Monday 14 September · Session 2 · 16:00

STINT 2026

Poster Lightning Madness

Nine posters · one minute each · your poster is on the screen behind you

15 minutes, hard stop at 16:15 · Irish College, Leuven

Session 2 · Protocols & Integration · Chair: Alberto Montilla

How it works

Fifteen minutes at the end of Session 2, then the welcome activity.

Each presenter gets **one minute** at the front. The poster is on the screen behind you: no slides, no laptop swap.

The pitch order follows the wall on the next slide (same order as the website).

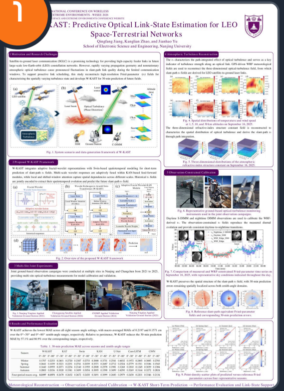
Posters go up on **Tuesday morning** and stay on display all day. The PDFs are already online.

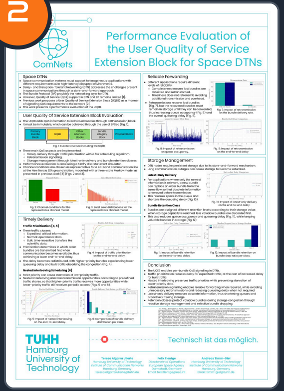
9 POSTERS	**60** SECONDS EACH
TUE ON DISPLAY	**PDF** ON THE WEBSITE

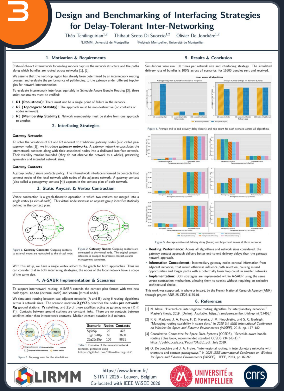
Bring your poster on Tuesday morning!
Boards go up at the registration desk · on display **all day Tuesday**

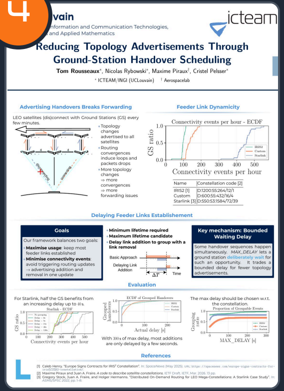
Nine posters, in pitch order

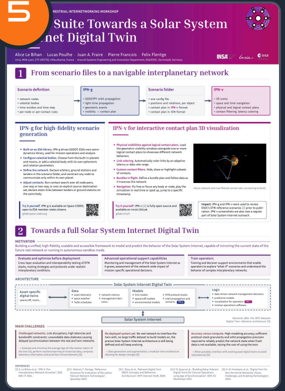
Same order as the Posters section of stintworkshops.org.

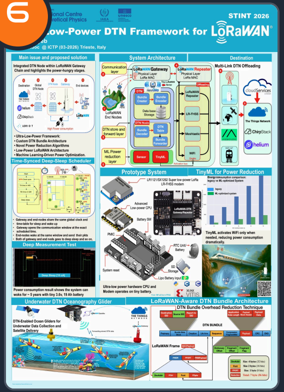
1

W-KAST
Jiang · Zhao · Yu

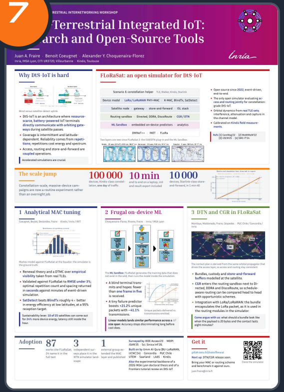
2

UQEB for space DTNs
Algarra Uliarte et al.

3

DTN inter-networking
Tchilinguirian et al.

4

GS handover scheduling
Rousseaux et al.

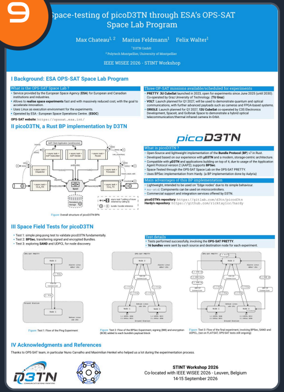
5

SSI digital twin
Le Bihan et al.

