

ASAR to NovaSAR – the Industrial Story

Sept 2012

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All the space you need

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Topics

■ Technology

- SAR instruments development path
- What it really means

■ Innovation

- Airborne demonstrator
- NovaSAR

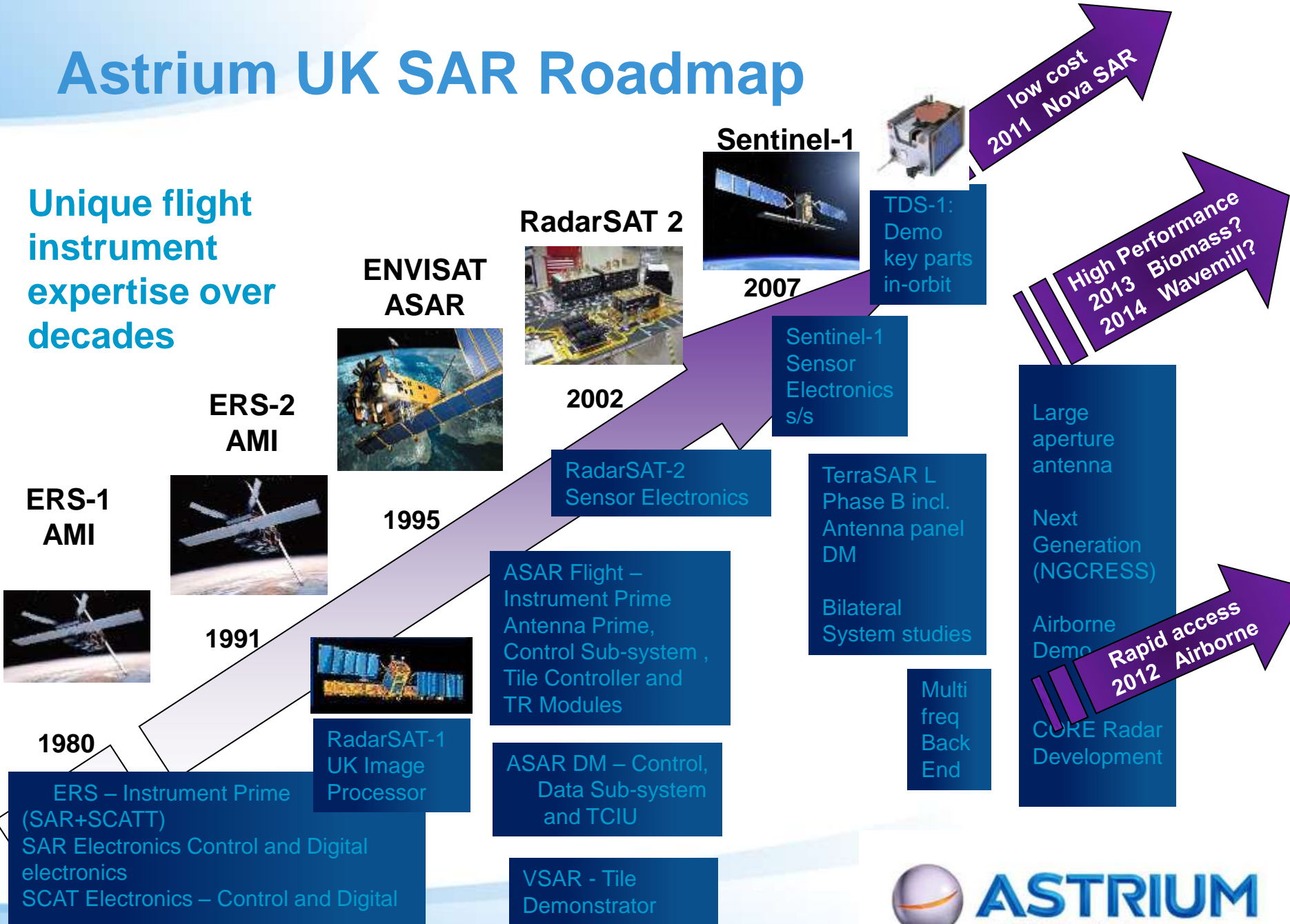
■ Value

- Past/present
- Future



Astrium UK SAR Roadmap

Unique flight instrument expertise over decades

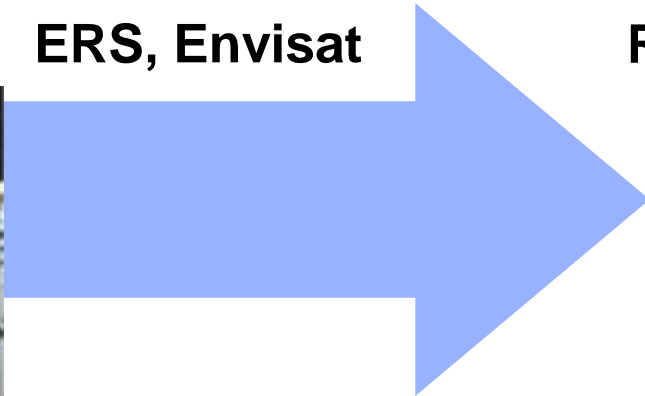


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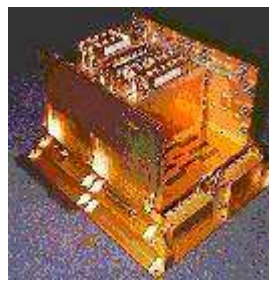
Technology Development: Central Electronics

- Surface Area 2m²
- Mass 120 kg
- Power 270 watts

ERS, Envisat



Radarsat2

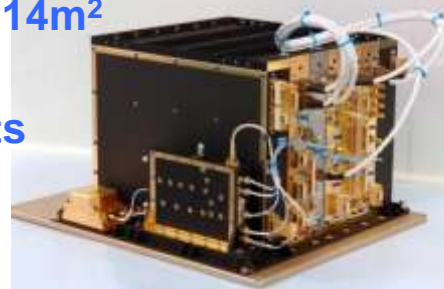


- Surface Area 0.2m²
- Mass 35 kg
- Power 200 watts



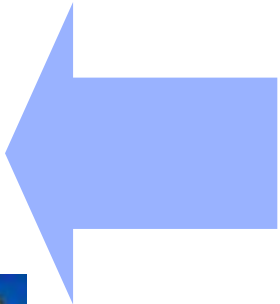
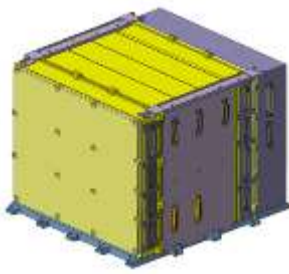
Sentinel-1

- Surface Area 0.14m²
- Mass 20 kg
- Power 140 watts



NIA/NovaSAR

- Surface Area 0.1m²
- Mass 15 kg
- Power 65 watts



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Evolution – what it really means

- **Towards NovaSAR: Surface area, mass, power**
 - Smaller spacecraft, lower cost, quicker
 - Cheaper launch, scope for multiple missions / constellations
 - Increased capability despite miniaturisation
 - Onboard processing for “analyst-ready” data
 - Better quality imagery
- **High performance: BIOMASS (EE7?), Wavemill (EE9?)**
 - Skills & capacity for new frequencies e.g. P band
 - New concepts including multi-antenna systems
- **Opens up more applications & end users**
 - Operational & commercial, e.g. maritime, security...
 - New science e.g. Biomass carbon, Wind/wave/current...



