WORLD METEOROLOGICAL ORGANIZATION

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OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS

INTER-PROGRAMME EXPERT TEAM ON SATELLITE UTILIZATION AND PRODUCTS

ITEM: 12

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WMO SPACE PROGRAMME ONLINE RESOURCES

OSCAR/Space v2.0

(Submitted by the Secretariat)

Summary and Purpose of Document

The document introduced the new features of OSCAR/Space Version 2.0 which went online on 25 September 2017, replacing the earlier version. It contains a proposed contribution of IPET-SUP to review content and functionality of OSCAR/Space database Version 2.0.

ACTION PROPOSED

The session is invited to provide guidance on:

a) The functionality of OSCAR/Space v2.0, especially the assessment of capabilities and the gap analysis;
b) The proposed management structure of OSCAR/Space v2.0.

WMO OSCAR/SPACE VERSION 2.0

1. INTRODUCTION

This paper introduces a new version of "OSCAR/Space", the space component of the Observing System Capability Analysis and Review on-line resource. This new version provides improved search capabilities, more accurate instrument status description, and contains a new instrument evaluation scheme based on an expert system approach.

The value of OSCAR/Space relies on a great extent on the collaboration of space agencies to provide detailed and current information on their systems. With the new version, a step is made towards a more collaborative resource with the possibility to involve expert groups in the review and continuous improvement of the instrument evaluation scheme.

2. OSCAR/SPACE OVERVIEW

2.1 OSCAR and OSCAR/Space

OSCAR (oscar.wmo.int) is comprised of the following components (Figure 1):

- OSCAR/Requirements is the repository of technology free observational user requirements recorded quantitatively for the WMO Application Areas. www.wmo-sat.info/oscar/observingrequirements

- OSCAR/Surface records WIGOS metadata (i.e. description of the observing platforms and instruments) for surface-based observing systems. It replaces WMO No. 9, Volume A. https://oscar.meteoswiss.ch/OSCAR/index.html. Developed in partnership with MeteoSwiss, it was deployed operationally on 2 May 2016.

- OSCAR/Space, which includes an inventory of satellite instruments, missions and programmes, and an assessment of the variables that the instruments have the potential to measure, is the subject of this document. (oscar.wmo.int/space)

Available since September 2012, OSCAR/Space currently records references and details of more than 900 instruments from more than 600 satellites. It is regularly updated with inputs from space agencies, including the reports to CGMS. OSCAR/Space is widely used, with more than 1000 visits per day in average from countries worldwide (see use statistics in the annex; note influence of major satellite user meetings). Users include space agencies, researchers, students, application centres, and consultants. OSCAR/Space is routinely feeding the "satellite status" on the CGMS and WMO websites. It is used as reference for reports, application planning, gap analysis, socio-economic benefit studies, frequency management, etc.

2.2 Satellite and instruments directory

Satellite details recorded in the OSCAR/Space database (see Figure 1) include for example the name of the satellite, its purpose, mass, power, orbit type, altitude, Equatorial Crossing Time (ECT) or orbit inclination or longitude, launch date, end date, status, telecommunication frequencies, and information on data access.

Following consultation with GSICS, details are also recorded on individual instrument status, including commissioning dates, and links to calibration information (see Figure 2).

Instrument details recorded in the database (see Figure 3) include for example the instrument name, purpose, mass, power, type, description, scan mode, resolution, field of view (FOV), coverage, status, and spectral characteristics.

2.3 Assessment of potential measurements

For each instrument, OSCAR/Space provides a “Tentative evaluation of measurements” listing the variables that can **typically** be retrieved, with a rough classification into five levels. Reciprocally, for each variable, the “Gap Analysis” view of OSCAR/Space provides a list of instruments that are potentially relevant to measure the said variable. Combined with programmatic information, this allows displaying time charts indicating when the measurements are potentially available, from which orbits, and with which expected quality, which is a basis for performing a gap analysis.

