THINK LOGISTICS – SPACE LOGISTICS!

Florian Loire
Strategy for civil launchers

Space School - 25 June 2019

#spaceenablers
1

DISRUPTION IN THE SPACE MARKET

COMPETITIVE LANDSCAPE
Existing
Space Economy
has real economic value
to society

Telecommunications

Earth Observation

Navigation/Positioning

Meteorology

Science &
Exploration
THE GOOD OLD DAYS:
A FEW WELL SEGMENTED LAUNCH SERVICE MARKET SEGMENTS
ARIANE 5
THE EUROPEAN WORKHORSE WITH 104 LAUNCHES PERFORMED

ARIANE 5 ES
Launch weight: 760 t
Thrust: 1,340 t

Last mission in 2018

ARIANE 5 ECA
Launch weight: 780 t
Thrust: 1,340 t

Still the benchmark for GTO missions

Fairing
Height: 17 m
Ø 5.4 m

Dual Launch System (SYLDA)
Ø 4 m useful

HM7B engine
Thrust: 6.5 t

Reignitable Aestus engine
Thrust: 2.7 t

2 boosters

Vulcan 2 engine
Thrust: 136 t

* All references to tons (t) are metric tons throughout
REVOLUTION: LEO SMALLSATS CONSTELLATIONS

SOURCE: ONEWEB

SPACE RACE FOR SATELLITE INTERNET

Source: bloomberg.com
REVOLUTION: IN ORBIT SERVICING

Source: ESA.blog.int

Source: Effective Space Solution
Institutional market complemented with Digital Economy financing
→ New business models

What Disruption is taking place?

High Tech Industry
→ Industrial optimization
→ Acceleration of Innovation Cycles
→ New work methodologies (digitalization, Agile…)

Geopolitical environment
→ National interests of contributing nations
→ Sovereignty and strategic / military interests
QUICK EVOLUTION OF COMPETITIVE LANDSCAPE

MEDIUM / HEAVY LAUNCHERS

<table>
<thead>
<tr>
<th>Rocket</th>
<th>1st Launch</th>
<th>Domestic Competition</th>
</tr>
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<tbody>
<tr>
<td>Ariane 5</td>
<td>2016</td>
<td>2021</td>
</tr>
<tr>
<td>Soyuz</td>
<td>2015 et 2016</td>
<td>2021</td>
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<tr>
<td>Proton</td>
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<tr>
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<tr>
<td>Long March-5</td>
<td>2016</td>
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SMALL LAUNCHERS

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<tr>
<th>Rocket</th>
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<tr>
<td>Vega</td>
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<td>Dnepr</td>
<td>2016</td>
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<td>Minotaur-C</td>
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<tr>
<td>Rockot</td>
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<td>2021</td>
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<tr>
<td>Long March-2</td>
<td>2016</td>
<td>2021</td>
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<tr>
<td>Soyuz-1</td>
<td>2016</td>
<td>2021</td>
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<tr>
<td>Vega C</td>
<td>2016</td>
<td>2021</td>
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<tr>
<td>PSLV</td>
<td>2016</td>
<td>2021</td>
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<tr>
<td>Angara 1.2</td>
<td>2021</td>
<td>2021</td>
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<td>Cyclone 4M</td>
<td>2021</td>
<td>2021</td>
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<tr>
<td>Epsilon 2</td>
<td>2021</td>
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<td>Long March-6 &amp; 7</td>
<td>2021</td>
<td>2021</td>
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<td>Electron</td>
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<td>2021</td>
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<tr>
<td>Vector</td>
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<td>2021</td>
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<tr>
<td>Alpha</td>
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TODAY

TOMORROW

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25/06/2019
TOWARDS SPACE LOGISTICS SERVICES
SPACE LOGISTICS CONCEPT
ADAPTING END-TO-END TRANSPORTATION SERVICE TO CLIENT NEEDS

Defining the nodes and flows of the space transportation network

To transport:
• Micro/small to large satellites
• Cargo / payloads
• Humans
• Raw materials
• Fuels
• …

For activities on nodes

Enabling growth in market segments

- Navigation
- Telecom
- Earth Observation
- Safety & Security
- Human flight + cargo
- Science
- Space Production
- Mining

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THE DRIVERS FOR SPACE ECONOMY

A (very) profitable business prospect

Conventional

Conventional commercial customers
- Telecom broadcast
- Broadband
- Earth observation
- …

Institutional enablers / customers
(NASA, DoD, EC, ESA, CNES, DLR, …)

Futuristic

Futuristic visions of scalability
- “Millions of people working and living in space” (Blue Origin)
- “Making life multi-planetary” (SpaceX)
- “Moon Village” (ESA)
- “Space belongs to everyone” (PTScientists)
- “There are $20 trillion checks up there to be cashed”
(Planetary Resources)
- “The addressable market could be as large as $37 billion”
(Bigelow)

Enabled through cash available for investment

- Customer contracts
- R&D contracts / Grants (institutional, conventional commercial)

Public Private Partnerships
- Company investments
- Private fortune
- Equity raises through venture capital
What is our European answer?

