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Integrating Satellite Constellation and Mobile Operations for Non-Terrestrial Networks: Preliminary Results of Dynamic Scheduling

Authors

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Presenter

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EMBRY-RIDDLE 1926 AERONAUTICAL UNIVERSITY

PRESENTER

Arnau Singla Manau was born in Barcelona, Spain. He received the degree in aerospace engineering from the Universitat Politècnica de Catalunya (UPC) in 2018 and the M.S. degree in aerospace engineering by both the Universitat Politècnica de Catalunya and the Technische Universität München (TUM) in 2020. His research interests are linked to non-terrestrial networks, satellite communication, spacecraft simulation, artificial intelligence, optimization algorithms and integration of IoT technologies with satellite systems.

i2CAT SpaceComms group

NTN

Contributions to Non-Terrestrial Networks

Research line that investigates technologies to deploy Non-Terrestrial Networks for IoT and broadband

Line Manager: Joan A. Ruiz-de-Azua

SDSat

Software Defined Satellites

Research line that investigates technologies to deploy SDN techniques for satellite systems in multi-layered networks

Line Manager: Hossein Rouzegar

SatNet

Satellite Network protocols and technologies

Research line that investigates on protocols and devices to interconnect satellites from different constellations

Line Manager: Joan A. Ruiz-de-Azua

QSat

Quantum technology for satellite communications

Research line that investigates Quantum-based protocols to enhance satellite based communications services

Line Manager: Xavier Jordán

Laboratory

Experimental Infrastructure to support research activities

Line Manager: Cesc Betorz

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Challenges

Satellite constellations as satellite networks

Necessary to fulfill envisioned 5G and 6G technologies

Satellite vs. network operations management

Can be mapped to low and high connectivity networks

Integrating satellite and network operations is necessary to:

a. Maximize constellation service
b. Achieve a STIN

Focus on the low connectivity networks

Use cases such as some IoT scenarios, non-instantaneous messaging, etc.

Challenges

Approach selected to follow is more close to what satellite operators use

Task scheduling and adapt it to network management → CMS

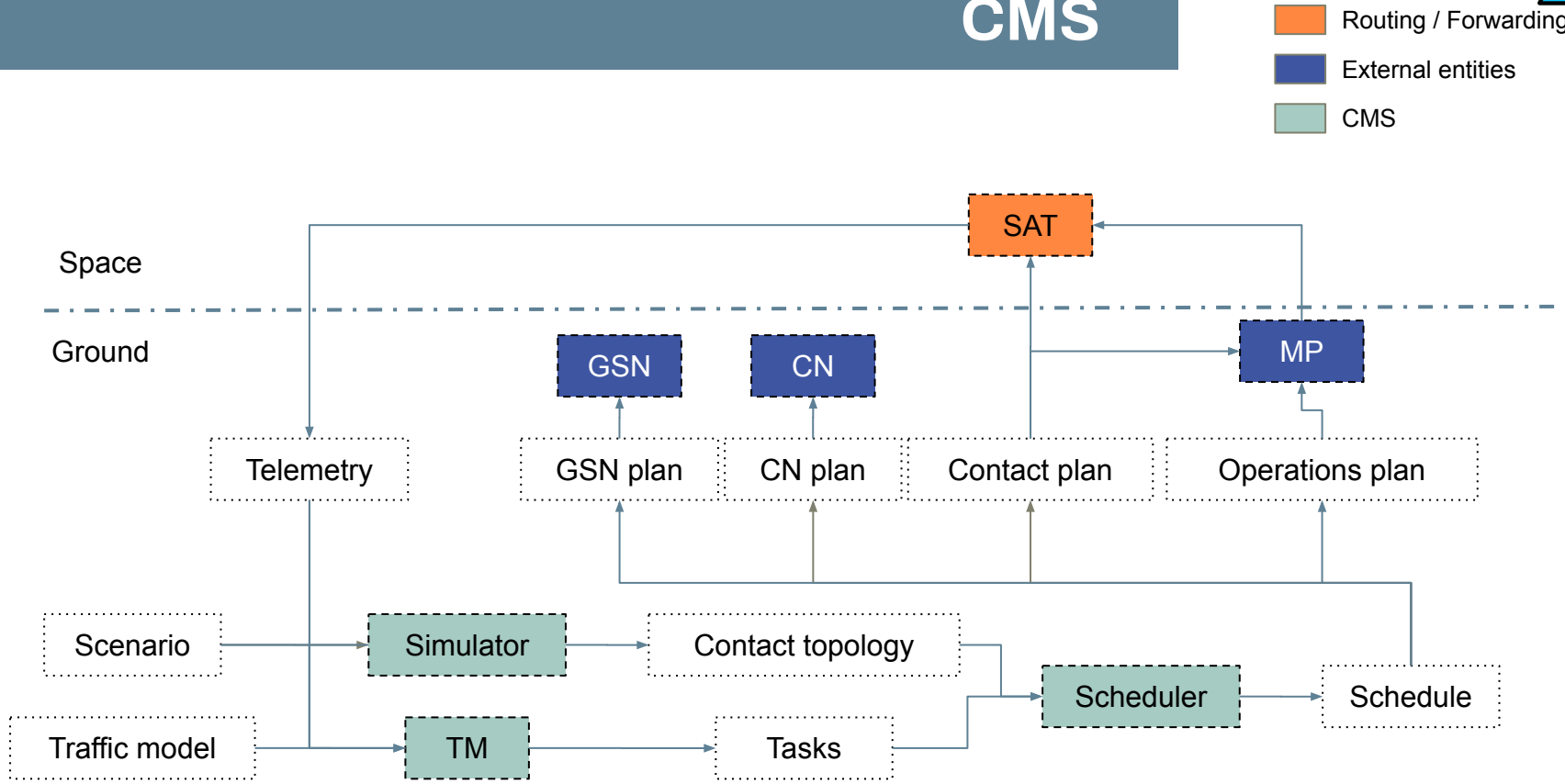
Reasons to move towards automated operations in satellite networks

