
Emerging Satellite Programs in Africa, Asia and the Middle East:

Systems Engineering and Project Management Approaches

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Innovative Partnerships Office: NASA Headquarters

Innovative Partnerships Program: Goddard Space Flight Center Code 504

Systems Engineering Seminar: July 12, 2011

NASA Goddard Space Flight Center

- Speaker Background & Career Path
- Overview of New Satellite Activity
- Motivations and Strategic Decisions for New National Satellite Programs
- Emerging approaches in satellite activity
- Choosing Systems Engineering Approaches to Promote Development
- Conclusions for NASA

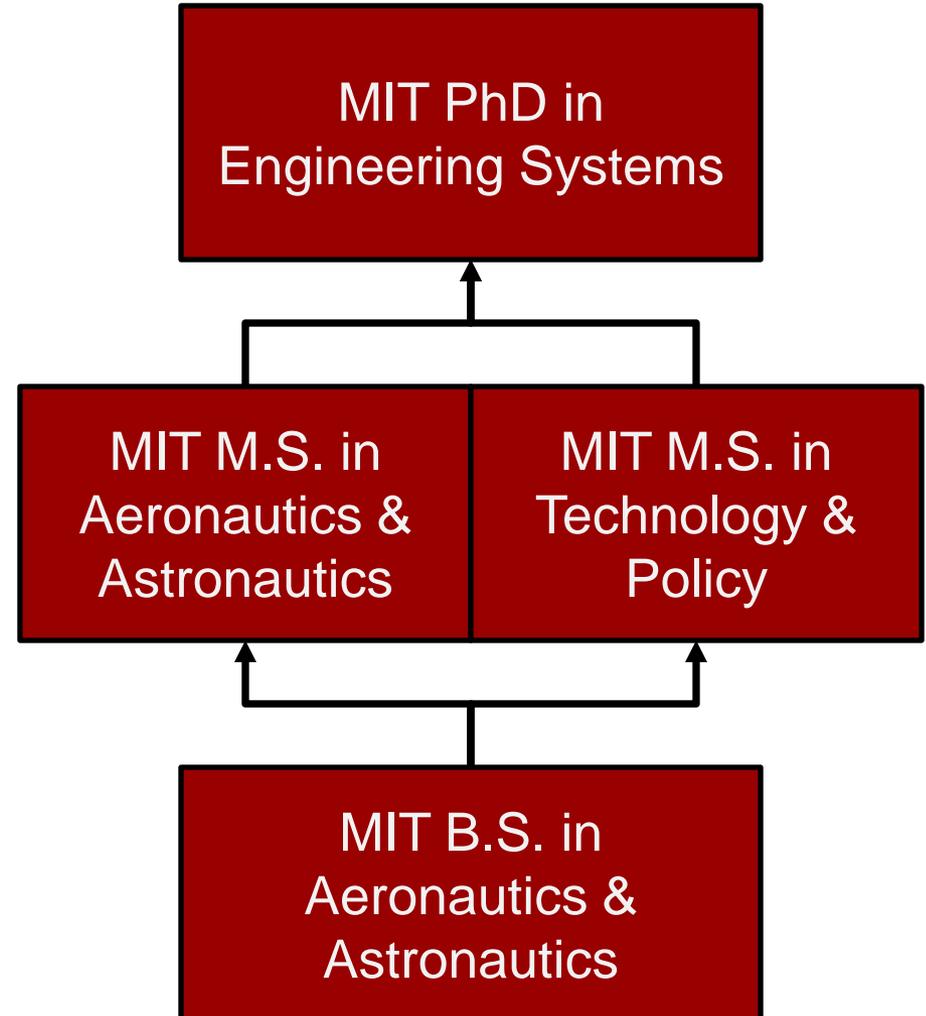
Technical Growth

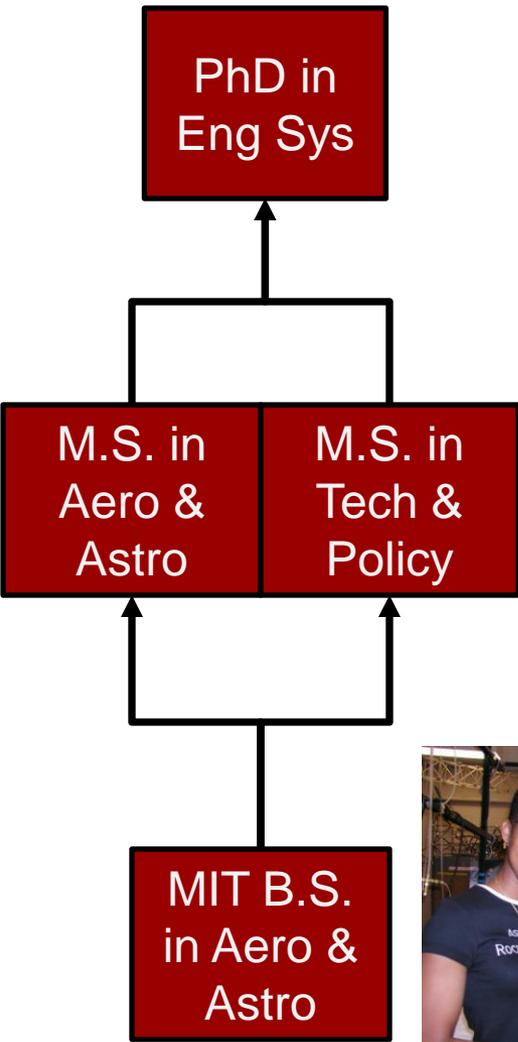
Applied **Engineering Systems** approach to socio-technical issues of new satellite programs

Technical focus on **System Engineering** development process for satellites

Strong technical foundation in theories behind **Aerospace Engineering**

Academic Experience





National & International Conferences



United Nations Internship, Vienna

NASA Academy Operations Manager



2010 NASA Student Innovator Award



NASA Student Ambassador



MIT Research



NASA Research



International Volunteer Work



- **Current internship at Goddard and NASA Headquarters**
 - Goddard's Innovative Partnership Program (Code 504) under Nona Cheeks
 - NASA's Office of the Chief Technologist in Innovative Partnership Office under Doug Comstock

- **Purpose of internship**
 - Find synergy between office work and my research
 - Understand NASA approach to technology transfer and community partnership
 - Look at opportunities to facilitate deployment of NASA [spinoffs](#) for benefit of developing countries

Overview of Satellite Activity in Latin America, Africa and Asia

Note: This overview excludes India, China and Japan which are advanced in satellite and launch technology

Region	Country	National Space Agency Or Office	Buy LEO Sat.	Buy GEO Sat.	Build LEO Sat. Locally
Africa	Algeria	ASAL	X		In process
	Egypt	NARSS & NILESAT	X	X	
	Kenya	In process			
	Nigeria	NASRDA	X	X	In process
	South Africa	SANSA			X

Region	Country	National Space Agency Or Office	Buy LEO Sat.	Buy GEO Sat.	Build LEO Sat. Locally	Build GEO Sat Locally	Launch LEO satellite
Latin America	Argentina	CONAE		X	X	X	
	Chile	ACE	X				
	Mexico	In Process		X	X		
	Venezuela	ABAE		X			
	Brazil	AEB		X	X		In process

	Country	National Space Agency Or Office	Buy LEO Sat.	Buy GEO Sat.	Build LEO Sat. Locally	Build GEO Sat Locally	Launch LEO satellite
Asia	Indonesia	LAPAN	X	X	In process		
	Malaysia	ANGKASA	X	X	In process		
	Pakistan	SUPARCO	X	In process			

	Country	National Space Agency Or Office	Buy LEO Sat.	Buy GEO Sat.	Build LEO Sat. Locally	Build GEO Sat Locally	Launch LEO satellite
Asia	South Korea	KARI	X	X	X		In process
	Thailand	GISTDA	X	X			
	Turkey	TUBITAK	X	X	X		
	United Arab Emirates	EIAST	X	X	In process		

- As satellite technology matures, new approaches are emerging
- Focus here on small satellites for optical earth observation
- Implications for Manufacturers
 - Pursuing more performance from smaller spacecraft platforms
 - Using commercial-off-the-shelf technology (not designed for space) to build subsystems
 - Build heritage gradually and deliberately
 - Control scope and performance requirements carefully
- Implications for Satellite Buyers
 - Buy satellites in addition to buying data
 - Buy training and spacecraft
 - Share launches with other small satellite buyers

Why are new countries investing in space technology?

