INTERNATIONAL® SPACE UNIVERSITY

MSS20 TEAM PROJECT

# CHIPSATS

## New Opportunities

EXECUTIVE SUMMARY

# MISSION STATEMENT

*"To envision innovative ChipSat applications which will inspire the space community, by analyzing technology and potential markets, and establishing a Roadmap for ISU to launch their own ChipSats within three to five years. Our path will encourage a sustainable relationship between the cosmos and humanity while promoting respect, professionalism, and team bonding."*

## Defining ChipSats

***ChipSats are a credit-card sized, sub-10-gram satellite***

The miniaturization mantra of "faster, better, cheaper" is driving technological innovation toward ever-smaller spacecraft. From the early massive titans that launched into space to CubeSats, spacecraft have been dropping in size and mass.

This progressive downscaling in satellite design has led to the emergence of an intriguing new generation of satellites, ChipSats.



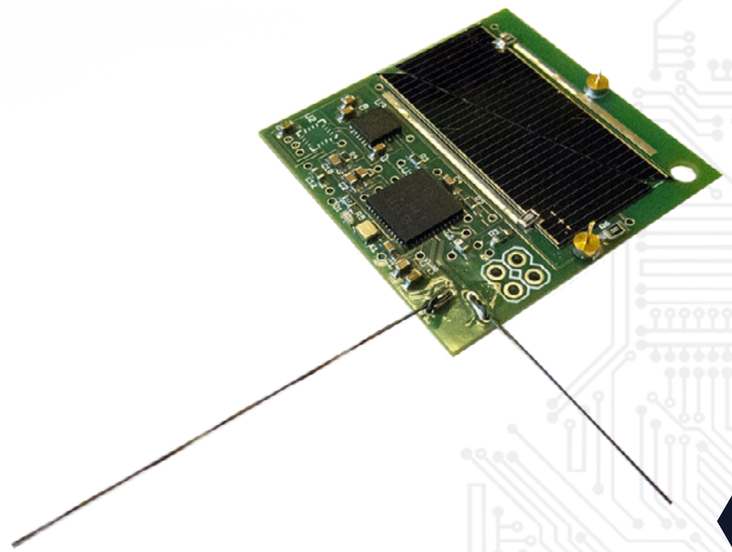
## Miniaturized Satellites

The advent of ChipSats symbolizes a shift in the conventional paradigm of satellite design, where high development costs trade against mission risk. Unlike traditional satellite design, ChipSats require simple, swift, and economical manufacturing techniques, unlocking unprecedented levels of flexibility.