a. Reduce operational costs
b. Increase scalability
c. Cope with the uncertainties of the telecom scenario

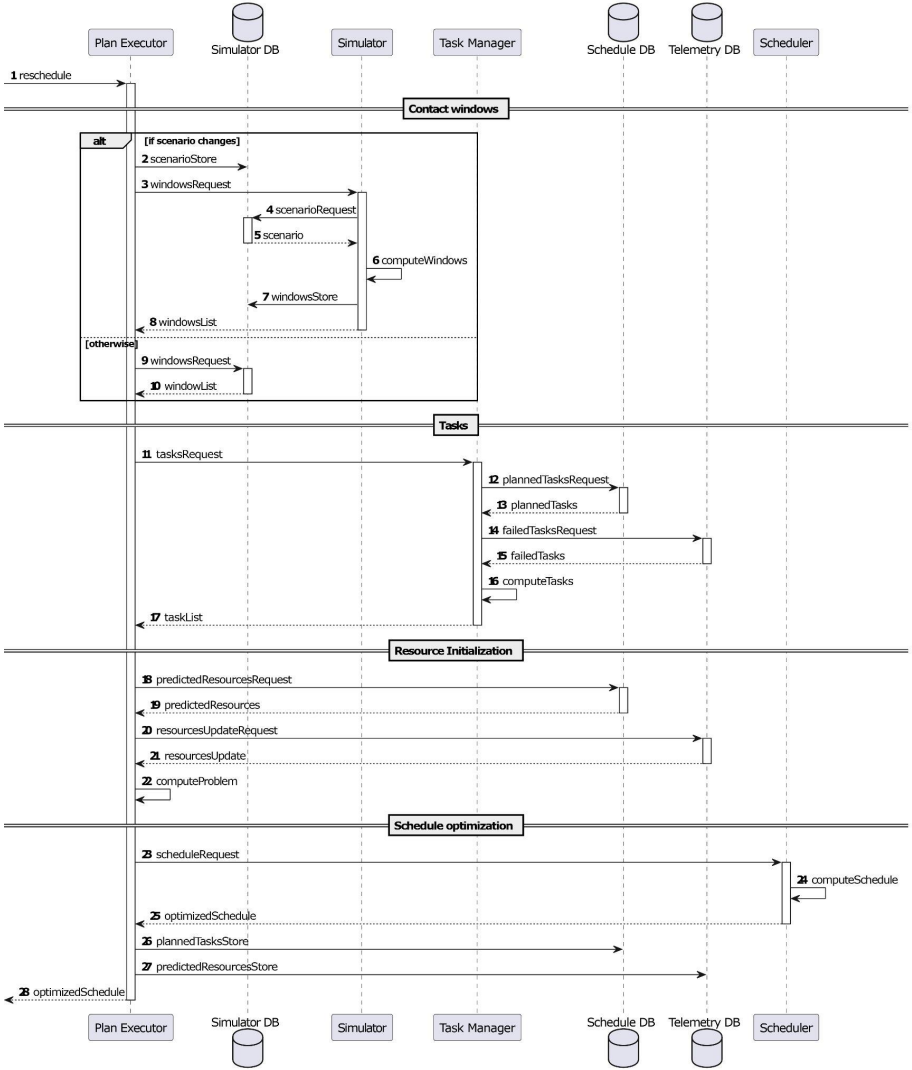
Enabling closed-loop optimization with dynamic scheduling

