AESS Distinguished Lecturer

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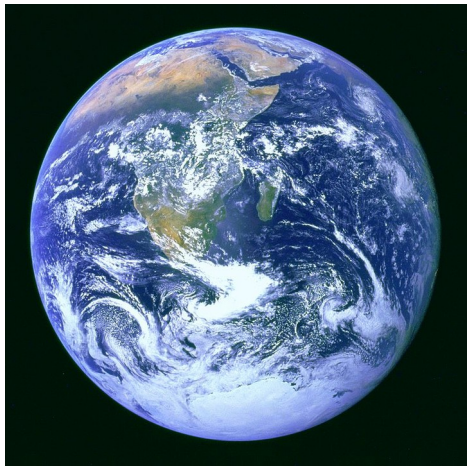
SPACE SUSTAINABILITY

Engineering a Responsible Future of Space

OUTLINE

- Sustainability: a Holistic Concept
- Are Space Trends Sustainable?
- Space Sustainability by Design
- Ally Technologies
- Perspectives

SUSTAINABILITY: A HOLISTIC CONCEPT



What are we doing to Earth?

SUSTAINABILITY: A HOLISTIC CONCEPT

MORE QUESTIONS THAN ANSWERS

What are we doing to Space?

Are space actors fully aware?

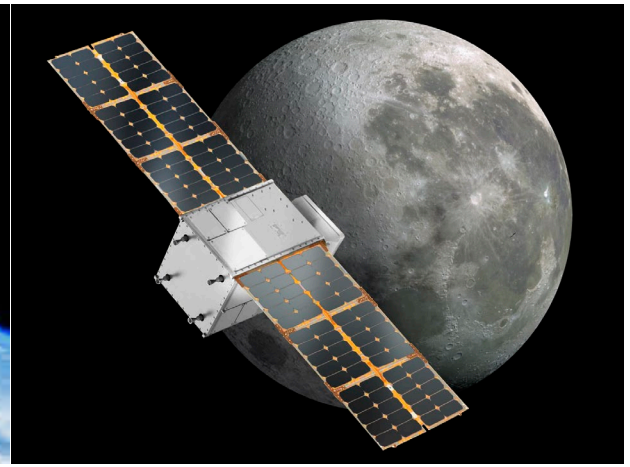
How can we approach Moon and Mars with the current space sustainability model?

ARE SPACE TRENDS SUSTAINABLE?

GO MEGA!

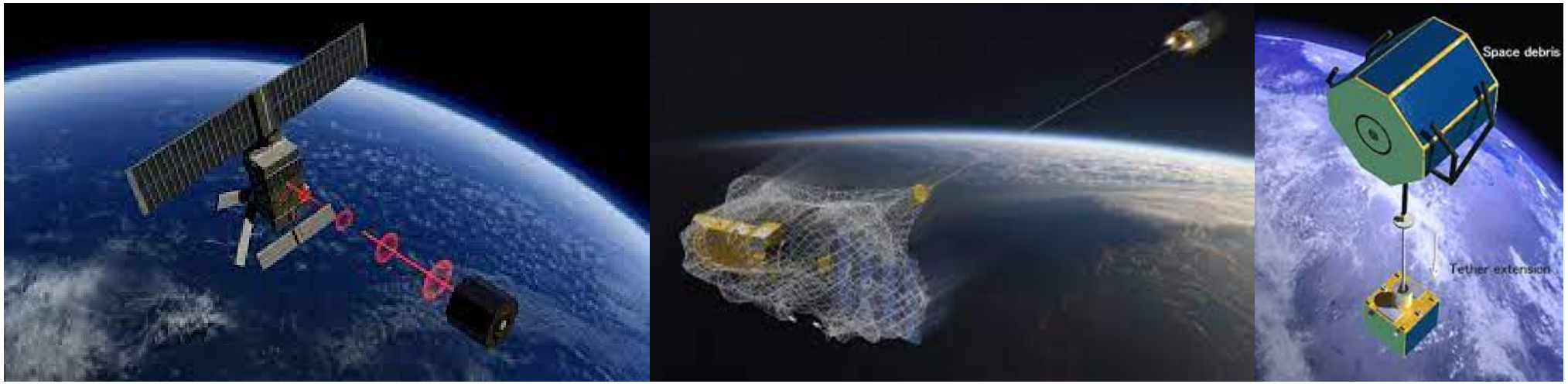
ARE SPACE TRENDS SUSTAINABLE?

GO SMALL!



ARE SPACE TRENDS SUSTAINABLE?

REMOVAL OF SPACE JUNK



SPACE SUSTAINABILITY BY DESIGN

A completely new approach to the conceivement, design and implementation of space systems is needed to:

- **STOP POLLUTING**
- **REPAIR DAMAGES**

SPACE SUSTAINABILITY BY DESIGN

Priorities need to be changed to change the trend, with consequences at various levels:

- **RESEARCH**
- **COORDINATION**
- **INVESTMENTS AND MARKET**

SPACE SUSTAINABILITY BY DESIGN

Key strategies for the evolution framework of a sustainable space:

- **Upcycling and Recycling**
- **Sustainable materials**
- **Sustainable management**

SPACE SUSTAINABILITY BY DESIGN

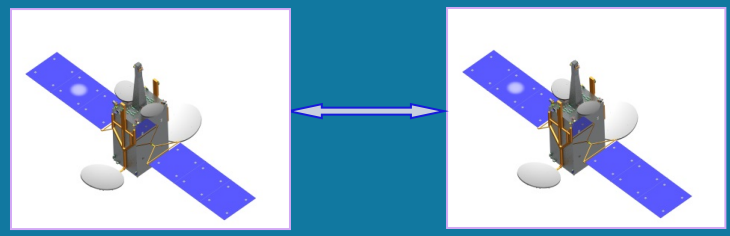
Upcycling and Recycling is based on the intelligent and flexible reuse, integration and modification of:

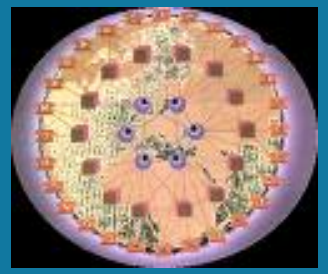
- **Space networks**
- **Space nodes**
- **Missions and services**

SPACE SUSTAINABILITY BY DESIGN

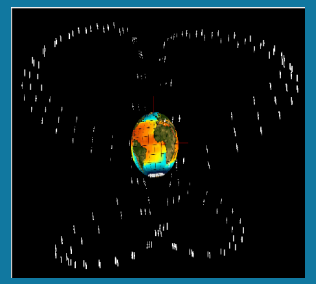
Flexibility is supported by system design choices, such as:

Inter-satellite link
Data relay





On-board
Routing



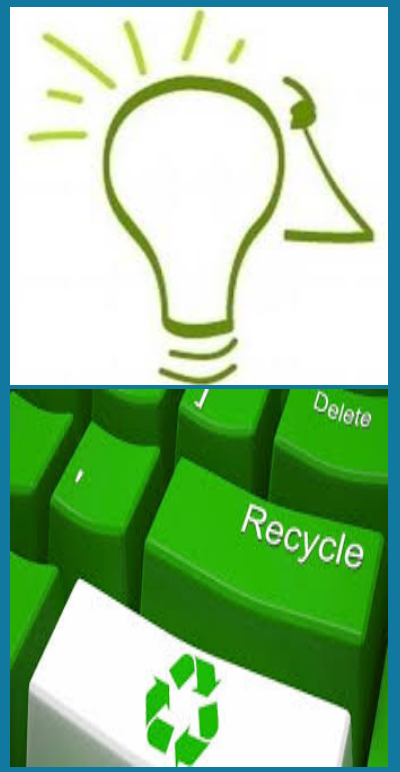
New constellation
concepts

Innovative
Control Center

SPACE SUSTAINABILITY BY DESIGN

Upcycling and Recycling strategies:

- **Backward compatibility**
- **Forward compatibility**



SPACE SUSTAINABILITY BY DESIGN

BACKWARD COMPATIBILITY needs for:

- **Knowledge about existing systems**
- **Design for suitable integration**
- **Coordination**

SPACE SUSTAINABILITY BY DESIGN

FORWARD COMPATIBILITY needs for:

- **Knowledge about future systems**
- **Design for suitable integration**
- **Coordination**

ALLY TECHNOLOGIES

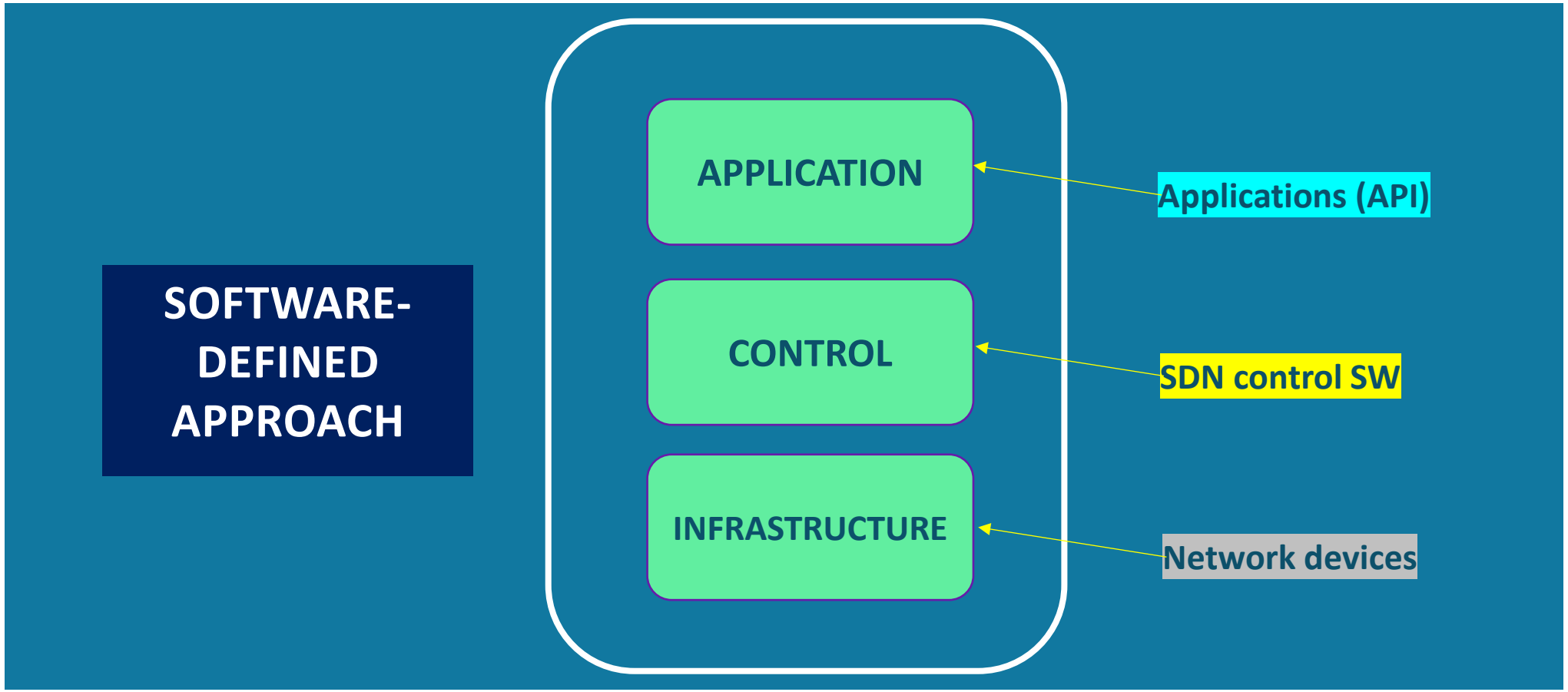
- **Software-Defined techniques**
- **Extremely High Frequencies devices**
- **Artificial Intelligence algorithms**

