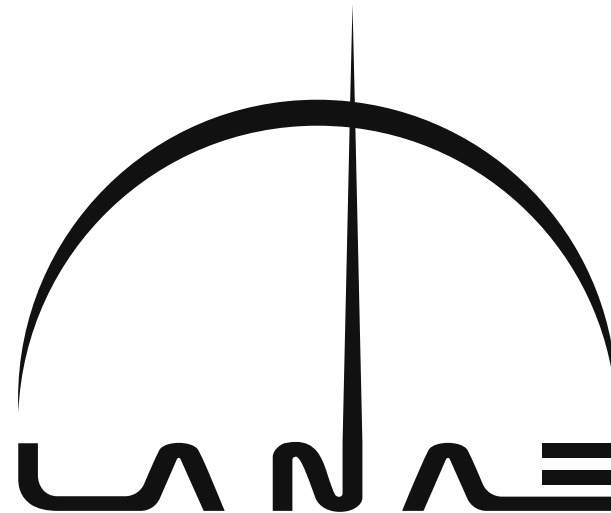


# Nano-Satélites y Micro-robótica espacial

## Raíces de una estrategia para disparar Espacio 4.0 en Latinoamérica

**Gustavo Medina-Tanco**

Laboratorio de Instrumentación Espacial,  
ICN-UNAM-México  
[gmtanco@nucleares.unam.mx](mailto:gmtanco@nucleares.unam.mx)



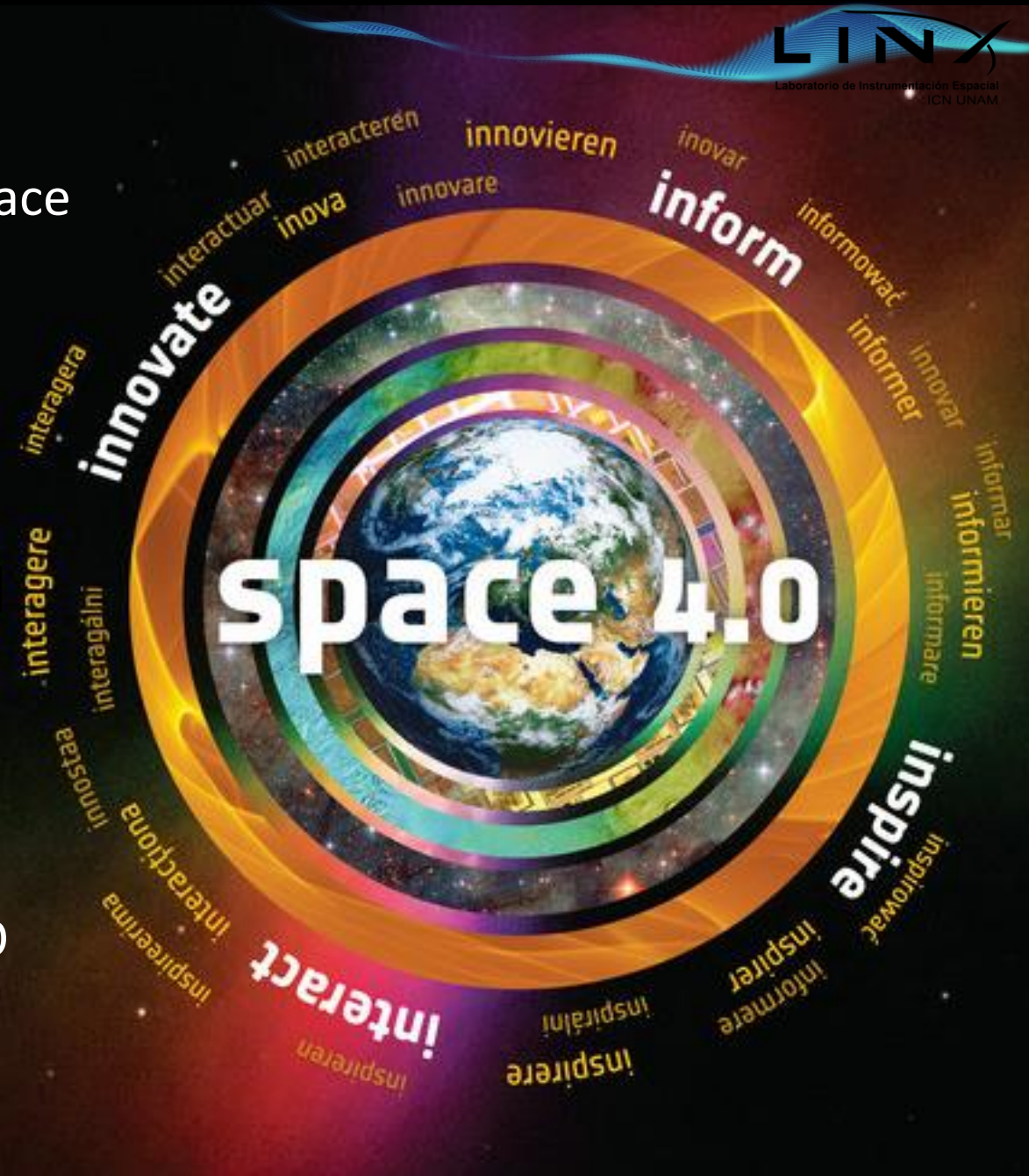
Laboratorio Nacional de  
Acceso Estratosférico