It is stressed that OSCAR/Space assesses “potential”, rather than “actual” instrument performance. This assessment is based on instrument specifications but does not take into account the real availability of data, or the instrument calibration accuracy. Furthermore, each sensor is assessed separately without considering the possible synergy of complementary sensor types (e.g. active & passive, or IR & MW), or of similar sensors to improve the sampling. For these reasons the output of OSCAR/Space should not be seen as an automatic “Gap Analysis”, but rather as a tool to assist experts in performing a Gap Analysis in the context of a critical review.

3. NEW FEATURES OF OSCAR/SPACE

3.1 New scheme for instrument –measurement mapping and evaluation

Maintaining an objective evaluation of hundreds of satellite sensors for hundreds of different variables (including Earth observation and space weather domains) is a challenge which has led to designing the new version described here.

The mapping between instruments and variables, with certain performance levels (from 1 to 5) is achieved in a simplified “expert system approach”, in two steps.

- First of all, for each variable we determine candidate instrument types, we identify performance-driving specifications and define “Rules” assigning to these specifications a certain performance level for this variable. These Rules are meant to be based on remote-sensing science considerations independently of any particular instrument, to ensure an objective process.
- In a second step, for each instrument, OSCAR/Space performs a compliance check to determine which rules are satisfied by the actual instrument specifications. The rating of the “best” satisfied rule gives the rating of the instrument for the given variable.

This new approach requires a significant amount of work to document the specifications of each instrument, but it has the advantage of being based on *explicit* and objective rules. These rules can be easily edited, they can be submitted to external reviews, thus providing more confidence than the “black-box” mapping used in the previous version of OSCAR/Space.

For this Variable	***With this type of instrument***	***If the following conditions are true***	***Then the relevance is***
Sea Surface Temperature	Microwave Radiometer	• >1 two-polarisations channels in 4-8 GHz • >0 multi-polarisation channel in 8-12 GHz	2. Very high
Solar wind velocity	Particle detector	• Detects protons, in 0-10 keV, • Over 2π solid angle, sun pointing • Energy spectral resolution <10% • Angular resolution <0.2π sr • Time resolution <10 s	1. Primary

Table 1: Example of rules for assessing relevance of instruments to measure specific variables.

3.2 Mission objectives and mission type analysis

As an alternative to the expert system analysis, the new version of OSCAR/Space provides a “simplified analysis” function, which simply considers the variables that are declared by the instrument provider as the primary, secondary or “opportunity” mission objectives of the instruments. This simplified approach allows to accommodate instruments for which the specifications are not fully documented, and which thus would not be selected by the rigorous expert approach.

A similar evaluation is made to classify instruments in pre-determined mission types.

In summary three kinds of “Gap Analysis” are available (See Figure 4):

- Gap analysis by variable, based on expert rules
- Gap analysis by variable, based on the declared mission objectives
- Gap analysis by type of instrument, comparing e.g. the plans to the “Vision”.

3.3 Instrument search

Each instrument being characterized by a set of searchable properties it enables powerful search/filter functions, and customized gap analysis. The list of 900+ instruments can be browsed in selecting certain instrument categories in a typology, certain spectral bands and orbit types.

3.4 Microwave sensor frequencies

Developments were also made recently to support the analysis of microwave sensor frequencies – in addition to the telecommunication frequencies - for frequency coordination purposes. (See Figure 5). This will be presented to SFCG-36.

4. TRANSITION TO OPERATIONAL STAGE

A proof of concept was developed in EXCEL to demonstrate the feasibility of the expert system approach, to develop and validate the Rules, and help defining the specifications of the on-line version. The new version was released in September 2016 after completing

a beta-testing phase. [Note: the space weather part of the knowledge basis is however still preliminary and will continue to grow significantly throughout 2018.]

Since OSCAR/Space 2.0 is public, it is envisaged to set up a management structure, to keep the knowledge basis and the functionality under review with the support of interested expert groups (Figure 6).

