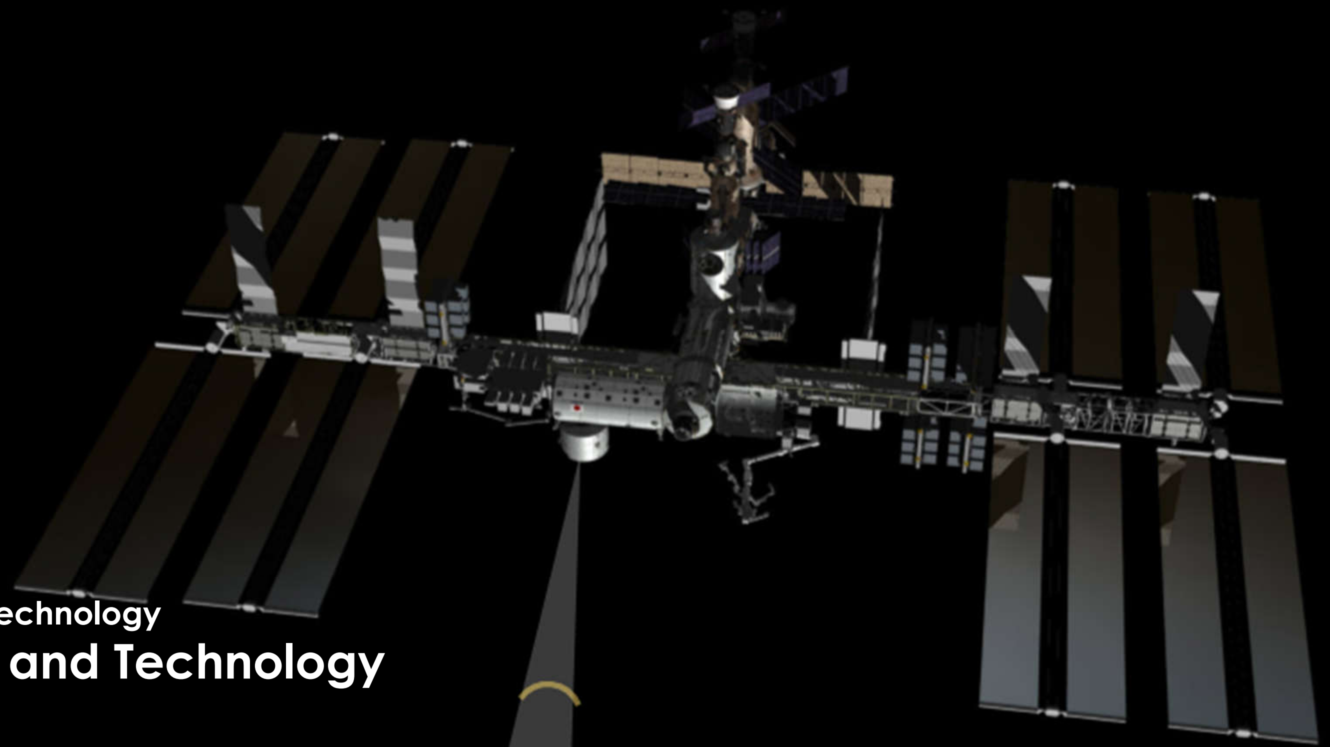
SPECTRUM **MO**NITORING FROM **S**PACE WITH **I-S**EEP (**SMOSIS**)



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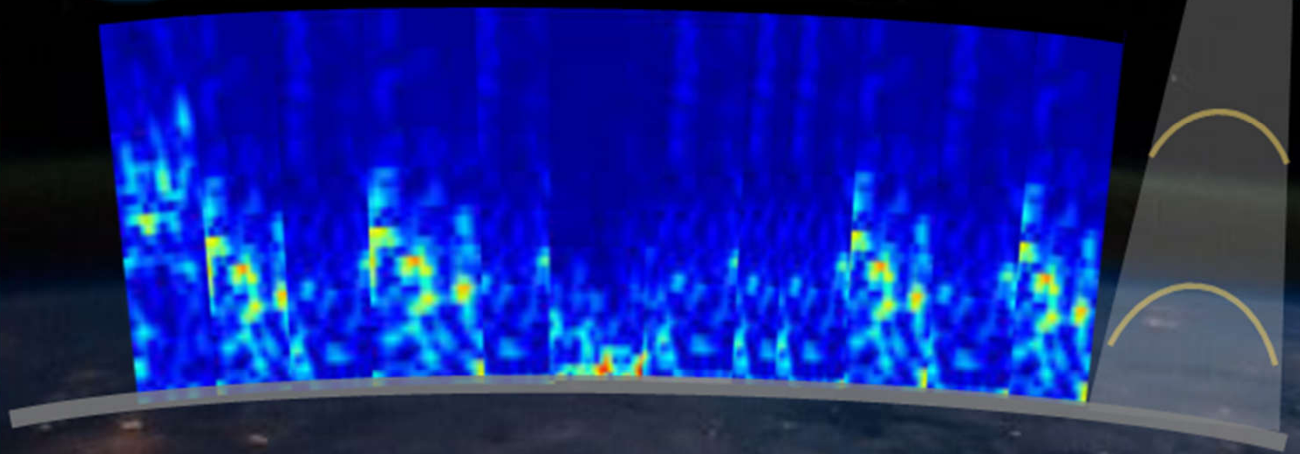


CAPTURING AND MAPPING THE DIGITAL DIVIDE FROM SPACE THROUGH RADIO FREQUENCY SPECTRUM MEASUREMENTS

Mar Francis D. De Guzman, **Genedyn Gems S. Mendoza**, Calvin Artemies G. Hilario, and Dr. Joel Joseph S. Marciano, Jr.

10 REDUCED INEQUALITIES

OUTLINE

- Motivation/Introduction
- Mission Objectives
- Overview and Key Performance Parameters
- Space Segment and Concept of Operations
- Implementation Plan
- Summary

