“Building Technological Capability within Satellite Programs in Developing Countries”

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Presentation Overview

- **Introduction**
  - Biography: Journey to Multidisciplinary Research
- **Satellite-enabled Information Services**
  - Opportunities and Challenges for Developing Countries
- **Building Local Capability**
  - Opportunities and Challenges for International Technology Partnerships
- **Conclusions**
  - Future Research Directions

Introduction:

Multidisciplinary Research within MIT's Engineering Systems Division

Biography

- Massachusetts Institute of Technology
  - 2000 to 2005: Bachelor of Science, Aerospace Engineering

Three Time Summer Volunteer in Kenya

Biography

- Massachusetts Institute of Technology
  - 2000 to 2005: Bachelor of Science, Aerospace Engineering

NASA Academy Intern and Staff

Goddard Space Flight Center

Biography

- Massachusetts Institute of Technology
  - 2005 to 2008: Dual Master of Science, Aerospace Engineering & Technology Policy

Volunteer Teacher in South Africa

Biography

- Massachusetts Institute of Technology
  - 2005 to 2008: Dual Master of Science, Aerospace Engineering & Technology Policy

Chosen as NASA Jenkins Pre-Doctoral Fellow

2006 JPFP Fellows Directory

Contact Information
dradams@mit.edu

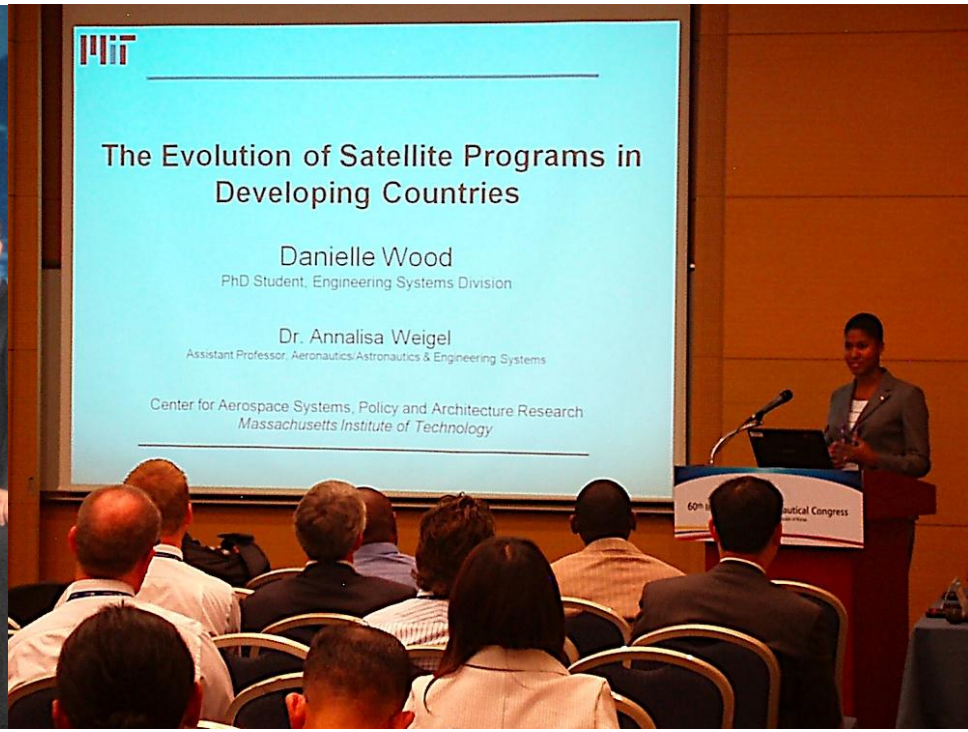
Current Degrees Sought
M.S., Aeronautics and Astronautics
M.S., Technology and Policy
Massachusetts Institute of Technology

Hometown
Orlando, FL

Biography

- Massachusetts Institute of Technology
  - 2008 to 2011: Doctoral Candidate, Engineering Systems

