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A concept for a European human rated microgravity and partial gravity research and testing facility

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Currently, the global space sector is undergoing a transformative shift, driven by the increasing involvement of private companies in activities traditionally dominated by governmental space agencies. At the same time, large space agencies are planning pioneering space missions, including lunar bases and human exploration of Mars. This rapid evolution further amplifies the need for advanced microgravity research facilities to address the technological and biomedical challenges to come. In Europe, existing microgravity platforms–specifically drop towers, parabolic flights, sounding rockets, and orbiting spacecraft–provide essential research opportunities, but suffer from limited accessibility, high costs, and low repeatability. Recently, a novel class of microgravity facilities, represented by the GraviTower Bremen Prototype and the Einstein Elevator, have enabled microgravity testing with rapid turnaround, but still with limited microgravity duration. This paper first reviews the currently most frequently used microgravity platforms in Europe. Then we envision an early-stage concept which could become Europe's next-generation facility: the "Alpine Low Gravity Exploration" (AlpG$_E$) platform. AlpG$_E$ could offer highly accessible and flexible microgravity and partial gravity conditions and would also be certified for human participation. The envisioned facility could enable accelerated research and development cycles in biomedical and physical sciences, engineering and space technology, thereby strengthening Europe's competitiveness in the emerging new space race.

KEYWORDS
Europe, facility, guided actuated parabola (GAP), microgravity, research and development

1 Introduction

The world's space tech sector is currently undergoing a rapid and fundamental development, often referred to as "new space" or the "new space race" (Denis et al., 2020; DiFrancesco and Olson, 2015). Demanding services and capabilities, such as launching astronauts into orbit or operating crewed space stations, have for decades only been provided by major space agencies, such as the American National Aeronautics and Space Administration (NASA), Roscosmos, the European Space Agency (ESA) or the Japan Aerospace Exploration Agency (JAXA). In recent years, the China National Space

Administration (CNSA) and the Indian Space Research Organisation (ISRO) have acquired similar technological expertise. Currently, a massive transfer of these capabilities to commercial companies is underway. In the near future, two commercial space companies will compete to launch crewed capsules (De Chiara and Sivolella, 2025) and at least four private consortia are currently working on commercial space stations (Axiom, 2026; Starlab, 2026; VAST, 2026; Zea, et al., 2024). In parallel, large public space agencies have set ambitious new goals and committed to establishing permanently crewed bases on the Moon and, at a later stage, human missions to Mars (ESA, 2022; NASA, 2023). Such endeavors come with great medical and technological challenges, which demand appropriate testing and research facilities.

In the first section of this publication, we review the currently most frequently used microgravity research and testing platforms in Europe, which are drop towers, parabolic flights, sounding rockets and orbiting spacecraft, mainly the International Space Station (ISS) (Ferranti et al., 2021; Graf et al., 2024). As access to sounding rockets and orbiting spacecraft is still very limited, drop towers and parabolic flights are by far the most frequently used platforms, constituting the backbone of modern low-gravity research and development. However, limited accessibility, long preparation times and low repeatability lead to small data sets and slowed progress. In order for Europe to keep pace in the ongoing space race and to achieve its bold goals, fast and cost-effective access to microgravity will be key. In the second section of this perspective article, we therefore envision, "Alpine Low Gravity Exploration" (AlpG$_E$), an advanced microgravity research and testing facility, which could be realized in the European Alps. This early-stage concept could eventually provide microgravity periods, quality and payload space comparable to nowadays parabolic flights, but with much better accessibility and higher repetition rate.

2 Europe's current microgravity capabilities

Since decades, European researchers, but also technology developing companies, have had access to drop towers, parabolic flights, sounding rockets and orbiting spacecraft, such as the permanent crewed ISS. Recently, a new kind of earth-based microgravity platform, which uses active drive systems to fly a guided capsule along a vertical parabola, has become available. All of these microgravity platforms have their unique technical properties, advantages and caveats, as outlined in the following.

