Old Space vs. New Space

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I am honored to be able to make this presentation before the Mauritius Research Council.

Thank you for this opportunity.
The peak of Old Space occurred in 1969 when the United States of America put a man on the surface of the Moon and return him safely to Earth. This year, 2019, is the 50th anniversary of that event. But what happened after the success of NASA’s Apollo program? As many of you know, the public lost interest in space, and humanity’s activities in space went into deep freeze for a long time. I am profoundly aware of that space “ice age” because I lived through it; I was born in 1959. However, a robust recovery is finally underway, since about 2005. This recovery is called by many as New Space. And it is very different from Old Space. I will discuss this revolutionary paradigm shift. And this shift is important to all of humanity. Because of New Space, all countries, including the country of Mauritius, can participate in space. In a nutshell, New Space has vastly lowered the barriers to getting involved in space. Therefore, I hope your country will passionately embrace this golden opportunity to explore and to exploit outer space for your own national needs.
“The Mauritius Research Council is pleased to invite you to attend a seminar on Friday 21 June 2019, at the MRC at 10:30 hrs, 6th floor, Ebene Heights Building, Ebene.”


I acknowledge the promotion of my talk by MRC at its website. Nice.
Mauritius Towards Space

“Change your thoughts and you change your world.”
Norman Vincent Peale

https://spacemauritius.com/
The world is changing. Especially the world of rockets and satellites.
Old Space \hspace{3cm} \rightarrow \hspace{3cm} \text{New Space}

It’s a huge and dramatic change
Old Space was dominated by
◆ Expensive rockets (over 100m USD per launch)
◆ Expensive satellites (over 250m USD each)
◆ Satellites that took 5 to 10 years to develop

Result:
Only a handful of rich nations could afford to go into space
But during the past ten years that has dramatically changed . . .

. . . New Space has arrived
“New Space is a movement and philosophy encompassing a globally emerging private spaceflight industry. Specifically, the term is used to refer to a global sector of new aerospace companies and ventures working independently of governments and traditional major contractors to develop faster, better, and cheaper access to space and spaceflight technologies, driven by commercial, as distinct from political or other, motivations to broader, more socioeconomically-oriented, ends.”
So that is a key difference

Old Space was driven by government spending, both civilian and military.

New Space is driven by commercial investments – and so it can grow much much much faster than government spending. The sky is the limit.
$329 billion in 2016

Gov’t space budgets
NASA 20 BILLION USD per year
ESA 7 BILLION USD
JAXA 2 BILLION USD

THE GROWTH IS OCCURRING IN THE COMMERCIAL SECTOR
New Space is dominated by:

- Satellites that can be developed in less than 2 years
- Cost less than a house
- Can be deployed as constellations

Result: Any nation can become space-faring

Spire, Inc., generates data for customers using small satellites. They use low-cost launch methods. For example, this is a Rocket Lab launch in New Zealand for Spire.
Countries that have put into orbit satellites of 10 kg or less
What enabled New Space?

There are many factors involved.

But one big factor is the technology used in smartphones.

Because of the volume (billions of units) of produced smartphones, the prices and the physical sizes of components (CPUs, memory chips, sensors, etc.) has fallen dramatically. This in part has enabled the birth of the modern CubeSat.
Nanosatellites

Nanosats are go!

Small satellites: Taking advantage of smartphones and other consumer technologies, tiny satellites are changing the space business

https://www.economist.com/technology-quarterly/2014/06/05/nanosats-are-go
Before discussing the BIRDS Project, I would like to mention four industry trends.
These trends come from this very expensive 2017 Executive Report by Euroconsult.

Here, “small” is defined as under 500 kg.

4000 Euros
Trend 1
Over the next 10 years, more than 6,200 smallsats are expected to be launched
Trend 2
The smallsat market from 2017-2026 will be driven by the roll out of multiple constellations accounting for 70% of smallsats to be launched, mainly for commercial operators.
Trend 3

From 2007 to 2016, the total market value of these smallsats was $8.9 billion (including manufacture and launch) and could reach $30.1 billion in the next ten years.
Trend 4

Concerning destination, most smallsats (80%) will be launched into LEO.
Summary of Trends

The space sector is changing right now at a tremendous pace. Nearly all old assumptions are outdated today. During Old Space, space was limited to a handful of nations (USA, Russia, France, Japan, China, etc.).