Chosen as NASA Student Ambassador

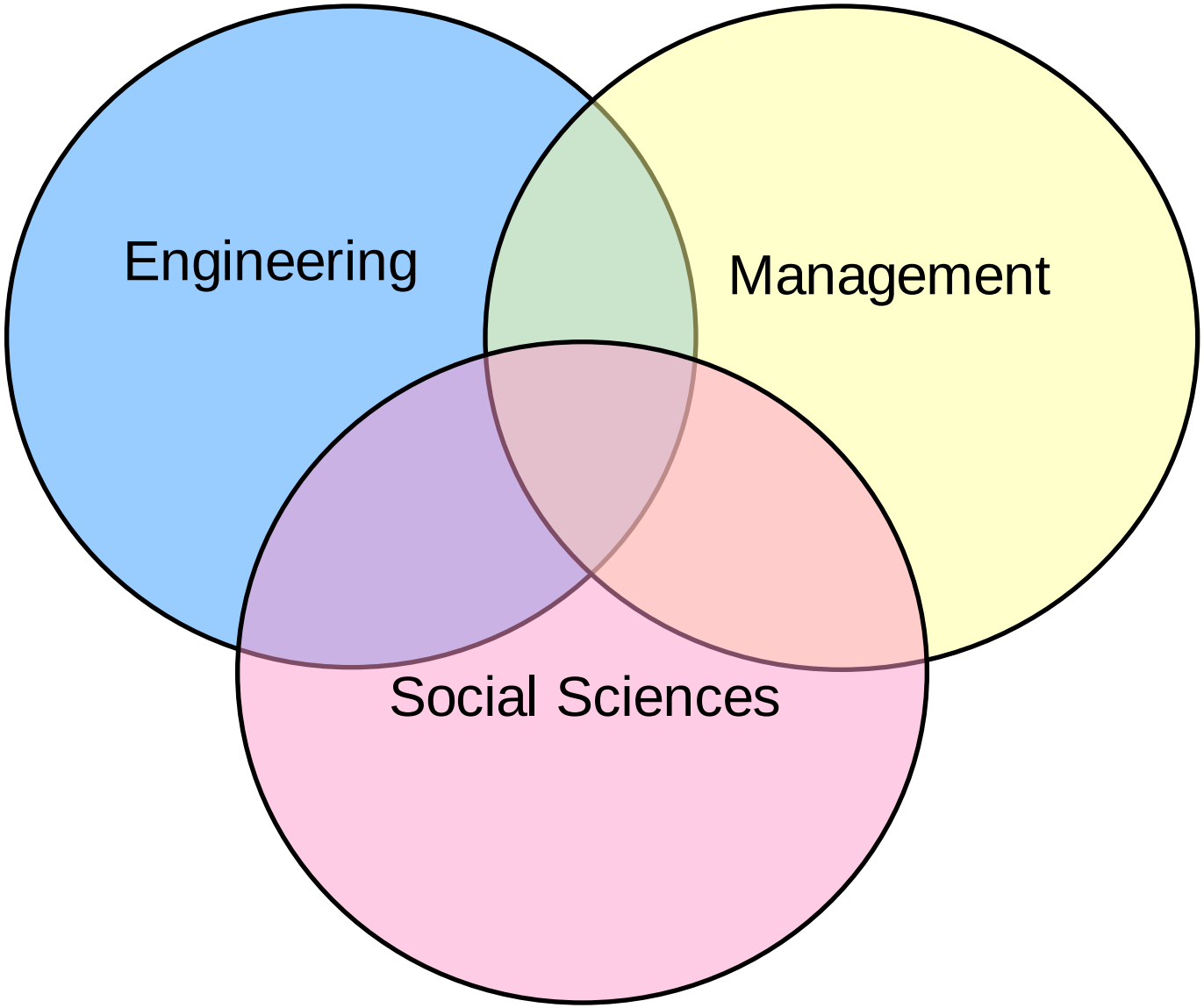


Biography

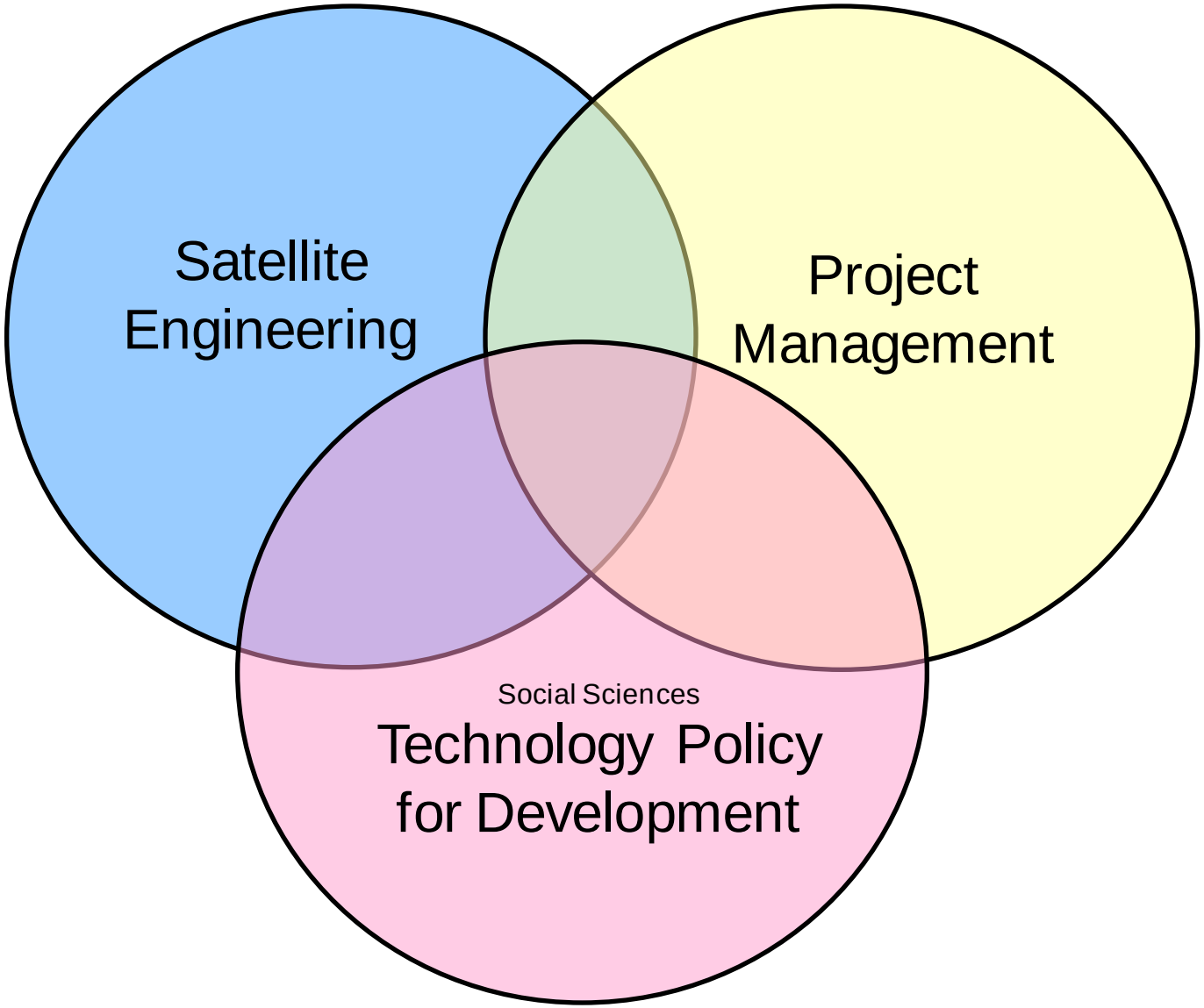
- Massachusetts Institute of Technology
  - 2008 to 2011: Doctoral Candidate, Engineering Systems

Pursuing Opportunities for Outreach

MIT's Engineering Systems Division (ESD)



This Work as an ESD Project



Key Messages

- Satellite-enabled information services provide valuable opportunities to developing countries, but…
  - Many challenges threaten their effectiveness.

- Many developing countries pursue international partnerships as part of their process of building local technological capability, but…
  - Such partnerships are also opportunities fraught with challenges.

- Both of these areas are ripe for multi-disciplinary research.

Satellite-Enabled Information Services:

Opportunities and Challenges for Developing Countries

- Satellite Remote Sensing
- Communication
- Navigation

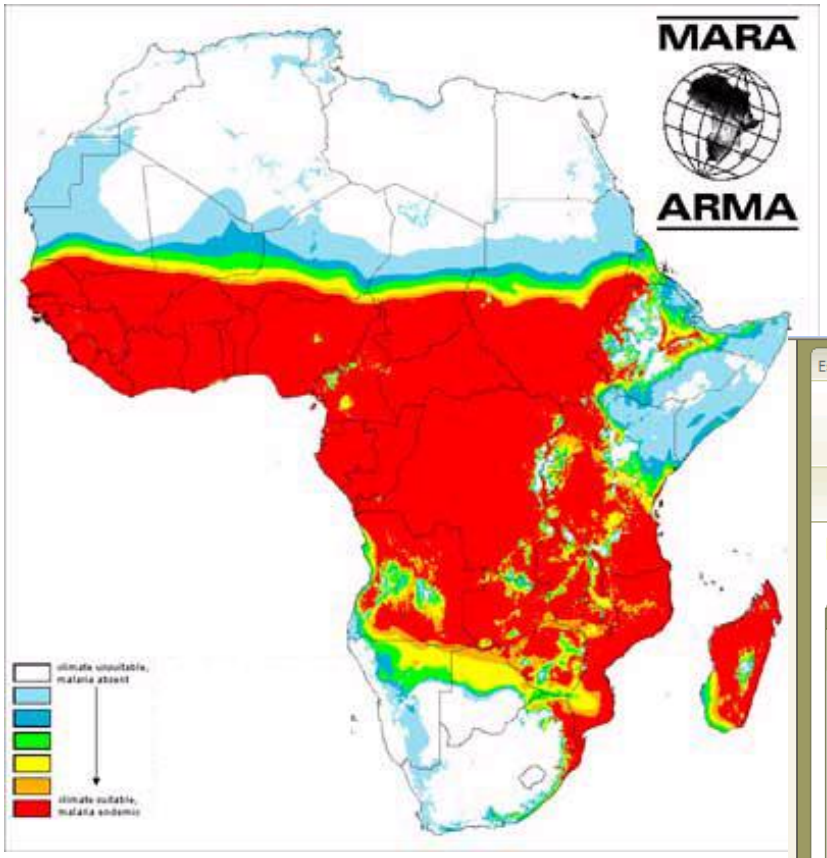
Satellite Services Impact Every Country

- Satellite services are ubiquitous, especially remote sensing, communication and navigation

- Countries can widely access space services without owning domestic satellites
  - Australia
  - Kenya

- Many developing countries have established processes to access satellite services through government and commercial activity

