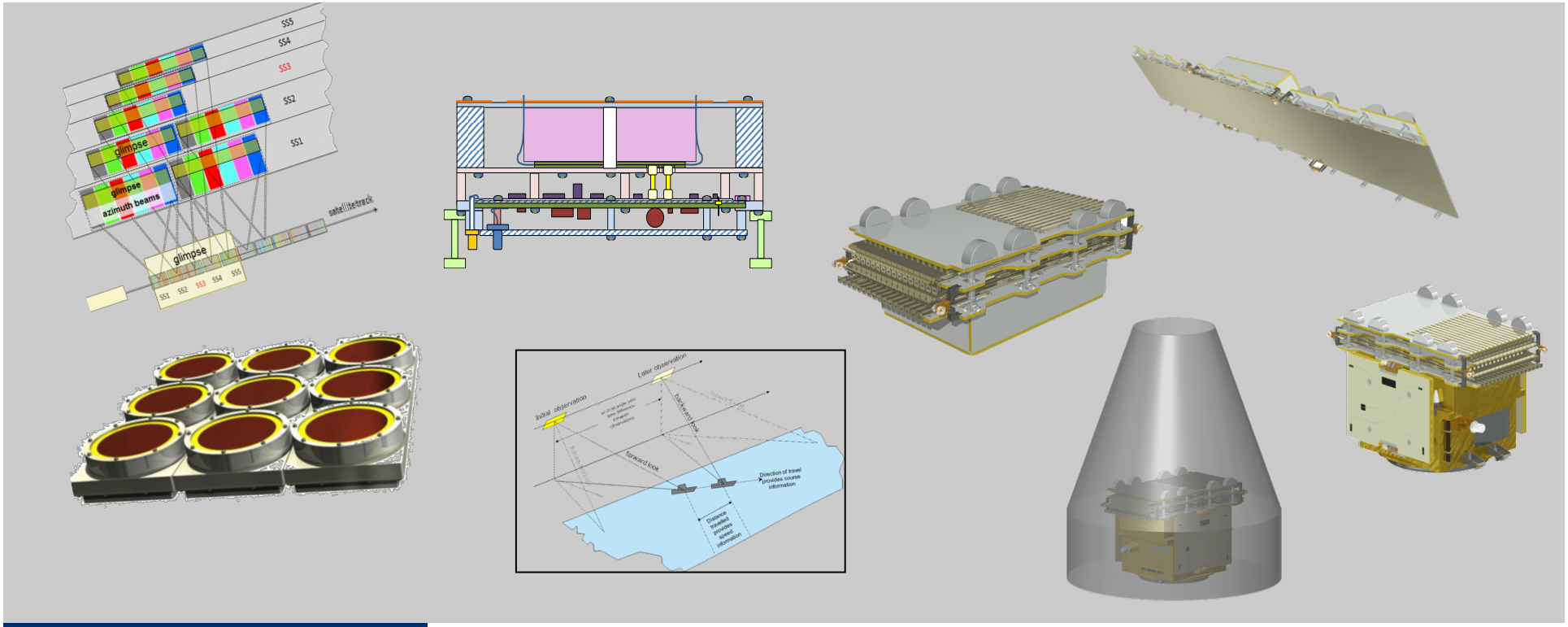

DEFENCE AND SPACE

Innovative SAR Technologies

David Hall, Geoff Burbidge

Airbus Defence and Space
4 May 2017

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Drivers of "innovative design"

- Need to accommodate financial constraints
  - Historically, space based SAR systems have been very expensive
    - large mass
    - large power demand
    - large data volume and downlink rate
    - provide specified performance in all 'corners' of the performance envelope
  - Launchers are expensive
    - Pack maximum SAR capability within low cost launcher fairing
    - Consider electric propulsion to enable operating at low altitudes with smaller launchers

- Need to monitor new geophysical parameters / Applications
  - Current designs incapable of providing adequate measurements
  - Identify new ways of operating SAR instruments
  - Enhance current designs to accommodate new measurement techniques

Excelsior Low Cost SAR Payload

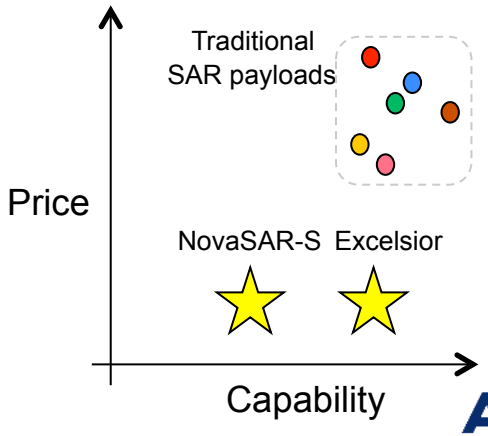
Background

During 2015, X-Band GaN devices have become available for the first time, enabling the developments on NovaSAR-S to be exploited in the context of an X-Band payload product :

- Higher bandwidth allocation (now up to 1200MHz) allows finer spatial resolution (down to 1m and finer)
- Provides the X-Band desired by some customers
- Enables >1000km swath width Maritime Ship Detection mode
- Enables wider access for the same **antenna area**

Furthermore, the physical configuration of the payload can be addressed to make it more readily compatible with standard platforms than the NovaSAR-S payload, and in particular make it more readily compatible with the lowest cost launchers for satellites in the 250-500kg class (i.e. PSLV dual launch), making overall cost of ownership lower still.

The goal of the 'Excelsior' SAR payload is to achieve finer resolution, greater access, and larger Maritime ship detection swaths than NovaSAR-S from an X-Band SAR payload that has a similar price tag.



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Excelsior Low Cost SAR Payload

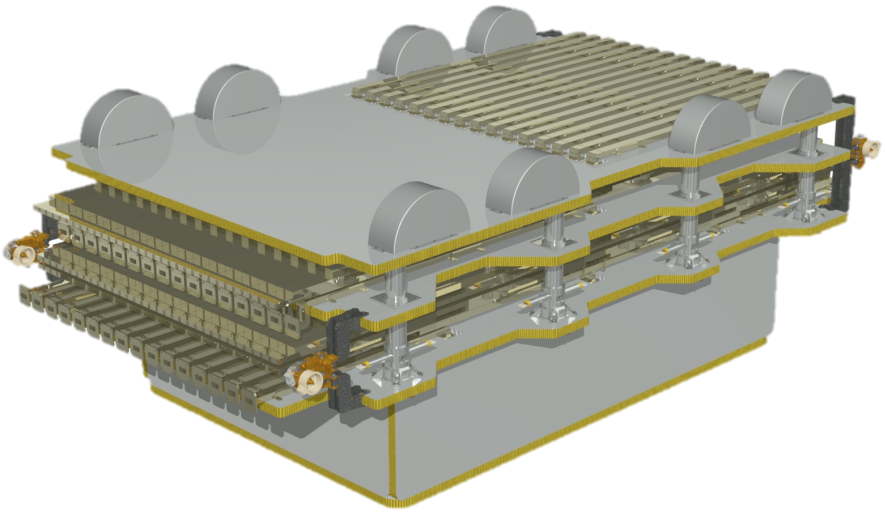
Configuration

Trade-offs have addressed many potential configurations and **have resulting in** the selection of the following **preferred configuration** :

