THE BUSINESS OF MICROLAUNCHERS

PHILIP PÅLSSON
Strategic Business Manager
SSC/Esrange Space Center

WE HELP EARTH BENEFIT FROM SPACE

AN INTRODUCTION TO THE MICRO LAUNCHER MARKET

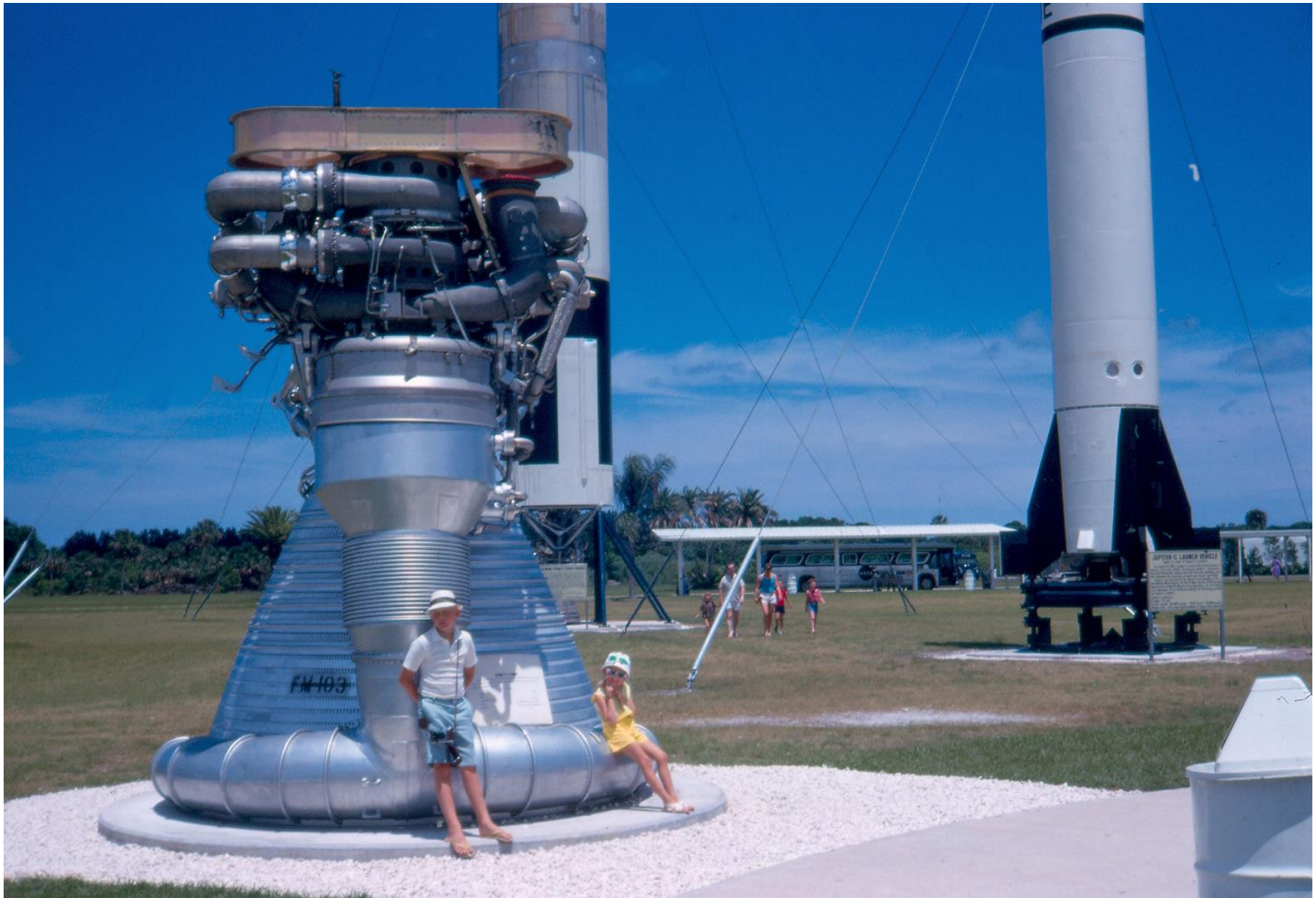
Ulf Palmnäs (presented by Philip Påhlsson)

