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Reimagining Icarus: Ethics, Law and Policy Considerations for Commercial Human Spaceflight

Sara M. Langston
Senmurv Consulting LLC, langstos@erau.edu

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Abstract

Commercial human spaceflight presents an area for engaging novel human activity and objectives, to include space exploration, entertainment, transportation and extraterrestrial resource acquisition. The inherent dangers and lack of scientific and medical certainty involved however raise interrelated questions of ethics, bioethics, law and public policy. This is particularly the case with spaceflight participant (SFP) screening, selection, and commercial human spaceflight activities where regulations are currently silent or lacking. In the absence of established law, ethics can play an important role by informing industry standards, policies and best practices. Understanding the fundamental ethical values at stake in the application of new technologies and societal opportunities therefore is a significant step in establishing a practical, moral and sustainable framework for human expansion into space. As the frequency and reliability of private human spaceflight activities advances, spaceflight is likely to take on the legal and ethical vestiges of common carriers, with distinct passenger rights and higher standards of care attributed to the launch operator as a common carrier. This chapter raises some of the complex issues and challenges that face the private spaceflight industry and that merit collaborative discussion across disciplines and the global space transportation community going forward.

Keywords: ethics, bioethics, space medicine, space law, spaceflight

1. Introduction

Commercial human spaceflight presents a novel area for diverse human activity, whether conducted for exploration, entertainment, transportation or extraterrestrial resource acquisition. The inherent dangers and lack of scientific and medical certainty involved raise interrelated questions concerning ethics, bioethics and public policy, particularly in regard to

spaceflight participant (SFP) screening, selection and commercial human spaceflight activities and practices. *Ethics* is the study of how things should be. It is through moral reasoning that society discerns ideal human values and what constitutes right action for governments, communities and individuals [1]. Ethical discussions concerning novel industry activities are particularly relevant to commercial human spaceflight because in developing these new technologies and spheres of human activity, existing social moral values are evaluated, developed and enacted with far reaching implications and consequences.

Ethical values were in fact acknowledged in discussions at the beginning of the Space Age, even serving a role in political agendas, and incorporated into the international legal framework. The United Nations' 1963 Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, along with the subsequent space treaties, are principle-based instruments and emerged out of the geopolitical climate of the Cold War (from 1950s–1970s). The utopian principles espoused by the international community at this time, most importantly: that outer space is to be used for peaceful purposes only and for the benefit and in the interest of all countries, were codified in the 1967 Outer Space Treaty, which remains the foundational treaty pertaining to space activities today [2]. Overall, the legal principles espoused in these international instruments can also be seen to apply traditional ethical principles of *beneficence* (duty to do good) and *non-maleficence* (duty to do no harm) in the space environment, on celestial bodies, and to other actors in space, while establishing a practical moral framework for action.

Contemporary social values on human spaceflight and exploration also impact the developing customs and social norms on new commercial practices, actual uses of space and its resources, and public human spaceflight development. Here, a *practical ethics* approach is useful in applying ideals or ethical principles to practical engagement in life through codes of conduct and protocols, usually specific to context, discipline and industry. Doctors, lawyers, and engineers are among the professional disciplines that have long established codes of conduct. Policy and law, on the other hand, generally apply *normative ethics*, establishing moral frameworks through applicable rules, theories, principles and guidelines. *Bioethics* specifically relates to practical ethics and issues arising in medicine and biology. Bioethical issues include healthcare, patient rights, individual rights over one's own body, medical malpractice, and the use of human subjects in studies and scientific experimentation. NASA, for instance, frequently confronts bioethical concerns in its human spaceflight program, which requires evaluating and balancing the actual and prospective risk of harm to astronauts with the prospective benefits and mission objectives.

In practice, ethics, policy and law, are not always distinguishable disciplines. Law and ethics are particularly intertwined in biomedicine. The public healthcare system and medical sector moreover are governed by a combination of laws and policies on a range of procedural and substantive bioethical issues [3]. New technologies and surgical options (e.g. telemedicine) and progressively increasing human activity in extreme environments that test the limits of human endurance (e.g. space), are pushing back the boundaries of established professional, legal and community values on acceptable risk and scientific uncertainty. As a result, the new commercial space transportation industry (NewSpace) requires new informed legal and ethical approaches to human spaceflight and emerging aerospace activities.

