 September 1976, 1023 UNTS 15 art I(a) [Registration Convention].

¹⁵² *Ibid* art II.

¹⁵³ Stephan Hobe, Bernhard Schmidt-Tedd, & Kai-Uwe Schrogl, *supra* note 103 at 151.

registry" define the obligations and rights of states. It would be critical for any kind of space accident investigation framework to harmonize the different parties that may be involved in the investigation.

5. Conclusion

As this chapter shows, although a space accident investigation does not exist under international law, international law still provides abundant sources for thinking about a potential international framework for space accident investigation. The origination of independent accident investigation was founded in international air law, and through the years Annex 13 has become the model of such investigational institutions. Emphasizing the independence of the investigation authority and the participation of interested parties, the Annex 13 model has been believed to be one of the reasons that made aviation the safest mode of transportation. International maritime law has followed the Annex 13 model by adopting the Casualty Investigation Code while making changes to the model to be compatible with the principles of maritime law. In particular, the definition of a marine casualty expands to environmental damages, and while the obligation to an accident investigation lies with the flag state, it must consult with other interested state which has a right under international maritime law regarding the marine casualty to agree on the terms of an investigation. Drawing from these characteristics, it is crucial to consider the issues of independence, the scope of initiating an investigation, and the participation mechanism for an international space accident investigation, as space activities are highly sensitive due to national security reasons and the space environment is unique than the air or the sea.

Furthermore, this chapter has argued that, under general international law, the law on state responsibility could be the basis that obligates the state to investigate a cross-border commercial space accident. States are responsible for their commercial space activities under Article VI of the Outer Space Treaty. If a space accident happens in orbit or causes damage beyond the responsible state's territory, the responsible state could violate its due regard obligation under the Outer Space Treaty and the principles of international environmental law. Additionally, space objects or debris falling onto another state's territory is an intrusion, and thus also violates the obligation to respect the territorial sovereignty of another state. Under these circumstances, a space accident, as this thesis argues, constitutes an internationally wrongful act, and thus, the responsible state is under the obligation to provide assurances and guarantees of non-repetition to the injured state as a future-looking action in response to the accident. An independent accident investigation is also forward-looking as its purpose is to prevent future accidents, and thus, such an investigation could be interpreted as an assurance and guarantee of non-repetition. However, states are free to exercise their power to investigate an accident in the way they see fit.

In the new space era, an international framework for space accident investigation might help to achieve the same goal for the space industry. As this thesis demonstrates, however, the Annex 13 model is not completely compatible with current international space law and common practice. Specifically, when the accident involves multiple states which all have a stake regarding liability under international space law. The absence of a binding international framework for space accidents presents challenges, especially when multiple interested states are involved under their rights and obligations provided by the space treaties or as Chapter 4 explains when export control laws hinder the sharing of critical technical information. Without binding international law addressing space accident investigation, cross-border space accidents would need to depend on international cooperation on an *ad hoc* or bilateral basis. To enhance the governance of space safety, the development of a new treaty or protocol specifically addressing independent investigations for space activities seems to be a path. The next chapter will delve deeper into this issue by offering a comparative analysis of national legal frameworks regarding space accident investigations. This comparative approach will explore how different countries have developed their regulations and procedures, often drawing from existing models in aviation law. By examining these national laws, we will identify potential best practices and highlight areas where international harmonization might be feasible. This comparative study will also shed light on the challenges and gaps in current national approaches, providing a critical foundation for the eventual creation of a cohesive and effective international framework for space accident investigations.

Chapter 3: Comparative Approach Towards Space Accident Investigation: National Laws and Practices of the United States, the United Kingdom and Australia

1. National Laws Towards Space Accident Investigation: An Overview

As the last chapter has shown, international law provides, while not mandatory, a potential basis for the investigation of cross-border commercial space accidents based on the law of state responsibility. Although commentators have called for establishing an international framework to address this issue, space accident investigation is not on the agenda of international space law-making. Not to mention that the making of an international space treaty has made little progress since the Moon Agreement was adopted by the UN General Assembly in 1979 and then entered into force in 1984. International space governance, however, does not stop there. Different instruments such as soft law, non-binding agreements and national laws have taken up a significant role in space governance. Notably, many of the national laws have provisions about general investigation authorities and some even expressly regulate the particulars of space accident investigation.

Space activities are ultra-risky in nature, and thus accidents are anticipated. It is unimaginable that a responsible state will leave an accident of a space activity it authorizes uninvestigated or unreported. A modern state has different ways to exercise its investigational power, be it administrative, judicial, or parliamentary. Especially in the administrative branch, as society and technology have entangled during the past century, new laws established specialized regulatory agencies and mandate investigational power over certain matters to them.¹⁵⁴ Since states are obligated to authorize and supervise their non-governmental space activities, it is unsurprising that

¹⁵⁴ See Sheila Jasanoff, *The Fifth Branch: Science Advisers as Policymakers* (Harvard Univ Press, 1990).

many spacefaring states have space laws that permit investigational powers to their respective competent authorities for space activities or accident investigation.¹⁵⁵

To fulfill the obligation of authorization and continuing supervision of non-governmental space activities under Article VI of the Outer Space Treaty, many national laws give inspection powers to their respective space authority. Take French legislation as an example, Article 7 of the French Space Operation Act allows state representatives to inspect operators' compliance with their obligations after receiving authorization. They can visit operational sites, including facilities and space objects, and request any relevant documents or files to ensure proper oversight.¹⁵⁶ Similar powers can be found in the authorization or licensing procedure in other different national laws.¹⁵⁷ Inspection power is thus widely used exercised as an *ex-ante* review for safety among other means.

Besides safety review and inspection before a space activity happens, some countries further require an investigation by the competent agency should a space accident occur. In this category of national laws, only the US, the UK, and Australia have laws and regulations that carefully lay organizational and procedural details to conduct a space accident investigation.¹⁵⁸ A comparative analysis of these three countries' laws and regulations about space accident investigation will be the focus of this chapter.

¹⁵⁵ Stephan Hobe, Bernhard Schmidt-Tedd, & Kai-Uwe Schrogl, *supra* note 103 at 120.

¹⁵⁶ Loi n° 2008-518 du 3 juin 2008 relative aux opérations spatiales (1), JO, 4 June 2008, no129, art 7.

¹⁵⁷ Stephan Hobe, Bernhard Schmidt-Tedd, & Kai-Uwe Schrogl, *supra* note 103 at 120, n 104.

¹⁵⁸ Taiwan might soon join this category. Pursuant to Article 18 of Taiwan's Space Development Act, space accident investigations shall be conducted by Taiwan Transportation Safety Board ("TTSB"). The definition of "space accidents" under Article 3(5) of the same act is any "[m]alfunction, collapse, collision, explosion and other accidents during the launch of a launch vehicle or operation of a spacecraft." The TTSB is the independent safety investigation authority in Taiwan that investigates aviation, rail, marine, and highway accidents. The amendment and regulations for space accident investigation are still in the drafting stage as of the time of writing, but once they are enacted, Taiwan might have a detailed space accident investigation procedure mandated by law.

Still other countries also have established general frameworks to address space accidents in their national space laws, although not as comprehensive as the ones discussed in this chapter. These countries include Japan, Korea, and Russia. In Japan, the law requires satellite managers to promptly report any incidents, such as collisions, that make satellite management impossible and irrecoverable, including details on the incident and satellite position, to the Japanese Prime Minister.¹⁵⁹ In the Republic of Korea, the law allows the Minister of Science and ICT to establish a Space Accident Investigation Committee with five to eleven members to investigate space accidents. The Committee can investigate individuals involved in space objects and request cooperation from relevant agencies, with further details set by a Presidential Decree.¹⁶⁰ Similarly, Law on Space Activities of Russia mandates that incidents, including accidents and disasters in space activities, must be investigated according to Russian law.¹⁶¹ While these national laws do not set up a permanent organization to investigate space accident and do not provide procedural rules about an investigation, they illustrate the varying approaches taken by national legislations to ensure safety in space activities. It is also worth noting that, in Japan and Korea the powers to investigate a space accident lies with the Japanese Prime Minister and a Korean Presidential Decree, which are the highest level of offices in the executive branches of both countries, showing that space accident investigations are taken seriously at both executive and political levels.

In addition to legislation, national independent investigation agencies are starting to put space accident investigations on their agenda in response to the recent awareness of space accidents and preparing for the required capacity for investigating such accidents. During the 2023 annual meeting of the International Transportation Safety Association held in Taipei, Taiwan,

¹⁵⁹ Act on Launching of Spacecraft, etc. and Control of Spacecraft (Japan), Act no 76, 16 November 2016, art 25.

¹⁶⁰ Space Development Promotion Act (Republic of Korea), Act no 19238, 21 March 2023, art 16.

¹⁶¹ Law of the Russian Federation No. 5663-I "On Space Activities", 20 August 1993, art 23.

representatives from the Swedish Accident Investigation Authority (Statens haverikommission) and the UK AAIB shared their respective experiences and insights about this topic.¹⁶² Parallel to building up investigational capacities, Taiwan, for instance, is the newest country to enact national law and regulations regarding space accident investigation, to respond to public safety concerns and clarify the competence for investigation in the commercial space era.¹⁶³ It could be said that the legislative trends towards preparing for space accident investigation have started to fill the void left by international law.

In the absence of an international framework for space accident investigation and taking note of the variety of relevant national laws, this chapter starts by comparing the national laws and regulations of the US, the UK, and Australia regarding space accident investigations to analyze their similarities and differences. The reason for comparing these three countries is not simply because their laws and regulations are written in English and thus convenient for the writer to understand, but due to the mere fact that these are so far the only three countries that have detailed laws and regulations about space accident investigation and they all have investigated a least one accident under their jurisdictions. Therefore, analyzing the national laws of these three countries is purely for practical reasons.¹⁶⁴

A comprehensive comparative analysis of national space accident investigation laws involves examining the legal frameworks of different countries to identify both commonalities and

¹⁶² International Transportation Safety Association, "Material 2023", (29 June 2023), online: https://itsasafety.com/material-2023/>.

¹⁶³ See Space Development Act (Taiwan), 28 June 2023, art 18; Regulations for Launch Permit for Launch Vehicle and Handling of Space Accidents (Taiwan), 18 January 2022, art 18.

¹⁶⁴ Indonesia also has a comprehensive legal framework for space accident investigations. However, there is no practical case that can be analyzed, and thus it will not be discussed in this thesis. See Mansur Armin Bin Ali, "Legal Status of Accident Investigation Results of Space Activities in The Process of Enforcement of Space Law Enforcement in Indonesia: Between Procedural Justice and Substance Justice" (2023) 11:2 Jurnal IUS Kajian Hukum dan Keadilan 292–300.

differences in their approaches. Section 2 analyzes the definitions of space accidents in these three countries, which serves as a threshold for opening an investigation. As will be demonstrated, the US has more than one and the broadest definition of space accident, while Australia has the narrowest definition, some still recommend making it even narrower. These definitions reflect not only their perception of safety but also the development of space technologies in these countries.

Section 3 provides the authorities of space accident investigation in these three countries. It shows that the differences come from their history of accidents and the resources allocated to an investigation authority. In particular, the debate over the NTSB's jurisdiction over space accident investigation in the US demonstrates that the independent investigation model of Annex 13 might not suit best a country which is fast developing and innovating in its space industry. A self-investigation of the operator overseen by the regulator seems to work best.

The last part to be compared, in Section 4, is the conduct and participation of an investigation. While the FAA allows the operator to investigate mishaps themselves in most cases, it puts its efforts into making sure organizational or operational causes are not left out by the operator. The FAA also contracted with third-party investigators to ensure the investigation was done thoroughly. In the UK's situation, the Annex 13 style participation and protection of safety information seems to look perfect in the book, but without an international cooperation framework, it will be difficult to execute in practice.

By comparing these practices, it becomes possible to suggest areas where international harmonization is needed, for example, a standardized definition of accidents, foreign representatives' participation, and sensitive data sharing standards. Ultimately, this comparative approach lays the groundwork for developing a cohesive international framework that can ensure consistent and effective handling of space accidents, encouraging greater global cooperation and public trust in the growing space industry.

2. To Investigate or Not to Investigate? The Definitions of Space Accidents

It would be impossible to compare national laws regarding space accident investigations without starting with a comparison of the definition of a "space accident" in the jurisdictions that this chapter analyzes. It is not surprising that the definition of a "space accident" varies significantly across jurisdictions, reflecting different legal structures and investigative objectives in the spacefaring nations analysed here. Different investigation authorities in the US operate different definitions for space accidents. The UK's law is close to Annex 13, which mandates that accidents with serious fatality or damages and an incident with a high probability could becoming an accident shall be investigated. Australia has the narrowest definition of a space accident and even has a temporal aspect in its definition. Each country's definition not only shapes how accidents are classified but also determines the scope and objectives of subsequent investigations. Comparing these definitions helps to better understand how different national regulatory systems address the complexities of space safety and accountability.

2.1 A Layered System: The United States

More than one definition of space accident can be found in the US laws since there are three different statutory investigation authorities. These different definitions reflect the purpose of these different investigation and correspond with the institutional goals of the different investigation authorities. First of all, for the FAA, the agency responsible for overseeing commercial launches, reentries, and safety in the US, an accident is coined as a "mishap", indicating a broader scope of application. The FAA used to use mishap as an umbrella term that encompassed 15 specific kinds

of unplanned events, including five types of accidents and incidents, each has its own definition.¹⁶⁵ The FAA acknowledged that the old definition caused inconsistency of whether an event constitutes a mishap and confusion of the applicability of the rules. Thus, to streamline mishap responses, the FAA consolidated all types of accidents and incidents into a single term "mishap" and provides descriptions of nine events that constitute a mishap.¹⁶⁶ Since March 10, 2021, a mishap, under the new definition, refers to any event related to a licensed or permitted space activity by the FAA that results in fatalities, serious injuries, critical safety system failures, operational failures, significant risks, substantial or unplanned property damage, vehicle loss, hazardous debris impact, or incomplete launches or reentries, as defined and assessed by the FAA.¹⁶⁷

On the other hand, the NTSB does not have a regulatory definition of space accident yet due to the controversy caused by its notice of proposed rulemaking for commercial space investigation (see subsection 3.1.4). However, according to its Memorandum of Agreement ("MOA") of 2022 with the FAA, the NTSB will lead an investigation for FAA-approved, licensed, or permitted commercial space launch or reentry mishaps that result in either:

i. A fatality or serious injury (as defined in 49 C.F.R § 830.2) to any person, regardless of whether the person was on board the commercial space launch or reentry vehicle; or

ii. Damage to property from debris (intact vehicle, vehicle fragments, payload, or any planned jettison bodies or substance) that could reasonably be expected to cause death or serious injury, and the property is not associated with commercial space launch or reentry activities or the launch site.¹⁶⁸

¹⁶⁵ Streamlined Launch and Reentry Licensing Requirements, 84 Fed Reg 15296 (2019) at 15351–2.

¹⁶⁶ Streamlined Launch and Reentry License Requirements, 85 Fed Reg 79566 (2020) at 79678-81.

¹⁶⁷ 14 CFR § 401.7 (2021).

¹⁶⁸ US, Memorandum of Agreement between the NTSB and FAA concerning Commercial Space Mishap Investigations (2022), s 3(a).

It should be noted that, under a strict reading of their definitions, neither the FAA nor the NTSB investigates satellites collisions in orbit. The FAA's definition of mishaps covers only events associated with FAA-licensed or permitted launches and reentries. As for the NTSB, it only has jurisdiction over accidents related to transportation, and satellites are mostly the transported item and not a means of transportation.