The operating principle of drop towers is straightforward, as essentially experiments are hauled up and dropped in a vacuum tube. They provide the best microgravity quality ($10^{-5} \ldots 10^{-6}$ g; 1 g = 9.81 m/s^2) among all microgravity platforms. The only European drop tower is located at the Center of Applied Space Technology and Microgravity (ZARM) in Bremen, Germany (Dittus, 1991; Kufner et al., 2011). It features a 120 m freestanding steel vacuum tube, which is protected by a concrete tower against the influence of wind and weather. Experiments are integrated into hermetically tight capsules with a usable inner diameter of 600 mm and a height of about 1.3 m. Due to the limited space, experiments are most often arranged on several vertically stacked, horizontal shelves (or platforms). As the experiments are not accessible while in the drop tower, remote-control capabilities are required, or the experiment must run fully autonomously. By default, ZARM drop capsules are equipped with a power supply (24 VDC), common data communication interfaces, as well as a real-time system providing various analog and digital outputs and data acquisition. After payload integration, the drop capsule is closed, hauled up and the drop tube is evacuated, which takes around 1.5–2 h. Once the vacuum is established, the capsule is dropped according to the experimenter's request and decelerated in a bath of polystyrene foam beads. Due to the limited height of the drop tower, the microgravity period is limited to 4.7 s. ZARM's drop tower also features a hydraulic catapult, which launches the drop capsule with an initial acceleration of around 30 g into the drop tube and thereby extends the microgravity period to 9 s. The short microgravity period, the harsh deceleration (up to 50 g) and the limited space greatly limit the application range of the ZARM drop tower. Furthermore, establishing the vacuum before each drop limits the turnaround time to typically two to three drops per day. Experiments conducted in the drop tower are mostly in the field of physics (e.g., quantum gases), combustion and engineering challenges, as summarized in (Kufner et al., 2011).

Parabolic flights provide up to 22 s of microgravity and are the only platform allowing human access to the aircraft after only a short briefing without any specialized training (Karmali and Shelhamer, 2008; Pletser, 2016; Pletser and Kumei, 2015). This permits research on human subjects and allows scientists to directly operate their own experiment without need for remote control capabilities. The parabolic flight maneuver starts from horizontal flight and transitions into a steep incline for about 20 s, during which elevated gravity (hypergravity) of typically 1.5–1.8 g is perceived. Subsequently, the airplane's thrust is reduced, such that it just compensates the air drag, and the aircraft is flown along a parabolic trajectory for around 22 s. During this period, the aircraft is in free-fall and the payloads inside experience microgravity. The maneuver is terminated by pulling the plane out of its deep dive back into a horizontal flight, which also results in a hypergravity period of about 1.8 g (Karmali and Shelhamer, 2008; Pletser, 2016). In Europe, Novespace (Bordeaux, France) is the most important parabolic flight operator, conducting all scientific campaigns for ESA, the German Aerospace Center (DLR) and the French Centre National d'Études Spatiales (CNES). Novespace operates an Airbus A310, which provides space for around eight to twelve experiments, a total payload mass of 4,000 kg, and up to 40 passengers (scientists and human subjects) (Pletser et al., 2016). Because the plane provides a large footprint (100 m^2) and scientists can operate on their experiments themselves, the degree of required automation is generally smaller compared to other microgravity platforms. This allows faster implementation and/or enables more complex and demanding experiments. In many cases, standard lab equipment is used after some small safety-relevant modifications. However, the advantages of parabolic flights come at the cost of reduced microgravity quality, due to structural vibrations of the fuselage and the turn rate of the plane during the parabola ($10^{-2} \ldots 10^{-3}$ g), and restrictive safety regulations. Beside Novespace, also other European parabolic flight providers operate on smaller aircrafts (De Crombrugghe et al., 2017; Pletser, 2016). Examples of typical parabolic flight experiments were summarized previously in dedicated reviews (Pletser et al., 2015; Pletser et al., 2016; Ullrich et al., 2023).

