

A space-themed background featuring a view of Earth's horizon from space. A bright, glowing arc of light, possibly a rocket launch or a celestial body, curves across the upper left portion of the frame. The sky is filled with stars and a faint Milky Way galaxy.

THE BUSINESS OF MICROLAUNCHERS

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WE HELP EARTH BENEFIT FROM SPACE

AN INTRODUCTION TO THE MICRO LAUNCHER MARKET

Ulf Palmnäs (presented by Philip Pålsson)

10 March 2020

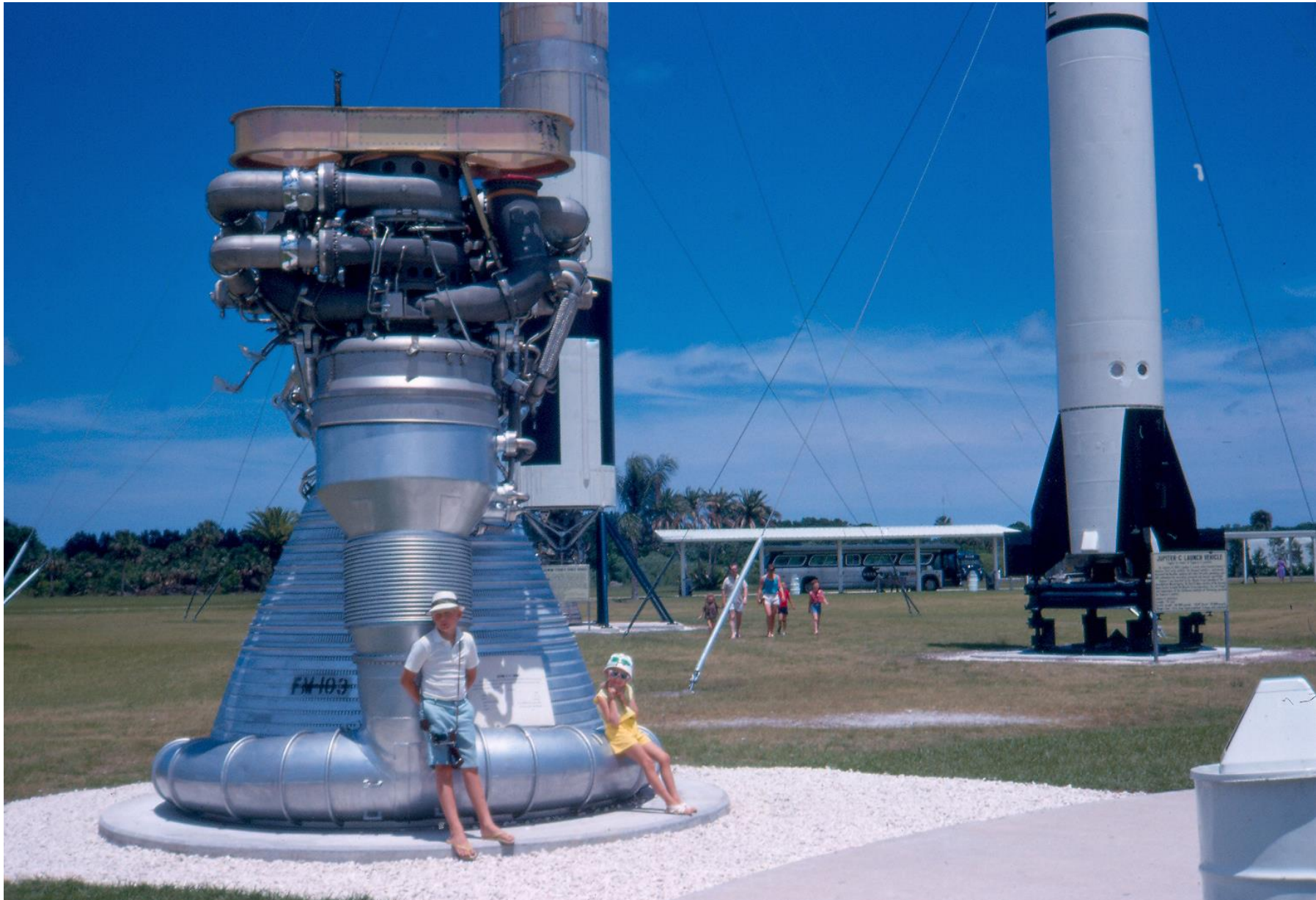


PRESENTATION



1. Introduction
2. Big Picture
 - market
 - payload size
 - launch method
 - ongoing developments
 - price & service
3. Space ports
4. Conclusions

JUNE 1969 – CAPE CANEVERAL



INTRODUCTION



- Summer of 1982, I had the privilege to work as an intern on the Conestoga 1 rocket, The first privately funded rocket to reach space.
- In autumn of 1983, the Conestoga was the rocket used for studying if it was possible to launch satellites from Esrange?
- And yes it was (and is) but the market was not ready, and also the development of the Conestoga rocket failed



