The Mission Simulator of COSMO-SkyMed di Seconda Generazione:

a valuable tool supporting the Developing, Verification and Operational Phases of the Programme

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Outline

Introduction

COSMO-SkyMed *di Seconda Generazione* Mission Simulator

Mission simulator utilization

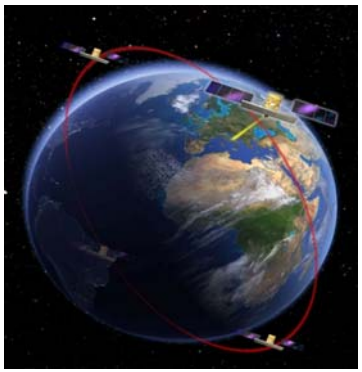
Future explotation of the Mission Simulator

Conclusions

Introduction

COSMO-SkyMed Overview

COSMO-SkyMed is the Italian end-to-end System for Earth Observation



COSMO-SkyMed constellation	
Orbit Type	SSO
Inclination	97.86°
Revolutions/day	14.8125
Orbit Cycle	16 days
Eccentricity	0.00118
Argument of Perigee	90°
Semi Major Axis	7003.52 km
Nominal Height	619.6 km
Nominal LTAN	6:00 A.M.
Deployment	Progressive

Introduction

COSMO-SkyMed Overview

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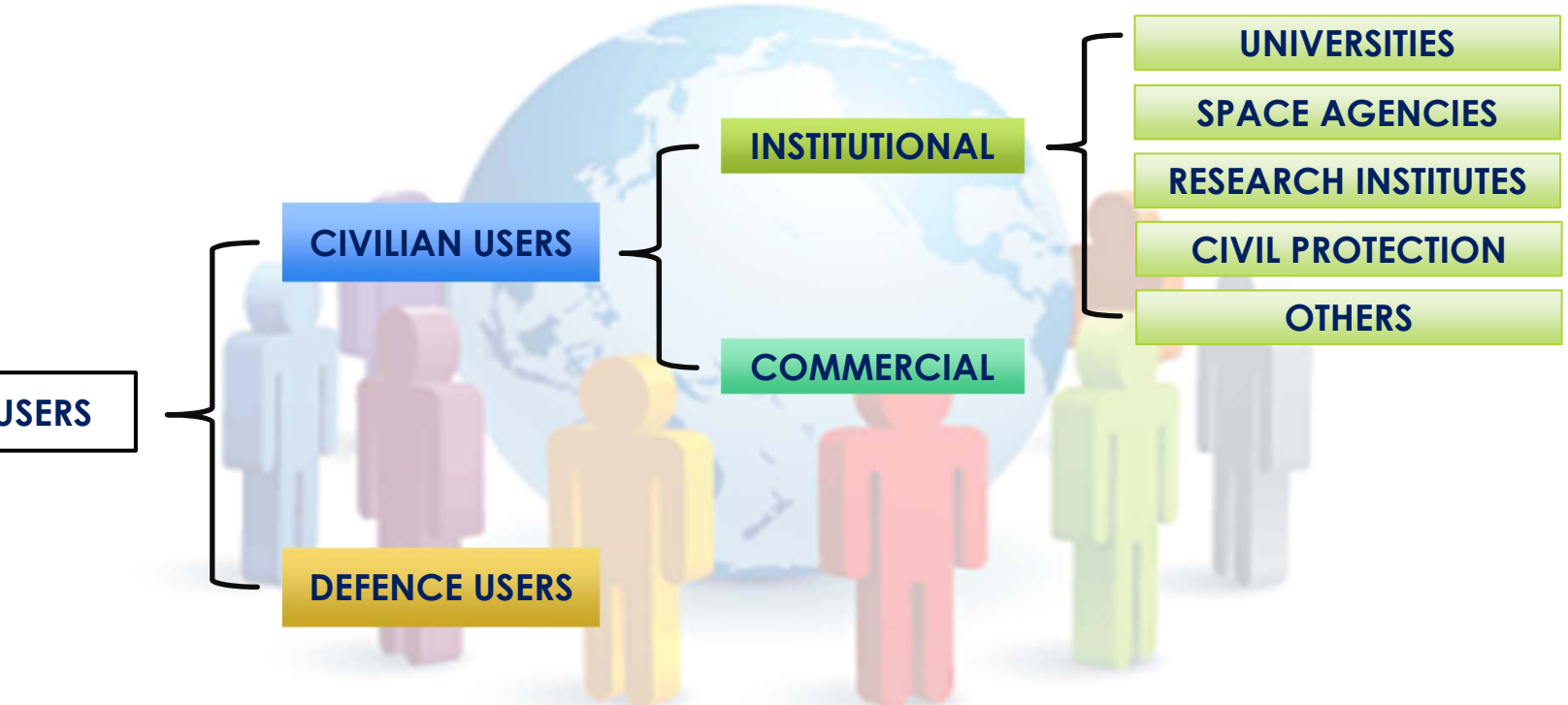

