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A university-based model for space-related capacity building in emerging countries

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ABSTRACT

Since 2011 the number of satellites less than 50 kg launched annually has increased by an order of magnitude. This trend is driven in part by proliferation of small satellite and lean satellite projects worldwide. In this decade alone, over 30 new countries are expected to achieve their first satellite in space. More than ever before, emerging countries are engaging in space-related activities. However, barriers such as lack of funding and underdeveloped human resources prevent many emerging nations from initiating or sustaining space programs. Kyushu Institute of Technology (Kyutech) has played an active role in space-related capacity building and international cooperation since 2009, then partnering with the United Nations Office for Outer Space Affairs to formulate a long-term fellowship programme hosted at Kyutech. Growing out of the success of the fellowship programme, Kyutech began significantly expanding its space-related capacity building project in 2013. This paper gives an overview of Kyutech's university-based model to enhance space-related capacity building and human resource development in emerging countries worldwide, and discusses advantages and disadvantages of alternative approaches.

1. Introduction

The barrier to space access is falling. Despite issues such as lack of funding, apathetic political support, limited technology, lack of expertise, and underdeveloped human resources, over 30 new countries are projected to achieve space access this decade [1]. Small satellites are driving this lower barrier to space for emerging countries. The number of small satellites launched annually has increased by an order of magnitude since 2011, and the global market for satellites less than 50 kg is projected to grow from ~$700 M USD in 2014 to ~$2 B USD by 2019 [2]. Many of these satellites can be categorized as "lean satellites" that employ untraditional risk-taking development approaches to achieve low-cost and fast-delivery with small teams. Utilizing the advantages of lean satellites, emerging countries and institutions can now much more quickly cycle through design, development, launch, and operation [1].

There are various models designed to provide support for small and lean satellite activities, such as programs conducted by established space agencies, purchases from private companies, commercial training packages, university-based practical education, etc. Numerous direct and tangential benefits can be leveraged in the process. Space faring nations and established space institutions have both for-profit and non-profit incentive to contribute to basic space technology and human resource development in emerging countries. However, emerging countries are not equipped to reap the benefits of space access by simply launching or operating a small or lean satellite. These launches are crucial but not sufficient first steps to initiate value-added space programs. The personnel and workforce must be adequately equipped to propagate sustainable space activities within their home countries.

Kyushu Institute of Technology (Kyutech) is a Japanese national university founded in 1909. This paper concerns Kyutech's university-based model to enhance space-related capacity building and human resource development in emerging countries worldwide, and discusses advantages and disadvantages of alternative approaches. A related publication [1] by the authors that has been submitted for review gives an overview of space-related activities in various emerging countries and categorizes countries in nine regions worldwide according to level of satellite activity. In Sec. 2 we describe our university-based model; in Sec. 3 we discuss capacity building intent and alternative approaches, and Sec. 4 is the conclusion.

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2. Kyutech's university-based model for space-related capacity building

Many dozens of universities are now utilizing satellite projects as official educational tools. Kyutech's model seeks to influence space-related capacity building worldwide through requirements inherent to all satellite projects: space environment testing and launch opportunities.

At Kyutech students engage in space engineering laboratory research, testing, and satellite projects having bona fide launch opportunities throughout their multi-year graduate degrees. In doing so participants come to understand the infrastructure necessary for satellite activity. Under this model Kyutech is engaging countries worldwide in a five-pronged approach to develop satellite capability and human resources. The approach consists of the following five elements:

1. Assessment of local conditions, infrastructure, and resources
2. Education and human resource development
3. Official agreements to spur collaboration
4. Low-cost and fast-delivery satellite testing
5. Assistance with launch opportunities

To achieve 1. the authors spend ~4 months on travel in ~20 countries per year. The trips consist of student recruitment, initiating partnerships and collaboration, and negotiating over personnel training and education, satellite testing, joint launch opportunities, and joint research.