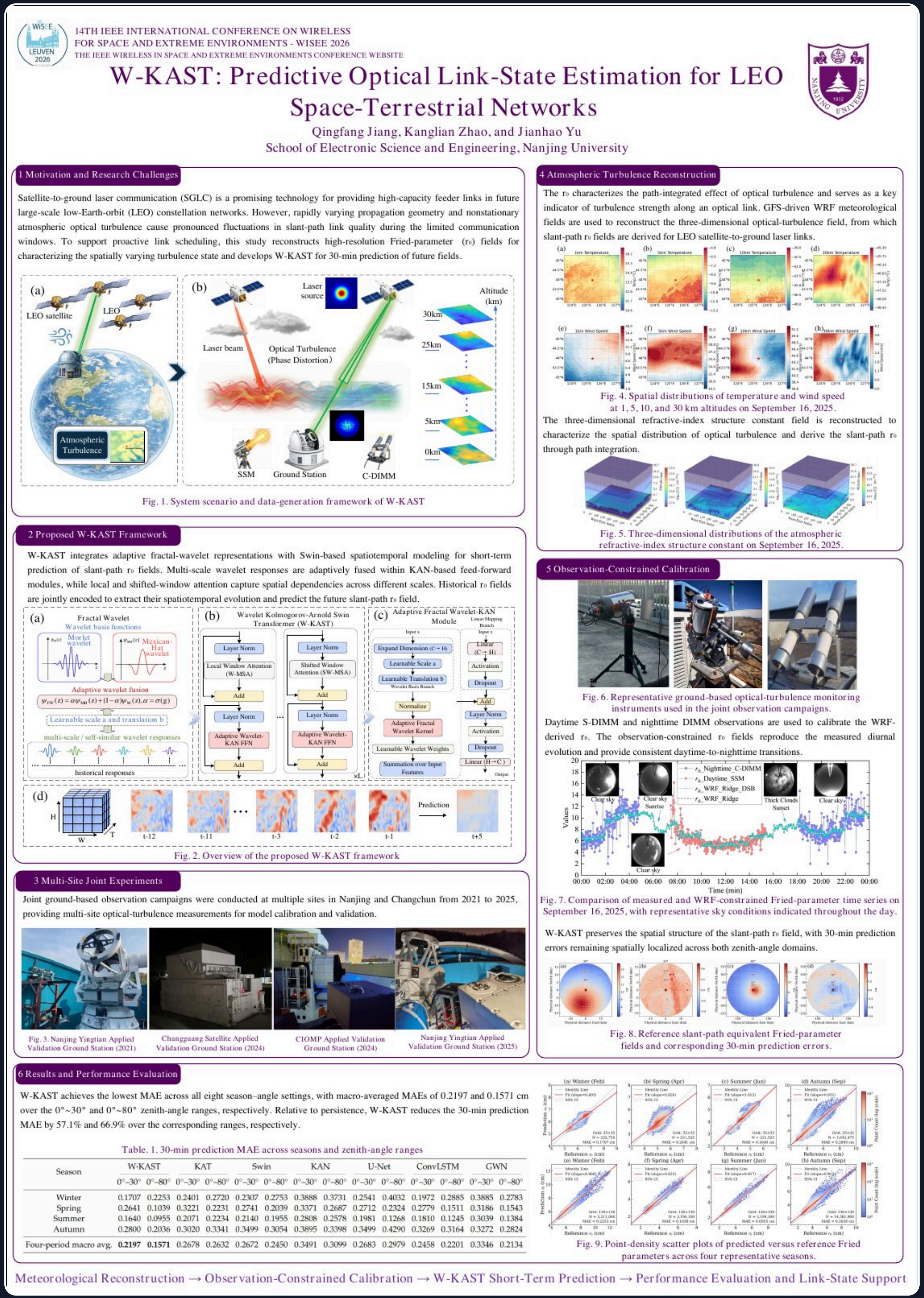
6

Low-power LoRaWAN
Altayeb

7

Space-terrestrial IoT
Coeugnet et al.

8

LunaNet-Sim
Jamal et al.

9

picoD3TN in space
Chateau et al.



POSTER 1 of 9 #44

W-KAST: Predictive Optical Link-State Estimation for LEO Space-Terrestrial Networks

Qingfang Jiang, **Kanglian Zhao**, Jianhao Yu

School of Electronic Science and Engineering, Nanjing University

60 s pitch

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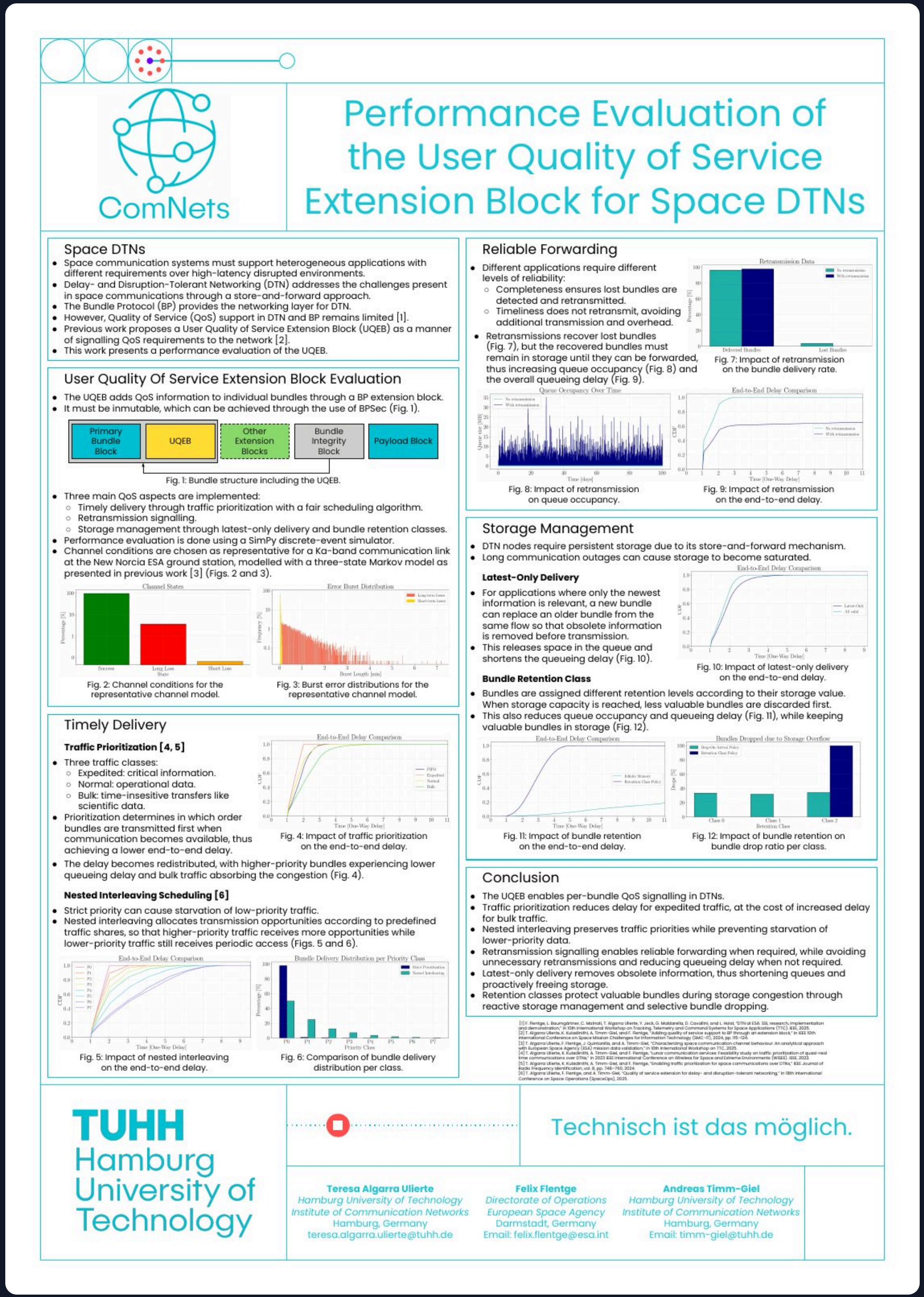
PDF on **stintworkshops.org**



POSTER 2 of 9 #64

Performance Evaluation of the User Quality of Service Extension Block for Space DTNs

