NATO SSA/SST capability provision or improvement by means of DADR/FADR type radar networking

"Space Sensors and Space Situational Awareness" (SET-SCI-297/RSM)

10 to 11 October 2022, Interlaken (CHE)

1. Introduction

We propose a new approach to enhance Space Surveillance and Tracking capabilities based on the upgrade of existing Air Defence Surveillance Radars (FADR/DADR) assigned to NATINAMDS with a new LEO object detection capability

Space must be seen as an integral part of the Alliance's broad approach to deterrence and defence, drawing upon all of the tools at NATO's disposal, to provide the Alliance with a broad range of options to be able to respond to any threats from wherever they arise.

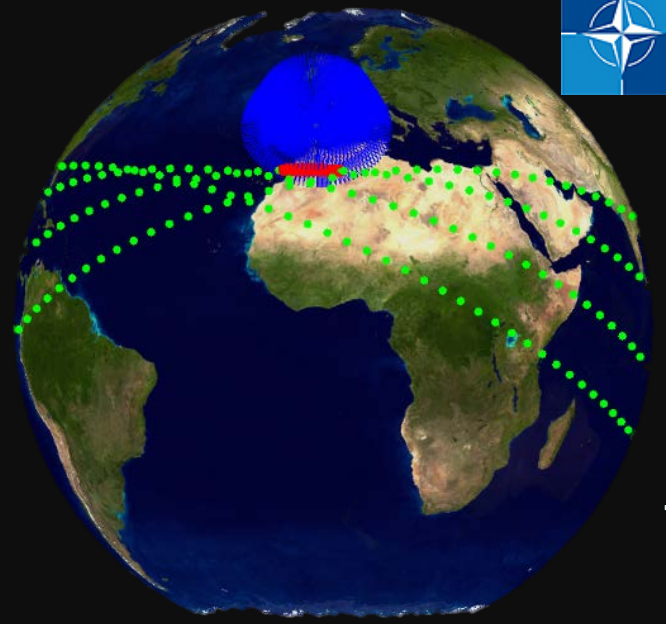
*(**NATO's overarching Space Policy**, Jan. 2022)*

2. SST Functionality

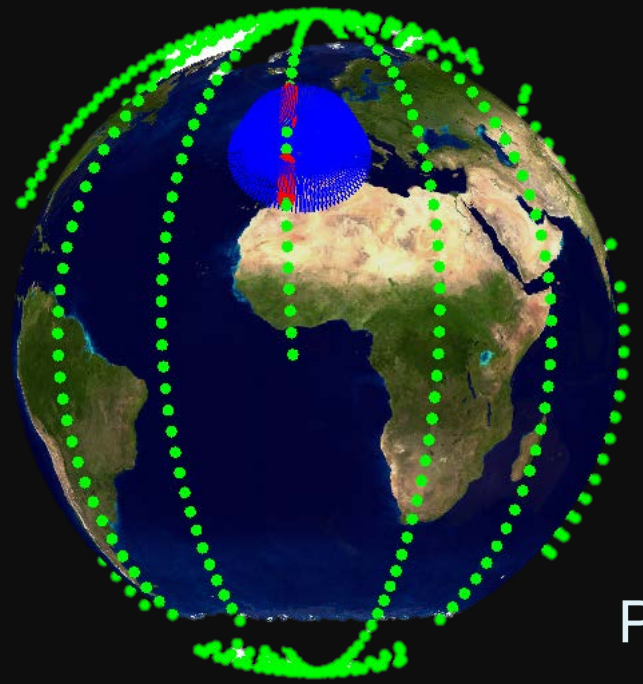
- LEO objects are located 200 – 2000 km.
- To provide LEO detection capability, four elements must be considered:
  - Local LEO catalogue remotely updated
  - Automatic orbit propagation and FOR cross calculation (when and where)
  - Schedule Radar actions according with estimated target location and system configuration (under operator control)
  - Report back the LEO event data

3. SST Functionality Provision: FoR

- The visibility of LEO objects by FADR/DADR sensors is limited by sensor location (Lat), defined sensor FoR (Range-Elevation), the LEO orbit (Inclination, Altitude) and the required minimum number of target detections to confirm a LEO event.