There are political (**subjective**) and technical (**objective**) motivations

<p>Investment Area</p>	<p>Satellite Service: <i>Using satellite services in earth observation, communication, navigation and science</i></p>	<p>Satellite Hardware: <i>Owning and operating a spacecraft and supporting ground system</i></p>	<p>Satellite Expertise: <i>Training personnel in satellite engineering</i></p>	<p>Satellite Infrastructure: <i>Establishing local facilities to fabricate satellites</i></p>
<p>Short Term Motivation</p>	<ul style="list-style-type: none"> • Address time sensitive national needs for information 	<ul style="list-style-type: none"> • Meet temporal frequency, spatial resolution, and spectral coverage requirements for information 	<ul style="list-style-type: none"> • Develop knowledge to be an informed consumer of satellite services 	<ul style="list-style-type: none"> • Increase technical involvement of local personnel in satellite activities
<p>Long Term Motivation</p>	<ul style="list-style-type: none"> • Enable informed regional planning • Enhance infrastructure and industry 	<ul style="list-style-type: none"> • Gain operations experience • Decrease dependence on uncertain technology sources • Ensure service continuity 	<ul style="list-style-type: none"> • Enhance education and research opportunities • Build up industrial capability 	<ul style="list-style-type: none"> • Use infrastructure to facilitate long term series of satellite projects

**Satellite
Infra-
structure**

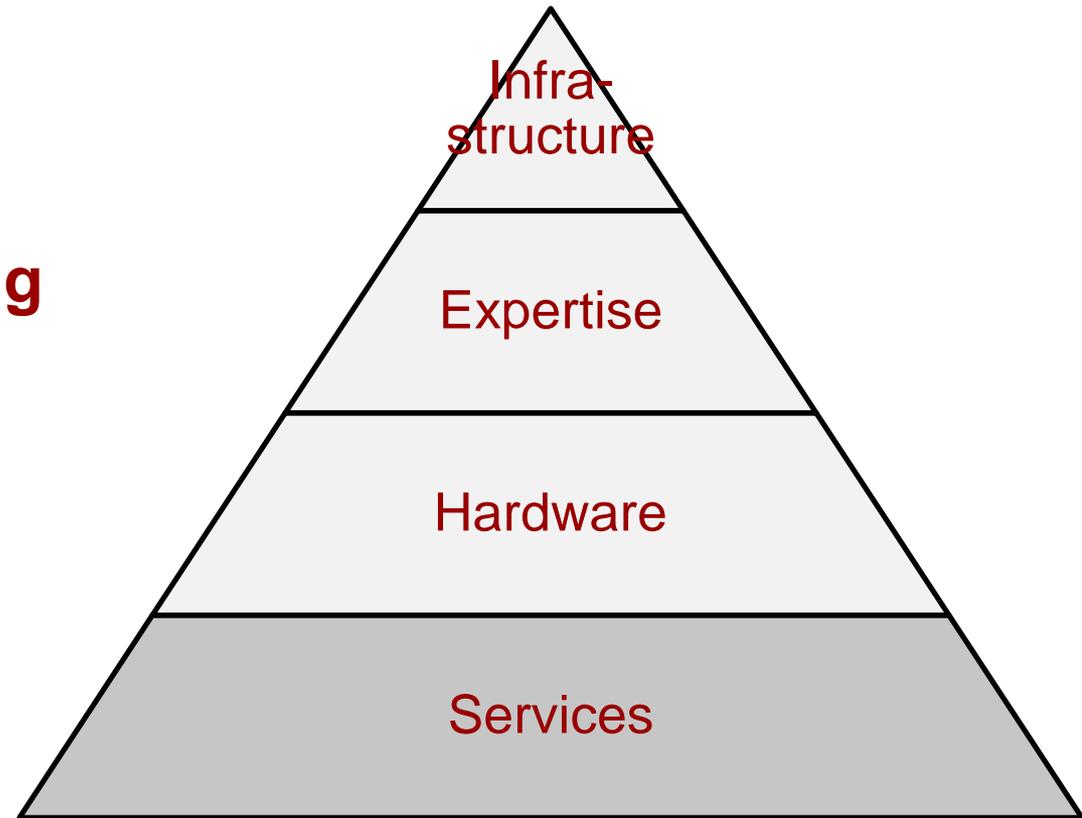
**Satellite
Expertise**

Satellite Hardware

Satellite Services

Satellite Services Have Global Impact

- **Satellite Remote Sensing**
- **Communication**
- **Positioning & Navigation**
- **Science**





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Rainfall Estimation

Get RFE for a region or country

The image to your left is calculated from the latest available data:

03/01 - 10, 2011 Dekad 7

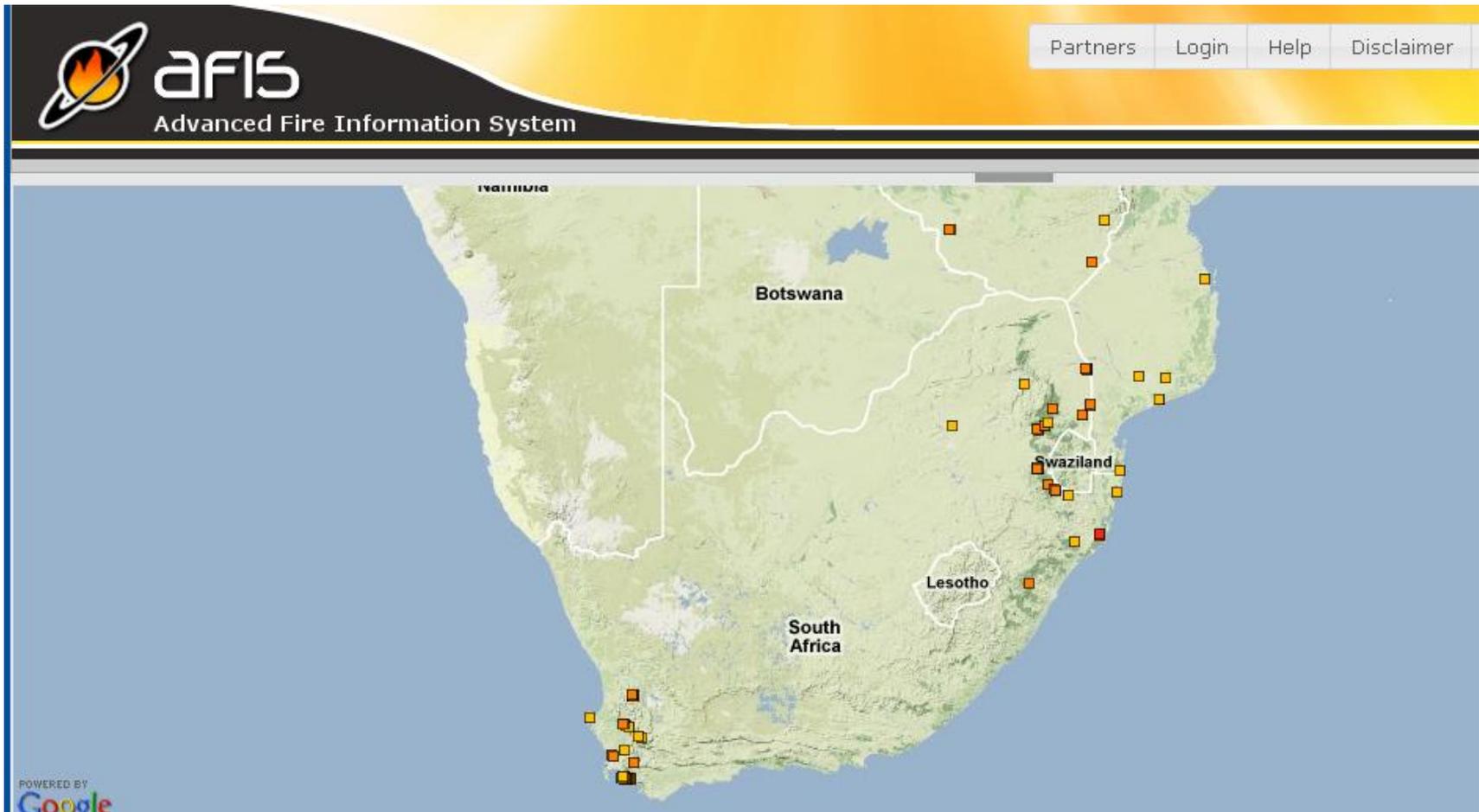
	0 - 1
	1 - 10
	10 - 25
	25 - 50
	50 - 75
	75 - 100
	100 - 125
	125 - 150
	150 - 200
	200 - 250
	250 + (units - mm)

Rainfall Estimation (RFE) imagery is an automated (computer-generated) product which uses Meteosat infrared data, rain gauge reports from the global telecommunications system, and microwave satellite observations within an algorithm to provide RFE in mm at an approximate horizontal resolution of 10 km. The main use of these data is to provide input for hydrological and agrometeorological models as well as to provide climate information e.g. compare the current state of rainfall with previous time periods.

Food Security:

The US government partners with local experts to monitor the health of crops via FEWS NET @ www.fews.net

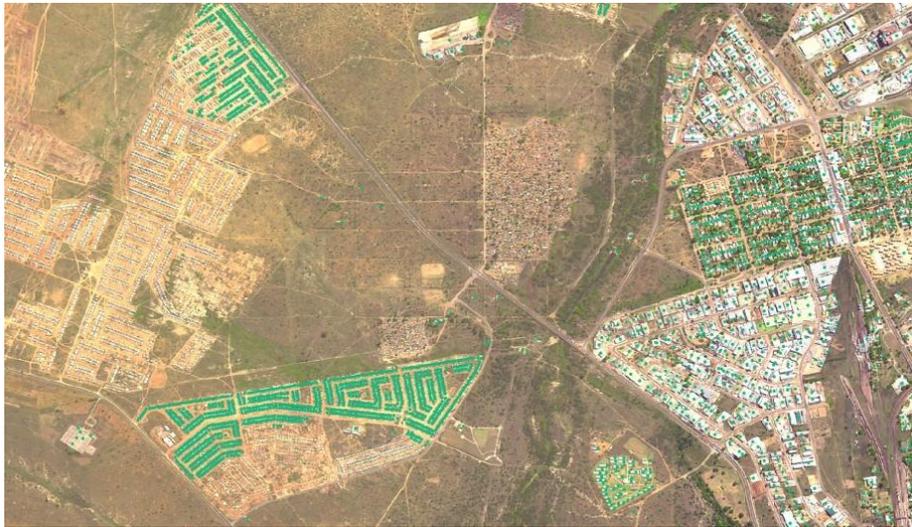
Goddard teams contribute to FEWSNET data products



