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Letter From Chairperson of the Board

To those who dare to imagine and build the future,

ULTEK has long been the destination of choice for participants who are passionate about technology, eager to develop their skills, and ready to share their innovative ideas. After a five-year hiatus, we return stronger and more comprehensive than ever before — and it is my honor to welcome you to ULTEK, the 4th International Congress on Technology and Society.

Over three days, you will engage with distinguished scholars, share forward-thinking ideas, and contribute to knowledge that bridges technology and society. ULTEK provides not just a platform for sharing, but a space for action — where ideas become solutions and collaborations create lasting impact. Welcome to ULTEK'25 — where the future begins.

Nilgün Nihal Çalık,

Chairperson of the Board

Letter From Under Secretary Generals

Dear Delegates,

It is our honor to welcome you to the Aerospace Research Committee. We are truly excited to have you as part of this important platform, where knowledge, discipline, and collaboration will guide our work. The future of aerospace exploration depends not only on technological development but also on the dedication and vision of individuals like you, who are ready to contribute to meaningful discussions and innovative solutions.

This committee will challenge you to think critically, research carefully, and remain committed to academic and diplomatic excellence. Every delegate is encouraged to approach the topics with seriousness, preparation, and curiosity. We believe that research is not just a tool, but the foundation of progress. Without study, analysis, and persistence, no advancement in aerospace can be sustainable. Therefore, your responsibility in this committee extends beyond debate—it requires genuine effort to understand, evaluate, and propose.

Our aim is not only to discuss aerospace research but also to reflect on the role it plays in shaping the future of humanity. The discoveries made in this field influence communication, security, exploration, and global cooperation. As delegates, your task is to ensure that the spirit of innovation is matched with responsibility and awareness.

We kindly remind you that preparation is the key to success in this committee. Read, analyze, and investigate every aspect of the agenda items. Approach your role with discipline and determination, and do not hesitate to bring creativity into your arguments. Together, we will make this committee a place of rigorous debate, insightful collaboration, and meaningful outcomes.

We look forward to witnessing your contributions, and we trust that with your dedication, this committee will reach its highest potential.

Sincerely,

Elmas CANDALI-Zeynep ÖZDEMİR

INTRODUCTORY UNIT: Aim of the Council

As the moderators of this council, our expectation from the delegates is to negotiate the future of aerospace research by taking into consideration both past and present developments, while seeking solid solutions to ongoing challenges, the role of international cooperation and security concerns.

UNIT 1: TECHNICAL ASPECTS OF AEROSPACE RESEARCH

1.Foundations of Aerospace Research

1.1 Definition & Historical Evolution

The ever evolving topics in aerospace include the traditional areas of gas dynamics, flight dynamics, control, structures and materials while exploring the future needs for the aerospace enterprise. It applies scientific knowledge to the design, manufacture and operation of aircraft.

The foundations of modern aerospace research were laid with experimental flights in the early 20th century.

In 1903, the Wright Brothers' first powered and controlled flight initiated a research revolution in understanding the physics of flight. The “wing torsion” method developed by the brothers advanced the aerodynamic knowledge of the time and became one of the first scientific methods of flight control. This development also demonstrated that flight could now be improved through systematic engineering research. However, this process had not only technological, but also legal and industrial effects; especially patent wars and licensing agreements paved the way for research and development investments in aviation.

During the First World War, the strategic importance of aviation became clear, but the inability of the American aviation industry and its lag behind the technical advances in Europe led the United States to institutional research. Therefore, the National Advisory Committee for Aeronautics (NACA), established in 1915 by an act of the US Congress, became the first systematic government sponsored aviation research organization. NACA conducted a lot of experiments and simulations focusing on aerodynamics, material durability and engine efficiency to enable aircraft to fly more safely at higher speeds. During this period, wind tunnels were widely used for the first time, and more scientific methods were adopted in aircraft design.

The Second World War caused a sudden increase in aerospace research. The competitive environment brought about by the war led to intense R&D activities, especially in areas such as jet engines, radar technology, aerodynamic optimization and high altitude flights. The first jet engines enabled the first jet aircraft to be flown in 1939, redefining the boundaries of aviation which were developed in 1937 by Frank Whittle in England and Hans von Ohain in Germany. In this period, it is seen that major innovations in production technologies, with approaches such as mass production, modular design and standardization of materials making it possible to quickly put research results into practice.

In the post war period, the direction of research turned to space. In 1957, the Soviet Union's launch of the Sputnik I satellite into orbit not only started in the space age, but also led the United States to restructure its aerospace research. NASA (National Aeronautics and Space Administration) replaced NACA in 1958, and it became the leading agency coordinating manned and unmanned space missions, bringing both aerospace and space research under one roof.

The NASA led Mercury, Gemini and Apollo programs paved the way for important research in areas such as life support systems, orbital mechanics and propulsion systems for manned spaceflight. The landing of Apollo 11 on the Moon in 1969 is considered the peak of these scientific attempts

From the 1970s, aerospace research began to rely more on international cooperation. In particular, the European Space Agency (ESA) and its technical subsidiary ESTEC (European Space Research and Technology Centre) created an integrated research and technology development network among European countries. This period also witnessed the development of civilian and military systems, and research accelerated in many areas such as satellite technologies, sensor systems, hypersonic flight and new materials resistant to the space environment.

Today, aerospace research has expanded into areas such as artificial intelligence, autonomous systems, composite materials, ion propulsion systems, microsatellites, extra atmospheric robotic missions and space tourism. Military research is also intertwined with innovative solutions such as radar deception systems, passive defense solutions, low thermal signature technologies and system resilience against electromagnetic attacks.

Understanding this historical development at the committee level is critical, not only to witness past achievements, but also to ensure that future aerospace policies are better grounded.

To those who dare to imagine and build the future,¶

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1.2 Key Terms

Aerospace: The branch of technology and industry concerned with both aviation and space flight.

Aeronautic: The science or practice of building or flying aircraft.

Satellite: The science or practice of building or flying aircraft.

Orbit: The curved path of a celestial object or spacecraft round a star, planet, or moon, especially a periodic elliptical revolution.

Aircraft: An aeroplane, helicopter, or other machine capable of flight.

NASA(National Aeronautics and Space Administration): NASA is in charge of U.S. science and technology that has to do with airplanes or space.

ESA(The European Space Agency): Its mission is to shape the development of Europe’s space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world.

Manufacturing: the making of articles on a large scale using machinery; industrial production.

Digital Twins: A digital twin is a virtual representation of reality, including physical objects, processes, and relationships. When built on a foundation of geography, it becomes a geospatial digital twin. A Digital Twin will continuously learn and update itself using data from sensors that monitor various aspects of the real life product’s environment and operating conditions. It can also factor in historical data from prior usage.

Federal Aviation Administration (FAA): The FAA is responsible for ensuring the safety of the national airspace system. It sets standards for aircraft design, production, and operation, and is responsible for certifying aircraft and aircraft components.

European Aviation Safety Agency (EASA): EASA is responsible for ensuring the safety of the European airspace system. It sets standards for aircraft design, production, and operation, and is responsible for certifying aircraft and aircraft components.

2.Recent Technical Developments

2.1 Propulsion Innovations

The technological development towards space exploration began with gunpowder rockets, which had a rather simple, but revolutionary principle of operation for the time. Rockets have been our first window to the speed and power needed to defy Earth's gravity. In the late 1950s two events of great magnitude took place, the first of which was the launch of the Sputnik 1, the first artificial satellite, in 1957, was launched into orbit by the R-7 Semiorka, an intercontinental ballistic missile powered by liquid oxygen and kerosene.

