OUTCOME
of
IMAGERY CHANNEL SELECTION

POST-MSG IMAGERY MISSION

FIRST MEETING
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EUMETSAT
Am Kavalleriesand 31, D-64295 Darmstadt, Germany
Tel: +49 6151 8077 * Fax: +49 6151 807555

1 INTRODUCTION

Following the recommendations of the Remote Sensing Experts (RSEs) at the post-MSG user consultation workshop in November 2001 (WS-1), a group of selected external (members of post-MSG RSE and AEG) and internal (ESA and EUMETSAT) experts participated in an 'Imagery Channel Selection' meeting at ESA/ESTEC on 16-17 May. The purpose of the meeting was firstly to agree on preliminary set of channels for the post-MSG imagery mission, and secondly to specify as complete as possible the corresponding requirements at level 1.

The starting point for the selection and the prioritisation of the channels was the summary of user/service needs of NWC and NWP-Regional/Global applications to assure an explicit reference to products and possible breakthrough as they were discussed at WS-1 and endorsed by STG.

In preparation of the meeting a set of 'questionnaire tables' were prepared to establish the links between the **user/service needs** the related set of **products** needed to be derived from space observations and finally a straw man list of **channels** potentially used for the product retrieval. The straw man list of proposed channels were based on the heritage of current, planned, and prospective instruments like the Moderate Resolution Imaging Spectro-radiometer (MODIS), the Spin Enhanced Visible and Infrared Imager (SEVIRI), the Advanced Baseline Imager (ABI), and the Advanced Geosynchronous Studies – Imager (AGSI). The Secretariat distributed these tables and based on the synergy of the individual views of the participants prepared a preliminary selection of channels to be presented at the meeting as starting point for the discussion.

2 SUMMARY OF MEETING OUTCOME

2.1 Background Presentations

It was recalled that as starting point two AEGs collected prospective user/service needs for NWC and NWP-Regional/Global applications and specified for corresponding variables or proxies requirements in terms of – threshold, breakthrough, and goal- for the time frame 2015-2025. Threshold thereby represents the minimum performance making the variable or proxy of some interest, while goal on the other hand characterises the maximum performance beyond that no additional value is provided to the corresponding user/service need. The breakthrough level is the most important information for finally deciding on channels and their corresponding level 1 requirements, as it is the performance at which a variable or proxy provides a major delta improvement for the corresponding application.

In a further step, the group of RSEs analysed at WS-1 the related variables or proxies concerning their potential as being a product of space observations and finally identified those for which the contribution from the geostationary orbit is 'unique'. It was concluded that the uniqueness of the geostationary orbit is to provide, as key technique, visible and infrared images of rapidly evolving weather patterns and atmospheric motion vectors. The corresponding variables or proxies of highest priority, for which products derived from GEO

VIS/IR imagery are unique or essential and achieve or approach the breakthrough levels, will then determine the channels and level 1 requirements. Those 'key-user/service needs' and corresponding variables or proxies were identified as NWC parameters for convection, NWC non-convective phenomena as cyclone development, snow cover, water and land surface temperature, fire detection, fog area, total aerosol, and volcano ash, NWP parameters as profiles of 2D-winds, cloud cover, and cloud top temperature.

It was recognised by the RSEs that time/space scales do vary for individual applications starting from the natural scale of cloud updraughts of about 400m. The RSEs therefore recommended to look at two GEO-VIS/IR imagery missions (I-1 and I-2) and to propose on the basis of the identified key-user/service needs a set of channels and related level 1 requirements separately for I-1 and I-2. The scales recommended for these two missions by the RSE at WS-1 where 500 m and 5 minutes for I-1 and 1km and 15 min for I-2. The RSE further recommended analysing how the channel selection for the imagery mission I-2 might change if it is assumed that a GEO-IR sounding mission does provide supporting information.

Since the continuity in the derivation of products and also the potential of transferring certain applications to areas covered by satellites maintained by different Agencies is an import aspect for operational services, two background presentations on:

- SEVIRI channel definition, performances and meteorological relevance,
- Channel selection for the US VIIRS and ABI instruments

were given in support of the discussion on channel selection and specification on level 1 requirements (softcopies of both presentations are available from the Secretariat on request).

2.2 Review key user/service needs and related products

Based on the breakthrough levels provided at WS-1 for the variables or proxies those user/service needs were identified for which the GEO imagery I-1 and I-2 missions will contribute in a unique or essential way. These user/service needs were then ranked according to their priorities (very high, high, and medium), as specified by the AEGs for WS-1, to build the set of 'key user/service needs' for the following selection of channels for the GEO imagery missions I-1 and I-2.

The first part of the discussion was devoted to review these key user/service needs. The outcome of this discussion was to agree on which of the two imagery missions will be in support of which application and what are the corresponding 'satellite derived geophysical products', further referred to as products, serving as variables or proxies in support of that specific application.