ALLY TECHNOLOGIES

SOFTWARE-DEFINED APPROACH

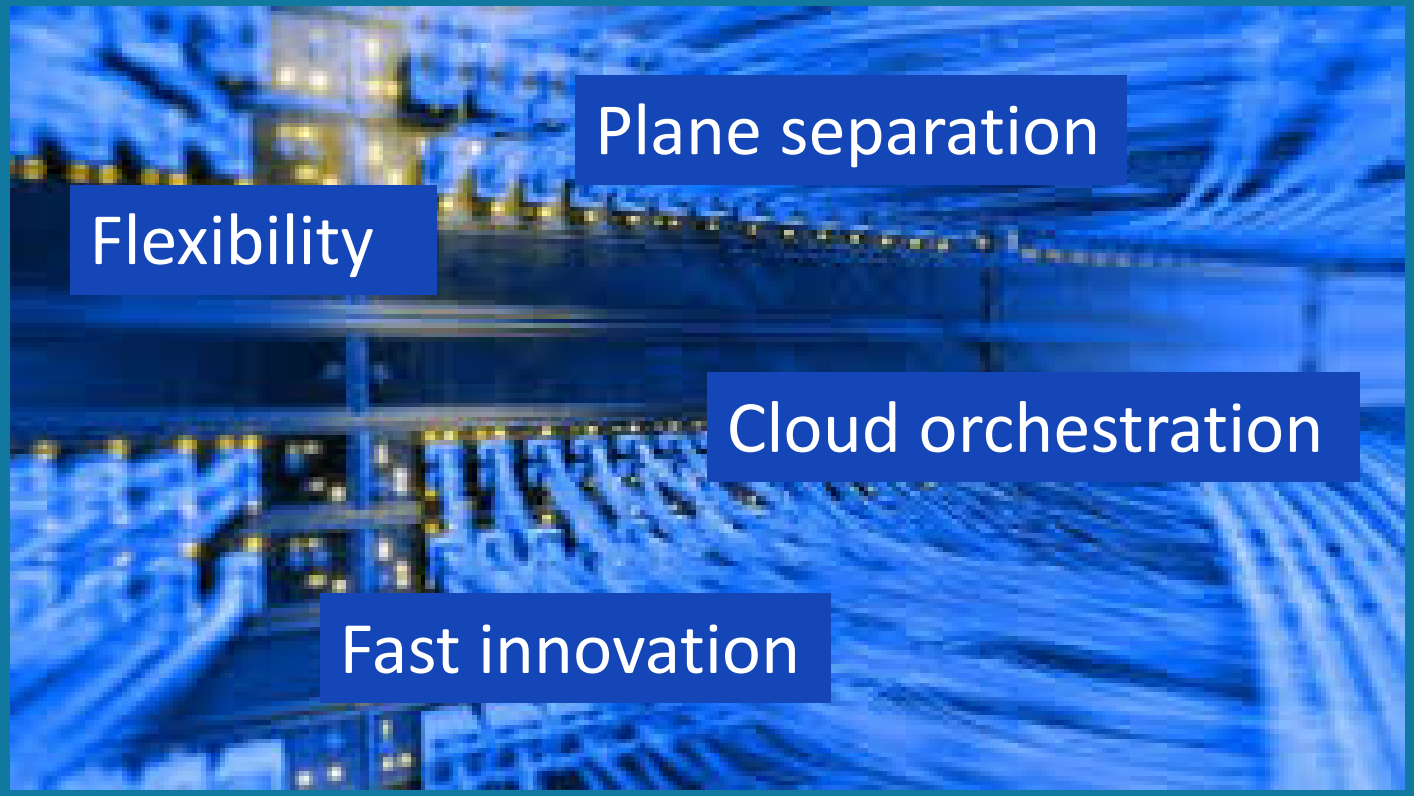
- Software-Defined Networking (SDN)
- Software-Defined Storage (SDS)
- Software-Defined Data Center (SDDC)
- Software-Defined Everything (SDE)

ALLY TECHNOLOGIES



ALLY TECHNOLOGIES

SDN



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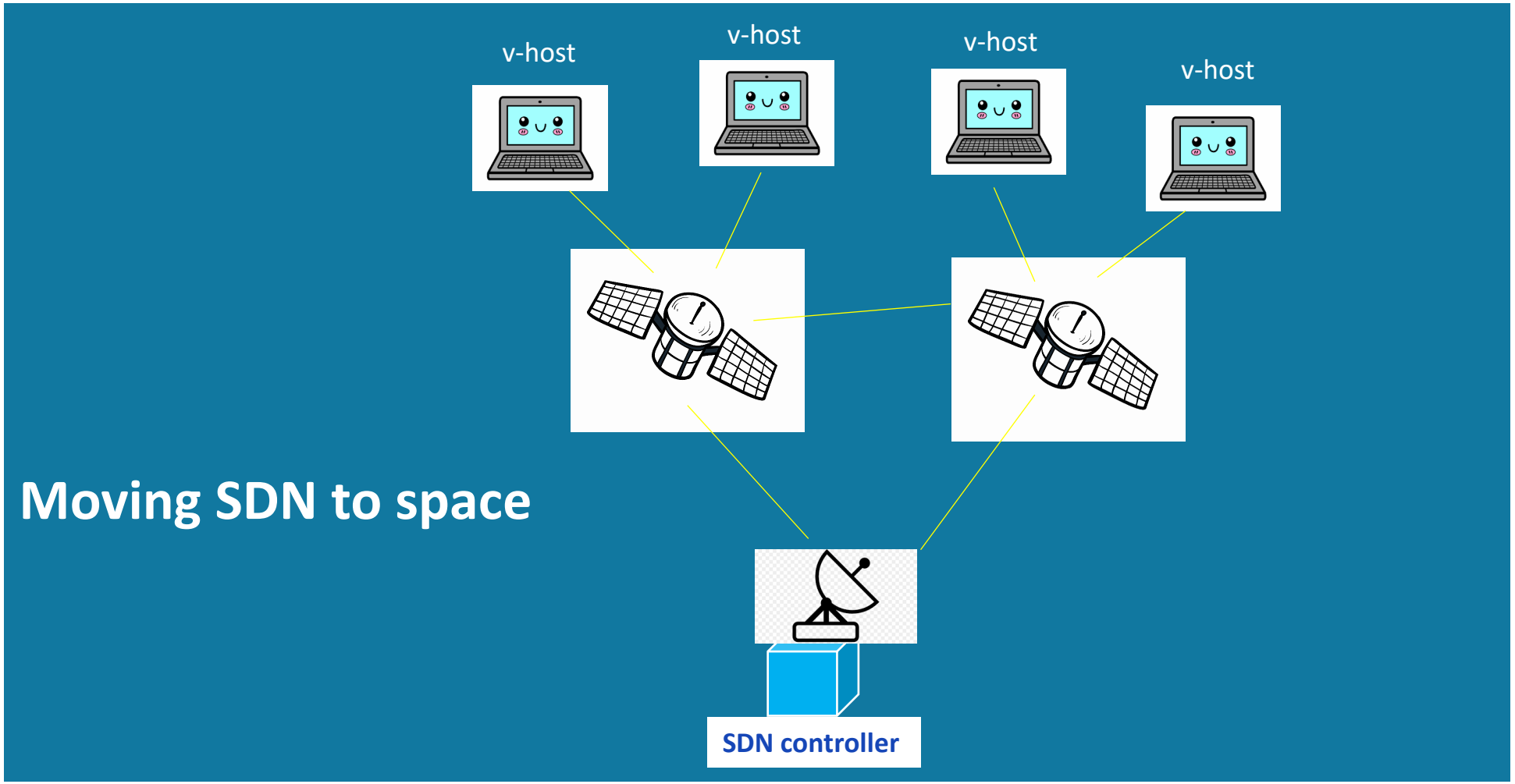