Applications of Satellite Remote Sensing

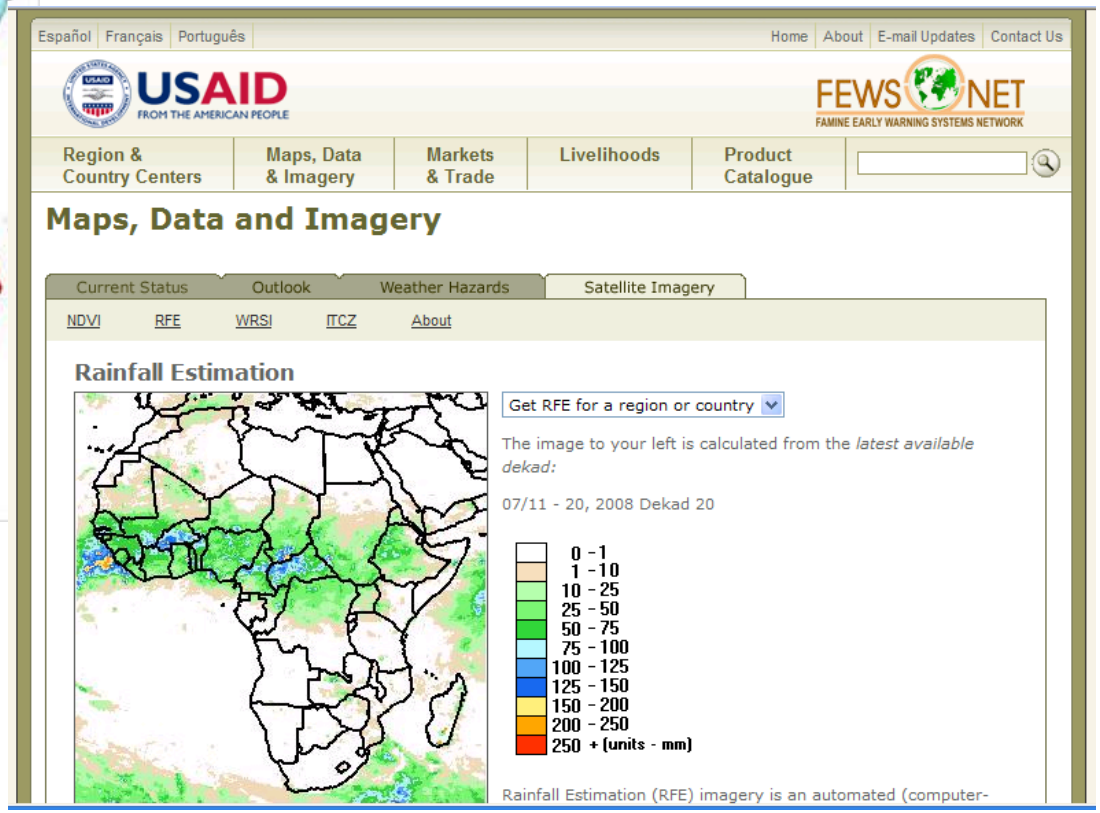


(Below)

Food Security:

Monitor Health of Crops

FEWS NET @ www.fews.net



(Above)

Disease Management:

Mapping Malaria Risk in Africa based on environmental satellite data

http://www.who.int/heli/tools/Africamaras.jpg

Applications of Satellite Communication

(Right)

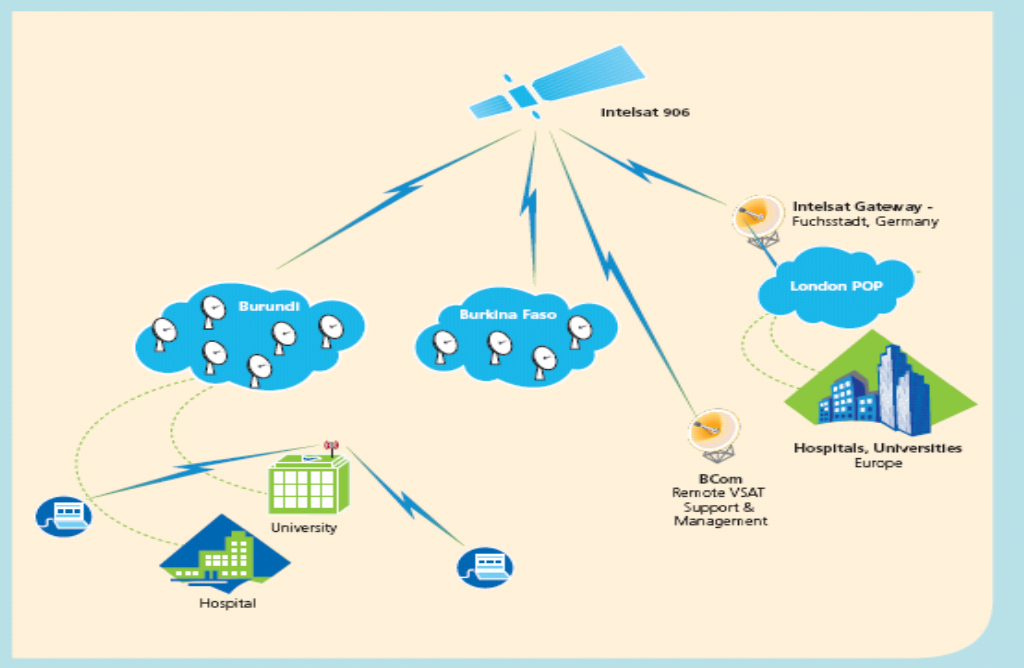
Telemedicine:

AIDS treatment in Burundi and Burkina Faso

(Below)

Distance Education:

Mindset Network



http://www.mindset.co.za/corporate/templates/about.htm

Applications of Satellite Navigation

News

EGNOS trans-Africa team

Success for the first trans-african flight with EGNOS

25 May 2005
A pioneering flight from Dakar to Mombasa using the European Geostationary Navigation Overlay Service (EGNOS), the European satellite navigation system that corrects and improves GPS data, was a complete success.

Africa was crossed at its widest part with a plane using this accurate and guaranteed positioning system provided by the EGNOS test bed signal, to navigate and make landings.

(Above)

Aviation Management:

Satellite Navigation to support Air Traffic Management

http://www.esa.int/esaNA/SEMOZ00DU8E_index_0.html

(Below)

Census Data Collection and Management:

Example from Zambian Census Agency

http://unstats.un.org/unsd/demographic/meetings/wshops/Zambia_8Oct07/list_of_docs.htm

Research Directions about Satellite Services and Developing Countries

- By what means are satellite services accessed in developing countries?
- What enablers or barriers influence the use of satellite services?
- How do countries compare in their space-related activity?