- 5.0 x 0.8m antenna, folded as three identical size panels, centre panel fixed to platform body
- 32 rows of radiators, fed as 16 active phase centres
- Active ‘lower assembly’, comprises a single ‘box’ underneath the fixed central panel containing all active payload electronics
- 16 PCE’s slide into a cage in lower assembly for ease of maintenance after platform integration
- Passive ‘upper assembly’: waveguide radiators + feeds, 16 choke flanges along each hinge-line
- 16 further choke flanges to connect RF between lower and upper assemblies

Result is a complete free standing payload that can be integrated with a range of platforms.

Not reliant on additional facilities from platform



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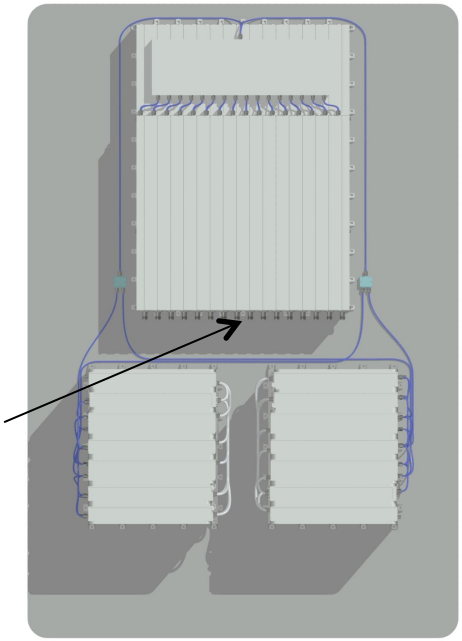
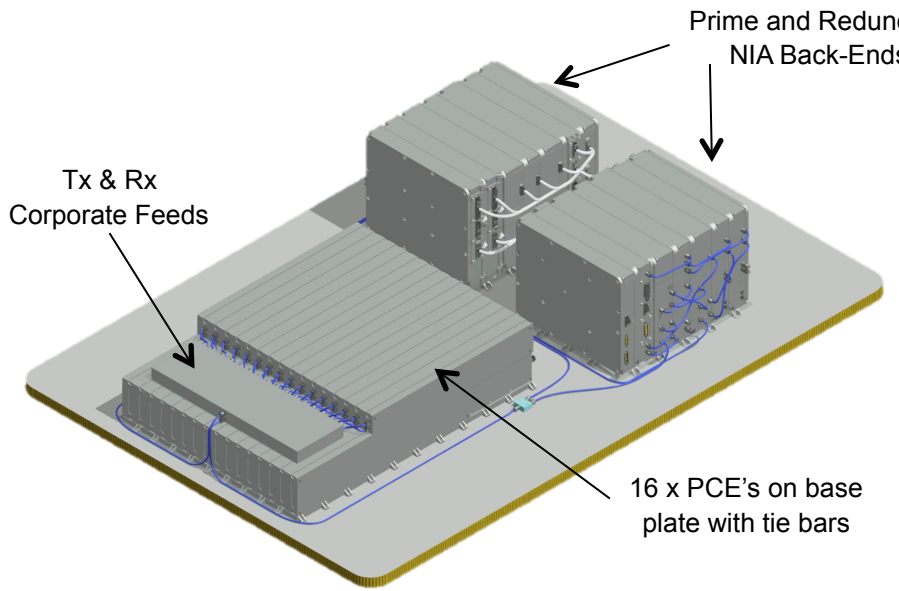
Excelsior Low Cost SAR Payload

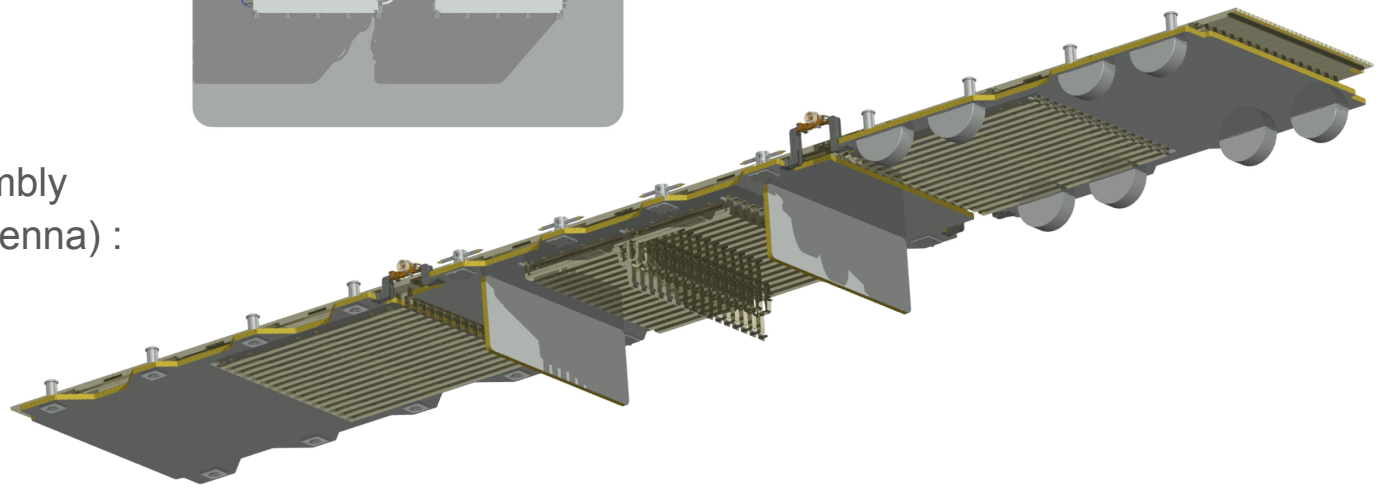
Specification and Capabilities

Lower Assembly
(Active Electronics) :





Upper Assembly
(Passive Antenna) :



