ILNAS

UNIVERSITÉ DU LUXEMBOURG

Workshop
Space & Technical Standardization

ILNAS

UNIVERSITÉ DU LUXEMBOURG

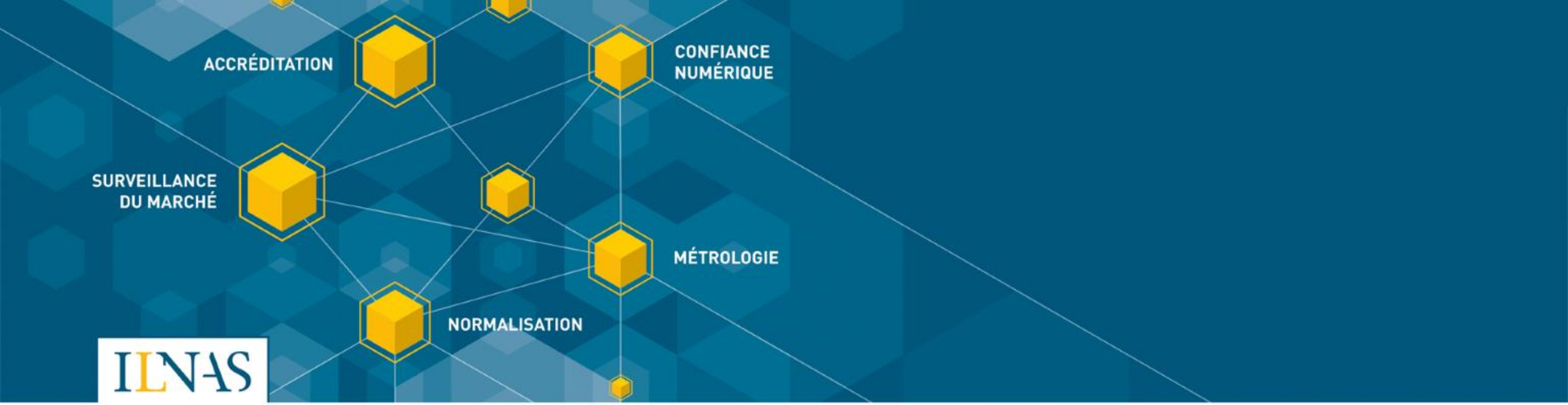
Speakers

Session 1: Space and related Technical Standardization developments

Dr. Jean-Philippe HUMBERT
Deputy Director
ILNAS

Mr. Jérôme HOEROLD
Head of Department
ILNAS/OLN

Mr. Clément HUBER
Aerospace and Technical Standardization
ANEC GIE



National Policy on Aerospace Technical Standardization (2021-2025)

29th June 2022

Jérôme Hoerold
Head of standardization departement

ILNAS

- Public administration under the authority of the Minister of the Economy
- Created by the amended Law of July 4, 2014
- Total staff : 58 (June 2022)
- ISO 9001:2015 certification (Budget and administration department, National Standards Body, Digital Trust department, Market surveillance department)

National Standards Body

- Composed of 6 people
- Close collaboration with the GIE ANEC-N

1. Presentation of ILNAS

ANEC – Agency for standardization and knowledge-based economy

➔ **Support for the implementation of the Luxembourg standardization strategy**

- **Creation**: October 4, 2010
- **Status**: Economic Interest Group (GIE)
- **Objectives**: Promotion, awareness raising and training, applied research in the field of standardization and metrology in order to support companies' competitiveness in Luxembourg
- **Human resources**: 6 employees in the Standardization department
- **Partners** :

ILNAS · CHAMBRE DES METIERS Luxembourg · CHAMBRE DE COMMERCE LUXEMBOURG · LE GOUVERNEMENT DU GRAND-DUCHÉ DE LUXEMBOURG Ministère de l'Économie

2. National standardization strategy 2020-2030

Towards performance:

Pillar I — Value and promote the use of relevant technical standards

Pillar II — Foster and support the involvement in the technical standardization process

Towards excellence:

Pillar III — Ensure the active participation of the NSB in EU and INT standardization organizations and relevant technical committees

Pillar IV — Organize and participate in the development of research and education about standardization

Technical standardization

"Inclusive tool for performance and excellence to serve the economy"

3 growth sectors identified

INFORMATION AND COMMUNICATION TECHNOLOGIES

CONSTRUCTION

AEROSPACE

3. Policy on Aerospace Technical Standardization

In January 2021, ILNAS published its « Policy on Aerospace Technical Standardization (2021 - 2025) ».

The objective of this policy is **to promote and strengthen the involvement of the national market in standardization activities** through three flagship projects:

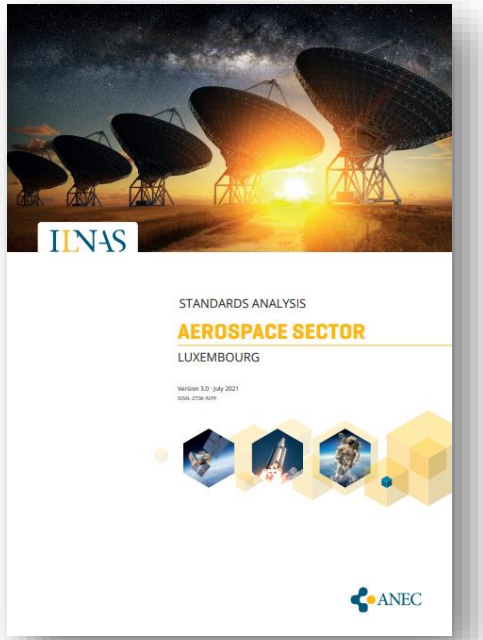
1) Promoting aerospace technical standardization to the market
2) Reinforcing the valorization and the involvement regarding aerospace technical standardization
3) Supporting and strengthening Education about Standardization and the related research activities

A. Draw up a yearly national standards analysis for the aerospace sector

→ Sector-based "Snapshot"

This document is composed of different type of information:

- Standards watch of the related sector
  - Inventory of standards – both published and under development – at the European and international levels
  - Identification and description of technical standardization committees
  - Mention of the related national representation
- Relevant national companies, agencies and Fora/Consortia related to the aerospace sector
- Final report with the results of the above mentioned standards watch and the identified opportunities



B. Define a national implementation plan for aerospace technical standardization

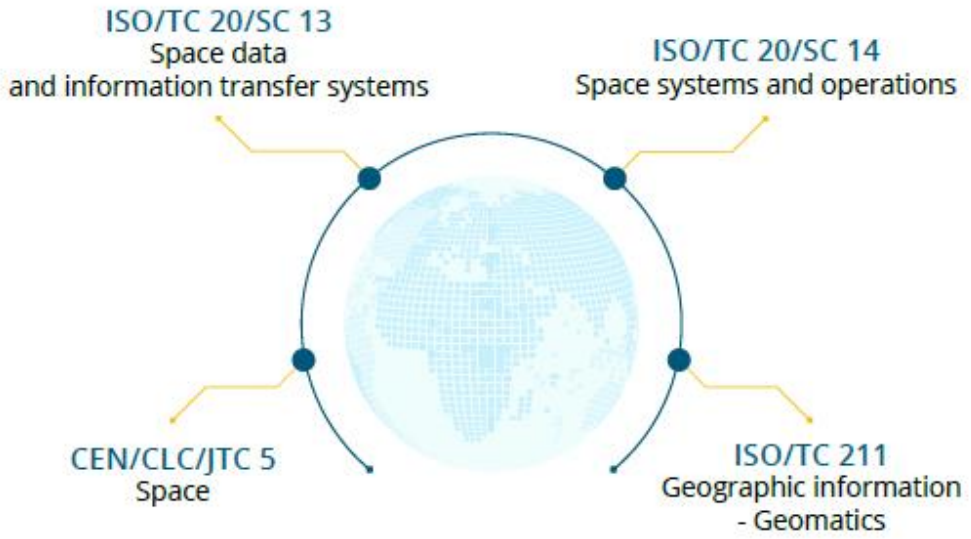
→ The aim is **to involve targeted stakeholders of the Grand Duchy of Luxembourg in a global approach to standardization in order to support the sector in terms of competitiveness, visibility and performance, while enhancing the international recognition of Luxembourg at the standards level**

The implementation plan is drawn up on a yearly basis by ANEC GIE, under the supervision of ILNAS, in order to ensure that it is in line with the national standardization priorities

A. Participate in relevant technical committees

In order to provide the most relevant information on technical standardization to the national aerospace community, ILNAS commissioned ANEC GIE to analyze the national market needs of this specific sector in order to define a list of relevant technical committees.

These technical committees are followed closely and directly by ANEC GIE in order to provide the most relevant information to the interested national actors.



B. Promote the participation of the national market in technical standardization committees and the use of relevant standards

Three main actions have been defined:

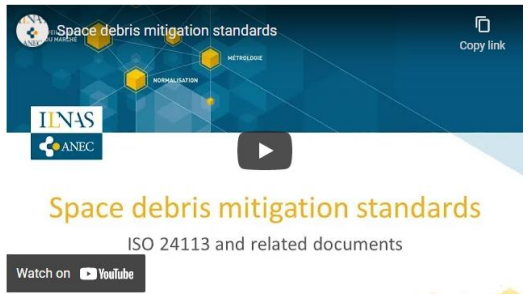
1) <u>Promote the use of the ILNAS reading stations</u>

- Free consultation of European (CEN, CENELEC & ETSI), international (ISO & IEC) and national (ILNAS & DIN) standards
- More than 200.000 normative documents at your disposal
- National network currently composed of 9 lecture stations

2) Organize events to promote participation in technical standardization committees and the use of relevant standards in the aerospace sector

Presentation of the new ANS Aerospace (July 2021)

Online training – Aerospace standardization (July 2021)



Presentation of ISO 24113 – Space debris mitigation (November 2021)

3) Meet and raise the awareness of the national stakeholders (companies, national agencies, Fora/Consortia, etc.) of the aerospace sector

- In 2021, 52 national stakeholders from the aerospace sector have been contacted by GIE ANEC in this specific context

C. Create transversal links with the ICT domain

The aerospace sector is evolving in parallel with the development and the usage of ICT.

→ It is important to create transversal links with technical standardization of the ICT domain in order to identify new opportunities for common developments.

Relevant information will be provided to the national stakeholders active in the aerospace sector, in order to allow them :

- to improve the efficiency of their processes
- to facilitate communication
- to identify new business opportunities
- to develop new markets

3. Supporting and strengthening education about standardization and the related research activities

ILNAS commissioned ANEC GIE **to reinforce the research and innovation activities related to technical standardization in the aerospace sector**, notably by defining and carrying out new research and education projects.

In this frame, the developments are/could be:

- Analysis of the current research trends and outlooks related to the aerospace sector
- Support of doctoral students (in collaboration with the University of Luxembourg), for example on research projects concerning the use of ICT in the aerospace sector
- The publication of white papers and / or other research publications on technical standardization in the field of aerospace
- Evaluate the possibilities to integrate educational content on aerospace technical standardization into educational programs or creating new educational programs dedicated to aerospace technical standardization

3. Policy on Aerospace Technical Standardization

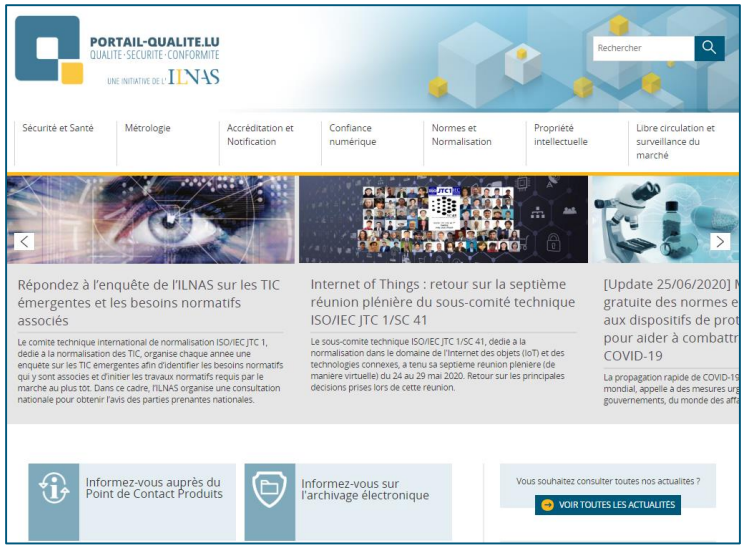
Conclusion

The Luxembourg's policy on aerospace technical standardization (2021-2025) will enable to:

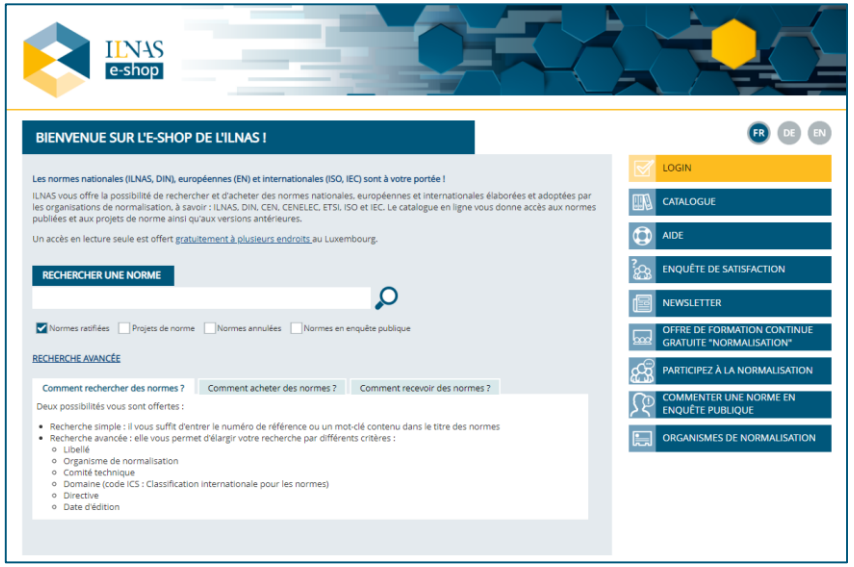
- Strengthen the national aerospace standardization community
- Organize and develop the aerospace technical standardization community at national level
- Raise awareness on aerospace technical standardization according to the market needs
- Increase the national representation within European and international technical committees in the field of aerospace technical standardization
- Foster the use of relevant standards in business activities for the benefit of the national stakeholders
- Develop research and education activities in relation to aerospace technical standardization considered as being of national interest

For more information

Portail qualité
www.portail-qualite.lu



ILNAS e-shop
ilnas.services-publics.lu



Organisme luxembourgeois de normalisation

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Workshop Space &Technical Standardization
Aerospace Sector Standards Analysis”

29th June 2022

Clément Huber
ANEC GIE

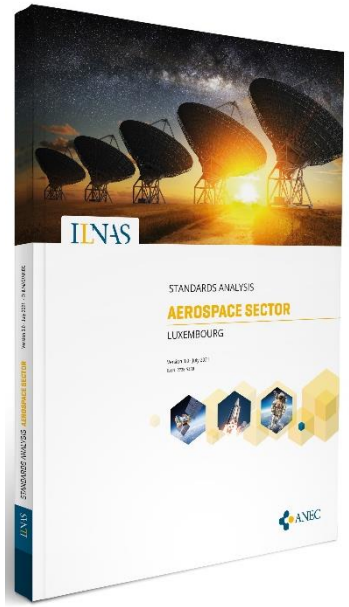
What is this document?