The second major milestone would be the arrival of man in outer space, who made this achievement was the cosmonaut Yuri Gagarin in 1961, who boarded the Vostok 1 rocket, achieved a benchmark for new propulsion systems and the design of aerospace engines of the future. Man's arrival in space thanks to propulsion was only one step, since years later, in 1969, the Apollo 11 mission was carried out, which culminated in the conquest of the moon. To achieve this enormous feat, the Saturn V expendable rocket was needed. This rocket had three stages that used liquid oxygen, as well as refined petroleum (first stage) and liquid hydrogen (second and third stages).

From this point on, NASA has been working hard to improve space exploration. An example of this is the Space Shuttle Program, the only vehicle implemented for the transportation of U.S. astronauts during the years 1981-2011, which even had reusable features.

Today's propulsion innovations are geared towards the search for new propulsion technologies, with the aim of increasingly efficient and sustainable explorations. As a result of this research, innovative concepts such as all electric propulsion, nuclear propulsion, and even the application of automation in exploration missions have been achieved.

2.2 Advanced Materials & Manufacturing

This topic will spotlight the research and technological advancements that are shaping the future of energy and manufacturing processes. The development of high performace materials and innovative manufacturing became critical as the aerospace industries evolve to meet the demands of space exploration, aircraft and sustainable aviation;

-Extreme-temperature and lightweight materials for energy and aerospace applications.

-Advanced and additive manufacturing of components for energy systems, air vehicles, and spacecraft.

-Materials characterization and performance under extreme conditions of temperature, corrosion, catalysis, plasma, and radiation exposure.

-Metals, composite materials, and multifunctional structures. Advanced integrated coatings and surface engineering.

-Digital manufacturing, AI driven process and composition control, AI driven design, advanced materials, and Industry 4.0 in energy and aerospace.

2.3 Avionics & Autonomous Flight Systems

Avionics covers all electronic systems used in aircraft and spacecraft. This includes communication devices, navigation systems, autopilot, radars, sensors and cockpit displays. In simple terms, everything from the screens the pilot sees to the radio that communicates with the ground, from the GPS systems that navigate the aircraft to the computers that automatically manage the flight is avionics.

Aerospace flight systems are all the mechanical and electronic control systems that make flight itself possible. In other words, the hardware that controls the direction, speed, stability and course of an air or spacecraft are grouped under this heading. For example, the ailerons, rudders, propulsion systems (engines) and the computers that manage them are part of flight systems. In spacecraft, rocket engines, guidance systems, sensors and stabilizing propulsion units (such as reaction control systems) take on this task. Thanks to these systems, the vehicle can both stay in orbit and steer to the target.

Within these systems, some components stand out. The autopilot allows the aircraft to fly on its own at a given altitude and on a given route. The pilot only gives general commands, the system does the rest. Navigation systems determine the position of the aircraft and navigate with satellite data such as GPS. Communication systems enable the pilot to communicate with air traffic control and other aircraft. Instrument displays provide pilots with information such as speed, altitude and fuel status. Radar systems alert the pilot to other aircraft, weather conditions and terrain obstacles. All of these systems work in conjunction with each other; in modern aircraft, most of these systems are integrated on a single computer network.

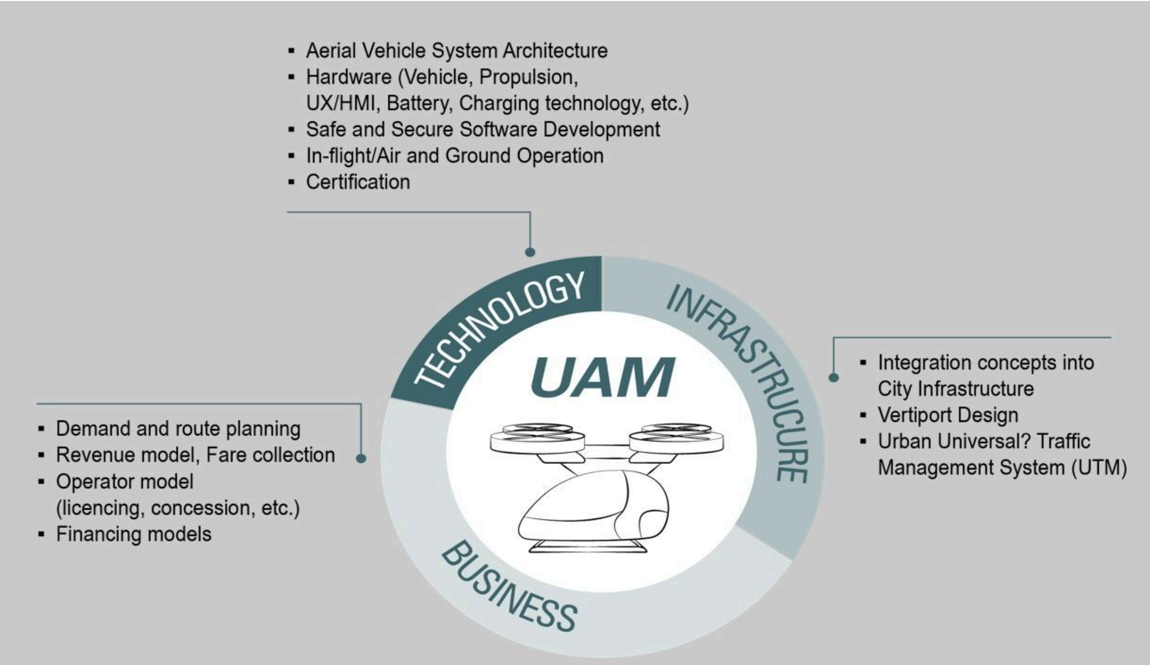
So what is the future of these systems? The aviation industry is rapidly digitalizing. Innovations such as electric airplanes, autonomous aerial vehicles (unmanned drones), flying taxis are being tested. Touch screens are now used in cockpits instead of traditional analog displays; these systems are called “glass cockpits”. On the other hand, sustainable aviation fuels (SAF) and hybrid engines are being developed to reduce carbon emissions. Electric vertical take off and landing vehicles (eVTOL), developed especially for urban transportation, are being tested in major cities such as Paris. In the near future, it is also possible that we will encounter artificial intelligence supported systems that replace pilots.

Artificial intelligence (AI) is the most exciting aspect of these technologies. Today, AI has started to analyze flight data and help pilots make safer decisions. For example, it interprets weather data to suggest routes and predict potential collisions. Some systems can even automatically make the optimal landing plan in the event of an emergency. By combining radar and camera data, AI allows the aircraft to better “see” its surroundings. In the long term, these developments will make it possible for autonomous aircraft to fly without human intervention. This will reduce the workload of pilots and prevent accidents caused by human error.

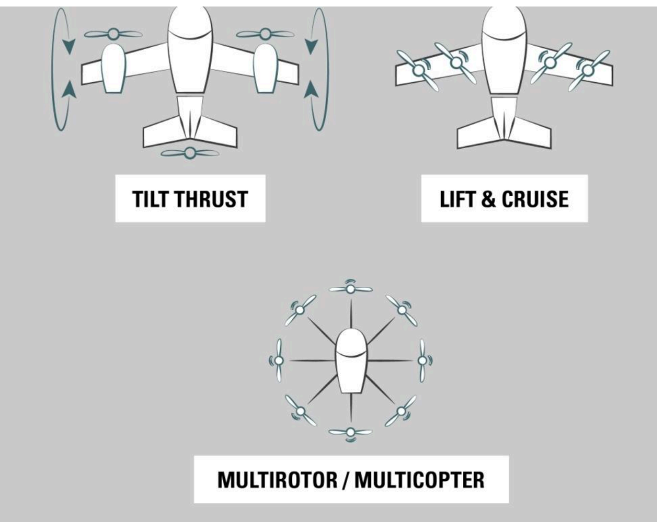
3.Technical Trends & Emerging Capabilities

3.1 Urban Air Mobility & eVTOL Vehicles

As populations in megacities continue to grow, the increased urbanization and traffic situation is pushing ground transport systems to their limits. Bringing urban mobility to the third dimension offers the potential to create a faster, cleaner, safer, and more integrated transportation system. Autonomous aerial vehicles and flying cars are no longer science fiction: Projects and trials are already taking place around the world. Major aviation and automotive manufacturers, city authorities and technology companies are working on innovative urban mobility.