For example, WMO would invite the contribution of the International Winds Working Group (IWWG), the International Precipitation Working Group (IPWG), the International TOVS Working Group (ITWG), the International Radio-Occultation Working Group (IRWG), the International Clouds Working Group (ICWG), and the future Inter-Programme Team on Space Weather Information, Systems and Services (IPT-SWeISS), to lead the review of the rules in their respective areas of expertise, with oversight from IPET-SUP and ET-SAT.

5. CONCLUSION

The new approach is expected to increase the value and reliability of OSCAR/Space as a reference tool for the rolling Review of Requirements, studies and applications. It should also enable engaging expert groups to review the rules related to their fields of competence leading potentially to a truly collaborative resource. Beyond its primary role to support the WIGOS Rolling Review of Requirements, OSCAR/Space is expected to be a valuable resource for the satellite community.

It will require however a comprehensive documentation of sensor characteristics and status, which can only be achieved through close collaboration between space agencies and the WMO Secretariat.

IPET-SUP members are invited to provide guidance on:

- The functionality of OSCAR/Space v2.0, especially the assessment of capabilities and the gap analysis;
- The proposed management structure of OSCAR/Space v2.0.

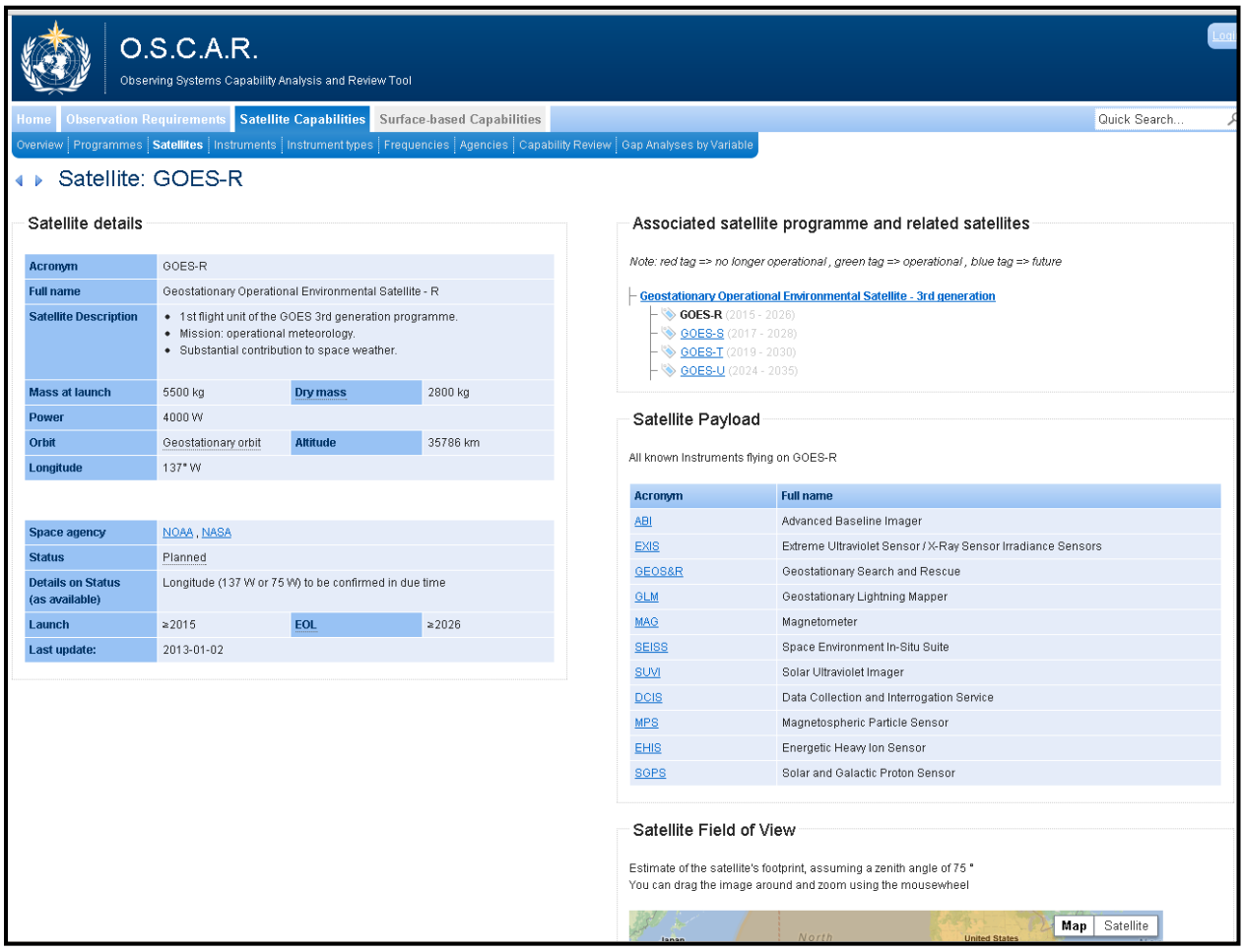


Figure 1: Example of satellite details from OSCAR/Space

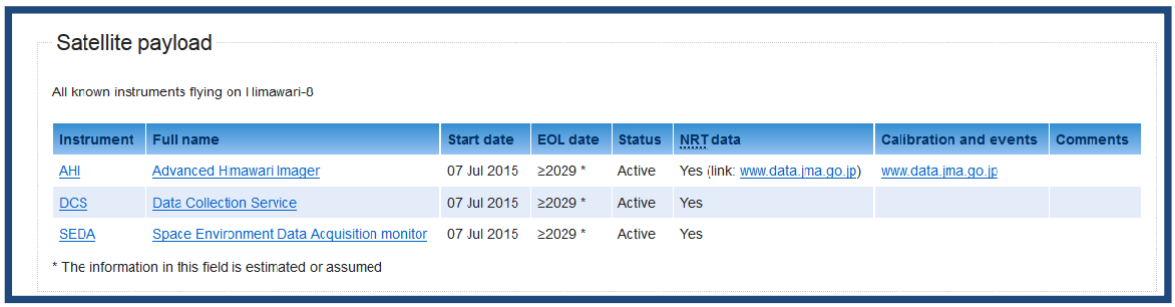
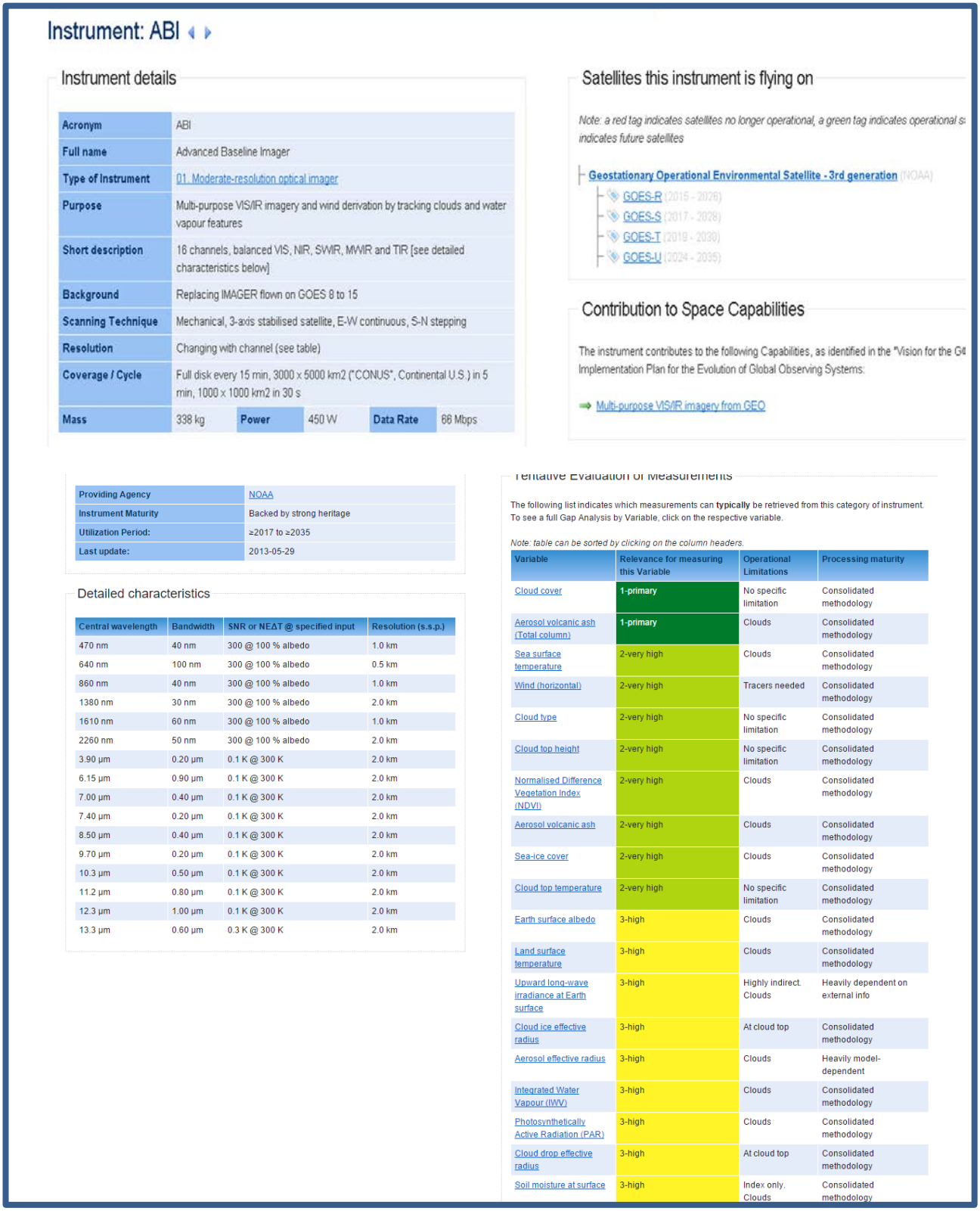