Besides the FAA and the NTSB which are mandated to investigate most commercial space accidents, a Presidential Commission shall be established for the investigation of government-related accidents. 51 USC § 70702(a) provides that, a Presidential Commission shall be established for any incident that results in the loss of:

(1) a space shuttle;

- (2) the International Space Station or its operational viability;
- (3) any other orbital or suborbital space vehicle carrying humans that is—
 - (A) owned by the Federal Government; or

(B) being used pursuant to a contract or Space Act Agreement with the Federal Government for carrying a government astronaut or a researcher funded by the Federal Government; or

(4) a crew member or passenger of any space vehicle described in this subsection.¹⁶⁹

The purpose of a Presidential Commission is to assure the accountability of the governmental space program and the independence of applicable investigations. Thus, in its relevant statutes, an "incident" is only briefly defined as "either an accident or a deliberate act."¹⁷⁰ In other words, the focus of a Presidential Commission is the loss of specific government-related space objects and the people they carried.

In sum, multiple definitions of space accidents exist under US laws and regulations because there are several investigation authorities in the country. This reflects again that different agencies have different missions in terms of commercial space activities. Take the example of the FAA, a

¹⁶⁹ 51 USC § 70702(a) (2010).

¹⁷⁰ 51 USC § 70701(2) (2010).

broader definition of mishap, i.e. a lower threshold to open an investigation, aligns with its goal of promoting commercial space launches in the US while also achieving supervision from a safety point of perspective. Letting the operators investigate by themselves also saves the limited resources and expertise that they can provide in the investigation. Furthermore, the lessons learned are shared through a system which improves space safety among the US operators and thus benefits the whole industry.¹⁷¹ While the FAA officials do not think a common definition is needed, stakeholders and commentators may reduce the cost of communication and streamline the process of navigation the regulations for operators.¹⁷²

2.2 Taking Analogy from Annex 13: The United Kingdom

The definition of accident can be found in Section 20 of the Space Industry Act 2018 of the UK ("UK Act 2018"), which reads: "… 'accident' includes any fortuitous or unexpected event by which the safety of any spacecraft or person is threatened."¹⁷³ The Spaceflight Activities (Investigation of Spaceflight Accidents) Regulations 2021 ("UK Regulations 2021") further provides separate definitions for "serious spaceflight accident", which is:

(a) a spaceflight accident occurring in the course of the operation of a launch vehicle in which an individual is fatally or seriously injured, or
(b) a spaceflight accident occurring during the course of spaceflight activities where there was a high probability that such injury would occur, as a result of that accident[.]¹⁷⁴

In such a case, the chief inspector of the Space Accident Investigation Authority ("SAIA") is obligated to investigate the accident.¹⁷⁵ The UK's definition of a "serious spaceflight accident" is

¹⁷¹ US Government Accountability Office, *Commercial Space Transportation: FAA Should Improve Its Mishap Investigation Process* (2023) at 33–40.

¹⁷² *Ibid* at 47–8; J Steven Jarreau & Jeanne L Amy, "The Investigation of Domestic Commercial Space Accidents by the United States" (2024) 36:2 Air & Space Lawyer 1, 15–9 at 18–9.

¹⁷³ UK Act 2018, s 20.

¹⁷⁴ UK Regulations 2021, supra note 16, s 3.

¹⁷⁵ *Ibid*, s 14.

very close to a combined definition of Annex 13's definition for "accident" and "serious incident" which are both mandatory to be investigated under Annex 13.¹⁷⁶

First, the UK's definition focuses on fatality resulting from the operation of a spacecraft, which is in line with Annex 13's vehicle-centric view of an accident. Second, under Annex 13, contracting states have the obligation to investigate accidents and serious incidents, which is "an incident involving circumstances indicating that there was a high probability of an accident ..."¹⁷⁷ Understanding the cause of a serious incident could prevent a real accident of the same cause from happening. This risk-based analysis of defining the scope of an independent investigation is an effective way to balance the distribution of investigational resources and the improvement of safety in the industry.¹⁷⁸

On the other hand, if an accident is classified as a "spaceflight accident", then the chief inspector will have discretion over whether to investigate for the purpose of drawing expected safety lessons.¹⁷⁹ A difference between the definitions of Annex 13's "accident" and "incident" and UK's "serious spaceflight accident" worth pointing out is that the UK's definition does not cover the loss of the spacecraft or property damages while Annex 13 does cover such losses and damages. Under UK law and regulations, thus, it is not mandatory to investigate an accident if it only causes damage to a spacecraft or a property. Following this interpretation, a satellite collision is not covered under the definition of "serious spaceflight accident". However, it constitutes a "spaceflight accident" since the definition of spaceflight activities covers space activities that

¹⁷⁶ ICAO, *supra* note 26 at 1–1, 1–3.

¹⁷⁷ *Ibid* at 1–3.

¹⁷⁸ *Ibid* at ATT C-1.

¹⁷⁹ UK Regulations 2021, supra note 16, s 15.

include "any activity in outer space."¹⁸⁰ Therefore, SAIA has discretion over whether to investigate a satellite collision.

In addition, the SAIA has jurisdiction not only over spaceflight accidents in or over the UK, but also when the accident outside of the UK if the vehicle was launched from the UK, or if the UK has jurisdiction over the design, manufacturing, assembly, maintenance, or the spaceflight operator's principal place of business, and if no other state is conducting an investigation or the UK is requested to assist with one.¹⁸¹ This regulation is also close to a state's obligation to investigate an aviation accident under Annex 13, which ensures a thorough jurisdiction to accidents. However, when it comes to space accident investigation, without an international framework to coordinate investigations for cross-border space accidents, how and to what extent could the UK exercise its jurisdiction under Regulation 16 is yet to be seen.

2.3 The Highest Investigation Threshold with a Temporal Cap: Australia

Under the Space (Launches and Returns) Act 2018 of Australia ("Australia Act 2018"), the minister must appoint an investigator if "an accident involving a space object rocket occurs[.]"¹⁸² An accident means if:

(a) a person dies or suffers serious injury as a result of the operation of the space object or high power rocket; or

(b) the space object or high power rocket is destroyed or seriously damaged or causes damage to other property.¹⁸³

Although the Australian definition covers damages to the vehicle and property, it does not cover near-miss events. Near-miss events are covered by the definition of an incident, which the minister may also appoint, not mandatory, an investigator if it happens.¹⁸⁴ An incident under the same act

¹⁸⁰ Space Industry Act 2018 (UK), ss 1(4), 1(6).

¹⁸¹ UK Regulations 2021, supra note 16, s 16.

¹⁸² Australia Act 2018, s 88(1).

¹⁸³ *Ibid*, s 85.

¹⁸⁴ *Ibid*, s 88(2).

is defined as an event related to the operation of a space object or high-power rocket that impacts or has the potential to impact its safe operation or suggests conditions where an accident was nearly avoided.¹⁸⁵

Besides defining an accident by its situation, Australian law adds limits to the scope of investigation by temporal and spatial factors. The provisions of investigation only apply to an accident or incident involving a space object that occurs during the *liability period* for its launch from an Australian facility or aircraft, or for its return to a location in Australia.¹⁸⁶ For the launch of a space object, liability period means "the period of 30 days beginning when the launch takes place, or such other period as is specified in the rules[.]"¹⁸⁷ And for the return of a space object, it means "the period beginning when the relevant re-entry manoeuvre is begun and ending when the object has come to rest on Earth, or such other period as is specified in the rules[.]"¹⁸⁸ This limitation, therefore, excludes the applicability of the law for investigating satellite collisions outside the liability period.

Compared with the FAA, the NTSB, or the UK's definitions of an accident, the Australian definition excludes mandatory investigation for near-accidents and has limitations on the temporal scope of accidents that require investigation. Despite that, some still consider the definition of accident to be too broad under Australian law. The Hapith I Rocket accident investigation (see subsection 3.3) was triggered because the launch vehicle was destroyed on the launchpad and thus constitute an accident that requires an investigation under the Australia Act 2018.¹⁸⁹ In the case's final report, the investigator found that there was no non-compliance of the conditions of the

¹⁸⁵ *Ibid*, s 86.

¹⁸⁶ *Ibid*, s 84.

¹⁸⁷ *Ibid*, s 8.

¹⁸⁸ *Ibid*.

¹⁸⁹ Australian Space Agency, Summary of the investigation report into the accident relating to the Hapith I Rocket at WWOLC, South Australia on 16 September 2021 (2022) at 1.

launch facility license and launch permit, and he also praised the launch facility's personnel for their safety awareness that prevented any ground personnel injury. ¹⁹⁰ Accordingly, the investigator recommends the Australian Space Agency to propose an amendment to the definition of "accident" in order to give the minister discretion on whether to investigate when a space object "is destroyed but no or seriously damaged, but a person does not die or suffer serious injury or there is no damage to third party property[.]"¹⁹¹ This could be explained by the limited recourses which are put into space accident investigation in Australia, i.e. there is no permanent organization that exercises the space accident investigation authority, and the fact that the investigator works almost on her or his own, this recommendation is understandable. However, it also limits safety lessons that could from learned for the Australian space industry.

3. The Authorities and Objectives of Space Accident Investigation

The authorities responsible for space accident investigations vary between different countries, reflecting not only their legal frameworks but also their objectives in promoting space safety and accountability. This section compares how the US, the UK, and Australia structure space accident investigation powers and goals. Each country has established its mechanisms and procedures to address accidents, shaped by its unique experiences, regulatory philosophies, and specific objectives, such as enhancing public safety, ensuring transparency, and fostering industry development. By examining these various types of authority and their objectives, their broader goals of ensuring the safety and success of space activities will be revealed.

3.1 Multiple Authorities with Different Objectives: The United States

The US has always played a leading role in space exploration, with a rich history of ambitious missions and cutting-edge space technology. The US government's space achievements have not

¹⁹⁰ *Ibid* at 2.

¹⁹¹ *Ibid* at 4.

been without accidents. Today, in the New Space Age, three statutory authorities exist which have jurisdiction over commercial space accident investigation under US federal laws: a Presidential Commission, the FAA, and the NTSB. The FAA and the NTSB primarily concentrate on commercial transportation activities, while a Presidential Commission addresses government missions, which could also involve commercial operators.

3.1.1 Historical Investigations for Governmental Space Accidents and the Responses

The US, as the second spacefaring nation, has a long history of space accidents in its governmental missions. Some tragic examples include the Apollo 1 fire, the Space Shuttle Challenger, and the Space Shuttle Colombia. These examples are not commercial spaceflight – they are all NASA space missions operating NASA space vehicles –, and thus are not the focus of this thesis. Having said that, these investigations are worth mentioning for two reasons. First, since NASA has entered public-private partnerships for some of its space programs, the investigational procedure of NASA-procured commercial spaceflight is similar to these cases. Second, these investigations are part of the foundation of today's investigation framework in the US.

In the aftermath of the Apollo 1 fire that killed three astronauts on the launch complex on January 27, 1967, NASA Deputy Administrator Robert C. Seamans, Jr. established the Apollo 204 Review Board under his authority in accordance with NASA Management Instruction 8621.1.¹⁹² The board was consisted of nine experts (six of them were from NASA) in charge of reviewing the circumstances and probable causes of the accident, considering the impact on Apollo activities, evaluating factors like design and management, and developing recommendations, etc.¹⁹³ This

 ¹⁹² National Aeronautics and Space Administration, "Memorandum For the Apollo 204 Review Board", (27 January 1967), online: https://www.nasa.gov/history/Apollo204/15.html.
 ¹⁹³ *Ibid*.
was an *ad hoc* investigational board within NASA itself and was not mandated by laws or regulations.

The investigational body of the Space Shuttle Challenger accident and the Space Shuttle Colombia accident were also *ad hoc* organizations. For the Challenger accident, a Presidential Commission was established by Executive Order 12546 of February 3, 1986, under the US President's power granted by the Federal Advisory Committee Act.¹⁹⁴ The commission consisted of a diverse group of non-NASA experts, including former astronaut, military leaders, aerospace engineers, professors, a journalist, and legal professionals.¹⁹⁵ The Colombia accident, on the other hand, was investigated by the Columbia Accident Investigation Board established by NASA Administrator. Its members are also a group of mostly non-NASA experts.¹⁹⁶

3.1.2 Presidential Commission: Response to Public Trust in Government-Related Space Accident Investigation

The investigation of the Colombia accident raised political concern about the independence of the Columbia Accident Investigation Board from NASA, as it was appointed by, reported to, and staffed by NASA personnel. The concern led to legislation of the establishment of a Presidential Commission for accidents related to US government space missions.¹⁹⁷ In the event of the loss of specific space assets or their crew member or passenger, a US President today is under the obligation to create an independent and nonpartisan commission within the executive branch.¹⁹⁸ Qualifying space assets include space shuttles, the International Space Station, and government-owned or contracted orbital or suborbital space vehicles carrying government astronaut or a

¹⁹⁴ Jarreau & Amy, *supra* note 172 at 15.

¹⁹⁵ Report to the President By the PRESIDENTIAL COMMISSION On the Space Shuttle Challenger Accident (Washington, D.C., 1986) at 202.

¹⁹⁶ Columbia Accident Investigation Board Report Volume 1 (Washington, D.C., 2003) at 239–41.

¹⁹⁷ Jarreau & Amy, *supra* note 172 at 16.

¹⁹⁸ 51 USC § 70702(a) (2010).

researcher funded by US federal government. As the US enters a new era of private-public partnership in space exploration, an accident involving a commercial spaceflight contracted by NASA, for example, the Commercial Crew Program¹⁹⁹ or the Artemis Program²⁰⁰, may require an investigation by a Presidential Commission. The law specifies seven days for the US President to establish an *ad hoc* commission after a qualifying incident. A commission is required to investigate the incident in question, determining its cause and identifying all contributing factors. Furthermore, a Presidential Commission must provide recommendations for corrective actions, offer any additional findings or recommendations considered important, even if not directly related to the incident, and ultimately prepare and submit a comprehensive report to the US Congress, the US President, and the public.²⁰¹ The requirement to report to not only the Congress and the president but also the public implies the political gravity behind this kind of accident.

A Presidential Commission shall consist of 15 members, with the US president appointing members. The leaders of the US Congress may provide lists of candidates, from which the president may make selections. Federal officers and employees, members of Congress, individuals with contractual relationships with the administration, and those with conflicts of interest are barred from serving on a Presidential Commission.²⁰² The restriction on commission members means that a Presidential Commission could not involve accident investigation experts as its member from federal agencies such as NASA, the FAA or the NTSB.²⁰³

¹⁹⁹ NASA's Commercial Crew Program was established to support the development of a US commercial crew transportation system aimed at providing access to the International Space Station and low-Earth orbit. See NASA, "Commercial Crew Program Essentials", online: https://www.nasa.gov/humans-in-space/commercial-space/commercial-crew-program-commercial-crew-program-essentials/>.

²⁰⁰ The Human Landing System Program collaborates with industry to create lunar landers designed to transport astronauts to and from the Moon's surface on Artemis missions. SpaceX has been contracted to develop its Starship HLS for Artemis III and IV, while Blue Origin is developing its Blue Moon MK2 Crew Lander for Artemis V. See NASA, "Human Landing Systems", online: https://www.nasa.gov/reference/human-landing-systems/.
²⁰¹ 51 USC § 70703 (2010).

²⁰² 51 USC § 70704 (2010).

²⁰³ Koller et al, *supra* note 94 at 27.

Overall, the Presidential Commission provides a comprehensive and accountable approach at the highest level of the US to space accident investigation, emphasizing public awareness and bipartisan features. It should be noted that this type of Presidential Commission was only introduced in 2010 and has not been established yet for investigation in the US.²⁰⁴

3.1.3 The Federal Aviation Administration: A Conflicting Authority of Regulatory and Investigation

The Office of Commercial Space Transportation ("AST") under the FAA is the institution that exercises the US Secretary of Transportation's authority to license or permit and otherwise regulate commercial space transportation.²⁰⁵ 51 USC 50917(b) provides that the Secretary may conduct investigations and inquiries to enforce his or her authority regarding commercial space activities. The power to investigate is delegated to the FAA. As part of the licensing requirements under Part 450, an operator must have a mishap plan which documents the responsibilities of personnel involved in implementing safety requirements, reporting and conducting investigations, and the division of roles between the launch operator and site operator for addressing and investigating mishaps during ground activities.²⁰⁶ This means the FAA asks the operators to investigate a mishap by themselves according to the plan unless otherwise specified.