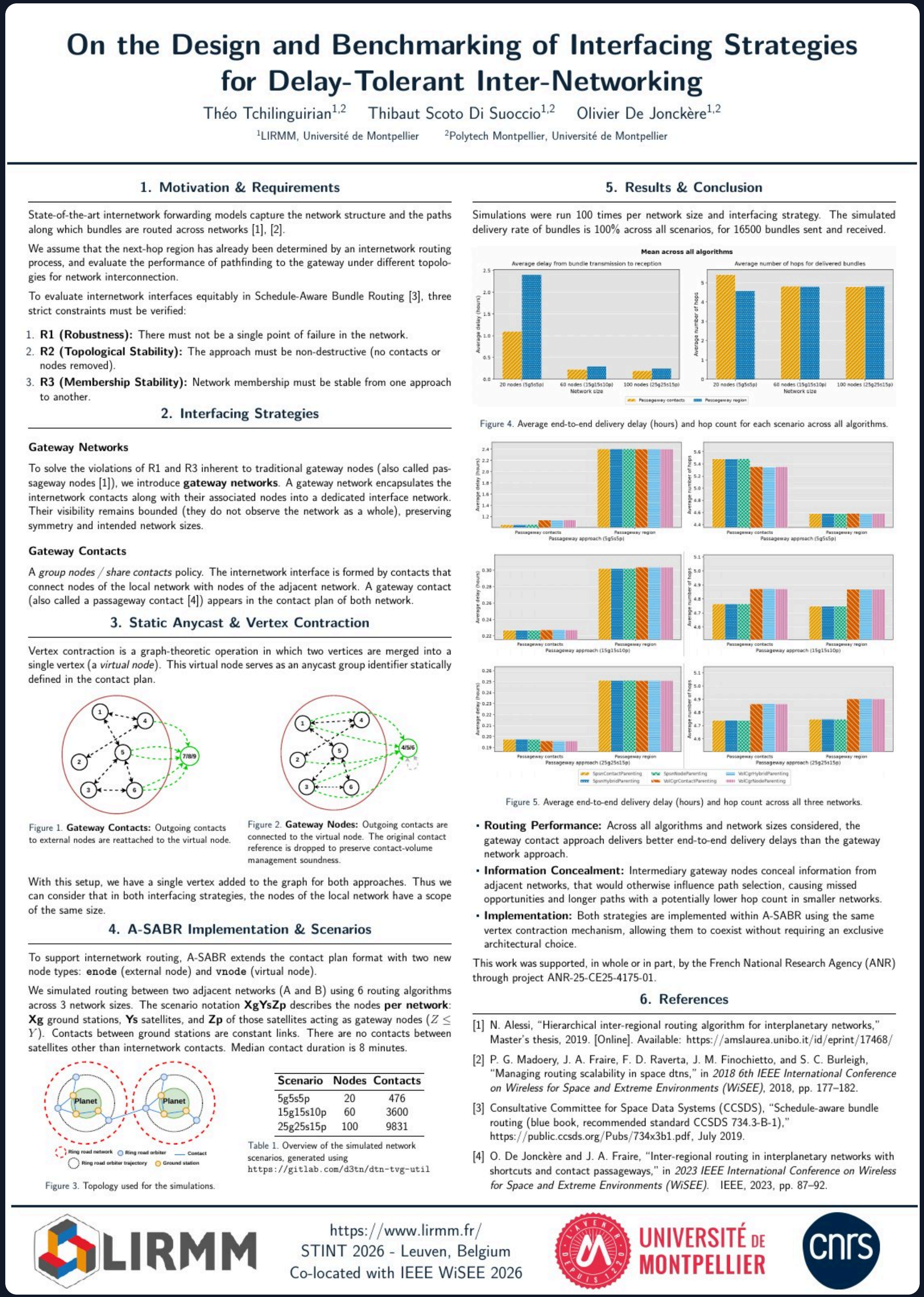
Teresa de Jesús Algarra Uliarte, Felix Flentge, Andreas Timm-Giel

Hamburg University of Technology · ESA/ESOC

60 s pitch

Board goes up **Tuesday morning**

PDF on **stintworkshops.org**



On the Design and Benchmarking of Interfacing Strategies for Delay-Tolerant Inter-Networking

Théo Tchilinguirian[1,2] Thibaut Scoto Di Suoccio[1,2] Olivier De Jonckère[1,2]
[1]LIRMM, Université de Montpellier [2]Polytech Montpellier, Université de Montpellier

1. Motivation & Requirements

State-of-the-art internetwork forwarding models capture the network structure and the paths along which bundles are routed across networks [1], [2].

We assume that the next-hop region has already been determined by an internetwork routing process, and evaluate the performance of pathfinding to the gateway under different topologies for network interconnection.

To evaluate internetwork interfaces equitably in Schedule-Aware Bundle Routing [3], three strict constraints must be verified:

1. **R1 (Robustness):** There must not be a single point of failure in the network.
2. **R2 (Topological Stability):** The approach must be non-destructive (no contacts or nodes removed).
3. **R3 (Membership Stability):** Network membership must be stable from one approach to another.

2. Interfacing Strategies

Gateway Networks

To solve the violations of R1 and R3 inherent to traditional gateway nodes (also called passageway nodes [1]), we introduce **gateway networks**. A gateway network encapsulates the internetwork contacts along with their associated nodes into a dedicated interface network. Their visibility remains bounded (they do not observe the network as a whole), preserving symmetry and intended network sizes.

Gateway Contacts

A *group nodes / share contacts* policy. The internetwork interface is formed by contacts that connect nodes of the local network with nodes of the adjacent network. A gateway contact (also called a passageway contact [4]) appears in the contact plan of both network.

3. Static Anycast & Vertex Contraction

Vertex contraction is a graph-theoretic operation in which two vertices are merged into a single vertex (a *virtual node*). This virtual node serves as an anycast group identifier statically defined in the contact plan.

Figure 1. **Gateway Contacts:** Outgoing contacts to external nodes are reattached to the virtual node.

Figure 2. **Gateway Nodes:** Outgoing contacts are connected to the virtual node. The original contact reference is dropped to preserve contact-volume management soundness.

With this setup, we have a single vertex added to the graph for both approaches. Thus we can consider that in both interfacing strategies, the nodes of the local network have a scope of the same size.

4. A-SABR Implementation & Scenarios

To support internetwork routing, A-SABR extends the contact plan format with two new node types: `enode` (external node) and `vnode` (virtual node).

We simulated routing between two adjacent networks (A and B) using 6 routing algorithms across 3 network sizes. The scenario notation **XgYsZp** describes the nodes **per network**: **Xg** ground stations, **Ys** satellites, and **Zp** of those satellites acting as gateway nodes ($Z \leq Y$). Contacts between ground stations are constant links. There are no contacts between satellites other than internetwork contacts. Median contact duration is 8 minutes.

Figure 3. Topology used for the simulations.