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

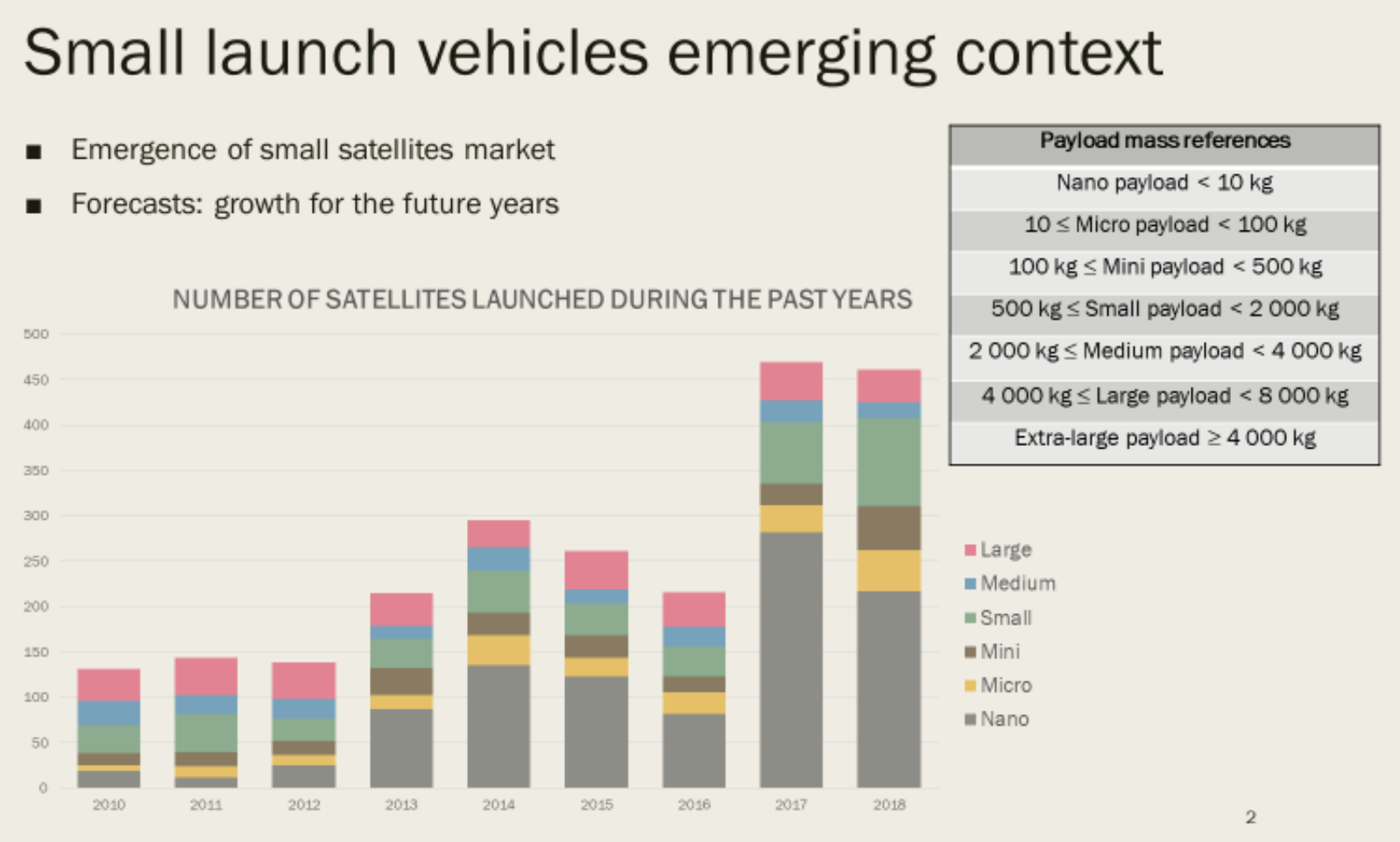
https://www.youtube.com/watch?v=AGCFWOVeSS4

INTRODUCTION

- So is there a market today?

YES !

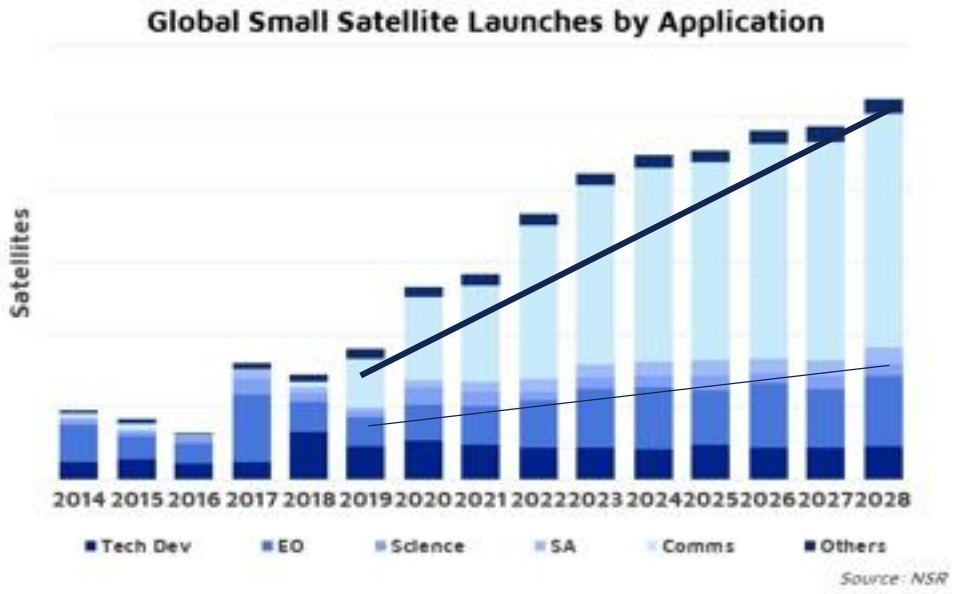
- A formidable explosion in the number of small satellites < 500kg that have been launched. And are predicted to be built and launched in the coming years.

