INTERVENANTS

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Ms. Maria HARTMANN
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Doctorant
Programme de recherche
Université du Luxembourg

“ World Standards Day 2024 ” OCTOBER 2024

ILNAS-SnT Research Programme and Other Developments

Dr. Grégoire Danoy

Research Scientist, Head PCO Group

University of Luxembourg

The University of Luxembourg

The University of Luxembourg is a research university with a distinctly **international**, **multilingual** and **interdisciplinary** character.

Ranked

25th Young University
4th International outlook
Top 125 in Computer Science

worldwide in the Times Higher Education (THE) World University Rankings 2023

UNIVERSITY OF LUXEMBOURG

20 YEARS

7000+ students

1000+ PhDs

300 faculty members

135 nationalities

60% international students

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

Management:
- Head: Dr. Grégoire Danoy

15+ researchers

1 Professor

1 Research Scientists

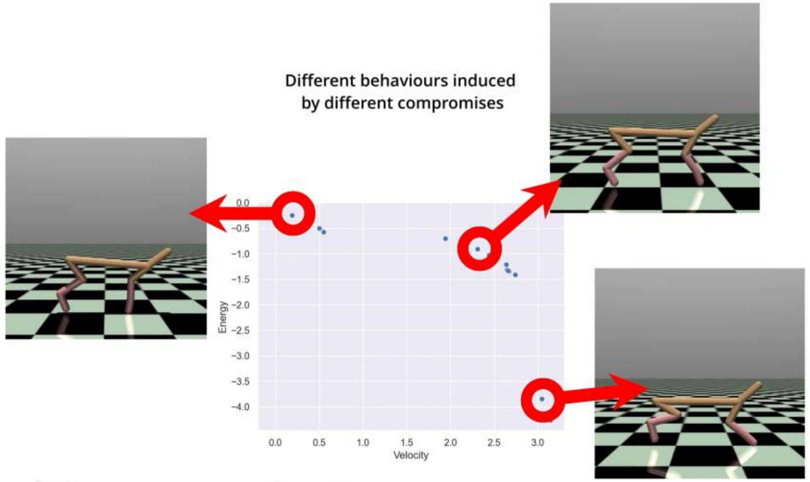
8 Postdocs

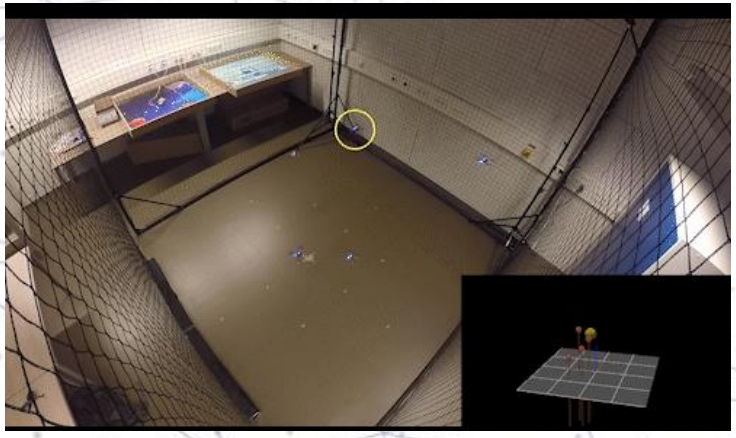
9 PhD students

13 nationalities

Parallel Computing and Optimisation Group

Focus Area: Parallel & Evolutionary Computing, Machine Learning, Swarm Intelligence





Focus Area: High-Performance Computing

ILNAS
Office of Naval Research GLOBAL Science & Technology
EUROPEAN DEFENCE AGENCY
Luxembourg National Research Fund
uni.lu SnT

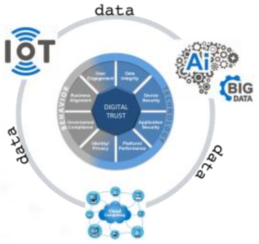
Research & Education Collaboration

2015

Education Programme

First Smart ICT Certificate

2017



First Research Programme

2018

Education Programme

Second Smart ICT Certificate

2021

Second Research Programme

Education Programme

Master in Technopreneurship

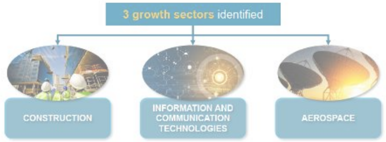
2024

Education Programme

Master in Technopreneurship

3rd cohort

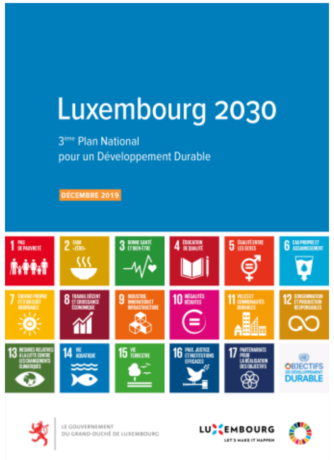
2025



Third Research Programme

Third Research Programme*

* Content under finalisation



Focused on the National Standardisation Strategy 2020-2030

- ICT
- Construction
- Aerospace

With Sustainability as a transversal axis

Construction

Sustainable and people-centered design

ICT

Quantum
(Hybrid-)Quantum Optimisation

Space

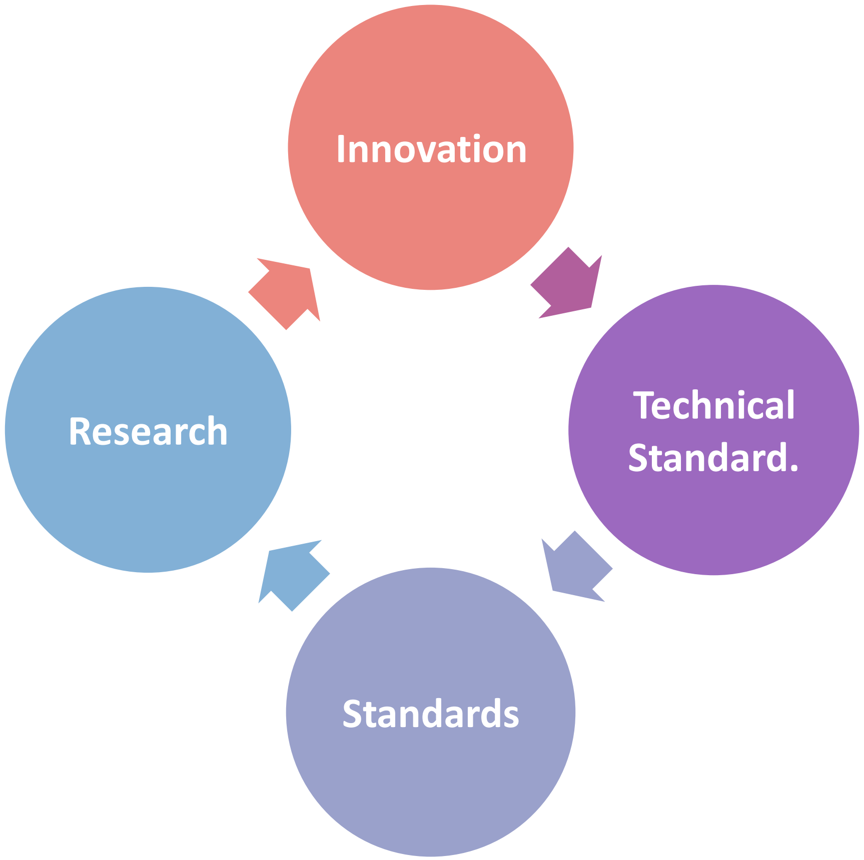
Sustainable Space
(e.g., debris/traffic management),

Sustainable development

Research Programme

Technical Standardization Research

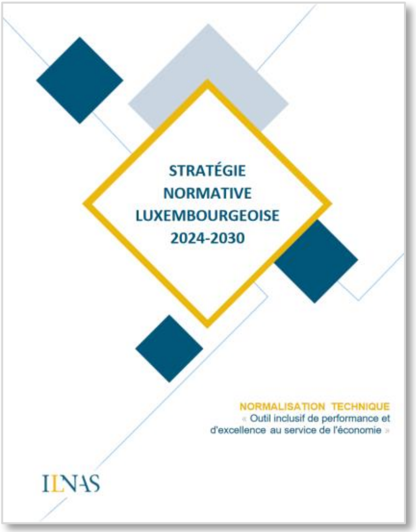
- **Objective**
  - Optimizing the interface and exchange between researchers and technical standardization
- Analyzing **standardization processes**
  - Diffusion, influence, impact
- Aimed **outcomes**
  - Opportunities for researchers (spreading their innovation)
  - Identifying needs for technical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

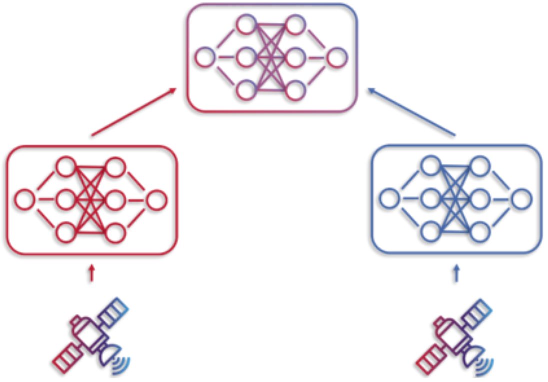


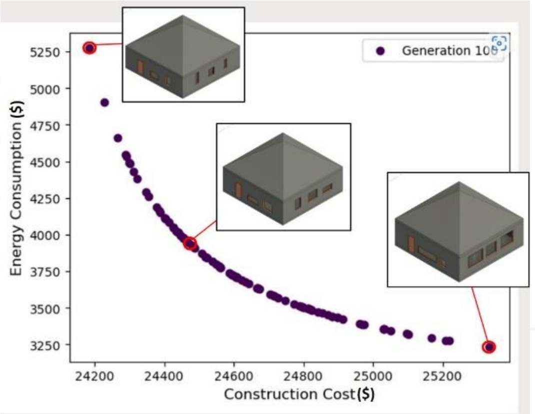
The Second Research Programme 2021-2024

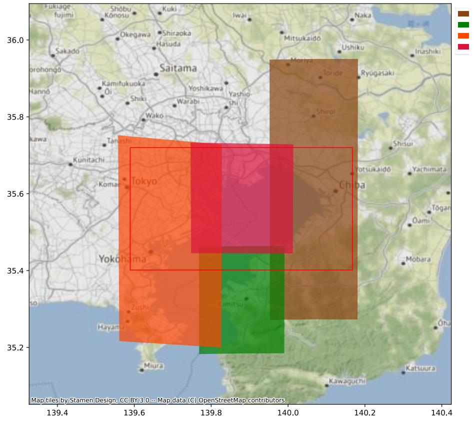
Technical Standardisation for Trustworthy ICT, Aerospace, and Construction

NATIONAL STANDARDISATION STRATEGY 2024-2030









https://ilnas-snt.uni.lu/

The UL-SnT 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

Lena Maria Hartmann
(PhD student)