# Revolution in Access to space and space technologies

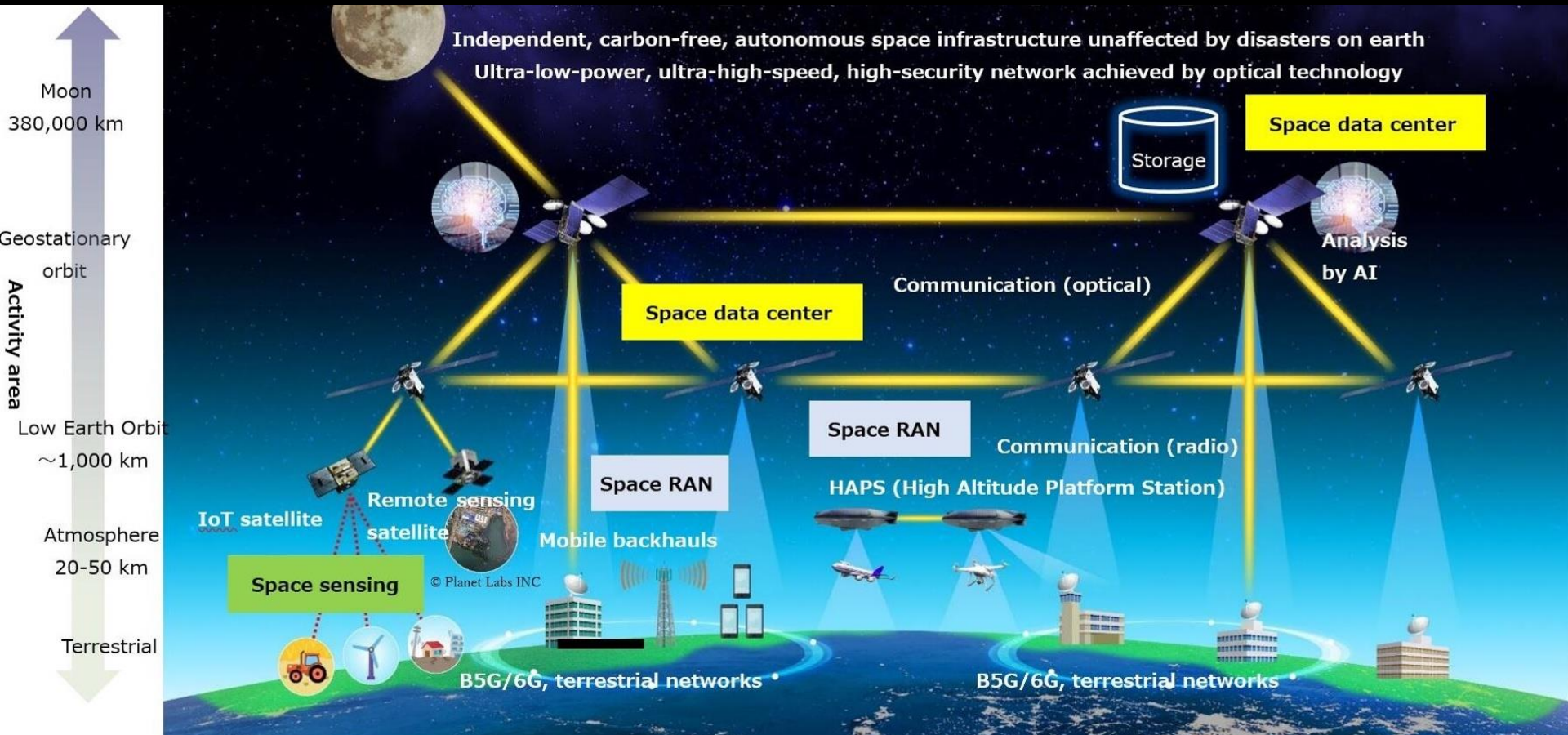
- Actors
- Aplicationes
- Solutions

TODAY most notably @ Low Earth Orbit

NEAR FUTURE beyond LEO

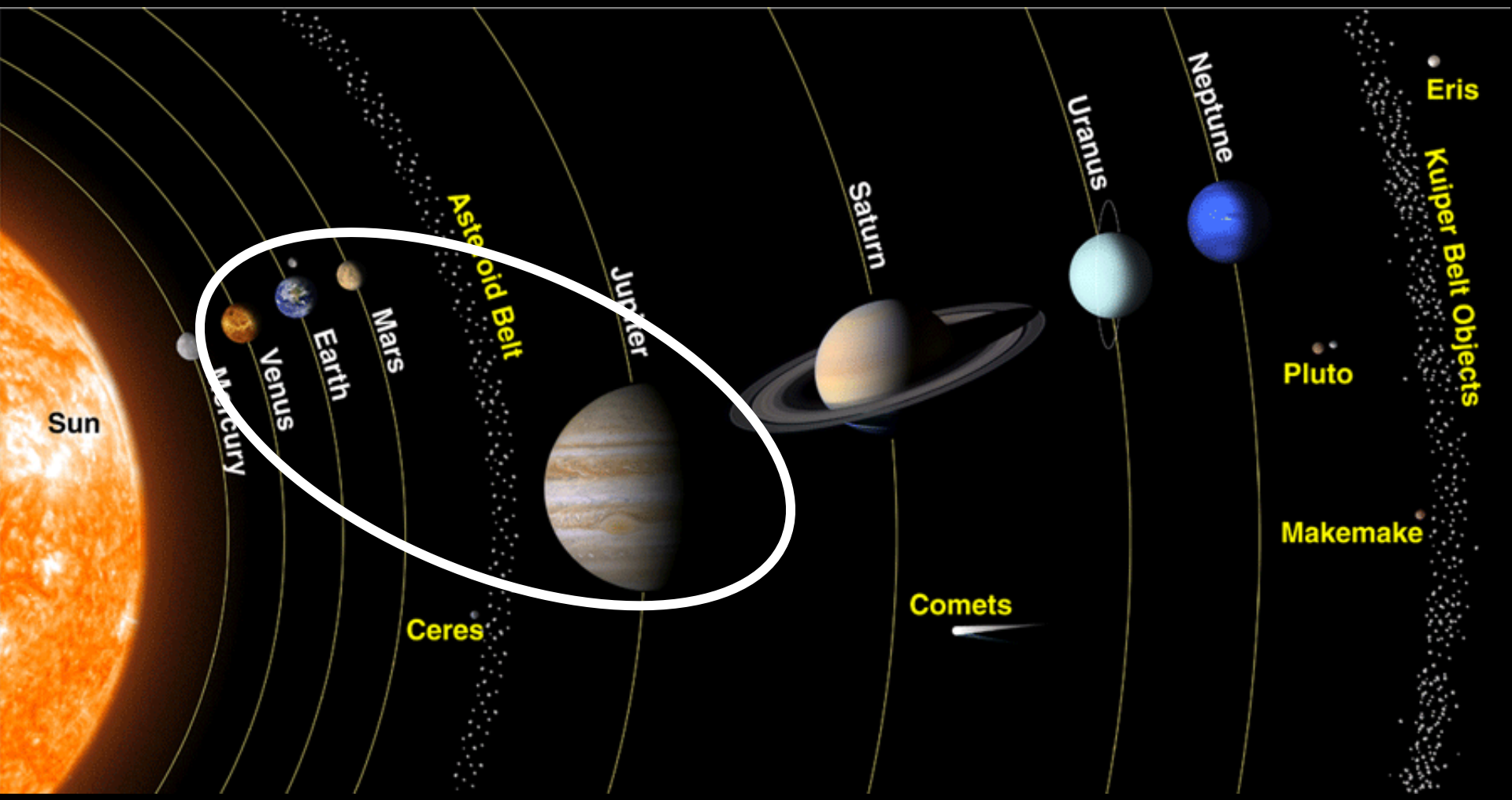