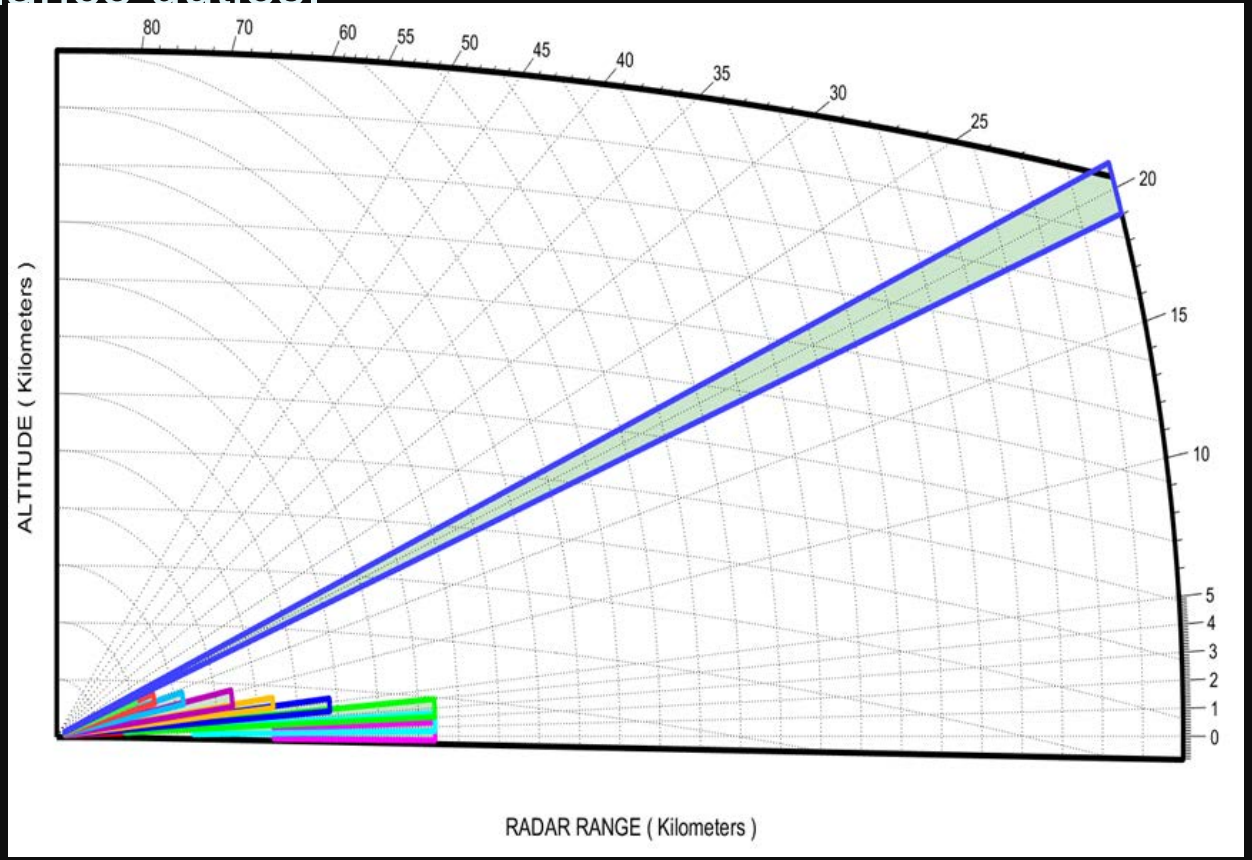
Tangential orbit



Polar orbit

4. DADR/FADR Adaptive Capabilities

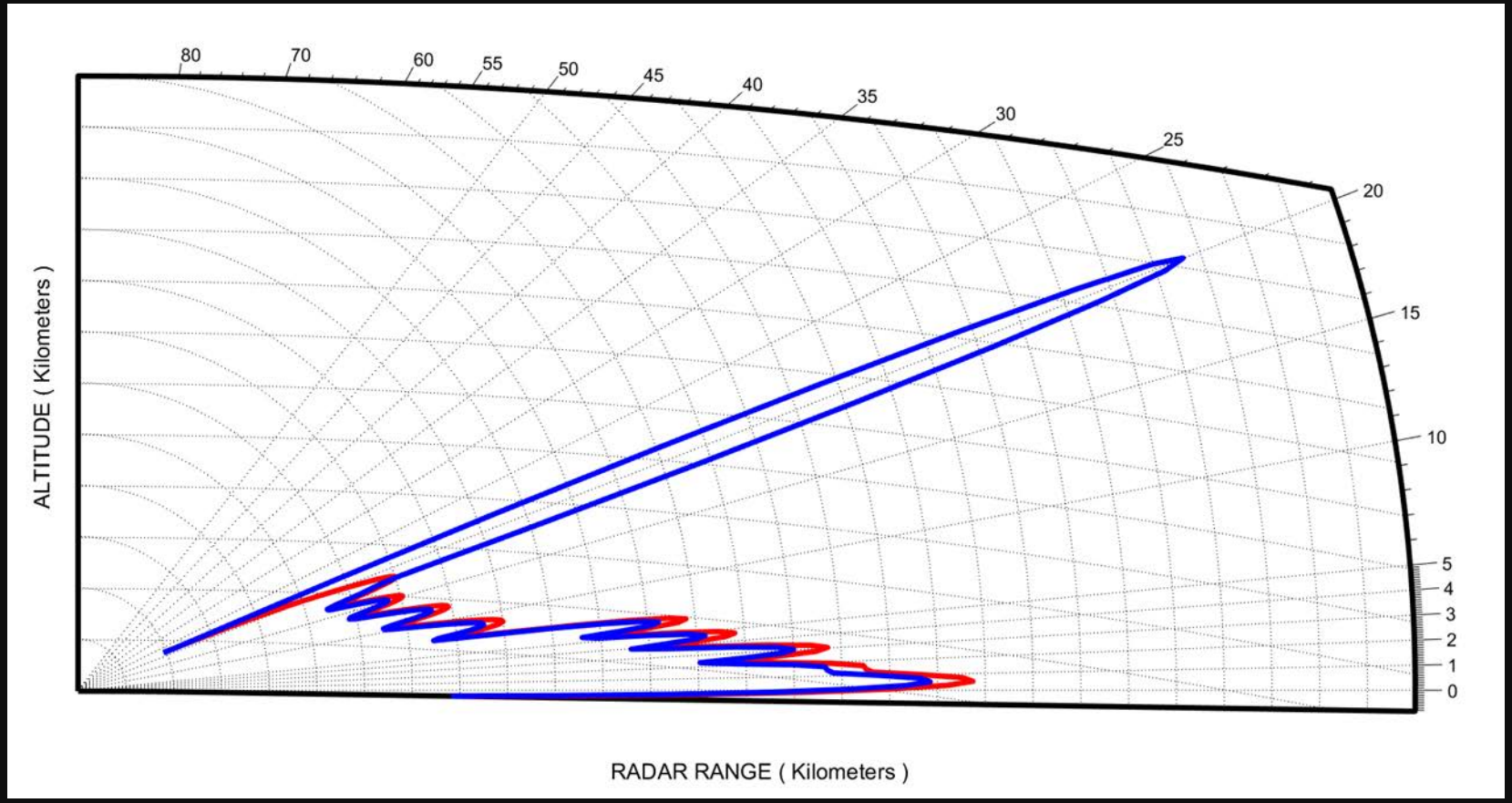
- DADR/FADR systems uses pencil-beam design and digital beam steering.
- A beam template is a set of beams, designed to provide optimum performance. DADR/FADR base template assume Air Surveillance duties.
- Special beams for specific missions can be used to modify the template.
- EXAMPLE: Simultaneous ABT & TBM track capability is achieved including TBM dedicated beams (increased elevation).
- Same approach can be used for other functionalities that require wider elevation coverages.