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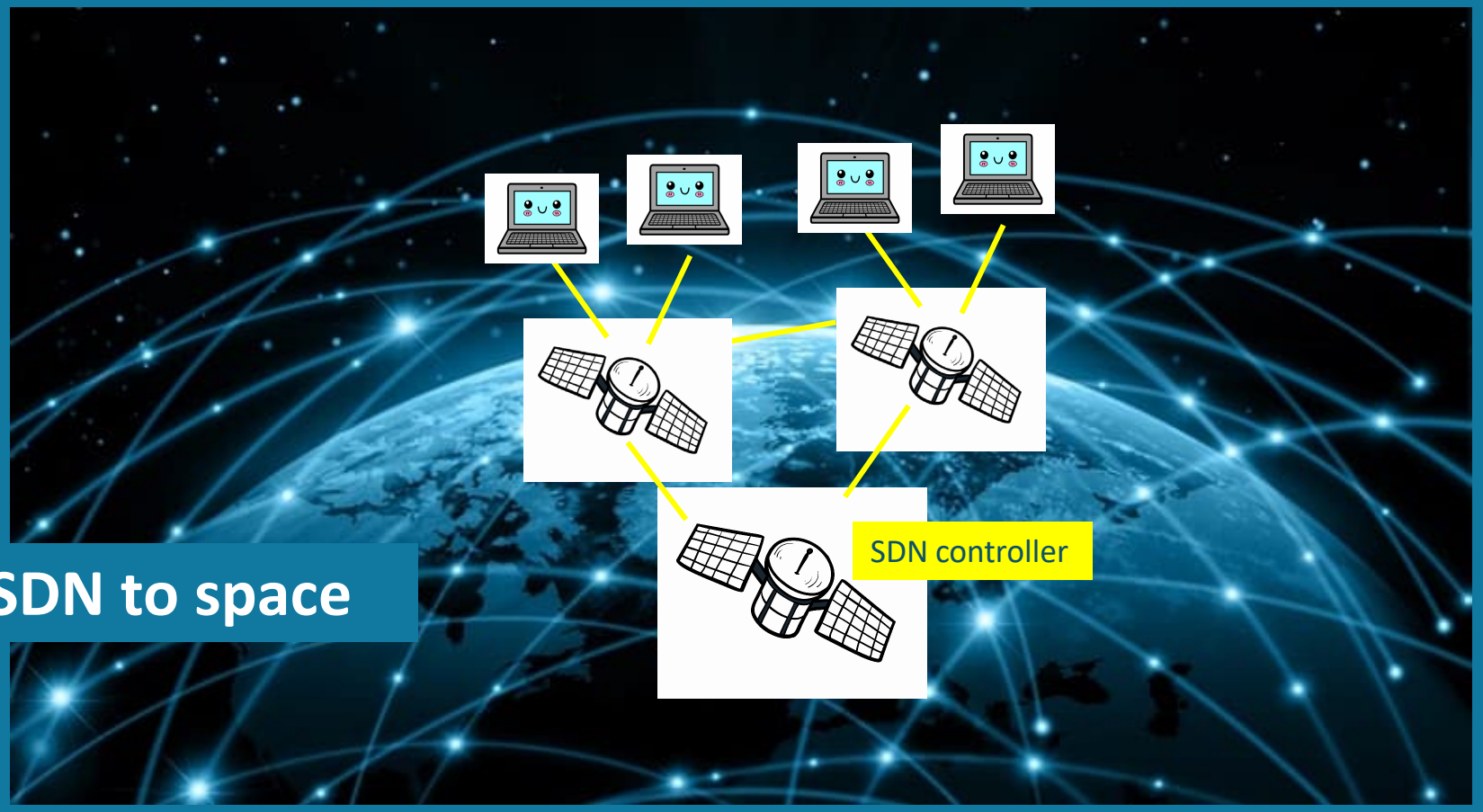
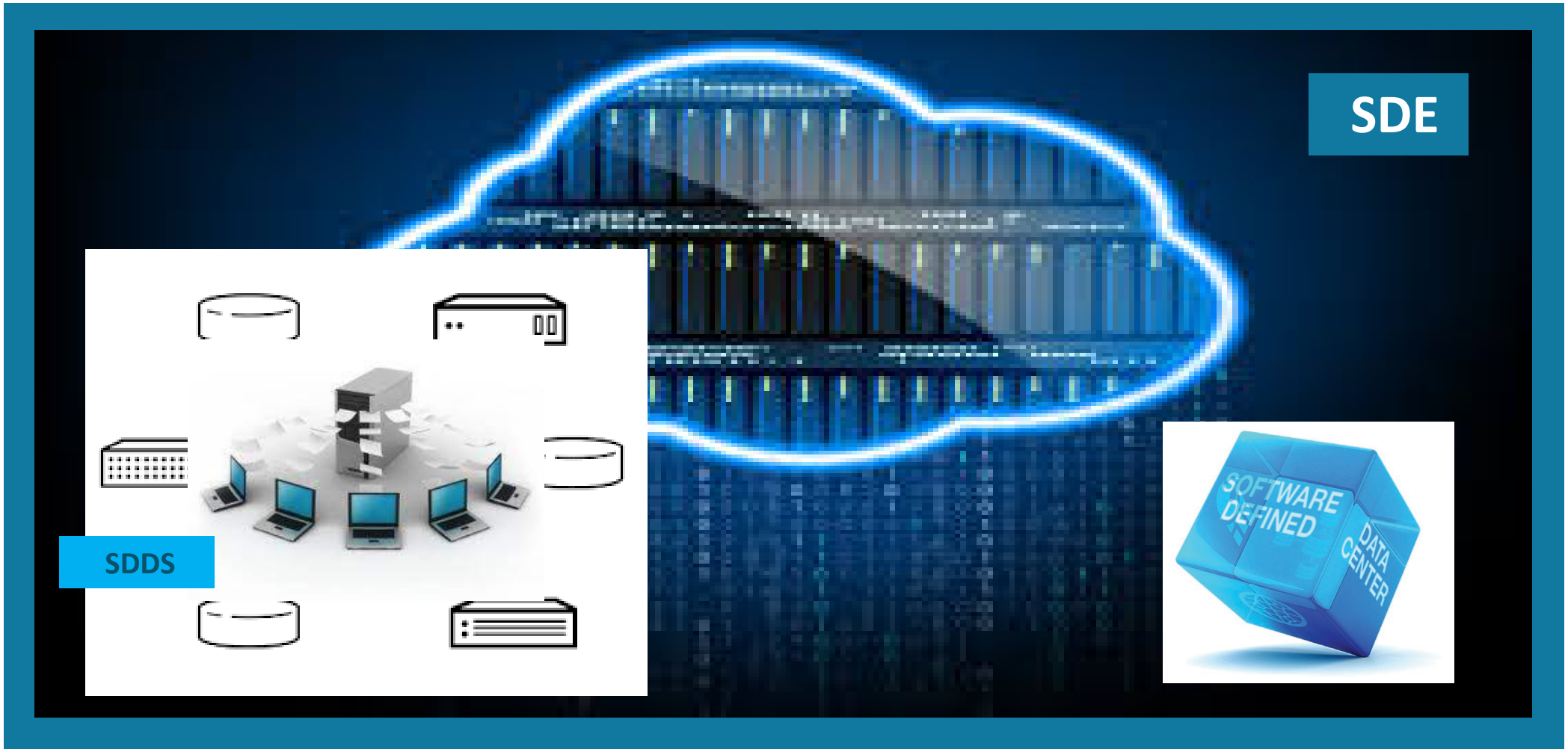