The expansion of commercial space capabilities and actors, in particular, require a meaningful understanding of the values and implications of these activities to society in order to adopt appropriate standards and guidelines. This chapter raises primary ethical issues in commercial human spaceflight along with relevant law and policy concerns. Identifiable categories of ethics and spheres of practice in this regard include:

- Medical ethics
- Scientific research and ethics
- Ethical decision-making frameworks
- Astronaut ethics
- Technology and ethics
- Environment and ethics

2. Medical ethical implications

Space medicine and ethics questions have existed since human spaceflight programs began. The distinguishing factor with commercial spaceflight lies in the accountability and regulatory oversight that exists for government space programs and civil space agencies unlike private space research and human spaceflight enterprises. NewSpace entities and related industries bear the burden of establishing practical ethical policies, procedures and professional codes of conduct for private individuals. Apart from the professional responsibility of participating disciplinary experts (doctors, lawyers, scientists and engineers etc.), ethics-based principles and procedures are not currently identified in the commercial human spaceflight regulatory or industry decision-making frameworks.

While a notable distinction may be drawn between law and ethics the two disciplines often work hand in hand. To be clear, law is focused on external acts and consequences rather than the internal moral intentions of a person [3]. After all a divergent intention alone does not constitute an unlawful act, although intention alone can form the basis for a moral framework. In law, the action or practical steps taken in furtherance of the intention form the basis for a judicial determination of lawful/unlawful activity. In the absence of a regulatory regime governing the human aspects of commercial spaceflight activities—particularly where questions of risk, uncertainty and persons are concerned—it becomes even more crucial to establish a practical ethical framework for operation as spaceflight activities fundamentally invoke a myriad of moral issues in human interrelationships.

2.1. Medical forum shopping

Medical forum shopping is a foreseeable ethical and legal concern where regulatory standardization is lacking or is inconsistent between jurisdictions. No regulatory requirements currently exist for SFP medical screening and health selection criteria. The current regulatory perspective is that individuals have the right to participate in novel spaceflight activities at their own risk. As a

result, screening, selection and training discrepancies may arise between states, launch operators and certifying medical practitioners. This lack of standardized requirements creates a potential lacuna for SFPs with specific health profiles (e.g. pacemaker recipient) to shop across states for medical certification or waive into a 'go' status in order to participate in one or more desirable human spaceflight experiences. This could lead to increased risk of harm for the individual (in-flight/post-flight), spaceflight and crew, as well as uninvolved third parties. Analogous cases of forum shopping for licensing and/or obtaining legal and jurisdictional benefits have occurred in other areas, for example, in transportation and private international law.

2.2. Physician's professional responsibility

The United States is currently the only state with national space legislation and regulations directly pertaining to commercial (private) spaceflight operators, crew and ordinary civilians as spaceflight participants. Since the flight requirements, actors and requirements are distinguishable from state-sponsored astronaut/ cosmonaut corps this chapter will focus on the pertinent commercial space regulations as relates to private and commercial human spaceflight in the U.S. In this regard, the U.S. Code of Federal Regulations (CFR), Title 14, Parts 67 and 460.5 specifically requires spaceflight crewmembers to be cleared by an Aviation Medical Examiner (AME), as required for regular air crews. The regulations are silent, however, as to SFPs. Lawmakers and industry favor a regime of informed consent and liability waivers over governance for SFPs due to the novelty and numerous uncertainties of private spaceflight. Regardless, this does not waive a physician's professional and ethical duty towards the SFP.

In the absence of regulation, the Federal Aviation Administration Office of Commercial Transportation's (FAA-AST) published Recommended Practices for Human Space Flight Occupant Safety (2014) (Recommended Practices), providing voluntary guidance for limited duration suborbital and orbital spaceflights. The Recommended Practices suggest that SFPs seek consultation from a medical professional with "appropriate aerospace knowledge and experience" [4]. No clarification or definition for this 'knowledge' or 'experience' is provided. As a result, the interpretation and implementation of this requirement fall under the purview of the medical examiner and commercial operator.