# Space 4.0 through an example





... SOOM at least at the Moon, near asteroids  
Mars and the Galilean satellites



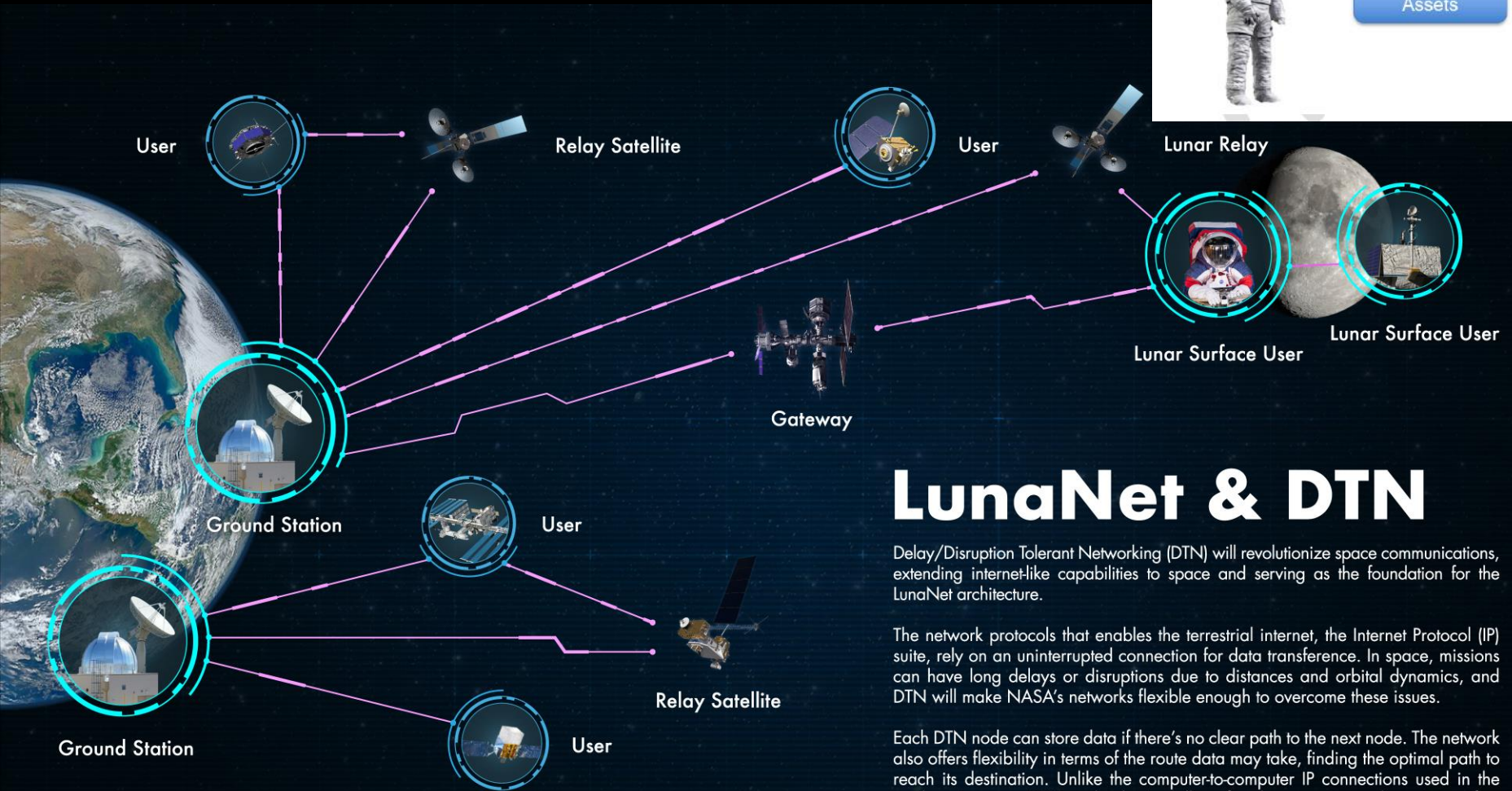
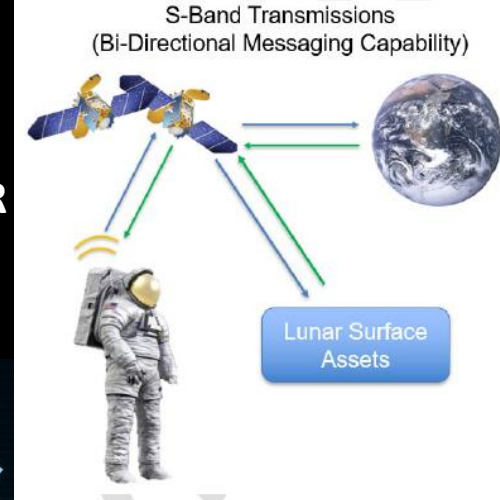
# The Gateway