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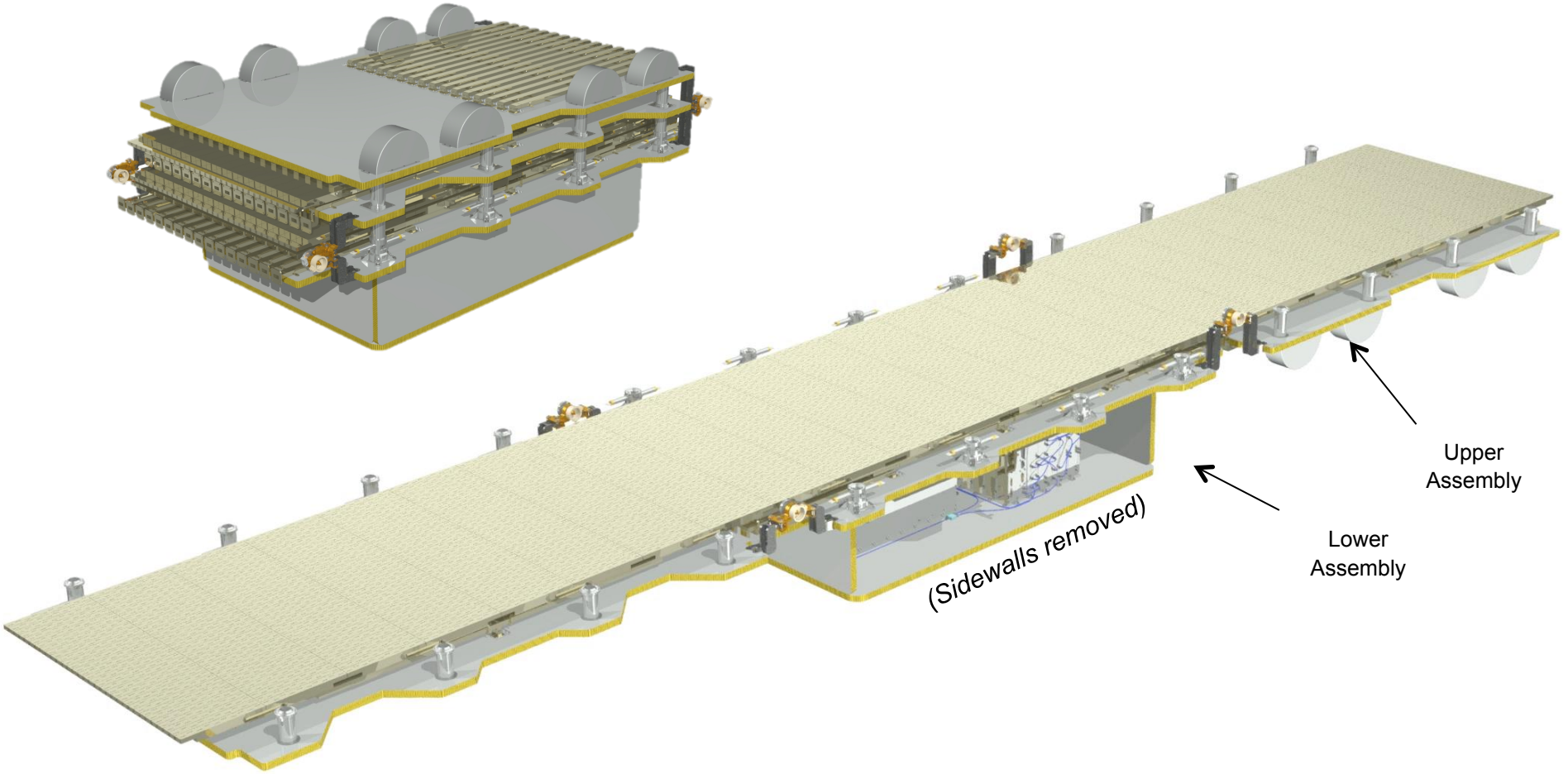
Excelsior Low Cost SAR Payload

Integrated, Stowed, Deployed



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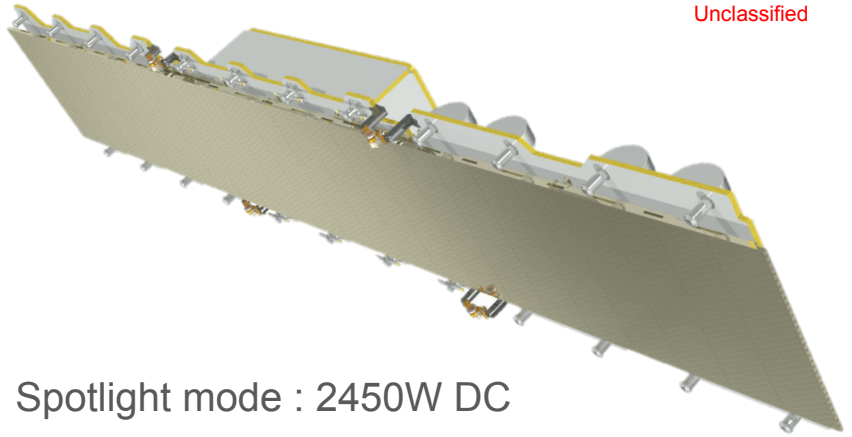
Excelsior Low Cost SAR Payload

Specification and Capabilities



- Payload Name : EXCELSIOR (Latin for 'higher')
- Payload Mass : ~205kg
- DC Power : All Modes except Spotlight : 1650W DC, Spotlight mode : 2450W DC
- Redundancy : Dual redundant Back-End, Gracefully Degrading Front-End
- Nominal orbital altitude : 580km
- Polarimetry : Single-Polar

Mode Name	Range Resolution	Swath Width	Sensitivity	No. of Looks	Access Range (each side)	Data Rate /Mbps	DC Power draw from platform
Spotlight (VV)	1m	10km	< -18dB	1	192-595km (20-50°)	< 1200 Mbps	2500 W
Stripmap (VV)	3m	25km	< -18dB	1	184-600km (19.2-50°)	< 500 Mbps	1700 W
ScanSAR_20 (VV)	20m	120km	< -19dB	4 (Rg)	192-595km (20-50°)	< 250 Mbps	1700 W
ScanSAR_30 (VV)	30m	200km	< -19dB	4 (Rg)	192-595km (20-50°)	< 200 Mbps	1700 W
Maritime Ship Detection (VV)	30 x 6m 30 x 6m 30 x 6m 50 x 6m	400km 675km 750km 1020km	N/A	1	456-856km (41-60°) 852-1527km (60-77°) 983-1733km (65-80°) 529-1549km (46-77°)	< 115 Mbps < 115 Mbps < 100 Mbps < 150Mbps	1700 W