But with New Space, it is a whole new ball game. Anyone can enter the space sector. My university helped Bhutan to build and launch its first satellite. Bhutan’s population is only 700,000 – less than Mauritius.
The thesis of my talk

Why Mauritius should establish a space engineering laboratory
Location of your space engineering laboratory:

◆ Government,
◆ Academia, or
◆ Private Industry

Any one of the above should be considered
Purpose of the lab:

- Train engineers (Capacity Building)
- Develop your satellites
- Operate the satellites you have in space
To fully exploit space for national profit, it is necessary to design, build, test, and launch, your own satellites.

Buying satellites does nothing to develop your engineering workforce!
All problems are local

Local Expertise
Problem and Solution ID

New Low-Cost
Space Solutions

Problems of agriculture are all local

This slide is from Prof. Jordi Puig-Suari
I do not recommend you make satellites that take photos. There is a lot of photographic data that is available on a commercial basis.

There is a huge amount of photographic data being created each day.
They are many more useful applications for small nations to consider
This is just one example. This is the example of Irazu, the first satellite of Costa Rica, which is a small nation in Central America.

The mission of this satellite was simple. Just **Store-and-Forward.**
Remote stations are installed throughout the jungles of the country.
A buoy that collects data – but how to get the data to shore?

You could install a large network of buoys in the region around Mauritius, for example.
The **Irazu** satellite is just 10 cm x 10 cm x 10 cm in size. It is working right now in space.

**Note:**
1. It was built inside of Costa Rica
2. It was tested at Kyutech by their students (see photos above)
3. It was put into space via the ISS under contract between JAXA and Kyutech.
So Costa Rica selected store-and-forward.

What will Mauritius select?  
*The ball is in your court.*
How to Get Started

(one way)
The BIRDS Project delivers the technical competence to build satellites inside of your own country.
This is our track record with BIRDS satellites.

- Japan
- Ghana
- Mongolia
- Nigeria
- Bangladesh
- Thailand
- Taiwan

BIRDS-II (2016-2018)
- Bhutan
- Malaysia
- Philippines

BIRDS-III (2017-2019)
- Japan
- Sri Lanka
- Nepal
Kyutech is now recruiting for BIRDS-5 Project, which starts April of 2019
This is the essence: Learn the *entire* satellite development process from start to finish.

- **Start**
  - Breadboard
  - Design

- **Engineering Model**

- **Flight Model**

- **Deploy in space**
  - Extensive environmental testing

- **End**
One BIRDS Project from start to finish is exactly 24 months.
BIRDS-1 (duration of 2 years)  Finished

BIRDS-2 (duration of 2 years)  Still in orbit

Deployed on
17 June 2019

BIRDS-3 (duration of 2 years)

Now being developed

BIRDS-4 (duration of 2 years)

Projects overlap by one year
Kyutech invites Mauritius to join the BIRDS-5 Project, which starts in April of 2020.

BIRDS-2 CubeSats undergoing thermal vacuum testing at Kyutech in January of 2018
Cost of BIRDS-5

- Cost of satellite hardware and for its launch is 15m JPY (about 140,000 USD)
- Scholarships for the students (just $25K per student per year, which covers all conceivable costs)
- Ground station ($25K if turnkey but $6K if built by engineering students)
Training Potential

Flexible High-Tech Workforce

Training Tool

Applicable Industries

This slide is from Prof. Jordi Puig-Suari
Small Sats fulfill training needs

• Multi-disciplinary Project
• High-Tech Integrated System
• Hands-on Project (*must build something*)
• High Quality Manufacturing
• Policy & Documentation Requirements
• High motivation (*SPACE!*
Additional Benefits

• Exciting projects for Educators
  • Retain experts

• National Pride / Political PR
  • Funding opportunities
  • Science outreach

• Many Opportunities for Collaboration
  • Supportive community

• Emerging Industry
  • Nobody is far behind

IMPORTANT POINT
Options for New Space Players

- Invest in New Space infrastructure
  - Low barrier to entry
  - Commercial technology base
  - Low to medium performance
  - Workforce development
  - Short schedules

- Modest short term results

- Great long term potential
  - Including new local industry
About my university in Japan
Kyushu Institute of Technology (Kyutech)

- A national university founded in 1909
  - 4,200 Undergraduate students
  - 1,300 Graduate students
  - 360 Faculty members
  - Engineering, Computer science, Life-science
- Located in the Kitakyushu region
  - Population of more than 1 million

Main, and original, entrance to the Tobata Campus
Space Engineering Research and Educations at Kyutech

• Space Engineering Education at Tobata Campus since 1993
  • Undergraduate (30 students/class) and graduate levels
• Laboratory of Spacecraft Environmental Interaction Engineering (LaSEINE)
  • Established in 2004
• Center for Nanosatellite Testing (CeNT)
  • Established in 2010
• Member of International Astronautical Federation (IAF) since 2011
• Department of Space Systems Engineering from April, 2018
Kyushu Institute of Technology
Laboratory of Spacecraft Environment Interaction Engineering (LaSEINE)