<https://www.youtube.com/watch?v=AGCFW0VeSS4>

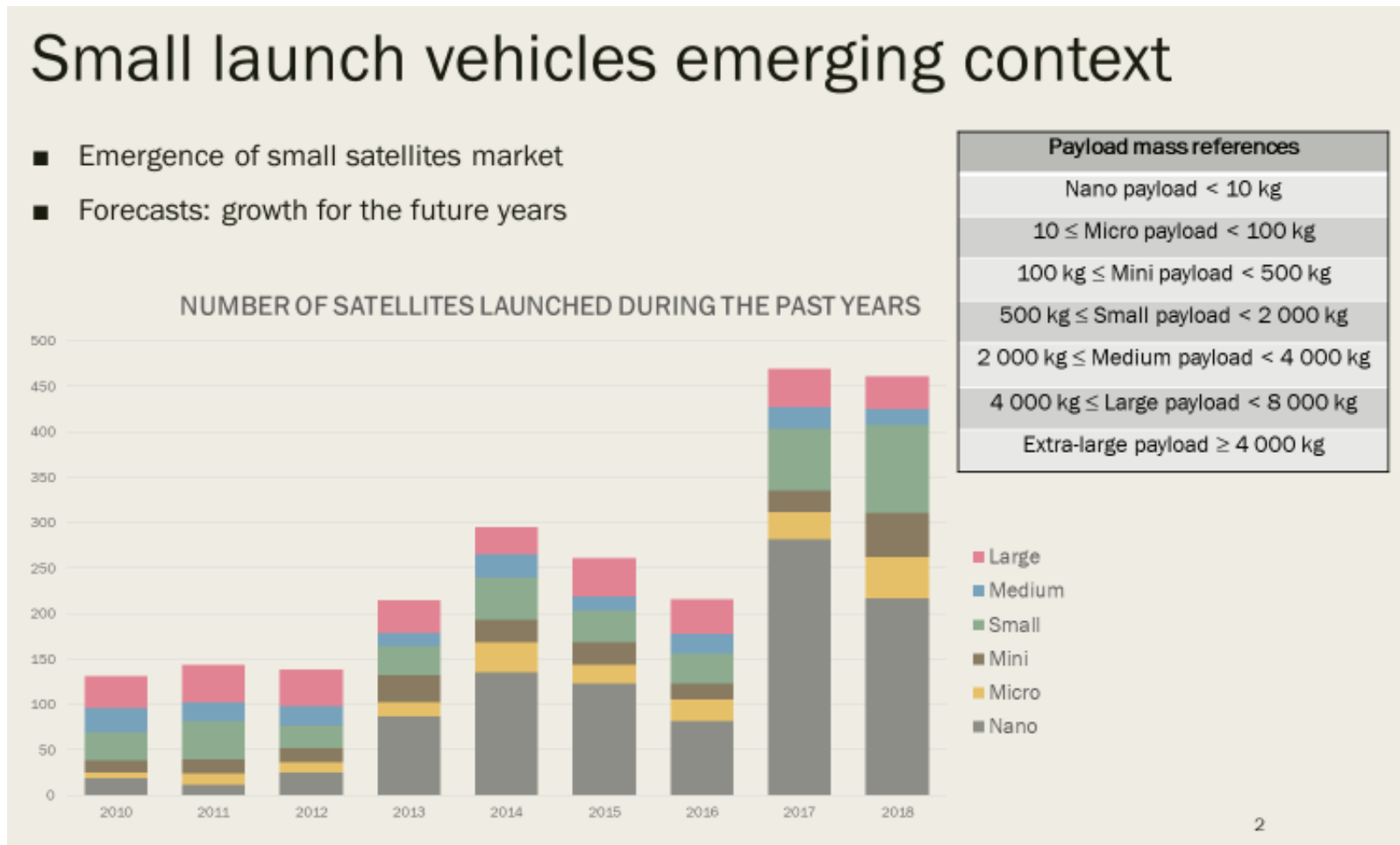
INTRODUCTION



- So is there a market today?

