AirSAR – Multi-frequency SAR data gathering from a NERC airborne survey platform

David Hall
June 2014

AIRBUS
DEFENCE & SPACE

AirSAR = an Airborne Synthetic Aperture Radar Demonstrator Facility

*A collaborative project between **The Satellite Applications Catapult**, **Airbus D&S,** and **NERC***

NERC ARSF Dornier 228 in Greenland, Summer 2013

NERC Twin Otter in Cambridge, Spring 2014

Twin Otter radar fit, Spring 2014

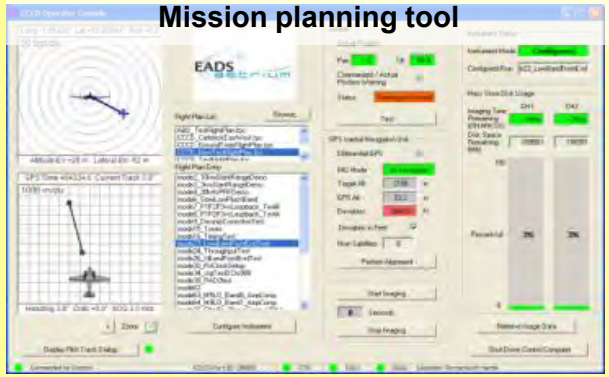
S-band front-end electronics

Astrium X+S-band Airborne SAR Demonstrator Instrument

X-band front-end electronics

S-band + X-band antenna assembly

Mission planning tool



Operator control console

Objectives of the AirSAR project

- To provide UK scientists with access to a high resolution, multi-frequency, multi-polarisation SAR facility producing co-time and co-located data streams
- To ensure that the facility can be made available on a regular year by year basis to create confidence that long term temporal effects can be studied
- To enable, in addition, the acquisition of co-located data streams from lidar, multi-spectral, and hyper-spectral sensors (but only) in *near* real time (minutes apart)
- To provide data sets representative of those that will be acquired from the NovaSAR-S satellite

Dornier 228 (G-ENVR)

Twin Otter (VP-FAZ)

AIRBUS DEFENCE & SPACE

Applications and science interests for the AirSAR project

- Marine: including ship detection, ocean currents, oil slicks and pollution
- Forestry: canopy height, logging
- Agriculture: soil moisture, eco-system mapping, crop identification, rice crop monitoring in tropical locations
- Moorland: habitat monitoring, heathland burning,
- *InSAR*** : *archeology, slope stability*
- **NovaSAR**: preparation of representative data sets to support development of Applications

** *Not yet demonstrated. Processing techniques for repeat pass InSAR data sets are still under development.*

Dornier 228 (G-ENVR)

Twin Otter (VP-FAZ)

AIRBUS DEFENCE & SPACE

Calibration status of the AirSAR radar instrument

Maintenance of short term stability

- Ultra-stable reference oscillator
- Loop-back of phase and radiometric measurements before and after each data acquisition
- Reference chirp read-out
- Well characterised antenna with gain profile & cross-pol isolation carefully established (*still to be done*)
- Gimbal platform driven from GPS / INU system

Achievement of absolute radiometric calibration

- Inclusion of reference trihedral reflectors of known RCS within the data acquisition field of view

Dornier 228 (G-ENVR)

Twin Otter (VP-FAZ)

AIRBUS DEFENCE & SPACE

Planned data acquisition campaigns for the AirSAR radar instrument

Proving Flight 14 May: Tested all SAR operating modes defined for scheduled 26June demo flights

- imaging performed at altitudes of 10,000ft, 7,500ft, 4,500ft, 3,000ft, 2,500ft on E-W and W-E passes
- designated flight lines maintained within good tolerance – planned swaths acquired successfully