1. Promoting the Aerospace technical standardization to the market
2. Reinforcing the valorization and the involvement regarding Aerospace technical standardization
3. Supporting and strengthening the education about standardization and the related research activities

3 main objectives:

- Baseline resource
- Practical information
- Freely available online

What is this document?



Main information

The importance of technical standardization in the Aerospace sector

Purpose

To help you identify :

- Relevant technical committees related to the Aerospace sector
- Relevant standards and projects addressing the Aerospace sector

What aims?

- Sources of technical standards that might impact you
- Understand the importance of technical standardization in Aerospace sector
- Identify standards development connected to your business in which participating in their development could be of interest

Content of the document

Part 1

Introduction to Aerospace sector
- Aerospace overview
- Aerospace market economy

Part 2

Standardization in the field of Aerospace
- Standards organizations and standards development process
- The importance of technical standardization in the Aerospace sector

Part 3

Opportunity for the national market
- How can technical standardization benefit the national market?
- How to become a national delegate and the advantage to be one?

Part 4

Aerospace Sector standards watch
- List of relevant Technical Committees

Part 1: Introduction to the Aerospace sector

Aerospace overview

Europe

- Political guidance
- Funding programs and projects
- Entities

Luxembourg

- Aerospace policy and partnership
- Legal framework
- LSA
- ESRIC
- SpaceResources.lu

esa

esric
powered by LSA, ESA & LIST

LSA

SPACE RESOURCES.LU

Aerospace market economy

Dynamic development areas

- Telecommunications
- Earth Observation
- Satellite Navigation

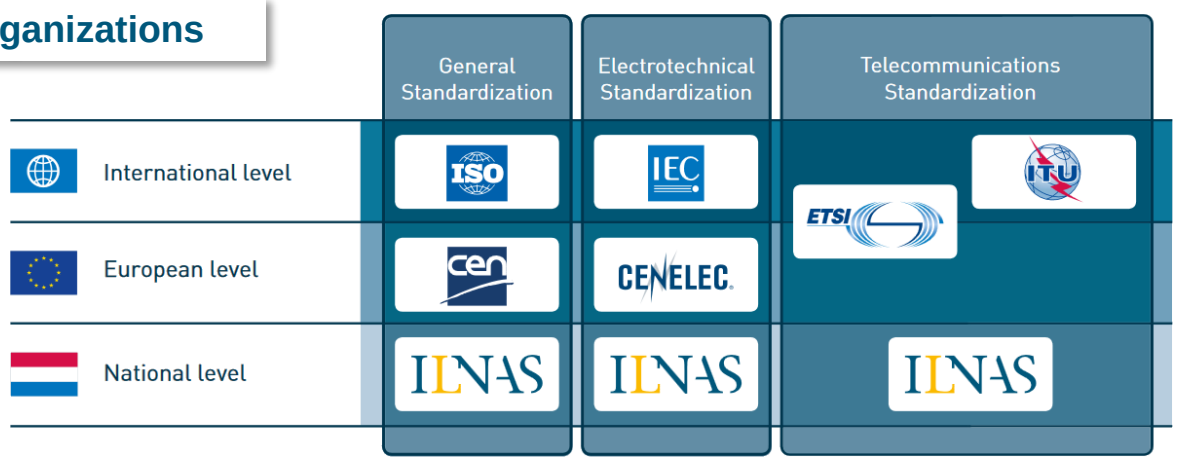
Promising development areas

- Space debris
- Space tourism
- Small satellite launch services
- Information and Communication Technology (ICT)
- Space resources

Part 2: Standardization in the field of Aerospace

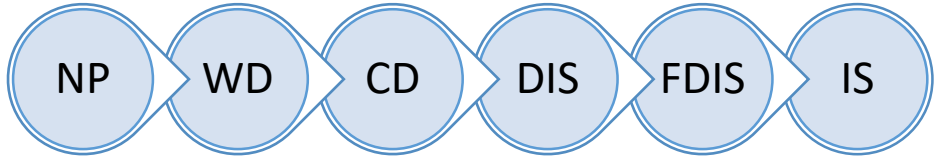
Standards organizations and standards development process

Standardization organizations



Standards development process

- Proposal (NP)
- Study and preparation (WD & CD)
- Public enquiry and approval (DIS & FDIS)
- Publication (IS)



Technical standardization

- **Facilitate international collaboration** through the integration of products and services

- **Facilitate the interoperability of products**, to reduce the technical barriers between the different stakeholders and to facilitate the interface of systems

- Provide a set of guidelines and good practices that will **increase efficiency and reduce costs**

Part 3: Opportunity for the national market

How can technical standardization benefit the national market?

Which benefits?

- National market can **benefit from the definition of the future market rules.**
- The **common ground** provided by technical standardization is essential in the Aerospace sector as external cooperation is almost always involved. It can **extend the market and increase the number of partnerships.**
- Technical standardization is meant to **facilitate cooperation and reduce technical barriers** between the different stakeholders by promoting interoperability and the use of common interfaces.
- This increases the standards of **quality, security and transparency** of your company.

Part 3: Opportunity for the national market

How to become a national delegate and the advantage to be one?

Why get involved in standards development?

- Collaborate to defend common interests
- Learn about your competitors and their positions in meetings
- Promote your organization and your skills at national, European and international levels
- Access drafts standards and influence their content based on your know-how
- Propose new standards projects
- Increase your knowledge regarding the state of the art in standardization of your core business
- Anticipate the evolution of your activity sector's good practices
- Integrate strategic network of national, European or international experts

Becoming a delegate

- Who can participate? → Open to all socio-economic actors in Luxembourg
- Cost of participation? → Registration is free-of-charge
- How to register? → Registration is done using ILNAS/OLN/F001a form (Initial registration) or ILNAS/OLN/F001b form (Additional registration).

List of relevant Technical committees

Technical committees

Regrouped into 5 parts:

- Solely dedicated to the space sector, with a wide range of applications
- Telecommunication
- Earth Observation
- Technical areas (mechanical, electrical…)
- Systems engineering, Quality, Safety and Management processes

3 major technical committees:

- ISO/TC 20/SC 14 “Space systems and operations”
- CEN/CLC/JTC 5 “Space”
- ASD-STAN “Aerospace”

Part 4: Aerospace sector standards watch

List of relevant Technical Committees

Technical Committees

ISO/TC 20/SC 14 Space systems and operations			
GENERAL INFORMATION			
Creation date	1992	**Secretariat**	ANSI (United States)
Chairperson	Mr. Paul Gill	**Committee Manager**	Mr. Nick Tongson
Scope	Standardization for manned and unmanned space vehicles, their design, production, testing, integration, maintenance, operation, and disposal, and the environment in which they operate, as well as the safety requirements associated.		
Structure	AG 1 Chairman's advisory group (CAG) AG 2 Terminology task force WG 1 Design engineering and production WG 2 System requirements, verification and validation, interfaces, integration, and test WG 3 Operations and support systems WG 4 Space environment (natural and artificial) WG 5 Space System Program Management and Quality WG 6 Materials and processes WG 7 Orbital Debris Working Group		
Webpage	ISO - ISO/TC 20/SC 14 - Space systems and operations		
STANDARDIZATION WORK			
Published standards	186	**Projects**	44
INTERNATIONAL MEMBERS			
P-Members	16	**O-Members**	11 (including **Luxembourg**)

ILNAS and ANEC GIE services

Products and services

ILNAS in collaboration with ANEC GIE offers the following products and services to national socio-economic actors:

- Dissemination of normative information
  - Sectoral Standards Analyses (Fundamental Sectors)
  - White papers
  - Newsletters
  - Etc.
- Continuous training in standardization
- Targeted standards watch

To conclude…

Main takeaways of the Aerospace Standard Analysis

- **Know the importance of technical standardization in the Aerospace sector**
  - Know some existing technical committees
  - Know who is developing standards that might impact you
  - Follow committees' work and standards' evolution
  - Join as a delegate to
    - Shape new standards that are in project form
    - Rework published standards that are under revision
    - Propose new standards and lead projects
- **Know what services ILNAS and ANEC GIE can offer to support you**
  - Coach you as a delegate
  - Serve as an interface to submit comments
  - Propose standards watch

DON'T HESITATE TO:

- **DIVE INTO THE DOCUMENT!**
- **CONTACT US!**

Thank you for your attention!

- Satisfaction survey of the workshop
- Declaration of interest
- Presentation sheet

ILNAS ANEC

ILNAS

UNIVERSITÉ DU LUXEMBOURG

Speakers

Session 2: Research and Education perspectives in relation with Space Standardization

Pr. Dr. Pascal BOUVRY
Chargé de Mission auprès du Recteur
University of Luxembourg

Dr. Grégoire DANOY
Research Scientist
University of Luxembourg

Dr. Mohammed ALSWAITTI
Postdoctoral Researcher
University of Luxembourg

Ms. Maria HARTMANN
PhD Student - Research Program
University of Luxembourg

Workshop
“Space & Technical Standardisation”

Dr. Grégoire Danoy
Research Scientist, Deputy Head PCO Group
University of Luxembourg

Parallel Computing and Optimisation Group

http://pcog.uni.lu

Research Topics:
- Parallel/Decentralised computing
- Optimisation/Search/Learning

Aim:
- Efficient, scalable and robust solutions to solve large-scale discrete/combinatorial problems.

Applications:
- Robust/sustainable/efficient HPC/Grid/Cloud/IoT
- Unmanned Autonomous Systems (UAS)
- Next generation networks and protocols
- Systems Bio-medicine
- Information/Document Management for Bio and Finance

Management:
- Head: Prof. Pascal Bouvry
- Deputy Head: Dr. Grégoire Danoy

20+ researchers

1 Professor

4 Research Scientists

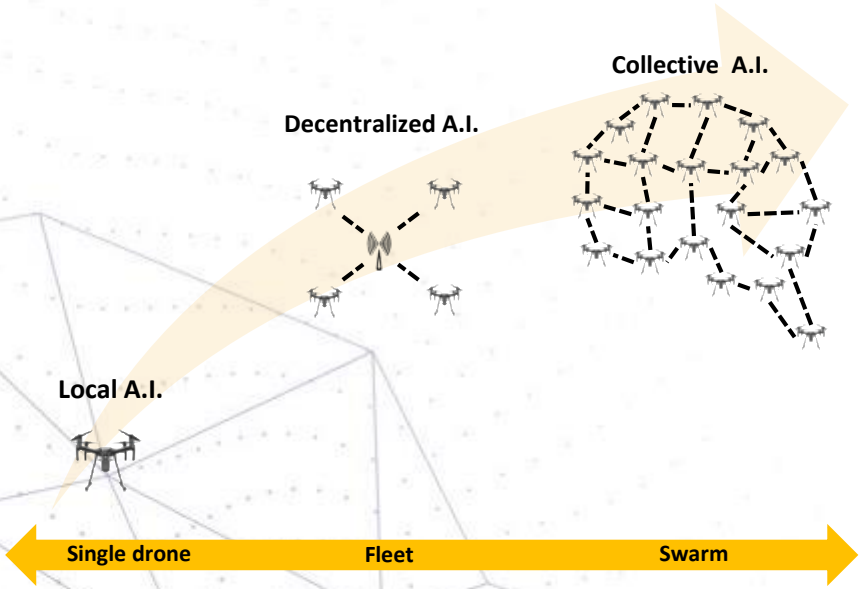
7 Postdocs

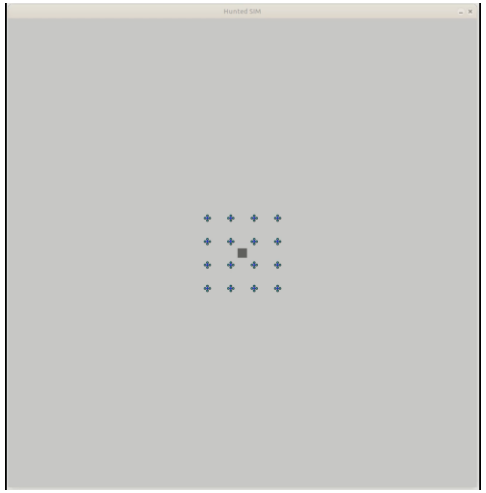
8 PhD students

12 nationalities

Focus Area: Parallel & Evolutionary Computing, Swarm Intelligence

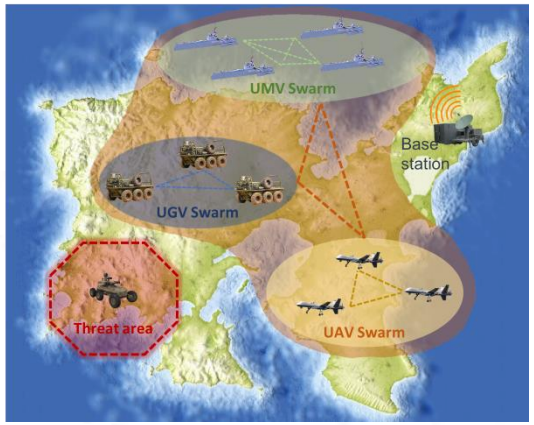
- Swarm of Unmanned Autonomous Systems (UAS)
- New mobility models for UAS swarms
  - Nature-inspired approaches
  - Automated algorithm design