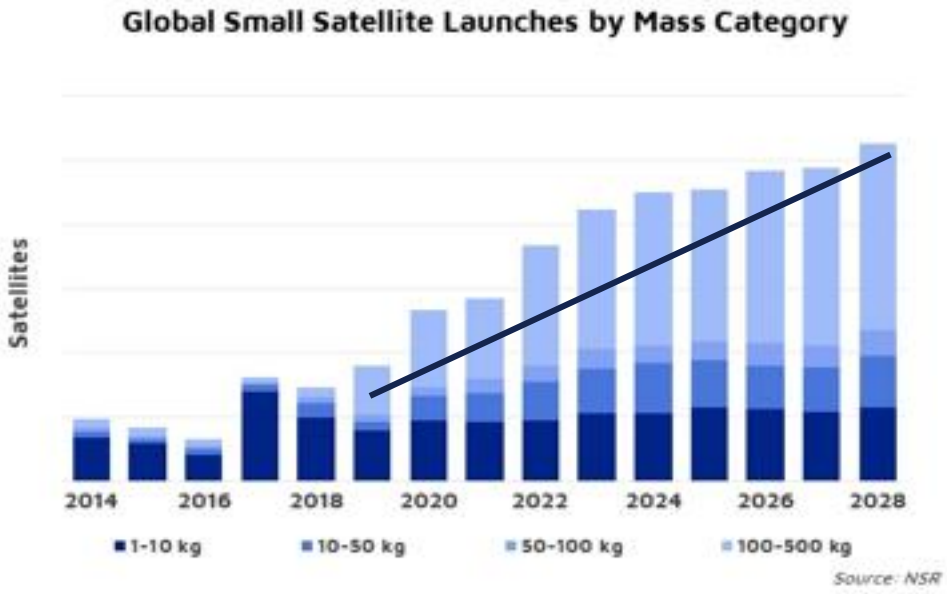


Source IAC-19, D2.7-9

NORTHEN SKY RESEACH -

- 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 ?

- <u>Piggy-back</u>
  + PRICE / kg
  - shared ride
  - wait…
  - wrong orbit

- <u>Dedicated launch</u>
  - Price / kg
  + Prime
  + when you want
  + to where you want
  + from Europe…
  ? Reliability
  (rocket lab 100%
  after test flights)

Image ESA, Ariane 6

KEY QUESTION FOR MICRO LAUNCHERS…

- Bus or Taxi ?

- Piggy-back
  - Falcon 9
  - PSLV
  - Soyus
  - VEGA
  - Ariane
  - H-2 / H-3
  - …

- Dedicated launch
  - Pegasus (US)
  - Minotaur (US)
  - Shavit (Israel)
  - Safir (Iran)
  - …
  - ~~Falcon 1~~
  - Electron
  - LM 6, LM11… (China)
  - …

