



## Deliverable D5.2

# Report on Dissemination of Project Startup

### Deliverable

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1.0	2023-11-XX	First official release

### Project

<i>Title:</i>	Models in Space Systems: Integration, Operation, and Networking		
<i>Acronym:</i>	MISSION	<i>Start date:</i>	01-10-2021
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<i>Call:</i>	H2020-MSCA-RISE-2020	<i>Website:</i>	<a href="https://mission-project.eu">mission-project.eu</a>



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## 1 Overview

The Report on Dissemination of Project Startup (D5.2) aims to report on the MISSION project's first wave of dissemination and training activities. The focus of these activities is on sharing background knowledge and gaining momentum in the project. The first wave of actions encompasses reporting on the *First MISSION School* (Rio Cuarto Summer School 2023) and the *MISSION Space Workshop* (hosted at the 2023 IEEE WiSEE conference). The following two sections of this document provide further details on the dissemination activities during these events.

## 2 First MISSION School

The Río Summer School of Informatics (RIO) is organized annually by the Department of Computer Science of the National University of Río Cuarto (*Universidad Nacional de Río Cuarto*, UNRC). In its 2023 edition, the RIO school was supported by MISSION and occurred on February 13-17 (1 whole week), 2023, in Río Cuarto, Córdoba, Argentina. Its schedule is shown in Fig. 1.

MISSION project members offered courses and talks to disseminate the advances of different MISSION work packages in the Rio Cuarto and Argentinian communities. Two social events (“choripaneada”, a famous Argentinian sandwich, and an “asado”, namely, a barbeque) were offered to blend the European and South American attendees beyond the academic content of the courses.

### 2.1 Courses Given by MISSION Members

#### 1. Course 1 (in Spanish): *Routing in the Space Internet* (see Fig. 2)

- Taught by Dr. Juan A. Fraire (Universidad Nacional de Córdoba, Argentina – UNC)
- UNRC room: Amphitheater 2, Pavilion 2 (Lecture Room 2, Building 2)
- **Abstract:** The space sector is thriving. More and larger fleets of spacecraft are being deployed in near-Earth and deep space with increasing capabilities. Among these, networking requires efficient routing routines in coordination with mission operations. In the first part of this course, we will first overview the present and future of space networks and supporting architecture, protocols, and models. The second part will dive into the state-of-the-art routing solutions spanning scheduled, probabilistic, and opportunistic space topologies, including their interaction in inter-regional routing. In the third part, we introduce DtnSim, an event-driven simulator based on Omnet++, implementing the aforementioned routing algorithms. We can run performance trade-off analysis and reason about routing in the Space Internet.

#### 2. Course 2 (in English): *Modeling and Analyzing Concurrent Systems* (see Fig. 3)

- Taught by Dr. Thomas Noll (RWTH Aachen University, Germany – RWTH)
- UNRC room: Amphitheater 2, Pavilion 2 (Lecture Room 2, Building 2)
- **Abstract:** This course aims to provide a basic understanding of modeling formalisms for concurrent systems. It will follow the so-called interleaving approach, which reduces the phenomenon of concurrency to a non-deterministic merging of sequential executions of sub-processes. Milner's Calculus of Communicating Systems represents this method. This process algebra provides a mathematical basis for describing both the structure and the behavior of systems in a compositional way. To support formal reasoning about their correctness properties, we will introduce behavioral equivalences and logic-based techniques, and will demonstrate their tool-based application on mutual-exclusion algorithms.

	Lunes	Martes	Miércoles	Jueves	Viernes
8:00			Course 1 Enrutamiento en la Internet Espacial	Course 1 Enrutamiento en la Internet Espacial	Exams
08:30					
09:00	Registración Hall del Anfiteatro 2 del pabellon 2. (Hall of building 2. (in front of lecture room 2))	Registración Hall del Anfiteatro 2 del pabellon 2. (Hall of building 2. (in front of lecture room 2))		MISSION Industry talk (Ascentio)	
09:30					
10:00					
10:30	Course 2 Modeling and Analyzing Concurrent Systems	Course 2 Modeling and Analyzing Concurrent Systems	Course 2 Modeling and Analyzing Concurrent Systems	Course 2 Modeling and Analyzing Concurrent Systems	
11:00					
11:30					
12:00					
12:30					
13:00					
13:30					
14:00					
14:30					
15:00		Course 1 Enrutamiento en la Internet Espacial	Course 1 Enrutamiento en la Internet Espacial		
15:30					
16:00					
16:30				Charla ETENDO	
17:00					
17:30					
18:00	Course 3 Formal Approaches to Decision-Making under Uncertainty	Course 3 Formal Approaches to Decision-Making under Uncertainty	Course 3 Formal Approaches to Decision-Making under Uncertainty	Course 3 Formal Approaches to Decision-Making under Uncertainty	
18:30					
19:00					
19:30					
20:00					
20:30		Acto de bienvenida Anfiteatro 2. Pabellon 2. (Lecture Room 2, Building 2)	Choripaneada. Salon del Gremio Docente. (Rivadavia y las Heras)		
21:00		Recepción Hall del Anfiteatro 2. (Hall Building 2)			
21:30					
22:00					
23:00					
00:00					

