

# **Reusable Suborbital Market Characterization**

**Prepared by The Tauri Group for Space Florida  
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# Introduction

- ✦ **Purpose:** Define and characterize the markets reusable suborbital vehicles will address
- ✦ **Goals**
  - ✦ Define market categories
  - ✦ Identify market drivers
  - ✦ Characterize current activities
  - ✦ Provide basis for future market forecasting (Note that this study is not a forecast)
- ✦ **Benefits**
  - ✦ Shared understanding improves quality and productivity of industry discourse
  - ✦ A consistent taxonomy enables communications across the community, with Congress, press, and investors
  - ✦ Accessible information helps industry participants assess opportunities, plan and coordinate activities, seek funding, and budget

# Agenda

- ✦ Methodology
- ✦ Suborbital spaceflight attributes and vehicles
- ✦ Value proposition
- ✦ Characterization and analysis of markets
  - ✦ Commercial human spaceflight
  - ✦ Basic and applied research
  - ✦ Aerospace technology test and demonstration
  - ✦ Remote sensing
  - ✦ Education
  - ✦ Media & PR
  - ✦ Point-to-point transportation
- ✦ Conclusions

# Methodology

- ✦ Literature review and data collection
  - ✦ Articles, reports, and publications
  - ✦ Available launch and research datasets
  - ✦ Applicable payloads
  - ✦ Initial customers
- ✦ Interviews
  - ✦ Researchers
  - ✦ Launch service providers
  - ✦ Funding agencies
  - ✦ Potential commercial customers
  - ✦ Users
- ✦ Analysis and findings
  - ✦ Vehicles
  - ✦ Payload types
  - ✦ Markets
    - ✦ Opportunities
    - ✦ Challenges
    - ✦ Users
    - ✦ Economic buyers

# Reusable Suborbital Vehicles

- ✦ Industry catalyzed by Ansari X PRIZE, won in 2004 by SpaceShipOne
- ✦ Of vehicles under development, 5 vehicles submitted data to NASA Flight Opportunities program
  - ✦ SpaceShipTwo, Virgin Galactic
  - ✦ New Shepard, Blue Origin
  - ✦ Xaero, Masten Space Systems
  - ✦ Lynx, XCOR Aerospace
  - ✦ SuperMod, Armadillo Aerospace
- ✦ Other vehicles have been announced, including those potentially in development by Sierra Nevada, EADS, Dassault Aviation, Rocketplane, Copenhagen Suborbitals

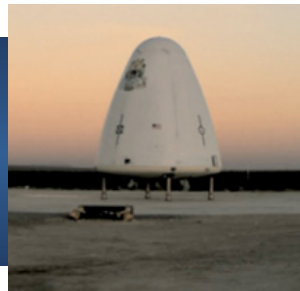


# Reusable Suborbital Spaceflight Attributes

- ✦ Vehicles typically cross the threshold of space (~100km/~62 mi)
- ✦ Safe for human transportation
- ✦ 1 – 4 minutes of microgravity
- ✦ Traverses upper atmospheric regions
- ✦ Substantially reduces cost for space access
- ✦ Anticipation of frequent flights
- ✦ Opportunity for satellite launch
- ✦ Several companies have received deposits
  - ✦ Virgin Galactic: 390 customers, \$50 million
  - ✦ XCOR: \$50 million wet leases



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# Reusable Suborbital Value Proposition

- ✦ Least expensive access to space (potential order-of-magnitude reduction per unit mass)
- ✦ Frequent flights
- ✦ Can carry humans
- ✦ Return capability
- ✦ Potential for launch on demand
- ✦ Commercial providers
  - ✦ Customer oriented
  - ✦ Flexible
- ✦ Longer duration microgravity than
  - ✦ Drop towers
  - ✦ Parabolic flights
- ✦ Larger payload capacity than
  - ✦ Sounding rockets
  - ✦ Drop towers
- ✦ Higher quality microgravity than
  - ✦ Parabolic flights
- ✦ Gentler ride than
  - ✦ Sounding rockets



# Defining Suborbital Spaceflight Markets

## MARKET NAME

Submarket  
Submarket  
Submarket

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*Market definition here. Markets are defined based on similar purpose, activities, and customers (both users and economic buyers)*