## Great Potential

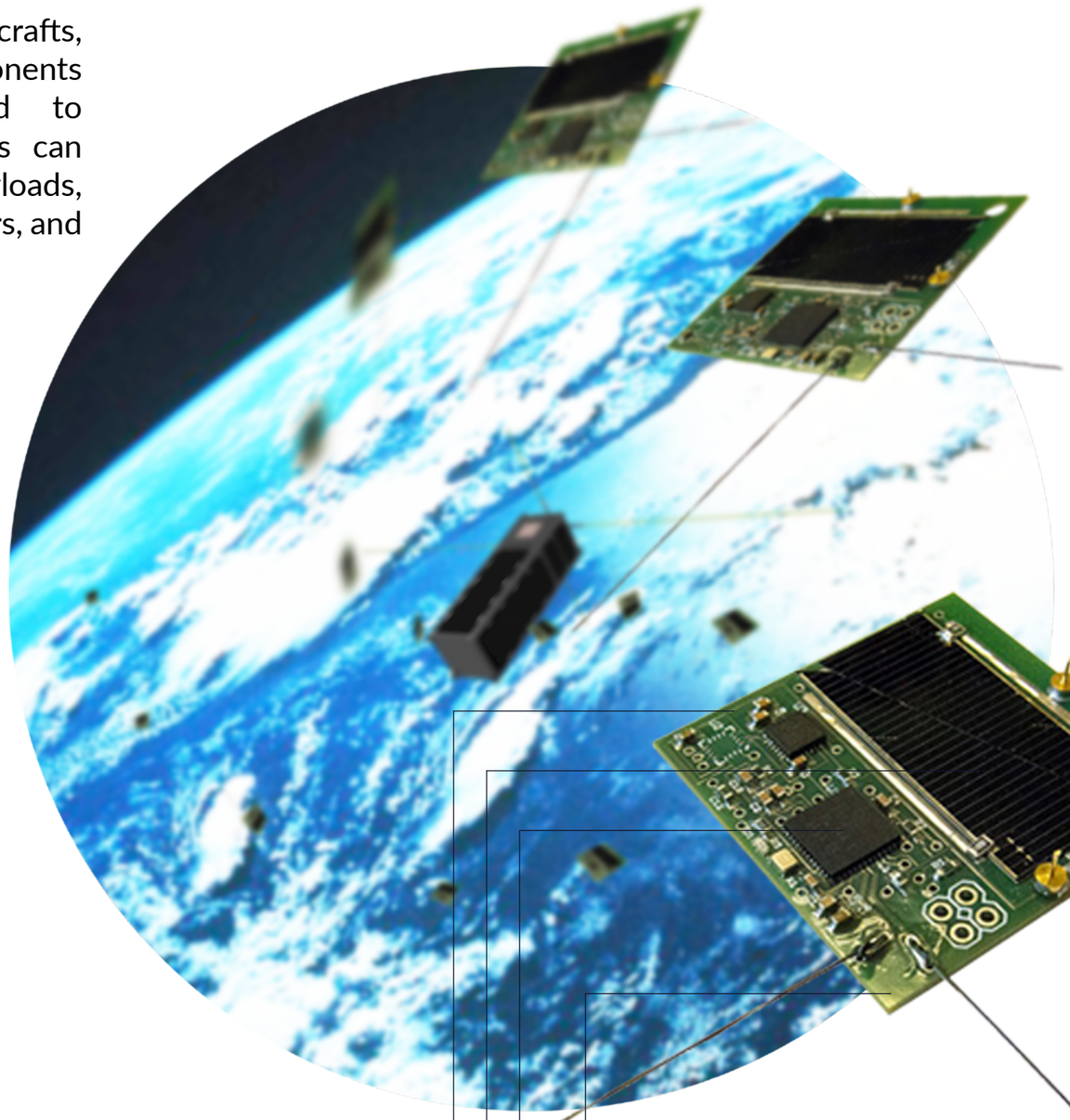
Leveraging these features can disrupt the space industry by democratizing space and enables the development of radically different space missions. ChipSats presents a unique opportunity for the space community. Space agencies and commercial entities can investigate unprecedented possibilities for space exploration using innovative ChipSat architectures. Academic institutions and educators can use ChipSats to reinforce the delivery of space education and spark wonder in space aspirants.

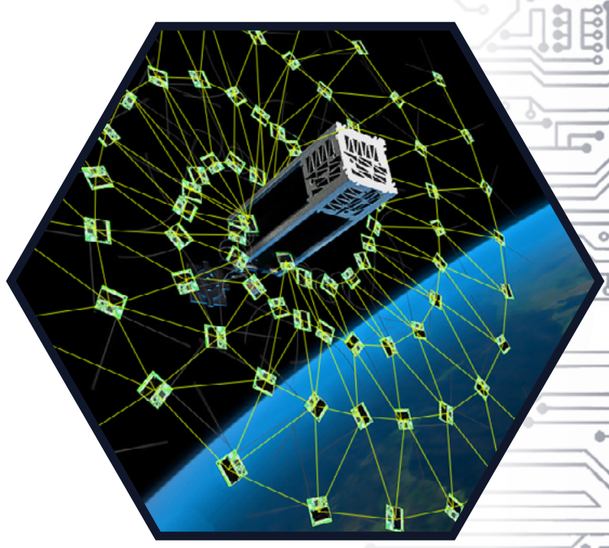
*Sputnik-1 weighed 83.6 kilograms and transmitted a simple beep. ChipSats can demonstrate the same at under 10 grams.*



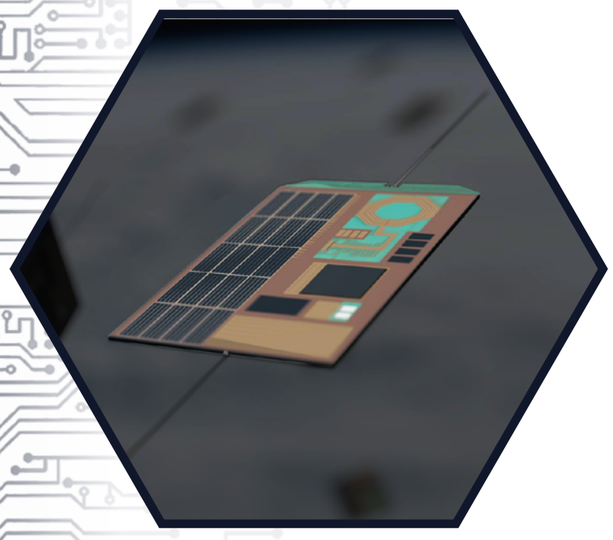
# ChipSat Crash Course

ChipSats are fully-functional spacecrafts, incorporating several core components and software packages, required to sustain satellite operations. ChipSats can accommodate various miniaturized payloads, such as magnetometers, accelerometers, and Ultraviolet (UV) sensors.





