Is building a CubeSat a good way for a country to get started in space?

George Maeda

Former assistant professor, Kyutech

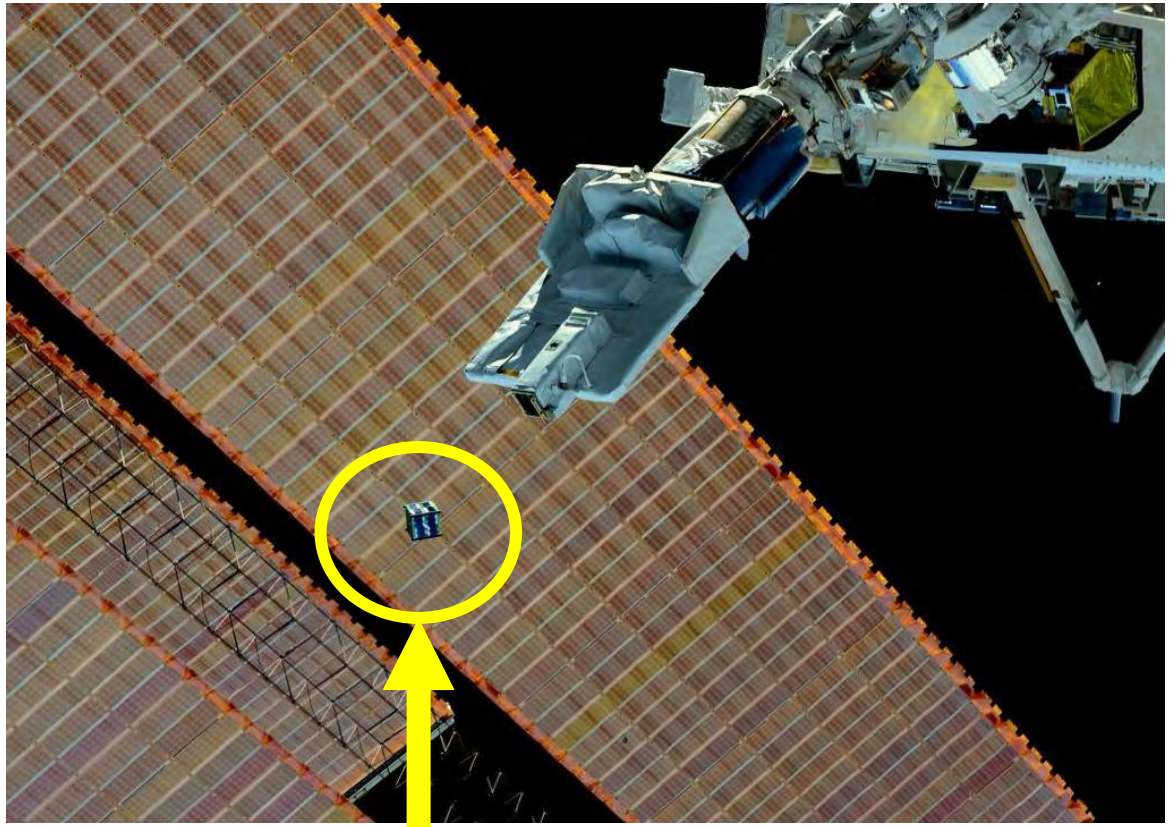
Presented during:

KiboCUBE Academy Session

on 25 August 2022

Tunis Science Center

Tunis, Tunisia



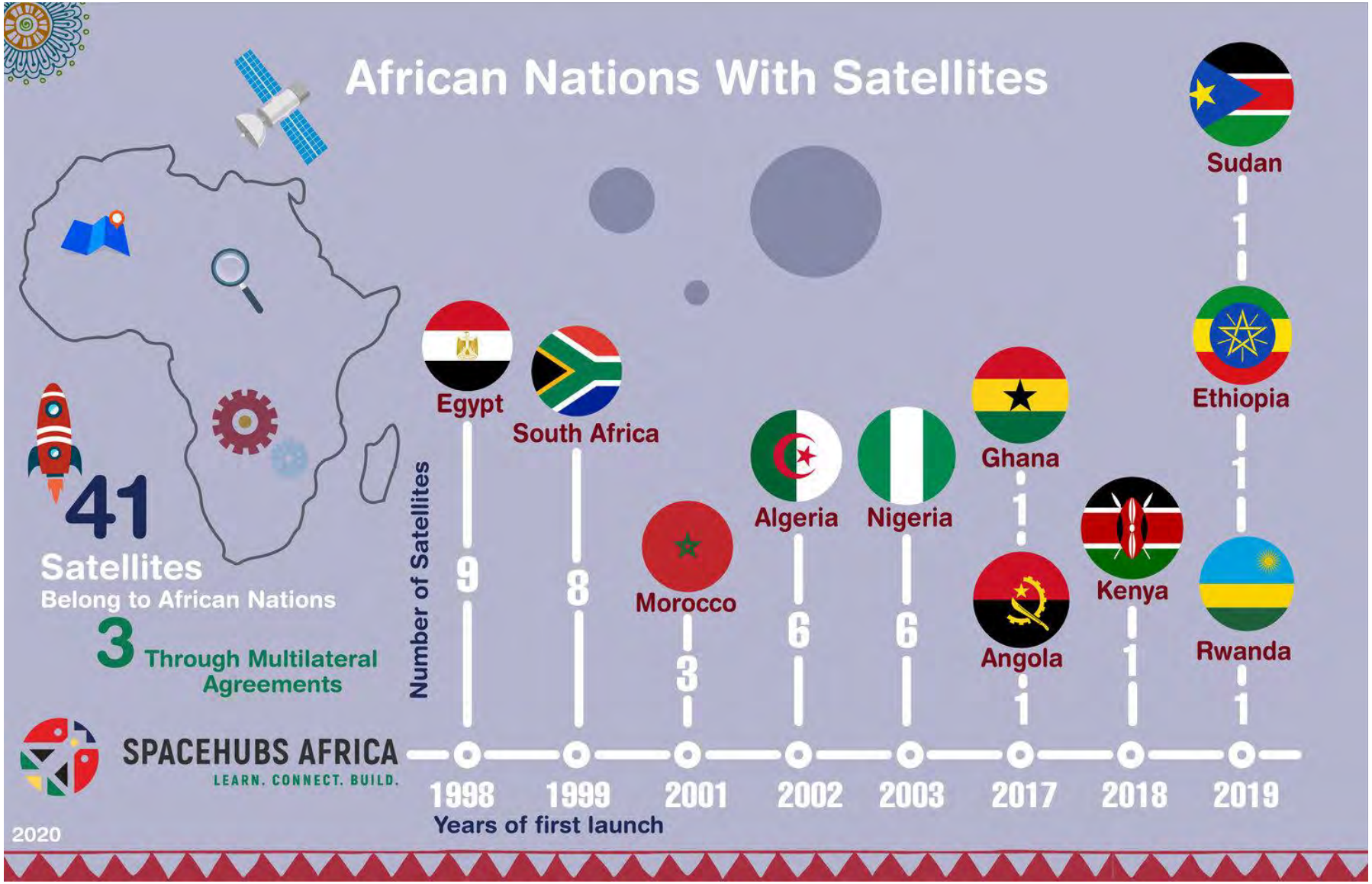
A 1U CubeSat being deployed from the ISS into low earth orbit

A primary goal of KiboCUBE is to help countries get started in space -- by inserting into Earth orbit a 1U CubeSat for such countries.