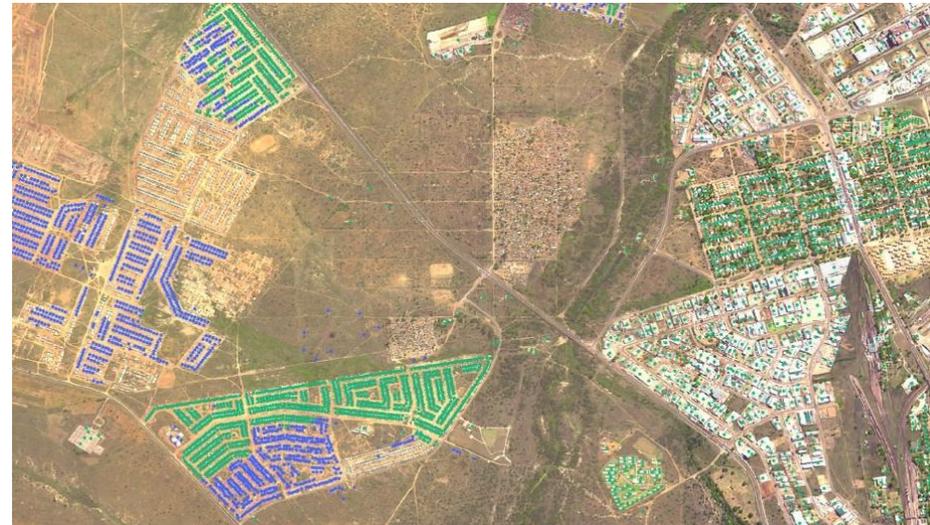
Fire Detection: South Africa uses satellite data from MODIS on NASA's Terra and Aqua satellites and Europe's Meteosat satellites as part of a system to detect fires

Land Use Planning:

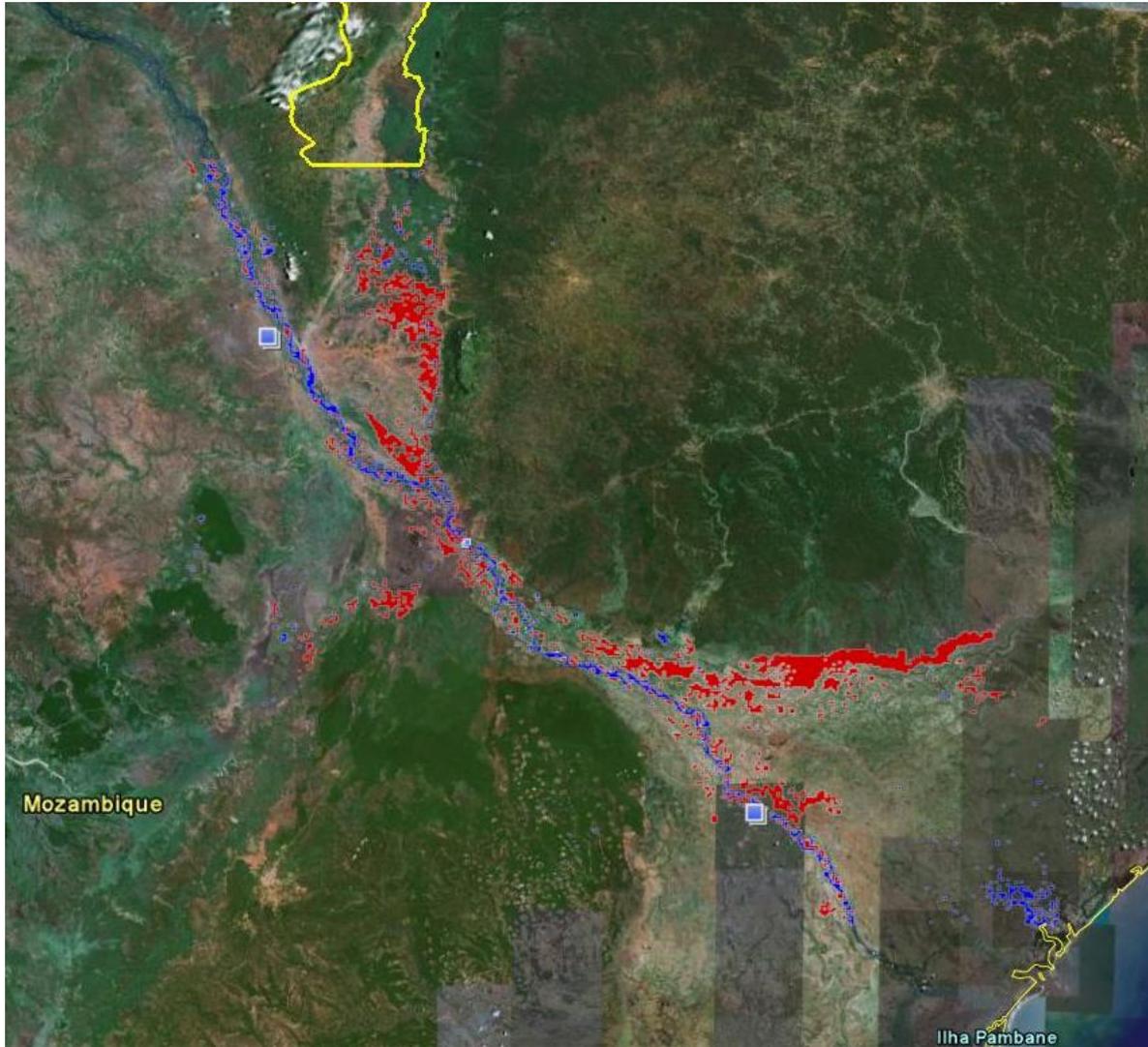
- South Africa uses satellite data products to track the changes in land use by making inventories of dwellings



2006



2007

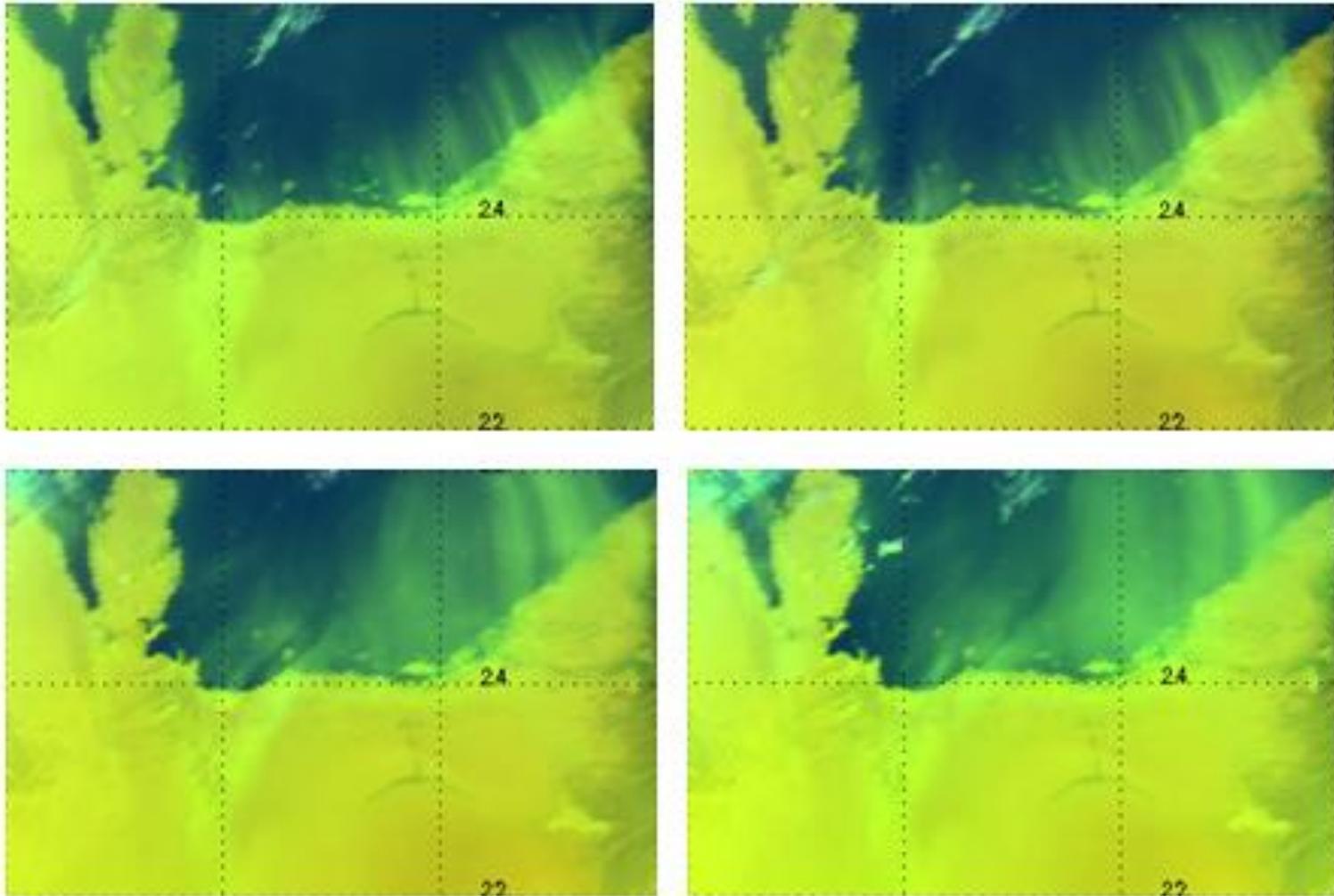


Flood Mapping

The regional remote sensing center in Kenya supports Mozambique by producing a map of 2008 floods



Regional Centre for Mapping of Resources
for Development
{RCMRD}



Dust Monitoring: Dubai uses satellites to monitor a dust storm

Developing countries face **common strategic questions** regarding the application of satellite remote sensing data



How do we access the data we need – affordably and consistently?



Department of Remote Sensing in Nairobi, Kenya



Many organizations in Africa receive foreign data



Sensor	Owner	Status
Landsat 5	USGS (USA)	Direct ingestion
Spot 2, 4 & 5	Spotimage (France)	Direct ingestion
ERS 1 & 2	ESA	Direct ingestion
Noaa series	NOAA (USA)	Direct ingestion
Seawifs	NASA (USA)	Direct ingestion
MODIS	NASA (USA)	Direct ingestion
SAC-C	Argentine	Direct ingestion

Supporting satellite operators world-wide; receiving and distributing earth observation data [more]





SERVIR-AFRICA

Regional Visualization and Monitoring System

1. What is SERVIR-Africa?

Enabling the use of
earth observations
and predictive models
for timely decision
making to **benefit**
society



INTERNATIONAL CHARTER SPACE AND MAJOR DISASTERS

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esa

The International Charter The International Charter aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through Authorized Users. Each member agency has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property.

