
SNT
Expertise of the Signal Processing and Communications (SIGCOM) group of the University of Luxembourg, related to HORIZON-JU-SNS-2026-STREAM-B-01
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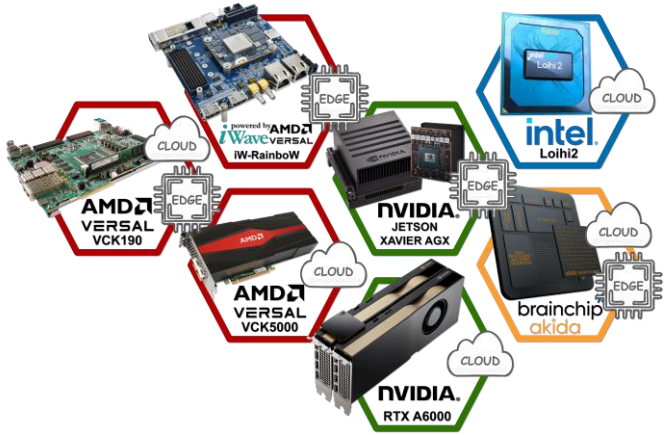
On-board AI… are we there yet?

TelecomAI-Lab

- ✓ The SIGCOM AI Lab is dedicated to pioneering ***AI technologies tailored for telecommunications***, particularly in wireless and SatCom systems, with a specific focus on enhancing future communications through AI-driven optimization.
- ✓ Its research explores *neuromorphic and edge computing* paradigms for *energy-efficient and high-performance* AI-driven enhancements for 5G/6G networks and NTN. The lab also investigates AI-based optimisations in ***edge-data processing, signal processing, resource allocation, and interference management***.

AI/ML Platforms at SIGCOM



AI-Chip must be energy efficient and radiation tolerant, with memory and computational power adapted to the targeted application.

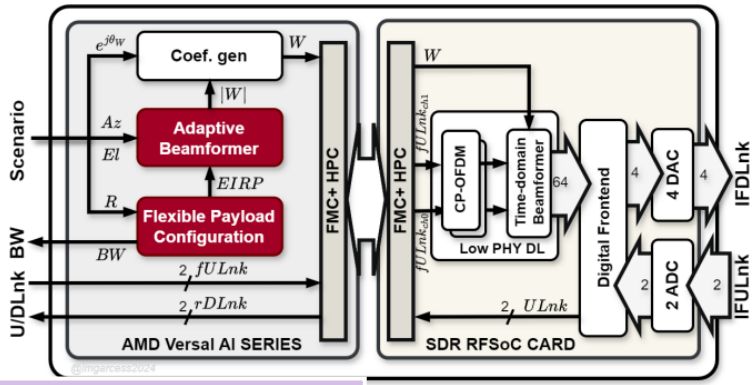
Edge AI - Equipment	Year	Comments
Akida BrainChip Development Kit	2024	for bio-inspired, low-power computation. We are looking at a second Akida, purchase has already been requested
Intel Loihi 2	2024	for bio-inspired, low-power computation.
Workstations - Precision 7960 Tour XCTO Basique	2024	(2 in lab). For training and deploying deep learning models in communication networks (together with HPC)
VERSAL	2023	Versal VCK190, Serval iW-RainboW
NVIDIA Jetson Orin Nano Dev. kit, 67TOPS, 8GB DDR5	2025	3 kits in lab. GPU for low-power Edge-AI computation.
NVIDIA Jetson AGX Thor Dev. Kit, 2070 TFLOPS, 128GB DDR5	2025	GPU for low-power Edge-AI computation. For developing Edge Vision Language Model.
Apple Vision Pro (256GB)	2025	For VR-assisted industrial 5G-network demo in 5G-ARTEMIS
Ipad 11" M3 • WiFi+Cellular 256GB	2025	For VR-assisted industrial 5G-network demo in 5G-ARTEMIS

Capabilities:

- ➢ **Advanced AI Chipsets**: Leverage cutting-edge AI chipsets such as Akida BrainChip and Loihi2 for real-time data processing and decision-making in space environments.
- ➢ **Simulation and Testing Facilities**: Equipped with state-of-the-art simulation tools and testing facilities to model space conditions and validate the functionality and resilience of AI algorithms under space-like conditions.
- ➢ **Dedicated Research Team**: A multidisciplinary team of experts in AI, neuromorphic computing, NTN.
- ➢ **Educational Outreach**: Engage with the academic community through workshops, seminars, and courses to disseminate knowledge and inspire the next generation of researchers in the field of AI and space technology.

