Acta Astronautica 83 (2013) 260–272

Contents lists available at SciVerse ScienceDirect

Acta Astronautica

journal homepage: www.elsevier.com/locate/actaastro

Technological learning through international collaboration: Lessons from the field

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ARTICLE INFO

Article history:
Received 1 March 2012
Received in revised form
17 July 2012
Accepted 21 September 2012
Available online 30 November 2012

Keywords:
satellites
technological learning
developing countries
capability building
systems architecture

ABSTRACT

Countries on every continent are making new or renewed commitments to domestic satellite programs. These programs have the potential to address national needs by enhancing access to information, improving infrastructure and providing inspiration to the public. How do countries without local expertise in space technology begin a new satellite program? What is the role of international collaboration in supporting the efforts of a new space fairing country? This paper explores such questions by highlighting outputs from intensive field work in Africa and Asia. Specifically, the study explores case studies of early space activity in these countries to search for lessons about the management of a young space program. The observations from field work are compared to ideas from scholarly literature on technological learning. The findings are organized using principles from systems architecture. The paper presents a model that captures many of the influences and strategic decision areas for a collaborative satellite development project. The paper also highlights the growth of capability among African countries in the area of satellite technology.

1. Introduction and overview

Space and the technology that humans use to explore it have strong relevance to the global community. Space is relevant to countries along the entire spectrum of technological advancement; not merely to countries that have traditionally led the development of space technology. Global participation in national space activity is growing as space technology matures and spreads. Many countries in Africa, Asia and Latin America are creating or reinvigorating domestic satellite activity at the national level. Often these countries seek to build local technological capability regarding space technology among their citizens through a process of technological learning. They sometimes pursue this goal via collaborative satellite development projects with international partners that provide training. Previous work by the authors [1] organized lessons from the literature on technology learning in the international development community that are relevant to the challenges of collaborative satellite development projects. As a follow on to this theoretical work, the authors conducted extensive field work that explored the dynamics of training-oriented satellite programs executed by countries in Africa, the Middle East and Asia. The fieldwork included extensive meetings and interviews with project stakeholders as well as observation of the project facilities and activities. This paper draws insights from the fieldwork to develop a model that captures key facets of the implementation approaches of satellite programs. At a high level the model maps the relationship between goals for building technological capability with other key factors in the project. These key factors include contextual constraints as well as technical performance

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http://dx.doi.org/10.1016/j.actaastro.2012.09.014

requirements. At a more detailed level, the model also defines specific dimensions of satellite projects that can be thoughtfully chosen to balance learning objectives, contextual constraints and technical performance requirements. This paper introduces the model and provides an initial discussion of the insights it provides. The discussion also harnesses the concepts from the learning literature to provide guidance on potential priorities for decision makers within collaborative satellite development projects.

The paper is organized as follows. Section 2 provides background information about potential benefits from space activity and the contributions space can provide to the countries all over the world, with particular reference to the experiences of African countries. Section 3 reviews the key concepts from the technological learning literature that lay a foundation for harnessing capability building. Section 4 introduces the model of project influences; it is based on extensive field work in Africa, the Middle East and South East Asia. This section further describes the research methods used to collect data; defines the key elements of the model; and details major dimensions of satellite programs that signal strategic decisions. Section 5 discusses the implications of the model by connecting it to the ideas from the technological learning literature. Often there are compromises between the ideal prescription from the literature and the feasible actions due to contextual constraints. Section 6 closes with a summary. Future work will continue to examine the data from the fieldwork to uncover insights and relationships between project dimensions.

2. Background

Space is relevant to countries around the world because it provides infrastructure, information and inspiration to our societies. Since the beginning of the space era, leaders have recognized the potential of space resources to serve the entire planet. An example is the founding of INTELSAT under President Kennedy to provide global satellite communication [2]. The three benefits of infrastructure, information and inspiration are often provided through five types of space activities, as summarized in Table 1 below. First, these benefits can be harnessed by applying satellite services. Satellite remote sensing enables earth observation and monitoring of the environment. This capability can improve the response to problems such as disease outbreaks, drought, fires and deforestation. Satellite communication is a part of the global infrastructure that allows the world to share information seamlessly. Satellite navigation and positioning have become integrated into the global transportation infrastructure, while the timing function serves many industries and communities. Satellite services are ubiquitous around the world; less developed countries are part of the user-base for these services [3]. The second type of space activity is building technological capability. The risks and challenges associated with operating technology in space sharpen the skills of the engineers, technologists and scientists. When a country begins new activities with space technology, they necessarily enter a posture of learning and self-improvement for both individuals and teams. The third type of activity through which space brings benefit is enabling economic activity. As space resources and information bring value to customers, new organizations can be formed that create jobs and products that leverage space. The fourth activity area is inspiring technology applications. When engineers and technologists solve problems to allow operations or innovation in a space system, the new invention is often relevant to terrestrial applications as well. The unique environment of space often inspires creative engineering approaches and innovative solutions might not be otherwise attempted. In some cases new systems or technologies are developed with both a space and earth application in mind. In other cases, technologies that are first created to solve a challenge with space operations are later found to be useful for an unrelated activity in another field such as health care, energy or manufacturing. Finally, space activity builds the scientific knowledge of society. By venturing into space, humankind has made immense discoveries. New players in space can achieve local scientific progress with their own space activities. Even with limited resources, it is possible to access and analyze space science data collected on satellite platforms. There are valuable measurements that can be taken using terrestrial sensors that provide insights about the relationship between the earth and sun. Human spaceflight and suborbital operations open the opportunity for scientists all over the world to engage in microgravity research. All of these represent practical opportunities to harness the benefits of space for improved infrastructure, valuable information and global inspiration. The benefits of space span societal sectors; space is relevant to the industrial, civil and security arenas.

Table 1
Space activity can provide benefit to countries around the world through these five activities.

Five types of space activity that provide benefit
Applying satellite services
Building technological capability
Enabling economic activity
Inspiring technology applications
Building scientific knowledge

The discussion above highlights the ways that space impacts countries around the world. Countries differ, however, in the level to which they make direct investments in local satellite-based activity. This concept is summarized in Fig. 1 below. The broad base of the figure represents the reality that every country is a user of satellite services—remote sensing, communication and navigation. These services have global reach and decentralized operational models. As the levels rise on the pyramid, fewer countries make direct investments in domestic satellite hardware (owning satellites or launch vehicles), local satellite expertise or the infrastructure required to build and operate satellites. There are both objective (technically-based) and subjective (value-based) motivations for countries to invest in these various levels of the pyramid. For an in-depth discussion on the potential motivations for such investments, please see previous work by the authors [1].

Some countries in Africa, Asia and Latin America that have traditionally been thought of as technologically limited are pursuing independent capability with satellite