Supervisor: Dr. Grégoire Danoy
Since 15.02.2022
Aerospace

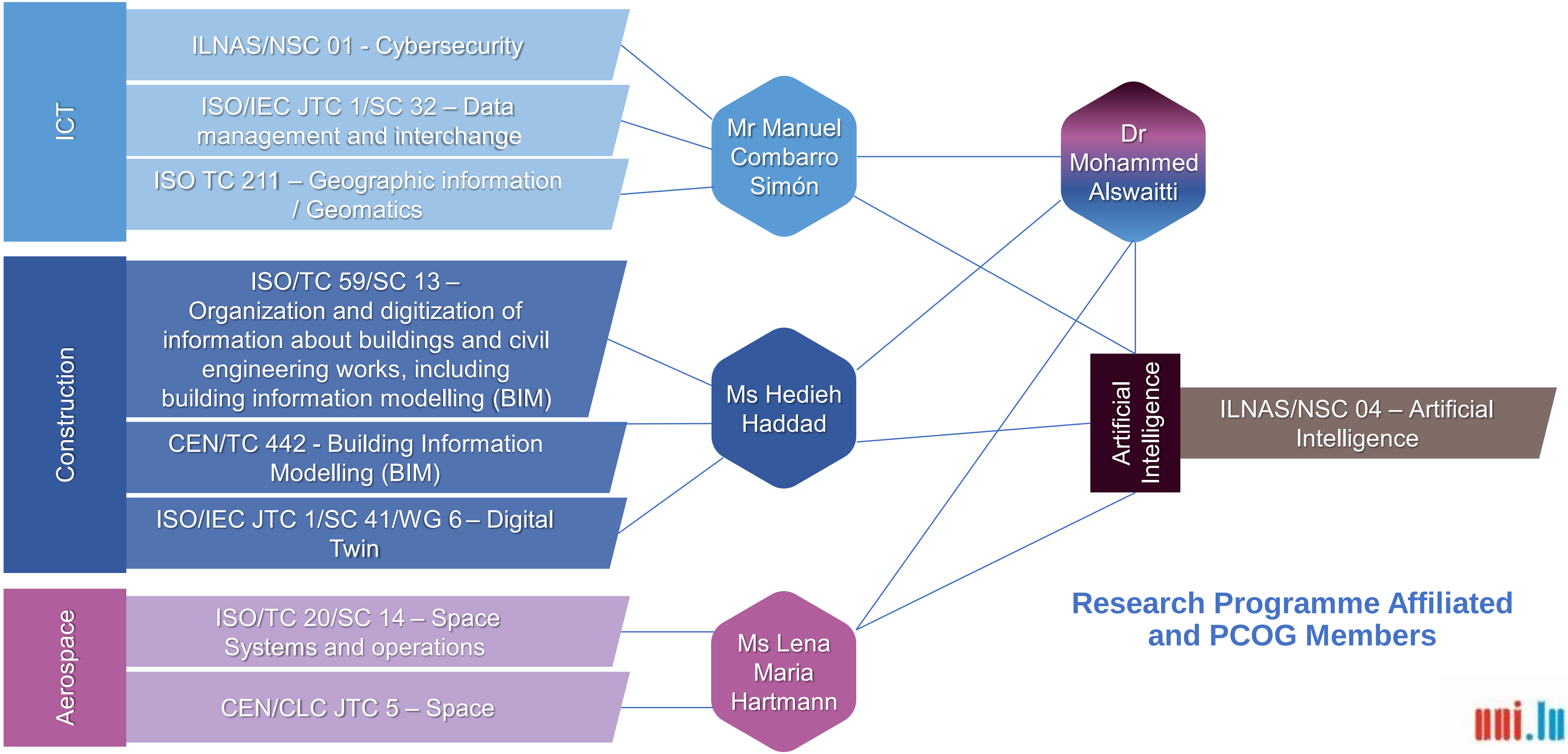
Manuel Combarro Simón

(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



Activities and Outlook

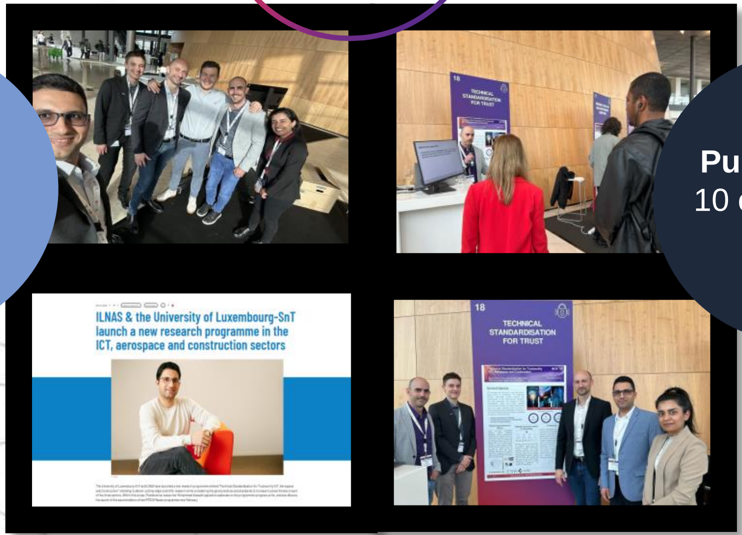
- Workshop – Technical Standardization in Space and Cybersecurity (June 2023)
- SnT Partnership Day (May 2023 & 2024)
- FARVEST interview about the research programme (January 2023)
- World Standards Day (October 2022, 2023 & 2024)
- Space and technical standardisation workshop (June 2022)

White Paper (2023) + Technical Report (2024)

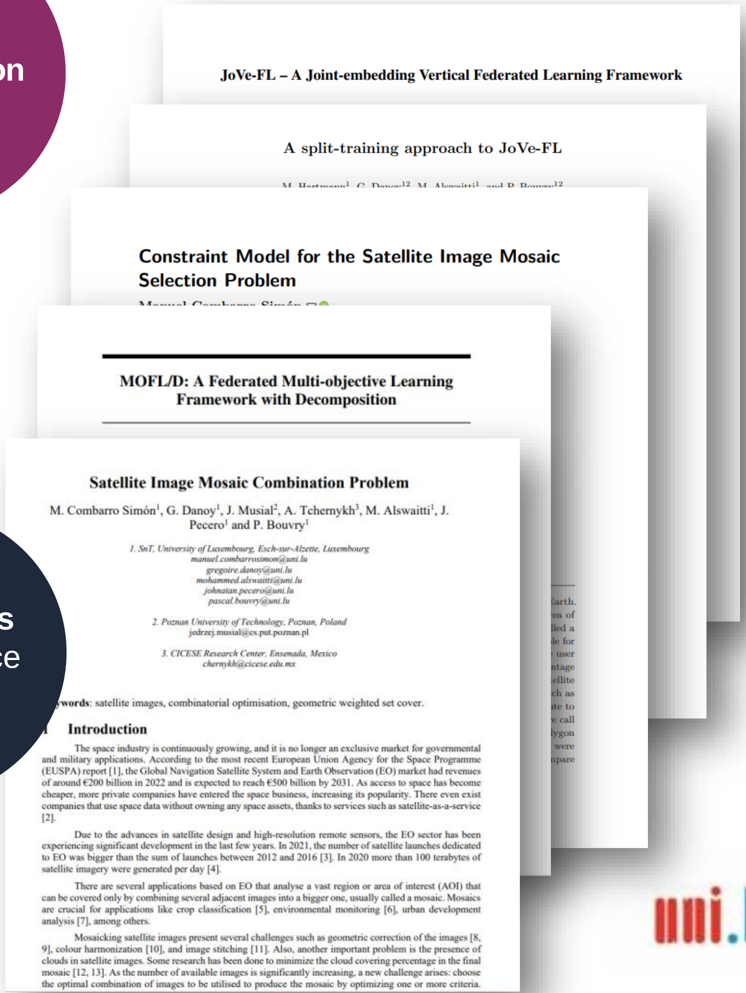
Dissemination

Progress

Website



Publications
10 conference articles



SnT

Parallel Computing and Optimisation Group

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SnT, Interdisciplinary Centre for Security, Reliability and Trust

“ World Standards Day 2024 ” OCTOBER 2024

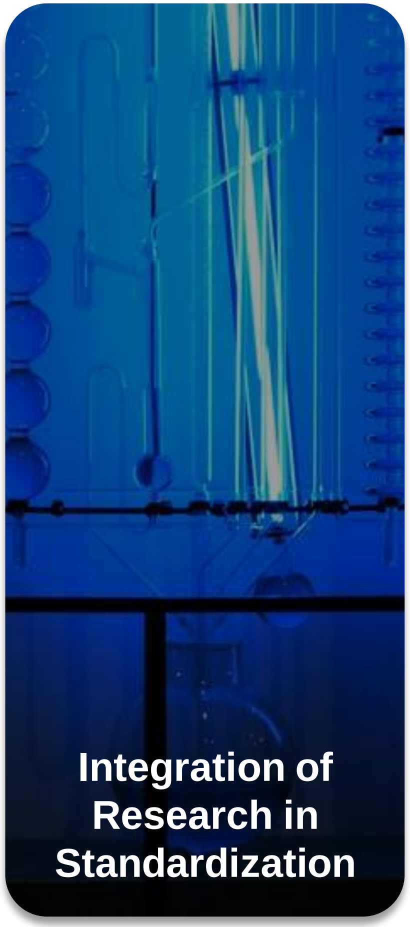
Technical Report- Research-driven Standardization Opportunities for ICT, Construction and Aerospace

Dr. Mohammed Alswaitti
Postdoctoral Researcher
University of Luxembourg

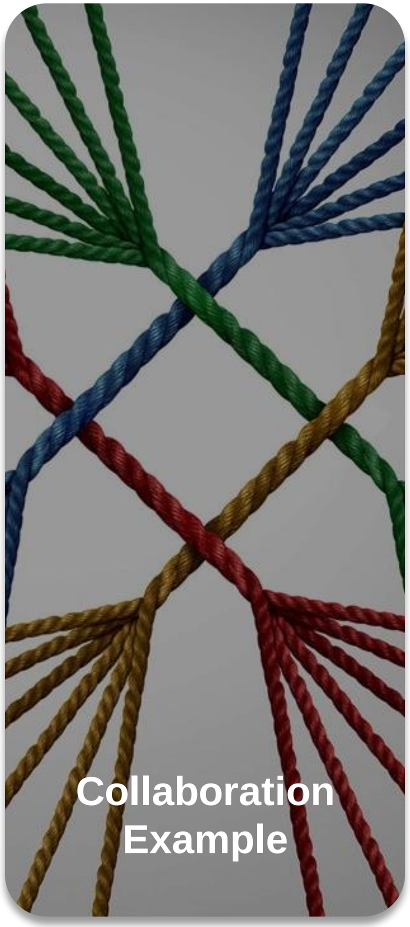
Technical Report Overview

Research-Standardization Linkages

Empowering innovation through the seamless integration of research and standards, driving progress with solutions that are tested, trusted, and transformative.



Scientific research enhances standardization, improving guidelines for industries.



ILNAS and the University of Luxembourg have collaborated since 2018.

The partnership helps identify challenges in both parties and suggests improvements.

•Three Research Pillars

Opportunities & Challenges found across the three domains

1 Extending geographic information imagery standards for mosaic generation

ICT

2 Extending communication standards to facilitate machine learning on-board spacecraft

AEROSPACE

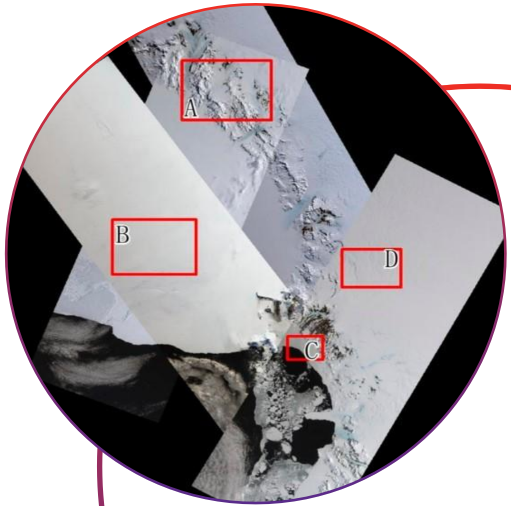
3 Demonstrating the integration of a construction sector standard in a constraint programming model

CONSTRUCTION

Opportunities in ICT

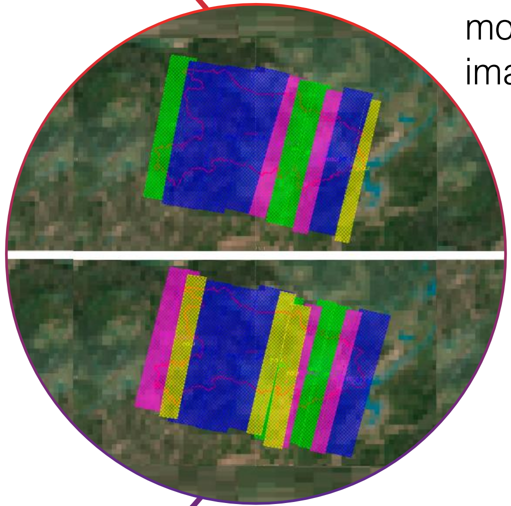
Image Mosaic & Geographic Imagery Standards

Addressing gaps in standards of geographic imagery to create seamless mosaics.



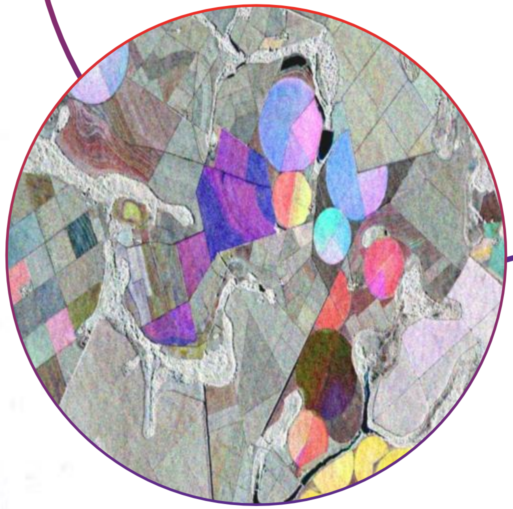
Multi-objective Mosaic Generation

Providing customers with tradeoff mosaics created from the same set of images.



Multi-source Image Mosaic

Improving flexibility of image mosaic generation from multi-source satellite images.



Opportunities in Aerospace

One-way Machine Learning Models Transmission

Uncovering a key gap in protocols for transmitting machine learning models between ground stations and spacecraft. By adapting proven standards from other industries, space communication can be revolutionized.

Harnessing existing standards towards a unified ML model transfer format

Distributed Machine Learning Models Transmission

Efficient communication of participants in a Federated Learning system through a well-defined protocol.

Opportunities in Construction

Optimizing BIM Practices for Windows Design

Showcasing the potential of thermal transmittance standards guided by Constraint Programming (CP) solvers for sustainable construction.

AI-Driven Compliance Solutions

Exploring the integration of CP solvers on wider building design components, materials, and parameters coupled with the existing standards to facilitate seamless and sustainable BIM.