5. SST Functionality Provision: Performance (I)

- Modifications of the beam sequence in azimuth sectors allows the sensor to achieve LEO capabilities.

- Dedicated beams with Range & Elevation extension and dedicated LEO operative modes could be also considered.

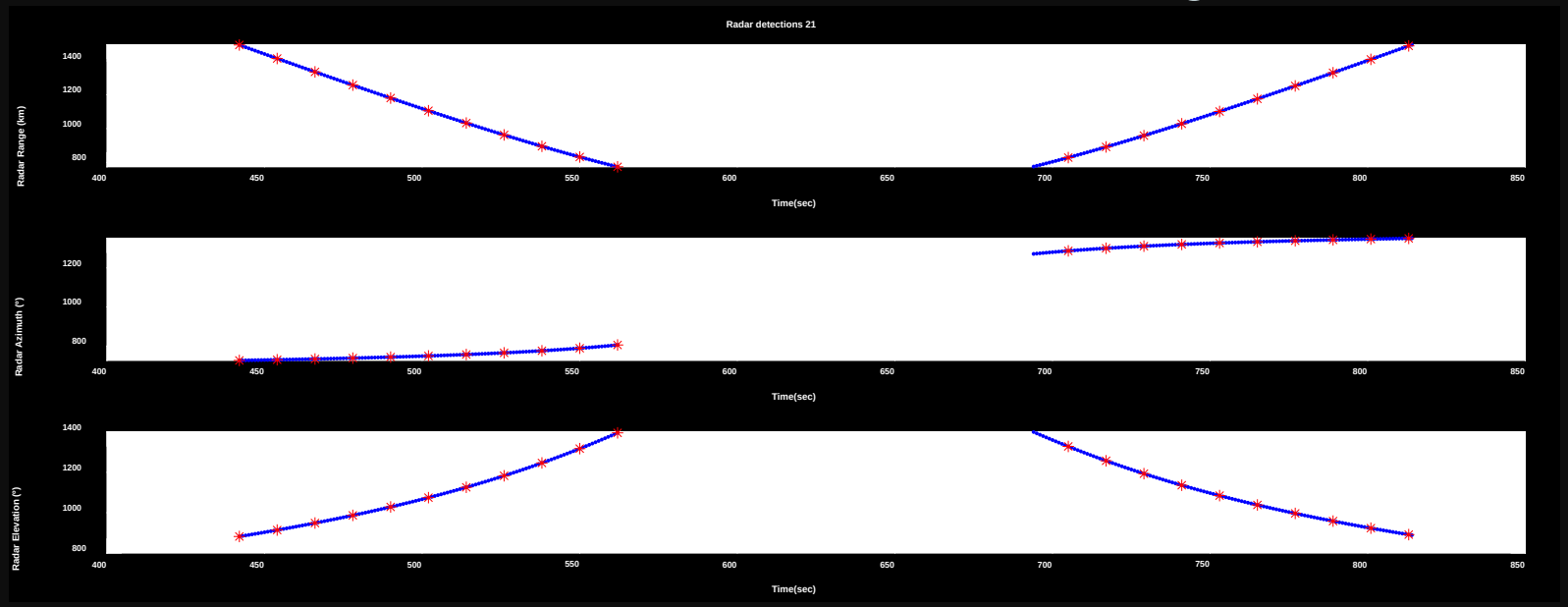


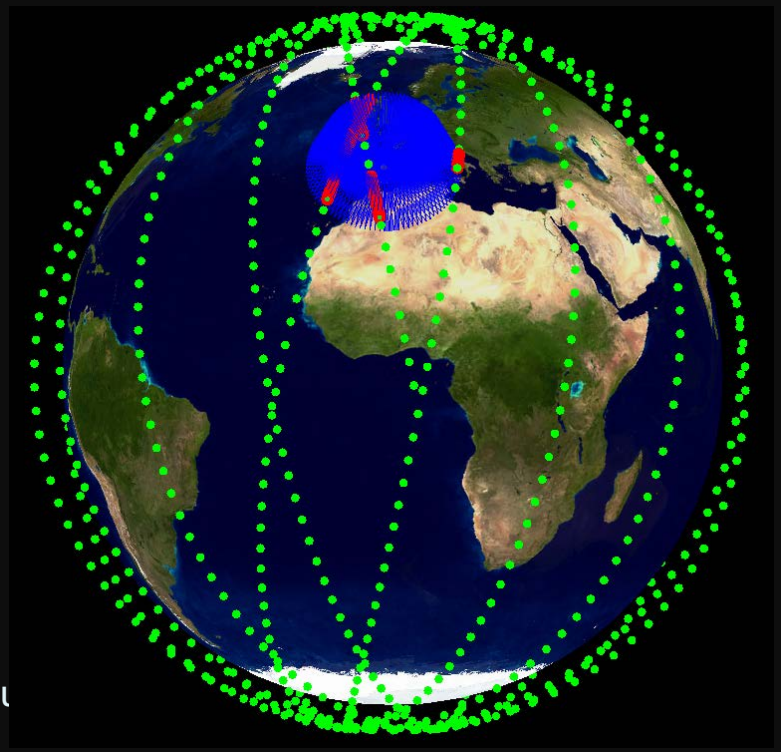
Simultaneous Air Surveillance & LEO detection with minimum impact in coverage (<5%)

5. SST Functionality Provision: Performance (II)

- New beam mode available for FADR and DADR

  FoR: sectorized in azimuth up to 360º, up to 40º/60º in elevation, up to 1500 km in range.