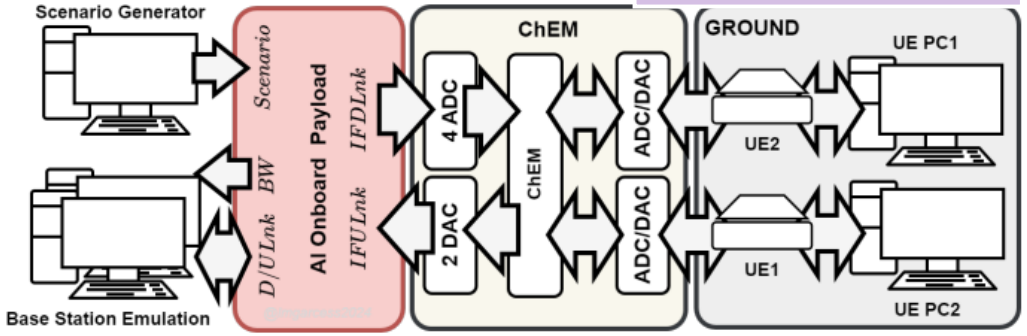
AI in Space Works

Artificial Intelligence Satellite Telecommunication Testbed using Commercial Off-The-Shelf Chipsets



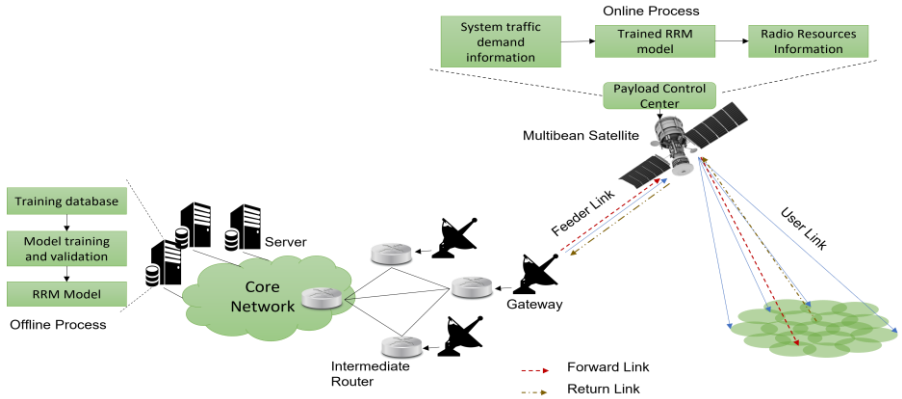
Onboard Payload Firmware Diagram.

AISTT Functional Diagram.

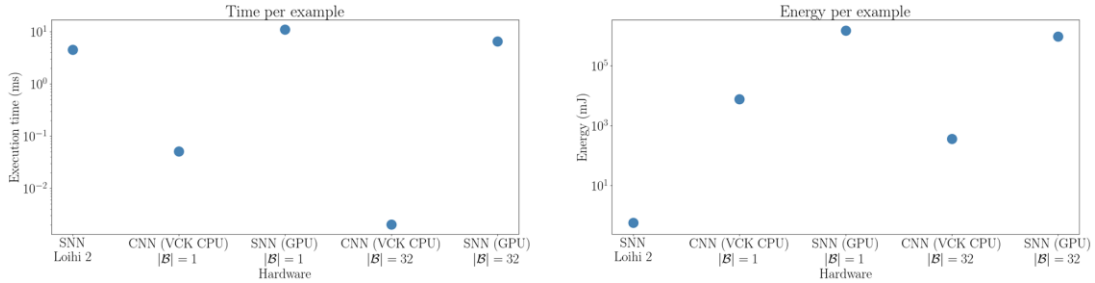


The Artificial Intelligence Satellite Telecommunications Testbed (AISTT), part of the **ESA project SPAICE**, is focused on the transformation of the satellite payload by using AI and ML methodologies over available commercial off-theshelf (COTS) AI chips for on-board processing.