But that begs the question: *Why do countries need to get started in space?*

First, let's look at the African countries that have placed satellites into space.

This diagram shows the rough situation as of 2020→



Data credit: SPACEHUBS AFRICA; LÕÕTSA TEE, TALLIN, HARJU MAAKOND, ESTONIA

As of June 2020, 11 African countries:

1. Algeria
2. Angola
3. Egypt
4. Ethiopia
5. Ghana
6. Kenya
7. Morocco
8. Nigeria
9. Rwanda
10. South Africa
11. Sudan

have launched a total of 38 satellites.

Note:

Some of these satellites were made domestically, and some were simply purchased from big space manufacturers: Airbus, Boeing, Mitsubishi, Thales Alenia Space, ISRO, China Academy of Space Technology (CAST), and so on.

If you buy a satellite, you acquire nearly zero design and manufacturing skills.

A group of institutions from several African countries collaboratively launched three additional multilateral satellites: *RascomStar-QAF-1*, *RascomStar-QAF-1R* and the *NewDawn Satellite*. This brings the total to 41 satellites as of 2020.

Data credit: *"*Space in Africa" - June 17, 2020

All countries of Africa listed in order of population size

1. **Nigeria**
2. **Ethiopia**
3. **Egypt**
4. Democratic Republic of the Congo
5. Tanzania
6. **South Africa**
7. **Kenya**
8. **Sudan**
9. **Algeria**
10. Uganda
11. **Morocco**
12. **Angola**
13. Mozambique
14. **Ghana**
15. Cameroon
16. Madagascar
17. Ivory Coast
18. Niger
19. Burkina Faso
20. Mali
21. Malawi
22. Zambia
23. Senegal
24. Chad
25. Somalia
26. Zimbabwe
27. South Sudan
28. **Rwanda**
29. Guinea
30. Burundi
31. Benin
32. Tunisia
33. Sierra Leone
34. Togo
35. Libya
36. Republic of the Congo
37. Central African Republic
38. Liberia
39. Mauritania
40. Eritrea
41. Namibia
42. Gambia
43. Botswana
44. Gabon
45. Lesotho
46. Guinea-Bissau
47. Equatorial Guinea
48. Mauritius
49. Eswatini
50. Djibouti
51. Réunion (France)
52. Comoros
53. Cape Verde
54. Western Sahara
55. Mayotte (France)
56. São Tomé and Príncipe
57. Seychelles
58. Saint Helena, Ascension and Tristan da Cunha (UK)

RED indicates that the nation has put a satellite into space.

SOURCE: https://en.wikipedia.org/wiki/List_of_African_countries_by_population

Total Number of Countries in Africa	**58**
Countries that have launched satellites	**11**
Countries that have not launched satellites	**47**

Source of data:

IS THE UNITED STATES LOSING THE AFRICAN SPACE RACE?

https://warontherocks.com/2020/06/is-the-united-states-losing-the-african-space-race/

Flag of Mauritius

Note:

The Africa data of the preceding pages are based on the Year 2020. Last year, in 2021, Mauritius successfully placed its first satellite into orbit (3rd winner of KiboCUBE competition).

HIGHLY RECOMMENDED READING

To understand the journey into space by the nation of Mauritius, download this 58-page document

https://www.mric.mu/_files/ugd/f94712_9e23c44c3a3e4546b3ed965fe4318c7c.pdf

https://i1.sndcdn.com/artworks-000652773541-a86v74-t500x500.jpg

Before any country embarks on a national commitment to get into space, there should be some extensive internal discussion. Some basic questions needs to be asked by politicians, farmers, bureaucrats, academicians, entrepreneurs, leaders of industry, and policy makers.

The questions to be asked are:

- Why go into space?
- How does space strengthen our industrial base?
- How does space strengthen our agricultural base?
- How does space strengthen our national defense?
- How does space improve our workforce?
- How does space improve our R & D abilities?

https://d1qq9lwf5ow8iz.cloudfront.net/live-images-1/ImageDetail_9189bbd5-b794-499e-b7f9-c4e6dab10077_Large

These questions are relevant to countries of Africa because today any country in Africa can build its own satellites and get them into space – for the specific purpose of helping its own citizens.

There was a time when space was for "national prestige projects". Those days are over. Today, space must directly assist people with survival issues or else space projects should not be done.

The questions to be asked are:

- **Why go into space?**
- **How does space strengthen our industrial base?**
- **How does space strengthen our agricultural base?**
- **How does space strengthen our national defense?**
- **How does space improve our workforce?**
- **How does space improve our R & D abilities?**

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Please be aware that during the past 20 years, a truly massive *Game Change* has occurred in the space industry.

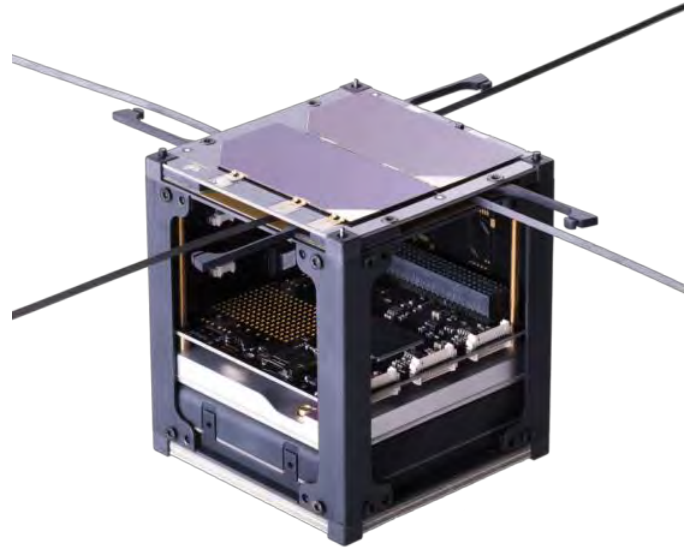
Space Policy Makers in Africa need to be aware of this development.