LINK



# LunaNet

+LunaSAR



*\*Conceptual visualization. Not meant to show actual present or future network architecture. Not to scale.*

## LunaNet & DTN

Delay/Disruption Tolerant Networking (DTN) will revolutionize space communications, extending internet-like capabilities to space and serving as the foundation for the LunaNet architecture.

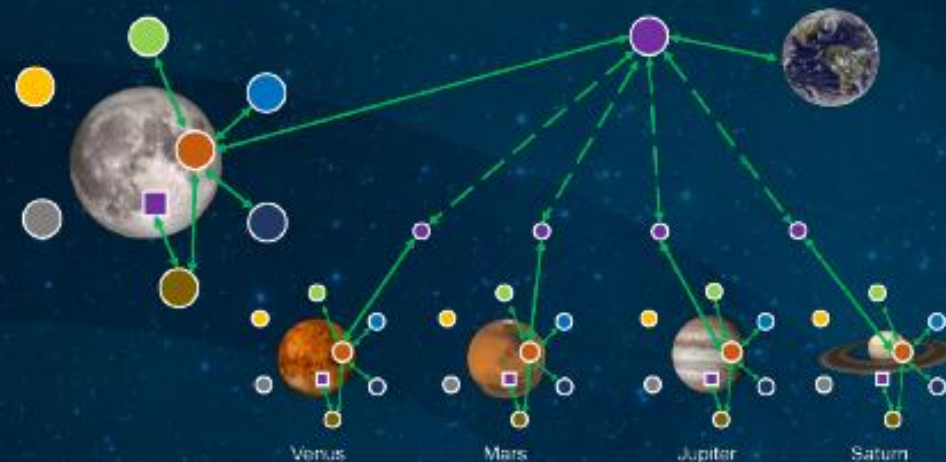
The network protocols that enables the terrestrial internet, the Internet Protocol (IP) suite, rely on an uninterrupted connection for data transference. In space, missions can have long delays or disruptions due to distances and orbital dynamics, and DTN will make NASA's networks flexible enough to overcome these issues.

Each DTN node can store data if there's no clear path to the next node. The network also offers flexibility in terms of the route data may take, finding the optimal path to reach its destination. Unlike the computer-to-computer IP connections used in the modern internet, DTN technologies allow for the temporary disruptions often experienced by spacecraft far from Earth.



# LunaNet

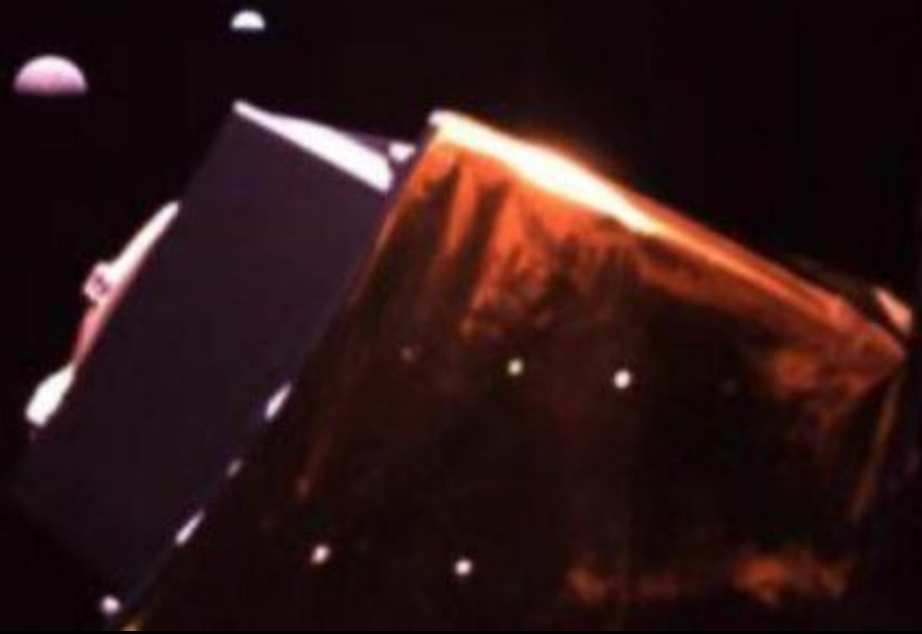
1. LunaNet is a flexible and scalable architecture for the provision of Network, PNT, and Science Utilization Services at the Moon.
2. The infrastructure can be built up over time as mission requirements and operations concepts evolve.
3. SmallSats can be providers or users of the LunaNet architecture.
4. Infrastructure nodes can be provided by any combination of NASA, commercial, or other partner systems.
5. The LunaNet architectural approach is applicable to any planetary body to establish the solar system internet.



# China is another important independent player

The moon and distant Earth seen from Earth-moon Lagrange point 2 by the Queqiao relay satellite.