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COSMO-SkyMed Overview

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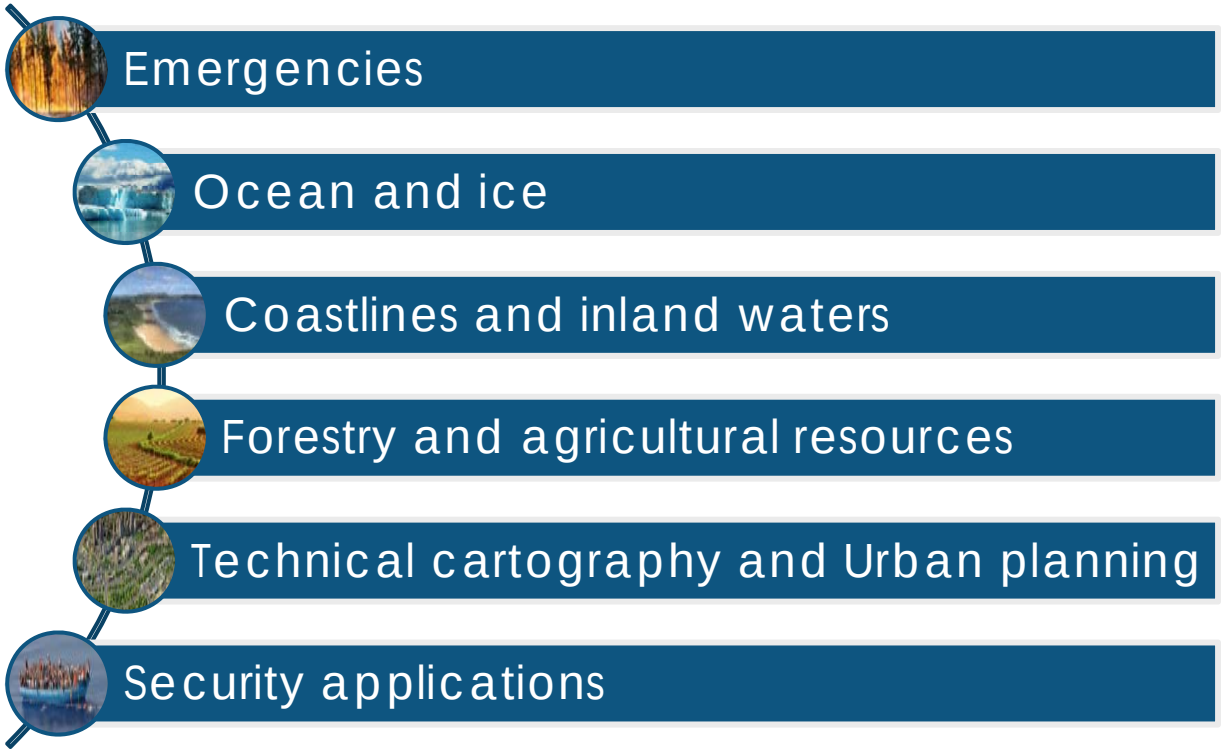