Research Directions about Satellite Services and Developing Countries

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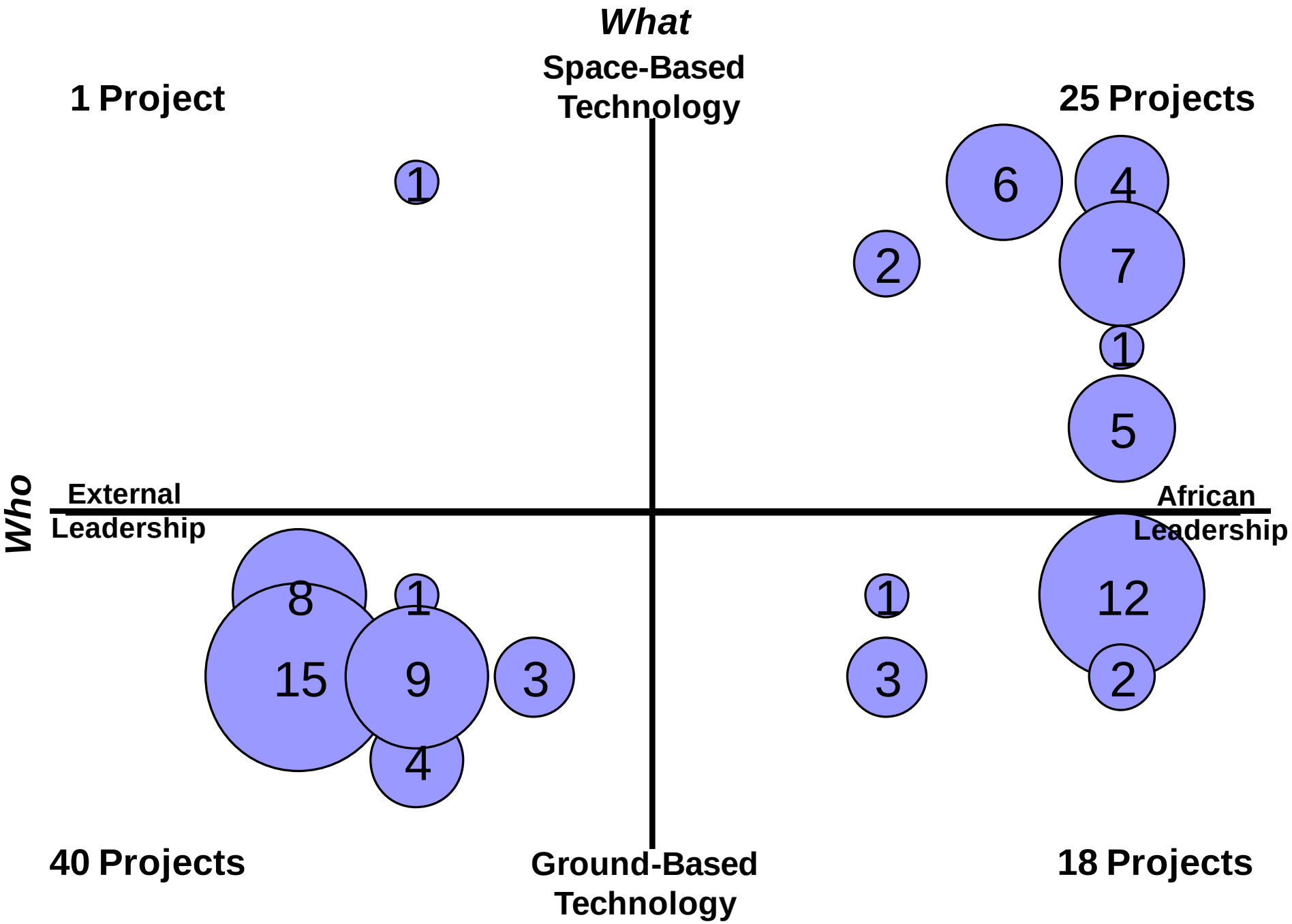
90 Case Studies of African Projects Reveal Patterns in Use of Satellite-Enabled Information Services

Remote Sensing – Communication – Navigation

Technology Ladder

Level	Description	Country Technology # of Projects
A	Design, Build, Operate Satellite	4
B	Train in Satellite Production	7
C	Buy or Lease and Operate Satellite	9
D	Operate Others' Satellites	1
E	Lease Satellite Capacity	5
F	Operate Satellite Ground Segment	22
G	Process Satellite Data	11
H	Use Satellite Data Products	16
I	Participate in Regulatory Action	4

Management Ladders		Leadership Ladder	Finance Ladder	Expertise Ladder
Level	Description	# of Projects	# of Projects	# of Projects
1	Single African Country	34	32	19
2	Non-regional African Collaboration	1	1	0
3	Regional African Collaboration	4	3	3
4	External Collaboration, Effort from Africa	2	0	5
5	External Collaboration, Mutual Efforts	3	14	22
6	External Collaboration, Effort from External Partner	34	28	29


What
Space-Based Technology
1 Project
25 Projects
1
6
4
2
7
1
5
Who
External Leadership
African Leadership
8
1
15
9
3
4
1
3
12
2
40 Projects
Ground-Based Technology
18 Projects

Research Directions about Satellite Services and Developing Countries

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- How do countries compare in their space-related activity?

African Embassy Interviews

Lessons from Interviews about Barriers

- Limited funding is a reality, but so are partnerships
  - Ministry for science and technology is present but not adequately funded (23/30)
  - Government agencies and universities work frequently with external and multilateral organizations (24/30)

- Interviews show awareness of the benefits of satellites
  - Satellite technology is extremely important to their country (20/30)

- There is evidence of local expertise in using satellite data
  - Government agencies concerned with environment use satellite technology (19/30)

- There are diverse, local education opportunities
  - There is engineering and science education available at national university (22/30)

Research Directions about Satellite Services and Developing Countries

- By what means are satellite services accessed in developing countries?

- What enablers or barriers influence the use of satellite services?

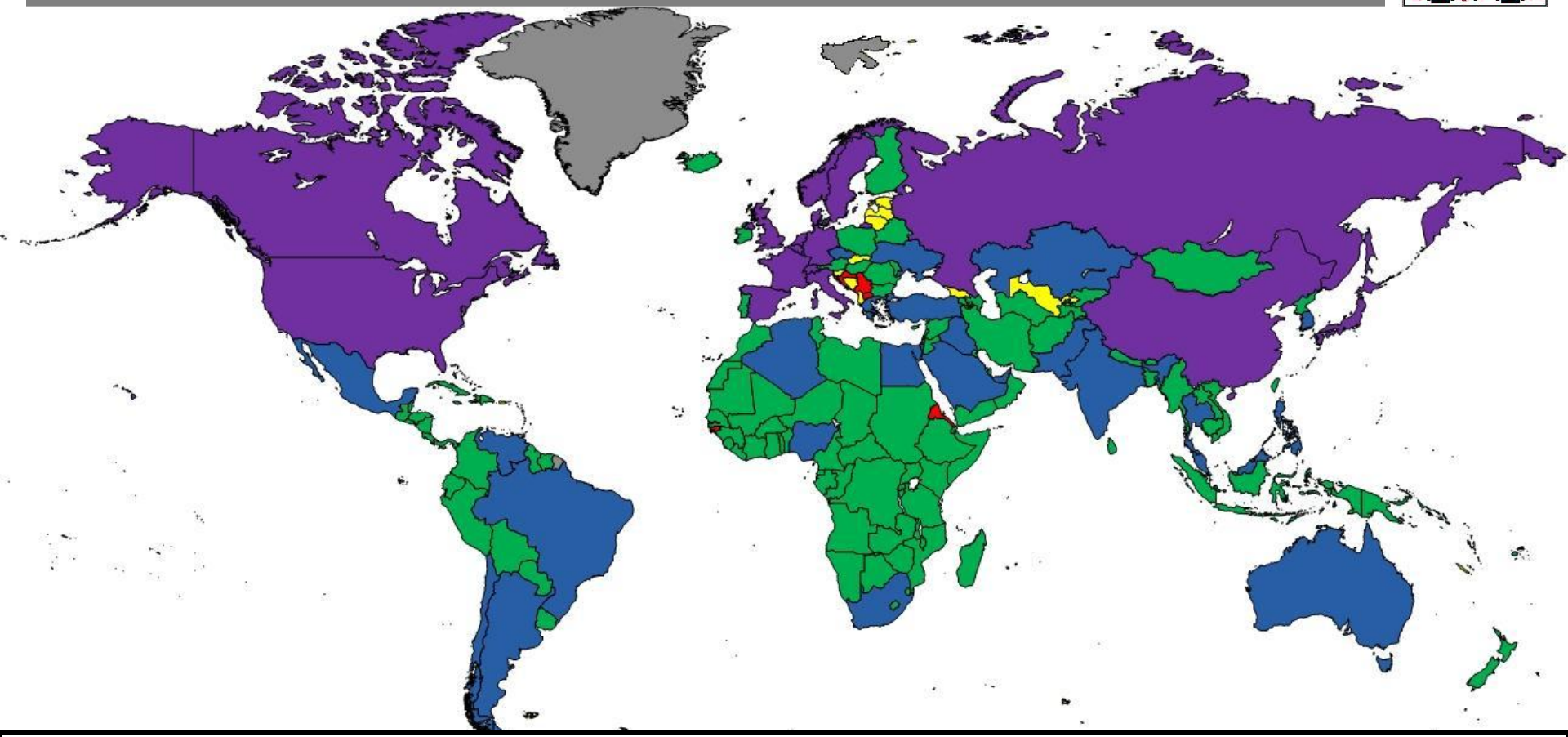
- **How do countries compare in their space-related activity?**