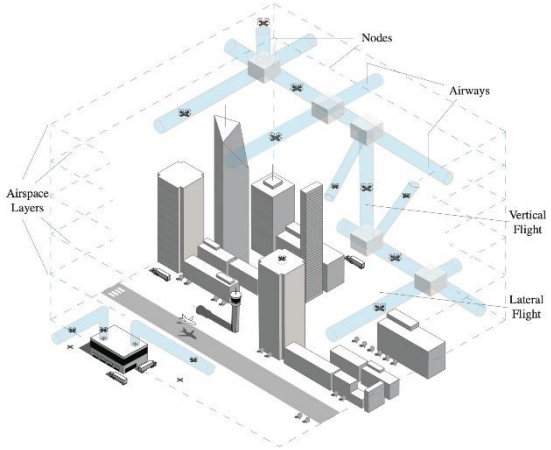


UAS Applications

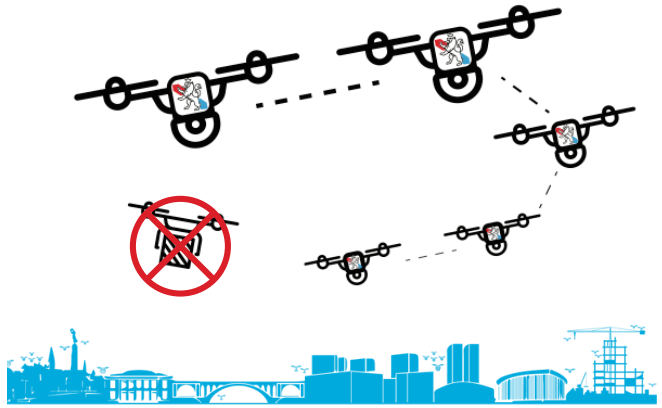
Surveillance & Tracking with Multi-Swarm Systems



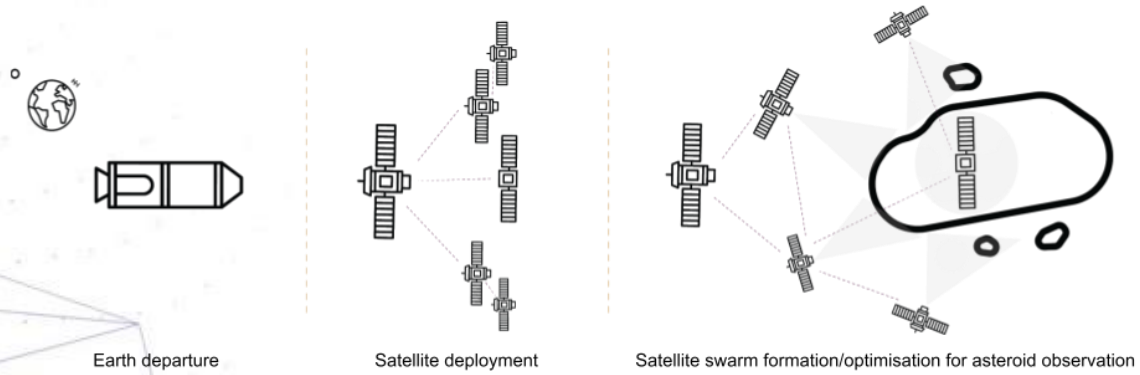
Distributed UAS Traffic Management



Counter UAS Systems



Asteroid Observation



Focus Area: High-Performance Computing

- 2nd largest HPC facility in Luxembourg
- National HPC-BD Competence/Excellence Centre
- First European Master's programme on HPC
- Member of EU HPC projects:
  - ETP4HPC - European Technology Platform (ETP) for HPC
  - PRACE - Partnership for Advanced Computing in Europe
  - EuroHPC: bringing new {peta,[pre-]exascale systems

Computing Capacity:

5 clusters / 2 sites
2.76 PFlops
11228 cores

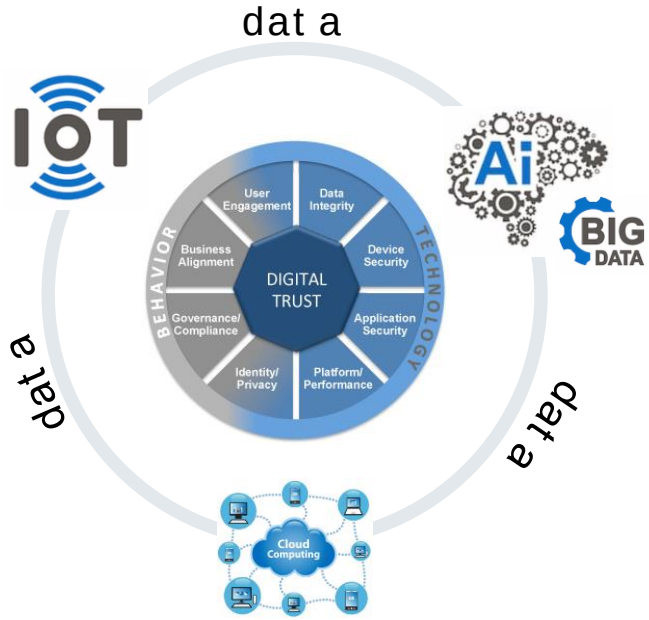
Storage Capacity:

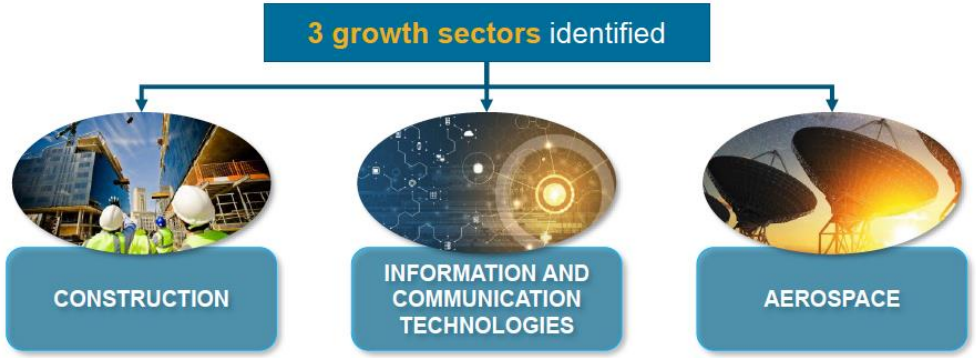
4 distributed/parallel FS
Total capacity: 10.68 PB

Research & Education Collaboration

- **Research Programmes**
  - First Research Programme (2017-2021)
  - Second Research Programme (2021 – 2024)

- **Education Programmes**
  - Smart ICT Certificate (2016 – 2018)
  - Master in Technopreneurship (2021 -)



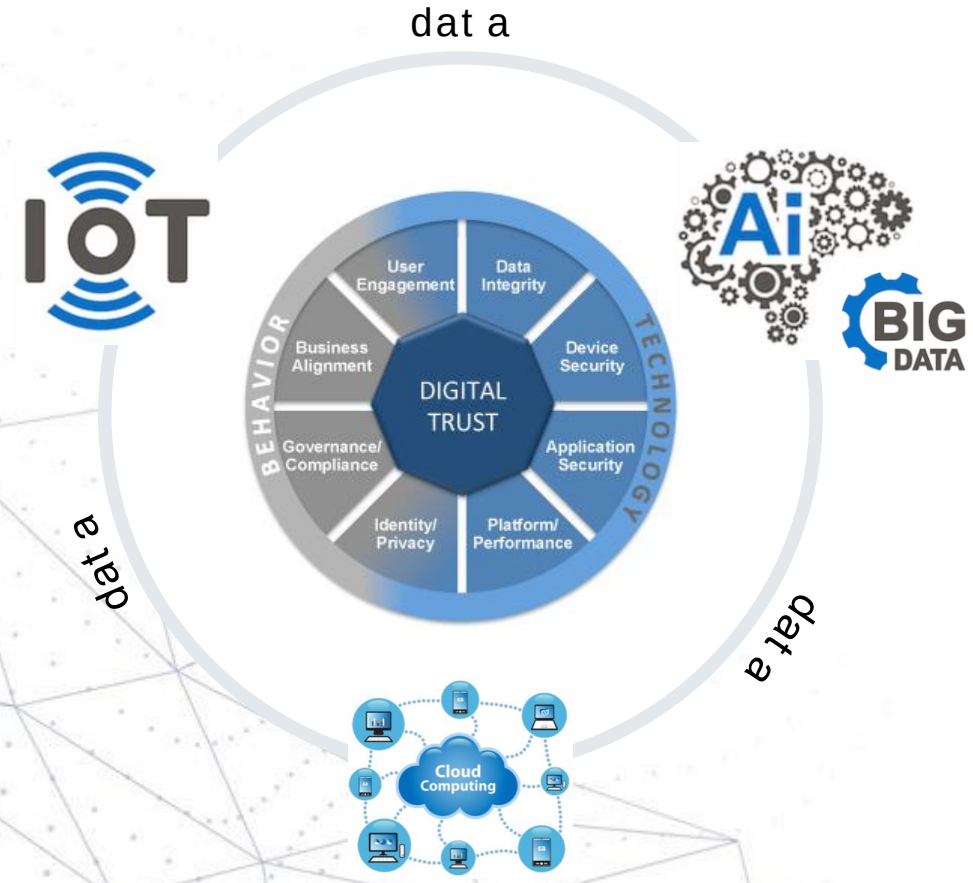


The First Research Programme

First Research Programme - The Smart-ICT Ecosystem

“Technical Standardisation for Trusted Use in the Field of Smart ICT”

NATIONAL STANDARDISATION STRATEGY 2010-2020 & POLICY ON ICT



Smart ICT Key Components

1. **Core research pillars**
   - **Internet-Of-Things,**
   - **AI/Big Data**
   - **Cloud Computing**
2. **Connecting structural layer**
   - **Data**
3. **Transversal component**
   - Digital Trust and Security
   - Intersection between pillars

With special focus on

1. Core scientific research areas
2. Technical standardisation needs
   - Identification of gaps between research and standardisation

Objectives

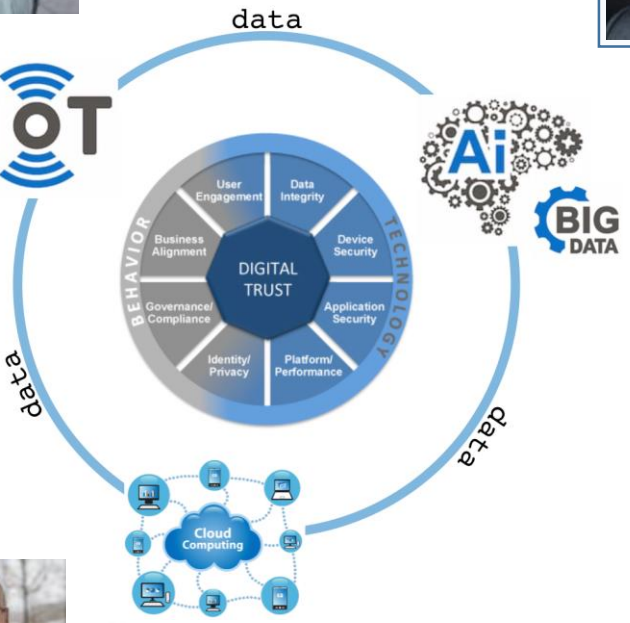
An innovative environment on digital trust for Smart ICT and related standardisation

The Smart-ICT Team

Nader Samir
Supervisor: Dr. Grégoire Danoy
Industrial experience in UAVs

Prof. Pascal Bouvry
Principal Investigator
Project coordination
PhD supervision

Dr. Grégoire Danoy
Research Scientist
PhD supervision



Saharnaz Dilmaghani
Supervisor: Dr. Matthias Brust
Standardisation experience

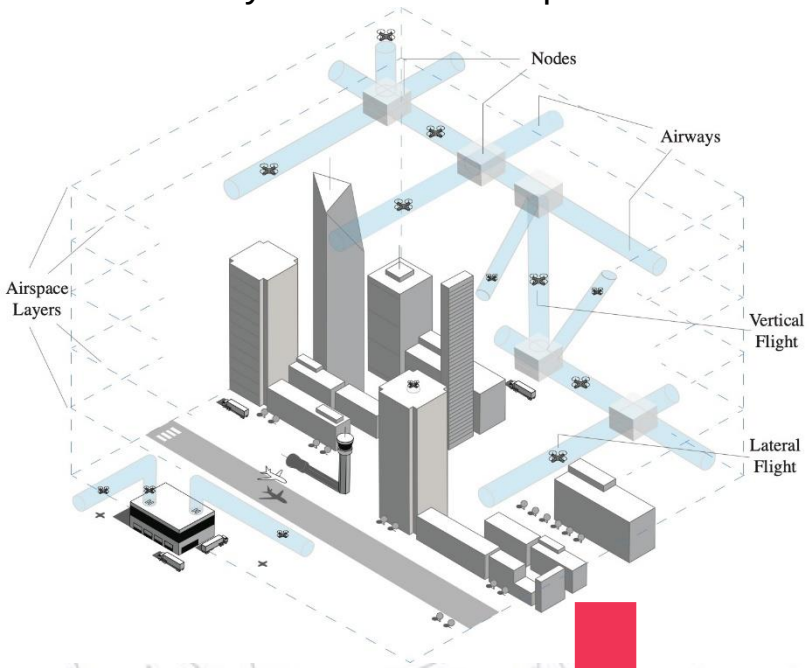
Chao Liu
Supervisor: Prof. Pascal Bouvry
Cloud Computing