Here professional ethics would suggest that a general practitioner performing a pre-flight evaluation on a SFP collaborate with a qualified AME, whether this is required by the launch operator or not. Relevant aerospace medical knowledge is essential to provide necessary preventative and post-flight treatments tailored to the particular SFP, particularly those with any preexisting conditions, and in relation to the specific flight activity and duration. For instance, with pharmaceutical treatments, drugs metabolize differently in microgravity environments, and a person may experience related physiological events even after returning to Earth [5]. This signifies greater implications of administering over-the-counter and/or prescription drugs before, during and after spaceflight. Mitigating and preventative treatments therefore need to consider all stages of spaceflight.

In addition, health, safety and medicine are closely aligned in spaceflight, as it is in aviation. Adverse effects of over the counter and prescription drugs may impair a SFP's ability to

perform required safety critical functions as well as his/her reaction time in conducting these functions or in the event of an emergency [6]. If the SFP were to become impaired in flight due to the effects of a medication or an exacerbated preexisting condition this could jeopardize the safety of the individual, as well as that of the crew, mission and potentially other third parties. The expertise of an aerospace medical practitioner and access to professional aerospace medical research networks (e.g. Civil Aerospace Medical Institute) are thus invaluable resources for certifying physicians in determining individual risks for health events and appropriate courses of medical intervention for commercial SFPs.

2.3. Conflicts of interest

It has long been acknowledged that physicians owe a duty of care to their patients—this entails both a professional ethical and legal obligation. Since health and fitness screenings of SFPs are left largely to the approval of the commercial launch operator under US law, it is essential that a physician is clear of potential conflicts of interest. For example, physicians and medical personnel contracted by commercial launch operators to screen SFPs for spaceflight could present a conflict of interest if, for instance, they receive any incentive or benefit (from anyone) for doing so. In any case, physicians are morally and legally obligated to maintain their professional integrity, standard of care and patient confidentiality regardless of third party (e.g. commercial operator, research entities) incentives or desires to clear customers for spaceflight activities, or reliance on the SFP's consent to blanketly waive liability for his/her own health and safety.

In a conflict of confidentiality situation where doctor-patient confidentiality may be justifiably limited—where the physician owes a duty to both an organization (such as government agencies, astronaut corps (NASA), military, schools) and an individual—the individual-patient must be clearly informed of the limitations and scope of doctor-patient confidentiality [7]. This may also include scenarios involving remote medical assistance and telemedicine. In addition, where medical screening, profiling and the exchange of medical data are conducted for studying and augmenting medical knowledge, the situation requires delineated procedures and communications to the SFP. Ultimately, additional discussions between industry and government are still necessary to further clarify the ethical and legal parameters for conflicts of issues, as these scenarios will inevitably arise in the near future and the current personal liability waiver regime may not suffice in such instances.

2.4. Standardization

Another issue that has yet to be addressed is the lack of standardization in space medicine.

Standardization is a traditional tool in science and technology fields that seeks to reduce risk and enhance reliable quality results by implementing technical and operational control mechanisms across people, time and space [8]. Space agencies use medical standardization to some extent to determine astronaut flight readiness, establish baselines, guide countermeasures, assessments and any necessary post-flight rehabilitation to return the astronaut to preflight health status.

However, the global medical community acknowledges distinctions in medical practices across cultures. This is evident, for instance, in traditional Chinese medicine (TCM) approaches and Western medicine. Among national human spaceflight programs and agencies recognizable cultural differences exist in medical philosophies and approaches, diagnostic equipment and treatment in orbital human spaceflight [9]. Differences also exist internationally in the medical recognition of psychological disorders. In the case of the International Space Station (ISS), an Integrated Medical Group, comprised of representatives and experts from partner agencies, cooperate and compromise in leading the multilateral implementation plan for astronaut-patient health and space medical research [10]. As a treaty (agreement) based endeavor, differences in medical practices are limited to the cultures of partner nations. Commercial spaceflight, on the other hand, presents a broader challenge, especially as a prospective means of private and global public transportation.

Without standardized medicine and approaches for commercial spaceflight medical events there is potential opportunity for multilateral conflicts of priority, approach, and for SFPs to 'forum shop' physicians, spaceports or jurisdictions that suit their interests.