Source ESA, Ariane 6

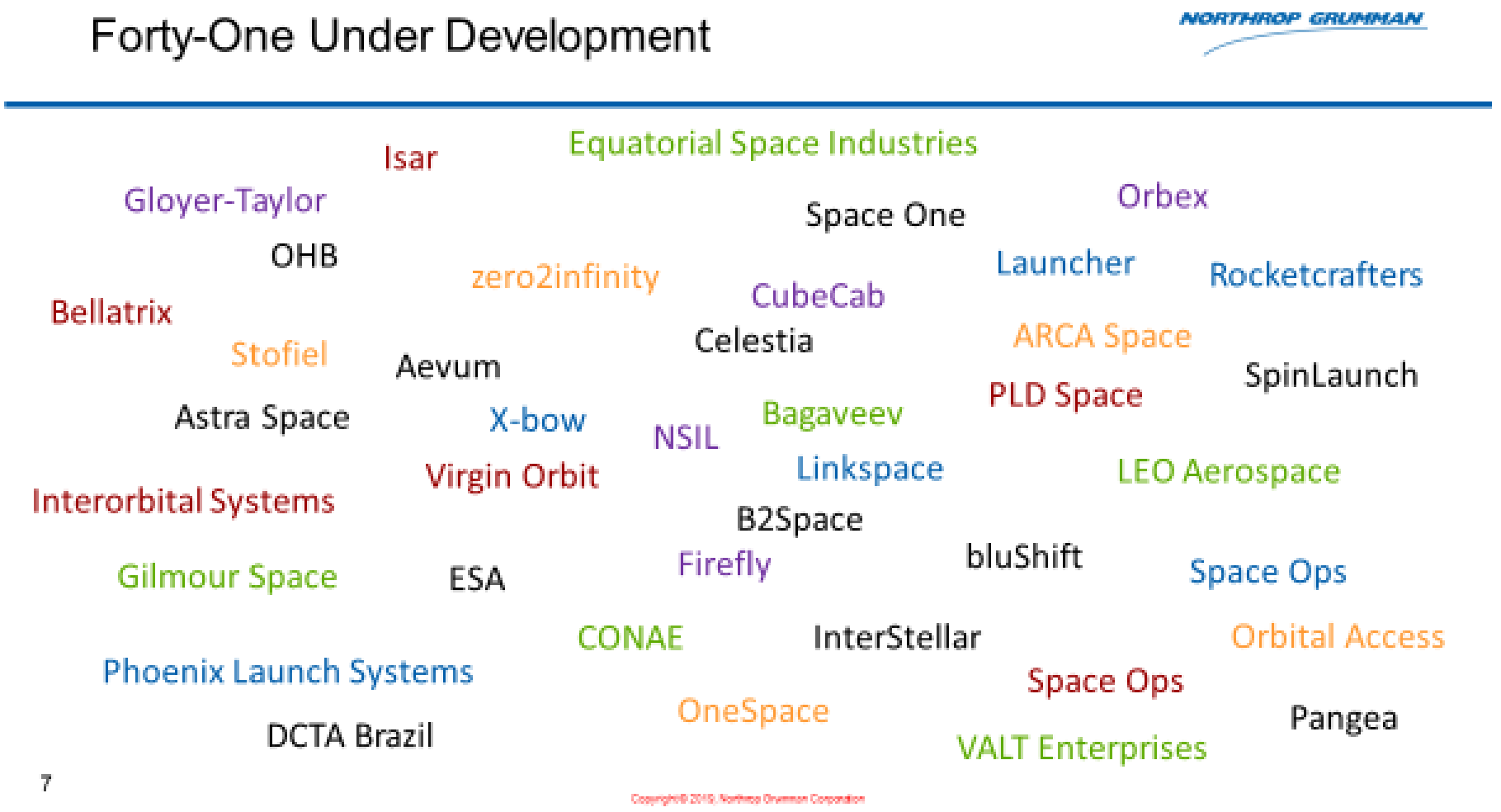
BIG PICTURE

- 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



BIG PICTURE
- UNDER DEVELOPMENT

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

Country of Origin

NORTHROP GRUMMAN

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

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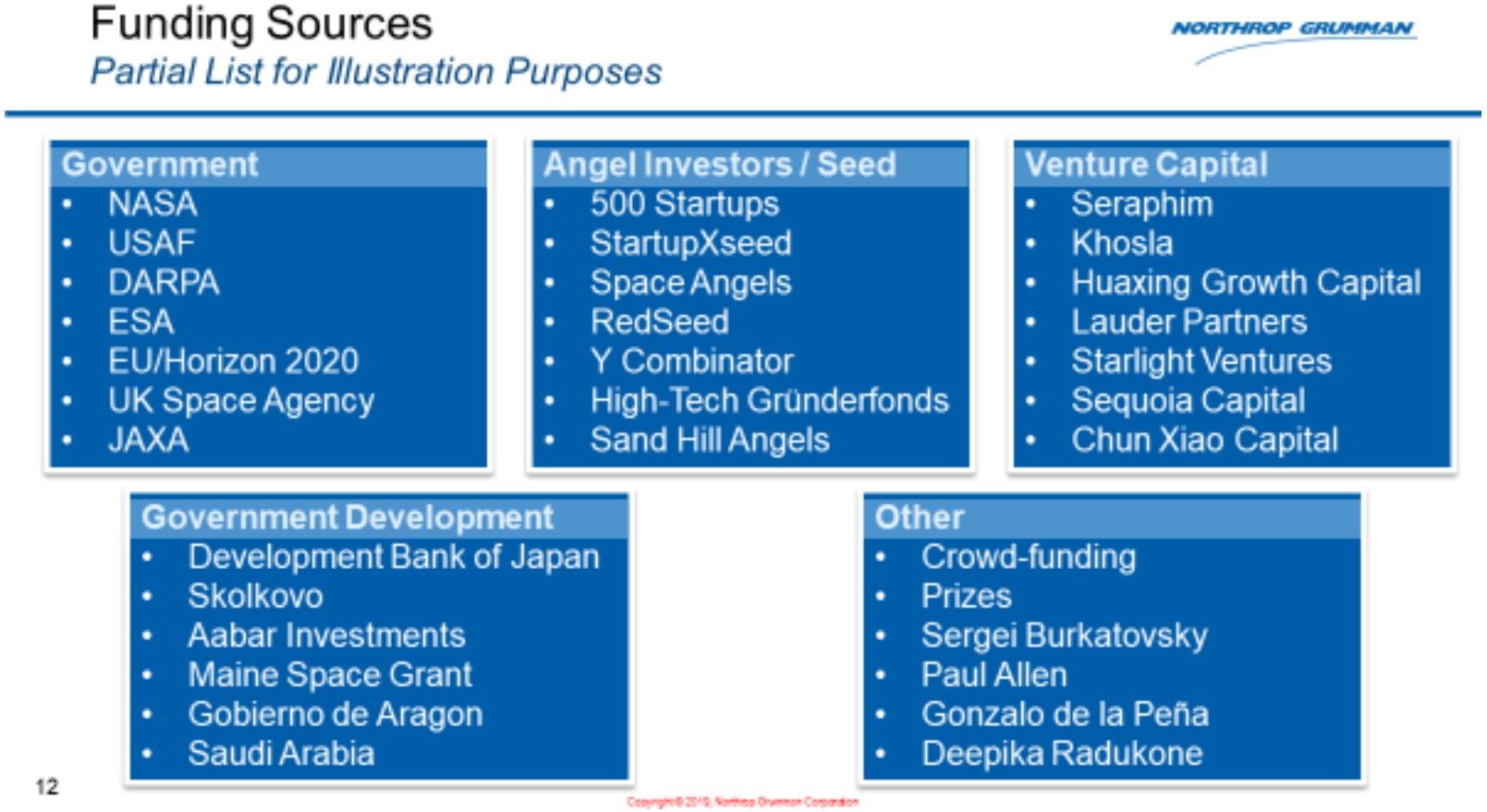
BIG PICTURE – FUNDING