Scenario	Nodes	Contacts
5g5s5p	20	476
15g15s10p	60	3600
25g25s15p	100	9831

Table 1. Overview of the simulated network scenarios, generated using https://gitlab.com/d3tn/dtn-tvg-util

5. Results & Conclusion

Simulations were run 100 times per network size and interfacing strategy. The simulated delivery rate of bundles is 100% across all scenarios, for 16500 bundles sent and received.

Figure 4. Average end-to-end delivery delay (hours) and hop count for each scenario across all algorithms.

Figure 5. Average end-to-end delivery delay (hours) and hop count across all three networks.

- **Routing Performance:** Across all algorithms and network sizes considered, the gateway contact approach delivers better end-to-end delivery delays than the gateway network approach.
- **Information Concealment:** Intermediary gateway nodes conceal information from adjacent networks, that would otherwise influence path selection, causing missed opportunities and longer paths with a potentially lower hop count in smaller networks.
- **Implementation:** Both strategies are implemented within A-SABR using the same vertex contraction mechanism, allowing them to coexist without requiring an exclusive architectural choice.

This work was supported, in whole or in part, by the French National Research Agency (ANR) through project ANR-25-CE25-4175-01.

6. References

[1] N. Alessi, "Hierarchical inter-regional routing algorithm for interplanetary networks," Master's thesis, 2019. [Online]. Available: https://amslaurea.unibo.it/id/eprint/17468/

[2] P. G. Madoery, J. A. Fraire, F. D. Raverta, J. M. Finochietto, and S. C. Burleigh, "Managing routing scalability in space dtns," in *2018 6th IEEE International Conference on Wireless for Space and Extreme Environments (WiSEE)*, 2018, pp. 177–182.

[3] Consultative Committee for Space Data Systems (CCSDS), "Schedule-aware bundle routing (blue book, recommended standard CCSDS 734.3-B-1)," https://public.ccsds.org/Pubs/734x3b1.pdf, July 2019.

[4] O. De Jonckère and J. A. Fraire, "Inter-regional routing in interplanetary networks with shortcuts and contact passageways," in *2023 IEEE International Conference on Wireless for Space and Extreme Environments (WiSEE)*. IEEE, 2023, pp. 87–92.

https://www.lirmm.fr/
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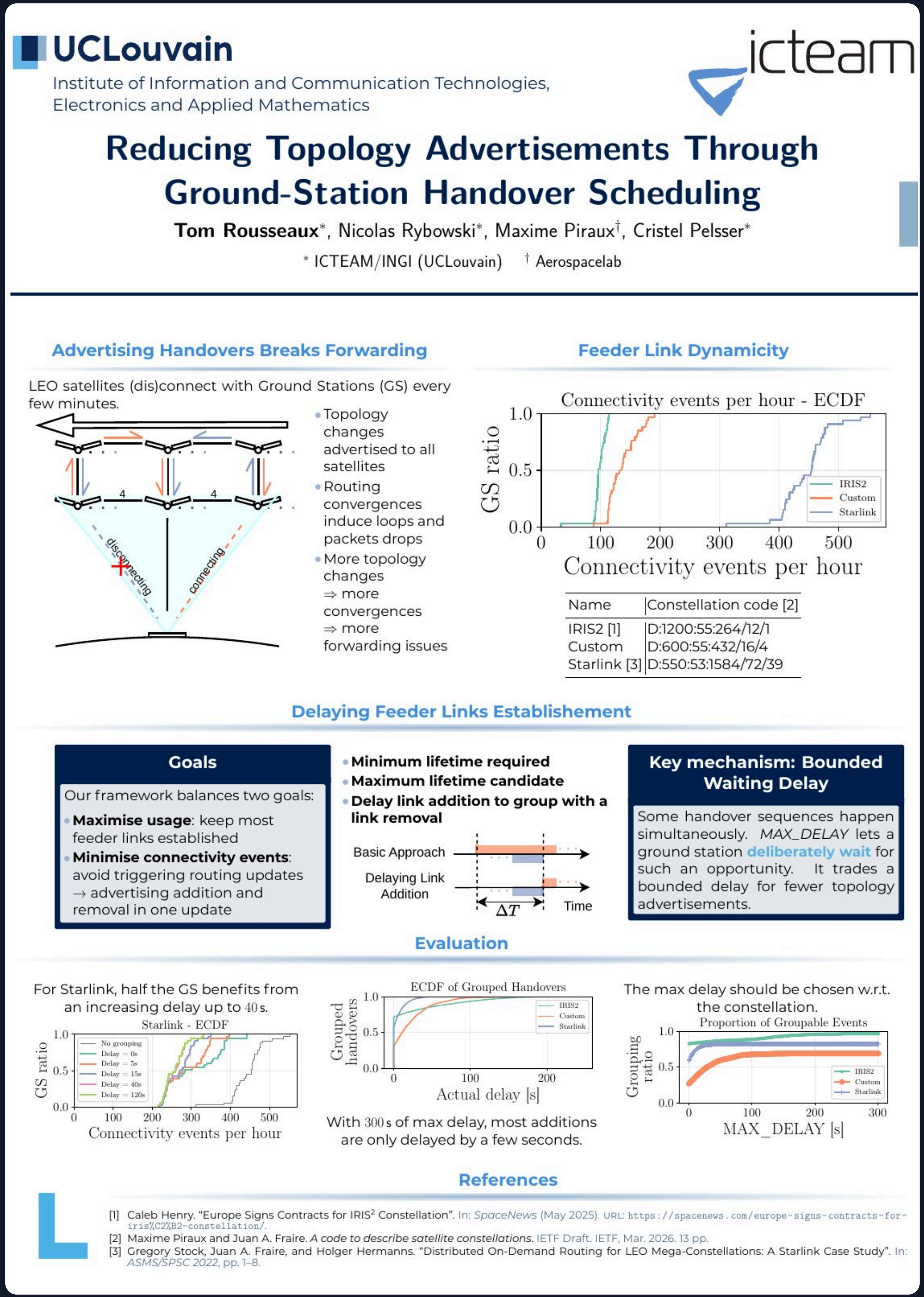
POSTER 3 of 9 #71

On the Design and Benchmarking of Interfacing Strategies for Delay-Tolerant Inter-Networking