Neuromorphic Computing for Radio Resource Management



A neuromorphic model based on a **spiking neural network (SNN)** and a non-neuromorphic model based on a **convolutional neural network (CNN)** were developed to compare the performance of both approaches.

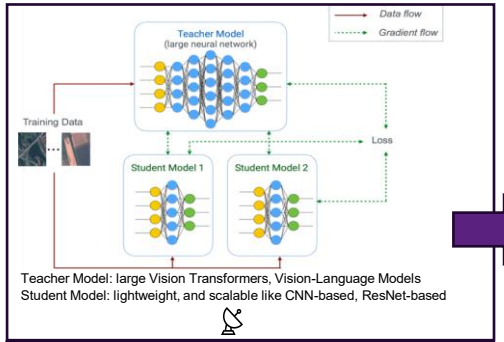


Comparison between execution of a Spiking Neural Network (SNN) on Loihi 2 and Convolutional Neural Network (CNN) on the CPU of the VCK 5000 (AI accelerator). Left: Average execution time per example. Right: Energy expenditure.

On-board AI for EO Data Processing

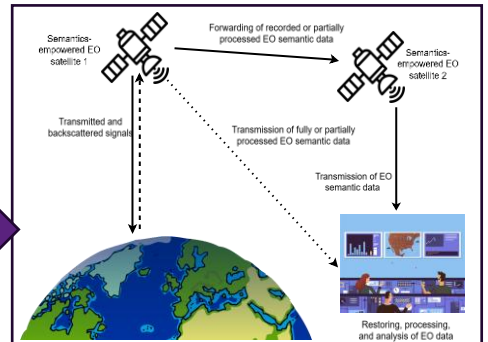
❖ *Onboard real-time inference*:

Developing a dynamic weighting knowledge distillation (KD) framework optimized for efficient pre-processing EO data before forwarding data to the ground.



Teacher Model: large Vision Transformers, Vision-Language Models
Student Model: lightweight, and scalable like CNN-based, ResNet-based

On-ground Training by "*Knowledge Distillation*" to have:
- Small and efficient ML models for edge devices
- Scalable ML models that can be deployed flexibly



On-air Inference AMD VCK 190, Akida, Loihi, NVIDIA Jetson
Optimal trade-off between performance and resource efficiency
Distributed edge computing and federated learning for satellite swarms

Performance

Compare to on-ground processing ↓ 1.5%

Models	Accuracy (↑)	Precision (↑)	Recall (↑)
EfficientViT	99.52	99.52	99.52
MobileViT	**99.66**	**99.66**	**99.66**
w/o KD			
ResNet	80.18	79.42	80.18
ResNet-SE	86.34	86	86.34
ResNet-gated-SE	86.02	85.80	86.02
ResNet-GLUSE	88.16	87.93	88.16
with KD			
ResNet	97.73	97.70	97.73
ResNet-SE	98.02	98	98.02
ResNet-gated-SE	97.98	97.98	97.98
ResNet-GLUSE	**98.09**	**98.09**	**98.09**

Computation

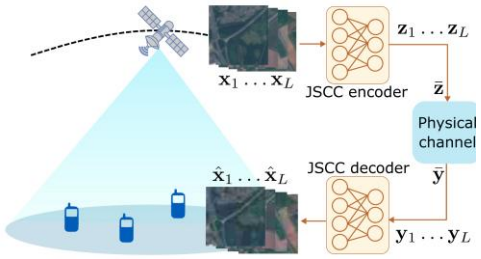
↓ 30 x

Models	Total Parameters (↓)	FLOPs (↓)	Size (MB) (↓)	Inference time (s) (↓)	Power (W) (↓)
ResNet8	**98,522**	**60,113,536**	**5.95**	**5.84**	**10.94 ± 0.83**
ResNet8-SE	120,589	60,151,840	6.04	5.87	11.51 ± 1.58
ResNet8-gated-SE	126,077	60,271,904	6.06	5.99	13.05 ± 0.74
ResNet8-GLUSE	131,565	66,557,984	7.92	6.01	13.80 ± 1.39
EfficientViT	3,964,804	203,533,056	38.19	10	29.04 ± 0.96
MobileViT	4,393,971	1,843,303,424	259.30	16	79.23 ± 1.45