Extended microgravity periods of several minutes can be achieved by suborbital sounding rockets. European sounding rockets dedicated to microgravity experiments, are typically launched from the Esrange Space Center near Kiruna, Sweden (Seibert, 2006). Nowadays, rockets are typically 17-inch rockets (431.8 mm diameter), flying their payload beyond the Earth's atmosphere to apogees often reaching around 260 km, providing high-quality microgravity (typically 10^{-4} g) for around 5–6 min (Kirchhartz et al., 2018). [Stronger rockets with apogees of up to 700 km have been used in the past but are currently discontinued (Palečka et al., 2020; Schütte et al., 2005)]. The rockets usually have two motor stages onto which the service module and multiple payload modules are stacked. The GPS module, the recovery system and the nose cone form the upper end of the rocket. The total payload mass is often around 400 kg (including the module structure). Sensitive payloads, such as plants or live cells, can be prepared only hours before launch in the on-site lab and are subsequently loaded into the rocket via a late-access hatch shortly before the motors are armed. During launch, first the lower motor stage is ignited and separated after burnout. After a brief coasting phase, the second stage is ignited and, after burnout, also detached from the payload for the subsequent free-fall phase. During launch, the hardware and samples must endure large linear accelerations (ca. 13 g), fast spinning (ca. 3 Hz), and strong vibrations. Microgravity quality is improved by stabilizing the payload during the free-fall phase to avoid rotation and tumbling. As the rocket falls back through the Earth's atmosphere, vibrations get increasingly stronger until a parachute deploys and glides the payload safely down to Earth. European sounding rockets are often launched during spring or autumn to favor landing on ice and snow rather than splashing into a lake or river. Shortly after landing, the payload is picked up by a helicopter. Among all microgravity platforms, sounding rockets pose the harshest launch conditions, which is often challenging for samples and hardware design. In addition, the rocket shell is exposed to extreme temperature fluctuation ranging from −30 °C environmental temperature after flight, to peak temperatures above 200 °C during the flight. Due to the limited space and payload mass, a higher degree of automation and optimization of hardware size, weight, and power consumption is required (Seibert, 2006).

Even longer microgravity periods can only be achieved with orbiting platforms, such as uncrewed return satellites or crewed space stations. In 2008 the Columbus module was integrated into the ISS and since then is Europe's permanent laboratory in orbit (O'Sullivan, 2016). The ISS has the advantage that experiments can often be integrated into already existing facilities on the station, which provide standardized interfaces. In addition, the habitable environment in the station (room temperature and a terrestrial atmosphere), simplifies hardware design and reduces upload mass. Furthermore, astronauts can assist in deploying or handling experiments or even resolve unexpected malfunctions. However, crew time is very limited and expensive. Therefore, experiments still require a high degree of automation or remote-control capabilities. ISS experiments are often uploaded and returned on large rocket systems as part of a regular resupply mission. The physical stress on these large carriers is often moderate compared to sounding rocket flights (max. 4–6 g). Some launchers even allow warm, cold, frozen, or powered uploads. However, the possibility of launch delays or scraps are critical and could affect the outcome of time-sensitive experiments (NASA, 2010; Rai et al., 2016).

After decommissioning of the ISS (currently planned for the end of 2032), experiments requiring extended microgravity periods will be deployed on either commercial space stations still in development or return satellites (Burgess and Dubbs, 2007; Fedele et al., 2018). Similar to sounding rockets, experiments on return satellites are integrated before launch and recovered after successful landing (Duan and Long, 2019). Hardware development is demanding as the experiments must be fully automated and payloads are subjects to tight constraints in terms of size, weight, and energy consumption. In addition, the space environment is harsh, with extreme temperature fluctuations and not forgiving for engineering shortcomings. Launch and recovery are comparable to ISS experiments in terms of mechanical stress and operational constraints and capabilities. However, experiments cannot build on existing facilities in orbit, such as cold stowage, which increases the complexity of the hardware or limits the experiment design. To date, Europe did not operate its own return satellites and European experiments were performed within international cooperations (Burgess and Dubbs, 2007). Currently, the European Space Rider (Fedele et al., 2018) and several commercial return capsules are under development.