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COSMO-SkyMed Overview

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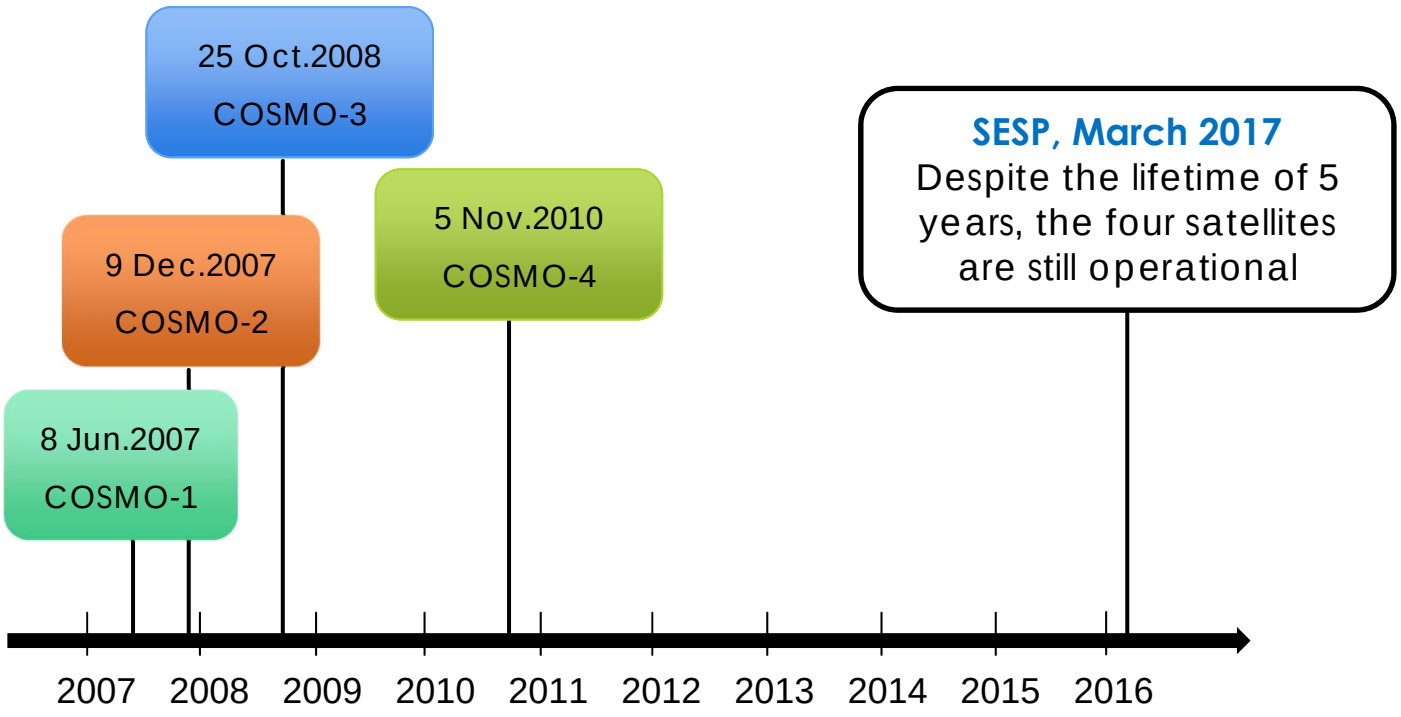

Introduction

COSMO-SkyMed *di Seconda Generazione* (CSG)

CSG has been conceived with the aim to ensure operational continuity to the currently operating constellation and to achieve a step ahead in terms of functionality and performances

2 additional satellites

ew and more demanding performances vs first generation in terms of:

- new products
- image quality
- number of acquisitions per orbit and per day
- greater flexibility in the system resources' use
- responsiveness

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CSG Mission Simulator (CSG-MS)

Overview

Need to model and simulate the functional characteristics and the performances of CSG

Given the complexity of the system, conventional SW tools were not able to provide all the required features

A dedicated tool has been developed in the framework of the CSG program

CSG-MS is a Mission specific tool, capable to simulates the innovative characteristics introduced by the CSG Mission both at GS and SS level, maintaining, at the same time, the ability to simulate the technical and performance behavior of the first generation CSK

CSG Mission Simulator (CSG-MS)

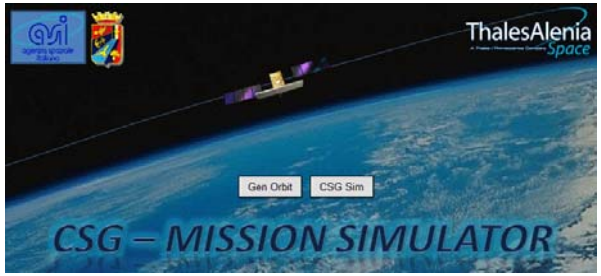
Overview

CSG-MS replicates the end-to-end mission behavior in response to a given scenario

INPUT

configuration

Handbook



OUTPUT

- Mission Plan
- Time performances
- Resource usage profiles
- Eclipses, Nodal Crosses, Ephemeris

TOOLS

- System and Mission configuration
- Flight Dynamics Simulator
- Planner
- System simulator
- Data analyzer
- Time performance

CSG Mission Simulator (CSG-MS)

System and Mission Configuration

Mission time window and planning constraints

Orbital propagator parameters

SS scenario

- Spacecraft parameters, Kepler elements or State Vector
- BUS, SAR, PDHT, AOCS, POWER, TC/TM

GS scenario

- Down/Up-link stations: location, S-band and X-band parameters
- User Ground Segments (UGSs): processing chain parameters and network parameters

User Requests' Handbook

& lon, request type, look side, orbit pass, polarization, priority, validity time

CSG Mission Simulator (CSG-MS)

Flight Dynamics Simulator & Access Computation

propagation of satellites ephemeris over the selected time windows

computation of the satellite eclipse times

computation of all the possible access times and geometries to the ground stations

computation of all the possible access times and geometries to the targets (DTO of the user requests)