[More](#) | [Charter Members](#) | [Text of the Charter](#)

Latest Charter Activation

Earthquake in Japan
Friday, March 11, 2011
 Earthquake hits north-east of Japan causing extensive damage, triggering a tsunami.

[Read more](#) [RSS](#) [XML](#)

Recent Activations

- [Earthquake in Japan](#)
- [Earthquake in New Zealand](#)
- [Snow Hazard in Rep. of Korea](#)
- [Landslides in Turkey](#)
- [Cyclone in Australia](#)
- [Activations Archive](#)

Latest Charter News

How do we ensure that we have professionals in our country who are adequately trained in how to use and apply satellite data?



RCMRD

REGIONAL CENTRE FOR MAPPING OF RESOURCES FOR DEVELOPMENT



RCMRD



Contracting Members States

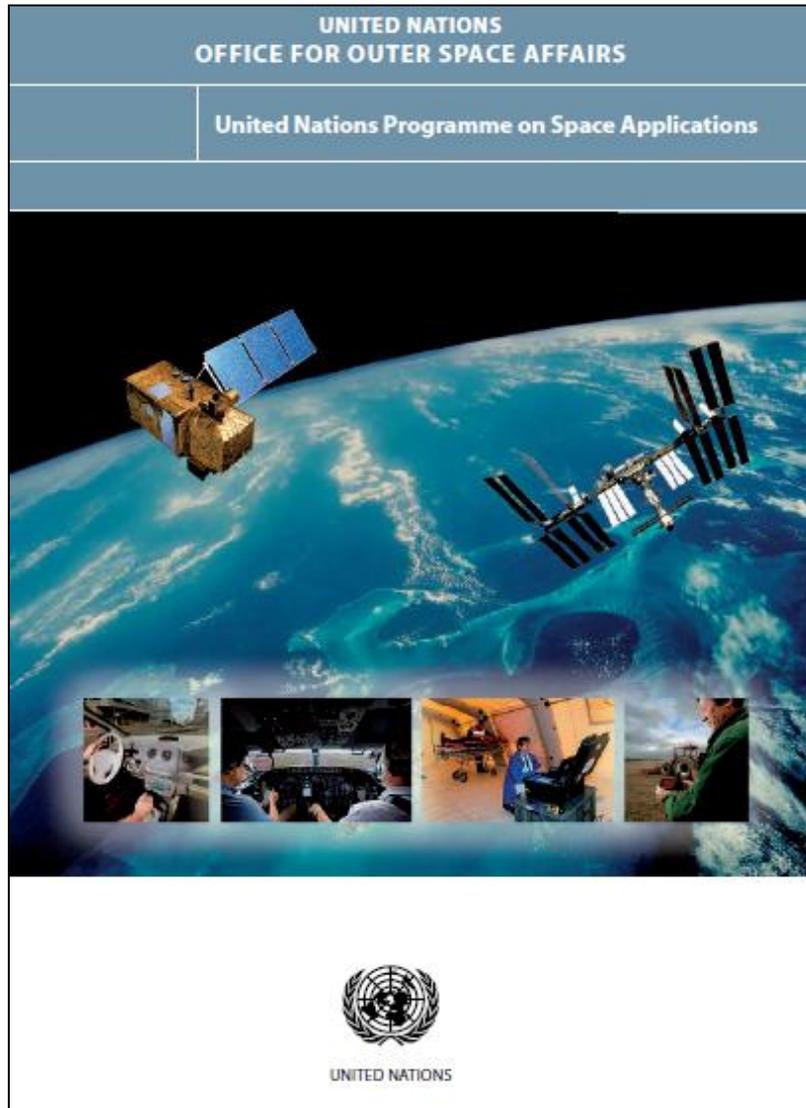
Non-contracting Members States

Our Vision

To be a premier Centre of excellence in the provision of Geo-Information & Information Technology Applications in Africa & beyond

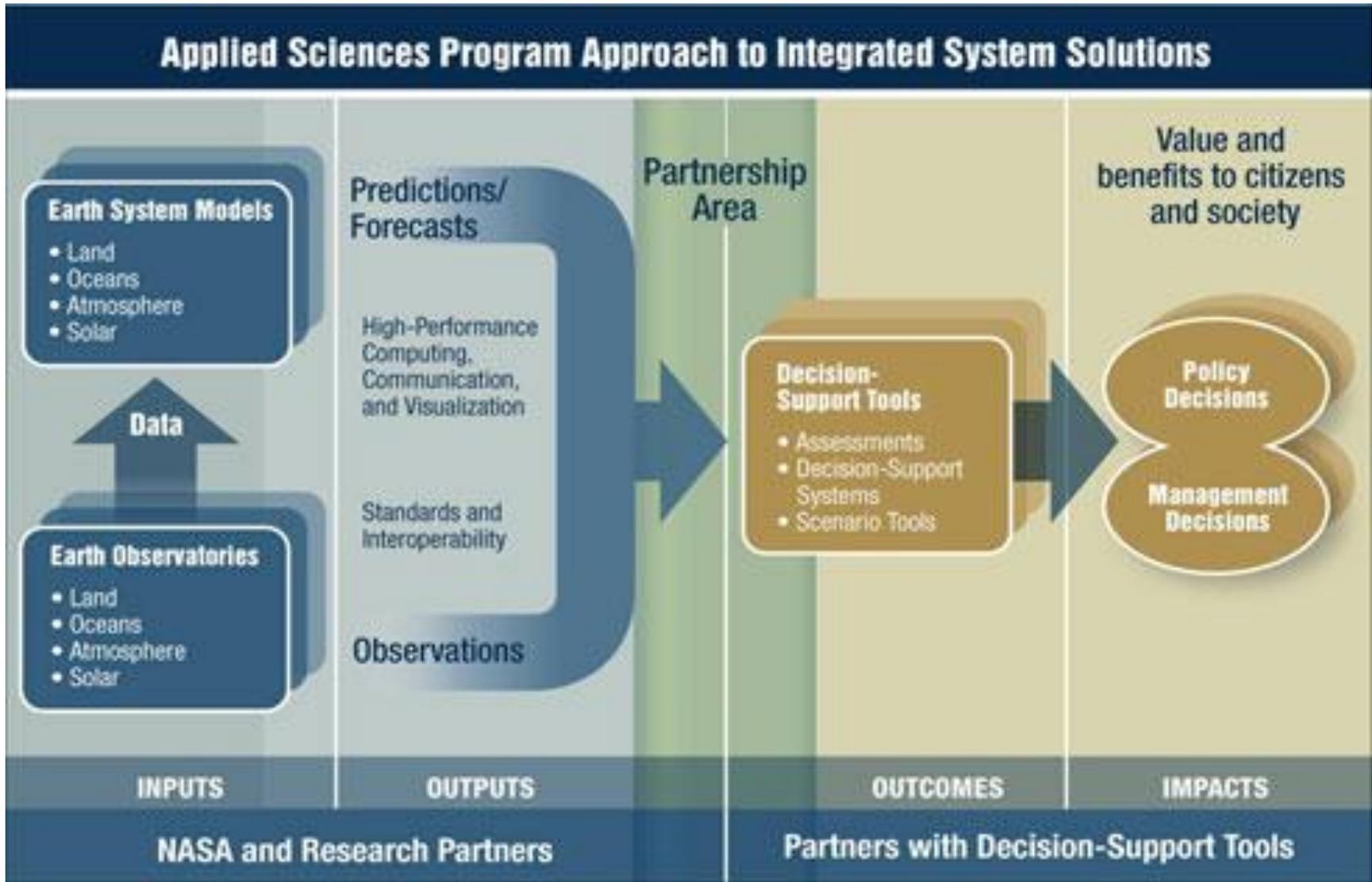
Our Mission

To provide quality Geo - Information & allied Information Communication Technology products & services in environmental & resource management for sustainable development in our Member countries & beyond



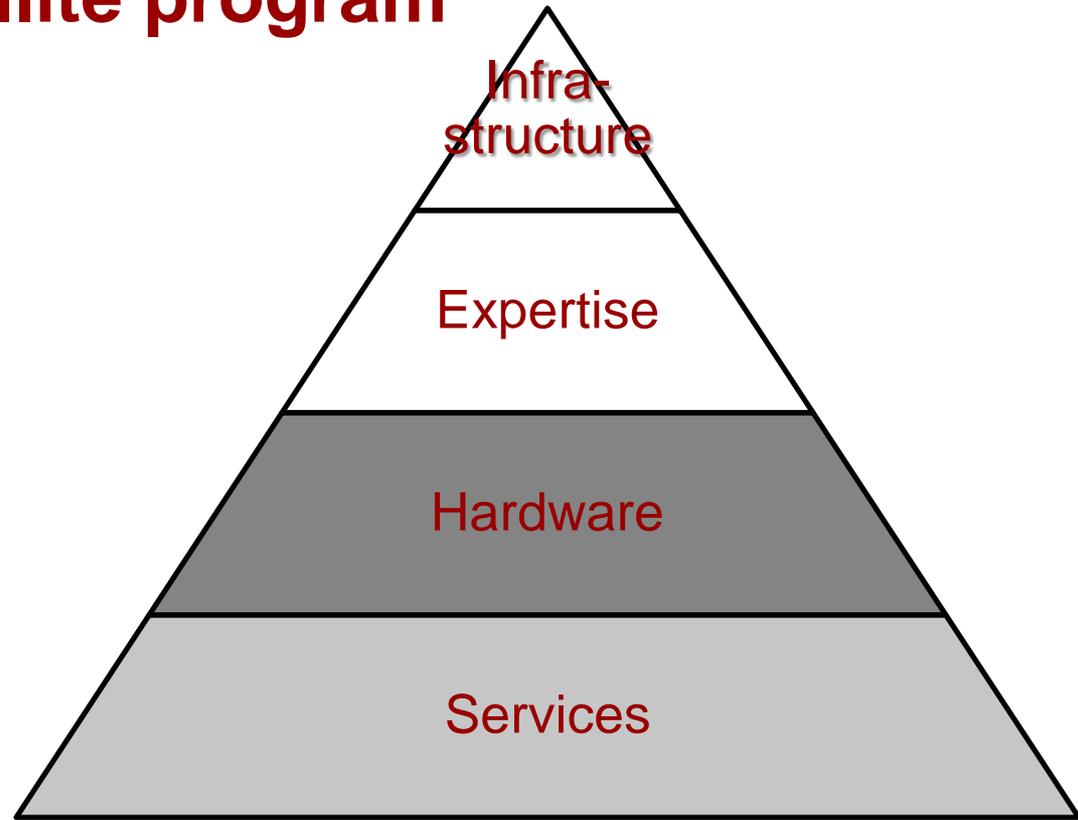
Every year the United Nations hosts events to spread awareness and provide training on satellite applications

How do we ensure that the information from satellite data is best organized and applied to social challenges?