Figure 2: Example of instrument status and links to satellite operators' "landing pages" with calibration information



Instrument: ABI

Instrument details

Acronym	ABI				
Full name	Advanced Baseline Imager				
Type of Instrument	01. Moderate-resolution optical imager				
Purpose	Multi-purpose VIS/IR imagery and wind derivation by tracking clouds and water vapour features				
Short description	16 channels, balanced VIS, NIR, SWIR, MWIR and TIR [see detailed characteristics below]				
Background	Replacing IMAGER flown on GOES 8 to 15				
Scanning Technique	Mechanical, 3-axis stabilised satellite, E-W continuous, S-N stepping				
Resolution	Changing with channel (see table)				
Coverage / Cycle	Full disk every 15 min, 3000 x 5000 km2 ("CONUS", Continental U.S.) in 5 min, 1000 x 1000 km2 in 30 s				
Mass	338 kg	Power	450 W	Data Rate	66 Mbps

Satellites this instrument is flying on

Note: a red tag indicates satellites no longer operational, a green tag indicates operational s: indicates future satellites

- Geostationary Operational Environmental Satellite - 3rd generation (NOAA)
  - GOES-R (2015 - 2026)
  - GOES-S (2017 - 2028)
  - GOES-T (2019 - 2030)
  - GOES-U (2024 - 2035)

Contribution to Space Capabilities

The instrument contributes to the following Capabilities, as identified in the "Vision for the GC Implementation Plan for the Evolution of Global Observing Systems:

- Multi-purpose VIS/IR imagery from GEO

Providing Agency	NOAA
Instrument Maturity	Backed by strong heritage
Utilization Period:	≥2017 to ≥2035
Last update:	2013-05-29

