

CEOI 5th and 6th Open Calls Final Review

Level 1 On-Board Processing for Squinted SAR

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BMA House, London
20 March 2013

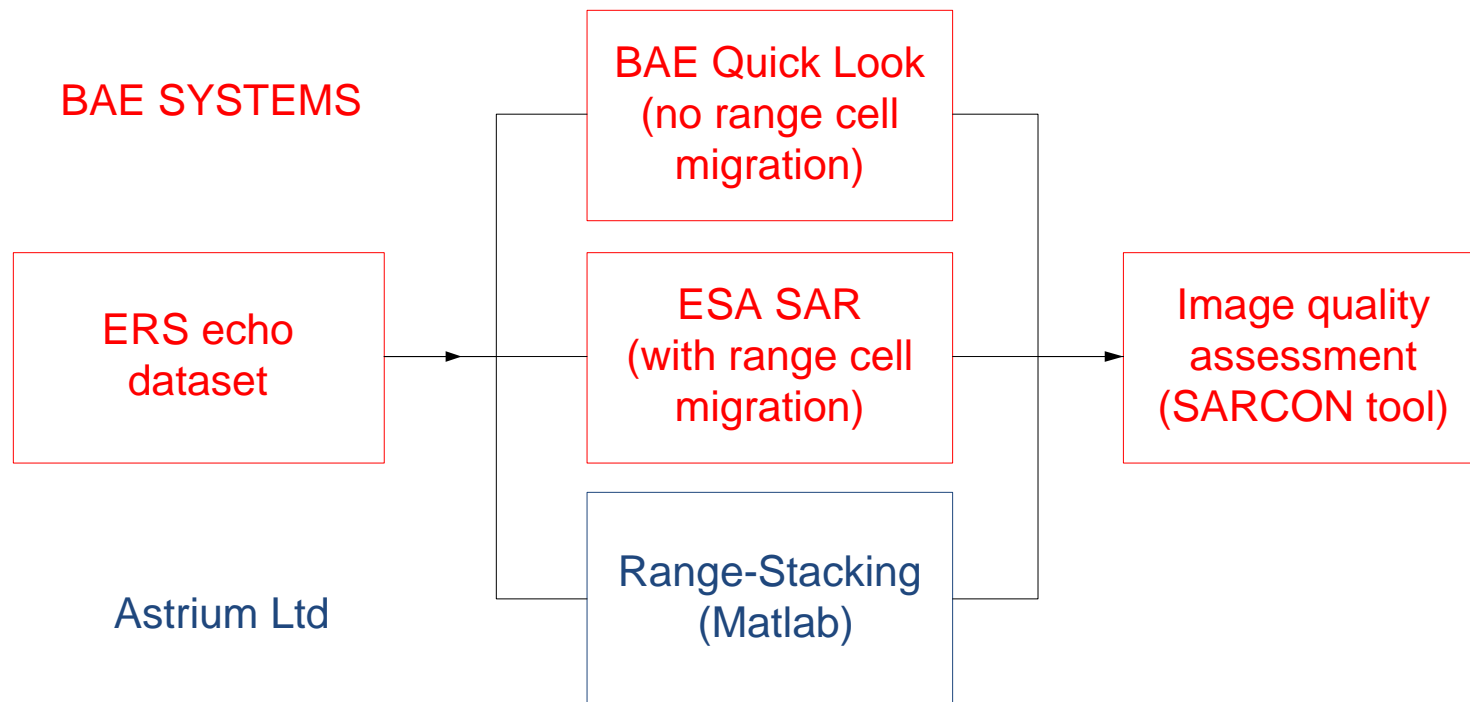
Project Introduction (1 of 2)