Théo Tchilinguirian, Thibaut Scoto Di Suoccio, Olivier De Jonckère

LIRMM, Université de Montpellier · Polytech Montpellier

60 s pitch | Board goes up **Tuesday morning** | PDF on **stintworkshops.org**



POSTER 4 of 9 #72

Reducing Topology Advertisements Through Ground-Station Handover Scheduling

Tom Rousseaux, Nicolas Rybowski, Maxime Piraux, Cristel Pelsser

UCLouvain, ICTEAM

60 s pitch

Board goes up **Tuesday morning**

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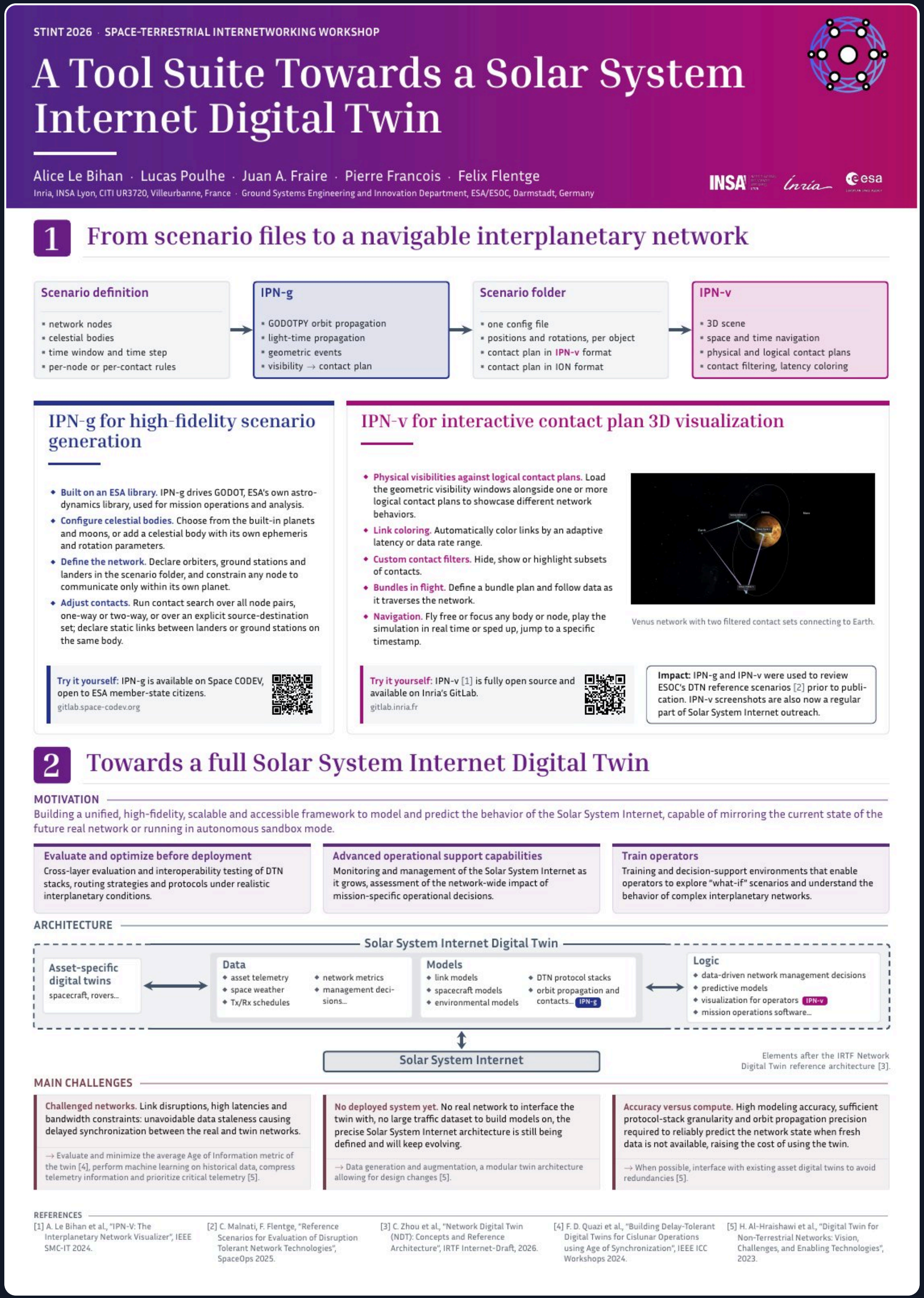

STINT 2026 · SPACE-TERRESTRIAL INTERNETWORKING WORKSHOP

A Tool Suite Towards a Solar System Internet Digital Twin

Alice Le Bihan · Lucas Poulhe · Juan A. Fraire · Pierre Francois · Felix Flentge
Inria, INSA Lyon, CITI UR3720, Villeurbanne, France · Ground Systems Engineering and Innovation Department, ESA/ESOC, Darmstadt, Germany

1 From scenario files to a navigable interplanetary network

Scenario definition
- network nodes
- celestial bodies
- time window and time step
- per-node or per-contact rules

→ **IPN-g**
- GODOTPY orbit propagation
- light-time propagation
- geometric events
- visibility → contact plan

→ **Scenario folder**
- one config file
- positions and rotations, per object
- contact plan in IPN-v format
- contact plan in ION format

→ **IPN-v**
- 3D scene
- space and time navigation
- physical and logical contact plans
- contact filtering, latency coloring

IPN-g for high-fidelity scenario generation

- **Built on an ESA library.** IPN-g drives GODOT, ESA's own astro-dynamics library, used for mission operations and analysis.
- **Configure celestial bodies.** Choose from the built-in planets and moons, or add a celestial body with its own ephemeris and rotation parameters.
- **Define the network.** Declare orbiters, ground stations and landers in the scenario folder, and constrain any node to communicate only within its own planet.
- **Adjust contacts.** Run contact search over all node pairs, one-way or two-way, or over an explicit source-destination set; declare static links between landers or ground stations on the same body.

Try it yourself: IPN-g is available on Space CODEV, open to ESA member-state citizens.
gitlab.space-codev.org

IPN-v for interactive contact plan 3D visualization

- **Physical visibilities against logical contact plans.** Load the geometric visibility windows alongside one or more logical contact plans to showcase different network behaviors.
- **Link coloring.** Automatically color links by an adaptive latency or data rate range.
- **Custom contact filters.** Hide, show or highlight subsets of contacts.
- **Bundles in flight.** Define a bundle plan and follow data as it traverses the network.
- **Navigation.** Fly free or focus any body or node, play the simulation in real time or sped up, jump to a specific timestamp.

Venus network with two filtered contact sets connecting to Earth.

Try it yourself: IPN-v [1] is fully open source and available on Inria's GitLab.
gitlab.inria.fr

Impact: IPN-g and IPN-v were used to review ESOC's DTN reference scenarios [2] prior to publication. IPN-v screenshots are also now a regular part of Solar System Internet outreach.

