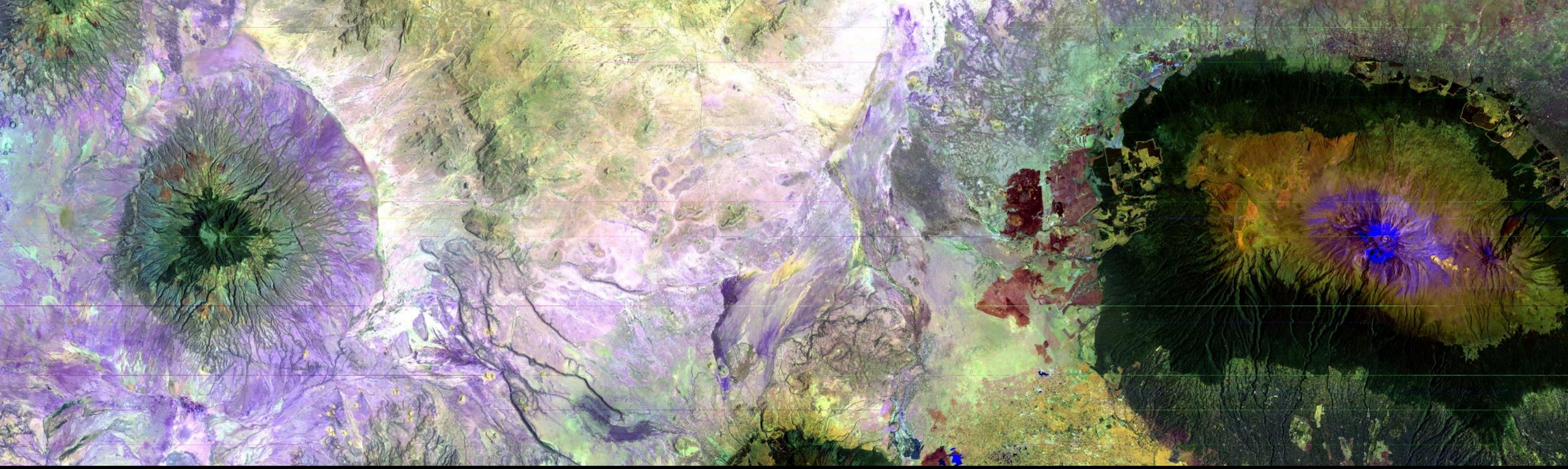


Expanding Space Accessibility via Capability Building and Innovation

Danielle Wood, PhD
Assistant Professor, Massachusetts Institute of Technology
Director, Space Enabled Research Group

Image Credit: USGS, Dept. the Interior, https://eros.usgs.gov/earth-art/kilimanjaro

“The exploration and use of outer space should be carried on for the benefit of all peoples irrespective of the degree of their economic or scientific development…”

Outer Space Treaty, 1967

http://www.un.org/News/dh/photos/large/2015/September/09-09-E-SDG-Poster.jpg

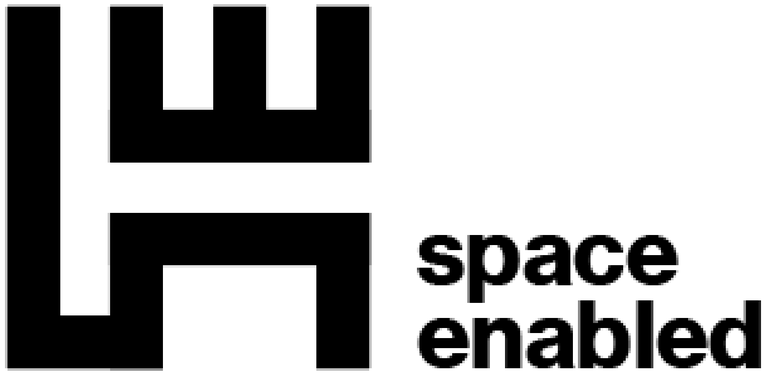
Space-enabled activities contribute to sustainable development…

1. Earth Observation
2. Satellite Communication
3. Satellite Positioning & Timing
4. Human Space Flight and Microgravity research
5. Inspiration (including education, outreach)
6. Space Spinoffs
7. Scientific Research (earth science, astrophysics, space weather, astrobiology, etc)

Universities can contribute to the Global Space Partnership for SDGs

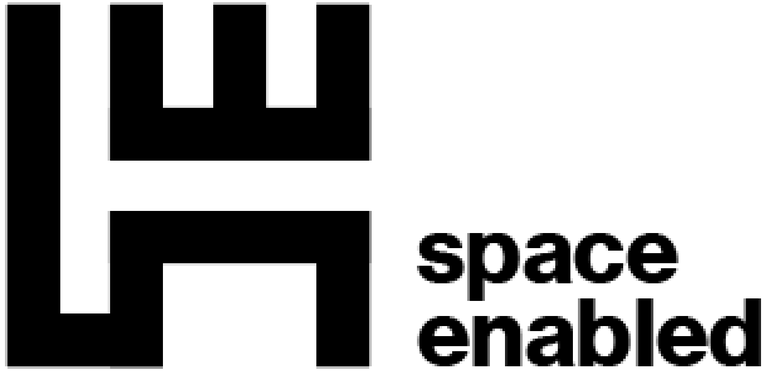
- Users Needs
  - Consult on methods to define and assess user needs
  - Document case studies and evaluations illustrating impact of space for SDGs
- Space Systems Capacity Coordination
  - Propose methods to use software-base modeling to inform design of coordination of space systems
- Access to Space Assets
  - Perform studies and assessments identifying barriers to access and examples of effective projects; Perform pilot projects demonstrating best practices
- Capacity Building
  - Host capability building programs, international research collaboration and personnel exchange
  - Study and evaluate capacity building outcomes

http://www.lampartners.com/wp-content/uploads/2014/09/MediaLab_ESTO_006.jpg



Research Group at the MIT Media Lab:

Advancing justice in Earth's complex systems using designs enabled by space



The Space Enabled Research Group uses four types of methodology:

1) **Research social and historical aspects of space initiatives**
2) **Using software to model space-enabled systems**
3) **Creating novel approaches to spacecraft engineering**
4) **Designing and evaluating space-enabled applications for development**