ROLE OF THE INTERNET

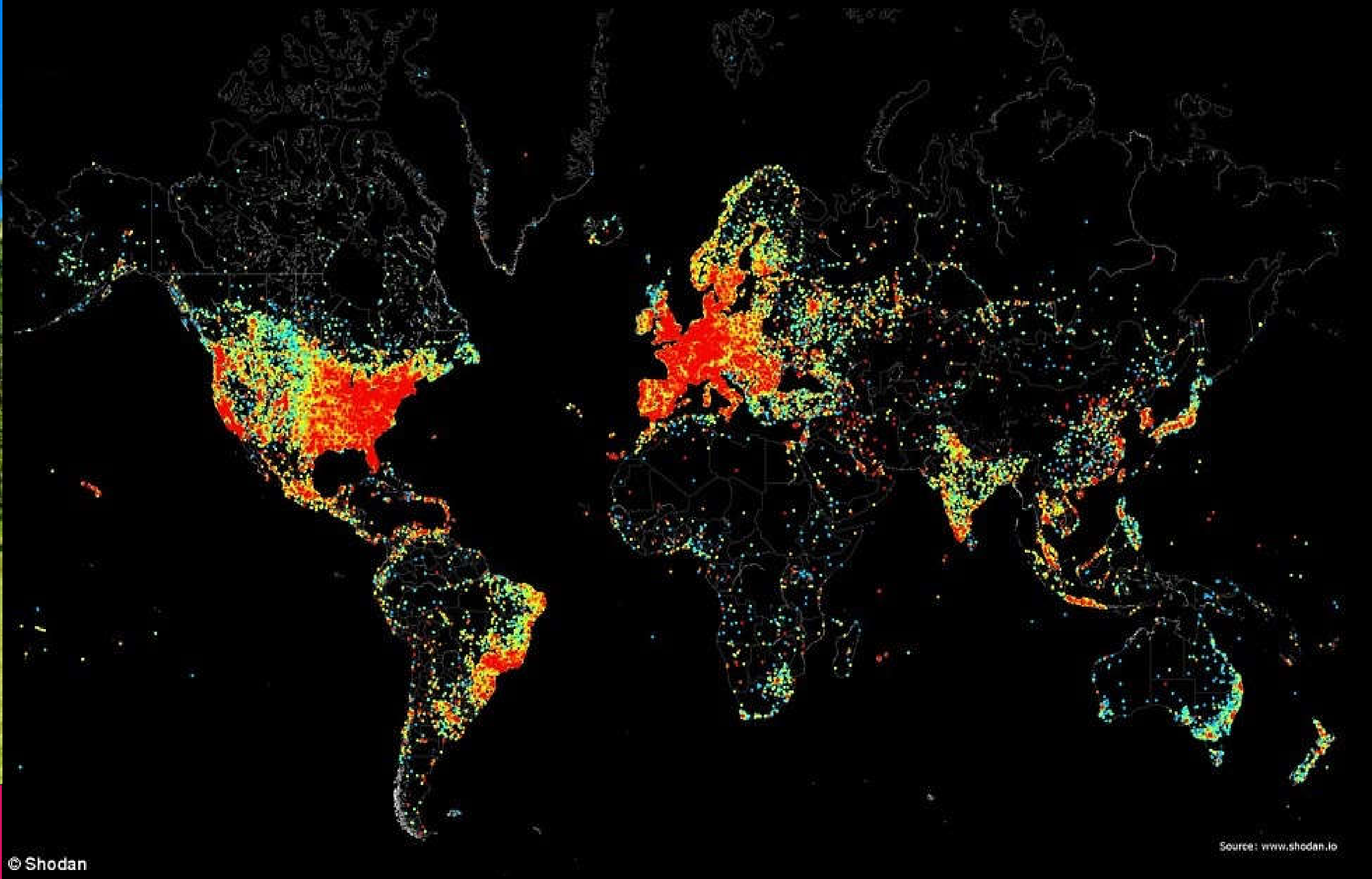
- Direct selling of **small businesses** to customers **removing traditional barriers** - distance, advertising cost, and intermediate distribution chains. [1]
- Delivery of basic services like **education and health** information to remote areas: **access to same database** information, **distance learning** such as open universities and language websites
- **Global reach** to integrate **concerns of developing society** in the international setting. Several disparate social movements can form new coalitions and become **more connected** to **mobilize the global civic society**.

Basic access is **REQUIRED** before the potential benefits of the Internet can flow to remote/poorer societies!

[1] P. Norris, *Digital Divide: Civic Engagement, Information Poverty, and the Internet Worldwide*. Cambridge: Cambridge University Press, 2001.