- 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 invstors to thrive.
- Investors loves assured customers and not competing with governments.



BIG PICTURE

- Different market segments sought.

How Small is Small?

NORTHROP GRUMMAN

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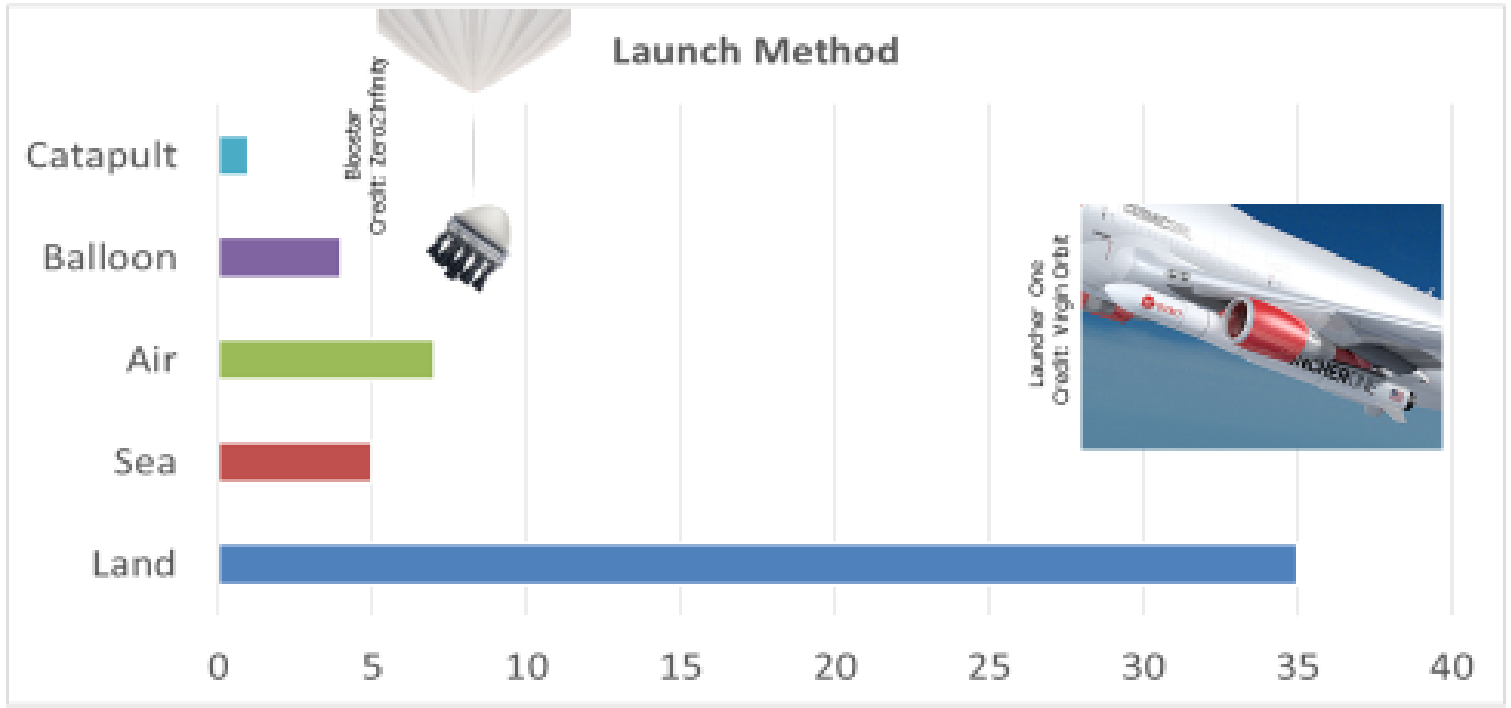
BIG PICTURE

- Different launch methods.

Varied Launch Methods



Note: A number of vehicles have multiple launch methods

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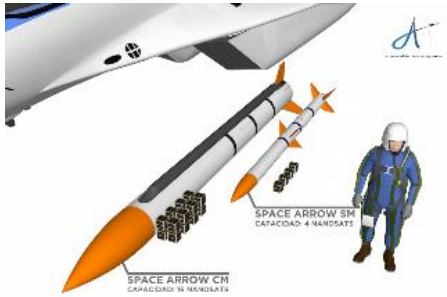
MICRO LAUNCHERS - METHOD

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.