Due to the costly nature of long-term microgravity experiments, ground-based microgravity simulations, e.g., by continuous rotation, have become very common, especially in the biomedical field. The interested reader is here referred to dedicated publications on ground-based microgravity simulations, e.g., (Beysens and Van Loon, 2015; Brungs et al., 2016; Ferranti et al., 2021; Herranz et al., 2013; Wuest et al., 2015).

In recent years, a new class of microgravity platform has been introduced, which are termed here guided actuated parabola (GAP). These systems accelerate a rail-guided capsule from ground along a vertical parabola, using active drive in a controlled feedback loop. Inside the capsule is the actual experiment capsule, which separates by a few millimeters from the outer capsule during the microgravity phase. The outer capsule absorbs air drag and other mechanical disturbances. The control loop of the active drive adjusts the speed of the outer capsule, such that the inner experiment capsule is fully separated, decoupled and in free-fall, ensuring high-quality microgravity. Compared to traditional drop towers, this design does not require vacuum and therefore allows much higher repetition rates (Könemann et al., 2015). Using a parabola instead of a simple free-fall, doubles the experiment time and drastically reduces the required peak velocities, but brings the limitation of a hypergravity phase before the microgravity period.

The GraviTower Bremen prototype (GTB-Pro) at ZARM is one of the facilities using the GAP concept. The drag capsule is driven by hydraulic drives and steel cables (Gierse et al., 2017; Gierse et al., 2022). Thanks to the flexible design of the drive system, the acceleration time sequences can be freely adapted by the scientists according to the experiment's needs. For initial acceleration and final deceleration, the perceived hypergravity is freely adjustable between 1.1 and 5 g. The actual experiment capsule (Ø 600 mm × 1.3 m) is fully compatible with ZARM's traditional drop tower, enabling experiments on both platforms without modification. The experiment capsule is mounted on a sophisticated release caging mechanism (RCM), which is built up from multiple stacked pneumatic air bearings. The RCM ensures high-quality microgravity (10^{-4} g) and minimal mechanical disturbance during acceleration and deceleration. A large door in the side of the drag capsule ensures easy access to the experiment. The safety architecture allows people to work inside the drag capsule while the hydraulic drive is already under full pressure. This enables flying the first parabola within seconds after door closing. Parabolas can be repeated after only a few seconds, if no access to the experiment is required. In addition, the GTB-Pro has already been prepared for partial gravity operation between microgravity and near 1 g. [For some experiments partial gravity has already been used, even though the currently used RCM was not designed for partial gravity parabolas (Madden et al., 2025)]. However, due to the limited parabola apogee of maximum 12 m, the microgravity period is limited to 2.5 s, depending on the chosen dynamic accelerations. The GTB-Pro was opened to scientific operation in 2022 and was well received by the research community with steadily increasing demand (Gierse et al., 2022). Until early 2026 over 10′000 parabolas were performed (personal communication). In comparison, the ZARM drop tower performed its 10′000th flight in 2024 after 34 years in operation (ZARM, 2026). The Novespace's A310 flew over 2′960 parabolas since it was taken into service in 2015 until early 2026 (AirZeroG, 2026).

A second GAP facility is the Einstein-Elevator (EE) at the University of Hannover (Germany) which entered operation in 2020 (Lotz et al., 2017; Lotz et al., 2018; Raudonis et al., 2023). In contrast to the GTB-Pro, the EE uses electrodynamic linear drives for propulsion, enabling high speeds and high control accuracy (Lotz et al., 2014). It also features a capsule-in-capsule design but additionally establishes a vacuum in the narrow gap between the inner and outer capsules to further reduce mechanical disturbances. The inner capsule accommodates experiment with a diameter of up to 1.7 m, a maximum height of 2.0 m and a payload mass up to 1000 kg. The parabola is flown along a 40 m high tower, allowing 4 s of high-quality microgravity (10^{-6} g). More precisely, the tower consists of two towers that are entwined into each other. On one tower, the linear drives are mounted, while the other serves as the rails to guide the capsule. The two towers only have a single point of contact, which is the coupling rod connecting the capsule to the drive. With the EE, also a high repetition rate of up to 300 parabolas per day is possible. However, in comparison to the GTB-Pro, closing the heavy capsule is more tedious and access to the experiment in case of malfunction currently takes approximately 5 minutes, while it takes less than a minute on GTB-Pro.