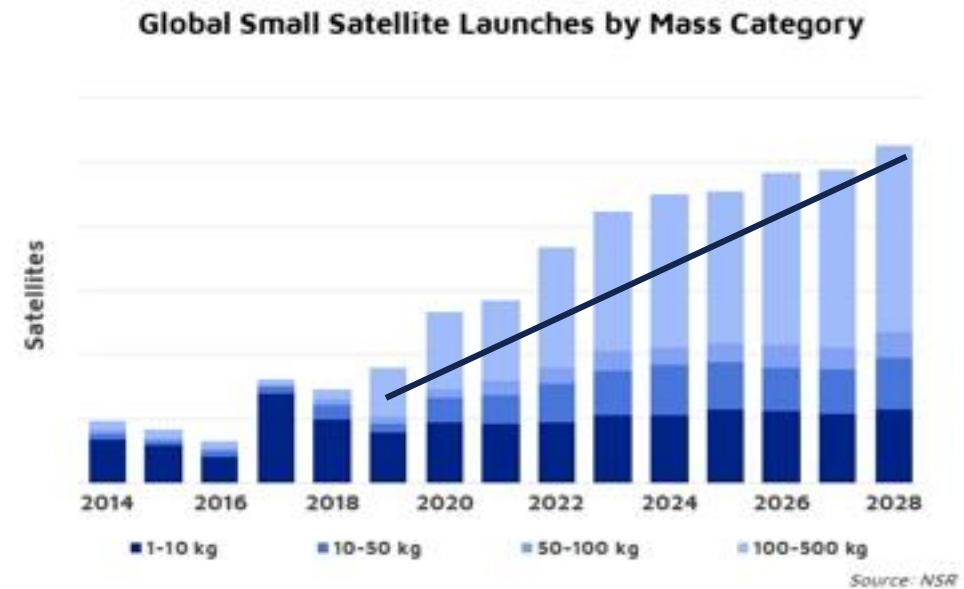
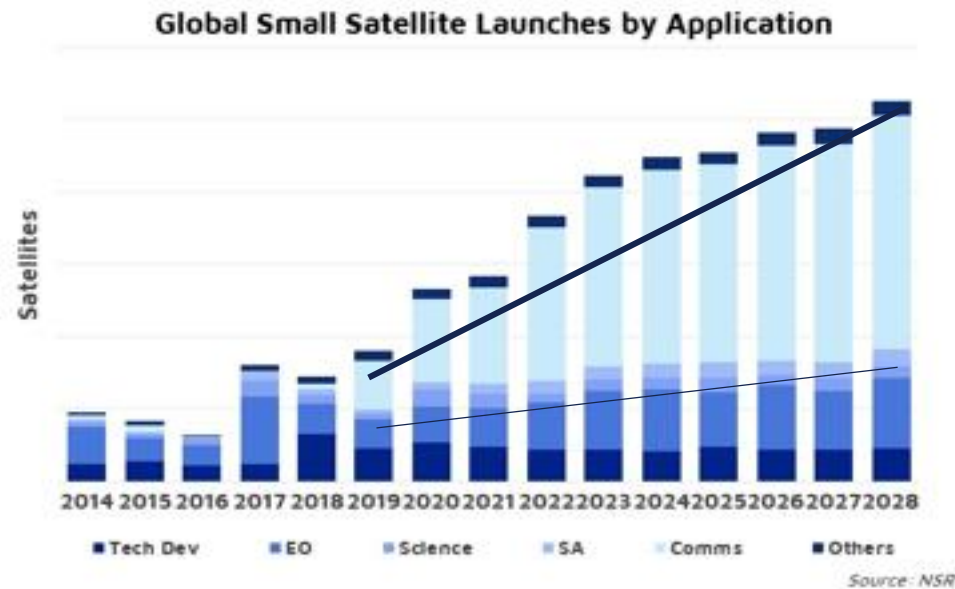
YES !

- A formidable explosion in the number of small satellites < 500kg that have been launched. And are predicted to be built and launched in the coming years.



NORTHEN SKY RESEARCH -

- NSR forecasts the market to yield close to \$42 billion in cumulative revenues from smallsat manufacturing and launch services by 2028.



- Forecasted growth in number of s/c, and in \$ also in segments outside the telecom sector.

KEY QUESTION FOR MICRO LAUNCHERS...



- Will customers choose a Bus or Taxi ?
- Piggy-back
 - + PRICE / kg
 - shared ride
 - wait...
 - wrong orbit
- Dedicated launch
 - Price / kg
 - + Prime
 - + when you want
 - + to where you want
 - + from Europe...
 - ? Reliability
(rocket lab 100% after test flights)



KEY QUESTION FOR MICRO LAUNCHERS...



- Bus or Taxi ?
- Piggy-back
 - Falcon 9
 - PSLV
 - Soyuz
 - VEGA
 - Ariane
 - H-2 / H-3
 - ...
- Dedicated launch
 - Pegasus (US)
 - Minotaur (US)
 - Shavit (Israel)
 - Safir (Iran)
 - ...
 - ~~Falcon 1~~
 - Electron
 - LM 6, LM11... (China)
 - ...



BIG PICTURE

- NUMBER OF MICRO LAUNCHER PROJECTS IDENTIFIED BY NORTHRUP GRUMMAN



- Able to launch up to 1000 kg to LEO
- Active online or in conference in last 2 years

