EUMETNET OBSERVATION ROADMAP

Draft V06

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CONTENT

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1. EXECUTIVE SUMMARY

General trends for 2011-2020

The purpose of this Observation Roadmap is to provide an implementation plan for the EUMETNET observation strategy. As such it outlines the EUMETNET key activities aiming at maintaining and developing the EUMETNET Composite Observing System (EUCOS) during the period 2011-2020. The two objectives of this Roadmap can be reflected by the following observation goals:

O1. EUMETNET will develop an integrated composite observing system for Global, Regional and 1 km Scale Convection Resolving Models and for Climate, building on existing infrastructure.

O2. EUMETNET will ensure that observational and climate data gathered by the composite observing system will be of appropriate quality to meet the requirements of NWP and climate by working with Members to share and implement best practice and methodologies within the system.

This Roadmap documents the general trends of the EUMETNET Observation Capability Area comprising of the central Observation Programme EUCOS, six existing Observation Programmes (new term: 'Projects') E-AMDAR, E-ASAP, E-GVAP, E-SURFMAR, E-WINPROF, and OPERA and two potential new Observation Projects (E-PROFILE and E-MODE-S). First, the development of the various observation activities is envisaged under two different budget scenarios, the first one assuming a reduced budget, the other one a constant level of funding. Second, further actions aiming at improving and optimizing the different observing networks, or creating new observation means (to be possibly integrated in EUCOS during the decade 2011-2020), are proposed to be included as additional deliverables. These new actions may require additional resources. It can be noted that the current existing programmes (2011) spend most of the budget resources on the operational production of observations rather than on R&D activities.

There is still a huge potential for progress in the development of EUCOS and the existing Observation Programmes, and it is thus proposed to continue these programmes, while maintaining the quality of their routine operational production as well as launching R&D activities to develop and further improve the quality of the corresponding observing systems. It is also suggested to develop two new programmes, the first of which, E-MODE-S, has the long-term purpose of operationally collecting aircraft MODE-S data on a European scale. The purpose of the second one, E-PROFILE, is to gather ceilometer data, volcanic ash measurements and remote-sensed measurements of temperature/humidity and to combine these observations at a European level similar to the wind profiler and GNSS water vapour networks. In addition, EUCOS should maintain a close

scientific watch on several new or emerging activities such as 'opportunity measurements' resulting from the exploitation of atmospheric attenuation of GSM signals used for mobile phones or on Unmanned Aeronautical Vehicles (UAV), gondolas, GNSS receivers installed on drifting balloons or aircrafts. Also, close collaboration is suggested between EUMETNET and the different research groups and organizations working on these activities: European COST actions, space agencies, WMO, etc... Collaboration should not be limited to Europe, as these activities are studied and developed around the world: they are envisaged in the future WIGOS.
Monitoring quality and impact on various meteorological applications of the different observing systems is a EUCOS activity which has been run for years and which should be reinforced. A significant improvement of the overall quality of EUCOS can be expected from network optimization and from better observations, without deploying any new observation means.

The targeting strategy (consisting in deploying or providing a subset of the operational observations purely depending on the meteorological situation and its predictability) has to be studied and further examined for each individual observing system. The AMDAR and ASAP observing systems are probably flexible enough to allow efficient targeting. With respect to the present situation of AMDAR and ASAP observations, it is suggested to develop 'reduced' observing scenarios, i.e. scenarios producing less observations without jeopardizing the AMDAR or ASAP infrastructures. These reduced scenarios could be used in the future for two occasions: (i) during episodes of highly predictable weather regimes; (ii) when reduction of observation cost is necessary because of a budgetary crisis. In the context of targeting, 'upgraded' observing scenarios are also to be designed for weather regimes of low predictability.

An inexpensive way to improve data availability is to organize the access to third party data, and to integrate them into EUCOS where possible. The WIGOS project of WMO has a similar purpose at the global scale (see http://www.wmo.int/wigos).
In general, third party observations are primarily made for activities which are closely related to meteorological activities: electricity production, transport, hydrology, water management, oceanography. The first step of the suggested EUCOS activity consists in an analysis of existing third party observations, especially those which are already available in at least one NMS or NMHS. Special attention has to be given to quality and representativeness of these observations as they have not been designed for meteorological purposes. This stresses again the role of EUCOS in the area of quality control and monitoring.

Main actions related to Observation Programmes

The present Observation Roadmap classifies the various activities in three different ways according to different criteria:

- There is a list of 18 High Level Activities (HLA) which have been analysed and classified according to their priority.
- The development of observations is also presented by observing system: land surface observations, marine surface observations, upper-air observations, etc…
- Finally, in the annexes, the different activities are itemized, observing programme by observing programme, for both existing and proposed new activities.

The list of 18 HLA gives highest priority to radar activities due to the potential which raw data and processed radar products offer for nowcasting and kilometric scale NWP. In addition, it is very important to ensure a consistent processing, exchange and utilization of the radar data in Europe, which are important at all scales including the global one. Next on the HLA priority list is the standardisation of surface observing systems and the improvement of the upper-air network covering Europe and the North Atlantic Ocean. These activities concern more especially AMDARs, radiosondes (including ASAPs), Mode-S and profilers.

The North Atlantic observing network has been considerably improved during the last few decades in both its surface and upper-air components. This is mainly due to the actions of the observing programmes E-AMDAR, E-ASAP and E-SURFMAR. One challenge for the coming decade is to optimize and maintain North Atlantic coverage, to extend coverage to the north polar cap (and to the Mediterranean area) and to improve vertical resolution.

The list of itemized actions by observing programme (see annexes) includes 10 EUCOS actions (only 3 of which require additional resources). The list presents important actions related to data exchange on an hourly basis (or even more frequently), standard coding and access to third party data. As to the other Observation Programmes, the highlights are as follows:
- E-AMDAR: development of humidity sensor;
- E-ASAP: study of flexible sounding timetable (first step towards reduced and upgraded scenarios for targeting);
- E-SURFMAR: development work to improve the SST measurements (in collaboration with other observation programmes dedicated to SST);
- E-GVAP: design of a system for more frequent (even globally) distribution of observations (at least hourly);
- E-WINPROF: development of a system to deliver observations every 15 minutes;
- OPERA: production of 3D reflectivity composites and rain products;
- E-MODE-S: collect Mode S data on European scale;
- E-PROFILE: collect ceilometer data and other ground-based remote sensing data to measure temperature, humidity and aerosols like volcanic ash.

Expected benefits and impacts

This Roadmap documents different funding scenarios for the evolution of EUCOS until 2020. The benefits are expected to be considerable in absolute terms for forecasting, climatology, aviation and other activities in the highest funding scenario. The benefit-cost ratio is also expected to increase significantly. Even if the lowest funding scenario had to be applied, the benefit-cost ratio would still slightly go up (although the absolute benefits are uncertain) due to the many optimization actions suggested, inexpensive actions to produce more data, more accurate data and utilisation of more and better existing observations.

The improvement of NWP products - as a major task during the last decade - is expected to continue at the same speed during the coming decade, partially depending on the availability of high resolution observations. The highest benefits are expected for the kilometric scale in NWP, in nowcasting and in the area of very short range forecasting. These forecasting improvements will be of direct benefit for aviation. The aviation sector will be able to take advantage of a more and more rapid exchange of new products, like Rapid Update Cycles combining NWP and (new) observations (especially aircraft, radar and profiler observations). An increasing number of other applications and users are likely to draw benefits from these products and from EUCOS improvements in general.

An improved EUCOS by 2020, i.e. in the highest funding scenario, would make a substantial contribution to the improvement of GCOS and the climate activities in general. Any improvement made to time series at fixed observation points will benefit GCOS to the effect that the quality of global monitoring of the climate change will improve too. Local climate monitoring will become much easier and more accurate with denser observation networks. Climate studies will benefit from reanalyses made with observations which are denser and better distributed in time and space, which implies more consistency in the reanalysis time series.

A common property of investments in NWP and climate activities is that their benefits can be assessed quantitatively only several years after they have been done. The investors in EUCOS observation systems have to be patient to see the full benefits of their investments. Progress that comes from observation improvements is more immediately visible in nowcasting and all activities (such as aviation) strongly dependent on rapid real-time processing and exchange of observations.

2. EUMETNET MISSION AND VISION

The EUMETNET mission is the following: *to help its Members to develop and share their individual and joint capacities through cooperation programmes that enable enhanced networking, interoperability, optimization and integration within Europe; and also to enable European bodies to use these capacities effectively.*

The EUMETNET vision can be summarized in the following way: *by 2020 EUMETNET will have enabled its Members to provide a cost-efficient, world-class, shared infrastructure that is significantly more interoperable and integrated with shared basic services. These improvements will enable Members to better fulfil their official duties, enhance their individual capacities and provide a basis for Members to deliver, collectively, joint public information services at the level of the European Union (EU) and its Agencies.*

Based on these vision and mission statements, the Assembly has developed a EUMETNET strategy which was established in November 2009. To implement the strategy it was decided to develop roadmaps for each of the capability areas. As a first step for observations, an outline roadmap was developed which describes various scenarios on three ambition levels: 1) *overall reduction in funding*, 2) *no change in overall funding and more cooperation* and 3) *increased funding of observations for shared services which will lead to reduced overall costs for Members' own operations*. At its meeting of November 2010, the Assembly chose to elaborate a detailed roadmap for scenario 2C, i.e. *an integrated composite observing system for Global, Regional and 1 km Scale Convection Resolving Models and for Climate*, which is presented through this document.

In agreement with later information on possible budget reductions, the Drafting Team also considered less ambitious scenarios than the one originally chosen by the Assembly.

With respect to mission and vision, there is a very large heterogeneity between the different surface-based observing systems: some of which, for example, do not match the mission and vision requirements, especially in terms of interoperability, optimisation and integration (e.g. voluntary observing ships, weather radars, ground-based GNSS networks and many new or 'undiscovered' observing systems, such as ceilometers or 3rd party networks). For others, Members have already begun to coordinate and optimise observation practices, networks, data processing and data exchange (e.g. synoptic weather stations, land-based and shipborne radiosondes, AMDAR aircraft, drifting buoys, wind profilers).

Many of the actions and scenarios documented in this roadmap are directly linked to the EUMETNET Forecasting and Climate Roadmaps and to the observation requirements of Forecasting and Climate activities in

Europe. More specialized applications are also taken into account, for instance aviation requirements derived from the EU&Aviation Roadmap. Aviation is the main user of volcanic ash monitoring.

This Observation Roadmap is intended to provide a vision for the evolution of the EUMETNET Observing Capability Area, give guidance to the Programme Managers and form the basis for Assembly's decision on the future direction of EUMETNET Observation Programmes and Projects.

The roadmap presented here deals with European non-satellite observing systems, covering both in-situ and remote sensing measurements, and taking into account the global requirements as well.
The Integrated Composite Observing System, ICOS, stands for the entire set of meteorological observing systems including both satellite, run by EUMETSAT, and non-satellite systems which are run by EUMETNET, its Members or any 3rd party in the EUCOS area. EUCOS consists of all EUMETNET owned observation systems and of a selection of observing sites operated by Members. All of these observing systems are non-satellite systems. Satellite (space-based) and non-satellite (terrestrial) systems are complimentary within ICOS, therefore a strong interaction between EUCOS and EUMETSAT is prerequisite for the implementation of this Observation Roadmap.
Though not subject of this EUMETNET Observation Roadmap, the satellite infrastructure will be taken into consideration in dedicated studies to ensure that satellite and non-satellite observations complement each other in the best possible way. For information about the satellite system, see

- http://www.wmo.int/pages/prog/sat/Refdocuments.html#spacebasedgos
  http://www.wmo.int/pages/prog/sat/gos-intro_en.php
  (WMO web page containing a comprehensive dossier on past, present and future satellites, with their instruments);
- http://www.eumetsat.int/groups/cps/documents/document/pdf_br_eum05_en.pdf
  (EUMETSAT strategy);
- http://www.esa.int/esaLP/SEMOMS4KXMF_LPgmes_0.html
  (an overview of the GMES space component).

Complementarity between the observations described in this roadmap and satellite observations is important at all scales, especially the global scale where ECMWF plays a key role in modelling. The list of satellite observations used and monitored at ECMWF can be viewed at http://www.ecmwf.int/products/forecasts/d/charts/monitoring/satellite/

This website also provides information on some EUMETSAT SAFs. The SAFs cover different applications from global to local scales, and they typically use in-situ observations for complementing, anchoring and validating satellite data.

3. OBSERVATION GOALS

The objectives of this EUMETNET Observation Roadmap sum up in two main observation goals: O1 and O2.

O1. *EUMETNET will develop an integrated composite observing system for Global, Regional and 1 km Scale Convection Resolving Models and for Climate, building on existing infrastructure.*

O2. *EUMETNET will ensure that observational and climate data gathered by the composite observing system will be of appropriate quality to meet the requirements of NWP and climate by working with Members to share and implement best practice and methodologies within the system.*

Goal O1 classifies the observational requirements at three different horizontal scales. Global and especially regional requirements have been studied and dealt with by EUMETNET since its establishment, but consideration of ’kilometric’ (1km horizontal scale) requirements has started only recently in relation with the development of operational convection-resolving models, mainly for operational NWP. In the past, several numerical studies have been carried out on observation requirements of global and regional NWP, leaving now similar studies to be carried out to define observation requirements of kilometre-scale NWP. Kilometric requirements may be translated into higher horizontal and vertical resolutions and more frequent measurements. Higher horizontal resolution may be achieved by using in-situ measurements as a reference for satellite measurements that already support a high horizontal resolution. Kilometric NWP is also increasingly used for nowcasting (not only short-range and very short-range forecasting). Kilometric requirements are a large subset of nowcasting requirements which are also considered in this roadmap.

Goal O2 stresses the importance of quality, quality control and quality management for two important applications: NWP and climate. The current situation is highly variable across the different observing systems. Some of them require many more developments and progress to be made in the field of homogeneity and quality to achieve this goal. This is particularly the case with observing systems, such as GNSS networks which have been developed by several public or private actors outside the meteorological community and present a huge potential for meteorological applications, but have only recently begun to be used in operational NWP.

4. OBSERVATION ROADMAP DEVELOPMENT

A special process for reviewing and updating observational requirements has been set up by WMO. This process is called ‘Rolling Review of

Requirements’ (RRR). Requirements are classified according to different application areas, and they are quantified in terms of data coverage, data density, accuracy, etc. through regularly reviewed and updated tables. Global and ’high resolution’ NWP are two important applications which are processed in this way, together with more specialized and user-oriented applications, such as aviation, hydrology, agriculture, etc. However, detailed observational requirements for Europe cannot be reduced to a pure set of figures in RRR tables. A specific analysis is often needed to find out how a specific observing system can efficiently serve several applications, and to determine whether the measures to be taken are purely local or fall under the responsibility of EUMETNET or its Members.

The WMO process for reviewing observation requirements is followed by a comparison with the ensemble of operationally available data, leading to a ’gap analysis’. The gap analysis point out the main deficiencies of current observing systems and leads to the ’Statements of Guidance’ (SoG). Documentation on RRR and SoG is available at
http://www.wmo.int/pages/prog/sat/RRR-and-SOG.html#SOG

Similar to the WMO approach of conducting an RRR which finally leads to the SoG, the EUMETNET Observation Roadmap Drafting Team conducted a review of European meteorological observation capabilities followed by a gap analysis and compilation of a list of ’high level activities’ aimed at filling the identified gaps.