Old Space

New Space

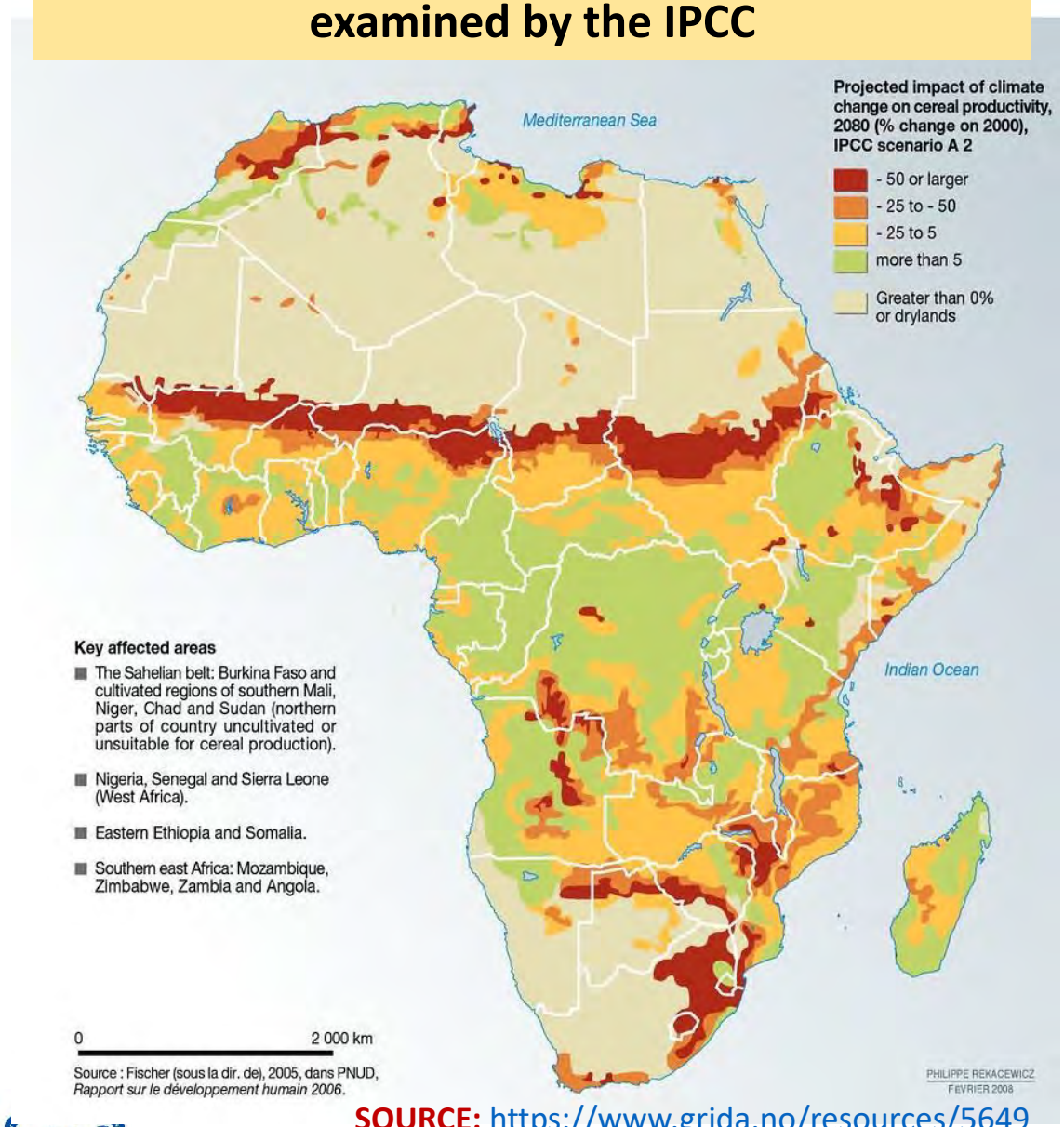
Name: SPOT 5 Satellite (April 2002)
Built by: *Astrium* (France)
Weight: 3 tons
Cost: 300 million Euros

Paradigm Shift



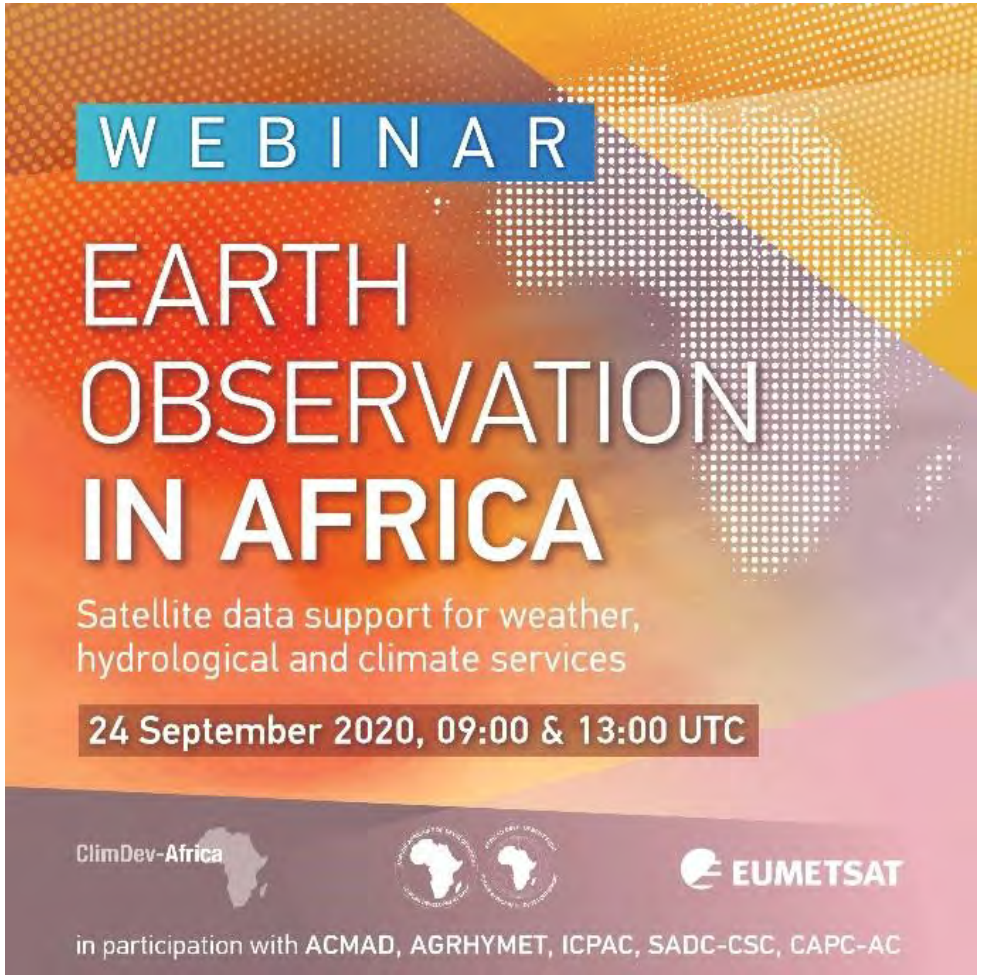
Name: Quetzal-1
Built by: Guatemala
Weight: 1.2 kg
Cost: About 200,000 USD

Cereal productivity in Sub-Saharan Africa as examined by the IPCC



SOURCE: https://www.grida.no/resources/5649

This *Game Change* is significant for Africa



With the advent of New Space, *Africa can now design, develop, build, test, and launch, its own Earth Observation satellites.*

Satellites track locust swarms as they attack crops in East Africa

28-Sep-2020

The African Development Bank's Climate for Development Africa Special Fund (CDSF) is using earth observation to build Africa's resilience to extreme weather events, through the €20 million Satellite and Weather Information for Disaster Resilience (SAWIDRA) Program.

https://www.afdb.org/en/news-and-events/satellites-track-locust-swarms-they-attack-crops-east-africa-earth-observation-webinar-hears-38028

Important question to ask yourself

Why should I build my own satellites if I can:

- **Buy satellites, or**
- **Buy satellite data from commercial services**

To fully exploit space for national profit, it is necessary to design, build, test, and launch, your own satellites.

A BIG BAD COMMERCIAL SATELLITE

Buying satellites does *nothing* to develop your engineering workforce!

