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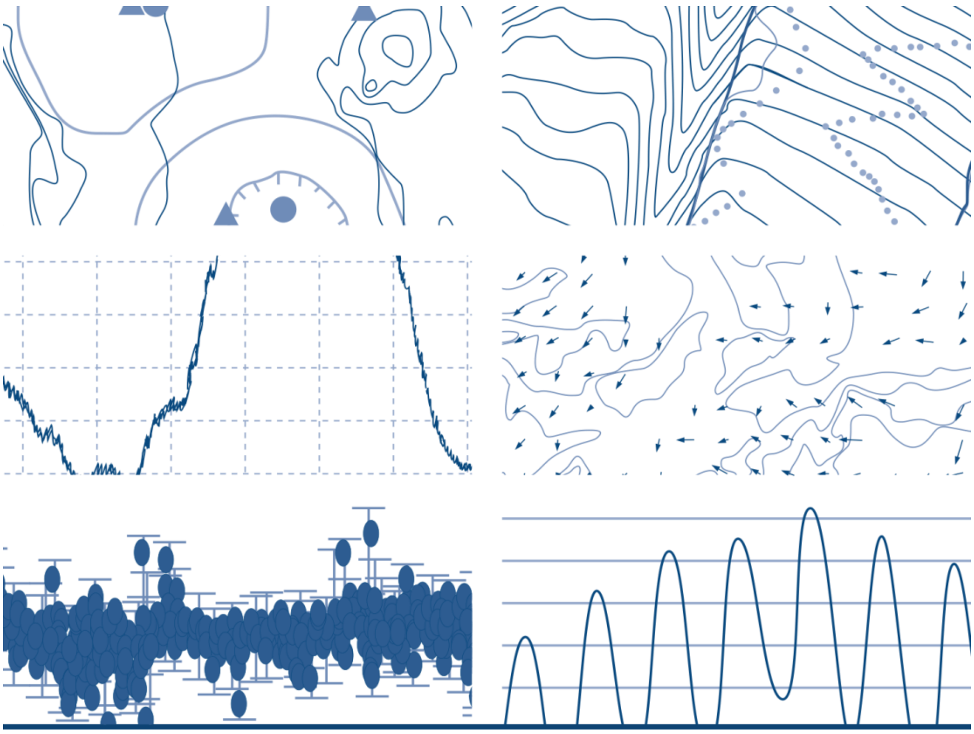

CGPS Workgroup
Network status June 2011
Final Report

Sigurður Fjalar Sigurðarson
Matthew J. Roberts
Benedikt G. Ófeigsson
Einar Kjartansson
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Þorgils Ingvarsson

Report

VÍ 2011-005

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Report

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Summary:

The main purpose of this report is to assess the present status of the CGPS network, focusing on hardware issues, communication routes, network optimization, data processing and archival. The work is motivated by a need to better automate the daily operation of the network, maximize operational efficiency and minimize costs.

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1 Introduction

The group's main task was to assess the present status of the CGPS network, focusing on hardware issues, communication routes, network optimization, data processing, and archival.

The work is motivated by a need to better automate the daily operation of the network, maximize operational efficiency and minimize costs.

1.1 Project details

Group leaders:

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Project management:

Heiðveig María Einarsdóttir – Project Manager, Icelandic Met Office

1.2 Overall aims

The following tasks were defined for the project:

1. Inventory of site hardware and assessment of station health.
2. Identification of weaknesses in data transfer and preparation.
3. Assessment of IP-based communication options for dial-up connections.
4. Review of station locations and possibilities for network optimization.
5. Appraisal of data processing, including existing drawbacks, alternative software, future needs for monitoring purposes, data archival, and sharing of CGPS data.

1.3 Modifications to original aims

As work progressed on the original aims it became clear that modifications were necessary. Because tasks 2 and 3 are interrelated, it was decided that they should be merged. Additionally, two other tasks were included to help assess the completeness of time-series GPS data and to outline a list of work priorities. These aims are as follows:

1. Evaluating the completeness of the data series that have been collected so far. The completeness or lack thereof might indicate underlying and possibly long standing problems with the stations.
2. Create a list of projects that are recommended to further mature the GPS network and prioritize the list.

1.4 Deliverables and next steps

The main deliverable of this project is this report. The report contains the results of aforementioned tasks but the tasks go quite far in touching on all the main cornerstones of the CGPS network. The report gives an overview over the network as it is today and also emphasizes future tasks. This report does not provide a complete overview of the CGPS network, although it covers key tasks that can be used as a development strategy.

1.5 CGPS sub-networks

Table 1 presents a list of the sub-networks in the CGPS network and a short description for each network.

Table 1. The CGPS sub-networks.

Network name	Short background
CHIL	University of Iceland, University of Arizona, and IMO
Hekla	Penn State University and IMO
ISGPS	IMO and foreign associates
NICE	ETH, Zürich and IMO
Savoie	University of Savoie and IMO
Semi-CGPS	University of Iceland, University of Savoie, and IMO

1.6 Other networks

Table 2 presents a list of networks run by other organizations currently accessible to IMO.

Table 2. Other networks providing GPS data.

Network name	Short background
IGS	International GNSS Service
LMI	Landmælingar Íslands

2 Equipment inventory, age and health

2.1 Network health

The health of the network is dependent on several factors: receiver hardware health, modem hardware health, power connection health, communications link health, plus externals factors such as weather conditions.

This year, out of 63 stations, around 13 to 27 have not delivered data automatically on daily basis, representing around 20-45% of the network. Although there can be problems with communications to the stations, the receivers continue to log data while there is enough power and the receiver itself is healthy. This is sometimes the case with wireless communications. When this is the case, data is downloaded when communication conditions allow. In the event of a power problem, a station will go into sleep-mode and stop logging data. This creates a discontinuity in the data series for that particular station. Receiver hardware malfunction also creates gaps in the data series.

Table 3 contains a list of stations that have been off-line for at least two weeks in the spring of 2011.

Table 3. Off-line stations.

Station ID	Station name	Category	Problem
BALD	Búrfellsalda við Kárahnjúka	A	Receiver is not logging. Needs to be reset
ENTA	Enta	B	No data from University of Iceland
FITC	Fitjarás	B	Data link down since 12-04-2011
HAUC	Háumýrar	B	Poor radio link
HVEL	Hveravellir	B	Being upgraded to 3G data link
INSK	Innri Skúti	B	Data link down since 12-04-2011
KIDC	Kiðagilsdrög	B	Poor radio link
LFEL	Lambafell á Kili	B	Data link down since 12-04-2011
OFEL	Öldufell	B	Data transfer is under way by University of Iceland
RHOF	Raufarhöfn	A	Persistent problems with communication and receivers
SKDA	Skriða	B	Modem needs to be reset on site
STE2	Steinsholt	B	No response from receiver since 22-04-2011
SNAE	Snæbýli	?	Off-line due to hardware failure with the receiver

Some of these stations are difficult to get back online without site visits. Consequently they may therefore be out-of-service for extended periods. Based on an estimate of the completeness of the GPS data-set in 2010, the uptime of the network is about 70.5%. For further details, see section 6.

In the above context, a communication problem with a station is less problematic than a power shortage or receiver hardware problem. However, the severity of a receiver hardware problem depends on the receiver type and its attributes. Table 4 gives a snapshot of the health of the network on 1st May 2011. The stations are grouped in three categories; 'A' stations for permanent sites and 'B' and 'C' stations for semi-permanent monitoring and research purposes.