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- ✦ Each market characterized in terms of
  - ✦ **Opportunities** provided to customers by reusable suborbital spaceflight
  - ✦ **Challenges** to market growth
  - ✦ **Users** of spaceflight
  - ✦ **Economic buyers** of spaceflight
    - ✦ Space agencies, military organizations, civil government agencies, colleges and universities, K-12 schools, grant-making foundations, commercial firms, space firms, not-for-profits / NGOs, individuals
    - ✦ As markets evolve over time, users and economic buyers may change



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# Suborbital Markets

## COMMERCIAL HUMAN SPACEFLIGHT

Individuals  
Corporate sales  
Raffles, contests, and promotions  
In-space personnel training

## BASIC AND APPLIED RESEARCH

Biological and physical R&D  
Earth science  
Space science  
Human research

## AEROSPACE TECHNOLOGY TEST AND DEMONSTRATION

Demonstrations requiring space/launch environment  
Hardware qualification and test  
Program management training

## REMOTE SENSING

Commercial earth imagery  
Civil earth imagery  
Military surveillance

## EDUCATION

K-12 education  
Post graduate education and training  
University research and educational missions

## MEDIA & PR

Film and television  
Media, advertising, and sponsorship  
Public relations and outreach

## POINT-TO-POINT TRANSPORTATION

Fast package delivery  
High-speed passenger transportation (civil)  
High-speed troop transportation (military)



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## PEOPLE

COMMERCIAL HUMAN SPACEFLIGHT

BASIC AND APPLIED RESEARCH

AEROSPACE TECHNOLOGY DEMONSTRATION AND TESTING

REMOTE SENSING

EDUCATION

MEDIA & PR

POINT-TO-POINT

## CARGO

## ASSOCIATIONS

MEDIA & PR

# Commercial Human Spaceflight

## COMMERCIAL HUMAN SPACEFLIGHT

Individuals  
Corporate sales  
Raffles, contests, and promotions  
In-space personnel training

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*Human spaceflight experiences for  
tourism or training*

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### ✦ Opportunities

- ✦ New and unique offering
- ✦ More affordable, easier access to space
- ✦ Networking / prestige for early customers
- ✦ May lead to long-term applications like adventure sports

### ✦ Challenges

- ✦ High costs
- ✦ Real and perceived safety risks
- ✦ Uncertainty about regulatory requirements

### ✦ Users include

- ✦ Space tourists
- ✦ Professional in-space personnel (astronauts, crew)

### ✦ Economic buyers

- ✦ Individuals (High and ultra-high net-worth individuals, space enthusiasts)
- ✦ Space agencies
- ✦ Space firms
- ✦ Commercial firms



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# Basic and Applied Research

## BASIC AND APPLIED RESEARCH

Biological and physical R&D

Earth science

Space science

Human research

*Basic and applied research in a number of disciplines, leveraging the unique properties of and access to the space environment and microgravity*

### ✦ Opportunities

- ✦ Access to space
- ✦ Quality microgravity of meaningful duration
- ✦ Frequent flight opportunities
- ✦ Within important funding thresholds
- ✦ Broad range of feasible experiments
  - ✦ Payload recovery
  - ✦ Large payloads
  - ✦ Humans and equipment together
  - ✦ Sensitive equipment and instrumentation

### ✦ Challenges

- ✦ Duration is not suitable for all types of space research
- ✦ Frequency of flight opportunities not sufficient for all research objectives
- ✦ Still expensive, with limited access, compared to most non-space research environments

### ✦ Users include

- ✦ Scientists and researchers (includes in-space researchers)
- ✦ Engineers and technologists
- ✦ Graduate students
- ✦ Students and teachers

### ✦ Economic buyers

- ✦ Space agencies
- ✦ Civil government agencies (R&D agencies)
- ✦ Colleges and universities
- ✦ Not-for-profits / NGOs
- ✦ Grant-making foundations
- ✦ Commercial firms
- ✦ Military organizations
- ✦ K-12 schools

# Basic and Applied Research

## BASIC AND APPLIED RESEARCH

### Biological and Physical R&D

- *Biotechnology*
- *Animal biology*
- *Cellular biology*
- *Microbiology*
- *Plant biology*
- *Fluid physics*
- *Fundamental physics*
- *Particle conglomeration*
- *Combustion science*
- *Macromolecular crystal growth*
- *Plasma physics*
- *Materials science and research*