Detailed Summary of National Space Activity

Algeria's Country Technology Ladder

Level	Activity	Algeria's Projects
	Space-Base Technology	
A	Design, Build, Operate Satellite	1
B	Buy and Operate satellite; Train in sat design	3
C	Buy/Lease and Operate Satellite	2
D	Operate others' satellites	0
	Ground-Based Technology	
E	Lease Satellite Capacity and Distribute Service	0
F	Operate Ground Segment to Send or Receive Satellite Data	1
G	Process Satellite Data and Create Data Products	1
H	Use Satellite Data Products	1
I	Participate in Regulatory Action Regarding Satellites	2
	Total Projects	***11***

Space Participation Metric: Technology-Based

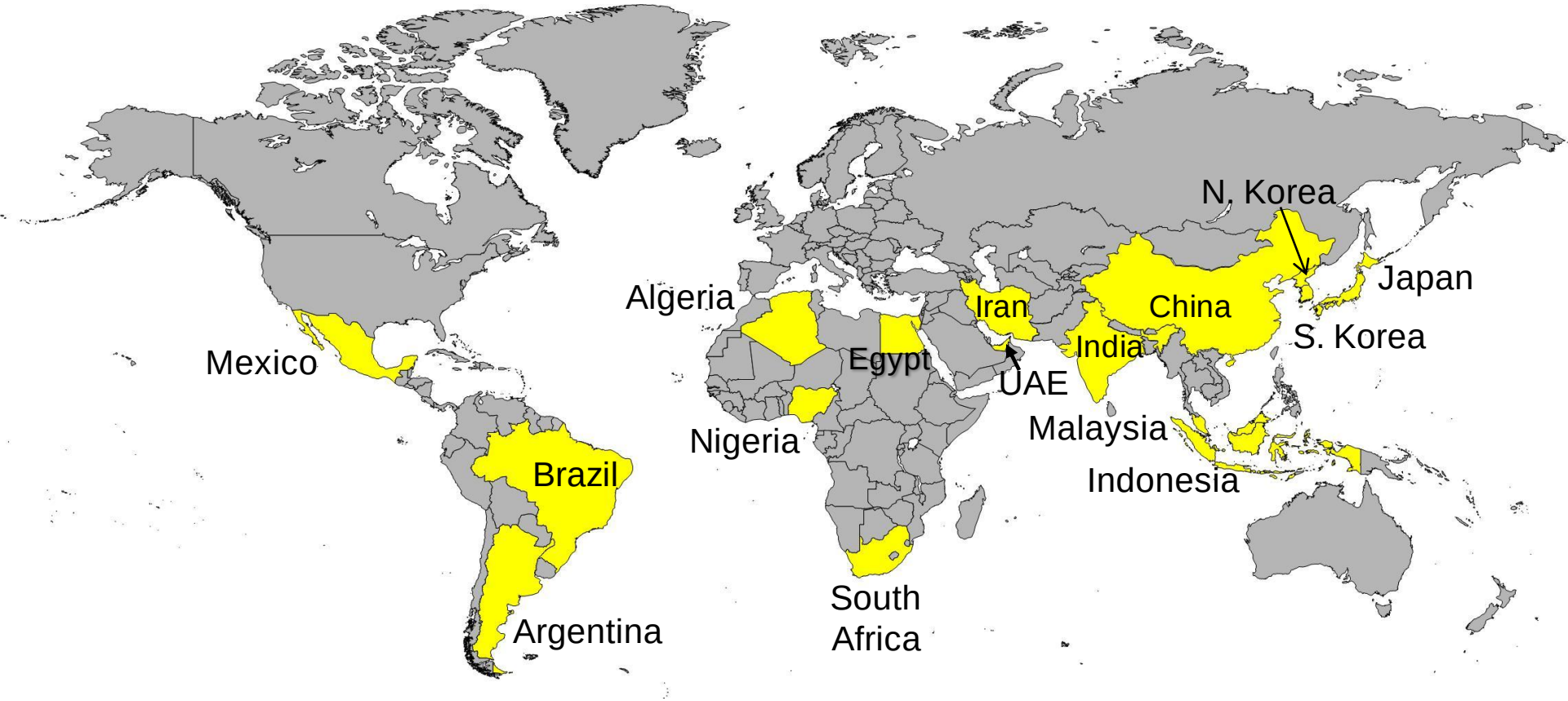


Colors show the technology level reached by each country				
Violet (High)	Blue	Green	Yellow	Red (Low)
Human Space Flight	Space Hardware	Ground Hardware	Education & Research	Organization and Regulatory

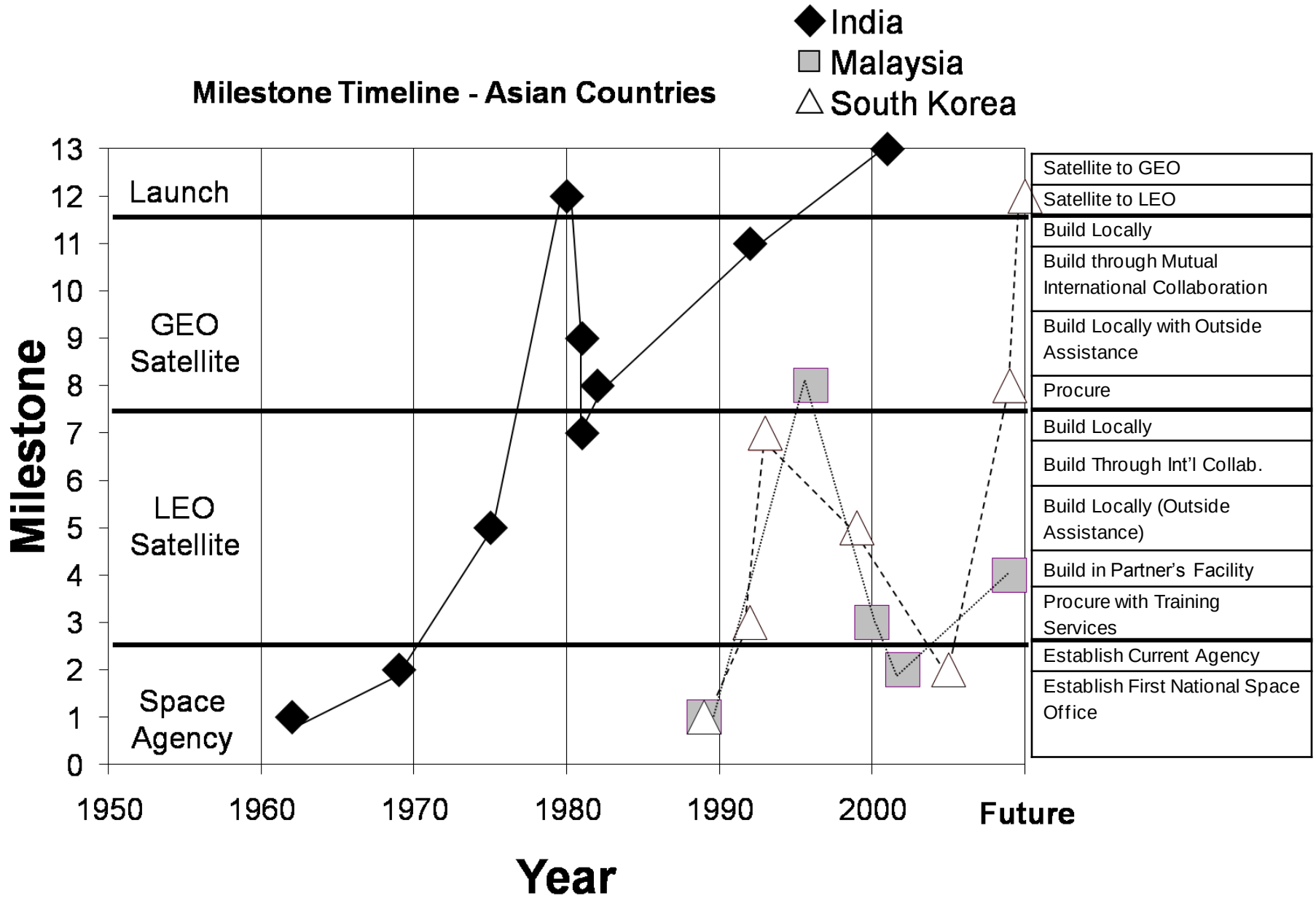
Building Local Technological Capability:

Opportunities and Challenges for Technical Partnerships

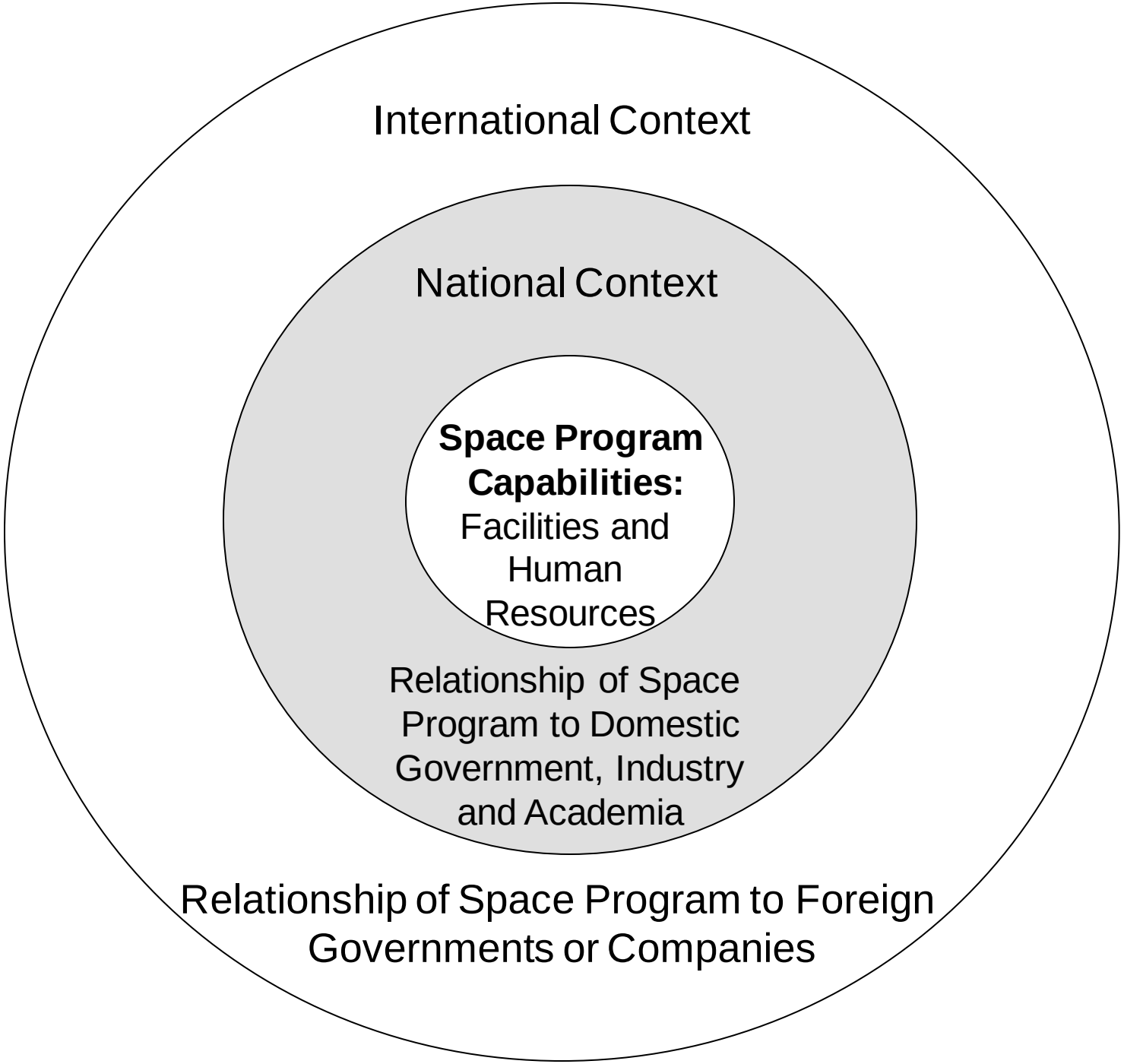
Many African, Asian and Latin American countries are enhancing their space programs



Developing countries pursue diverse paths in their process of establishing a local satellite program


Milestone Timeline - Asian Countries
India
Malaysia
South Korea
Milestone
Year
Launch
GEO Satellite
LEO Satellite
Space Agency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
1950
1960
1970
1980
1990
2000
Future
Satellite to GEO
Satellite to LEO
Build Locally
Build through Mutual International Collaboration
Build Locally with Outside Assistance
Procure
Build Locally
Build Through Int'l Collab.
Build Locally (Outside Assistance)
Build in Partner's Facility
Procure with Training Services
Establish Current Agency
Establish First National Space Office

Developing countries face common strategic decisions about their satellite programs


International Context
National Context
Space Program Capabilities:
Facilities and Human Resources
Relationship of Space Program to Domestic Government, Industry and Academia
Relationship of Space Program to Foreign Governments or Companies

Many countries make use of international partnerships as part of their process of establishing or strengthening their space program

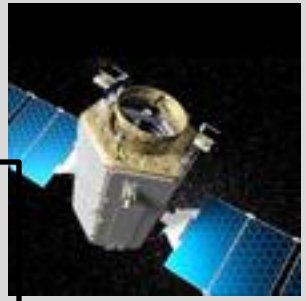
The Development of South Korea's Satellite Program

Increasing Technical Complexity

Project Participants & Launch Date

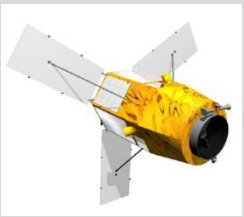
KITSAT-1 1992	KITSAT-2 1993	KITSAT-3 1999	KOMPSAT-1 1999	KOMPSAT-2 2006	KOMPSAT-3 2010
UK + Korean Universities	Korean University	Korean University	US Firm + Korean Space Agency	European Firm + Korean Space Agency	European Firm + Korean Space Agency