10 REDUCED INEQUALITIES

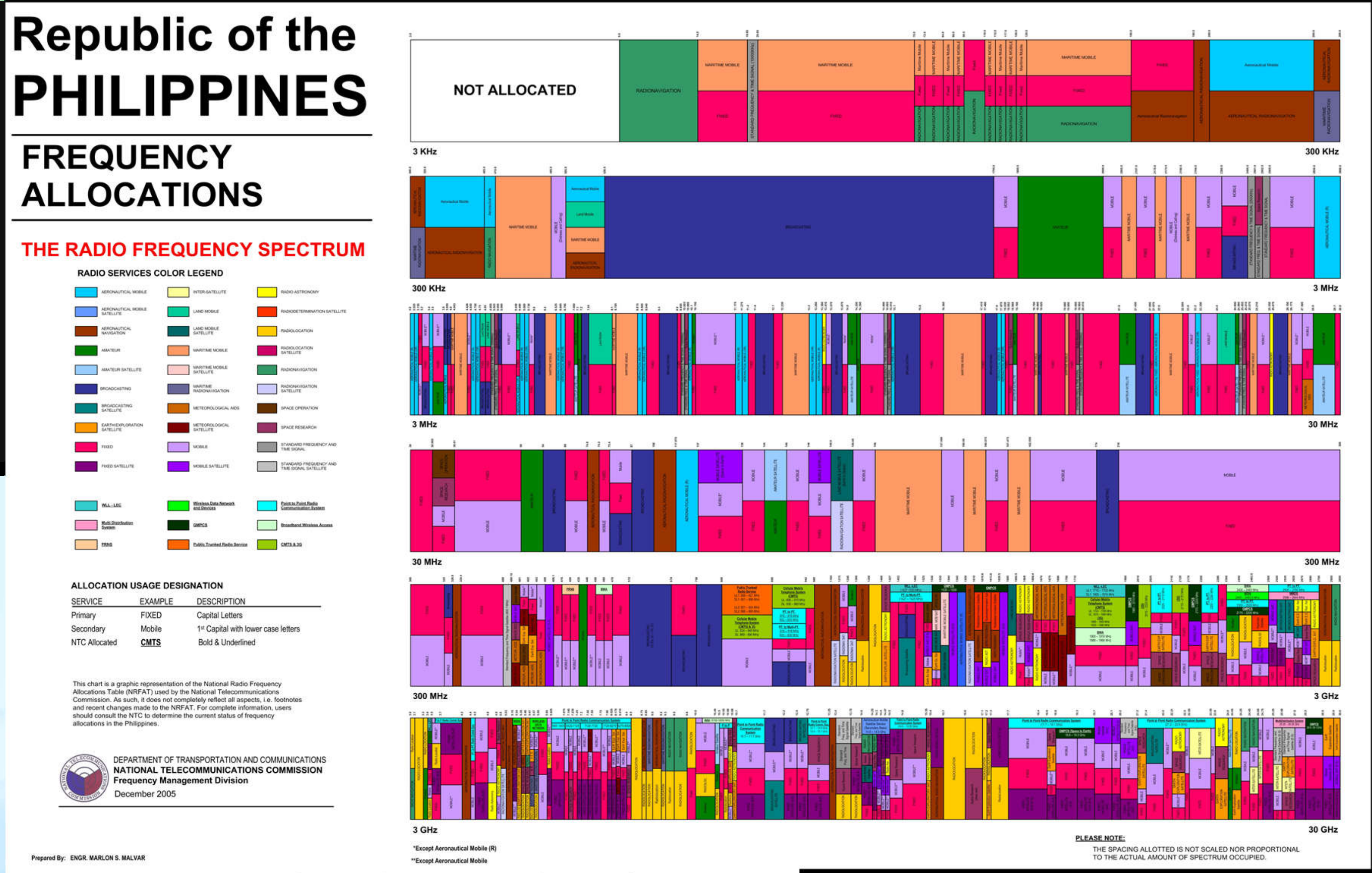
DIGITAL DIVIDE

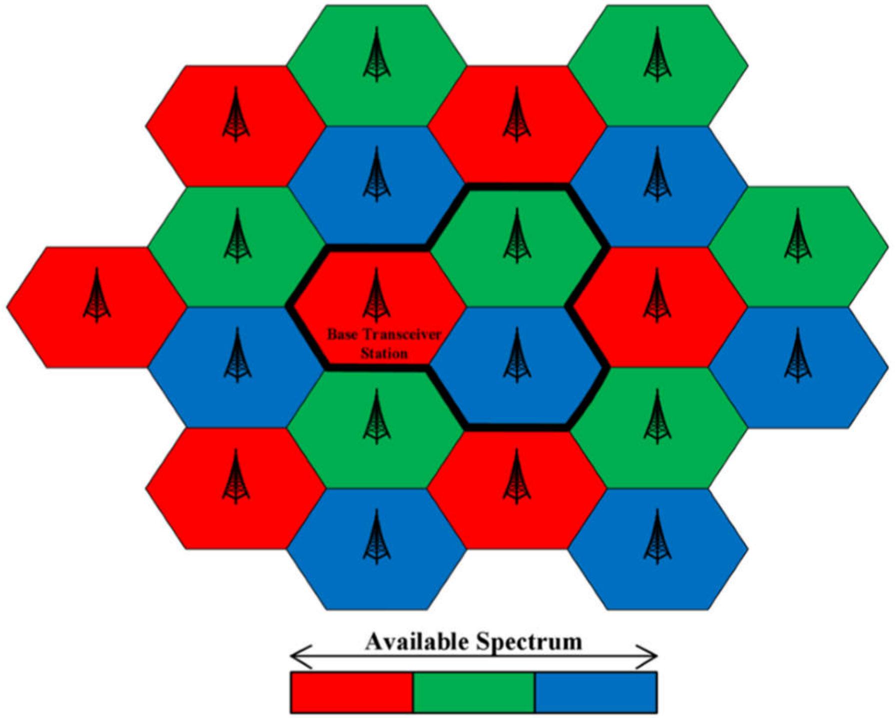


"We must work to close the digital divide, where more than half the world has limited or no access to the Internet"

- António Guterres, UN Secretary-General

Determine the extent of disruption of telecommunications infrastructures during disasters



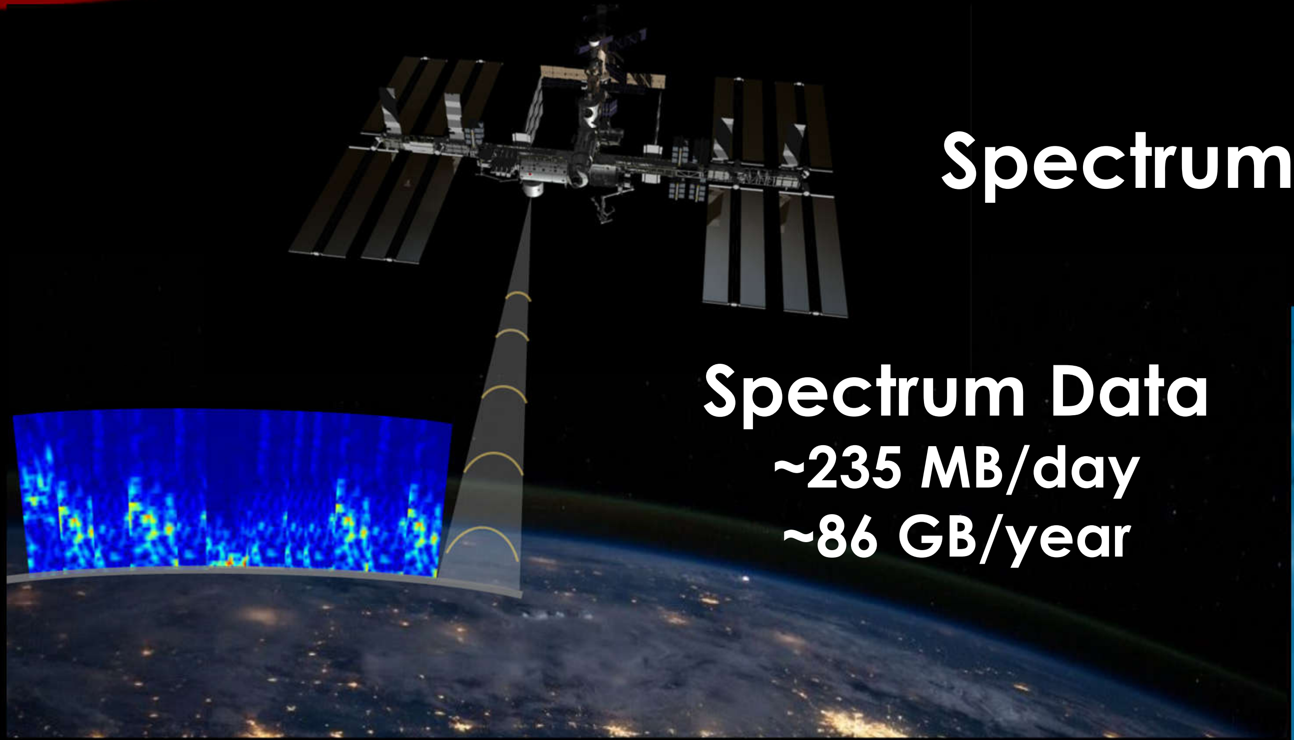


Towards better planning, management and regulation of radio spectrum

MISSION OBJECTIVES

- Collect radio frequency (RF) spectrum utilization and occupancy data at a global scale through spectrum measuring payload instrument placed in orbit;
- Obtain the measured data and conduct analysis to derive a global "heat map" showing the spatio-temporal level and variation of the radio frequency spectrum; and
- Share the raw and processed data from the measurements to the general public and interested groups through a web portal or API for research and policy formulation towards creating better awareness and motivating further action on bridging the "digital divide".