Some practical ethical questions and issues that remain to be clearly addressed for commercial space transportation include:

- Whether the *experimental* nature of spaceflight raises a higher duty of care or ethical concern among the private persons and entities involved (physicians, operators and SFPs)?
- What are the ethical implications for compiling, analyzing, and sharing medical data on commercial SFPs?
- Whether an appropriate medical consultation forum should be established (similar to aviation) to provide physicians, prospective and actual crew and SFPs etc. with a place to lodge substantive questions and concerns on issues of health and the physiological implications of spaceflight?
- What are the ethical parameters for contractual 'informed consent' and selection criteria when dealing with an open manifest spanning diverse health profiles and various physical differences (e.g. someone who is deaf versus a wheelchair bound individual), foreign language comprehension, and legal capacity?
- Whether insurance companies' interest in passenger screening, selection and clearance poses a potential medical and ethical conflict of interest?
- What protocols, safeguards and operations need to be established for telemedicine to guarantee medical standards, ethics and patient confidentiality are maintained where members of the public are engaged in spaceflight?

Obviously, this is a not an exclusive list. Additional professional and practical ethics questions for physicians and passengers alike will inevitably arise as spaceflight emerges from its current experimental phase and becomes a norm of transportation. When spaceflight qualifies as common carriage and flight access is granted to a wider sector of the public, known health and safety risks may require standard physician ethical responsibilities to patients as well as to

society in determining and certifying fitness-to-fly. Ethical and medical concerns for conditions that may present safety concerns for spaceflight, may be analogous to cases of epilepsy and driving today. When does a physician, society and/or a private launch operator have a right to discriminate and restrict access to prospective spaceflight participants? These issues have yet to be discussed.

2.5. Compliance and enforcement

Professional ethical compliance is largely self-regulated within the medical profession and national ethics committees. While some conflicts of interest may appear straightforward other ethical issues may arise in the application of commercial human spaceflight—these scenarios will likely be fact, mission and personnel dependent. Legal consequences, such as malpractice suits, may also follow where a breach of duty occurs. For instance, where negligence occurs in assessing, screening or treating an SFP with a precarious medical condition, or failure to detect or divulge potential critical medical information to the SFP. In the event of an incident, contributory negligence on the part of the SFP or crewmember to honestly and promptly report medical events may also be raised in accordance with the appropriate jurisdiction and applicable law.

3. Commercial space stations

The FAA's regulatory authority over commercial spaceflight is limited to launch and reentry activities. The United States Code (USC), Title 51, Section 50905(c) further restricts the scope of regulatory authority over design and operations to where health and safety are concerned. Consequently, orbiting space stations (e.g. space habitats/ space hotels), long distance and long duration spacecraft (space cruiseliners), and extraterrestrial stations on celestial bodies are not regulated at the present time. The FAA voluntary guidance on human spaceflight requirements is likewise limited in scope to a brief human presence in space. Neither does the scope of the CSLAA extend to orbiting activities. Nonetheless, the FAA may recognize a vehicle as space capable and has related high altitude aerial tourism as a 'space activity' subject to national space law for purposes of determining and implementing an applicable regulatory regime.¹

In the absence of a comprehensive space regulatory regime and the acknowledged fact that spaceflight is an inherently dangerous activity, the ethical obligations for commercial launch operations and space station operators are heightened. Ethical practices and public policy would suggest that operators adopt similar standards of care as that of other analogous public transportation providers—airlines and ocean cruise liners, for instance—even when not legally mandated. The higher the ethical standards adopted in practice the less likely a commercial space operator is to be found negligent in the event of an accident. In law, negligence constitutes a breach of duty (which implies an ethical and legal responsibility), so applying the

¹For instance, the FAA acknowledged Paragon's World View high altitude balloon capsule for its space worthy technology and design, even if its function is limited to stratospheric flights. The US government, however, does not currently *certify* commercial space vehicles as safe for public transport.

highest standard of care towards SFPs as well as crewmembers from the outset, even if more costly, significantly serves the commercial operators best interests and greater good. For instance, a demonstration of a high standard of care may include: instituting clear informed consent procedures throughout the space flight and in-orbit residence; ensuring up-to-date emergency training, medical preparedness, technologies and accessibility; in-flight biometrics and health monitoring; engaging relevant expertise and experts on substantive questions and concerns; establishing reliable communications, event reporting practices; and customized personnel (passenger) assistance.

