A Multinational CubeSat for Forest Monitoring

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United Nations / Brazil Symposium on Basic Space Technology
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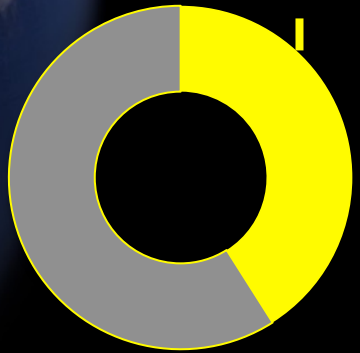
1. Background
   - Central America
   - Central American CubeSat projects
     - Costa Rica (Irazú)
     - Guatemala (Quetzal-1)
2. Baseline Work
   - Preliminary Mission Selection
   - Mechanism of Collaboration
3. Future Work
   - Integration of interested institutions and countries
   - Final Mission Selection
   - Mission Concept Design
   - Central American CubeSat Mission Design Workshop
4. Conclusions

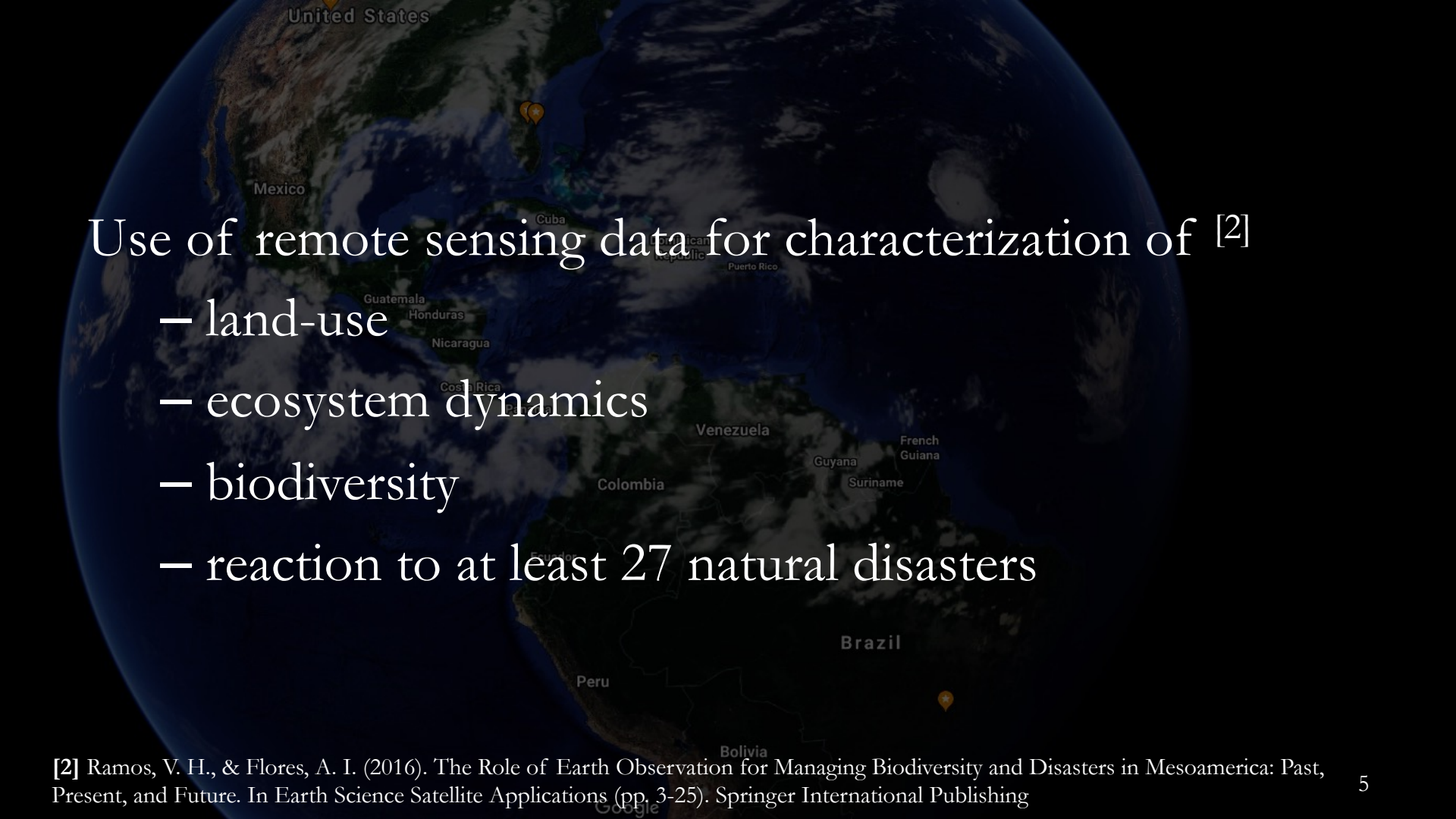
Background

- Forest land coverage [1]
  - Costa Rica: 54%
  - Central America: 41%
  - Guatemala: 33%



[1] World Bank (2017). World Bank Database - Forest Area. Retrieved from: http://data.worldbank.org/indicator/AG.LND.FRST.K2

image: Google Maps



Use of remote sensing data for characterization of [2]