2 Towards a full Solar System Internet Digital Twin

MOTIVATION

Building a unified, high-fidelity, scalable and accessible framework to model and predict the behavior of the Solar System Internet, capable of mirroring the current state of the future real network or running in autonomous sandbox mode.

Evaluate and optimize before deployment
Cross-layer evaluation and interoperability testing of DTN stacks, routing strategies and protocols under realistic interplanetary conditions.

Advanced operational support capabilities
Monitoring and management of the Solar System Internet as it grows, assessment of the network-wide impact of mission-specific operational decisions.

Train operators
Training and decision-support environments that enable operators to explore "what-if" scenarios and understand the behavior of complex interplanetary networks.

ARCHITECTURE

Solar System Internet Digital Twin

Asset-specific digital twins
spacecraft, rovers…

↔

Data
- asset telemetry
- space weather
- Tx/Rx schedules
- network metrics
- management decisions…

Models
- link models
- spacecraft models
- environmental models
- DTN protocol stacks
- orbit propagation and contacts… IPN-g

↔

Logic
- data-driven network management decisions
- predictive models
- visualization for operators IPN-v
- mission operations software…

↕

Solar System Internet

Elements after the IRTF Network Digital Twin reference architecture [3].

MAIN CHALLENGES

Challenged networks. Link disruptions, high latencies and bandwidth constraints: unavoidable data staleness causing delayed synchronization between the real and twin networks.
→ Evaluate and minimize the average Age of Information metric of the twin [4], perform machine learning on historical data, compress telemetry information and prioritize critical telemetry [5].

No deployed system yet. No real network to interface the twin with, no large traffic dataset to build models on, the precise Solar System Internet architecture is still being defined and will keep evolving.
→ Data generation and augmentation, a modular twin architecture allowing for design changes [5].

Accuracy versus compute. High modeling accuracy, sufficient protocol-stack granularity and orbit propagation precision required to reliably predict the network state when fresh data is not available, raising the cost of using the twin.
→ When possible, interface with existing asset digital twins to avoid redundancies [5].

REFERENCES
[1] A. Le Bihan et al., "IPN-V: The Interplanetary Network Visualizer", IEEE SMC-IT 2024.
[2] C. Malnati, F. Flentge, "Reference Scenarios for Evaluation of Disruption Tolerant Network Technologies", SpaceOps 2025.
[3] C. Zhou et al., "Network Digital Twin (NDT): Concepts and Reference Architecture", IRTF Internet-Draft, 2026.
[4] F. D. Quazi et al., "Building Delay-Tolerant Digital Twins for Cislunar Operations using Age of Synchronization", IEEE ICC Workshops 2024.
[5] H. Al-Hraishawi et al., "Digital Twin for Non-Terrestrial Networks: Vision, Challenges, and Enabling Technologies", 2023.

A Tool Suite Towards a Solar System Internet Digital Twin

Alice Le Bihan, Lucas Poulhe, Juan A. Fraire, Pierre Francois, Felix Flentge

Inria Lyon · ESA/ESOC

60 s pitch

Board goes up **Tuesday morning**

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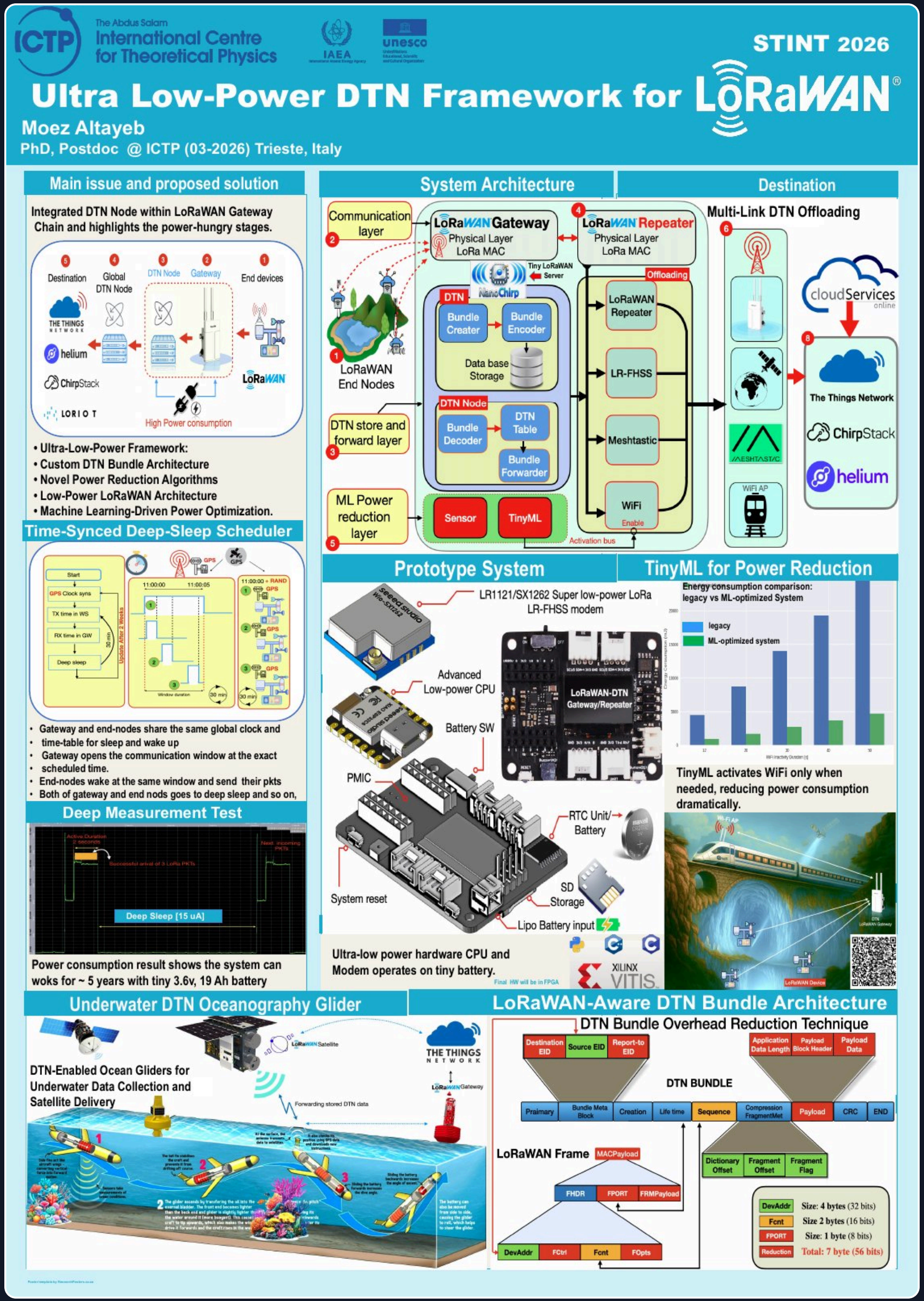

POSTER 6 of 9

Ultra Low-Power DTN Framework for LoRaWAN

Moez Altayeb

ICTP, The Abdus Salam International Centre for Theoretical Physics, Trieste

The author could not travel to Leuven: no pitch and no board on Tuesday. The poster is online only, on stintworkshops.org.