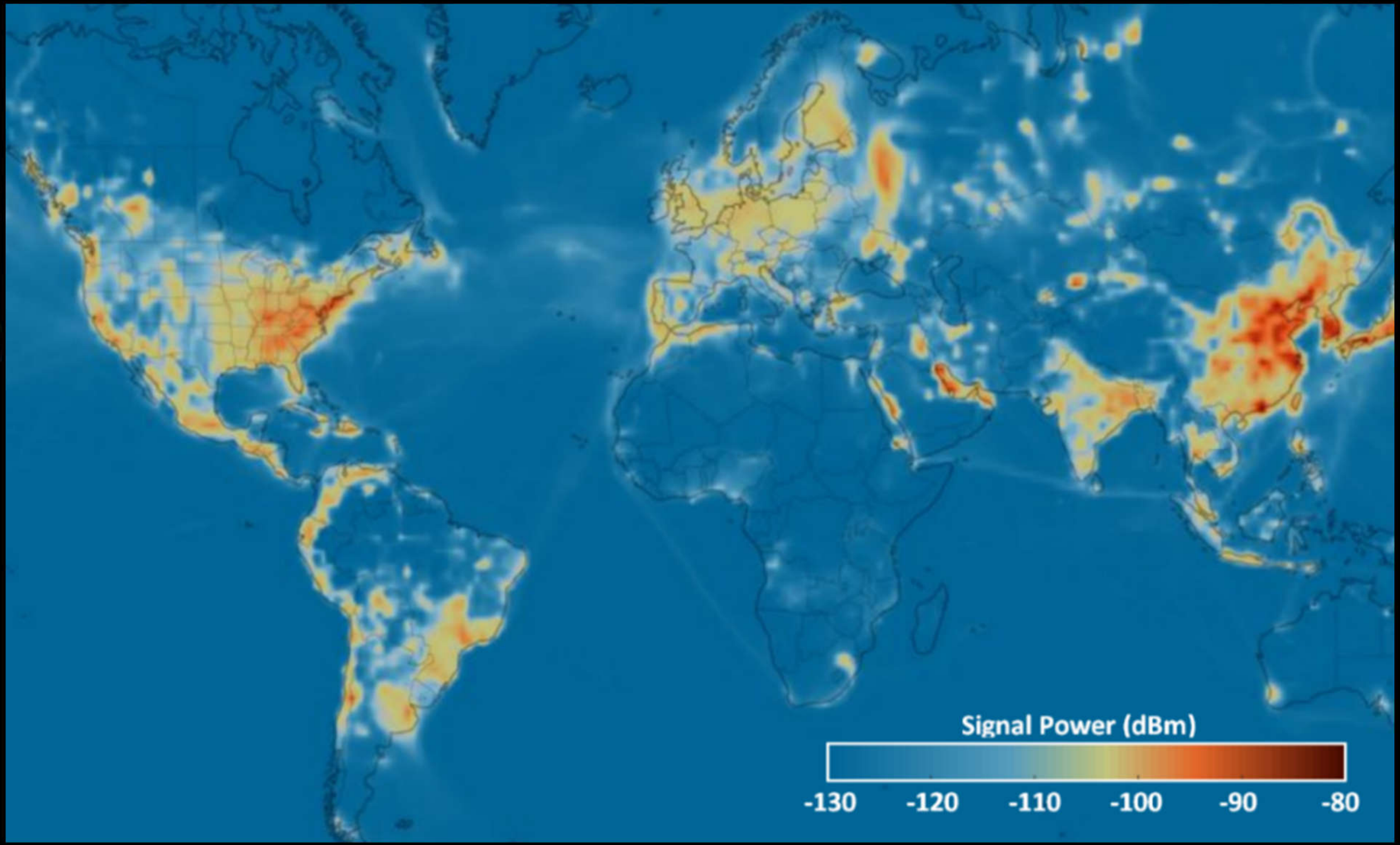
EXPERIMENTAL CONCEPT AND SETUP



Spectrum Analyzer and Wideband High-Gain Antenna

Spectrum Data
~235 MB/day
~86 GB/year

Global cellular (downlink) frequency bands (728-806, 832-894, 925-960, 1710-1990, 2110-2170, 2570-2690 MHz)



Hypothetical Spectrum Heat Map

KEY PERFORMANCE PARAMETERS

Sensing Ground Sensitivity

45 dBm for 900 MHz
51 dBm for 1800 MHz

minimum power level detectable from a ground transmitter assuming the worst-case quality of uplink (e.g. base station antenna has very low sidelobe pointing to the payload)

Data Quality

Data validity in terms of

- **Frequency accuracy**
- **Correctness of geo-tagging**

Verified through comparison of the retrieved location tagged spectrum data and available database of ground transmitters