Universities can contribute to the Global Space Partnership for SDGs

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Users Needs

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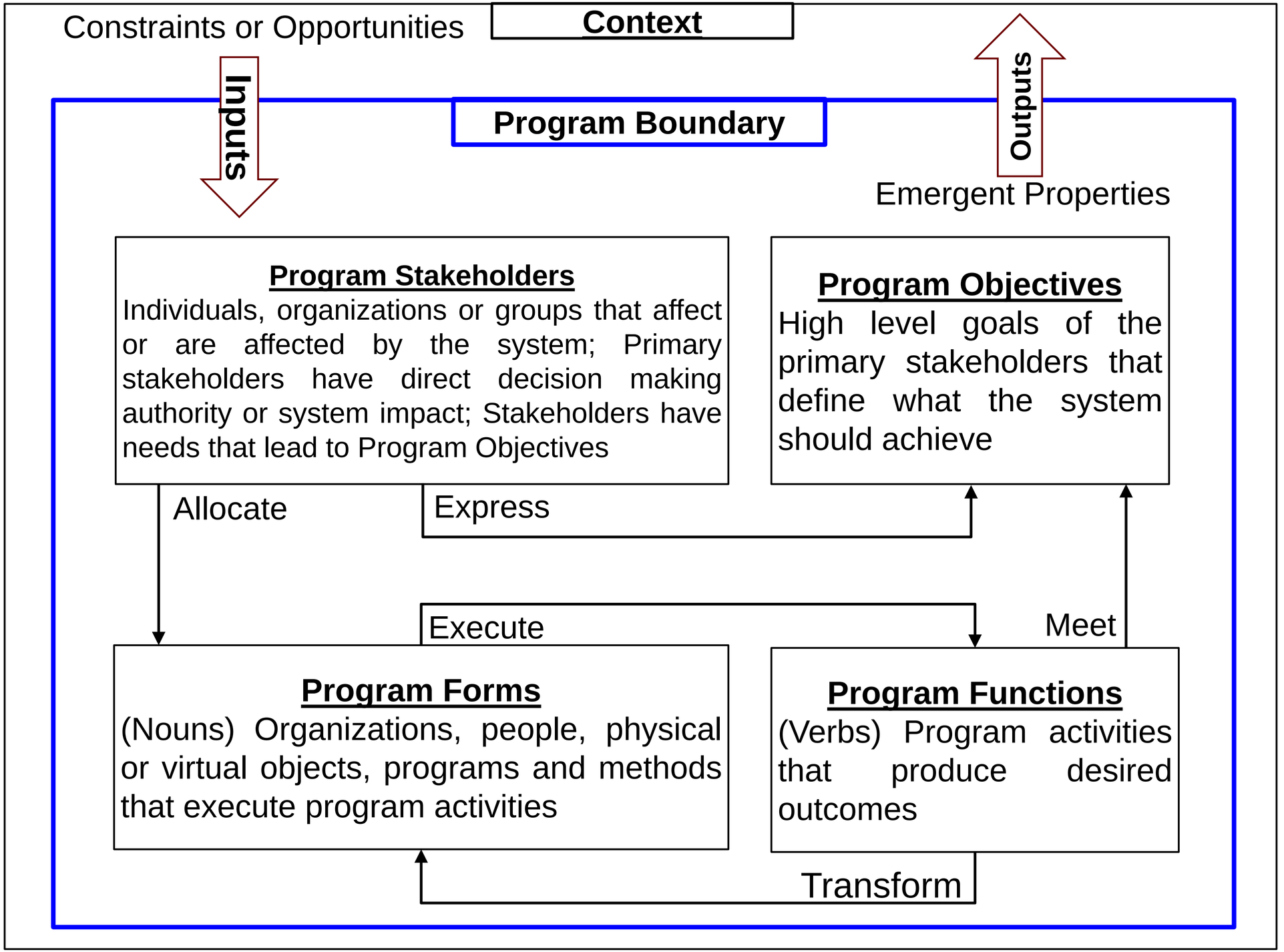
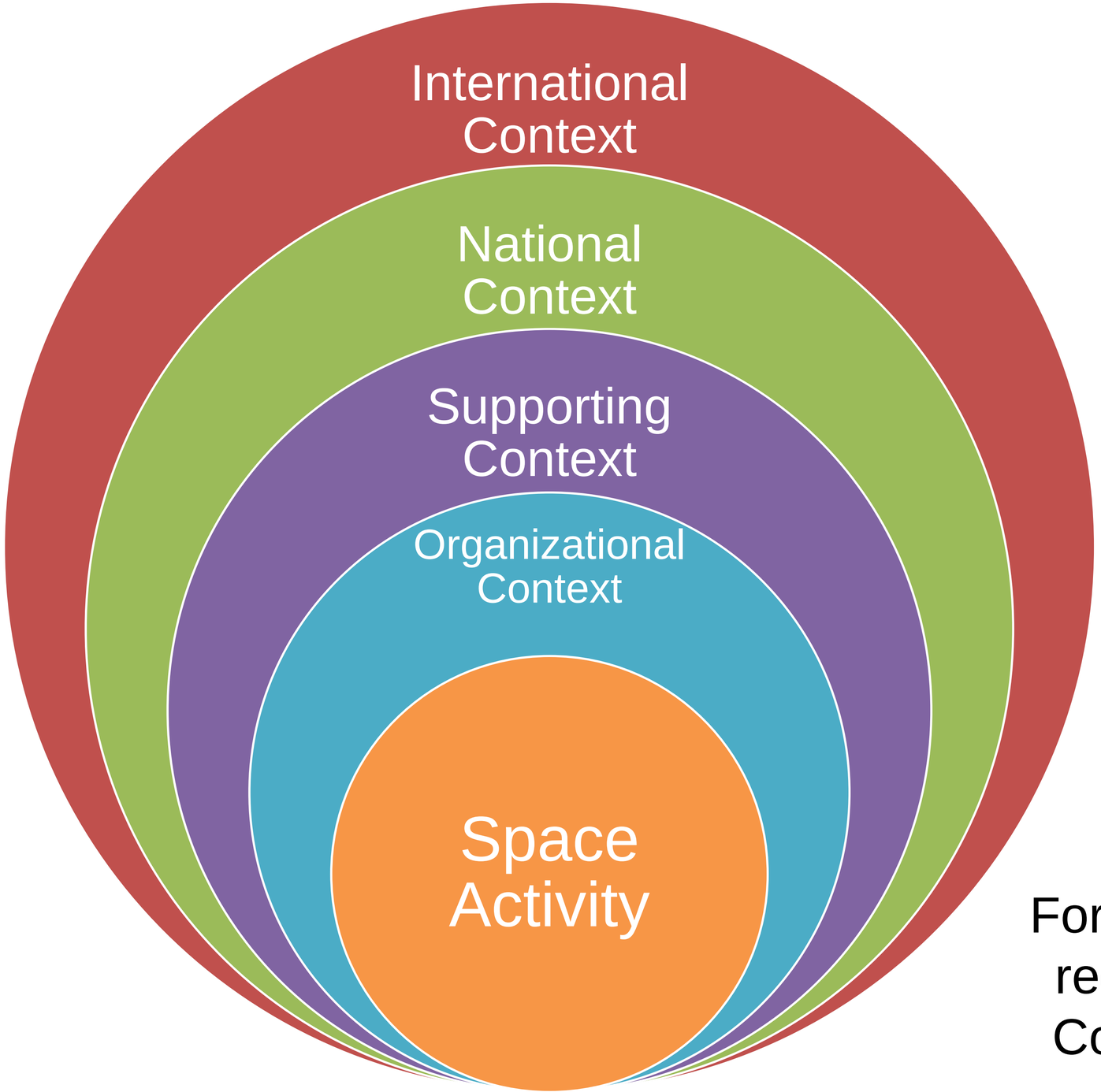

Constraints or Opportunities
Context
Inputs
Program Boundary
Outputs
Emergent Properties
Program Stakeholders
Individuals, organizations or groups that affect or are affected by the system; Primary stakeholders have direct decision making authority or system impact; Stakeholders have needs that lead to Program Objectives
Program Objectives
High level goals of the primary stakeholders that define what the system should achieve
Allocate
Express
Execute
Meet
Program Forms
(Nouns) Organizations, people, physical or virtual objects, programs and methods that execute program activities
Program Functions
(Verbs) Program activities that produce desired outcomes
Transform

Contextual Sectors	Narrow Contextual Levels	Broad Contextual Levels
Technology	What is your organization’s technological capability?	What is the state of the art of the technology?
	What are your innovative technologies?	What technology is available on the international market?
	What relevant technologies are you missing?	What opportunities to collaborate with international partners on technology development?
Organization	What experiences does the implementing organization have with space activities?	What is the operating model for each organization contributing to the satellite program?
Facilities	What facilities exist in the organization to support the space activity?	What facilities are available among partner organizations to support the program?
Regulation and Legislation	What regulation and laws within the country impact the execution of the space activity?	What international law, agreements and norms impact the execution of the program –especially in the areas of spectrum management, export control and liability?



Understanding Space Activity Context

For each level, consider factors regarding Technology, Policy, Collaboration and Economics

Analyze Stakeholders

Stakeholder Categories

- Primary Stakeholders: Making decisions to shape the system
- Secondary Stakeholders: Influencing decisions of Primary Stakeholders
- Tertiary Stakeholders: Beneficiaries of the System

Source: Wood and Wolf in Alonso Perez and Qedar, 2014

Identify Stakeholder Needs, Desired Outcomes and Objectives for the System

Stakeholder Need	• What problems or desires are stakeholders facing?
Desired Outcomes	• What do stakeholders want the world to be like in the future?
System Objectives	• What activities will a system do to contribute to the desired outcomes?

Example: Monitoring Risk of Malaria Epidemics to Inform Disease Control Strategies

Need

- *What problem are stakeholders facing?*
- Approx. 200 million malaria cases and 580,000 deaths in 2013, especially impacting less developed countries

Desired Outcomes

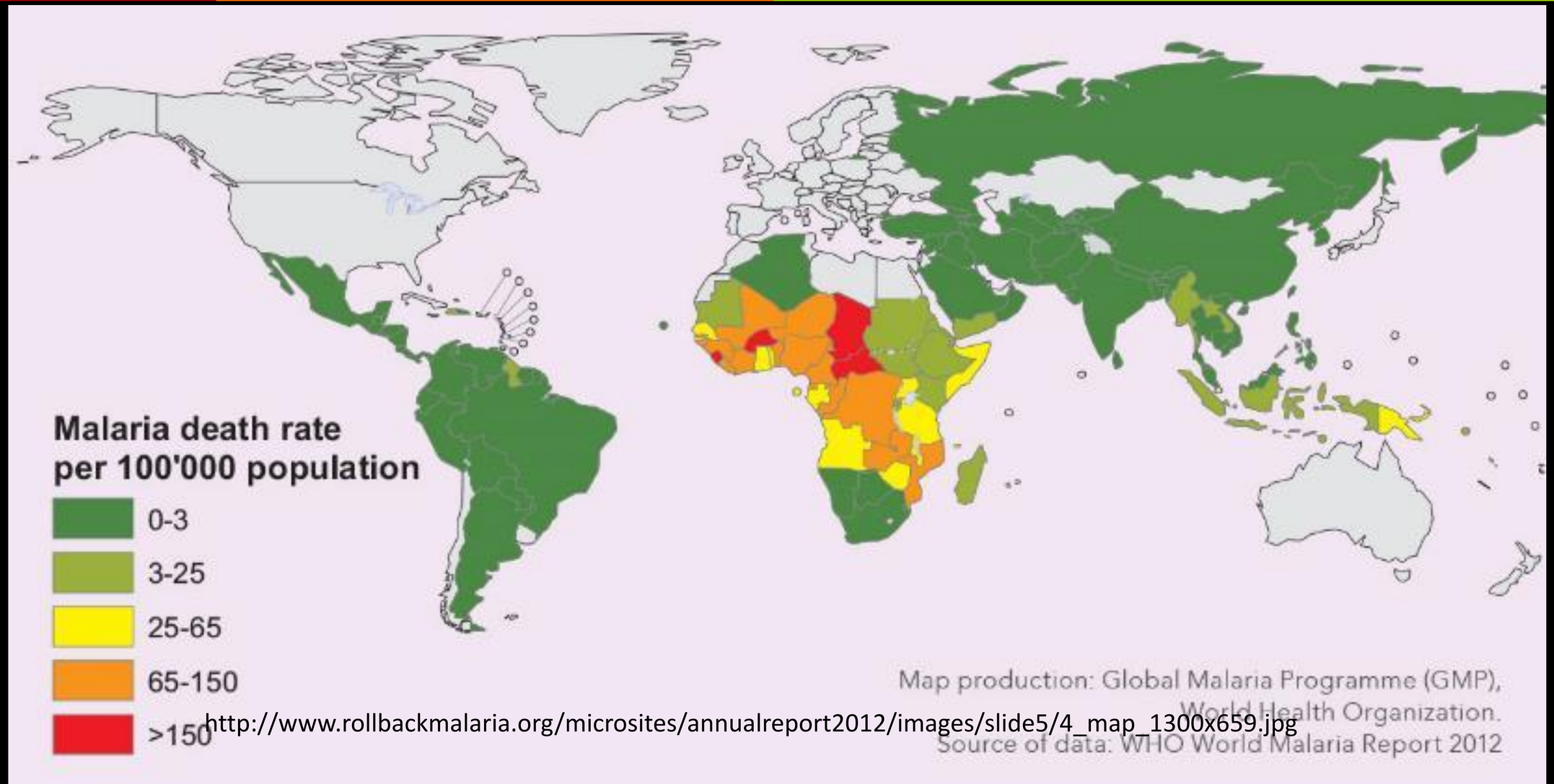
- *What do stakeholders want the world to be like in the future?*
- Reduce malaria deaths to near zero; reduce global malaria cases by 75% of 2000 levels