Some countries pursue answers to the previous questions by forming a national satellite program

Emerging national satellite programs **face common strategic decisions** about their satellite programs



Societal Needs & Goals

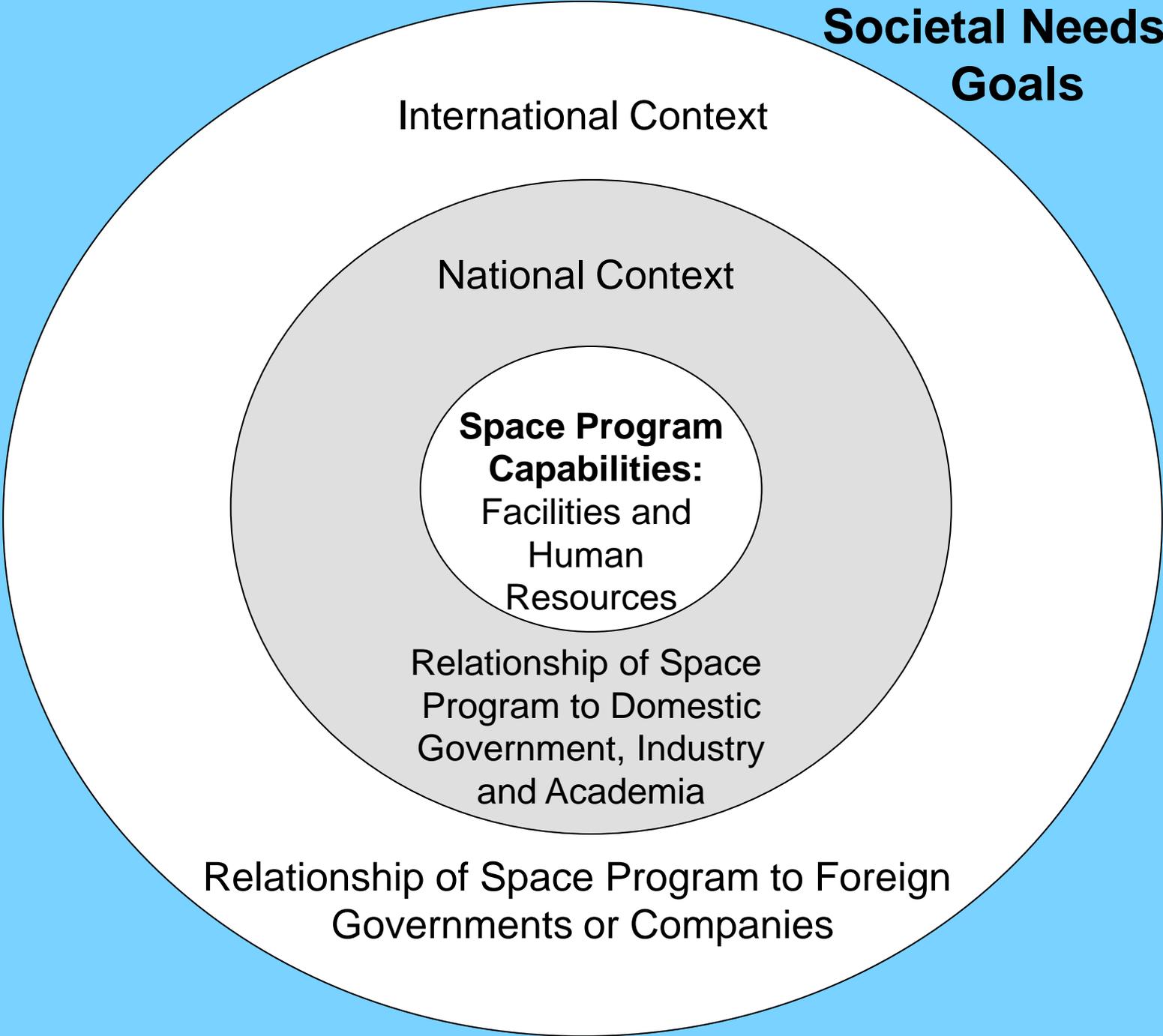
International Context

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



LAUNCH CAPABILITY

SATELLITE IN GEOSTATIONARY ORBIT

SATELLITE IN LOW EARTH ORBIT

NATIONAL SPACE AGENCY



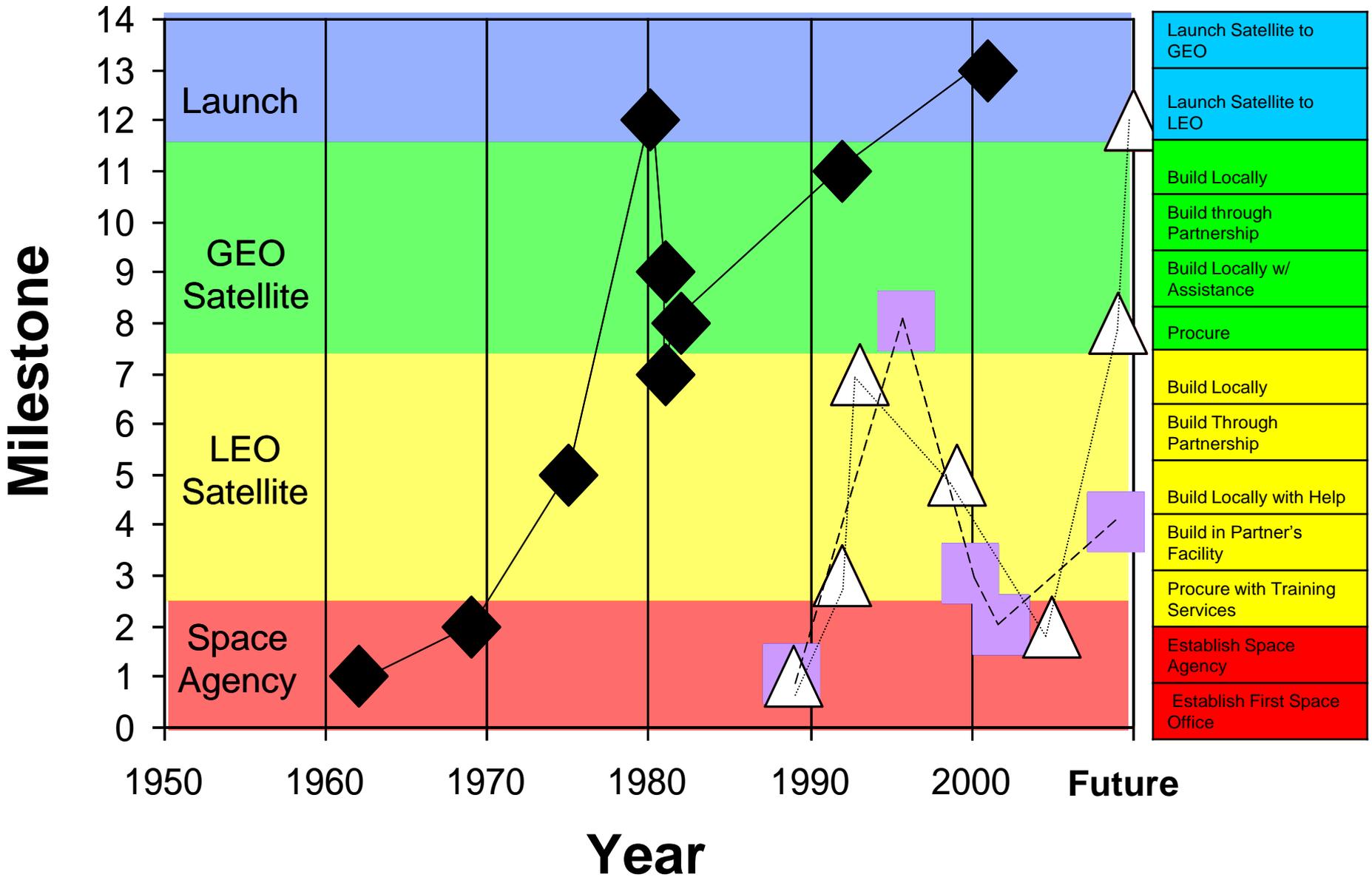
Space Technology Ladder



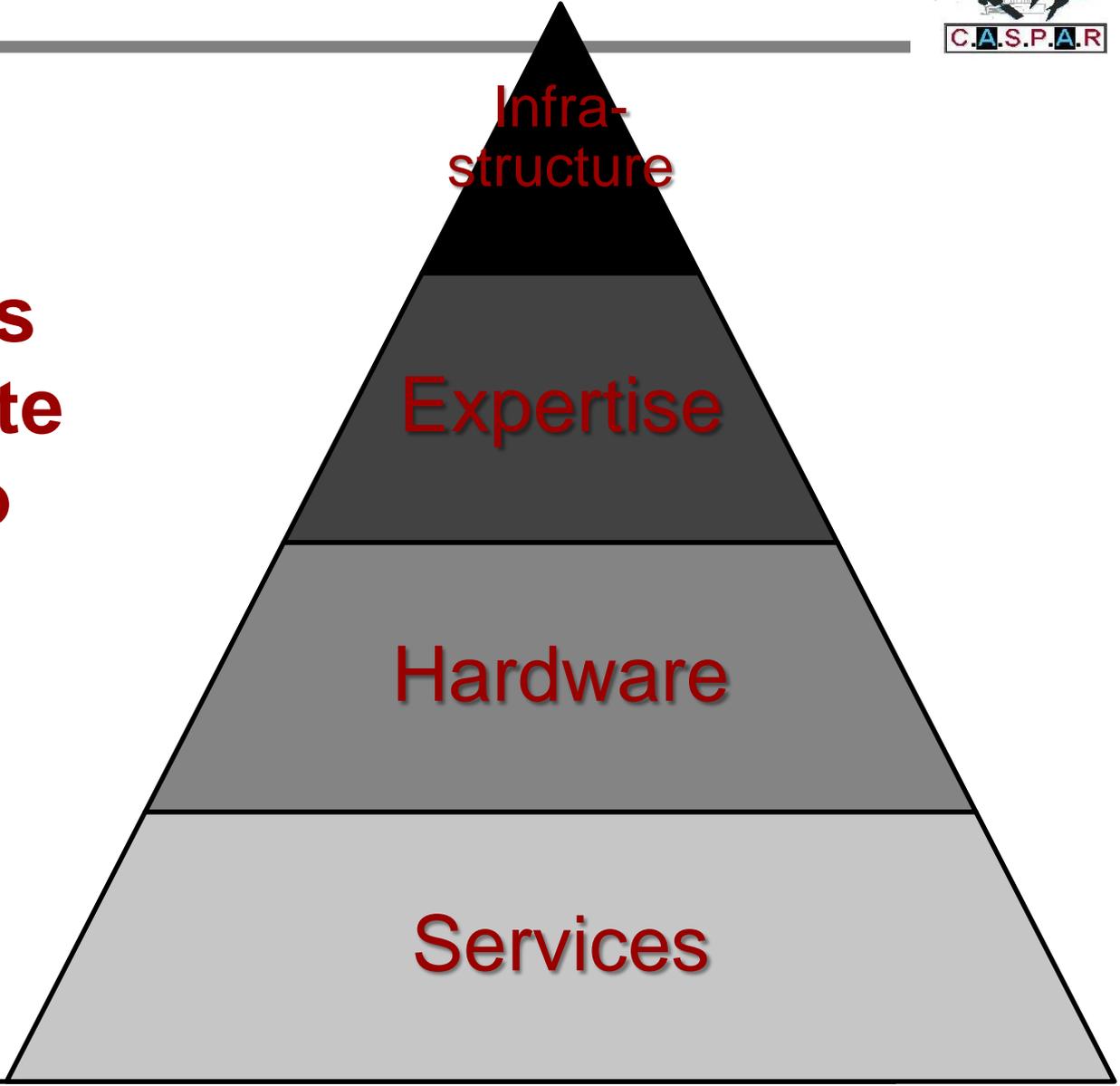
13	Launch Capability: Satellite to GEO
12	Launch Capability: Satellite to LEO
11	GEO Satellite: Build Locally
10	GEO Satellite: Build through Mutual International Collaboration