All problems are local

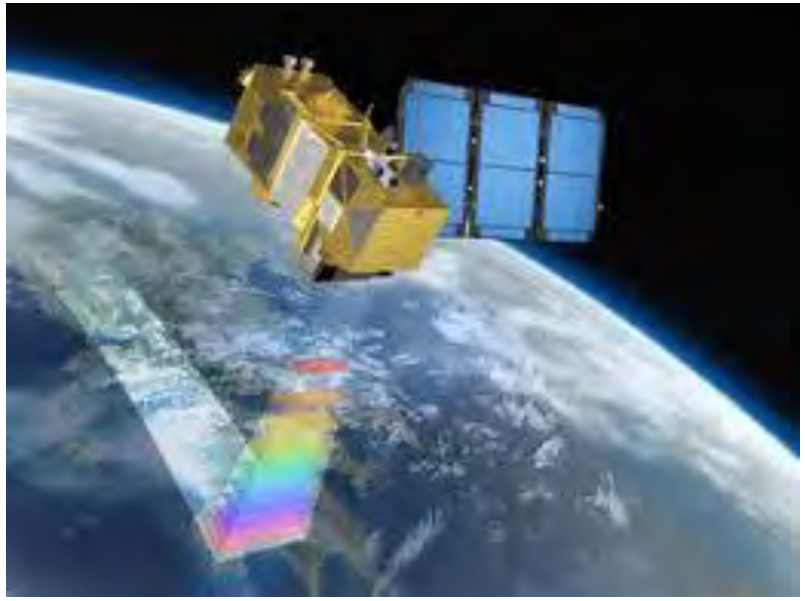
This slide is from Prof. Jordi Puig-Suari

Local Expertise
Problem and Solution ID

New Low-Cost Space Solutions

Problems of agriculture are all local

If you want to precisely attack your local problems, then you need to design and build your own satellites.



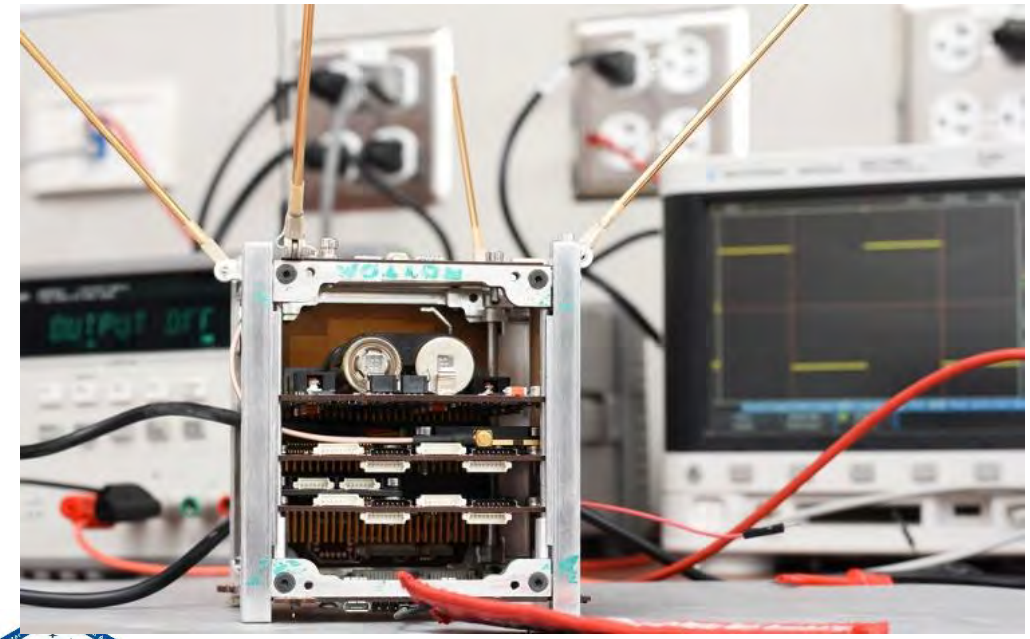
There is a huge amount of photographic data being created each day.

I do not recommend you make satellites that take photos. There is a lot of photographic data that is available on a commercial basis.

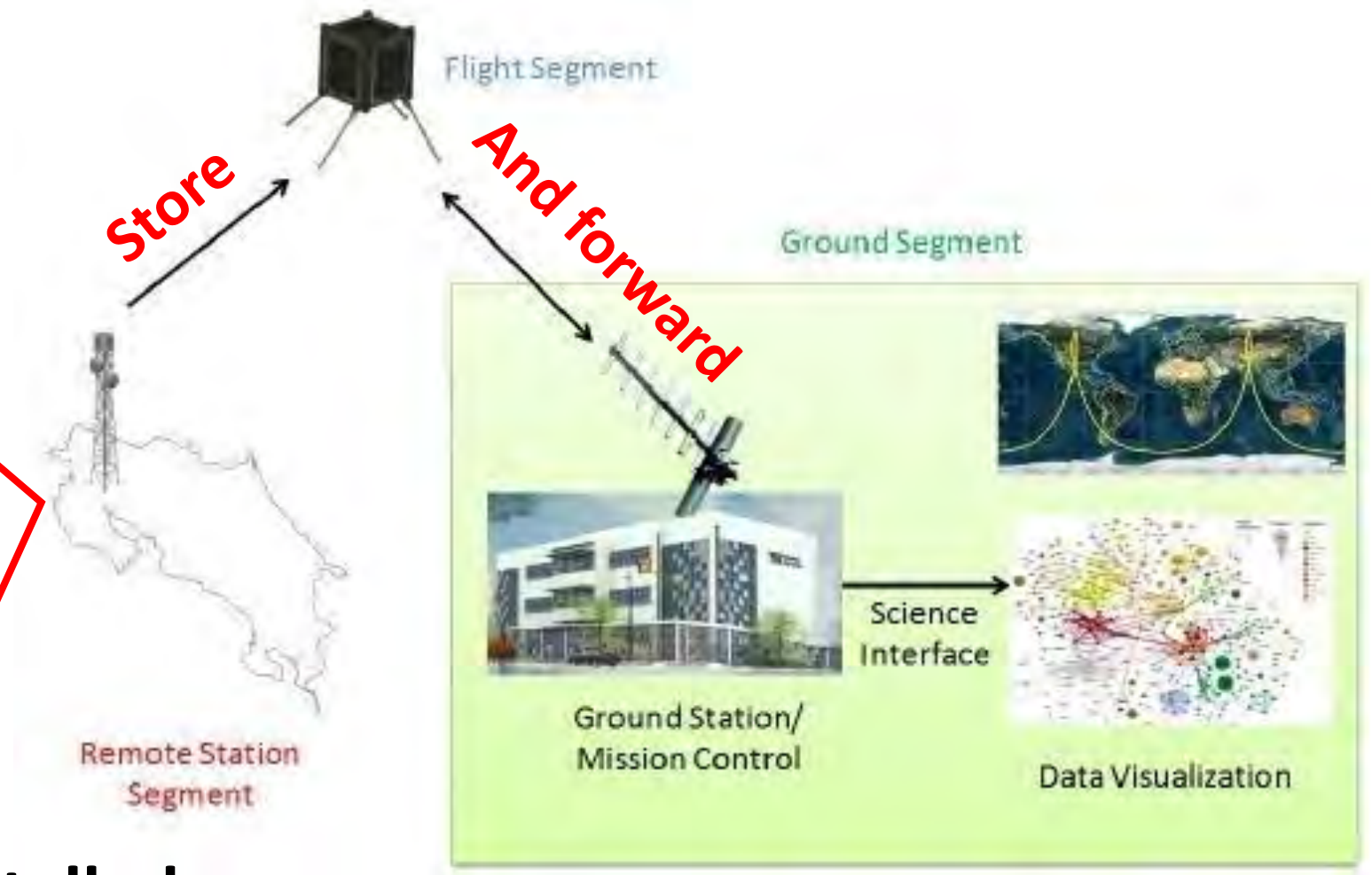
Space to help people on Earth

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.