Objectives

- *What activities will a program do to contribute to the desired outcomes?*
- Apply data from satellites and other sources to inform malaria control strategies; create Malaria Early Warning System

3 GOOD HEALTH AND WELL-BEING

One of the targets of SDG 3 is to eliminate epidemics of malaria and other vector-bourne diseases



http://www.rollbackmalaria.org/microsites/annualreport2012/images/slide5/4_map_1300x659.jpg

Malaria Early Warning System Objectives

Acquire and Manage Data

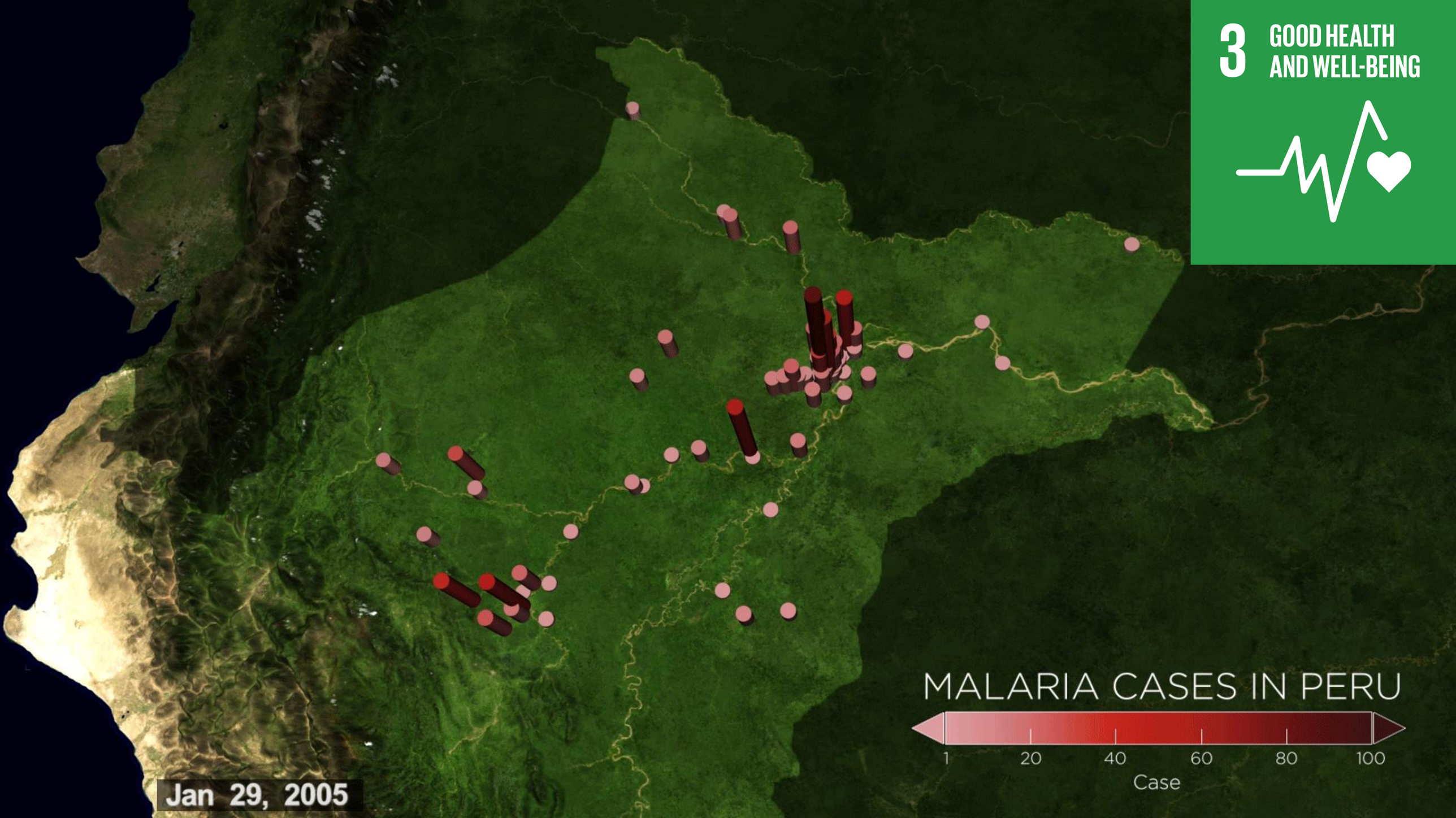
- Access census and health information
- Access weather and climate data from satellite, airborne and ground-based sensors
- Access Environmental information from satellite, airborne and ground-based sensors
- Maintain historical malaria prevalence data
- Monitor current malaria statistics

Develop Value-Added Products

- Derive hazard model from environmental and weather data
- Produce vulnerability model from census data and health information
- Run transmission model based on the life-cycle of malaria parasite and vector
- Forecast which regions will be most vulnerable to a malaria outbreak based on model above

Respond to Threat

- Treat malaria-infected patients
- Coordinate response
- Notify regional and local leaders
- Move supplies to local health facilities
- Educate local population
- Execute indoor residual spraying campaign
- Distribute bed nets
- Identify and document malaria cases
- Manage migration of people from high transmission areas


3 GOOD HEALTH AND WELL-BEING
MALARIA CASES IN PERU
1
20
40
60
80
100
Case
Jan 29, 2005

Space Systems Capacity Coordination

Propose methods to use software-base modeling to inform design of coordination of space systems

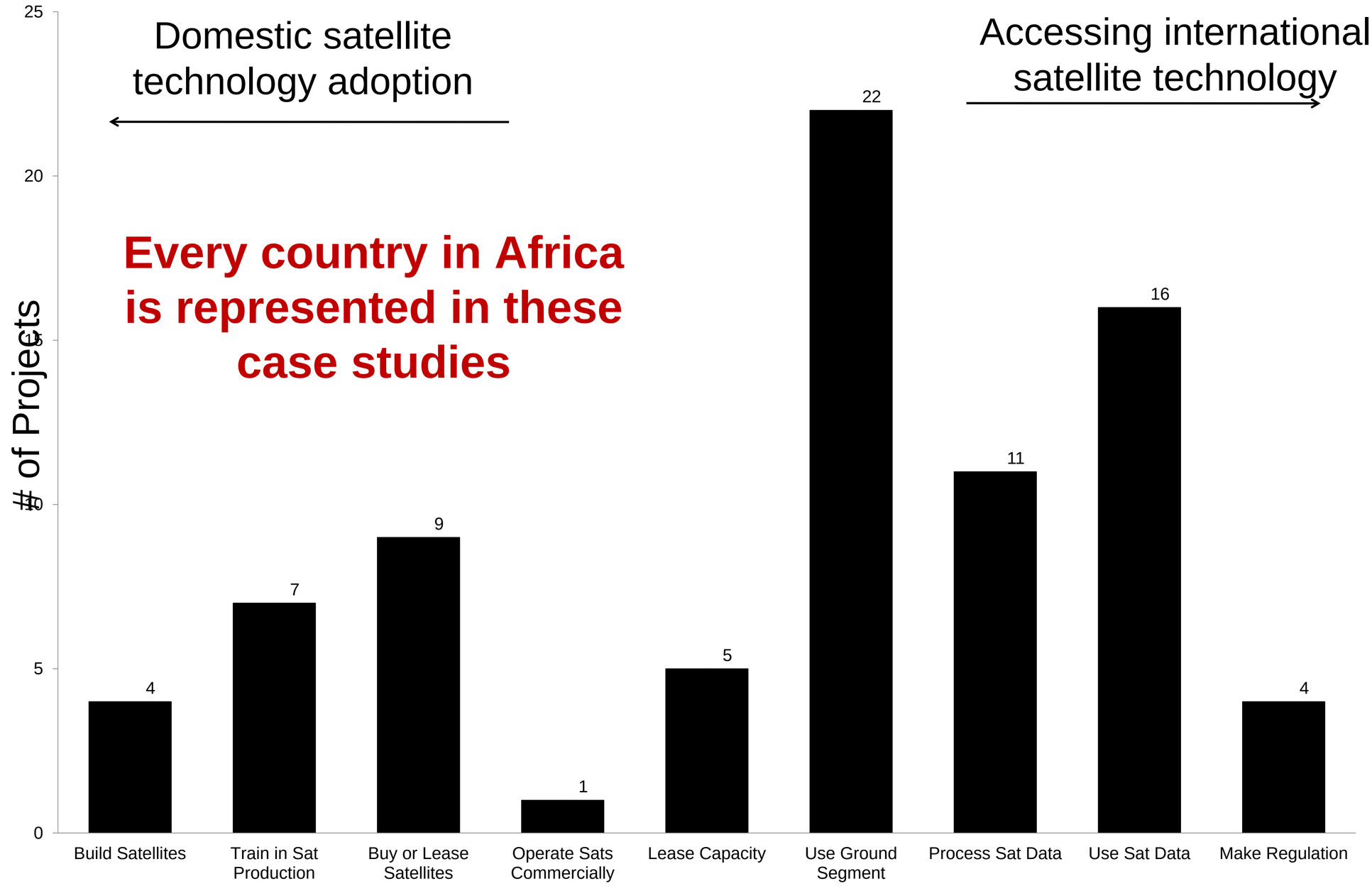
Tools for design and engineering of space systems can be used to inform coordination of space systems for development