From 2000 to mid-January 2023, FAA logged 50 mishaps among 433 commercial spaceflights, none of which resulted in fatalities, serious injuries, or significant public property damage, though incidents included launch explosions and system failures.²⁰⁷ As the frequency of launches has increased, so have mishaps, with half occurring in from 2020 to 2023.²⁰⁸ Among the

²⁰⁴ *Ibid*.

²⁰⁵ 14 CFR § 401.3.

²⁰⁶ *Supra* note 91.

²⁰⁷ US Government Accountability Office, *supra* note 171 at 9.

²⁰⁸ *Ibid*.

50 mishaps, FAA has been the lead investigation authority for 49 of them.²⁰⁹ When the FAA serves as the primary investigative agency, its usual practice is to allow operators to investigate into their mishaps, while the agency oversees the process.

FAA and industry experts emphasize that mishaps are expected in the development of commercial space transportation, with a focus on learning from failures while maintaining public safety.²¹⁰ New FAA regulations aim to distinguish between operational missions and high-risk testing to promote innovation and improve designs safely.²¹¹ Moreover, commentators point out that the FAA could be potentially in conflict of its dual mandate between effectively ensuring public safety and promoting commercial space launches, including those with spaceflight participants, which could be seen as constraining the impartiality of FAA-lead investigations.²¹² As of now, the FAA has utilized its investigative authority only once in the SpaceShipTwo accident, which was an investigation collaborated with and primarily led by the NTSB.²¹³

3.1.4 The National Transportation Safety Board: An Independent Investigation Authority

Initially created under the Department of Transportation ("DOT") in 1967, the NTSB aimed to enhance safety in the transportation system more effectively by having a single organization with a clear mission.²¹⁴ The NTSB became an entirely independent investigative board in 1974, emphasizing the need for total independence to properly perform investigatory functions.²¹⁵ The rationale behind this move was to ensure objectivity in investigations and recommendations,

²⁰⁹ *Ibid* at 13.

²¹⁰ *Ibid* at 9–10.

²¹¹ *Ibid* at 9, n 19.

²¹² Koller et al, *supra* note 94 at 25.

²¹³ US Government Accountability Office, *supra* note 171 at 13–4; Koller et al, *supra* note 94 at 25.

²¹⁴ Dempsey, *supra* note 52 at 416.

²¹⁵ *Ibid*.

especially as the DOT's broad responsibilities in transportation operations and regulations could intersect with safety concerns revealed in accident investigations.²¹⁶ This separation led to distinct scopes and approaches in accident investigations between the FAA and the NTSB.

The NTSB is mandated to investigate or direct investigations to establish the facts, circumstances, and cause or probable cause of various transportation accidents. These accidents include civil aircraft accidents, highway accidents selected in cooperation with a state, railroad accidents involving fatalities, substantial property damage, or passenger trains, pipeline accidents with fatalities, substantial property damage, or significant environmental injury, major marine casualties on or under US navigable waters, and other transportation-related accidents.²¹⁷ The NTSB stated that its statutory authority to investigate commercial space launch accidents derives from 49 USC 1131(a)(1)(F), which gives the NTSB discretion to investigate:

any other accident related to the transportation of individuals or property when the Board decides—

- (i) the accident is catastrophic;
- (ii) the accident involves problems of a recurring character; or
- (iii) the investigation of the accident would carry out this chapter.²¹⁸

However, NTSB's interpretation of its statutory authority over commercial space accidents has caused a controversy.

To enhance the NTSB's investigation procedures regarding its investigative authority in commercial space safety, it issued a Notice of Proposed Rulemaking for commercial space accident investigation in November 2021.²¹⁹ Through the formulation of its investigative role in commercial space transportation, the NTSB aimed to strengthen transportation safety. The addition

²¹⁶ "History of The National Transportation Safety Board", online: ">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>">https://www.ntsb.gov/about/history</ap>"">https://www.ntsb.gov/ab

²¹⁷ 49 USC § 1131 (2022).

²¹⁸ *Ibid*.

²¹⁹ Proposed Rule for Commercial Space Investigations, 86 Fed Reg 63324 (2021).

of Subpart F is anticipated to empower the board in fulfilling its statutory mission, involving safety investigations, the identification of corrective measures, and the prevention of future space transportation accidents and incidents.²²⁰ This proposal backfired. The US House Committee on Science, Space, and Technology raised their concerns, stating that the proposed rules are not only in conflict with the existing statutory authorities related to commercial space launch and reentry activities, which would hinder US national interest and stunt the growth of its space industry.²²¹ Moreover, the House Committee argues the proposed rules overlap with the FAA's rules over launch and reentry mishap investigation, therefore, causing confusion among the space industry.²²² In terms of NTSB's jurisdiction on space accident investigation, the House Committee indicated that Congress explicitly mentioned aircraft, highway, railroad, pipeline, and marine vessels in 49 USC 1131(a)(1), but it is clear that the statute does not include commercial space launch or reentry.²²³ The letter goes on specifying that commercial Space Programs", does not fall under the category of transportation modes, which is in Title 49 "Transportation".²²⁴

In the past, the NTSB had been involved in four space accidents in the US including: in 1986, the NTSB investigators assisted the investigation into the loss of the Space Shuttle Challenger; in 1993, the NTSB led the investigation of a procedural anomaly associated with the launch of an Orbital Sciences Corporation Pegasus expendable launch vehicle; in 2003, the NTSB investigators assisted the Columbia Accident Investigation Board with the investigation into the loss of the

²²⁰ *Ibid*.

²²¹ The House Committee on Science, Space and Technology, "Chairwoman Johnson and Ranking Member Lucas Letter to President Biden Urging Rescindment of NTSB Proposal that would Exceed Agency Authority", (6 April 2022), online: https://democrats-science.house.gov/chairwoman-johnson-and-ranking-member-lucas-letter-to-president-biden-on-ntsb-proposal-that-would-exceed-agency-authority, at 2.

²²² *Ibid*, Attachment A at 7-8.

²²³ *Ibid*, Attachment A at 4.

²²⁴ *Ibid*, Attachment A at 5.

Space Shuttle Columbia; in 2014, the NTSB, in cooperation with the FAA, led the investigation into the fatal in-flight breakup of SpaceShipTwo.²²⁵

On October 31, 2014, SpaceShipTwo, a reusable suborbital rocket operated by Scaled Composites LLC, broke up during a rocket-powered test flight near Koehn Dry Lake, California. The accident occurred after SpaceShipTwo separated from its launch vehicle, WhiteKnightTwo, causing the copilot injured fatally and the pilot sustained serious injuries.²²⁶ Since the flight was conducted under an experimental permit issued by the FAA-AST, the FAA had the authority to investigate. Due to its fatal outcome, the FAA did not allow the operator to investigate by itself.²²⁷ However, the agency also lacked the experience and capacity to lead the case, thus, it asked the NTSB to lead the investigation.²²⁸ The NTSB, on the other hand, deemed itself having the authority to investigate the accident immediately started its investigation after the tragic occurred.²²⁹

The conflict of understanding their authorities over this accident reflects the legal uncertainty at the time. Although no statutory amendment was made to address this issue, the FAA and the NTSB signed a new MOA on September 9, 2022 regarding commercial space mishap investigation.²³⁰ According to section 3 of this MOA, NTSB will take on the primary investigative

²²⁵ National Transportation Safety Board, "Commercial Space", online: https://www.ntsb.gov/about/organization/AS/Pages/Commercial-Space-aspx.

²²⁶ National Transportation Safety Board, *Aerospace Accident Report: In-Flight Breakup During Test Flight Scaled Composites SpaceShipTwo*, N339SS Near Koehn Dry Lake, California October 31, 2014 (Washington, D.C., 2015) at 1.

²²⁷ US Government Accountability Office, *supra* note 171 at 20–1.

²²⁸ *Ibid* at 21, n 44.

²²⁹ The NTSB based its interpretation of 49 USC 1131(a)(1)(F) on the *Chevron* doctrine. The *Chevron* doctrine gives deference to federal administrative agencies' interpretations of ambiguous statutes within their jurisdiction. See National Transportation Safety Board, *Aerospace Accident Report: In-Flight Breakup During Test Flight Scaled Composites SpaceShipTwo*, *N339SS Near Koehn Dry Lake, California October 31, 2014* (Washington, D.C., 2015) at 73–7. However, the *Chevron* doctrine was overturned by the US Supreme Court. Thus, the NTSB's reasoning for its jurisdiction over commercial space investigation could be legally challenged based on this new development.

²³⁰ "NTSB and FAA Sign Agreement on Commercial Space Mishap Investigations", (9 September 2022), online: https://www.ntsb.gov/news/press-releases/Pages/nr20220909.aspx>.

role for mishaps related to commercial space launch or reentry in cases where there is a fatality or serious injury to any individual, irrespective of their presence on the launch vehicle; additionally, it will lead investigations if there is damage to property unrelated to the launch activities or site caused by debris that could reasonably be anticipated to result in death or serious injury.²³¹ The FAA will lead the investigation for all other commercial space mishaps.²³² Although this MOA did not resolve the fight over jurisdiction, it facilitates collaboration between the two agencies.

3.2 Single Investigation Authority from the Aviation Side: The United Kingdom

The UK Act 2018 serves as the regulatory framework for spaceflight activities within the UK, requiring individuals or organizations involved in such activities to obtain the relevant license.²³³ Section 20 of the UK Act 2018 empowers the making of regulations specifically addressing the investigation of accidents related to spaceflight activities, which includes any fortuitous or unexpected event by which the safety of any spacecraft or person is threatened.²³⁴ The UK Regulations 2021 which came into force in July 29, 2021, were promulgated under the powers conferred to the UK Government under the same section.

To exercise the investigational authority under the UK Regulations 2021, the UK Secretary of State for Transport nominated AAIB to serve as the SAIA on July 29, 2021.²³⁵ The AAIB is the UK's equivalent to the independent aviation accident investigation authority under Annex 13.²³⁶ This appointment is one of the proofs that the UK space accident investigation framework is based on the aviation accident investigation legal concepts and investigation expertise. As we shall see

²³¹ US, *supra* note 168, s 3(a).

²³² *Ibid*, s 3(c).

²³³ UK Act 2018, supra note 82.

²³⁴ *Ibid*, s 20.

²³⁵ "Air Accidents Investigation Branch appointed as Space Accident Investigation Authority for the United Kingdom", (29 July 2021), online: *GOVUK* https://www.gov.uk/government/news/air-accidents-investigation-branch-appointed-as-space-accident-investigation-authority-for-the-united-kingdom>.

²³⁶ The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 (UK), s 7.

below, the UK Regulations 2021 have many provisions similar to the one under the Annex 13 regime and share its spirits while adjusting to the needs of the space industry in the UK.

As of the time of writing, AAIB has investigated one space accident in the UK, which was the investigation into Virgin Orbit's failed LauncherOne launch from Cornwall Spaceport on January 9, 2023.²³⁷ AAIB and the US FAA jointly investigated why the rocket, dropped from a modified Boeing 747-400, failed to reach orbit. The involvement of the FAA was because Virgin Orbit is using a US launch vehicle licensed by the FAA.²³⁸ As previously described in the FAA subsection, the agency let Virgin Orbit investigate this mishap according to its mishap plan. Although AAIB was involved in the investigation, due to export control approval requirement of US, AAIB could not receive up-to-date information during the investigation.²³⁹ In the end, both AAIB and FAA acknowledged the credibility of the operator's findings of the technical failure.²⁴⁰ Through this investigation, it is evident that, in a space accident that involves more than one country, the Annex 13 model cannot run smoothly without an international framework to coordinate the rights and obligations of the participating parties. The export control issue is one of the most significant obstacles towards the investigation of cross-border space accidents. Chapter 4 discusses more on this topic.

3.3 An Ad Hoc Investigator: Australia

Australia has a well-equipped aviation accident investigation authority, the Australian Transport Safety Bureau ("ATSB"), which investigated a rocket accident in 2001 under the appointment of the Minister for Industry, Science and Resources by his power from the then

 ²³⁷ Air Accidents Investigation Branch, Statement on an investigation into why launch vehicle LauncherOne did not reach orbit following its launch from Cornwall Spaceport on 9 January 2023 (2024) at 2.
 ²³⁸ Ibid at 2–3.

 $^{^{239}}$ *Ibid* at 3.

²⁴⁰ *Ibid* at 4.

effective Space Activities Act 1998.²⁴¹ Nonetheless, Australia did not make ATSB the investigation authority for space accident. The Australia Act 2018 aims to regulate Australia's space object and high-power rocket launches, balancing innovation with safety, while fulfilling Australia's obligations under UN space treaties.²⁴² Part 7 of the Australia Act 2018 lays out detailed provisions for the investigation of accidents. Unlike the US or the UK, Australian law does not set up a permanent authority to investigate space accidents, nor does it require an *ad hoc* investigational organization. Instead, it requires the Australian Minister for Industry, Science and Technology to appoint a person as the investigator of the accident involving space object.²⁴³ An investigator may invite other persons to assist him or her, otherwise he or she will be investigating the accident alone.²⁴⁴ At the end of the investigation, the investigator must give the Minister a written report and the Minister may publish information from a report or document if deemed necessary to promote space industry safety.²⁴⁵

To date, one accident has been investigated under the Australia Act 2018. On 9 August 2021, Taiwan Innovative Space Inc. was granted a permit to test launch its Hapith I vehicle. The launch attempt on 16 September 2021 resulted in the vehicle catching fire and being destroyed, with no injuries but some infrastructure damage.²⁴⁶ This accident triggered an investigation under the Australia Act 2018, and an investigator, then Deputy Head of the Australian Space Agency Anthony Murfett, was appointed on 24 September 2021 to prevent future accidents.²⁴⁷ The investigation report was submitted to the Minister on 21 March 2022 with findings and

²⁴¹ See Neville McMartin, *Final Report of the Investigation into the anomaly of the HyShot Rocket at Woomera, South Australia on 30 October 2001* (Australian Transport Safety Bureau, 2002).

²⁴² Australia Act 2018, supra note 19, s 3.

²⁴³ *Ibid*, s 83.

²⁴⁴ *Ibid*, s 90.

²⁴⁵ *Ibid*, s 93.

²⁴⁶ Australian Space Agency, *supra* note 189 at 1.

²⁴⁷ Ibid.

recommendations of the investigator. According to the Australia Act 2018, the Minister has both the authority to license a launch and the authority to appoint an investigator should an accident occur.²⁴⁸ In this investigation of the Hapith I accident, the investigator appointed by the minister was from the Australian Space Agency which is the organization that helps the minister to exercise his or her authorization and supervision over space operators. Thus, the execution of this case reaffirms that the Australian space investigation legislation is not an independent one.

4. The Conduct and Participation of the Investigations

Each nation's approach towards investigational power reflects its unique legal framework, goals, and procedures for handling space accident investigations. The United States, with its multiple investigatory bodies, grants extensive powers to Presidential Commissions, the FAA, and the NTSB, each focusing on different aspects of space activities, from government missions to commercial space operations. In contrast, the United Kingdom's investigational authority is modeled after aviation accident investigations, emphasizing international cooperation and sensitive information handling. Australia, while providing its investigators with considerable authority over accident sites, takes a less complex approach, lacking both the party system and detailed protections for sensitive foreign information found in the UK model. By examining these diverse approaches, we gain insights into the balance between transparency, accountability, and national security concerns in space accident investigations across jurisdictions.