ASAR to NovaSAR – the Industrial Story

- Technology
- Innovation
 - Airborne demonstrator
 - NovaSAR
- Value



Airborne SAR Demonstrator

- Demonstrator developed by Astrium over the last decade:
 - designed and built under UK government contract and Astrium R&D
 - system/instrument exercised on extensive flight trials campaigns
 - has been an important tool as a radar test bed to provide support to SAR research and development
 - SAR image processor developed to evaluate acquired imagery
- Key features of the design:
 - software-definable radar electronics
 - current implementation comprises up to 3 simultaneous frequencies
 - X-band (9.5-10.7GHz); S-band (3.1-3.3GHz); Low band (100-1300MHz)
 - with provision for any additional band to be added (C, Ku-Band)
 - integrated X+S-band antenna assembly on gimbal providing pan/tilt
 - one antenna phase centre – mechanical steering to bore-sight direction
 - 100W peak RF power
- Sensor available for exploitation by academics, agencies, research institutions and commercial customers



Airborne SAR demonstrator configurations / heritage

2004 Aircraft Fit



**Midi tiles + interferometry
+ polarimetry: 215MHz config**

2004 - 2007



**Central
Electronics
215 MHz
configuration**

2005 Aircraft Fit



**Hog horn antenna
+ polarimetry
0.215 - 1.5 GHz config**



**Central
Electronics
Wide band
Multi frequency
configuration**

2007



Front end wide X-band



2008 Aircraft fit



2012 Aircraft certification

S-Band Quad Polar



X-Band Quad Polar



Langstone Harbour, Portsmouth

- For more details, contact Geoff.Burbidge@astrium.eads.net
 - In the audience...

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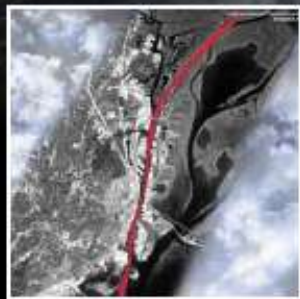
NovaSAR

- A new concept in low-cost radar missions
 - New application of technologies, arising from earlier developments
 - Novel payload design on a small platform, new price/performance point
 - Different approach to design philosophy & procurement processes
 - Smaller antenna, FPGAs, move to GaN devices (S band available now, higher bands in future), small & multiskilled team
 - Lower parts quality, outsourcing manufacturing to a local company
 - New industrial partnerships & funding approach
 - SSTL prime, Astrium payload
 - Wider supply chain of UK companies, several new to space sector
 - Kick-start money from UKSA multiplied several times by EADS funding
- Progress
 - Working demonstrator 2011 (inverse imager)
 - Long lead items started 2012, EQM also
 - TechDemoSat-1 will fly key parts in 2013 for space heritage
 - SSTL marketing the concept to potential customers



NovaSAR-S

the small satellite
approach to Synthetic
Aperture Radar



A new benchmark in affordability and performance
for responsive spaceborne radar



NovaSAR-S
represents an
evolutionary step
for SAR systems



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Medium resolution applications

Flooding

NovaSAR-S is particularly suitable for rapid and large scale flood assessment when optical satellites are limited due to cloud cover. Flooded areas are easily detected by S-band SAR and can be highlighted on standard maps using change detection techniques.

Disaster Monitoring

NovaSAR-S will provide rapid response imagery to support disaster relief planning and operations as well as damage assessment.

Forestry

Spaceborne SAR is well suited to detailed forestry assessments since a large proportion of the world's forests are found in tropical areas where cloud cover is prevalent and in higher latitudes with low illumination during winter months.

Maritime

- NovaSAR-S is equipped with a super wide 750 km maritime mode for ship detection across oceans.
- Conventional SAR modes can be used to assess particular targets in more detail.
- Ship wake detection can be used to determine speed and heading.
- ScanSAR modes will detect oil spill in coastal areas and open ocean.
- Combining SAR and AIS data will provide additional information for shipping, fishing and customs authorities.



S-band River

Crop monitoring and classification

NovaSAR-S supports agricultural applications including classification of crop type, mapping agricultural land, assessing crop condition and moisture content.



NovaSAR payload demonstration of crop classification



Ice Monitoring

NovaSAR-S will monitor large areas of ice formation in polar latitudes where there are long periods of darkness during the winter months.