Figure 1: RIO School Schedule (from Monday/Lunes Feb 13th to Friday/Viernes Feb 17th, 2023).



Figure 2: Course 1 (Routing in the Space Internet) with more than 50 attendees. Juan Fraire (UNC), a MISSION member, gave this course and is seated in the lower left.

### 3. Course 3 (in English): *Formal Approaches to Decision-Making under Uncertainty*

- Taught by Dr. Arnd Hartmanns (University of Twente, Netherlands – UT)
- UNRC room: Postgraduate Room, Faculty of Exact Sciences
- **Abstract:** Robots, control software, and us humans continuously interact with uncertain environments: where the outcomes of our own actions are uncertain, but the possibilities are often quantifiable with probabilities. Sometimes, we intentionally introduce uncertainty, e.g. via randomised algorithms. In this course, I will introduce a formal approach to modelling agents and systems acting under – or intentionally exploiting – uncertainty, based on Markov models (notably discrete-time Markov chains and Markov decision processes) and the Modest modelling language. I will give an overview of different algorithms to estimate or optimise the probability or reward to reach a goal, including probabilistic and statistical model checking as well as variants of reinforcement learning. The course combines lectures on theory and algorithms with hands-on modelling and programming sessions with Modest and Python.

## 2.2 Talks Given by MISSION Members

- **Ascentio (ASC, in English):** *Software Functional Testing applied to Space Industry* (see Fig. 4)
  - Amphitheater 2, Pavilion 2 (Lecture Room 2, Building 2)
  - Thursday, February 16, 9:00 AM



Figure 3: Course 2 (Modeling and Analyzing Concurrent Systems) by Thomas Noll (RWTH).



Figure 4: Talk given by Ascentio (ASC), MISSION partner with headquarters in Rio Cuarto.

## 2.3 More Information

Useful links:

1. RIO School web page: <https://rio2023.dc.exa.unrc.edu.ar/>
2. Twitter/X account of the event: <https://twitter.com/escuelaRio>

## 3 MISSION Space Workshop

The MISSION Space Workshop was hosted at the 2023 Space-Terrestrial Internetworking Workshop (STINT, see Fig 5). This workshop addresses emerging technical topics related to data exchange between and among space-based and terrestrial network nodes. Such communication systems are generally based on adopting DTN (delay-/disruption-tolerant networking) architectures and related protocols. STINT brings together some of the most influential members of the field of data transfer between space and terrestrial nodes via delay-tolerant networks with time-varying topologies. In this context, STINT was chosen as an adequate event to disseminate MISSION research, especially content related to the topic of Links and Networks (WP3).

The STINT workshop, and by consequence, the MISSION Space Workshop, was held under the organizational umbrella of the 11th IEEE International Conference on Wireless for Space and Extreme Environments (WiSEE 2023). The conference venue took place at the University of Aveiro, in Aveiro, Portugal. STINT was allocated days one and two at WiSEE (September 6 and 7, 2023), from which the afternoon during the last day (September 7, 2023) was devoted to the MISSION Space Workshop. The full IEEE WiSEE program is publicly available [online](#).

### 3.1 Talks Given by MISSION Members

Juan Fraire (UNC) acted as the moderator of the MISSION Space Workshop. Three talks were provided to the STINT and IEEE WiSEE audience (more than 20 people were in the room).