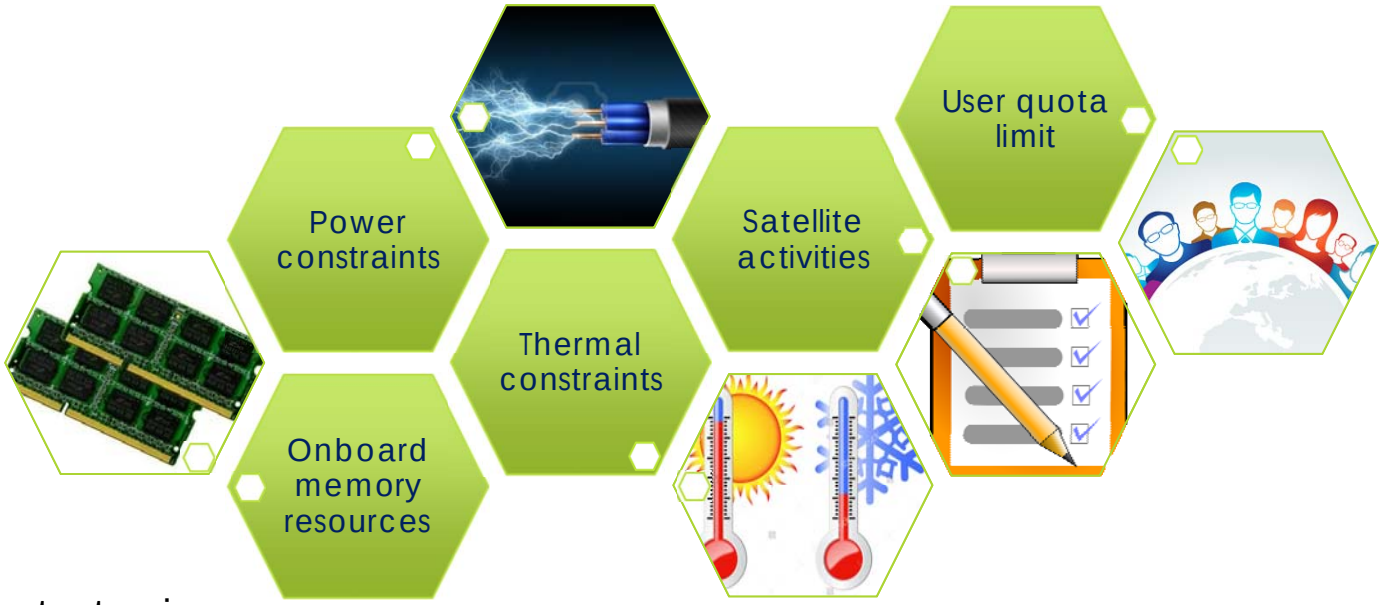
PLANNER

e accesses computation algorithm exploits an instance of the SAR ARameters Calculator (SPARC) tool, that allows to refine the DTO and to stimate the SAR Payload programming parameters, taking into account the al geometric topography of the scene to be acquired and the real satellite bit altitude, leading to an optimization of the image quality features.

CSG Mission Simulator (CSG-MS)

Planner

- Generates a feasible, conflict free mission plan considering:

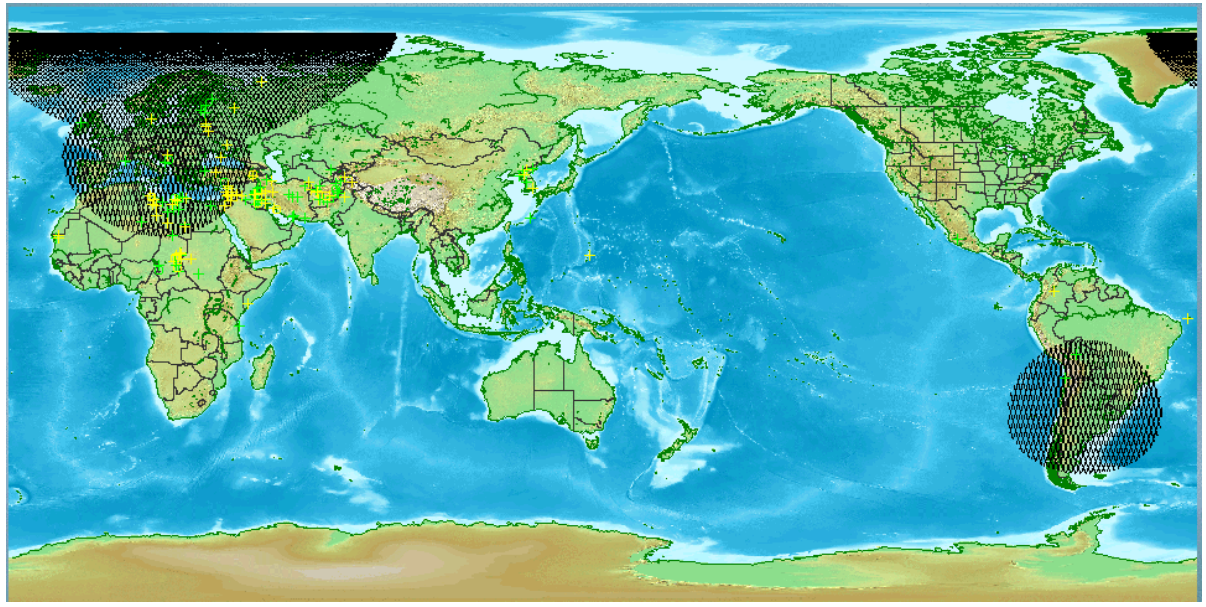


nning strategies:
ank-based algorithm for prioritized requests
optimization-based algorithm for unranked requests