Dr. Matthias Brust
Research Scientist
Project support
PhD supervision/support

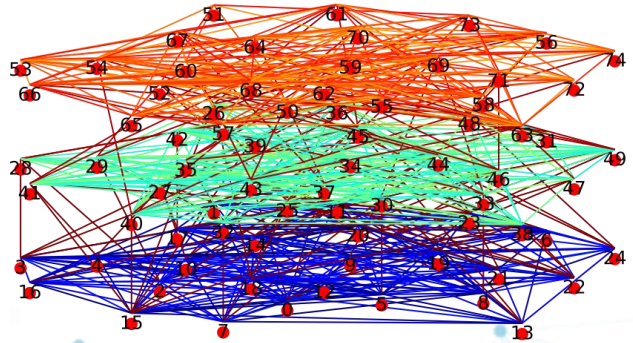
Multilayer Low-Altitude Airspace Model for Distributed UTM

http://smartict.gforge.uni.lu

New layered class G airspace model



Multi-level multi-weigthed graph model



Distributed UTM optimisation model

$$\min \; P = \sum_{i=1}^{I} \sum_{l=1}^{L} a_{il} * e_l \tag{1}$$

$$\min \; T = \sum_{i=1}^{I} \sum_{l=1}^{L} a_{il} * t_l \tag{2}$$

$$\text{s.t.} \; \sum_{i=1}^{I} a_{il} = c_l, \; l = 1, \ldots, L, \tag{3}$$

$$c_l \leq c_l^{max}, \; l = 1, \ldots, L, \tag{4}$$

$$a_{il} \in \{0,1\}, \; i = 1, \ldots, I, \; l = 1, \ldots, L, \tag{5}$$

$$P, T \in \mathbb{N}, \tag{6}$$

$$e_l, t_l, c_l \in \mathbb{N}, \; l = 1, \ldots, L, \tag{7}$$

Key figures

1 White Paper

1 Technical Report

15 Wide Audience Talks

21 Conference Articles

4 Journal Articles

2 Awards

Parallel Computing and Optimisation Group

Contact:

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Connect with us

@SnT_uni_lu

SnT, Interdisciplinary Centre for Security, Reliability and Trust

Workshop
“Space & Technical Standardisation”

Dr. Mohammed Alswaitti
Postdoctoral Researcher
University of Luxembourg

The Second Research Programme

The Second Research Programme 2021-2024

Technical Standardisation for Trustworthy ICT, Aerospace, and Construction

NATIONAL STANDARDISATION STRATEGY 2020-2030

Core research pillars

- ICT
- Aerospace
- Construction

With special focus on

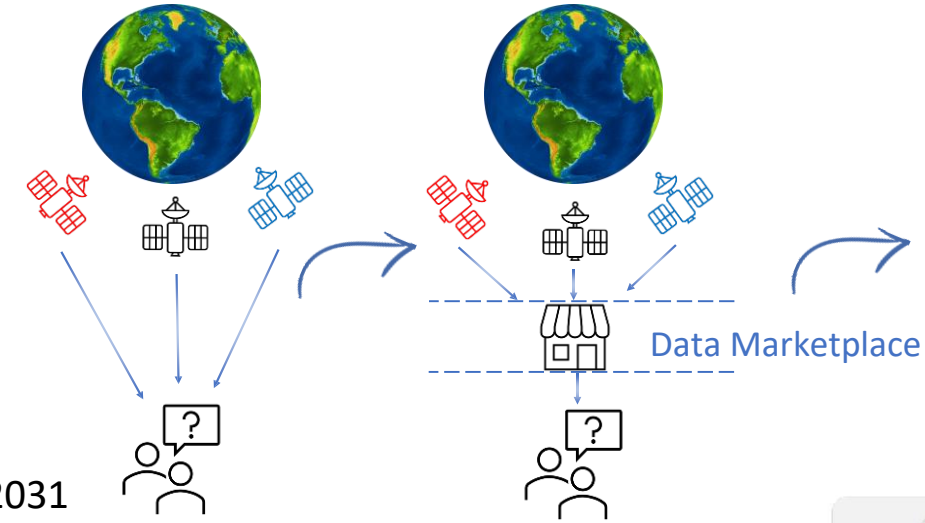
- Core scientific research areas
- Technical standardisation needs
- Identification of gaps between research and standardisation

Objectives

- Deepen data and AI capabilities and continuous drive innovation in the 3 growing sectors of Luxembourg

ICT

Satellite Images Data Marketplace



Pricing Strategies

Combinatorial Problems

Key Figures

13,910 satellites

<500 kg will be launched by 2031

Source Euroconsult, February 2019

8.3% CAGR

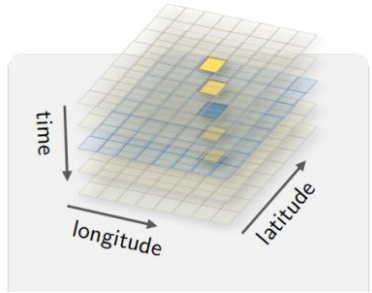
(Compound Annual Growth Rate) over 2021-2026

Source Mordor Intelligence, February 2020

€3.38 billion

(Commercial Earth Observation Data Global Sales from Enterprise and Defense, Midstream Segment, in 2022

Source Mordor Intelligence, February 2020



Satellite Image Time Series

Image mosaicking

Recommendation for Cost Minimization. Increase revenue by demand forecasting

Developing heuristics and Machine learning Algorithms/Tools

Construction

Smart Cities - Building Information Modelling (BIM) & Digital Twin

Digitalised Construction, 2020-2030

Market Size

$18.42 Billion

Source : market research future

CAGR

13.63%

Source : market research future

New Job Creation

700,000 across EU

Traditional Way:

Cost Overruns

Shortage Labor

Human Mistakes in Design

Changing Order

Artificial Intelligence

...

Machine Learning Tools

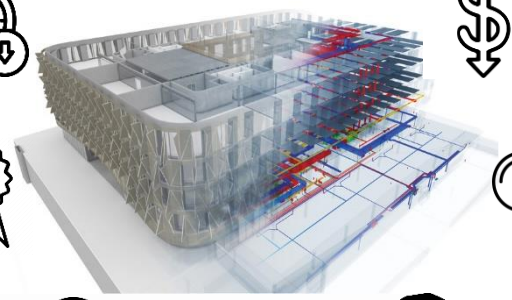
Digital Modelling

Optimization Algorithms

Internet of Things

Save Time

Budget Reliability



High rate of quality

Error Detection

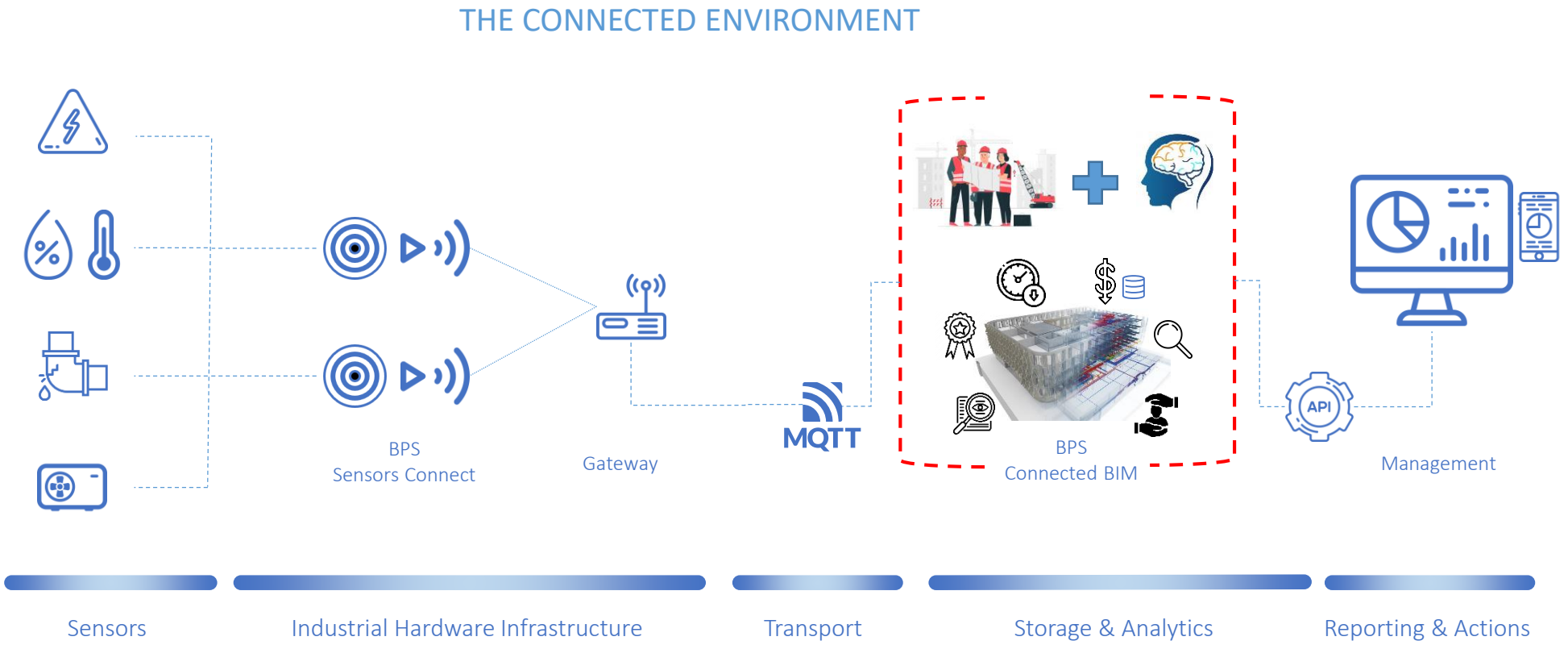
Transparency

Prefabrication

Construction

Smart Cities - Building Information Modelling (BIM) & Digital Twin

Digitalised Construction, 2020-2030



Aerospace

Aerospace Swarms of Nano-Satellites

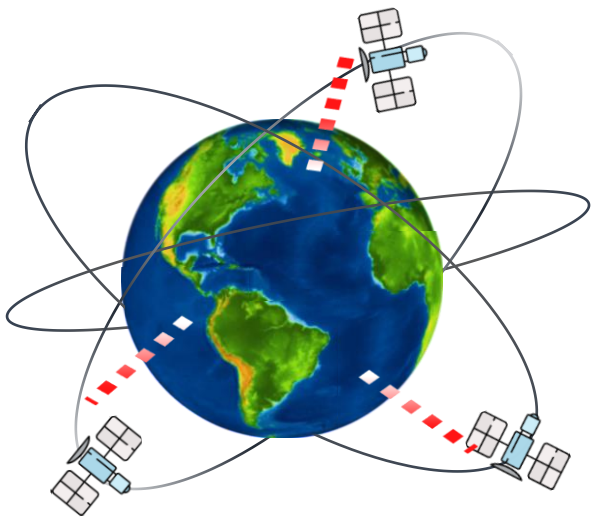
State of the art Challenges

Computation
Power is limited

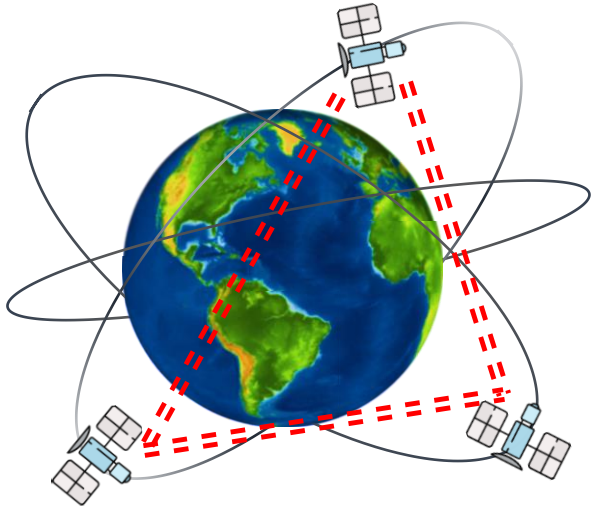
Communication
needs power

Transmission
Latency

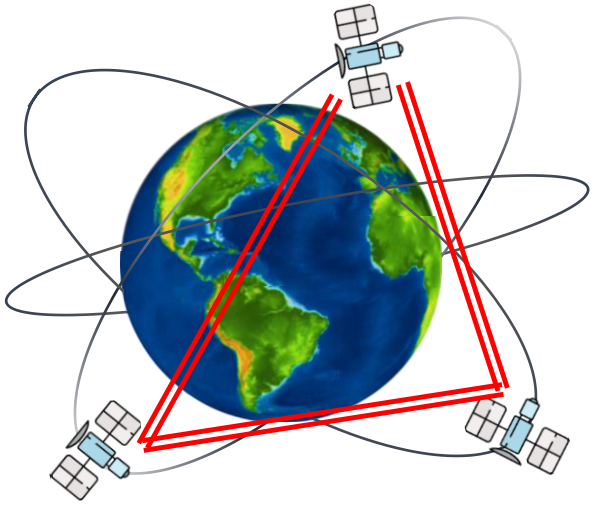
LeSS



Conventional



Swarm Data Exchange



Swarm Model Exchange (Federated Learning)

