# Lessons for Flying Astronauts with Disabilities Drawn from Experience in Aviation

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**INTRODUCTION:** Accessible spaceflight may seem a distant concept. As part of a diverse European Space Agency funded Topical Team, we are working on the physiological feasibility of space missions being undertaken by people with physical disabilities. Here, the first activity of this team is presented in the form of key lessons learned from aviation to inform new work on space missions.

**DISCUSSION:** The first lesson is agreeing on realistic expectations about impairments, their severity, and the possibility of flying independently. This is important in terms of astronaut recruitment and societal expectations. The second lesson relates to training and adjustments for people with disabilities. Flexibility is important while maintaining safety for everyone involved. The third lesson is about managing unconscious bias from the different stakeholders. We conclude by arguing that engagement with people from different backgrounds is essential for the success of the first space mission with people with physical disabilities.

**KEYWORDS:** disability, accessibility in aviation and space exploration, astronauts with physical disabilities.

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The European Space Agency (ESA) launched the Parastronaut Feasibility Project in 2021 to recruit people with a physical disability to become part of the astronaut corps. This initiative has opened a new frontier in space exploration. Considering that 15% of the world's population has a disability,[1] the aim of our ESA funded Topical Team is to make sure that space is truly accessible for all. While the intent of including people with disability in space exploration is clear, before this can happen in practical terms, scientific research, evidence, and data gathering, including input from the disabled community, are essential for the safety of such missions. This paper aims to introduce our work to inform future space missions. This is a complex topic and space missions are very diverse in terms of duration, tasks performed, and environmental exposures. The first step in this journey is to consider different disabilities, with a specific focus on physical disabilities to comply with the ESA's recruitment requirements, and draw parallels with aviation to establish key basic lessons to inform future work in this field.

## Key Lessons

Aerobility, a leading disabled flying charity (based at Blackbushe Airport, United Kingdom) is a member of our Topical Team. When Aerobility was founded in 1993, it was uncommon to see people with disabilities driving, let alone flying. In societal terms, "the disabled" were often treated as second-class citizens, with little to contribute to society.[2] Legislation combined with committed agents of change helped remove bias or preconceived ideas and foster a sense of equality.[3,4] In the aviation field,

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Aerobility and the UK Civil Aviation Authority have been instrumental in changing both attitudes and legislation.

While the vast majority of Aerobility's fliers come for a single flight experience, a core of service users undergo flight training and are successful in achieving flight medicals, solo flying status, and pilot's licenses. The majority are private pilots with a Class 2 medical license for leisure flying, but some of Aerobility's disabled pilots have achieved a Class 1 medical status, with at least 10 professional pilots in the United Kingdom flying with a single or double lower limb amputation. In this paper, we will review the key lessons learned in aviation and from pilots with disabilities, as the medical requirements are similar to those required for astronauts, and the approaches, training techniques, and assistive technology (including aircraft adaptations) provide significant parallels with space exploration.

*Lesson 1: impairment and flying.* From its inception, Aerobility has faced one, pre-eminent challenge: how do we make sure that people with a range of disabilities achieve a standard of flight safety equivalent to able-bodied pilots? Aerobility flies with a broad spectrum of disabilities (**Fig. 1**) and, between January 2024 and mid-May 2024, 76 solo flights were completed by licensed pilots with a disability. The pilot's primary disabilities for these flights were physical (58, including paraplegia $N = 17$, cerebral palsy $N = 15$, spina bifida $N = 10$, hemophilia $N = 7$, amputation $N = 6$, other $N = 3$), learning ($N = 11$), mental ($N = 3$), and 4 with other disabilities. The pragmatic approach adopted thus far is to realize that not everyone can qualify for a pilot's medical, and solo flight for some is not a realistic expectation. Unsuitability for solo flight is typically because of either:

- A physical disability that makes it impossible to egress unaided during an emergency;
- A severe disability or medical condition which is incompatible with safe flight; or
- Prescription medication that is incompatible with safe solo flight.

This draws parallels to spaceflight considerations, as some disabilities may be suitable for individuals in flight safety critical roles (such as professional astronauts), others may not be currently suitable for spaceflight, while a broader range of disabilities might be acceptable in nonprofessional astronauts (such as in the growing commercial spaceflight market). A realistic solution-based, rather than problem-based, approach appears key when considering space missions, in terms of recruitment criteria and consideration for whole crew safety, as the vast array of disabilities and their severity may discourage those who make these assessments.