4.1 The United States

This subsection provides an overview of the roles and authorities of federal agencies and commissions involved in space accident investigations. The Presidential Commission's statutory powers, including evidence collection, hearings, and public reporting, underscore its role in

²⁴⁸ Australia Act 2018, supra note 19, ss 28, 88.

ensuring public accountability. The FAA's oversight, primarily through operator-developed mishap plans, balances public safety with operator-led investigations, often involving third-party reviews due to resource limitations. The NTSB's independent investigative authority highlights its "party system" for collaboration with qualified technical entities. This structure underscores a tiered US approach to space accident investigation, with each entity's involvement based on its jurisdictional scope and investigative capacity.

4.1.1 Ensuring Transparency and Accountability: Presidential Commission

51 USC 70705 empowers a Presidential Commission, or any subcommittee or member authorized by the commission, to conduct hearings, gather evidence, and take testimony to fulfill its responsibilities under the code. A commission or its designated entities have the authority to hold hearings at suitable times and locations, administer oaths, and compel the attendance of witnesses, as well as the production of relevant documents through subpoenas or other means as deemed advisable by the commission.²⁴⁹ National security issue is also considered in the provision as Presidential Commission investigations should be high-profile and technological sensitive cases. Thus, the appropriate federal agencies or departments shall cooperate with a commission in expeditiously providing to the commission members and staff appropriate security clearances to the extent possible pursuant to existing procedures and requirements.²⁵⁰

51 USC 70706 stipulates that a commission must conduct public hearings and meetings to the extent deemed appropriate.²⁵¹ It allows a commission to submit interim reports to the President and Congress, containing findings, conclusions, and recommendations for corrective actions that have received a majority approval from commission members.²⁵² The section also mandates the

²⁴⁹ 51 USC § 70705 (2010).

²⁵⁰ 51 USC § 70709 (2010).

²⁵¹ 51 USC § 70706 (2010).

²⁵² 51 USC § 70710 (2010).

submission of a final report to the President and Congress, which must be made concurrently available to the public. The final report should include agreed-upon findings, conclusions, and recommendations, along with any minority views or opinions not reflected in the majority report. ²⁵³ Judging from these provisions, the statutory requirements for a commission investigation are mainly to ensure the public accountability of a commission the answerability of the persons involved in an accident. Aside from that, however, it is up to a commission to determine the investigation procedure it wishes to conduct.²⁵⁴

4.1.2 Balancing Public Safety and Operator Expertise: The Federal Aviation Administration

The FAA's investigation procedure is mainly based on the mishap plan submitted by operators before obtaining FAA approval for a launch license.²⁵⁵ The FAA has the option to either investigate on its own or authorize the operator to investigate as per their approved mishap plan.²⁵⁶ Mishap reporting obligations include immediate notification to the FAA in case of fatalities or serious injuries, a 24-hour notification for mishaps without such outcomes, and a written preliminary report to the FAA Office of Commercial Space Transportation within five days.²⁵⁷ Emergency response requirements mandate actions to protect the public and property, contain mishap consequences and preserve data and evidence. Operators must investigate mishap root causes, report results to the FAA, and implement preventive measures to be approved to launch

²⁵³ *Ibid*.

²⁵⁴ Jarreau & Amy, *supra* note 172 at 16.

²⁵⁵ *Supra* note 91.

²⁵⁶ US Government Accountability Office, *supra* note 171 at 13.

²⁵⁷ *Supra* note 91.

the next flight by the FAA.²⁵⁸ To facilitate operators in developing a mishap plan, the FAA publishes an Advisory Circular to provide guidance and a recommended approach.²⁵⁹

According to the FAA officials, when considering whether to authorize the operator to investigate or to conduct the investigation itself, the agency mainly takes into account the seriousness of the mishap or its outcomes, as well as the extent of public interest.²⁶⁰ In practice, according to the report of the US Government Accountability Office, the FAA has authorized operators to investigate for all FAA-lead mishap investigations. This is not a surprise, given that the FAA lacks resources for investigating mishaps related to highly technical space objects. Operators, with their intimate knowledge of the vehicles they developed, are best suited to identify the root cause of failures.²⁶¹ To supplement its insufficient investigational recourses, the FAA contracted the Aerospace Corporation²⁶² to conduct third-party reviews of selected operator mishap investigations to gain technical expertise and independent assessments.²⁶³ As of August 2023, the Aerospace Corporation had reviewed four investigations, offering broader analyses and insights into larger process and organizational issues which contributes to the overall safety.²⁶⁴

Once an operator finalizes the investigation, the FAA officials review companies' draft investigation reports, offering guidance to ensure key findings are included.²⁶⁵ Given the FAA's close oversight during mishap investigations, approval of final reports is generally expected upon

²⁵⁸ *Ibid*.

²⁵⁹ US, Federal Aviation Administration, Advisory Circular: Part 450 Mishap Plan – Reporting, Response, and Investigation Requirements (AC no 450.173-1) (2021).

²⁶⁰ US Government Accountability Office, *supra* note 171 at 20.

²⁶¹ *Ibid* at 21.

²⁶² The Aerospace Corporation, an independent nonprofit organization that manages the US Federally Funded Research and Development Center dedicated to space, conducts technical analyses and evaluations for government, civil, and commercial clients. See Aerospace Corporation, "About Us" online: < https://aerospace.org/about >.
²⁶³ US Government Accountability Office, *supra* note 171 at 26–8.

²⁶⁴ *Ibid* at 27–28.

²⁶⁵ *Ibid* at 22–3.

submission.²⁶⁶ The FAA adjusts its involvement based on the circumstances of the mishap and the company's experience, with deeper involvement for serious mishaps or inexperienced operators; for experienced operators, the FAA allows companies more freedom in structuring their investigations.²⁶⁷

While the FAA has put a lot of effort into overseeing the mishap investigation to ensure public safety, problems remain with its procedure. According to the US Government Accountability Office, one major problem is the lack of clear criteria for deciding when operators should lead their mishap investigations.²⁶⁸ This undermines the FAA's ability to consistently and reliably determine which entity should lead, affecting the oversight and effectiveness of investigations. However, it should be noted that the only FAA-led investigation was the SpaceShipTwo accident which is the only fatal accident of US commercial space activities to date. During that investigation, the FAA said they approached the NTSB to lead the investigation due to the lack of resources to deal with a fatal mishap.²⁶⁹ The NTSB, however, said they led the investigation out of its initiatives as it was under its authority (see subsection 3.1.4). Now, according to the MOA, NTSB will lead an investigation like the SpaceShipTwo accident.

4.1.3 The National Transportation Safety Board

The NTSB has statutory authority to inspect and investigate transportation accidents, granting access to accident scenes, vehicles, and records.²⁷⁰ It can control the movement of materials involved in accidents, ensuring proper preservation for investigation.²⁷¹ The NTSB can order

²⁶⁶ *Ibid* at 23.

²⁶⁷ *Ibid*.

²⁶⁸ *Ibid* at 40–1.

²⁶⁹ *Ibid* at 21, n 44.

²⁷⁰ 49 USC § 1134(a) (2024).

²⁷¹ 49 USC § 1134(b) (2024).

autopsies and access medical records to determine causes of accidents.²⁷² Additionally, it has exclusive rights to conduct tests, require reports, and limit others' access to evidence.²⁷³ Since NTSB's notice of proposed rulemaking on commercial space investigation has not become a final rule yet, its detailed methods of reporting and preservation of wreckage, evidence, and records will not be discussed here.

One main characteristic of the NTSB investigation is the so-called "party system". Under the MOA between the FAA and the NTSB, in a NTSB-led space accident investigation, the FAA will be a party to that investigation.²⁷⁴ A party to a NTSB investigation is an entity is directly involved in an accident and able to provide qualified technical personnel.²⁷⁵ The party system is consistent with Annex 13's principle of participation.

4.2 The United Kingdom

In the UK, the main investigational power of an inspector for spaceflight accidents is gathering evidence and interviewing witnesses. The investigator-in-charge has broad access and control rights, including immediate and unrestricted access to the accident site, wreckage, and data recordings related to the launch vehicle, moreover, he or she can list evidence, remove debris for analysis, and obtain medical examination results from involved individuals, including autopsies.²⁷⁶ Additionally, an inspector has the power to call witnesses, require the production of evidence, and record interviews.²⁷⁷

²⁷² 49 USC § 1134(f) (2024).

²⁷³ 49 USC § 1134(g) (2024).

²⁷⁴ US, *supra* note 168, s 3(e).

²⁷⁵ 49 CFR § 831.11.

²⁷⁶ UK Regulations 2021, supra note 16, s 23.

²⁷⁷ *Ibid*, s 25.

4.2.1 Parties involved in the investigation

Being aware of the importance of international cooperation in the UK's space industry, the UK Regulations 2021 outline the participation of accredited representatives, advisers, experts, and observers in space accident investigations. When a state expresses interest in a UK safety investigation, it may appoint an "accredited representative" to facilitate information flow and assistance.²⁷⁸ The SAIA may also send an accredited representative to a foreign investigation.²⁷⁹ Currently, no international conventions govern spaceflight accident investigations, therefore, how would the SAIA exercise its right to appoint an accredited representative in foreign investigations remains unclear. The investigator-in-charge and accredited representatives can appoint advisers to assist the investigation, ensuring comprehensive factual information is collected.²⁸⁰ Like the NTSB's party system, the UK Regulations 2021 also allow the SAIA to invite organizations providing operational and technical assistance, such as operators or regulatory bodies, to appoint advisers.²⁸¹ In addition, similar to the rights Annex 13 confers to a state having suffered fatalities or serious injuries to their citizens in an aviation accident, states with an interest in a UK spaceflight accident investigation, particularly involving fatalities or serious injuries to their citizens, can appoint experts.²⁸² These experts play roles like identifying victims, attending survivor meetings, and having rights to information on the investigation's progress and published data.²⁸³

4.2.2 Sensitive safety information

The UK Regulations 2021 advocate for a self-reporting system by encouraging the Just Culture of safety-related issues. This approach extends to safety investigations, where individuals

²⁷⁸ *Ibid*, s 18(1).

²⁷⁹ *Ibid*, s 20.

²⁸⁰ *Ibid*, s 18(2).

²⁸¹ *Ibid*, s 17(4).

²⁸² *Ibid*, s 19(1).

²⁸³ *Ibid*, s 19(2).

providing evidence should have confidence that their cooperation will not lead to adverse consequences. To support this, the SAIA is granted rights that facilitate the collection of the best evidence for safety investigations. The information provided to the SAIA receives protections against disclosure, acknowledging the sensitivity of some data and promoting an open method of gathering information.²⁸⁴

During the investigation, specific information may be disclosed to relevant parties solely to enhance safety. For instance, if a safety issue is identified with a particular type of launch vehicle used by multiple operators, the relevant parties may be informed to address and improve safety collectively.²⁸⁵ The UK Regulations 2021emphasize the importance of fostering a transparent and cooperative environment for safety reporting and investigations, ensuring that shared information contributes to the overall enhancement of safety in spaceflight activities.

By the designation of Regulation 29, US Technical Data is one type of sensitive safety information that requires protection. This arrangement provides us with a sense of hominization of the Annex 13 accident investigation model and the national security concerns of foreign states in an investigation. The "UK-US Technology Safeguards Agreement" sets forth the technical safeguards that uphold US space launches from the UK, ensuring the appropriate treatment of sensitive technology in line with their enduring partnership and roles as original members of the Missile Technology Control Regime.²⁸⁶ Under the agreement, "US Technical Data" is defined as information that "is required for the design, development, production, manufacture, assembly, operation, repair, testing, maintenance, or modification of U.S. Launch Vehicles, U.S. Spacecraft,

²⁸⁴ *Ibid*, s 23.

²⁸⁵ *Ibid*, s 30.

²⁸⁶ Agreement in the form of an Exchange of Notes between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the United States of America on Technology Safeguards associated with United States Participation in Space Launches from the United Kingdom, UK and US, 16 June 2020.

and/or U.S.-Related Equipment.²⁸⁷During a space accident investigation conducted by the UK, US Technical Data may only be disclosed with the consent of the US government after consultation between the SAIA and the US government.²⁸⁸ In practice, a transfer of technical data to a non-US person usually requires a technical assistance agreement ("TAA"). During the investigation of the LauncherOne accident, although the operator in question was allowed to share technical data of the launch vehicle with the AAIB for investigational purposes under a TAA, any data must be approved by the US Defense Technology Security Administration before it could be disclosed.²⁸⁹ This legal requirement affects the SAIA from getting the most up-to-date information during the investigation.

The UK-US Technology Safeguards Agreement showcases how like-interest states could utilize bilateral treaties to find common grounds for their obligations under multilateral export control regimes, national security concerns and commercial interests. However, this kind of arrangement is only possible between allies such as the UK and the US also poses question to the possibility of an international framework for space accident investigation. On the other hand, the approval requirement in practice remains the most critical problem towards timely cooperation for cross-border space accident investigation, which again reflects the balance between individual national security and international space safety is tilted towards the country controlling the technology.

4.3 Australia

Much like an inspector in the UK, an investigator appointed by the Australian Minister has the power to gather information and enter the accident site. In investigating, an investigator has the

²⁸⁷ *Ibid* art 18.

²⁸⁸ UK Regulations 2021, supra note 16, s 30(2).

²⁸⁹ Air Accidents Investigation Branch, *supra* note 237 at 3.

authority to issue a written notice requiring a person to attend and answer questions or to provide specific documents, records, or components related to the investigation.²⁹⁰ The Investigator may retain any materials provided for the duration of the investigation and make copies of documents.²⁹¹ In particular, information or materials obtained cannot be used as evidence against the person in most legal proceedings, except for false statements.²⁹² At an accident site, an investigator has the power to enter to conduct an investigation. Once on site, the investigator can control and secure the area, search it, and inspect or examine objects or wreckage. The investigator can also remove wreckage or other items for further examination or testing.²⁹³ The custody of the space object or the space object wreckage will be taken by the investigator.²⁹⁴

Unlike the US or the UK, the Australian space accident investigation system does not adopt the party system, and it does not contain provisions on the protection of sensitive information as in the UK Regulations 2021. Under the Australia Act 2018, the limitations on the disclosure of safety records are similar to the ones in Annex 13, focusing on building a firewall to protect safety information being used to apportion blame or determine liability. Furthermore, under Australian law, the relevant authorization of launch and reentry are immediately suspended after an accident occurs, which is different in the case of the US. Lastly, while an investigator does not have express power to give recommendations to relevant parties, in the Hapith I accident report, the investigator did give recommendations to the rocket operator, spaceport operator, and the Australian Space Agency.

²⁹⁰ Australia Act 2018, supra note 19, s 91(1).

²⁹¹ *Ibid*, s 91(4).

²⁹² *Ibid*, s 91(5).

²⁹³ *Ibid*, s 99.

²⁹⁴ *Ibid*, s 94.

5. Ruling the Unruly Space Technology: Best Practices and Legal Obstacles

Space accidents are unavoidable, especially as commercial space activities flourish. After comparing the US, the UK, and Australia's laws and regulations regarding the investigation of space accidents, this thesis would like to point out a few best practices and legal obstacles. Although aviation investigation is a highly developed area of practice and legal framework, the debate in the US over the jurisdiction of the NTSB manifested that aviation investigation rules are not fully compatible with space accident investigation. Brian Wynne took the Space Shuttle Challenger accident to illustrate that the public often perceives technology as operating according to rules. Which is also the perception of accident investigations which often attribute the causes of an accident to individual misconduct and a negative organizational culture that does not follow the rules.²⁹⁵ In reality, however, technology is "unruly".²⁹⁶ Influenced by its operational environments and organizational factors which generate a set of "unruly rules", technology deviates from the norm within acceptable risks.²⁹⁷. In a similar vein, the abovementioned House Committee letter regarding NTSB's jurisdiction over space accident investigation makes clear that "[a]s Congress has consistently found, and independent investigators have warned, space launch and reentry are developmental activities that are not comparable to modes of transportation as the inherent risks are vastly higher and our experience is vastly lower."²⁹⁸ Therefore, when discussing the necessity for an international framework on space accident investigation, the intrinsic differences between aviation accidents and space accidents should be considered.