Recently, a much smaller, lab-scale GAP device was published (Pelluet et al., 2025) intended for cold-atom physics applications. It performs 3 m-parabolas, using linear motors and air bearings for guidance and provides 500 milliseconds of microgravity (10^{-2} g) at a record repetition rate of every 13.5 s. An alternative similar sized platform is currently also under development (Wilhelm and Murdoch, 2025), while there could be also comparable ongoing projects which have not been published to date.

3 A concept for a European advanced microgravity research and testing facility

The traditional microgravity platforms—drop towers, parabolic flights, sounding rockets and orbiting spacecraft—all suffer from limited accessibility, repeatability and opportunities for rapid iteration. ZARM reduced these limitations by offering a flexible drop tower operation with short-notice bookings and the option for near-term rescheduling in case of technical difficulties. This enables technical issues to be solved without wasting precious microgravity time, allows quick responds to new findings and supports iterative refinement of experiments. As only one scientific experiment uses the drop tower at a time, operations can be fully tailored to the scientist's needs. However, access to the experiment is limited once the vacuum pumps are running, making the replacement of delicate samples difficult. Also, the evacuation time of up to 2 h could be limiting for certain experiments and reduces the number of repetitions to two or three drops per day.

The European A310 aircraft provides a large experiment area, can accommodate large payload masses and allows scientists to operate their experiments during the flight. Parabolic flights are typically organized in large campaigns involving around eight to twelve experiment teams simultaneously. Preparing these campaigns usually takes around six to 12 months. A typical parabolic flight campaign consists of a preparation week followed by three flight days, during which 31 consecutive parabolas are flown per day. Consequently, the campaign and the flights follow a strict and binding schedule for all participating teams. Opportunities to deviate from the flight plan due to technical difficulties with experimental hardware or other constraints are very limited. Furthermore, the closed aircraft environment, combined with the high density of scientific experiments from different research fields, and the heterogeneous composition of experiment teams, requires all experiments to pass a strict safety assessment. The use of chemicals, biological samples (such as human specimens or genetically modified organisms), or other potentially hazardous objects is highly restricted or prohibited and requires the implementation of rigorous safety measures.

Access to sounding rockets and orbiting spacecraft is still very limited, despite the increasing number of launches into orbit (SpaceStats, 2026) and significant decline in launch costs (Weinzierl and Rosseau, 2025). The preparation of space flown experiments often takes several years. However, the promotion of standardized interfaces (e.g., CubeSat format), the availability of in-orbit facilities and the reuse of existing hardware have shown that space experiments can also be implemented much faster. Nevertheless, in the foreseeable future, access to space will remain constrained by the limited number of flight opportunities and high launch costs. Therefore, even in the "new space" age, ground-based microgravity facilities will remain competitive and necessary.

The two large GAP facilities, GTB-Pro and EE, were transformative in terms of accessibility and repetition rate. These advantages make it possible to respond quickly to new findings, to explore larger parameter spaces and to acquire large data sets, permitting solid statistics. Like the drop tower, these facilities host only one experiment at the time. Therefore, its operation is