Parallel Computing and Optimisation Group

Contact:

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Connect with us https://ilnas-snt.uni.lu/ @SnT_uni_lu SnT, Interdisciplinary Centre for Security, Reliability and Trust

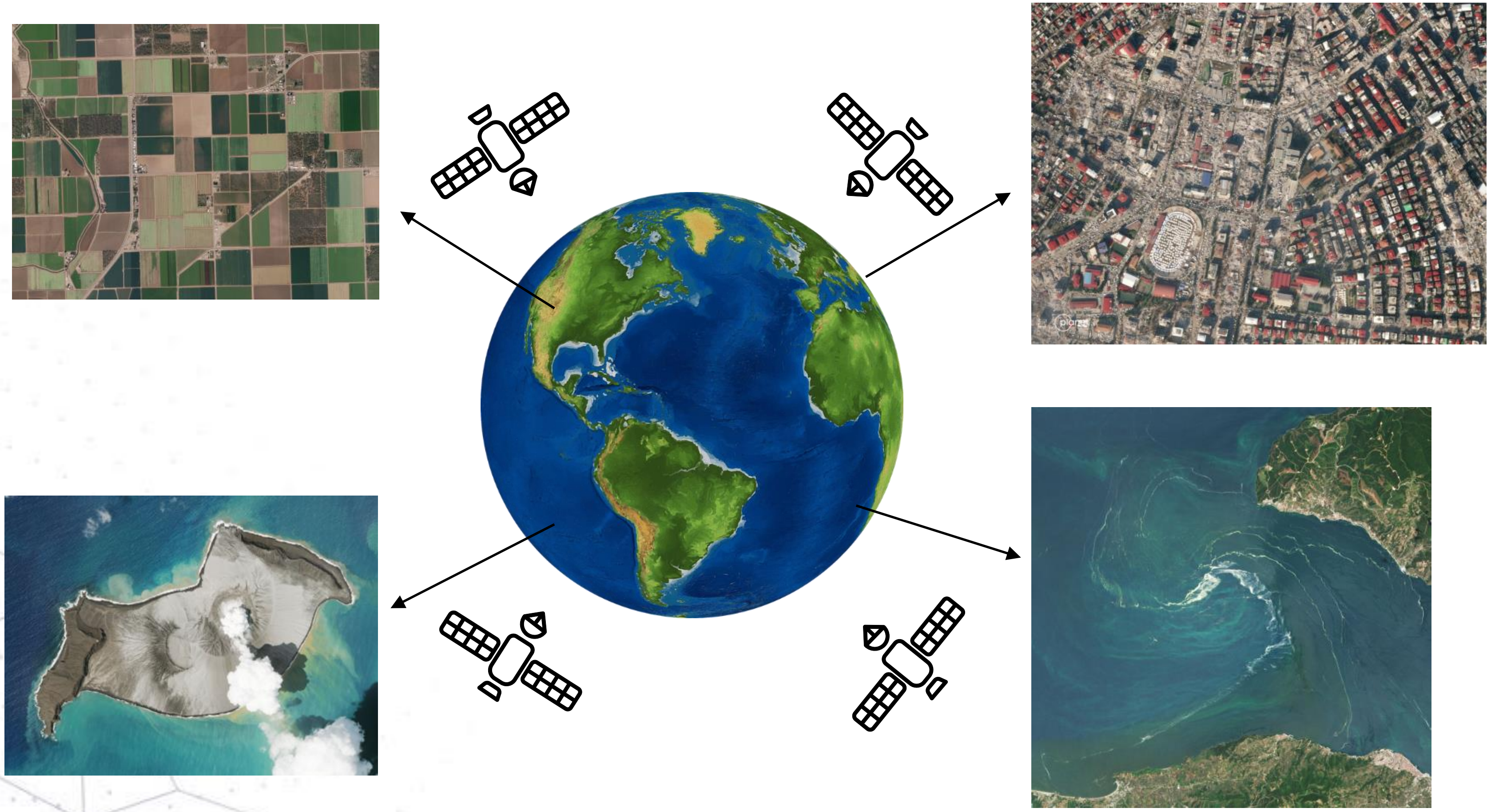
Extending geographic information imagery standards for mosaic generation

Manuel Combarro Simón

PhD Student (ILNAS/SnT – ICT)

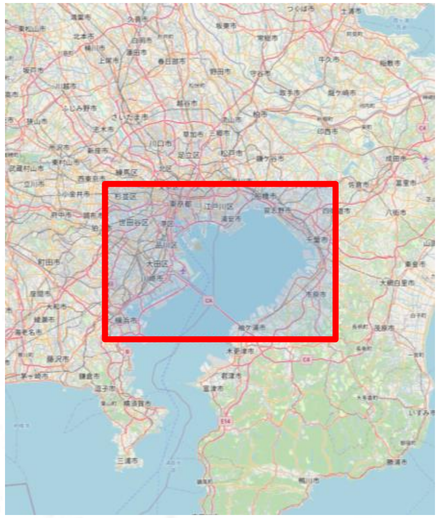
University of Luxembourg

Geographic imagery



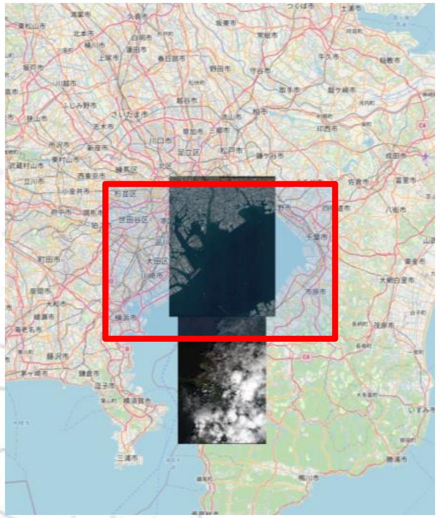
Satellite images: Planet Labs, Inc.

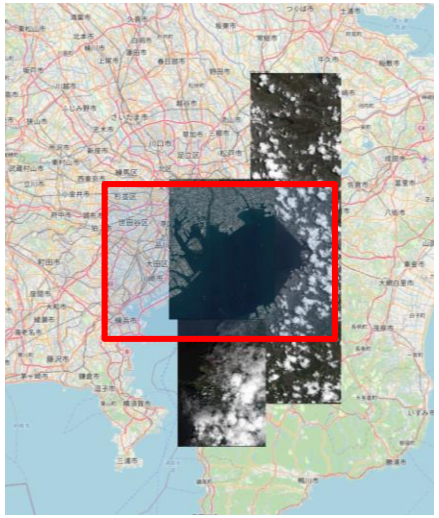
Satellite image mosaic

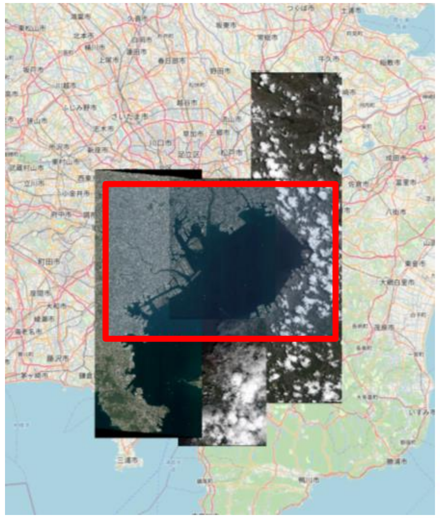


To cover large areas we need several images

Mosaic (almost)





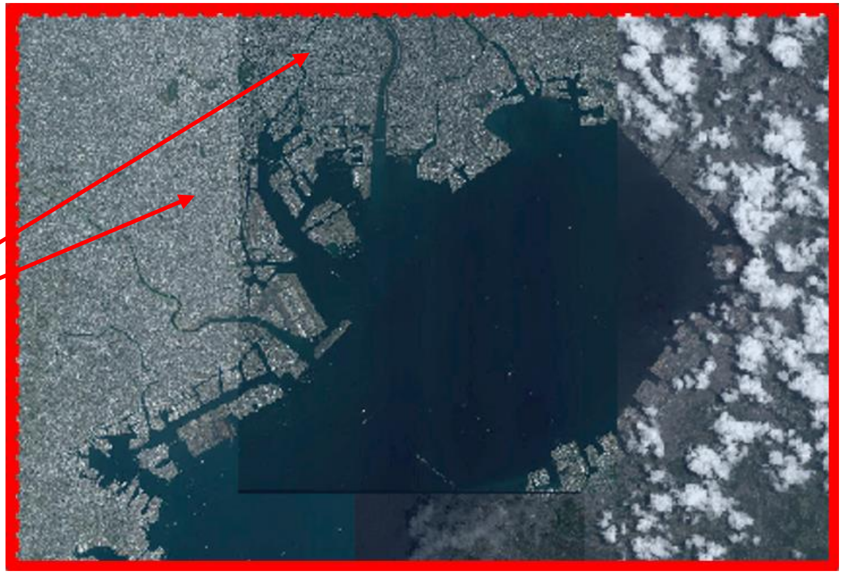


Satellite image mosaic

Defined in the OGC - Image Exploitation Services[1] as:

"an **assembly of** two or more overlapping or adjacent orthorectified (or rectified) **images** to **form** a **continuous image** of a larger ground area"

Not continuous image

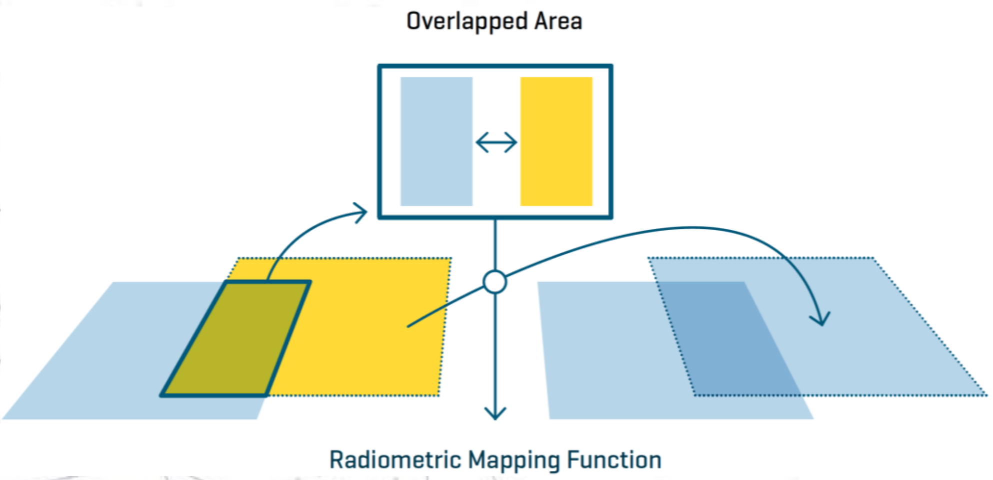


[1] OpenGeospatial® Consortium Abstract Specification, Topic 15 — Image Exploitation Services, 2000, OGC document 00-115

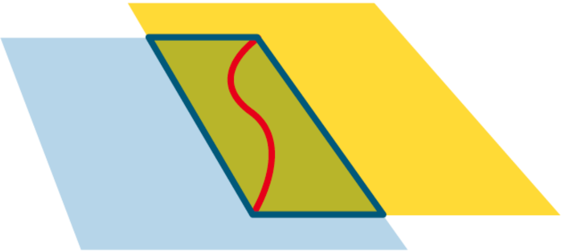
Seamless mosaic

Key steps to produce seamless mosaic:

- Radiometric normalisation (tonal adjustment). The model colour space defined in ISO/CIE 11664-4:2019[1] has been used in research.



- Seamline detection



Road → better seamline

[1] ISO/CIE 11664-4:2019 - Colorimetry - Part 4: CIE 1976 L*a*b* colour space
Image taken from Google Maps

Considerations for standardisation

A simplified version is described in ISO/AWI 19123-4[1] (drafted by ISO/TC 211 - Geographic information/Geomatics) where the images are treated as axis-parallel rectangle tiles with low consideration about overlapping. In real scenarios images are not axis-parallel rectangles

No overlap.
No radiometric. Edge seamline

Too small overlap.
Bad radiometric and seamline

Too big overlap. Expensive

Recommended overlap.

[1] ISO/AWI TS 19123-4 - Geographic information - Schema for coverage geometry and functions - Part 4: Tiling Schema standard

Considerations for standardisation

Radiometric normalisation

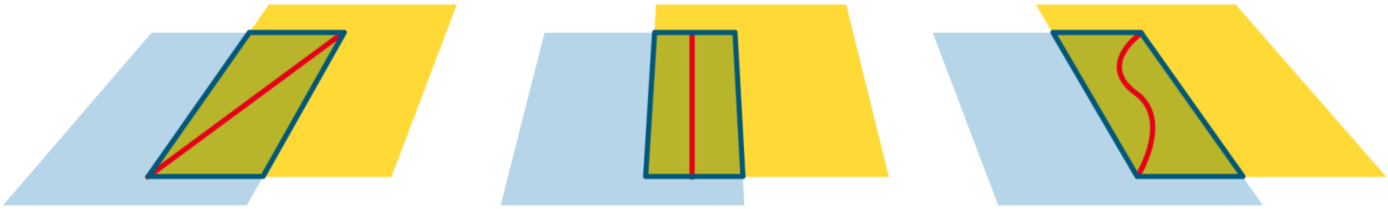
- Selection of the normalisation model depends on the resolution of the image and the complexity of the terrain.

- To facilitate the execution of the radiometric function, the metadata schema should have information regarding the colorimetry information of the image. The ISO 19115 series defines the metadata schema of geographic imagery but does not include any information related to image colorimetry.