9	GEO Satellite: Build Locally with Outside Assistance
8	GEO Satellite: Procure
7	LEO Satellite: Build Locally
6	LEO Satellite: Build Through Mutual International Collaboration
5	LEO Satellite: Build Locally with Outside Assistance
4	LEO Satellite: Build with Support in Partner's Facility
3	LEO Satellite: Procure with Training Services
2	Space Agency: Establish Current Agency
1	Space Agency: Establish First National Space Office

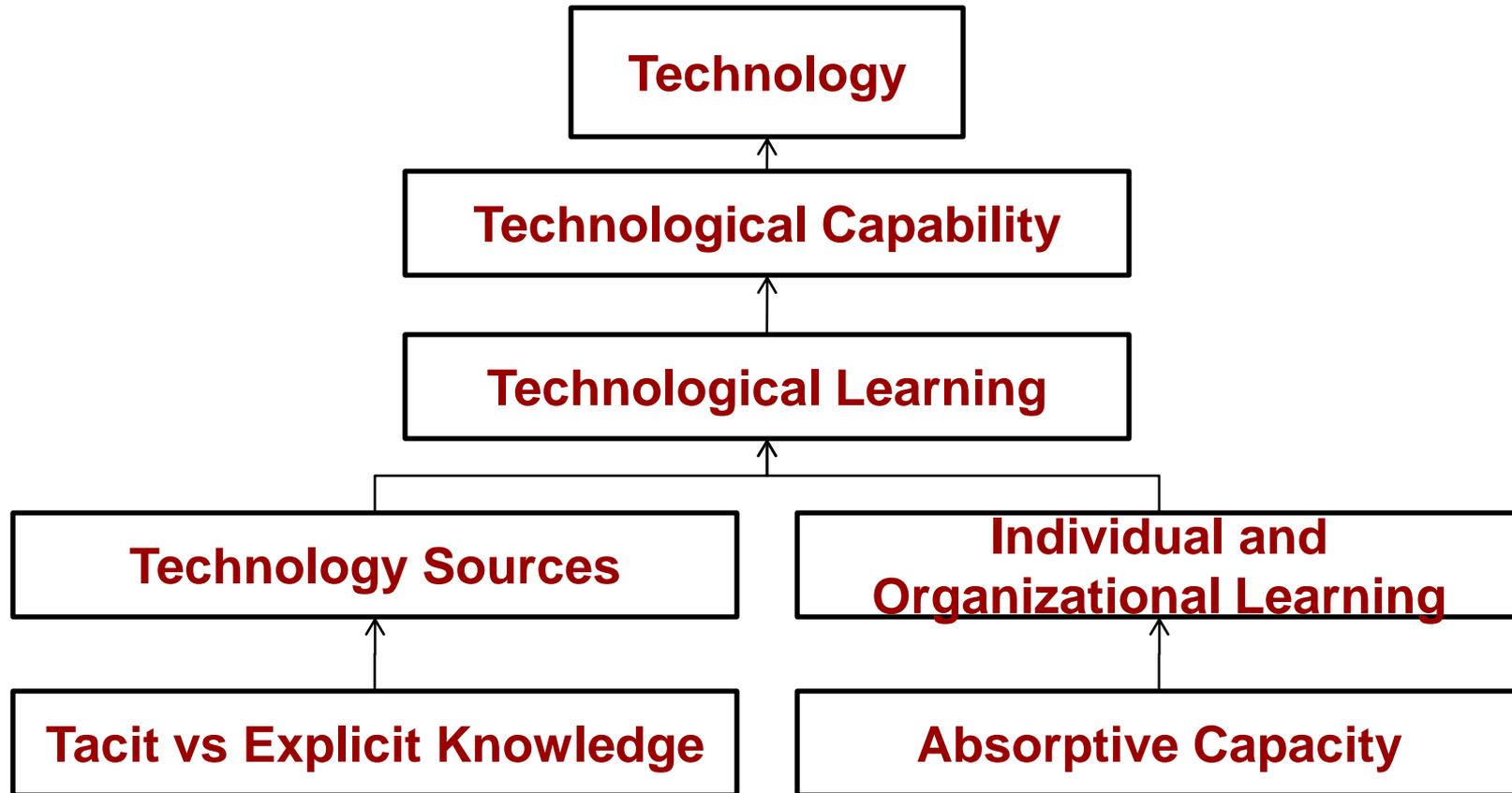
Summary - Asian Countries

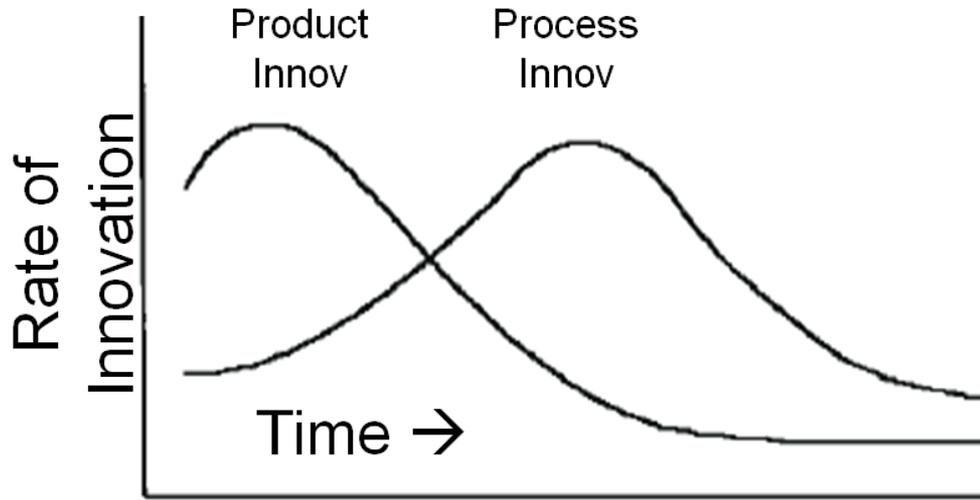
- ◆ India
- Malaysia
- △ South Korea



Some countries with new satellite programs also invest in local expertise and infrastructure