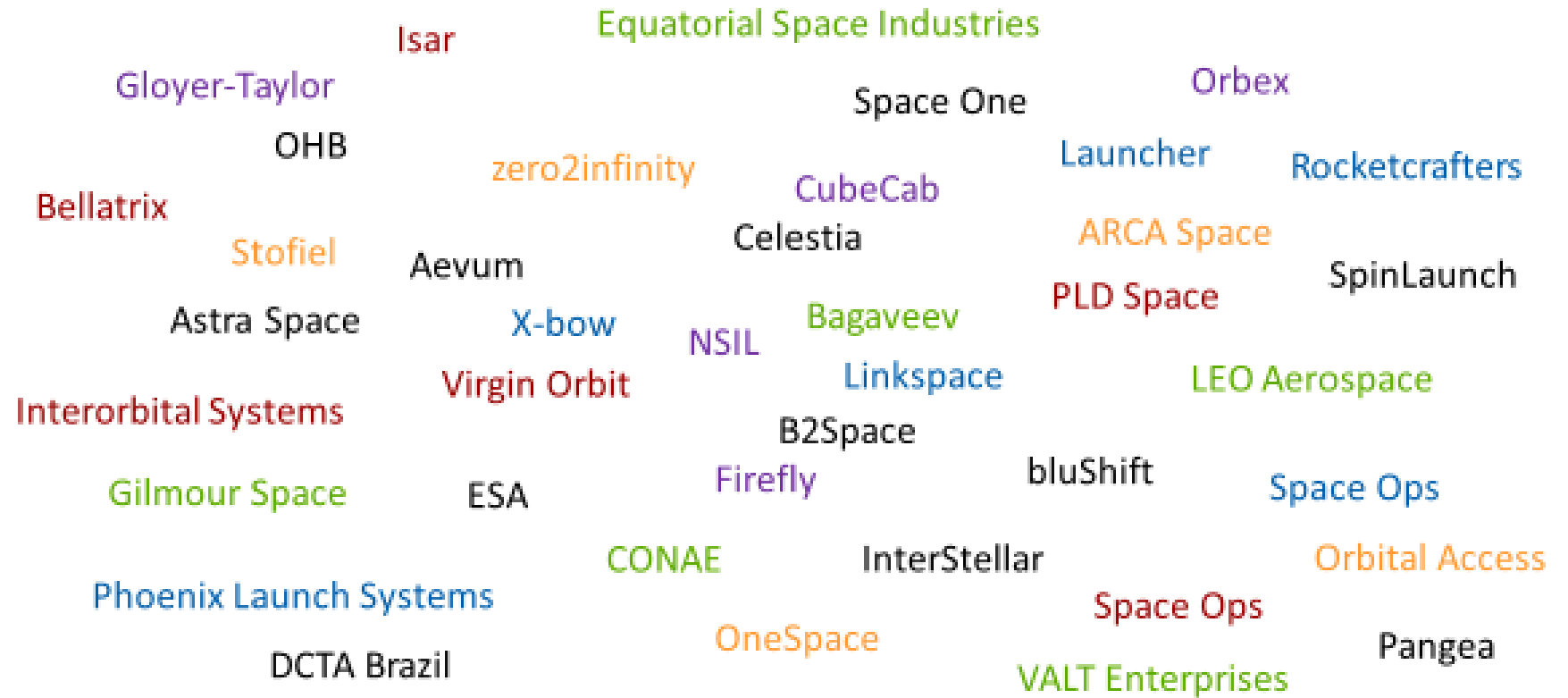


BIG PICTURE



- Of 148,
- 8 are operational of which 5 are Chinese + Pegasus Minotaur & Electron
- 41 are under "development"
- 58 are on the "watch list"
- 41 are in limbo

Forty-One Under Development



BIG PICTURE

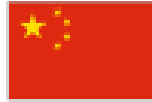
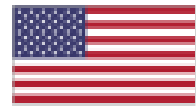
- UNDER DEVELOPMENT

- USA and China dominate.
- Entrepreneurs, Gov. support and Funding is a discriminator.

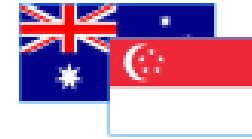


NORTHROP GRUMMAN

Country of Origin



Country	Count
USA	21
China	7
Spain	4
United Kingdom	3
Germany	2
India	2
Japan	2
Argentina	1
Australia	1
Australia/Singapore	1
Brazil	1
Europe	1
Singapore	1
UK/Ukraine	1
USA/New Zealand	1



BIG PICTURE – FUNDING



- ESA estimate is that it takes ~150 M\$ to get to first launch.
- Private investors are expected to invest most of that amount.
- The Micro launcher eco systems needs investors to thrive.
- Investors loves assured customers and not competing with governments.

Funding Sources *Partial List for Illustration Purposes*

NORTHROP GRUNMAN

Government	Angel Investors / Seed	Venture Capital
<ul style="list-style-type: none">• NASA• USAF• DARPA• ESA• EU/Horizon 2020• UK Space Agency• JAXA	<ul style="list-style-type: none">• 500 Startups• StartupXseed• Space Angels• RedSeed• Y Combinator• High-Tech Gründerfonds• Sand Hill Angels	<ul style="list-style-type: none">• Seraphim• Khosla• Huaxing Growth Capital• Lauder Partners• Starlight Ventures• Sequoia Capital• Chun Xiao Capital
Government Development	Other	
<ul style="list-style-type: none">• Development Bank of Japan• Skolkovo• Aabar Investments• Maine Space Grant• Gobierno de Aragon• Saudi Arabia	<ul style="list-style-type: none">• Crowd-funding• Prizes• Sergei Burkatovsky• Paul Allen• Gonzalo de la Peña• Deepika Radukone	

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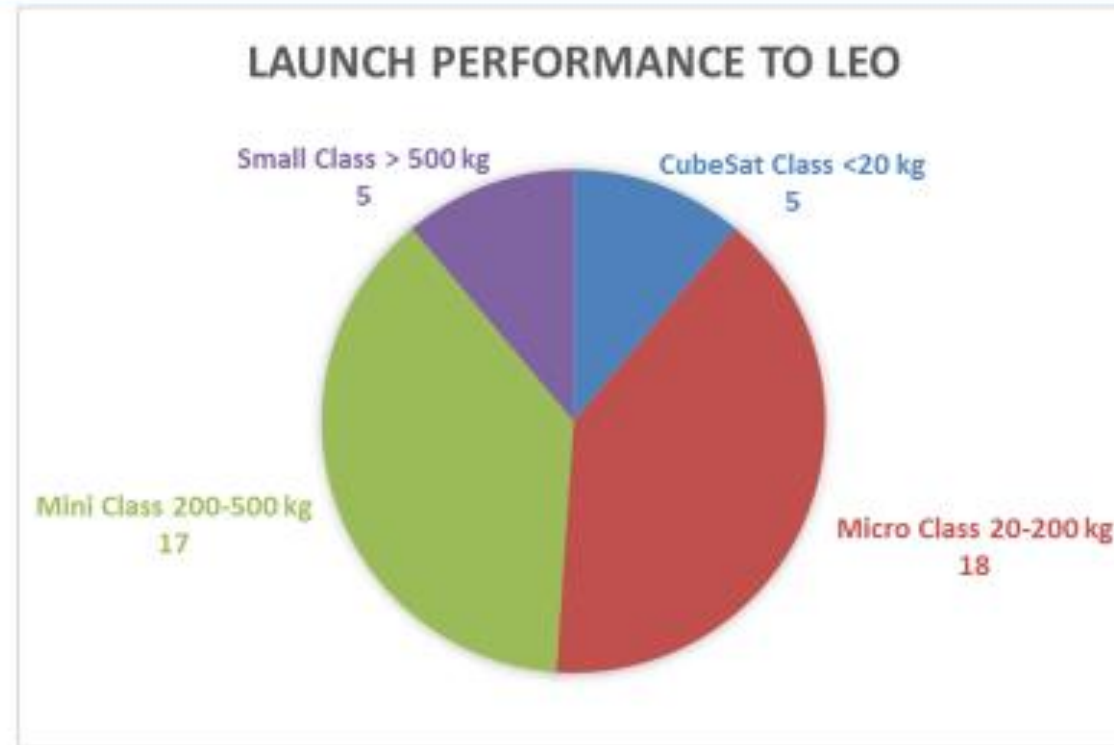
BIG PICTURE