Considerations for standardisation

Seamline detection. Research findings that should be included in future standards

- The choice of method depends on the number of images.
- Definition of optimal seamline and when it is necessary to find it.
  - The optimal seamline is located where geometric and pixel intensity differences between overlapping images are minimal.
  - For low-medium resolution images, finding the optimal seamline is not necessary. The seamline can be a straight line.
  - For high resolution images, finding the optimal seamline is critical. It should be curved as the human eye can detect it better if it is a straight line

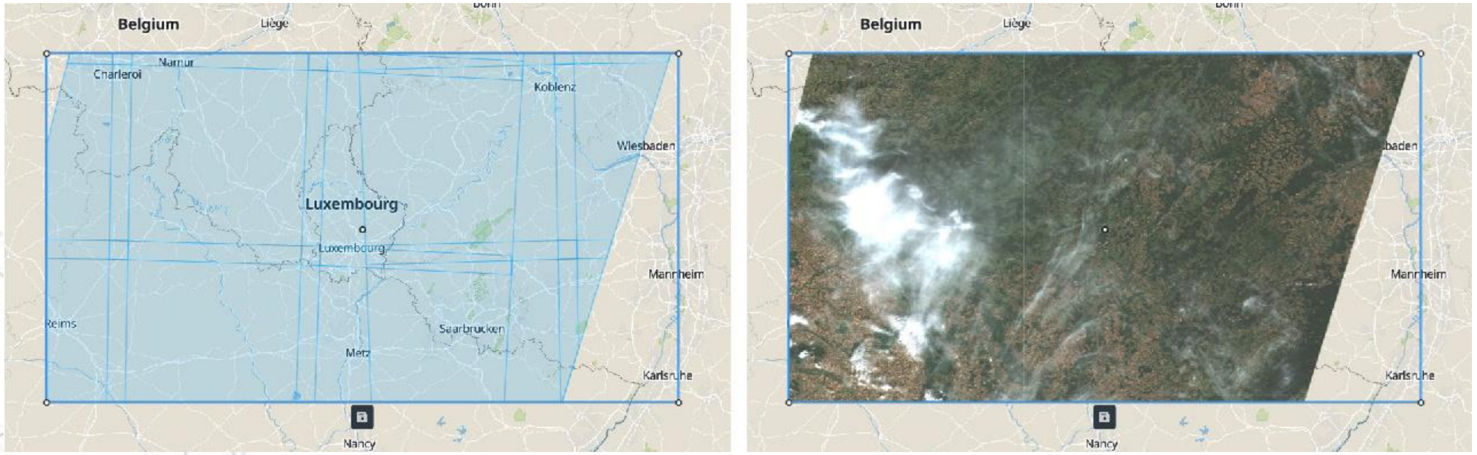


Low-Medium resolution High resolution

Multi-source image mosaic

In the existing standards mosaics are typically considered to be created using images from a single source (this is true when studying an area in the future).

When it is necessary to study an area in the past, archive images should be used.
- Using images from a single satellite constellation might not be enough to create a mosaic



EOSDA LandViewer marketplace failed to create a mosaic by using single-source images

Images from multiple satellite constellations can be used to create the mosaic, also, it can improve certain parameters, like the cost and the cloud coverage

Mosaic attempt by *EOSDA LandViewer* using images only from Sentinel-2 for 15/07/2024

Considerations for standardisation

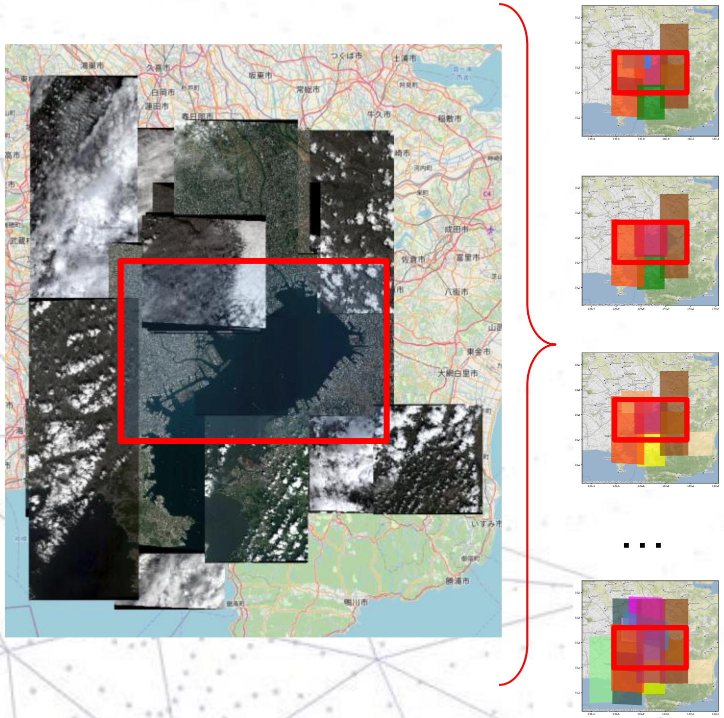
Despite ISO 19101-2:2018[1] (image processing) and ISO 19115-1:2014[2] (metadata schemas) :

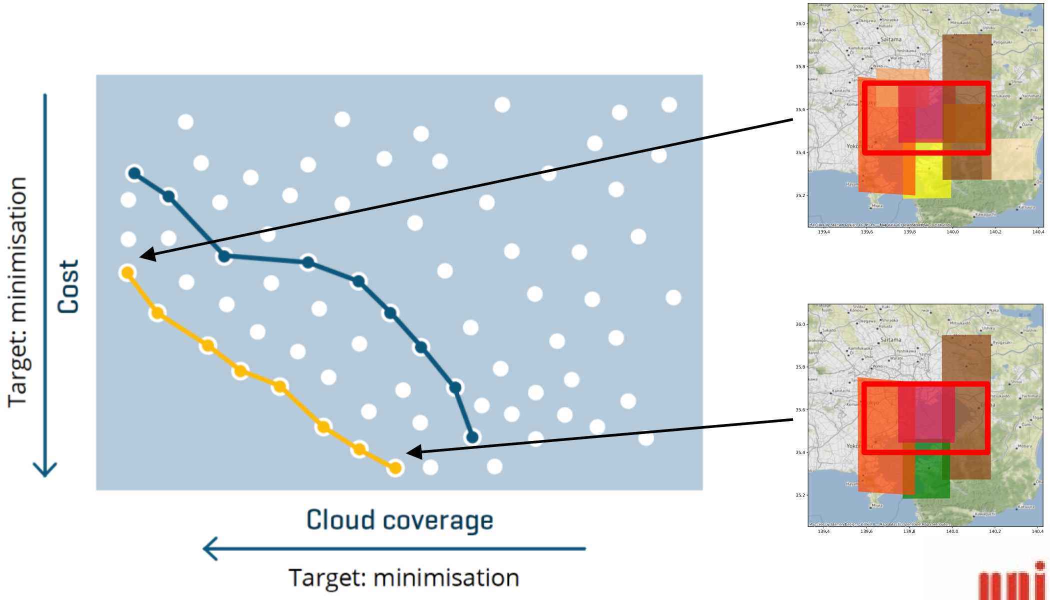
- No clear guidelines on how to fuse multi-source data
- No well-defined procedures for
  - Aligning
  - Calibrating
  - Radiometric normalisation

[1] ISO 19101-2:20218 - Geographic information - Reference model - Part 2: Imagery
[2] ISO 19115-1:2014 - Geographic information - Metadata - Part 1: Fundamentals

Multi-objective mosaic generation

- Simultaneously optimise conflicting parameters, for example, cost and quality parameters (image resolution, cloud cover)
- For the same area, multiple mosaics can be generated. It is unlikely that one mosaic has the best values for all the parameters
  - Instead of a single mosaic, a set of trade-off mosaics.

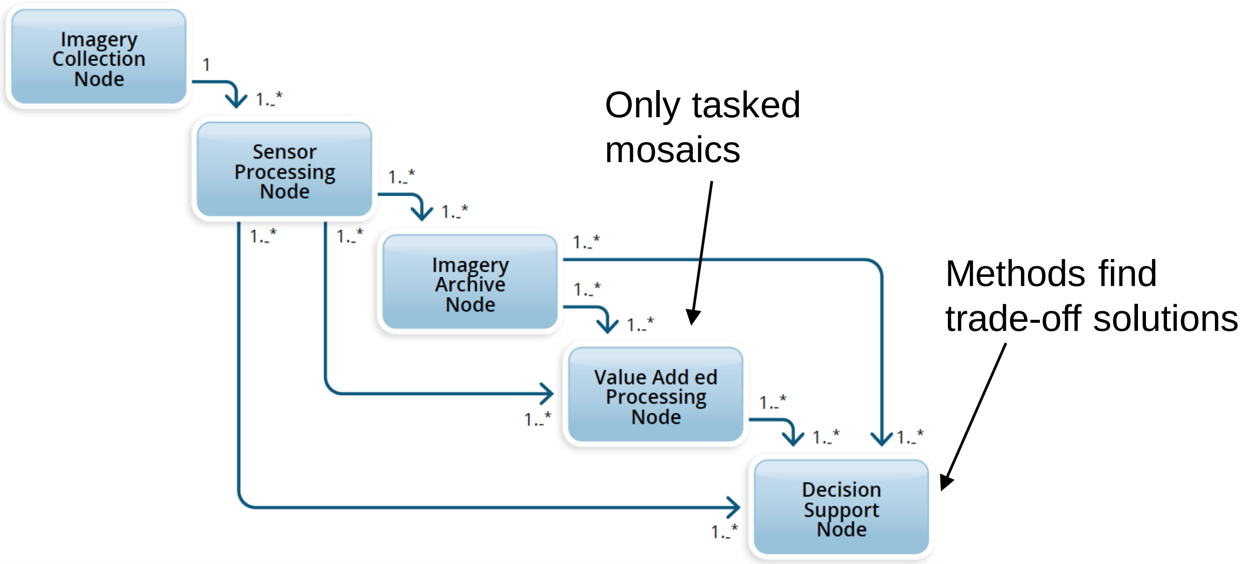




Considerations for standardisation

- Multi-objective mosaic generation is a complex and computationally expensive process. Before starting, it should be guaranteed that all images can be merged. This can be done by adding metadata fields, for example, to indicate whether two images can be merged despite radiometric intensity differences.

- Existing standards need revision to consider the possibility of multiple mosaics.
  - In ISO 19101-2, it is assumed that only one available mosaic can be generated in the *Value Added Processing* or *Decision Support* nodes.
  - Only tasked mosaics can be created in *Value Added Processing* nodes.
  - *Decision Support* nodes should implement methods to obtain the trade-off subset



Conclusion

- Current standards do not fully cover key challenges in seamless mosaic creation, multi-source image mosaic, and multi-objective mosaic generation.
- There is a need to establish common metadata schemas which include special fields to facilitate mosaic creation. This is particularly important in multi-source and multi-objective mosaics.
- Multi-objective mosaic generation should be considered in current standards.
- Future standards should focus on filling these gaps to better support the diverse needs of users, ensuring high-quality and reliable geographic imagery mosaics.

Parallel Computing and Optimisation Group

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Extending communication standards to facilitate machine learning on-board spacecraft

Maria Hartmann

PhD Student (ILNAS/SnT – Aerospace)

University of Luxembourg

Uses of AI on-board spacecraft

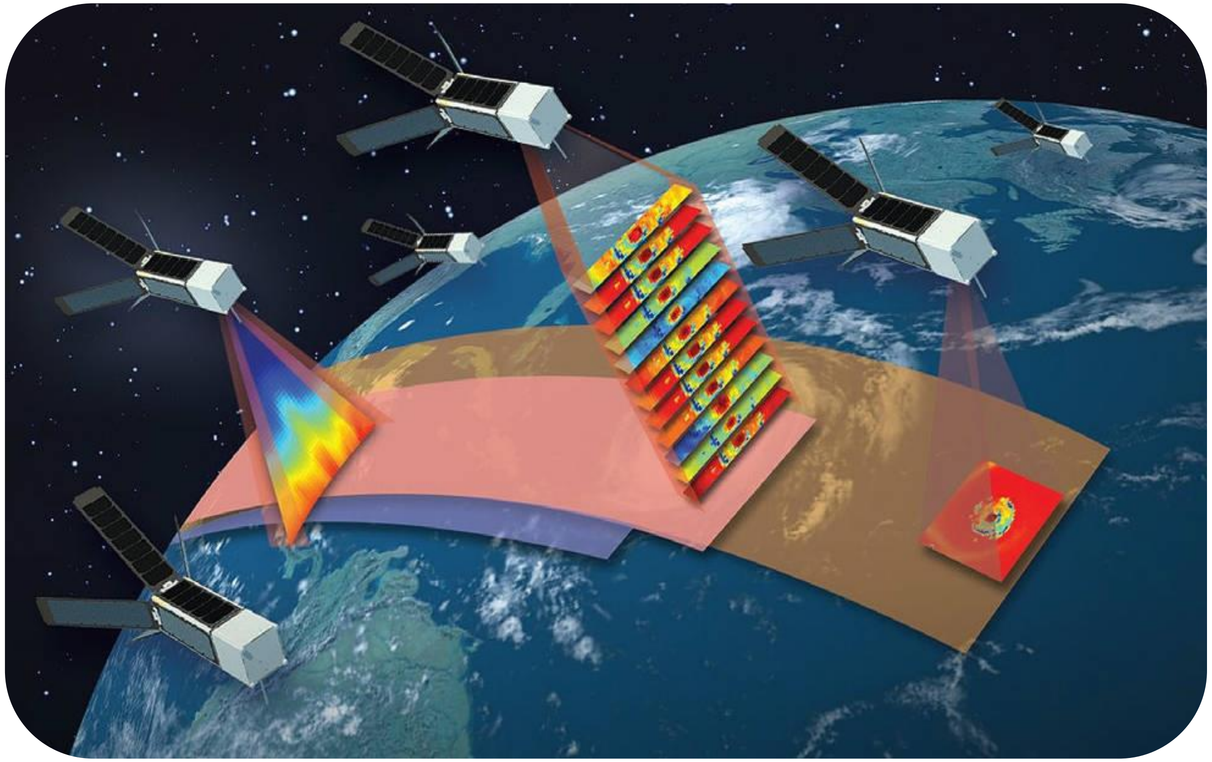
Can optimise satellite services, reduce delays, and automate critical functions