4. Ethics and public policy

4.1. Minors as SFPs

The US Commercial Space Launch Amendments Act of 2004 (CSLAA) and regulations are silent on the issue of minors as SFPs and a full public debate on ethics and public policy have yet to follow on this question. As a result the legal, public policy and ethical dimensions of this issue are convoluted. In 2006 the FAA responded to public commentators taking the position: “the FAA does not consider a person under the age of 18 someone who can provide informed consent” and “[g]iven the risks involved, parental consent may not substitute for the minor’s inability to be informed” [11] The rationale for this age demarcation is that “[s]ocietally, the United States has acknowledged that it is reasonable to place restrictions on individuals under the age of 18, including restrictions on their ability to legally consent” and “[w]hile some states classify a person as a minor until the age of 21, in many states the age of majority is 18.”

Nothing has been addressed in analogy, however, as to a minor’s legal capacity to enter into enforceable contracts in daily society (e.g. ticket purchases) or to engage in other risky and extreme sports and surgeries, where minor consent is recognized or acceptably acquired from a consenting parent or guardian. The current regulatory exclusion of minors from spaceflight therefore suggest a distinct periphery of risk that society has not yet deliberately addressed.

4.2. Human test subjects

Research on humans in space may feature in several ways, as an active participant consenting to a medical study or test; or indirectly, as a SFP or crewmember whose medical screening and health data is collected and analyzed for studying the effects of spaceflight on healthy individuals, those with particular pathologies, or for comparative demographic purposes. Possible scenarios include, for instance:

- A commercial SFP may voluntarily consent to become a human test subject for pharmaceutical research or scientific knowledge on human physiology, drug metabolism, and spaceflight/ microgravity environments. In point of fact, NASA astronauts routinely serve as test subjects in space for medical and scientific purposes, and private astronauts to the International Space Station have been sponsored by national space agencies to conduct

medical research and tests on themselves while in space. Consequently, it is foreseeable that these activities will occur with commercial SFPs.

- Given the novelty of the technology and scope of uncertainty in regard to spaceflight on human physiology, psychology and sociology, the pioneers in commercial spaceflight, whether deemed healthy crewmembers or SFPs, are in many ways participatory subjects of an ongoing experiment.
- To a greater extent, in the absence of relevant medical knowledge, and regulation, on more vulnerable health categories and age groups, the question on whether minors, geriatrics, physically impaired individuals, those with special conditions or overall deemed 'less fit-to-fly' individuals can engage in any human spaceflight activity and training remains open.

Collecting and analyzing space travelers' medical data is the only way to augment the human database of knowledge and lessen uncertainty. Moral and legal issues of collecting medical data from pre-flight and post-flight screenings and assessments from adult participants may be satisfied by applying ethically established protocols, procedures, and obtaining valid informed consent from each participant. Commercial companies and individuals interested in leading human studies and trials in space should follow the proper channels for conducting human research studies. This usually means obtaining authorization from the appropriate university or Institution Review Boards, independent ethics committees, national ethics committees etc. Following the example of governmental space agencies (e.g. NASA, ESA) commercial research investigators in space should also comply with the research principles of the World Medical Association incorporated in the Declaration of Helsinki, and relevant national regulations and guidelines (e.g. USFDA) as if the studies were conducted on Earth.

When the industry matures to the point of enabling safe routine flights and lawmakers allow for minors to participate in spaceflight activities as SFPs, these ethical concerns and duties will likely be heightened. As with adults, at some point healthy children will become space pioneers if the medical and space communities are to obtain any significant medical data on the physiological effects of spaceflight on this demographic. The ethical quandaries surrounding risk, especially concerning potentially irreversible damage to pediatric health, may be curtailed in the near future by technological advances in launch/reentry, safety, vehicle and mission design and architecture.