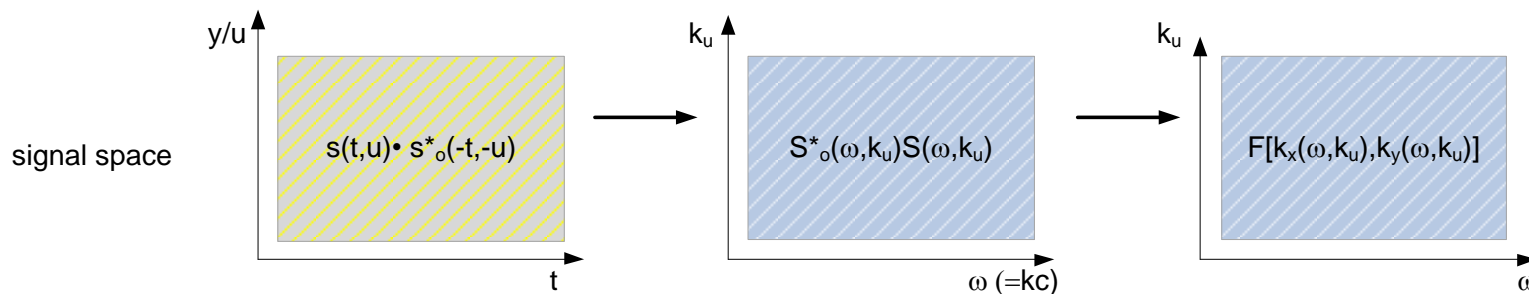
- In conventional spaceborne SAR, Level 1 products are generated in ground segment:
 - Detected SAR images (intensity)
 - Complex images preserving phase for interferometric products
 - Interest in generating SAR Level 1 products on board the spacecraft
 - Rationale
 - Real-time dissemination of imagery direct to users
 - met-ocean products for ship navigation, offshore engineering (including gas & oil platforms) and weather forecasting
 - sea-ice products for navigation
 - humanitarian aid and disaster monitoring (earthquakes, floods, forest fires, oil spills)
 - Data compression (mass memory, TM bandwidth constraints)
 - *Wavemill* oceanographic SAR (squinted system)
 - planetary missions
- ⇒ Develop SAR Level 1 algorithm in form suitable for flight processor

Project Introduction (2 of 2)

- **Astrium Ltd**
 - Techniques and technologies for on-board processing
 - Acquired in telecoms applications, applied to SAR Level 1 processing
 - CEOI 5th call activity: MATLAB algorithm
 - Stephen Brown, Kehinde Latunde-Dada, Alex Wishart
- **BAE SYSTEMS ATC**
 - SAR Level 1 image processing and commercial applications
 - CEOI 5th call activity: echo dataset preparation and image quality analysis
 - Steven Blythe, Trevor Macklin, Peter Meadows
- **Team worked together on CEOI 4th Call study on SAR Level 1 OBP**
 - Focus on range, azimuth compression in range-Doppler algorithm
- **5th Call Study extends this work to general case, which includes squint**

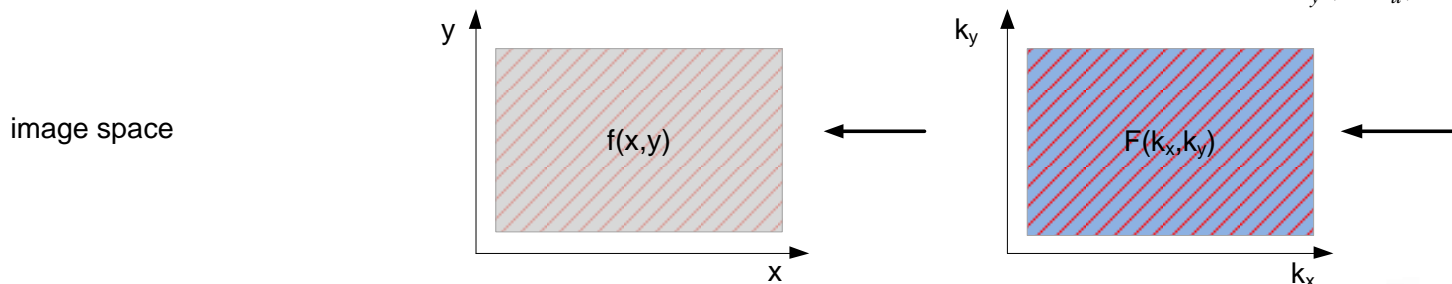
Technical Report (1 of 5)





$$k_x(\omega, k_u) = \sqrt{4k^2 - k_u^2}$$

$$k_y(\omega, k_u) = k_u$$



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- Image results for ERS-2 Greenland scene (acquired 21st March 2011)
 - Measure azimuth offset: difference between azimuth positions of distinctive features at near range (left) and far range (right).
 - Astrium-processed image at 4x coarser spatial resolution (range) – positions of features agree with ESA-processed image.
 - BAE-processed quick-look image omits the correction for range cell migration: some features appear displaced relative to the other two images.
 - ESA-processed image includes range cell migration.