Table 4. Snapshot of stations status.

Status	**Number of A stations**	**Number of B stations**	**Number of C stations**	**Total number**
On-line	19	29	5	53
Off-line	5	11	1	17
Total number	24	40	6	70

2.2 Equipment inventory

Currently inventory listings for stations and equipment in the CGPS network are far from being up-to-date. Part of the problem here is that different groups of people are working with different parts of the network in a semi-centralized way. That is, keeping information about parts of the network in different places instead of having all information in one place. Other part of the problem is copies of out-dated information in different places. For example, information on the stations can be found on at least two websites on hraun.vedur.is, the IMO's wiki page has comprehensive information and Division of Observations maintains their own information on the stations in files in shared folders. Maintaining the information in all these places is not a simple task. A database with all the stations, equipment and other relevant information is recommended in this context. The database has to be accessible by all parties involved in the daily operations of the network, the data in it must be version controlled. A means to minimize manual work in updating information in the database, a system could be put in place to automatically collect information from the stations on regular bases and update the database.

With a centralized documentation in place, progressive updates should be done by Division of Observations when at the stations to verify the accuracy of the inventory listings and update when needed.

If there will be a database in place, all involved parties should look up information in the database and all information relevant to the CGPS system should only be updated in the database. Scripts that are part of the production environment should be able to query the database and user groups should be able to query the database, through an interface, e.g. a website or client program.

Detailed equipment listing can be found in Appendix II.

2.3 Receivers

Out of 63 CGPS stations that have been in the daily download routine since the beginning of the year, about 67% currently use Trimble NetRS receivers. Septentrio receivers are used in the NICE network on the north coast of Iceland. According to the number of 4000 – 5700 Trimble receivers, the total network is relatively modern. Trimble NetRS receivers have an ethernet and serial interface, but the older models have serial interfaces only, making data transfer more cumbersome with modern communication technology such as GPRS and 3G. In general the receivers have been reliable. The NetRS type is probably the least reliable because of its memory and operation system design. Comprehensive information on how much maintenance has been done for each model has not been collected, but it is advisable to do. In the near future, several of the oldest receivers will have to be upgraded with newer models. Number of receivers for each model is given in Table 5.

Table 5. Receiver models in the CGPS network.

Receiver model	Number of receivers
Trimble 4000	2
Trimble 4700	5
Trimble 5700 / R7	4
Trimble NetRS	39
Septentrio PolaRX2e	10
Ashtech Z-12 CGRS	2
Ashtech µZ-12/Martec Mira-Z	1

2.4 Communication

Remote communication with stations is mainly IP-based but some stations still rely on dial-up modems. The dial-up modem technology is slowly being phased out by the telecommunication companies and this type of data connection is the most expensive for greater amount of data because charging is based on connection time but not by the amount of transferred data.

With IP-based communications, the connection route can go through different systems between endpoints; ADSL, ISDN, microwave data connections and WiFi data connections. An example of this is station GOLA. This station is connected to IMO via an ADSL link from SIL station *god* (short for Goðabunga), whose computer is located in Hvolsvöllur. Communication with GOLA, located on the western flank of Mýrdalsjökull, is via a radio modem over a distance of over 45 km. In addition, the SIL station receives GPS data from STOR by means of long-range WiFi. The station will have to be within a 5 km range for the WiFi. A graphical overview for routes of all the stations to the servers at IMO is presented in Appendix VI. Number of stations for each type of data connection is given in Table 6.

Table 6. Data collection types.

Type of communication	Number of stations
Dial-up modem	7
GSM dial-up modem	9
IP-based communications	47

Analysis of data connection costs for all stations has revealed especially high costs for stations that still have dial-up modems. This high cost is most likely due to repeated and failed attempts to download data when data connection quality is low for some reasons, but part of this can be explained by high rate data that was downloaded in 2010. It is recommended that all stations with dial-up modems will be upgraded with newer data connection technology like 3G/GPRS modems where feasible. This work has begun already and will probably finish before the end of summer 2011. The analysis is further discussed in section 3.

2.5 Electrical power

The division between stations with on-site power production and mains electricity is fairly even as shown in Table 7. Stations with on-site power production do occasionally suffer power shortages due to weather conditions or malfunction in the power production equipment. For stations that only have solar panel power, this occurs mainly during high winter. The stations therefore go on stand-by until sufficient power is available. This fact can affect the completeness of the time-series gathered from these stations. It is therefore recommended that the completeness of data series will be compared to possible problems to see if this is actually a problem. The completeness of the data series is discussed in section 6.

Table 7. Power connection.

Type of communication	Number of stations
Main Power	35 (55%)
Produced on site	28 (45%)

For CGPS stations reliant on remote power sources, the preferred solution is a photovoltaic solar panel and a wind generator. However, several sites rely solely on solar power due to the high operational costs of wind generators. This applies especially to semi-continuous stations that have since been incorporated into the permanent network. Dual power sources are needed because of large seasonal variations in solar intensity and wind strength. Experience has shown that a wind generator alone cannot provide year-round power, as wind strength is often light during the summertime. A combination of wind and solar power ensures ample charging of batteries, thereby making it possible to co-locate another sensor at the site, such as a seismic station.

2.6 What needs to be done

This section summarizes the work tasks that should be defined in relation to site equipment. A list of recommended projects is also given in Appendix II.

1. Create and maintain an inventory system that serves the needs of the CGPS network and its users.
2. Analyse how much maintenance each model of receivers has had and how much costs are involved with special focus on older models of receivers.
3. Upgrade dial-up data connections. For further details, see section 3.
4. Evaluate the need to upgrade receivers to phase out serial communications.
5. Compare receiver hardware problems to the quality of data series and try to fix or upgrade stations with the lowest quality connected to hardware problems first.
6. Compare power problems to the completeness of data series and try to fix or upgrade stations with the lowest level of completeness first.

3 Analysis of data connections

Out of 62 stations in the network today, 11 stations use dial-up modem connections and GSM dial-up connections. The stations and relevant transfer costs in 2010 are listed in Table 8 and Table 9.

Table 8. List of land-line dial-up stations and annual data transfer costs in 2010.

Station ID	Station name	Receiver	Data transfer cost
ARHO	Árholt	Martec Miraz/Ashtech	23,412 ISK
HLID	Hlíðardalsskóli	Trimble 4000	47,625 ISK
HVER	Hveragerði	Trimble 4700	21,273 ISK
ISAK	Ísakot	Trimble 5700	16,038 ISK
RHOF	Raufarhöfn	Martec Miraz/Ashtech	108,010 ISK
THEY	Þorvaldseyri	Trimble 4700	11,864 ISK
VMEY	Vestmannaeyjar	Trimble 4000	32,177 ISK
		Total	**260,399 ISK**

Some of the transfer costs in Table 8 are not excessive but these cost figures are possibly incomplete. Another reason may be problems at the stations, for example the receiver was off-line and did not have any data for downloading. Another explanation is the different size of data packages collected from the stations. On average the costs are too much based on these numbers. Outliers like RHOF illustrate what the costs can sum up to in some cases.

Table 9. List of GSM dial-up stations and annual data transfer costs in 2010.