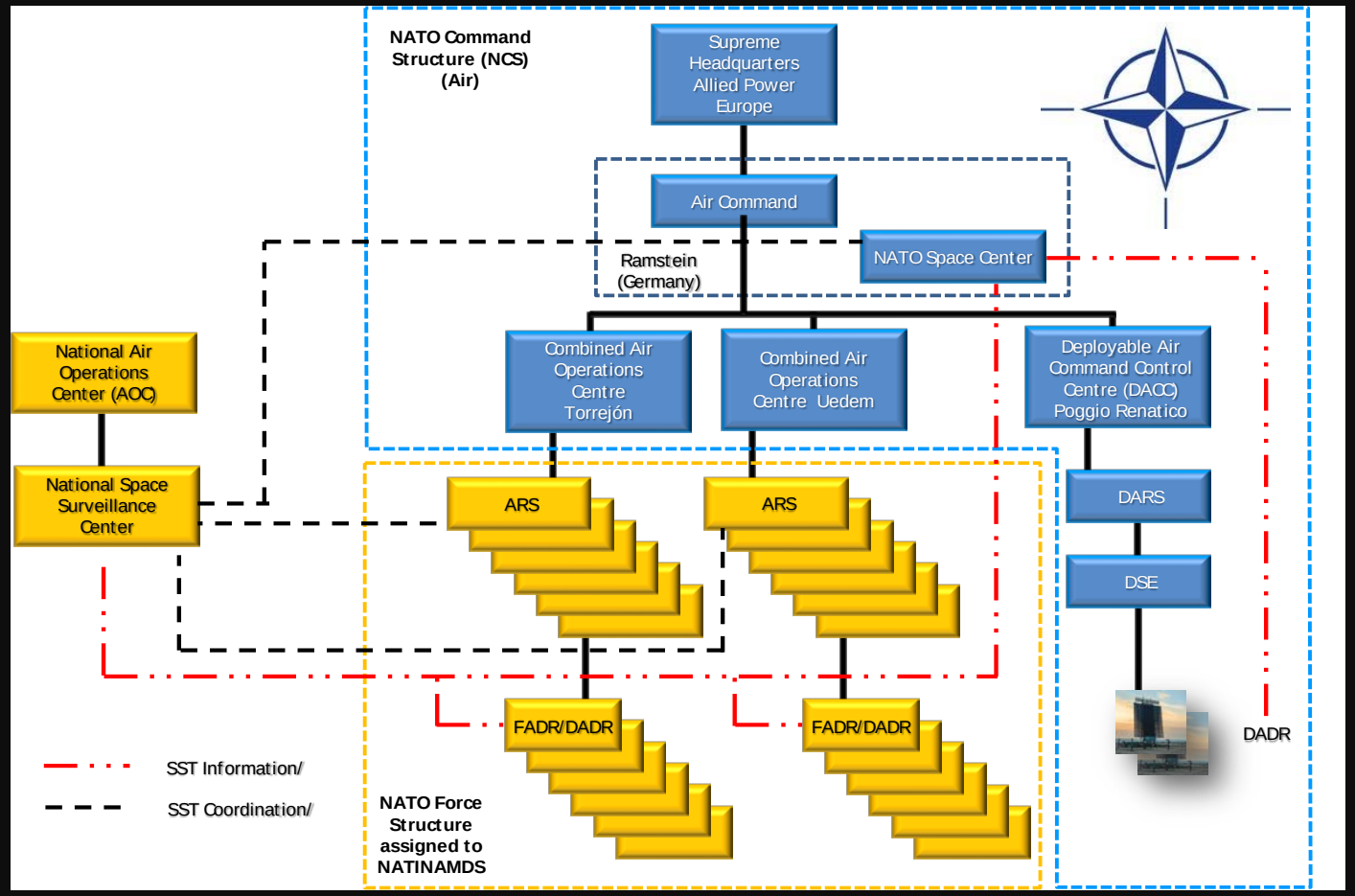


Example TerraSAR-X : Polar Orbit (97.44 deg), 514 km altitu

LEO event detection capability >80%

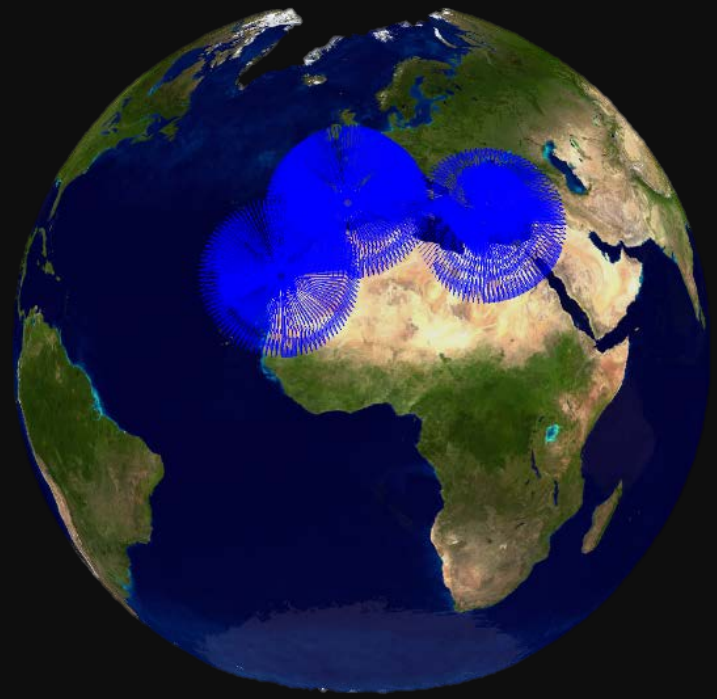
6. Radar Network Operative Concept (I)

- Early Warning radars with TBM capability (or provision for) assigned to NATINAMDS are candidates for SST capability.
- SST C2 assigned to NATO Space Center (Ramstein) within NATO Air Command Structure (NCS).
- Coordination required between NATO Space Center and Air C2 entities (NCS and NATO Force Structure)
- Benefits of integration of NATINAMDS DADR/FADR sensors network with SST capability



6. Radar Network Operative Concept (II)

- Simulations have been carried out for geometrical visibility performance.
- Three different locations and 2 different sensors have been considered.
- LEO object visibility for the network take advantage of the site location diversity.