Astrium Image



BAE quick-look Image



ESA Image

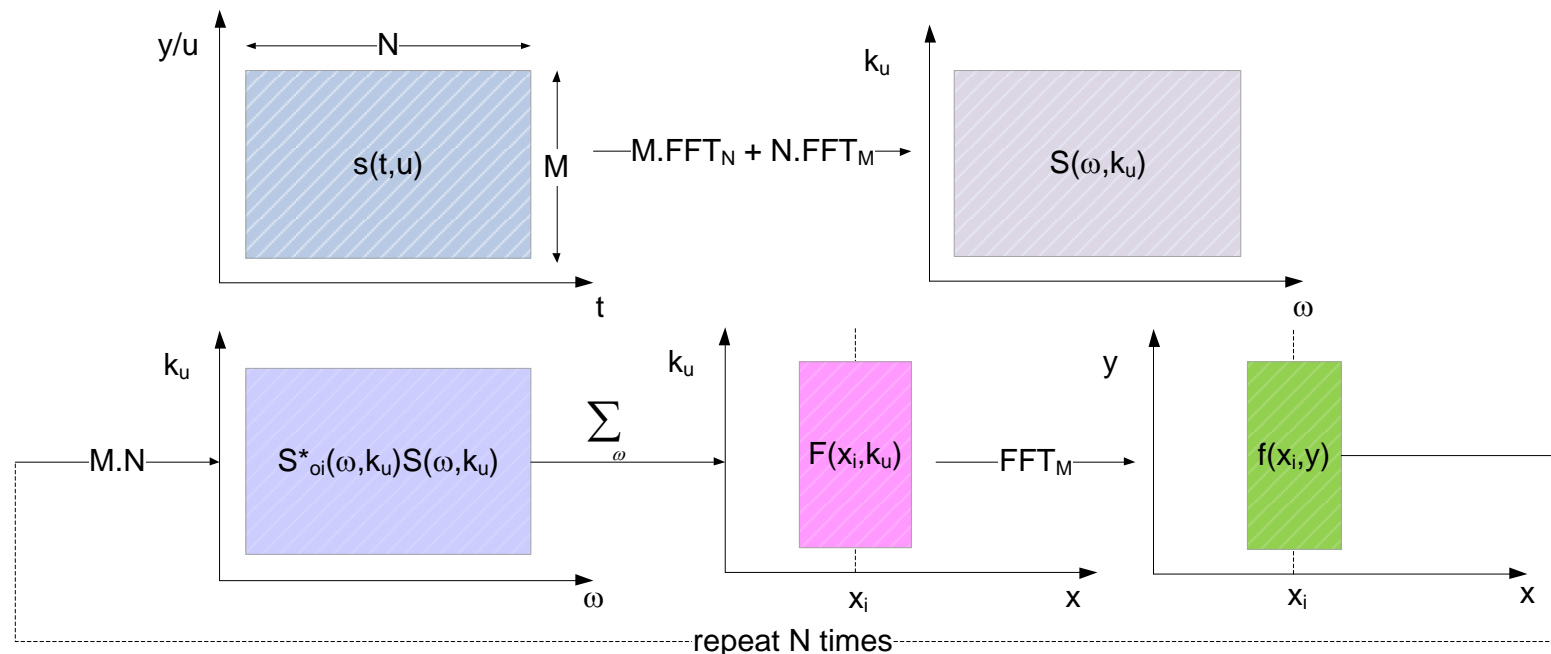


Technical Report (4 of 5)

- Measured azimuth offsets between features at near and far range show that range cell migration has been successfully applied to the Astrium-processed image.
 - Results confirmed on 3 ERS-2 SAR images, including one case where there is 1° squint
 - Summary of measured azimuth offsets (two pairs of features are measured on each scene):

Image	Notes	Astrium	ESA	BAE
Greenland 21 Mar 2011	Astrium at 4x resolution.	3000 m 2050 m	3410 m 2200 m	5010 m 3810 m
Flevoland 13 Dec 1995	Astrium at full resolution.	333 m 554 m	324 m 550 m	279 m 418 m
Flevoland 18 Apr 2001	1° squint. Astrium at 4 x resolution.	2890 m 3340 m	2640 m 3160 m	1090 m 1760 m

Technical Report (5 of 5)