Detailed characteristics

Central wavelength	Bandwidth	SNR or NEΔT @ specified input	Resolution (s.s.p.)
470 nm	40 nm	300 @ 100 % albedo	1.0 km
640 nm	100 nm	300 @ 100 % albedo	0.5 km
860 nm	40 nm	300 @ 100 % albedo	1.0 km
1380 nm	30 nm	300 @ 100 % albedo	2.0 km
1610 nm	60 nm	300 @ 100 % albedo	1.0 km
2260 nm	50 nm	300 @ 100 % albedo	2.0 km
3.90 µm	0.20 µm	0.1 K @ 300 K	2.0 km
6.15 µm	0.90 µm	0.1 K @ 300 K	2.0 km
7.00 µm	0.40 µm	0.1 K @ 300 K	2.0 km
7.40 µm	0.20 µm	0.1 K @ 300 K	2.0 km
8.50 µm	0.40 µm	0.1 K @ 300 K	2.0 km
9.70 µm	0.20 µm	0.1 K @ 300 K	2.0 km
10.3 µm	0.50 µm	0.1 K @ 300 K	2.0 km
11.2 µm	0.80 µm	0.1 K @ 300 K	2.0 km
12.3 µm	1.00 µm	0.1 K @ 300 K	2.0 km
13.3 µm	0.60 µm	0.3 K @ 300 K	2.0 km

Tentative Evaluation of Measurements

The following list indicates which measurements can **typically** be retrieved from this category of instrument. To see a full Gap Analysis by Variable, click on the respective variable.

Note: table can be sorted by clicking on the column headers.

Variable	Relevance for measuring this Variable	Operational Limitations	Processing maturity
Cloud cover	1-primary	No specific limitation	Consolidated methodology
Aerosol volcanic ash (Total column)	1-primary	Clouds	Consolidated methodology
Sea surface temperature	2-very high	Clouds	Consolidated methodology
Wind (horizontal)	2-very high	Tracers needed	Consolidated methodology
Cloud type	2-very high	No specific limitation	Consolidated methodology
Cloud top height	2-very high	No specific limitation	Consolidated methodology
Normalised Difference Vegetation Index (NDVI)	2-very high	Clouds	Consolidated methodology
Aerosol volcanic ash	2-very high	Clouds	Consolidated methodology
Sea-ice cover	2-very high	Clouds	Consolidated methodology
Cloud top temperature	2-very high	No specific limitation	Consolidated methodology
Earth surface albedo	3-high	Clouds	Consolidated methodology
Land surface temperature	3-high	Clouds	Consolidated methodology
Upward long-wave irradiance at Earth surface	3-high	Highly indirect. Clouds	Heavily dependent on external info
Cloud ice effective radius	3-high	At cloud top	Consolidated methodology
Aerosol effective radius	3-high	Clouds	Heavily model-dependent
Integrated Water Vapour (IWV)	3-high	Clouds	Consolidated methodology
Photosynthetically Active Radiation (PAR)	3-high	Clouds	Consolidated methodology
Cloud drop effective radius	3-high	At cloud top	Consolidated methodology
Soil moisture at surface	3-high	Index only. Clouds	Consolidated methodology