5. Ethics and culture

5.1. Cross-cultural ethics

In general, ethics is the study of what should to be done. What *should* be done does not equate with what *can* be done. In theory, philosophical arguments hold that ethics are universalizable—a valid ethical principle that applies to one should apply to all. However, in life value principles, rules and practices frequently diverge across cultural groups [12]. This is particularly true in the field of bioethics and where human initiatives carry risk and great uncertainty, such as exploration

and invention. The more an action, implementation measure or enterprise deviates from the certainty of the status quo, the higher the unprecedented risk. National policies on the value of life, autonomy, community, risk and human space flight/exploration reflect contemporary community values on these issues. Some distinctions indicate comparative perspectives between western and non-western cultures and values. Yet distinctions can also be found within similar cultural regions. For instance, the United Kingdom's national space policy declined national participation in human space exploration programs until 2009, even though it is a founding member of the European Space Agency, which established and still operates a European Astronaut Corps since 1978.

Looking forward, decision-makers and international space forums will benefit from engaging in transcultural dialog and value reciprocity discussions on human risk and commercial ventures in space. Cross-cultural ethics, based on mid-level values, such as the framework recommended by the Institute of Medicine for NASA's long duration spaceflight in 2014, [13] can provide a starting point and balanced approach in establishing best industry practices, as well as future law, for space access and transportation. The fundamental ethics outlined in the IOM's ethical decision-making framework for long duration and exploration spaceflight may, for instance, be applied to private space ventures as follows: an ethical duty to

1. Avoid harm—by preventing harm, exercising caution, and removing or mitigating harms that occur.
2. Uphold beneficence—using spaceflight to benefit society, this includes transportation, entertainment, scientific research and exploration.
3. Seek and maintain a favorable and acceptable balance of risk of harm and potential for benefit in spaceflight operations.
4. Respect for individual crew and participants' autonomy – especially concerning voluntary decision-making.
5. Ensure fairness—in company procedures and operations; and
6. Fidelity—recognize individual contributions of crew and SFPs as appropriate, and honor societal obligations to employees.

5.2. Risk and culture

Risk is a social construction, a determination subjective to culture, context, perception and communication of an identifiable or potential hazard versus opportunity [14]. This understanding is particularly relevant to the nature, risks and perceived benefits inherent to human spaceflight. The United States and Russia, for instance, present great risk-taking cultures and histories, particularly in regard to rocket launches and spaceflight activities. On a practical level both these nations also have greater technological capabilities, government sponsorship, and the national resources to take on big risks, such as transporting humans into Earth orbit and beyond. On the cultural level individual independence and autonomy are deemed fundamental values in American culture, and this is particularly evident in the national space culture. Other countries may demonstrate a more risk adverse culture when it comes to

evaluating the cost/benefit of spaceflight and may decline to participate in human spaceflight missions. While legally it may be permissible for individuals to engage voluntarily in extremely hazardous activities in countries and cultures that are neutral or favorable to voluntary risk, there is no clear comparative ethical evaluation on moral standards directly addressing the issue in the public debate on spaceflight.

One of the precepts of an ethical principle is its universalizability. If a principle should apply to one person, ethics generally dictates that it should apply to all. Fairness and equity for instance are principles applied in ethics, public policy and law, and yet even here societal value determinations can diverge between cultures. Meaning, a person's right to autonomous risk assessment, decision-making and action is not universally held. A particular gap can be seen between existing spacefaring nations and non-spacefaring nations. Which implies that voluntary risk is not purely a matter of individual autonomy but also coincides with a vested interest of society in maintaining a collective value. For instance, a person's right to autonomy or to engage in a hazardous activity—one that cannot be made safe no matter how much care is taken—can conflict with a society's right to not be harmed as a consequence of that activity, or to not have to expend state resources and efforts in rescue missions to assist those few voluntarily engaged in the hazardous activity. This is where public policy comes in and requires a practical balancing approach to leverage these two distinct ethical rights.

5.3. Indulging the wealthy?

With regard to ensuring public health and ethics in public policy, questions have been raised that distinguish the choices and consequences of the wealthy over the non-wealthy. For instance, distinguishing someone who can purchase the \$250,000 plus spaceflight ticket, to one that wins a public competition to fly to space. But is there a moral distinction? Spaceflight advocates argue that people should be allowed to take risks that they voluntarily choose to participate in, and can pay for (this may include event tickets, mandatory insurance, and applicable fees). A prime example can be seen in extreme sports, such as undertaking to climb Mount Everest—a high-risk activity that does in fact claim lives every year, and that routinely calls on state resources for emergency response. Analogously, spaceflight is not only an inherently dangerous activity like climbing the world's highest mountain, but it is the least safe means of transportation. Risk mitigation at this point is limited – unlike an emergency row passenger on a commercial aircraft, who can decline the heightened risk/ duties and request reassigned seating, today's spaceflight technologies do not currently provide SFPs with any alternative safer options for participation in spaceflight.