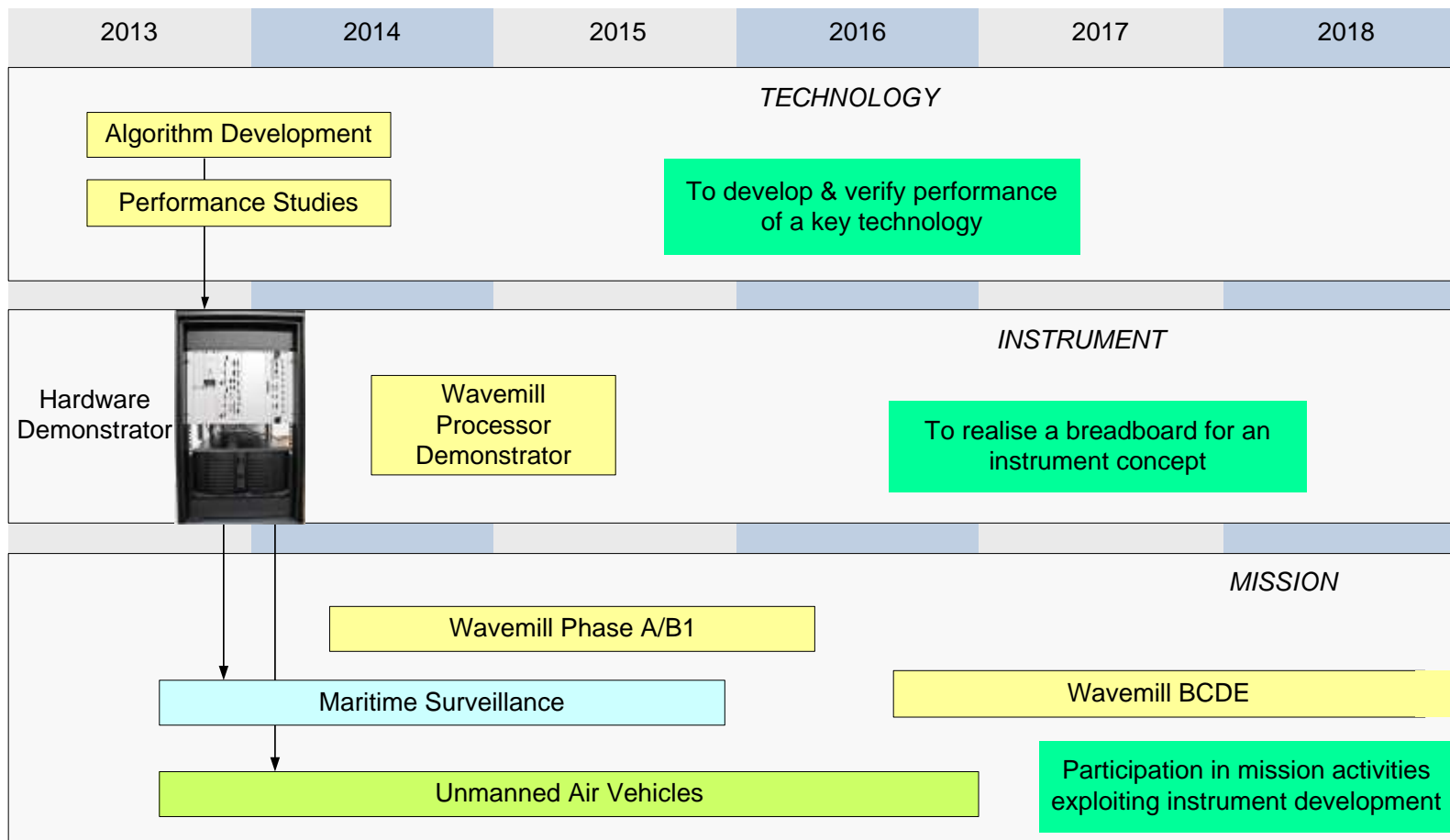
$$\frac{M \cdot N [2 \log_2 M + \log_2 N + N]}{M \cdot PRI} \approx PRF \cdot N^2$$

- PRF = 2000 Hz, N = 2000 pixels \Rightarrow multiplications/sec $\sim 8 \cdot 10^9$
- Virtex 5 FPGA multiplications/sec $\sim 5 \cdot 10^{10}$
- ASIC (180 nm) 0.1 nJ/multiplication $\Rightarrow 10^{10}$ multiplications/sec ~ 1 Watt

Achievements and Positioning (1 of 1)

- Insight into 'wavefront reconstruction' approach to SAR imaging
 - Places 'conventional' algorithms in context
- Developed methodology for systematic performance analysis
 - Initially applied for modest squint
 - Further work would include IR characterisation, greater degree of squint
- First assessment of on-board processing hardware resources
- Strengthened Astrium Ltd/BAE SYSTEMS teaming
 - Complementary expertise, enhances UK capability
- Presentations
 - NCEO CEOI Conference, Nottingham, September 2012
 - CEOI Knowledge Exchange Event, London, January 2013

Roadmap (1 of 1)



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