Focus of this paper/presentation

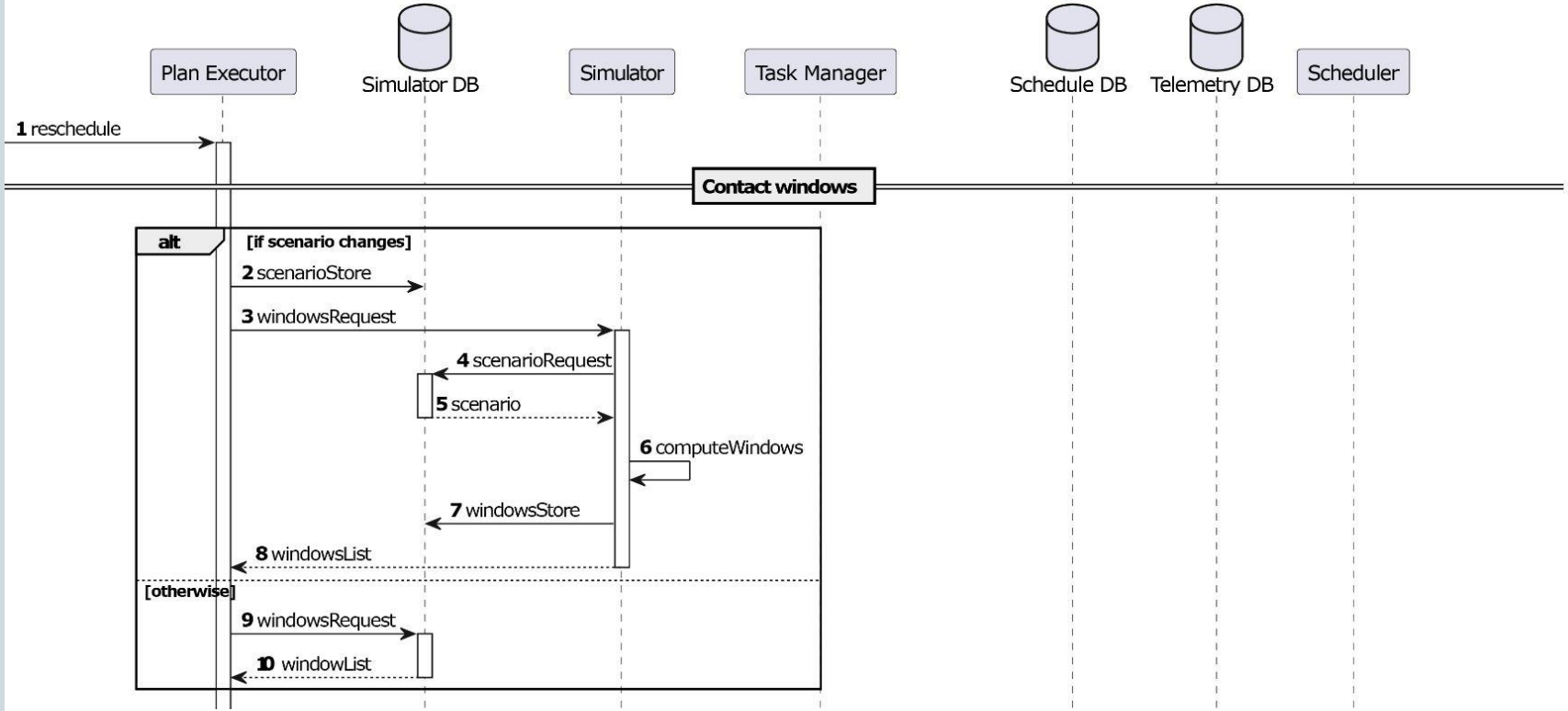
CMS


Routing / Forwarding
External entities
CMS
Space
Ground
SAT
GSN
CN
MP
Telemetry
GSN plan
CN plan
Contact plan
Operations plan
Scenario
Simulator
Contact topology
Scheduler
Schedule
Traffic model
TM
Tasks