The Team

Dr. Grégoire Danoy

Research Scientist
PhD supervision

Prof. Pascal Bouvry

Principal Investigator
Project coordination
PhD supervision

Dr. Mohammed Alswaitti

Postdoctoral Researcher
PhD students & Project support

Maria Hartmann

(PhD student)
Supervisor: Dr. Grégoire Danoy
Since 15.02.2022
Aerospace

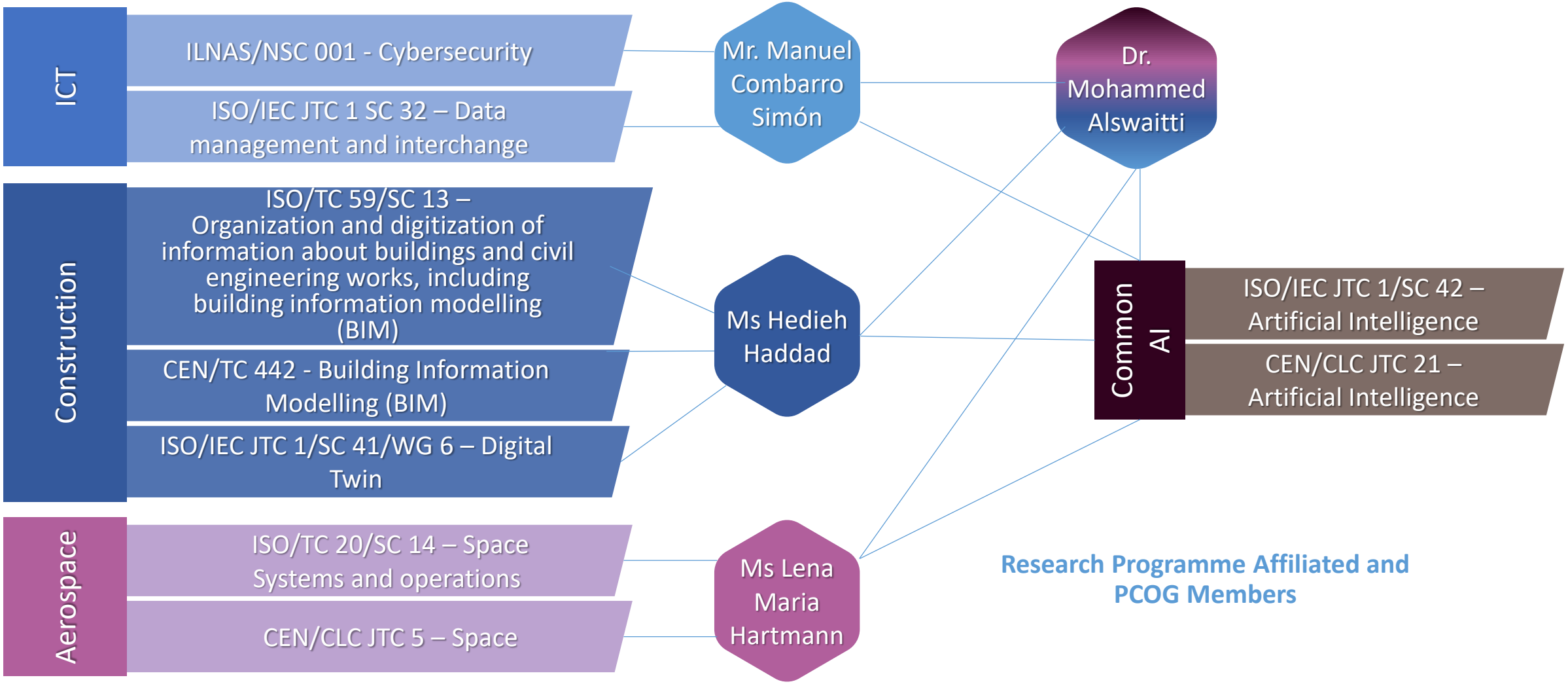
Manuel Combarro Simón

(PhD student)
Supervisor: Prof. Pascal Bouvry
Since 01.11.2021
ICT

Hedieh Haddad

(PhD student)
Supervisor: Prof. Pascal Bouvry
Since 15.01.2022
Construction

Involvement in Standardisation Committees, Work Groups, Advisory Groups



Parallel Computing and Optimisation Group

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Workshop
“Space & Technical Standardisation”

Swarms of Nano-Satellites

Maria Hartmann
PhD Student (ILNAS/SnT – Aerospace)
University of Luxembourg

Autonomous satellite swarms are the future

“How swarms of small satellites could revolutionize space exploration” [1]

“Scientists and engineers around the world expect that satellite formation-flying will provide breakthroughs in astronomy and astrophysics, planetary science and space exploration.”

October 4, 2016

“NASA Mission To Test Technology for Satellite Swarms” [2]

January 21, 2021

“NASA Works to Give Satellite Swarms a Hive Mind” [3]

Sep 1, 2021

Source: Eutelsat

[1] How swarms of small satellites could revolutionize space exploration | Stanford University School of Engineering
[2] NASA Mission To Test Technology for Satellite Swarms (cmu.edu)
[3] Giving Satellite Swarms a Hive Mind | NASA

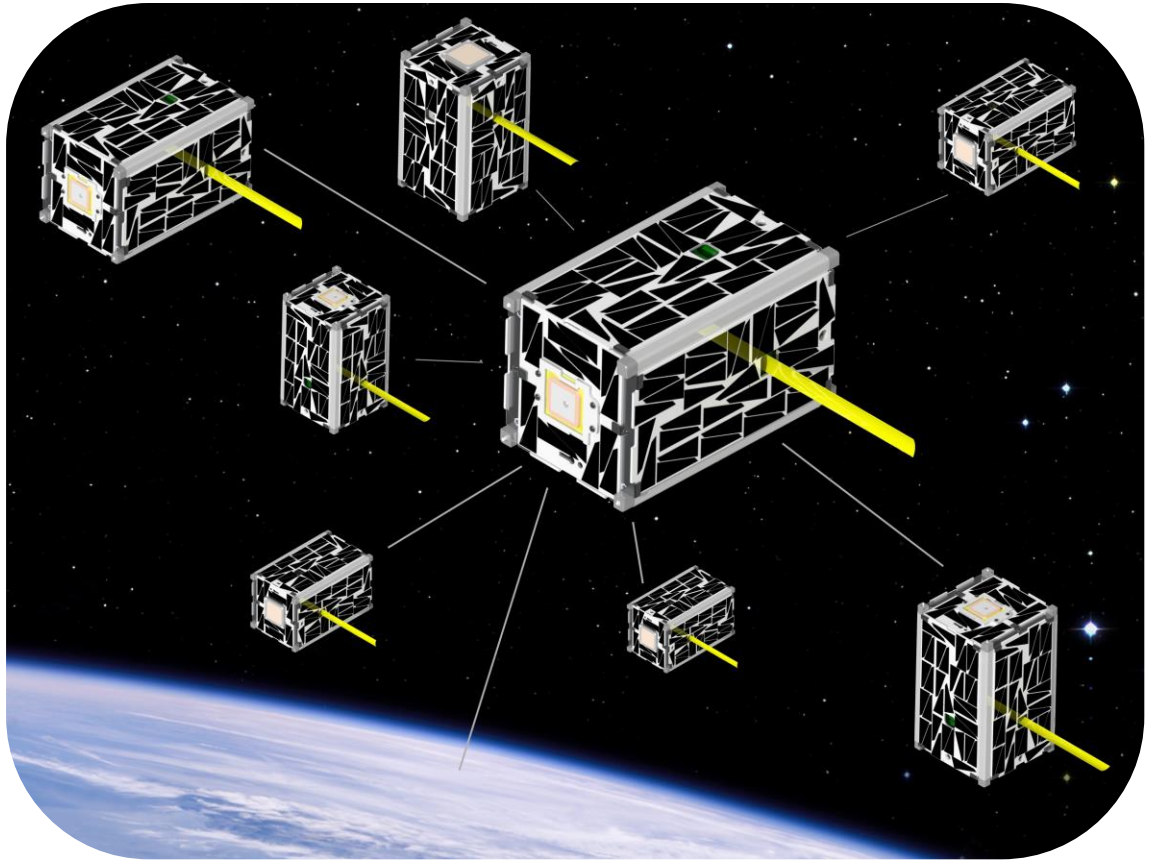
Autonomous satellite swarms have systemic advantages

Flexibility:
- Can manifest collective behaviour beyond individual capability
- Can react to unforeseen circumstances without delay

Scalability:
- Number of satellites may be extended over time

Resilience:
- Can compensate for loss of individual satellites

Cost-effectiveness:
- Can mass-produce standard multi-purpose satellites
- Launching smaller satellites is less expensive



Source: NASA

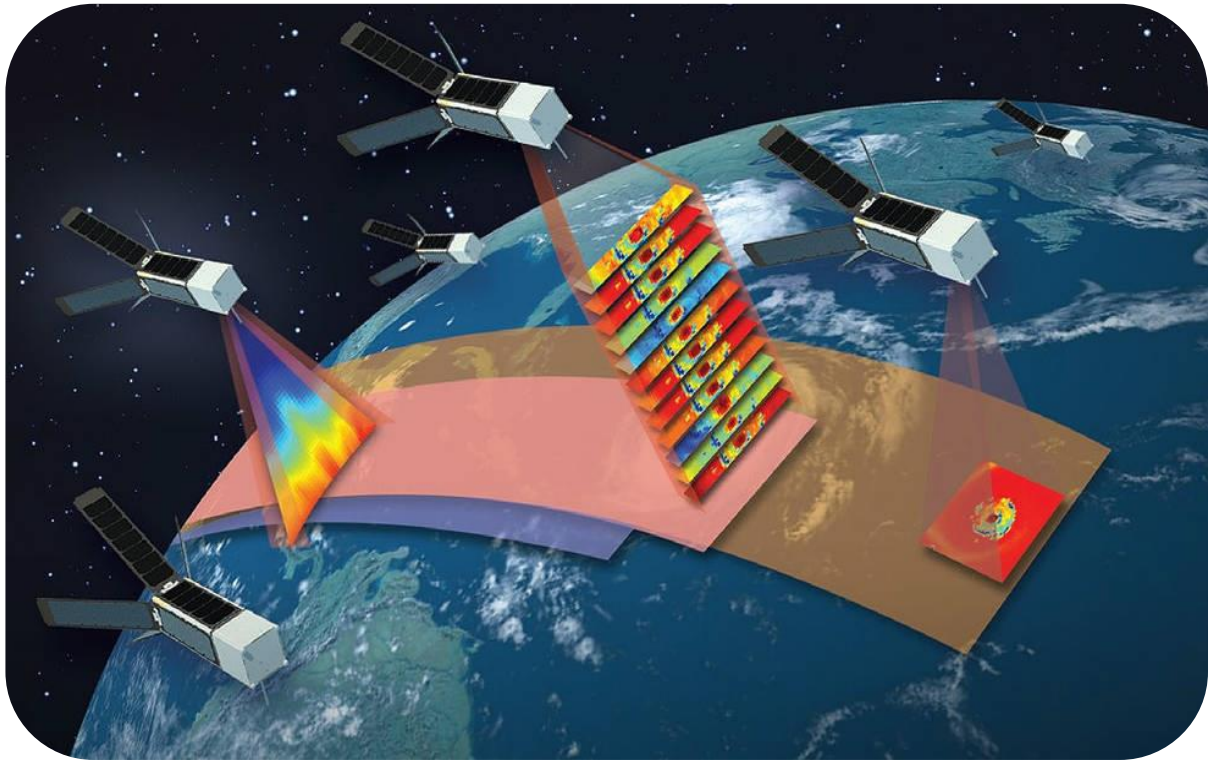
Autonomous satellite swarms have many use cases

Earth observation:
- Fast response times for disaster management
- Multi-view imaging capability

Communication:
- Relay networks for planetary exploration missions

Exploration:
- Deep-space exploration missions
- Heterogeneous swarms for planetary exploration

Mining:
- Support satellite network for mapping, coordination of asteroid mining



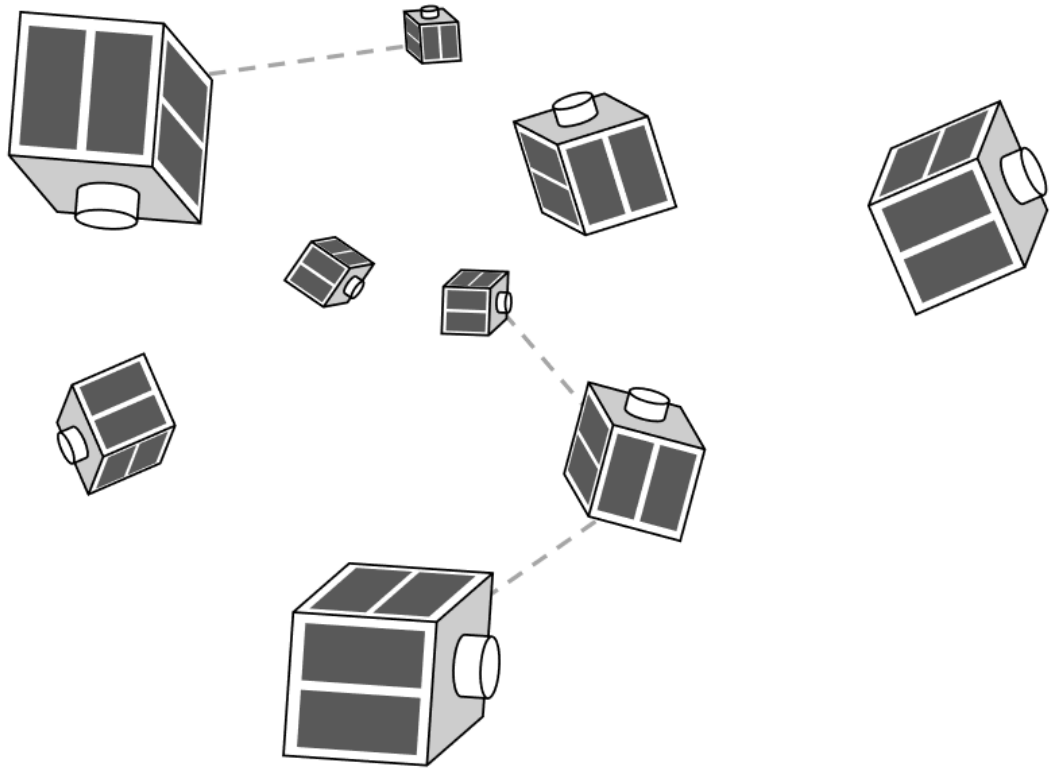
Source: NASA/MIT Lincoln Laboratory

Definitions

Satellite Swarm: Distributed system of satellites capable of communication and cooperation towards a common goal.