Earth  
Moon



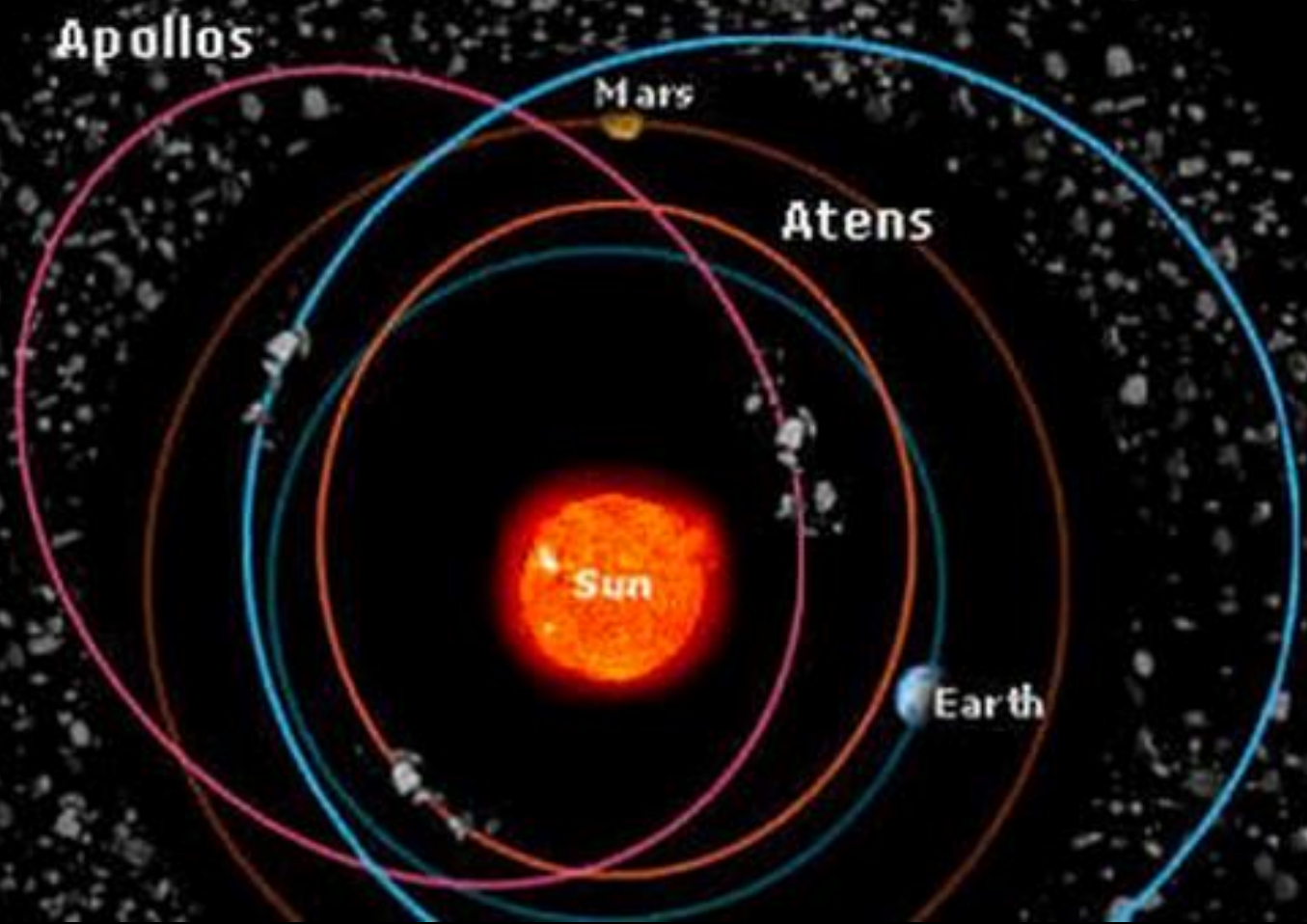


# China lunar program

- Chang'e 1: orbiter
  - Chang'e 2: orbiter
  - Chang'e 3: Lander + rover (near side)
  - Chang'e 4: Relay satellite +Lander + rover (far side)
  - Chang'e 5: Sample return (near side)
  - Chang'e 6: Sample return (far side / South pole) **2024**
  - Chang'e 7: Orbiter + Relay satellite +Lander + rover + flying probe (far side / South pole) **2024**
  - Chang'e 8: ISRU, 3D printing **2025+**
  - ZhengHe: near-Earth asteroid 2016 HO5 – return 0.2 -- 1 kg sample **2025+**
  - Lunar base: orbital, 60 tons **2030's**
- Already done and successful

Scientific exploration  
... but also commercial exploitation

LINK



# The Moon has valuable resources

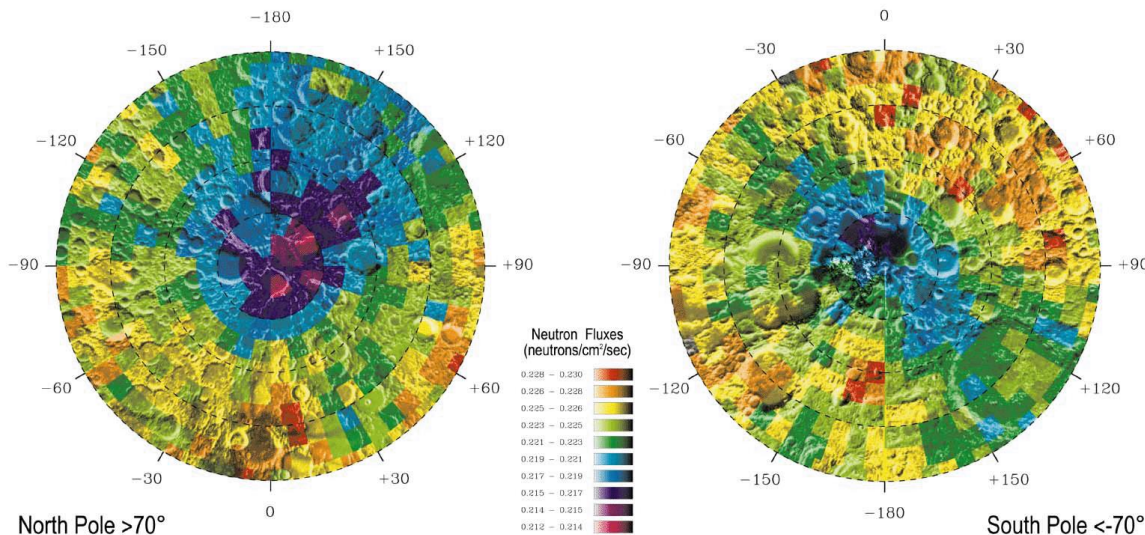
- Water
- $^3\text{He}$
- Rare earth metals
- Aluminum, Thorium, Uranium ....