From a legal perspective there is no significant distinction between one who voluntarily engages in an extreme sport or activity costing tens of thousands of dollars and the average person who wins or is gifted a ticket. Both are engaging in the activity and both persons must provide voluntary and informed consent to partake in the activity. From an ethical perspective, valid points of consideration call for an evaluation of the fundamental issue at play: should we indulge the whims of the wealthy because they can choose to pay for an experience? If so, how far does this autonomy extend? And how do principles of ethics and justice apply to commercial spaceflight? These are questions that merit acknowledgement and discussion looking forward.

5.4. Paternalism

Paternalism is the philosophical concept that a state can interfere with an individual's right of autonomy if it is in the individual's own best interest (this is a distinct notion from interference for the community or another's sake). There are varying degrees of paternalism that allow for less or more abrogation of personal autonomy (analogously seen, for example, with bioethical questions involving body modification, extreme surgeries, drug use etc.). The overall question that deserves to be acknowledged here for spaceflight is to what extent can the average reasonable person engage in an extreme and dangerous activity? And what are the ethical parameters for state interference in regard to this autonomy?

These ethics questions deserve acknowledgement because practically the conclusion may differ depending on the subjective country, culture, social norms and values, the type of legal system (e.g. common law vs. civil law system) and existing legal codes. Raising and evaluating these ethical and bioethical issues, serves to maintain the overarching human good—the fundamental reason for morality—through respect for human autonomy, dignity and life [12]. Consequently, the resulting issue presented here is how to identify, define and approach an optimal bioethical framework that can and should be applied to the commercial space transportation industry as a whole.

6. Astronaut ethics

The 1967 Outer Space Treaty applies only one requirement to individual spacefarers. Article V stipulates that astronauts in space “shall render all possible assistance” to other astronauts in space and on celestial bodies. This is the only personal duty required of astronauts under the international space law regime, and stems from traditional maritime principles and law of the sea. However, no uniform definition of ‘astronaut’ currently exists and US legislation governing SFPs is silent on this specific obligation. Thus it is unclear whether commercial launch operators and SFPs fall under this treaty provision.

The significance of distinguishing SFPs from astronauts under the treaty directly relates to implications of SFP health, safety and law. A legal duty to render assistance would exclude SFPs who are unwilling or unable to do so. For instance, Stephen Hawking would be unable to render assistance to another person on a suborbital flight even if cleared by a physician and launch operator. This also raises additional liability issues for the SFPs and the launch operator as the personal liability waiver is not generally concluded between passengers. Any commercial astronaut with limited fitness and related restrictions will likely fail to comply with this international obligation. What then?

The underlying ethical question raised here is whether a moral duty to render possible assistance to other persons in space exists, regardless of whether one is a SFP or crewmember. This is also a question of public policy. If the answer is yes, it follows whether the ‘Good Samaritan’ Principle, as applied in the US for instance, should also be extended to commercial human spaceflight and in-space activities to promote and protect prospective rescuers. The practical ethics and legal implications of this question have yet to be addressed by the greater space community.

7. Technology and ethics

The objectives of human health and safety are fundamental values where technology is concerned. Given the wide scope of commercial space activities proposed and human spaceflight experience gained to date, future health and medical events are a high possibility. This leads to two ethical implications for space technology and ethics pertaining to human spaceflight:

- *Duty to report safety concerns*—One of the acknowledged lessons of the 1986 Challenger accident is the reminder of professional responsibility and ethics of engineers and operation managers to voice concerns in regard to launch activities. Launch operators should also institute policy and procedures for reporting and evaluating concerns and issues, whether related to operational, personnel or technical issues, from employees, SFPs and any concerned third parties.
- *Engineering, mission design and ethics*—vehicle/station design should incorporate necessary structures to ensure human health, hygiene and safety, even when not mandated by law. This includes, medical equipment and appropriate facilities. Priority conflicts can arise, however, when space, weight, size, mission objective and fuel are limited. For instance, when determining which medical equipment and supplies should be included. Operators, will inevitably face competing interests, like NASA, in vehicle and mission design and will have to arrive at ethical determinations on these critical issues. A baseline approach is to maintain equal or equivalent health and safety requirements by analogous transportation systems, such as maritime and aviation. This may include: medical (trained) personnel, medications in various forms, and essential medical equipment.