**The Swarm**



**The Spacecraft**

Structure (PCB)

Electrical Power Subsystem (Solar Cells)

On-Board Data Handling

Thermal Protection System (coating)

Communications (Omni-directional antenna)

A streamlined manufacturing approach for large-scale ChipSat replication permits the creation of extensive satellite architectures, including swarms. A swarms is a constellation of tightly knit ChipSats, enabling simultaneous multi-perspective data collection of phenomenons in space.

# ISU ChipSat Roadmap

The ISU ChipSat Roadmap is a proposal to the International Space University (ISU) to design, assemble, test, and launch a ChipSat into Low Earth Orbit within a five-year timeframe.

## ISU ChipSat Program

Implement the required elements for ISU to develop educational and manufacturing capabilities of ChipSats within five years:

Educate students on ChipSats technologies and subsystems.

Develop skills to design PCB, power storage capabilities, attitude and orbit control and mission management software.

Establishing the facilities for ChipSat Assembly, Integration, and Testing.

The Roadmap addresses ISU Strategic Goals by integrating the required ChipSat research and development with set space education targets.

## Regulatory Framework

The key regulatory and legal aspects to consider are:

**Frequency Allocation**
Approval of the registered frequencies from ANFR

**Space Object Registration**
Approval of the registered frequencies from ANFR

**License**
Obtain License/permit of CNES to launch operate

**Space Debris Mitigation Measures**
Comply with the IADC guidelines

The three core elements underpinning the delivery of the ISU ChipSat mission are: *[1] ISU ChipSat Program, [2] Regulatory Framework, and [3] Outreach Activities.*

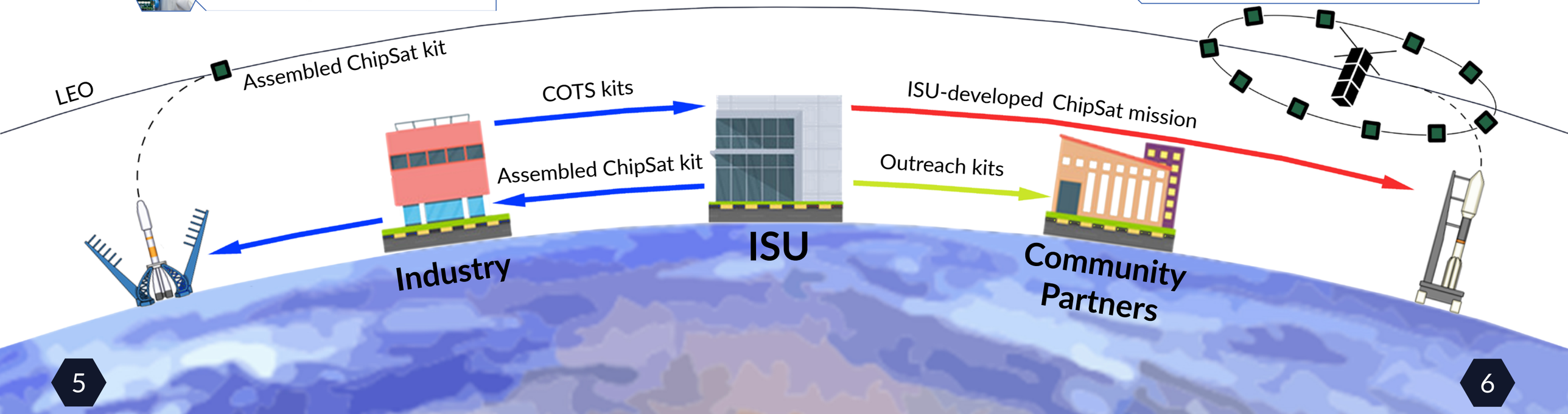
## Outreach Activities

Developing and launching a ChipSat presents education and outreach opportunities for ISU:

**Reputation:** strengthen ISU's status as a world-leading institution in space education.

**Education:** enhance the curriculum across ISU's programs for delivering high-quality space education.

**Outreach:** engage space community by leading small satellite symposia and satellite design competitions.



# ISU CHIPSAT ROADMAP

## 2021

### ISU CHIPSAT PROGRAM
- Identify funding opportunities and apply for it
- Kickoff software development and teaching

### REGULATORY FRAMEWORK
- Commence frequency allocation and launch state legal framework

### OUTREACH PROGRAM
- Purchase AmbaSat kit
- Formalize partnership, the budget, and Outreach Campaign for students

## 2022

### OUTREACH PROGRAM
- Launch AmbaSat #1
- Outreach Campaign & organize a competition for students

### REGULATORY FRAMEWORK
- Obtain frequency allocation

### ISU CHIPSAT PROGRAM
- Kickoff PCB design and teaching
- Initiate relevant IPs with PCB and software and ChipSat lab
- Organize ChipSat lab with essential equipment

## 2023

### ISU CHIPSAT PROGRAM
- Kick off power management, communication development, and teaching
- Organize Chip Sat lab with essential equipment supporting key technology
- Build a ChipSat demonstrator

### REGULATORY FRAMEWORK
- Obtain launch state documents

### OUTREACH PROGRAM
- Launch AmbaSat #2 (subject to avail)
- Organize 1st annual AttoSat Symposium

## 2024

### OUTREACH PROGRAM
- Launch AmbaSat #3 (subject to availability)
- Launch Outreach campaign
- Organize annual AttoSat symposium

### REGULATORY FRAMEWORK
- ChipSat registration and launch support

### ISU CHIPSAT PROGRAM
- Use IPs to develop missions and components
- Build a ChipSat prototype for testing

## 2025

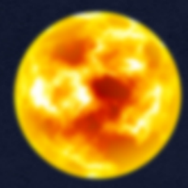
### ISU CHIPSAT PROGRAM
- Produce, test, and provide operational ISU ChipSat to launch for Outreach purposes