SOFIA Oct/2020 – H<sub>2</sub>O

dispersed sunny regions  
Clavius crater

- 340 cm<sup>3</sup>/m<sup>3</sup>
- x100 less than in the Sahara



Dark (cold) craters in the  
Moon poles

- 1–3 km<sup>3</sup> of water

## Neutron emission

Purple&DarkBlue H-rich deposits (H<sub>2</sub>O?) covered  
by dry regolith (?)



Hands-on  
education  
on space



Concrete projects

International collaboration  
Astroparticle physics  
Ultra-high energy cosmic rays



- space
- stratosphere

small engineering projects



- laboratory
- stratosphere

nanosatellites  
sub-system validation  
imaging  
space weather



- space
- stratosphere

Micro-robotics  
autonomous operation  
Science



- space
- Moon

Frontier physical science  
as a driver

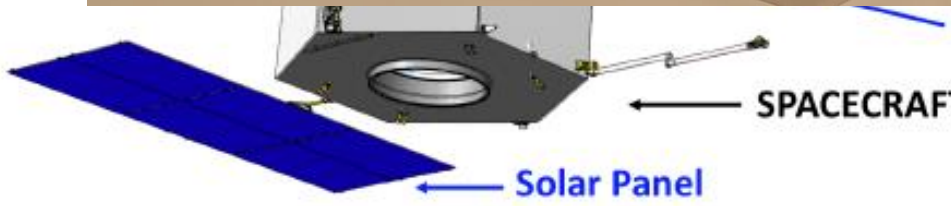
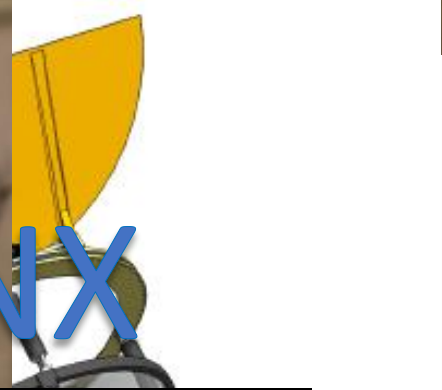
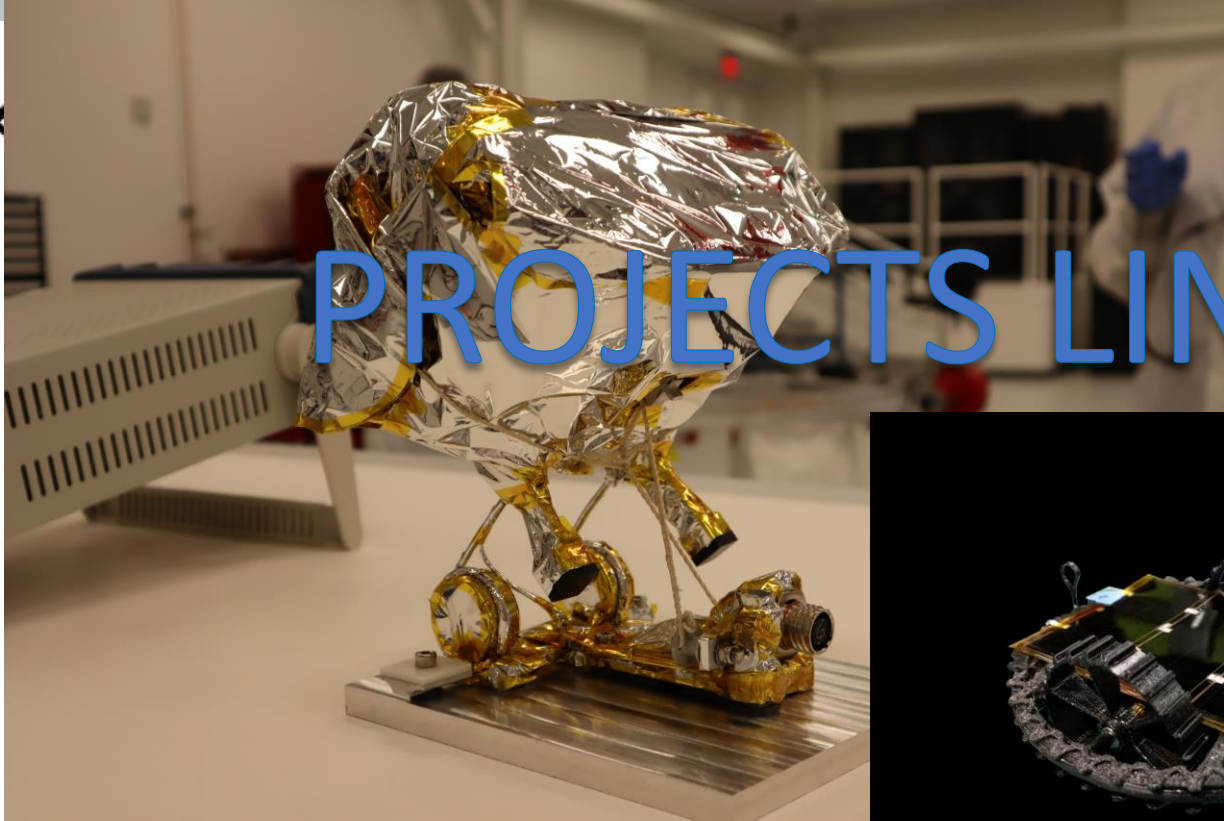
- Valid purpose
- Standards of quality
- Strict chronogram
- Two-way cooperation among equal partners
- Know how transfer through interface implementation
- Access to basic and applied research founding