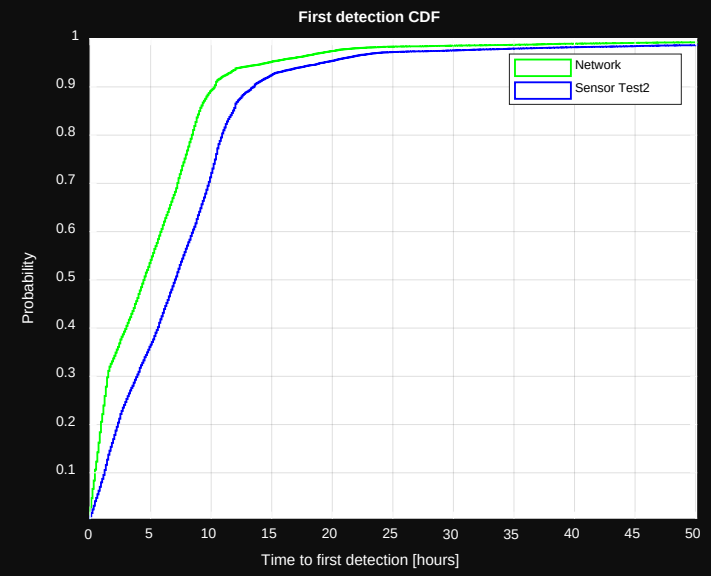
	Site 1	Site 2	Site 3	Network
SA: Cat_{ill} (12H)	69,89%	70,35 %	70,25 %	78,12 %
			Sensor type B	85,5 %

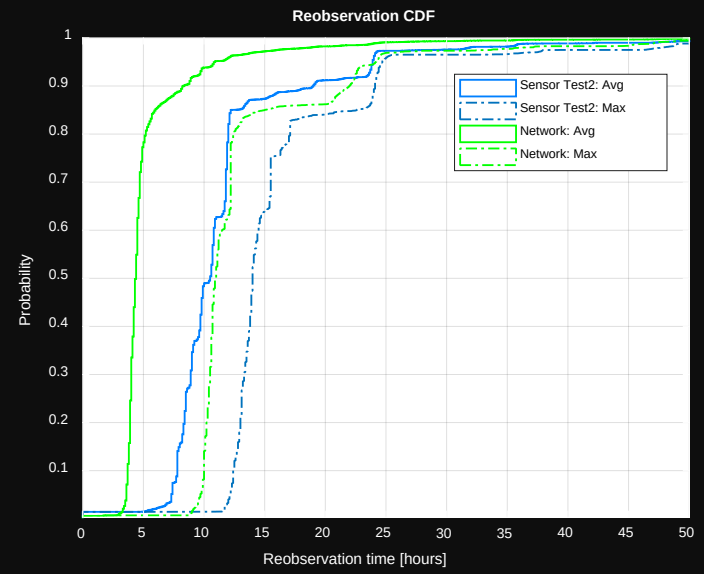
Sensor type A: Instr. Range 1500Km, Elevation 40º
Sensor type B: Instr. Range 1500Km, Elevation 60º

6. Radar Network Operative Concept (III)

- Wait time until target visibility, is expected to be also improved in cooperative mode.
- First observation time & re-observation time

	Site 1	Site 2	Site 3	Network
F_{obs} (6H)	41,38%	43,17%	43,5%	61,34%
F_{obs} (6H)	83,03%	86,54%	85,66%	93,81%
Avg_{Re} (9H)	7,04%	34,66%	20,55%	91,89%
Avg_{Re} (12H)	68,25%	82,1%	77,98%	95,91%
Avg_{Re} (24H)	93,93%	96,97%	95,47%	98,88%





7. Conclusions

- SSA/SST capabilities at LEO level, have been proposed for FADR / DADR radars.

- By the digital beam steering capability of this radars, coverage extension in Elevation and Range for specific azimuth sectors can be perform.

  → FADR/DADR are able to support Space Defence and Air&Missile Defence simultaneously

- A network configuration with multiple radars in different locations shows a multiplicative effect that allows to obtain a greater coverage and improved first / re-observation times.

INDRA has confirmed this capability in a DADR, upgraded with an updated SW, that demonstrates the capability to detect LEO object from a TLE database.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At the core