### REGULATORY FRAMEWORK
- Maintain frequency allocation

### OUTREACH PROGRAM
- Organize annual AttoSat symposium
- Launch ISU ChipSat

## ...

# Space Weather

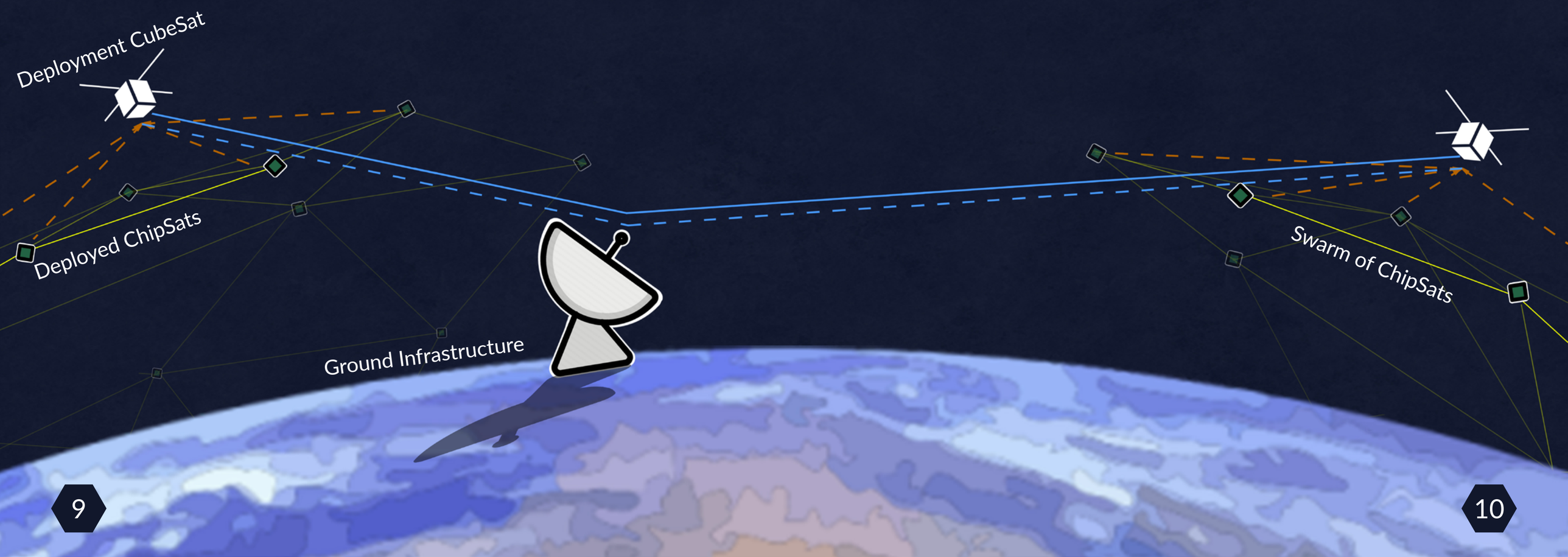


Solar activity influences and interacts with Earth's magnetosphere, ionosphere, and thermosphere. It can affect both space and ground-based infrastructure including satellites, telecommunication networks, and electrical power grids. A low Earth orbit ChipSat constellation can provide a means of capturing reliable data regarding changes in the Earth's near-space environment for scientific and commercial purposes.

The objective of a Space Weather mission is to use ChipSats to capture magnetic field data during significant solar events. A CubeSat will facilitate the deployment of hundred of ChipSats when a significant solar event is predicted or detected. The ChipSats will collect data and transmit it, via the CubeSats, to ground stations and stored in a database. The data may be used by academic institutions for scientific research or by space weather forecasting organizations for calibrating their models.