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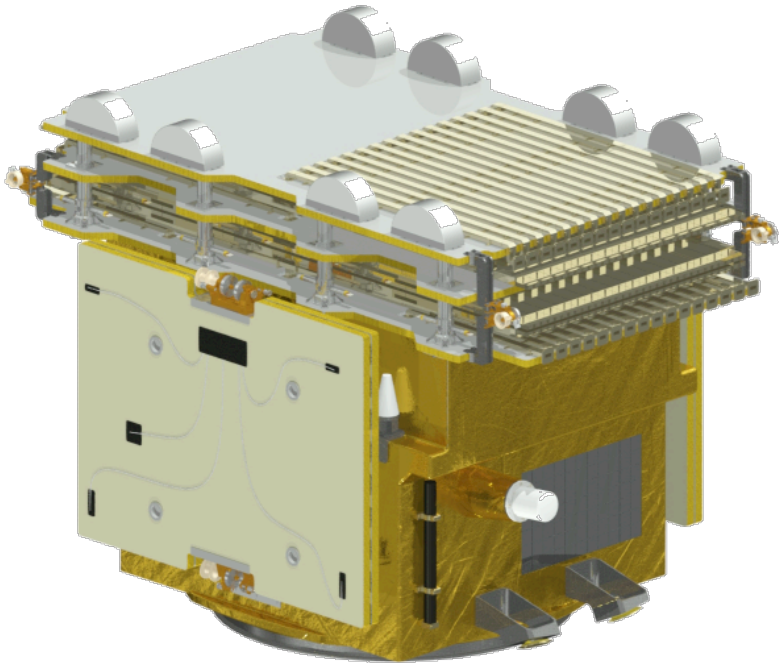
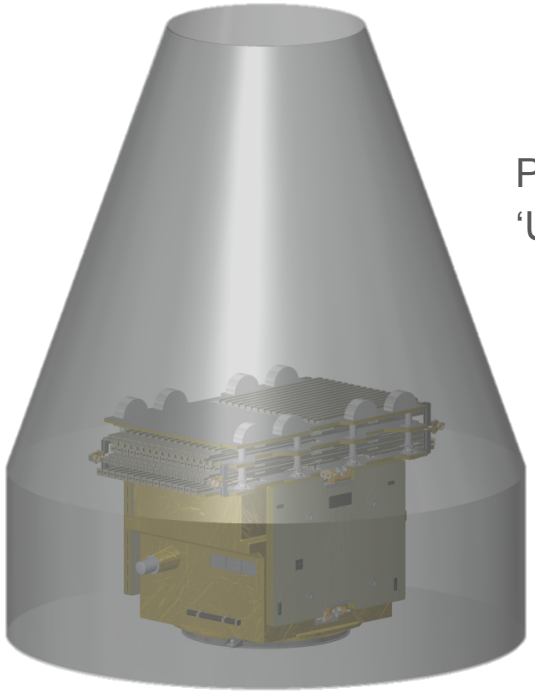
Excelsior Low Cost SAR Payload

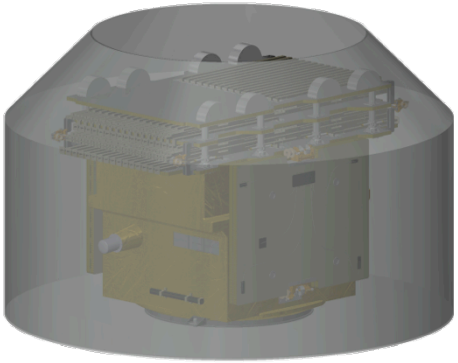
PSLV Launcher Accommodation

‘Excelsior’ SAR Payload on Astrobus-S platform





PSLV Dual-Launch ‘Upper’



PSLV Dual-Launch ‘Lower’

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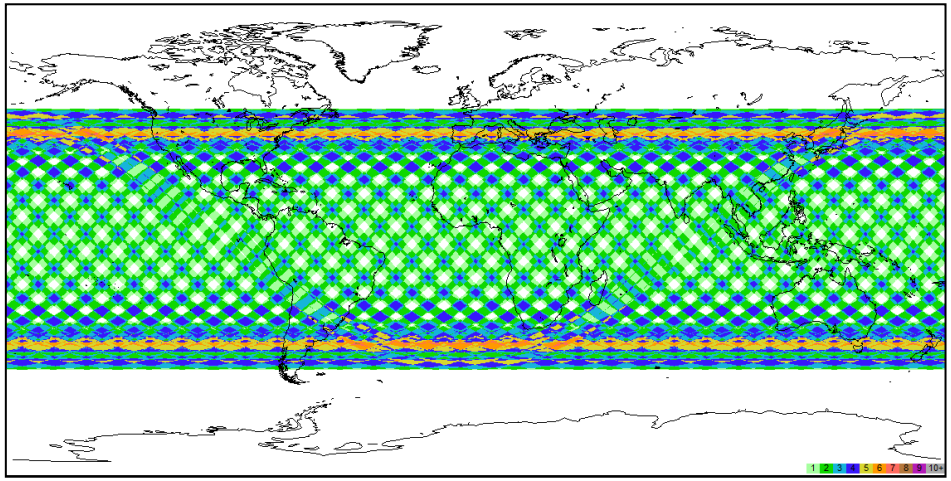
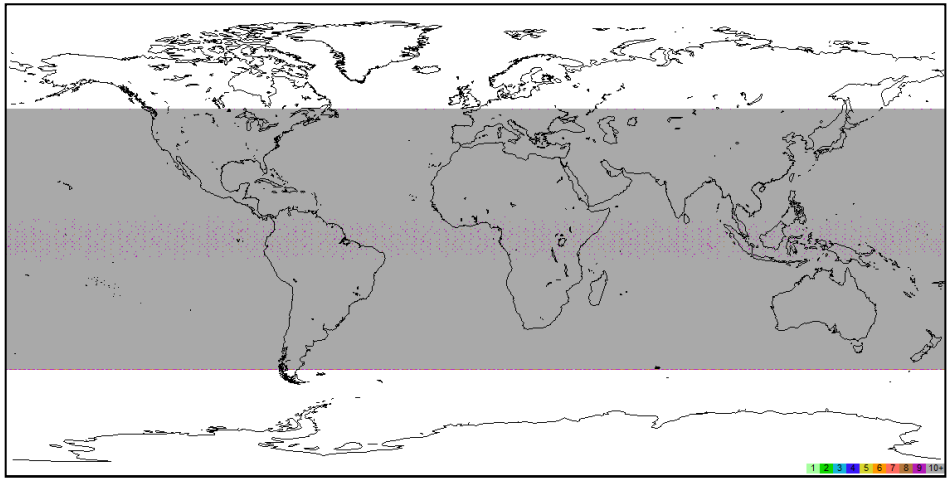
Excelsior Low Cost SAR Payload