NovaSAR - A new benchmark in affordability and performance

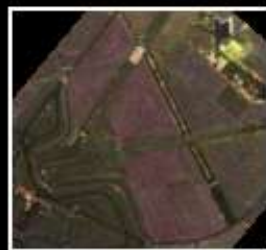
SSTL has been delivering small satellite missions for more than 30 years – longer than anyone else in the world – giving us the experience to justify our reputation as the world's premier provider of operational and commercial satellite programmes. SSTL designs, manufactures and operates high performance satellites and ground systems for a fraction of the price normally associated with space missions, with over 400 staff working on turnkey satellite platforms, space proven satellite subsystems and optical instruments.



S-band for truly low cost SAR capability

Our applications driven approach has resulted in a SAR system which is truly low cost. NovaSAR-S is compatible with low cost launches, supports flexible imaging modes, provides attractive imaging throughput, and is supported by a development programme that includes ground and airborne demonstrators.

Airfield S-band image comparison with optical



S-band



© Google Earth (optical)



Reliable SAR capability

NovaSAR-S combines SSTL's flight proven spacecraft subsystems with an imaging payload that has been developed by an accomplished spaceborne SAR team at Astrium UK, fusing heritage SSTL-300 avionics with state of the art S-band solid state power amplifier technology to achieve impressive imaging performance. Major milestones completed include:

- Airborne trials validating S-band imagery
- Spacecraft Preliminary Design Review
- Payload demonstration to produce inverse SAR image of International Space Station
- Successful demonstration of avionics suite currently operational onboard NigeriaSat-2

An airborne demonstrator has been tested to validate the payload chain. In the same trial S-band data was shown to compare well with X-band SAR data products.

Flight trials show that S-band is comparable with X-band

Pembroke River image comparison between optical and SAR



S-band

© Google Earth (optical)

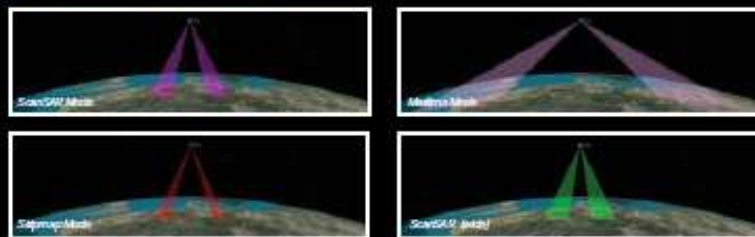
Maritime use: Shipping clearly detectable in Pembroke dock



S-band

© Google Earth (optical)

Highly flexible modes of operation



Modes	Typical Swath width	Spatial resolution	Incidence angle	Number of looks	Ambiguity ratio	Sensitivity
ScanSAR	100 km	20 m	16-30 degs.	4	< 16dB	< 18dB
Maritime Surveillance	750 km	30 m	48-73 degs.	2	< 18dB (Range)	< 12dB
Stripmap	15-20 km	6 m	16-34 degs.	3.7	< 16dB	< 17.5dB
ScanSAR (wide)	150 km	30 m	15-31 degs.	4	< 16dB	< 19dB

Resolving Imaging Modes (based on 100km swath)

Regular revisits

The mission is designed for several Polar or Equatorial orbits depending on the target area of interest. A single satellite using the fine resolution strip map mode can return to the same place anywhere on the globe twice a week. Similarly, a constellation of three satellites can provide maritime surveillance of the same area every few hours.

Global NovaSAR-S average revisit times in days

Mode	Polar Orbit (SSO LRAM)		Equatorial Orbit (16°)	
	1 satellite	3 satellites	1 satellite	3 satellites
ScanSAR	4.4	1.5	1.3	0.4
Maritime	0.9	0.3	0.5	0.2
Stripmap	3.2	1.1	0.9	0.3
ScanSAR (w)	3.7	1.2	1.0	0.3

NovaSAR-S supports impressive imaging capacity

Not only does NovaSAR-S support flexible modes of operation but it also achieves an impressive volume of image data.