"An unmanned aerial vehicle (UAV) swarm can be simply defined as a group aerial robotic platform, usually similar in form, coordinating and cooperating to achieve a common goal. Swarms extend robotic capabilities beyond those of a single vehicle through various methods of coordination and cooperation between the different agents." [4]

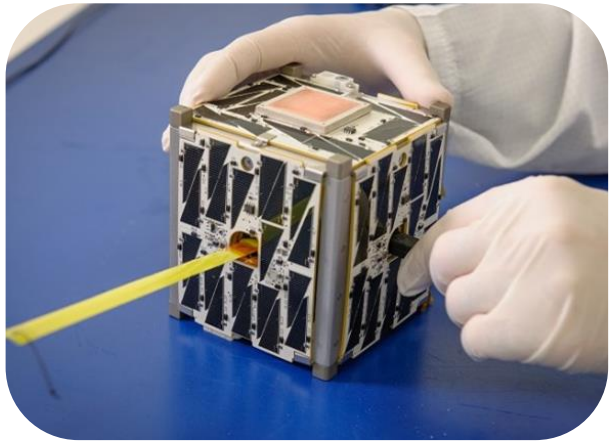
Autonomous system: "Systems capable of reasoning, deciding and executing their activities without human intervention, in pursuit of a given set of goals set by operators" [5]



Source: [5]

[4] Loianno, G., Weinstein, A., Kumar, V. (2020). Unmanned Aerial Vehicles Swarms. In: Ang, M., Khatib, O., Siciliano, B. (eds) Encyclopedia of Robotics. Springer, Berlin, Heidelberg.
[5] Araguz, C., Bou-Balust, E., Alarcón, E. (2018). Applying autonomy to distributed satellite systems: Trends, challenges, and future prospects.

Autonomous satellite swarms: state of the art



Source: NASA Ames

CubeSats as readily available, low-cost building blocks

- Modular units of 10x10cm

Non-autonomous multi-satellite missions in Earth orbit

- GPS, SWARM, TROPICS, ...

Technology demonstration missions for swarm mobility

- SAMSON, EDSN, Starling-1, …

Source: Technion

Autonomous satellite swarms face challenges

Constraints on computational power
- Nano-satellites' on-board computers have limited capability

Constraints on communication
- Communication requires power, bandwidth and is susceptible to noise

Long Earth-Satellite transmission latency
- Transmission time is proportional to distance

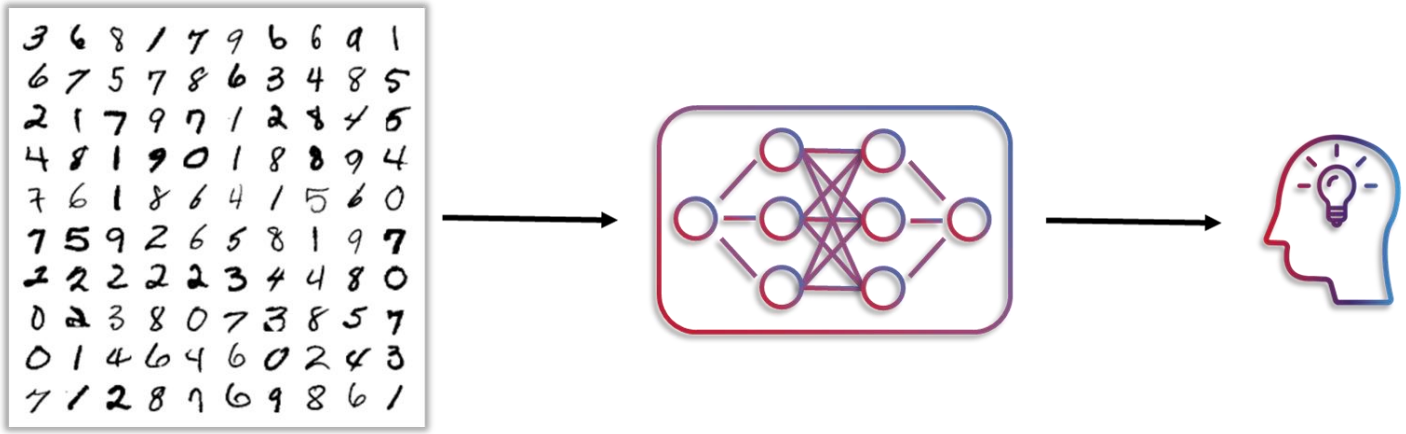
Federated Learning can overcome challenges

Constraints on computational power
- Computational load is shared between satellites

Constraints on communication
- Satellites transmit less data

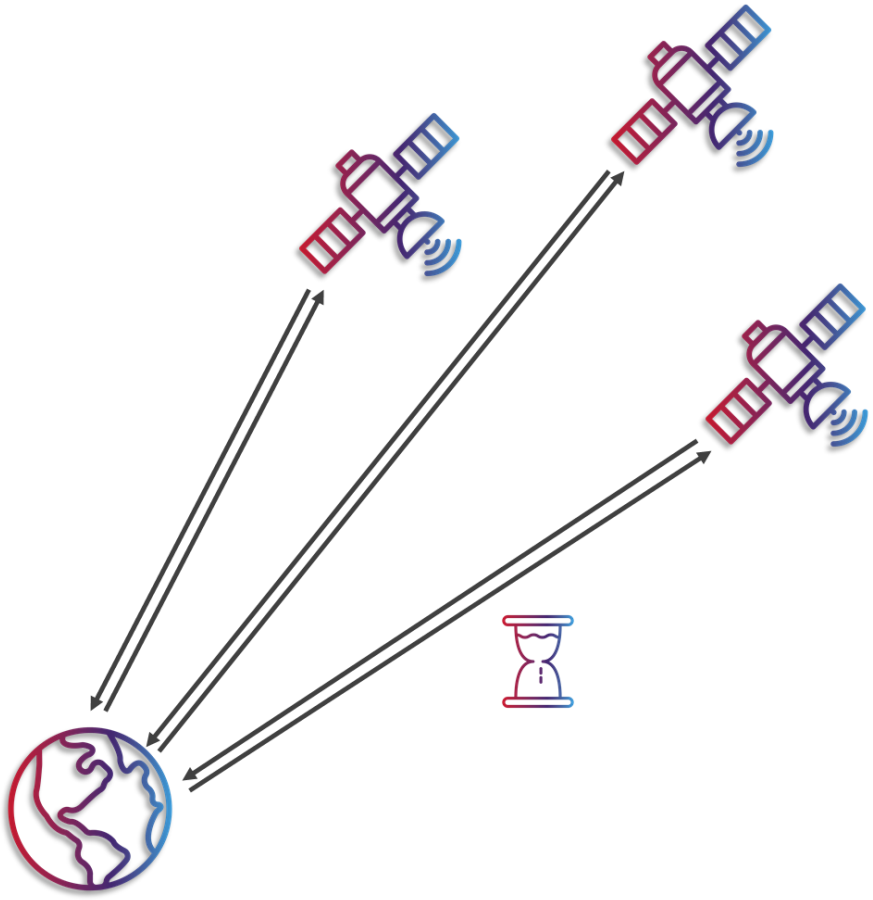
Long Earth-Satellite transmission latency
- Learning is not dependent on a connection to earth

How would classical machine learning work?



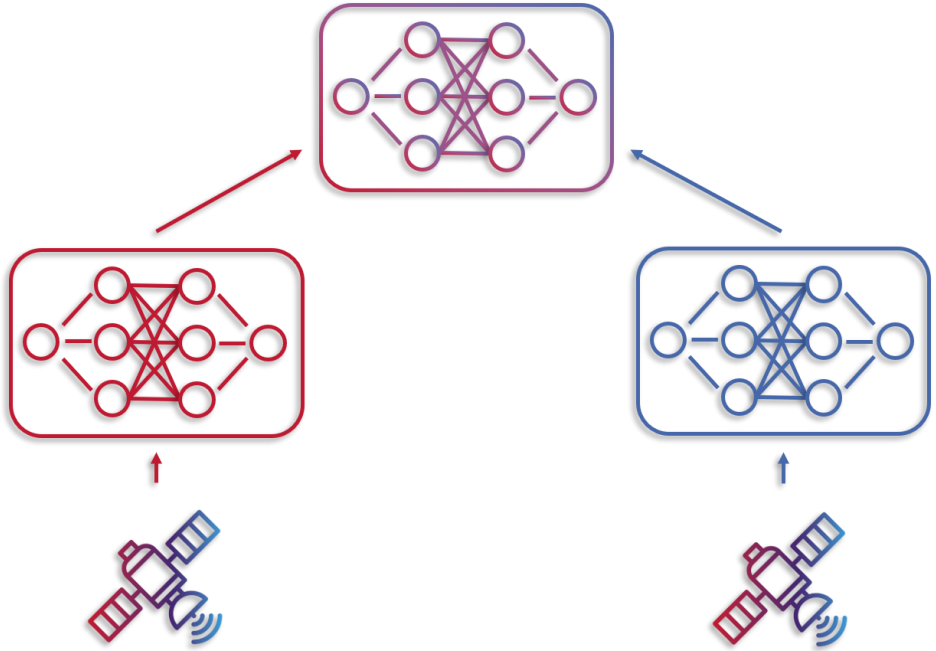
Source: Anatomies of Intelligence

One dataset – one model

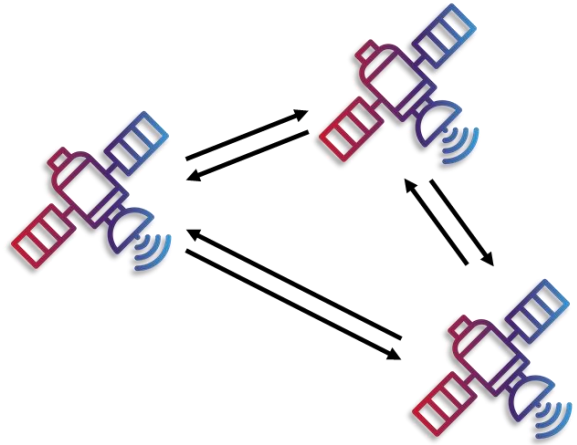


Data aggregation via Earth

How does Federated Learning work?



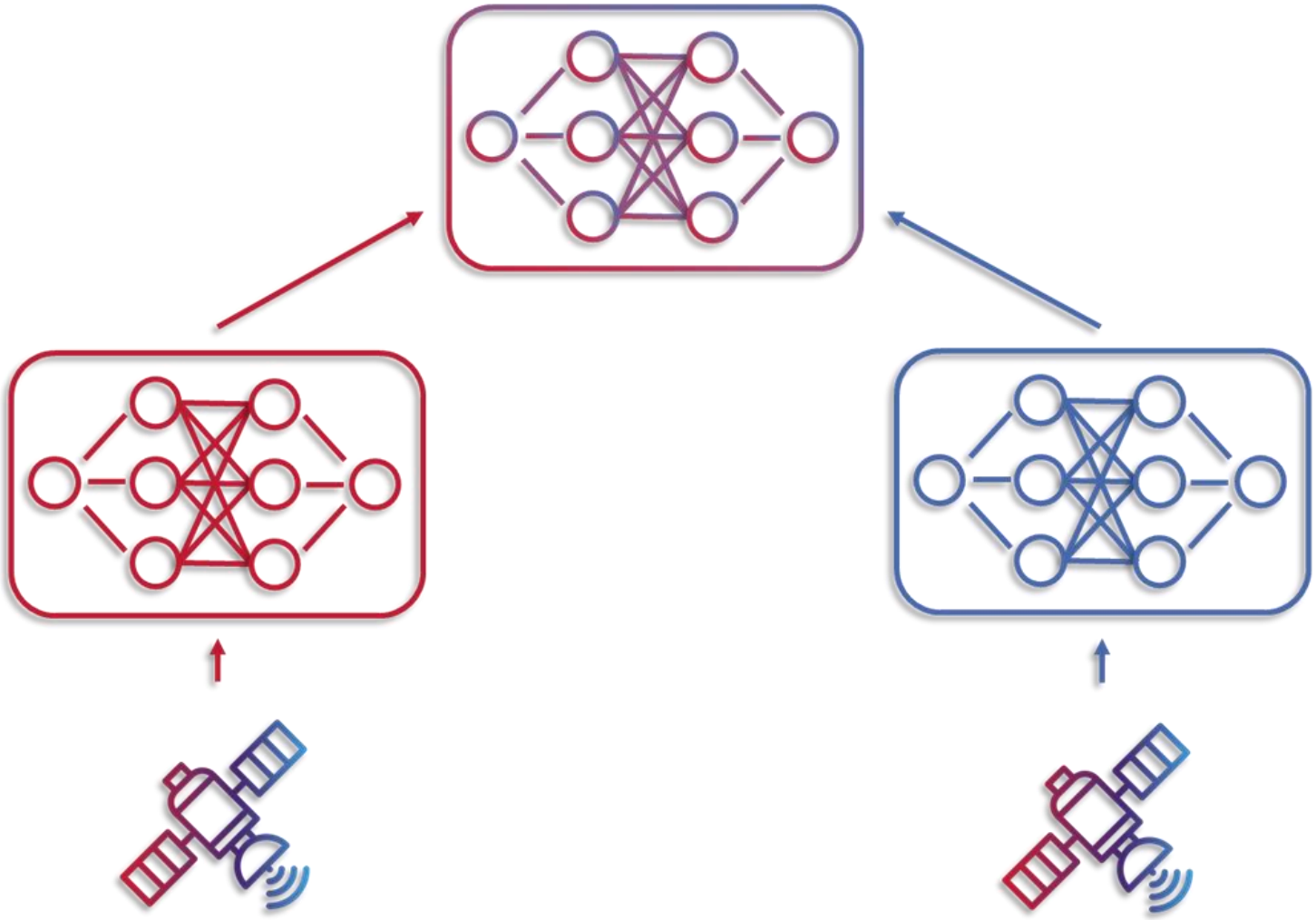
Sharing models, not data



Inter-satellite communication only

How does Federated Learning work?

