Answers to Questions of the evaluation team of the bid of DMI for the E-GVAP III Programme

1. *Evaluators have the impression that E-GVAP III is essentially a continuation of E-GAVAP II with a few changes. It would have been useful to have a critical appraisal of phase II. Could you comment?*

   Our bid is a response to the EIG EUMETNET Observation Programme Requirements, which specifies in detail what should be included in E-GVAP-III. The Programme Requirements are themselves the result of an about two year evaluation process in EUMETNET, involving the Observation Roadmap Drafting Team, STAC/PFAC and Assembly. This has included a critical view on all EUMETNET observing programmes, including E-GVAP-II, on the new possible developments in the programmes in the period 2013-2020, and on the in-ability of EUMETNET to fund extra developments in the light of the economic crisis.

   Regarding success of E-GVAP-II we can in brief say that E-GVAP-I started April 2005. At the end, March 2009, we had enlarged the network from about 600 to about 1200 GNSS sites. Then E-GVAP-II started. By now we have increased coverage by another 600 sites. The enlargement has taken place at no extra cost to EUMETNET. On the contrary E-GVAP-II was cheaper to EUMETNET by 10,000 Euros annually than E-GVAP-I. During E-GVAP-II processing of GNSS data has improved, thanks in part to better GNSS processing software and new antenna phase centre models.

   A formal evaluation of E-GVAP-II was planned at the end of E-GVAP-II, which was scheduled to terminate by end 2013. EIG EUMETNET has decided to prematurely terminate E-GVAP-II, to bring E-GVAP into sync with the other observing services/programmes in EUMETNET. As a result some final parts of the original E-GVAP-II planning cannot be realised.

   During the latter part of E-GVAP-II there have among NMSs been a strong focus on the development of high resolution NWP, with resolutions of the order 1.5 to 3 km, and to be used in rapid update cycling. This has resulted in a strong request for observations to initialise such models, and ground-based GNSS data have been identified, in common with radar and ModeS data as being the most promising. However, this type of use requires faster access to the E-GVAP type of data than the current hourly uploads and 90 min timeliness criteria enable.

   The inclusion of sub-hourly data processing and upload in E-GVAP-III is a very significant enhancement of the E-GVAP product. Likewise the planned expansion, in particular in Eastern Europe and regarding global data.

   Notice, that the attempt to obtain a "satellite orbit and clock estimate" product with operational status (target 21), can be expected to have big effects if successful. With such a product estimation of ZTD becomes much simpler and faster, using so-called

"precise point positioning" methods instead of "network solutions". It will enable faster access to data, and more distributed ZTD estimation, reducing the impact of a complete AC failure. On the other hand the access to and quality of the "satellite orbit and clock estimates" is absolutely vital, which is why the product need operational status before a widespread movement to precise point positioning can be made. For next generation GNSS data (gradients and slants) access to "satellite orbit and clock estimates" will have similar benefits. There is on the geodetic side also a high interest in such a product, for use in positioning services. If there were extra resources to run E-GVAP, “meteorology” could help finance a facility producing “orbits and clocks”.

2. *Is the data flow structure optimal or could be another approach more advantageous (method statement 2)?*

   As regards the flow of GNSS ZTD data to the users, the proposed flow (second figure in method statement 2 description) is as close to the standard flow of meteorological observations as one can get in E-GVAP, given that the majority of the ACs have no GTS access. Notice that distribution plans include the future WIS, with E-GVAP planning to become a VGISC.

   However, the total data flow in E-GVAP is complex and different to that of “ordinary” meteorological observational data. The optimal strategy would be to collect and process all GNSS data at a single facility. That is not possible, the meteorological community does not own the raw GNSS data, and the owners limit the distribution of the majority of the raw data, especially raw data of high density networks. The many ACs are necessary to obtain a high horizontal density of included GNSS stations.

   As regards the data flow in connection with ZTD data monitoring, validation and quality control, as well as IWV determination and animations, it utilises in the best way the resources at the three E-GVAP team institutions. A new bidder might have decided to do it all at one institution. In the case of the current E-GVAP team, it will on the other hand cost many resources to change the setup, without gaining anything. Notice, that the time critical aspect, the AQC, will be moved from DMI to run at UKMO, when finished (see method statement 4), this fact is not visible in the mentioned figure.

3. *Concerning target no. 2 could you provide detailed information what specific actions are planned to increase the number of sites particular in regions with poor coverage and data? How you will increase the homogeneity and quality of the NRT ZTD´s?*

   The E-GVAP team people contact the relevant geodesists at meetings and via email. And we have geodesists from many of the current ACs promote participation in GNSS meteorology to other geodesist. One should know here, that many of the involved AC

people are among the leading geodesists in the field of GNSS positioning in Europe and world wide, wherefore they are very good ambassadors.