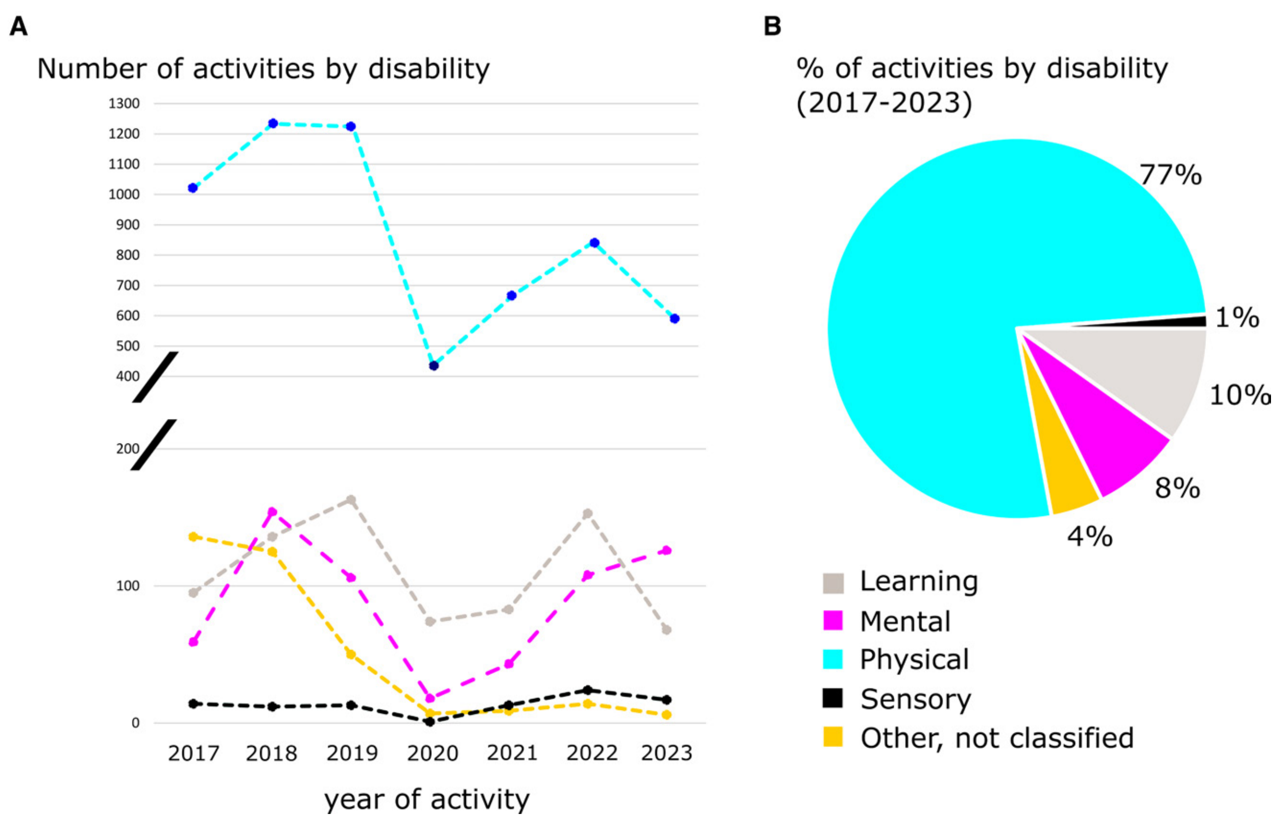


**Fig. 1.** Aerobility's anonymous data on different participants' disability types recorded between January 2017 and October 2023. Five disability categories are included: learning (gray), mental (pink), physical (cyan), sensory (black), and others not within these categories (orange). A) number of flying activities performed according to disability category over time. Note the broken vertical axis and the different scale for physical disabilities. B) Total percentage of flying activities carried out according to the participant's disability over the period under consideration: mental ($N = 614$, approx. 8%), learning ($N = 772$, approx. 10%), physical ($N = 6019$, approx. 77%), sensory ($N = 94$, approx. 1%), and others ($N = 347$, approx. 4%).

*Lesson 2: training and technical adjustments.* Aerobility instructors adopt a flexible approach (combined with relevant technical adaptations as required), and if an individual cannot achieve a specific skill (for example a crosswind landing with lower limb deficiency), then the trainee is encouraged to use an alternative technique to achieve the same goal successfully. Although each disability is different and the approach varies every time, more prevalent physical disabilities, such as spinal injuries, can often make use of a particular control interface such as using the Turner Hand-Control to operate the rudder pedals (**Fig. 2A**). Examples of safety methodologies and training techniques based on experience that have created a safe flight training environment for the majority of disability types are braking systems for the hand, instead of foot-operated brakes (**Fig. 2B**), combined throttle and rudder control (**Fig. 2C**), adapted light aircraft (fitted with certified aircraft modifications), and access equipment, such as the hoist to lift a wheelchair user into the pilot seat (**Fig. 2D**). Space missions which are truly accessible will require adjustments in terms of training and interfaces, involving both experts in space missions and in adjustments for different disabilities. Furthermore, new research and discussions on the effect of different missions in terms of their duration, tasks performed, exposure to environmental factors, training, and recovery are needed at this stage. In fact, the adjustments established in aviation and on Earth may need to be adapted and tested to maintain safety and facilitate all those involved (for example adopting a design for all approaches).