Collection of Uplink Data

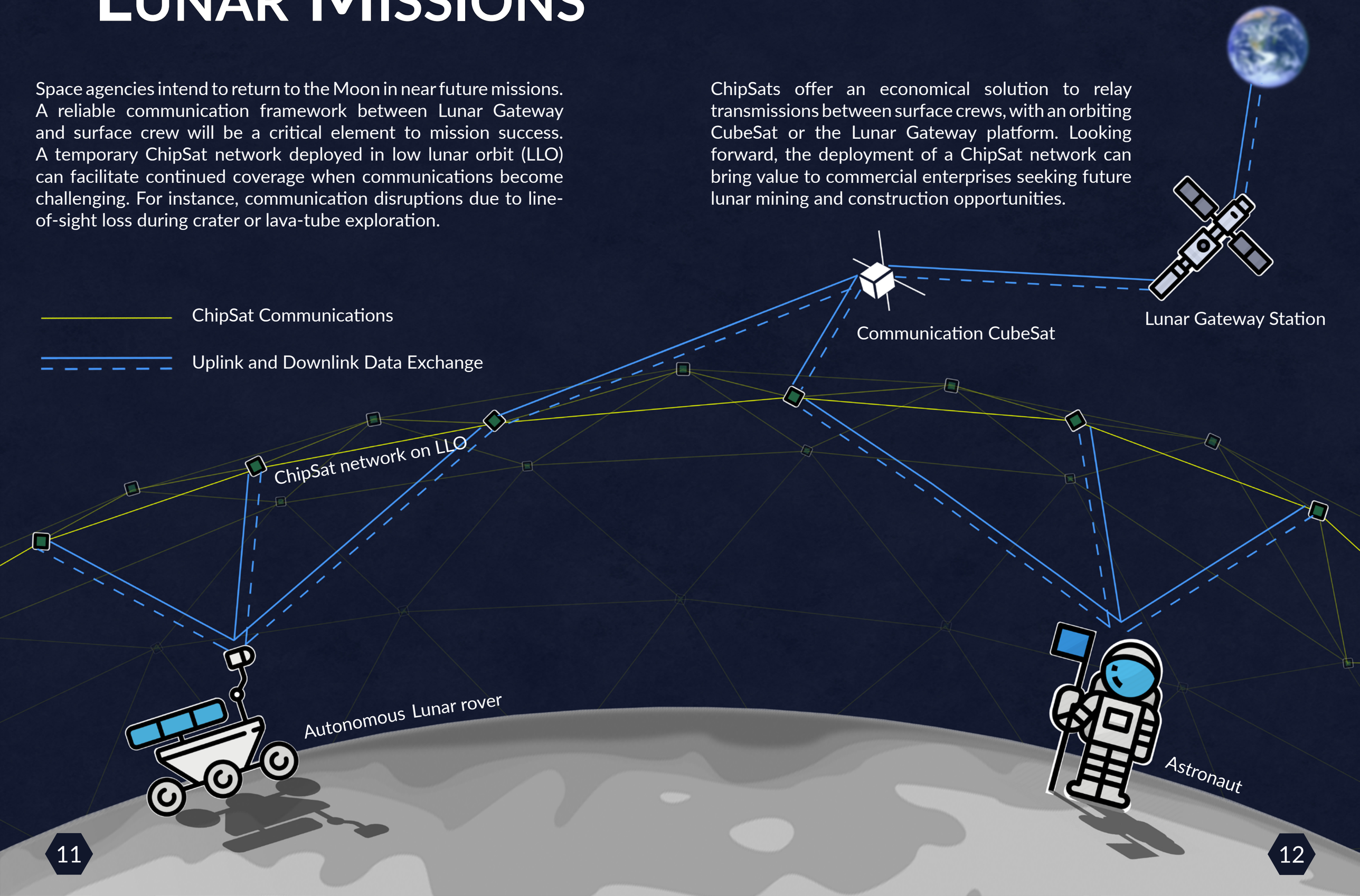
Uplink and Downlink Data Exchange



# Lunar Missions

Space agencies intend to return to the Moon in near future missions. A reliable communication framework between Lunar Gateway and surface crew will be a critical element to mission success. A temporary ChipSat network deployed in low lunar orbit (LLO) can facilitate continued coverage when communications become challenging. For instance, communication disruptions due to line-of-sight loss during crater or lava-tube exploration.

ChipSats offer an economical solution to relay transmissions between surface crews, with an orbiting CubeSat or the Lunar Gateway platform. Looking forward, the deployment of a ChipSat network can bring value to commercial enterprises seeking future lunar mining and construction opportunities.



# Conclusion

The emergence of ChipSats opens up new opportunities for space agencies, commercial enterprises, and academic institutions. The uniqueness in ChipSat simplicity, cost, and redundancy command attention. The maturation of ChipSats depends on whether there is action to address the following recommendations:

[1] *Technology* - Driving forward miniaturized subsystem development to maximize platform lifetime and utility
[2] *Space Debris* - Clarifying existing space debris legislation while developing compliant end-of-life strategies

Human nature coalesces around solving difficult challenges. The capacity to shape a promising future using ChipSats is in our hands.

# Acknowledgements

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Justyna Redelkiewicz: *GSA*
Antonella Sgambati: *OHB*
Daniel Sors: *Open Cosmos*
Andreas Stamminger: *OHB*



# Meet The Team

Sarah Blyde (BEng) - New Zealand
sarah.blyde@community.isunet.edu

Natalia Lemarquis (MSc) - Poland
natalia.lemarquis@community.isunet.edu

Andrea Carrillo Flores (BEng) - Mexico
andrea.carrillo@community.isunet.edu

Yuwei Ma (BEng) - China
yuwei.ma@community.isunet.edu

Sehaz Dayal (BEng) - Canada
sehaz.dayal@community.isunet.edu

Marco Marsh (MSc) - United Kingdom
marco.marsh@community.isunet.edu

Mohamed Elhariry (BSc) - Italy
mohamed.elhariry@community.isunet.edu

Anamol Mittal (BEng) - Nepal
anamol.mittal@community.isunet.edu

Fei Fan (MSc) - China
fei.fan@community.isunet.edu

Guillem Olivella (BSc) - Spain
guillem.olivella@community.isunet.edu

Uri Greisman Ran (MBA) - Israel
uri.greismanran@community.isunet.edu

Shreya Sarkar (PhD) - India
shreya.sarkar@community.isunet.edu

Taavishe Gupta (BEng) - India
taavishe.gupta@community.isunet.edu

Frederic Schoutetens (MSc) - Belgium
frederic.schoutetens@community.isunet.edu

Alexander Guzeev (BArch) - Russia
alexander.guzeev@community.isunet.edu

Tasmia Tahmid (MSc) - Bangladesh
tasmia.tahmid@community.isunet.edu

Supreet Kaur (BSc) - United States
supreet.kaur@community.isunet.edu

Iliass Tanouti (BEng) - Morocco
iliass.tanouti@community.isunet.edu

Evon Koprowski (BCom) - Australia
evon.koprowski@community.isunet.edu

Christine Tiballi (MArch) - United States
christine.tiballi@community.isunet.edu

Morgane Lecas (LLM) - France
morgane.lecas@community.isunet.edu

International Space University
1 Rue Jean-Dominique Cassini, 67400 Illkirch-Graffenstaden, France

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