### Space Science

- *Heliophysics*
- *Astrophysics*
- *Planetary science*

### Earth Science

- *Atmospheric science*
- *Weather*
- *Climate variability and change*
- *Carbon cycle and ecosystems*
- *Water and energy cycles*
- *Earth surface and interior*
- *Oceanography*

### Human Research

- *Large population medical research*
- *Space radiation*
- *Human health countermeasures*
- *Exploration medical capability*
- *Behavioral health and performance*
- *Space human factors and habitability*



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# Basic and Applied Research Submarkets

## Earth Science

- *Atmospheric composition*
- *Weather*
- *Climate variability and change*
- *Carbon cycle and ecosystems*
- *Water and energy cycles*
- *Earth surface and interior*

### ✦ Opportunities:

- ✦ Unique and repeated access to mesosphere, thermosphere and lower ionosphere
- ✦ Resolution / field of view niche between aerial and satellite

### ✦ Challenges

- ✦ Limited locations
- ✦ Capabilities of existing aerial, space systems

## Biological and Physical R&D

- *Biotechnology*
- *Animal biology*
- *Cellular biology*
- *Microbiology*
- *Plant biology*
- *Fluid physics*
- *Fundamental physics*
- *Particle conglomeration*
- *Combustion science*
- *Macromolecular crystal growth*
- *Plasma physics*
- *Materials science and research*

### ✦ Opportunities

- ✦ Removal of gravity from complex systems
- ✦ Exposure to vacuum and radiation

### ✦ Challenges

- ✦ Limited timeline, frequency for some experiments



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# Basic and Applied Research Submarkets

## Space Science

- *Heliophysics*
- *Astrophysics*
- *Planetary science*

### ✦ Opportunities

- ✦ Access to observations uncompromised by atmospheric disturbance
- ✦ Space weather measurements
- ✦ Access to particular wavelengths

### ✦ Challenges

- ✦ Short timeframe for observation
- ✦ Precise pointing required
- ✦ Relatively expensive compared to terrestrial options

## Human Research

- *Large population medical research*
- *Space radiation*
- *Human health countermeasures*
- *Exploration medical capability*
- *Behavioral health and performance*
- *Space human factors and habitability*

### ✦ Opportunities

- ✦ Sufficient time to practice / demonstrate in-space life saving procedures
- ✦ Easy measurement of physiological mechanisms
- ✦ Hyper / micro gravity transition
- ✦ Large population datasets (better reflecting general population)
- ✦ Repeated measurements of the same individual
- ✦ Capacity for large imaging equipment

### ✦ Challenges

- ✦ Relatively few experiments designed that focus on general human health, rather than astronaut health
- ✦ Participation of spaceflight customers, crew, and providers



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# Aerospace Technology Test and Demonstration

## AEROSPACE TECHNOLOGY TEST AND DEMONSTRATION

Demonstrations requiring space/launch environment  
Hardware qualification and test  
Program management training

*Aerospace engineering to advance technology maturity or achieve space demonstration, qualification, or certification*

### ✦ Opportunities

- ✦ Suborbital space qualification and testing can reduce cost and accelerate TRL advancement
- ✦ Overcomes “chicken and egg” problem of being demonstrated in space
- ✦ Potential value to all space organizations
- ✦ Micro / nano satellite launch
- ✦ More hands-on space project management

### ✦ Challenges

- ✦ Suborbital provides important, but limited analog to orbital environment
- ✦ Extensive terrestrial test facilities exist

### ✦ Users include:

- ✦ Engineers and technologists
- ✦ Scientists and researchers
- ✦ Graduate students

### ✦ Economic buyers

- ✦ Space agencies
- ✦ Military organizations
- ✦ Space firms
- ✦ Colleges and universities



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# Remote Sensing

## REMOTE SENSING

Commercial earth imagery  
Civil earth imagery  
Military surveillance

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*Acquisition of imagery of the Earth and Earth systems for commercial, civil government, or military applications*

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### ✦ Opportunities

- ✦ Resolution / field of view niche between aerial and satellite
- ✦ Safe and responsive intelligence, surveillance, and reconnaissance
- ✦ Micro / nano satellite launch

### ✦ Challenges

- ✦ Limited locations
- ✦ Robust capabilities of existing systems
  - ✦ Aerial and satellite for civil and commercial markets
  - ✦ Satellite and UAV for military applications (also new ISR rocket in development)