4.1. Review of existing EUMETNET Observation Programmes

All existing ground-based EUMETNET observing capabilities either operated by Members or by the EUMETNET programmes E-AMDAR, E-ASAP, E-GVAP, E-SURFMAR, E-WINPROF, OPERA and EUCOS have been reviewed with respect to the newly set observation goals. This review reveals that the existing EUMETNET Observation Programmes are essential to ensure comprehensive supply of EUMETNET Members with observations. The range of activities undertaken by these programmes is considered to be of appropriate scale and design. No possibilities for cancelling any of the activities or significantly reducing tasks have been identified. However, it has been recognised that efficiency savings should be made where possible. The Observations Roadmap Drafting Team considers especially one already existing activity of the E-AMDAR programme particularly promising technically; it is therefore important to assess the economic viability of the AMDAR Humidity sensor and prepare plans to implement this valuable technology in an affordable manner.

4.2. Gap Analysis of Observations with respect to Forecasting and Climate requirements

In addition to the review of already existing observing capabilities, a gap analysis of observations was carried out with respect to the EUMETNET Forecasting and Climate requirements.

Using the gap analysis of the PB-OBS Outline Roadmap as a basis, the following gaps were identified:

CLIMATE:

- Network design
- Horizontal distance or resolution
- Access of data
- Parameters (especially precipitation)
- Harmonization of quality control/monitoring and meta data

FORECASTING:

- Horizontal distance or resolution
- Planetary boundary layer
- Humidity and precipitation
- Surface characteristics
- Improvement of quality assurance of humidity and surface data
- Update frequency and timeliness
- Data sharing besides GTS due to data policy issues
- Data discovery

The OBS Roadmap Drafting Team discussed these gaps and identified potential 'High Level Activities' (HLA) to close these gaps. The actions suggested in chapter and annex B of this document are mainly based on this gap analysis applied to Europe and on potential developments which could contribute to fill the gaps.

4.3. Current EUMETNET Observation Programme budget

Table 1 shows approximate annual programme costs of EUMETNET Observation Programmes. Management costs usually also include costs for quality monitoring activities because this is typically part of the deliverables of EUMETNET Observation Programmes. 'Fixed costs for infrastructure' usually cover software and hardware costs, e.g. for running data hubs. R&D costs are non-recurring expenditures, paid e.g. for developing software and equipment. When the management of a programme includes a significant amount of R&D work, e.g. software development for QC and data processing, then 'Combined management and R&D' figures are given. 'Observations' costs typically cover data procurement fees (e.g. in E-AMDAR) and costs of consumables (e.g. in E-ASAP). In order to describe the budget situation as transparent as possible, 'in-kind' contributions of Members are included when such extra funding is provided. Figure 1 depicts that the present EUMETNET Observation Programmes spend two-thirds of their budgets on delivering observations.

Costs in k€	E-AMDAR	E-ASAP	E-SURFMAR	E-WINPROF	E-GVAP	OPERA	EUCOS	Total
Management	177	172		108		33	205	755
In-kind contributions of Coordinating Members to Management	50		44			10		104
Fixed costs for infrastructure	168			30		90		288
R&D	185	51		10		86	302	634
Combined management and R&D			167		120			331
Observations	1,001	1,595	607				435	3,638
Total	1,581	1,818	818	148	120	219	942	5,646

Table 1: Approximate annual programme costs of EUMETNET Observation Programmes.

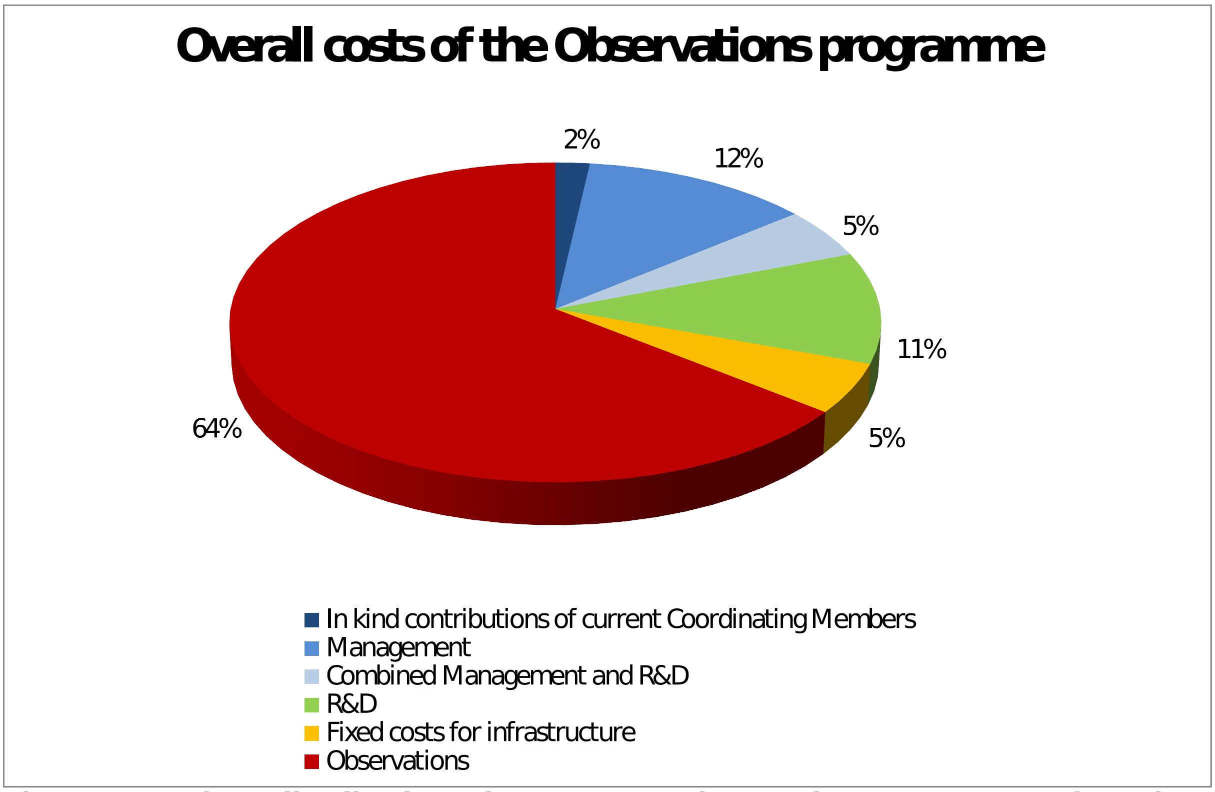

Figure 1: Budget distribution of EUMETNET Observation Programmes based on 2010 budget figures.

The fact that the bulk of the money is spent on operational data production leaves a limited flexibility for launching new actions to fill the gaps without increasing the total budget. In other words, the 'affordability' of new ambitious high level actions which could help to reduce observation gaps is very limited.

4.4. Consideration of third party observation networks

Nevertheless, an alternative to the relatively expensive development of new observation systems to fill the gaps is to increase access to existing third party datasets and to establish a real-time exchange of some of these data. Indeed, many specific observing networks have been developed and are still being developed to monitor local phenomena, such as weather along roads, motorways or railway tracks, for the purposes of urban or airport meteorology, agro-meteorology and 'renewable energy' production. This ensemble of networks is very heterogeneous in terms of observed parameters, observing practices and standards as well as observation frequency. However, some of the observed variables are not only very useful for the main and local application they are supposed to serve, but also for many other regional or even global applications including NWP and climate monitoring. Most of the time such specific observing systems are fully automatic and use new technologies; they often produce very frequent observations. To make the data from these systems available to a wider range of users, harmonization of data transmission codes, reporting practices, quality management standards and the use of metadata would be needed. In addition, data processing standards should be developed for being able to provide different sets of observations to different types of users (local, national, regional, global).

The access to third party observations is likely to be facilitated by cooperation with the EEA and its EIONET and under the GMES programme (see http://www.eea.europa.eu/data-and-maps)
The website describes several environmental topics, related datasets, European organizations and networks whose activities are of interest for EUMETNET, especially for searching new sources of observation and environmental information.

It must be noted, however, that the search for third party data is an activity which is mainly expected to start at the national level rather than the European level. NMSs and NMHSs are in a better position than EUMETNET to initiate a first step (such as an inventory of nationally available third party data that are potentially useful). The second step then is to bring together the national inventories at a European level; this should be done by EUCOS.

4.5. Definition of ‘High Level Activities’

The two general observation goals O1 and O2 have been analysed and expanded into different High Level Activities (HLA) with precise objectives. These activities are listed in Table 2 with a priority order from 1 to 18, whereby HLA 1 has the highest priority, HLA 18 the lowest. This priority order is the result of an assessment made by the Observation Roadmap Drafting Team (comprising of EUCOS Team Members, several European observation experts and managers from different National Meteorological Hydrological Services (NMHS)). The assessment is based on the different observation requirements and involves to some extent also the feasibility and the cost of the actions. Chapter and annex B present an analysis of the 18 HLA and their expansion into more detailed activities by observing system in comparison with the different EUMETNET Observation Programmes and their evolution until 2020.

When examining the different observation programmes and activities, a clear distinction must be made between

(i) activities which help meeting the requirement of continuity of certain operational observing capacities;
(ii) activities aiming at filling the observation gaps in the current composite observing system.

Table 1 and Figure 1 in chapter show that most of the current budget is spent on (i) rather than (ii). Most of the current observation gaps are directly linked with the EUMETNET Forecasting and Climate requirements. Filling these gaps remains a challenging task. Climate and forecasting gaps may be expressed in terms of meteorological parameters (e.g. lack of precipitation observations needed to analyse the required precipitation fields) or geographical gaps (e.g. lack of observed atmospheric profiles over the North Atlantic Ocean and the north polar cap), or in several other ways including observation coding and transmission. Another example relates to aviation requirements: the lack of frequent and detailed vertical wind profiles in areas around airports (see the EUMETNET Forecasting, Climate and EU&Aviation Roadmaps, especially the annexes dedicated to observations).

Priority	**High Level Activity**
1	Weather Radar: work on exchange of 3D radar raw data and products (Doppler winds, composite products, raw data exchange, refractivity, dual-polarisation data), improve consistency of radar data from different national networks
2	Weather Radar: work to improve the processing (detection of non-meteorological echoes and quality management) of radar data and the accuracy of radar products building on the Odyssey data-hub in order to make the existing Odyssey products suitable for applications such as NWP, nowcasting and hydrology
3	Promote surface weather station (especially AWS) standardisation (i.e. snow depth observing methods, soil parameters, precipitation, humidity observation methods, ensure that transition to AWS does not introduce breaks or inhomogeneities in time series, enhance automatic QC of AWS systems, etc.)
4	Improve the vertical resolution of profile temperature, humidity and wind observations (e.g. by distributing 2s radiosonde data, increase AMDAR reporting frequency)
5	Investigate new upper air observing capabilities (Mode-S, TAMDAR, AMDAR-Humidity, aircraft borne GPS Radio Occultation measurements)
6	Enhance upper-air network coverage: e.g. extend E-ASAP soundings to Arctic Ocean, include more airlines in E-AMDAR programme in order to get AMDAR observations from more airports
7	Improve boundary layer observations: e.g. improve vertical and temporal resolution of temperature, humidity and wind measurements (further investigate remote sensing techniques for profile measuring: LIDAR, GNSS, radiometers, wind profiler, ...), enhance boundary layer profiling network resolution (e.g. try getting AMDAR night time data)
8	Enhance land surface weather station network performance by gaining access to more frequent observations from existing sites
9	Coordinate standardisation: Methods for replacing ‘manual visual observations’ should be developed and standardized for AWS. Parameters of special interest here for the climatic community are: cloud cover, (cloud types), state of ground and type of precipitation. Exchange information on present weather

Priority	High Level Activity
	sensor trial results.
10	Coordinate standardisation of - data exchange (migration to BUFR), - meta data databases, - generation and exchange of 'non-standard' meteorological messages (urban or voluntary observations for example).
11	Enhance marine surface observation network resolution by for example deploying additional buoys / AWS and gaining access to third party data
12	Enhance land surface weather station network resolution by establishing additional stations and gaining access to third party data (especially: improve access to more rain gauge measurements)
13	EUCOS studies: – comparing the geographical coverage versus the temporal frequency in small scale models, – Observing System Experiments (OSE) on E-AMDAR impact, especially look at a possible data denial/sensitivity of cruise data, – role of in-situ observations versus satellite data
14	Enhance marine surface observation network performance by for example gaining access to more frequent observations from existing systems
15	Coordinate harmonization of quality control and monitoring e.g. develop common quality control procedures and rules, progress with development of E-VCOMP (EUMETNET coordination role including liaison/lobbying with WMO)
16	Study and make recommendations to establish a European data targeting process
17	Liaise with COST actions dealing with ground-based meteorological observations, e.g. EG-CLIMET, in order find out whether joining or collaborating with COST actions might help observation Programmes
18	Study Unmanned Aerial Systems (UAS) capability and assess the potential role such systems could play as an element of the European composite observing system. e.g. for monitoring of the atmospheric boundary layer and the underlying surface of the Earth, in the framework of data targeting

Table 2: Definition and ranking of ‚high level activities'.

This ranking of the 18 HLA was obtained by averaging the individual rankings made by experts from about 10 NMHS of EUMETNET Members. The standard deviations of the scores have been evaluated as well and the results are visualised in Figure 2. Small standard deviations from the ranking show that the priority of HLA is felt consistently throughout

Europe; a large standard deviation suggests that the different Members do not agree on the priority to be given to this HLA. HLA 1 and 2 (related to weather radars) are ranked highest very consistently by the different Members, whereas the priority of HLA 3 and 9 (related to AWS and standardization) varies widely among the Members. As a conclusion this Observation Roadmap gives less emphasis on activities related to HLA 3 and 9.

In addition to the ranking of HLA, an assessment of the activities has been made to find out whether the activity was mainly within EUMETNET role or within NMHS role. In other words, the required level of European integration for each activity was evaluated. All activities except HLA 8 and 12 (which are related to an enhancement of the resolution and frequency of land surface stations) are more EUMETNET activities than national ones. The weather radar activities HLA 1 and HLA 2 as well as the activities related to the improvement of conventional upper-air resolution and coverage, HLA 4 and HLA 6, are considered as pure EUMETNET activities.

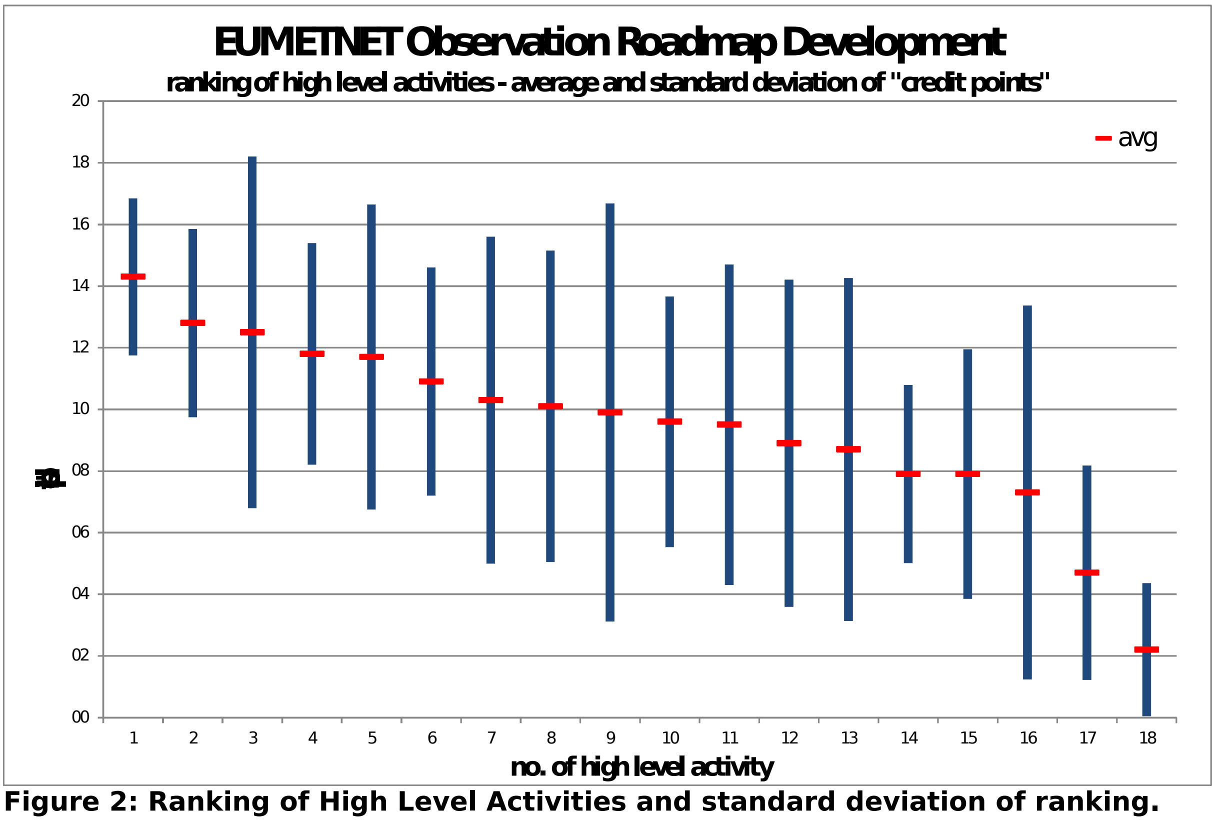

Figure 2: Ranking of High Level Activities and standard deviation of ranking.