An eVTOL is an electric powered vertical take off and landing (eVTOL) aircraft that can hover, take off, and land vertically. They replace a helicopter's engine and rotors with a distributed electric propulsion (DEP) system that turns smaller rotors. Today, we see three main concepts of eVTOLs with different characteristics and benefits depending on the targeted mission profile, e.g. for intra- vs. intercity mobility:



Tilt-Thrust: Tilt of wings or rotors for lift and cruise

Lift and Cruise: Independent propulsion used for lift and cruise

Multirotor: Wingless with multiple fixed rotors for lift and cruise, tilt of airframe

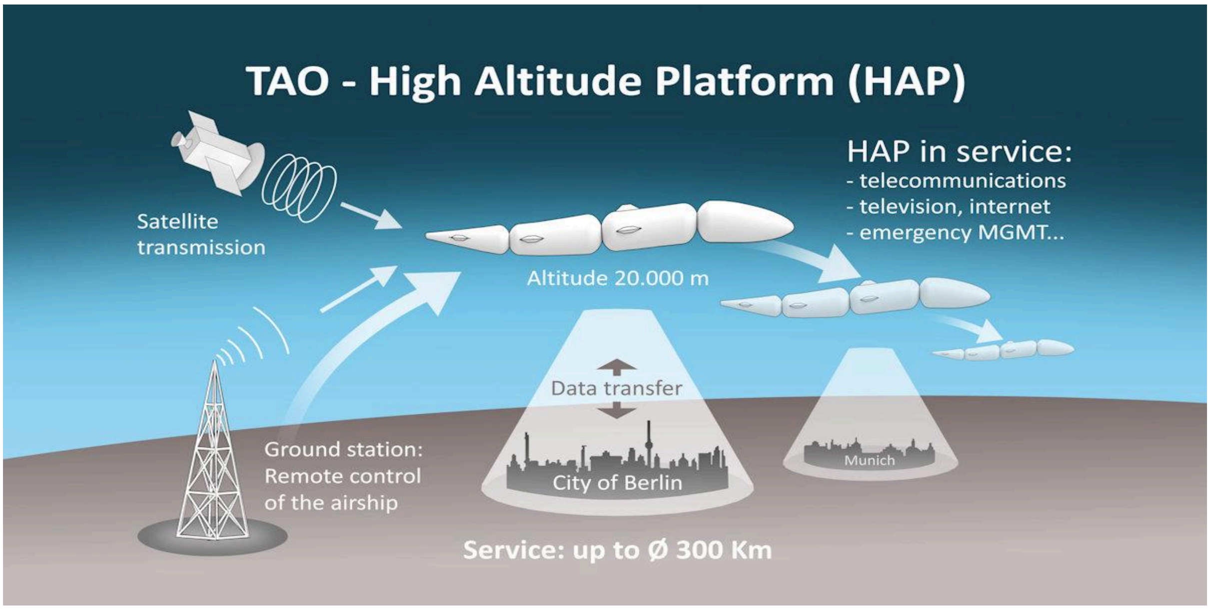
Compared to a traditional single main rotor helicopter with combustion engine, an eVTOL is significantly quieter, more reliable and safer and significantly less expensive.

VTOLs can be powered by different propulsion systems, ranging from hybrid (conventional combustion engine or gas turbine combined with e-motor) to fully electric powered solutions. Future concepts could also consider fuel cells as the primary energy source. While the different propulsion concepts have different requirements for the infrastructure and landing locations, weight and volume of the propulsion are especially important for aerial vehicles.

3.2 Hypersonic Flight & High-Altitude Platforms

Hypersonic flight provides a never before seen capability by simultaneously extending range and reducing transit time, enabling rapid reach and global targeting. High performance hypersonic offensive and defensive weapons require efficient aerodynamic designs with lightweight, durable control surfaces and leading edges capable of sustaining the extreme exposure during flight across a wide range of conditions. The Hypersonic Aerothermodynamics, High Speed Propulsion and Materials program aims to advance technologies enabling hypersonic and high speed weapons as well as scientific knowledge. Improvements in computational models and measurement techniques enable more aggressive designs that enhance lethality, survivability and range. Affirmed margin predictive multidisciplinary design tools that confidently reduce the allowable design margins enable high performance hypersonic and high speed weapons.

HAPS (High Altitude Pseudo Satellites) are a novel concept that is being developed to provide several types of services that can complement and enhance satellite based services. HAPS are aircraft (airplanes, balloons, or similar platforms) which operate in the high atmosphere in order to provide high availability and proximity services such as Earth Observation and telecommunications. In 7 years the High Altitude Platform Market has grown at over 5% CAGR (Compound Annual Growth Rate). This increase in the High Altitude Platform (HAP) market is due the demand for telecommunication services in rural and underserved locations, largely supported by government push. When compared to a terrestrial network, HAPSs provide wider coverage, less interference due to obstacles like buildings, ground elevations and have shorter time to deployment. In comparison to satellites, HAPS have lower latency (transmission delay) and could be called back for maintenance or payload reconstruction.



3.3 Unmanned Aerial Systems & Swarming Technologies

An Unmanned Aerial System (UAS) is an aircraft with no human pilot, crew, or passengers on board, but rather is controlled remotely or is autonomous. It has three components which are an autonomous or human operated control system which is usually on the ground or a ship but may be on another airborne platform; an Unmanned Aerial Vehicle (UAV); a command and control system ,sometimes referred to as a communication, command and control system, to link the two. These systems include remotely piloted air systems (RPAS) in which the UAV is controlled by a pilot using a radio data link from a remote location. UAS can also include an autonomous UAV or a semi autonomous UAV ,this is more likely. In recent years, the tendency to refer to any UAV as a drone has developed but the term is not universally considered appropriate. UAVs can vary in size from those which can be hand launched to purpose built or adapted vehicles the size of conventional fixed or rotary wing aircraft.

Swarming operations enable a group of autonomous drones to operate in a coordinated and synchronized manner. This concept is inspired by the collective behavior seen in natural swarms, such as birds or insects. Each UAV communicates with its peers in the swarm, sharing information and working together to accomplish tasks more efficiently and effectively than a single drone could on its own.

There are some kinds of applications of swarming operations. One of the most well known applications of swarming operations is in the military and defense sectors. Swarms of drones can be used for searching, surveillance, and even offensive operations. Their ability to work together provides a significant advantage in both offensive and defensive scenarios, allowing for better target identification and data collection. Swarms of drones can be used for search and rescue missions. They can quickly cover a large area, locate survivors, and communicate their findings to first responders, expediting the rescue process. Swarming operations are also making a significant impact in agriculture. UAV swarms can be used for precision agriculture, and even monitoring crop health. Lastly, Swarming UAVs can be used to monitor and protect the environment. They can survey wildlife populations, track deforestation, and even aid in firefighting efforts by providing real time information to firefighting teams.