- Different market segments sought.

How Small is Small?

NORTHROP GRUMMAN



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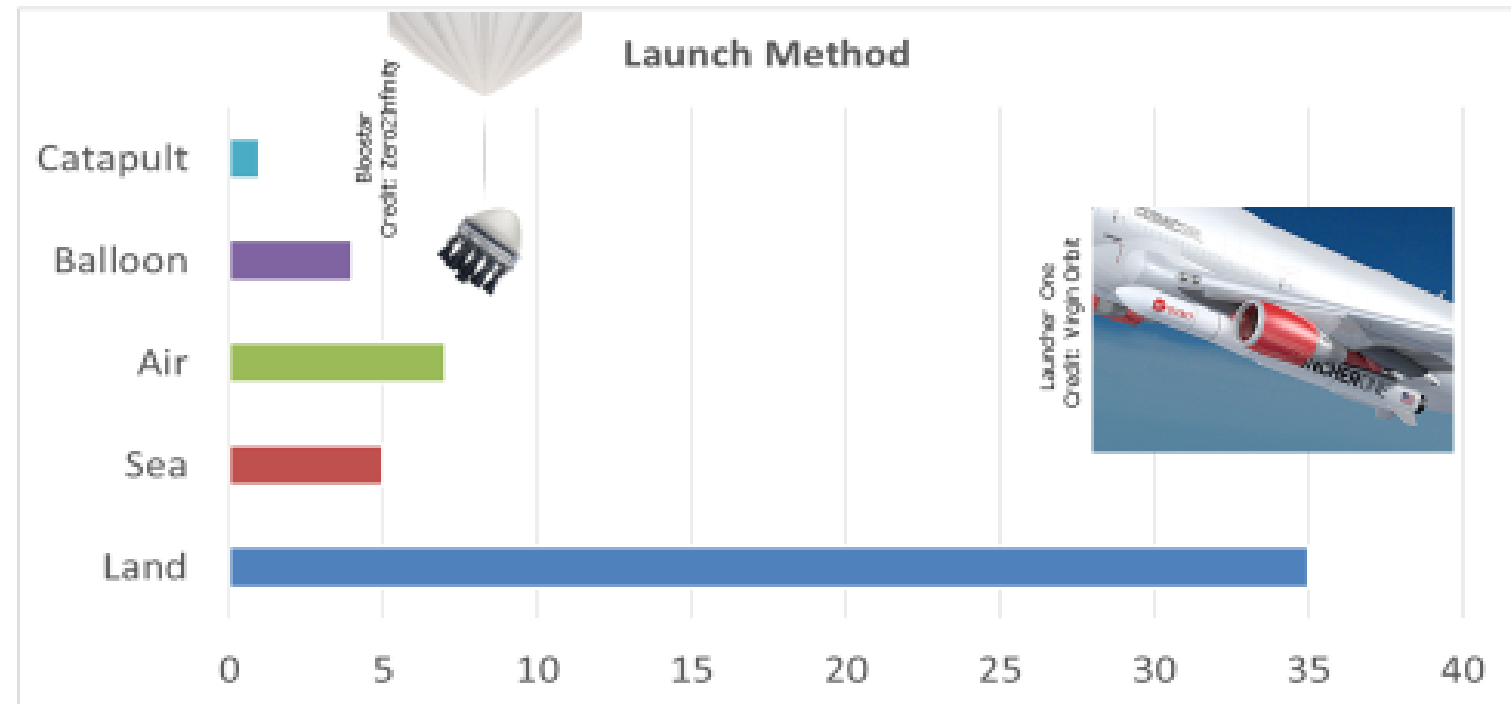
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BIG PICTURE



- Different launch methods.