CSG Mission Simulator (CSG-MS)

Data Analyzer

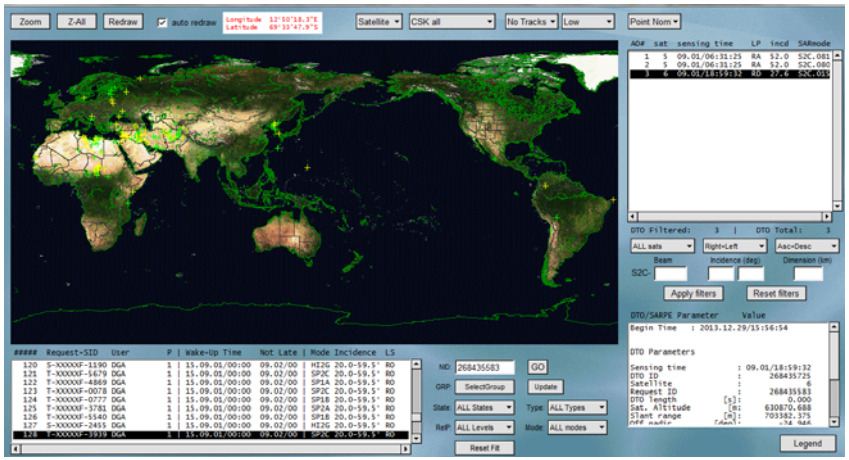
Data Analyzer is a set of tools which allow the operator to get a quick and fast access to most of the data generated by the various simulator functions and stored into the databases.



Visibility circles of the ground stations & Acquisition opportunities

CSG Mission Simulator (CSG-MS)