The following chapter, as well as the annex B, will put a special emphasis on developing activities related to radar observations which, due to their vital importance for meeting the kilometric requirements, have been identified a large consensus in Europe as the highest priorities in the above classification. A focus is also given to standardisation of surface weather observations and all activities aiming at improving the upper-air observing network (optimization of radiosonde, including ASAPs, and AMDAR coverage, improvement of their vertical resolution, development of profiler networks, and development of new or emerging upper-air capacities). Although the activities related to data targeting (HLA 16) and access to third party observations (HLA 10 to 12) have not been consistently rated of high priority, the roadmap still suggests detailed actions in their context because of their importance for developing and optimizing both the surface and upper-air networks. A small part of this roadmap is also dedicated to activities which are not listed in HLA 1-18, for example the scientific or technological watch to be kept by EUCOS on new or emerging observation capabilities which could become new EUMETNET observation projects at some stage, or the development of lightning networks suggested by the Lightning Task Team (LTT). Action in the area of lightning is also taken into consideration, but with a low priority; it should start by a survey of ongoing studies, in particular the EUMETSAT study on satellite and surface-based lightning detection systems.

5. DETAILS OF THE OBSERVATIONS ROADMAP

5.1. Surface observations

5.1.1. Land surface observations: HLA 8 and 12 (3 and 9 less emphasized)

AWS networks have already been largely developed by EUMETNET members. They still represent a large potential (which, however is not fully exploited yet) especially for soil parameters which are highly variable in space and time: soil moisture, snow depth, vegetation type and cover. A standardisation of observation practices for AWS is required for a correct estimation of these space/time variations. Such standardisation will lead to (i) modifications in existing AWS and (ii) deployment of new stations. These actions should be carried out without harming the homogeneity of climate time series from existing stations.

For both atmospheric and soil parameters, a simple way to increase data availability is to have access to more frequent observations produced by existing stations (automatic or not). For example, many stations are producing observational data on an hourly or even more frequent basis, but with a less frequent real-time transmission of subsets. Regional and global NWP can draw benefits from the assimilation of hourly data and the exchange of even more frequent data would be very useful for nowcasting activities. Progress in forecasting activities in general can be improved significantly by exchanging all observations available on an hourly basis.

Besides establishing additional stations there is an inexpensive way to improve data availability by providing access to third party observations. In general, third party observations are primarily made for activities which are closely related to meteorological activities, such as electricity production, transport, hydrology, and water management. The observation content is generally different from that of meteorological SYNOP stations, but it is still worth extracting the relevant meteorological parameters and making them available to EUMETNET Members. This task implies an analysis to be made of existing third party networks and the cooperation with them to (i) analyse the observation content; (ii) coordinate the extraction, coding and real-time transmission of required parameters.

5.1.2. Marine surface observations: HLA 11 and 14

During the last decade, significant progress has been achieved towards a North Atlantic surface marine network meeting the EUCOS global and regional requirements. The progress requirements are largely due to the E-SURFMAR programme which ensures proper running of buoy deployment and ship observation activities. The main objective of E-SURFMAR for the period 2012-2020 should be to maintain this high quality buoy/ship network. Among other tasks, this means to continue to regularly deploy new drifting buoys (whose life-time is limited to a few months on average). As to data coverage, the geographical gaps which are difficult to fill are the usual ones: northern polar cap, high latitudes in general, Labrador Sea, and all parts of the oceans which are covered with ice every year.

Optimizations and improvements to the current situation are still possible. The general strategy consisting in (i) ensuring that platforms produce and transmit data at least on an hourly basis, (ii) efforts for accessing third party observations (strategy described for land surface observations) is also valid for marine surface observations. Another specific ongoing action consists in progressively equipping all buoys with pressure sensors. Another one is the continuous reduction of communication costs for Voluntary Observing Ships (VOS) and buoys.

According to WMO SoG accurate SST measurements are of high importance for seasonal and inter-annual forecasting. Although satellites provide SST observations with global coverage and a good horizontal and temporal resolution nowadays, nevertheless accurate in-situ measurements of SST are still required for satellite bias-correction. Drifting buoys are a suitable means for providing such in-situ SST measurements. The E-SURFMAR Programme should collaborate with the international Group for High Resolution SST (HRSST) to seek external funding sources (e.g. space agencies, EUMETSAT) for making drifting buoys capable of measuring high-quality SST data.

Once the revised network design studies for E-SURFMAR are completed in 2012, the developments will follow the three guidelines:

- automation of the observation systems onboard VOS in order to provide the basic measurements of pressure, temperature, humidity and wind on an hourly basis;
- continuation of a common specification and procurement of S-AWS in order to achieve a good homogeneity in utilised equipment;
- continuation of efforts to deploy buoys in the Arctic, in collaboration with third parties (e.g. institutes interested in polar activities).

5.2. Upper-air observations

5.2.1. Radiosonde and aircraft observations: HLA 4, 5, 6 and 7

For global and regional scale requirements, radiosonde and aircraft observations are the backbone of the conventional upper-air network and complement the various satellite observing systems. In fact, general impact studies have proved

- the complementary role of upper-air conventional and satellite observations;
- the importance of isolated profiles of wind, temperature and humidity.

(see: http://www.wmo.int/pages/prog/www/OSY/Reports/NWP-4_Geneva2008_index.html)

In addition, the AMDAR system has the capacity to produce frequent wind / temperature profiles (plus humidity in the future) at kilometric scale in the vicinity of many airports. Such data are important for high resolution NWP and nowcasting requirements, in addition to aviation requirements.

The E-AMDAR Programme has made great progress towards an overall programme meeting the EUCOS requirements in the most cost-effective way: considerable increase in the amount of aircraft data, start of humidity measurement trial, test of the efficiency of 'data targeting' schemes, beginning of a test concerning the production of high vertical resolution data. A suitable programme management is now available to ensure proper running of the operations. The E-AMDAR Programme should continue at least until 2020, with specific goals related to HLA 4 and 6 (i.e. general improvement of resolution and data coverage for upper-air observations), but also to HLA 5, 7, 10, 13 and 16 (general optimization of data coverage, but also by 'data targeting', once this mechanism has been implemented).
The further development of a new upper-air observing system based on MODE-S data (more details in chapter Error: Reference source not found) could potentially be progressed under the auspices of the E-AMDAR Programme. Further information on the possible overall organisational structure of the EUMETNET Observation Capability Area and this specific issue can be found in chapter Error: Reference source not found.

In addition to the actions dealing with humidity measurements and vertical resolution, the E-AMDAR programme should design at least two other observation scenarios, with the overall optimization of the upper-air observation network as a main goal:

- **Reduced observation scenario**: to be used in two different special cases: (i) when economic or budgetary crises oblige the European NMHSs to reduce their observation costs; (ii) when the weather regime is affected by a synoptic blocking over the North Atlantic

Ocean and western Europe, and appears to be highly predictable according to objective analyses and numerical forecasts up to medium-range. This reduced scenario (to be designed) should be characterized by less aircraft observations (especially at cruise levels) over the North Atlantic Ocean and western Europe; the use of such a scenario would be part of the 'systematic' targeting described in 3.5.

– **Upgraded observation scenario**: according to the targeting strategy to be used during weather regimes of low predictability, characterized either by intense cyclogeneses moving rapidly from the North Atlantic Ocean to Europe or Rossby waves moving slowly eastwards at the latitude of the Mediterranean basin, with strong cyclogeneses. This upgraded scenario should be characterized by more aircraft observations (especially at cruise levels) over the North Atlantic Ocean and western Europe, and should be designed on the experience of the EUCOS-supported MEDEX data targeting campaign of 2009 (see 3.5).

The E-ASAP Programme has finalized the full integration of national ASAP units in 2011. It has also achieved the progressive deployment of ASAP systems on a total of 19 ships, producing around 4500 soundings in 2011 (target of 4700 reached within the 10% uncertainty). Every day, 5 to 12 ASAP observations (mostly 00 and 12 UTC) are delivered to contribute to the North Atlantic Ocean coverage (partly also Mediterranean coverage) of vertical wind, temperature and humidity profiles. The ASAP Programme has undoubtedly brought considerable added value to the regional and global models, as was demonstrated by OSEs. Radiosonde and AMDAR data coverage maps still show a big gap over the northern polar cap, i.e. Arctic Ocean and higher latitudes of the North Atlantic Ocean.

The benefits which forecasting has gained from ASAPs (and isolated radiosondes in general) has already been evaluated in the past and should be re-assessed regularly (approx. every 3-5 years) due to (i) the high programme costs caused by the total number of soundings financed through EUMETNET, (ii) the development of other observing systems in the North Atlantic area, particularly satellite and aircraft measuring systems, (iii) the comparison with the northern Pacific Ocean where a completely different strategy was chosen by the Americans, i.e. use of targeted dropsondes over the Pacific Ocean rather than ASAP systems. The E-ASAP Programme should continue at least until 2020 to pursue several objectives one of which is the said re-evaluation. A study re-assessing the importance of ASAPs and isolated radiosonde sites should be launched in 2012 and 2013, with comprehensive results expected to be available in 2014. The study should be based on OSEs, but also on sensitivity computations performed using adjoint techniques, which allow each individual ship or radiosonde site to be assessed. Other objectives of an E-ASAP Programme running at least until 2017 should be:

- to improve and optimize (or at least maintain) North Atlantic Ocean ASAP coverage, especially in the Arctic Ocean (search for ships operating at high latitudes);
- to pursue the other objectives which are common to all radiosonde observations.

The E-ASAP programme should also define a ’reduced’ observation scenario as well as an ’upgraded’ one, to be used in the same (economical or meteorological) circumstances as the above-described AMDAR scenarios. The reduced ASAP scenario should be based on a reduced observation frequency and not on the suppression of existing ASAP systems. The upgraded ASAP scenario should use possibility to perform more than two soundings per day on some ships.

The main objectives in connection with the European radiosonde network in general are:

- optimization of data coverage (together with AMDARs and profilers);
- increase in vertical resolution (data transmission every 2s);
- proper BUFR encoding of the whole information.

These last three objectives are valid for the whole globe (see WMO documents – requirements and statements of guidance http://www.wmo.int/pages/prog/sat/rrr_en.php) and thus will contribute mainly to HLA 4 and 6, but also to HLA 7.

5.2.2. Remote-sensing profile measurements: HLA 7

Research and development efforts are ongoing to better observe the atmospheric boundary layer, and the E-WINPROF programme is part of these efforts (although some profilers are able to collect observations higher in the atmosphere). In fact, the lack of detailed vertical profiles of the boundary layer (especially wind profiles) is one of the big weaknesses of the ensemble of meteorological observing systems. Globally, it is probably the biggest gap which appears when analysing the different requirements versus current observing facilities, although is less severe over the European continent than over the oceans (and many other areas of the globe). This is partly due to the fact that current satellite instruments are not able to measure wind profiles while their temperature / humidity profiles of the boundary layer provide no better than a coarse resolution (or are not possible at all below the clouds in the case of infra-red sounders).

Ground-based wind profilers and also profiling stations which measure wind, temperature and humidity or aerosols, are the best hope for high frequency observation of the boundary layer. Measurements at ‘supersites’ like Lindenberg, Cabauw, Chilbolton, Palaisseau, Payerne may not only contribute to high frequency boundary layer measurements but also to model validation. Research efforts are still needed before the implementation of homogeneous operational networks. The observation of the boundary layer will also be improved by actions in the field of radiosondes (though with a generally poorer observing frequency: every 12h) and aircraft measurements (only in the vicinity of airports), as explained in chapter . Other potential contributors to boundary layer observation are ground-based GNSS networks (depending on their capacity to retrieve 3D information on humidity, to be investigated), new and emerging observation capacities and radar observations (see the chapters to).

Ground-based remote sensing observing systems are capable of measuring the whole set of atmospheric profiles up as far as the stratosphere, not only the boundary layer. As to their development in Europe, three types of options are possible (from the less to the more ambitious one):

a) **Continue the developments begun under the current E-WINPROF programme** with a main objective being unchanged: to develop a consistent operational network of wind profiling stations in Europe to complement (mainly because of the high observing frequency) radiosonde and aircraft observing systems.
b) **Develop capabilities in order to handle ceilometer backscatter data and ash concentration estimates from lidars.** This is especially important for the purpose of volcanic ash monitoring and aviation (see the EU&Aviation Roadmap and the EU project WEZARD at http://lib.bioinfo.pl/projects/view/29446).
c) **Develop all necessary capacities for an 'E-Remote Sensing' programme** which at the same time addresses HLA 5, 6 and 7 and develops temperature profile observations from ground-based remote sensing. An important objective here is to include remote sensing sites that observe both wind and temperature profiles. Previous impact studies have shown that NWP models usually benefit from the co-located observation of both temperature and wind. New studies are needed (numerical and instrumental) to pursue this option.

Only option 'a' can be achieved without a significant increase in the E-WINPROF budget. To pursue options 'b' or 'c', new observation programmes would have to be initiated. The simplest way is to build on the existing WINPROF programme.

5.2.3. Ground-based GNSS observations: HLA 7

Networks of ground-based GNSS receiving stations exist in several areas of the world. They are installed for non-meteorological purposes, but meteorological information can be obtained through processing of the data. In Europe, this is done under the E-GVAP programme, providing near real-time (NRT) Zenith Total Delay (ZTD) data. ZTD can be separated into a 'wet delay', which is proportional to Integrated Water Vapour (IWV) and relates weakly to temperature, and a 'dry' or 'hydrostatic' delay, which is proportional to surface pressure. No information is currently produced on the atmospheric profile (humidity). Operational NWP models generally assimilate the ZTD information, and impact studies have revealed a significant positive impact.

While ZTD and IWV were not used operationally before 2005, very rapid progress has been achieved since then in Europe, mainly through the E-GVAP programme which coordinates the collection of data from GNSS stations, their processing through various centres, and NRT dissemination of the meteorological information to the NMHS. The use of ground-based GNSS data in meteorology is a typical example of 'observations of opportunity', i.e. observations provided by a system which was not designed initially for meteorological applications and belongs to third parties (e.g. geodetic institutes and private firms servicing land surveyors).