To deal with accidents resulting from high-risk space activities, a higher threshold for an investigation by an independent government authority will benefit the space industry. The US's

²⁹⁵ Brian Wynne, *supra* note 32 at 150–1.

²⁹⁶ Ibid.

²⁹⁷ *Ibid* at 154.

²⁹⁸ The House Committee on Science, Space and Technology, *supra* note 221, Attachment A, n 40 at 7.

layered system makes sure that mishap responses are planned, and mishaps of all levels are investigated by operators with expertise while the most serious accident will be investigated by the NTSB, an independent authority, to strike a balance between public safety and self-learning and developing of the industry. However, two primary considerations can be drawn from the US. First, clarity in statutory authority and regulation is imperative to prevent regulatory ambiguity; second, the regulator acting also as an investigator must strike a balance between addressing industry interests and upholding public safety and trust. As for countries that do not have a space industry comparable to the US, the Australian norms could be a reference as it only puts resources into an investigation when serious cases happen and that reflects the status of the country's space activity development while also emphasizing safety of the public and the industry.

Moreover, the space accident investigation laws and regulations of the three countries reflect that space activities are deeply tied not only to their commitment to public trust and safety, but also to national security, national interests, and obligations under the multilateral export control regime. On these grounds, it would be difficult if not impossible to directly implement the Annex 13 model to international space law which obligated the state to be responsible for their national activities in space. As the UK's Annex 13 inspired model reflects, its nuanced adjustments are tailored to the specific requirements of the UK's developing space industry, especially regarding the investigation of US rockets launched in the UK. The scope of the UK Regulations 2021 defines a spaceflight accident and jurisdictional parameters, offering clarity on when a safety investigation can be initiated. Despite this clarity, the absence of an international framework introduces uncertainties about the UK's jurisdiction in cases of cross-border space accidents.

Participation in a UK investigation is well-defined, involving accredited representatives, advisers, experts, and observers, with provisions for international collaboration. However, the lack

of international conventions governing spaceflight accident investigations places limitations on the rights of UK representatives in foreign investigations. The handling of sensitive safety information, particularly the protection of US Technical Data under the UK-US Technology Safeguards Agreement, highlights the intricate balance between national security concerns, multilateral export control regimes, and commercial interests.

6. Conclusion

Despite the lack of international instruments to unify space accident investigation, investigating space accidents and preventing the same cause from happening again aligns with the state's responsibility under Article VI of the Outer Space Treaty. A comparative analysis of national space accident investigation laws reveals both shared principles and distinct approaches among countries. By examining the legal definitions, investigative authorities, and investigative processes in the United States, Australia, and the United Kingdom, this study highlights the diverse ways in which each nation addresses space safety and regulatory responsibilities.

The definitions of space accidents set the threshold for launching an investigation. The United States, with multiple and broad definitions of what constitutes a space accident, demonstrates a high level of inclusivity in its safety protocols. Australia, on the other hand, has adopted the narrowest definition, with some advocates pushing for an even more restrictive scope. These variations reflect not only each country's unique safety priorities but also the differing levels of technological advancement and engagement within the space sector.

The same reason can be used to explain the authorities responsible for space accident investigations, revealing how historical experiences and resource allocation shape these frameworks. The ongoing debate around the NTSB role underscores the potential limitations of adopting an independent investigation model, such as that found in Annex 13, in a rapidly evolving

space industry. Instead, an investigation model led by operators under regulatory oversight may better serve countries experiencing fast-paced development in their space sectors.

The UK's investigation laws and regulations are the most comprehensive of the three as they took inspiration from the Annex 13 model. Evidence of this can be found in its definition of an accident, parties involved in an investigation, and the protection of sensitive safety information. However, without a structured international cooperation framework, executing such a model effectively may prove challenging.

Chapter 4: Beyond Safety: The Entanglement of Insurance, Social Impacts, and Export Control in Commercial Space Accident Investigation

1. Issues of International Space Accident Investigation: The Launch Failure of Intelsat 708

During the late 1980s and early 1990s, the US-China relations developed rapidly in all aspects. Among the trade issues was the launching of US satellites in China with a Chinese launcher. In 1988, the US and China entered into the first "Memorandum of Agreement on Satellite Technology Safeguards", which paved the way for US customers to Chinese launch providers.²⁹⁹ Then the second and superseding "Memorandum of Agreement on Satellite Technology Safeguards" was signed in 1993.³⁰⁰ The purpose of these agreements is to prevent unauthorized transfer of sensitive US technology for satellite launches from China. It outlined strict security protocols, including controlled access to equipment, data, and procedures, and granted US oversight of compliance. These measures sought to maintain US technological security while allowing for China-based launches of US-manufactured satellites under regulated conditions.

Due to the lower price of Chinese launches and a backlog of available launchers at the time, US operators decided to launch their satellites on the Chinese Long March rockets.³⁰¹ Everything seemed to be working, then two launch failures happened in 1995 and 1996, destroying two satellites manufactured by US companies. While safety concerns needed to be addressed in the aftermath of these failures, the investigations of these two launches brought questions beyond

²⁹⁹ Memorandum of Agreement on Satellite Technology Safeguards Between the Governments of the United States of America and the People's Republic of China, 17 December 1989, 28:3 ILM 604–9.

³⁰⁰ Memorandum of Agreement on Satellite Technology Safeguards Between the Governments of the United States of America and the People's Republic of China, 11 February 1993, online: <https://csps.aerospace.org/sites/default/files/2021-08/Tech%20Safeguards%20Agreement%20-%20China%20Feb93.pdf>.

³⁰¹ United States, *Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China* (Washington: U.S. G.P.O, 1999) at 172.

safety concerns. These broader issues include the involvement of insurers as risk underwriters and national security issues of the countries that export space technology, especially the US.

In April 1992, Intelsat entered into a launch contract with the China Great Wall Industry Corporation ("CGWIC"), a state-own company, to launch its Intelsat VIIA series of satellites.³⁰² Intelsat 708, manufactured by Space Systems /Loral ("Loral"), was the first to be launched. At 3:00 am on February 15, 1996, the Intelsat 708 satellite was launched by a Long March 3B rocket.³⁰³ Immediately after liftoff from the Xichang Satellite Launch Center, however, the rocket started to tilt and deviate from its intended trajectory.³⁰⁴ Only 22 seconds later, it crashed into the hill and the explosion destroyed not only the rocket itself and its payload but also impacted a nearby village. The Chinese official said that six villagers were killed but other sources estimated that more than 100 people died because of the accident.³⁰⁵

Indeed, safety is always the priority of the aerospace industry and the main purpose for an accident investigation. However, this tragic accident and its subsequent investigation opened the black box of a commercial launch failure and the entanglement of safety, insurance, and export control. Moreover, the death of the nearby villagers poses questions about how a space accident investigation framework could respond to the social and emotional needs of the affected. Safety ensures the prevention of both physical and financial losses but needs to take national security into account. In other words, this case underscores the critical need for a clear framework in investigating space accidents, particularly as international stakeholders began probing the factors behind a failure.

³⁰² *Ibid* at 107.

³⁰³ *Ibid* at 119.

³⁰⁴ *Ibid* at 102–5.

³⁰⁵ *Ibid* at 100.

Starting with insurance, Section 2 shows how insurers are deeply involved in accident investigations. The reason is the high stakes that insurers have in these accidents. Section 2 will approach the insurers' involvement from the general market performance of space insurance to the specific case of Intelsat 708. In addition, a comparison of insurers' involvement in aviation accident investigation points to potential areas that insurers might be cautious of in a space accident investigation.

Section 3 briefly addresses the social and environmental impacts of space accidents. Besides direct impacts, the most concerning danger of launches is the contamination from the propellant used. This Section explores the possibility of opening space accident investigations to experts or representatives appointed by the affected residents.

Last but not least, as mentioned in the previous chapters, export control remains the greatest challenge for an international space accident investigation. Section 4 discusses how export control, especially the US export control rules, works in terms of accident investigation, the effects it has on space accident investigation, and the recent efforts to facilitate cross-border data sharing for investigational purposes through bilateral agreements.

2. Insurance and Accident Investigation

2.1 The Stakes of Space Insurance

Space is an ultra-hazardous environment, making space launch high-risk activities. Additionally, satellites are high-cost instruments. For example, a heavy geostationary satellite may cost hundreds of millions of dollars.³⁰⁶ Thus, satellite operators could purchase insurance to cover the risks associated with their assets.

³⁰⁶ Dan Swinhoe, "Paying the premium: Why 2023 was a bad year for space insurance", (3 September 2024), online: <https://www.datacenterdynamics.com/en/analysis/paying-the-premium-why-2023-was-a-bad-year-for-space-insurance/>.

Generally speaking, three types of coverage for first-party space insurance exist, namely, prelaunch, launch, and in-orbit satellite operation. Pre-launch insurance covers satellites and/or rockets before launch and its coverage generally concludes at the moment of intentional ignition or liftoff of the rocket.³⁰⁷ Launch insurance's coverage starts where pre-launch insurance ends until the satellite separates from the rocket and completes an initial functionality test phase.³⁰⁸ Inorbit insurance covers after the test phase ends and the start of the normal operation, and it is usually renewed on a one-year basis.³⁰⁹

Since geostationary satellites are valued at more than a hundred million dollars, their insurances are syndicated and reassured.³¹⁰ However, for one geostationary satellite, a single space insurance underwriter could be exposed to around 40 million dollars, thus, if more than one claim is made, the insurance market will suffer a great loss.³¹¹ 2023 was a challenging year for space insurers, as three claims at the total cost of close to 1 billion dollars were made, exceeding the premium of around 557 million dollars insurers collected that year.³¹² Therefore, detailed data of the risks associated with a space object must carefully be evaluated before an insurer underwrites such risks.

It would not be surprised that insurer analyzes the aggregated data on mishaps, while the FAA, which is responsible for mishaps investigation, does not conduct such research.³¹³ Furthermore, in the new space era, space insurers are particularly concerned about the increasing collision risk

³⁰⁷ United States, *supra* note 301 at 302.

³⁰⁸ *Ibid*.

³⁰⁹ *Ibid* at 302–3.

³¹⁰ *Ibid* at 300–1.

³¹¹ Swinhoe, *supra* note 306.

³¹² David Todd, "Space Insurers wither from 'worst year' in over twenty years as claims get close to US\$1 billion (Updated and corrected)", (7 December 2023), online: *Seradata* https://www.seradata.com/space-insurers-wither-from-worst-year-ever-as-claims-get-close-to-us1-billion/>.

³¹³ See *Commercial Space Transportation: FAA Should Improve Its Mishap Investigation Process*, by United States Government Accountability Office (2023) at 46.

in low earth orbit and the vague legal regime over commercial human spaceflight.³¹⁴ A safety investigation framework that produces concrete factual information could help to mitigate such risks and prevent contentious claims.

2.2 Insurers are Deeply Involved: The Case of the Intelsat 708 Launch Failure

Since insurers have high stakes in the insured's space activities, they are deeply engaged in accident investigations. The most evident example is the investigation into the launch failure of the Long March 3B rocket carrying Intelsat 708. CGWIC, the launch provider, set up two groups of Chinese engineers to investigate the failure.³¹⁵ On February 27, 1996, the Chinese groups identified the cause of the failure as a malfunction in the rocket's inertial measurement unit. This critical component is responsible for providing the rocket with its attitude orientation, essentially determining the rocket's up direction.³¹⁶ The Chinese investigation, however, did not convince their Western counterparts, particularly the insurers.

On March 14, 1996, a group of launch insurance representatives met in Beijing to examine the risk of launching the Apstar 1A satellite (manufactured by Hughes) on a Long March 3 rocket scheduled in July of the same year.³¹⁷ During the meeting, an insurance broker representative demanded that no satellite should be launched from China before the Chinese could issue a final report on the failure and organize an independent investigation of the Long March 3B rocket.³¹⁸ As a result, in April 1916, an independent investigation committee of experts from Loral, Hughes, and other western engineering companies, was established by CGWIC.³¹⁹ As will be discussed

³¹⁴ Christopher T W Kunstadter, "What Keeps Space Insurers Up at Night?" (2022) 34:3 Air & Space Lawyer 10–11 at 10–1.

³¹⁵ United States, *supra* note 301 at 107.

³¹⁶ *Ibid*.

³¹⁷ *Ibid* at 107–8.

³¹⁸ *Ibid* at 122–3.

³¹⁹ *Ibid* at 123–4.

below, this independent investigation committee would later be accused of transferring sensitive data that requires export control licenses to the Chinese. Nonetheless, this example shows that insurers are deeply involved in an accident investigation.

2.3 Insurer's Perspective on Accident Investigations

Insurer's participation in aviation accident investigations can provide insights about an insurer's potential role and concerns in an independent space accident investigation. First of all, as a basic principle of insurance, insurers are entitled to recoveries that could recover the sums paid for a claim. These include subrogation, salvage, and abandonment. In particular, salvage means the insurer may recover from the material of a vehicle or other form of claim.³²⁰ Although aviation insurers may not always exercise to salvage, ICAO advises investigation authority "to obtain written authorization from both the owner of the aircraft and the insurance company" before destructive testing of components.³²¹ Therefore, although space assets or launch vehicles are usually destroyed in explosions, independent investigators should be aware of insurers' right over the wreckage.

Secondly, since insurers are bearing the financial consequences of an aviation accident, they have a strong interest in preventing future accidents. The abovementioned independent review committee of Intelsat 708 is proof of the insurers' influence in such incidents. Even in an aviation accident investigation, which is not led by insurers, they still have high stakes during the investigation. As one insurance lawyer describes, "[i]nsurers have consistently taken an interest in and been active in the field of loss prevention. They are as much interested in air safety as any of the regulatory authorities – they have a different but equally great direct interest in the continual

³²⁰ Katherine B Posner & Wendy A Grossman, "An Aviation Insurance Primer: An Overview for the Aviation Practitioner" in Andrew J Harakas, ed, *Litigation the Aviation Case*, 4th ed (Chicago: American Bar Association) 617 at 623.

³²¹ ICAO, Manual of Aircraft Accident and Incident Investigation, 2d ed, Doc 9756 AN/965 (2015), s 5.7.1.1.

efforts to make air travel safer."³²² In other words, the insurers' interest is in line with the purpose of Annex 13. Therefore, insurers generally welcome a thorough investigation and undisputed report, as these efforts could lower the possibility of costly liability litigation.³²³ However, insurers are usually barred from directly participating in an investigation. For example, the NTSB specifically bars persons, *inter alia*, representing insurers from participating as a party in an investigation.³²⁴ A similar provision is found in the UK's Guidance on the investigation of spaceflight accidents, barring any person, *inter alia*, representing insurers to participate an investigation.³²⁵ Thus, the insurers of the operators or manufacturers will have to indirectly participate in an investigation through the representatives from the State of Operator, the State of Manufacture, or the State of Design.³²⁶

Lastly, independent safety investigation requires a great number of resources. Aviation insurance sometimes covers the search and recovery costs of an aircraft. ICAO thus recommends that the investigation authority discusses the cost of search and recovery with the aircraft's insurer as early as possible.³²⁷ In the space context, Article 5, paragraph 5 of the Rescue Agreement provides that: "[e]xpenses incurred in fulfilling obligations to recover and return a space object or its component parts ... shall be borne by the launching authority."³²⁸ Although this article does not directly apply to the search and recovery for a safety investigation, the same logic seems to be applicable in accident investigation to ask the owner or the launching state to bear the cost of the search and recovery. It is then not surprising to find that under the UK's regulations, the SAIA has

³²² Ian Awford, "Aircraft Accident Investigation: from an insurance perspective" (1984) Air and Space Law 13–26 at 13.