Sagitarius 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 loft 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

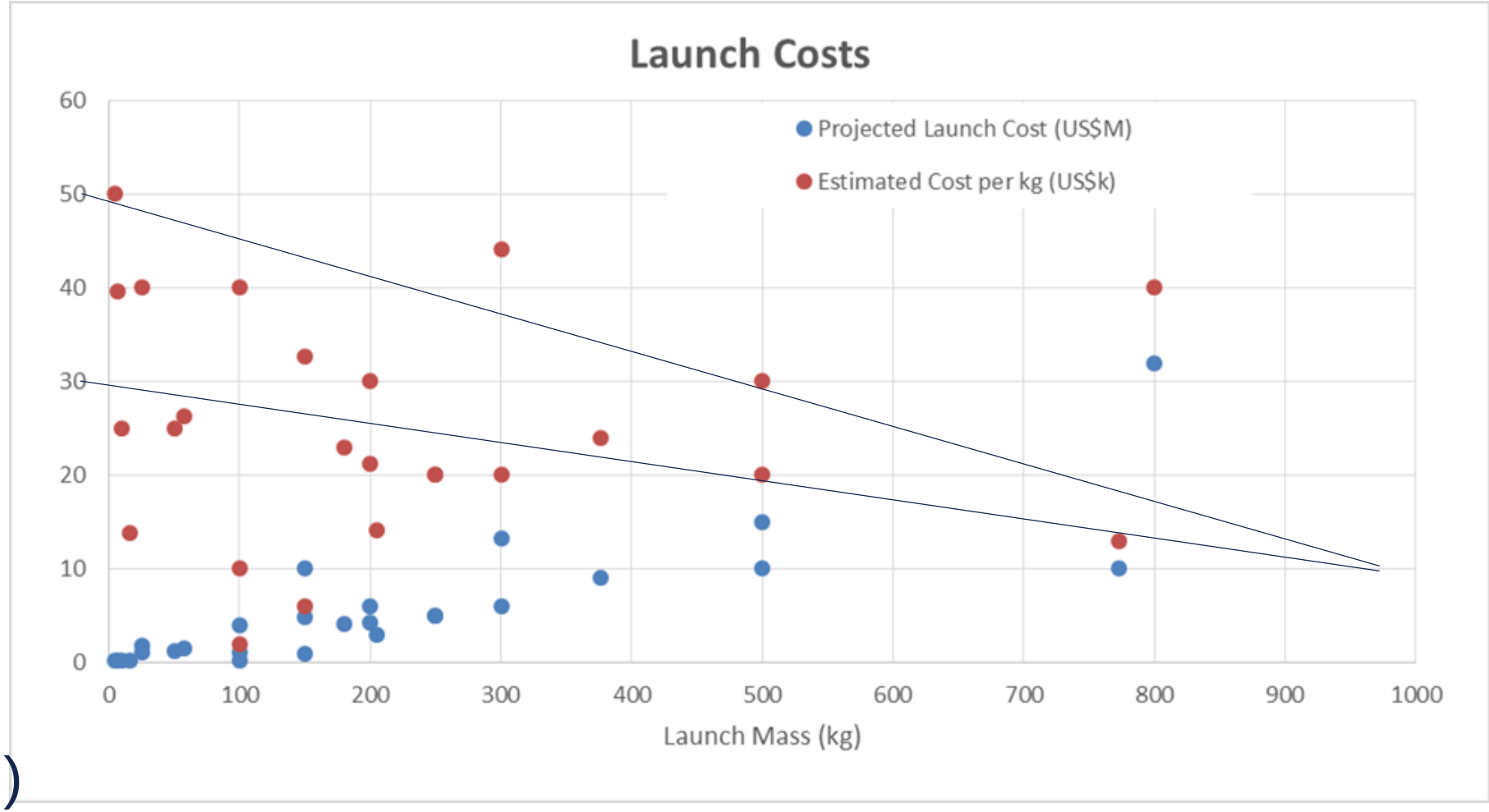
Electron is a two-stage LOx/kerosene ground launched vehicle using 3D printed engines with electric fuel pumps with 200 kg capabilities from Rocket Lab.

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.