2.2.1 Relation to GEO-imagery mission I-1

Those key user/service needs identified as being supported by a GEO-imagery mission I-1 do belong primarily to the NWC applications for 'Convective Forecasting Techniques' and to support estimate of two dimensional wind profiles. The relevant key user/service needs and corresponding variables or proxies identified at the meeting as being served by a GEO-imagery I-1 mission are listed below in the same manner as they were presented at WS-1 in the position paper on NWC:

- Identification of likely locations of initiation of convection
  - Motion of boundary layer stratocumulus cloud lines to identify planetary boundary layer convergence (very high priority)
  - Cloud top rise to identify likely locations of initiation of convection and to identify areas of precipitation before it starts (very high priority)
  - Changes in cloud structure indicating upward motion to identify initiation by gravity waves, identify outflow boundaries (medium priority)
- Use of tracer motion to support estimate of 2-d wind profiles (very high priority)

It was commented that identifying imagery I-1 key user/service needs only by looking at the breakthrough level might be too conservative, since the breakthrough level, estimated for the targeted time frame of 2015-2025, is likely to change. The imagery I-1 mission could certainly also support parts of the imagery I-2 key user/service needs for which the space/time scale of the breakthrough is below, however, that of the 'goal' within the domain of that of imagery I-1. Table 1 summarises these user/service needs to be satisfied in 2015-2025 and links them to a set of products likely to be derived from a GEO imagery-I1 mission.

Tab. 1: User/Service Needs Potentially be Satisfied by Products derived from the GEO Imagery I1 mission

Input taken from the AEG tables at WS-1		Proposed products to be retrieved from a GEO imagery-I1 mission			
User/Service Needs identified to be compliant with a GEO imagery I1 mission	**AEG priorities**	**cloud mask / imagery / pattern**	**cloud top temp. / pressure**	**Cloud top drop size**	**Cloud motion Vectors**
Cloud imagery to identify lines etc indicating PBL convergence ahead of thunderstorm development	VH	X			
Cloud top temperature to indicate rise cloud tops ahead of thunderstorm initiation	VH	X	X		
Cloud imagery to identify wave structures that might trigger thunderstorms	M	X			
Cloud top temperature and droplet size to indicate speed of updraught and hence thunderstorm intensity	VH	X	X	X	
Cloud top height to identify surface fog	VH	X	X		
Cloud density to identify thick fog	VH	X	X	X	
Land surface temperature to identify fire or volcanic eruption	VH	X			
Cloud top temperature to identify convective overshoot indicating intensity of convection	H	X	X		
Cloud imagery to identify mesoscale rotation indicating likely tornado development	H	X			
Wind profile to identify mesoscale cloud rotation indicating likely tornado development	M	X			X
Cloud cover to indicate changes in low level stability to support local wind systems	H	X			
Cloud top to indicate early development of shallow fog as precursor to fog	VH	X	X		
Fog top height to identify time to clear	VH	X	X		
Fog top drop size to indicate riming rate	H	X		X	
Wind vector over land to indicate motion of fire	VH	X			X
Wind vector over land for pollution dispersion	VH	X			X
Wind vector over sea for prediction of movement of pollutant slicks	VH	X			X
Priority ranking of identified products/observables:		**1**	**3**	**4**	**2**

Based on the set of key user/service needs and the related variables or proxies it was discussed what the corresponding products and their priorities are, which need to be derived from the GEO-imagery I-1 observations. The priority ranked list of products identified at the meeting to be derived from the GEO-imagery I-1 mission is listed below:

- Cloud detection
- Horizontal tracking of tracers (in particular over land surfaces)
- Vertical tracking of cloud top heights
- Height assignment for clouds
- Structure of cloud microphysics at cloud top

It was generally agreed that for deriving any of the products listed above from satellite observations it is mandatory to first do a cloud detection (cloud mask). It was further agreed that in particular within the time frame for post-MSG it is not always true that user/service needs will be supplied via related products, since they will sometimes be met directly from the multispectral imagery. However, for the selection of potential channels and related level 1 requirements it may be helpful to think in terms of a 'pseudo-product', even if it might never be generated.