*Lesson 3: involving different stakeholders to address unconscious bias.* In the early days of the certification of disabled pilots, regulators were naturally cautious. However, the synergy of both education and track record of flight safety gave disabled aviation credibility, and now legislative bodies are proactive champions of disabled flight. With changing attitudes, hand-control adaptions were developed and certified, and aviation medical professionals recognized that there was no evidence to suggest that safety was compromised.

Any latent bias or unconscious discrimination has been balanced through practical experience and knowledge. In both selection and training, unconscious bias may be affecting the process, with assumptions being made on behalf of an individual. The first accessible space missions could be affected by unconscious bias from society, organizations, and those involved. Aerobility's success is based on an open mind approach, including the individual in the process to determine their physical challenges and solutions to learn to fly.

To conclude, in our work as a Topical Team, not only do we review scientific literature, but we also learn from different experiences, as in the case of Aerobility, to build on the excellent work already done and to make sure that we can support

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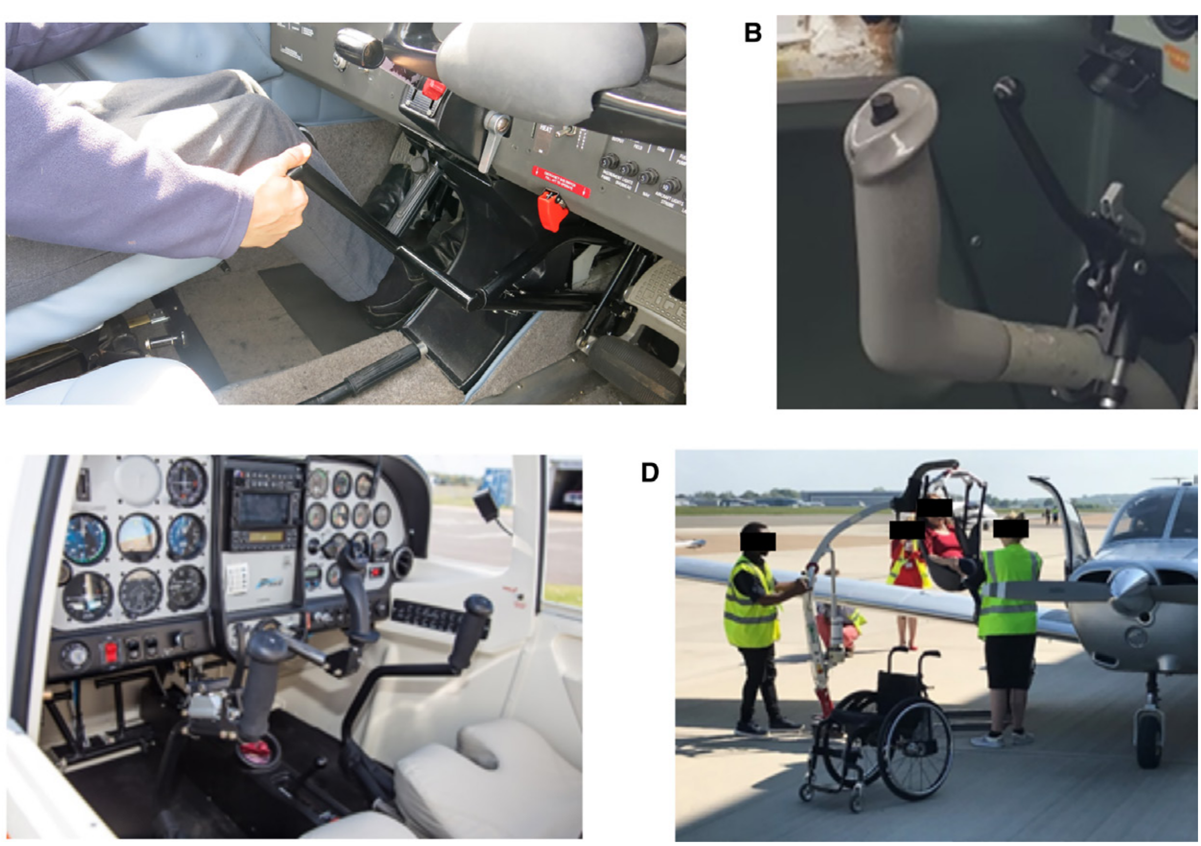

**Fig. 2.** Examples of adjustments implemented to facilitate people with disabilities flying. A) Turner Hand-Control to operate the rudder pedals; B) hand-operated braking system; C) combined throttle and rudder control; D) small airplane access equipment showing a hoist to safely lift a wheelchair user from their chair into the seat.

the first (of many) accessible space missions. The lessons presented in this short paper drive our future work to make sure that selection, training, and adjustments for astronauts are put in place, accepted, and understood without bias.

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