For the future, the E -GVAP programme should continue along the two following lines:

a) **improvement of GNSS data availability, quality, and timeliness** with the aim to significantly improve European coverage with data that are good enough to be assimilated in NWP models and delivered sub hourly;
b) **monitoring and helping the research on the next generation processing and use of GNSS data in meteorology,** in order to obtain more detailed atmospheric information from the same basic measurements, by collaboration with European institutes and programmes involved in ground-based GNSS meteorology R&D.

The activities along line 'a' are at the border between operations and research; they imply sustained interactions with GNSS station owners and processing centres in order to homogenize procedures and quality control. This is an ongoing and continuous task. If line 'a' is followed, more data will need to be collected by interacting with a larger number of producers, especially in the eastern and southern countries of Europe, where data availability is rather poor. Improved access to information on orbits and clock errors of GNSS satellites would significantly improve NRT processing and the overall quality of GNSS atmospheric estimates.

Currently E-GVAP delivers solely ZTDs, which are delay estimates along the vertical. ZTD gradients and Slant Total Delays (STD) can be estimated by different processings of the very same GNSS data. 3D water vapour can be obtained via tomography using STDs and making additional assumptions. Bringing production and usage of these alternative products to a near-operational state requires significant R&D. E-GVAP should monitor such R&D and help facilitate it as resources allow. The state of this research should be reviewed in 2016 and the yearly E-GVAP expert team meetings should include discussion about the state of research.

5.2.4. New and emerging upper-air observation capacities: 5 and 18

The two preceding chapters illustrate the importance of research and development activities aimed at improving observation of the atmospheric boundary layer. Another general trend (global trend, i.e. not limited to Europe) is to increasingly use ‘observing systems of opportunity’ rather than observing systems specifically developed for meteorological purposes. The best example of successful opportunity measurements are the GNSS signals from the ground as described in the preceding chapter. Basically, all telecommunication signals propagating in the atmosphere (not only GNSS signals) are potentially able to indirectly provide information about the atmospheric state. This has already been successfully tested for estimating precipitation rates from the attenuation of the Global System for Mobile communications (GSM) signals (mobile telephones) (see ‘Messer, H. (2007): Rainfall monitoring using cellular networks. IEEE Signal Proc. Mag., 24, 142-144’). GNSS signals which are received by devices that are neither on the ground nor on a satellite, but on-board an aircraft or a balloon, can also be exploited for radio-occultation measurements. This has been tested for example during the CONCORDIASI campaign over the Antarctica in 2010, but is still very far from being operational. Humidity data of the boundary layer can also be obtained by using the radar signals from fixed targets (or refractivity measurements by radar).

Windmills used for electricity production provide another potential opportunity for gathering local information on the wind. Power production here is dependent on the wind, a fact which allows translation into wind information. In addition, windmill sites are ideal to have 100m posts installed which can be instrumented with meteorological sensors at different heights for providing high vertical resolution profiles from the first 100m of the atmospheric boundary layer.

Some other technologies (still at the research or development stage) show great promise to become included in operational meteorological observing systems in the future, though without any certainty of reaching the operational stage by 2020:

- **Unmanned Aeronautical Vehicles (UAVs)**

UAVs have been used in several meteorological campaigns to obtain detailed information on temperature, humidity and wind for a limited geographical area in the lower troposphere (see ‘Mayer, S., A. Sandvik, M. Jonassen and J. Reuder, 2010: Atmospheric profiling with the UAS SUMO: A new perspective for the evaluation of fine-scale atmospheric models. Meteorology and Atmospheric Physics, DOI 10.1007/s00703-010-0063-2’). Unlike normal aircraft, UAVs can fly up and down, and thus provide vertical profiles of meteorological variables. UAVs could also become an adaptive element of EUCOS at some later stage.

- **Driftsonde balloons (gondolas)**

The driftsonde technique consists in launching a constant-level balloon which rises into the stratosphere with several dropsondes (stored in a gondola) to be started on demand and provides vertical profiles of temperature, humidity and wind (like normal radiosondes or dropsondes launched from aircraft). Driftsonde balloons are well adapted to meteorological campaigns and have been used frequently, but are difficult to use in routine mode as a key element of the composite observing system.

- **New aircraft measurements**

The natural extension of the E-AMDAR programme (aircraft observations described in 3.3.1) is an attempt to obtain more measurements either through the so-called TAMDAR system or the so-called MODE-S system. Compared to AMDARs, TAMDARs do not have the potential for significantly improving global data coverage, but with their platform being regional aircraft flying to regional airports where the major airlines are not flying, they can provide an increased number of atmospheric vertical profiles. The MODE-S system is a very good complement to the AMDAR system; it has already proven its capacity to provide good quality wind data at very high resolution from the vicinity of airports. As soon as results from the SESAR WP 11 project on the ‘MODE-S New Sensor’ will be available in 2014/2015 STAC should reconsider whether and how the MODE-S observation capability should be further developed within EUMETNET. There are two possibilities in general. Either MODE-S will become a new activity within the existing E-AMDAR Programme which could be given a new name ‘E-AVIOBS’ in this case or alternatively it could be decided to launch a completely new Observation Project ‘E-MODE-S’. Merging the handling of AMDAR and MODE-S data into one Observation Project could potentially lead to efficiency savings because of common management and monitoring structures.

The emerging capacities have not yet reached the same level of development. But none of them deserve the creation of a new EUMETNET programme right now. The development of new methods for aircraft measurements should be followed closely by the E-AMDAR programme whereas possible progress in the field of data obtained from GNSS receivers onboard planes or balloons should receive attention by the E-GVAP programme. EUCOS should maintain a scientific and technical watch on the other activities of this type: precipitation estimates from mobile phone signals, wind estimates from electricity production, UAVs, gondolas. At this stage, no dates can be given for the launch of any new projects or continuous activities. EUCOS could review the status of emerging observing systems every 3 to 5 years, i.e. parallel to the impact studies evaluating the different components of EUCOS.

5.2.5. Radar observations: HLA 1 and 2

The use of radar data in forecasting activities has increased considerably during the last few years. Having been used by forecasters for several decades as a tool to diagnose and estimate precipitations, their application in NWP is more recent and not fully developed yet. The use of radar reflectivity and wind data in kilometric resolution models for operational NWP is an important step forward in forecasting. Radar data not only play a key role in kilometric horizontal resolution NWP, they are also important for regional models (say Limited Area Models covering a continent like Europe) and even for global models (which would justify the global exchange of an adhoc subset of radar products),
(see http://www.wmo.int/pages/prog/www/OSY/Reports/NWP-4_Geneva2008_index.html).

Therefore, the European radar network has the capacity to serve a wide range of atmospheric scales, even though its strongest value is on the small scales. Due to the large volumes of radar data, it is crucial to coordinate the processing of the data in order to efficiently serve the different users at different scales by providing different products.
The OPERA Programme has been established to support utilisation of radar data from the European weather radar network and has the capacity to improve harmonization of radar data and their exchange at the European level.

The Operational Data Centre (ODC) has been developed in 2009 and 2010 in the framework of the OPERA programme III. It is operational since January 2011 and delivers three European composites, surface rain-rate, maximum reflectivity and hourly accumulation in BUFR and HDF5 and is monitored by the EUCOS QMP. First assessments of these products have shown that further improvement of the products is required in order to make them quantitatively usable for NWP, Nowcasting and Climate applications. The planned improvements are beam blockage correction, residual clutter removal, VPR identification and correction, attenuation correction, gauge adjustment, spurious echo filtering and quality index scheme.

The OPERA Programme should continue at least until 2020, thereby putting emphasis on the two high level activities HLA 1 and 2 being related to 3D data exchange and improvement of pre-processing and product dissemination (see annexes). The work involves many different tasks from operational maintenance to research on new technologies, from monitoring of data quality and data exchange to research on dual polarization or integration of S/C/X band radars.

5.2.6. Lightning detection

The Lightning Task Team (LTT) was founded by the EUMETNET Program Board on Observations in 2007 and serves as a platform to compare lightning detection networks and user requirements of several European countries. The different NMS in Europe obtain lightning data via two different routes; either it is provided by their own network or the data is purchased from the available private providers. This diversity makes it challenging to interchange information among members. However, with the ongoing evolution of lightning detection possibilities, lightning data starts to play an ever increasing part in for instance real-time storm monitoring and leads to the development of specific applications, such as automated storm tracking and nowcasting. LTT addressed oneself to the task of introducing a common base for the exchange of knowledge and data across national borders in Europe, in order to enhance the role of the NMS in this field. The future of lightning detection networking in Europe includes the exchange of knowledge, data inter-comparison, and development of the lightning networks and assessing of the user requirements.

5.3. Data exchange, monitoring and quality control: HLA 10 and 15

The basic rules for data exchange, especially data format definitions, are established by WMO. Nevertheless, EUCOS can have a coordinating and supporting role at the European level and help EUMETNET Members to adopt the correct data formats. The observation formats used by EUMETNET should also comply with INSPIRE rules.

EUCOS will continue monitoring data availability, timeliness and accuracy of all EUMETNET and Members observation networks. It is suggested that EUCOS immediately reviews the ‘EUCOS Performance Standards’ document in the next programme phase. This document defines all data availability (i.e. data volume), timeliness and accuracy targets for EUMETNET observing systems. Such review is necessary because ‘new’ data users like ‘Climate’ or ‘km-scale NWP’ (cf. Observation Goal O1 in chapter) have different and usually stronger requirements on data volumes, timeliness and accuracy. Another review of observation performance standards will be necessary when aviation meteorology requirements have been defined by SESAR WP 11 projects. Specific climate requirements, such as sufficient amounts of metadata, long time series, parallel measurements when migrating from one observing system to another one, should become part of the standard data monitoring and quality control procedures.

A further extension and improvement of the EUCOS Quality Monitoring Portal will help observation network managers both in EUCOS programmes and NMHSs to detect problems and trace them back to the original source of error.

Finally, the development of a central observation monitoring facility (E-VCOMP) will lead to an increased effectiveness and efficiency of the integrated EUMETNET observing system. This could be achieved by means of a central, but EUMETNET-wide monitoring of incoming observational data, blocking of GTS distribution of individual data sets in case of error and notification of data providers and customers about specified issues. Another capability of such a central observation monitoring facility could be an operational ‘data targeting system’ (DTS; see chapter).

This central observation monitoring facility should be the natural place to receive and monitor extra data coming from ‘third parties’ (see examples given in chapter). To initiate the process leading to an access to such extra data (not originating from NMSs and NMHs), a preliminary inquiry (led by EUCOS) is suggested in order to:

- investigate the usefulness of EIONET for EUCOS (in cooperation with the EEA);

- investigate with the different EUMETNET Members the existence of third party data which are already available in at least one NMS or NMHS.

5.4. Observation studies

5.4.1. Data targeting: HLA 16

Some of the observing systems provide the capability of being ‘adaptive’, i.e. the amount of observations or the reporting frequency can be varied according to the meteorological situation. For a given forecast the ‘sensitive areas’ can be computed a priori on a daily basis. The idea of ‘adaptive observations’ or ‘data targeting’ is to support the observations within the sensitive area. This can be done either by requesting the existing observation sites or platforms within the chosen sensitive areas to provide more observations or by sending special ‘measuring platforms’ to the sensitive areas in question (typically aircraft launching meteorological dropsondes).

A study should be made for each EUCOS observing system to investigate feasibility and cost-effectiveness of its operation in adaptive mode. The adaptive mode is obviously more adequate when the cost of observations is approximately proportional to the number of observations (radiosondes because of the consumable costs, AMDAR because of the transmission costs). It is less adequate, however, where automatic observation systems can produce more or less frequently a large volume of data without any significant change in the costs (profilers, GNSS, radars). In the case of these high data volume observing systems, the adaptive process can possibly be transferred to data processing, which would mean that more data are processed for rapid dissemination in sensitive areas than in non-sensitive areas. This is mainly valid for satellite data but also for some surface-based observing systems.

In the past, several studies and campaigns which were also supported financially and managerially by EUCOS have shown that in some cases NWP forecasts can be significantly improved by using additional targeted observations deployed within a-priori computed sensitive areas.
See for example studies performed in the context of the WMO programme THORPEX:
http://www.wmo.int/pages/prog/arep/wwrp/new/TTISS_presentations.html
See also the results of the Mediterranean campaign of autumn 2009:
http://www.hymex.org/public/workshops/4/Presentations/THU-morning/TH1.1_4th-HYMEX-Workshop-Jansa-et-al-v4.pdf
So far, EUCOS involvement in such campaigns has been mainly through on-demand activation of radiosonde and AMDAR data in some sensitive areas (with a notification one or two days in advance). 'Genuine' targeted observations (i.e. specifically deployed by sending a special observation system to a sensitive area at short notice) are still at research stage. Continuous (daily or weekly) regional (versus highly localized) and 'systematic targeting' during flow regimes of low predictability could be easier to implement. This systematic targeting could also be based on 'on-demand requests' for activation / deactivation of AMDARs and radiosonde sites, as well as adaptive processing of satellite observations.

In the future, EUCOS should carry out the two following types of targeting activities:

- continue to support research campaigns with radiosondes and AMDARs (as for the Mediterranean campaign in 2009);
- long-term 'systematic targeting' for weather regimes known for their poor predictability (more manageable).

'Systematic targeting' design activities should be treated with a high priority. To start with, they should be limited to ASAPs and AMDARs and should include the 'reduced' and 'upgraded' scenarios as planned for the E-ASAP and E-AMDAR programmes (see chapter .). Another step could be to include fixed radiosonde sites, keeping in mind that a variable observation programme at such sites should not affect the requirements from the climate sector. The design of (at least) one reduced and one upgraded EUCOS scenario as part of systematic targeting activities, plus the operational possibility to switch from the current standard scenario to either of the alternatives, is expected to contribute significantly to the general optimization efforts facing two challenges: (i) the high variability in the predictability of weather regimes; (ii) the necessity to reduce observation costs due to economical and budgetary crises.

5.4.2. Other studies: HLA 13

An important task during to the period 2013-2020 is to initiate both a regular repetition of the so-called general 'Space-Terrestrial Study' and several dedicated OSEs or 'Forecast Sensitivity to Observation' (FSO) analyses in order to base network design decisions on scientific studies.

Especially the recently developed km-scale NWP applications demand for a specific set of OSEs or FSO analyses to be able to assess the impact of measurements from weather radars or other observing systems that are not so widely used in global or regional NWP. The ASAP network (as well as the North Atlantic radiosonde network in general) is another observing system requiring special attention through regular OSE and FSO studies due to (i) the low density of the network, the small number of individual observations and the relatively high impact on the forecast per individual observation, (ii) the quite rapidly growing availability of satellite data over the North Atlantic, and (iii) the high costs of the overall E-ASAP programme.

In addition to the tools available from NWP (such as OSEs), further mechanisms will have to be identified and tested in order to measure the impact of network design changes on products from other data users, like climate or nowcasting. Impact studies performed with kilometric NWP models are likely to be very useful tools for evaluating the impact of the various observing systems on nowcasting; they will have to be complemented by other tools (to be defined) able to evaluate the benefits (or potential benefits) of observing systems that provide information which cannot be assimilated directly into NWP models (such as radar and satellite imagery, type of precipitation, etc.).

For evaluating the impact of observing systems on climate applications, new ad hoc tools will have to be defined in collaboration with European climate experts and European projects / services described in the climate roadmap, as there exists no standard tool, such as OSEs or FSOs that are used in NWP.

5.5. Liaising with other parties: HLA 17

In the area of meteorological and environmental observations several organizations play a major role, especially the already mentioned WMO, EUMETSAT and other satellite agencies, EEA and EU (through COST actions).