Mission Analysis



Imaging Modes Access in 24 hours



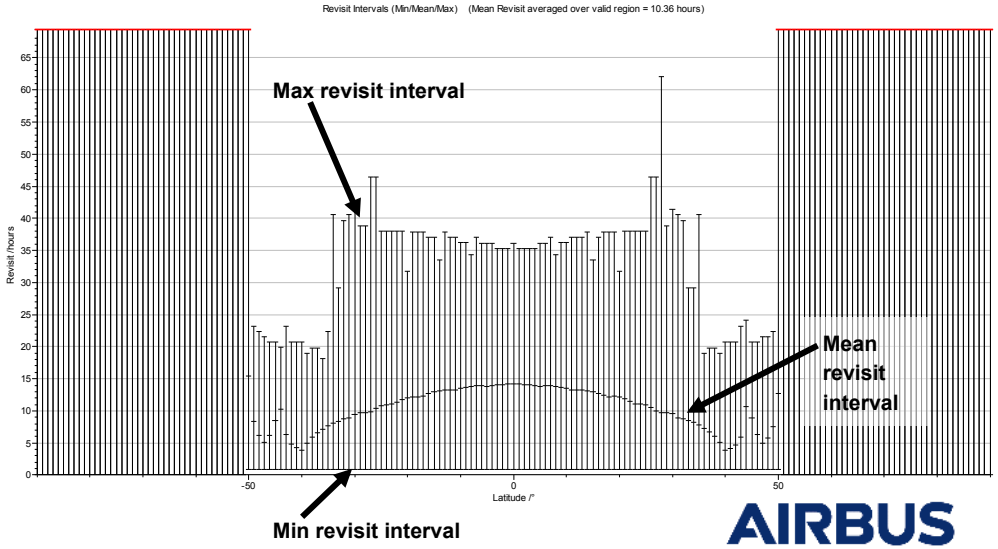
Imaging Modes Access in 1 week

Revisit Statistics, **Imaging Modes**

2 Excelsior spacecraft

- 180° apart in same plane
- 45° Inclination
- 20° – 50° access both sides on nadir track

10hr mean revisit (between latitudes ± 50°)



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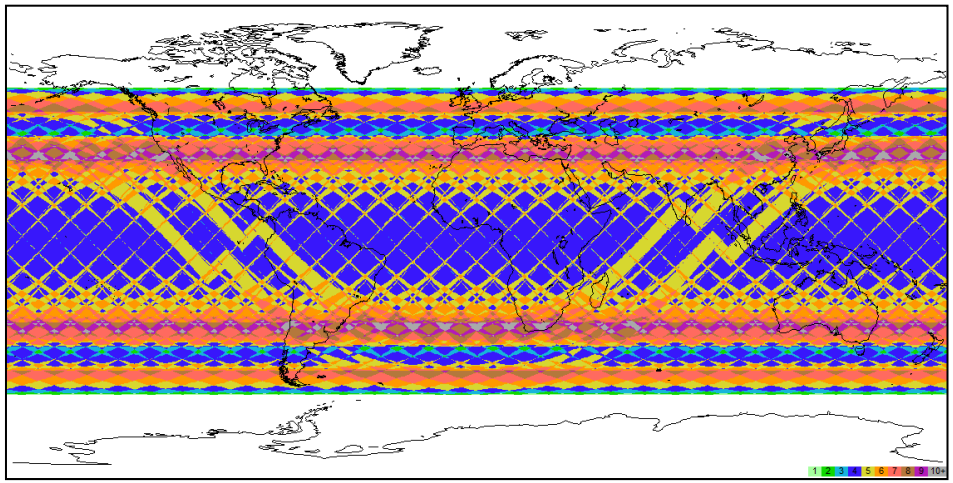
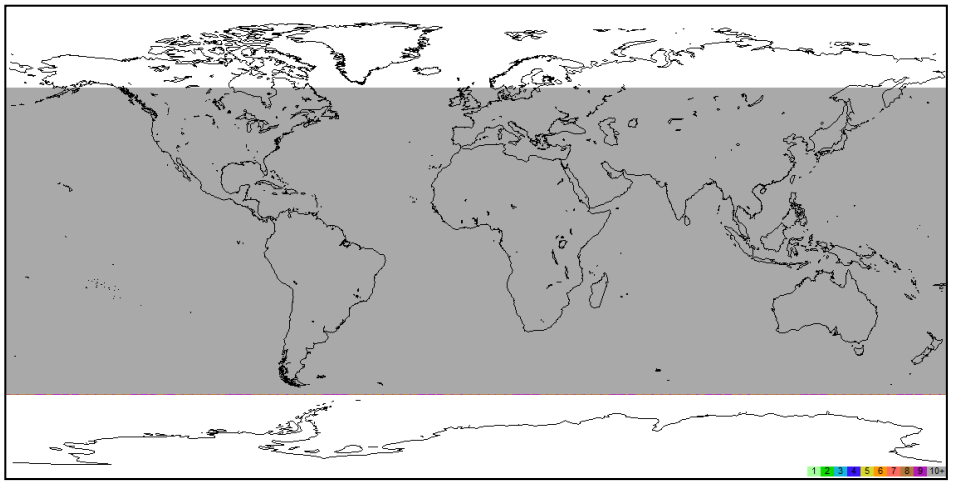
Excelsior Low Cost SAR Payload

Mission Analysis



Maritime Mode Access in 24 hours



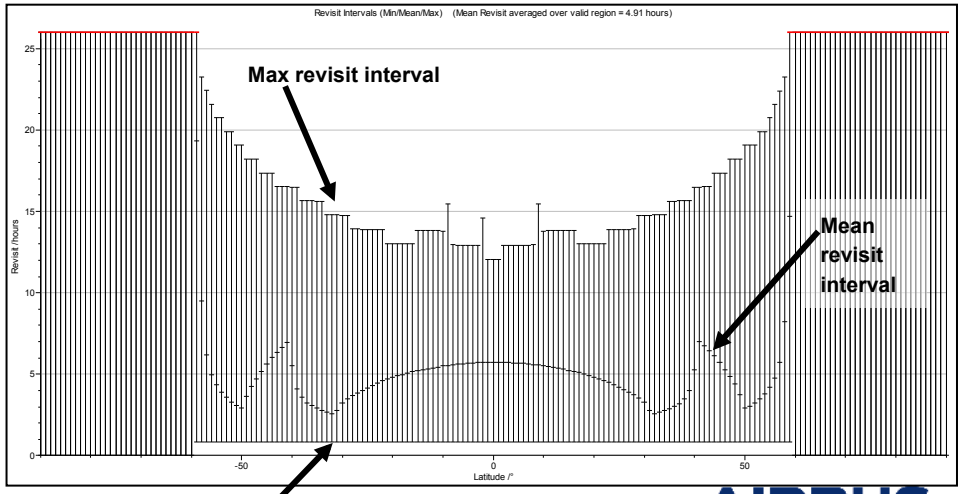
Maritime Mode Access in 1 week

Revisit Statistics, M**aritime Mode**

2 Excelsior spacecraft

- 180° apart in same plane
- 45° Inclination
- 46° – 77° access both sides on nadir track

5hr mean revisit (between latitudes ± 58°)



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Drivers of "innovative design"