- land-use
- ecosystem dynamics
- biodiversity
- reaction to at least 27 natural disasters

[2] Ramos, V. H., & Flores, A. I. (2016). The Role of Earth Observation for Managing Biodiversity and Disasters in Mesoamerica: Past, Present, and Future. In Earth Science Satellite Applications (pp. 3-25). Springer International Publishing

Current state of aerospace affairs in Central America (CA) [3]

1. Space-based imagery is already being used
2. The current development of space technologies enable CA-applicable Earth monitoring applications using the CubeSat standard
3. Active CubeSat projects in Costa Rica and Guatemala

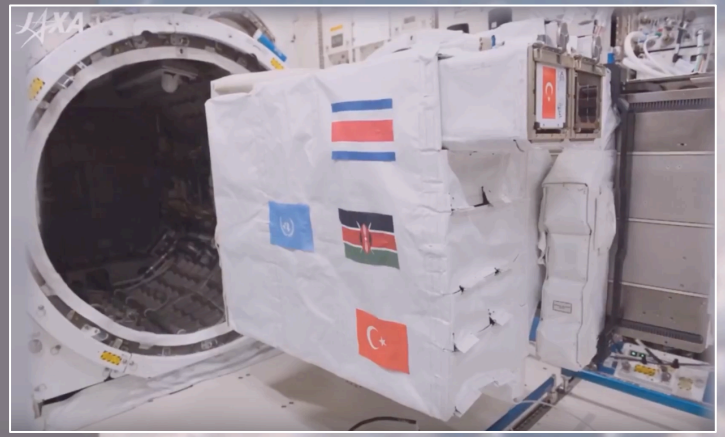
[3] Gómez Jenkins, M., García, B., Chaves Jimenez, A., García, D., Carvajal-Godínez, J., Lara, J., Zea, L., Mechanism of Cooperation for the Development of a Central American International Space Project – A Regional CubeSat, IAC-17-E3.1.11, 68th International Astronautical Congress (IAC), Adelaide, Australia, 25-29 September 2017