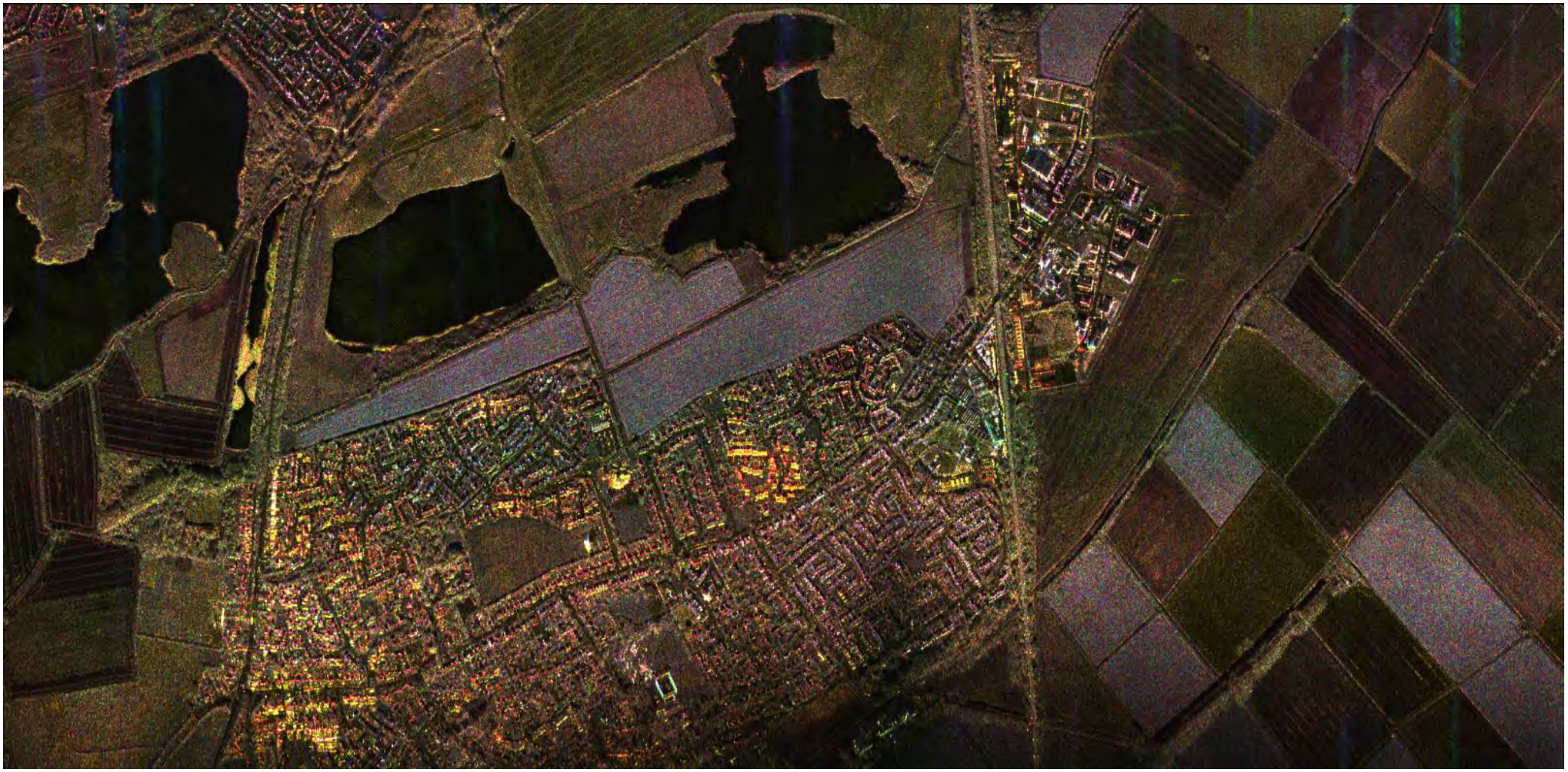
AIRBUS DEFENCE & SPACE

Acquired products (1, S-band)

S-band fully polarimetric, RGB composite

Red=HH, Green=VV, Blue=HV

Acquired products (1, X-band)