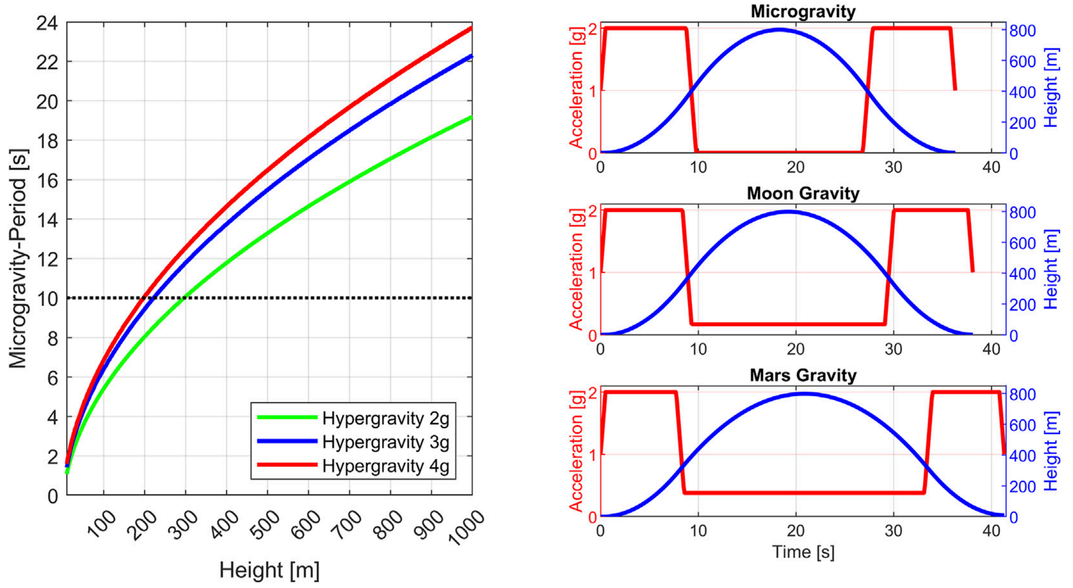
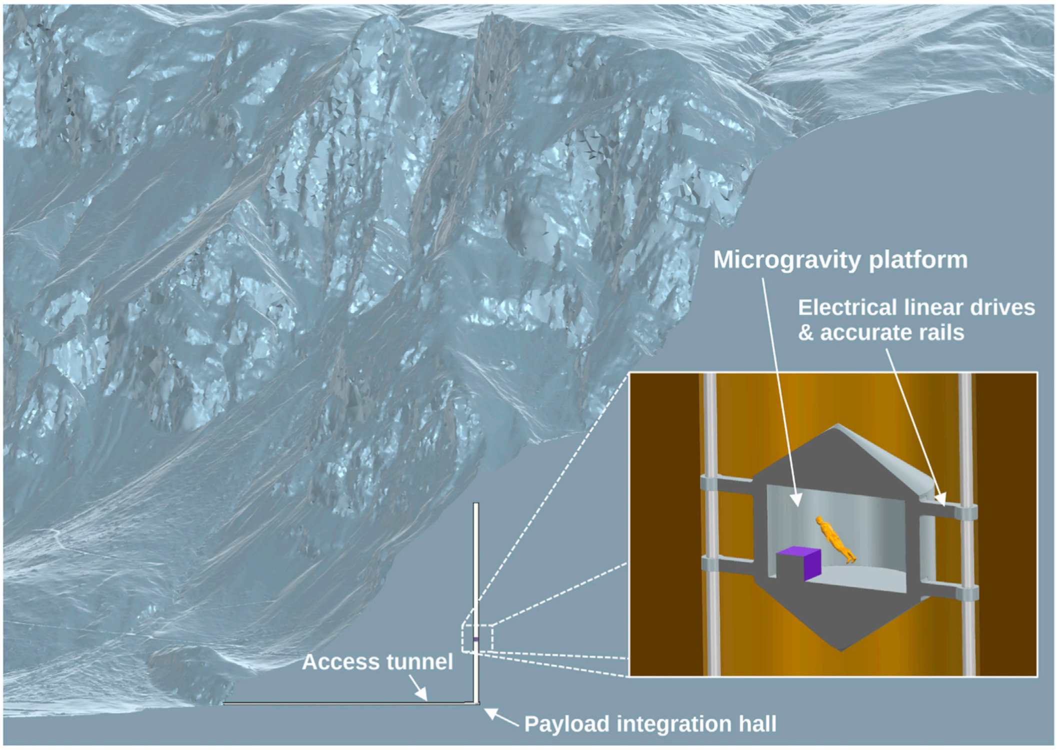