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  - Historically, space based SAR systems have been very expensive
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  - Launchers are expensive
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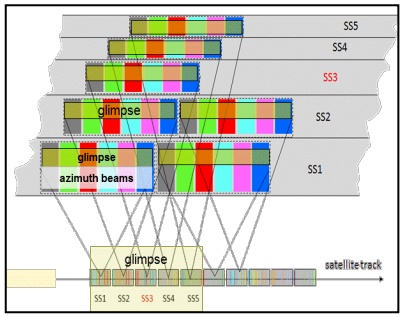
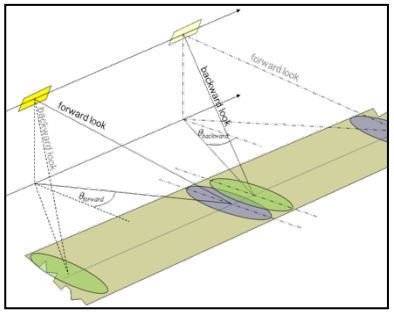
- Need to monitor new geophysical parameters / Applications
  - Current designs incapable of providing adequate measurements
  - Identify new ways of operating SAR instruments
  - Enhance current designs to accommodate new measurement techniques

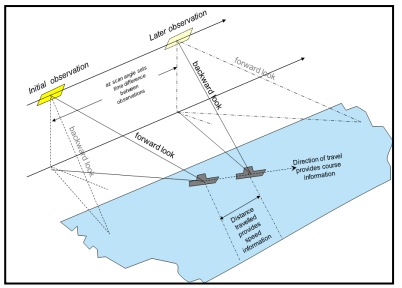
Innovation for new Applications

➢ Typical new geophysical parameters

- 3D deformation monitoring
- Soil moisture monitoring
- Enhanced maritime surveillance
- 3D wind velocity mapping
- Ocean current mapping

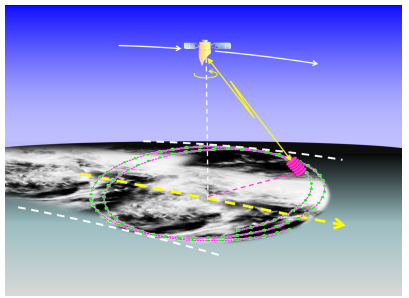


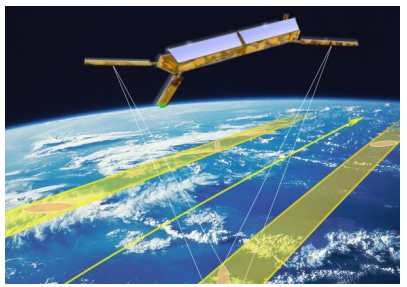




➢ New design capabilities

- High resolution wide swath based on multiple azimuth beams
- **Wide angle az beam separation**
  - 3D deformation monitoring
  - enhanced maritime surveillance





- Wide area, **high radiometric accuracy** imaging for
  - soil moisture monitoring
- Implementations that enable **on-board FR mitigation** where VV-HH coherence is not important

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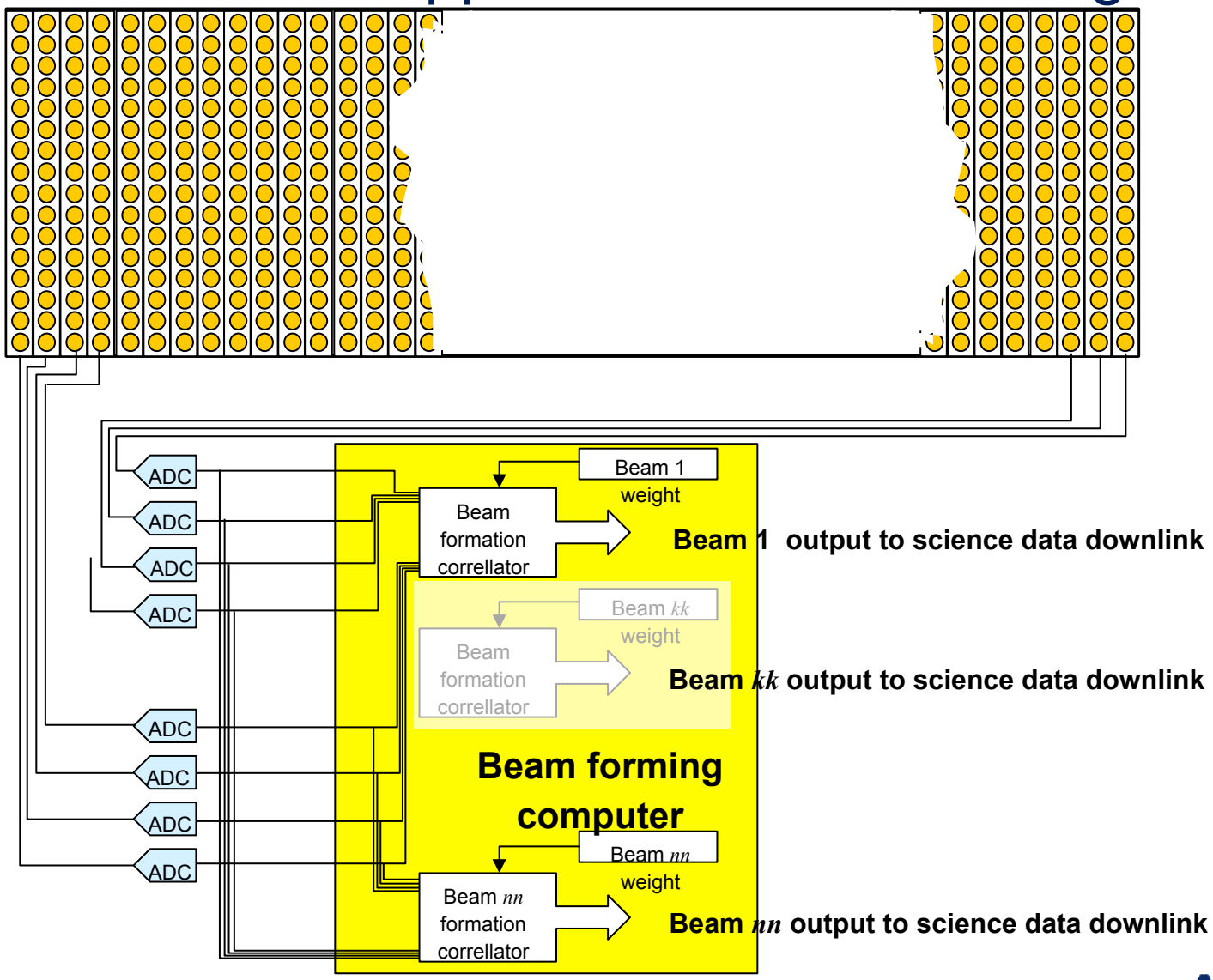
Innovation for new Applications – 2D steering antenna