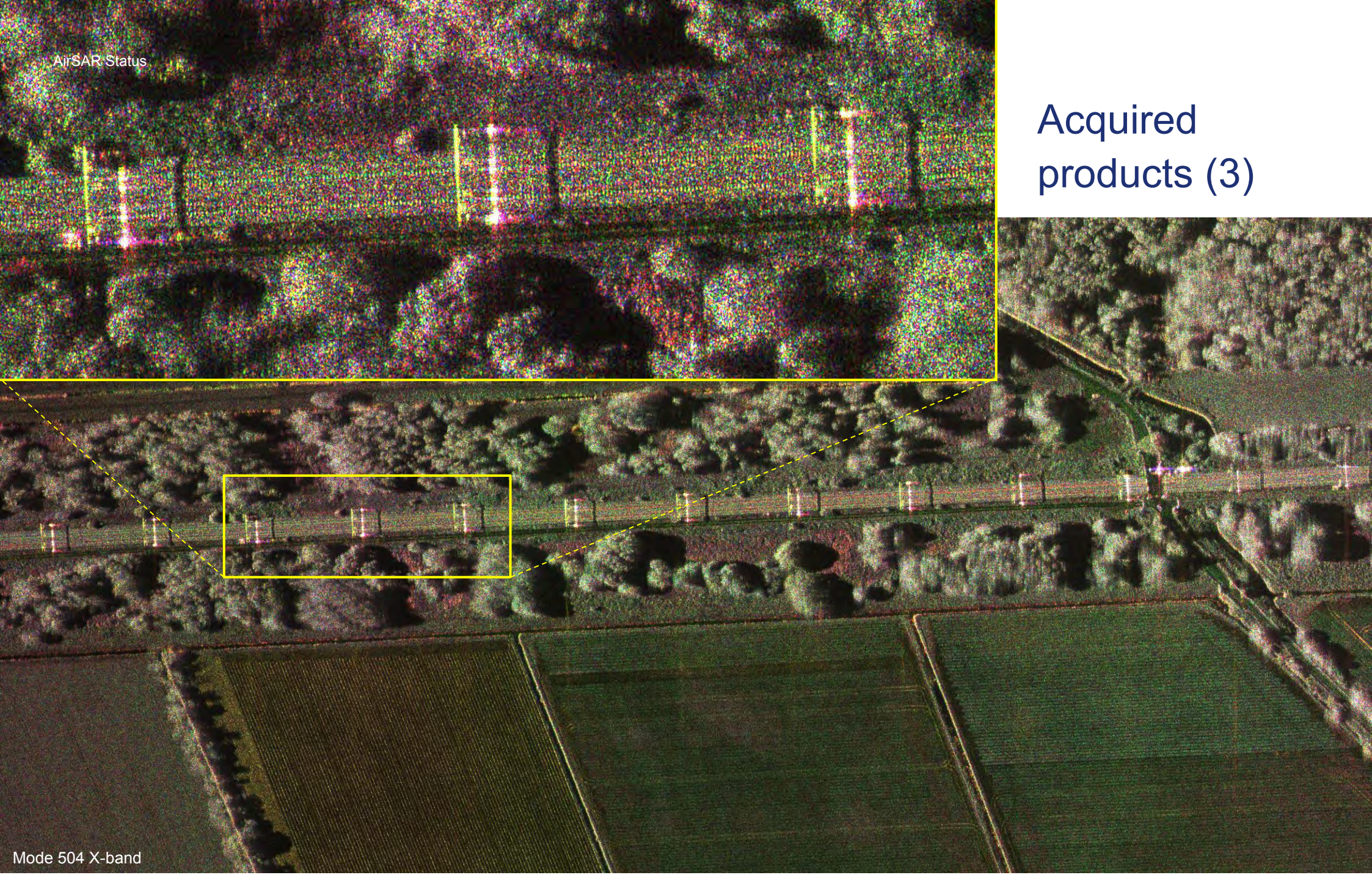
X-band fully polarimetric, RGB composite

Red=HH, Green=VV, Blue=HV

Acquired products (2)