DYNAMIC SCHEDULING



DYNAMIC SCHEDULING



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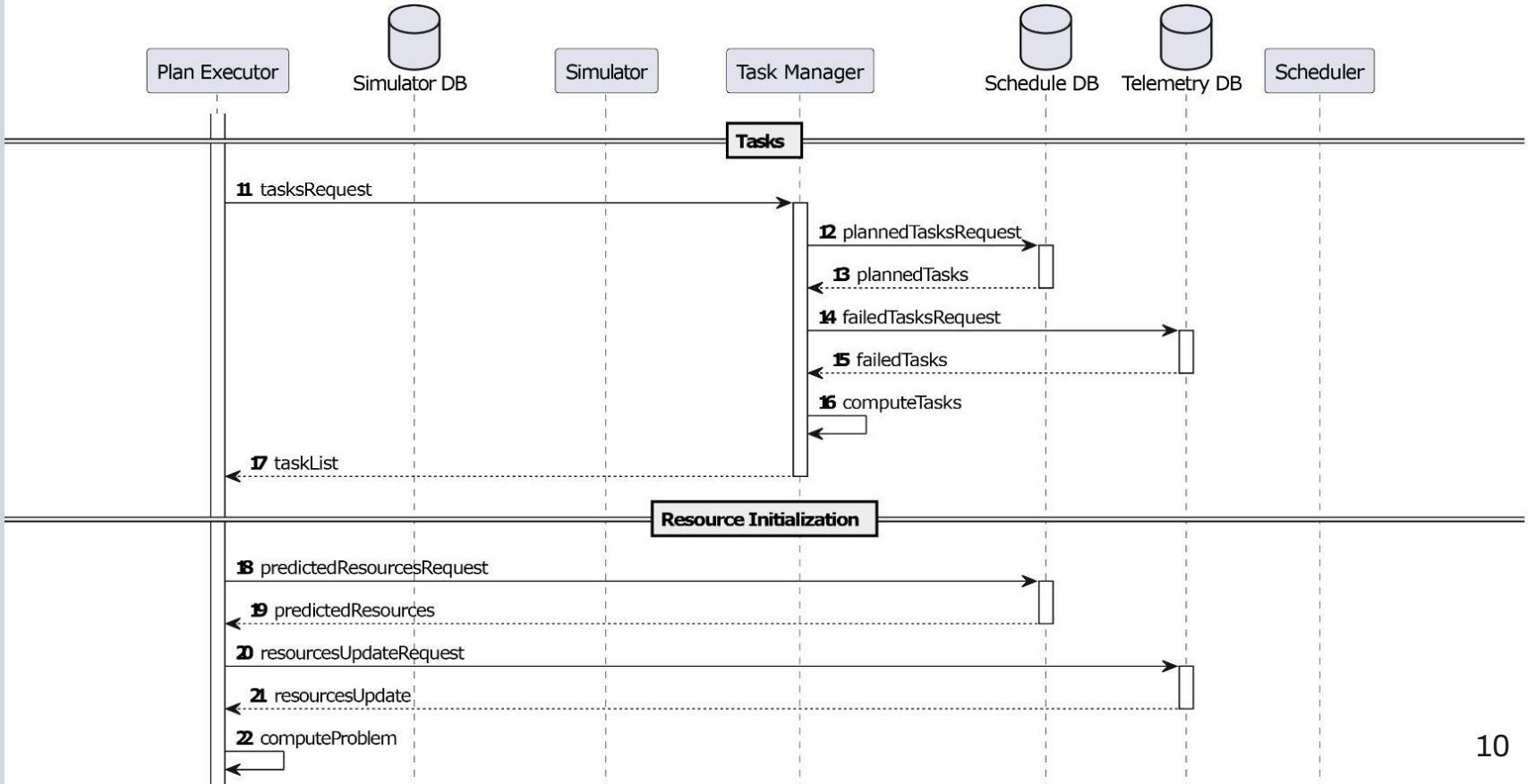
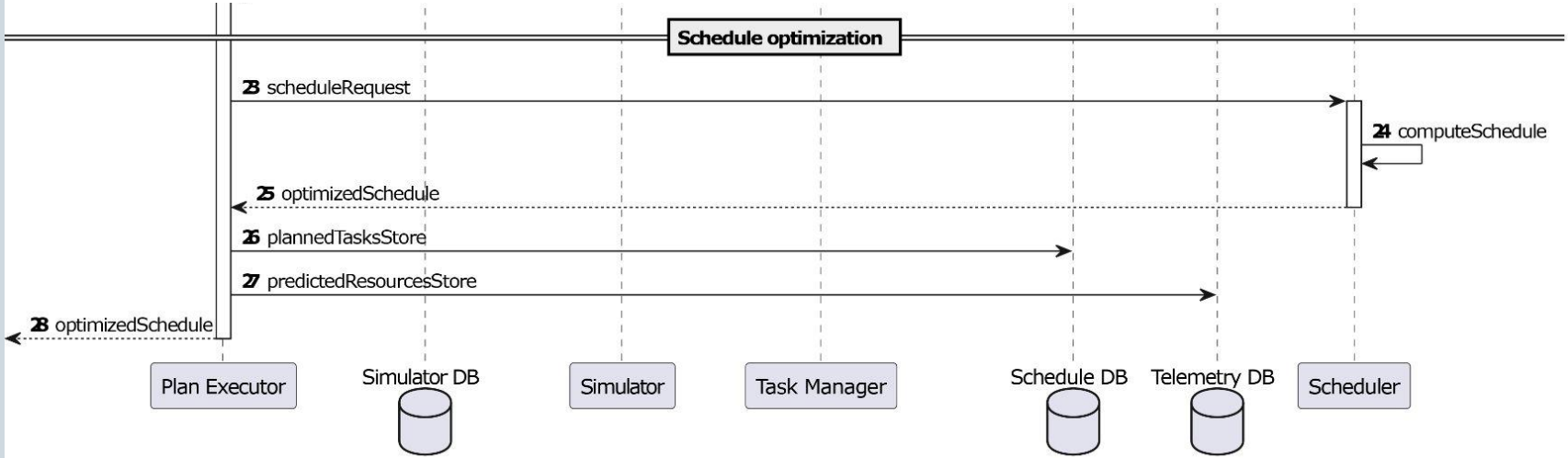
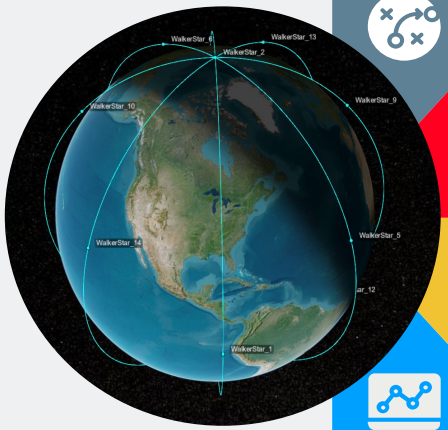