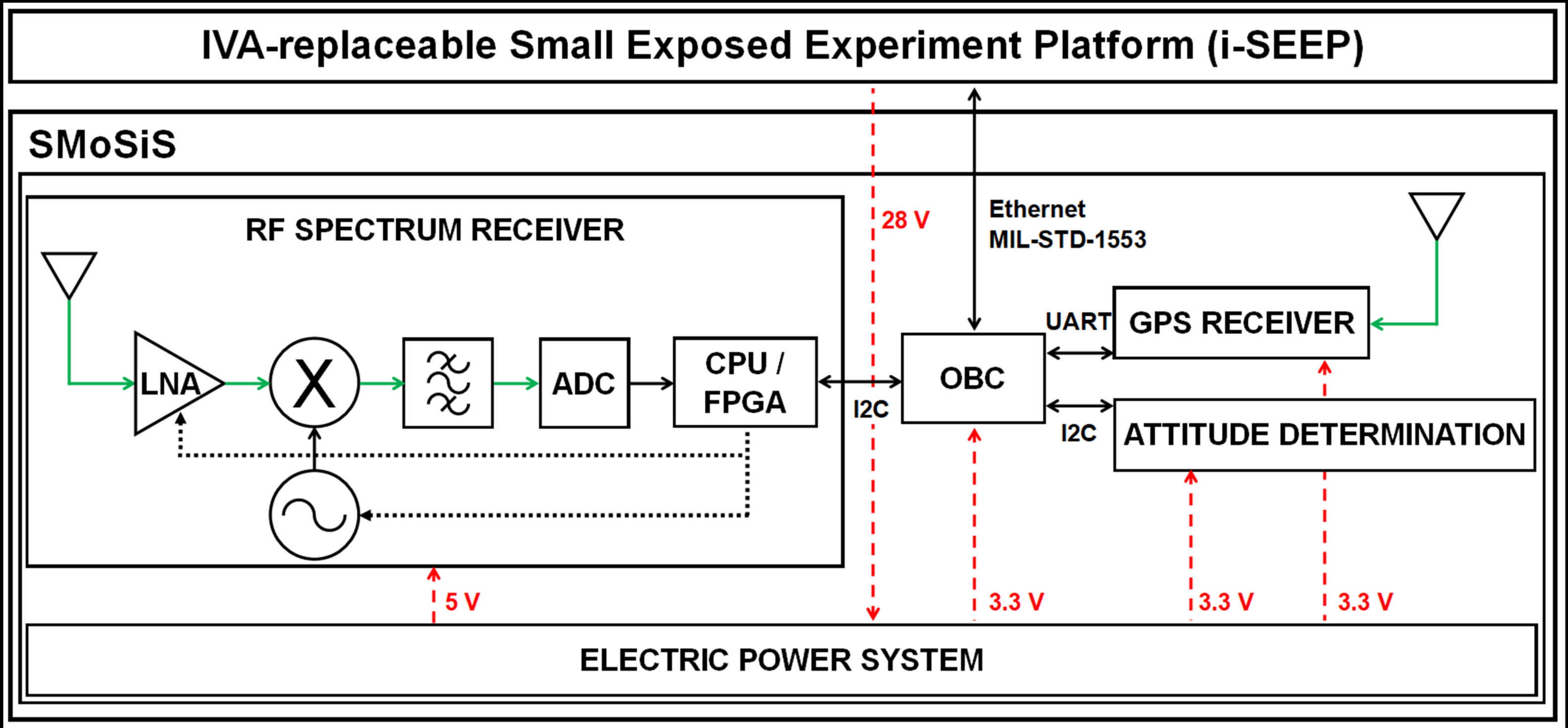
Data Updates

>= once per week

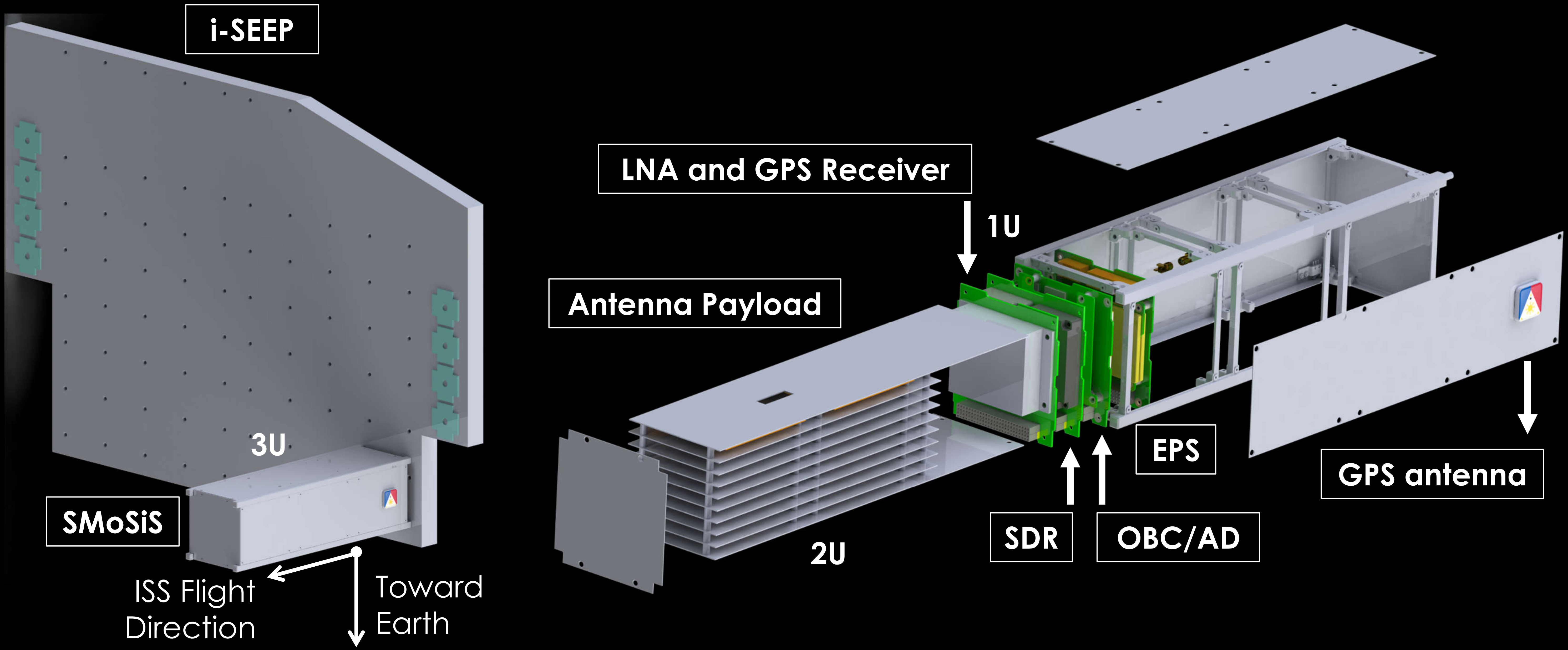
>=109,431 sweeps

or 90% of target 121,590 spectrum Sweeps per week.

SPACE SEGMENT



SMOSIS MECHANICAL LAYOUT



*Modeled by Delburg Mitchao, images rendered by Gabriel Mabini

LINK BUDGET ANALYSIS

	Ground Segment (Cellular Base Station)		
	Frequency	900 MHz	1800 MHz
A	Typical Transmitter (Tx) Radiated Power Output	43 dBm	43 dBm
B	Typical Zenith Sidelobe Antenna Gain	-20 dBi	-20 dBi
C	Tx Line Loss	3 dB	3 dB
D	EIRP = A+B-C	20 dBm	20 dBm
E	Antenna Pointing Loss	3 dB	3 dB
F	Polarization Loss	3 dB	3 dB
G	Atmospheric + Ionospheric Loss	2 dB	2 dB
H	Path Loss (420 km)	144 dB	150 dB
I	Power at the satellite = D - E - F - G - H	-132 dBm	-138 dBm
	Satellite Segment		
J	Antenna Pointing Loss	3 dB	3 dB
K	Antenna Gain	8.5 dBi	8.5 dBi
L	Receiver (Rx) Line Loss	0.5 dB	0.5 dB
M	Received Power	-127 dBm	-133 dBm
N	SDR with LNA Noise Floor	-130 dBm	-130 dBm
O	Received SNR = M - N	3 dB	-3 dB

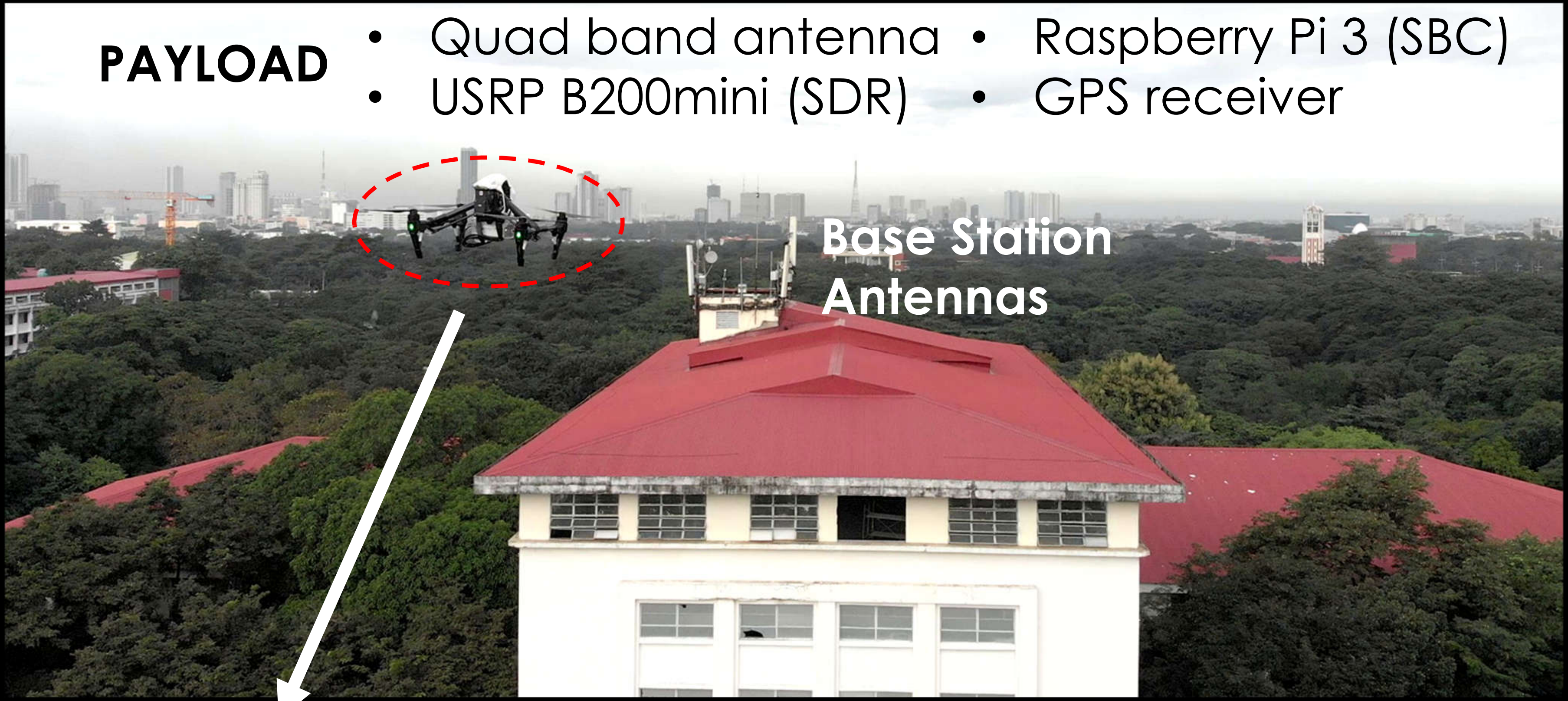
To further improve the system's effective sensitivity and enable the detection of weak leakage signals from the terrestrial base stations, the following **sub-objectives** are defined for this mission:

1) Design of high-gain small form-factor antenna;
2) Design of low-noise amplifier with ultra-low noise figure and high gain;
3) Implementation of spectrum sensing algorithm with low SNR requirement.

