INTERIM WMO REQUIREMENT FOR DIGITAL SATELLITE IMAGE DATA AND EXTRACTED PRODUCT EXCHANGE OVER THE GTS

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1. INTRODUCTION

1.1 Satellite image data and extracted products are now fundamental to operational and research activities of WMO Programmes and represent a unique and irreplaceable source of information.

1.2 Considerable resources are expended globally developing, implementing and supporting the space-based sub-system of the Global Observing System by satellite operators. It has long been recognized that appropriate resources must be devoted to ground-based systems able to exploit the data provided by such systems - in the past this effort has, for valid reasons, concentrated on the reception of data from systems using local reception systems. Increasingly, WMO Programmes involved with operational meteorology and hydrology demand satellite image data and extracted products which can not be received locally. This document states the requirement of WMO Members for satellite image exchange beyond the local reception footprint of the geostationary or polar orbiting satellite which captures the data. It briefly addresses the characteristics of the entailed telecommunication requirement and reviews the capability of current data management methods and the capacity of the Global Telecommunication System (GTS) to meet the need.

1.3 This WMO requirement for satellite imagery is based on the WMO satellite data requirements as described in the Final Report from the EC Panel of Experts on Satellites. It should be noted that satellite imagery is used to determine many types of products including the following:

* sounding data,
* winds,
* snow and sea ice parameters,
* surface temperature (land and sea)
* cloud parameters,
* etc.

1.4 The WMO requirement for satellite image data and extracted products explicitly describes requirements for:

* satellite
* resolution
* frequency and
* timeliness.

1.5 This document describes the reasons why specific data are required but deliberately excludes detailed specification of how data will be used and presented to users.

1.6 WMO recommends that the ad-hoc systems used at present be replaced by a well ordered system for the exchange of satellite image data and extracted products.

2. CURRENT SITUATION WITH RESPECT TO SATELLITE IMAGE DATA AND EXTRACTED PRODUCTS EXCHANGE

2.1 Certain satellite image data and extracted products are already exchanged internationally using a variety of systems. For example, the WEFAX broadcast from METEOSAT also contains WEFAX images from geostationary satellites other than METEOSAT.

2.2 These arrangements for the exchange of satellite data have developed in a somewhat ad-hoc fashion to meet specific requirements. Due to this ad-hoc nature, many of the links are used in a less than optimum manner. As an example, Europe receives analogue fax image data (one-way) over a dedicated 64 kbps digital link. This bandwidth could be used much more effectively for the two-way exchange of digital image information.

2.3. There is also a current lack of standard formats for the transmission and storage of satellite image data and extracted products. A number of 'standard formats' exist but each is tuned to specific requirements - for example, one format is able to accommodate raw satellite data including spacecraft engineering data. Such a format is too complex for the more restricted requirements of the meteorological community.

2.4 WMO has defined binary codes such as BUFR and GRIB which are capable of handing digital satellite image data and extracted products. Unfortunately, there has been a lack of agreement on precisely how such codes should be utilized for image data. The lack of widely accepted and supported codes dictates that unnecessary efforts are needlessly expended on conversion software.

3. APPLICATIONS

3.1 The primary reasons for exchanging satellite data beyond the local footprint are to enable global and regional centres to accurately determine the position and characteristics of major synoptic features - particularly where these are upstream, are moving or evolving rapidly and are associated with severe, hazardous weather. Such data are also useful in conceptualising weather systems, both for professional meteorologists and their end users.

3.2 At such centres satellite image data and extracted products are used in a number of ways:

Analysis Satellite imagery plays an important role in the analysis of meteorological features at all scales from the broad to the mesoscale. Here, the meteorological requirement is to understand the current behaviour of the atmosphere and weather in terms of a number of conceptual models, such as fronts, air masses and cloud clusters. On the broad scale, identification of major cloud masses helps to position dynamic features such as fronts and troughs, whilst on the mesoscale, detailed imagery allows cloud conditions to be assessed at specific locations. Imagery in the infrared (IR) spectrum adds a vertical dimension by distinguishing between surface and cloud top temperature. This allows discrimination between high and low cloud and, if the images are calibrated, then, by reference to upper air soundings, the level and vertical extent of cloud. On the mesoscale such imagery, particularly when used in conjunction with visible images, may enable forecasters to identify, and distinguish between, fog and low cloud. Analysis may be further improved by the use of derived products such as surface wind fields, sea temperatures etc.

Forecasting The use of imagery directly in Numerical Weather Prediction (NWP) is in its infancy, but such data provide a useful source of quality control information; firstly at the initialization stage and subsequently in verifying, and as appropriate, modifying the guidance obtained from NWP. Thus, skilled analysts are able to generate so-called bogus observations, particularly in the vicinity of tropical cyclones, which can be used in initializing a numerical model while forecasters make extensive use of timely remotely sensed data - from satellites and radar networks - in judging the quality of very short period NWP forecasts as a guide to subsequent predictions.

Presentation Reference to an appropriate satellite image is an effective way of indicating cloud distribution to a customer. Satellite images now form an important part of TV presentation and also as a briefing aid for aviation purposes especially where cloud cover is a feature important to the task such as aerial photograph, low level reconnaissance or maritime patrol flights.