DYNAMIC SCHEDULING



Scenario I



Walker star pattern with four polar planes and 16 satellites: 90º:16/4/1

Constellation topology

2 KSAT + 3 AWS

Ground station network

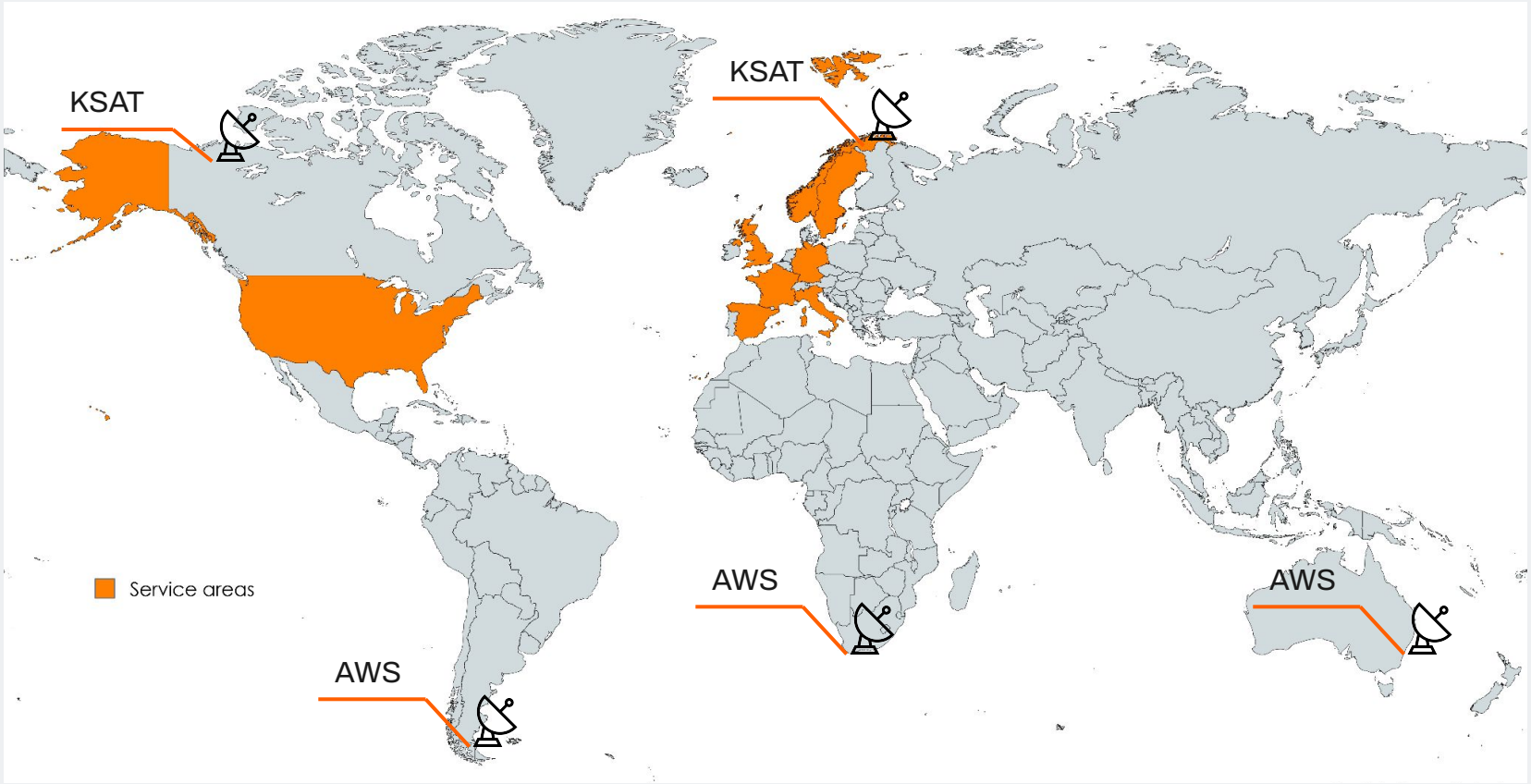
12 service areas (6 in USA and 6 in EU)