However while UAV swarming holds huge potential, it has challenges and considerations. For a UAV swarm to function effectively, communication and cooperation between individual drones are critical. Creating reliable algorithms and communication networks is an ongoing challenge. As the usage of swarm technologies increases it is important to provide safety and regulation. Against any cybercrime, protecting the swarm's security from cybersecurity threats is essential. Lastly the battery life of swarming drones is an ongoing problem as it is hard to maintain the drones in the air, extending periods can be challenging.

3.4 Artificial Intelligence’s role in Aerospace Researches

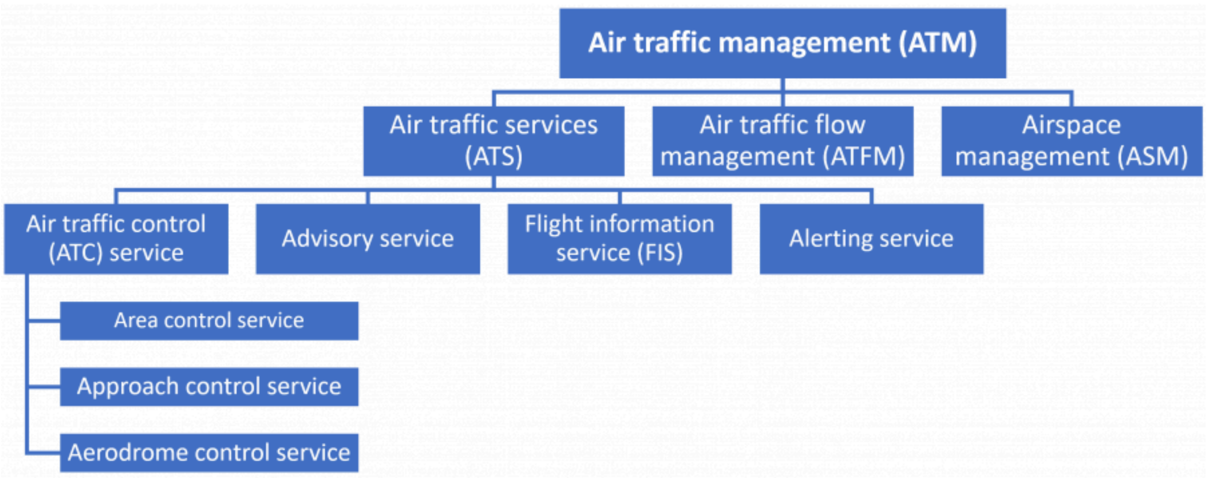
Aerospace engineering has witnessed large advancements recently, with a focus on enhancing safety, efficiency, and overall performance of aerospace systems. One area that has garnered considerable attention is the application of Artificial Intelligence (AI) techniques in aerospace engineering. AI has the potential to revolutionize the industry by enabling autonomous systems, optimizing operations, and improving decision making processes. The research significance of AI in aerospace engineering lies in its ability to address complex problems and improve system performance. AI algorithms can process large volumes of data, analyze complex patterns, and make intelligent decisions in real time. This capability is particularly valuable in the context of autonomous navigation and flight control, where AI algorithms can enable aircraft to adapt to changing environments, optimize trajectories, and ensure safe and efficient operations. Despite the potential benefits of AI in aerospace engineering, the current state of research and applications in this field is not sufficiently comprehensive. Existing literature lacks a thorough analysis and overview of the advancements, challenges, and future directions of AI in aerospace engineering.

4.Industry Applications & Use Cases

4.1 Commercial Aviation & Air Traffic Management

Commercial Aviation refers to the sector of the aviation system that involves the operation of airlines, commercial airports, and aircraft for the purpose of transporting passengers and cargo for profit. It is regulated by the Federal Aviation Administration (FAA) to ensure safety and security in air transportation.

The dynamic, integrated management of air traffic and airspace including air traffic services, airspace management and air traffic flow management through the provision of facilities and continuous services in collaboration with all parties and involving airborne and ground based functions.



Air traffic services (ATS), with the general purposes of ensuring safe and orderly traffic flow as well as providing the necessary information to flight crews and, in case of an emergency, to the appropriate bodies (alerting service). ATS is mostly performed by air traffic controllers. Their main functions are to prevent crashes by applying appropriate separation standards and issue timely clearances and instructions that create orderly flow of air traffic.

Air traffic flow management (ATFM), the primary objective of which is to regulate the flow of aircraft as efficiently as possible in order to avoid the congestion of certain control sectors. AFTM measures can be seen as pre-tactical, as they do not affect the current situation but rather the near future.

Airspace management (ASM), the purpose of which is to manage airspace, a scarce resource, as efficiently as possible in order to satisfy its many users, both civil and military. This service concerns both the way airspace is allocated to its various users (by means of routes, zones, flight levels, etc.) and the way in which it is structured in order to provide air traffic services.

4.2 Defense & National Security

The aerospace industry is a vital component of national security, providing the military with advanced aircraft, engines, and avionics. This industry is responsible for designing and manufacturing everything from fighter jets and bombers to reconnaissance drones and spacecraft. These technologies provide essential capabilities for reconnaissance, surveillance, and intelligence gathering, as well as the ability to deploy military force rapidly and effectively.

The aerospace and defense industries often work closely together, collaborating on the development of advanced technologies and equipment. This collaboration has led to significant advancements in areas such as stealth technology, unmanned aerial vehicles, and precision guided munitions. The military implementations of aerospace industry imcludes operations such as satellite based observation and missile deployment. Space has been used for military operations and as a strategic platform.

The detailed narration of the aerospace industries which we use in defense and national security has been described in our study guide under other titles.

4.3 Space Exploration & Satellite Technologies

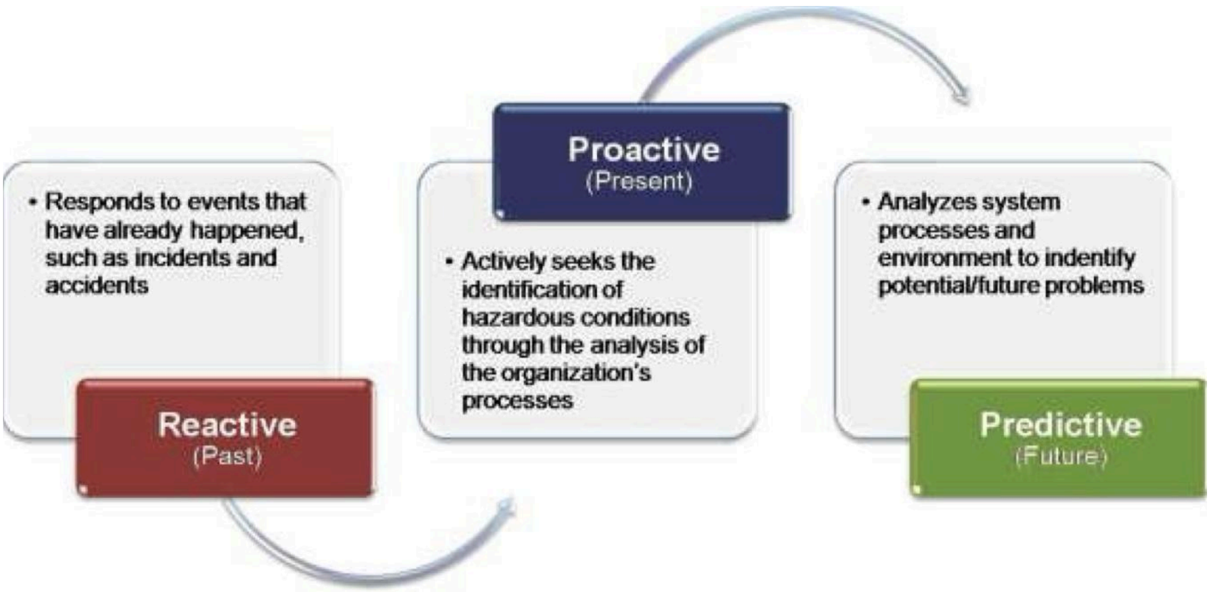
Among the services that satellites can provide for disaster risk management and emergency response are weather forecasting, remote sensing, geo-positioning, navigation, television and telecommunication. Instruments onboard satellites circling the Earth are designed to cover specific wavelength ranges of the electromagnetic spectrum in order to capture images, atmospheric sounding, satellite communication, geo-positioning and navigation.