4. THE WMO REQUIREMENT FOR DIGITAL SATELLITE IMAGE DATA AND EXTRACTED PRODUCTS EXCHANGE OVER THE GTS

4.1 Detailed specifications for the exchange of geostationary and polar-orbiting satellite image data and extracted products can be found in Annexes A and B, respectively. The image projection to be employed in the exchange is relatively unimportant, provided that available resolution and accurate referencing to geographical coordinates are maintained; most receiving centres will have the ability to re-project. In describing the WMO requirement, the following definitions have been utilized:

Acceptable - the minimum level required to provide a worthwhile service to the user.

Goal - if met would provide maximum advantages to the user.

5. ADDITIONAL REQUIREMENTS

5.1. It is recommended that digital satellite image data and extracted products be exchanged using a standard system over the GTS. Since the present bandwidth of the GTS is insufficient for the requirements contained in Annexes A and B, the GTS capacity must be increased. The standard system should have the following characteristics:

(a) data should be available to any co-operating centre on the GTS;
(b) use standard communications protocols (e.g. TCP/IP);
(c) use a standard data format for image data (e.g. a standard WMO binary representation form);
(d) use a file transfer mechanism rather than the bulletin format presently in use on the GTS;
(e) provide expected performance and response times;
(f) provide appropriate levels of security;
(g) operate automatically.

6. COMMUNICATIONS ASPECTS

6.1 The existing GTS system is optimized for the regular transmission of relatively short bulletins. Unfortunately these characteristics make it unsuitable for the transmission of large files associated with satellite image data and extracted products.

6.2 The GTS also has rather limited capacity. Although the fastest links are 64 kbps, typical links are only 4.8 or 9.6 kbps. A full disk Meteosat 5 km resolution image would take more than one hour to be sent over a 9.6 kbps link.

6.3 WMO has agreed to implement the Distributed Data Base System (DDBS) which is based on TCP/IP and allows data transfer using higher level protocols. DDBS depends on TCP/IP being implemented on the GTS. It should be noted that the DDBS satisfies most of the required characteristics described in paragraph 5.1. The only unsatisfied characteristic is that of a standard data format for image data and the CBS Working Group on Data Management Sub-group on Codes and Data Representation Formats is addressing this issue.

6.4. Using the acceptable and goal requirement figures for Meteosat full-disk images involves the transfer of the following amounts of data.

Target	Satellite	Channels	Width	Height	Size (Mbytes)	Tx. Time (mins)	Implied bandwidth

Acceptable	Meteosat	IR	1250	1250	1 x 1.56	20	11 kbps
Goal	Meteosat	IR, Vis, WV	2500	2500	3 x 6.25	10	250 kbps

6.5 Thus, to meet the acceptable target for distribution of the data from one satellite requires a bandwidth of 11 kbps; to distribute the goal data would require a bandwidth of 250 kbps.

6.6 These figures can be reduced by compression of the data - typically full disk satellite images can be losslessly compressed to below 50% of their original size. The figures will, however, be increased by the requirement to exchange data from all the geostationary satellites. Assuming that 5 are operational and that data are exchanged over a 'ring' network which allows two-way data exchange then the above figures will be increased by a factor of 2.5 (625 kbps).

7. CONCLUSIONS

7.1 It can be seen that the present bandwidth available on the GTS is inadequate and that much higher bandwidths are required (typical available is 4.8 kbps while required is almost an order of magnitude larger). Therefore, the GTS must be increased to accommodate bandwidths of at least 625 kbps.

7.2. The decision has already been taken to implement the Distributed Data Base System (DDBS). Therefore, its implementation must occur as well as its accompanying requirement to utilize TCP/IP.

7.3 The CBS Working Group on Data Management Sub-group on Codes and Data Representation Formats should make a recommendation as to a standard data format for image data.

ANNEX A

WMO REQUIREMENT FOR GEOSTATIONARY DIGITAL IMAGE DATA

1. SATELLITES

All current and future geostationary satellites (GOES, METEOSAT, INSAT, GOMS, GMS). The bit depth of an image pixel will correspond to that utilized by the particular satellite, e.g. 10 bit for GOES, 8 bit for METEOSAT, etc.

2. CHANNELS

acceptable	-	IR (long-wave Infrared)
goal	-	all available channels

3. RESOLUTION

acceptable	-	8 km at sub-satellite point
goal	-	4 km at sub satellite point

4. FREQUENCY

acceptable	-	6 hours
goal	-	15 minutes

5. TIMELINESS (available for display)

acceptable	-	within 6 hours of nominal image time.
goal	-	within 15 mins of nominal image time.

6. FORMAT

a standard WMO binary representation form

7. CALIBRATION

navigation and calibration files for raw satellite data

ANNEX B

WMO REQUIREMENT FOR POLAR ORBITER DIGITAL IMAGE DATA

1. SATELLITES

All current and future polar orbiting platforms (NOAA, METEOR, EPS, FY-1 series). The bit depth of an image pixel will correspond to that utilized by the particular satellite.

2. CHANNELS

acceptable - IR
goal - all available channels

3. RESOLUTION

acceptable - 4 km GAC (Global Area Coverage)
goal - 1 km LAC (Local Area Coverage)

4. FREQUENCY

Daily (A full global coverage once per day from each satellite to be made available pass-by-pass when the GAC coverage is recorded)

5. TIMELINESS

acceptable - within 60 mins of pass over the main receiving station
goal - within 40 mins of pass over the main receiving station

6. FORMAT

a standard WMO binary representation form

7. CALIBRATION

navigation and calibration files for raw satellite data