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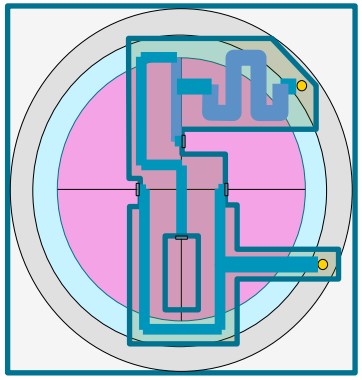
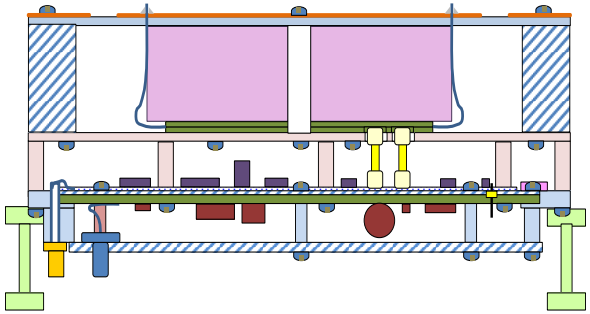
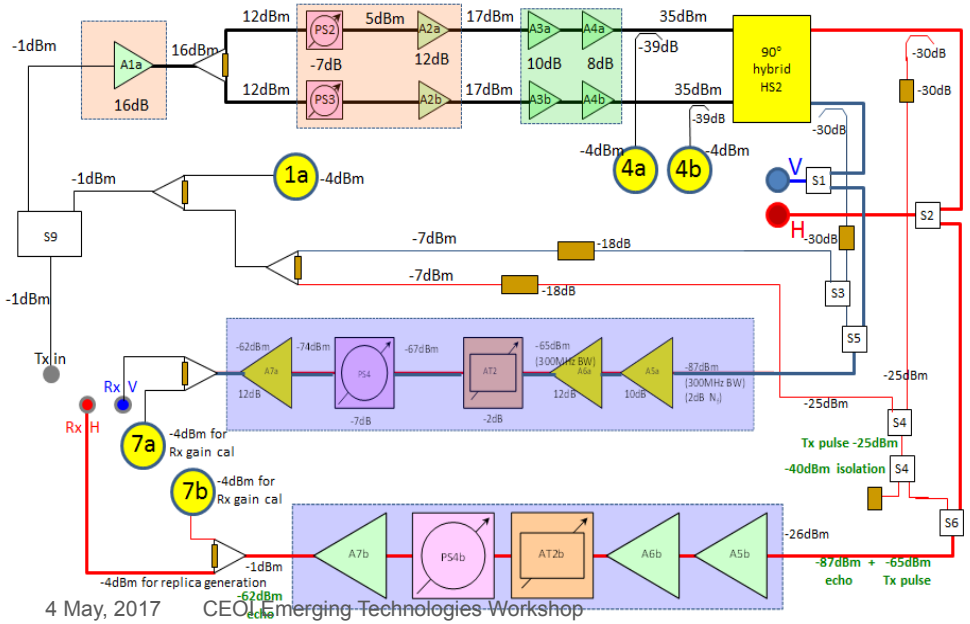
Innovation for new Applications – Active module design

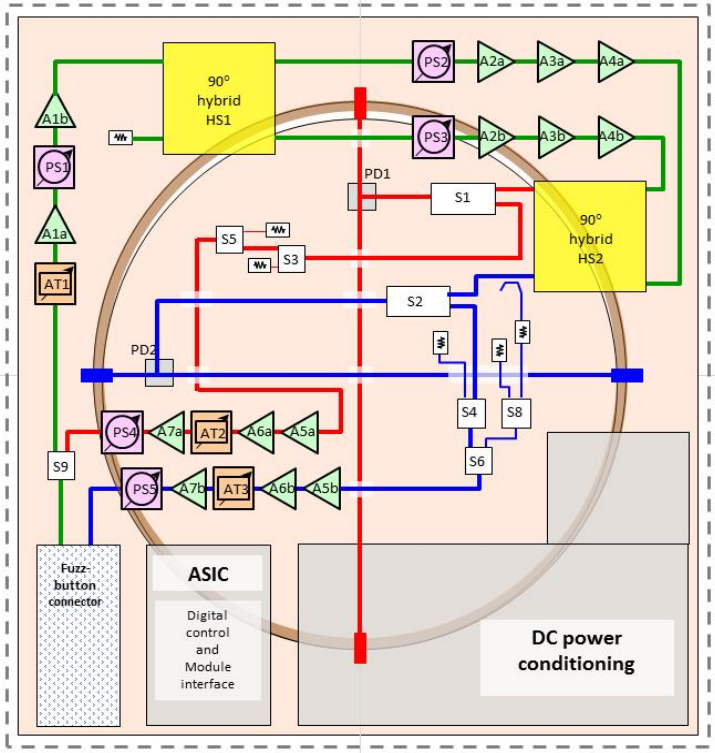
➢ Module architecture

- Twin Tx channels enable radiator to be excited to provide any plane of polarisation
- Twin Rx channels enable polarimetric SAR
- Thermal paths from electronics take waste heat to front surface