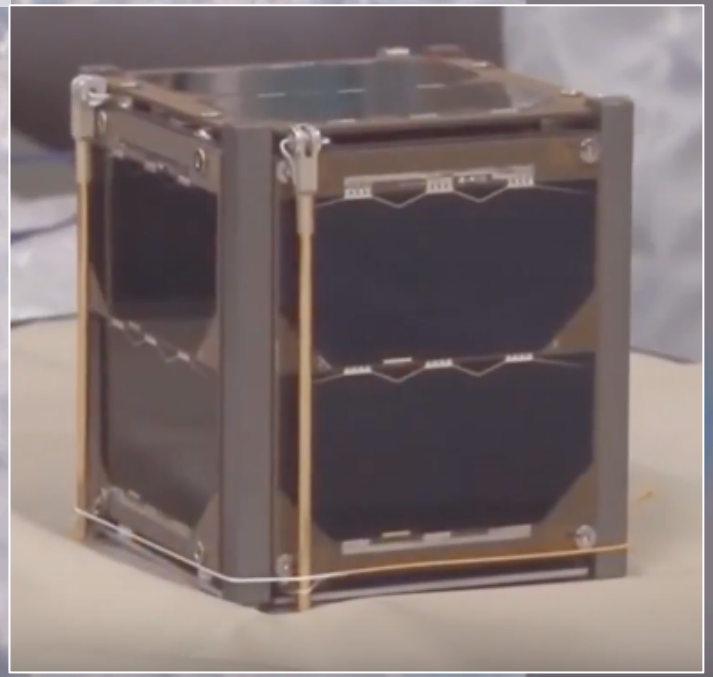
Costa Rican CubeSat: Irazú

- Developed by the Costa Rican Institute of Technology (TEC) & the Central American Association of Aeronautics and Space (ACAE)
- Mission: to monitor carbon fixation through a 'Store and Forward' approach, collecting data from dendrometers in remote forest and relaying to the Ground Control Station in Cartago (TEC)

Costa Rican CubeSat: Irazú

- Launched and deployed from ISS in 2018
- Currently active

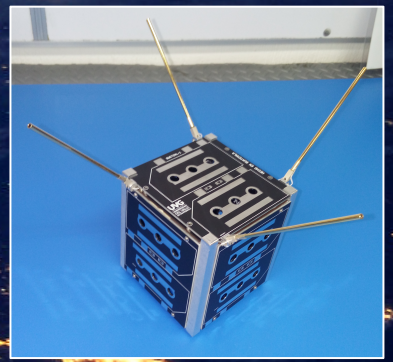




Images: JAXA

Guatemalan CubeSat: Quetzal-1

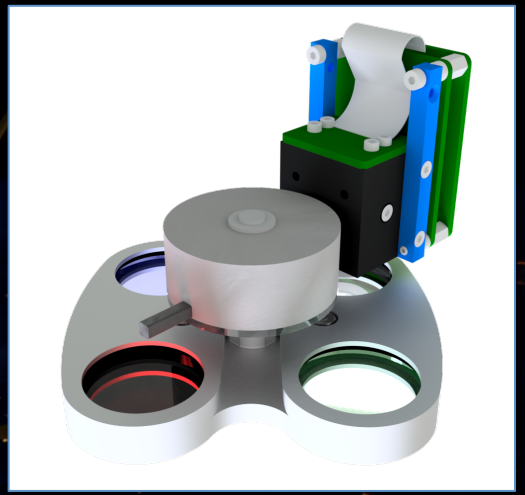
- Developed by students, faculty, and volunteers at Universidad del Valle de Guatemala (UVG) [4]
- In-house developed Structure, EPS, ADM, Passive ADCS, and Payload



[4] Martínez, M., González, D., Rodríguez, D., Birnie, J., Bagur, J.A., Paz, R., Miranda, E., Solórzano, F., Esquit, C., Gallegos, J., Álvarez, E., Ayerdi, V.H., Zea, L. (2018) Guatemala's Remote Sensing CubeSat - Tools and Approaches to Increase the Probability of Mission Success. 32nd Annual AIAA/USU Conference on Small Satellites, Logan, Utah, August 4-10, 2018

Guatemalan CubeSat: Quetzal-1

- Payload: Monochromatic sensor with motorized carrousel
- Carrousel enables changing light filters for myriad applications
- Proof-of-concept: water color monitoring (algal bloom – water contamination)