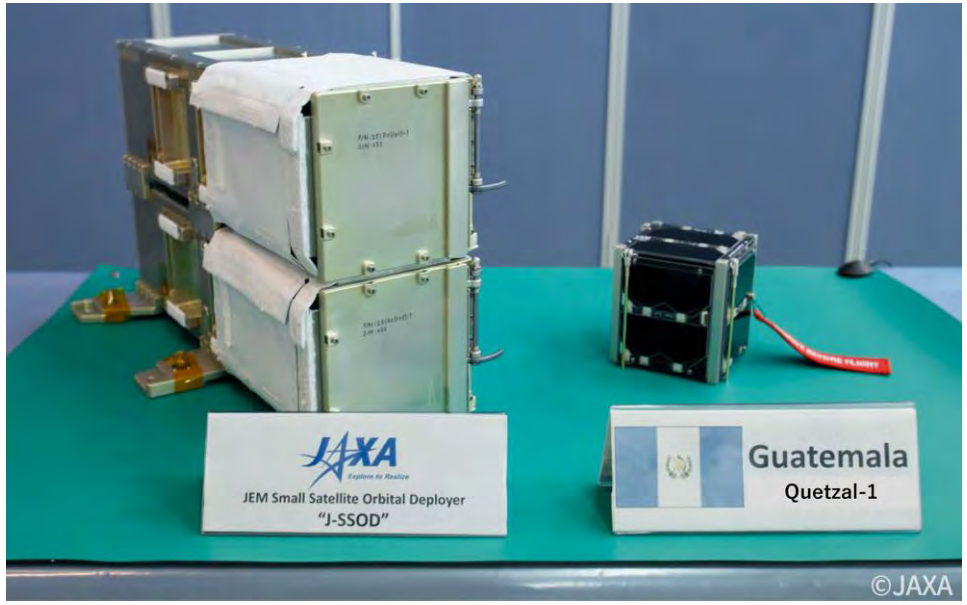
The mission of this satellite was simple. Just Store-and-Forward.

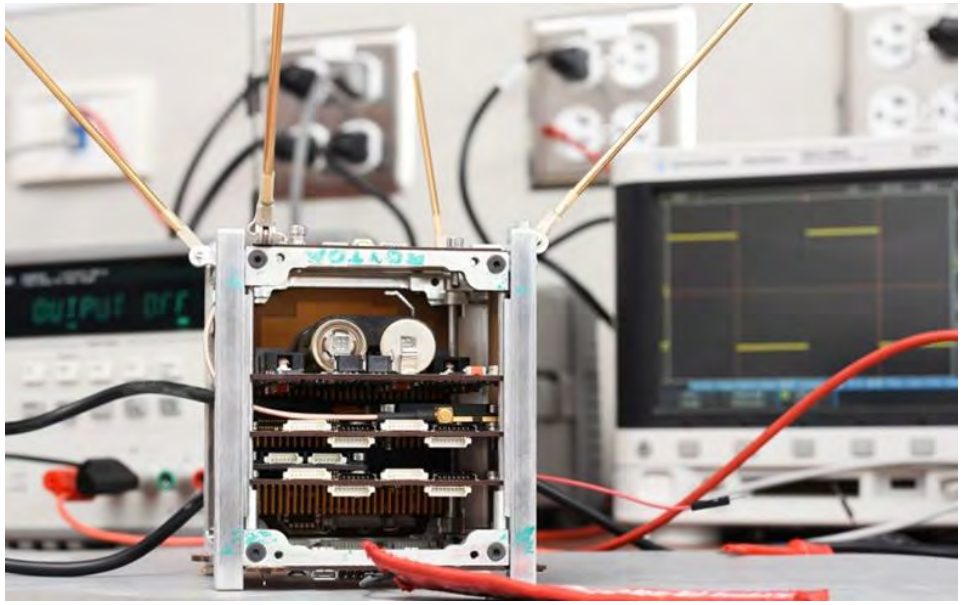


Remote stations are installed throughout the jungles of the country

https://www.google.co.jp/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwjrh_PR0u_iAhUBD6YKHQTkAHAQjRx6BAgBEAU&url=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2FMission-concept-of-the-Irazu-Project-13_fig2_328127269&psig=AOvVaw2iCI_zEm4k4SGVcdkZLNpK&ust=1560830967727487

I have presented two examples of 1U CubeSats so far:





Quetzal-1

The first satellite of Guatemala

IRAZU

The first satellite of Costa Rica

Quetzal 1 CubeSat

IRAZU CubeSat

What they have in common:

- ✓ **Both were designed and built domestically**
- ✓ **Both were funded domestically**
- ✓ **Both were deployed into space via the ISS using JAXA's J-SSOD, *JEM Small Satellite Orbital Deployer***
- ✓ **Both created in-house human resources for future space projects**

So now I come to the central thesis of my presentation today:

Why you (as a non-space-faring nation) should build a 1U CubeSat to become a sustainable member of the global space community.

Point Number One

If you wish to be a serious and long-term actor in the space industry, then it is imperative that you develop *human resources in the space sector.*

This means you must create an entire generation of space engineers and competent managers. *There is no short cut to this.*

Point Number Two

Learn by doing. **Although NEW SPACE has immensely lowered the barriers into space for developing countries, it is still not a cake walk. It remains a significant national undertaking.**

To deeply understand the advantages and disadvantages of using space to help the citizens of your country, you need to master the entire satellite development process:

- **Selecting payload missions**
- **Designing the satellite for those missions**
- **Fabricating that satellite**
- **Testing that satellite (environmentally)**
- **Getting it quickly and cheaply into space**
- **Operating the satellite as it orbits the Earth once every 90 minutes**

Point Number Three

As a first satellite for your country, a 1U CubeSat is a very, very reasonable proposition:

① Not costly (300K to 600K USD range, including launch cost)
② Can be done quickly (design-to-launch in under two years)
③ A CubeSat is reliable (if thoroughly tested environmentally)
④ Scores of nations have done it already
⑤ It is easy to get it into space

In any case, with this first satellite, you can train your first generation of space engineers. They will acquire the confidence and skills to develop more and more useful satellites for your country. *But you have to start somewhere.*

To create a durable, long-term, productive, and sustainable, national space program in your country, you must first perform some

CAPACITY BUILDING

And my argument to you is that doing a 1U CubeSat as a first space project is the best way to go about that. Scores of countries of done this already – and have learned immensely from the hands-on experience.