FIGURE 1
Left: Achievable microgravity time as a function of usable elevation difference and the initial acceleration and deceleration, which is perceived as hypergravity (elevated gravity). Right: Calculated example parabolas for microgravity, Moon- or Mars gravity in the case of 800 m usable elevation difference. This scenario is possible in an existing shaft near the village of Sedrun, Switzerland.

primarily guided by scientific needs rather than organizational constraints. Furthermore, the facilities remain accessible throughout the year and all weather conditions, while experiment capsules can be exchanged rapidly. This enables scientists and engineers to use the facility on a day-by-day basis, permitting fast iterations of construction, testing under microgravity conditions and hardware improvements. As a result, the excellent accessibility and the high repetition rates of the GAP facilities allow faster development iterations and larger data volumes within shorter time, likely leading to faster progress. However, current limitations include the short duration of the microgravity phase and limited available space. Moreover, neither facility permits flight operations with humans inside.

The two GAP facilities have laid the technological foundations for an upscaled system that could become Europe's next cutting-edge microgravity research and testing platform. The combination of electrodynamic linear drives, precision rails, an advanced RCM and a robust safety architecture enables a large cabin to be accelerated along a parabolic trajectory with passengers on board. The proposed facility could combine the excellent accessibility of the GTB-Pro and EE with the main advantages of parabolic flights, including a large experiment space (ca. 12 m^2), high payload capacity (up to 1000 kg) and clearance for untrained personnel to fly. The electrical drive in a controlled loop allows precise and repeatable generation of any arbitrary low-gravity condition, such as Moon, Mars or even asteroid gravity. An active release-caging mechanism with full motion control in six degrees of freedom will ensure effective reduction of role rates and vibrations coming from structural eigenfrequencies and deflections due to the changing gravitational load. Rapid decay of mechanical disturbance originating from the ascending acceleration phase and smooth transitions will be key to maximize the usable microgravity duration, which can also be achieved using active decoupling systems. By avoiding vacuum, high repetition rates (up to 100 parabolas per day) will be possible. The flexible, science-centered operation and the easy accessibility allow rapid evacuation of human subjects who may experience discomfort or motion sickness. This also enables experiments without preventive medication, which is common practice during parabolic flights. Drop towers in general and GAP facilities in particular have the potential to increase scientific output by integrating large computer clusters, enabling real-time simulations, simultaneous data evaluation and immediate adaption of experiments to new results. This approach opens the possibility for experiments to autonomously control the microgravity platform. In the near future, this capability will be limited mainly to ground-based facilities.

Such a microgravity research platform requires free-fall conditions over a certain time and distance. To enable parabolas comparable to current parabolic flights (ca. 20 s microgravity and max. 2 g hypergravity), a vertical free-fall distance of approximately 1′000 m would be required. However, a vertical distance of 300 m would already provide approximately 10 s of high-quality microgravity (Figure 1). Scaling the drive system to high speeds, longer distances and larger payloads is technically feasible but not trivial and will require further technological development. A more pressing limitation is the inability to construct a freestanding tower of this height with sufficiently low lateral deflections. For this reason, the platform would preferably be integrated into a high vertical tunnel or attached to a rigid vertical structure, such as a reservoir dam or a rock face. From this perspective, the European Alps represent an ideal location for such a novel low-gravity exploration platform. This early-stage concept has therefore been named "AlpG_E" standing for "Alpine Low Gravity Exploration". The



