# Brief: Microgravity Experimentation Services

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# Findings

*Rotoiti interviewed experts in microgravity experimentation services. Based on those conversations, this brief summarizes and problematizes the apparently increasing demand for microgravity research services. It also categorizes the reasons why clients want such services.*

## Increasing Interest in Microgravity Experimentation Services

**Microgravity offers unique conditions for experimentation.** Objects experience near weightlessness when they are located on platforms that are in free fall. One can access microgravity environments via various platforms such as satellites, parabolic flights, and drop towers. In such environments, phenomena occur differently than they do normally. On some microgravity platforms, objects are also exposed to increased levels of radiation. This is because Earth's atmosphere offers protection against various sources of radiation coming from beyond Earth. The extent of exposure depends on altitude, proximity to radiation belts around Earth (zones of charged particles held near the planet by Earth's magnetosphere), and other factors.

- Objects do not experience total weightlessness in microgravity because various phenomena mean g-forces are not totally absent – e.g. tidal effects, gravity from other objects, air resistance, and movements onboard the platform. It is also worth noting that platforms are not "gravity-free" – they are still falling due to Earth's gravity.

**Many firms are trying to sell services to facilitate microgravity experimentation.** In line with growing popular interest in the space industry, there has been an increasing number of firms offering to put payloads in microgravity environments for experimentation purposes. Many of these firms focus on facilitating access to orbital platforms in particular. Several of these firms have successfully raised rounds of capital. The prospects of these firms, though, is uncertain; enthusiasts believe there is growing demand for services, but skeptics question how much demand exists, especially in the absence of government support. Skeptics problematize factors that enthusiasts often cite as spurring demand for microgravity research. Three such factors – lowering launch costs, proliferating platforms, and returning mass – are discussed below.

**Lowering launch costs are one factor that is arguably spurring demand for microgravity experimentation services.** A common argument amongst enthusiasts is as follows: sending payloads to space entails a launch, and launch costs have been lowering, so lowering launch costs make microgravity research cheaper and thus spur more demand for such research. Critics, though, debate this. What portion of overall costs do launch costs represent to most customers? How do savings from lowering launch costs compare to government subsidies financing microgravity experimentation? If launch costs only represent a small portion of overall costs, or if the benefits of lowering launch costs pale in comparison to the benefits of government subsidies, then lowering launch costs are unlikely to significantly affect demand.

**Another factor that may be spurring demand for microgravity experimentation services is a proliferation of platforms on which such experimentation may be conducted.** The number of satellites orbiting Earth has grown dramatically in recent years. Many of these satellites might conceivably host microgravity experimentation payloads. If the supply of microgravity platforms is increasing, then all else equal, this should lead to an increase in demand. But again, this argument can be problematized. Depending on the type of experiment, many existing satellites are unsuitable. And though there are planned platforms which could rival the ISS in terms of hosting microgravity experiments, that's all they are for now: plans. Will plans inspire demand?

**Another factor potentially driving demand for microgravity experimentation services is easier return of mass, not just data, to Earth.** A shortcoming of orbiting platforms besides the ISS (and a limited number of other platforms) is that it is difficult to return their payloads to Earth. In space, payloads' responses to microgravity are often detected by onboard sensors which transmit data to Earth. Upcoming technologies may facilitate the returns of payloads to Earth, though. And this would make experimentation more valuable by allowing more comprehensive testing. Skeptics question if these new mass-return-from-space options will be more expensive than those that already exist, and if there will be enough customers willing to buy them. Skeptics also note suborbital platforms already exist for customers prioritizing return of mass.

- Several plans are in place to develop new platforms that spend time in orbit and then return, thus bringing payloads back to Earth. Other technologies are in development to allow more satellites to survive atmospheric reentry and thus return payloads.

- Parabolic flights and drop towers do not face such difficulties in returning mass to Earth. Of course they have other limitations, though, notably briefer stints in microgravity.

**As is the case with many business segments of the space industry, it is debatable whether there is enough demand for microgravity experimentation services to justify supplying them.** There are two common perspectives on this matter. One is optimistic. It acknowledges there is limited demand for such services, but believes greater supply will spur corresponding growth in demand. The other view is pessimistic. It doubts demand will catch up with supply, and thinks microgravity experimentation service providers are acting prematurely. Where one stands on the issue largely corresponds to one's sympathies for and extent of investment in the business.

## Reasons Customers Want Microgravity Experimentation Services

**Though the extent of demand for microgravity experimentation services is debatable, there is more consensus about the reasons why customers find such services valuable.** Microgravity experiments are often classified according to fields of study – life sciences or materials science, for example. But it is also possible and perhaps more useful to conceptualize demand according to categories defining what experimentation enables customers to do; thinking about what experimentation enables is useful for understanding why customers value experimentation,

and thus also perhaps for assessing how commercially viable such experimentation services are. Experts identified five reasons customers demand experimentation services, discussed below.

**One reason customers demand microgravity experimentation services is to conduct fundamental research.** Typically associated with government or academia in some way, such customers conduct research that is not specifically linked to any plans for commercialization. Life sciences and materials science are two fields where there is a significant amount of such fundamental research. For these customers, microgravity research services help advance research agendas and also justify spending resources that are allotted to such research.

**Another reason customers demand microgravity research is it helps them develop proofs of concept that they can use to justify operations back on Earth.** There are operations on Earth that can theoretically be done, but which are very costly to do. Before spending significant resources to carry out such operations, therefore, stakeholders seek proof that the operations will function according to expectations. This is one reason why some customers may find value in microgravity experimentation services; they are willing to spend a relatively small amount of resources in microgravity to then justify spending significantly more resources back on Earth.

**Yet another reason customers demand microgravity services is to test and validate space systems.** For systems meant to function in space (e.g. satellite-borne computers), it is important to show the systems work in space. This convinces customers and other stakeholders that the systems are worth developing and buying. There are many stages of testing and validation in systems' development. And the scope of focus varies, sometimes looking at overall systems or at other times looking at specific subsystems. Relatedly, systems developers seek to gain "flight heritage", a somewhat nebulous term connoting successful performance in space. Note that a large amount of space systems' testing and validation can occur on Earth.

**A fourth reason, or rather a collection of reasons that customers demand microgravity experimentation services is that they help sell novelty, aesthetic, or luxury products.** Though this perhaps stretches the concept of "experimentation", it was identified in many conversations with experts. There is an obviously exotic quality to products which have been to space; for most humans, space is inaccessible and about as strange or unusual a setting as can exist. Some market actors can leverage this exotic quality as a selling point – whether by selling products that have been to space (e.g. cosmetics or wristwatches), or by selling products whose space origins help "transport" customers there (e.g. movies, advertisements, or video games).

**A final reason customers find value in microgravity experimentation services is to enable them to manufacture products in space, to be sold either in space or back on Earth.** This was noted by several of the experts, though they admitted it is the most "sci-fi" reason for demand for microgravity experimentation services. Most experts believe there will come a time when it will make sense to manufacture certain products in space, whether to be sold to customers in space or back on Earth. Ultimately, to be economically justifiable, the value of manufacturing in space will need to outweigh the costs. Long-term thinking customers may be willing to pay now for microgravity services that test and validate technologies that enable such manufacturing.