Satellites are circling Earth in different orbits depending on the type of application or instrument onboard: A satellite in a geostationary orbit circles the Earth above the equator (0° latitude) synchronously to the Earth's rotation. It makes it suitable for communications and regional climate observation of that specific area, with high temporal but low spatial resolution.

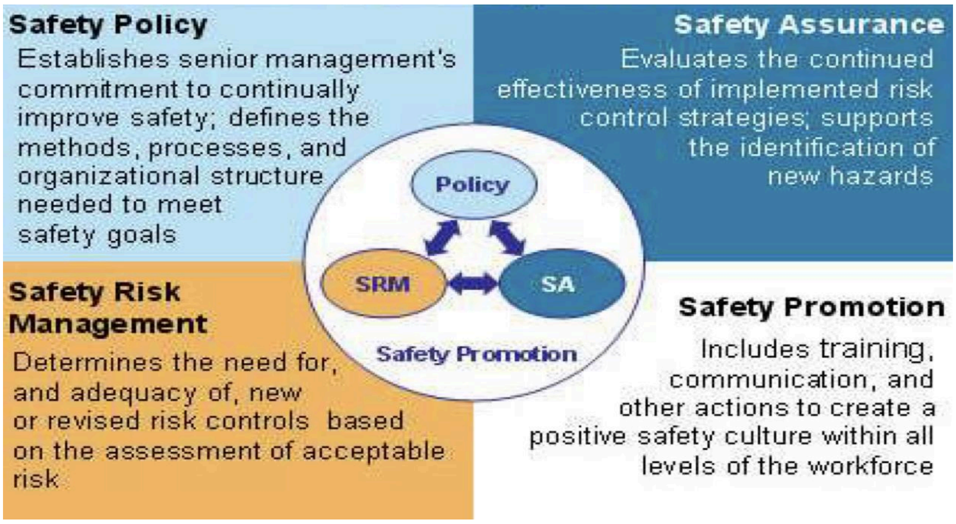
Earth observation satellites and satellites for meteorological purposes are located in low Earth orbit at an altitude. Due to the high costs of space transportation, constellations of communication or navigation satellites are also placed in Low Earth Orbit. Earth Observation satellites use either optical or radar sensors to capture images of Earth.

5.Safety and Regulation

According to the International Civil Aviation Organization (ICAO) the definition of safety is "The state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management."



An SMS is a management system for the management of safety by an organization. The framework includes four components and twelve elements representing the minimum requirements for SMS implementation:



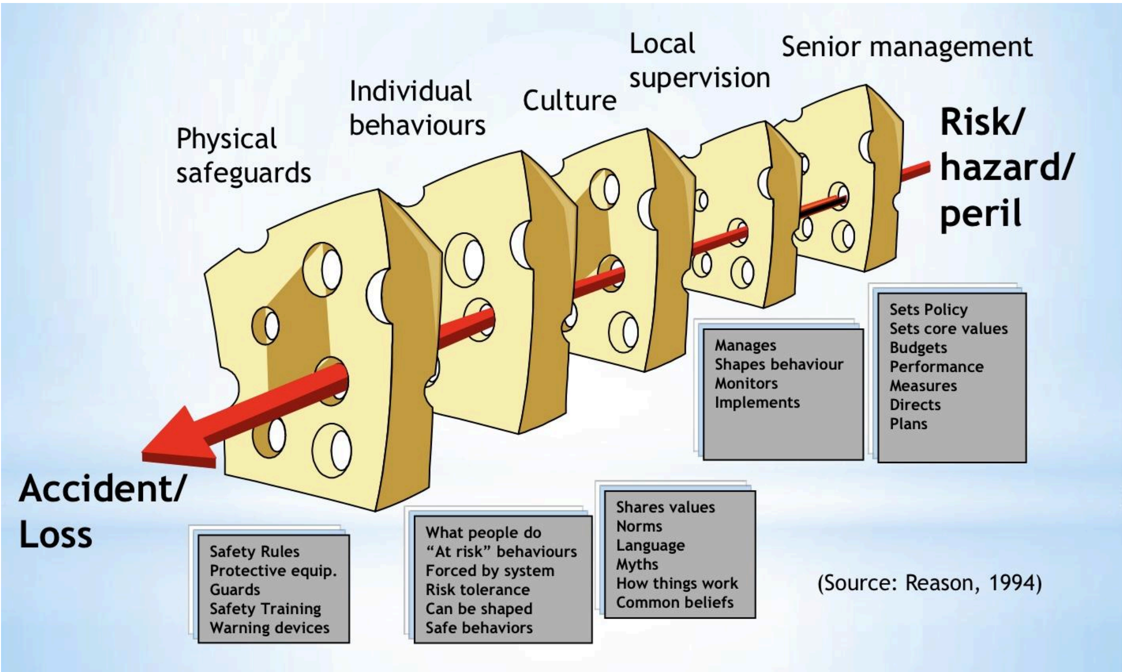
5.1 Risk Assessment & Accident Investigation

The sole objective of an investigation into an aircraft accident or incident conducted under the provisions of Annex 13 shall be the prevention of accidents and incidents. Annex 13 also states that it is not the purpose of an investigation to apportion blame or liability. Any judicial or administrative proceedings to apportion blame or liability shall be separate from any investigation conducted under the provisions of Annex 13.

An aircraft accident or incident provides evidence of hazards or deficiencies within the aviation system. A well-conducted investigation should identify all immediate and underlying systemic causes and/or contributing factors of the accident or incident. The investigation may also reveal other hazards or deficiencies within the aviation system not directly connected with the causes of the accident. The emphasis of an aircraft accident or incident investigation shall be on determining why the accident or incident happened and on recommending appropriate safety actions aimed at avoiding the hazards or eliminating the deficiencies. A properly conducted accident investigation is an important method of accident prevention.

An investigation shall also determine the facts, conditions and circumstances pertaining to the survival or non-survival of the occupants of the aircraft. Recommendations for improvements to the crashworthiness of the aircraft are aimed at preventing or minimizing injuries to aircraft occupants in future accidents.

The Final Report, which is produced at the completion of an investigation, constitutes the official conclusions and record of the accident or incident.



5.2 Data Integrity & Supply-Chain Security

Data integrity is the extent to which data is stored and transported without being corrupted. ICAO Annex 15 defines the assurance level of data integrity, a”A degree of assurance that an aeronautical data and its value has not been lost or altered since the origination or authorized amendment.”

Keeping data integrity is very important in aerospace systems because control, navigation, and monitoring all depend on accurate and consistent data for safe operation. As systems become more connected and more automatic, integrity becomes even more critical. If the data is wrong or inconsistent, it can lead to false commands or sensor readings, reduce reliability, and put safety at risk. Making sure the data is correct is difficult because of the harsh environments, complex designs, and many possible sources of faults. To reduce these risks, systems use several layers of protection. For example, backup sensors or processors check each other’s results, and digital communication and storage use error checks to find and correct damaged data. Careful testing and validation, including simulations and detailed analysis, are also used to show that data handling systems meet strict safety and reliability needs. Together, these steps help aerospace systems deal with data problems without losing safety or reliability.