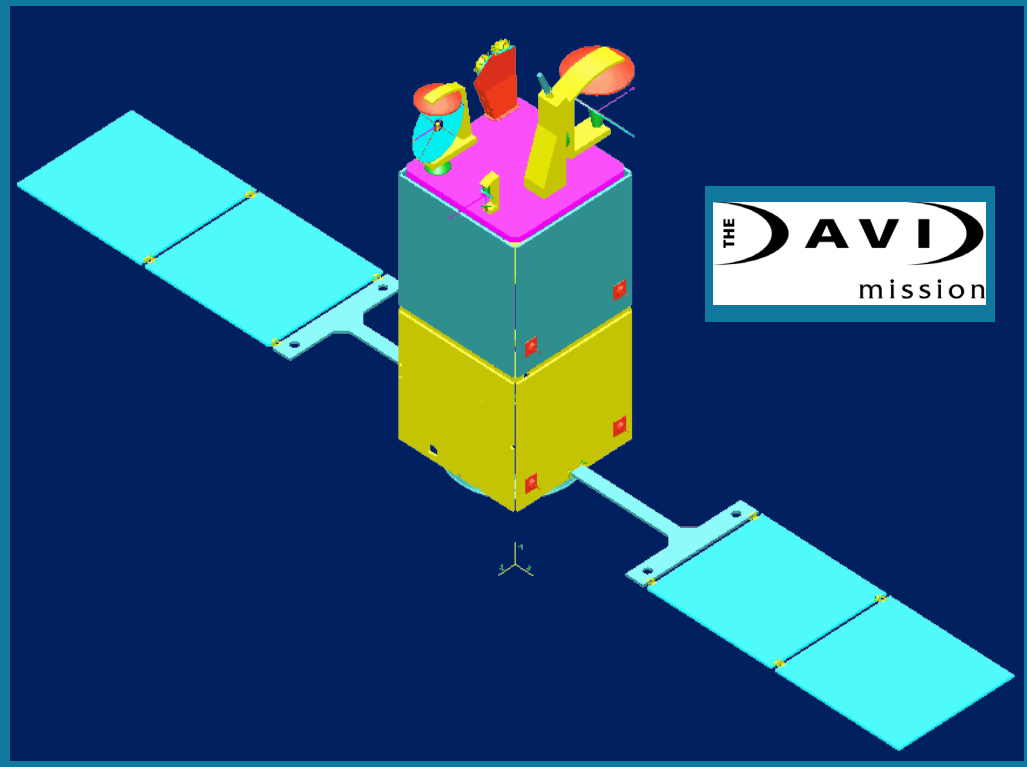
Moving SDN to space

ALLY TECHNOLOGIES



ALLY TECHNOLOGIES

EHF (Q/V & W band)