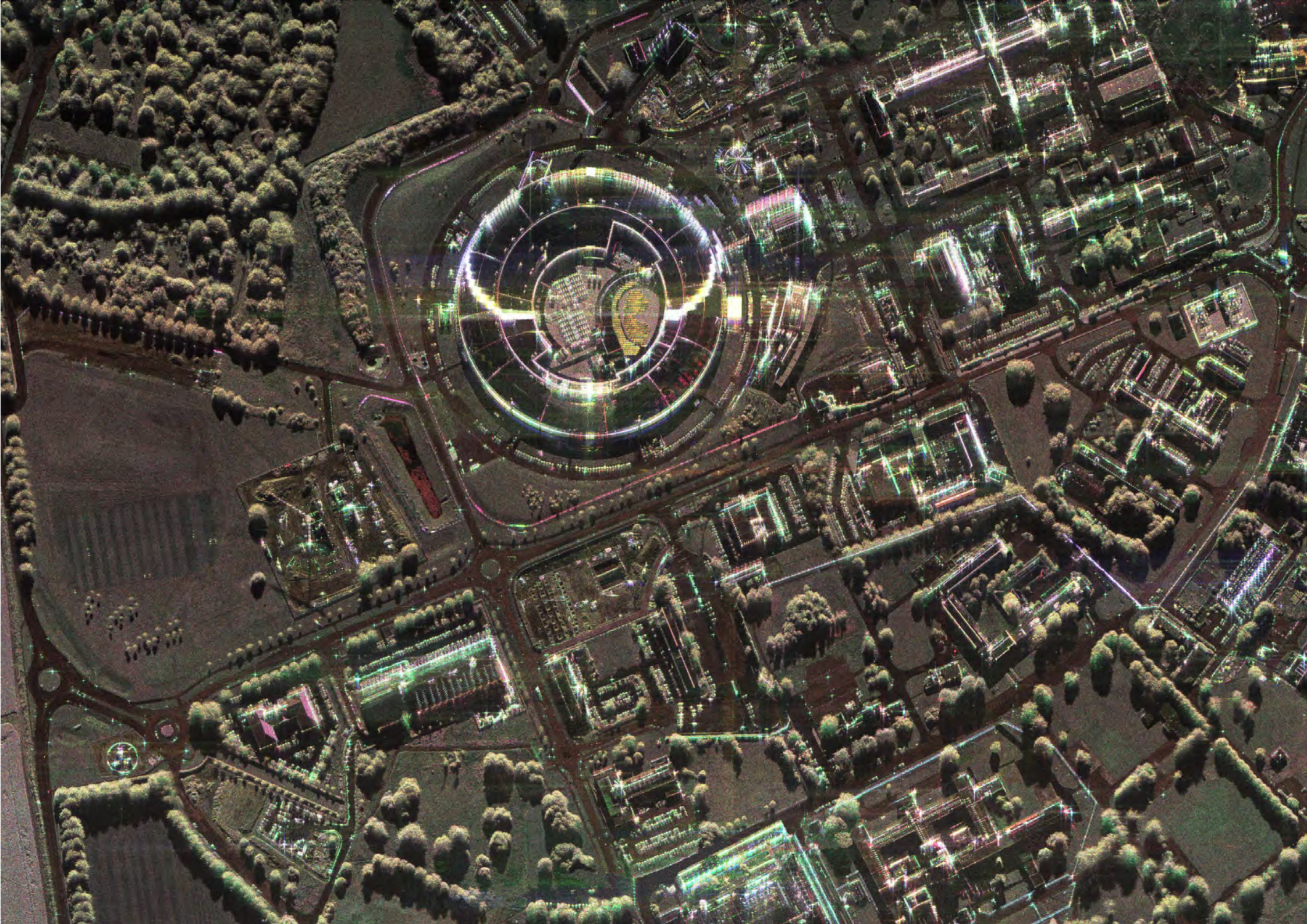
S-band fully polarimetric, RGB composite

Acquired products (3)