Supply chain security is management of the supply chain that focuses on risk management of external suppliers, vendors, logistics, and transportation. It identifies, analyzes, and mitigates risks associated with working with outside organizations as part of your supply chain. It can include both physical security and cybersecurity for software and devices.

Top Cybersecurity Threats Facing Aviation Supply Chains which are;

Ransomware Attacks: Vendors and third-party suppliers are increasingly targeted by ransomware, which can cripple their ability to deliver critical services. This, in turn, can delay airline operations or worse, impact passenger safety if essential components are compromised.

Data Breaches: Aviation supply chains hold vast amounts of sensitive data, including design specifications, intellectual property, and personal customer information. A breach at any point in the supply chain can lead to significant financial and reputational losses.

Malware Insertion and Counterfeit Parts: With complex procurement networks, it is possible for malicious actors to insert malware through compromised components or counterfeit parts. These can be used to manipulate or corrupt the operational integrity of aircraft systems.

Insider Threats: Not all risks come from external attackers. Disgruntled employees or poorly vetted contractors within the supply chain can also pose significant risks by either leaking sensitive data or deliberately sabotaging systems.

Fourth-Party Risk: It's not just direct suppliers but also their vendors (fourth parties) that aviation companies need to monitor. Many organizations may not have visibility into these fourth-party relationships, yet the risk to the supply chain persists.

UNIT 2: ETHICAL ASPECTS OF AEROSPACE RESEARCH

6. Economic, Legal & Social Impacts

6.1 Market Dynamics & Funding Models (public vs. private)

The prominence of independent private companies in the space industry brings to light new ethical questions of how corporate greed could impact the well-being of future generations, as humanity looks to space as not only a scientific enterprise but also an untapped economic marketplace. Current experts in the field have named this conversation "space ethics" , an evolving and contentious set of guidelines that determine human conduct beyond Earth.

While the ethics of space exploration has been a topic of lively debate these past few years, the common framework in which space exploration is discussed fails to account for the infancy of the problem at hand and some of the novel ethical dilemmas that are presented. Conversations surrounding space ethics are typically discussed through the lens of utilitarian ethics, weighing the benefits of space commercialization against the potential negative consequences . Under this framework, "ethical" private space exploration is a model which maximizes innovation and technological progress, while regulation minimizes the exploitation of resources by corporations. However, the utilitarian model of ethics fails to consider the nuance that comes with a field as nascent as the "space-for-space" industry; specifically, this framework deals in absolutes and encourages behavior that results in "good" when, in reality, the idea of right and wrong is yet to be clearly defined in the industry.

Instead, virtue ethics provides a promising lens through which one can view commercial space exploration. A model that prioritizes “the role of character and virtue,” virtue ethics focuses on the journey to develop virtuous habits rather than maximizing the “good” across one’s actions . As space privatization continues to grow and change, the ethical standard for private enterprises should then be judged as an ongoing process, one that leaves room for the unknown consequences of space exploration and exploitation and adapts to the dynamic environment of the space industry. This virtue ethics framework would encourage businesses to learn to emphasize technological processes with a continual goal of improving life on Earth and beyond.

The growth of commercial involvement in the space industry would not only upend the existing economic landscape but could also potentially cause widespread ramifications in the social and political worlds, as well. In his article, Power Dynamics in the Age of Space Commercialisation, researcher Santiago Rementeria speaks to the impact the “alleged democratization” of space can have on existing power structures on Earth . In particular, Rementeria discusses two potential realizations of this phenomenon: one where the immense wealth of transnational corporations dilutes the power of government and another where countries with a greater space-based economic presence dominate over others. This discussion raises ethical questions of who deserves access to the resources space provides and whether these actors can be trusted to use that power to benefit the public rather than a select few. In either case, the freedom of corporations not tied to government agencies can create an imbalance in an already imperfect global society. This impact illustrates why corporations in the space industry must carefully consider any actions they take, especially when their technology can have such far-reaching economic, social, and geopolitical ramifications that can reshape the global power dynamics.

The changing view of space as not just a resource but as an untapped economic marketplace gives rise to the question: how much of a role should private enterprises and governments have in space? Business pundits advocate for a more decentralized model of the new space economy, which they argue will allow businesses to take on more risk than would be acceptable for the government. In the past decade, the private space industry has surpassed NASA in speed and innovation, achieving more with smaller budgets and quicker turnaround times. The capitalist model of technological innovation, dubbed the “Silicon Valley Model” by researcher Steven Casper, is at its peak in the space industry, where corporate leaders prioritize innovation and opportunities for growth above all else . Companies like SpaceX and Blue Origin have embraced this methodology, pushing the bounds of space transport and exploration under the incentives of the capitalist market [8]. Where governments are held back by the overhead of red tape and increased public scrutiny, corporations are free to pursue technological innovation in search of profits, allowing the private sector to achieve a level of scientific advancement that could have otherwise taken decades.

The technological innovation fostered by the American free-market approach highlights capitalism's dark side, including its inherent tendency toward wealth inequality. Afar magazine names Jeff Bezos, Richard Branson, and Elon Musk as the top "three space barons" of the modern age as owners of new space companies Blue Origin, Virgin Galactic, and SpaceX . These three multi-billionaires are among the nation's wealthiest, and their services, including space voyages costing more than the average U.S. home, cater exclusively to the rich, serving only a "narrow slice of humanity." This model of space privatization only further reinforces the position of the rich, providing premier access to seemingly unlimited resources to those who already possess most of the Earth's wealth and widening the wealth gap that plagues the global population.

6.2 Dual use technologies & export controls

Dual use export control is common the world over. In the United States, as in Norway, the dual use regime fosters suspicion surrounding research, leading to *prior restraint*, or censorship before the expression—in this case, publication of research—occurs. For example, US research on artificial intelligence is subject to special scrutiny and limits on knowledge-sharing, which incentivizes secrecy, discourages university-based researchers (many of whom are foreign born) from involvement in the field, and potentially limits innovation. These obstacles to academic collaboration contribute to AI research moving out of universities and into the private sector, which will determine how the technology is developed in the future.

Protecting fundamental research requires export control systems that are designed to be sensitive to the need for scientific collaboration and research openness before they are enforced. It's notable that even though the verdict of the NTNU case was overturned, it did lasting damage to the professor's career and to Norway's culture of research collaboration. Rather than continuing down this path, the research enterprise should consider alternatives to the dual use framework that better support nonproliferation and other security concerns without sacrificing scientific development.

7. ETHICAL DILEMMAS IN AEROSPACE

7.1 Militarization & weaponization of Air/Space platforms & Environmental Impact / societal implications

The National Aeronautics and Space Act of 1958 states that "activities in space should be devoted to peaceful purposes for the benefit of all [humankind]." Assessing how NASA's Moon to Mars work benefits "all humankind" can be complex. NASA has a long tradition of forward-thinking research, including research on the ethical and societal impacts of the Apollo Program in the 1960s, and a 2007 historical volume on the Agency's societal impact. NASA also has a history of exploring potential ethical and societal impacts of astrobiology research, primarily the implications of finding extraterrestrial life. 3 NASA has enlisted outside thinkers to speculate on the future of humanity. Other U.S. government activities have included research on the ethical and societal aspects of science in general, such as the Human Genome Project. NASA has not, however, systematically addressed the societal and ethical implications of human exploration, including the ongoing Moon to Mars effort.