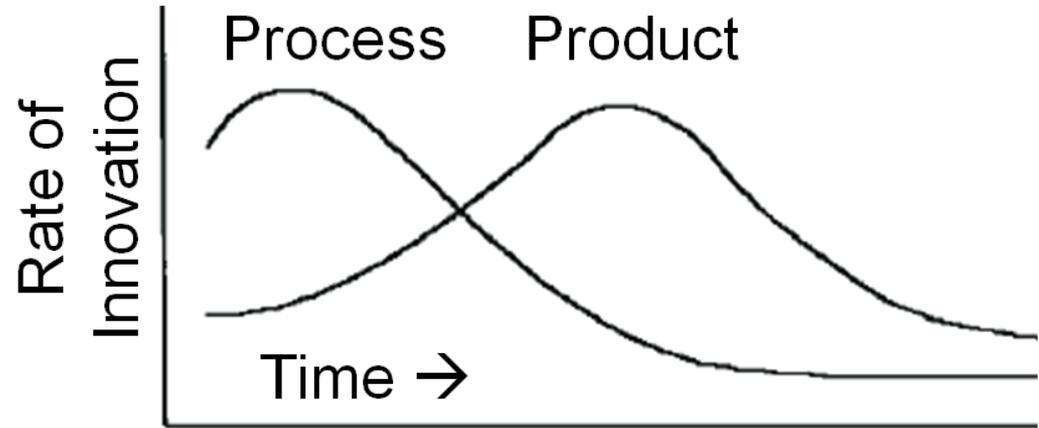




Advanced Industrial Countries

Emergence Consolidation Maturity

Developing Countries



Adapted from Utterback and Kim

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

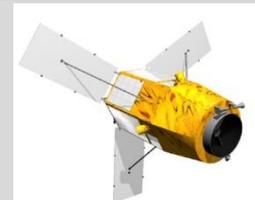
National Space Agency



KOMPSAT-1



KOMPSAT-2



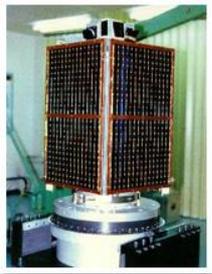
KOMPSAT-3

Technical University

KITSAT-1



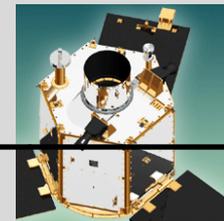
KITSAT-2



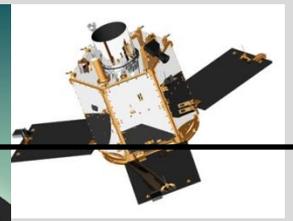
KITSAT-3



Spin-Off Firm



RazakSat (2009)



DubaiSat (2009)

Korean Firm + Malaysian Space Agency

Korean Firm + UAE University



Examples from African Satellite Programs



AlgeriaSat-1 and **NigeriSat-X** purchased from same English Firm, SSTL
(Source: SSTL)



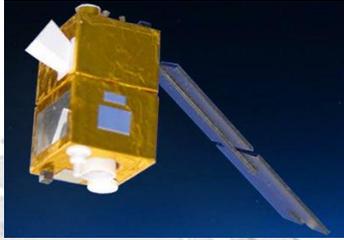
EgyptSat-1 purchased from Ukraine
(Source: Yuzhnoye)

SumbandillaSat built by South African firm, SunSpace
(Source: SunSpace)