Sharing models, not data

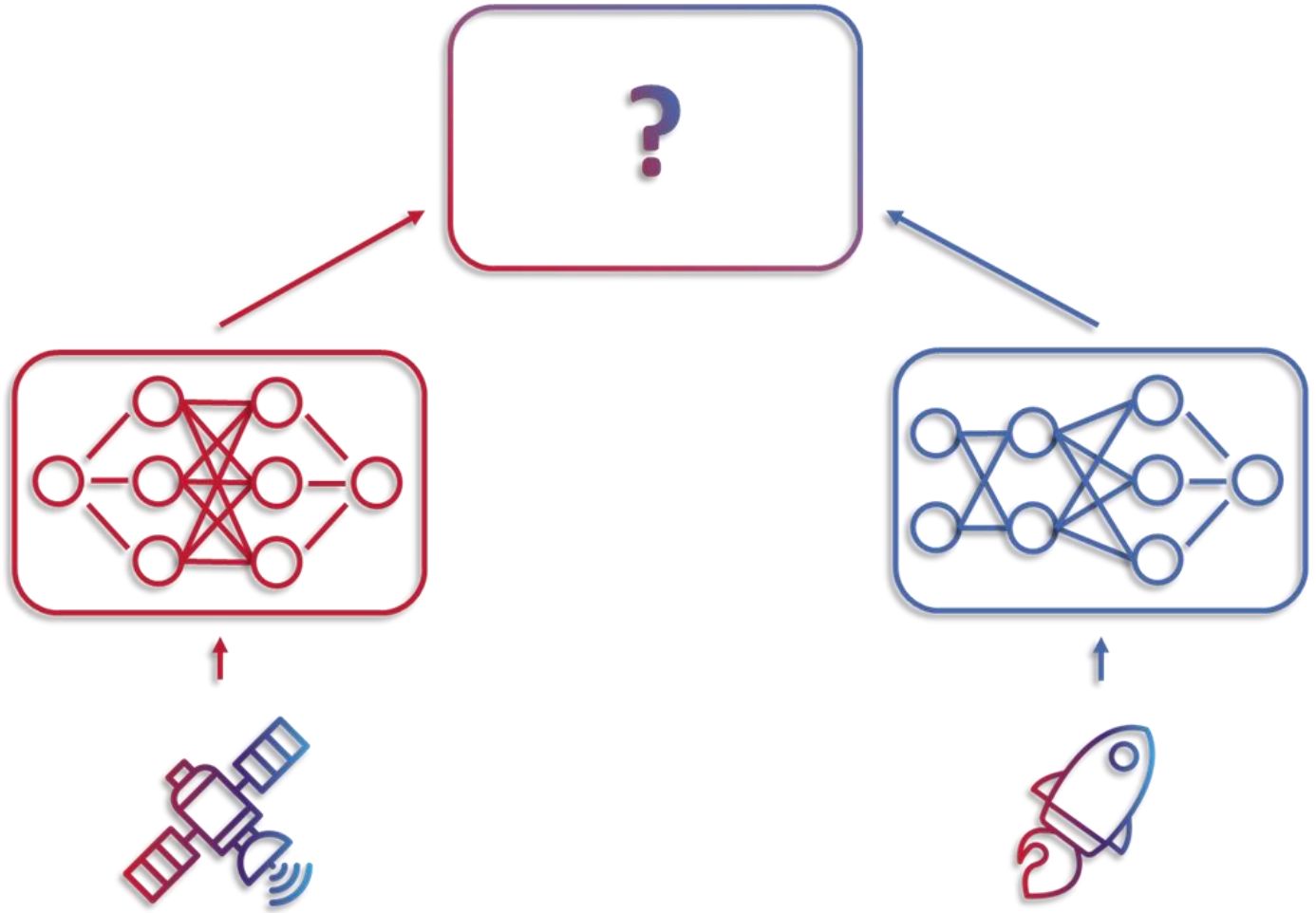


Global Aggregation
One joint model

Local Machine Learning
One model on each satellite

Homogeneous Satellites
Same sensors, different data

Federated Learning for heterogeneous swarms

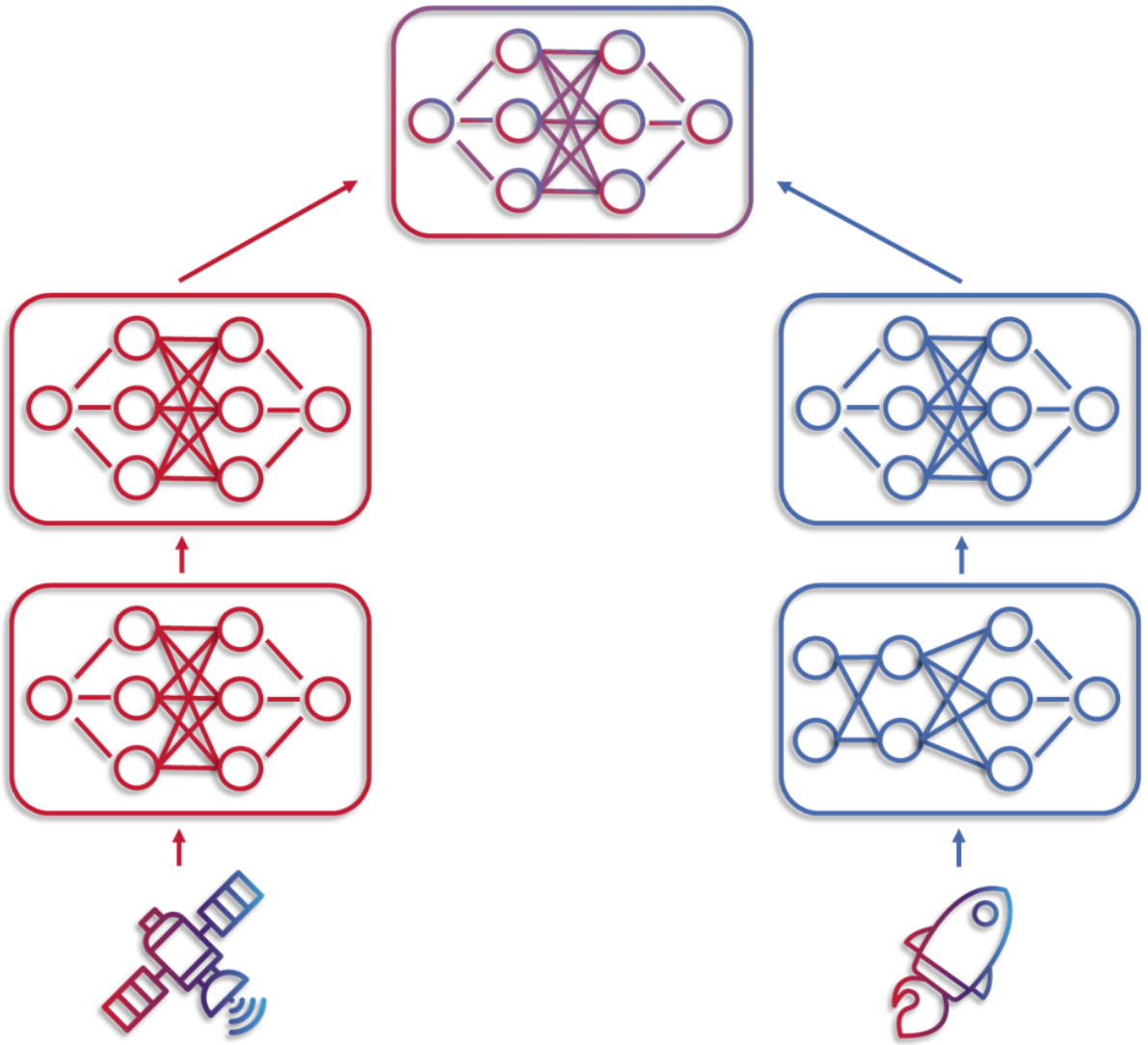


Global Aggregation?
Open question!

Local Machine Learning
One model on each satellite

Heterogeneous Satellites
Different sensors, different data

Two-step Federated Learning for heterogeneous swarms



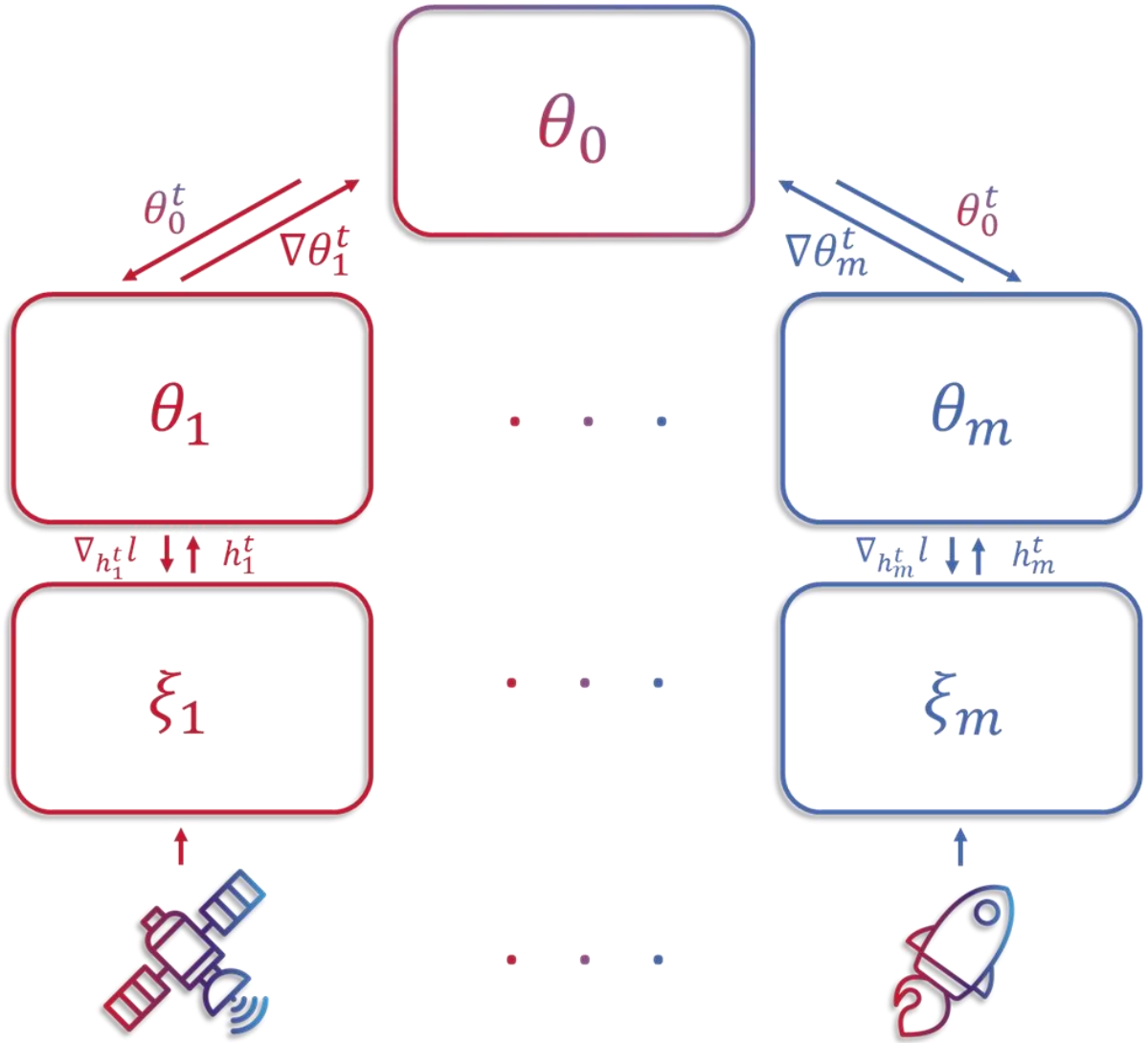
Global Aggregation:
One joint model

Local second step:
Homogeneous models

Local first step:
Heterogeneous models

Heterogeneous Satellites:
Different sensors, different data

Two-step Federated Learning - Theory



Global Aggregation:

$$\theta_0^{T+1} = \theta_0^T - \eta_{0,k}^T(\theta_k^T - \theta_k^{T+1})$$

Local second step:

$$\theta_k^{t+1} = \theta_k^t - \eta_k \nabla\zeta_k^{t+1} - r, \quad (1)$$
$$\nabla\zeta_k^{t+1} := \nabla_{\theta_k}\ell(\theta_k^t, h_k^t, y_k^t) - \nabla_{\theta_k}\ell(\theta_k^{t-1}, h_k^{t-1}, y_k^{t-1}) + q_k^t, \quad (2)$$
$$q_k^t + 1 := \beta q_k^t + (1-\beta)\nabla_{\theta_k}\ell(\theta_k^t, h_k^t, y_k^t), \quad (3)$$

Local first step:

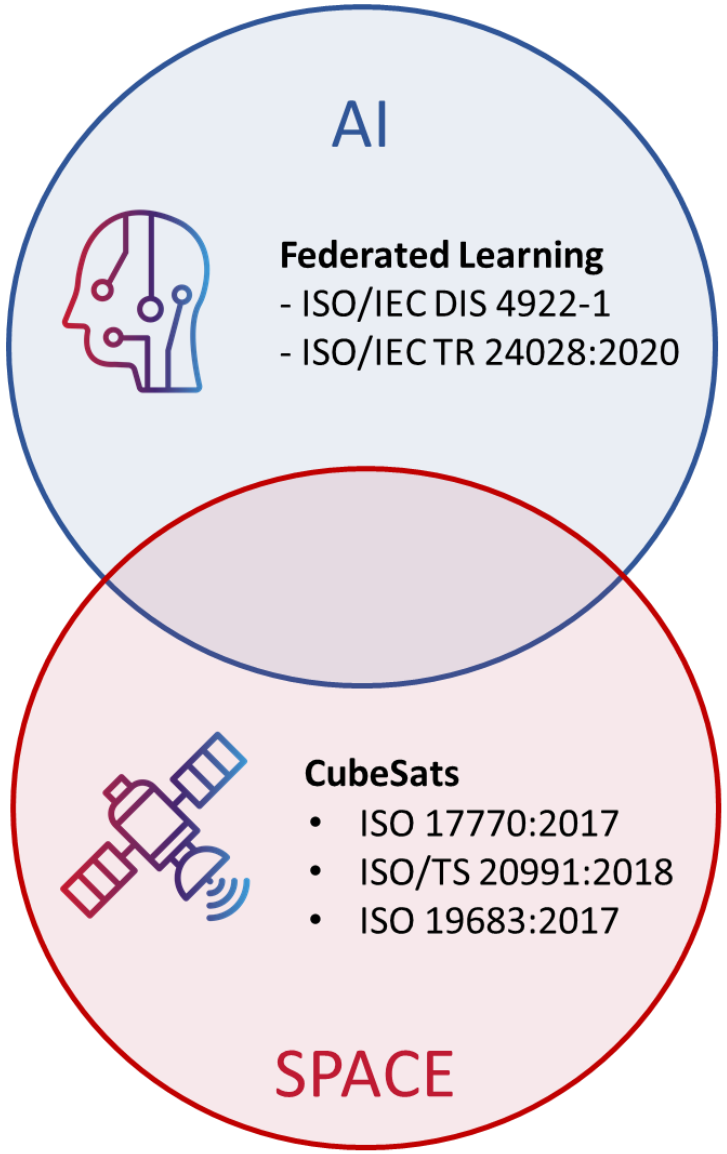
$$\nabla_{\xi_k}^{t+1}\ell(\theta_k^t, h_k^t, y_k^t) - \nabla_{\xi_k} h_k^t \nabla\phi_k^{t+1}, \quad (4)$$
$$\phi_k^{t+1} := \nabla_{\xi_k}\ell(\theta_k^t, h_k^t, y_k^t) - \nabla_{\xi_k}\ell(\theta_k^{t-1}, h_k^{t-1}, y_k^{t-1}) + p_k^t, \quad (5)$$
$$p_k^{t+1} := \gamma p_k^t + (1-\gamma)\nabla_{\xi_k}\ell(\theta_k^t, h_k^t, y_k^t), \quad (6)$$
$$\textit{so finally}\quad \xi_k^{t+1} = \xi_k^t - \eta_k' \nabla_{\xi_k} h_k^t \nabla\phi_k^{t+1} - r' \quad (7)$$