Station ID	Station name	Receiver	Data transfer cost
BALD	Búrfellsalda við Kárahnjúka	Trimble NetRS	50,692 ISK
FIM2	Fimmvörðuháls	Trimble NetRS	66,315 ISK
HLFJ	Hlíðarfjall	Trimble NetRS	82,165 ISK
OLKE	Ölkelduháls	Trimble 4700	95,964 ISK
HAHV	Hafrahvammagljúfur	Trimble NetRS	94,579 ISK
SKDA	Skriða	Trimble NetRS	74,451 ISK
SKOG	Skógarheiði	Trimble NetRS	64,640 ISK
STE2	Steinsholt	Trimble NetRS	55,509 ISK
STKA	Stóra Kjalalda	Trimble NetRS	114,951 ISK
SOHO	Sólheimaheiði	Trimble 4700	142,736 ISK
		Total	**842,000 ISK**

When the numbers are summed up in Table 8 and 9, the figures are way too high compared to standard 3G connection contract, where monthly costs are around 2,700 ISK for standard 1 Gigabyte connection, resulting in around 32,000 ISK annual costs. In addition the costs of the IP based 3G connections are fixed beforehand, thus not subject to the same uncertainty as the dial-up modems. Upgrading the data connections for these stations is therefore a priority to lower the annual operational costs. Appendix IV gives a detailed analysis of the operational costs involved in the current setup and also for a setup recommended by this work group and compares the two cases with zero-point analysis.

Further down the road it is the aim to collect continuous high rate data and that requires some of the newer receiver models and modern data communications.

3.1 Idealized situation

All of the stations installed with GSM dial-up modem produce their power on-site, e.g. FIM2, OLKE and SKDA. All the stations with land-line dial-up modems use main power, e.g. VMEY, THEY and RHOF. With this in mind it is reasonable to focus on alternative solution, which consumes a minimum amount of power while operational for the GSM dial-up modem stations. Division of Observations has good experience with 3G/GPRS Conel modems and it is recommended that this model is bought and installed as soon as possible at the GSM dial-up stations. For stations that are connected to main power, other solutions can and should be considered. A cost analysis for buying and installing Conel modems at all the dial-up sites is presented in Appendix IV. Summing up the foreseeable projects we get the following list:

1. Upgrade all land-line and GSM dial-up connections with IP-based connections, 3G or ADSL.
2. Install some kind of watchdog to reset the 3G modems if they freeze and are unreachable.
3. Review contracts for data connections and find a way to minimize the data tariffs in consultation with telecommunication providers.

4 The CGPS Station Network

The Icelandic Meteorological Office started running a continuous GPS network (ISGPS) in 1999 for monitoring and research of crustal deformation as a primary purpose. Since then the institute has been leading in operating continuous GPS stations in Iceland. A total number of 64 continuous GPS stations were in operation in Iceland at the beginning of 2010, of those the Icelandic Meteorological Office was responsible for operating 58 of these sites on a daily basis. Besides IMO, continuous GPS stations in Iceland are operated by the National Land Survey of Iceland (LMI) and their collaborators (IGS, BEK); a private company (ISMAR); and the Icelandic Harbour Authority, although data from the two latter institutions have not been utilized for monitoring and research of crustal deformation on a regular basis.

Many of the sites operated by IMO are run in cooperation with, or directly for other institutes. Most of the sites were installed in cooperation with other institutes, or even installed by other institutes without direct intervention by IMO. Before 2006 the network build-up was primarily driven by individual events and spurious funding for installation of new sites. In 2006 a grant of excellent from the Icelandic Research Fund allowed IMO and the Earth Science Institute, University of Iceland, to lead an umbrella project facilitating cooperation with various institutes resulting in nearly triple the number of CGPS stations. The institutes formed sub-networks (Figure 1) that concentrated on various research projects.

4.1 Current stations

Figure 1 show the present extent of the CGPS network. The stations are divided between different networks as mentioned in introduction in section 1. Individual networks are indicated by colour-coding. IMO has worked with numerous institutions in establishing new CGPS stations in Iceland. As displayed, the station network consists of smaller networks, sub-networks, which have come to exist through localized research projects. The sub-networks were earlier discussed in section 1.5. The universities involved are University of Iceland, University of Arizona, Penn State University, Savoie University in France and ETH in Zürich & KAUST. The funding for these projects has come from various international and national funding sources. Different networks were originally set up with similar data connections that were state of the art at the time. Over time, some stations have been upgraded with more modern technology when possible.

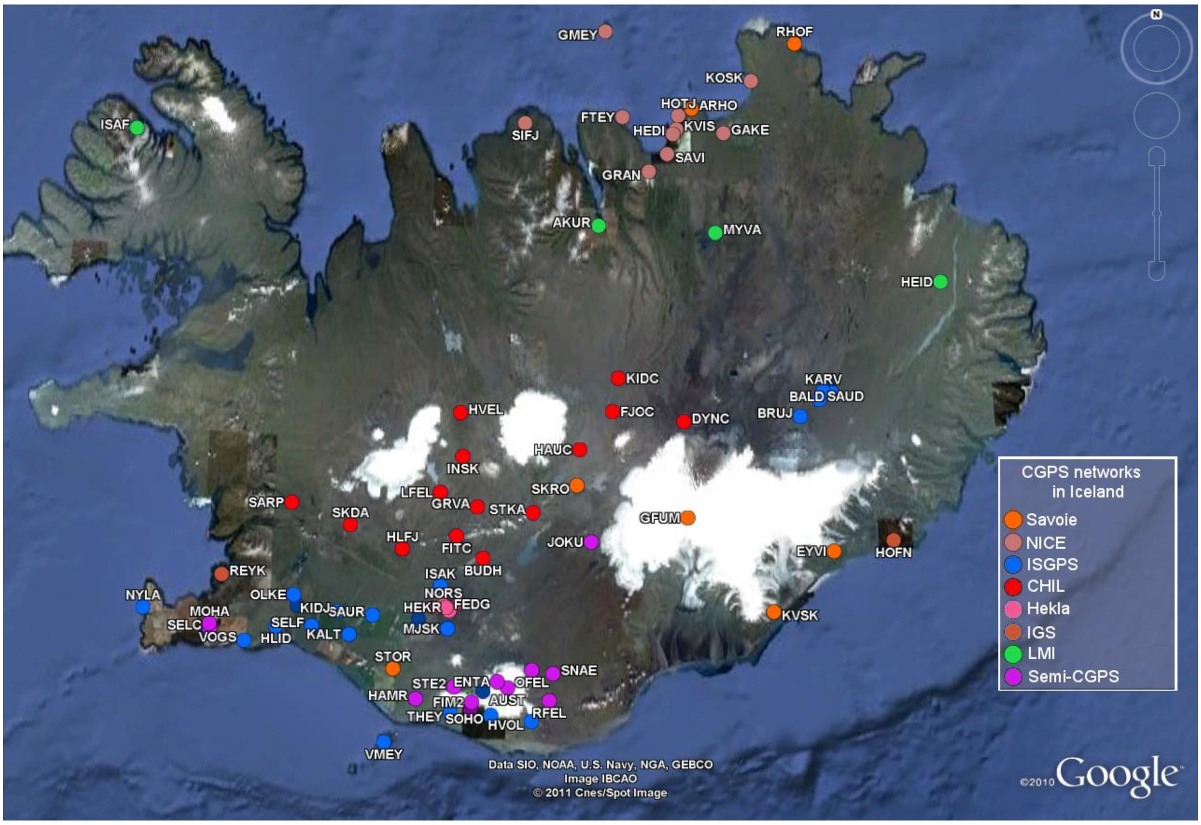


Figure 1. Current CGPS stations, sub-networks and other networks.