Figure 3: Example of satellite instrument details from OSCAR/Space

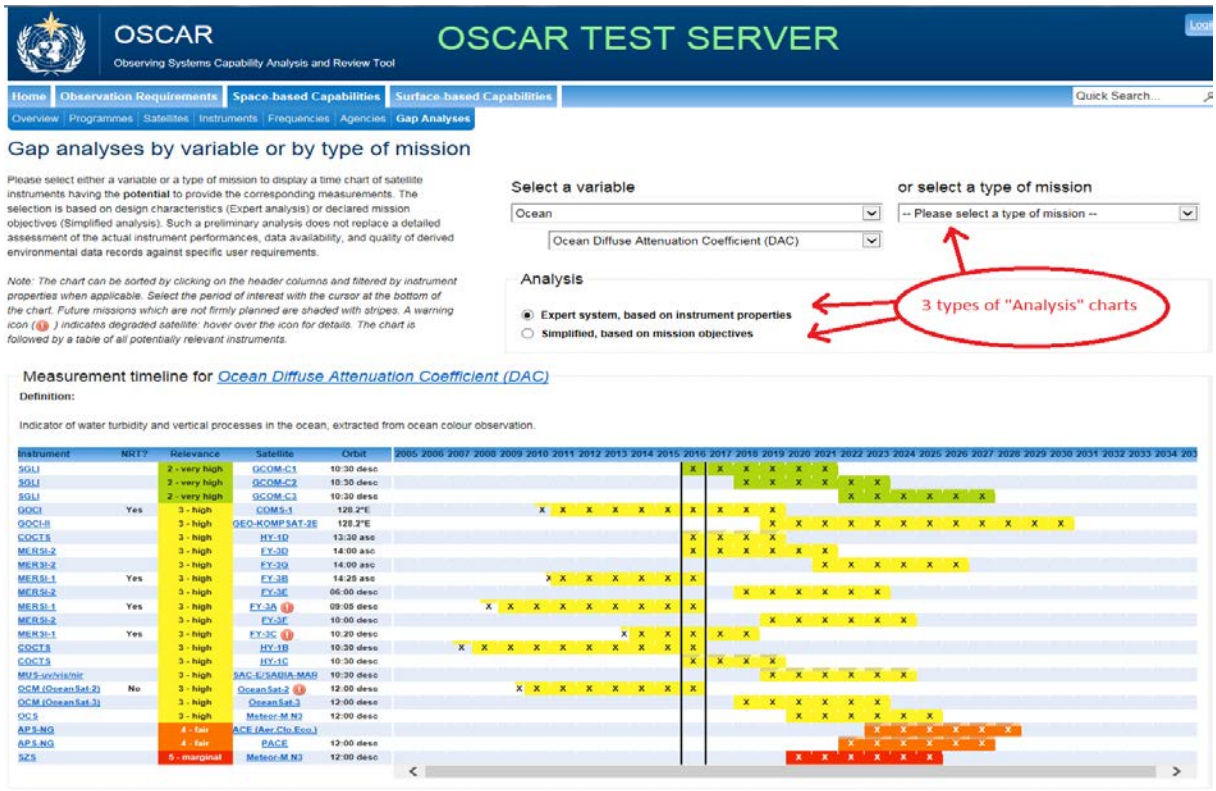
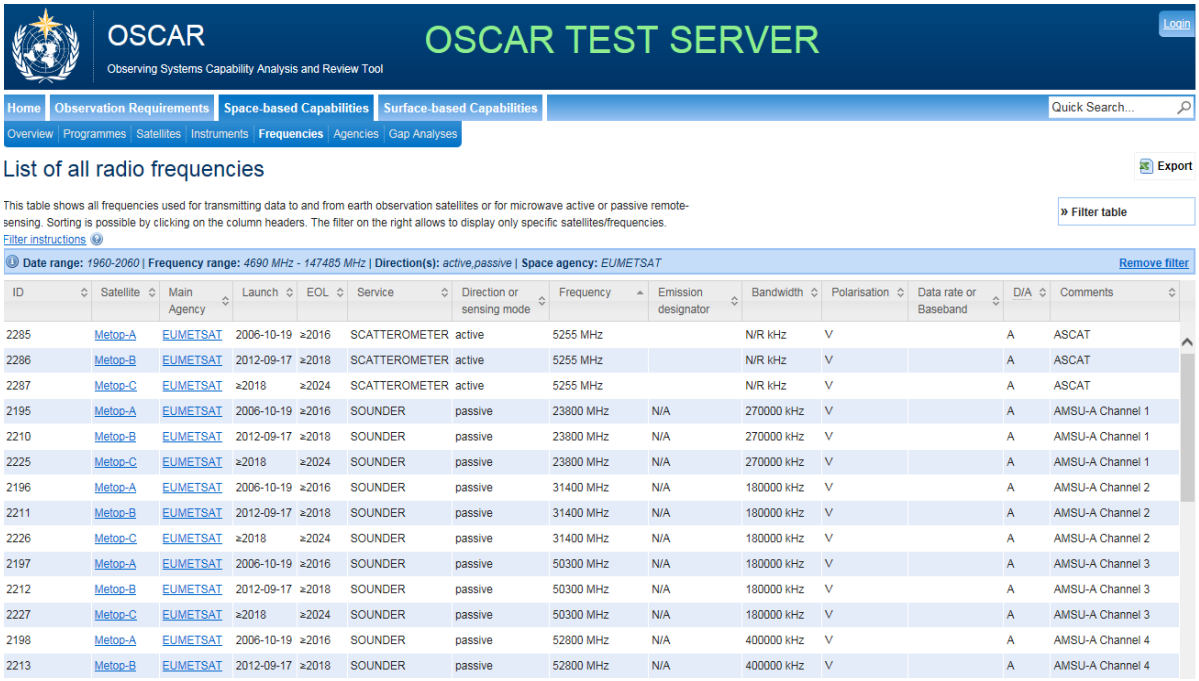