Earth observation:

- Disaster detection: flag areas of concern more quickly
- Image selection: pre-process observation images, e.g. to discard image of areas under cloud-cover

Satellite communications:

- Network traffic prediction
- Beam hopping

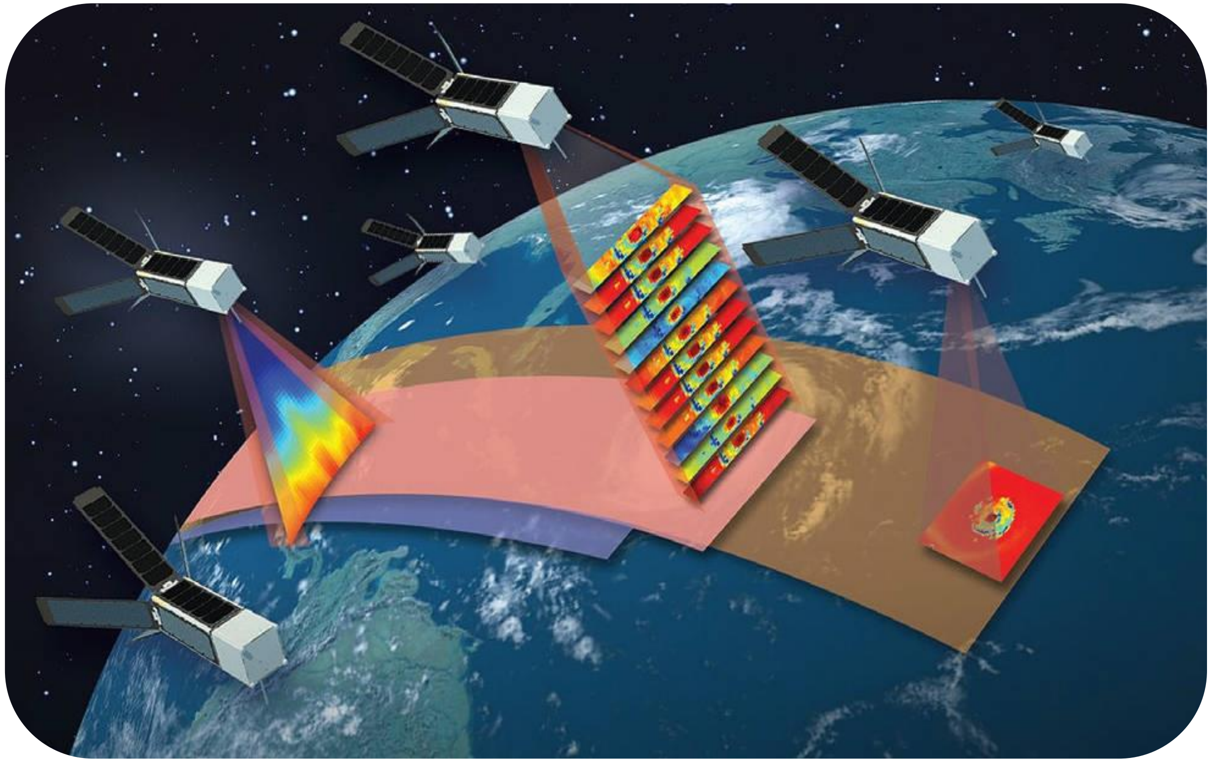


Source: NASA/MIT Lincoln Laboratory

Communicating models to spacecraft

Machine learning models are not typically launched with the satellite, but trained and deployed later.

This requires communication standards!



Source: NASA/MIT Lincoln Laboratory

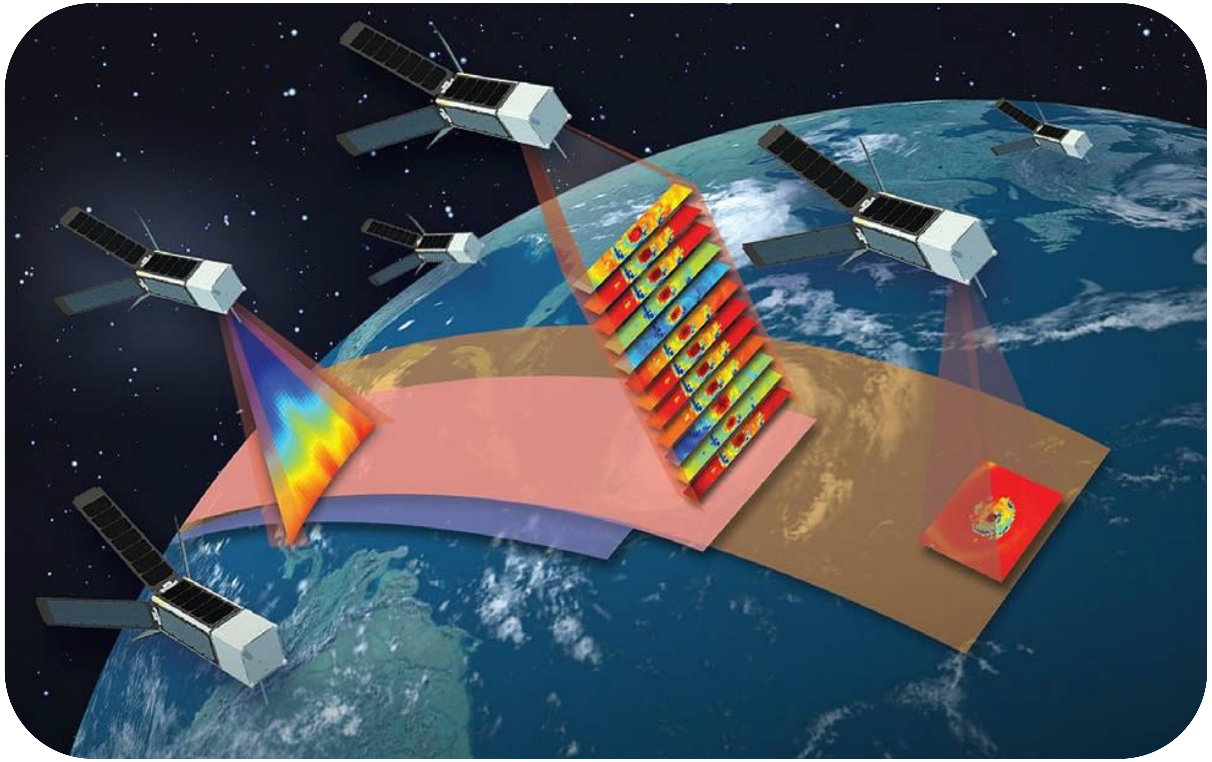
Communicating models to spacecraft

Machine learning models are not typically launched with the satellite, but trained and deployed later.

This requires communication standards!

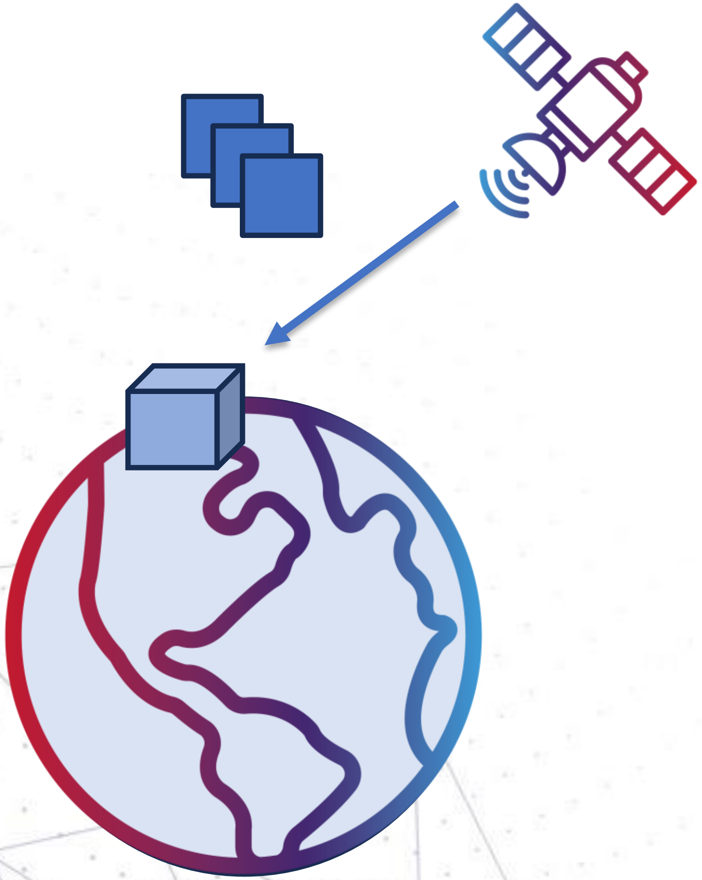
Two use cases are explored:

1. Deployment of a pre-trained model
2. Collaborative on-board training



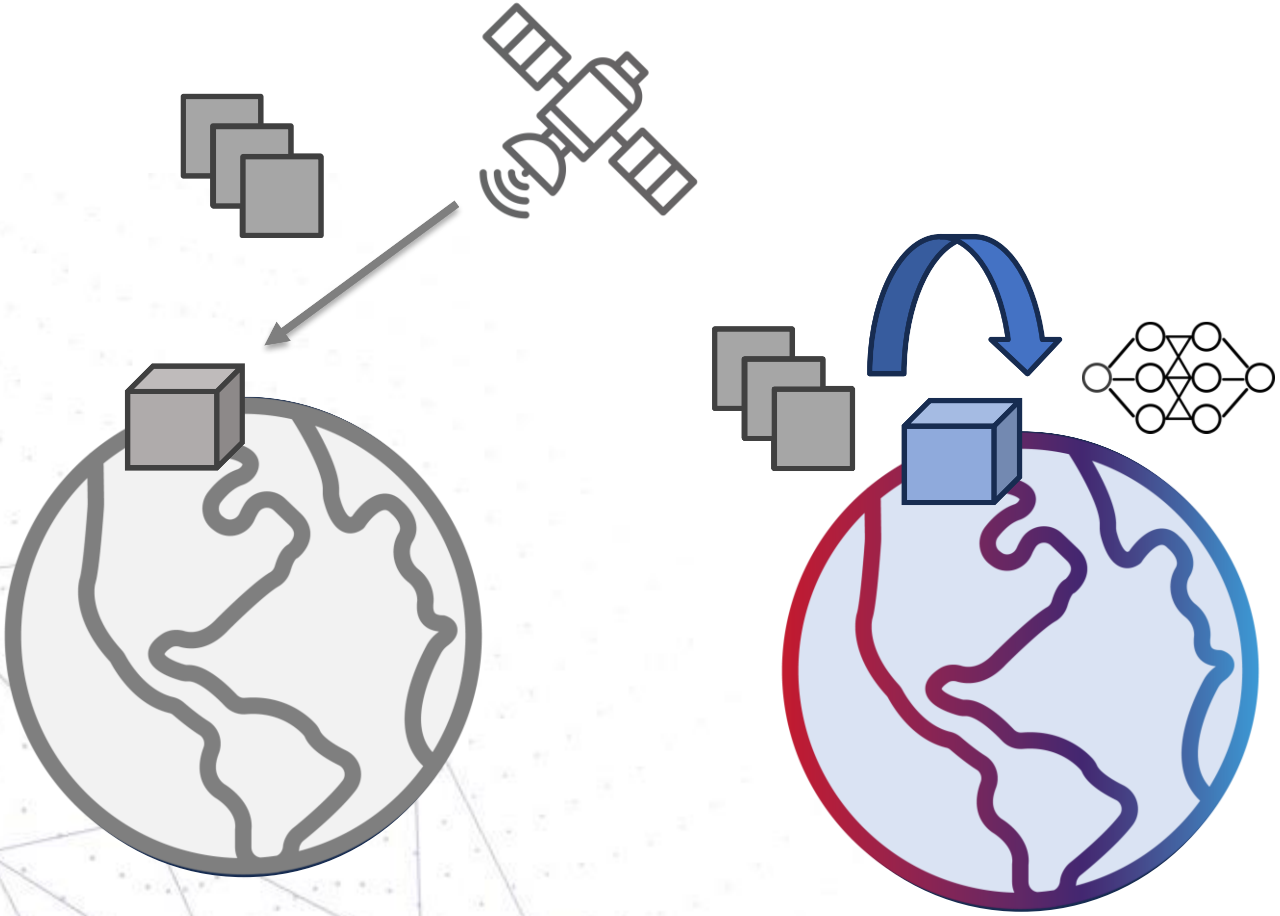
Source: NASA/MIT Lincoln Laboratory

Deploying pre-trained models on spacecraft



Satellite data collected
on ground

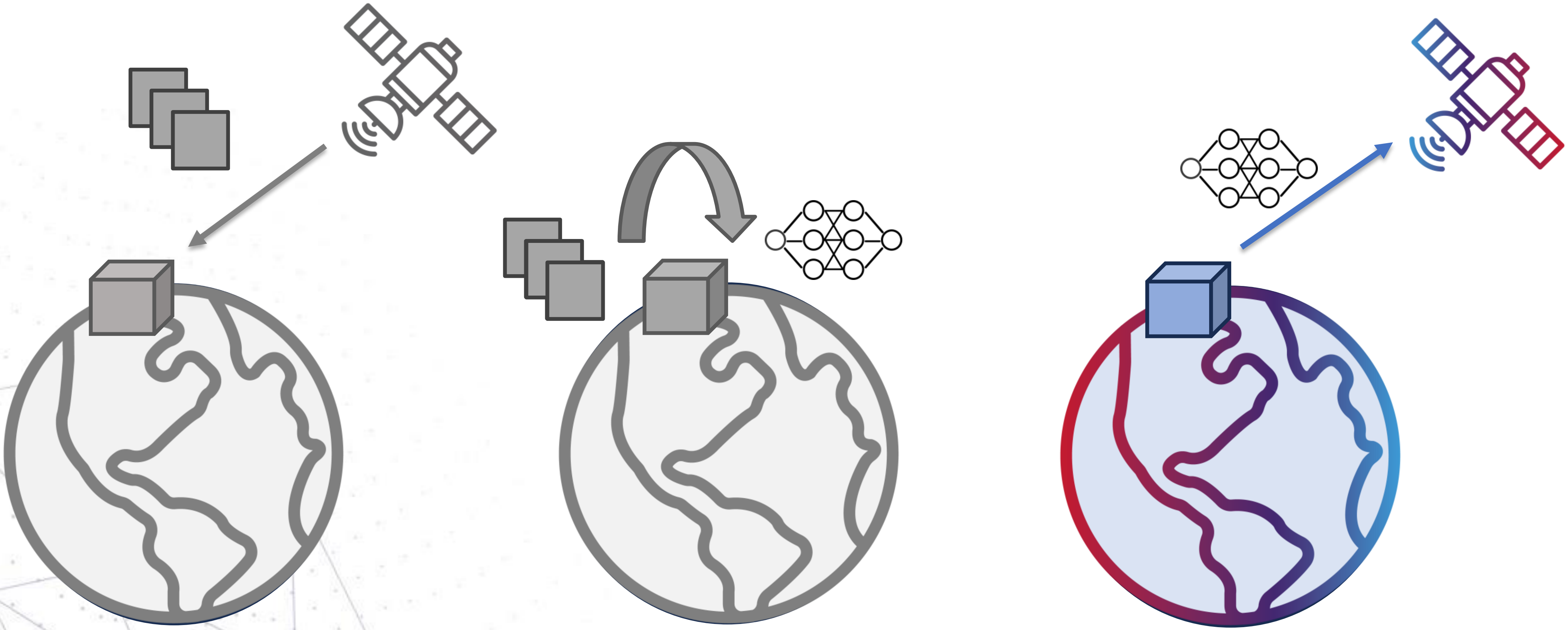
Deploying pre-trained models on spacecraft



Satellite data collected on ground

Model trained on collected data

Deploying pre-trained models on spacecraft

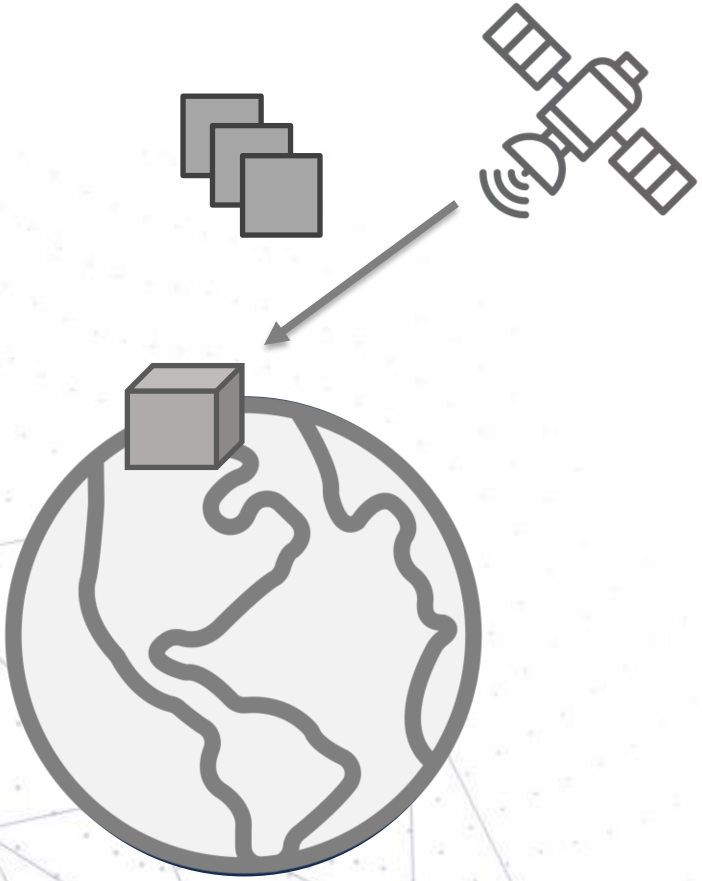


Satellite data collected on ground

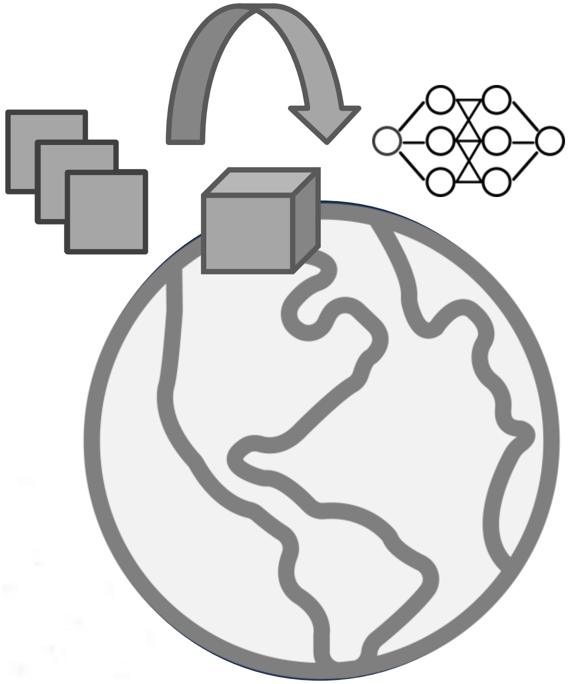
Model trained on collected data

Trained model transmitted to satellite

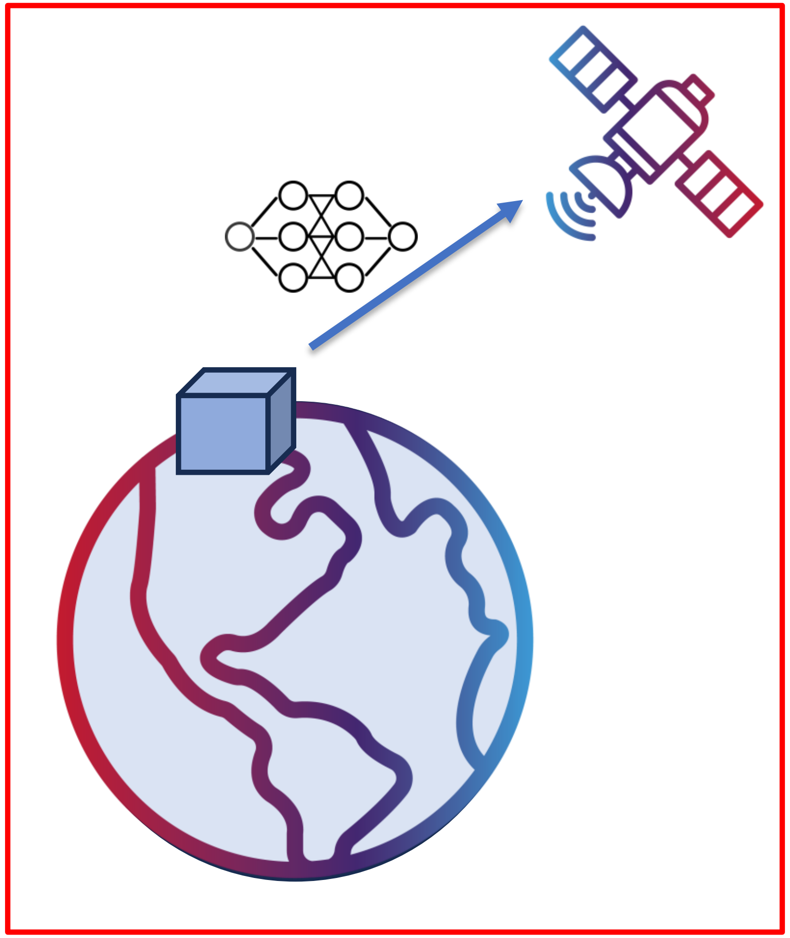
Deploying ML on spacecraft



Satellite data collected on ground



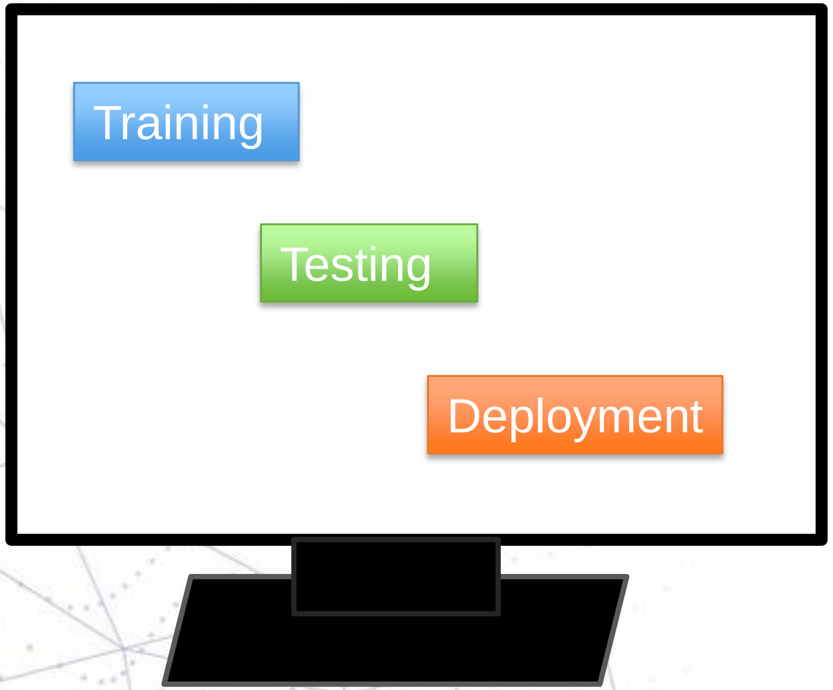
Model trained on collected data



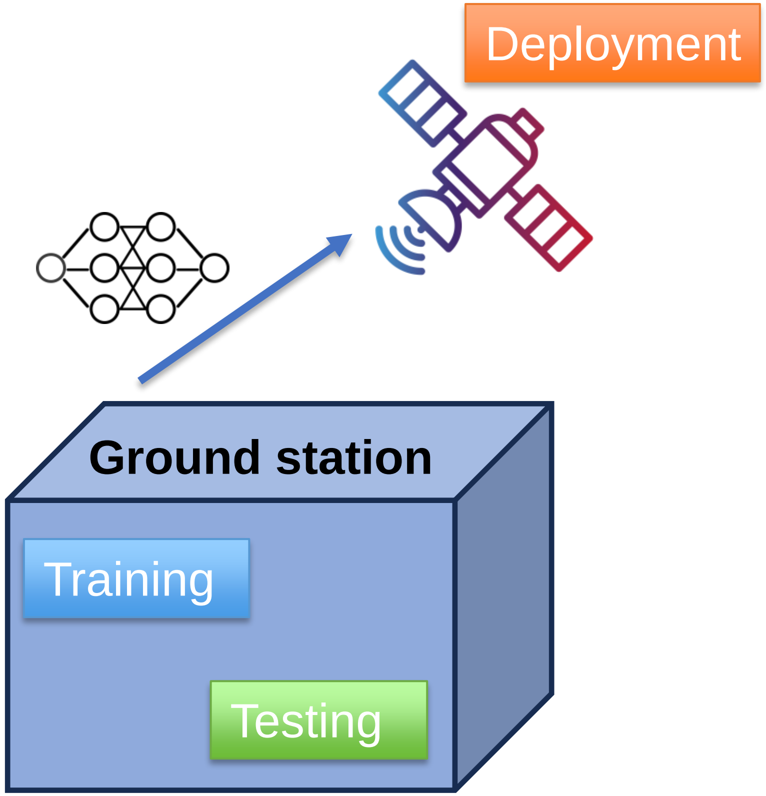
Trained model transmitted to satellite

Deploying ML on spacecraft

- Historically, ML models have been implemented, trained, and deployed in one framework
- For deployment on another device, model must be encoded *completely* and *unambiguously*



VS.