Two stations will be removed from the network in the coming months. These stations are Brúarjökull (BRUJ) and Kárahnjúkar (KARV), both part of the ISGPS network and located in the region of the hydro-power plant Kárahnjúkar. The stations are owned by Landsvirkjun and therefore under their authority.

Two stations, which are currently semi-continuous, will also become part of the network this summer. These two stations are part of the Savoie network and have so far been visited twice a year for data transferring and maintenance. In cooperation with Thierry Villemin at the University of Savioe the stations will be retrofitted with a 3G modem and data downloaded from then on a daily basis. The stations will for example strengthen the monitoring of the rapid on-going glacial-isostatic adjustments going on around Vatnajökull ice-cap and enable better monitoring of Öræfajökull volcano as well as increasing IMO's general monitoring capabilities of volcanoes in Vatnajökull.

A comprehensive summary of CPGS stations is presented in Appendix III.

4.2 Preferred layout of the network

The Iceland CGPS network has been installed mostly through research grants of different projects with various collaborators. As a result the network coverage is uneven around the country. Areas outside of the active plate boundary have hardly any GPS stations and the network coverage is lacking for large part of the plate boundary, many active volcanic systems, and areas around rapidly retreating ice-caps. Areas outside of active zones have hardly any coverage. In organizing the future setup of the CGPS network a comprehensive usage of the network needs to be considered. Monitoring long and medium term crustal deformation at volcanoes, in seismic zones and glacial isostatic adjustments constitutes the main usage of the current network, although the coverage is poor. Additionally GPS can be used for atmospheric studies and land surveying (such as LIDAR). High rate GPS has a potential for real time monitoring of volcanic activity. For a comprehensive monitoring and accurate interpretation of these processes, a base network covering the plate boundary areas as well as the more stable interiors of the tectonic plates, is necessary. In order to accurately interpret observed signals, estimate of a background movement is essential. Figure 2 shows a suggestion of a base network of GPS stations (volcano monitoring not included). Most of the currently operating stations are included with additional suggestions to widen the network.

Table 21 in Appendix V contains the geographic co-ordinates of all CGPS stations in Figure 2.

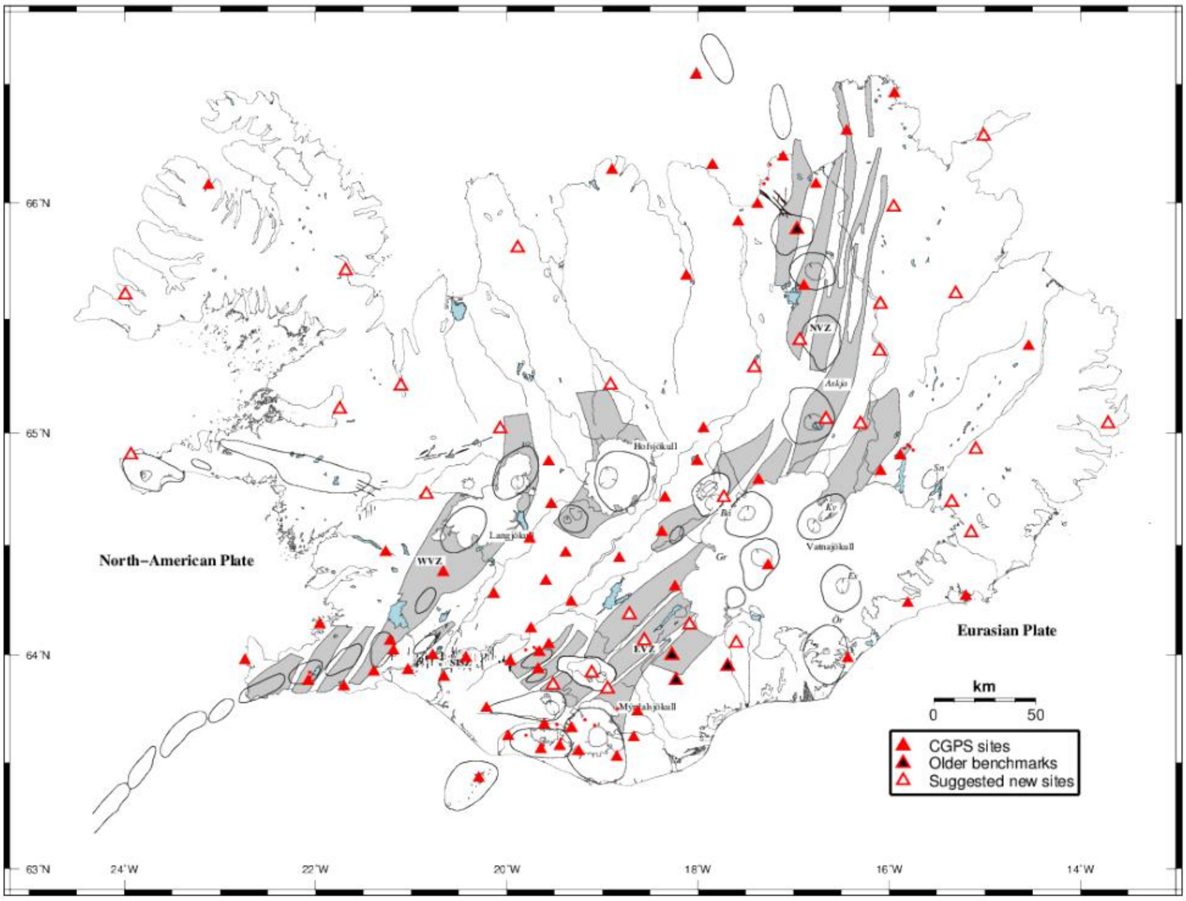


Figure 2. Stations for national network – suggested and existing.

4.3 Preferred locations of stations for volcano monitoring

A simple but very useful model to describe crustal deformation, associated with magma movement and volcanic eruptions, is the Mogi model, which describes deformation at the surface of an elastic half-space. It is specified using four parameters, volume change and three coordinates for the centre of the changed volume. One station can give at most three parameters; therefore two stations are needed to make to possible to describe the deformation. The horizontal deformation is greatest at distances that are comparable to the depth of the deformation centre. The volcanoes at Hekla, Eyjafjallajökull and Katla are already covered by at least two GPS stations. We think that at least eight other volcanic centres should be covered by at least two stations. Those are:

Krafla – KRA1 and KRA1

Askja – ASK1 and ASK2

Kverkfjöll – KVE1 and KVE2

Snæfell – SNE1 and SNE2

Öræfajökull – ORE1, ORE2 and VOT1

Bárðarbunga – DYNC and KVSK

Hofsjökull – HOF1 and HOF2

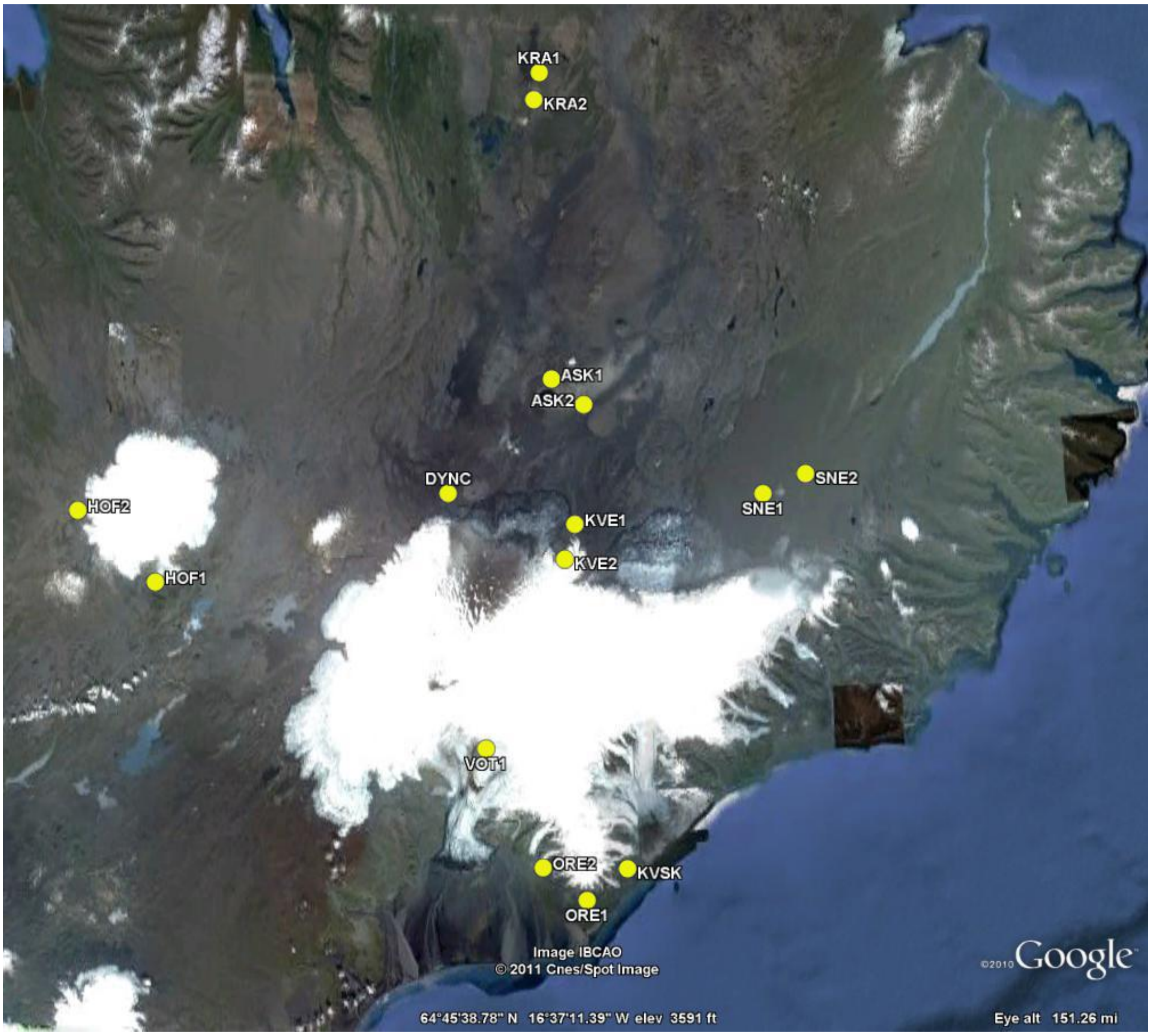


Figure 3. Additional stations intended for volcanic monitoring purposes.

The stations are notated with four letter names in Figure 3. All expect Snæfell include large calderas, which indicate that large explosive eruptions have taken place. Volcanoes are different in character, and the style of monitoring should take that into consideration. The volcanoes situated along the main area of active plate boundary should be considered more likely to show signs of unrest. The first effort of additional monitoring should be focused on volcanoes that currently show some activity, such as Bárðabunga, Askja and Krafla. Increased density of stations in well-known zones of rift events, such as Eastern Volcanic zone, Krafla and Askja, should be considered as the behaviour of the crust around the plate boundary can give indications on where in the rifting cycle these areas are, thus providing insight into the likelihood of such events.

Table 22 in Appendix V contains the geographic co-ordinates of all the stations in Figure 3.

5 The Server Environment

The server environment is the central processing part of the network. The servers are used to download data from the receivers and process it. This section briefly describes current environment and its key parts, but serves not as a complete documentation of the environment. The key parts are servers, processes, data storage and data distribution. Finally, a few ideas are given for projects that might further develop the environment and expand its potentials.

An overview of the organization of the whole system: servers, data connections, receivers and so on, can be found in Appendix VI.

5.1 Servers

The server environment of the CGPS network is made up of nine servers and can be viewed in Figure 4. The core servers are rek.vedur.is and rek2.vedur.is. They divide the task of downloading data from the stations based on three dial-up modems connected to them. The bigger part of the download tasks lies on rek2, which is the newer machine of the two. rek2 actually crashed during the Grímsvötn eruption in May 2011, so a new machine was configured in its place. rek on the other hand is 10 years old. Seven years ago rek2 was added to service and a copy was made of rek to rek2 so that they mirrored each other. Through time though rek2 has been given bigger role and the only reason for the continued service of rek are the dial-up modems connected to it.

The main division between the two servers today is that rek downloads data from stations with dial-up land-line modems or dial-up GSM modems, but rek2 downloads data from receivers through SIL computers and from IP-based receivers. rek2 has a dial-up land-line modem dedicated to one station at Raufarhöfn, but currently data is not downloaded from the station due to a persistent communication problem with the station.

5.1.1 SIL servers

kjarni.vedur.is and jar.vedur.is are the main servers for the SIL environment. Through kjarni and jar data is collected from GPS stations that share data connections with SIL stations, in the field. The SIL stations have computers on site that can collect data from the GPS stations, which then is copied through kjarni and jar to rek2 for archiving and from there to dump for storing, lapis for processing and hraun for sharing to parties outside IMO.

5.1.2 Shared servers

dump.vedur.is is the central data storage server, shared among different scientific groups at the IMO. On dump there is a dedicated partition where GPS data is stored and made accessible to scientists within IMO.

For parties outside IMO, another server is dedicated to the task of data distribution, hraun.vedur.is. Access to RINEX files via hraun is based on known IP addresses. Much of the data collected and produced by the IMO is publicly available by request.

lapis.vedur.is handles processing of RINEX files that produces location data for each station, plus figures with the information for each station.