Japan is helping non-space-faring nations with **Capacity Building** in many ways

Three examples from Japan

Many institutions in Japan are conducting space capacity building, but in this presentation I will mention only three:

I. **JAXA** (space agency of Japan)
II. **UNISEC-Japan** (University Space Engineering Consortium)
III. Kyushu Institute of Technology (**Kyutech**), an engineering college in the south of Japan

Capacity Building by JAXA

Working with UNOOSA, JAXA is providing the KiboCUBE program.

Details are presented in this 2-day workshop, and at this website: KiboCUBE (unoosa.org)

You have a chance to get your satellite into space with a free launch by JAXA

YOU CAN VIEW THIS INTRODUCTION TO KiboCUBE ACADEMY:
https://www.youtube.com/watch?v=wOfvl1DX27Q&t=736s

In support of *KiboCUBE*, JAXA has developed a series of free lectures in English by experts of space engineering.

You can access all KiboCUBE Academy lectures via the weblink shown below.

RECORDED KIBOCUBE ACADEMY LECTURES
https://www.unoosa.org/oosa/en/ourwork/access2space4all/SatDevTrack_Webinars.html#Tag1

▼ KiboCUBE Academy: Season 1: Technical insights for a better Application

<< CLICK HERE for details (agenda and bio of lecturers) >>

SPACE ENGINEERING LECTURES BY EXPERTS

14 January 2021 Click here for the video

- Introduction of KiboCUBE Academy by Yasuko Shibano, JAXA

(pdf and video 12:16-19:54)

- CubeSats Change the World by Toshinori Kuwahara, Tohoku Univ. (UNISEC)

(pdf and video 20:38-54:24)

- Introduction to CubeSat Technologies by Toshinori Kuwahara, Tohoku Univ. (UNISEC)

(pdf and video 1:04:49-1:56:47)

21 January 2021 Click here for the video

- Overview of Satellite Development Process by Shinichi Nakasuka, Tokyo Univ. (UNISEC)

(pdf and video 6:48-51:13)

- How to Make Your Satellite Survive in Space by Shinichi Nakasuka, Tokyo Univ. (UNISEC)

(pdf and video 1:02:10-1:39:43)

28 January 2021 Click here for the video

- Introduction to Satellite Testing by Mengu Cho, Kyushu Institute of Technology (UNISEC)

(pdf and video 4:25-49:16)

- CubeSats for Capacity Building by Mengu Cho, Kyushu Institute of Technology (UNISEC)

(pdf and video 1:00:57-1:43:11)

4 February 2021 Click here for the video

- Satellite Operation and Related Regulations by Toshinori Kuwahara, Tohoku Univ. (UNISEC)

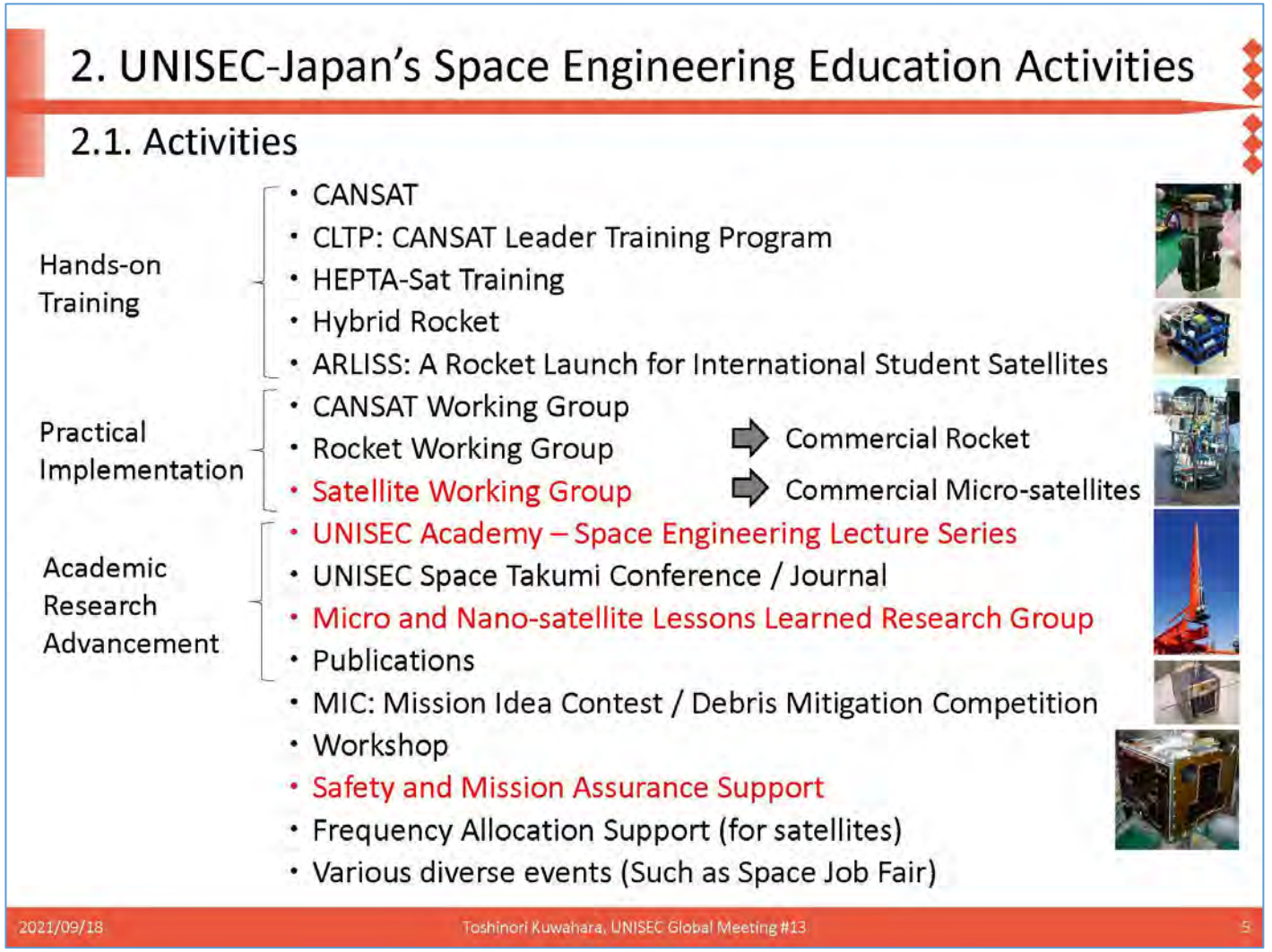
(pdf and video 5:02-1:05:07)