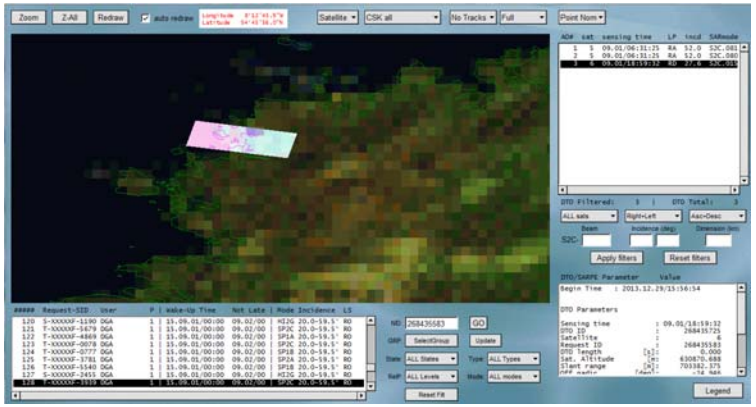
Data Analyzer



Select a DTO

Visualize DTO swath

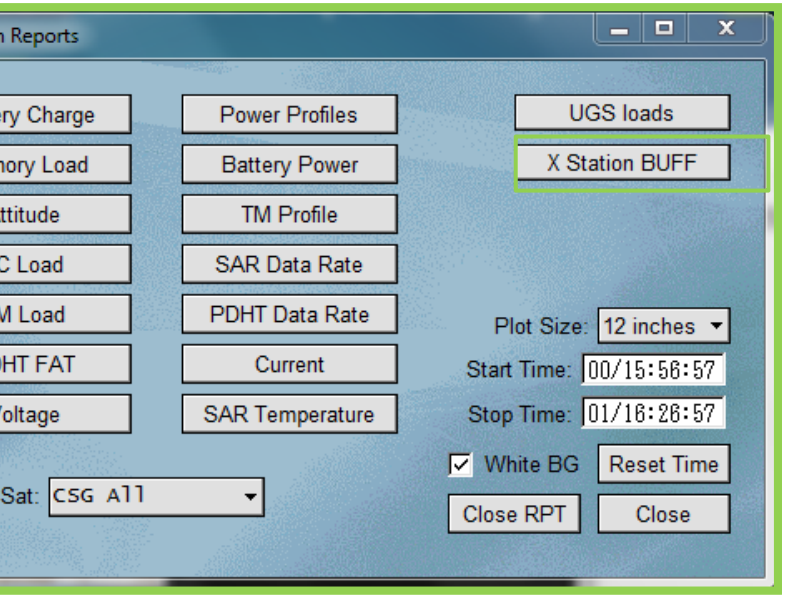
Visualize DTO parameters

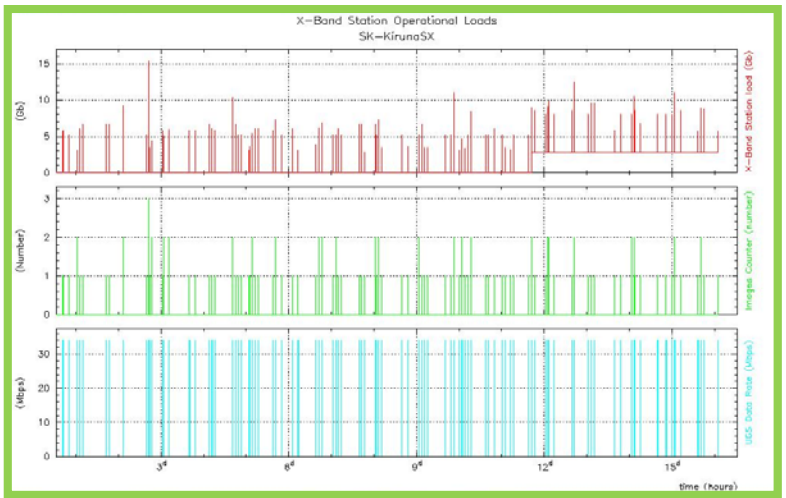


CSG Mission Simulator (CSG-MS)

Data Analyzer

Systems resource usage profiles





CSG Mission Simulator (CSG-MS)

Time Performance

arameters to be set:

- area of interest
- max and min incidence angle
- chronology parameters (duration of the feasibility, ranking and harmonization phases)
- side looking

olor maps (maximum, minimum and average) and statistics of:

- Revisit Time (time between observations of the same point)
- Reaction time (request deposit → data acquisition)
- Information Age (data acquisition → product delivery)
- Response Time (request deposit → product delivery)

CSG Mission Simulator (CSG-MS)

Tool For Coverage (TFC)

TFC allows to obtain optimal acquisitions lists that satisfies the total coverage of particular area selected by the user

TFC offers the best compromise between computation time and optimal solution

Output

- acquisition plan schedulable by real mission
- kml file to navigate into the solution

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Mission simulator utilization

Architectural design & Budgets verification wrt Time Performances

18 days simulation (CSG orbital repeat cycle + 2 days for managing satellite downlink queue for system response time calculation)

GS scenario :

- UGS: Matera (Civilian) and Pratica di Mare (Defence)
- X-band stations: Matera, Pratica di Mare, Kiruna, Cordoba
- S-band stations: Fucino, Kiruna, Cordoba

CSG satellites relative phasing: 180°

Mission simulator utilization

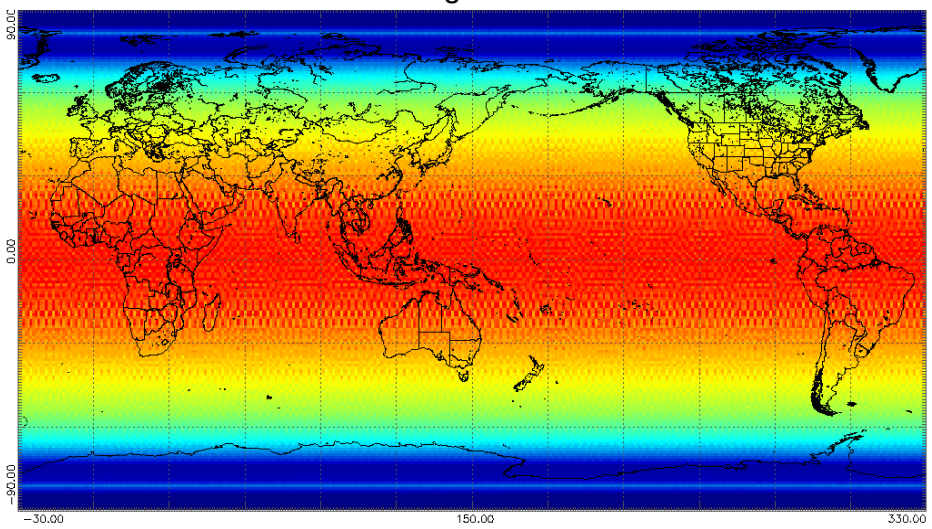
Architectural design & Budgets verification wrt Time Performances

he analyses showed that all the time performance requirements are et and the relevant budget have been properly allocated.