³²³ *Ibid* at 14.

³²⁴ NTSB, Information And Guidance for Parties to NTSB Accident and Incident Investigations at 2.

³²⁵ UK Civil Aviation Authority, *Guidance on the investigation of spaceflight accidents*, CAP 2219 (West Sussex:

Civil Aviation Authority, 2021), s 4.17. ³²⁶ Awford, *supra* note 322 at 23–4.

Awford, supra note 322 at 23-4.

³²⁷ ICAO, *supra* note 321, s 4.2.5.

³²⁸ Rescue Agreement, supra note 21 art 5(5).

the right to recover the cost of recovering, transporting, and storing evidence from a licensee for investigational purposes.³²⁹ Therefore, the UK government advises licensees to acquire sufficient funds and/or insurance coverage for these costs.³³⁰

3. Social and Environmental Context of Space Accidents

Space activities pose threats to not only the operating personnel but also the public. Launch accidents are especially concerning to the ordinary people in the vicinity of a launch site, as the civilian casualties caused by the launch failure of Intelsat 708 have shown. Besides direct impact, the hazardous materials released by rockets are particularly concerning for the residents and the environment.

When Maritime Launch Services started to construct its spaceport in Nova Scotia, residents of Canso were concerned about the proposed use of hydrazine fuel, which could cause eye damage and even liver and kidney damage.³³¹ The company later announced to switch to a "green" rocket.³³² In practice, the Russian Proton rockets and the Chinese Long March rockets launched from inland launch sites use unsymmetrical dimethylhydrazine ("UDMH") as propellent, which is a toxic carcinogen that can be absorbed by contacting the skin.³³³ Following the 1999 Russian Proton rocket explosions at Baikonur, Kazakhstan, Kazakhstan imposed a temporary launch ban, later lifted after soil detoxification and environmental compensation, and similar accidents in 2007, 2010, and 2013, prompting Kazakhstani authorities to reconsider Proton rocket use and explore additional compensation options.³³⁴

³²⁹ UK Regulations 2021, supra note 16, s 28.

³³⁰ UK Civil Aviation Authority, *supra* note 325, s 4.35.

³³¹ Webb, *supra* note 70 at 118.

³³² *Ibid*.

³³³ Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey, "Safety Issues" in Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey, eds, *The Need for an Integrated Regulatory Regime for Aviation and Space: ICAO for Space?* (Vienna: Springer Vienna, 2011) 69 at 78; Webb, *supra* note 70 at 119–20.

³³⁴ Nelly Bekus, "Outer space technopolitics and postcolonial modernity in Kazakhstan" (2022) 41:2 Central Asian Survey 347–367 at 14.

In addition, the environmental contamination of a launch accident could be extremely harmful. The 2007 accident of a Proton rocket is said to contaminate Kazakhstani agricultural land with 200 metric tons of toxic propellent.³³⁵ Similarly, the 2013 accident of the same rocket family caused the carcinogenic propellants to exceed maximum permissible concentrations by around 8900 and 6100 times.³³⁶ These accidents in a postcolonial context have sparked environmental activism in Kazakhstan.³³⁷ Yet the tension has not been solved.

How could a space accident investigation help to mitigate the social and environmental impacts of space accidents? As argued in Chapter 2, environmental damages should be contained in the definition of space accident that triggers an obligation to investigate. In addition, a state that has a sustainable interest in the environment should have the right to participate in an investigation if the accident causes harm within its jurisdiction. As for the social impacts, currently under Annex 13, a state that has fatalities or serious injuries sustained to its citizens has the right to appoint an expert to visit the accident scene, have access to relevant factual information, and receive a copy of the final report.³³⁸ The UK Regulations 2021 has a similar provision that grants the same right to a state that has a least one citizen died or suffered serious injuries in a spaceflight accident.³³⁹ However, these rights are merely rights to be informed. Furthermore, even in a scenario in which the state that suffered environmental and personal damages is the investigating state, the environment and the locals will still be treated as victims and not participants. Therefore, this thesis submits that a space accident investigation framework should consider involving an expert appointed by the residents who sustain social and environmental damages, to expand the function

³³⁵ Jakhu, Sgobba & Dempsey, *supra* note 333 at 78.

³³⁶ Webb, *supra* note 70 at 120.

³³⁷ supra note 334 at 13–5.

³³⁸ ICAO, *supra* note 26, s 5.27.

³³⁹ UK Regulations 2021, supra note 16, s 19.

of an investigation and to forge a resilient final report that addresses such social and environmental impacts.

4. Export Control: Challenge For Cross-Border Investigation and Bilateral Developments

Export control is an area of law that imposes restrictions on the export of goods and services from one country. Although this is against the principle of free trade, the justifications include national security reasons, technology protection, and fulfilling non-proliferation obligations.³⁴⁰ A recurring theme in this thesis is that the primary challenge for establishing an international framework for space accidents is the national security interest of countries that possess space technology. The implications of the international space treaties and the national laws on space accident investigations demonstrate that international cooperation is the key to a successful space accident investigation which could involve many states. However, as one expert has rightly pointed out, the greatest obstacle towards international cooperation or even an international framework of space accident investigation is the national security concerns of states.³⁴¹

Accordingly, this Section addresses the limitations of export control on space accident investigation in detail. One recent example is the UK AAIB's investigation into the LauncherOne accident as discussed in Chapter 3. During that investigation, the AAIB could not access the most up-to-date information from the US operator because the release of technical data is subject to the approval of the US Defense Technology Security Administration, which is an office that advises the US Secretary of Defense on export control matters.³⁴² As a side note, although export controls

³⁴⁰ Ulrike M Bohlmann & Gina Petrovici, "Space Export Control Law and Regulations" in Kai-Uwe Schrogl, ed, *Handbook of Space Security: Policies, Applications and Programs* (Cham: Springer International Publishing, 2020) 185 at 186–7.

³⁴¹ Sedor, *supra* note 31 at 7.

³⁴² Air Accidents Investigation Branch, *supra* note 237 at 3.

also apply to information provided to insurers for underwriting or proof of loss,³⁴³ it is beyond the scope of this thesis, which intends to focus on the data sharing in accident investigation processes.

4.1 The Intelsat 708 Failure Investigation: A Case of Violating the United States Export Control Rules

Cross-border space accident investigation started to become an issue of the US export control regime during the launch failure investigation of Intelsat 708 in 1996. As mentioned above, an independent review committee was established under the insurers' demand, to investigate the Chinese rocket's failure to carry US-made satellites. The committee met twice in 1996 and provided technical data to the Chinese launching company.³⁴⁴ Among these data was the material regarding the inertial navigation systems, which was later identified by the Chinese as the cause of the launch failure.³⁴⁵ However, the committee members from the manufacturer was not authorized by the US government to export such technical data.³⁴⁶ After the assessment of the US government, it was determined that transferring the technical data had helped to improve the reliability of the Long March rockets and Chinese ballistic missiles using the same guidance system.³⁴⁷ Thus, the US government determined that US national security was jeopardized.

Loral was not the only US satellite company launching in China that was suspected of violating the US export control laws. Hughes Space and Communications International, Inc. ("Hughes") experienced two failures: the first one in 1992, in which the satellite failed to reach orbit, and the other one was in 1995, in which the satellite was destroyed.³⁴⁸ It was later found that by providing,

³⁴³ Andrea J Harrington, "Space business and insurance issues in the United States" in *Space Insurance and the Law: Maximizing Private Activities in Outer Space* (Northampton: Edward Elgar Publishing, 2021) 117 at 126–7; United States, *supra* note 301 at 300–10.

³⁴⁴ United States, *supra* note 301 at 109.

³⁴⁵ *Ibid* at 157.

³⁴⁶ *Ibid* at 109, 148.

³⁴⁷ *Ibid* at 171.

³⁴⁸ *Ibid* at 6.

without an export licence, the technical data particularly regarding the rocket's faring in the investigations of the failures, Hughes had aided the improvement of the Chinese Long March 2E rockets.

The US government initiated criminal investigations against Loral and Hughes of violating export control laws.³⁴⁹ In 2002, Loral settled the charges for \$14 million,³⁵⁰ and in 2003, Boeing, which acquired Hughes, paid \$32 million in fines for multiple export violations.³⁵¹ The firms were penalized for enabling knowledge sharing during accident investigations that helped identify technological flaws in Chinese rockets. The above cases show that complying with export control rules during an accident investigation is critical as the consequences of violating the rules are extremely high.

4.2 Export Control and Accident Investigation: An Overview

Export control is usually enforced through a licensing system. In other words, an export that requires authorization would need to apply for a license. In general, there are two ways to determine whether exporting an item requires a license. First, several control lists contain the parameters of the goods and services that require authorizations.³⁵² Second, exporting to listed end-users or countries and for certain end-use might be prohibited as well.³⁵³

While the term "export control" seems to indicate the controlled objects are tangible items, export control, might also prohibit the exchange of technical data or technical assistance without

³⁴⁹ United States., *Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China*, Report / 105th Congress, 2d Session, House of Representatives ;105-851, 3 p. (Washington: U.S. G.P.O, 1999).

³⁵⁰ "Loral Agrees to a \$14 Million Settlement for Alleged ITAR Violations", (10 January 2002), online: *Export Compliance Training Institute* https://www.learnexportcompliance.com/loral-agrees-to-a-14-million-settlement-for-alleged-itar-violations/.

³⁵¹ "U.S. Department of State Reaches Settlement with Boeing and Hughes" (Department of State), accessed July 30, 2024, https://2001-2009.state.gov/r/pa/prs/ps/2003/18275.htm.

³⁵² Bohlmann & Petrovici, *supra* note 340 at 187

³⁵³ *Ibid*.
a proper license.³⁵⁴ For example, the US International Traffic in Arms Regulations ("ITAR") defines technical data as, *inter alia*, "[i]nformation, …, which is required for the design, development, production, manufacture, assembly, operation, repair, testing, maintenance, or modification of defense articles. This includes information in the form of blueprints, drawings, photographs, plans, instructions, or documentation[.]"³⁵⁵ Therefore, export control is also a regime that regulates how knowledge moves around the globe.³⁵⁶

Currently, four main multilateral export control regimes exist internationally. There are the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies ("Wassenaar Arrangement"), the Missile Technology Control Regime ("MTCR"), the Australia Group, and the Nuclear Suppliers Group.³⁵⁷ The former two are of particular interest regarding commercial space accident investigations. Commercial satellites are controlled by the Wassenaar Arrangement because of its dual-use nature, which means it could be used for both military and non-military purposes. On the other hand, launch vehicles, i.e. missiles, fall under the MTCR. It should be noted that these multilateral regimes are not binding international instruments, but they serve to coordinate the national export control lists.³⁵⁸

4.3 The United States Export Control Regime: Strict Requirement for Foreign Space Accident Investigation

The export control regimes of the US and Europe are notable examples in terms of the transfer of space technology. Since the cases regarding export control and accident investigation discussed

³⁵⁴ *Ibid* at 188.

³⁵⁵ 22 CFR § 120.33 (a)(1).

³⁵⁶ John Krige, "Export Controls as Instruments to Regulate Knowledge Acquisition in a Globalizing Economy" in John Krige, ed, *How Knowledge Moves: Writing the Transnational History of Science and Technology* (University of Chicago Press, 2019) at 76.

³⁵⁷ Lisa Gräfin von der Schulenburg & Matthias Creydt, "Export control and NewSpace: Reciprocal challenges" in *Routledge Handbook of Commercial Space Law* (Routledge, 2023) at 444; Bohlmann & Petrovici, *supra* note 340 at 190.

³⁵⁸ Bohlmann & Petrovici, *supra* note 340 at 191.

in this thesis are all related to the US export control regime, it will be examined to discuss its implications. Under the US rules, dual-use items are regulated by the Export Administration Regulations ("EAR"), which are administrated by the Bureau of Industry and Security under the Department of Commerce. Military items, on the other hand, are regulated by the ITAR, which is administrated by the Directorate of Defense Trade Controls under the Department of State. At present, most commercial spacecraft items are regulated by the EAR since the Export Control Reform of 2013.³⁵⁹ Under the classification of the United States Munitions List ("USML"), ITAR generally regulates the export of military and intelligence function satellites (Category XV) and launch vehicles (Category IV).³⁶⁰

Despite the export of space technology is controlled by two different regulations, assisting a non-US person in failure analysis that involves the transferring technical data of satellites and spacecraft, and launch vehicles is regulated by the ITAR. Category IV of the USML includes:

(i) ... Defense services ... also includes the furnishing of assistance (including training) to a foreign person in the launch failure analysis of a launch vehicle, regardless of the jurisdiction [ITAR or EAR], ownership, or origin of the launch vehicle, or whether technical data is used.³⁶¹

Category XV of the USML has a similar provision which reads:

(f) ... Defense services ... also includes the furnishing of assistance (including training) to a foreign person in the launch failure analysis of a satellite or spacecraft, regardless of the jurisdiction [ITAR or EAR], ownership, or origin of the satellite of spacecraft, or whether technical data is used.³⁶²

In addition, in the event of a launch failure from a non-US country for any satellite or spacecraft

controlled by the ITAR or EAR, a mandatory licensing requirement exists. Participation in any

investigation or analysis of the failure requires prior approval, regardless of whether a license was

³⁵⁹ *Ibid* at 197

³⁶⁰ *Ibid* at 198.

³⁶¹ 22 CFR § 121.1 Category IV(i) [emphasis added].

³⁶² 22 CFR § 121.1 Category XV(f) [emphasis added].

issued for the initial export of the satellite or its components.³⁶³ Moreover, all activities related to the investigation must be monitored by US Department of Defense officials to prevent unauthorized transfer of technical data or services.³⁶⁴ Therefore, a cross-border commercial space accident that involves a US space object or launch vehicle is strictly regulated by the ITAR and generally requires a license. These provisions especially regulating failure analysis service and data export were enacted after the violations of Loral and Hughes in the Chinese launch failure investigations.³⁶⁵ As a result, export control remains the greatest legal challenge for cooperation in cross-border accident investigations.

4.4 Recent Bilateral Development: Technology Safeguards Agreements Between the

United States and Its Partners

To facilitate the launch of US rockets in the territory of foreign countries, the US has signed Technology Safeguards Agreements ("TSA") with New Zealand,³⁶⁶ the UK,³⁶⁷ Australia,³⁶⁸ and Canada³⁶⁹ separately. A TSA is a legally binding treaty between the US and another nation, designed to facilitate the export of US space launch technology while ensuring its protection. The

³⁶³ 22 CFR § 124.15 (2014).

³⁶⁴ 22 CFR § 124.15 (2014).

³⁶⁵ Jason A Crook, "National Insecurity: Itar and the Technological Impairment of U.S. National Space Policy" (2009) 74:3 J Air L & Com 505–526 at 511.

³⁶⁶ Agreement between the Government of New Zealand and the Government of the United States of America on Technology Safeguards Associated with United States Participation in Space Launches from New Zealand, 16 June 2016, online: https://www.treaties.mfat.govt.nz/search/details/t/3858/c_1.

³⁶⁷ Agreement in the form of an Exchange of Notes between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the United States of America on Technology Safeguards associated with United States Participation in Space Launches from the United Kingdom, 16 June 2020, online: <https://www.gov.uk/government/publications/ukusa-agreement-in-the-form-of-an-exchange-of-notes-betweenthe-united-kingdom-and-the-united-states-of-america-on-technology-safeguards-associated>.

³⁶⁸ Agreement between the Government of Australia and the Government of the United States of America on Technology Safeguards Associated with United States Participation in Space Launches from Australia, 26 October 2023, online: https://www.aph.gov.au/Parliamentary_Business/Committees/Joint/Treaties/AU-USSpaceLaunches/Treaty_being_considered.