- Q and A

Capacity Building by UNISEC-Japan

UNISEC
University Space Engineering Consortium

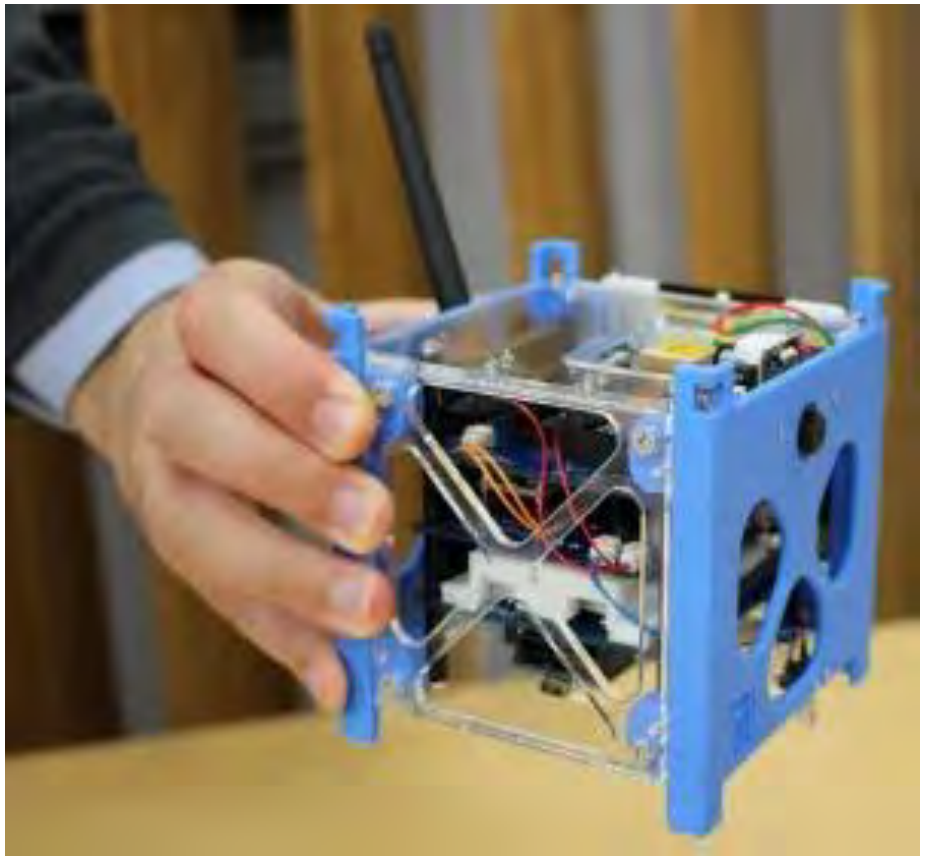
At the right, you can see the education activities. CLTP and MIC are two of the famous ones.



For full details, please view this YouTube video

VIDEO, 13th virtual UNIGLO meeting

https://www.youtube.com/watch?v=MDDWrsCV8Gk&t=2766s



CANSAT training is now based on the

HEPTA-Sat

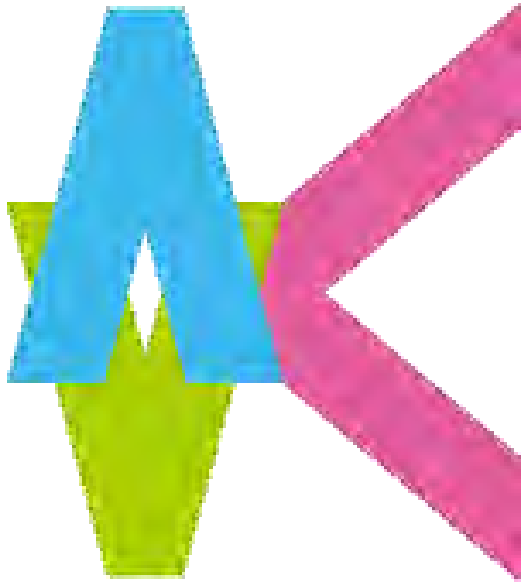
(shown in the blue frame at the left)

CLTP11 will be organized in Tokyo in August 2022.

CLTP is a program on space education. It aims to teach the actual process in space development by going through the whole process of satellite system integration, using the HEPTA-Sat kit. It is a training program for researchers and educators, and they are expected to return the results of the training to their institutions to lead the space development.

SEE: http://cltp.info/cltp11.html

Capacity Building
by Kyutech



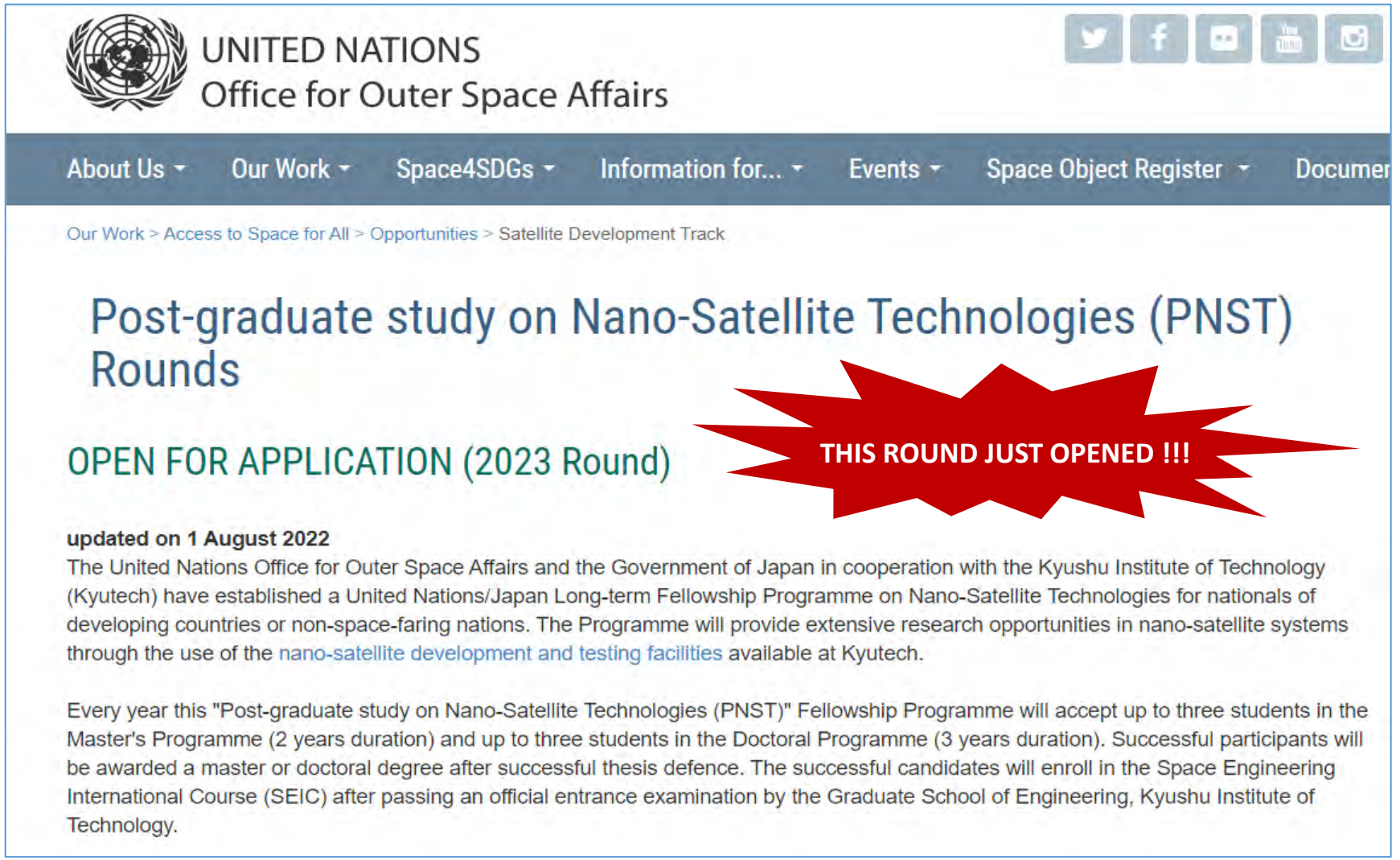
Kyushu Institute of Technology
Kitakyushu, Japan

Flagship programs are:

① PNST/SEIC
② BIRDS Program

Since 2013, working with UNOOSA, Kyutech provides six post-grad level scholarships each year (3 masters and 3 Phds). It is only open to applicants of non-space-faring nations.