Like WMO (see chapter), EUMETSAT has carried out a detailed analysis of observation requirements and has planned satellite missions for one or two decades ahead. It is important to liaise closely and regularly with EUMETSAT regarding the complementarity of terrestrial and satellite observing systems, both of which continue to develop without interruption. The EUMETSAT study on lightning detection will be one input to be considered within EUMETNET’s studies on lightning detection.

EUCOS will also have to maintain a scientific or technical watch on COST actions (HLA 17) as in the past several EUMETNET programmes were based on results from COST actions. In the future, joint workshops could be organized to fully exploit the results of COST actions. See: http://www.cost.esf.org/domains_actions/essem .

WMO’s general action in terms of observation requirements, gap analysis and SoG is described in chapter . WMO Regional Association VI (RA VI Europe) has a parallel action to EUMETNET going on in Europe which covers a different number of countries and NMSs. It is important to continue liaisons with RA VI on all actions related to network optimization and climate issues.

6. ORGANISATIONAL STRUCTURE OF THE CAPABILITY AREA OBSERVATIONS

Taking into account all activities proposed and described in chapter it is suggested to implement the following organizational structure for the EUMETNET Observations capability area, which is also visualized in Figure 3.

- Define the ‘EUCOS Programme’ as the central observation programme representing the EUMETNET ‘Observations Capability Area’. The remit of the current EUCOS Programme will be broadened to cover all existing and newly proposed Observation Projects. The EUCOS Programme will coordinate the activities of all Observation Projects, monitor the performance of their observing systems and coordinate the evolution of ‘EUCOS’. The EUCOS Programme Manager will take on the role of the Observations Capability Programme Manager.

- Following the new organizational structure of EIG EUMETNET all other existing ‘Observation Programmes’ will be renamed to ‘Observation Projects’. The Observation Projects: E-AMDAR, E-ASAP, E-GVAP, E-SURFMAR, E-WINPROF and OPERA will run under the umbrella of the EUCOS Programme.

- Set up a new ‘Observation Management Group’ giving advice to the Observations Capability Programme Manager. This group should assist the CPM in Observations related questions at times and on specific issues whenever STAC can’t provide the required information.

- Consider the implementation of new Observation Projects like E-MODE-S, E-PROFILE or E-VCOMP or alternatively a merging of these new projects with existing projects in order to achieve more efficiency. Some of the newly suggested projects are supposed to start at a later stage of the EUCOS development. Therefore, the ASSEMBLY decision on the exact organizational structure of these projects can be deferred to a later date after further preparations have been made and more information has been collected.

  - Keep Observation Project E-AMDAR and launch new Observation Project E-MODE-S or merge AMDAR and MODE-S data handling in a common E-AVIOBS Project;
  - Keep Observation Project E-WINPROF and launch new Observation Project E-PROFILE or merge the coordination of different remote-sensing networks in one common Observation Project E-PROFILE;
  - Launch new Observation Project E-VCOMP or include this new data handling capability in the EUCOS Observation Programme.

- The LTT will be renamed into LET and become part of the Observations Capability programme. The group will be set out of service temporarily until 2018, when the lightning detection of MTG becomes operational and data are available. In this phase LET has a big task in comparing two completely different systems.

- The EUMETFREQ Project remains under the auspices of the EIG EUMETNET Secretariat because of its prevailing task of 'lobbying' on both European and global political and governmental levels. However, an adequate exchange of information between EUMETFREQ, the EUCOS Programme and the Observation Projects must be guaranteed. The regular meetings of STAC twice a year should be the basis and if required the EUCOS Programme or the Observation Projects should invite the EUMETFREQ PM to their ET meetings.

- The STAC WG INS will continue to serve as the forum for EUMETNET Members to exchange information about all instrumentation related questions. The EUCOS Programme will report about WG INS activities at STAC and if required participate in WG INS meetings.

- The STAC WG E-HBC will continue to exist until its task of informing STAC about the required size of the E-AMDAR humidity sensor network has been accomplished. The EUCOS Programme will report about WG E-HBC results at STAC and both EUCOS Programme and E-AMDAR Project team members will contribute to the activities of this WG.

A more detailed description of EUCOS Programme and Observation Projects activities and deliverables for the period 2012 to 2020 is given in annex B.
Two different overall funding scenarios have been developed:

- Scenario 'I' offers running the corresponding programme/projects with a reduced budget and thereby accepting that less will be achieved. The overall saving in the EUMETNET Observations

Capability Area would accumulate to 500 k €, reducing the total budget from approx. 5.65 m € to approx. 5.15 m €.

- Scenario 'II' describes the continuation of the programme/projects with constant level funding and a total EUMETNET Observations Capability Area budget of approx. 5.65 m €.

Finally the additional rows in the tables of annex B numbered with Arabic numerals hold proposals for additional deliverables. These may require additional resources or not. Most of the proposed additional or new activities show no interdependencies with each other and among different programmes and projects. Therefore the lists offer a maximum of flexibility to STAC, PFAC and Assembly to make a choice of activities to be undertaken during the period 2013-2020.

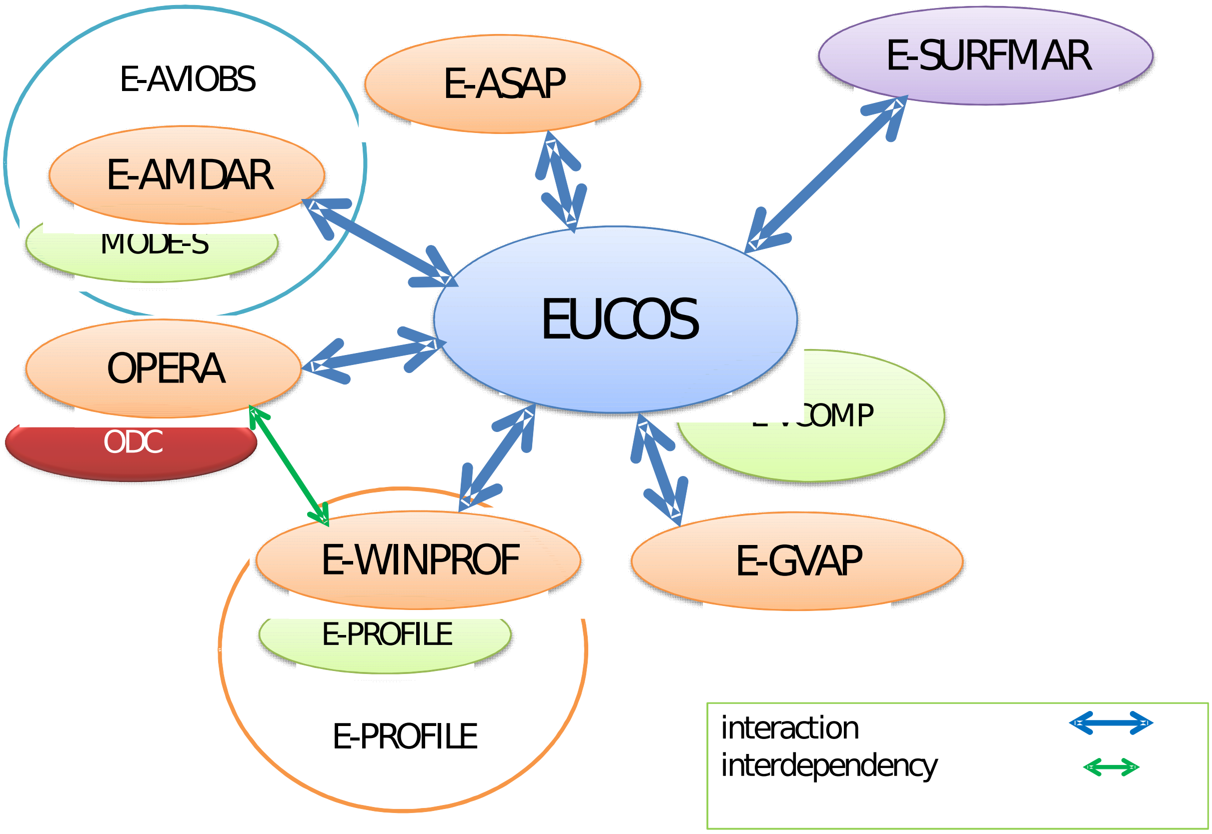

Figure 3: Organisational structure of the Capability Area Observations.

7. IMPACT ON EUMETNET MEMBERS

If the European composite observing system to be established by 2020 then meets the more ambitious options of this roadmap, this will mean that it has been possible to considerably increase the benefits for forecasting, climate and other applications while the efforts relating to observation systems remained moderat; in other words, a significant increase in the benefit-cost ratio will have been achieved.

Progress in forecasting activities is expected to be as rapid as during the last decade. Progress in nowcasting and high resolution NWP is expected to be more rapid than in short and medium range NWP due to the special effort put on obtaining high resolution observations and rapid processing and exchange of such data, at least at the European level. The potential for progress in monthly and seasonal forecasting is more uncertain due to its strong dependency on research and development in the field of numerical modeling.

An improved EUCOS by 2020 will make a substantial contribution to the improvement of GCOS and the climate activities in general. Any improvement made to time series at fixed observation points will benefit GCOS to the effect that the quality of global monitoring of the climate change will improve too. Local climate monitoring will become much easier and more accurate with denser observation networks. Climate studies will benefit from reanalyses made with observations which are denser and better distributed in time and space, which implies more consistency in the reanalysis time series.

A common property of forecasting and climate activities is that their progresses (and the benefits drawn) can be assessed quantitatively only several years after they have been achieved. The progress made in NWP between 2000 and 2010 couldn't be fully evaluated before 2011 due to the fluctuations in the quality scores caused by the inter-annual variability of predictability. It is even more difficult to identify that part of the benefits which results from improving the initial model state (and from the observations). For the decade 2000-2010, a significant part of this benefit can be put down to the use of satellite observations produced by missions which were decided one or two decades before! Quantification of benefits which climate time series and monitoring (observation or reanalysis time series) may have drawn from improved observation networks is possible only decades later. The investors in EUCOS observation systems have to be patient to see the full benefits of their investments (even if some beneficial aspects are visible almost immediately, at least locally).

A general tendency of the decade 2010-2020 is an ever-growing demand from users of meteorological products or products from neighbouring disciplines (oceanography, hydrology, pollution, land use, etc.). In addition, interaction between disciplines is expected to grow, which should have a positive impact for EUMETNET Members in two different ways:

- The mutualisation of observing networks from different disciplines is expected to increase the amount of observations for all disciplines, reducing at the same time the relative cost of observations.
- More users and more stake-holders for EUCOS would mean more sources for the funding of observations and increasingly efficient observing systems for each Member in terms of benefit-cost ratio.

In addition to general forecasting and climate activities, other applications will also benefit from the positive impacts. Aviation is an important user of meteorological observations and products. In the context of the establishment of EUCOS until 2020, special attention is given to the development of high resolution (in terms of space and time) observing systems in order to considerably improve knowledge of the weather within a limited area around each airport: such benefit will come mainly from the developments in the field of aircraft data, profilers, radars, automatic weather stations, in synergy with satellite data and high resolution models.

Annex A: Complete list of Goals (approved by Assembly 5)

FORECASTING GOALS (F1 to F3)

F1. Throughout the decade EUMETNET will support Members in ensuring that they always have highly skilled forecasters through shared training and shared best practice.

F2. EUMETNET will assist Members and their modelling consortia to develop their forecast models and processes in order to produce the best possible short term forecasts for their clients.

F3. EUMETNET will have facilitated, through a strategic discussion among Members, the identification and initiation of projects for collaboration, harmonisation and coordination in support of more efficient forecasting systems, and improved regional and short range weather forecasts.

OBSERVATIONS GOALS (O1 & O2)

O1. EUMETNET will develop an integrated composite observing system for Global, Regional and 1 km Scale Convection Resolving Models and for Climate, building on existing infrastructure.

O2. EUMETNET will ensure that observational and climate data gathered by the composite observing system will be of appropriate quality to meet the requirements of NWP and climate by working with Members to share and implement best practice and methodologies within the system.

CLIMATE GOALS (C1 to C3)

C1. EUMETNET will develop harmonized and coherent pan-European gridded daily climate data sets and analyses.

C2. EUMETNET will assist Members to provide trans-boundary and pan-European climatological information in near real time on major climate/weather events.

C3. EUMETNET will support Members to enable them to deliver applied climate services within the WMO GFCS.

EU GOALS (EU1-EU3)

E1. During this decade, the EU institutions are kept informed and updated of EUMETNET and its Members capabilities and always seek to utilise these capabilities for delivery of relevant policies and projects.

E2. EUMETNET and its Members will be partners in a range of weather, climate and waterprojects funded (partially or fully) by the EU institutions and which are consistent with the EUMETNET’s role in the EMI.

E3. EUMETNET will assist its Members in their implementation of the Oslo declaration to meet the needs of the national and European authorities, and the general public.

AVIATION GOAL A1

A1. EUMETNET will assist Members to ensure that the present providers of aviation meteorological services continue to be the primary source of future regulated meteorological services to aviation and to reinforce the argument for funding of key components of infrastructure.

Annex B: Activities and deliverables during 2011-2020

This annex contains 9 tables with detailed detailing scenarios and additional deliverables for the Observation Capability Programme EUCOS, the six Observation Projects E-AMDAR, E-ASAP, E-GVAP, E-SURFMAR, E-WINPROF and OPERA, one potential new Observation Project E-PROFILE and for one potential new Activity E-MODE-S. In most tables the first two rows contain information on two completely different ‘scenarios’ for the running of the respective Programme/Project. These rows are numbered with Roman numerals I and II. Scenario I refers to the running of the corresponding project with a reduced budget with the understanding that less will be achieved. Scenario II describes the continuation of the Programme/Project with constant level funding. The additional rows numbered with Arabic numerals contain proposals for additional deliverables. These may or may not require additional resources. This is indicated by the colour coding described below. The following two columns show timetable, key decision points and an initial estimate of the scale of resources required for delivering the projects and activities. The budget figures shown for the two scenarios I and II are based on 2010 actual costs of the respective programmes and also include in-kind contributions of Coordinating Members if such support was given. The last two columns show constraints, dependencies and risks required for delivering the projects and activities.

	Proposal for a reduced budget, requested by the Secretariat.
	Additional resources not required if option ‘Programme-II’ is chosen.
	Additional resources required (please refer to annex D).

Observation Capability Programme EUCOS

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
EUCOS-I	Running programme as is but reduction of: Management budget: -5%, consequence: less attendance of scientific conferences and meetings with other organisations like WMO, EUMETSAT and COST, less EUMETNET internal meeting participation and less internal meetings with Observation programmes R&D budget: -15%, consequence: less money for outsourcing observation impact studies, OSE, FSO investigations, causing delay of studies and decision making about the future evolution of EUCOS, delayed incorporation of Climate and Forecasting requirements Observations budget: -9%, consequence: risk of losing 9% observations from Ekofisk, remote islands and those Members where national RS networks are supported by EUCOS.		2012-2020	~ 650 k€ per annum		Losing 9% of observation data
EUCOS-II	Running programme as is with constant funding: • Run EUCOS Quality Monitoring Portal		2012-2020	~ 740 k€ per annum		

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	and perform active quality control of the EUCOS and Members' observing networks • Run Studies Programme supporting the evolution of EUCOS (i.e. evolution of all EUMETNET observation programmes) • Use Special Project Fund to support observation related research activities and to further develop EUCOS QMP • Support national radiosonde operations (Ekofisk, remote islands, 2 Members) • Organise EUCOS (Observations) Project Manager meetings and EUCOS ET meetings (please also refer to activity 'EUCOS-01') • Attend meetings of STAC regularly and meetings of PFAC, ASSEMBLY and their special WGs if required • Participate in meetings of Observation Projects ETs • Attend scientific conferences and workshops of COST actions, WMO, and other international bodies • Compile quarterly and annual EUCOS reports and EUCOS Quality Monitoring reports			~ 2.3 FTE		

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	• Prepare specific input documents for STAC, PFAC and ASSEMBLY meetings as required					
EUCOS-01	Full EUMETNET Observation Capability Programme Management role with the aim of integration of new Climate and Forecasting requirements: Review the 'EUCOS performance standards' for all observation networks. Create an additional EUCOS Expert Team which will bring together experts from other capability areas in order to discuss and agree on the new targets for availability, timeliness and accuracy of EUCOS observational data and will also take into account requirements from Climate, Nowcasting and Aviation. The already existing EUCOS ET 'E-SAT' will continue to exist and advise EUCOS on NWP requirements.	General considera-tion of Climate and Forecast-ing require-ments	2013-2020	+ 0.5 FTE		
EUCOS-02	Regularly coordinate realisation of standard set of impact studies (OSE + FSO) in order to evaluate the impact of terrestrial observing networks versus impact of satellite observations on NWP forecast skill. Special attention should be given to impact of ASAP, remote radiosondes, AMDAR, Mode-S, and GNSS data. At the same time, develop objective	HLA 13	2013-2020	within EUCOS-II	Depending on willingness of NMHSs and other institutions to collaborate in the field of numerical experimentation; conduct of OSEs etc.	