Varied Launch Methods



Note: A number of vehicles have multiple launch methods

MICRO LAUNCHERS - METHOD

AIR LAUNCH



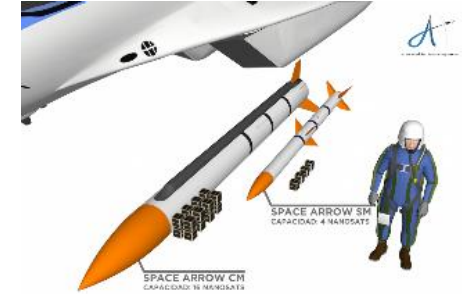
- Altitude and speed to reduce rockets Delta-V



Bloostar is a three-stage all composite pressure fed liquid cryogenically propelled balloon launched vehicle with toroidal tanks with 75 kg capabilities from Zero2Infinity.



LauncherOne is a two stage RP-1 fueled 747 air launched vehicle with LOx as an oxidizer with 500 kg capabilities from Virgin Orbit.



Sagittarius utilizes the *Archer* MiG29UB as the airborne platform to launch the three stage solid motor *Space Arrow* rocket. This system developed by Celestia Aerospace can lift up to 16 kg to LEO.

MICRO LAUNCHERS - SIZE



Blue Whale 1 is a two-stage ground launched vehicle with advanced engines running on LOx/LNG . ~60 kg to LEO from Perigee aerospace



Electron is a two-stage LOx/kerosene ground launched vehicle using 3D printed engines with electric fuel pumps with 200 kg capabilities from Rocket Lab.



LauncherOne is a two stage RP-1 fueled 747 air launched vehicle with LOx as an oxidizer with 500 kg capabilities from Virgin Orbit.

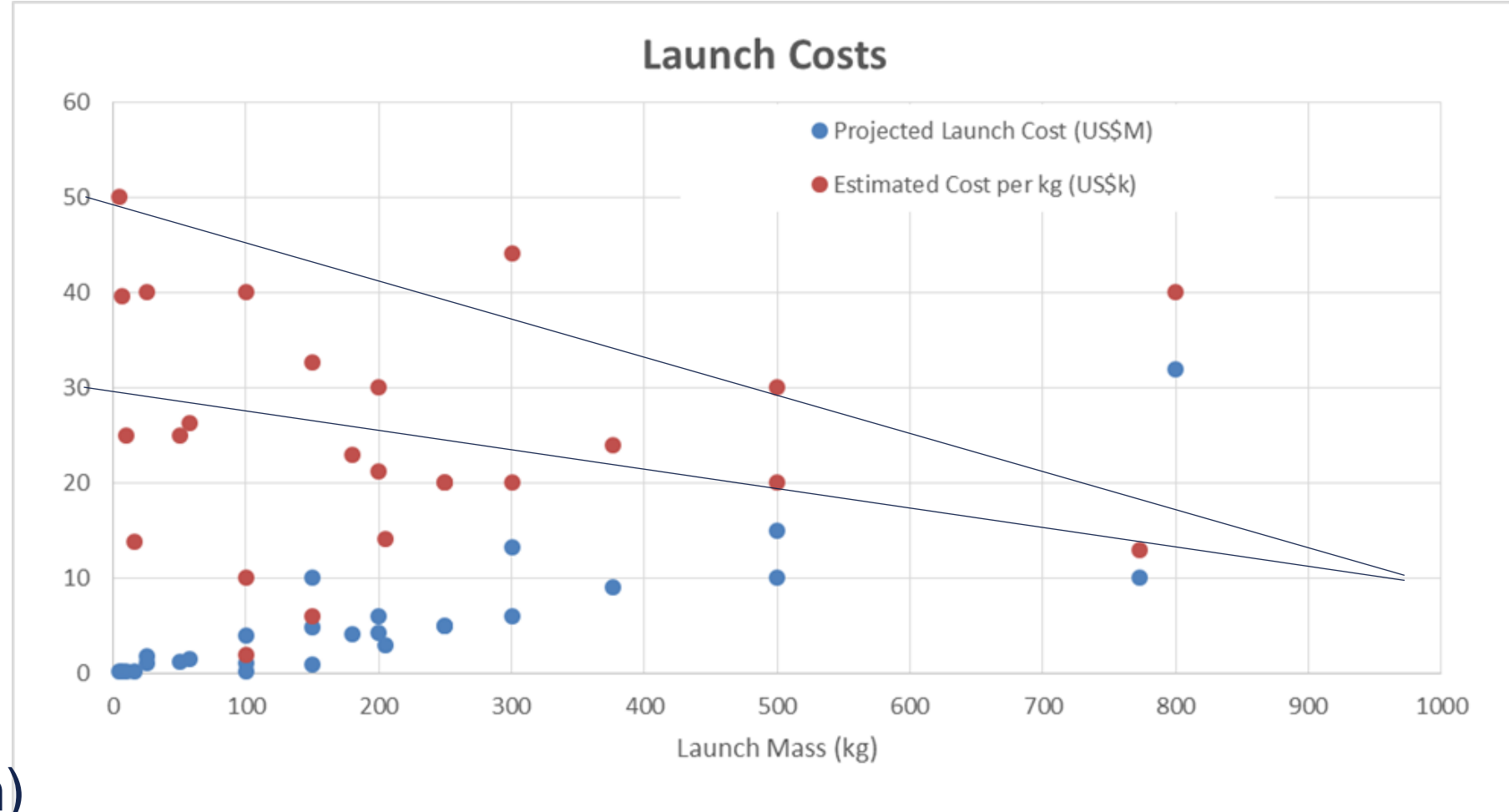


Alpha is a two-stage liquid ground launched vehicle utilizing “well-established technology” with 1000 kg capabilities from Firefly.