The 2023 round just opened at this website. Application period ends on 9 January 2023.



UNITED NATIONS
Office for Outer Space Affairs

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Our Work > Access to Space for All > Opportunities > Satellite Development Track

Post-graduate study on Nano-Satellite Technologies (PNST) Rounds

THIS ROUND JUST OPENED !!!

OPEN FOR APPLICATION (2023 Round)

updated on 1 August 2022

The United Nations Office for Outer Space Affairs and the Government of Japan in cooperation with the Kyushu Institute of Technology (Kyutech) have established a United Nations/Japan Long-term Fellowship Programme on Nano-Satellite Technologies for nationals of developing countries or non-space-faring nations. The Programme will provide extensive research opportunities in nano-satellite systems through the use of the nano-satellite development and testing facilities available at Kyutech.

Every year this "Post-graduate study on Nano-Satellite Technologies (PNST)" Fellowship Programme will accept up to three students in the Master's Programme (2 years duration) and up to three students in the Doctoral Programme (3 years duration). Successful participants will be awarded a master or doctoral degree after successful thesis defence. The successful candidates will enroll in the Space Engineering International Course (SEIC) after passing an official entrance examination by the Graduate School of Engineering, Kyushu Institute of Technology.

PNST website – please forward to suitable applicants

https://www.unoosa.org/oosa/en/ourwork/access2space4all/PNST/PNST_Rounds.html

All PNST fellows are entered into Kyutech's

SEIC

(Space Engineering International Course)

SEIC Highlights:

- **Lectures in English**
- **Interdisciplinary projects**
- **Multicultural teams**
- **Learn Japanese for beginners**
- **Eat delicious Japanese food**
- **Attend international conferences**
- **Earn masters degree (2 years) or Phd (3 years)**

A few short words about the

BIRDS Program

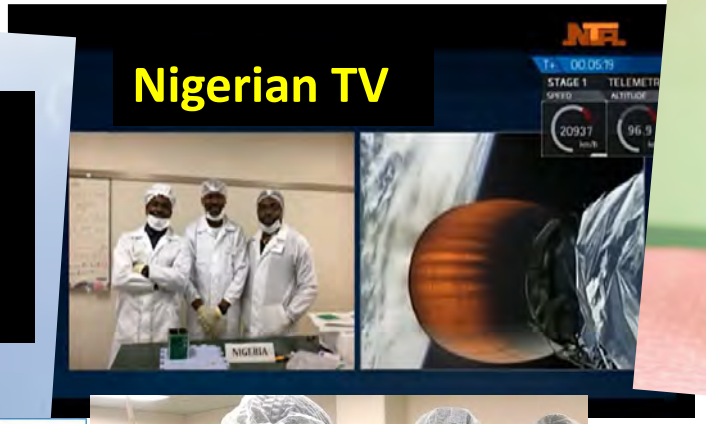
Starting year	Project title	Participating nations
2015	BIRDS-1	Ghana, Bangladesh, Japan, Nigeria, Mongolia
2016	BIRDS-2	Bhutan, Malaysia, Philippines
2017	BIRDS-3	Nepal, Sri Lanka, Japan
2018	BIRDS-4	Paraguay, Philippines, Japan
2019	BIRDS-5	Japan, Uganda, Zimbabwe

The main goal of the famous BIRDS Program of Kyutech was to help various non-space-faring countries get their first satellite into space. The members of BIRDS are shown above – the African nations are shown in red. (Only Nigeria had already place a satellite into space.)

PHOTOS OF BIRDS-1

Ghana and Nigeria

Ground station in Ghana



Ghana's 1st satellite

Nigeria's QSL card

Anechoic chamber at Kyutech

All members of BIRDS-1 Project

NTA Network News Extra 21-6-2017

Taiwo, Project Manager of BIRDS-1

CubeSats prior to insertion into deployers at JAXA

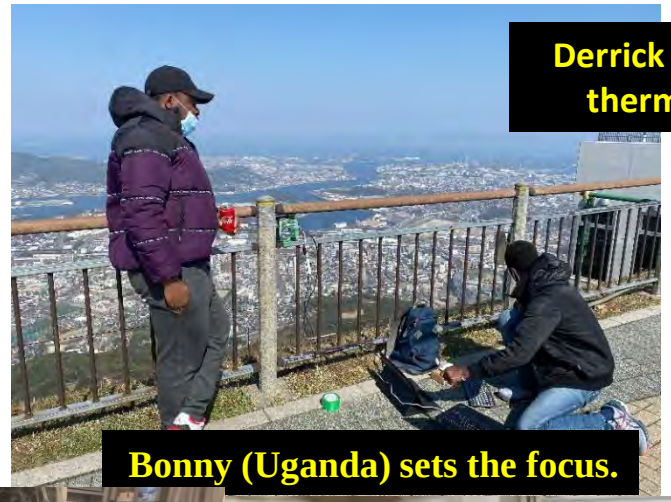
PHOTOS OF BIRDS-5

Zimbabwe and Uganda

Timothy (ZIM) at anechoic chamber of Kyutech

Victor (Zimbabwe), Project Manager of BIRDS-5

Stakeholders at Namulonge, Uganda



Bonny (Uganda) sets the focus.

Derrick (Uganda) operates a thermal vacuum chamber

Assembly of ground station in Zimbabwe

Uganda team departs Uganda in Oct 2020

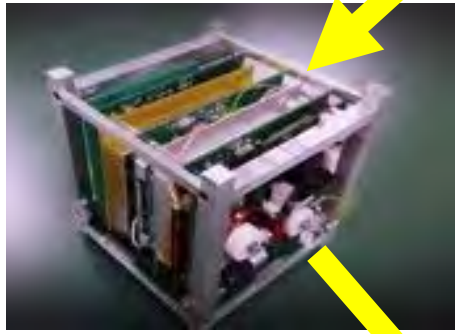
Timothy performs magnetic calibration of BIRDS-5 satellite in Oita Prefecture

Student members of the BIRDS-5 project team

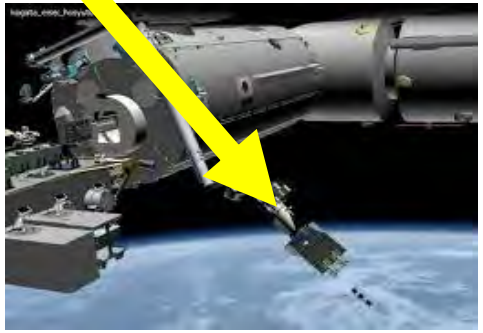
Handover of BIRDS-5 satellites to JAXA on 10 May 2022

Plan

Try



Build



Fly

Concluding remarks:

The only way young engineers can learn how to build a satellite is to build one with their own hands. ***Book learning or classroom learning does not work.***

After going through a BIRDS project, engineers gain the confidence to build satellites by themselves.

If your country wants to join the space age, the best way is to train your engineers in the BIRDS manner.

The End

Thank you for your attention