Winner of the 2nd UNOOSA/JAXA KiboCube Opportunity to be launched to and deployed from ISS in 2019

Baseline Work

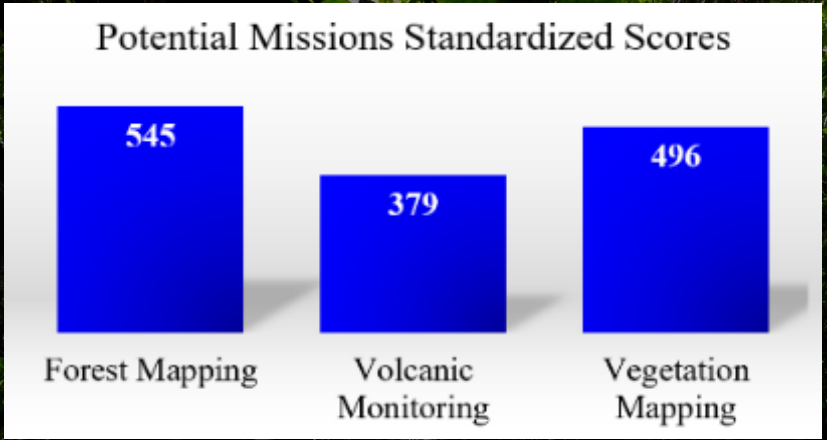
Preliminary Mission Selection

- A CubeSat mission selection tool [5] was used to select the Central American CubeSat mission
- The methodology takes into account (*i*) programmatic risk, (*ii*) technical feasibility, (*iii*) relevance, (*iv*) resources, and (*v*) benefits
- Enables to quantitatively compare mission options

Parameter	Importance
Natural resources	4
Relevance	4
Budget	4
Risk	3.9
Education	3.7
Applied Research	3.6
Impact on personnel	3.6
Alignment w/other projects	3.3
Technology development	3.3
New markets	3.1
Team leadership	3
In-house knowledge	2.9
Natural disasters	2.9
Basic Research	2.7
External alliances	2.7
Marketing	2.7
New technologies	2.7
Time	2.7
Technical / Infrastructure	2.6
Products / services	2
Health	1.9
Human resource retention	1.9
Job creation	1.9
Economic productivity	1.7
New customers	1.6
Return of Investement	1.6
Exports	1.4
Intelectual Property	1.4

[5] Zea, L., Aerdi, V., Argueta, S., Muñoz, A. (2016). A Methodology forr CubeSat Mission Selection, Journal of Small Satellites, JoSS, Vol. 05, No. 03, pp. 483–511