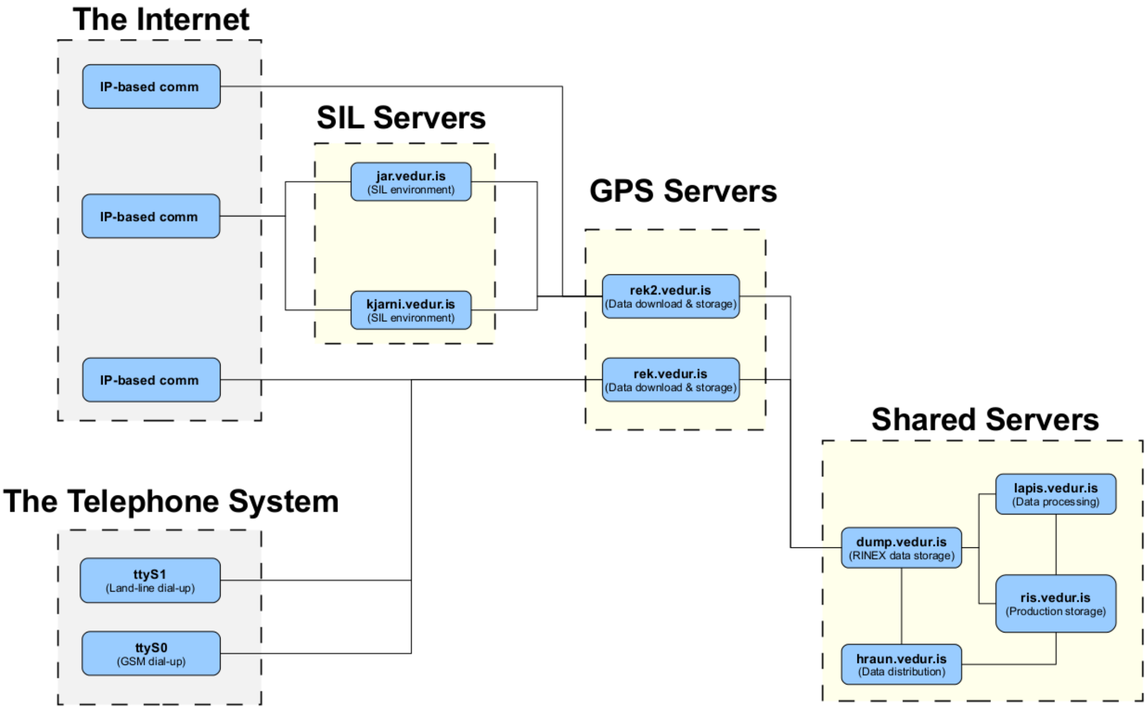


Figure 4. Servers used at IMO to download, process, store and distribute GPS data.

5.2 Automated download of receiver files

Data downloads take place automatically via shell scripts that are executed from crontab. For dial-up connections a single daily attempt is made to retrieve data, whereas IP-based downloads are triggered more frequently, often at hourly intervals. The shell scripts download data directly from the stations or from SIL stations that host and collect some of the data from the receivers. Then a secondary script is triggered that converts RINEX data format. Downloads for each day start soon after midnight on the following day.

Most mornings and after weekends, manual intervention is necessary to obtain data from stations that failed to download during the night. The reason for this can be everything from a frozen dial-up modem connected to the server rek, to a poor data connection due to bad weather conditions on site.

5.3 Processes

In this summary the main processes in the environment are listed and briefly explained. Part of the processes is implemented in scripts and part in binaries.

5.3.1 Data retrieval

Most of the data retrieving processes are implemented in shell scripts. This is understandable because downloading the data and putting it into the right place and structure demands custom-made logic. Basic reporting is also easily implemented in shell scripts as in the case with isgpslog.sh shown in Table 10.

Table 10. List of scripts used in GPS data downloading.

Scripts	Description	Location
getgdata_plusash.sh	Downloads data from stations connected with a land-line dial-up modem (ttyS1). This script is scheduled for run in the crontab.	**rek**
getgremdata.sh	Downloads data from stations connected with a GSM dial-up modem (ttyS0). This script is scheduled for run in the crontab.	**rek**
getgpsdata	Is used for manual downloading of data from stations. It takes one or more parameters, indicating the stations from which data should be downloaded.	**rek/rek2**
isgpslog	Compiles a list of all the stations and gives a static error message if no data has been downloaded from some of the stations, from the day before.	**dump**
fixgps.sh	Is a dial-up connection fixer that takes two parameters, 0 or 1, indicating which modem of two, ttyS0 (GSM) or ttyS1 (land-line) should be fixed. It uses the program rdisconn with proper parameters.	**rek**
get{station}.sh	Is a group of scripts for each station either connected to a SIL station or via IP data connection (IP-based downloads). These scripts reside only on *rek2*. An example is *getsoho.sh* that downloads data from Sólheimaheiði, or SOHO. All the scripts can be found under */usr/sil/gps/bin$* on *rek2*.	**rek2**
mall_{type+more}	Is a collection of shell scripts that create RINEX and qc format files from .T00 files from the receivers.	**rek2**

5.3.2 Data processing

The main data processing in the server environment takes place on *lapis*. Data translation to Rinex is run on *rek2* with the *mall_* shell script which converts receiver files into RINEX formats and generates quality check (QC) files using *teqc* discussed in section 5.3.3. Table 11 gives a short description of each shell script.

Table 11. List of shell scripts used in GPS data processing.

Scripts	Description	Location
runpre.sh	Is the main processing shell script which produces locations from the GPS data. It takes one integer parameter that indicates which day from the data-set is to be processed. Parameter 1 means the data-set from yesterday, 2 means the day before that and so on, going backwards for incremented integer. At the end of its run another script is run, **enuaut_shell.gmt**, repeatedly for each station being processed.	**lapis**
enuaut_shell.gmt	It creates plots from the results from runpre.sh. Location for each day is indicated with green dots except for “yesterday” which has a red dot. An example can be found here http://hraun.vedur.is/ja/gps/predorb/allar_pred.html.	**lapis**
runalot_downwards.sh	Is a version of **runpre.sh** to re-process data from selected stations for certain periods, for example when extra data is obtained from stations. In this case the variables BDAY (begin day) and EDAY (end day) are set. For example if BDAY is set to 10, BDAY = 10, it means that processing will start 10 days in the past from now. Then if EDAY is set to 1, EDAY = 1, it means that the processing will end 1 day in the past from now, that is “yesterday”.	**lapis**

Of the mall_ shell scripts the first two are most frequently referenced from the download scripts on rek and rek2, as described in last section. The scripts can be found under /usr/sil/gps/bin$ on both servers. Table 12 shows how many of the download shell scripts call different mall_ scripts for processing.

Table 12. Usage of different mall_ shell scripts.

Scripts	Count
mall_netrs_t00.sh	37
mall_netrs_t00_uofa.sh	21
mall_netrs_t00_1hz.sh	6
mall_4700_lapd.sh	1
mall_netrs_t00_met.sh	1
mall_netrs_t00_met2.sh	1
mallskro.sh	1

5.3.3 Common binaries

The listing in Table 13 gives an overview of the most common binaries used on different levels of GPS data management. Of course there is a long list of programs that are infrequently involved but the focus here is on the usual suspects.

Table 13. List of common binaries used in GPS data management.

Scripts	Description
eterm	Is used to establish a connection to dial-up modems to see if they answer and function properly.
rdisconn	Is used to disconnect the dial-up modems port ttyS0 and ttyS1 of the rfile software.
teqc	Is an approach to solving many translation problems with GPS, GLONASS, Galileo and SBAS data.
Runpkr00	Utility to unpack Trimble R00/T00/t01 files.
Lapdogs	Is a set of perl programs used to automate the downloading of Trimble receivers (4000 SSI/SSE, 5700, R7). See www.unavco.com for further details.

5.4 Data storage

As it is today, different types of data are divided between different servers. Table 14 gives an overview over different data types and where they are stored.

Table 14. Different types of data and storage locations.

Data type	Location
Receiver files	dump*, eldvarp, jar, rek, rek2, and several SIL stations
RINEX and qc data	dump
Receiver voltages and temperature	dump
Time-series data	lapis
Processing logs	lapis
Graphical output	hraun (via ris.vedur.is)

*Incomplete record: data from 2010 and 2011 are missing.