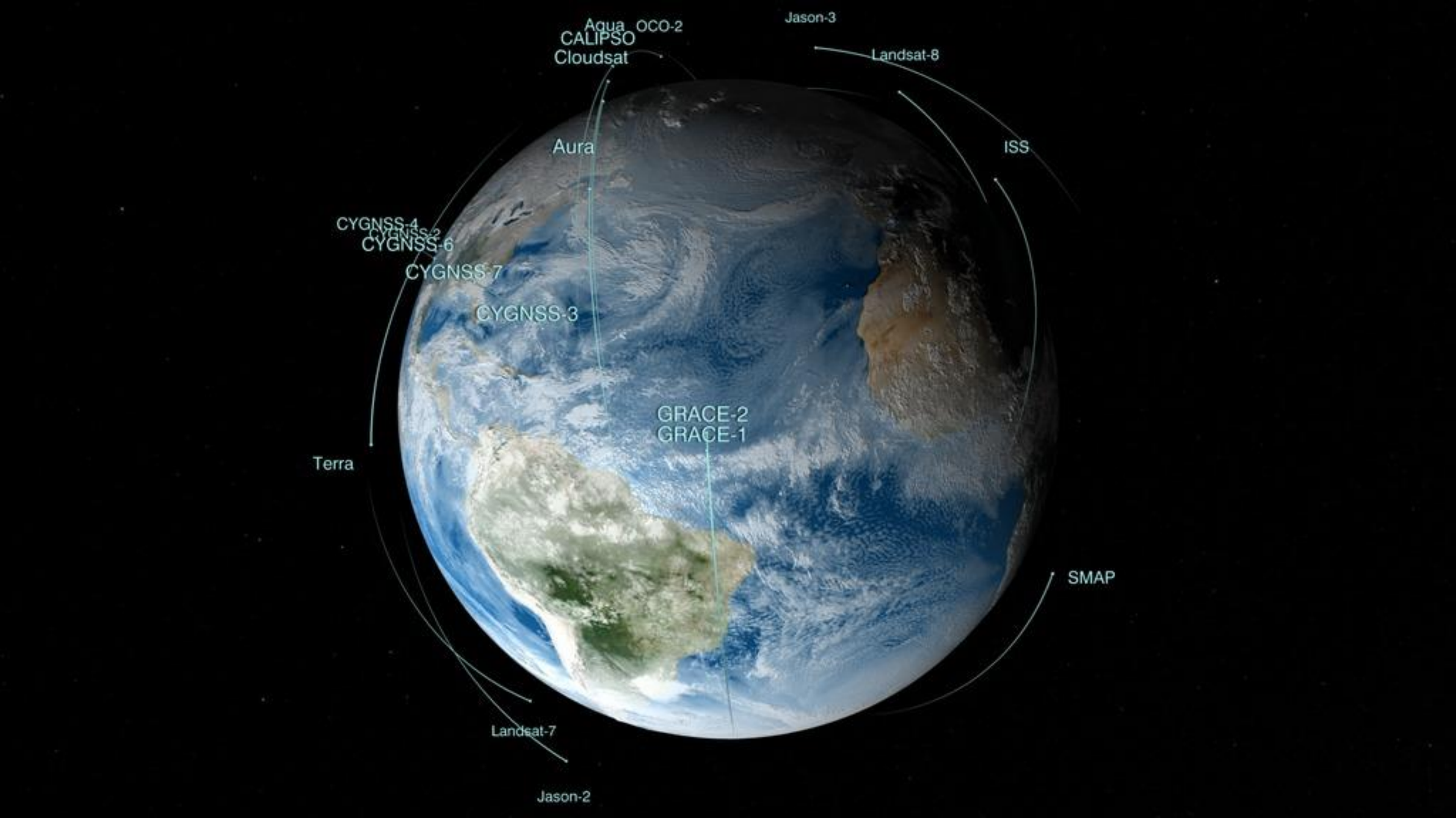
NASA Goddard: https://idc.nasa.gov/idc/index.php
Aerospace Corporation: http://aerospace.wpengine.netdna-cdn.com/wp-content/uploads/2013/09/Min-Concept-Design-Center-300-px.jpg
Jet Propulsion Laboratory: http://jpltreamx.jpl.nasa.gov/

Access to Space Assets

- Perform studies and assessments identifying barriers to access and examples of effective projects
- Perform pilot projects demonstrating best practices

Satellite-enabled Activity in Africa uses domestic and international satellite technology (79 Case Studies)




Aqua
OCO-2
CALIPSO
Cloudsat
Jason-3
Landsat-8
Aura
ISS
CYGNSS-4
CYGNSS-2
CYGNSS-6
CYGNSS-7
CYGNSS-3
GRACE-2
GRACE-1
Terra
SMAP
Landsat-7
Jason-2

1. Earth Observation (EO) System Design and Implementation
2. EO System Operation, Data Retrieval, Calibration & Validation
3. EO Data Correction and Processing
4. Earth Science Modeling and Assimilation of Earth Observations
5. EO Data Discovery & Visualization: Providing interface to find and explore data
6. EO Data Transformation: Creating data interface based on user needs
7. Knowledge Integration: Combining physical, social, economic and other data
8. Decision Support: Providing recommendations for action

Barriers limit the application of space-enabled technology for SDGs

Satellite Engineering	Traditional satellite engineering builds large, highly reliable, long-lasting satellites
Satellite Earth Observation	Overwhelming amounts of free data are available, difficult to find and apply
Satellite Communication	Traditional business models lead to high prices that exclude low-income users
Space Launch	Launch opportunities have traditionally been expensive and limited to certain orbits
Microgravity Research	Access has been expensive; research has focused on low maturity technology
Space Spinoffs	Spinoff opportunities are found through unplanned connections

Future opportunities for application of space-enabled technology for SDGs

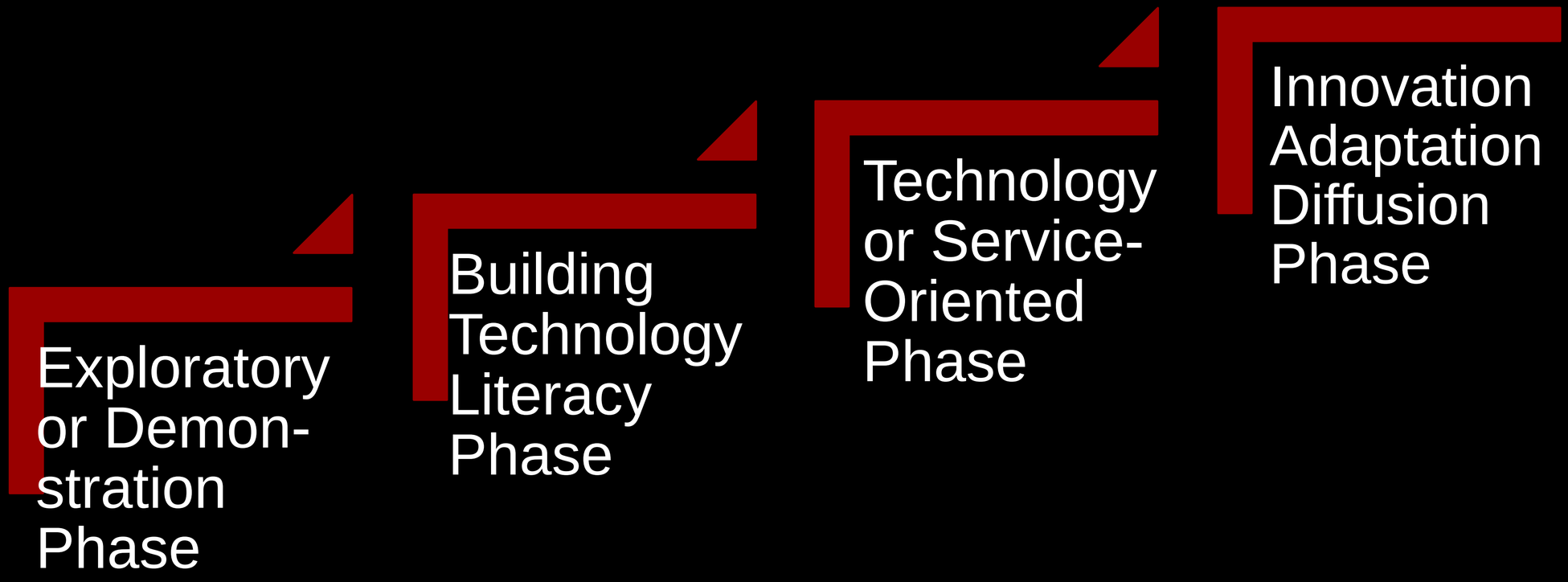
Satellite Engineering	New satellite engineering methods will reduce debris, reduce cost and provide new operational models
Earth Observation	Commercial market will form to apply machine learning, cloud computing and visualization to infuse satellite earth observation data into decision support systems
Satellite Communication	New communication constellations propose to reduce price and target low-income market
Space Launch	Launch prices are decreasing, new commercial launch players are emerging and new launch vehicles will focus on small satellites
Microgravity Research	Private and government entities will offer routine access to earth orbit and other microgravity environment
Space Spinoffs	Spinoffs will increase as the space industry engages more with other industries