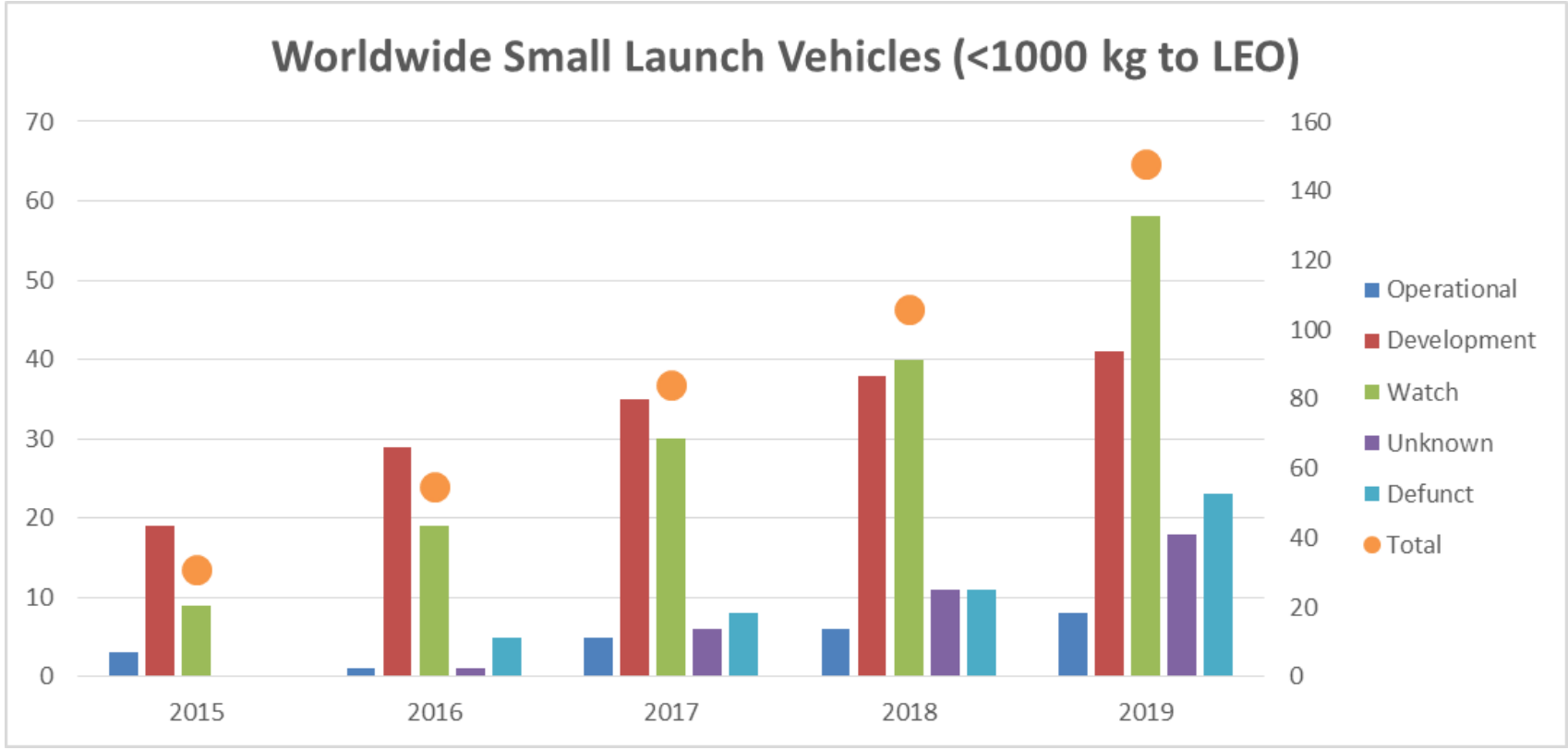
BIG PICTURE

- 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!

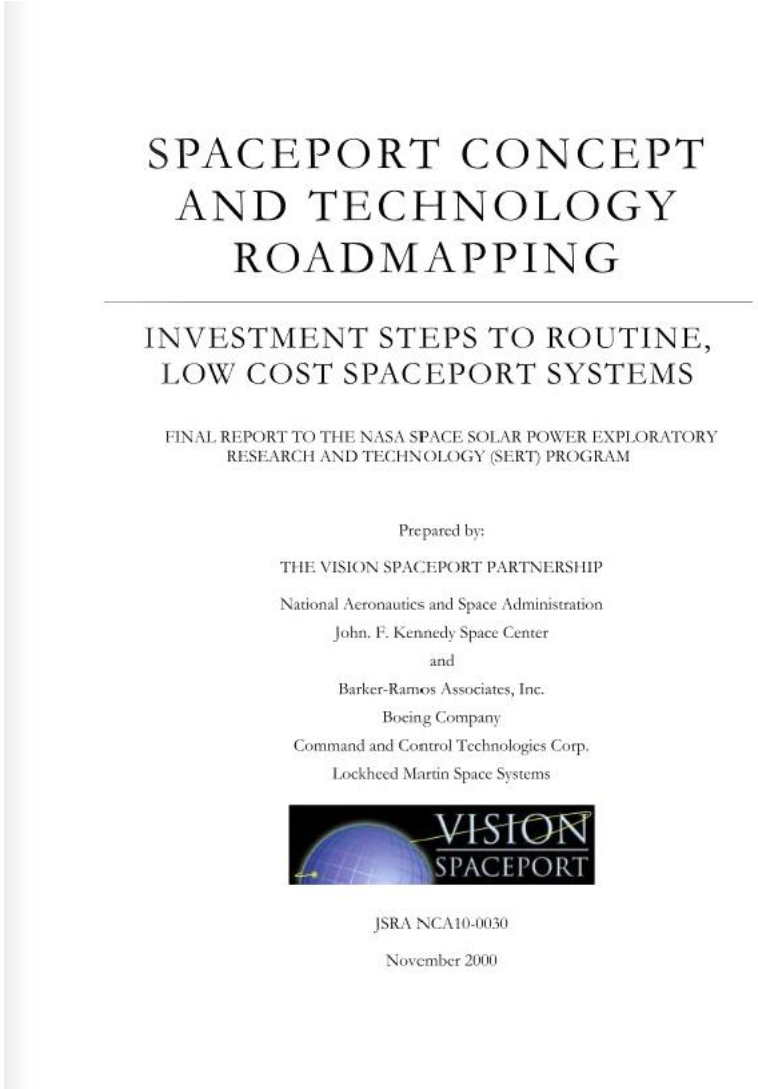
”Rocket lab to open its third launch pad …”