- Inauguration: December 2004
- 12 academic + 3 administrative staffs
- Annual research budget: 1 ~ 2 m USD
- 1400m² laboratory space
- Partners
  - Space agency
  - Space industries
  - Local small industries
  - International institutions

Spacecraft charging
Debris
Material degradation
Nanosatellite environment test

©ESA
Center for Nanosatellite Testing

We can test any satellite up to 50 kg in size

- Vibration
- EMC & Antenna pattern
- Pressure & Leak
- Thermal vacuum
- Thermal cycle
- Shock
- Outgas (ASTM E595)

Assembly & Integration

Maeda – 21_June_2019 - MRC

Kyutech

Slide 53 of 61
Kyutech is the No. 1 university in the world in one amazing respect
Smallsats by the Numbers 2019

This shows 13 satellites but since this was published we have launched 5 more ...

... our grand total now stands at 18 satellites.
<table>
<thead>
<tr>
<th>No.</th>
<th>Satellite name</th>
<th>(a) Date of Launch (b) ISS deployment</th>
<th>Nations involved</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HORYU-II</td>
<td>(a) 2012/5/18</td>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Shinen-2</td>
<td>(a) 2014/12/03</td>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>HORYU-IV</td>
<td>(a) 2016/02/17</td>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>AOBA VELOX-III</td>
<td>(a) 2017/01/19</td>
<td>Japan and Singapore</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>BIRDS-I : Ghana</td>
<td>(b) 2017/07/07</td>
<td>Japan and Ghana</td>
<td>Ghana’s first satellite</td>
</tr>
<tr>
<td>6</td>
<td>BIRDS-I : Mongolia</td>
<td>(b) 2017/07/07</td>
<td>Japan and Mongolia</td>
<td>Mongolia’s first satellite</td>
</tr>
<tr>
<td>7</td>
<td>BIRDS-I : Nigeria</td>
<td>(b) 2017/07/07</td>
<td>Japan and Nigeria</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>BIRDS-I : Bangladesh</td>
<td>(b) 2017/07/07</td>
<td>Japan and Bangladesh</td>
<td>Bangladesh’s first satellite</td>
</tr>
<tr>
<td>9</td>
<td>BIRDS-I : Japan</td>
<td>(b) 2017/07/07</td>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>BIRDS-II : Philippines</td>
<td>(b) 2018/08/10</td>
<td>Japan and Philippines</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>BIRDS-II : Malaysia</td>
<td>(b) 2018/08/10</td>
<td>Japan and Malaysia</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>BIRDS-II : Bhutan</td>
<td>(b) 2018/08/10</td>
<td>Japan and Bhutan</td>
<td>Bhutan’s first satellite</td>
</tr>
<tr>
<td>13</td>
<td>SPATIUM-I</td>
<td>(b) 2018/10/06</td>
<td>Japan and Singapore</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Ten-koh</td>
<td>(a) 2018/10/29</td>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>AOBA VELOX-IV</td>
<td>(a) 2019/01/18</td>
<td>Japan and Singapore</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>BIRDS-III : Nepal</td>
<td>(b) 2019/06/17</td>
<td>Japan and Nepal</td>
<td>Nepal’s first satellite</td>
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<tr>
<td>17</td>
<td>BIRDS-III : Japan</td>
<td>(b) 2019/06/17</td>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>BIRDS-III : Sri Lanka</td>
<td>(b) 2019/06/17</td>
<td>Japan and Sri Lanka</td>
<td>Sri Lanka’s first satellite</td>
</tr>
</tbody>
</table>

The 18 satellites that we have launched so far.
Finally, a word about pursuing a Masters Degree or Phd at Kyutech
Space Engineering International Course

- Taught in English
- You must have a bachelor’s degree in some field of engineering
- Masters degree in two years
- PhD in three years
- SEIC has between 45 and 60 students at any given time, mostly foreigners
- You will learn a lot about space engineering through *hands-on training*

After this talk, see me for a SEIC brochure
Post-graduate study on Nano-Satellite Technologies

- PNST, since 2013, a full scholarship
- Jointly administered by the UN and Kyutech
- Six persons selected each year, 3 Masters and 3 PhD
- Applications accepted during September thru January
- Apply through the website given below
- You must be from a non-space-faring nation


If accepted, you are placed into SEIC
Thank you for your attention from the BIRDS Family

BIRDS -1 -2 -3 and -4