BIG PICTURE



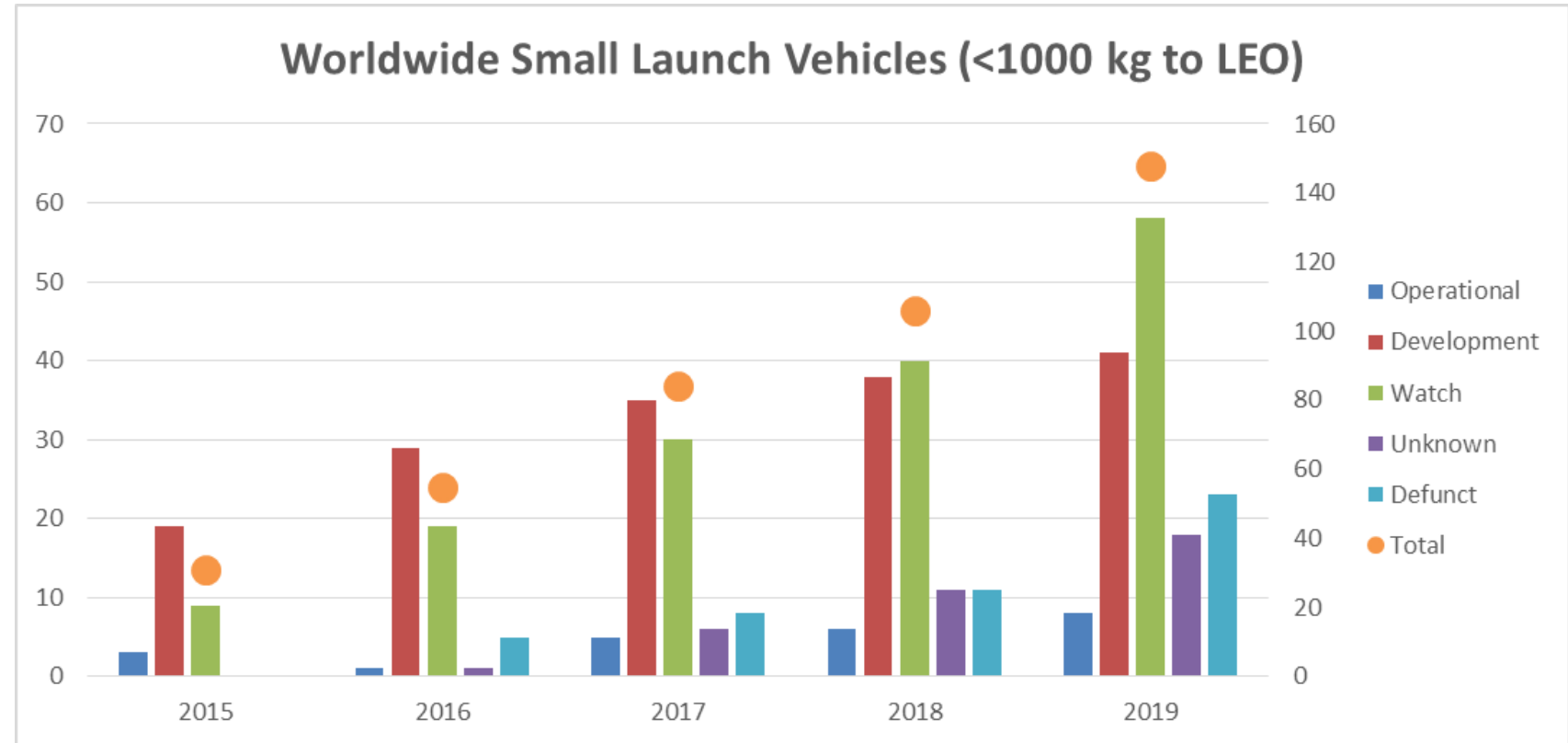
- Space X piggy-back = 5 k\$/kg
- For 500 kg:
20-30 k\$/kg
(10-15 M\$/launch)
- For 200 kg:
20-30 k\$/kg
(4-6 M\$/launch)
- For 50 kg:
30-50 k\$/kg
(1,5-2,5 M\$/launch)



BIG PICTURE



- Ever increasing:
 - operational
 - in "development"
 - unknown
 - defunct



BIG PICTURE



How to succeed ?

- Find market segment
 - Size ~6U, 65 kg, ~150 kg ~350 kg, 500 kg
 - Customer (private, government)
 - Constellation replacement
- Develop a concept that enables you to build and operate at price point that is profitable.
 - reusability
 - simplicity
 - high production and launch volume
- Raise 150 M\$ from Investors.
- Sell, MAI&T, launch, ... **repeat often**

”Rocket lab to open its third launch pad ...”



BIG PICTURE

How to succeed ?

And Yes, if you select land launch,

YOU NEED ONE OR MORE SPACE PORTS!



"Rocket lab to open its third launch pad ..."



MICRO LAUNCHERS – SPACE PORTS

GROUND LAUNCH

- Some Selection criteria
- Low Cost, Low Cost, Low cost
- Orbits achieved
- Market accessed (Europe, Rapid response)
- Location
- Logistics
- Launch rate
- Operational Synergies
 - engine testing
 - nearby MAIT



SPACEPORT CONCEPT AND TECHNOLOGY ROADMAPPING

INVESTMENT STEPS TO ROUTINE, LOW COST SPACEPORT SYSTEMS

FINAL REPORT TO THE NASA SPACE SOLAR POWER EXPLORATORY
RESEARCH AND TECHNOLOGY (SERT) PROGRAM

Prepared by:

THE VISION SPACEPORT PARTNERSHIP

National Aeronautics and Space Administration

John. F. Kennedy Space Center

and

Barker-Ramos Associates, Inc.