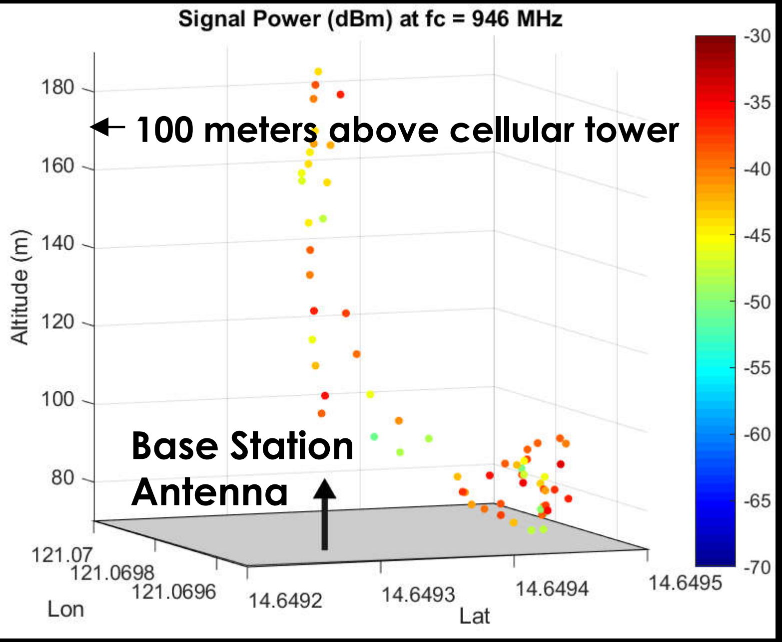
POWER AND MASS BUDGET

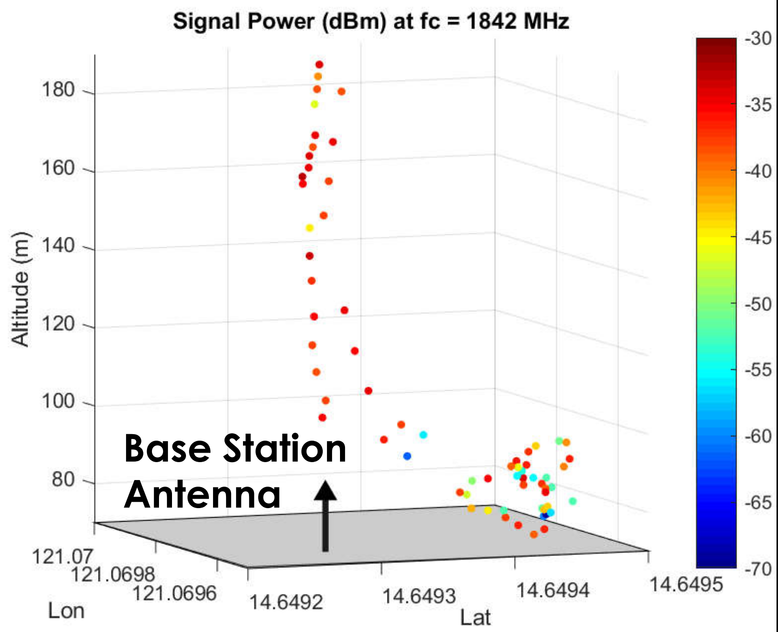
Device	Mode	Power Consumption Typical (mW)	Power Consumption Peak (mW)	Mass (g)
Low Noise Amplifier (LNA)	Receive	600	660	25
Software Defined Radio (SDR)	Receive	2800	3300	271
Attitude Determination System	All	150	150	64
GPS receiver and antenna	All	1320	1320	32
On Board Computer (OBC)	All	170	900	24
Electric Power System	All	165	165	137
Batteries	All	500	1500	500
Payload Antenna	Receive	-	-	137
Enclosure/Mechanical	All	-	-	793
TOTAL	-	5705	7995 **~8 Watts**	1983 **~2 kg**

PRELIMINARY WORK

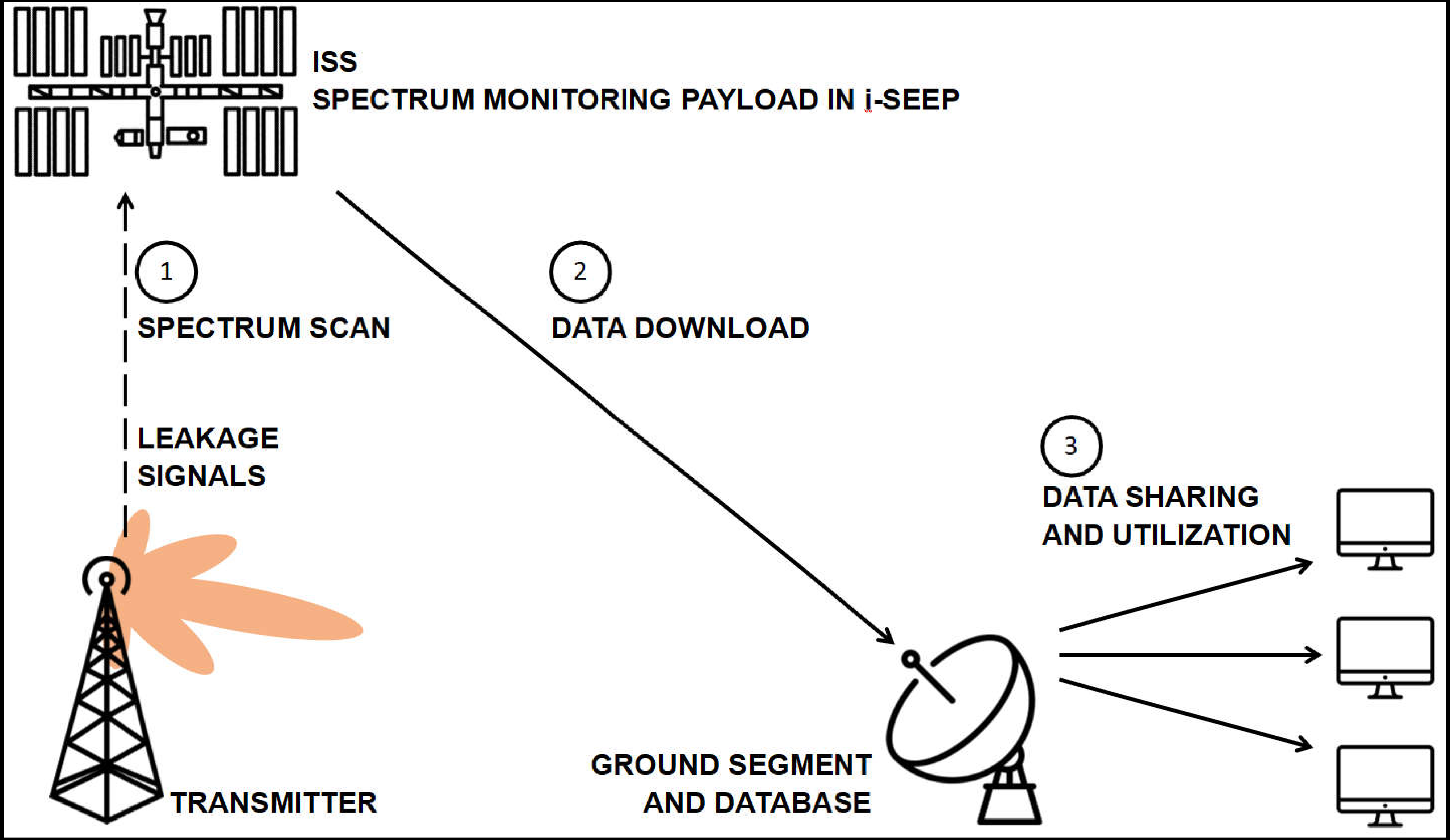


Frequency (MHz)	Signal Level (dBm)	
	Measured (average)	Computed (assumed link budget)
946	-47.39	-48.97
1842	-52.42	-54.75