Online only

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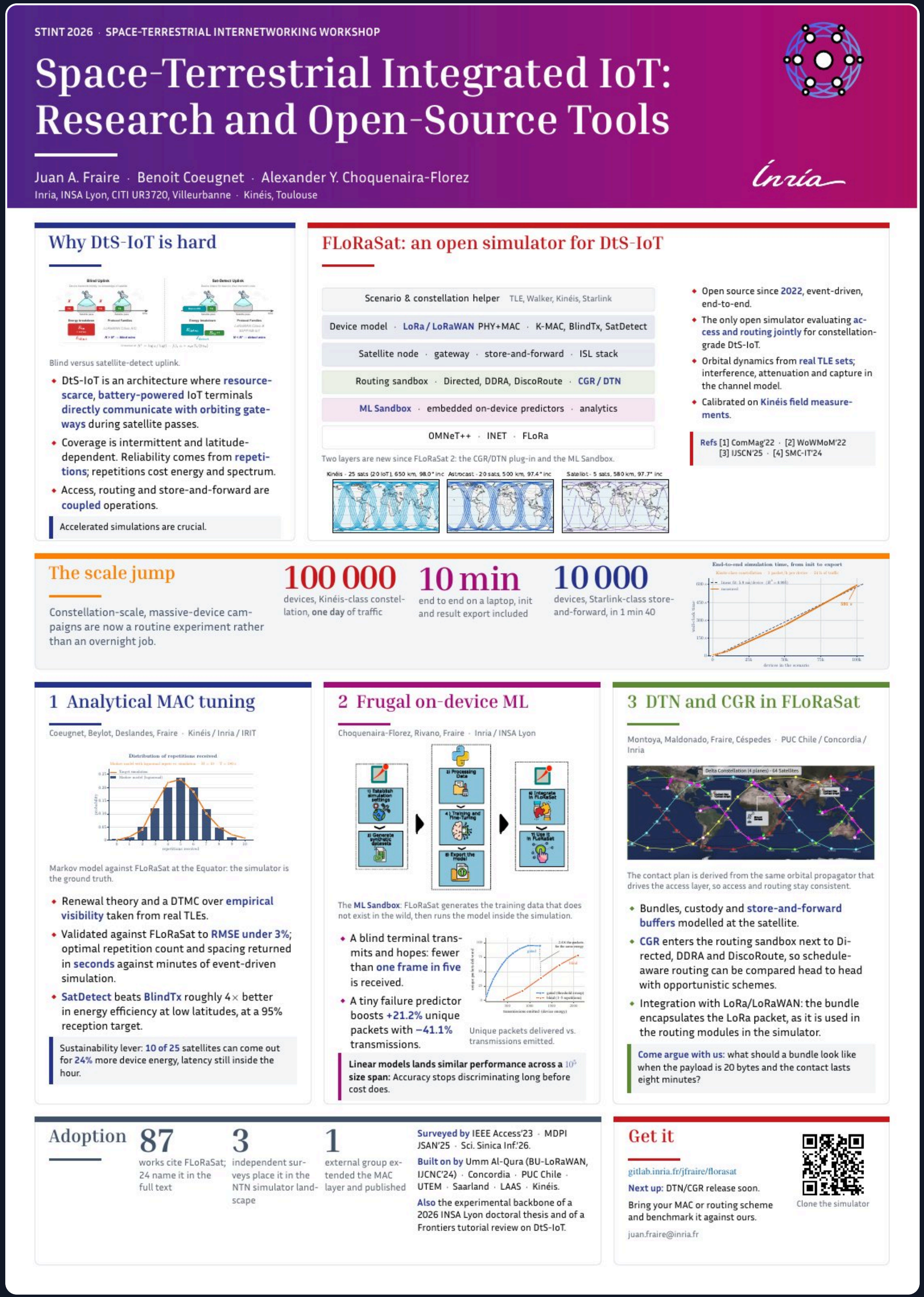

POSTER 7 of 9

Space-Terrestrial Integrated IoT: Research and Open-Source Tools

Benoît Coeugnet, Alexander Choquenaira Florez, Juan A. Fraire

Inria Lyon

60 s pitch

Board goes up **Tuesday morning**

PDF on **stintworkshops.org**

LunaNet-Sim: An Open-Source, Browser-Based 3D Interactive Testbed for Cislunar Delay-Tolerant Networking with Verified Hardware Interoperability

Syed Talha Jamal, Saad-Ullah-khan, Daniyal Ahad

Sir Syed University of Engineering and Technology, Karachi

The authors could not travel to Leuven: no pitch and no board on Tuesday. The poster is online only, on stintworkshops.org.