8. Environment, health and ethics

Other inherent implications of spaceflight may affect environmental health and safety. The projected increase of routine commercial spaceflight activities alone will inevitably impact Earth's environment, atmosphere, and space. For instance, the type of vehicle, fuel, ejected debris, and biological contamination may all effect the Earth and space environment. Human space settlements and activities on celestial bodies are likely to raise additional and convoluted ethical and practical questions with regard to the environment and human health.

The Outer Space Treaty contains only one provision tangentially applicable to environmental health. Article IX provides for state measures to be taken to avoid forward and backward contamination of Earth from space and vice versa. This is the only provision in the foundational space law instrument that deals with the environment. The scientific advisory body to the United Nations, Committee on Space Research (COSPAR), has since issued international guidelines for controlling biological contamination of celestial biospheres. While these constitute voluntary guidelines, national space agencies like NASA have incorporated COSPAR guidelines in their planetary protection policies.

Other environmental principles may also be applicable to space through the specific application of international law to outer space. International environmental law is based on ethical

principles such as the precautionary principle. The precautionary principle is a risk mitigation strategy that calls for decision makers or regulators to act preemptively to ensure that a harm does not occur rather than wait for scientific certainty on the actual or potential risks of harm from conducting a specific action or series of activities [15]. The precautionary principle can be applied to anything such as preventative exclusion of SFPs for a medical condition to restricting space mining activities in particular areas or on specific celestial bodies.

Another environmental health and ethics issue includes death and funerary rituals. Since 1997 private companies, such as Celestis, have been providing commercial space funeral rites, launching capsules with ashes of celebrities and customers into low orbital trajectory, to orbit the Earth a few times before burning up in the atmosphere [16]. Another company, Elyseum Space, is proposing a similar service to commence late this year, to include sending remains to the Moon and deep space, while providing value added services like Apple friendly app trackers [17]. The underlying idea is said to bring a poetic and celestial perspective to the human condition. These particular funerary activities in space are deemed to pose little to no risk and have not raised ethical concerns at the present time. Although, instituting extraterrestrial memorials on celestial terrains may trigger questions on planetary protection and environmental conservation.

Looking forward, however, it is not entirely clear what ethical implications and practical medical protocols will develop when a human (or perhaps even an animal companion or study subject) dies in space. Such events may result, for instance, from illness, accident, or SFPs planning the ultimate last adventure (e.g. terminally ill or elderly individuals who choose to end their days in space). Significantly, it may not always be practical or possible to return a deceased person to Earth. As commercial companies progressively seek to engage in long duration and distant missions these are inevitable questions that require societal forethought, moral respect and clear cross-cultural dialog.

9. Conclusion

Private and commercial human spaceflight present a myriad of bioethical, legal and policy implications for consideration. In many cases the ethical principles and legal/ policy positions on bioethical issues overlap. Understanding the fundamental ethical values at stake in the application of new technologies and societal opportunities therefore is a significant step in establishing a practical yet moral and sustainable framework for human expansion into space. Significantly, the inherent risks involved in spaceflight activities call for incorporating ethical risk management strategies and policies into industry standards and practices, even where not already instituted or mandated by law. As spaceflight progresses towards common carriage, spaceflight is likely to take on the legal and ethical vestiges of common carriers, with passenger rights and higher standards of care afforded to the launch operator as a common carrier. This chapter raises some of the complex issues and challenges that face the private spaceflight industry and that merit collaborative discussion across states, disciplines and the global space transportation community.

Author details

Sara M. Langston

Address all correspondence to: langstonsara@gmail.com

Senmurv Consulting LLC, Arlington, Virginia, USA

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