	GraviTower Bremen	Einstein-Elevator	Drop tower Bremen	AlpG$_E$	Parabolic flight
Microgravity period	≤2.5s	4s	Drop: 4.7s Catapult: 9.3s	ca. 10…16s	22s
Hypergravity	≤5g	5g	Drop: 0g / <50g Catapult: 30g / <50g	<4g	ca. 1.8g
Microgravity quality	10^{-4}g	10^{-6}g	10^{-5}…10^{-6}g	~10^{-3}g	10^{-2}…10^{-3}g
Partial gravity	✓	✓	✗	✓	✓
Experiment area	Several shelfs each Ø0.7m	Ø1.7m	Several shelfs each Ø0.7m	ca. 12m^2	typ. ca. 2x2 m max. 20x5 m
Paylaod weight	260 kg	1000kg	Drop: 260 kg / Catapult: 160 kg	ca. 1000 kg	200 kg/rack
Human access	✗	✗	✗	✓	✓
Repetitions/day	ca. 600	ca. 100	2-3	ca. 100	typ. 31
Safety restrictions	Low	Low	Low	Fair	High
Required automation	Fair	Fair	Fair	Low	Low
Accessability	Good	Fair	Fair	Good	Fair
Energy	Renewable 🍃	Renewable 🍃	Renewable 🍃	Renewable 🍃	Fossil fuel ⛽

FIGURE 2
Top: Schematic illustration of the AlpG$_E$ microgravity research and testing facility. A 300 m high shaft could be realized at the Hagerbach Test Gallery (The Underground Future Lab), near Flums, Switzerland. Bottom: Potential position of AlpG$_E$ concept on the European scientific market. In comparison to existing platforms, AlpG$_E$ allows medium sized experiments, high repetitions, good accessibility, human access and operation on clean, renewable energy. GTB-Pro and AlpG$_E$ offer "good" accessibility, as the facility can be operated independently of weather and campaigns and the platform is quickly accessible via a single door. The drop tower and the EE, have a similar mode of operation but closing of the airtight capsule reduces the accessibility to "fair". For parabolic flight, the accessibility is here rated "fair", due to the organization into few big flight campaigns and limiting safety constrains.

Alps offer many vertical structures, including solid rock faces, dams, and shafts, that already exist or could be realized. Due to the already existing excellent transport infrastructure by road and rail, many of these sites remain accessible throughout the year. Our team has identified six promising sites in Switzerland alone, where technical realization appears feasible. Among them, two prominent locations are two 800 m shafts near the village of Sedrun, which were built during construction of the Gotthard railway base tunnel (Figure 1); or the Hagerbach Test Gallery (The Underground Future Lab), near Flums (Figure 2).

4 Discussion

Currently, the European research community has access to a broad portfolio of platforms, providing microgravity of various durations and quality. These platforms have successfully met Europe's needs in research and development. However, the rapidly accelerating pace in the space sector will challenge both researchers and companies in providing deployable solutions in time. Therefore, there is a growing demand for microgravity platforms with a low entry barrier, easy accessibility and flexible operation (D'Angelo et al., 2026). Such platforms enable faster development cycles and support more efficient, data-driven research and development. In principle, Europe already possesses the key ingredients required to meet this demand. The two GAP facilities in Germany have already demonstrated the technical feasibility. Upscaling the technology from tens of meters to several hundred meters will be challenging but remains realistic. Finally, it will be possible to find an ideal location in the Alps. The Alps' solid rock formations allow the construction of rigid vertical structures with sufficient height differences for the installation of precision rails. In addition, the well-developed infrastructure ensures year-round accessibility of potential sites.

In conclusion, maintaining Europe's competitiveness in the "new space race" will require research, development and testing under realistic microgravity conditions. From our perspective, Europe is now well positioned to expand its capabilities and take the next step in advanced microgravity research and development.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Author contributions

SW: Conceptualization, Visualization, Writing – original draft, Writing – review and editing. SB-B: Writing – original draft, Writing – review and editing. AG: Writing – original draft, Writing – review and editing. MG: Writing – original draft, Writing – review and editing. KS: Writing – original draft, Writing – review and editing.

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Conflict of interest

Author AG was employed by Gierse Ingenieursdienstleistungen.

The remaining author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

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