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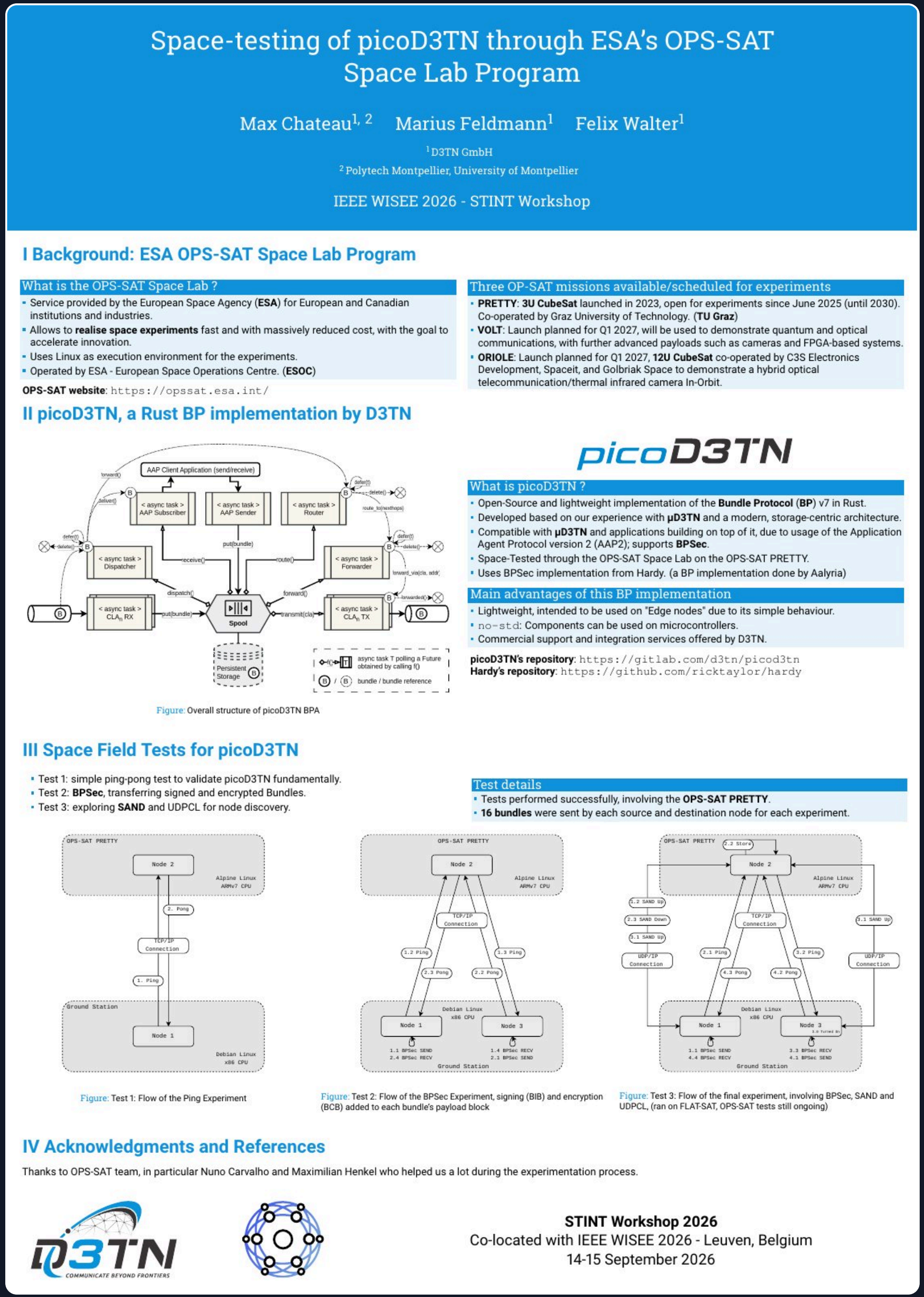

Space-testing of picoD3TN through ESA's OPS-SAT Space Lab Program

Max Chateau[1, 2] Marius Feldmann[1] Felix Walter[1]

[1] D3TN GmbH
[2] Polytech Montpellier, University of Montpellier

IEEE WISEE 2026 - STINT Workshop

I Background: ESA OPS-SAT Space Lab Program

What is the OPS-SAT Space Lab ?
- Service provided by the European Space Agency (**ESA**) for European and Canadian institutions and industries.
- Allows to **realise space experiments** fast and with massively reduced cost, with the goal to accelerate innovation.
- Uses Linux as execution environment for the experiments.
- Operated by ESA - European Space Operations Centre. (**ESOC**)

OPS-SAT website: `https://opssat.esa.int/`

Three OP-SAT missions available/scheduled for experiments
- **PRETTY**: **3U CubeSat** launched in 2023, open for experiments since June 2025 (until 2030). Co-operated by Graz University of Technology. (**TU Graz**)
- **VOLT**: Launch planned for Q1 2027, will be used to demonstrate quantum and optical communications, with further advanced payloads such as cameras and FPGA-based systems.
- **ORIOLE**: Launch planned for Q1 2027, **12U CubeSat** co-operated by C3S Electronics Development, Spaceit, and Golbriak Space to demonstrate a hybrid optical telecommunication/thermal infrared camera In-Orbit.

II picoD3TN, a Rust BP implementation by D3TN

Figure: Overall structure of picoD3TN BPA

picoD3TN

What is picoD3TN ?
- Open-Source and lightweight implementation of the **Bundle Protocol** (**BP**) v7 in Rust.
- Developed based on our experience with **μD3TN** and a modern, storage-centric architecture.
- Compatible with **μD3TN** and applications building on top of it, due to usage of the Application Agent Protocol version 2 (AAP2); supports **BPSec**.
- Space-Tested through the OPS-SAT Space Lab on the OPS-SAT PRETTY.
- Uses BPSec implementation from Hardy. (a BP implementation done by Aalyria)

Main advantages of this BP implementation
- Lightweight, intended to be used on "Edge nodes" due to its simple behaviour.
- `no-std`: Components can be used on microcontrollers.
- Commercial support and integration services offered by D3TN.

picoD3TN's repository: `https://gitlab.com/d3tn/picod3tn`
Hardy's repository: `https://github.com/ricktaylor/hardy`

III Space Field Tests for picoD3TN

- Test 1: simple ping-pong test to validate picoD3TN fundamentally.
- Test 2: **BPSec**, transferring signed and encrypted Bundles.
- Test 3: exploring **SAND** and UDPCL for node discovery.

Test details
- Tests performed successfully, involving the **OPS-SAT PRETTY**.
- **16 bundles** were sent by each source and destination node for each experiment.

Figure: Test 1: Flow of the Ping Experiment

Figure: Test 2: Flow of the BPSec Experiment, signing (BIB) and encryption (BCB) added to each bundle's payload block

Figure: Test 3: Flow of the final experiment, involving BPSec, SAND and UDPCL, (ran on FLAT-SAT, OPS-SAT tests still ongoing)

IV Acknowledgments and References

Thanks to OPS-SAT team, in particular Nuno Carvalho and Maximilian Henkel who helped us a lot during the experimentation process.

STINT Workshop 2026
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14-15 September 2026

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Max Chateau, Marius Feldmann, Felix Walter

D3TN GmbH · Polytech Montpellier

60 s pitch | Board goes up **Tuesday morning** | PDF on **stintworkshops.org**

Thank you, poster presenters

STINT 2026

See you at the boards on Tuesday

Posters go up on Tuesday morning and stay on display all day · PDFs at stintworkshops.org

Up next · Welcome activity, 18:00 · Leuven Botanical Garden