Service

3.8 KB of data every three hours in each service area

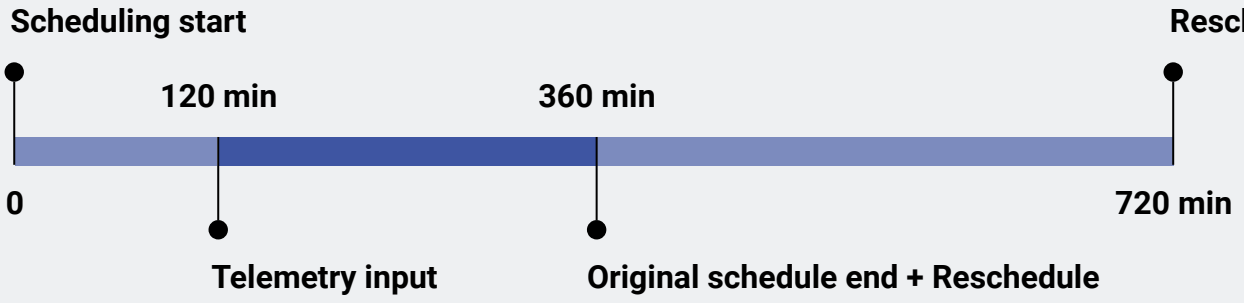
Traffic model

Scenario I

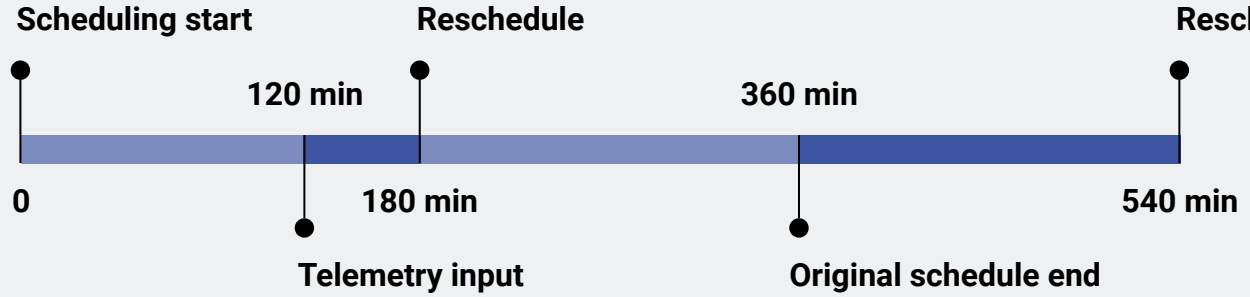


Scenario II

Open-loop timeline

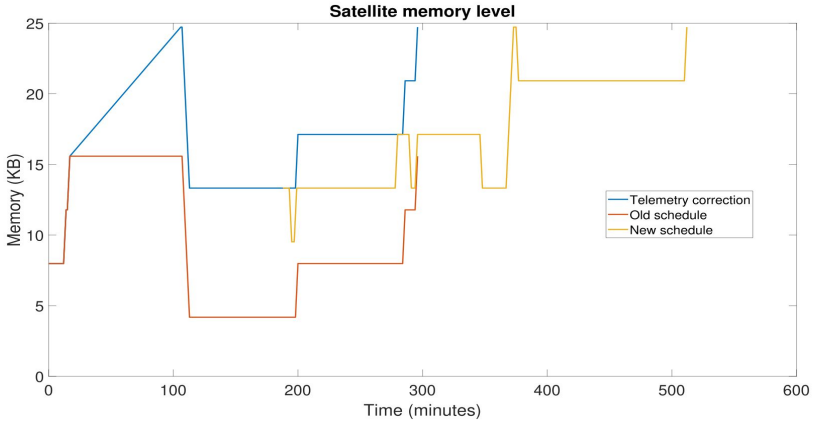


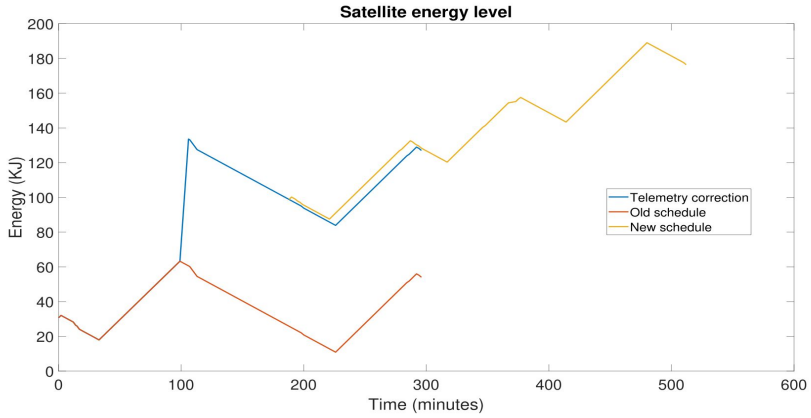
Closed-loop timeline



Results

	Original schedule	Reschedule
Remaining tasks	0	51
Failed tasks	0	30
Traffic model tasks	96	48
Total tasks	96	129
Schedule throughput (KB/h)	18.46	35.46
Open-loop test throughput (KB/h)	26.96	
Closed-loop test throughput (KB/h)	29.77	