Figure 4: Example of “Gap Analysis” view



ID	Satellite	Main Agency	Launch	EOL	Service	Direction or sensing mode	Frequency	Emission designator	Bandwidth	Polarisation	Data rate or Baseband	D/A	Comments
2285	Metop-A	EUMETSAT	2006-10-19	≥2016	SCATTEROMETER	active	5255 MHz		N/R kHz	V		A	ASCAT
2286	Metop-B	EUMETSAT	2012-09-17	≥2018	SCATTEROMETER	active	5255 MHz		N/R kHz	V		A	ASCAT
2287	Metop-C	EUMETSAT	≥2018	≥2024	SCATTEROMETER	active	5255 MHz		N/R kHz	V		A	ASCAT
2195	Metop-A	EUMETSAT	2006-10-19	≥2016	SOUNDER	passive	23800 MHz	N/A	270000 kHz	V		A	AMSU-A Channel 1
2210	Metop-B	EUMETSAT	2012-09-17	≥2018	SOUNDER	passive	23800 MHz	N/A	270000 kHz	V		A	AMSU-A Channel 1
2225	Metop-C	EUMETSAT	≥2018	≥2024	SOUNDER	passive	23800 MHz	N/A	270000 kHz	V		A	AMSU-A Channel 1
2196	Metop-A	EUMETSAT	2006-10-19	≥2016	SOUNDER	passive	31400 MHz	N/A	180000 kHz	V		A	AMSU-A Channel 2
2211	Metop-B	EUMETSAT	2012-09-17	≥2018	SOUNDER	passive	31400 MHz	N/A	180000 kHz	V		A	AMSU-A Channel 2
2226	Metop-C	EUMETSAT	≥2018	≥2024	SOUNDER	passive	31400 MHz	N/A	180000 kHz	V		A	AMSU-A Channel 2
2197	Metop-A	EUMETSAT	2006-10-19	≥2016	SOUNDER	passive	50300 MHz	N/A	180000 kHz	V		A	AMSU-A Channel 3
2212	Metop-B	EUMETSAT	2012-09-17	≥2018	SOUNDER	passive	50300 MHz	N/A	180000 kHz	V		A	AMSU-A Channel 3
2227	Metop-C	EUMETSAT	≥2018	≥2024	SOUNDER	passive	50300 MHz	N/A	180000 kHz	V		A	AMSU-A Channel 3
2198	Metop-A	EUMETSAT	2006-10-19	≥2016	SOUNDER	passive	52800 MHz	N/A	400000 kHz	V		A	AMSU-A Channel 4
2213	Metop-B	EUMETSAT	2012-09-17	≥2018	SOUNDER	passive	52800 MHz	N/A	400000 kHz	V		A	AMSU-A Channel 4

Figure 5: Use of OSCAR for frequency coordination. For example, selection of active and passive sensor frequencies in the 4.6 to 147 GHZ range, EUMETSAT satellites.

Figure 6: Proposed management structure of OSCAR/Space