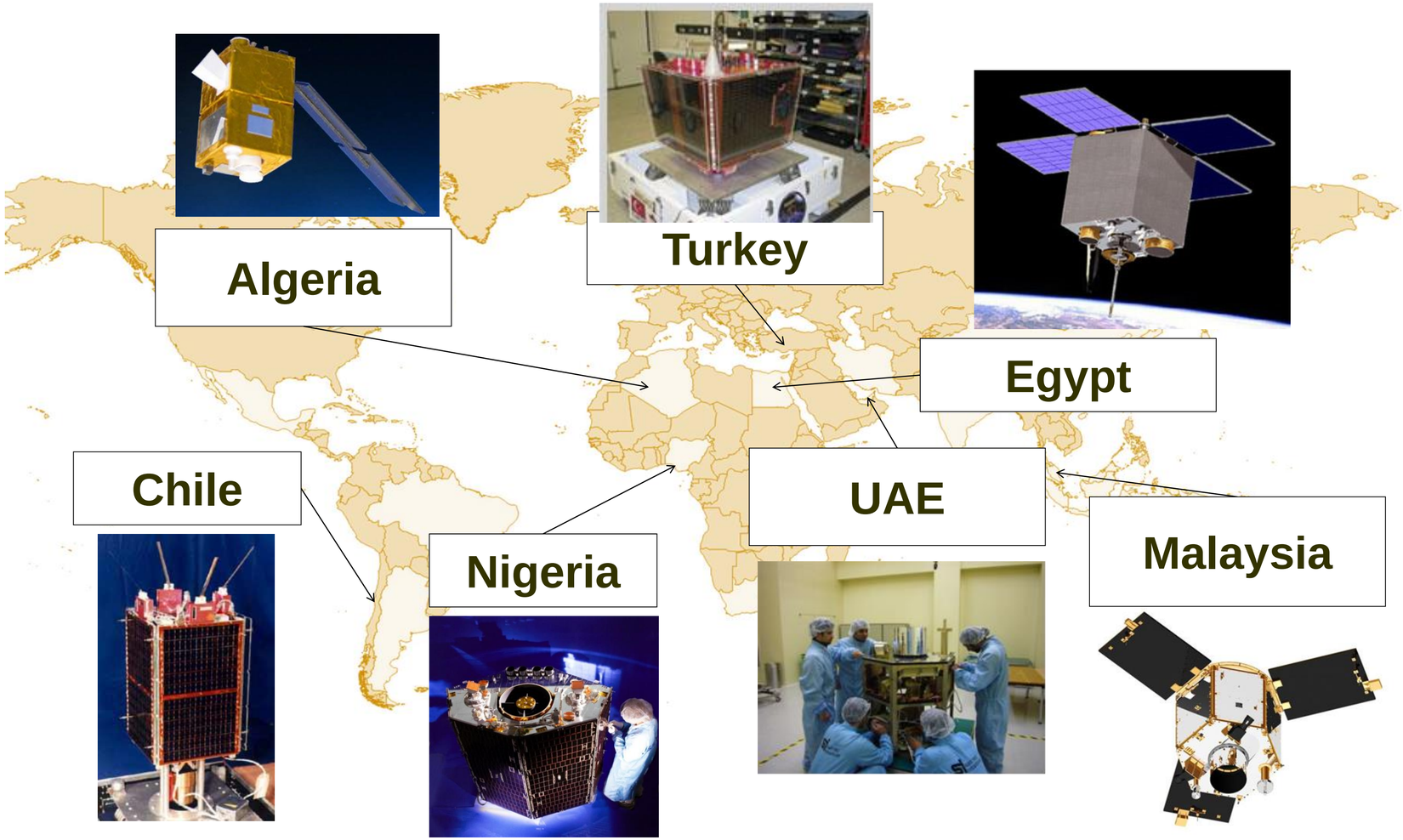
Capacity Building

- Host capability building programs, international research collaboration and personnel exchange
- Study and evaluate capacity building outcomes

Learning	Individual	Group	Institutional	Programmatic
Short Term	Individuals learning new knowledge and skills	Individuals converting tacit knowledge to explicit knowledge	Achieving new institutional milestones	Observing progress toward goals; making changes to ensure progress
Long Term	Individuals increasing autonomy in executing tasks	Individuals learning to leverage the contributions of group members	Communicating knowledge across organizational units	Observing both goals and progress toward goals; changing goals as needed