Furthermore the current E-GVAP team works in collaboration with the GNSS4SWEC (proposed EU COST Action), the GRUAN PWV Task Team and HYMEX (the latter being particular important regarding data from North Africa), and attempt to form more joined partnerships with other agencies around the world, such as NOAA.

For the moment there is very significant progress regarding getting access to more ZTDs from Eastern Europe (making an MoU with EUPOS (an East European Geodetic organisation), and preparing for data from Hungary, Bulgaria, and Poland). This work will be continued in E-GVAP-III.

The homogeneity and quality of the NRT ZTDs will be increased via determination of best processing practices and agreements on those at the expert team meetings. The user requirements, detailing the wishes to timeliness and precision by NWP and forecasting people, will be updated.

4. *Could you more specify target no. 4 and no. 6 regarding data security and availability, hardware maintenance and a more detailed risk assessment for the complete system?*

   The critical components of the ZTD distribution system at UK MetOffice belong to their operational computer system, they are as secure against lack of functioning as their operational system in general, which of course include backup in case of computer failure, but not backup against any mishap.

   The movement toward de-central data dissemination will enhance the robustness against single point failure.

   The ACs in general have no advanced backups against computer failure, with the exception of the ACs at NMSs. To establish such a backup would require E-GVAP to pay for it. Currently E-GVAP gets the ZTDs without direct payment. However, it is unlikely that more than one AC will fail at any one time.

5. *Could you give more detailed information to target no. 7 (migration to sub-hourly processing)? Could you inform about the planned timeliness regarding data availability?*

   The rules of file naming will be changed, enabling sub-hourly uploads. Expected already this year.

   A few ACs already do sub-hourly processing, they can start uploading sub-hourly data right away. Other ACs will gradually move toward sub-hourly processing. It is expected that those ACs which have sufficiently fast access to do sub-hourly

processing will change quite quickly, but some ACs only have hourly access the raw data, and it will take longer time before they can do sub-hourly processing.

The "age" of the sub-hourly data will be about 5 to 15 minutes when received at the NMSs.

6. *Regarding the target no. 9 could you specify how "supersites" data will be used to reduce the product latency?*

   The super-sites have no impact on product latency.

   The super-sites serve three purposes. Firstly, to enable comparison of the performance of different ACs and processing techniques, thereby helping to identify best processing practices. Secondly, to validate against non GNSS estimates of ZTD and IWV (e.g. radiosonde and VWR data). Thirdly, to enable on the fly detection of eventual problems with the processing at an AC, via inter-comparison of results across ACs. In practice there are many more sites available for the latter purpose, due to overlaps in the networks processed by the ACs.

7. *For target no. 11, more could be done to promote the use of the data and engage with users. The NWP community needs to be convinced that there is genuine added value in using these data so a more focused on-going effort would be appropriate. For example, while data assimilation experiments and research are performed within the 'limited area NWP' community a more formal GNSS OSE type of programme could be promoted (perhaps linked with other EUMETNET programmes?). Could you comment?*

   Awareness about GNSS ZTD data in the data assimilation NWP community is now becoming quite high, the demand for such data is increasing very strongly in Europe. Two examples: The LACE consortium wants to include E-GVAP data in their common database. The workshops and planned work on data assimilation for high resolution NWP done by the Harmonie consortium include E-GVAP ZTDs (along with radar radial velocities and reflectivities, and extra satellite data).

   There are very recent reports on impact in NWP from Meteo France and KNMI. The KNMI report demonstrates the impact with and without the GNSS ZTDs, the Meteo France report with and without *additional* GNSS sites included. These OSEs are, being done on operational NWP systems, as solid and formal as any OSE. The main goal of using ZTDs is to improve forecasting of precipitation, for which high resolution NWP is optimal.

   It is interesting, and planned, to include ZTD data in an ECMWF assimilation experiment. But the value of such an experiment is not higher than that of any other OSE study. It could turn out that in global, coarse resolution NWP the value of the

data is small, while in high res. NWP it is large. Then the ZTD data are still of value to the NMSs that run limited area NWP.

Having said that, we could do better than now in providing information about usage to NMSs, for example by making a larger database of material on that issue, and make it more visible. That will be done.

8. *Could you provide more information about the provision of suitable teaching material and documentation, including to EUMETCAL?*

   For the moment E-GVAP data is mainly used via data assimilation into NWP. For people working in data assimilation the presentations from the Expert team on data usage, and the related scientific articles, provide insight to the methods.

   Use of E-GVAP data in operational forecasting is currently not done. However, case studies are being made by E-GVAP experts at UK MetOffice and KNMI. Based on those advice on usage by forecasters will be made, and made available.

9. *In the Obs.Prog.Requirements there are some doubts about the necessity of the Plenary Board. This is not addressed in the bid. Could you comment?*

   Formally the Plenary Board is not necessary, since after the changes in EUMETNET it is the EIG Secretariat, STAC/PFAC and Assembly that have become the bodies governing E-GVAP.