Further work needs to be done to analyse the current distribution of data between the servers. For example it is not clear without some research if copies of the same data-sets are on different servers or not. The same goes for pre-processed data, RINEX data. The need for a better data management is quite clear.

5.5 Improvements to the server environment

The server environment needs to be reorganized with the following factors in mind:

1. Server organization and roles in the environment
2. Data retrieval from stations
3. Data processing
4. Data storage structures for different types of data (raw, pre-processed, processed)
5. Data distribution to different groups and parties
6. Monitoring of data retrieval and data processing
7. Backup and restore of data and process environment

The work of defining a new structure for the environment and then implementing that structure should start as soon as possible.

6 Completeness of data series

The completeness of the data series for each station was assessed to determine the overall uptime of the CGPS network. This was done using processed, time-series results from 63 stations, representing the size of the network in 2010. Daily solutions were compiled from lapis.vedur.is and gaps were identified; these gaps are shown as percentages in Figure 5. The overview reveals a wide variation in downtime, with results lacking from half of the network between ~9 and 45% of the time (median ~15%). Because GPS results are used, the overview combines both technical problems at individual sites as well as any centralised processing problem at IMO. This explains why no station achieves 0% downtime. For instance, FJOC ranks highest in Figure 5 with a downtime of 5.5% (i.e. 20 days). Although further checks are needed, it is possible that centralised processing errors could account for up to 5% of the downtime in 2010.

Another complication is that some stations in Figure 5 were established partway through 2010. For instance, BAS2, FIM2, SKOG, and STE2 were set-up in early 2010 in response to seismic unrest at Eyjafjallajökull. Consequently, the quoted downtime for the aforementioned stations is artificially high.

With the introduction of GAMIT-GLOBK software in preference to Bernese GPS software, it is hoped that processing errors will be reduced further.

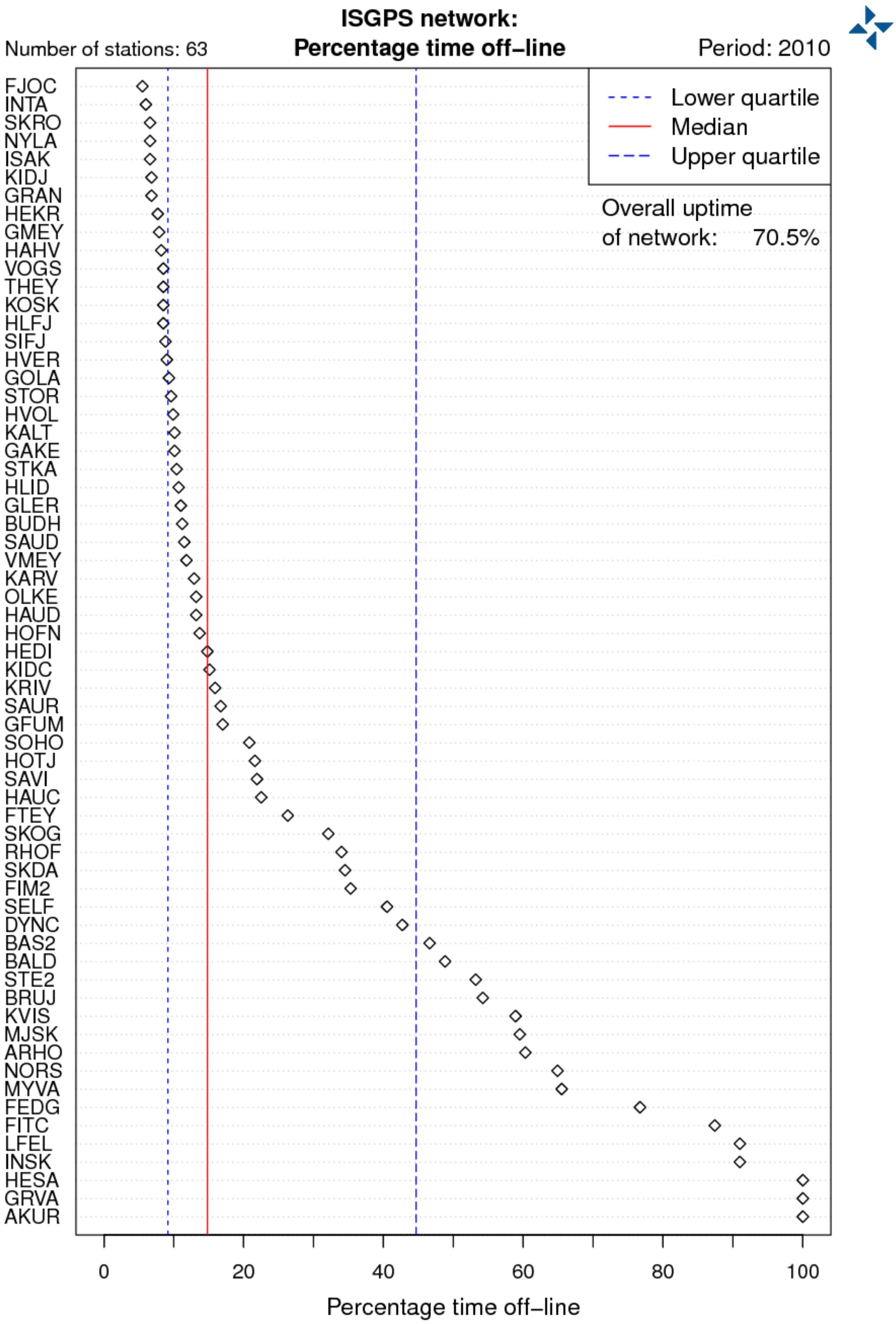


Figure 5. Completeness graph for data series in 2010.

7 Summary

The goal of this report was to assess the present status of CGPS network in terms of hardware and telemetry issues and data processing and archival needs. The report encapsulates the network at an important juncture following the deployment of additional GPS stations to monitor two eruptions of Eyjafjallajökull in 2010.

In mid-2011, over 65 stations comprised the national network, reflecting the collaborative effort between several partners to bring together eight sub-networks. In 2010, the overall uptime of the CGPS network was ~70.5%. Improving this figure requires several longstanding telemetry difficulties to be addressed. Communication with almost a quarter of the network is via landline and GSM dial-up modems; nowadays these data-links are inefficient and costly, as manifested in the review of download charges in 2010. By replacing dial-up modems with IP-based technology, substantial operational savings can be made. Additionally, telecommunication options such as GPRS and 3G allow the download of high-rate GPS data, thereby allowing solutions to be determined on a sub-daily scale.

A second focus of the report was the geographic optimisation of the network for monitoring crustal deformation. The stepwise expansion of the network has resulted in an uneven distribution of stations, particularly in relation to volcanic centres. It is recommended that a minimum of two GPS stations are established at every active volcano in the country. Fulfilling this aim will require substantial funding, but efforts are underway already through European grant applications. In particular, CGPS observations are needed at Öræfajökull because of its propensity for hazardous eruptions.

The final section of the report focussed on data processing and archival issues. As communication technology allows the download of increasingly higher volumes of data, an important factor is the long-term collection of observations. Improvements to the server environment will help to simplify and centralise the archival of all types of GPS data, making it easier to assess and evaluate processed results.

Note that the printed version of this report serves as a snapshot of the state and configuration of CGPS network. However, as development work progresses, the electronic version of this document will continue to be updated, remaining available on the IMO intranet.

Appendix I. Project Brief

CGPS Working Group

Purpose: To assess the present status of the CGPS network, focussing on hardware issues, communication routes, network optimisation, and data processing and archival.