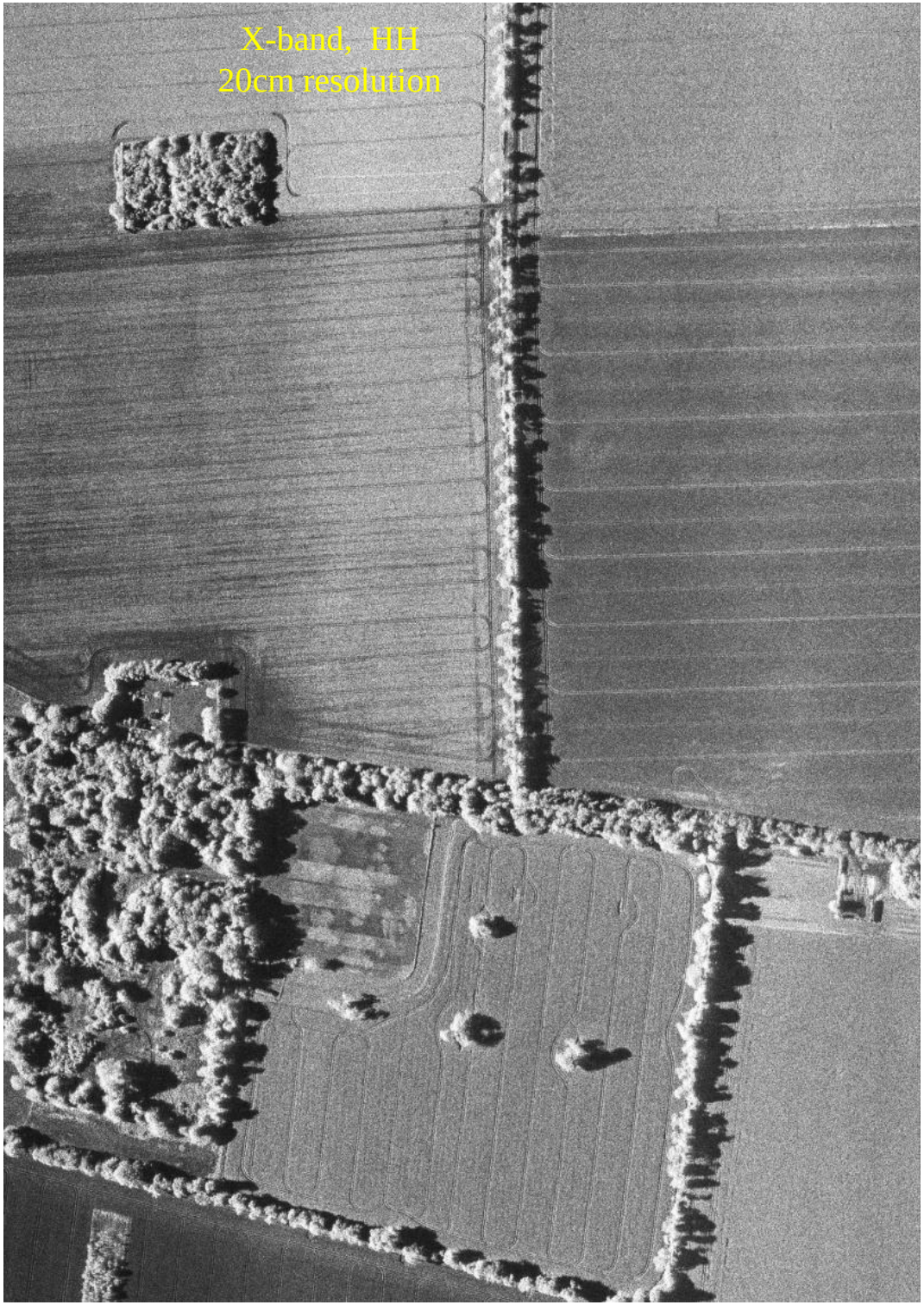
Harwell Science Park

Acquired Monday 23`rd June



Fields to the West of Harwell

Acquired Monday 23`rd June



Summary of the AirSAR facility

- **AirSAR is a facility that exists now to support UK science and UK scientists**
- **It will be available on a regular basis for the foreseeable future**
- **It can support Applications development**
- **Flying on the Twin Otter it can provide service during UK summer (Antarctic winter period)**
- **En route to the Antarctic it can potentially be diverted to image West Atlantic equatorial regions**
- **With additional funding, it can be implemented on NERC's Dornier 228,** *G-ENVR*

Twin Otter (VP-FAZ)

Dornier 228 (G-ENVR)

AIRBUS DEFENCE & SPACE

Principal AirSAR Contacts

- **NERC – ARSF**

  Gary Llewellyn 01452 859945

  gaew@nerc.ac.uk

- **Satellite Applications Catapult**

  Nick Veck 01235 567999

  Nick.Veck@sa.catapult.org.uk

- **Airbus Defence & Space**

  Geoff Burbidge 02392 704999

  geoff.burbidge@astrium.eads.net

  Martin Cohen 02392 705481

  martin.cohen@astrium.eads.net

AIRBUS DEFENCE & SPACE

Supplementary Information

Radar System characteristics

- Fundamental operation: programmable / dual frequency channel / coherent quad polar / deramp
- Characteristics of X-band channel
  - Antenna beam (along track) 5.6 º
  - Antenna beam (across track) 23.3 º
  - Frequency band ** 9350MHz - 10650MHz (set by drive electronics)
  - Swath widths ** 1km / 8km (selectable with chosen bandwidth)
  - Spatial resolution ** 0.15 m
  - Sensitivity ** NEσ0 < -30dB
  - Polarisation ** sequential, HH, HV, VV, VH
- Characteristics of S-band channel
  - Antenna beam (along track) 9.9 º
  - Antenna beam (across track) 28.7 º
  - Frequency band ** 3100MHz - 3300MHz (set by antenna bandwidth)
  - Swath widths ** 1km / 8km (selectable with chosen bandwidth)
  - Spatial resolution ** 1 - 2 m
  - Sensitivity ** NEσ0 < -30dB
  - Polarisation ** sequential, HH, HV, VV, VH
- Potential exists for a low frequency channel covering VHF to L-band