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	method similar to the NWP impact studies, which contributes assessing importance of aforementioned observing systems for the non-NWP data users such as Nowcasting, Climate and Aviation.					
EUCOS-03	Foster near real-time exchange of hourly or even more frequent observations from Members' surface stations.	HLA 8	2014-2015	within EUCOS-II	Restrictions because of differing data policies	Production of data volumes which are not used
EUCOS-04	Monitor migration to BUFR and advise EUCOS Projects and Members on introduction of BUFR for data exchange.	HLA 10	2013-2015	+ 0.25 FTE	Willingness and/or ability of NMS to work on this	
EUCOS-05	Analyse existence and accessibility of 3rd party meteorological observational data. Search for additional upper-air or surface observing networks by conducting inquiry among Members ("Which 3rd party data are already collected and used in at least one NMS or NMHS?"), with the goal of making these data available in near real-time to all Members.	HLA 12, HLA 7, HLA 6	2016-2020	+ 0.25 FTE	Dependence on 3rd party data	Gathering data which have not sufficient quality
EUCOS-06	Coordinate study on potential NWP impact of remote sensing observations of temperature and humidity at wind profiler sites (in support of E-PROFILE development). Discuss and coordinate Nowcasting, Aviation and Climate requirements for such remote sensing data.	HLA 7, HLA 13	2013-2015	+ 0.25 FTE	Depending on willingness of NMHSs and other institutions to collaborate in the field of numerical experimentation; conduct of OSEs etc.	Gathering requirements which cannot be fulfilled

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
EUCOS-07	Maintain scientific watch on research related to new observing technologies and on correct balancing of satellite observing systems within EUCOS (e.g.: GNSS tomography associated with use of radar data; geographical coverage versus observation time frequency).	HLA 13, HLA 17	2016-2017	+ 0.25 FTE		
EUCOS-08	Make EUCOS network more flexible for data targeting (supervise feasibility studies of targeting in each observation programme).	HLA 16	2016-2020	within EUCOS-II	Necessity that NMHSs make their observing schedules more flexible; agreements with Climatologist required because time series will be interrupted	Loss of uninterrupted time series possible at selected observation sites
EUCOS-09	Implementation of E-VCOMP: • Quality monitoring. o Fully automated monitoring of data availability, timeliness and accuracy if possible. o Interactive monitoring to exclude erroneous data sets from Global Telecommunication System (GTS) distribution or from product generation. Fault correction procedures by NMHSs or other operators;	HLA 15 WIGOS	2015-2020	Depending on configurat. Develop. Costs: 45-80 k€ Integration of existing infrastruct.: ~ 85 k€		

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	resumption of data distribution after fault correction. • Data visualisation for quality monitoring purposes. • Product generation.			Hardware costs: 50 k€ Oper. Costs per annum: 120 k€		
EUCOS-10	Review available lightning data in NMHSes and prepare proposal for collaborative EUMETNET undertaking (e.g. new WG or project).		2016-2017	within EUCOS-II	The LTT could be temporarily set out of service; Comparable satellite data become available in 2018, different sensors, networks or ways to deliver the data	Time consuming because of large variety of lightning detection systems being used

Observation Project E-AMDAR

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
E-AMDAR-I	Running project as is but reduction of: Management budget: -5%,		2012-2020	~ 1,200 k€ per annum	Budget insufficient to maintain current volume of	Risk to lose up to 15 -20 % of the entire data

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	consequence: less attendance of meetings, with airlines and EUMETNET internal meetings (e.g. by having more telephone conferences), long-term risk: less engagement and assistance from airlines for project, reduced contacts with EUCOS Management and thereby reduced communication with Members and users of observations, no targeted observations for DTS. R&D budget: -30%, consequence: GNSS height reporting not included, no high vertical resolution reporting, less flexibility to meet airlines development requirements resulting from changes in aircraft fleet or their equipment, adaptation of optimisation systems less likely Observations budget: -9%, consequence: ATTENTION: no simple linear relation between costs and number of observations!, risk of losing up to 15-20% of entire data volume, no increase in observations in data sparse areas, no provision of high resolution vertical profiles.				observations and necessary development.	volume. Risk for less engagement and assistance from participating airlines. Risk that necessary development cannot be done.
E-AMDAR-II	Running programme as is with constant funding: • Continue to deliver high quality data		2012-2020	~ 1.370 k€ per annum ~1.8 FTE	GNSS height reporting being tested on some British Airways	Possible delay if development costs for software is too

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	based on the current network, but with optimised data coverage (slight reduction in oversampled areas) and continue existing cooperating with airlines, and, • Complete extended Humidity Trial and plan for operational humidity programme; • If Brussels Airlines has not been added by 2012, this should be done during programme extension for provision of data in the South of EUCOS Area as well as in some selected European destinations; • If TAP and/or Icelandair have not been added by 2012, this should be done during programme extension for provision of more data in the South West and North West of EUCOS Area; • Take measures in order to get uniform spatial and temporal coverage, rather than simply increase data volumes, including recruitment of new airlines; • Keep contribution to the WWW in line with agreed programme objectives; • Evaluate AMDAR humidity sensor; • Continue work in collaboration with the WMO AMDAR panel and aircraft				aircraft. Can be introduced on other (several?) airline fleets but software development might be needed. Obs costs will increase. BUFR Template for handling the data not yet approved by WMO	high or if the BUFR Template will not be approved by WMO.

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	manufacturers (e.g. Airbus) in order to get humidity sensors and suitable software as optional equipment for aircraft; • Contribute to work of STAC WG on E-AMDAR Humidity Business Case (E-HBC); • Implement decision taken by ASSEMBLY regarding E-AMDAR project objectives for humidity observations; • Fully introduce efficient optimisation schemes and an efficient targeting technique, can be envisaged; • Introduce reporting of true height as well as of altitude in message from some airlines; • Implementation BUFR formatted reporting; • Investigate, in cooperation with the WMO AMDAR panel, new techniques such as icing and turbulence; • Get ready for implementation of NWP resolution requirements.					
E-AMDAR-01	Carry out high vertical resolution test(s) on AMDAR data aimed at increasing operational vertical resolution, high-resolution data procurement.	HLA 4	2012-2013	Requires money from EUCOS for	Technically everything is ready for implementation on LH aircraft. More	Development budget might prove to be insufficient.

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
				the test	complicated or costly with other airlines as software development needed.	
E-AMDAR-02	Improving geographical coverage by e.g. including several more airlines (e.g. in Southern Europe) -> plus 0.25 FTE	HLA 6	2012-2020	+ 0.25 FTE	Success depends on airlines´ willingness to cooperate.	Unability to finance.
E-AMDAR-03	Roll-out humidity sensor on XXX aircraft -> plus 0.25 FTE Begin with humidity trial testing on 3 aircrafts, then on 6 more. NOTE: The number XXX is expected from the Drafting Team on the Humidity Business Case.	HLA 5	2012-2020 2015-2020 (Roll out new sensors)	+ 21 k€ per annum for maintenance of 9 sensors. For the roll out -> + 0.25 FTE but NO cost estimate for purchase and installation as we do not know the number of sensors or which airlines will be	Cost calculations not yet available, but perhaps during 2011-2012	Unability to finance. Sensor works as well on US aircraft, but not yet tested on European fleets.

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement involved	Constraints and Dependencies	Risks
E-AMDAR-04	Advice on setting up of TAMDAR network, specifying requirements (e.g. from which airports do we want TAMDAR obs, flight configuration plan), -> plus 0.25 FTE permanent	HLA 5	2013-2020	+ 0.25 FTE	The entire data collection and dissemination is handled by AirDat Inc. and EUMETNET has no control of the process or of the data quality. EUMETNET must find a way to disseminate these data among members without using GTS.	NB. The objective of AirDat is not to sell data but to sell you weather forecasts. This is not as risk, but a fact.
E-AMDAR-05	Mode-S -> 3 FTE (rough estimate), start activity only when results from the SESAR WP 11 studies are available.	HLA 5	2013 -	+ 3 FTE	Availability of data and suitable partner, with good knowledge of Mode-S radars, to cooperate with.	Unability to finance and/or no partner found.
E-AMDAR-06	Pursue efforts towards implementation of regional aircraft measurements.	HLA 5, HLA 6	2013-2020	Use the resource in E-AMDAR-02	Success depends on airlines´ willingness to cooperate.	Unability to finance.
E-AMDAR-07	Pursue efforts towards optimization of data coverage (in relation to other EUCOS Programmes).	HLA 5, HLA 6	2013-2020	Ongoing task	Resources in the Management Team	Delays
E-AMDAR-08	Exploit new techniques for icing, turbulence and ash aerosol measurements.	HLA 5, HLA 7	2013-2020	Ongoing task	The speed of development in the aviation industry	Delays

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
					and the limited capacity of partners in WMO AMDAR Panel	
E-AMDAR-09	Check and compare regularly the prices of measurements of the different contributing airlines. At individual airports a selection of profile measurements of the cheapest airline should be made, where ever possible and politically sensible.	Efficiency	2013-2020	Ongoing task	Politically problematic	Eventually, to rely on one airline only is dangerous. For example in situations with sudden failures of data transmission one could lose all E-AMDAR data.

Observation Project E-ASAP

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
E-ASAP-I	Running programme as is but reduction of: Management budget: -5%, consequence: only core routine management, loose flexibility to mitigate impact of unexpected losses of ships,		2012-2020	~ 1,490 k€ per annum		Shortage in helium supply

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	leading to delayed acquisition of new ships and thereby causing reduction in number of soundings Extension to Arctic not possible R&D budget: -25%, consequence: no impact on the operations, long-term risk: no technical improvements Operations budget: -9%, consequence: -9% observations (e.g. discontinue 18 UTC soundings, possibly more…)					
E-ASAP-II	Running programme as is with constant funding: • Deliver 4700 soundings from 19 stations onto GTS. • Ensure procurement and maintenance of necessary equipment. • Ensure proper installation, training and logistics for supply of consumables. • Collaborate on technical and managerial level with national ASAP operating EUMETNET members. • Liaise with other components of EUCOS programme and with WMO ASAP Panel. • Produce required documents and		2012-2020	~ 1,650 k€ per annum ~ 2 FTE		Shortage in helium supply

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	routine reports. • Provide expert knowledge using experienced management team to oversee programme and to improve capabilities. • Sustain and broaden co-operation with shipping companies and ship managers. • Maintain supporting network structure within Europe to optimise routine operation and technical maintenance. • Consider technical developments to enhance efficiency of ASAP operations.					
E-ASAP-01	Try to extend data coverage, particularly in Arctic Ocean. Arctic soundings might be possible in summer periods while the station could be used on land in winter.	HLA 6	2012-2014	+ 0.2 FTE	No routine line service in arctic regions. Operations depend on available research campaigns or summer schedules.	Low performance due to low number of ships in the Arctic.
E-ASAP-02	Try to set up ASAP station on ship in the Mediterranean. Soundings in the Mediterranean are basically possible, if coastal areas and non-synoptic sounding times are allowed.	HLA 6	2012-2014	+ 0.2 FTE	-1- Ships in the Mediterranean use to sail in coastal areas, -2- Crews are very busy due to dense traffic, -3- Ships in the Mediterranean are smaller than in the	-1- Radiosondes falling on land (liability?), -2- Fixed sounding time windows collide with nautical tasks, -3- Limited number of

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
					Atlantic.	suitable ships due to required deck space.
E-ASAP-03	Increase the operational vertical resolution to 2s (same as for other radiosondes). Increased data volume (due to higher resolution) requires improved satellite communication techniques.	HLA 4	2012-2020	within E-ASAP-II	Satellite communications system required which enables transmission of binary data at low costs.	Different implementation by different system suppliers.
E-ASAP-04	Conduct market research to evaluate cost-efficient sounding systems and, if recommended, introduce change of sounding systems (note: possible replacement costs not included in this activity).	Long term cost saving	2012-2020	within E-ASAP-II (without procurement costs)	Selection of suitable systems based on WMO Intercomparison test, Yangjiang (China) 2010. Market research to be performed in collaboration with the suppliers.	Depending on outcome: Recommendation to replace sounding systems, resulting in major budget readjustments.
E-ASAP-05	Evaluate, in cooperation with EUCOS, benefit of non-synoptic (i.e. flexible) sounding times. Flexible sounding times would increase acceptance on board of ships.	HLA 6	2012-2015	within E-ASAP-II	Collaboration with EUCOS and ECMWF required.	Time delay

Observation Project E-GVAP

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Number	Activity/Deliverable	Rationale	Timetable / key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
E-GVAP-I	Running programme as is but reduction of: Management and R&D budget: -5%, consequence: less time for collaboration with ACs, risk of losing existing ACs, resulting in risk of losing data, slower access to additional data (e.g. in eastern Europe), reduced or delayed introduction of system-wide sub-hourly data processing and distribution		2014-2020	~ 115 k€ per annum	**Good collaboration with geodesists**	Increased risk to lose existing ACs (processing centres), finally risk to lose data, reduced speed in getting access to additional data, reduced or delayed movement to system-wide sub-hourly data processing and distribution
E-GVAP-II	Running programme as is with constant funding: • Produce process and transmit current GNSS meteorological data sub-hourly • Ensure maintenance and continued running of system set up by E-GVAP to make available data for assimilation and now-casting from sites currently available. • Continue established, fruitful close collaboration with the geodetic community, thus increasing number of sites, in particular in regions with poor coverage and data, and homogeneity and quality of NRT		2014-2020	~ 120 k€ per annum	Good collaboration with geodesists	

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Number	Activity/Deliverable	Rationale	Timetable / key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	ZTDs. • Further develop and improve construction of IWV maps and animations for use in now-casting. • In collaboration with geodetic community, and possibly EUMETSAT, attempt to improve quality and security of access to so-called ‘satellite orbit and clock estimates’, used in data processing by the processing centres. • Set up monitoring methods that enable near real time detection and subsequent withholding of certain types of incorrect NRT ZTD data. • Formalise and improve use of the ‘supersites’ introduced in E-GVAP for monitoring system stability and errors. • Convince EUMETNET members to use E-GVAP data and to become members of E-GVAP. • Follow development of the WIS and VGISC. Prepare for the E-GVAP data monitoring and distribution system to become a DCPC relative to WIS. • Coordinate the meteorological exploitation of national sources of GNSS data based on cost-effective					