2.2.2 Relation to GEO-imagery mission I-2

Those key user/service needs identified as being supported by a GEO-imagery I-2 mission do belong to all application areas, those for NWC as well as those for NWP-Regional/Global. The relevant key user/service needs and corresponding variables or proxies identified for the GEO-imagery I-2 mission are listed below in the same manner as they were specified for WS-1 in the three position paper on NWC, NWP-Regional, and NWP-Global. In addition, Table 2 summarises these user/service needs and links them to the set of products likely to be derived from a GEO imager-I2 mission in 2015-2025:

NWC convective forecasting techniques to:

- identify likely locations of initiation of convection
  - Land Surface Temperature to identify initiation (medium priority)
- monitor convetion
  - cloud overshooting as indicator of intensity (high priority)

NWC non-convective forecasting techniques:

- for Cyclones
  - monitoring of changes in cloud structures to identify rapid Cyclone development (high priority)
- for local wind systems
  - monitoring of LST, cloud and snow cover to detect local changes to instability (high priority

NWC observation and extrapolation techniques:

- wind profiles
  - use of tracer motions to support estimate of wind profiles (very high priority)
- surface precipitation
  - VIS reflection and IR emission at cloud (derived cloud microphysics) as proxy for rain

Tab. 2: User/Service Needs Potentially be Satisfied by Products Derived from the GEO Imagery-2 Mission

Input taken from AEG tables at WS-1		Proposed products to be derived from a GEO imagery-I2 mission																						
User/Service Needs (user parameters) identified to be compliant with GEO observations	**AEG priorities**	**Cloud mask / imag.**	**Cloud Type**	**Cloud Temp. /Press.**	**Cloud Top Phase**	**Drop. Size Distrib.**	**Cloud Optical Thickness**	**Low Vis. at Surface**	**Cloud Motion Vectors**	**LST and SST**	**Sea-Ice Temperature**	**Snow Cover**	**Aeros. Optical Thickness**	**Aerosol Size Distribution**	**Volcanic Ash Detection**	**Volc. Ash Tot. Opt. Depth**	**Fire Detection**	**Smoke Detection**	**Vegetation Stress**	**Dust Detection**	**Total Col. Humidity**	**Clear Sky AMVs**	**Tracer Height Assignment**	**Temp. / Humi. Gradient**
Monitor Land/Lake/Sea surface temperature to identify initiation of convection	medium priority	X								X														
Monitor cloud overshooting as indicator of intensity	high priority	X	X(?)	X	X				X															
Monitor changes in cloud structures to identify rapid cyclone development	high priority	X	X	X	X																			
Monitor LST, snow -, and cloud cover to detect changes to instability for local wind systems	high priority	X	X	X						X	X	X												
Monitor fog area for extrapolation of shrinking of fog area	very high priority	X	X	X			X	X																
Detection of low visibility for safety of marine and land transport	very high priority	X	X	X			X	X																
Monitor LST (>500K), location of smoke, and vegetation stress to detect fires and to model fire initiation and spread	very high priority	X					X			X							X	X	X					
Detection of volcanic ash and estimation of total column concentration to mitigate aircraft damage	very high priority	X	X				X						X	X	X	X								
Detection of sand/dust storm location for land transport safety	high priority	X	X				X	X					X	X						X				
Use of tracer motions to support the detection of horizontal movement in case of volcanic emission and accidental releases	very high priority	X							X				X		X	X						X	X	
Detection of volcanic eruptions as source for volcanic ash clouds used for aviation warnings	very high priority	X													X	X								
Detection of fires as sources for smoke polution	very high priority	X								X			X				X	X						
Use of tracer motions to support estimates of profiles of horizontal winds	very high priority	X		X					X													X	X	
IR/VIS cloud emission/reflection in support to detect/quantify sfc precip. (convective rain)	very high priority	X	X	X	X	X	X														X			X
Cloud cover in support of NWP regional and global models	very high priority	X	X	X	X																			
Cloud top height in support of NWP regional and global models	very high priority	X	X	X	X																			
Land Surface and Sea-Ice Surface temperature in support of NWP global models	very high priority	X								X	X													
Total column humidity in support of NWP global models	very high priority	X																			X			
Height assignment for cloud motion vectors and clear sky atmospheric tracers	very high priority	X		X																			X	
Instability for early warning of onset of convective intensity	very high priority	X								X											X			X
CAPE for early warning of convective intensity	high priority	X								X											X			X
DCAPE (down draught intensity for early warning of risks by downburts and severe outflow gusts	high priority	X								X											X			X
Stability for non-convective forecasting of inhibition to flow of local wind systems	high priority	X								X											X			X
Priority ranking of products/obsevables:		**1a**	**2a**	**1b**	**4a**	**4c**	**4b**	**7c**	**1c**	**3**	**8b**	**8a**	**7a**	**7b**	**9c**	**10a**	**9a**	**9b**	**10c**	**10b**	**6**	**2b**	**2c**	**5**

- changes in fog and low cloud cover and surface visibility
  - monitoring of fog area for extrapolation of shrinking of fog area (very high priority)
  - detection of fog with low visibility, less than 1000 m and less than 200 m for safety of marine and land transport, respectively (very high priority)
- Fire detection
  - Monitoring of Land Surface Temperatures above 500 K, identify location of smoke, monitoring of vegetation stress to model initiation and spread of fires(very high priority)
- Aviation and land transport
  - Detection of volcanic ash and estimation of concentration (total column) to mitigate damage to aircraft (very high priority)
  - Detection of low visibility situations for aerodrome and flight safety (very high priority)
  - Detection of sand/dust storm location for land transport safety (high priority)