Space Activity Learning Lifecycle




Algeria
Turkey
Egypt
Chile
Nigeria
UAE
Malaysia

South Africa

Kenya

Thailand

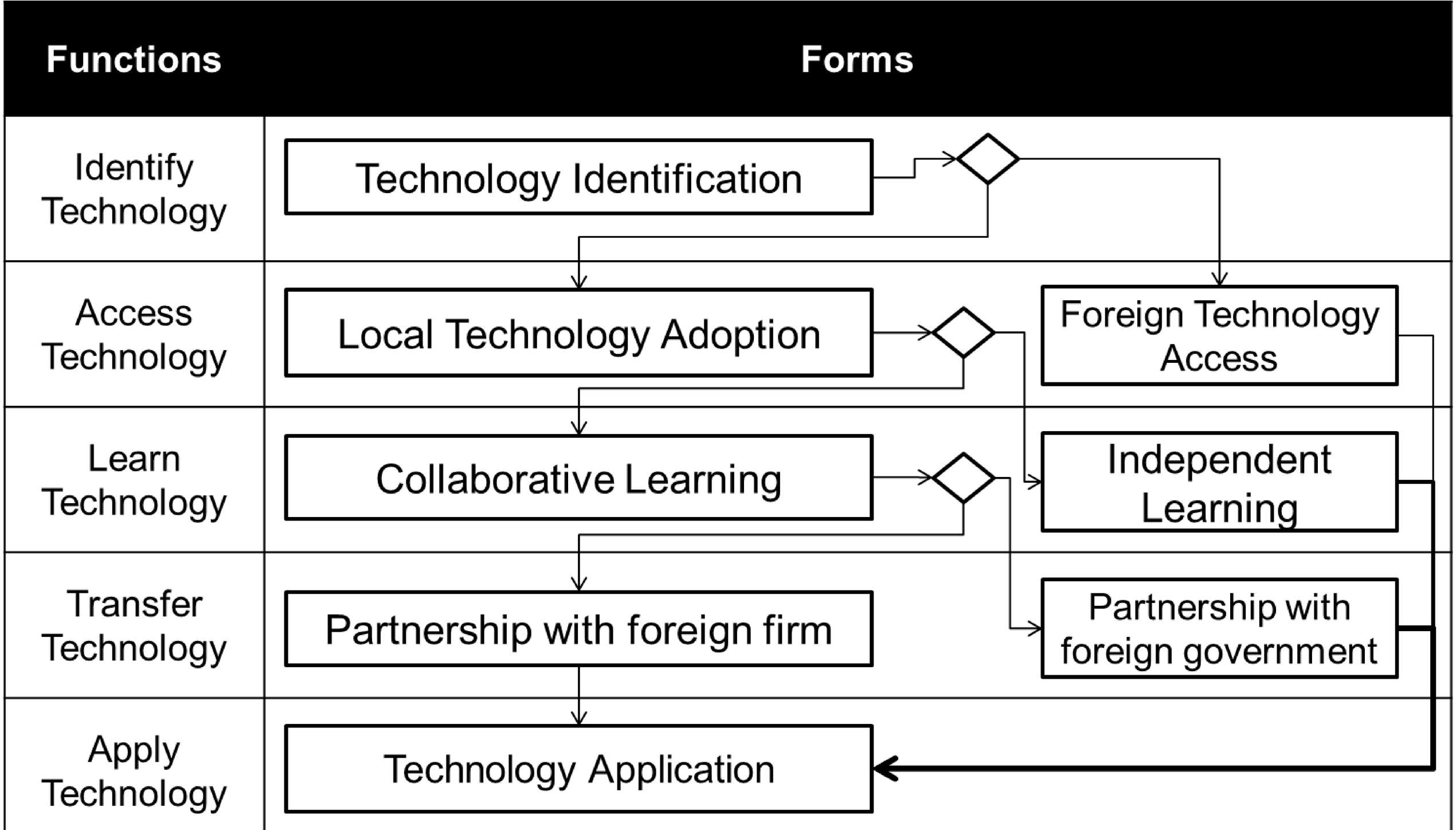
Nigeria


TELEMEDICINE PROJECT IN NIGERIA:
A DIGITAL BRIDGE
IN HEALTHCARE DELIVERY

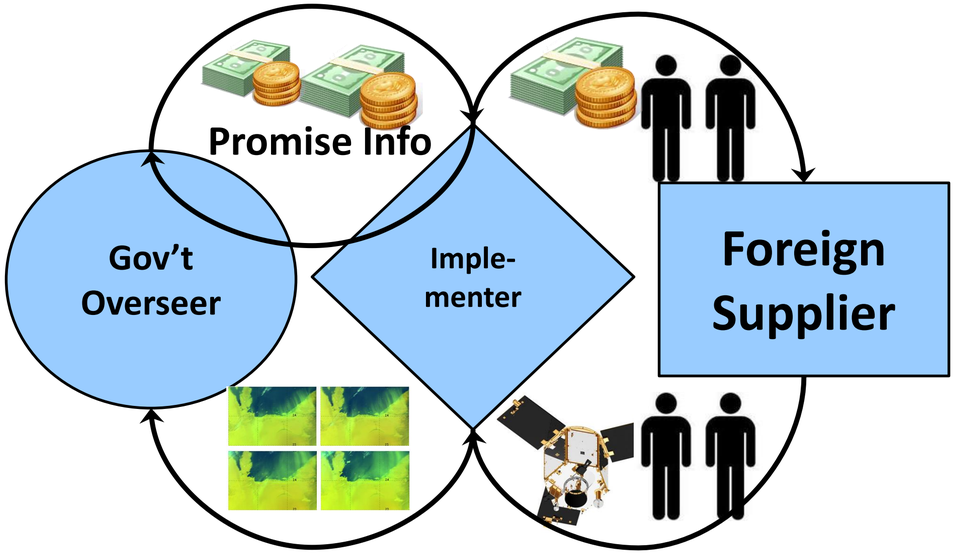
United Arab Emirates

Singapore

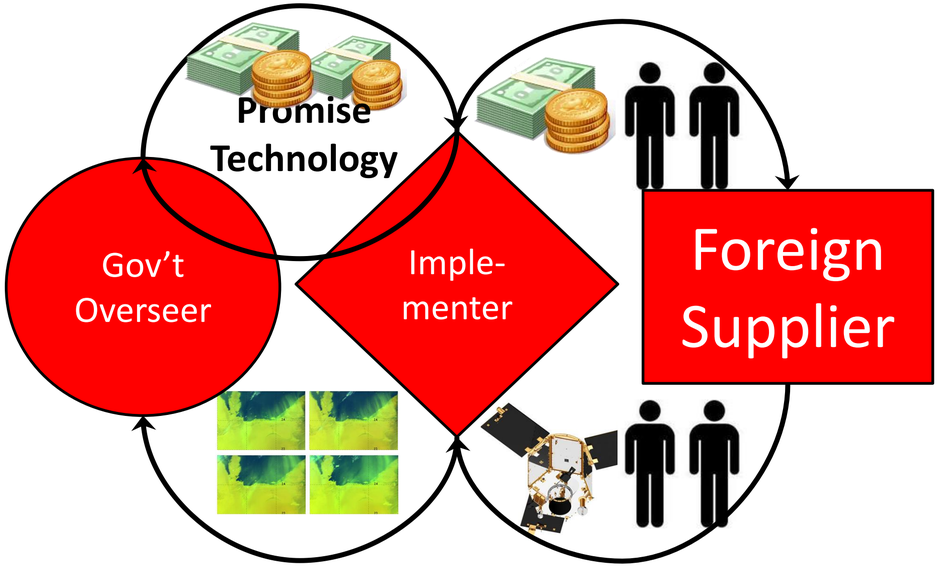

SCHOOL OF
EEE
http://www.sarc.eee.ntu.edu.sg
SaRC
Satellite Research Centre
Tap or Scan
Step 1
Download
QR Reader
Step 2
Tap or Scan
to watch video
X-SAT
Micro-satellite


Functions
Forms
Identify Technology
Technology Identification
Access Technology
Local Technology Adoption
Foreign Technology Access
Learn Technology
Collaborative Learning
Independent Learning
Transfer Technology
Partnership with foreign firm
Partnership with foreign government
Apply Technology
Technology Application

"Service-Oriented" Program



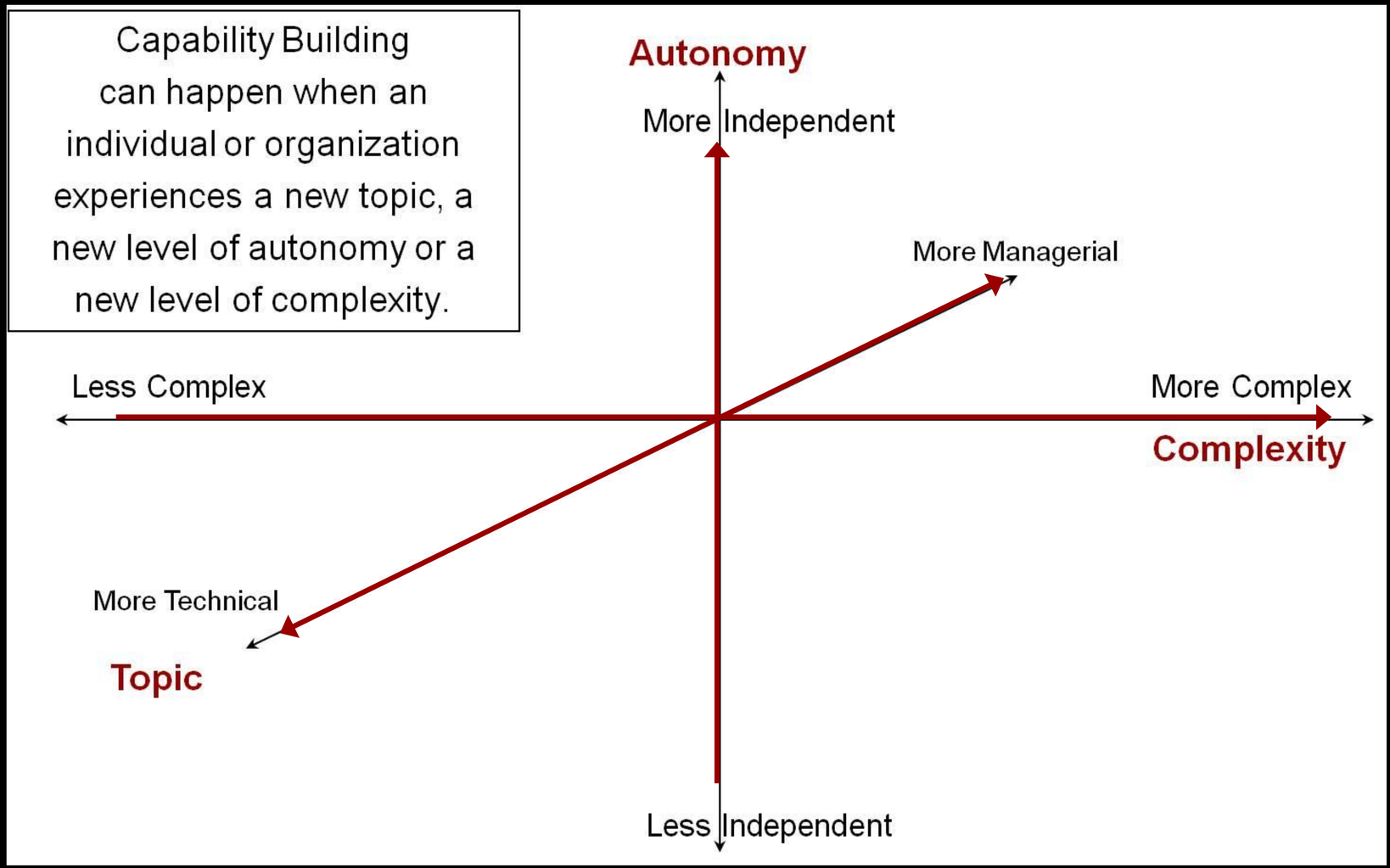
"Technology-Oriented" Program



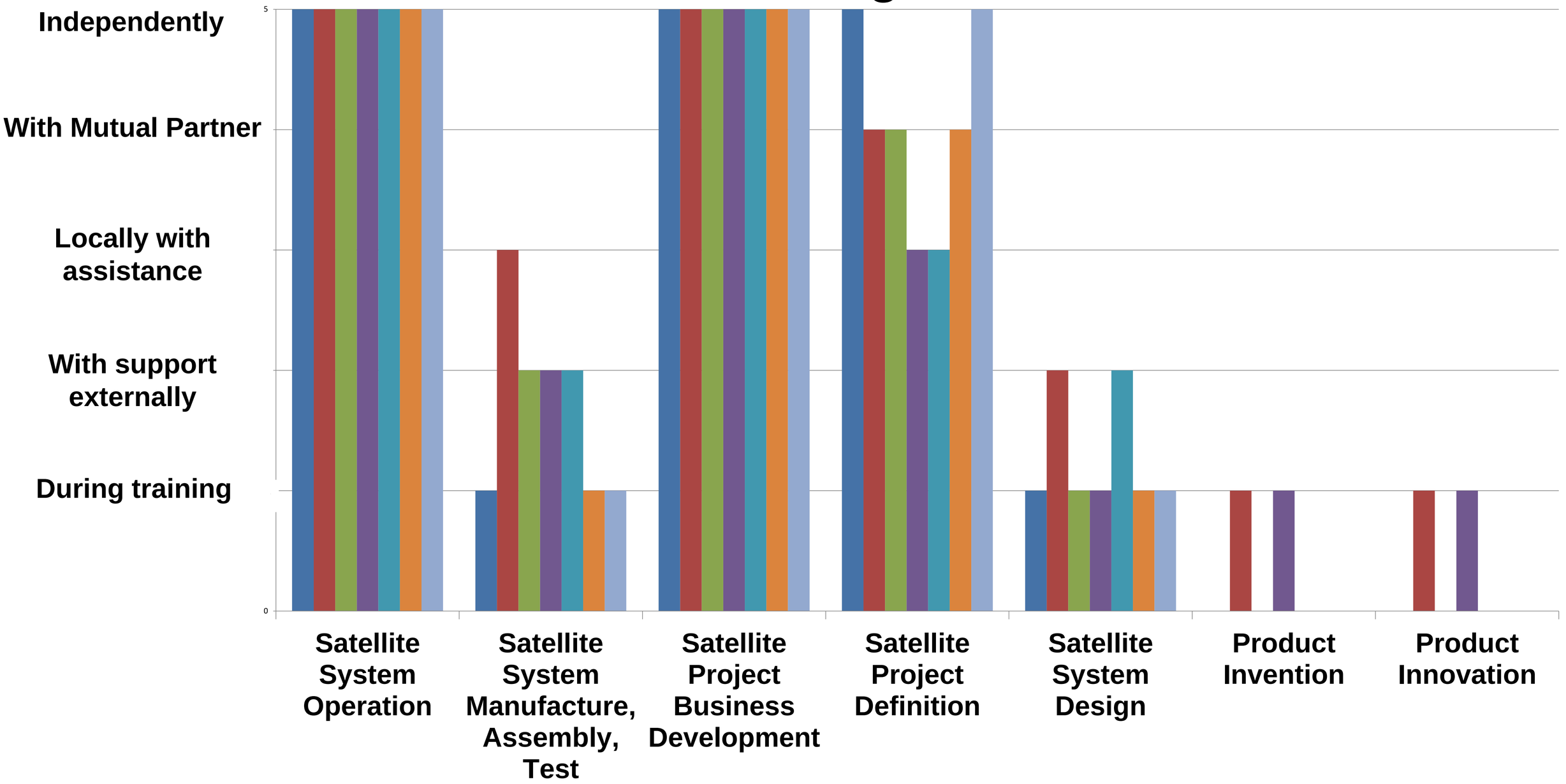
Functions	Service Oriented Attributes	Technology Oriented Attributes
Fundraising	Seek funding support formally through providing service	Seek funding support formally through providing new technology achievement
Supplier	Selected based on formal **process** that is acceptable to funders	Selected based on **trust** and common objectives
Satellite	**High** complexity and performance	**New** feature or performance
Training	Emphasizes **theory** and **formal mentoring**	Emphasizes **on the job** responsibility and **mentoring as needed** for the project goals