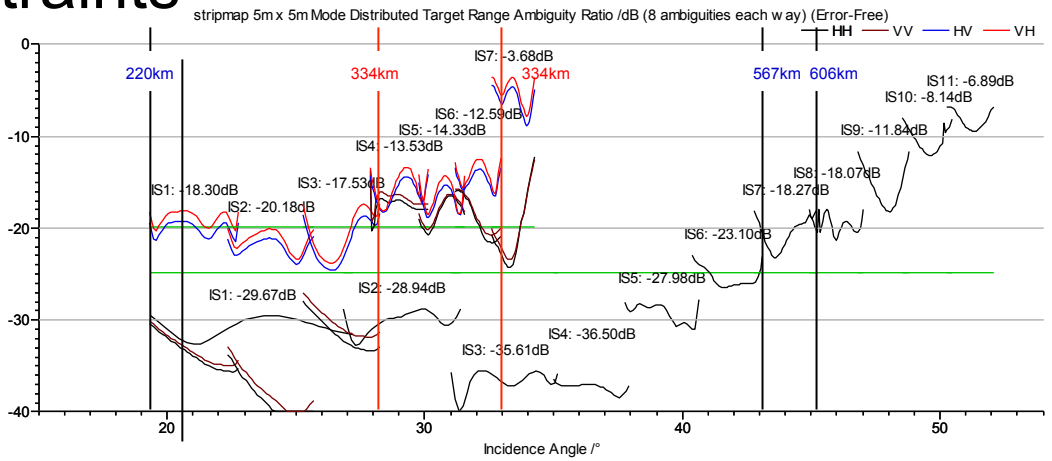




Innovation for new Applications – Antenna size

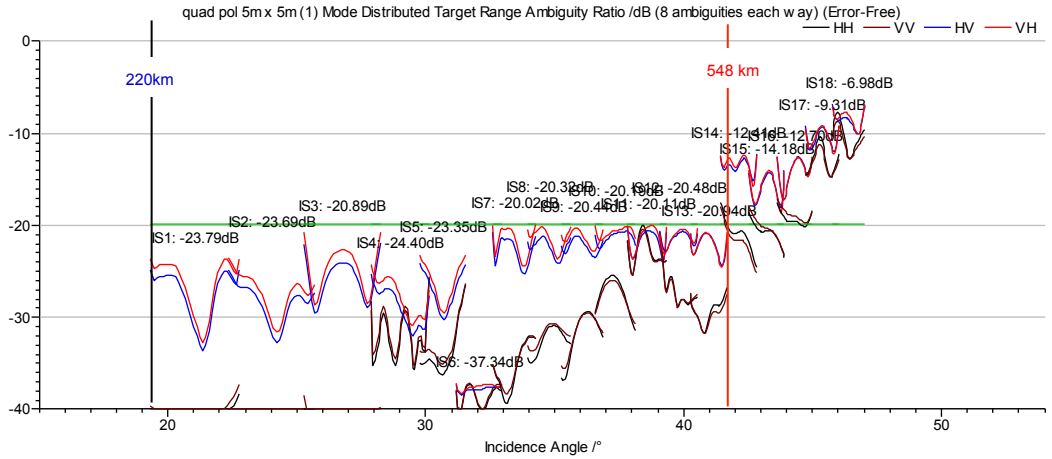
➢ Fundamental SAR constraints

- Mitigation of ambiguities
- Size of antenna aperture
- Width of swath
- Along track spatial resolution



➢ Antenna size issues

Antenna size	Mode	Max inc angle
9.5m x 2.4m	Dual pol	43°- 45°
9.5m x 2.4m	quad pol	28°- 31°
9.5m x 4.8m	quad pol	42°



Quad polar operation requires twice the antenna area to enable same unambiguous imaging as dual/single polar operation

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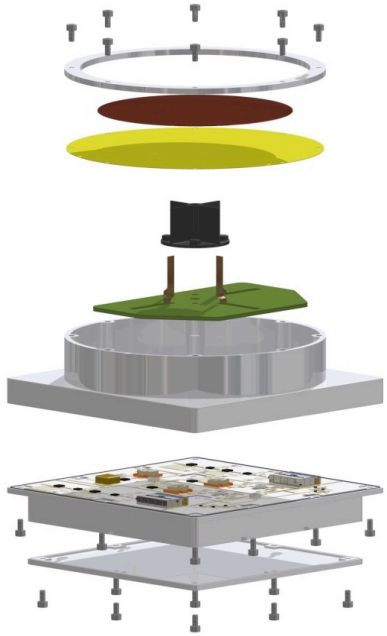
Innovation for new Applications – 2D steering antenna

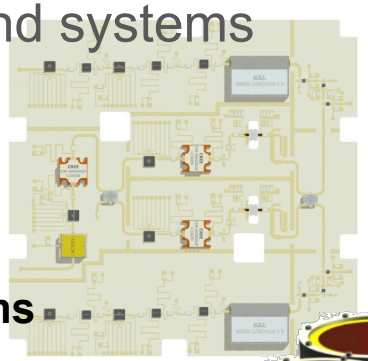
- 2D steering L-band phased array requires commandable control of every radiating element using "One-per-Element" technology

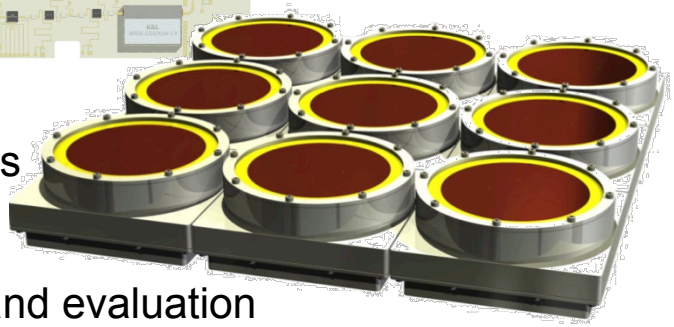
- Project Objective

to establish the technical and financial feasibility of a radiating element building block of an L-band radar with electronic beam steering in excess of ±30º in both elevation & azimuth enabling new SAR modes

→ disruptive & radical capability for L-band systems







- Main Technology Developments
  - individually commandable, phase and gain controllable, radiating active modules, enabling simultaneous propagation of **multiple (az) beams** and **Faraday Rotation pre-compensation**

- Current Status: detailed design progressed, budgets derived, antenna architecture developed, parts evaluated

- Future Plans: prototype build, module level testing and evaluation future funding route TBD

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Drivers of "innovative design"

Thanks for your attention

and

any questions?

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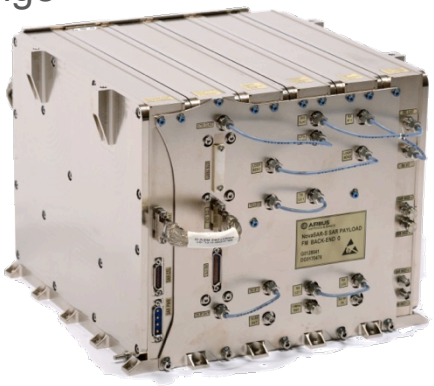
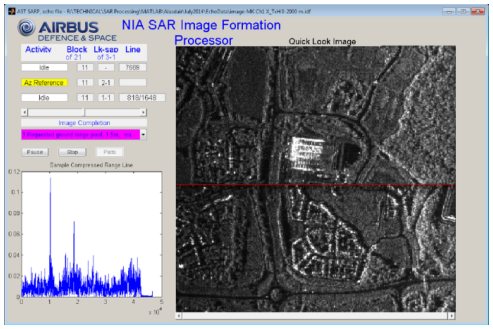
Excelsior Low Cost SAR Payload

Technical Approach

Maximise re-use of many NovaSAR-S developments :

- **NIA Back-End** (with some modifications for change of radar band and bandwidth)
- **Front-End Architecture**, Control scheme and charge control / RBU control circuitry
- **SAR Planning Utility** for payload operation
- Image Formation Processor





Key changes :

- Use **waveguide radiators** to keep loss acceptably low at X-Band (cannot use microstrip/coax)
- Need more elevation phase centres than for S-Band to **control elevation grating lobes**
- **Reduce test effort** by integrating PCU, RBU and Transmit Unit... a Phase Centre Equipment (PCE)
- **Payload is a single assembly** (easier platform integration with less payload harness disturbance)
- **Easy access** to all electronic units after integration with platform, for ease of maintenance
- Centre of mass is well positioned
- Good thermal paths are available to platform and/or deep space