NWC Dispersion, Chemistry and Biology models:

- Volcanic emission and accidental releases
  - Use of tracer motions to support the detection of horizontal movement (very high priority)
  - Location of volcanic eruptions as sources to model volcanic ash clouds used for aviation warnings (very high pririty)
- Air quality and biomass burning
  - Location of fires as sources for smoke pollution (high priority)

NWP Regional and Global imagery I-2 mission key user/service needs:

- Total cloud cover
- Cloud top height
- Tracer motions in support of horizontal wind profiles
- Land Surface and Sea-Ice Surface Temperature
- Total column humidity
- IR cloud top emission and VIS reflectance as proxy to support estimates of surface precipitation

In addition the following key user/service needs were identified as part of the GEO imagery I-2 mission, which, however, could potentially be supported by a GEO-IR sounding mission:

- Tracking of clear sky Atmospheric Motion Vectors (AMV) within the water vapour and ozone band
- Height assignment of cloud and water vapour tracers
- Instabilty for early warning of convective intensity
- CAPE early warning for convective instability
- DCAPE (down draught intensity) for early warning of risks by downbursts and severe outflow gusts.

Concerning the GEO-imagery I-2 mission it was stated that this mission would be the basic imagery mission and should cover the total FOV to be seen from the geostationary orbit. There was concern that the strategy for the basic imagery mission will be different from that of a sounding mission and perfect co-location in observations could only be reached by making concessions to both of the two missions. In terms of sounder support for synergy with an imagery mission, it was suggested to think of the GEO-imagery I-1 mission as a magnifying glass (targeted observation) over regions of interest identified by the sounder.

Based on the set of user/service needs and their related variables or proxies identified as key applications for the GEO imagery I-2 mission as listed above, it was discussed which type of products or pseudo products need to be derived from the imagery I-2 mission. The final list of products and their priority ranking in decreasing order within ten classes as agreed at the meeting is given below (see also Tab. 2):

- Cloud imagery (cloud mask), cloud type, cloud top temperature/pressure
- Cloud Motion Vectors (CMV), Atmospheric Motion Vectors (AMV), tracer height assignment
- Land Surface Temperature (LST), Sea Surface Temperature (SST)
- Cloud phase, cloud optical thickness, cloud top droplet size distribution
- Instability, temperature gradient, humidity gradient
- Total column humidity
- Aerosol optical thickness, aerosol size distribution, low visibility
- Snow cover, Sea Ice Temperature
- Vegetation stress, fire detection/monitoring, smoke location
- Volcanic ash detection, volcanic ash concentration, sand/dust storm location

Similar as for I-1 it was also agreed that for deriving any product from the satellite observation it is mandatory to have as a first step the cloud detection (cloud mask). It is again important to note that it is expected that within the time frame of 2015-2025 a larger number of the user/service needs listed above would be satisfied by direct assimilation of radiances. Therefore the list of ranked observations do also include ‘pseudo observation’, added to support the channel selection in a consistent manner.

2.3 GEO imagery I-1 and I-2 mission channel selection

In a second step the priority ranked lists of products to be derived from the two GEO imagery I-1 and I-2 mission were used to discuss at which part of the visible and infrared spectrum a measurement need to be taken to support a potential retrieval algorithm. By doing so the general constraint was already taken into account that a high spatial resolution measurement from the geostationary orbit would be very challenging (expensive) for the thermal infrared channels.

2.3.1 Selected channels for the imagery I-1 mission

First, based on the products and their priority as selected/ranked for serving the key user/service needs of the imagery I-1 mission, it was discussed which channels would be needed to be used within retrieval algorithms to derive the products listed in section 2.2.1 (see Tab. 1). Once agreed on the number and the wavelengths of these generic channels to be selected, their corresponding specific level 1 requirements were then discussed in a second step as summarised in section 2.4.

Since GEO imagery I-1 will be the high spatial and temporal resolution imagery mission, a decision was made to limit the number of channels with a focus on the shorter wavelengths. The finally agreed selection is as follows:

- For the most important product, the cloud detection (see 2.2.1), the three window channels at about 0.64µm, 3.8µm, and 11.2µm were selected.
- For the second priority product, the horizontal tracking of cloud tracers, no additional channel is needed.
- For the vertical tracking and the height assignment of cloud tops no channels in addition to the two already specified in the MIRW and TIRW windows are needed.
- For an improved monitoring of the effective radius for NWC purposes (indicative to the evolution of severe storms **before** they become severe) an additional channel in the window of the SWIR at about 2.13µm was added.