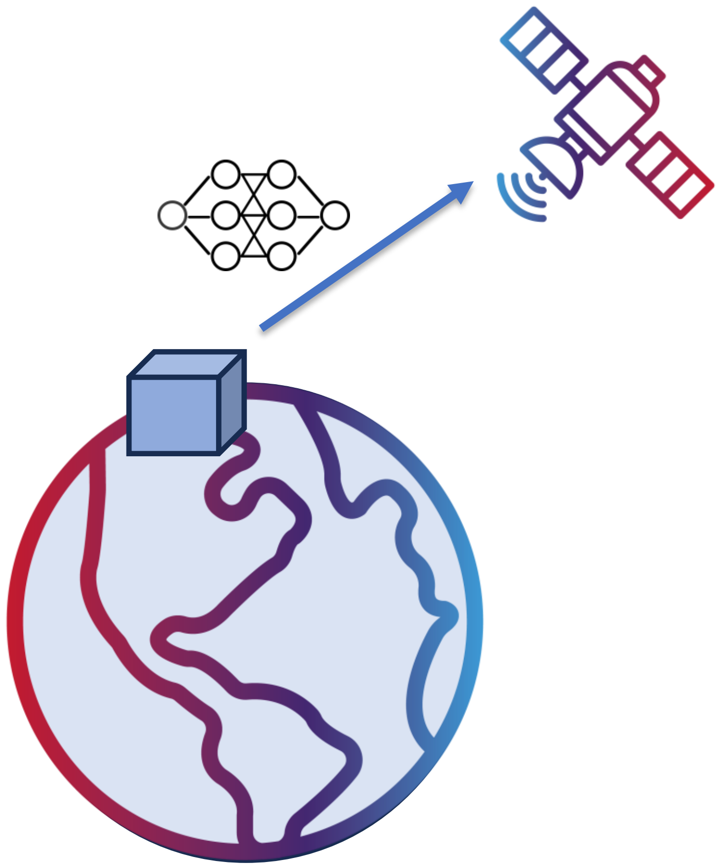


Trained model transmitted to satellite

Deploying ML on spacecraft

- Historically, ML models have been implemented, trained, and deployed in one framework
- For deployment on another device, model must be encoded *completely* and *unambiguously*

No general standard currently exists.



Trained model transmitted to satellite

Deploying ML on spacecraft – existing solutions

Can we integrate existing solutions to define a general model transfer protocol for space applications?

Model transfer formats

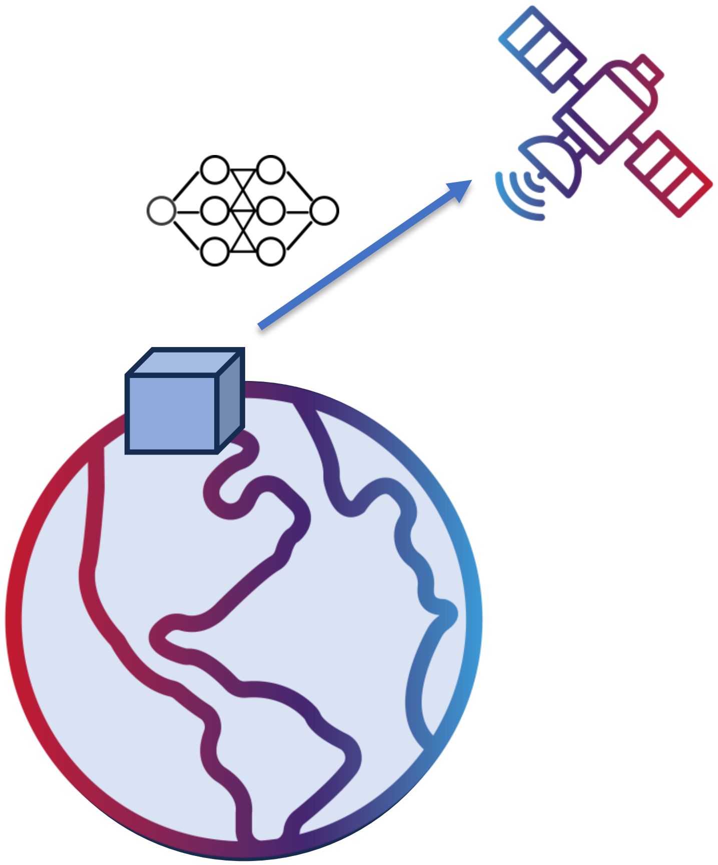
- Some proprietary tools
- Formats developed by industry consortia
  - NNEF (Neural Network Exchange Format)
  - ONNX (Open Neural Network eXchange)

PhiSat-1

- Technology demonstration by ESA, including deployment of a pre-trained artificial Intelligence model onto a satellite
- Used OpenVino, a proprietary tool, for model transfer

Space Communication standards (CCSDS)[1]

- Set of standards defining communication protocols for space missions

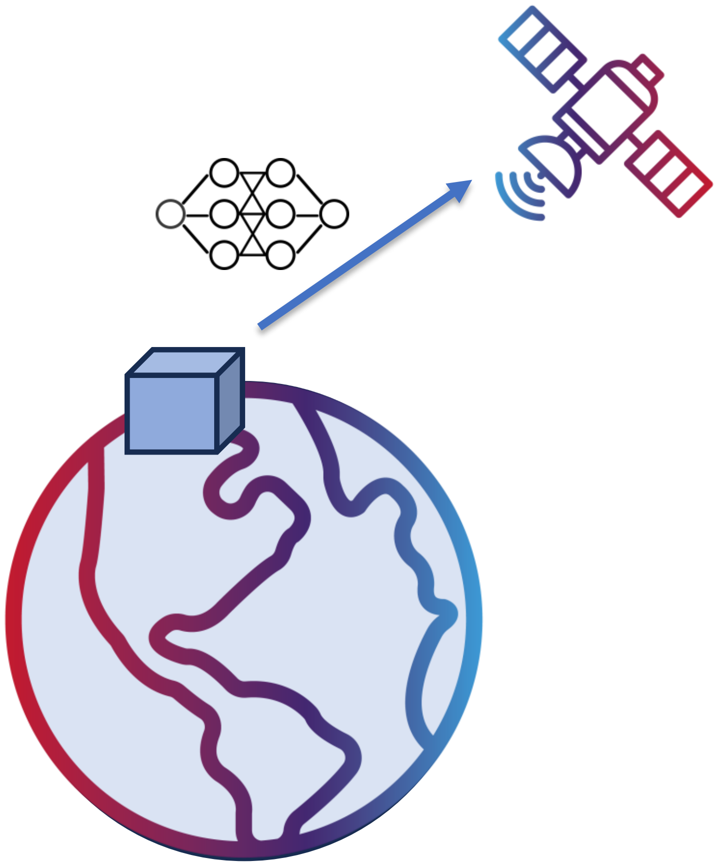


Trained model transmitted to satellite

[1] These standards have been adopted within ISO/TC 20/SC 13

Deploying ML on spacecraft – integrating existing solutions

- We suggest integrating one of the existing general model transfer formats (NNEF, ONNX) with CCSDS
- For simple model transfer, the encoded model can be encapsulated as a single message into a standard CCSDS communication stack



Trained model transmitted to satellite

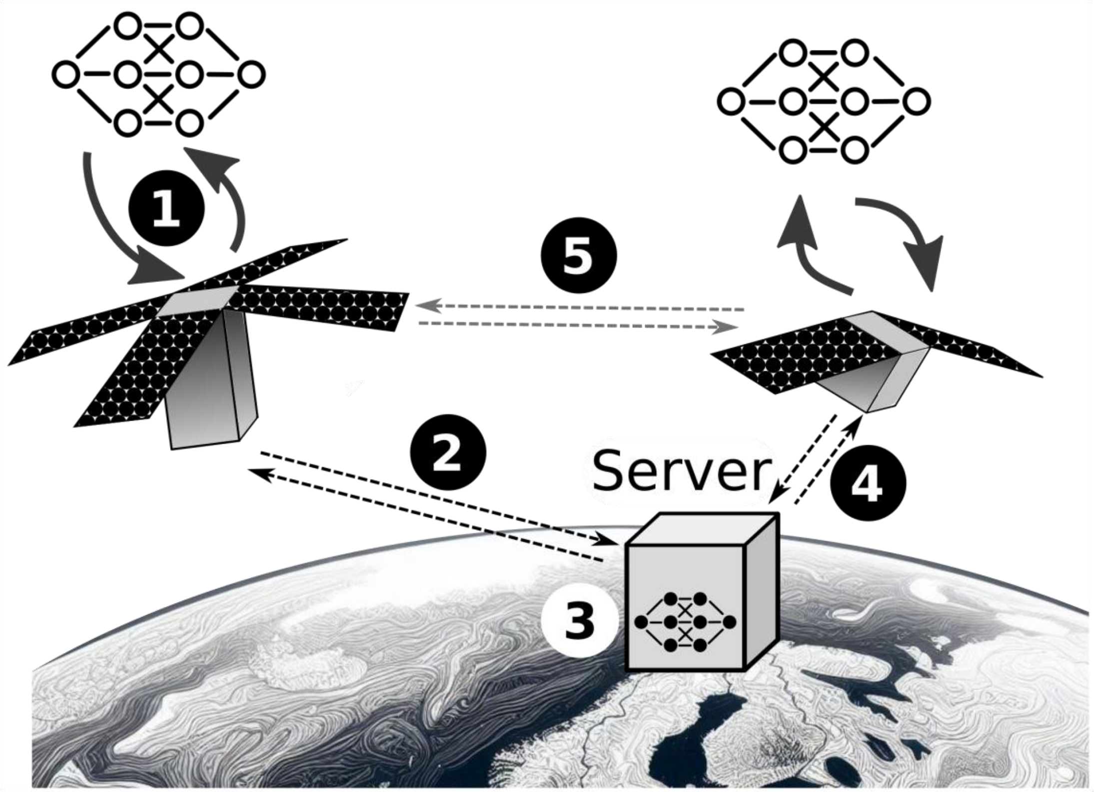
✓ Flexible

✓ Interoperable

✓ Little additional standardisation work required

One step further: enabling collaborative on-board machine learning

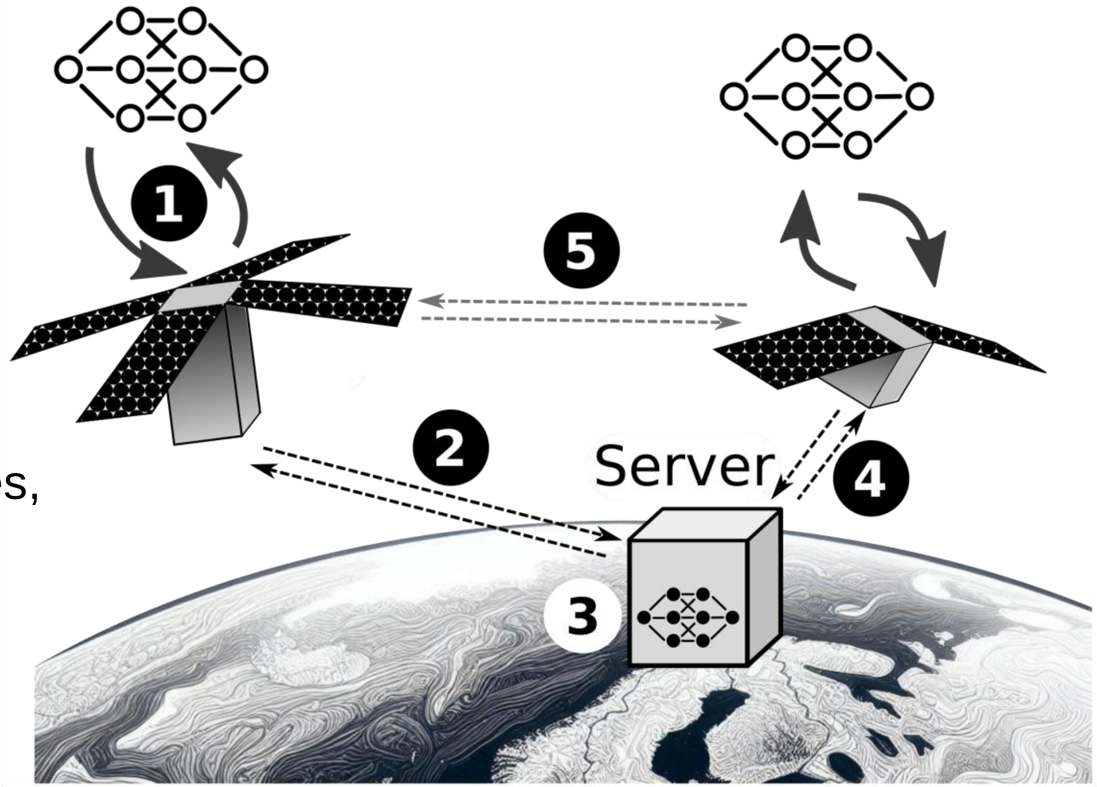
- Training a machine learning model on-board the spacecraft
- Possible approach: train collaboratively across multiple satellites, increasing model quality and reducing computational load



One step further: enabling collaborative on-board machine learning

- Training a machine learning model on-board the spacecraft
- Possible approach: train collaboratively across multiple satellites, increasing model quality and reducing computational load

- New challenges:
  - Need **new communication protocol** to set up and manage the collaboration process
  - Models are repeatedly transmitted between satellites, increasing communication cost



Setting up collaborative on-board machine learning

We characterise how a communication protocol to establish collaborative on-board machine learning could be defined, by suggesting possible attributes to be included.