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Number	Activity/Deliverable	Rationale	Timetable / key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	agreements and provide meteorological support for expansion of GNSS observing networks. • Report on progress of water vapour /zenith total delay data assimilation research and promote use of GNSS water vapour measurements in operational meteorology by the providing suitable teaching material and documentation. • Follow and report on developments in the field of assimilation of slant delays and ZTD gradient and tomography. Enable and encourage production and distribution of such products via E-GVAP facilities. • Explore possibilities for long-term central archiving of both raw (RINEX) and processed (ZTD) data for off-line research and potential future re-processing for climate applications.					
E-GVAP-01	Progressive improvement of data coverage of good quality GNSS data (IWV and ZTD) over Europe (quality assessed by NWP monitoring).	HLA 5, HLA 7	2014-2020	Incl. in 120 k€ E-GVAP	Good collaboration with geodesists	
E-GVAP-02	Synthesis of research results on techniques for extracting 3D information from GNSS signals.	HLA 5, HLA 7	2014-2020 Review every 2 years	Incl. in 120 k€ E-GVAP	Good collaboration with geodesists	
E-GVAP-03	Process centrally as much GNSS data as possible (contribution to E-GVAP-01).	HLA 5, HLA 7, HLA 8	2014-2020 Decision 2014	15 k€ extra per year on average,	Good collaboration with geodesists	

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Number	Activity/Deliverable	Rationale	Timetable / key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
				but with an expensive start, then reducing as regards annual cost		
E-GVAP-04	Distribution of additional atmospheric estimates deduced via refined data processing of existing raw GNSS data, such as ZTD gradients, GNSS slant delays, and 3-D water vapour fields derived by tomography.	HLA 5, HLA 7	2014-2020 Decision in connection with review of reviews from E-GVAP-02	If just awaiting progress and distributing and monitoring data, 2 to 5 k€ extra per year, depending on amount of data. If pushing development more strongly 10 k€ per year (far from enough to do all needed R&D)	Good collaboration with geodesists Rate of progress in relevant R&D (which is beyond E-GVAP)	Slow rate of progress in relevant R&D (which is beyond E-GVAP)
E-GVAP-05	Push dissemination (by GNSS operators) of improved orbit and clock products (contribution to quality improvement in actions E-GVAP-01 and E-GVAP-02).	HLA 7	2014-2020 2014 (consider again 2017 if	Depending on level of active E-GVAP	Good collaboration with geodesists Rate of progress in relevant R&D	Slow rate of progress in relevant R&D (which is

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Number	Activity/Deliverable	Rationale	Timetable / key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
			"no" in 2014	involvement, from 0 to 10 k€ extra on average per year More expensive in beginning, if E-GVAP to be one of the clock and orbit producers.	(which is beyond E-GVAP)	beyond E-GVAP)
E-GVAP-06	Prepare GNSS processing for global distribution of some products (at least hourly).	HLA 5, HLA 7	2014-2020	Incl. in 120 k€ E-GVAP	Good collaboration with geodesists	Slow increase in access to GNSS global data

New Observation Project E-MODE-S

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
E-MODE-S	Collection of Mode-S data on a European scale. (Wind and temperature observations from commercial aircraft downlinked via Mode-S ATC surveillance systems)	HLA 5, HLA 4, HLA 7	2013-2020		Required from aviation users	Higher amount of money and time needed to achieve operational stage
E-MODE-S-	To improve estimates of the total	HLA 5,	2013	1 FTE		E-AMDAR will

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
01	investment required both in terms of staff and infrastructure, it is advised to start with a preparatory phase to investigate: • Capabilities of current surveillance systems in use; • Willingness of aviation authorities to provide the data; • Optimal use of available systems (Mode-S, ADS-A/B/C, etc); • Possibility of central data processing and central data hub; • Estimated exploitation costs; • Lessons learned from the SESAR WP 11 Mode-S New Sensors project.	HLA 13	Decision point: autumn 2013: Was E-MODE-S-01 successful? Shall two more FTE be hired and E-MODE-S-02 started in 2014/2015?			not be developed any further
E-MODE-S-02	Operational collection of Mode-S data on a European scale. This task requires arrangements with ATC organisations: • Determination of radar sites, radar type, availability of Mode-S or ADS data; • Negotiations with aviation authorities; • Setting up of data transmission to NMS and extraction and processing of the data; • Investment in hardware is needed for coordination of central data	HLA 5, HLA 4, HLA 7	2014/2015-2020	3 FTE		

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	extraction, operation of the database and data processing. As the ATC organisations are owner of the data: • Negotiations are required to define under which conditions data can be made available. Aspects to be included are data protection, non-profit use and dissemination of the data within the international meteorological community.					

Observation Project E-SURFMAR

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
E-SURFMAR-I	Running programme as is but reduction of: Management and R&D budget: -5%, consequence: increased time-scales for implementation of full operational data processing, less flexibility to react without delay to occurring data transmission failures Observations budget: -8%, consequence: no extension of the network into the Arctic region, no high-resolution SST drifting buoy unless space-agencies or EUMETSAT agree to fund the upgrades, reduced compensation to NMSes operating VOS and moored buoys (estimates of the impact on the data volume provided by Members difficult), increased timescale for the development of E-SURFMAR S-AWS fleet (procurement and installation of e.g. 1 station per year instead of 2 stations per year)		2012-2020	~ 720 k€ per annum		
E-SURFMAR-II	Running programme as is at constant funding level: • Maintain 100 drifting buoys in operation in the North Atlantic, providing 24 hourly observations of air pressure and SST per day each.		2012-2020	~ 780 k€ per annum ~ 1.5 FTE	The programme covers several observations systems (buoys and ships) which require a substantial level	

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	• Deploy some of these buoys in the Arctic region every summer. • Search funding of HRSST upgrades near space agencies and/or EUMETSAT. • Maintain a fleet of 30-35 programme funded S-AWS. • Ensure procurement of drifting buoys and programme funded S-AWS as well as logistics for their deployment/maintenance • Ensure the day-to-day monitoring of programme funded systems and provide suitable tools to participant members for monitoring their own systems. • Coordinate evaluation of new S-AWS for the benefit of both the programme participant members. Most especially, evaluate the prototypes to be delivered in the framework of the EUMETNET tender. • Follow the deployment of the “half compression” technique on conventional VOS fleets. Evaluate the impact on communication costs. • Pursue the development of data processing for all components of the programme, taking advantage of new				of management (more than previously foreseen). 2 FTE would be a minimum. Many activities are in kind contributions from participants (not only from the coordinating member). Drifting buoys are presently deployed freely. Compensations for VOS and moored buoys observations do not cover their real costs, which currently are borne by some NMSs.	

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	transmission techniques (new satellite links, data compression). Provide assistance to EUMETNET members willing to process such data on their own account • Maintain the total budget for compensations (for the 4 "EUCOS" moored buoys and for national VOS ships), at the level reached in 2009-2011. No extension of fixed platform observations (oil rigs, light vessels…) • Technical and administrative collaborate with EUMETNET members operating national buoys and VOS • Liase with the other components of EUCOS programme as well as the JCOMM DBCP and SOT panels. • Produce required documents and routine reports.					
E-SURFMAR-01	Continue and, if possible, speed up automation of the observations onboard VOS in order to provide the basic measurements of pressure, temperature, humidity and wind on an hourly basis.	HLA14	2012-2020	Within E-SURFMAR-II	Most of future S-AWS funded by NMSs. E-SURFMAR mainly funds developments and prototypes.	Higher cost than expected for S-AWS as a result of the EUMETNET tender. Cuts in national budgets preventing the purchase of data series

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
E-SURFMAR-02	Deployment of more buoys in the Arctic, in collaboration with institutes interested in polar activities	HLA11	2012-2020	+ 25 k€ per annum	Deployments in summer only. Possible shorter lifetimes for buoys operating in this environment	No opportunity to deploy buoys one year due to cancellation of campaign(s) – as in 2010
E-SURFMAR-03	Increase densify of surface marine observations in European coastal areas and inland seas (e.g. Mediterranean, Baltic Sea).	HLA11	2016-2020	+ 20 k€ per annum	Linked to E-SUFMAR-01 (more S-AWS) and E-SURFMAR-04 (use of moored buoy data from third parties)	Wrong data sent to GTS due to lack of control and/or corrective actions S-AWS and related communication costs not borne by shipping companies and lack of programme own funds to cover these costs
E-SURFMAR-04	Invite oceanographers who operating moored buoys networks to report their data to GTS. Monitoring of such observations.	HLA11	2012-2020	Within E-SURFMAR-II	Oceanographers must provide their data in suitable formats. Conversion to BUFR and insertion into GTS by NMSs	Wrong data sent to GTS due to lack of control and/or corrective actions
E-SURFMAR-05	Consider-through discussions between WMO and IMO-the use of real time transmitting AWS on all vessels over a	HLA11 HLA14	2016-2020	+ 0.2 FTE per annum	Suggest existing S-AWS or, at least, their specifications.	Not being supported by IMO

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	certain tonnage				Interface them with AIS. Retrieve the data through national maritime authorities. Develop and implement data processing for GTS transmission	
E-SURFMAR-06	Improve availability and quality of SST measurements, in collaboration with the international programmes dedicated to SST	WMO SoG (calibration and validation of satellite SST data)	2012-2020	+ 50 k€ per annum unless funded by third parties	New drifting buoys under development (DBCP-GHRSST Pilot Project)	Not being financially supported by space agencies and/or EUMETSAT
E-SURFMAR-07	Consider compensations for Port Meteorological Officers for visiting ships, drifting buoy deployment centres and fixed platform observations (e.g. oil rigs).	HLA11	2012-2020	+ 25 k€ per annum	Evaluation of reasonable compensations to be proposed by E-SURFMAR Expert Teams.	Reducing of the number of ship visits leading to a decrease of quality observations. Lack of interest for partners in deploy. drift. buoys.

Observation Project E-WINPROF

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
E-WINPROF-I	Running programme as is but reduction of: Management budget: -5%, Consequence: Reduced ability to be pro-active as monitoring will prioritise current operational incidents plus increased timescales for introducing software changes and new developments. Risk: Maintaining and improving of quality targets and operational acceptance of changes. R&D budget: none Observations budget: not applicable		2012-2020	~ 40 k€ per annum	National plans and funding for the operations and network design of the wind profiler system	Increased risk of not meeting quality targets
E-WINPROF-II	Running programme as is with constant funding: Continue and build on management and support of the operational European network as a component of the EUMETNET integrated composite observing system, ensuring that the delivered data quality is suitable for both NWP and climate requirements. Provide quality monitoring and technical expertise/support service to all EUMETNET members allowing system operators, network managers and data users to reduce their operating costs at a national level		2012-2020	~ 40 k€ per annum ~ 1 FTE	• Wind profiler systems are only operated and/or considered as operational by a minority of the EUMETNET members • Outputs from E-WINPROF are significantly dependent of national support and plans	Meeting the agreed targets Increasing the benefit of the programme to all EUMETNET members

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
					• Reliance on OPERA to provide the technical support/advice for the configuration and delivery of the wind profilers from the weather radar systems	
E-WINPROF-01	Provision of a 24/7 operational service (hub) for collection, monitoring, active quality control (i.e. data blocking) and distribution of the wind profiles from wind profiler and weather radar networks	O2 HLA15	2012-2020	Within E-WINPROF-II	• Real-time monitoring of the network is only semi-automated and thus active reporting and/or resolution of any issues is currently limited to working hours only • E-WINPROF operational Hub service is embedded in the IT infrastructure of the Met Office.	Improving on the performance targets Increased costs and time-scales could make it necessary to relocate the E-WINPROF Hub to another member.
E-WINPROF-	Annual delivery of agreed operational	O2	2013-2020	Within E-	Same as for E-	Same as for E-

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
02	targets (availability, timeliness and quality) for wind profilers/weather radars(VAD) over Europe, with the aim to progressively improve year on year (quality as judged by NWP monitoring)	HLA15		WINPROF-II	WINPROF-II and E-EWINPROF-01 above	WINPROF-II and E-EWINPROF-01 above
E-WINPROF-03	Develop system operations in order to deliver observations every 15 minutes within “observation time + 15 minutes”.	HLA7	By end 2014	Within E-WINPROF-II	15min: national practices, data communication and technical understanding of the errors/quality in higher resolution data	Takes longer than expected Increased errors and data quality issues
E-WINPROF-04	Investigate and, if feasible/agreed, implement operationally the use of additional information from wind profiler systems (i.e. virtual temperature from RASS, vertical velocity, boundary layer height)	HLA 5 HLA 7	2013-2017	Within E-WINPROF-II	Same as for E-WINPROF-II and E-EWINPROF-01/03	Same as for E-WINPROF-II and E-EWINPROF-01/03
E-WINPROF-05	Develop an E-WINPROF Safeguarding policy to protect current and future operations, both from physical (i.e. wind turbines) and radio frequency (i.e. satellites) interference.	O2	2013-2015	Within E-WINPROF-II	Same as for E-WINPROF-II and E-EWINPROF-01/03 above Complex requirements requiring both technical and scientific expertise will need to involve	Same as for E-WINPROF-II and E-EWINPROF-01/03 Takes longer than expected

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
					industry	
E-WINPROF-06	BUFR message - Optimise/harmonise (Globally) and develop (new metadata & identifiers) to enable increased data access and simplified user access to data.	HLA 10 HLA 5 HLA 7	2013-2017	Within E-WINPROF-II	Same as for E-WINPROF-II and E-EWINPROF-01/03 Need to cooperate with the global community and WMO.	Same as for E-WINPROF-II and E-EWINPROF-01/03 Takes longer than expected
E-WINPROF-07	Incorporate the work/objectives of E-PROFILE under the management of the E-WINPROF PM (see E-PROFILE above)	HLA 7 HLA 17	2013-2020	~ +50 k€ per annum (Saving as no E-PROFILE)	Agreement to include E-PROFILE proposal as part of E-WINPROF. Resources required to scope and engage in this work Same as for E-PROFILE	Takes longer than expected, delayed timescale for integration and operational acceptance Increased costs

New Observation Project E-PROFILE

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
E-PROFILE	Working with members and according to recommendations of EG-CLIMET	HLA 17, HLA 7		~150k€ per annum	Future of the programme will	Remote sensing technology may

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	programme, to consider/scope requirements and costs for the development of new remote sensing networks (i.e. volcanic ash, ceilometer network, temperature, aerosol,...) at a European level similar to those existing for wind profiler and GNSS-water vapour networks (E-WINPROF & E-GVAP)				depend on decisions on the integration of temperature profile and aerosol observations	not be mature enough to reach many stations capable of wind and temperature measurements
E-PROFILE-01	Handling of ceilometer data to be integrated at a European level.	Volcanic Ash Monitoring	2013 decision to launch studies on integration of aerosol measurement 2016 decision on extension of E-WINPROF into a programme integrating aerosol measurements			
E-PROFILE-02	Several integrated stations observing wind and temperature by remote-sensing techniques, and data exchanged at a European level.	HLA 7	2016 synthesis of the different studies needed to decide on an extension of		Dependence from the results of **EUCOS-06** plans for implementing and integrating temperature and humidity	

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
			E-WINPROF to a programme integrating temperature measurement		measurements from radiometers and other profilers	

Observation Project OPERA

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
OPERA-I	Running programme as is but reduction of: Management budget: -5%, consequence: stricter concentration on running the programme, less effort on EUMETNET management level. Fixed costs budget (running ODC): -5%, consequence: less redundancy of data hub, longer response times in case of failures in the ODC production R&D budget: -9%, consequence: fewer radar studies, less software development and support, or delay of further development of ODC		2012-2020	~ 165 k€ per annum		Reduced contacts to EUCOS and EUMETNET, less effort on EUMETNET management level

Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
OPERA-II	Running programme as is at constant funding: • Exchange and harmonize radar data and products; • Study new radar measurement methods; • Production of 3D reflectivity composites, rain intensity and accumulation products within ODC; • Study new radar measurement methods (e.g. polarimetric data, use of spectrum width, refractivity, mixed S/C/X-band networks); • Maintenance and development of underlying operational infrastructure and services; • Radar data quality monitoring of the ODC products. • Work with data quality, taking account of increased quantitative use of data. • Liaise within EUMETNET and with international organisations • Interaction with meteorological, hydrological and other user communities		2012-2020	~ 180 k€ per annum ~ 0.25 FTE		Flat funding implies that the Odyssey development cannot be completed by 2015,but will take much longer.
OPERA-01	Increase the volume of radar data and extend the exchange to additional products. Increase the frequency of data	HLA 1	2012-2020	Within OPERA-II	With the increasing number of fields and indices files	

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Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	exchanged from 15 to 5 min. Work to harmonize radar data (reflectivity level, volume frequency, scanning strategies). Continue the development ODIM to include all radar data and products exchanged internationally.				sizes increase as well, which implies increased cost for data transmission. The details of measurements depend on national use. It is hard (and unnecessary) to harmonize everything. Radar HW/SW varies widely, which also makes harmonization more difficult.	
OPERA-02	Production of 3D reflectivity composites using radar volume data cleaned from non-meteorological echoes and corrected for blockage and attenuation where possible. The quality of the data is described with appropriate quality information. The corrected volume data is made available to users.	HLA 2	2012-2015	+ 3-5 FTE	3-D compositing requires that more elevation data are sent to Odyssey, which increases transmission costs. Making corrected volume data available is a request from NWP.	
OPERA-03	Produce rain products based on corrected reflectivity data by applying processing suitable to take account of the measurement altitude and water phase. Studies are underway to include the wind drift. Advection correction is applied for derivation of rain	HLA 2	2012-2015	Included in OPERA-02	This is a long-standing goal of radar meteorology. Finding solutions that are valid throughout Europe may be a	

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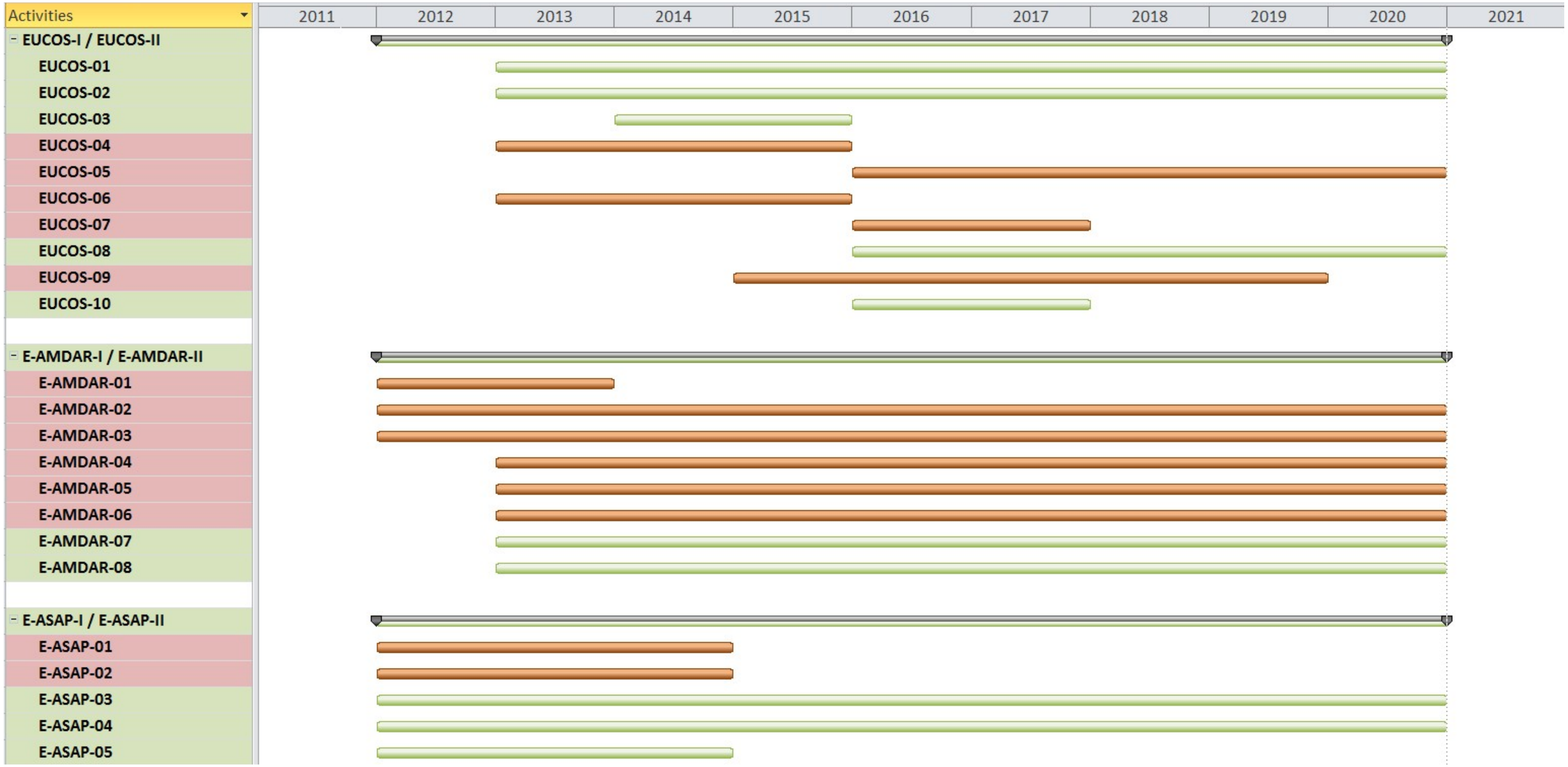
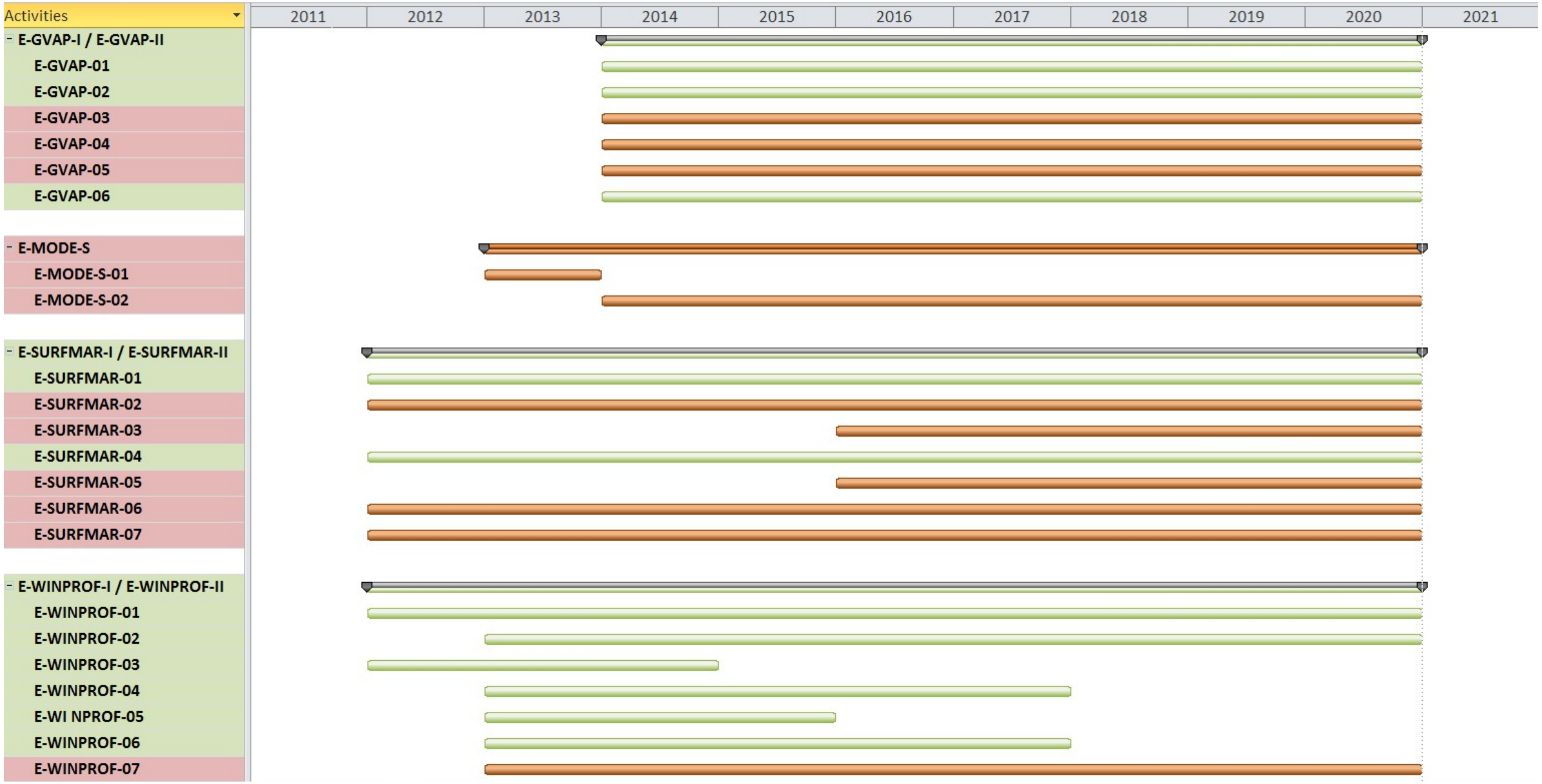
Number	Activity/Deliverable	Rationale	Timetable and key decision points	Estimated resource requirement	Constraints and Dependencies	Risks
	accumulation in case of insufficient data frequency. The products contain appropriate quality information.				demanding job.	
OPERA-04	Study new radar measurement methods (e.g. polarimetric data, use of spectrum width, refractivity, mixed S/C/X-band networks)	HLA 5	2012-2020	Within OPERA-II		
OPERA-05	Maintain and develop operational infrastructure of the data hub.		2016-2020	+ 0.5 FTE		
OPERA-06	Extend the existing radar data monitoring (availability, timeliness) to e.g. monitoring of reflectivity levels and antenna pointing	HLA 15	2016-2020	+ 0.5 FTE		

Annex C: Gantt diagram of Observations activities




Activities
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2021
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E-GVAP-02
E-GVAP-03
E-GVAP-04
E-GVAP-05
E-GVAP-06
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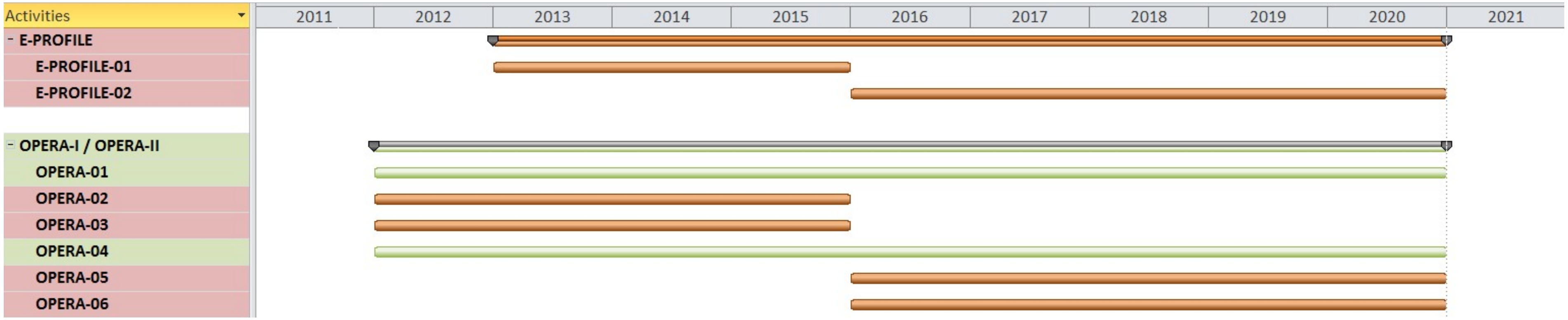

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List of abbreviations

AC	Analysis Centre
ADS	Automatic Dependent Surveillance
AMDAR	Aircraft Meteorological Data Relay
Anaprop	Anomalous propagation
ASAP	Automated Shipboard Aerological Programme
ATM	Air Traffic Management
AWS	Automatic Weather Station
BUFR	Binary Universal Form for the Representation of meteorological data
CONCORDIASI	Concordiasi is an international project
COST	European Cooperation in Science and Technology
E-AMDAR	EUMETNET Aircraft Meteorological Data Relay Programme
E-ASAP	EUMETNET Automated Shipboard Aerological Programme
ECMWF	European Centre for Medium-Range Weather Forecasts
EEA	European Environment Agency
EG-CLIMET	European Ground-Based Observations of Essential Variables for Climate and Operational Meteorology
E-GVAP	EUMETNET GNSS Water Vapour Programme
EIONET	European Information and Observation Network
E-SAT	EUCOS Scientific Advisory Team
E-SURFMAR	EUMETNET Surface Marine Programme
EU	European Union
EUCOS	EUMETNET Composite Observing System
EUCOS QMP	EUCOS Quality Monitoring Portal
EUMETFREQ	EUMETNET programme dealing with the protection of radio frequencies.
EUMETNET	European Meteorological Network
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
ET	Expert Team
E-VCOMP	EUMETNET Virtual Centralised Observations Monitoring and Production Data Hub
E-WINPROF	EUMETNET Windprofiler Programme
FSO	Forecast Sensitivity to Observations
GCOS	Global Climate Observing System
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile communications
GTS	Global Telecommunication System
HLA	High Level Activity
HRSST	High Resolution Sea Surface Temperature
IEEE	Institute of Electrical and Electronics Engineers
INSPIRE	Infrastructure for Spatial Information in the European Community

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IMO	International Maritime Organization
IWV	Integrated Water Vapour
JCOMM DBCP	Joint WMO-IOC Commission of Oceanography and Marine Meteorology Data Cooperation Panel
LIDAR	Light detection and ranging
LET	Lightning Expert Team
LTT	Lightning Task Team
MEDEX	MEDiterranean EXperiment
MODE-S	Mode select
MTG	Meteosat Third Generation
NMHS	National Meteorological Hydrological Service
NMS	National Meteorological Service
NRT	near real-time
NWP	Numerical Weather Prediction
OPERA	Operational Programme for the Exchange of Weather Radar Information
OSE	Observing System Experiment
OSSE	Observing System Simulation Experiment
PFAC	Policy and Finance Advisory Committee
PM	Programme Manager
QC	Quality Control
RA VI	Regional Association VI
RLAN	Radio Local Area Network
RRR	Rolling Review of Requirements
SAF	Satellite Application Facility
S-AWS	Shipborne Automated Weather Stations
SESAR	Single European Sky ATM Research
SoG	Statements of Guidance
SOT	Shop Observation Team
STAC	Scientific Technical Advisory Committee
STD	Slant Total Delays
SUMO	Small unmanned meteorological observer
SYNOP	Surface synoptic observations
TAMDAR	Tropospheric Airborne Meteorological Data Reporting
TAP	Transportes Aéreos Portugueses
THORPEX	Global Atmospheric Research Programme
UAS	Unmanned Aerial Systems
UAV	Unmanned Aeronautical Vehicles
USA	United States of America
UTC	Coordinated Universal Time
VOS	Voluntary Observing Ships
WEZARD	WEather HaZARD for aeronautics
WG E-HBC	Working Group on the E-AMDAR Humidity Business Case
WG-INS	Working Group on Meteorological Instrumentation and Future Developments
WIGOS	WMO Integrated Observing System
WMO	World Meteorological Organization
ZTD	Zenith Total Delay

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