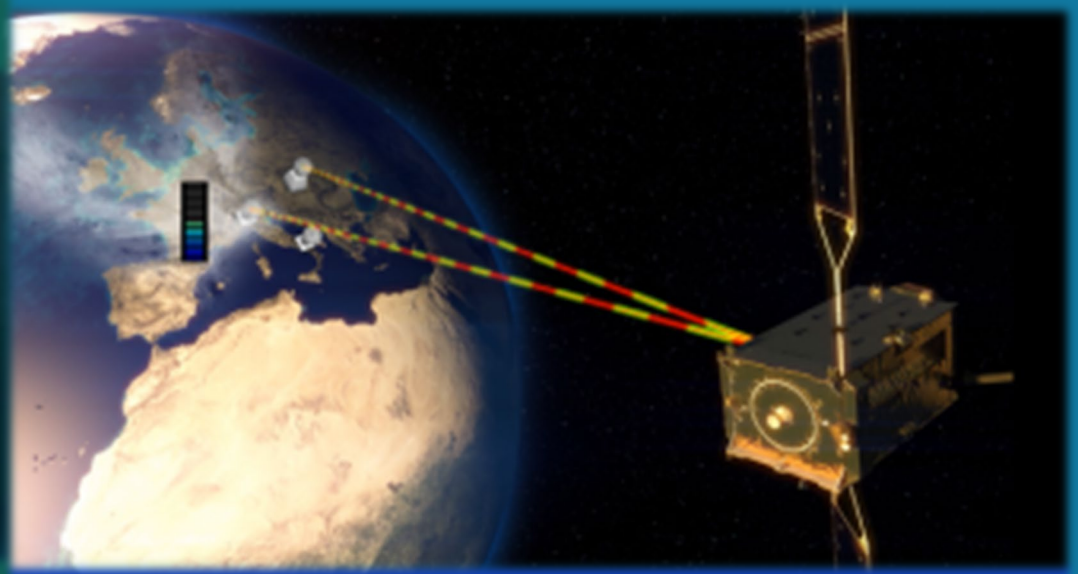


ALLY TECHNOLOGIES

EHF (Q/V & W band)