** *indicates User programmable / selectable*

AIRBUS DEFENCE & SPACE

Demonstration flight planning (1)

23 June – short flying day covering Oxfordshire, Wiltshire, North Hampshire
- AS14-08: WW
- AS14-12: RHS
- Imaging Harwell

24 June – longer day covering projects areas in Wiltshire, South Hampshire & IoW, Dorset
- AS14-21: Charmouth, Black Ven
- AS14-22: Cranborne, Avebury
- AS14-01: Portsmouth
- AS14-10: Sutton Farm
- AS14-08: Wytham, Savernake

25 June – fixed by planned logistics of ARL simulation, early start 07:30
- AS14-05: Isle of Wight
- AS14-21: Charmouth, Black Ven (repeat visit)

26 June – longest day, covering northern areas of North Yorshire and en route also Worcestershire
- AS14-15: Worcestershire
- AS14-17: Hollin Hill
- AS14-19: North York Moors, Peak district

Demonstration flight planning (2)

Demonstration flights to take place from ARSF facility at Staverton (Gloucester)

- w.b. 9 June: flight planning finalised; final dialogue with projects/users on logistics
  Noting that many projects will be conducting field work and setting up corner reflectors
- 19-20 June: Instrument installation on Twin Otter (VP-FAZ)
  Potential shakedown flight on 20 June (TBC)
- 23-26 June: SAR product acquisitions during Demonstration flights
  27 June potential contingency day
- w.b. 30 June: Initial data processing and release of priority data sets
- 7-26 July: Processing of acquired data sets
  Refinement of SAR processing parameters to maximise image quality
  Radiometric calibration of imagery
  Data processing and delivery to all projects in various formats

AIRBUS DEFENCE & SPACE

Demonstration flight planning (3)

Monday 23 June :

Run#	Run Name	mode
1	WW1	502
2	Harwell_SX	501
3	RHS.1	505
4	RHS.2	505
5	RHS.3	505
6	RHS.4	505
7	Harwell_X	504
8	WW2	502

Estimate 3 hours flying time

Tuesday 24 June :

Run#	Run Name	Mode
1	Charmouth1	502
2	BlackVen1	502
3	Cranborne1	502
4	Cranborne2	502
5	Ports1.1	233
6	Ports1.2	233
7	Ports1.3	231
8	SF3000.1	501
9	SF3000.2	501
10	SF3000.3	501
11	SF7500	502
12	Mar1	231
13	Mar2	231

Estimate 4 hours flying time

Wednesday 25 June :

Run#	Run Name	mode
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11	Charmouth1	502
12	BlackVen1	502

Estimate 4+ hours flying time

Thursday 26 June :

Run#	Run Name	mode
1	Crop1	501
2	Crop2	501
3	Crop3	501
4	Crop4	501
5	Crop5	501
6	Crop6	501
7	HH R1.S-band	502
8	HH R1.X-band	503
9	HH S2.West42.S	502
10	HH S2.West42.X	503
11	HH S.1 South	502
12	HH S.1 North	502
13	HH R2.S-band	502
14	HH R2.X-band	503
15	NYM.1	502
16	NYM.2	502
17	NYM.3	502
18	NYM.4	502
19	NYM.5	502
20	NYM.6	502
21	HH R3.S-band	502
22	HH R3.X-band	503
23	Peak	231
24	Crop7	501
25	Crop8	501
26	Crop9	501

Estimate 5+ hours flying time

Choice of modes dictated both by application requirements and by extent to which region of interest is in controlled airspace – constraints on operating altitude

Notes regarding run planning:

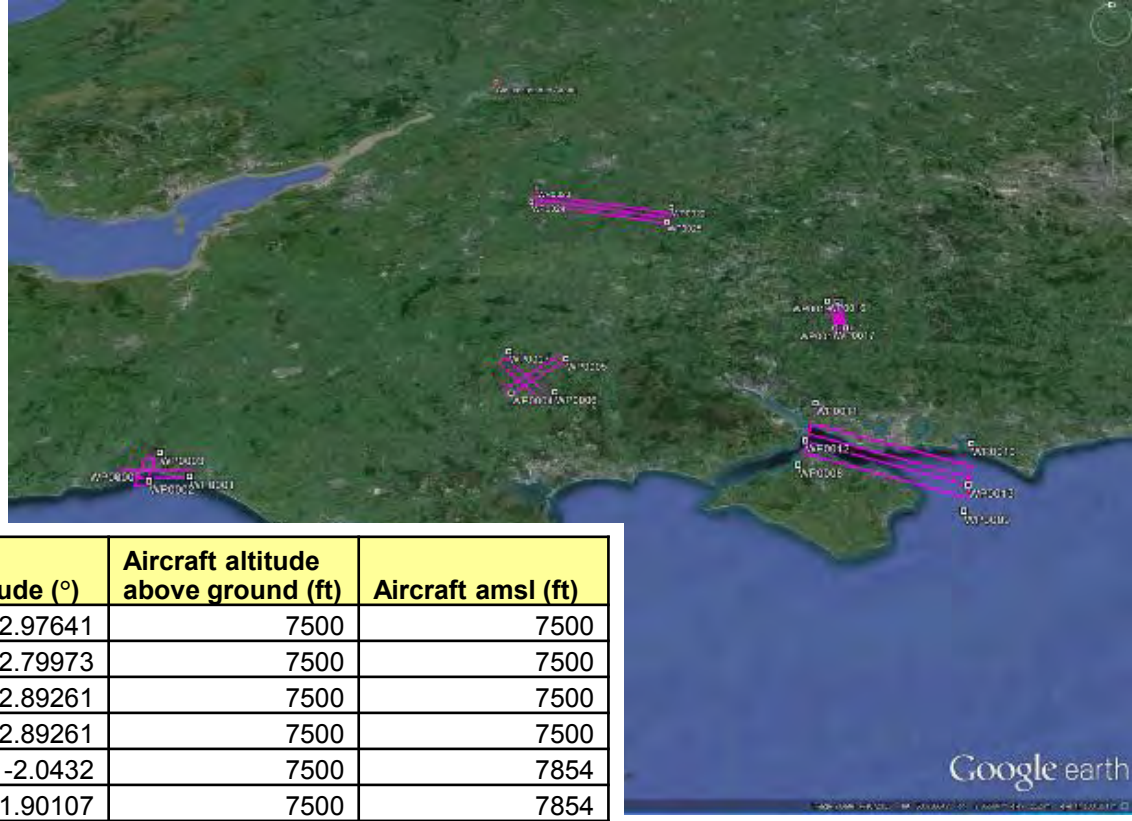
a) not including transit to run locations
b) not including calibration runs at Staverton (planned at end of day)
c) planning for monitoring of oil spill simulation still in work
d) final run order and mode selection to be confirmed in formally issued flight plan

AIRBUS DEFENCE & SPACE

Demonstration flight planning (4)

Example of flight planning for 24 June:

- run sequence
- start and end waypoints
- visualisation on Google Earth

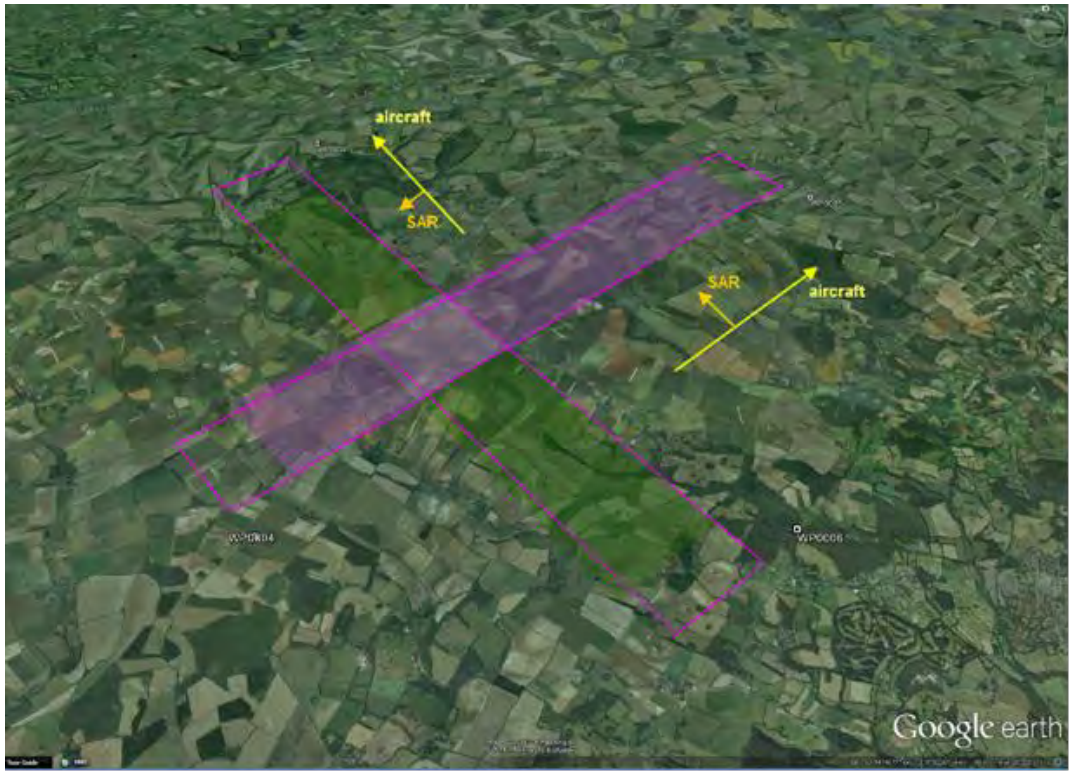


Run#	Run Name	mode
1	Charmouth1	502
2	BlackVen1	502
3	Cranborne1	502
4	Cranborne2	502
5	Ports1.1	233
6	Ports1.2	233
7	Ports1.3	231
8	SF3000.1	501
9	SF3000.2	501
10	SF3000.3	501
11	SF7500	502
12	Mar1	231
13	Mar2	231

Run Name	Latitude (°)	Longitude (°)	Aircraft altitude above ground (ft)	Aircraft amsl (ft)
Charmouth1 (502)	50.71326	-2.97641	7500	7500
Charmouth1 (502)	50.71326	-2.79973	7500	7500
BlackVen1 (502)	50.7042	-2.89261	7500	7500
BlackVen1 (502)	50.75998	-2.89261	7500	7500
Cranborne1 (502)	50.88715	-2.0432	7500	7854
Cranborne1 (502)	50.96601	-1.90107	7500	7854
Cranborne2 (502)	50.88844	-1.93001	7500	7854
Cranborne2 (502)	50.98348	-2.05487	7500	7854
Ports1.1 (233)	50.73475	-1.34435	10000	10000
Ports1.1 (233)	50.64611	-0.98445	10000	10000
Ports1.2 (233)	50.77601	-0.90548	10000	10000
Ports1.2 (233)	50.86329	-1.26543	10000	10000
Ports1.3 (231)	50.78372	-1.31347	10000	10000
Ports1.3 (231)	50.69459	-0.95198	10000	10000
SF3000.1 (501)	51.04126	-1.12056	3000	3358
SF3000.1 (501)	51.11349	-1.12056	3000	3358
SF3000.2 (501)	51.11349	-1.1587	3000	3358
SF3000.2 (501)	51.04126	-1.1587	3000	3358
SF3000.3 (501)	51.04126	-1.12991	3000	3358
SF3000.3 (501)	51.11349	-1.12991	3000	3358
SF7500 (502)	51.04126	-1.11623	7500	7858
SF7500 (502)	51.11349	-1.11623	7500	7858
Mar1 (231)	51.39868	-1.56644	10000	10525
Mar1 (231)	51.46665	-1.99503	10000	10525
Mar2 (231)	51.41702	-2.01243	10000	10591
Mar2 (231)	51.34946	-1.58645	10000	10591

AIRBUS DEFENCE & SPACE

Demonstration flight planning (5)



Cranborne1 / Cranborne2

Charmouth1 / BlackVen1 / Charmouth2 / BlackVen2

AIRBUS DEFENCE & SPACE

Demonstration flight planning (6)

Ports1.2

SF3000.2

AIRBUS DEFENCE & SPACE