**scientific international  
consortia**



**+ independent projects**

# PROJECTS LINX



Data Processor





# The vision of LINX

This is the pathway we are starting to develop with the COLMENA mission



Cooperative platform as a complementary tool for interplanetary exposed surface exploration / exploitation

## Cooperative micro-robotics



- ✓ Self-organization
- ✓ Low cost
- ✓ Simplicity
- ✓ Robustness
- ✓ Replaceability
- ✓ Low *g* suitability
- ✓ Specificity



# Self-organization based on pre-programmed interaction rules

**COLMENA: 5 units on the ground**



*RND start*

Energy  
Interaction  
Time  
→



- #1: navigation*
- #2: clustering*
- #3: limit-layer science*

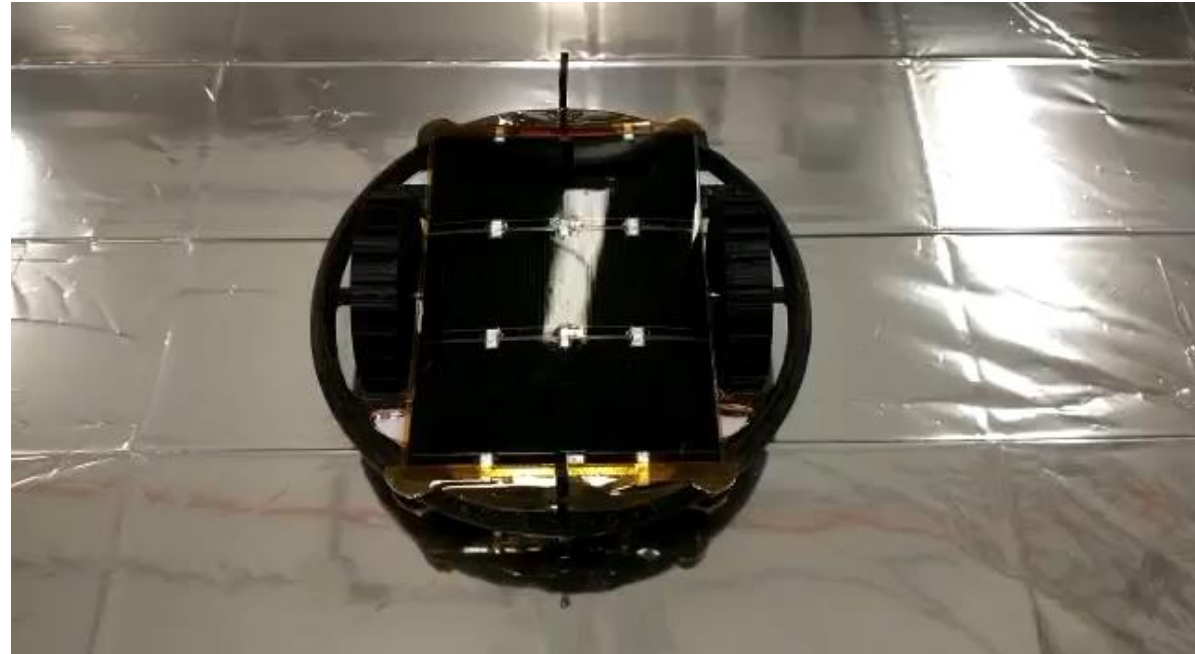
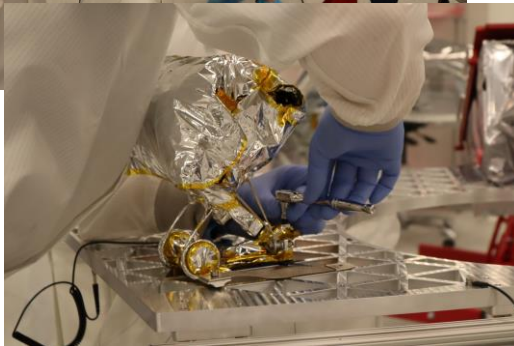
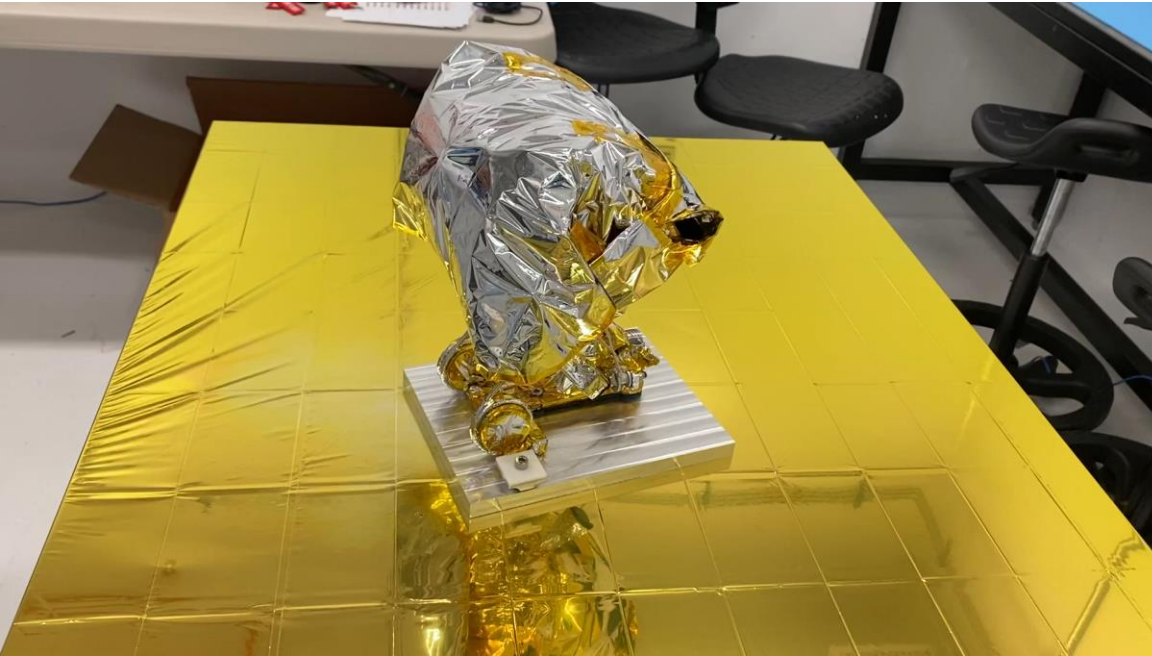