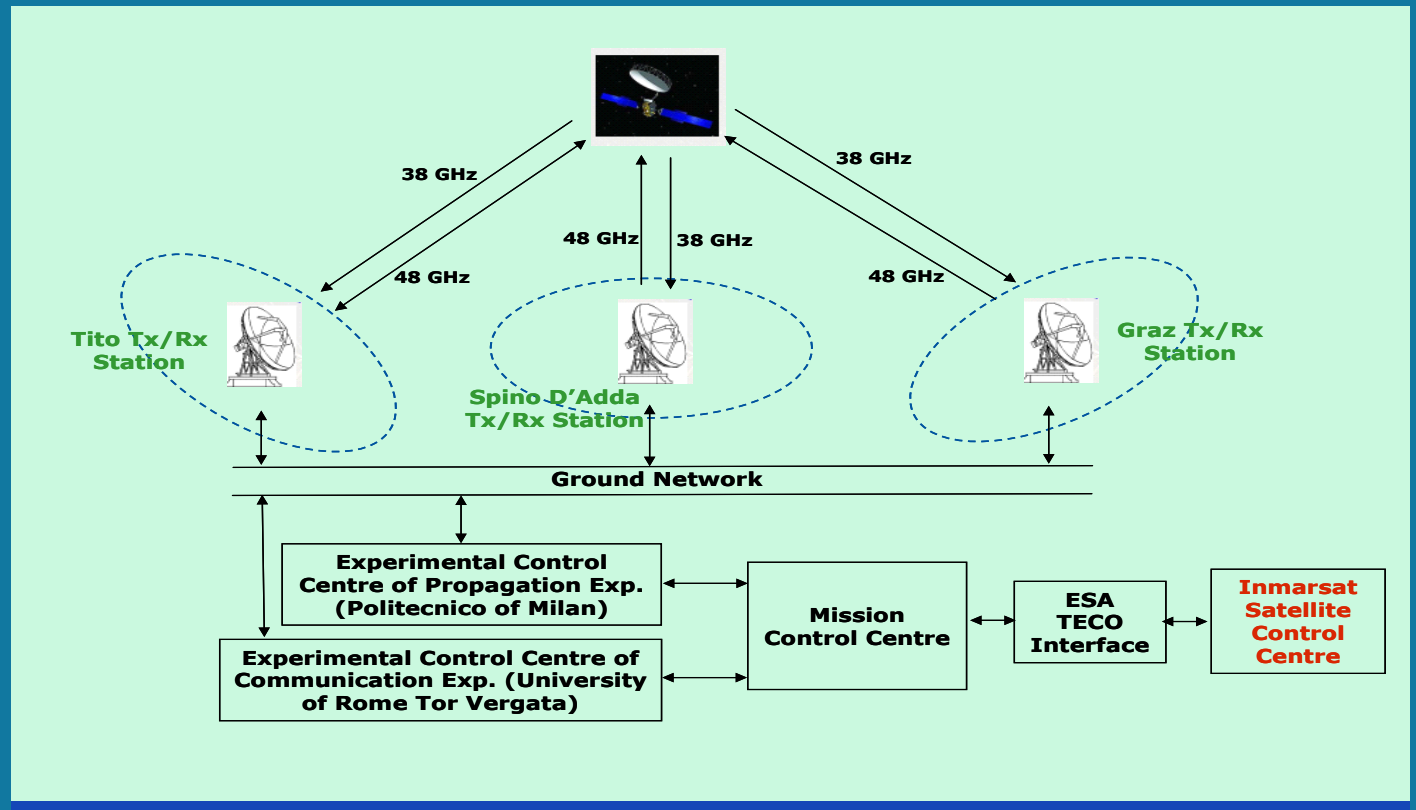
Kourou - July 25, 2013

Launch of Alphasat

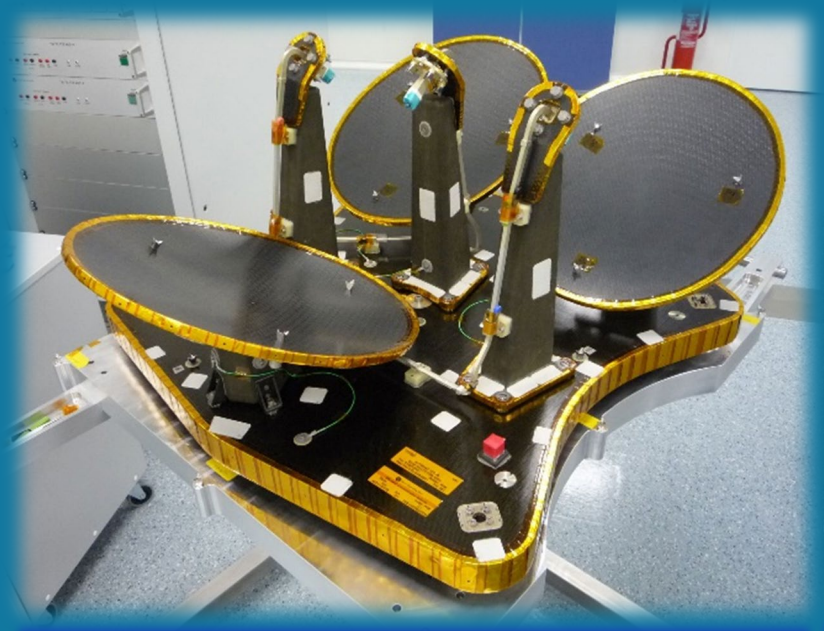


Alphasat embarkes TDP#5 payload

ALLY TECHNOLOGIES



ALLY TECHNOLOGIES



Q/V-band TDP#5 Payload

TDP#5 Tito Scalo station

ALLY TECHNOLOGIES

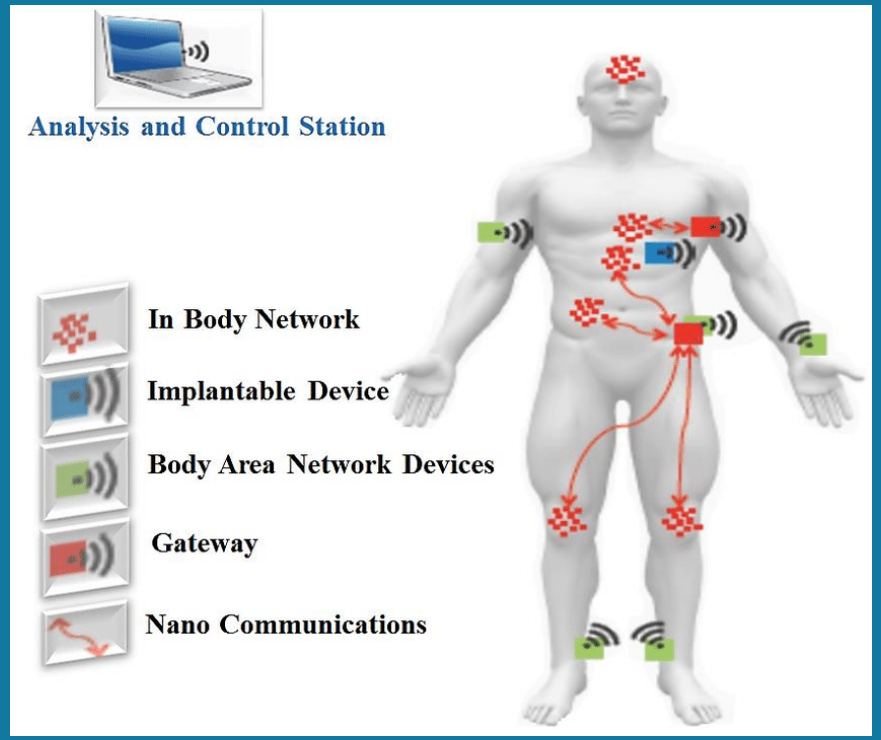
Artificial Intelligence as key of the human-robot cooperative approach in manned space operations and missions:

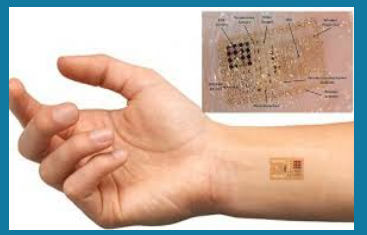
- **Human body cooperation in the network (body as a network node)**
- **Human-robot super-node**

ALLY TECHNOLOGIES

Body as a Network Node (ByN)

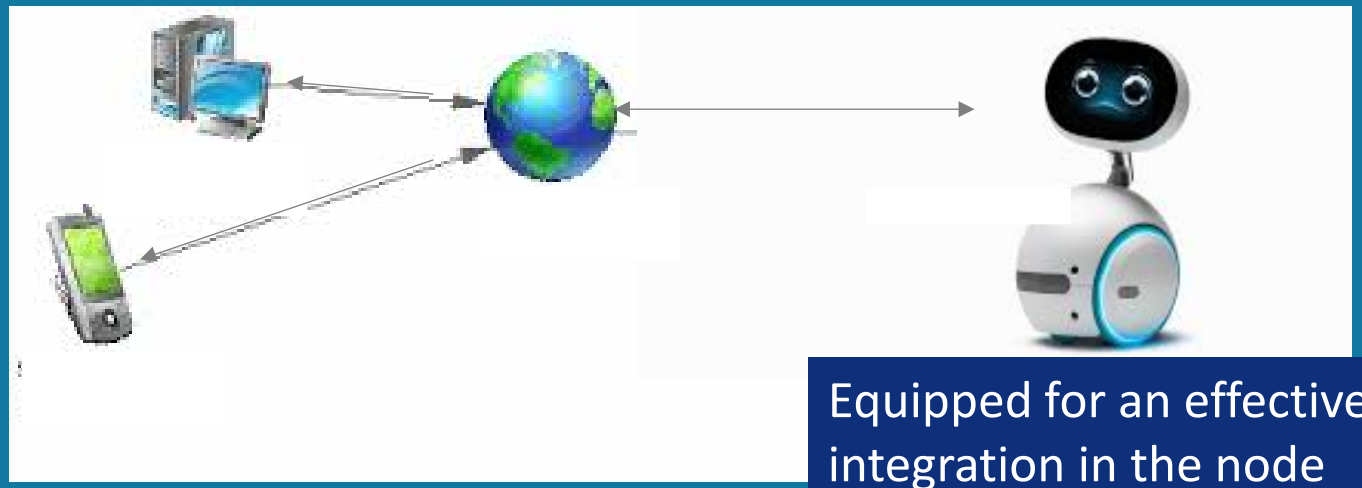
Intra-body, wearable and external devices