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

VISION SPACEPORT

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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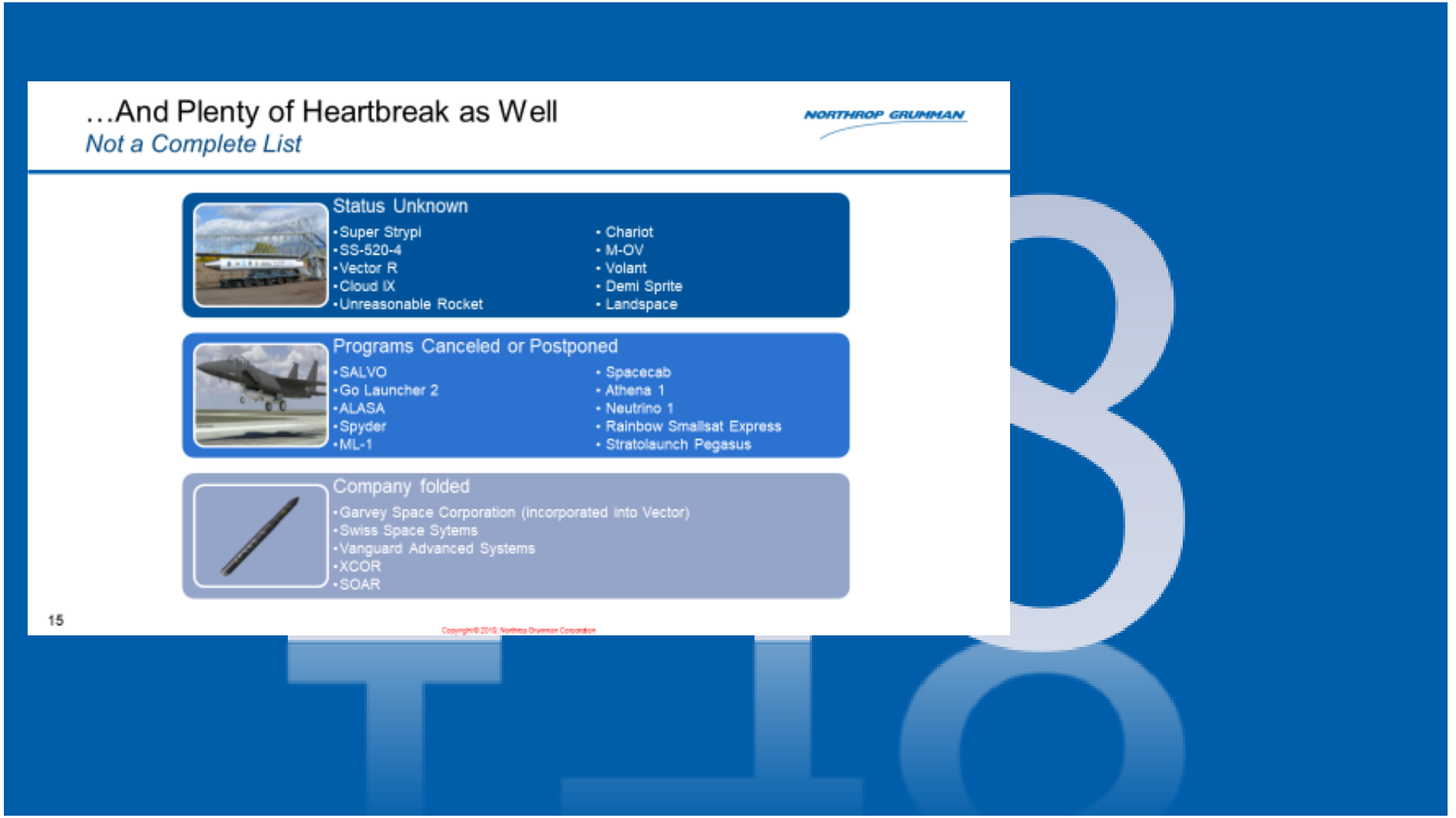
www.sscspace.com

CURRENT ”BIG PICTURE” SITUATION

BIG PICTURE

- Summer of



BIG PICTURE

- Summer of

BIG PICTURE

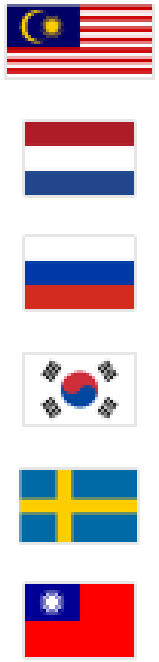
- Summer of

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
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

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

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