Table 3 summarises the outcome of the channel selection process for the imagery I-1 mission by linking the selected channels to the priority ranked products of section 2.2.1.

Channels #	Generic wavelength [µm]	Imagery I-1 mission: product channel relation				Selected channels	Ranking of channels
1	**0.64**	X	X		X	X	1
2	**2.13**				X	X	2
3	**3.8**	X	X	X	X	X	1
4	**11.2**	X	X	X	X	X	1
Priority ranking of products:		cloud detection 1	CMV 2	cloud temp/press 3	R_{eff} 4		

Tab. 3: Selected GEO imagery I-1 channels and their link to the products needed for the user/service needs.

Selecting the channels as presented above, a major part of the discussion was devoted to the improved detection of the cloud top effective radius for NWC purposes. The principle behind the idea that the effective radius is indicative of severe convective storms is that strongly rising air parcels have only little time for growth and coalescense, as well as for glaciation. Therefore the microphysics of the air parcels ascending to the cloud top reflects the time of ascend or the strength of updraught by smaller effective radii connected to stronger updraughts.

It had been recognised that measurements taken in the oxygen A absorption band could be of beneficial support in vertical tracking of cloud top heights (on a very small spatial scale) and also for height assignment. Since currently two studies on the use of the oxygen A band are conducted in support of the post-MSG user consultation, it was agreed to wait for the final presentation of these studies before deciding on additional channels in the oxygen A band.

2.3.2 Selected channels for the imagery I-2 mission

Similar as for imagery I-1, the prioritised products belonging to the key user/service needs to be satisfied by imagery I-2 were used in a first step to select the generic channels. After discussion and agreement on the final number and spectral position of the generic channels, their corresponding level 1 requirements were then specified in a second step (see section 2.4).

Following the discussion above, the GEO imagery I-2 mission has been treated as the basic imagery mission and, therefore, was analysed as a stand-alone mission without any support by a sounder as starting point. Table 4 describes the relationship between the products, as identified in section 2.2.2 and the generic channels finally selected at the meeting for the imagery I-2 stand-alone mission.

As described in section 2.2.2, highest priority has been given to the cloud detection/mask product, which is mandatory for satisfying all identified user/service needs (see Table 2). The channels necessary to do proper cloud detection have been added to Table 4 in the first place, indicated by crosses in green boxes. By going down the priority list of section 2.2.2, it was then analysed if additional channels are needed for a proper retrieval of the next lower priority product. In case that a channel is needed for the first time a cross in a green box indicates it in Table 4. If a higher priority product has already requested that channel a cross only indicates its use. Red crosses in yellow boxes indicate in Table 4 the final number/spectral position of the generic channels, as they have been identified/selected as the ‘core channels’ at the meeting.

It was also discussed at the meeting that sounding channels in the 4µm CO_2 band (total of about 250, heritage of AGIRS) and in the 13.4 to 14.5 µm CO_2 band (total of 9 to 15 bands, heritage from the SEVIRI CO2 slicing study) should be analysed as optional channels. It was further agreed that in case the CO2 pseudo slicing channels are not feasible, a second channel at about 14 µm should be included for cloud height assignment by the CO2 slicing method. The purple boxes indicate these optional channels in Table 4.

Table 4 clearly shows that the use of most of the core channels is already justified by deriving products of priority class ‘one’ as indicated in the last column ‘ranking of channels’. With second priority, as a heritage of the SEVIRI instrument, the ozone channel was added to support tracking of atmospheric motion vectors. The next channel added (about 2.13 µm; ranking number 3) is justified by deriving an improved information on the microphysics at cloud top (see also section 2.2.1). The last channel added is the blue channel (about 0.47; ranking 4) for deriving aerosol products and follows the recommendation made by the STG science Working Group at the 12th meeting.

It had been recognised that measurements taken in the oxygen A absorption band could be of beneficial support in vertical tracking of cloud top heights and also the height assignment. Since currently two studies on the use of the oxygen A band are conducted in support of the post-MSG user consultation, it was agreed to wait for the final presentation of these studies before deciding on additional channels in the oxygen A band.