National Space Agency



KOMPSAT-1

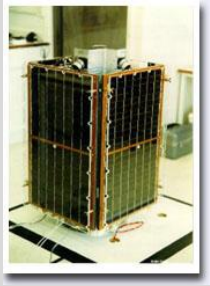
KOMPSAT-2



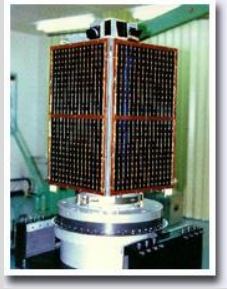
KOMPSAT-3

Technical University

KITSAT-1

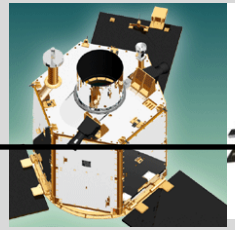


KITSAT-2

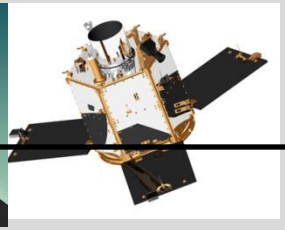


KITSAT-3

Spin-Off Firm



RazakSat (2009)

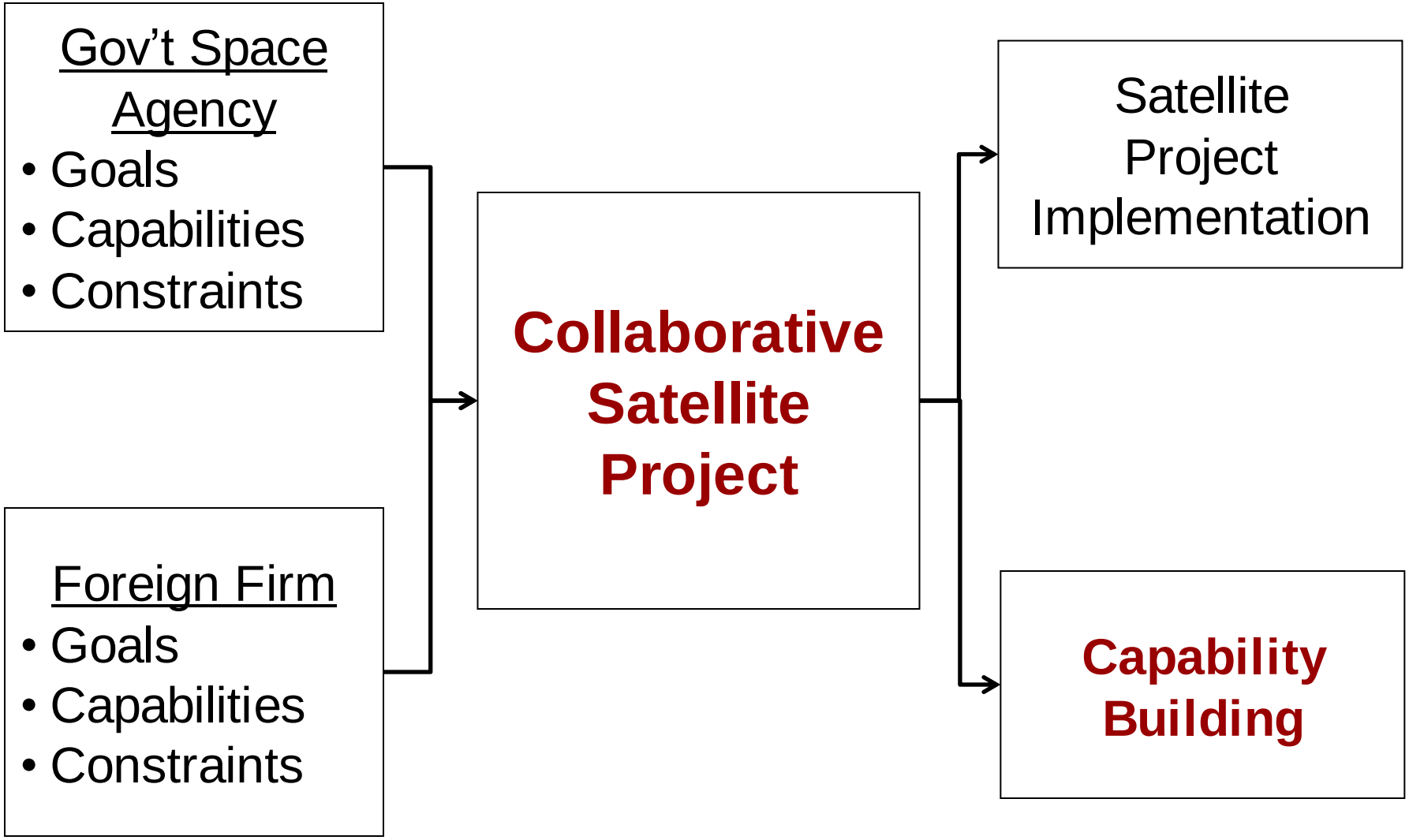


DubaiSat (2009)

Korean Firm + Malaysian Space Agency	Korean Firm + UAE University

Source: SaTReC http://satrec.kaist.ac.kr/english/SaTReC.html

Generic International Training Project



Challenges of International Satellite Training Projects

- There is the potential for…
  - **Misaligned** incentives between partners
  - **Differences** in culture and language
  - **Tension** between training and project execution
  - **Imperfect** information for partner with less technical capability
  - **Difficulty** ensuring training is completed effectively
  - **Problems** managing project constraints

Focus of Doctoral Research

Conclusions:

Future Research Directions

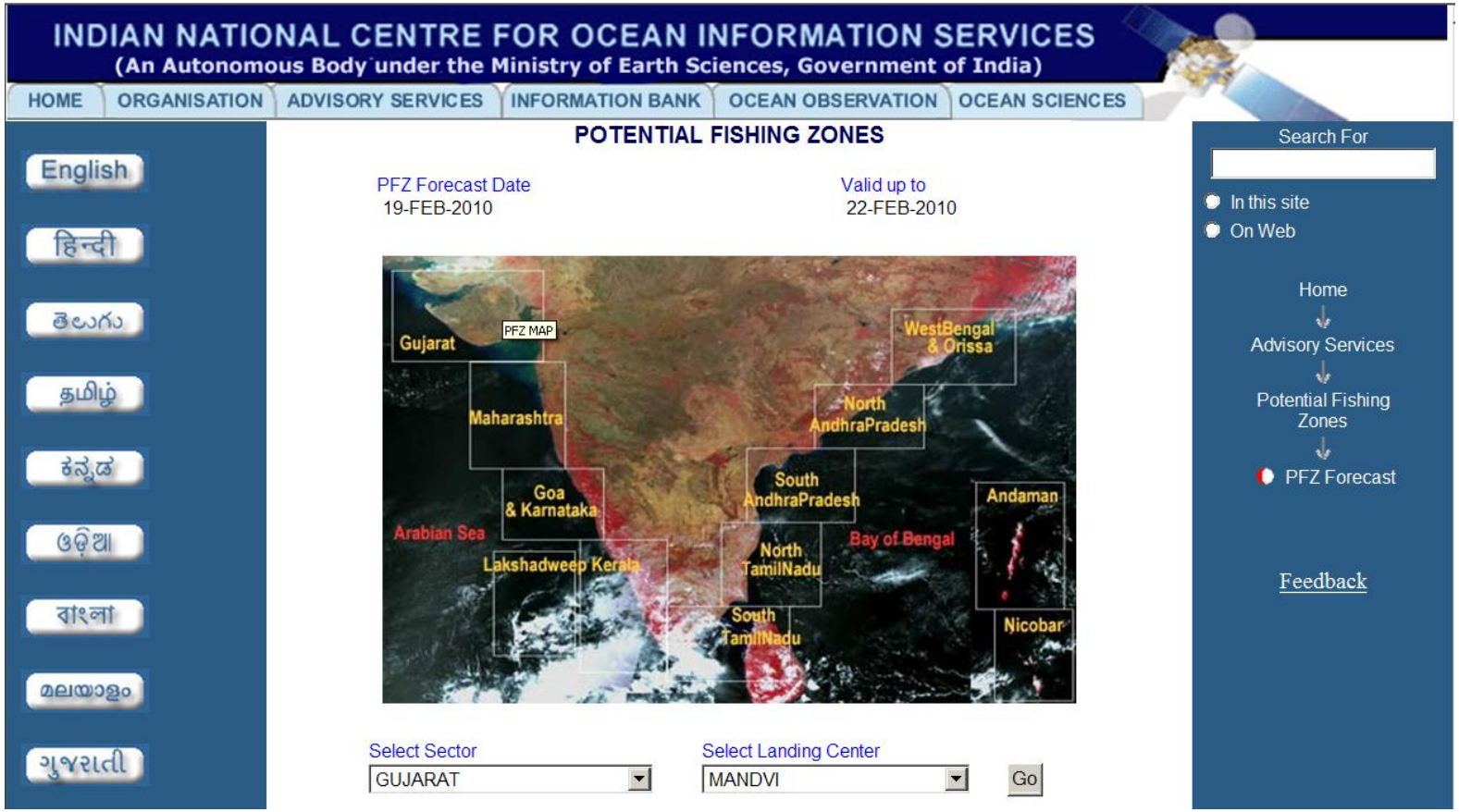
Future Research

- Decisions for developing country policy makers
  - How should investments in satellite services be evaluated?
  - How can we ensure that satellite-enabled information services reach the end user?
- The role of international collaboration
  - Bilateral with Europe, North America, Asia, etc
  - Multilateral, such as **the International Charter: Space and Major Disasters** or the **Group on Earth Observation**

Potential Fishing Zone Forecasts in India	Maps for Disaster Response in Haiti	Tele-education in South Africa

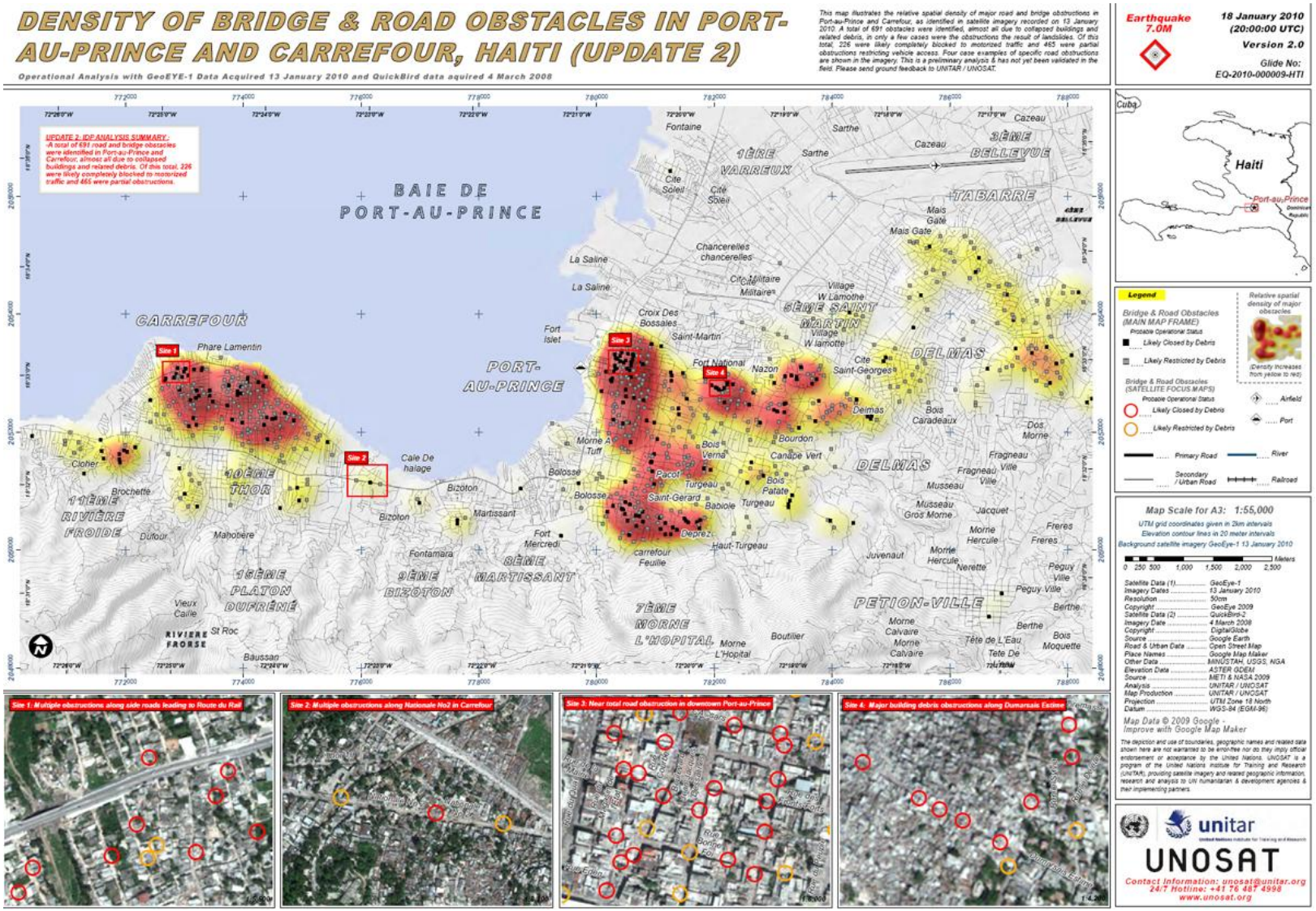
India's Potential Fishing Zone Forecast

- Satellite data for sea surface temperature and chlorophyll content are used to estimate fishing locations



http://www.incois.gov.in/Incois/advisory_pfz_main.jsp#

Maps for Disaster Response in Haiti



http://www.disasterscharter.org/image/journal/article.jpg?img_id=64006&t=1263989080812

Tele-education in South Africa: Mindset Network

Technology Platforms > Datacast

Broadcast | Datacast | **Web** | **Offline Application** | **Mobile**

Datacasting is a technology that allows Mindset to send large amounts of content via satellite to computers around South Africa.

Indeed, the satellite Mindset uses for this purpose has a footprint extending as far north as the Democratic Republic of Congo.

Summary & Conclusion

- Satellite-Enabled Information Services can help meet national needs in developing countries
- A number of developing countries use international partnerships to increase their local technological capability
- Developing countries are joining – and influencing – the space-based information community

These realities lead to rich research questions yet little formal or academic research is done in this area

For more information…

- Wood, Danielle & Annalisa Weigel, "The Evolution of Satellite Programs in Developing Countries," *60th International Astronautical Congress*, Daejeon, Republic of Korea, October 2009.

- Wood, Danielle & Annalisa Weigel, "A Framework for Evaluating National Space Activity," *American Institute of Aeronautics and Astronautics Space 2009 Conference*, Pasadena, California, September 2009.

- Wood, Danielle & Annalisa Weigel, "International Collaboration on Satellite-Enabled Projects in Developing Countries," *Space, Propulsion and Energy Sciences International Forum*, Huntsville, Alabama, February 2009.

- Wood, Danielle and Annalisa Weigel, "The Use of Satellite-Based Technology to Meet Needs in Developing Countries," *59th International Astronautical Congress*, Glasgow, Scotland, October 2008.