- **Title:** *Three Approaches to Routing in Uncertain Delay-Tolerant Networks Compared*
  - **Speaker:** Arnd Hartmanns (UT) (see Fig. 6)
  - **Abstract:** In delay-tolerant networks (DTNs) with uncertain contact plans, the communication episodes and their reliabilities are known a priori. To maximise the end-to-end delivery probability, a bounded network-wide number of message copies are allowed. The resulting multi-copy routing optimization problem is naturally modelled as a Markov decision process with distributed information. In this presentation, I summarise our recent and ongoing work on comparing three solution approaches: statistical model checking with scheduler sampling, the analytical RUCoP algorithm based on probabilistic model checking, and an implementation of concurrent Q-learning. We use an extensive benchmark set comprising random networks, scalable binomial topologies, and realistic ring-road low Earth orbit satellite networks. We evaluate the obtained message delivery probabilities as well as the computational effort. Our results show that all three approaches are suitable tools for obtaining reliable routes in DTN, exposing a trade-off between scalability and solution quality, but none of them works well in all scenarios.
- **Title:** *Polygon-Based Algorithms for N-Satellite Constellations Coverage Computing*
  - **Speaker:** Santiago Henn (UNC) (see Fig. 7)



Figure 5: STINT Flyer.



Figure 6: MISSION Talk by Arnd Hartmanns (UT): *Three Approaches to Routing in Uncertain Delay-Tolerant Networks Compared*. Arnd also presented the MISSION project to the audience.



Figure 7: MISSION Talk by Santiago Henn (UNC): *Polygon-Based Algorithms for N-Satellite Constellations Coverage Computing*.





Figure 8: MISSION Talk by Gregory Stock (USAAR): *Distributed On-Demand Routing for LEO Mega-Constellations*.

- **Abstract:** This talk explores the optimization of Free-Space Optical (FSO) terminal placement on satellites to enhance high-speed data transfer in networked space systems, considering the constraints imposed by the gimbal’s limited range. It introduces two heuristic algorithms, simulated annealing, and a genetic algorithm, to tackle this placement optimization problem. Through comprehensive simulations and analyses, the talk demonstrates that these optimization techniques can notably improve the contact time by up to 27.7%, underlining the potential of advanced optimization methods to enhance the performance of FSO links based on their spacecraft positioning.
- **Title:** *Distributed On-Demand Routing for LEO Mega-Constellations*
  - **Speaker:** Gregory Stock (USAAR) (see Fig. 8)
  - **Abstract:** The design and launch of large-scale satellite networks create an imminent demand for efficient and delay-minimising routing methods. With the rising number of satellites in such constellations, pre-computing all shortest routes between all satellites and for all times becomes more and more infeasible due to space and time limitations. Even though distributed on-demand routing methods were developed for specific LEO satellite network configurations, they are not suited for increasingly popular mega-constellations based on Walker Delta formations. The contributions of this paper are twofold. First, we introduce a formal model that mathematically captures the time-evolving locations of satellites in a Walker Delta constellation and use it to establish a formula to compute the minimum number of ISL hops between two given satellites. In the second part, we present an on-demand hop-count-based routing algorithm that approximates the optimal path while achieving superior performance compared to classical shortest-path algorithms like Dijkstra.



Figure 9: STINT panel with the participation of MISSION Workshop attendees. In the picture, from left to right: Scott Burleigh (former JPL, NASA, USA), Edward Birrane (APL, USA), and Carlo Caini (Bologna University, Italy)

### 3.2 More Information

Useful links:

1. STINT web page: <https://www.stintworkshops.org/>
2. IEEE WiSEE web page: <https://2023.ieee-wisee.org/>

A panel with experts was held at STINT, where MISSION Workshop attendees actively participated. The panel was composed of Scott Burleigh (former JPL, NASA, USA), Edward Birrane (APL, USA), and Carlo Caini (Bologna University, Italy); see Fig 9. The gala dinner and social event of the IEEE WiSEE conference were performed on a beach near Aveiro (see Figs. 11 and 10).

## 4 Other Dissemination Activities

In addition to the two events described above and regular scientific publications, MISSION continuously disseminates the results of and knowledge exchange happening during its secondments and other interactions via the project's website at [mission-project.eu](http://mission-project.eu) and its [Twitter/X account](#).

Internally at the project partners, the results of and experiences during secondments are disseminated via, e.g., dedicated seminars and presentations related to MISSION such as the special MISSION Colloquium of the FMT group at UT on June 15, 2023 (see Fig. 12).



Figure 10: Social event at the beach near Aveiro, where MISSION members interacted with the WiSEE community.



Figure 11: IEEE WiSEE gala dinner with MISSION speakers.



Figure 12: MISSION Colloquium at the University of Twente on June 15, 2023.