Channel #	Generic wavelength [µm]	cloud detection	cloud type	cloud temp. press.	CMVs	AMVs	tracer heights	LST and SST	cloud phase	cloud optical thichness	cloud drop size distribution	instability gradT(p) gradHu(p)	total column humidity
1	**0.47**												
2	**0.645**	X	X		X				X	X	X		
3	**0.865**	X	X		X				X	X	X		
4	**1.375**		X						X		X		
5	**1.61**	X	X						X	X	X		
6	**2.13**										X		
7	**3.8**	X	X	X	X			X	X		X	X	
8	**4,33-5,49**					X	X	X				X	X
9	**6.7**		X	X		X	X					X	X
10	**7.35**		X	X		X	X					X	X
11	**8.55**		X	X			X	X	X		X	X	X
12	**9.7**					X							
13	**11.2**	X	X	X	X		X	X	X		X	X	X
14	**12.3**	X	X	X	X		X	X	X		X	X	X
15	**13.4**			X	X		X					X	X
16	**14**						X					X	
17	**13.2 - 14.4***						X					X	
	Priority ranking of products:	1a	1b	1c	2a	2b	2c	3	4a	4b	4c	5	6

Channel #	aerosol optical thickness	aerosol size distribution	low visibility	snow cover	sea-ice temperatue	vegetation stress	detect./ monitore fires	smoke location	volcanic ash detection	volc. Ash column concentration	sand/dust storm location	selected channels	Ranking of channels
1	X	X							X	X	X	X	4
2	X	X	X	X		X		X	X	X	X	X	1
3	X	X	X	X		X		X	X	X	X	X	1
4	X	X										X	1
5	X	X	X	X		X		X	X	X	X	X	1
6	X	X										X	3
7	X	X	X	X	X		X		X	X	X	X	1
8					X							X	O-2
9												X	1
10												X	1
11					X				X	X	X	X	1
12												X	2
13			X	X	X		X		X	X	X	X	1
14			X	X	X				X	X	X	X	1
15									X			X	1
16												X	O-2
17												X	O-2
	7a	7b	7c	8a	8b	9a	9b	9c	10a	10b	10c		

Tab 4: Selected GEO imagery I-2 channels (no sounder) and their link to the products to be derived for the related user/service needs

2.3.3 Change of imagery I-2 channel selection in case of sounder support

Under the precondition that from the mission point of view the mutual benefit of linking a GEO imagery mission and a GEO IR-sounder mission would be larger in case of the GEO imagery I-1 than the GEO imagery I-2 mission, it was discussed how to de-scope the GEO I-2 mission.

A GEO IR-sounding mission would benefit in supporting the key user/service needs of the GEO imagery I-2 mission related to (see section 2.2.2):

- tracking of clear sky atmospheric motion vectors,
- height assignment of cloud and clear sky atmospheric tracers,
- early warning of convective intensity (instability, CAPE, and DECAPE)

Starting from the AMVs, its was agreed to discard the optional pseudo sounding channels in the 4µm CO_2 band (channel 8 in Table 4). Furthermore it was agreed that there is no need for tracking clear sky atmospheric features with the imager. Consequently, the second water vapour channel at 7.35µm and the ozone channel at 9.7µm (channels 10 and 12 in Table 4, respectively) were discarded. For the height assignment it was agreed that neither the second channel at 14µm (channel 16 in Table 4) for the CO_2 slicing method nor the nine optional sounding channels in the 13.4 to 14.5 CO_2 band (channel 17 in Table 4) are needed. The remaining channels were identified as essential to keep as ‘core channels’, even in the case of an optimal support by a sounding mission.

2.4 Definition of Level 1 requirements.

Following the selection of channels, the level 1 requirements for both imagery missions were discussed. It was generally agreed that de-scoping the GEO imagery I-2 mission in case of a support by the sounder will not change the level 1 requirements for the remaining channels.

It was further agreed that in terms of channel bandwidth and noise@reference level the requirements specified for the GEO imagery I-1 mission could be relaxed compared to those specified for the I-2 mission.

Since there is a trade off between different level 1 requirements, the group was tasked to specify, where possible/needed, a range (upper and lower boundary) for the specific requirements.

Concerning spatial resolution the Application Experts stressed that for the I-1 mission it is important to resolve for individual clouds their variability in the cloud top microphysics. It was claimed necessary that a spatial resolution of 1km (at mid latitudes) for the VIS and SIRW bands (the SIRW band at 3.8µm will be the driver) is desirable, while 2km at least is necessary.

It was agreed to discuss and specify requirements for the Spatial Sampling Interval (SSI) or sampling distance for both of the imagery missions in the first place. Based on the fact that the IFOV, the SSI, the Modulation Transfer Function (MTF) and the acceptable Noise level at a certain reference are linked it was further agreed that the IFOV and the MTF need to be optimised by the engineers within the overall instrument radiometric budget. The Application Experts emphasised, that once the IFOV for each of the imagery missions, and in particular for the high spatial I-1 mission, are characterised it would be necessary to analyse if their specification is still compliant with the user needs.

Concerning the MTF it was agreed that ESA should have a look at it based on the experience gained with SEVIRI.

As regards the spatial resolution, it was finally agreed that the SSI need to be the same for all spectral channels and the range was fixed as 0.5 – 1 km for the GEO imagery I-1 mission, and 1 – 3 km for the GEO imagery I-2 mission at SSP.