Recent years have brought several calls for research on the ethical and societal aspects of NASA's Moon to Mars work. Some of NASA's international partners highlighted the need for broader engagement at the 2022 Moon to Mars Objectives workshop in London; so did the 2022 summary report from a Lunar Surface Science workshop on Inclusive Lunar Exploration. The latter called for research on how to integrate existing expertise in the social sciences and humanities into NASA decision-making. The National Academies' recent Planetary Science and Astrobiology Decadal Survey said NASA should study the ethics of planetary in-situ resource utilization?

NASA has been working to codify the need to assess ethical and societal implications in ways that reflect a significant realignment and structuring of Agency goals. In September 2022, NASA released its latest Moon to Mars Objectives report, which was updated and expanded based on solicited input from individuals, industry, academia and international space agencies. These updated objectives elevated science to a higher priority than had historically been the case for human exploration programs and centered some of the rationale for human exploration on benefits including improvements to the human condition, economic growth, and scientific return. These benefits are described in detail in an April 2023 NASA document on the Moon to Mars strategy. Of particular relevance, the Moon to Mars objectives report had "responsible use" as a recurring tenet (RT-6) of how NASA will explore, stating that NASA will "conduct all activities for the exploration and use of outer space for peaceful purposes consistent with international obligations, and principles for responsible behavior in space." This raises questions about the definition of responsible behavior, which requires an understanding of the societal and ethical implications of NASA's activities. In the 2023 Architecture Definition Document, NASA stated that "the responsible use of the Moon to Mars architecture may require deeper scrutiny of cultural and societal implications of future exploration."10 The Artemis and Ethics Workshop and the analysis in this report represents an initial effort to help advance understanding in that area, which will inform continued refinement of NASA's Moon to Mars plans.

7.3 Human Subject Ethics in Commercial Space (Surveillance, Privacy & Civil Liberties)

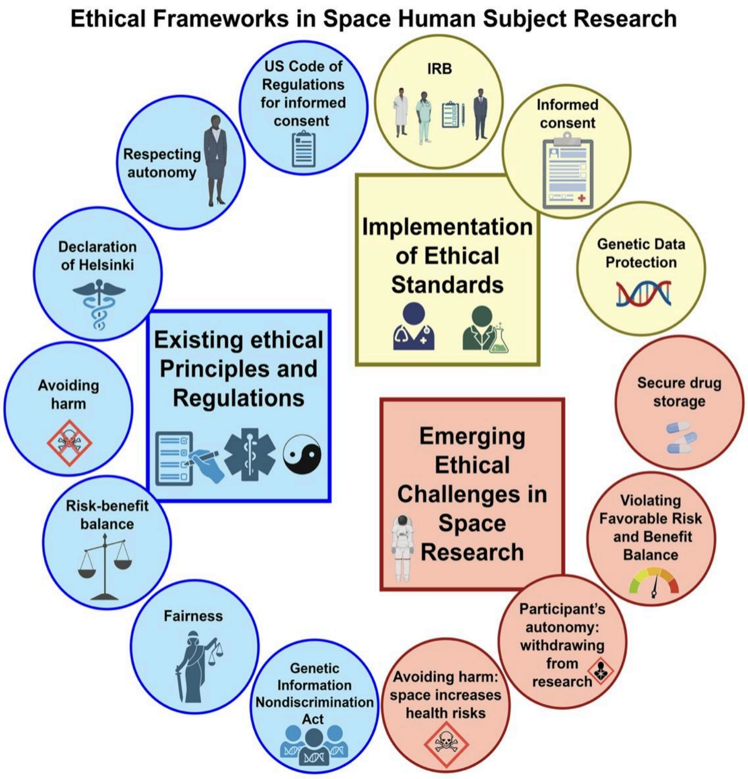
As technical and research abilities evolve, so do the ethical considerations for using human subjects for research. While NASA estimated the chance of survival of the first mission to the Moon (Apollo 8) at 50-50, such odds for harm would not be accepted for any present-day study involving human subjects. NASA's ethical principles are defined to ensure human research subject welfare and minimize health risks.

Further, research protocols can be implemented only if a risk/benefit analysis demonstrates that the risks to the subjects are reasonable in relation to the anticipated benefits and the expected importance of new knowledge. In addition to the prevention of direct harm, other important considerations include protecting privacy, ensuring strict data security, and maximizing the positive social impacts of research.

Human Subject Research projects in space, supported or otherwise subject to regulation by any US federal department or agency, are strictly regulated under the Code of Federal Regulations

NASA Institutional Review Board (IRB) committees review such research proposals to guarantee enforcement of these policies and the ethical, safe, and equitable treatment of human research subjects. In addition, the Office of Research Assurance ensures that all activities comply with applicable federal regulations and guidelines, prioritizing human subject welfare and minimal health risk for all decisions. The highest level of concern involves human subject research studies involving genetic testing. NASA defines genetic testing based on the Genetic Information Nondiscrimination Act.

Studies involving genetic testing in human subjects are deemed of the highest concern and automatically categorized as "greater than minimal risk." These studies require additional measures to protect the research subjects, including policies that prohibit the public release of genetic data without prior approval from the individual or their direct family members. NASA enforces strict rules as genetic data must be stored separately, and cross-referencing is forbidden without IRB approval. After genetic testing, all electronic data is deleted and given solely to NASA.



8. Innovation vs. Originality & Public Welfare

8.1 Codes of Ethics & Professional Standards

- Recognising the lives, safety, health and welfare of the public in the performance of their duties

- Reporting suspected violations of this element of the code to the proper authority and cooperating in furnishing further information and assistance as required.
- Ensuring that technical contributions are not compromised or biased by a conflict of interest or other inappropriate influences.
- Inform employers, silencers or other professional associations of any relationship, interests or circumstances that could influence or could be perceived to influence judgments.
- Issue no statements, criticisms, arguments or professional opinions that are paid for by interested parties, unless it's indicated on whose behalf those statements are made.
- Protect the proprietary interests or confidences concerning the business affairs or technical processes of current and former employers, clients, and colleagues except where disclosure or reporting is required by law, or consent granted.

9. MANIPULATIVE AND UNINTENDED USES

9.1 Autonomous Weapons & Ethical AI Controls

A significant challenge for operationalizing Al in AWS is the propensity for human bias to be programmed - inadvertently or otherwise - into its component algorithms. There are therefore two linked tasks: understanding the nature and potential for human bias; and coding in such a way as to avoid inputting that bias into an AWS. Such bias could have serious repercussions when distinguishing, for example, between combatants and noncombatants, or even in making judgements about the legitimacy of AWS in the first place.

Human bias

Perhaps the greatest bias that a person might have - if they are even aware of the human propensity for bias - is a sense that it does not affect them, that their own rationality can keep bias at bay. When it comes to AWS, bias operates on different levels: at a policy level there is the question of whether they should be allowed to exist, while at an operational level there are questions about how they can be used in ethical ways. Almost 50 years ago, Tversky and

Kahneman described how bias in imagining the unknown can inform the extent to which an activity might be perceived as risky:

The risk involved in an adventurous expedition, for example, is evaluated by imagining contingencies with which the expedition is not equipped to cope.
If many such difficulties are vividly portrayed, the expedition can be made to appear exceedingly dangerous...Conversely, the risk involved in an undertaking may be grossly underestimated if some possible dangers are either difficult to conceive, or simply do not come to mind.