Enabling Space Economy

- Identification of minimum bricks for an efficient transport service
- Simplification for customer by offering end-to-end service
- Increasing addressable market by offering extra service capabilities

for increased societal return
**ARIAINE 6**
**UNPRECEDEDENT FLEXIBILITY, MODULARITY AND COMPETITIVENESS**

**ARIAINE 62**
(2 BOOSTERS)

- Performance: 4.5-5 t GTO
- Launch weight: 530 t*
- Thrust: 816 t

**ARIAINE 64**
(4 BOOSTERS)

- Performance: 12 t* GTO
- Launch weight: 860 t
- Thrust: 1,530 t

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**ARIAINE 62 (2 BOOSTERS)**

- **Fairing**
  - Height: 14 or 20 m
  - Ø 5.4 m

- **Dual launch system**
  - Ø 4.5 m useful

- **Reignitable Vinci engine**
  - Thrust: 18 t

- **2 or 4 P120C boosters**
  - (common with Vega C)
  - Thrust: 459 t

- **Vulcain 2.1 engine**
  - Thrust: 140 t

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* All references to tons (t) are metric tons throughout

25/06/2019
ARIANE 6
ALL COMMERCIAL AND INSTITUTIONAL MISSIONS

ARIANE 64 PERFORMANCE

Single launch
Main and auxiliary payloads
Conf. 2 payloads
Heavy LEO missions
Large science satellites
LEO constellations
LEO mega-constellations

MEO
GTO 12 t
SSO
LEO 20 t

25/06/2019
LAUNCHERS ARE THE FIRST KEY ENABLER FOR SPACE LOGISTICS

A competitive and continuously improving launcher family is the first key building block

ICARUS
new lightweight upper stage (by 2025)

Vega-C
2020 maiden flight

Prometheus

Development of alternative launch vehicles targeting the same timeframe

Ariane 6
2020 maiden flight
FOC 2023

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MISSION VERSATILITY IS KEY COMPETITIVE ADVANTAGE

A family of innovative dispensers and future AG kickstage to answer several market needs and improve Ariane 6 market capture

Multi-payload for GTO and GEO
- Dual launch towards GTO
- Transportation of stack of small sats to GEO

MLS Rideshare
- A regular piggyback Launch Service for light Satellites
- Offering affordable tickets to any Orbit, to all segments of the light Satellites market
- From the spare capacity of the Launcher, after the primary passenger mission

M/LEO constellation dispatching
- Deploying (big) constellations
- Replenishing in multiple planes
- Galileo 1st and 2nd generation

Enabling complex and long duration missions
- Exploration (lunar and cargo)
- Large Science missions

Dispenser(s)
Kick Stage(s)
LUNAR EXPLORATION

Global interest converging towards the Moon

2008-2017 -> 6 Mars missions
2018-2027 -> 10 Mars missions
2008-2017 -> 8 Lunar missions
2018-2027 -> 50 Lunar missions

Lunar Surface End-to-End Services (ISRU)

Ariane 6 + Lander + ~300kg payload transportation to the Moon starting in 2021

A flagship missions for Europe, by Europe, for strategic lunar Exploration capabilities

Total Government Investment

<table>
<thead>
<tr>
<th>Period</th>
<th>Investment</th>
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<tbody>
<tr>
<td>2013-2017</td>
<td>$67B</td>
</tr>
<tr>
<td>2018-2022</td>
<td>$81B</td>
</tr>
<tr>
<td>2023-2027</td>
<td>$93B</td>
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</tbody>
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2017 $15B (74% from US)

- 53% transportation
- 25% orbital infrastructure
- 10% Mars exploration
- 9% other deep space exploration
- 3% Moon exploration

2027 $20B (64% from US)

- 44% transportation
- 26% orbital infrastructure
- 14% Moon exploration
- 9% other deep space exploration
- 7% Mars exploration
LUNAR PAYLOAD DELIVERY SERVICE (ESA HRE STUDY) ROADMAP BENEFITTING OF PLANNED ARIANE 6 IMPROVEMENTS

Moon Surface Basic

Upper Position: GTO payload

Lower Position: Lunar Lander

Moon Surface Medium

Shared launch with orbit raising sat is assumed

Kickstage doubles lunar surface P/L capability at marginal extra cost

Moon Surface Medium Evo

Increased pairing capability due to lighter Upper Stage

Moon Surface Heavy payload

Lunar surface P/L

~300kg

~600kg

~600kg

New Upper Stage

ESA Heracles Mission

Heracles Mission

Kickstage doubles lunar surface P/L capability at marginal extra cost

Increased pairing capability due to lighter Upper Stage

Shared launch with orbit raising sat is assumed

~300kg

~600kg

~600kg

Moon Surface Basic

Moon Surface Medium

Moon Surface Medium Evo

Moon Surface Heavy payload

Upper Position: GTO payload

Lower Position: Lunar Lander
EUROPEAN INDEPENDENT ACCESS TO THE LUNAR SURFACE

- Strategic European positioning on lunar exploration for future cooperation
- 100% European ‘New Space’ approach through innovative partnering between ArianeGroup and PTScientists leveraging on private investments
- Short term, affordable and feasible sovereign access to lunar surface guaranteeing European interests in future moon village
- Proving A64 versatility using mixed mission dual launch with Arianespace
- Roadmap towards increased lunar surface capability taking benefit of planned improvements of Ariane 6

A mission for Europe, by Europe, for strategic lunar Exploration capabilities
TOWARDS A SPACE LOGISTICS COMPANY

LEO/MEO Constellation deployment

Efficient access to GEO

Sample Return capsule

Enabling RTG launch: MSR, Ice Giant etc...

Kick Stage for heavy payloads to the Moon/cis-lunar

Lunar surface mission

Ascender/lander to the Moon surface

Cis-lunar human-rated vehicle

Sample Return capsule

LEO/MEO Constellation deployment

Efficient access to GEO