Concerning the temporal resolution, the range for the temporal sampling or repeat cycle was identified to be 2 – 5 min and 5 – 15 min for the GEO imagery I-1 and I-2 missions, respectively.

For the total field of view to be covered within each repeat cycle, it was agreed that it has to be the full disk (full square) for imagery I-2. For imagery I-1 it was agreed that the size of the region to be scanned over one repeat cycle should be about that of HRV, equal to ½ of the full square potentially split into 3 parts for targeted observation.

Concerning the discussion on inter-channel co-registration errors, it was emphasised that the process deriving at the final number will be iterative. For imagery I-2 it was agreed to start with a goal of errors not exceeding 0.1 pixels. For imagery I-1 it was agreed that the requirements could be relaxed to ¼ of a pixel as goal and 1 pixel as threshold.

As regards the absolute accuracy for I-2, it was agreed to take, as the baseline, the 0.5 K as specified for SEVIRI thermal channels and to request as stability requirement a drift of less than 0.5 K over the time period of a month, with a maximum drop over lifetime not exceeding 2.0K.

In addition, it was agreed that polarisation, in particular for the ‘blue channel’, is an important issue. It was agreed to characterise polarisation rather than rotate the detector array for keeping the mirror angle constant. The demand is to keep the polarisation within the 5% error of the SW vicarious calibration.

Tables 5 to 8 summarise, the preliminary level 1 requirements for the GEO imagery I-1 and I-2 missions as they where discussed and agreed at the time of the meeting. Table 5 lists the requirements for 16 channels of I-1 and I-2. The four I-1 channels are coloured in red. The twelve channels specified for imagery I-2 are the ‘core channels’ in case of an optimal support by an IR-sounder. Table 6 lists the five additional channels, requested for imagery I-2 (3 core and 2 optional sounding channels) in case of no support by a sounder. Tables 7-8 details the level 1 requirements for the two optional sounding channels in the 4µm CO_2 band (total of 250, heritage of AGIRS) and in the 13.4 to 14.5 µm CO_2 band (the 9 bands from the SEVIRI split of 13.4 µm channel study), respectively.

Table 5: Imagery 1 (marked red) and Imagery 2 (with sounder)

Band #	λ_{min}	λ_{max}	**Center wavelength**	**Width**	**Noise @ reference level**		**Reference Level**		**Dynamic range**		Coverage	Repeat cycle		SSI @ SSP	
					(1)	NEDL (3)	(2)	L (3)	(2)	L (3)		T	G	T	G
	micron	micron	micron	micron		$W.m^{-2}.sr^{-1}.\mu m^{-1}$		$W.m^{-2}.sr^{-1}.\mu m^{-1}$		$W.m^{-2}.sr^{-1}.\mu m^{-1}$		min	min	km	km
1			0.443	0.02	10	0.602	1%	6.016	120%	721.931	Full disk	15	5	3	1
2	**0.5**	**0.7**		**90 % within [λ_{max}-λ_{min}]**	**10**	**0.553**	**1%**	**5.532**	**120%**	**663.816**	**TBC**	**5**	**2**	**1**	**0.5**
3			0.645	0.05	10	0.516	1%	5.162	120%	619.468	Full disk	15	5	3	1
4			0.865	0.04	10	0.315	1%	3.146	120%	377.511	Full disk	15	5	3	1
5			1.375	0.03	10	0.114	1%	1.142	100%	114.232	Full disk	15	5	3	1
6			1.61	0.06	10	0.079	1%	0.788	100%	78.841	Full disk	15	5	3	1
7			2.25	0.15	10	0.024	1%	0.244	100%	24.369	Full disk	15	5	3	1
8			**2.25**	**0.15**	**2**	**0.122**	**1%**	**0.244**	**100%**	**24.369**	**TBC**	**5**	**2**	**1**	**0.5**
9			3.8	0.6	0.1		300		340		Full disk	15	5	3	1
10			**3.8**	**0.6**	**0.5**		**265 - 300 K**		**340**		**TBC**	**5**	**2**	**1**	**0.5**
11			6.7	0.4	0.3		250		300		Full disk	15	5	3	1
12			8.55	0.3	0.1		300		300		Full disk	15	5	3	1
13			10.8	1	0.1		300		335		Full disk	15	5	3	1
14	**10**	**12.5**		**90 % within [λ_{max}-λ_{min}]**	**0.5**		**265 - 300 K**		**335**		**TBC**	**5**	**2**	**1**	**0.5**
15			12	1	0.1		300		335		Full disk	15	5	3	1
16			13.4	0.6	0.3		270		300		Full disk	15	5	3	1

Note
Imagery 1 channels
Imagery 2 with sounder channels
Imagery 2 without sounder channels

SSI Spatial Sampling Interval
T Threshold
G Goal
Full Disk Cone of total angle of 18 ° centered at SSP