Boeing Company

Command and Control Technologies Corp.

Lockheed Martin Space Systems



JSRA NCA10-0030

November 2000

MICRO LAUNCHERS – SPACE PORTS

LAND LAUNCH



- **“If you think developing a rocket is difficult, try building a space port! I know...”** (*Peter Beck at SmallSat in Utah, 2017*)
- Existing, Government
(tailored to big rocket, often expensive, are launch slots available ?) CSG
- New, Private
(green field, often high NR, lead time, experience, location) Sunderland, AZ, ASC...
- Esrange, SSC
(tailored to Micro Launchers and extended from sounding rockets, commercially driven, available in 2020...)



CONCLUSIONS



- YES, there is a market
- YES, there is VC available
- ESA and EU are coming around
- The business model is key
- Vertical integration and collaboration between launch site and vehicle developer is key
- Low Cost, Low Cost, Low cost
- Time to market
- Welcome to Esrange Space Center!



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www.sscspace.com



CURRENT "BIG PICTURE" SITUATION

BIG PICTURE



- Summer of

...And Plenty of Heartbreak as Well
Not a Complete List

NORTHROP GRUMMAN

Status Unknown

- Super Strypl
- SS-520-4
- Vector R
- Cloud IX
- Unreasonable Rocket
- Chariot
- M-OV
- Volant
- Demi Sprite
- Landspace

Programs Canceled or Postponed

- SALVO
- Go Launcher 2
- ALASA
- Spyder
- ML-1
- Spacecab
- Athena 1
- Neutrino 1
- Rainbow Smallsat Express
- Stratolaunch Pegasus

Company folded

- Garvey Space Corporation (Incorporated into Vector)
- Swiss Space Systems
- Vanguard Advanced Systems
- XCOR
- SOAR

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BIG PICTURE



- Summer of

Fifty-Eight Additional Vehicles On the Watch List

NORTHROP GRUMMAN

	Acrux Space Technologies Aerojet Rocketdyne Agnikul ArianeGroup ARRC Avio SpA Beyond Earth Black Arrow Space Technologies Blue Origin C6 Launch Systems Dawn Aerospace Deep Blue Aerospace Delta Space Systems Deywoss One Eclipse Orbital Exos Aerospace Firehawk Aerospace Green Launch HyImpulse		Independence-X Aerospace iRocket JAXA Jiuzhou Yunjian JP Aerospace KB Yuzhnoye LIA Aerospace Massterra Space MT Aerospace NDA Company New Ascent New Rocket Technologies Newton Launch Systems Odyne Space Onera Perigee Aerospace proximTE Pythom Reaction Dynamics		Roketsan Rose Galactic Skyroot Aerospace SmallSpark Space Systems S-Motor Space Alpha Space Transportation Space Walker SpaceDarts SpaceRyde StratoBooster Swala Aerospace Thor Launch Systems TiSpace TLON Space UP Aerospace Velodyne Lidar Vogue Aerospace Wagner Industries Xinghe Power	

Not enough information to qualify for the survey. Some are hearsay/rumors

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BIG PICTURE



- Summer of

Since IAC 2018 New Players and Progress ... 

 <p>New Players Include ...</p> <ul style="list-style-type: none">• Bellatrix• Phoenix Launch Systems• X-Bow• And many more on "watch list"	 <p>New Orbital Launches</p> <ul style="list-style-type: none">• iSpace• China Rocket Company	 <p>Suborbital Flight Tests</p> <ul style="list-style-type: none">• Onera• InterStellar• Space Transportation• And many more engine tests	 <p>Significant General Press Coverage</p> <ul style="list-style-type: none">• Motley Fool• The Economist• Forbes• Wall Street Journal• Ars Technica
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Fifty-Eight Additional Vehicles On the Watch List

	Acrux Space Technologies Aerostar Rocketdyne Agnikul ArianeGroup ARRC Avio SpA Beyond Earth Black Arrow Space Technologies Blue Origin C8 Launch Systems Dawn Aerospace Deep Blue Aerospace Delta Space Systems Deywoss One Eclipse Orbital Exos Aerospace Firehawk Aerospace Green Launch HyImpulse		Independence-X Aerospace iRocket JAXA Jiuzhou Yunjian JP Aerospace KB Yuzhnoye LIA Aerospace Massterra Space MT Aerospace NDA Company New Ascent New Rocket Technologies Newton Launch Systems Odyne Space Onera Perigee Aerospace proximITE Pythom Reaction Dynamics		Roketsan Rose Galactic Skyroot Aerospace SmallSpark Space Systems S-Motor Space Alpha Space Transportation Space Walker SpaceDarts SpaceRyde StratoBooster Swala Aerospace Thor Launch Systems TiSpace TLON Space UP Aerospace Velodyne Lidar Vogue Aerospace Wagner Industries Xinghe Power	
					SmallSpark Space Systems	
					Space Alpha	
					Space Walker	
					SpaceDarts	
					SpaceRyde	

Not enough information to qualify for the survey. Some are hearsay/rumors