### ✦ Users include

- ✦ Current users of aerial / satellite remote sensing
- ✦ Warfighters

### ✦ Economic buyers

- ✦ Space agencies
- ✦ Civil government agencies (NOAA, USGS, resource management agencies)
- ✦ Commercial firms (agricultural, resource exploration)
- ✦ Military organizations



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# Education

## EDUCATION

### K-12 education

#### Post graduate education and training

#### University research and educational missions

*Providing opportunities to K-12 schools, colleges, universities, and graduate programs to increase access to and awareness of space*

#### ✦ Strengths

- ✦ Direct access to space
- ✦ Allows graduate students timely, predictable data for theses
- ✦ Within K-12, undergraduate education budgets
  - ✦ Within range of existing expenditures
  - ✦ Space field trip for 200 students to the Challenger Center, MA: \$4,000

#### ✦ Challenges

- ✦ Competing with other education priorities
- ✦ K-12 spending has tight upper limits per school
- ✦ Integration with state and federal testing and required curricula
- ✦ Reliance on availability of secondary and tertiary payloads may limit opportunities, control

#### ✦ Users include

- ✦ Graduate students
- ✦ Students and teachers

#### ✦ Economic buyers

- ✦ Space agencies
- ✦ Civil government agencies (education, other STEM related agencies)
- ✦ Colleges and universities
- ✦ K-12 schools
- ✦ Grant-making foundations

# Media and PR

## MEDIA & PR

Film and television

Media, advertising, and sponsorship

Public relations and outreach

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*Using space to promote products,  
increase brand awareness, or film  
space-related content*

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### ✦ Strengths

- ✦ Space images and associations have appeal
- ✦ Small existing market for video on parabolic flights

### ✦ Challenges

- ✦ Scheduled events required in advance for promotion and planning
- ✦ Limited “eyeballs” for space launches
- ✦ Commercial launches to date have not attracted substantial or mainstream advertising
- ✦ In-space filming competes with CGI

### ✦ Users include

- ✦ Content developers
- ✦ Communications professionals

### ✦ Economic buyers

- ✦ Commercial firms (advertising, PR agencies and clients; studios and production companies)
- ✦ Colleges and universities



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# Point-to-Point Transportation

## POINT-TO-POINT TRANSPORTATION

Fast package delivery  
High-speed passenger transportation (civil)  
High-speed troop transportation (military)

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*Future transportation of cargo or humans between different locations*

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### ✦ Opportunities

- ✦ Reduced air time for transportation of cargo or humans

### ✦ Challenges

- ✦ Infrastructure and vehicle development required
- ✦ Uncertainty about regulatory requirements
- ✦ Global overnight possible with “merely” supersonics
- ✦ Air time not always the driver of total travel time

### ✦ Users include

- ✦ Space tourists
- ✦ Warfighters
- ✦ Couriers
- ✦ Travelers

### ✦ Economic buyers

- ✦ Civil government agencies
- ✦ Military organizations
- ✦ Commercial firms (Logistics companies)
- ✦ Individuals



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# Conclusions

- ✦ Significant opportunities across all markets
  - ✦ Clear and immediate benefits for entities already engaged in space activities, particularly in research and aerospace technology markets
  - ✦ Potential to reach new customers, particularly in commercial human spaceflight and education markets
- ✦ Challenges
  - ✦ Cost, while much lower than existing access to space, remains high
  - ✦ In many markets there are competing alternatives
- ✦ Growth in interest from potential economic buyers requires relationship building and education
  - ✦ Educating potential customers on value of space
  - ✦ Education within the space community on different customer needs
- ✦ Value proposition is relative to the market, alternatives, and particular customers
- ✦ Thank you to Space Florida



# Contact

- ✦ Carissa Christensen, Managing Partner
  - ✦ carissa.christensen@taurigroup.com
- ✦ Paul Guthrie, Senior Analyst / Project Lead
  - ✦ paul.guthrie@taurigroup.com
- ✦ Jason Hay, Senior Analyst
  - ✦ Jason.hay@taurigroup.com
- ✦ Rachael Graham, Research Assistant
  - ✦ Rachael.graham@taurigroup.com

The Tauri Group  
675 N. Washington St., Suite 220  
Alexandria, VA 22314  
[www.taurigroup.com](http://www.taurigroup.com)  
703-683-2883



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