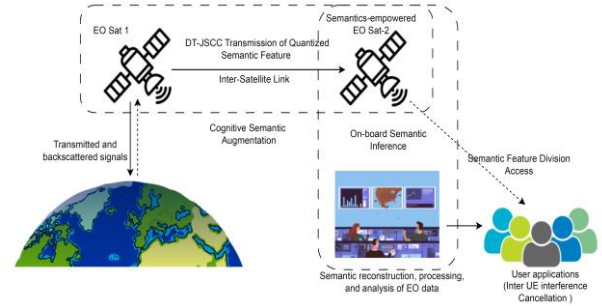
❖ *Joint Source Channel Coding*:

- **JSCC** leverages DL architectures to directly map input data into channel symbols (replacing traditional source coding, channel coding, and modulation) and reconstructs semantic representations at the receiver end.
- ➔ more robust and efficient communication, especially under low SNR and dynamic channel conditions.
- In EO systems, JSCC can be employed for Sat-UE and Sat-Sat (ISL) transmissions.

Sat-UE JSCC



Sat-Sat (ISL) JSCC



❖ *Quantification of Semantic Task-Oriented Losses*

❖ ***Model robustness***: Quantifying two primary types of semantic task-oriented loss of the EO data sent to ground:
1. Source coding loss, assessed via a data quality indicator measuring the impact of processing on raw source data,
2. Transmission loss, evaluated by comparing practical transmission performance against the Shannon limit.
3. Supporting optimization strategies to maintain high semantic quality of satellite-derived data, essential for ensuring reliability and mission-critical decision-making accuracy.

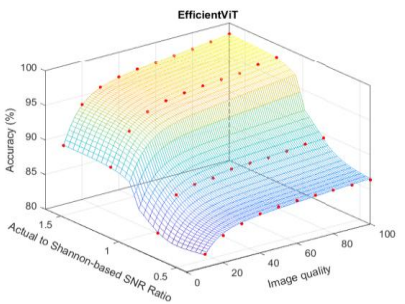


Fig. 7: Curve fitting model for the EfficientViT case ($N_c = 4$).

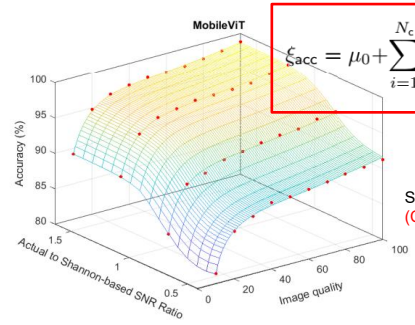


Fig. 8: Curve fitting model for the MobileViT case ($N_c = 4$).

$$\xi_{acc} = \mu_0 + \sum_{i=1}^{N_c} \left(\mu_{1,i} + \frac{\mu_{2,i}}{1 + \exp\left(-\mu_{3,i} s - \mu_{4,i}\right)} \right) \exp(\mu_{5,i} q), \quad (5)$$

Shanon-based SNR ratio (Communication Loss)

Compression ratio (Data extraction loss)

What can SIGCOM offer for HORIZON-JU-SNS-2026-STREAM-B-01?

❖ Core Offer:

AI-aware **high-fidelity datasets** and **open-source simulation tools** for 6G / NTN, explicitly capturing **network behaviour, AI decisions, and edge compute-energy constraints**.

❖ Contributions

- Realistic datasets from advanced NTN/SatCom testbeds (PHY → APP layers).
- Open-source simulator extensions for cross-layer, multi-RAT (cellular + NTN) 6G data generation.
- Synthetic dataset framework modelling user density, mobility, traffic, anomalies, and attacks.
- **AI execution traces:** latency, memory, CPU, and energy (Cloud, Edge AI, neuromorphic, Versal, NVIDA) together with dataset validation & auditing using semantic/task-oriented loss and information-theoretic metrics aligned with SNS data-space and AIaaS requirements.

❖ Role in Consortium

- Technical lead for **AI-dataset realism, validation, and open-source tooling**, complementing industrial partners providing operational data.
- Strong expertise in **edge AI, neuromorphic computing, NTN, and semantic communications**

Interdisciplinary Centre for Security, Reliability and Trust

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