³⁶⁹ Global Affairs Canada, "Canada and United States conclude negotiations on Technology Safeguards Agreement", (2 August 2024), online: https://www.canada.ca/en/global-affairs/news/2024/08/canada-and-united-states-conclude-negotiations-on-technology-safeguards-agreement.html Last Modified: 2024-08-02.

primary purpose of a TSA concerning export control is to establish a legal and technical framework that enables the transfer of US spaceflight technology to the partner country for space launch activities while safeguarding against unauthorized access or transfer of this sensitive technology. By implementing a TSA, both countries commit to adhering to non-proliferation principles, such as those outlined in the MTCR. This ensures that space launch technology, which could potentially be used for launching weapons of mass destruction, is adequately protected during its use in the partner country.

Within these TSAs and their side agreements, the issue of access to technical data in a launch accident investigation is addressed. Specifically, for instance, Article VIII (3) e of the US-UK TSA provides that:

The Government of the United States of America and Her Majesty's Government agree to authorize the U.S. Licensees and the U.K. Licensees respectively, through licenses, permits or authorizations, to provide, to the extent the national security interests and foreign policy of the respective States permit, information necessary to determine the cause of the launch anomaly or failure.³⁷⁰

Furthermore, the investigation authority of the respective state may be required to secure, examine, and even dismantle or destroy US technology if necessary, during an investigation, with US authorization and presence, ensuring thorough investigations while safeguarding US technological interests.³⁷¹

It should be noted that the US-UK TSA is not in force at the time of writing. Nonetheless, according to Article 18 of the VCLT, "[a] State is obliged to refrain from acts which would defeat the object and purpose of a treaty when ... it has signed the treaty or has exchanged instruments

³⁷⁰ *Supra* note 65 art VIII (3) e.

³⁷¹ Arrangement between the Government of the United States of America and the Government of the United Kingdom of Great Britain and Northern Ireland relating to the Agreement between the Government of the United States of America and the Government of the United Kingdom of Great Britain and Northern Ireland On Technology Safeguards Associated with United States Participation in Space Launches from the United Kingdom, 16 June 2020 at para 7.1.e.

constituting the treaty subject to ratification, ...".³⁷² One of the objects of the US-UK TSA is to acknowledge that the UK authorities can ensure spaceflight activities conducted in the UK is safe.³⁷³ Therefore, the US is under the obligation to facilitate a UK space accident investigation involving a US spacecraft as Article VIII (3) e of the US-UK TSA provides.

However, in practice, during the LauncherOne accident investigation, although the operator of LauncherOne was licensed to disclose information to the UK AAIB by the US under a launch failure TAA, every disclosure still requires approval from the US Defense Technology Security Administration.³⁷⁴ Although such approval process was not an act to hinder AAIB's investigation, and therefore the US could argue its TSA obligation to provide information was not violated. The result, however, was that the UK inspectors were not able to obtain the most recent information to conduct a functional investigation from their end. Furthermore, a TAA does not authorize the export of "manufacturing know-how", 375 thus the AAIB was not able to obtain "...design methodology, manufacturing know-how, models, methods or tools..." to determine the cause of the accident. The UK government intends to discuss with the US about the issue of information sharing in a space accident investigation that involves US technology.³⁷⁶

One might wonder why export control is not an issue for aviation accident investigation. According to Article 27 of the VCLT, "[a state] may not invoke the provisions of its internal law as justification for its failure to perform a treaty."³⁷⁷ Thus, states are not allowed to invoke national export control rules regarding aircraft to justify their obligation to provide evidential material³⁷⁸

³⁷² *VCLT*, *supra* note 36 art 18.

³⁷³ Supra note 367 Preamble.

³⁷⁴ Air Accidents Investigation Branch, *supra* note 237 at 3.

³⁷⁵ US Department of Commerce & FAA, Introduction to U.S. Export Controls for the Commercial Space Industry, 2d ed (Washington D.C., 2017) at 44.

³⁷⁶ UK Government, Space Regulatory Review 2024, Research Paper Number 2024/007 (London, 2024) at 35.

³⁷⁷ *Supra* note 36 art 27.

³⁷⁸ ICAO, *supra* note 26, s 5.4.3.

and relevant information ³⁷⁹ during an investigation under Annex 13. Thus, without an international treaty providing a binding obligation to share information relevant to a space accident, states may enforce export control laws on such data transfer.

In summary, international cooperation is crucial for successful space accident investigations involving multiple state parties, yet geopolitical concerns significantly hinder this process. National security issues, enshrined in export control laws, restrict the exchange of technical data, complicating collaboration. While the US and its allies have made progress regarding the permission to exchange information in an accident investigation, the practical process of export control approvals still delays the other party's access to investigational information. Without an international treaty to address this issue, national security concerns will remain the greatest challenge of any international cooperation over space accident investigation.

5. Conclusion

This chapter examines the aspects beyond the safety of space accident investigation. By situating commercial space accident investigation in the insurance, social and environmental, and export control contexts, it shows that a space accident investigation framework cannot avoid dealing with issues other than international law and domestic investigation rules as discussed in the previous chapters.

Insurance has an intricate and indispensable role in the domain of space activities, particularly concerning accident investigation. Through cases like the Intelsat 708 incident, it is clear that insurers are deeply interested in risk prevention, pushing for independent investigations to ensure reliability and transparency in failure analyses. Additionally, the parallels between space and aviation insurance emphasize that insurers generally advocate for thorough investigations, as these

³⁷⁹ *Ibid*, s 5.26.

ultimately align with their goals of minimizing future claims. However, given the legal restrictions on their direct involvement, insurers' roles remain indirect, working through state representatives in the investigation process. Furthermore, the financial responsibilities associated with investigation costs underline the necessity for operators to ensure adequate coverage for potential recovery and investigational expenses.

As for the social and environmental risks of space accidents, incidents like the Intelsat 708 disaster and toxic contamination from Proton rocket failures underscore the need for a more inclusive investigation framework. Current norms, such as Annex 13 and the UK Regulations 2021, grant limited rights to affected states but largely exclude local voices. To better address these broader impacts, this thesis argues for the inclusion of community-appointed experts in investigations, ensuring that reports comprehensively reflect the social and environmental consequences of space accidents.

The greatest challenge to a functional cross-border space accident investigation framework is the political interest behind national security and economic completeness. While space accident investigations rely on cross-border collaboration, national security concerns, particularly from the United States, impose strict controls on sharing technical data, often hampering effective investigations. The Intelsat 708 failure and recent obstacles faced by the UK AAIB in the LauncherOne investigation, underscore the serious legal challenges created by these export controls. Although TSAs offer a bilateral framework for sharing information, practical restrictions still impede timely access to data. However, these bilateral efforts could pave the way to a potential regional or multilateral framework of investigational data sharing. Before that happens, export control remains the foremost challenge in establishing an effective, cooperative framework for space accident investigation.

Chapter 5: Conclusion

In her article about NTSB's preparedness for space accident investigation in the new space era, Lorenda Ward, the chief of NTSB Air Carrier and Space Investigations Division, shared the story about the SpaceShipTwo accident investigation: "[a]t the end of the investigation, a couple of the party members mentioned that when we first arrived on scene, wearing our blue jackets with giant yellow letters, they had no idea what to expect or what they were in for. They thought they were being invaded. ... That initial reaction turned to one of trust as the investigation progressed."³⁸⁰ The confusion and uncertainty among the investigated parties are understandable. As Chapter 3 has discussed, the NTSB does not have a clear investigation authority over space accident investigation under US domestic law at the time and until now. Having this in mind, imagine the chaos a cross-border space accident could bring without an international framework to cooperate in an investigation and harmonization of relevant national laws and interests.

This thesis has highlighted the absence of a formal international framework for space accident investigations while demonstrating that international legal principles offer valuable guidance for its development. Drawing on the successes of aviation and maritime law, particularly Annex 13 and the Casualty Investigation Code, it underscores the importance of independent investigations, broad participation, and adaptability to domain-specific needs. These models illustrate how tailored frameworks can enhance safety.

Article VI of the Outer Space Treaty establishes state responsibility for national activities, including those of private entities. Space accidents that extend beyond a state's territory may breach the principle of due regard under the treaty, the obligation of not causing transboundary harm or respect of territorial sovereignty. In such cases, investigations could serve as assurances

³⁸⁰ Lorenda Ward, "Ready to Answer the Call", (21 July 2022), online: *NTSB Safety Compass Blog* .

and guarantees of non-repetition, aligning with the law on state responsibility. However, the lack of binding international provisions for space accident investigations currently leaves such efforts reliant on an *ad hoc* basis, which is often inconsistent and could be hindered by export controls.

By conducting a comparative analysis of national laws and practices in the US, the UK, and Australia, this study highlights shared principles, divergent approaches, and the lessons they offer for developing a cohesive international system. The definitions of space accidents, which determine the threshold for initiating investigations, vary significantly across the examined countries. The US employs broad definitions, reflecting a comprehensive safety-first approach. Australia, by contrast, adopts the narrowest definition, with recommendations about further restricting its scope. These differences illustrate how national priorities, levels of technological advancement, and the scale of space sector involvement shape regulatory choices.

The authorities responsible for space accident investigations also vary, influenced by historical experiences and resource availability. In the US, ongoing discussions about the NTSB role reveal potential challenges in applying an independent investigation model to the rapidly evolving space industry. For emerging spacefaring nations, an operator-led investigation model under regulatory oversight may offer a more pragmatic approach.

The UK has adopted the most comprehensive framework of the three, drawing heavily on the Annex 13 model. This is evident in its detailed definitions of accidents, the inclusion of relevant parties in investigations, and robust protections for sensitive safety information. However, without structured international cooperation, implementing such a model effectively remains a significant challenge.

Beyond the primary purpose of preventing reoccurrence and promoting safety, the interconnected issues of insurance, social and environmental impacts reveal that any effective

framework for space accident investigation must address not only international law and domestic investigatory rules but also broader legal, financial, and political factors. Insurance plays a critical role in space activities, particularly in the aftermath of accidents. The parallels with aviation insurance highlight the importance of thorough investigations, which align with insurers' objectives of reducing claims and fostering risk prevention. Despite their indirect role, insurers influence investigations through state representatives and contractual obligations, ensuring that financial liabilities, such as recovery and investigation costs, are appropriately managed.

The social and environmental consequences of space accidents add another layer of complexity. Annex 13 or the UK Regulations 2021 largely exclude the voices of affected communities and states, focusing primarily on technical aspects. To bridge this gap, this thesis argues for the inclusion of community-appointed experts in investigations. Their participation would ensure that reports comprehensively address the social and environmental dimensions of space accidents, fostering accountability and building public trust.

Ultimately, the most formidable challenge to a functional cross-border space accident investigation framework is the tension between national security interests and the need for international cooperation. Export control laws, particularly those of the US, impose significant restrictions on sharing technical data, often stalling investigations and complicating collaborative efforts. While bilateral frameworks, such as TSAs, provide limited pathways for collaboration, they remain insufficient for addressing the broader challenges of export control. However, these efforts could serve as a foundation for regional or multilateral data-sharing frameworks in the future.

As commercial space activities expand, the need for a cohesive international framework for space accident investigations becomes increasingly critical. Such a framework must address jurisdictional challenges, balance transparency with national security, and facilitate cross-border cooperation while considering financial, social, and political dimensions. Developing a treaty or protocol specifically tailored to space accidents offers a promising path forward, drawing on lessons from existing legal regimes and fostering international collaboration. This thesis highlights the limitations of fragmented national efforts and underscores the necessity of a unified system to enhance safety, responsibility, and sustainability in the global space sector. By tackling these challenges, the international community can ensure a more secure, cooperative, and inclusive future for space exploration.

BIBLIOGRAPHY

LEGISLATION

14 CFR § 401.3.

14 CFR § 401.7 (2021).

14 CFR § 450.173.

22 CFR § 120.33.

22 CFR § 121.1.

22 CFR § 124.15 (2014).

49 CFR § 831.11.

49 USC § 1131, 2022.

49 USC § 1134(a).

49 USC § 1134(b).

49 USC § 1134(f).

49 USC § 1134(g).

51 USC § 70701.

51 USC § 70702, 2010.

51 USC § 70703, 2010.

51 USC § 70704, 2010.

51 USC § 70705.

51 USC § 70706, 2010.

51 USC § 70709.

51 USC § 70710.

Act on Launching of Spacecraft, etc. and Control of Spacecraft (Japan).

Commercial Space Investigations, 86 Fed Reg 63324 (2021).

Law of the Russian Federation on Space Activities (Russia).

Loi n° 2008-518 du 3 juin 2008 relative aux opérations spatiales (1), JO, 4 June 2008, no129.

Space Development Act, 2021 (Taiwan).

Space Development Promotion Act (Republic of Korea).

Space Industry Act 2018 (UK).

Space (Launches and Returns) Act 2018 (Commonwealth), 1998/123, (Austl).

The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 (UK).

The Spaceflight Activities (Investigation of Spaceflight Accidents) Regulations 2021 (UK).

INTERNATIONAL TREATIES

Agreement between the Government of Australia and the Government of the United States of America on Technology Safeguards Associated with United States Participation in Space Launches from Australia, 26 October 2023, online: <https://www.aph.gov.au/Parliamentary_Business/Committees/Joint/Treaties/AU-USSpaceLaunches/Treaty_being_considered>.

Agreement between the Government of New Zealand and the Government of the United States of America on Technology Safeguards Associated with United States Participation in Space Launches from New Zealand, 16 June 2016, online: <https://www.treaties.mfat.govt.nz/search/details/t/3858/c_1>.

Agreement in the form of an Exchange of Notes between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the United States of America on Technology Safeguards associated with United States Participation in Space Launches from the United Kingdom, 16 June 2020.

Agreement on the rescue of astronauts, the return of astronauts and the return of objects launched into outer space, 3 December 1968, 672 UNTS 119.

Arrangement between the Government of the United States of America and the Government of the United Kingdom of Great Britain and Northern Ireland relating to the Agreement between the Government of the United States of America and the Government of the United Kingdom of Great Britain and Northern Ireland On Technology Safeguards Associated with United States Participation in Space Launches from the United Kingdom, 16 June 2020.

Articles on Responsibility of States for Internationally Wrongful Acts, UNGA, UN Doc A/RES/56/83 (2001).

Convention on Civil Aviation, 7 December 1944, 15 UNTS 295.

Convention on Registration of Objects Launched into Outer Space, 15 September 1976, 1023 UNTS 15.

Convention on the international liability for damage caused by space objects, 29 March 1972, 961 UNTS 187.

Memorandum of Agreement on Satellite Technology Safeguards Between the Governments of the United States of America and the People's Republic of China, 17 December 1988, 28:3 ILM 604–9.

Memorandum of Agreement on Satellite Technology Safeguards Between the Governments of the United States of America and the People's Republic of China, 11 February 1993, online: https://csps.aerospace.org/sites/default/files/2021-08/Tech%20Safeguards%20Agreement%20-%20China%20Feb93.pdf>.

Statute of International Court of Justice, 26 June 1945, TS 993.

Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 27 January 1967, 610 UNTS 205.

Vienna Convention on the Law of Treaties, 23 May 1969, 1155 UNTS 331.

JURISPRUDENCE

Arbitral Award of 31 July 1989 (Guinea-Bissau v Senegal), [1991] ICJ Rep 53.

Corfu Channel Case (United Kingdom of Great Britain and Northern Ireland v Albania), [1949] ICJ Rep 4.

Gabčíkovo-Nagymaros Project (Hungary v Slovakia), [1997] ICJ Rep 7.

LaGrand (Germany v United States of America), [2001] ICJ Rep 466.

Legality of the Threat or Use of Nuclear Weapons, [1996] ICJ Rep 226.

Military and Paramilitary Activities in and against Nicaragua (Nicaragua v United States of America), [1986] ICJ Rep 14.