To achieve 2. Kyutech utilizes its English-based Space Engineering International Course (SEIC) graduate degree curriculum that was launched in April 2013 [3,4].

To achieve 3. Kyutech works with partner institutions to sign Memorandums of Understanding (MOUs) pertaining to student/staff exchange and joint research, Double-Degree Program (DDP) agreements for joint long-term educational efforts, contracts for satellite testing, contracts related to launch opportunities with JAXA, or other official agreements. The objective is to create sustainable relationships and a Kyutech global network that does not over rely on external funding.

To achieve 4. Kyutech employs small/lean satellite testing that is not possible for traditional satellites. This testing has been instrumental to the development of the standard ISO-19683/CD on small/lean satellite testing. The ISO standard is not yet published[1] but in the meantime Kyutech follows the standard and encourages partners to do so as well.

To achieve 5. Kyutech works with the JAXA to enable foreign institutions to launch nanosatellites from the ISS (International Space Station). JAXA requires that a given foreign institution have a Japanese partner to be eligible for extremely competitive launch costs.

2.1. Kyutech global network

The five tasks listed above have been pursued by Kyutech since 2013. Kyutech's global network for space-related capacity building extends to over 40 countries. The joint United Nations/Japan fellowship programme named Post-graduate study on Nano-Satellite Technologies (PNST) allows Kyutech to award six fellowships per year for five years (2013–2017) to nationals of non-space faring nations. Collaboration status worldwide is totaled in Table 1.

Table 2 gives the total number of Kyutech official agreements, pending agreements, local visits, PNST students, and self-funded students by region.[2] At present Africa and Southeast Asia are Kyutech's strongest regions. Central/North America and South America are up-and-coming regions of Kyutech collaboration.

Table 1
Kyutech worldwide collaboration status totals as of this writing.

Local visits:	43
Agreements in progress:	10
Agreements official:	14
PNST students:[a]	21
Self-funded students:	26

[a] Includes 4 students from an earlier version of PNST known as DNST.

Table 2
Kyutech collaboration status by region.

	AF	ME	CN	SA	EA	SN	SE	EE	OA	Total
Local visits:	8	1	5	11	1	1	15	0	1	**43**
Agreements in progress:	3	0	2	2	1	0	1	0	1	**10**
Agreements official:	2	1	1	0	1	1	8	0	0	**14**
PNST students:	6	1	2	1	3	1	4	3	0	**21**
Self-funded students:	9	1	2	1	1	2	9	0	0	**26**

2.2. Importance of university speciality area

For a university to maintain a global capacity building network it is important to have a speciality area with broad appeal. Kyutech's speciality is space environment testing. At Kyutech satellite testing is conducted in the Center for Nanosatellite Testing (CeNT). CeNT is capable of testing satellites with size and weight up to 50 cm and 50 kg, respectively. Tests include vibration, shock, thermal vacuum, thermal cycling, electromagnetic compatibility, outgassing, and others. Approximately two-thirds of all Japanese small satellites and many foreign small satellites conduct environmental testing at CeNT.

In general, a given university or academic center running a broad-scale capacity building network should have at least one speciality or focus area to attract a wide range of users and to compensate for possible lack of resources compared to government agencies, private companies, etc. If no such speciality area exists, entities may turn to “resource providers” that specialize in university projects, such as those promoted by the University Space Engineering Consortium.

2.3. Importance of national policy and international cooperation

The Government of Japan supports various elements of Kyutech's capacity building project, including PNST fellowships through Monbukagakusho (MEXT), ISO standardization activities through the Ministry of Economy, Trade and Industry (METI), and the HORYU-IV nanosatellite project through the Japan Society for the Promotion of Science (JSPS). Also, UNOOSA supports and advocates internationally on behalf of the PNST fellowship programme.

[1] Projected to be published in 2016.

[2] AF: Africa, ME: Middle East, CN: Central/North America, SA: South America, EA: Eastern Asia, SN: Southern Asia, SE: Southeast Asia, EE: Eastern Europe, OA: Oceania.