CONCEPT OF OPERATIONS



IMPLEMENTATION PLAN

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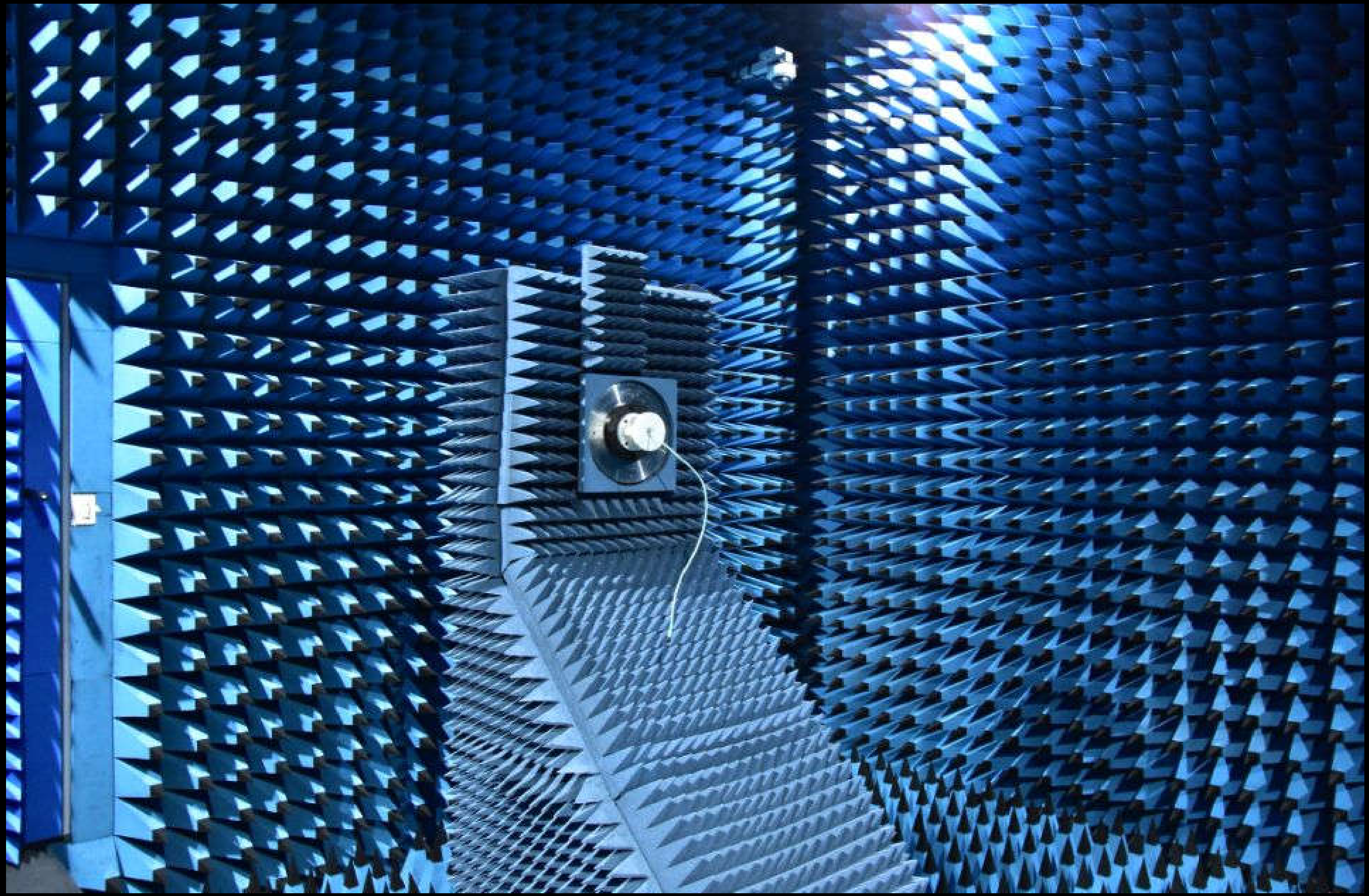
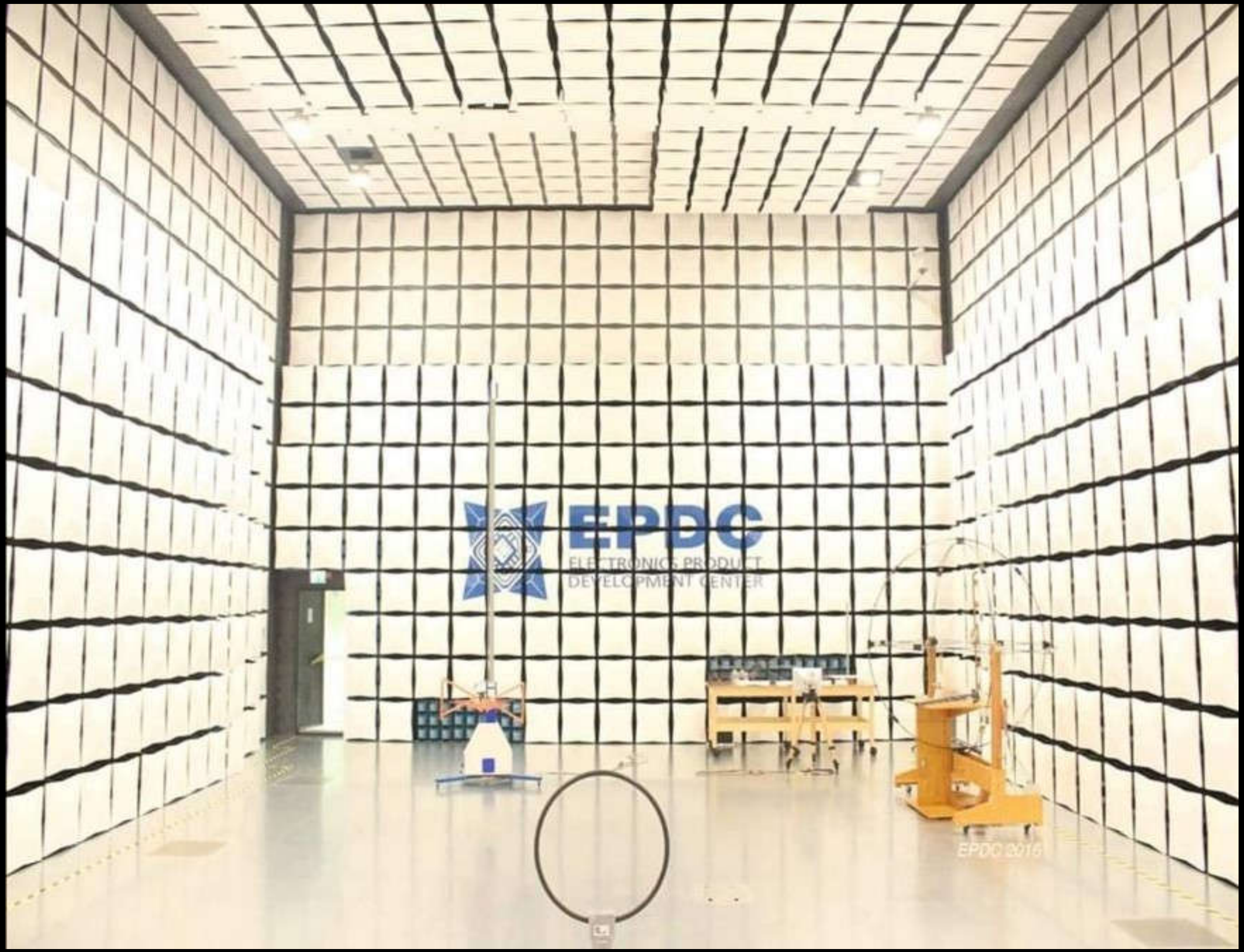
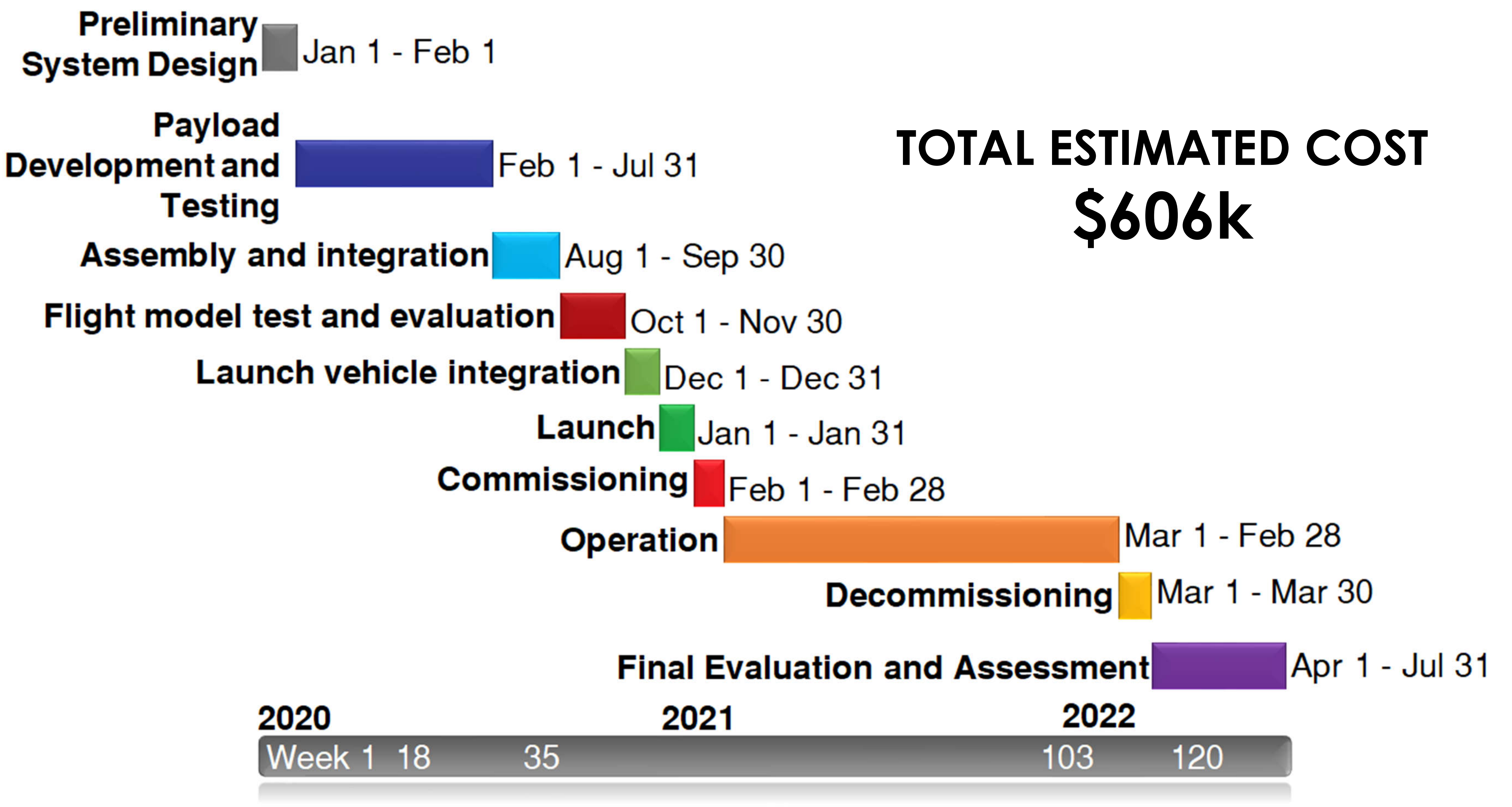