Name of client parameter	Description	Comments
System topology	Different federated algorithms use different aggregation control schemes, e.g. fixed star topology (one central server), fully decentralised (no server at all), ...	
Server identity	Identity/address of the server, if it exists.	Needs to be fixed for clients if (1) clients are required to contact server, or (2) for security, to allow clients to verify server if contacted.
Local submission trigger	Defines how model submission is triggered on the local client: after a given number of steps, by reaching a certain training loss, upon contact by the server etc.	

Setting up collaborative on-board machine learning

- We characterise how a communication protocol to establish collaborative on-board machine learning could be defined, by suggesting possible attributes to be included.
- We also propose a modification of the NNEF model transfer format to reduce the resource cost of repeated model updates.

Conclusions

Two standardisation gaps identified:

- Model transfer format in the space domain
- Communication protocol to handle collaborative on-board learning

Possible solution approaches outlined:

- Adopting existing model transfer formats, combined with CCSDS protocols
- Defining new protocol to manage collaborative on-board learning
- Modifying model transfer format to optimise size of repeated messages

Parallel Computing and Optimisation Group

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Connect with us @SnT_uni_lu SnT, Interdisciplinary Centre for Security, Reliability and Trust

Demonstrating the integration of a construction sector standard in a constraint programming model

Hedieh Haddad
PhD Student (ILNAS/SnT – Construction)
University of Luxembourg

Environmentally sustainable-economic activities

- According to the EU taxonomy regulation (EU) 2020/852[1]:
  - Contribution to climate change mitigation
  - Improve thermal transmittance
  - Energy-efficient and environmentally friendly

- European commission directive 2010/31/EU on the energy performance of buildings[2]:
  - Reducing carbon footprint in the building sector
  - Enforcing strict energy efficiency standards
  - Promoting the use of renewable energy sources

1. https://eur-lex.europa.eu
2. https://europarl.europa.eu

Sustainable-economic design in construction

- Minimises environmental impact
- Promotes resource efficiency
- Reduces costs
- Enhances the quality of life for future generations

Sustainable-economic design in construction

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- Reduces costs
- Enhances the quality of life for future generations
  - Energy efficiency
  - Resource conservation
  - …

- Reducing environmental impact
- Making comfort for building occupants
  - ✓ Air Permeability, G-Value, **U-VALUE,** Building Orientation, Insulation Quality, Lighting, Type of Heating and Cooling Systems, …

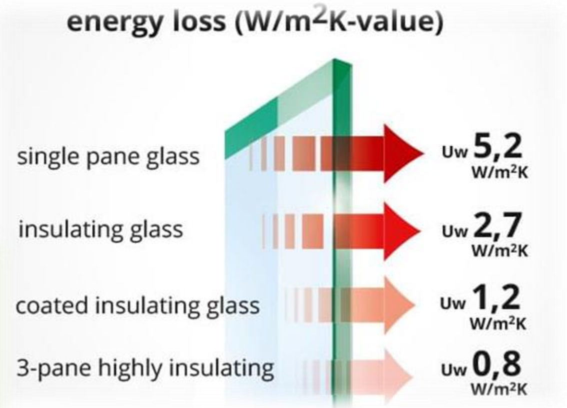
U-value (U_w)

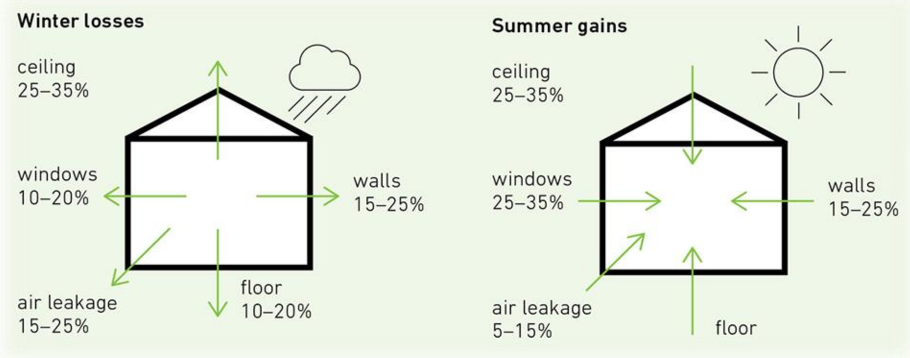
Thermal transmittance, or U-value, measures how well a building component conducts heat.

- **Building design and energy efficiency**
- **Heating/cooling costs and sustainability**

Improving U-value

- Focus on windows, doors, and shutters
  - Statistic says over one-third of energy used to heat buildings is lost through windows and doors





https://theconstructor.org
https://www.sustainability.vic.gov.au/

Calculation challenges

- **Complexity of thermal transmittance calculations**
    - Various materials and components
    - Environmental conditions
    - Material interactions
    - Geometric considerations

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- **Complexity of thermal transmittance calculations**
  - Various materials and components
  - Environmental conditions
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✓ Compliance with standards like ISO 10077-1:2017[1] (**Thermal performance of windows, doors and shutters — Calculation of thermal transmittance**)

✓ Specific methods and assumptions required by regulations

1. https://www.iso.org/standard/ISO 10077-1:2017

Standardisation landscape

Input data | *Optimisation via BIM* | *Output data*

ISO 16739-1 – Provides information definition exchanged and shared between BIM contributors during the different steps of building life-cycle

Input data

EN ISO 23386
Message format definition in order to reach easy interoperability between different project contributors

ISO 10916:2014
Provides method for energy calculation based on daylight

ISO/IEC 10077-1:2017[1]
Thermal performance of windows, doors and shutters

Optimisation via BIM

EN ISO 19650 series
Concept and principles for information management of BIM

ISO/IEC 33063:2015
Software testing

ISO/IEC 25000:2014
Software quality managment

Output data

EN ISO 23386
Message format definition in order to reach easy interoperability between different project contributors

ISO 52000-1:2017
Provides framework for energy prediction

ISO/IEC 20086:2019
Provides method for energy calculation based on daylight

ISO 15469:2004
Provides method for energy calculation based on daylight

1. https://www.iso.org/standard/ISO 10077-1:2017

Methodology

- ISO 10077-1:2017[1] (Thermal performance of windows, doors and shutters) standard
    - Methods to calculate thermal transmittance
    - Comprehensive assessment of thermal performance

$$U_W = \frac{\sum A_g * U_g + \sum A_f * U_f + \sum l_g * \Psi_g + \sum l_{gb} * \Psi_{gb}}{A_f + A_g}$$

1. https://www.iso.org/standard/ISO 10077-1:2017

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! Complexity of thermal transmittance calculations

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Solution: artificial intelligence (AI)

- AI technologies
  - Machine learning techniques
  - Enhancing accuracy and speed of calculations

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Real-time adjustments during design and construction

Solution: artificial intelligence (AI)

- **Constraint programming (CP)**
  - Solving combinatorial problems
  - Scheduling, planning, and resource allocation
- **Benefits of integration**
  - Improved problem-solving efficiency
  - Enhanced solution quality

nd

Use case: CP model for U_w calculation

- Variables and constraints
  - Realistic ranges for each variable
  - Core equation for U_w
  - XML format compatible with XCSP3 standards
- Objective
  - Minimise U_w for optimal insulation

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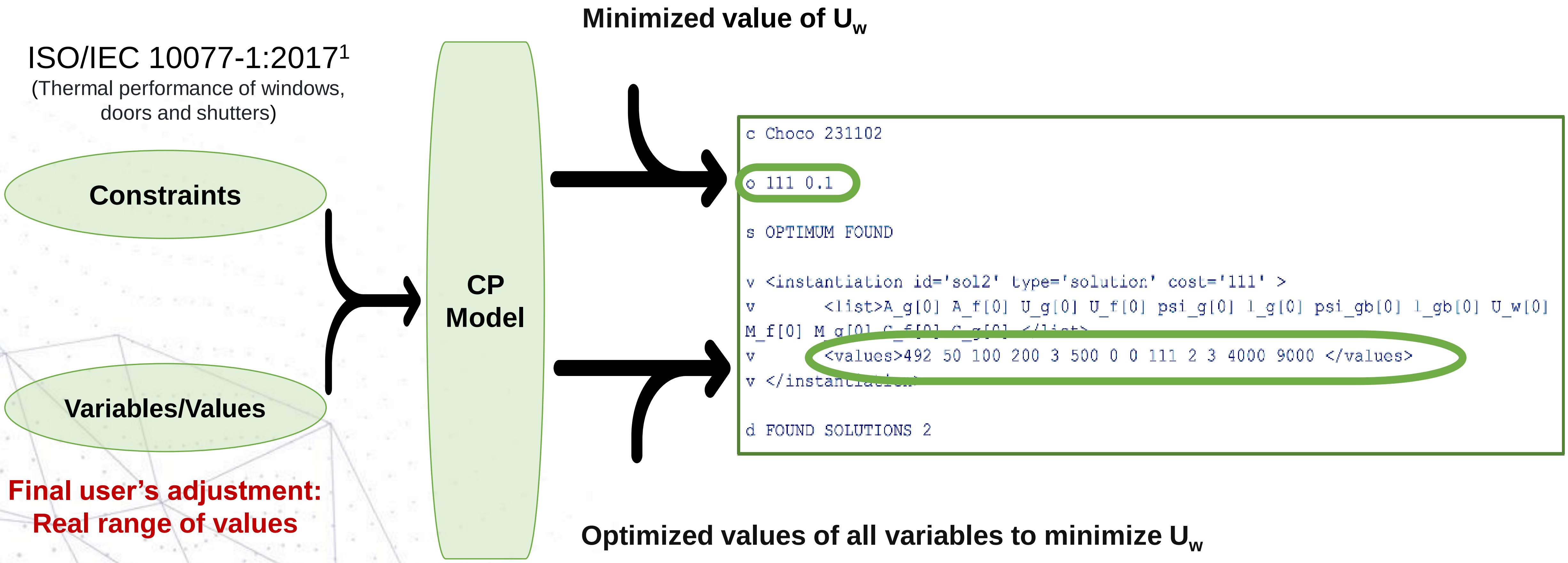
Minimising the cost of construction

CP result



1. https://www.iso.org/standard/ISO 10077-1:2017

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- Essential for energy efficiency in buildings.
- Lower U-values improve insulation and save energy.

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- Supports the European Green Deal.
- Promotes sustainable-economic activities.

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Remise du trophée
« Délégué National en Normalisation 2024 »

Lauréat 2024

Quelques indices...

Diplôme d'Ingénieur Génie Civil
-
Université de Kassel (DE)

Partenaire fondateur
-
Pôle d'innovation NeoBuild S.A.

Membre fondateur et administrateur
-
Conseil National de la Construction Durable (CNCD) a.s.b.l.

Membre représentant
-
CemBureau (EU)

Président
-
Groupement des Fabricants de Matériaux de Construction a.s.b.l. / FEDIL

Lauréat 2024

Quelques indices…

Suite à l'obtention de son diplôme d'Ingénieur en génie civil en 1995, il a évolué au sein de différentes organisations du domaine de la construction :

- Conducteur de travaux de 1995 à 2000 au sein de l'entreprise Poeckes ;
- Responsable du centre d'excellence Conseil en Construction du Groupe Ciments Luxembourgeois à partir de 2000 ;
- Président du Luxembourg EcoInnovation Cluster de 2009 à 2013 (Luxinnovation / Ministère de l'Economie et du Commerce extérieur) ;
- Fondé de pouvoir, responsable relations institutionnelles, conseil et information de Cimalux S.A. à partir de 2006.

Son coeur de métier est axé sur le conseil dans le secteur de la construction, plus particulièrement dans le domaine du ciment. Dans ce cadre, il propose notamment des conseils d'expertise, des formations et de l'assistance technique auprès des administrations, des ingénieurs-conseils, des architectes et des entreprises de construction dans tous les domaines relatifs aux matériaux à base de ciment.

Il gère également les relations avec les instances décisionnaires publiques et privées (relations institutionnelles / *public affairs*).

Il est représentant actif au sein de groupes de travail de différents organismes du secteur luxembourgeois de la construction (IFSB, CRTI-B, Uni.lu).

Enfin, il est en charge de la rédaction et de la transposition de la feuille de route relative à la décarbonation de la filière ciment et béton pour le Luxembourg.

Lauréat 2024

Quelques indices…

Il est membre du Conseil Consultatif Recherche, Développement et Innovation du groupe BUZZI (maison mère de DYCKERHOFF / CIMALUX).

Aujourd'hui, il apporte son expertise et suit les travaux de différents comités techniques de normalisation :

- Les comités techniques nationaux ILNAS/TC 102 – Béton et ILNAS/TC 110 - DNA - EN 1916 ;
- Les comités techniques européens CEN/TC 104/SC 1 - Concrete and related products; Concrete - Specification, performance, production and conformity; Execution of concrete structures et CEN/TC 104/SC 2 - Concrete and related products; Execution of concrete structures ;
- Le comité technique international ISO/TC 265 - Carbon dioxide capture, transportation, and geological storage.

IEC ISO ITU

Lauréat 2024

Fondé de pouvoir, responsable relations institutionnelles, conseil et information

Cimalux
Ciments & Matériaux

Félicitations !

Merci à tous les experts impliqués dans la normalisation technique.

ILNAS ANEC

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Journée Mondiale de la Normalisation
World Standards Day

15.10
2024

IEC ISO ITU