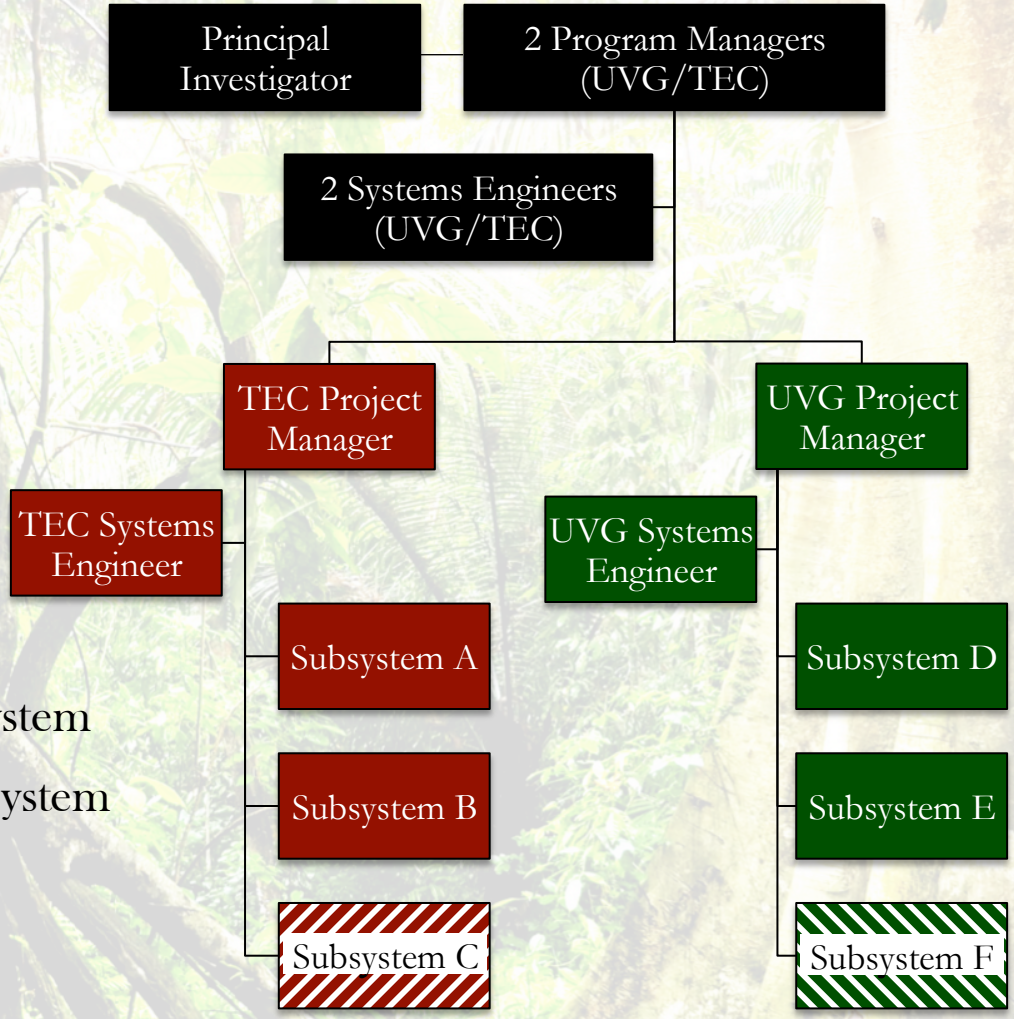
Preliminary Mission Selected: Forest Mapping



- Differentiate land use – forest vs. agroindustry, cities, desert, etc.
- Enable prompt reaction to illegal deforestation and for the conservation and protection of natural resources

Mechanism of Collaboration

- Supranational
- TEC
- UVG
- TEC managed, non-TEC subsystem
- UVG managed, non-UVG subsystem



Future Work

Future Work

- Integrate other interested institutions and countries
- Final Mission Selection
- Mission Concept Design
- Central American CubeSat Mission Design Workshop


Publicize Opportunity
Integrate new members
Acquire funds for Workshop
Workshop

Central American CubeSat Mission Design Workshop

- Application pitches by topic experts (3-4 potenital applications)
- Application selection
- Training on Mission Concept Design (MCD) (by international experts)
- MCD Development
- MCD selection
- Mission Concept Review (MCR) (reviewed by international experts)