RF Full-Anechoic Chamber
University Laboratory for Small Satellites and Space Engineering Systems (ULyS3ES)



Electronics Product Development Center (EPDC)

IMPLEMENTATION PLAN



TOTAL ESTIMATED COST

$606k

O-SMOSIS OF OPPORTUNITIES

- Access to the internet is a privilege that is now a necessity in this digital age.

- "Spectrum Monitoring from Space with i-SEEP (SMoSiS)" aims to provide measurement of the RF spectrum occupancy on earth to detect presence/lack of telecommunication and broadcast services.

- From the processed SMoSiS spectrum data, we can
  - determine unserved or "under-served" areas;
  - detect anomalies, including the disruption and subsequent recovery of wireless technology services during disasters;
  - study the utilization of the radio spectrum towards better planning, management and regulation of this **vital resource in support of fulfilling SDG-10 (reduced inequalities)**

10 REDUCED INEQUALITIES

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THANK YOU FOR YOUR ATTENTION.

The 6th
Mission Idea Contest
For Achieving Sustainable Development Goals with Human Spaceflight

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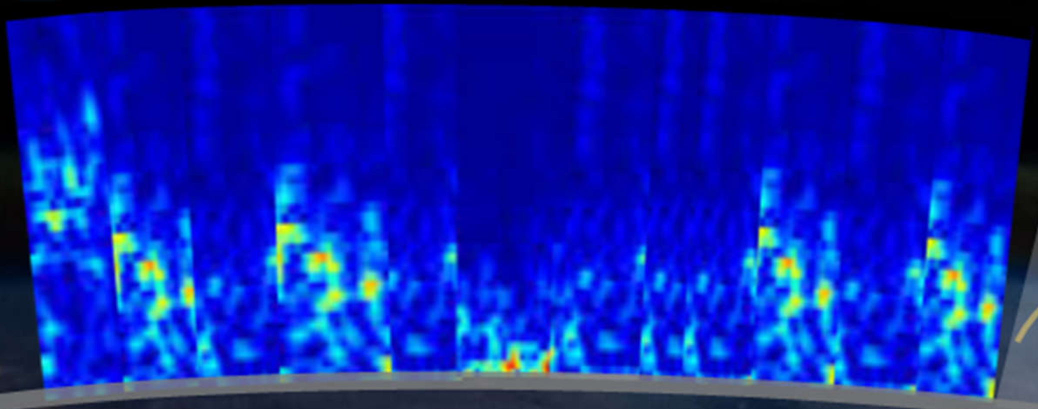

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