ALLY TECHNOLOGIES

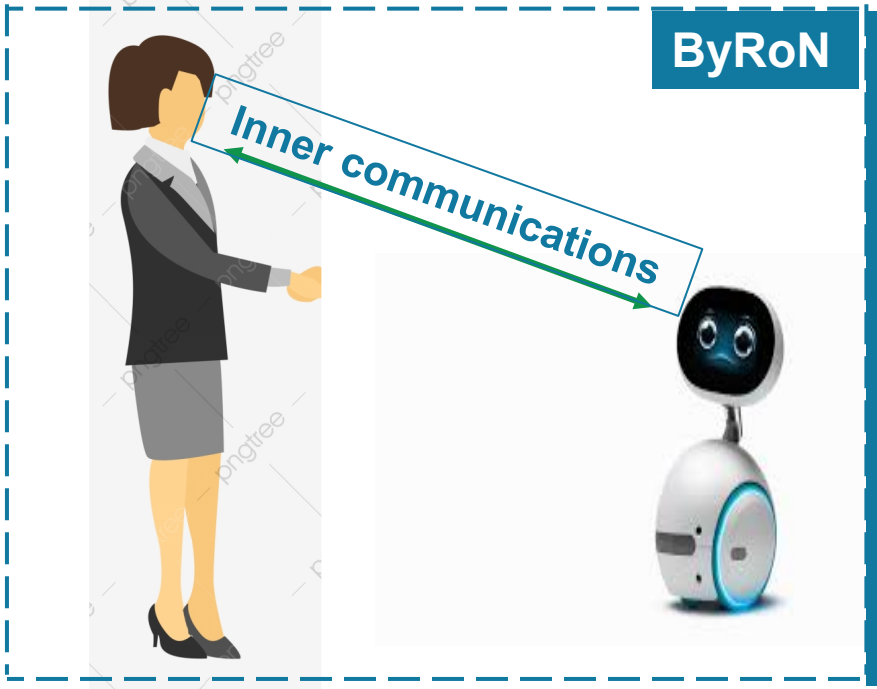
Robot as a Network Node (RoN)



Equipped for an effective integration in the node and network functions

ALLY TECHNOLOGIES

Human-Robot advanced Cooperation within a ByRoN super-node



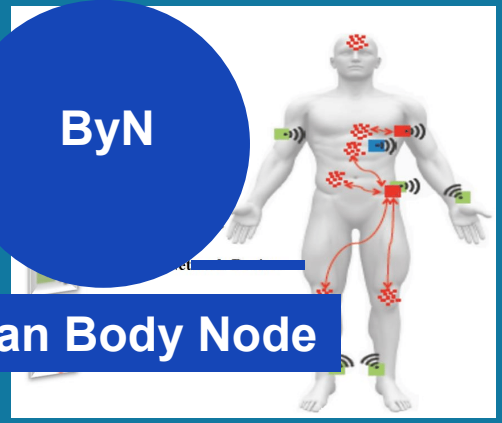
- Human-Robot P2P approach
- Joint decision-making
- Joint operations
- Common network interface

ALLY TECHNOLOGIES

T-Node

Technical node

ByN



Human Body Node

RoN

AI Robot Node

Human-Robot integrated networking

ByRoN

Human Body and AI Robot Super Node

ALLY TECHNOLOGIES

ByRoN in manned space missions

- **Spacecraft** (enhanced digital capabilities)
- **Spacecraft** (reduced delay effects)
- **Lander/Rover** (enhanced digital capabilities)

PERSPECTIVES

- 6G could be an enabler to space sustainability
- In fact, resolution of human needs and social issues is core of the 5G-to-6G transition
- 6G-Space integration must then be/become intrinsically **sustainable** for both Earth and Space

PERSPECTIVES

- Space sustainability calls for a profound change in priorities and paradigm in the space community

- A broad awareness and an active behavior in Earth sustainability matter are key to success in the space sustainability challenge.

SUGGESTED READING [1/2]

[1] E. Cianca, M. De Sanctis, T. Rossi, M Ruggieri, (2024) "*Advanced Technologies for a Sustainable Future of Space*", IEEE COMPUTER, Special Issue on Tech Predictions 2024, August, Vol. 57, pp. 45-54, ISSN 0018-9162, DOI 10.1109/MC.2024.3402083.

[2] E. Cianca, J. Dauncey, G. Fasano, Z.M. Kassas, W. Neil, M. Ruggieri, (2024) "*Autonomy for Sustainability: An AESS Vision and Perspectives*", IEEE Aerospace and Electronic Systems Magazine, June, Vol. 39, Issue 6, pp. 32-41, ISSN 0885-8985, DOI 10.1109/MAES.2024.3376295.

SUGGESTED READING [2/2]

[3] E. Cianca, S. Morosi, M. Ruggieri, (2023), "*Technologies and Infrastructures for a Sustainable Space*", Chapter 8 in "A Roadmap to Future Space Connectivity - Satellite and Interplanetary Networks", Springer, ISBN 978-3-031-30761-4, pp. 185-200, DOI 10.1007/978-3-031-30762-1_8.

[4] E. Cianca, M Ruggieri, (2023) "*Space Sustainability: Toward the Future of Connectivity*", Chapter 3 in "Women in Telecommunications", Springer, ISBN 978-3-031-21974-0, pp. 375-391, DOI 10.1007/978-3-031-21975-7_14.


Thank you!