Example: Revisit Time

visit Time	World wide
Req.	≤13 h
Design	≤12.4 h

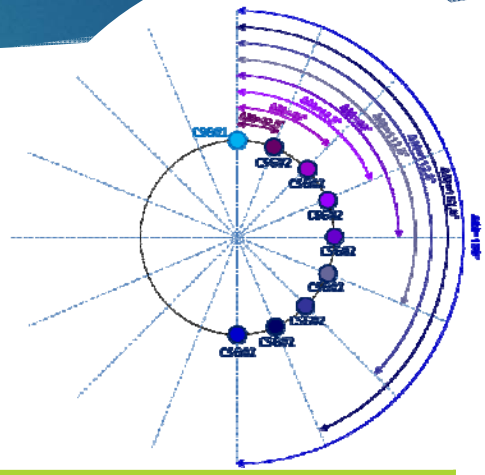
CSG average Revisit Time



Mission simulator utilization

Analysis of different orbital configurations

- Different phasing corresponds to different interferometric configurations
- An analysis has been performed to help in selecting the best configurations considering together both interferometric and time performance needs

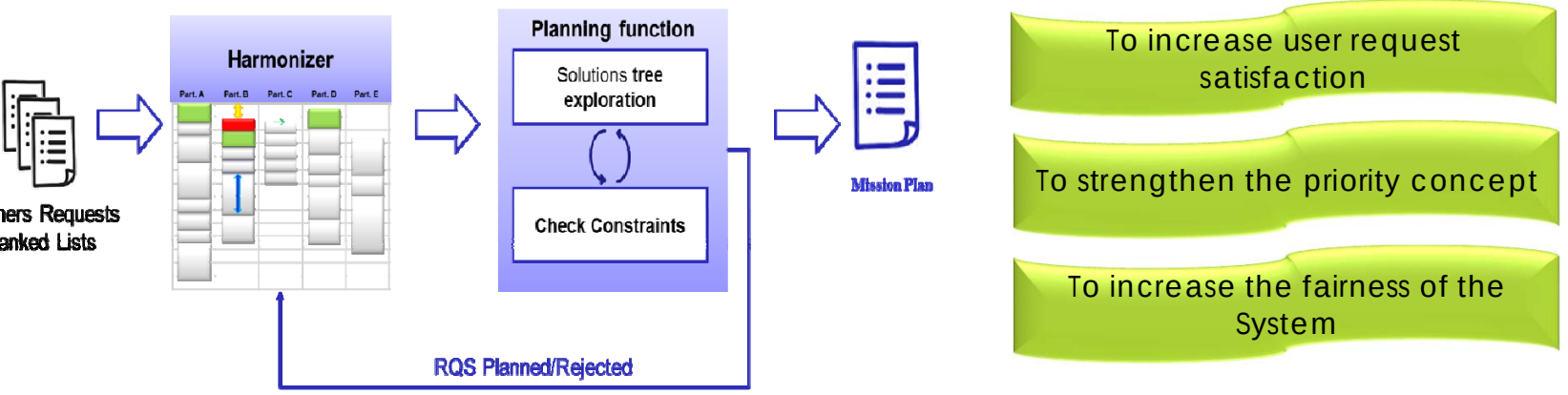


Orbital Configuration		Simulation Results	
Phasing	Interferometry delay	Revisit Time req.	Response Time req.
22.5°	5-11 days	✘	✘
45°	6-10 days	✘	✓
67.5°	1-15 days	✘	✓
90°	4-12 days	✘	✓✓
112.5°	7-9 days	✘	✓✓
135°	2-14 days	✓	✓
157.5°	3-13 days	✓	✓

Mission simulator utilization

Mission planning improvements evaluation effectiveness

Several significant improvements have been made in the CSG Mission Planner and in the subsystem devoted to the Harmonization of the Acquisition Requests w.r.t. the First Generation (*).



During the development phase, an extensive simulation campaign has been carried out with the CSG-MS to assess the effectiveness of the improvements designed.

Mission simulator utilization

Mission planning improvements evaluation effectiveness

mulation set-up

- 8 days of mission have been simulated
- 4 international partners having different System access rights.