Heterogeneous Satellites:

$x_1^t, \ldots, x_m^t$

$y_1^t, \ldots, y_m^t$

Impact on Standardisation



Involvement in Standardisation Committees, Work Groups, Advisory Groups

- **ISO/TC 20/SC 14** – Space systems and operations
- **CEN/CLC JTC 5** – Space
  - **WG 2** – Space Situational Awareness Monitoring
  - **WG 7** – Future activities in space standardisation
- **ISO/IEC JTC 1/SC 42** – Artificial Intelligence
- **CEN-CENELEC JTC 21** – Artificial Intelligence

Parallel Computing and Optimisation Group

Contact:

Maria Hartmann
PhD Student
maria.hartmann@uni.lu

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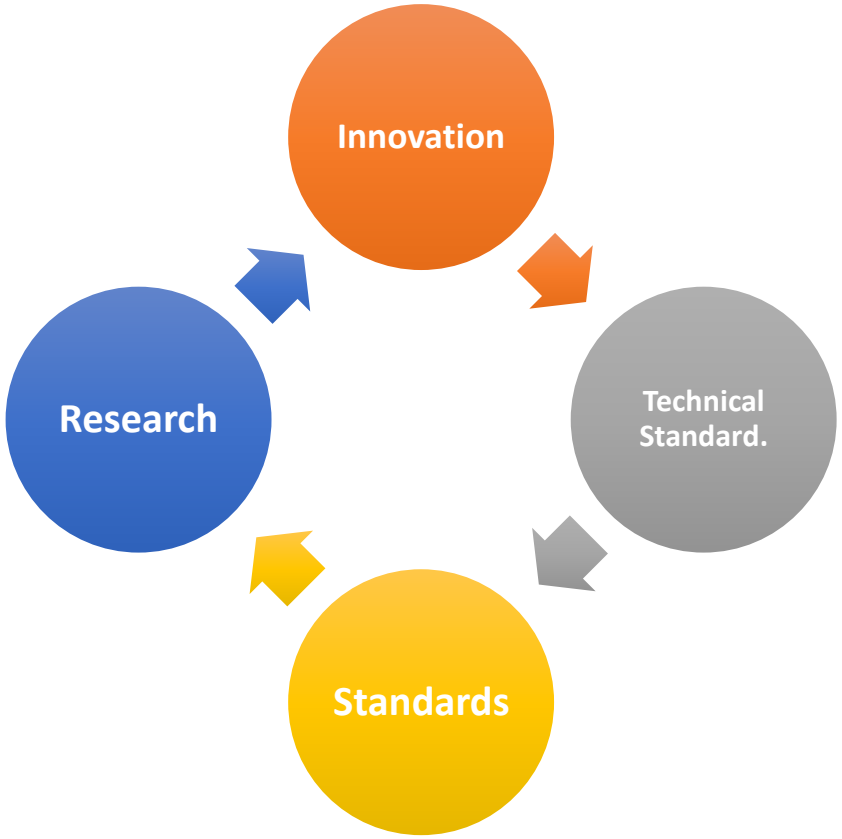
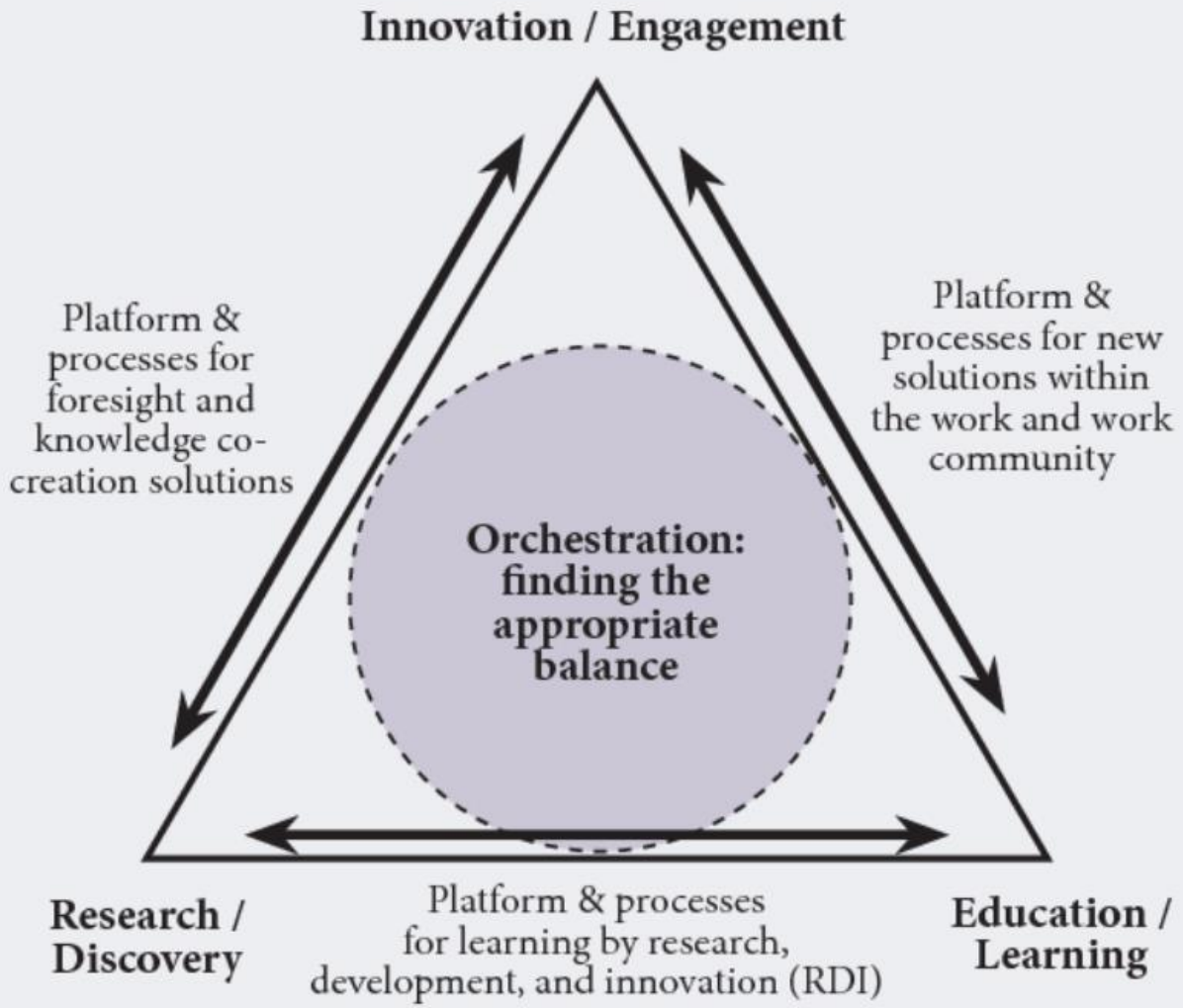
Workshop
“Space & Technical Standardisation”

Prof. Dr Pascal Bouvry
Head of the Computer Science Department
University of Luxembourg

Technical Standardisation Research

- **Objective**
  - Optimizing the interface and exchange between researchers and technical standardisation
- Analyzing **standardisation processes**
  - Diffusion, influence, impact
- Aimed **outcomes**
  - Opportunities for researchers (spreading their innovation)
  - Identifying needs for technical standardisation (for existing innovations/product/processes)
  - Shorten the gap between research outcome and technical standardisation





Source: [*Sjoer et al.*, 2011].

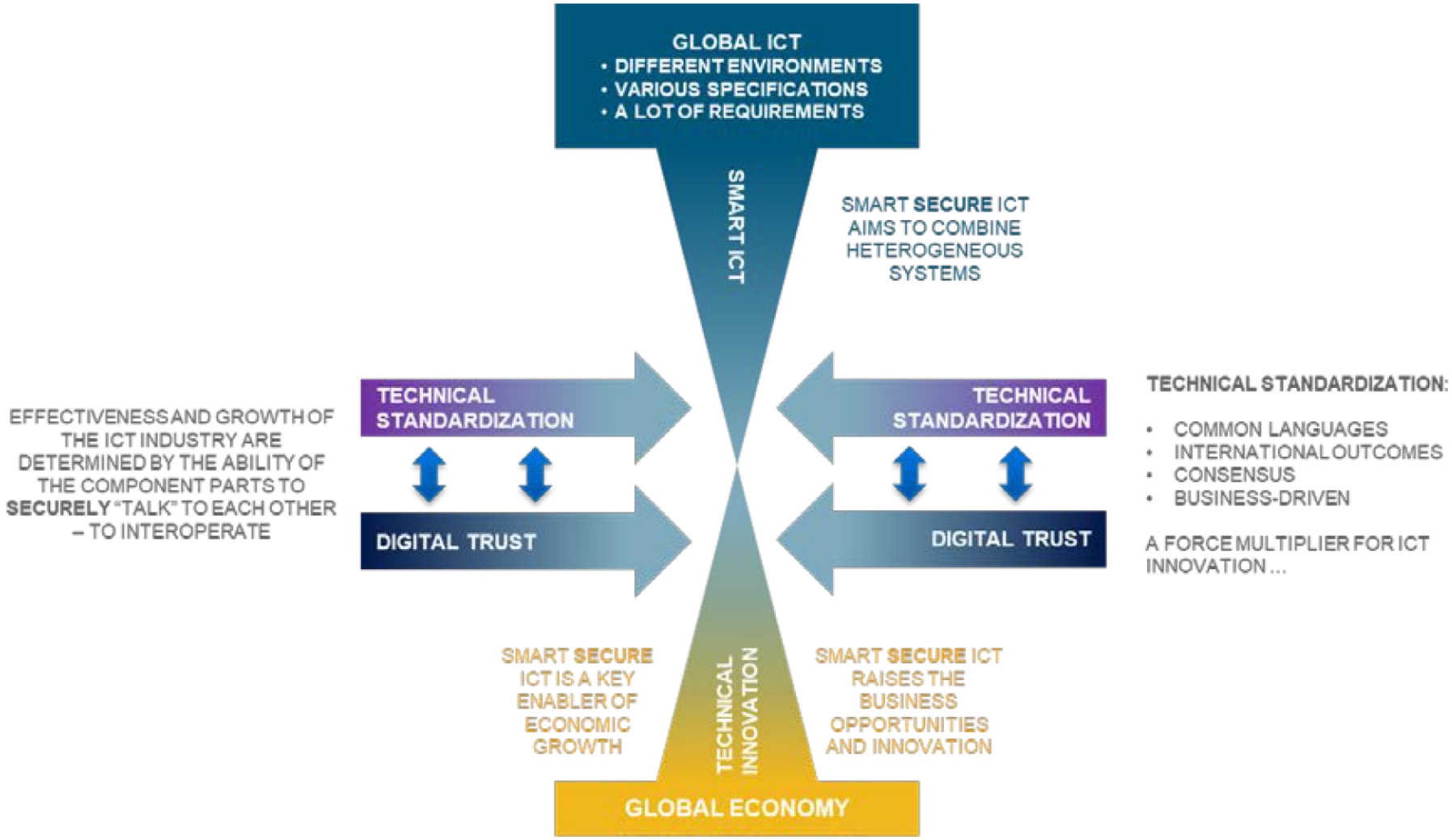


Figure 1: Matrix Reading Grid of the Master programme

Mtech

DIGITAL TRUST FOR SMART ICT	ECTS
Security for Smart ICT I	2
Security for Smart ICT II	3
Trust Architectures for Smart ICT	4
TOTAL	9

TECHNOPRENEURSHIP	ECTS
Management of Business and Technical Innovation	3
Digital Intelligence	2
Legal Aspects	2
TOTAL	7

Mtech

STANDARDISATION	ECTS
Smart Secure ICT and Innovation	1
Technical Standardisation	3
TOTAL	4

SMART ICT	ECTS
Smart ICT Technologies I	5
Smart ICT Technologies II	5
TOTAL	10

Training and Master Thesis

- Development of a Crypto-as-a-Service platform for (crypto-) fund initiator or Security Token issuer
- Back office process automation
- Implementation of a container orchestration tool to manage a container-based environment
- Digital transformation in financial Services
- Remote identity (ID) proofing
- The “intelligent” Finance Organisation
- Redefine Data Warehouses towards more performant and efficient services
- Real-Time remediation system for banking
- Real-time analysis and crime prediction / prevention.

In a glance

DURATION:	4 semesters - including 1 semester internship
CREDITS:	60 ECTS
LANGUAGE:	English
ORGANISATION:	courses organised on Fridays and Saturdays, every two weeks
PLACE:	alternately at the LLLC (Friday) and at the University of Luxembourg (Saturday)
REGISTRATION:	6.400 € for the 4 semesters
APPLICATION PERIOD:	Sep - Dec 2022
START:	February 2023

Contact: mtech@uni.lu

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Thank you for your attention!