Minimum average daily imaging throughput per satellite	
Mode	10 ⁶ km ² per day
ScanSAR	1.2
Maritime	0.0
Stripmap	0.4
ScanSAR (w)	1.0

Multi-polarisation image products

The baseline payload can be operated in any of the four standard polarimetric configurations (HH, VV, HV or VH). Image products supported may contain single, dual or tri-polarimetric information.



Tri-polar

Single-polar

Zoomed-in resolution with Bistatic-reflectionable

NovaSAR-S Specification	
Imaging frequency band	S-band (3.1-3.3GHz)
No. of phase centres	18
Peak RF power	1.8kW
Design Lifetime	7 years
Mass	<400kg
Lead time	24 months (KO to Flight Readiness Review)
Antenna	Microstrip patch phased array (3m x 1m)
Imaging polarisations	Single, dual or tri-polar (HH, HV, VH, VV)
Optimum orbit	580 km (SSO or low Inclination Equatorial orbit)
Propulsion system	Xenon
Payload duty cycle	At least 2min per orbit (multiple images or single image >800km long)
Payload data memory	32GBytes
Downlink rate	105Mbps
TTC frequency band	S-band (2025-2110MHz, 2200-2290MHz)
Downlink frequency band	X-band (8.025-8.4GHz)

ASAR to NovaSAR – the Industrial Story

- Technology
- Innovation
- Value
 - Past/present
 - Future



ASAR to NovaSAR – the Industrial Story

■ Growth benefits to the UK economy: Space Segment

‘80s: ERS1, ERS2 - AMI & ATSR; SAR algorithms €69M

■ Led directly to...

‘90s: ENVISAT – prime, ASAR, AATSR, other €950M

■ And in turn led to:

‘00s: RadarSat, Sentinel 1 €75M

■ Thence Govt. investment in NovaSAR €25M

Leverages industry investment in NovaSAR €150M

■ With export potential for constellations €??M

■ Creates lead position for future Explorer missions... BIOMASS

CoReH2O

WaveMill



ASAR to NovaSAR – the Industrial Story

■ Growth benefits to the UK economy: Ground Segment

‘90s: ERS PAF, ENVISAT PAC €50M

■ Led directly to...

Follow-on & spin-off work €10M

■ And in turn led to:

RadarSat data processor €2M

Plus export ground segment & tech transfer €20M

■ Thence NovaSAR processor €?M

■ Shows beneficial linkage of upstream to downstream



ASAR to NovaSAR – the Industrial Story

- Growth benefits to the UK economy: Applications
 - Upstream technology developments can stimulate downstream applications
 - Shorten time to market, improve the innovation cycle
 - More missions means more data, new frequencies and techniques offer new insights
 - Scope for user pull-through of desired features in future instruments
 - Increases volume of existing applications, enables new ones, allows transitioning of 'research grade' apps to operational status
 - SAR applications development activities have been proposed as part of Catapult
 - Studies* show 4:1 jobs multiplier effect to the economy overall
 - Development of in-house expertise
 - Technology spin-offs to other areas
 - Benefits to other downstream industry
- The Case for Space: The Impact of Space Derived Services and Data Final Report - July 2009
Undertaken by oxford economics commissioned by South East England Development Agency



ASAR to NovaSAR – the Industrial Story

■ Growth benefits to the UK economy: Summary

- Past UK subscriptions to EOEP have established some fundamental capabilities with UK industry
 - prime contractor skills, systems engineering, mechanical systems, structural, thermal and propulsion
 - a wide range of instrument and platform sub-systems
- UK technology can be world leading whilst allowing key science objectives to be met
 - Future opportunities: implement Explorer 7, leading ideas for Explorer 9
 - Additional activities including long term data access, calibration etc.
- Studies show 4:1 jobs multiplier effect to the economy overall
- And all this is just for radar – other areas in EOEP over the years will show the same dynamic...



Thank you



Polarimetric Airborne SAR Imagery of South Wales
Acquired by Astrium UK Airborne SAR Demonstrator
on July 28th 2010 from 10,000ft through total cloud cover.

Locations : Llanrhidian Sands (Gower), Milford Haven and Port Talbot