nalysis results

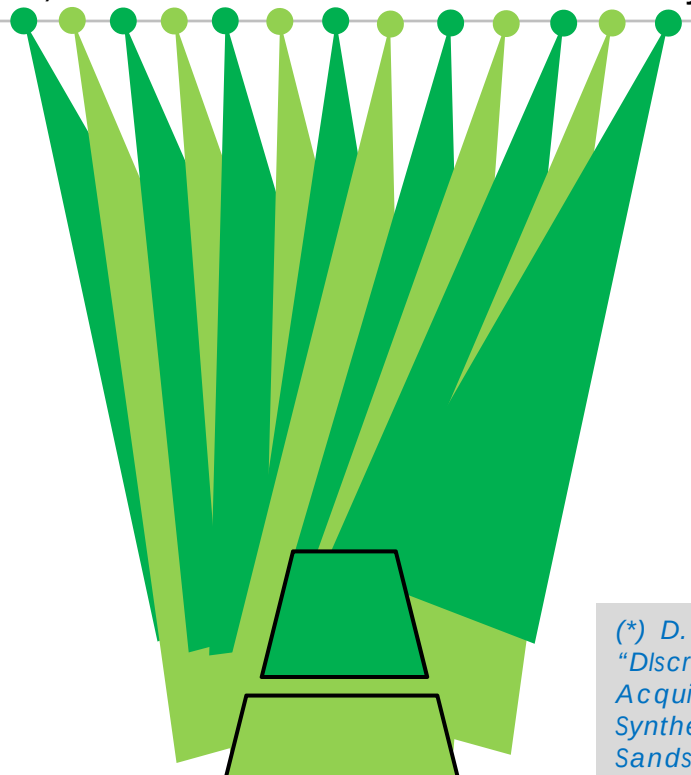
- for all the partners, 100% of the rank 1 AR were planned
- the percentage of satisfied AR of each Partner is fair
- the simulated mission plan is capable to fully exploit the programming rights of each partner
- the constraint imposed to the System are correctly implemented in the Mission Planner and the Mission Plan is consistent with all the

Mission simulator utilization

DI2S Spotlight effects

A new acquisition mode, known as DI2S (Discrete Stepped Strip) Spotlight Multi Swath, has been introduced in CSG System.

allows to achieve a couple of images ultaneously picked up, increasing the mber of acquirable es on a given area wise not feasible for time gap violation



The DI2S is based on performing two almost simultaneous (half a Pulse Repetition Interval apart) acquisitions, which can be used to imagine two different sites (*)

(*) D. Calabrese, V. Mastroddi, S. Federici, S. Serva. "DIscrete Stepped Strip (DI2S) for Multi-Swath Acquisitions", The 5th Asia-Pacific Conference on Synthetic Aperture Radar, APSAR 2015, Marina Bay Sands, Singapore, 1-4 September 2015.

Mission simulator utilization

DI2S Spotlight effects

In case a conflict arises between two requests and before the final rejection of one of the two requests, the DI2S algorithm tries to couple the requests, solving their conflict

The DI2S algorithm has to verify the following constraints:

- requests and DTOs characteristics compatibility (e.g. sat, looking side, SAR mode, etc)
- SAR payload constraints
- Temporal and system constraints with the rest of the plan

nalysis results

increase of the de-conflicting capability

the amount of DTOs taken with DI2S corresponds to the **10-20%** of the total DTOs in the final mission plan

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Simulation campaign to set the pre-rankization parameters

Simulation of the actual status of all the subsystems

International Cooperation

Commissioning activities

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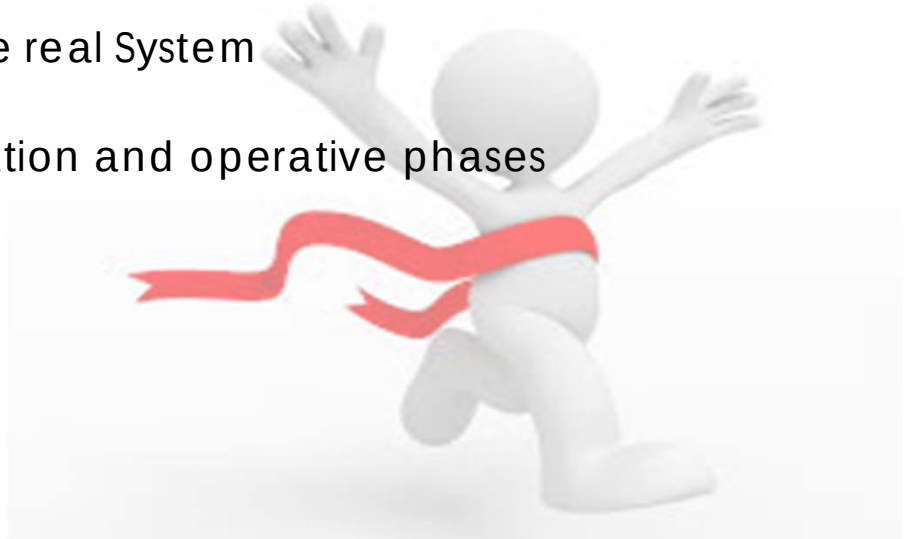
Conclusions

he COSMO-SkyMed di Seconda Generazione Mission Simulator is a valuable ool to:

- Simulate the end-to-end behavior of the real System
- Support the CSG System design, verification and operative phases
- Support international cooperation



Thank you!

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