(1) SNR for solar channels (1 to 8)
NEDT (K) for TIR channels (9 to 21)
(2) Albedo TOA for solar channels (1 to 8)
Brightness temperature (K) for TIR channels (9 to 21)
(3) Radiance at zenith

Table 6: Additional Imagery 2 (without sounder) channels

Band	λ_{min}	λ_{max}	Center wavelength	Width	Noise @ reference level	Reference Level	Dynamic range	Coverage	Repeat cycle		SSI @ SSP	
#									T	G	T	G
	micron	micron	micron	micron	K	K	K		min	min	km	km
17	**4.33**	**5.49**	**continuous coverage with $\Delta\nu = 2\ cm^{-1}$**		**see table 7 below**			**Full disk**	**15**	**5**	**3**	**1**
18			**7.35**	**0.3**	**0.3**	**250**	**300**	**Full disk**	**15**	**5**	**3**	**1**
19			**9.7**	**0.4**	**0.3**	**270**	**310**	**Full disk**	**15**	**5**	**3**	**1**
20			**14**	**0.6**	**0.3**	**250**	**300**	**Full disk**	**15**	**5**	**3**	**1**
21			**13.2 - 14.4***	**see table 8 below**				**Full disk**	**15**	**5**	**3**	**1**

Table 7: "AGIRS" Channels

Band	λ_{min}	λ_{max}	Center wavelength	Width	Noise @ reference level	Reference Level	Dynamic range	Coverage	Repeat cycle		SSI @ SSP	
#					(4)				T	G	T	G
	micron	micron	micron	micron	K	K	K		min	min	km	km
17-1	**4.43**	**4.47**			**0.1 -0.25**	**200-275**	**275**	**Full disk**	**15**	**5**	**3**	**1**
17-2	**4.47**	**4.55**			**0.1 -0.25**	**200-300**	**300**	**Full disk**	**15**	**5**	**3**	**1**
17-3	**4.55**	**5.2**			**0.1 -0.25**	**200-315**	**335**	**Full disk**	**15**	**5**	**3**	**1**
17-4	**5.2**	**5.35**			**0.1 -0.25**	**200-310**	**310**	**Full disk**	**15**	**5**	**3**	**1**
17-5	**5.35**	**5.49**			**0.1 -0.25**	**200-300**	**300**	**Full disk**	**15**	**5**	**3**	**1**

(4) NEDT (K) defined at a temperature of 280K. At temperatures different from 280K, the specified value shall be scaled by the factor [dB(λ,280K)/dT]/ [dB(λ,T)/dT]
where B is the Planck's function, λ is the wavelength and T is the target temperature in K. This implies an accuracy constant in term of radiance.
Goal: 0.1 K - Threshold: 0.25 K

Table 8: CO2 slicing channels

Band #	λ_{min}	λ_{max}	**Center wavelength**	**Width**	**Noise @ reference level**		**Reference Level**		**Dynamic range**		Coverage	Repeat cycle		SSI @ SSP	
												T	G	T	G
	micron	micron	micron	micron	K		K		K			min	min	km	km
21-1			**13.4775**	**0.125**	**1**		**270**		**300**		**Full disk**	**15**	**5**	**3**	**1**
21-2			**13.6985**	**0.125**	**1**		**250**		**300**		**Full disk**	**15**	**5**	**3**	**1**
21-3			**13.986**	**0.25**	**1**		**250**		**300**		**Full disk**	**15**	**5**	**3**	**1**
21-4			**14.035**	**0.25**	**0.6**		**250**		**300**		**Full disk**	**15**	**5**	**3**	**1**
21-5			**14.134**	**0.25**	**0.6**		**250**		**280**		**Full disk**	**15**	**5**	**3**	**1**
21-6			**14.184**	**0.25**	**0.6**		**250**		**280**		**Full disk**	**15**	**5**	**3**	**1**
21-7			**14.336**	**0.26**	**0.7**		**230**		**280**		**Full disk**	**15**	**5**	**3**	**1**
21-8			**14.493**	**0.26**	**0.7**		**230**		**280**		**Full disk**	**15**	**5**	**3**	**1**
21-9			**14.599**	**0.26**	**0.7**		**230**		**260**		**Full disk**	**15**	**5**	**3**	**1**

3 PARTICIPANTS

External Experts (AEG/RSE):

B. Bizzarri, Rome, Italy
B. Golding, Met Office, Bracknell, UK
J. Eyre, Met Office, Bracknell, UK
W.P. Menzel, NOAA/NESDIS, Madison, USA
D. Rosenfeld, The Hebrew University of Jerusalem, Israel

ESA-ESTEC:

D. Aminou
P. Benzi
J-L. Bezy
P. Ingmann

EUMETSAT:

A. Ratier
J. Schmetz
R. Stuhlmann
S. Tjemkes