SECONDARY MATERIAL: MONOGRAPHS AND REPORTS

Air Accidents Investigation Branch, *Statement on an investigation into why launch vehicle LauncherOne did not reach orbit following its launch from Cornwall Spaceport on 9 January 2023* (2024).

Australian Space Agency, Summary of the investigation report into the accident relating to the Hapith I Rocket at WWOLC, South Australia on 16 September 2021 (2022).

Crawford, James, *Brownlie's Principles of Public International Law* (Oxford: Oxford University Press, 2019).

Dempsey, Paul Stephen, *Public International Air Law*, 2d ed (Montreal: Centre for Research of Air and Space Law, McGill University, 2017).

Hobe, Stephan, Space law, 2d ed (Baden-Baden: Nomos/Hart, 2023).

ICAO, Annex 13 to the Convention on International Civil Aviation (2020).

———, Manual of Aircraft Accident and Incident Investigation, 2d ed, Doc 9756 AN/965 (2015).

Jasanoff, Sheila, The Fifth Branch: Science Advisers as Policymakers (Harvard Univ Press, 1990).

Koller, Josef S et al, *Commercial Human Spaceflight Safety Regulatory Framework* (The Aerospace Corporation, 2022).

McMartin, Neville, *Final Report of the Investigation into the anomaly of the HyShot Rocket at Woomera, South Australia on 30 October 2001* (Australian Transport Safety Bureau, 2002).

National Transportation Safety Board, Aerospace Accident Report: In-Flight Breakup During Test Flight Scaled Composites SpaceShipTwo, N339SS Near Koehn Dry Lake, California October 31, 2014 (Washington, D.C., 2015).

NTSB, Information And Guidance for Parties to NTSB Accident and Incident Investigations.

Reason, James, Managing the Risks of Organizational Accidents (London: Routledge, 2016).

Stephan Hobe, Bernhard Schmidt-Tedd, & Kai-Uwe Schrogl, eds, *Cologne Commentary on Space Law: Volume 1 - Outer Space Treaty* (Cologne: Carl Heymanns Verlag, 2009).

Stubbe, Peter, *State Accountability for Space Debris: A Legal Study of Responsibility for Polluting the Space Environment and Liability for Damage Caused by Space Debris* (Brill Nijhoff, 2017).

U S Government Accountability Office, *Commercial Space Transportation: FAA Should Improve Its Mishap Investigation Process* (2023).

UK Civil Aviation Authority, *Guidance on the investigation of spaceflight accidents*, CAP 2219 (West Sussex: Civil Aviation Authority, 2021).

UK Government, *Space Regulatory Review 2024*, Research Paper Number 2024/007 (London, 2024).

United States, *Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China* (Washington: U.S. G.P.O, 1999).

United States, *Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China*, Report / 105th Congress, 2d session, House of Representatives ;105-851 (Washington: U.S. G.P.O, 1999).

US, Federal Aviation Administration, Advisory Circular: Part 450 Mishap Plan – Reporting, Response, and Investigation Requirements (AC no 450.173-1) (2021).

US Department of Commerce & FAA, Introduction to U.S. Export Controls for the Commercial Space Industry, 2d ed (Washington D.C., 2017).

Vaughan, Diane, *The Challenger launch decision: risky technology, culture, and deviance at NASA* (Chicago: University of Chicago Press, 1996).

Viikari, Lotta, *The Environmental Element in Space Law: Assessing the Present and Charting the Future* (Brill Nijhoff, 2008).

Adoption of the Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code), IMO, 2008, Res MSC.255(84).

Columbia Accident Investigation Board Report Volume 1 (Washington, D.C., 2003).

Commentary to ARSIWA, in Yearbook of The International Law Commission 2001, vol 2, part 2 (New York: UN 2007).

Report to the President By the PRESIDENTIAL COMMISSION On the Space Shuttle Challenger Accident (Washington, D.C., 1986).

SECONDARY MATERIAL: ARTICLES AND OTHERS

AAIB, *Investigating Space Accidents* (delivered at International Transportation Safety Association Annual Meeting, Taipei, 6 June 2023) online: <a href="https://itsasafety.com/material-2023/selign:com/material-2023/selig

Agencies, "China satellite triggers air raid alert", *Taipei Times* (10 January 2024), online: https://www.taipeitimes.com/News/taiwan/archives/2024/01/10/2003811888.

Ali, Mansur Armin Bin, "Legal Status of Accident Investigation Results of Space Activities in The Process of Enforcement of Space Law Enforcement in Indonesia: Between Procedural Justice and Substance Justice" (2023) 11:2 Jurnal IUS Kajian Hukum dan Keadilan 292–300.

Awford, Ian, "Aircraft Accident Investigation: from an insurance perspective" (1984) Air and Space Law 13–26.

Bekus, Nelly, "Outer space technopolitics and postcolonial modernity in Kazakhstan" (2022) 41:2 Central Asian Survey 347–367.

Bohlmann, Ulrike M & Gina Petrovici, "Space Export Control Law and Regulations" in Kai-Uwe Schrogl, ed, *Handbook of Space Security: Policies, Applications and Programs* (Cham: Springer International Publishing, 2020) 185.

Byers, Michael et al, "Unnecessary risks created by uncontrolled rocket reentries" (2022) 6:9 Nat Astron 1093–1097.

Canada, Global Affairs, "Canada and United States conclude negotiations on Technology Safeguards Agreement", (2 August 2024), online: https://www.canada.ca/en/global-affairs/news/2024/08/canada-and-united-states-conclude-negotiations-on-technology-safeguards-agreement.html>.

Challinor, Chloe AS, "Accident Investigators Are the Guardians of Public Safety: The Importance of Safeguarding the Independence of Air Accident Investigations as Illustrated by Recent Accidents" (2017) Air and Space Law 43–70.

Chen, Lung-chu, "International Law in a Policy-Oriented Perspective" in *An Introduction to Contemporary International Law: A Policy-Oriented Perspective* (Oxford University Press, 2015) 3.

Chen, Stephan Hobe, Kuan-Wei, "Legal status of outer space and celestial bodies" in *Routledge Handbook of Space Law* (Routledge, 2016).

Cheng, Bin, "From Air Law to Space Law" in Bin Cheng, ed, *Studies in International Space Law* (Oxford University Press, 1997).

Crook, Jason A, "National Insecurity: Itar and the Technological Impairment of U.S. National Space Policy" (2009) 74:3 J Air L & Com 505–526.

Department Of State, "U.S. Department of State Reaches Settlement with Boeing and Hughes", online: https://2001-2009.state.gov/r/pa/prs/ps/2003/18275.htm>.

Fitzgerald, P Paul, "Questioning the Regulation of Aviation Safety Section I: Leading Articles: Part A: Air Law" (2012) 37 Annals Air & Space L 1–46.

Galison, Peter, "An Accident of History" in Peter Galison & Alex Roland, eds, *Atmospheric Flight in the Twentieth Century* (Dordrecht: Springer Netherlands, 2000) 3.

Harrington, Andrea J, "Space business and insurance issues in the United States" in *Space Insurance and the Law: Maximizing Private Activities in Outer Space* (Northampton: Edward Elgar Publishing, 2021) 117.

Hasin, Gershon, "Confronting Space Debris through the Regime Evolution Approach" (2021) 97 Int'l L Stud Ser US Naval War Col 1073–1159.

Hedgepeth, Anna, "Mica Nguyen Worthy Submits First-of-its-Kind Claim to NASA Seeking Recovery From Damages Sustained from Space Debris", (21 June 2024), online: *Cranfill Sumner LLP* https://www.cshlaw.com/news/mica-nguyen-worthy-submits-first-of-its-kind-claim-to-nasa-seeking-recovery-from-damages-sustained-from-space-debris/.

Howell, Elizabeth, "Junk from a SpaceX Dragon 'trunk' may have crashed into a Canadian farmer's field (photos)", (17 May 2024), online: *Space.com* https://www.space.com/space-crew-dragon-trunk-space-debris-canada.

Jakhu, Ram S, "Iridium-Cosmos collision and its implications for space operations" in Kai-Uwe Schrogl et al, eds, *Yearbook on Space Policy 2008/2009: Setting New Trends* Yearbook on Space Policy (Vienna: Springer, 2010) 254.

Jakhu, Ram S & Steven Freeland, "The Relationship Between the Outer Space Treaty and Customary International Law" (2016) SSRN Electronic Journal, online: https://www.ssrn.com/abstract=3397145>.

Jakhu, Ram S, Steven Freeland & Kuan-Wei Chen, "The Sources of International Space Law: Revisited" (2018) 67:4 ZLW 606–667.

Jakhu, Ram S, Tommaso Sgobba & Paul Stephen Dempsey, "Background" in Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey, eds, *The Need for an Integrated Regulatory Regime for Aviation and Space: ICAO for Space*? (Vienna: Springer Vienna, 2011) 1.

——, "Background" in Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey, eds, *The Need for an Integrated Regulatory Regime for Aviation and Space: ICAO for Space?* (Vienna: Springer Vienna, 2011) 1.

———, "Proposal for a New Regulatory Regime" in Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey, eds, *The Need for an Integrated Regulatory Regime for Aviation and Space: ICAO for Space*? (Vienna: Springer Vienna, 2011) 117.

——, "Safety Issues" in Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey, eds, *The Need for an Integrated Regulatory Regime for Aviation and Space: ICAO for Space?* (Vienna: Springer Vienna, 2011) 69.

Jarreau, J Steven & Jeanne L Amy, "The Investigation of Domestic Commercial Space Accidents by the United States" (2024) 36:2 Air & Space Lawyer 1, 15–9.

Kischel, Uwe, "The Comparative Method" in *Comparative Law* (Oxford University Press, 2019) 87.

Krige, John, "Export Controls as Instruments to Regulate Knowledge Acquisition in a Globalizing Economy" in John Krige, ed, *How Knowledge Moves: Writing the Transnational History of Science and Technology* (University of Chicago Press, 2019).

Kunstadter, Christopher T W, "What Keeps Space Insurers Up at Night?" (2022) 34:3 Air & Space Lawyer 10–11.

Kwai, Isabella, "A Rocket Took Off From Sweden. Part of It Landed in Norway.", *The New York Times* (26 April 2023), online: https://www.nytimes.com/2023/04/26/world/europe/sweden-norway-rocket.html>.

Mey, Jan Helge, "Space Debris Remediation" (2012) 61:2 ZLW 251–272.

Milde, Michael, "Aircraft accident investigation in international law" (1984) 9:1 Air and Space Law.

Moscow, Joshua C, "Independence and Liability in Civil Aviation Accident Investigations through Annex 13 and the Montreal Convention Notes" (2022) 55:3 Vand J Transnat'l L [ix]-874.

NASA, "Commercial Crew Program Essentials", online: https://www.nasa.gov/humans-in-space/commercial-crew-program/commercial-crew-program-essentials/.

------, "Human Landing Systems", online: <https://www.nasa.gov/reference/human-landing-systems/>.

—, "NASA Statement on Orbital Debris", (15 April 2024), online: *NASA* https://blogs.nasa.gov/spacestation/2024/04/15/nasa-completes-analysis-of-recovered-space-object/.

National Transportation Safety Board, "Commercial Space", online: https://www.ntsb.gov/about/organization/AS/Pages/Commercial-Space-.aspx.

National Aeronautics and Space Administration, "Memorandum For the Apollo 204 Review Board", (27 January 1967), online: https://www.nasa.gov/history/Apollo204/15.html.

Nelson, Timothy G, "Regulating the Void: In-Orbit Collisions and Space Debris" 40 J Space L 105–130.

Posner, Katherine B & Wendy A Grossman, "An Aviation Insurance Primer: An Overview for the Aviation Practitioner" in Andrew J Harakas, ed, *Litigation the Aviation Case*, 4th ed (Chicago: American Bar Association) 617.

Savitt, Lisa J, "Admissibility and Use of Government Aviation Accident Investigation Reports" in Andrew J Harakas, ed, *Litigating the Aviation Case*, fourth edition ed (Chicago: American Bar Association, 2017) 479.

Schulenburg, Lisa Gräfin von der & Matthias Creydt, "Export control and NewSpace: Reciprocal challenges" in *Routledge Handbook of Commercial Space Law* (Routledge, 2023).

Scully, Janene, "Mountain Biker Dodges Debris from Alpha Rocket Explosion on Orcutt Ride",
NoozhawkNoozhawk(3September2021),online:<http://www.noozhawk.com/vandenberg</td>hotline seeks details about alpha rocket debris/>.

Sedor, Joseph M, "Do We Need an Annex 13 for Commercial Space Accidents?" (2021) 54:1 ISASI Forum 4–7.

Swinhoe, Dan, "Paying the premium: Why 2023 was a bad year for space insurance", (3 September 2024), online: https://www.datacenterdynamics.com/en/analysis/paying-the-premium-why-2023-was-a-bad-year-for-space-insurance/.

The House Committee on Science, Space and Technology, "Chairwoman Johnson and Ranking Member Lucas Letter to President Biden Urging Rescindment of NTSB Proposal that would Exceed Agency Authority", (6 April 2022), online: https://democrats-nthrows.pdf

science.house.gov/chairwoman-johnson-and-ranking-member-lucas-letter-to-president-biden-on-ntsb-proposal-that-would-exceed-agency-authority>.

Todd, David, "Space Insurers wither from 'worst year' in over twenty years as claims get close to US\$1 billion (Updated and corrected)", (7 December 2023), online: *Seradata* .

United States Government Accountability Office, *Commercial Space Transportation: FAA Should Improve Its Mishap Investigation Process*, by United States Government Accountability Office (2023).

US, Memorandum of Agreement between the NTSB and FAA concerning Commercial Space Mishap Investigations (2022).

Ward, Lorenda, "Ready to Answer the Call", (21 July 2022), online: *NTSB Safety Compass Blog* .

Webb, David, "The Environmental Effects of Space Tourism" in *Space Tourism* (Routledge India, 2024).

Wynne, Brian, "Unruly Technology: Practical Rules, Impractical Discourses and Public Understanding" (1988) 18:1 Social Studies of Science 147–167.

Xinhua, "Chinese, European scientists join hands to explore universe's mystery", *Xinhua Net* (18 January 2024), online: https://english.news.cn/20240118/25c7e9fedcc3407fb6cb059d69296d1b/c.html.

"Air Accidents Investigation Branch appointed as Space Accident Investigation Authority for the United Kingdom", (29 July 2021), online: *GOVUK* https://www.gov.uk/government/news/air-accidents-investigation-branch-appointed-as-space-accident-investigation-authority-for-the-united-kingdom>.

"Canada: Claim Against the Union of Soviet Socialist Republics for Damage Caused by Soviet Cosmos 954" (1979) 18:4 International Legal Materials 899–930.

"Damages to U.S. Government Buildings Overseas*" (1965) 4:4 International Legal Materials 696–698.

"History of The National Transportation Safety Board", online: https://www.ntsb.gov/about/history/Pages/default.aspx>.

"Loral Agrees to a \$14 Million Settlement for Alleged ITAR Violations", (10 January 2002), online: *Export Compliance Training Institute* https://www.learnexportcompliance.com/loral-agrees-to-a-14-million-settlement-for-alleged-itar-violations/>.

"Material 2023", (29 June 2023), online: *ITSA - International Transportation Safety Association* https://itsasafety.com/material-2023/.

"NTSB and FAA Sign Agreement on Commercial Space Mishap Investigations", (9 September 2022), online: https://www.ntsb.gov/news/press-releases/Pages/nr20220909.aspx.

Protocol between the Government of Canada and the Government of the Union of Soviet Socialist Republics (Canada and USSR) (1981).

"Recovery and Return of Objects Launched into Outer Space", online: https://www.unoosa.org/oosa/en/treatyimplementation/arra-art-v/unlfd.html.

"Taipei 2023", (29 June 2023), online: ITSA < https://itsasafety.com/taipei-2023/>.

Technical report on space debris: text of the report adopted by the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space, A/AC.105/720 (New York: UN, 1999).