   However, meeting the members is valuable to the E-GVAP team. And it is reasonable the members of an optional service like E-GVAP have the possibility of directly interacting with the E-GVAP team, even if not all members take advantage of the possibility. As mentioned on page 11 of the bid, we see benefits in maintaining the plenary board, providing a possibility for the members meet to with the E-GVAP team and the expert teams, in order to both give their opinion and learn. Since the meetings are made in connection with the Expert Teams meetings, the amount of resources it costs E-GVAP to have the plenary meetings is next to nothing. The cost to members is also limited, since it is few that partake in all the plenary meetings. At the meetings the members are active and enthusiastic, demonstrating that also to them the meetings are of high value.

10. *Could you give more detailed information about the specific responsibilities of the institutions/members? Who is responsible for the agreements with the data processing centers?*

    In principle each member is responsible for the collaboration with the national geodetic institutions as regards access to GNSS data. In practice it functions that way in certain countries, but E-GVAP obtains ZTD data from many countries that are not members of E-GVAP, most notably Germany. In those cases the ACs processing the data have agreements with the data owners (in the majority of the cases for other reason than E-GVAP), while E-GVAP has an agreement with the ACs to process data for E-GVAP. The MoU between EUMETNET and EUREF govern that.

11. *Could you give more information about risks and performance metrics of deliverables?*

    The high number of ACs and (relatively) local network they process, combined with the significant degree of network overlap, reduces the risk for E-GVAP ZTD products dropping out entirely. As mentioned elsewhere the apparent single-point-of-failure in the MetOffice collection hub is low risk due to the fully operational nature of the system (for many critical data types beyond E-GVAP). The future plan for distributed BUFR conversion and GTS dissemination will further reduce the risk of outage.

    The performance goals of E-GVAP are specified in the "EIG EUMETNET GNSS Water Vapour Programme (E-GVAP-II) Product Requirements Document", which is based on WMO recommendations and input from users of E-GVAP data. At expert team and plenary meeting E-GVAP experts and members have the possibility of updating this document. For global and regional NWP it specifies regarding accuracy: 15, 10 and 5 mm for respectively "threshold", "target" and "optimal" (the usual WMO division), for timeliness 2, 1.5, and 1 h, for horizontal sampling, 200, 100 and 30 km. This is the prime product of E-GVAP-II and will be one of the prime products of E-GVAP-III. For Nowcasting and Local NWP, it specifies for sub-hourly ZTD: accuracy 15, 10 and 5 mm, for timeliness, 1 h, 30 min and 15 min, for horizontal sampling, 100, 50 and 20 km. This will be another prime product of E-GVAP-III.

    Today all ACs meet the "threshold" requirements for the regional NWP ZTD, while some are better. One objective of E-GVAP-III will be to have all ACs meeting the "target" requirements for regional NWP, and several meeting the requirements for nowcasting.

12. *In regard to the sustainability of the programme could you make a statement that the "in kind" hardware/database is guaranteed to be available in the future? Are there MoU´s with the appropriate MNS´s for these services?*

    The are currently no MoU as regards access to hardware/databases associated with E-GVAP between the three team member institutions. For the duration of E-GVAP-III I expect that can be made in connection with the making of the E-GVAP-III "contract". I am not certain one can extend this to the longer term. If another team was to run E-GVAP, it would be natural to set up the system on the computer system of the new team, or the new team negotiate with members of the old team access to their system. What we can do during E-GVAP-III is to make it more transparent and more easy to move to another computer system.

13. *To promote a better engagement between members meetings of the expert teams twice per year would be appropriate. Could you comment?*

    In practice the majority of the members of the expert teams meet twice or more a year, in connection with other meetings. Nearly all processing experts partake in the EUREF annual symposium early June, as do 3 people from the E-GVAP team. Many of the experts from both expert teams partake in the EGU each April, which since

many years include a session on "Atmospheric monitoring by space geodetic techniques", which dominated by GNSS meteorology, both regarding observation and usage of GNSS atmospheric estimates. Finally the big NWP consortia, such as Harmonie, regularly have workshops on data assimilation, which often includes common work on assimilation of GNSS data or planning thereof, enabling many of the experts on data usage to meet. Even though E-GVAP is not the formal course for those meetings, E-GVAP matters are discussed in connection with those meetings.

As it on the other hand would be quite costly (there are many processing experts) and difficult (the experts do not have much time) to gather the experts for an extra expert team meeting each year with solely a focus on E-GVAP, we recommend to stay at one formal expert team meeting a year, with the possibility of the E-GVAP team calling for additional meetings if necessary.

14. *Are there financial resources left over from E-GVAP-II that will transfer to E-GVAP-III?*

    The currently expected surplus by end of E-GVAP-II end of 2012 is 25,075 Euros. This can be verified with EIG EUMETNET Secretariat.

    I believe the surplus will transfer into E-GVAP-III, but ask Steve Noyes to verify this.

Questions finished 31 July 2012

Answers finished 9 August 2012, by Henrik Vedel, DMI.