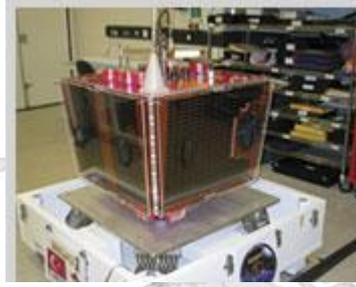




Many countries pursue collaborative satellite projects with foreign partners



Algeria



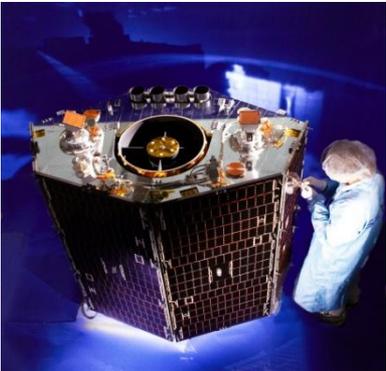
Turkey



Egypt

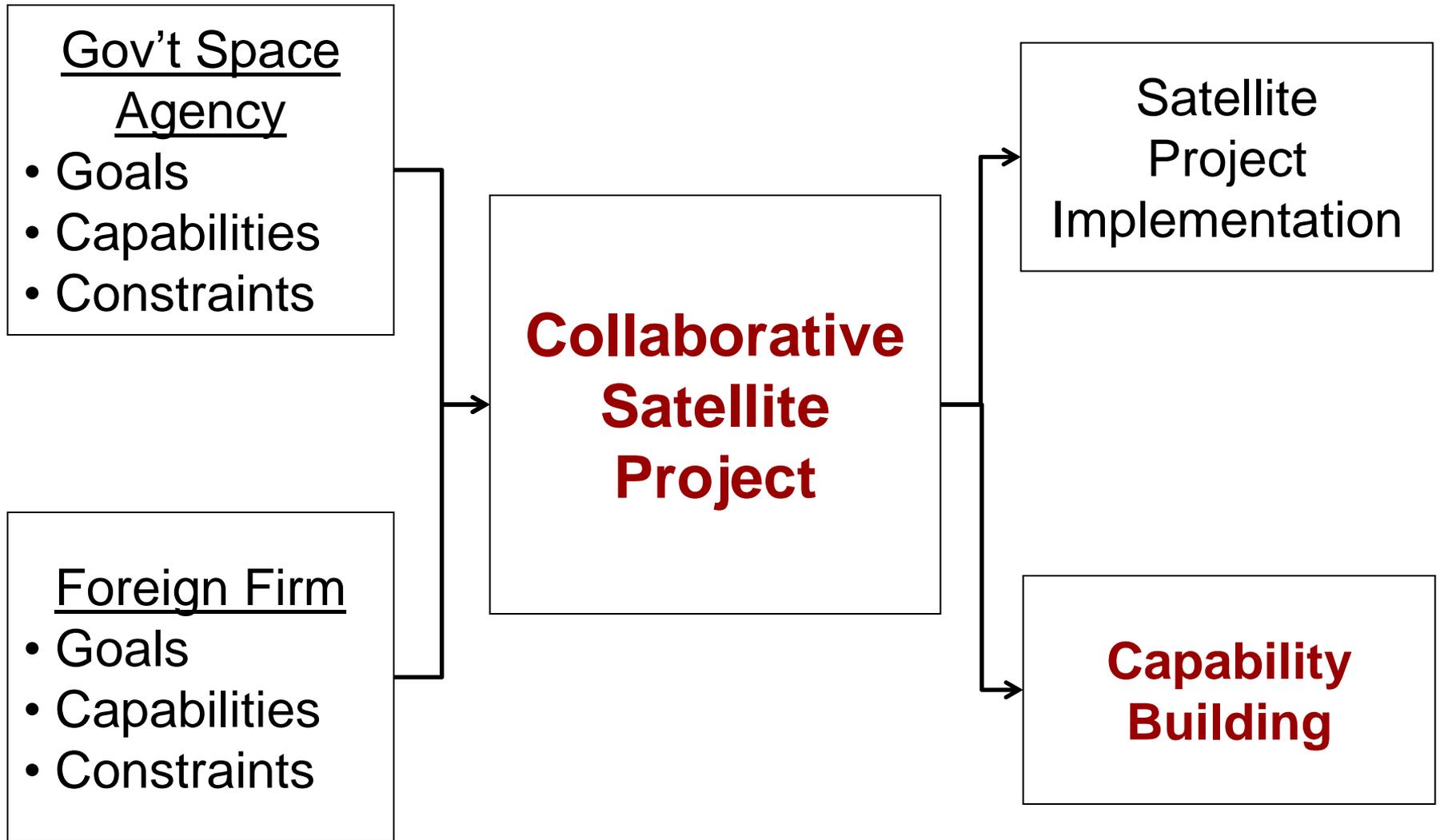
UAE

Malaysia



Nigeria





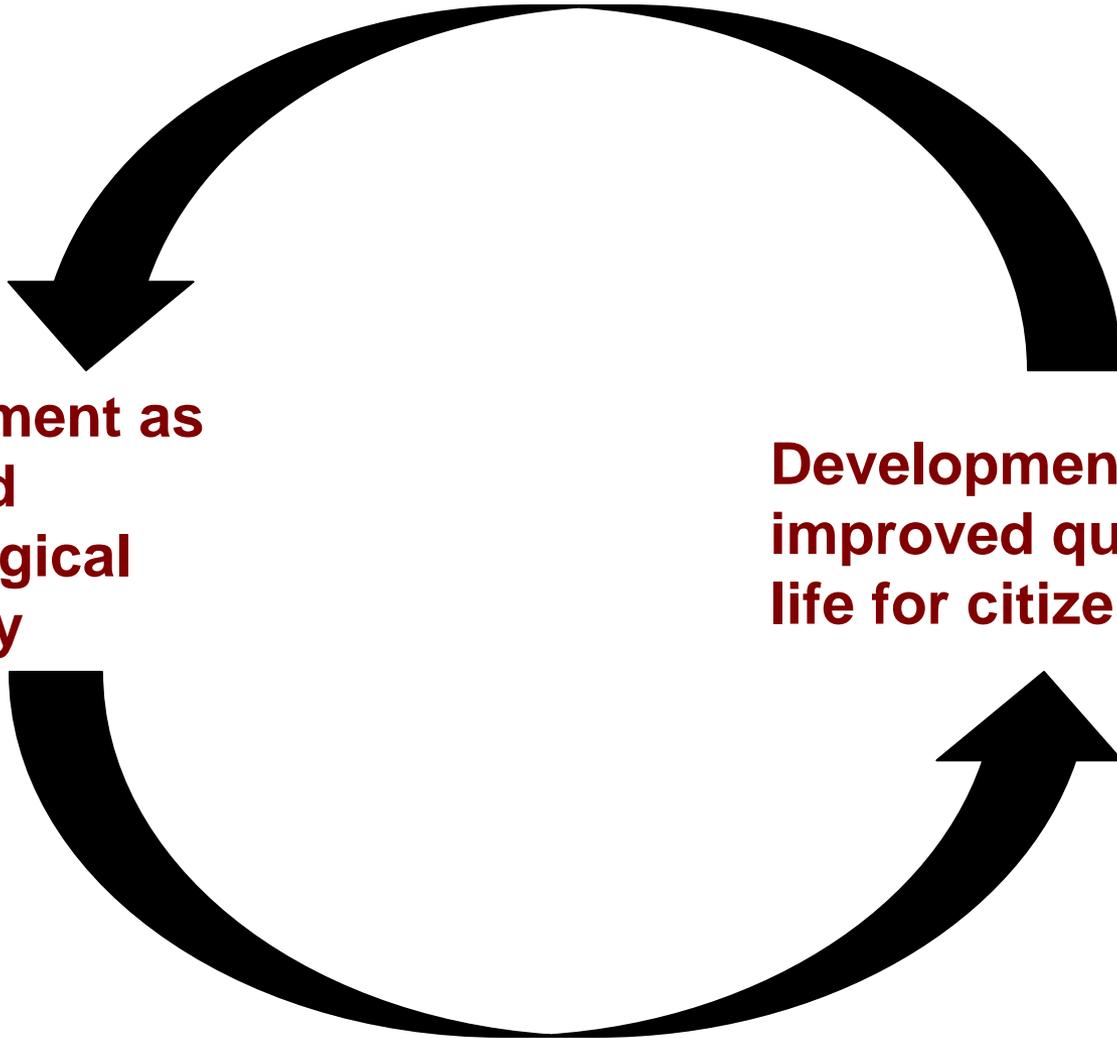
Contribution of Space Activities and Resources to National Development

- Definition of Development from Prof Alice Amsden, political economist:
 - Development is the process of transition from an economy built on **primary goods** and **unskilled labor** to an economy built on **knowledge-based assets** and **skilled labor**
- Therefore...
 - A country becomes more developed as it makes better use of knowledge and technology for productive activity

- Definition of development from United Nations Human Development Report
 - Development is the process of increasing people’s chances to obtain “a long and healthy **life, knowledge** and a decent **standard of living.**”
- Therefore...
 - A country becomes more developed as it better provides these opportunities to its citizens

**Development as
improved
technological
capability**

**Development as
improved quality of
life for citizens**



- **Applying Satellite Services:** *Using communication, earth observation, navigation*
- **Building Technological Capability:** *Investing in local space hardware, expertise and infrastructure*
- **Enabling Economic Activity:** *Founding new space-related businesses*
- **Inspiring Technology Applications:** *Deploying and facilitating space spinoffs*
- **Building Scientific Knowledge:** *Harnessing space-based science data, ground-based space science or microgravity research*

Emerging satellite technology approaches

- As satellite technology matures, new approaches are emerging
- Focus here on small satellites for optical earth observation
- Since 1980s these approaches have evolved from technology demonstrations to operational missions
- There are implications for satellite manufacturers and buyers
 - Manufacturers are pursuing non-traditional engineering approaches
 - New buyers are entering satellite market

- **Systems Engineering Approaches**
 - Use Commercial-off-the-Shelf components
 - Design specific subsystems for your organization
 - Build subsystems from component level
 - Flight qualify components or subsystem, then reuse heritage pieces
 - Define standard set of performance options
 - Build small (in mass) missions with focused requirements

- Project Management Approaches
 - Use small, focused teams
 - Balance portfolio between engineering research, technology demonstration with operational missions
 - Work with fixed price contracts
 - Carefully evaluate testing priorities
 - Look for benefits from in-house production versus outsourcing
 - Launch multiple spacecraft simultaneously to save money
 - Accept and manage risk

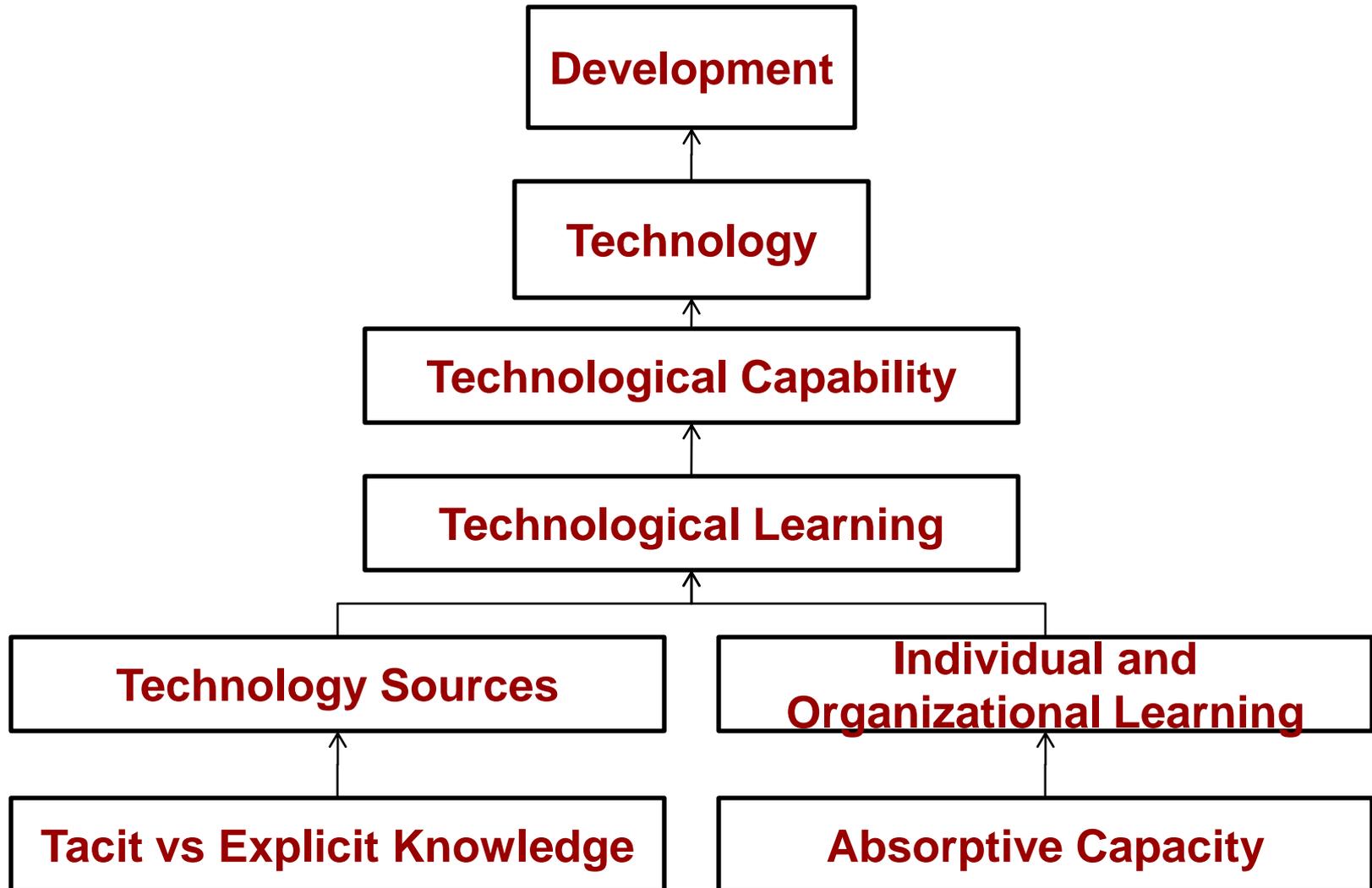
Choosing Systems Engineering and Project Management approaches that contribute to development

- Design of Satellite Systems
 - Design of Satellite Programs
-

- The engineering approaches will impact the progress of new space countries toward development and policy goals
- Design of Satellite Systems includes choosing...
 - Performance and Functionality Requirements
 - Payload, Pointing Accuracy, Memory, Processing Power, Data Rates, etc
 - Level of Autonomy
 - Satellite; Ground Control System; Data Reception, Archiving and Processing System
 - Manufacturing Approach
 - Materials and Components Sourcing

- The engineering approaches will impact the progress of new space countries toward development and policy goals
- Design of Satellite Programs includes choosing....
 - Team members and leaders
 - Training approach
 - Partners (satellite supplier, consultant, launch provider, trainer, subcontractors, etc)
 - Infrastructure and facilities
 - Team work locations
 - Mentorship approaches
 - Contracts
 - Review process

Choose the program and satellite attributes to contribute to this process



Conclusions

Implications for NASA

- It is valuable for the NASA community to stay aware of these new engineering trends and contribute to world wide satellite engineering dialog
- There may be lessons from NASA projects that can benefit the newly emerging space organizations
- There may be mutually beneficial opportunities for collaboration and partnership in areas such as...
 - Science data and instruments
 - Outreach and education
 - Shared launch opportunities
 - Spinoff Technologies

- There are several organizations that host meetings and discussion on these topics, including...
 - United Nations Program on Space Applications
 - International Astronautical Federation
 - International Academy of Astronautics
 - Committee on Space Research
 - Utah Conference on Small Satellites

Thank you!

Now it's time for discussion...

- How has Goddard innovated in systems engineering methods and approaches?
- How would you compare and contrast the methods discussed here with Goddard's satellite system engineering or program management approaches?
- What opportunities do you see for Goddard to benefit from new global space activities?
- What technologies advances may enable new satellite applications that could support global development needs?