Central American CubeSat Mission Design Workshop

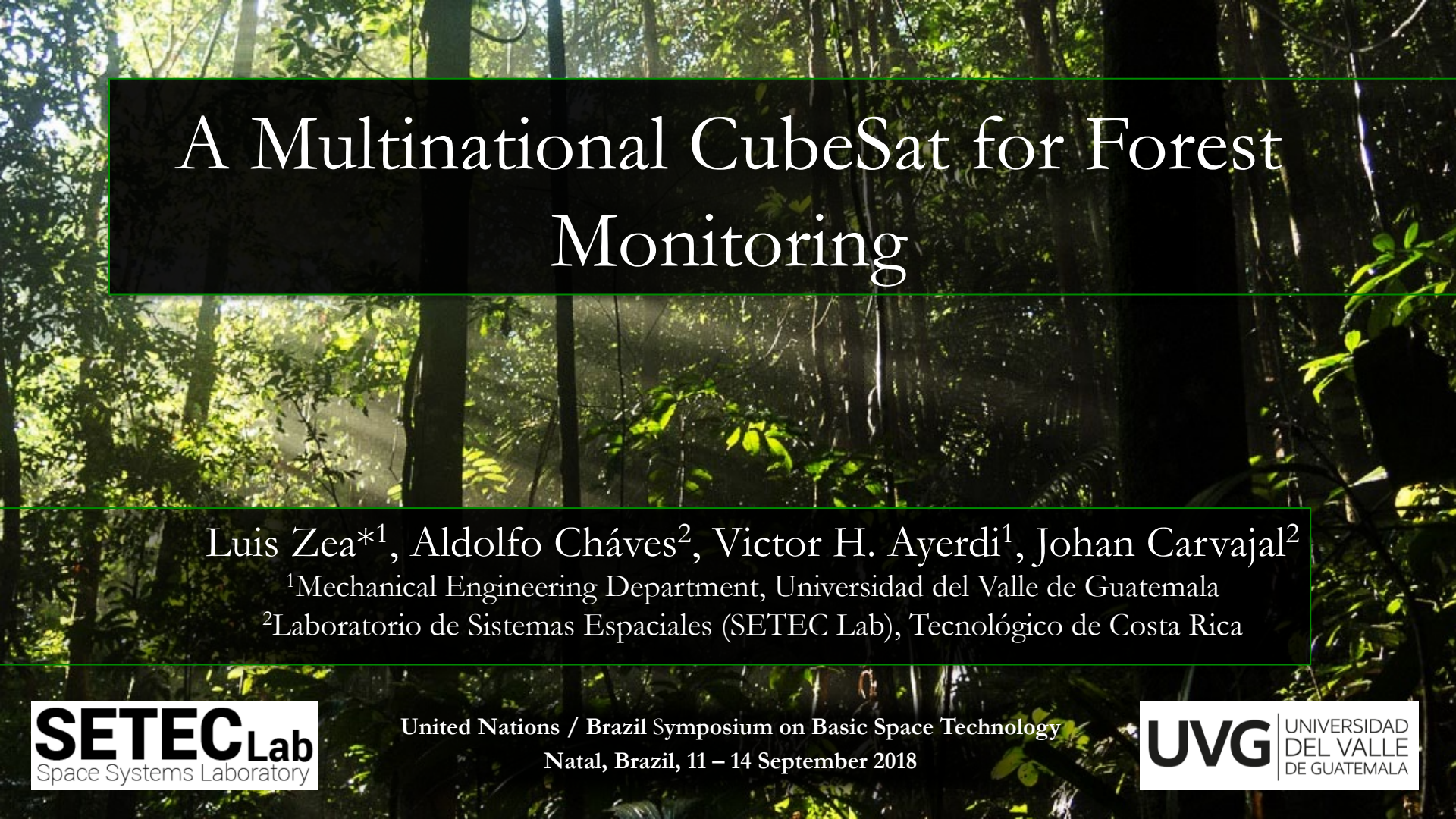
Participants (total of 36, planned max of 50)

- Two topic experts for each of the four potential applications (8)
- Two international experts on MCD (2)
- Two special guests (experts on other topics, e.g. policy, management, etc.) (2)
- Six engineers/scientist from each leading institution (TEC, UVG) (12)
- Two engineers/scientist from each Central American country (14)

Conclusions

Conclusions

- C.A. is on initial steps to change from space data *consumer* to *producer*
- Costa Rica has an operational CubeSat, Guatemala plans to launch its own in 2019
- C.A. CubeSat proposed to galvanize collaboration
- Methodology used for the preliminary selection of a mission: forest mapping
- Supranational *Program* Management, per-institution *Project* Management
- Program structure designed to incorporate other interested institutions/ countries
- Workshop planned for application selection and Mission Concept Review



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