Space tests I

2 types of task failure

- Satellite failure → Reported in the telemetry
- Environmental failure (sensor not reachable, channel interferences, etc.) → This one is detected by post-processing the telemetry readings of the satellite resources → Working on this intelligent module

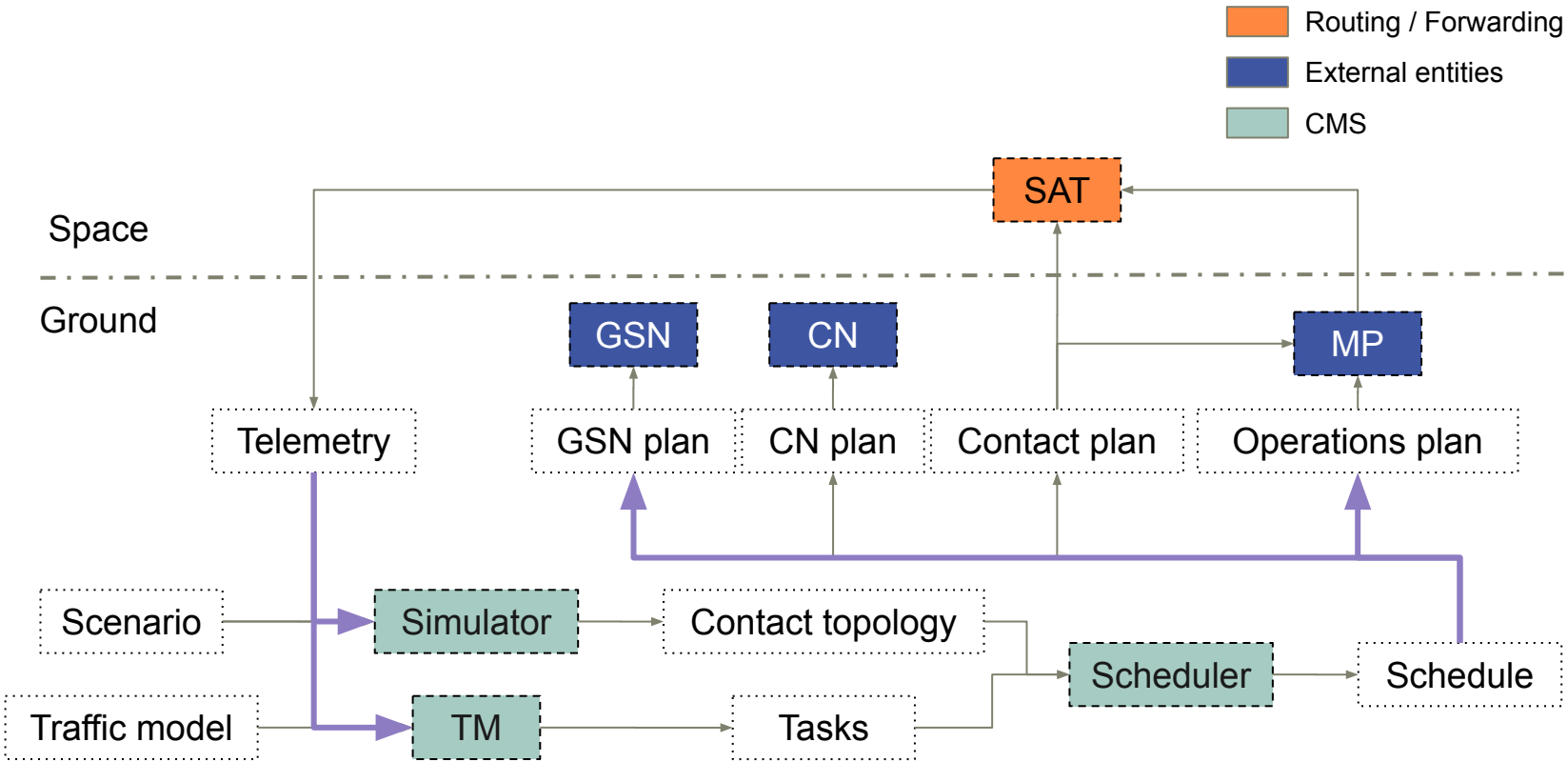
New developments

Developing the telemetry and schedule APIs (to satellite operator and GS)

Work in progress

An in-orbit demonstration with Sateliot as part of Catalonia's New Space strategy

Space tests II



Thank you!

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