**Astrobotic (Peregrine)**  
**Launch : Q4/2022**

**The validation laboratory MUST be REALISTIC**

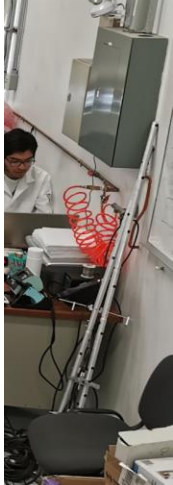
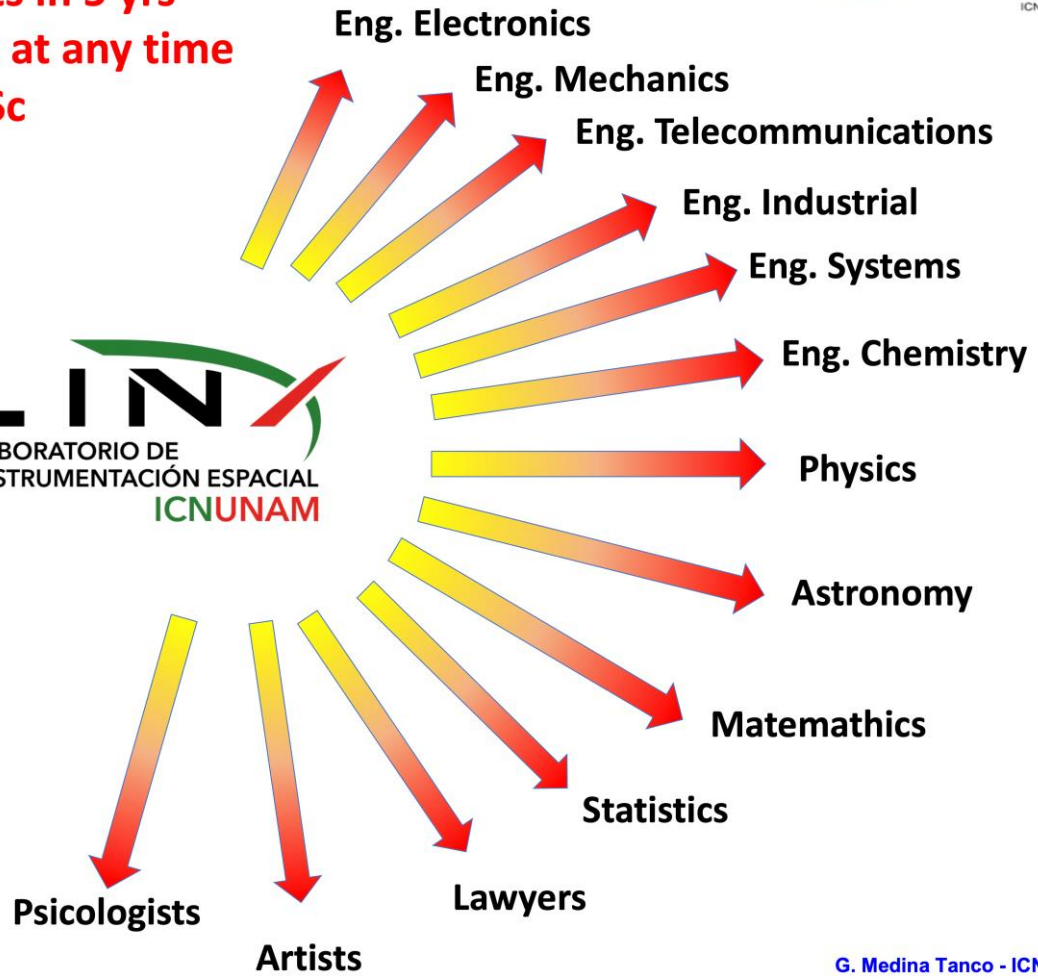
## on the Moon in 2022







**~250 students in 5 yrs**  
**~50 students at any time**  
**PhD, MSc, BSc**

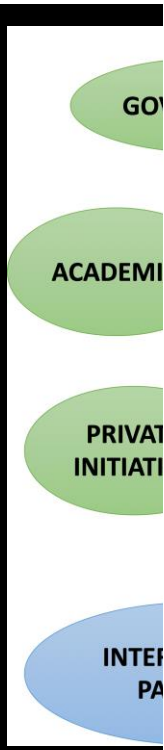


G. Medina Tanco - ICN/UNAM





# LANAE in Hidalgo: the next step



## COMMON SPACE

- Design
- Manufacturing
- AIT
- Stratospheric validation
- Human social and technical interaction
- Mission control
- Ground station

## OPERATION PHILOSOPHY

- Proprietary projects
- Support to external projects
- Visitors stays (with access to infrastructure)

## USERS

- Academia
- Private companies
- Government

## STARTUP INCUBATION

- Support to young innovators/students
- Coworking and technical infrastructure sharing
- Market generation through our own projects

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