Consider these words in the context of potentially building and operating an AWS. Discussion around AWS necessarily involves imagination because future systems that are being conceived and developed do not exist yet, even though the legal, ethical and operational challenges must be considered during the ongoing developmental process.
Take two possible opposed views. On the one hand there is implacable opposition to AWS, where they are 'made to appear exceedingly dangerous,4s drawing on science fiction tropes and imaginings that are informed by films like Terminator and I-Robot. On the other hand, technical experts and experienced military figures might be less concerned about the potential of AWS, perhaps because 'some possible dangers are either difficult to conceive, or simply do not come to mind'as a result of familiarity with the use of lethal force in a military context and the multiple legal and practical constraints that they operate within. It seems highly unlikely that either position, as they have been exaggerated here, is without bias.

Coding bias

When it comes to using AWS, bias has the potential to surface in different guises. One potential widespread risk is that the subjective bias of the coder is somehow encoded into the system through the particular lines of code that are used as the building blocks of the autonomous elements of the system. As long ago as 1996, Friedman and Nissenbaum highlighted three different categories of bias in computer systems: preexisting bias, technical bias, and emergent bias. Preexisting bias has its roots in social institutions, practices, and attitudes. Technical bias arises from technical constraints or considerations. Emergent bias arises in a context of use! Each of these types of bias is a field of study on its own, so consider the implications for AWS if coding bias was to influence their operations.

9.2 Human–Machine Teaming: Responsibility & Liability

Liability as blameworthiness is thus a common cornerstone to both civil and criminal law, even if they are crafted and applied in different contexts 45 In civil law, blameworthiness is usually established by applying common law principles such as taking reasonable care not to harm one's "neighbour" or person proximate to their conduct, 1 whereas for the criminal law it is the written Acts of some governing body such as Parliament or Congress that set out rules to be complied with. In respect of making determinations of liability, the arbiter of law (the judge) and the arbiter of fact (often a judge but occasionally a jury) are called to offer an assessment of whether one party has broken a particular rule or breached a given duty.

Given the further social significance of a criminal finding of guilt (potentially involving the loss of an individual's liability through a custodial sentence) versus the pecuniary imposition of damages through establishing negligence, the standard of proof for criminal liability is objectively higher than in civil law. This concept is expressed in most legal systems as 'beyond reasonable doubt' as opposed to
'on the balance of probabilities', 4 and is expressed in somewhat equivocal terms in Currie v Dempsey:50. In my opinion [the legal burden of proof] lies on a plaintiff, if the fact alleged (whether affirmative or negative in form) is an essential element in his cause of action, e.g. if its existence is a condition precedent to his right to maintain the action. The onus is on the defendant, if the allegation is not a denial of an essential ingredient in the cause of action, but is one which, if established, will constitute a good defence, that is, an "avoidance" of the claim which, prima facie, the plaintiff has.

Moral and physical blameworthiness is also imported into other terms used in the determination of liability. Upon assessment of a particular factual situation, questions may be asked around intent to engage in a particular act, which in turn invoke determinations of whether an action involves "strict" liability or whether liability is contingent upon finding a person held a particular state of mind - legally, the mens rea or "guilty mind" " It is only after exploring the complete factual situation that a person can be held responsible for some kind of illegal or wrongful act.This determination involves the importation of concepts of knowledge and intention to constitute moral blameworthiness, responsibility and punishment 3 Put differently, the concept of intent provides for the ascription of blameworthiness, a reflection of the aphorism that 'an agent is responsible for all and only his intentional actions'" Collectively, lawyers commonly talk of intent as both a mental state of intending some action, and intentionality of the action as motivated by that mental state. Intentionality in criminal law has a very defined, and very precise, meaning and purpose: consisting of both the intention to engage in certain conduct and an intention to bring about a result because of that conduct (or knowledge that it will occur) " This is a deliberate choice: though "strict" liability exists in crime where no proof of intention is needed, it is usually reserved for minor or regulatory offences where the removal of proving intent is not considered procedurally unfair to the accused. Equally, punishing only those offences that a person actually plans and then carries out severely constrains the legal system in regulating unlawful conduct.

So whilst intentionality and intention may appear similar in both civil and criminal law, they are treated differently and can achieve different outcomes. Good motives cannot rescue or defend wrongful conduct, either in tort or crime. In Caldwells an individual erected a wharf on public property and was charged with public nuisance. His defence - that the wharf was at the request of, and benefitted, the
local community - was dismissed by the court because he had infringed a common right. On the other hand, a malign motive will taint any form of conduct, even if the conduct itself is morally acceptable. For example, a contract is a lawful arrangement between two parties and may be undertaken by any persons in society at large to regulate their dealings. However, a contract that is objectionable on public policy or legal grounds - such as a contract to commit murder - is void and unenforceable."º
Thus, the criminal law departs from civil law because the bare formulation of mental state and conduct grounds liability: there is no need to prove a particular effect or outcome. This explains the criminalisation of conduct even where both parties may consent (such as drug dealing or prostitution"') where the offence never actually took place (such as attempting to commit a crime 2) or where the offence was actually committed by someone else (inchoate crimes such as aiding or abetting, which are treated differently to contributory negligence 3). Further, it is almost always the State - and not the infringed party - who brings proceedings for the commission of crimes. Conduct might also be criminalised without reference to culpability if there was a serious social cost. In Blackstone's Commentaries he observed that the formulation of early "Crown" offences such as treason, carnal knowledge of the queen, piracy, serving a foreign monarch or harbouring a Catholic priest were punishable without any proof of intent. Conversely, the purpose of proving intention in civil law (especially torts) — as opposed to in criminal law, where intention may be a fundamental proof of the charge - may be unnecessary. Torts are almost always actioned by the aggrieved parties, and not the State, in order to receive remedies that place the aggrieved parties as near to their original

position before the infringement. Because the focus of tort liability is generally on the existence of a duty of care, a breach of that duty, and in most cases the suffering of harm, one cannot attempt a tort, plan one or conspire to cause one." Intention is usually relevant to penalty, not liability; again, this is a deliberate choice. For the victim whose rights have been infringed, they might not necessarily care if an infringement was actuated by malice, recklessness or negligence. A search for intentionality may well be meaningless to compensate for the harm the victim suffered. That is not to say that intention in civil law is a dead or useless concept. Exemplary damages may be issued by the court in cases where the conduct was deliberately engaged in and 'of a sufficiently reprehensible kind' In this way, torts can "punish" intentional conduct in circumstances where an 'assertion of one's autonomy which, if it produces harmful consequences, may justify more onerous liability than negligence' Intention may also become more relevant where torts regulate activity that has a high social value but is inherently risky, such as transporting dangerous goods or manufacturing poisonous chemicals. In these contexts, it is apparent that the differences between negligence and malice are far more relevant to tortious conduct: in the words of Cane, 'when a harm-causing activity has high social value, a requirement of intention for tort liability helps to protect society's interest in the continuance of that activity.

Questions to Ponder

-What are the risks of the usage of artificial intelligence in autonomous flight systems

-What are the main technical challenges in designing aerospace systems that balance performance, safety, and cost?

-How can autonomous aerial vehicles be integrated into civilian air traffic systems?

-How can aerospace systems ensure data integrity and reliability in harsh and complex environments?

-How can advanced technologies, such as AI and automation, be safely integrated without compromising data accuracy?

-How can we integrate aerospace technologies into the defense and national security industry by not posing a threat?

-How can governments and private companies ethically balance market competition, funding models, and public trust in the rapidly expanding aerospace sector?

-To what extent should dual-use technologies and export controls be regulated to prevent misuse, while still allowing scientific collaboration and innovation?

-What ethical boundaries should exist regarding the militarization of aerospace technologies and the development of autonomous weapons?

-How should issues of privacy, surveillance, and civil liberties be addressed in human subject research and the use of aerospace data systems?

-In cases of human–machine teaming, who should hold ultimate responsibility and liability when AI systems make mistakes or cause harm?

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