Defining capability building

Capability Building can happen when an individual or organization experiences a new topic, a new level of autonomy or a new level of complexity.



Evaluating Technical Achievements of Space Capability Building



What Individual Capabilities Do We Want to Build?

Satellite Engineering Skills
Overall Project Skills: Project Definition Requirements Management Software Tools Overall Design skills Procurement, Manufacture, Assembly, Integration &Testing Management & Documentation Launch & Operations Space Systems Engineering
Subsystem Specialties: Mission Orbit Design Ground Station Design Communication systems Structural and thermal Attitude control and determination systems Electrical power system On-board computer

Academic Research Skills
Identify Topic and Motivation
Identify Literature Gap
Define Research Question
Define Research Methodology
Define Data Sources and Analysis Method
Collect Data; Develop Simulation or Model
Analyze Data
Interpret Findings
Answer Research Question
Present Research

Wood, D., Polansky, J., Cho, M., “University Partnerships As A Model For Capability Building In Emerging Space Nations,” *International Astronautical Congress,* Jerusalem, Israel, October 2015.

Capability Building Evaluation: Technical Learning Outcomes in Academic Research Project

Independent Implementation

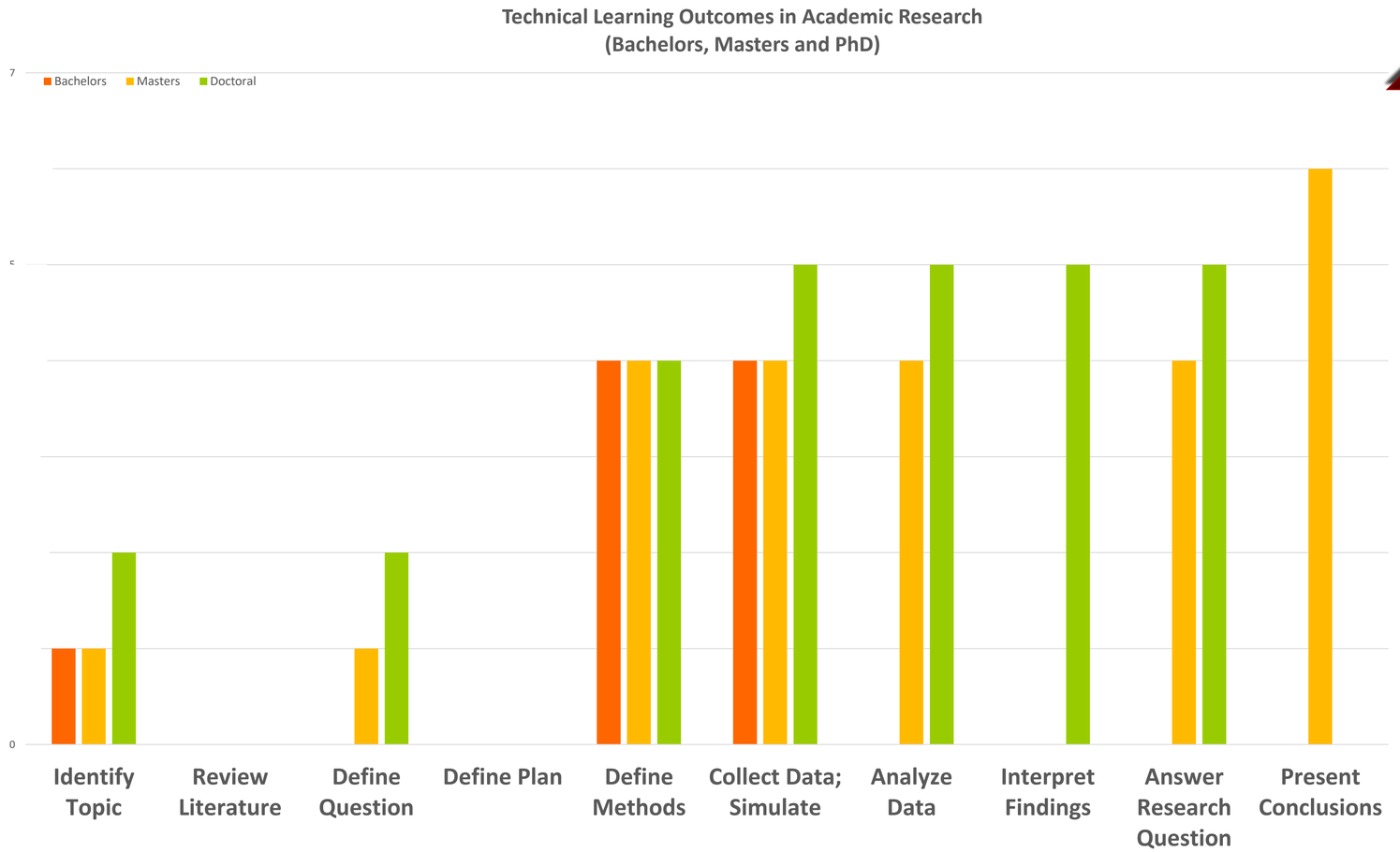
Supervised On the Job Experience

Practical Training

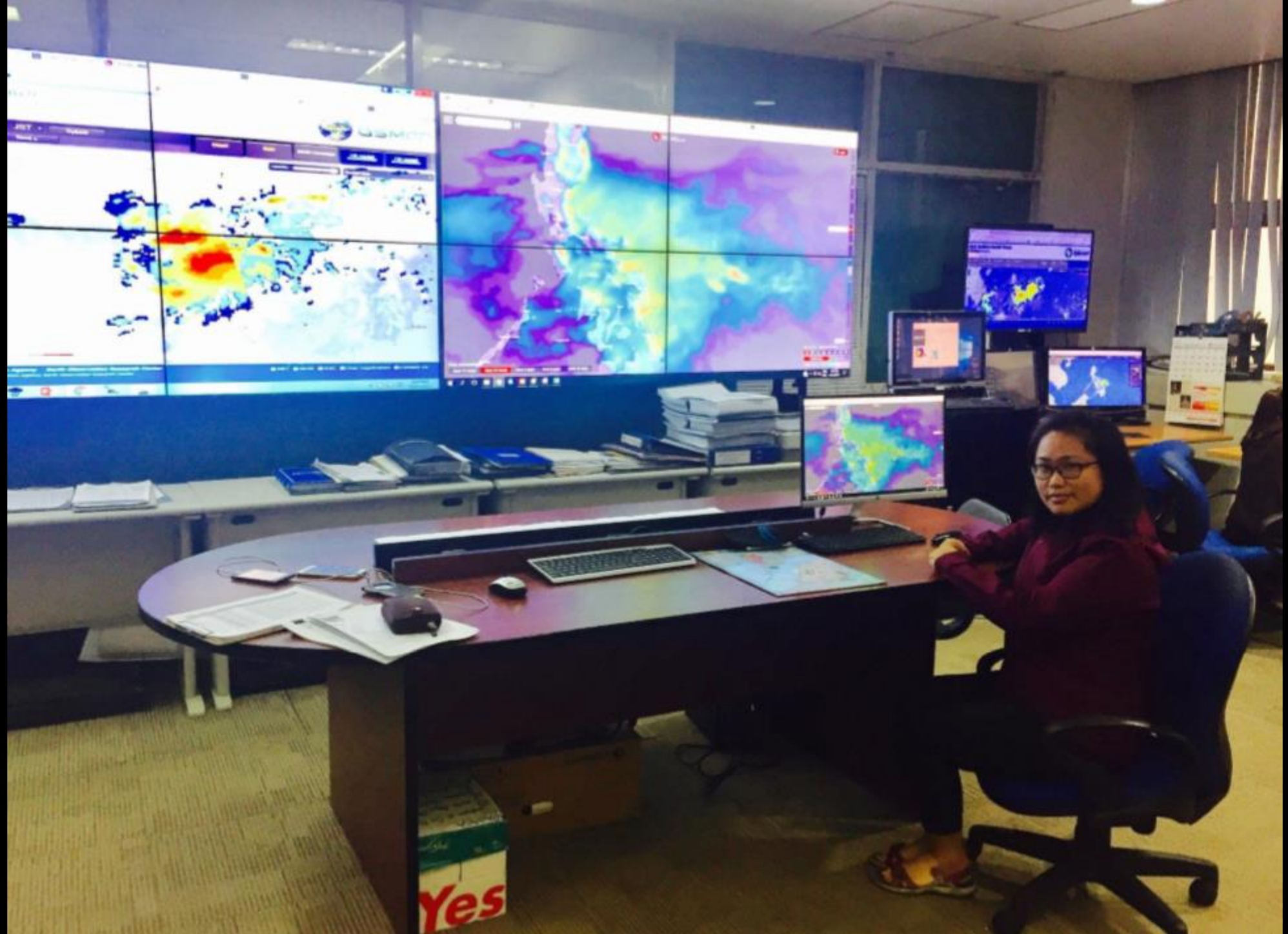
Related Practical Experience

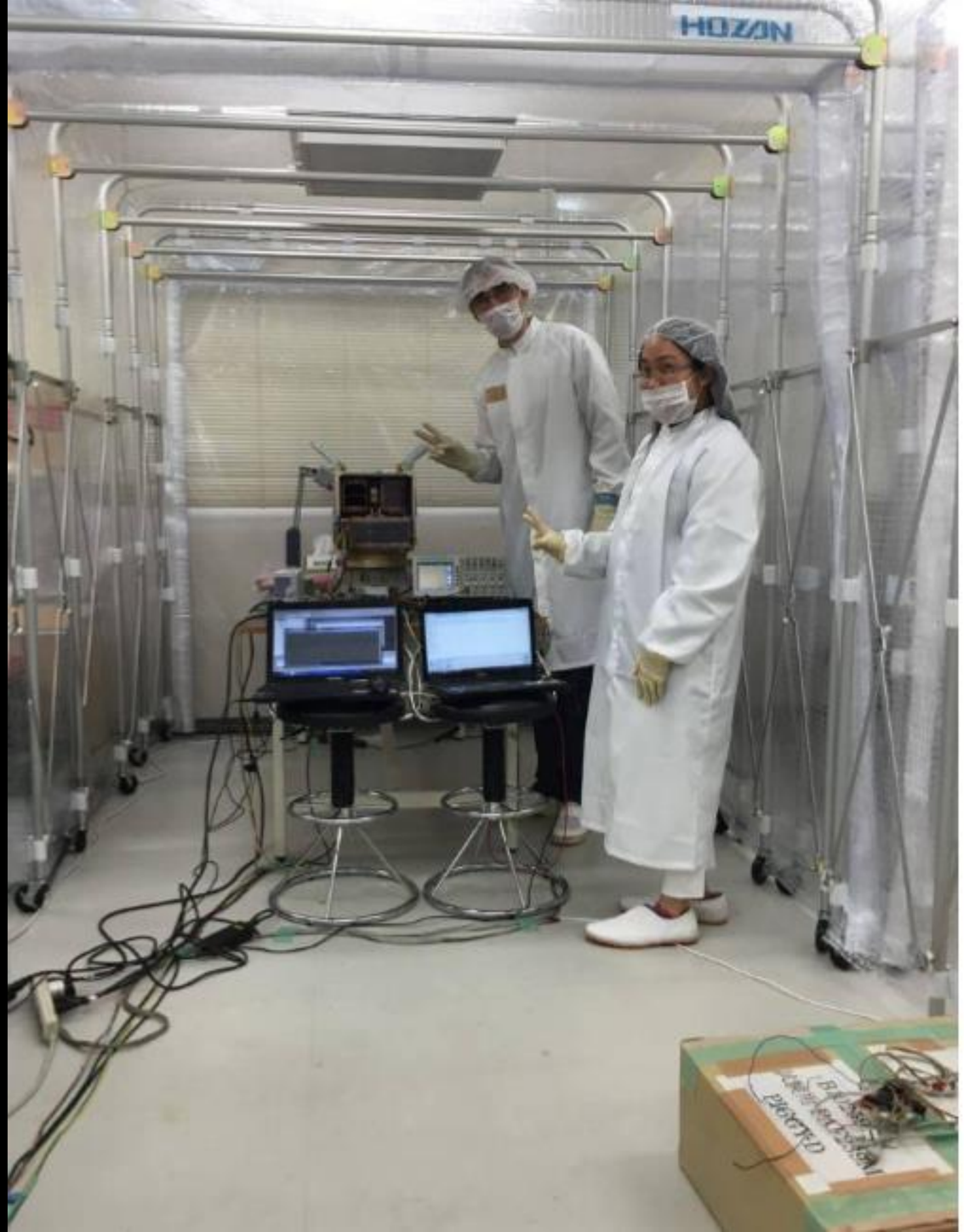
Theoretical Training

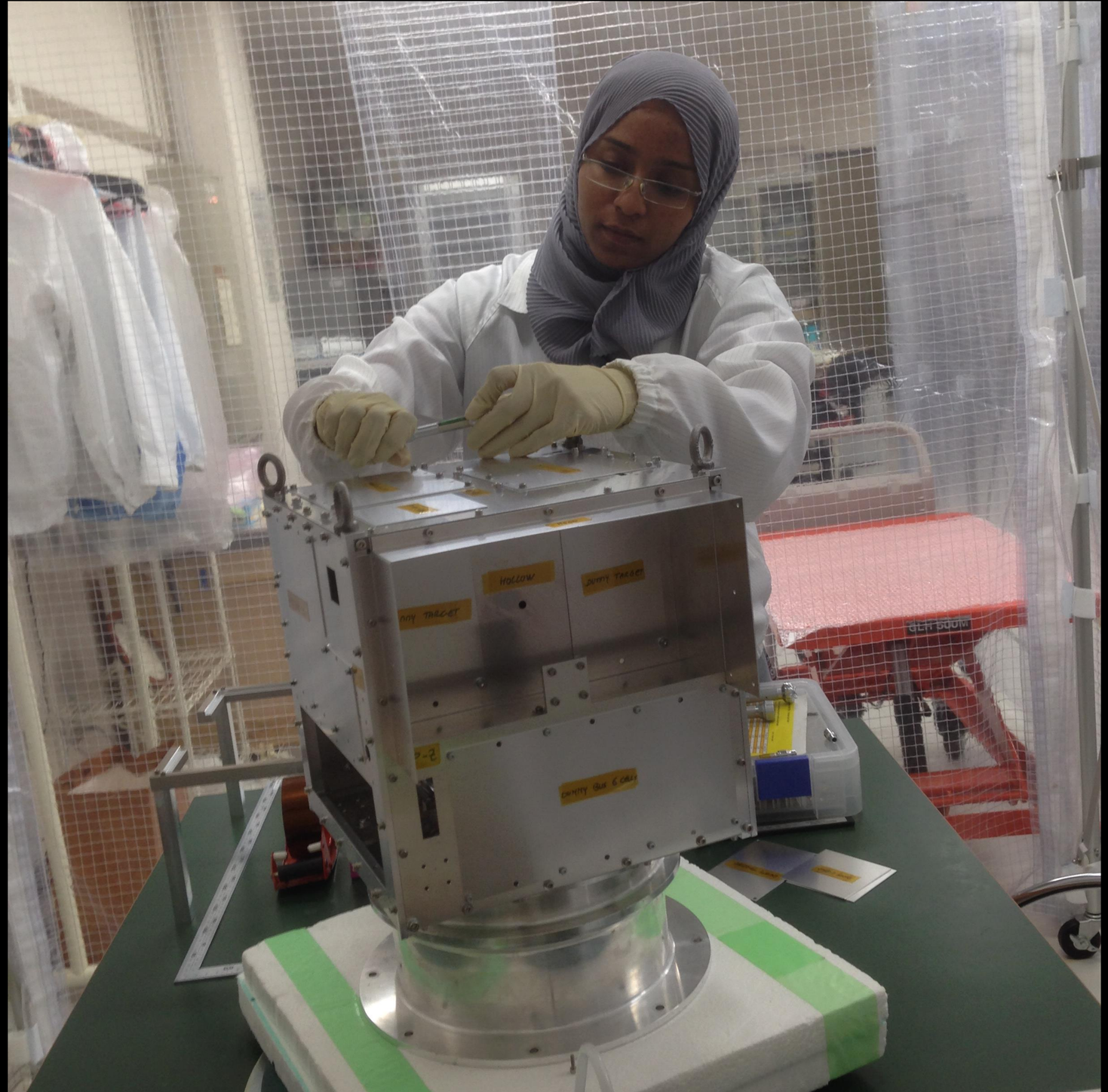
Related Theoretical Training

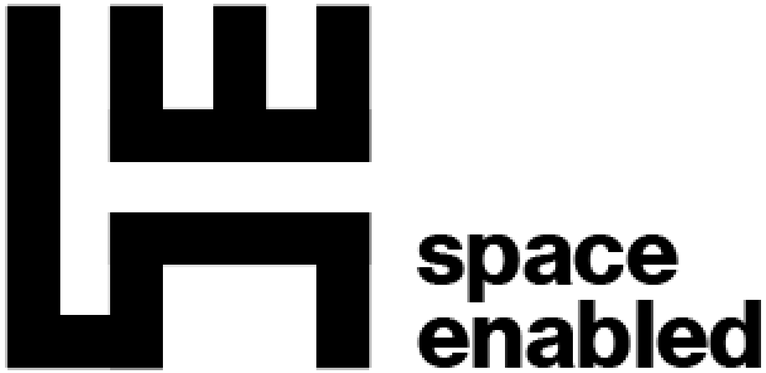


Application and Autonomy


Yes


HOZAN


HOLLOW
DUMMY TARGET
GEM BOOM



- **The MIT Media Lab stands ready to collaborate with UNOOSA and the Global Space Partnership for SDGs to support application of space for sustainable development.**
- **The MIT Media Lab is be eager to join and play a leadership role in a network of universities supporting capability building, accessibility and innovation**