The work is motivated by a need to better automate the daily running of the network and to maximise operational efficiency, thereby allowing greater opportunity for data analysis.

Tasks: The following tasks will be fulfilled:

- i. inventory of site hardware and assessment of station health;
- ii. identification of weaknesses in data transfer and preparation;
- iii. assessment of IP-based communication options for dial-up connections;
- iv. review of station locations and possibilities for network optimisation;
- v. appraisal of data processing, including existing drawbacks, alternative software, future needs for monitoring purposes, data archival, and sharing of CGPS data.

Leader: Matthew J. Roberts

Members: Benedikt Gunnar Ofeigsson (ÚR), Sigurður Sigurðarson (FOR), Einar Kjartansson (ÚR), Hjörleifur Sveinbjörnsson (EOS), Þorgils Ingvarsson (AOT), and Matthew J. Roberts (EOS).

Informal advice will also be sought from Halldór Geirsson (Penn State University) and Sigrún Hreinsdóttir (JHÍ).

Work plan: Two group members will be assigned to each task; this will be done in the group's first meeting. Over the course of the project, the group will meet at two-week intervals to review progress and to outline the working report. The group leader will arrange and co-ordinate the meetings, summaries of which will be available on the VÍ intranet. A common directory will be set-up on the VÍ network to allow the exchange of work material.

Contacts: The managing director of EOS will be group's primary contact, with the findings of this work communicated as an internal report to the executive committee at the end of the project.

Finance: The group's research will be funded under the existing CGPS budget; other financial considerations will be referred to the executive committee.

Schedule: The working group will be active over a 12-week term from late January 2011. The results of the work will be submitted as an internal report no later than 29 May 2011. Group members will contribute about four hours each week to the assessment, resulting collectively in ~288 hours of work-time.

To ensure efficient work-flow, time and project management resources will be used throughout the work.

27 January 2011
Revised: 22 February 2011

Figure 6. Project Brief for the CGPS Working Group

Appendix II. List of recommended projects to further develop the network

The following is a categorization of the GPS environment. The categorization will be used to group all the potential projects and thus put greater emphasis on different aspects of the CGPS network. Projects within each group are then prioritized. This list of categories is an idea put forward in this report and will be used to categories the projects that follow here below.

NM – Network Management (Up to date inventory)

- Stations
- Equipment
- Data connections
- Power

MO – Monitoring (What needs to be monitored on daily basis)

- Receivers
- Connection
- Power
- Data retrieval: streaming and download
- Production: Rinex data / qc data / pictures / graphs

DM – Data Management (All actions with data except processing)

- Retrieving / Downloading data
- Storing raw data
- Storing processed data

PM – Production Management (Production processes)

- Processing data

DD – Data Distribution (What are we distributing and to whom)

- Raw data
- Streaming data
- Processed data (Rinex data / qc data / pictures / graphs)

The projects are listed in Table 15–17 here below.

Table 15. Network Management projects (NM).

Title	Description	Importance
Better telecomm contracts	Call for offers from the telecom companies for the communication part of the GPS Network.	MEDIUM
Inventory System	Setup a equipment and station database, accessible to all relevant parties.	MEDIUM
Decommission old servers	All GPS stations on eldvarp should be migrated to rek2. All GPS stations on rek should be migrated to rek2 when the GSM and tel stations have been upgraded to IP-communications.	HIGH
Version control for all scripts	All GPS scripts should be added to Subversion.	LOW
Documentation for jarðvakt	GPS notes for the jarðvakt team should be evaluated and expanded, where necessary.	HIGH

Table 16. Monitoring projects (MO).

Title	Description	Importance
Station health	Make information about all stations and their status (monitoring) visually available with e.g. Google map. Display / issue warnings if problems occur.	LOW
Data processing health	We need a better way of checking whether the processing run was successful. The ideal solution would be a single web-page providing a strategic overview of downloaded data, processing status, etc. Display / issue warnings if problems occur.	MEDIUM
Data download health	Monitor the status of downloaded data for each day and give statistics for selected days or periods. Display / issue warnings if problems occur.	MEDIUM
Data backup health	Display the status of backed up or rsync-ed data with paths.	MEDIUM
Disk space health	Display status of disk space and issue warnings if defined parameters are reached.	MEDIUM

Table 17. Data Management projects (DM).

Title	Description	Importance
Download processes	Simplify the data download procedure → simplify the scripts	MEDIUM
Server organization	Redesign the GPS server environment: What servers do we need and what role should they have.	MEDIUM
Raw data storage	Move raw data from all SIL computers to mogi. Direct all downloads of raw data to mogi and then what needs to be distributed to other parties to dump. One-second data on rek2 needs to be archived on dump. Raw receiver files on eldvarp, rek, and rek2 need to be moved to dump (and subsequent transfers should be automated). [This is particularly important work!]. All data should be migrated to mogi.vedur.is	HIGH
Data storage on SIL computers	Disk-space issues need to be handled better at SIL stations; an automated 'clean-up' script is required.	HIGH
Network history	The history of the IMO network and related projects is known by few people and is valuable to have documented.	LOW

Table 18. Process Management projects (PM).

Title	Description	Importance
Update the processing	Change to Gamit!! (in the long term calculate more than one solution)	HIGH
	Update the processing to ITRF2008 reference frame	HIGH
	Final orbital solutions are needed.	HIGH
	Final orbital results should be available as graphs.	LOW
	Plots of GPS data need to be put into a more usable format: longer time-series; interactive graphs (?); graphs clustered according to region.	HIGH
Checking of data information	Station configuration data should be checked: Are the RINEX headers accurate?	HIGH
Data available in a database	Time-series results should be available via a database (e.g. MySQL).	MEDIUM
Post processing of data	Present time series in station specific reference (residual time ser.) should be the standard representation	HIGH
	Present time series relative to some chosen reference station (where that is appropriate)	MEDIUM
	Looking at both long term and short term time series.	MEDIUM
	Present time series on a map. i.e. vectors looking at different time scales (could be relevant at volcanos)	MEDIUM
	Do some preliminary near real time modelling of deformation signals (part of volcano anatomy, something we should do despite that)	MEDIUM
	Near real time processing (automatic processing of 1Hz data or higher rates)	MEDIUM
	Strain maps should be made from GPS data so that stress levels can be visualised.	LOW
	For monitoring current sea level changes a GPS stations near the coastlines are necessary	LOW

Table 19: Data Distribution projects (DD)

Title	Description	Importance
Renovate the GPS webpage on www.vedur.is	The site http://hraun.vedur.is/ja/gps.html needs a complete overhaul: station maps, contact details, significant results, data availability, etc.	HIGH
Install a data distribution system	There is a great need for a data distribution system that can distribute or manage data files and streams to different groups outside IMO with different privleges.	HIGH

Appendix III. List of all stations in the CGPS network

This list represents the status of the network on the 1st of June 2011.

Table 20. List of all stations in the CGPS network, alphabetically ordered by name.

Name	ID	Receiver type	Receiver model	Data connection	Electric power	Receiver Owner
Akureyri	AKUR	NN	NN	IP-based	Main power	LMI
Árholt	ARHO	Martec	Miraz/Ashtech	Land-line	Main power	Savoie
Austmannsbunga	AUST	Trimble	NetRS	IP-based	Main power	UI
Brúarjökull	BRUJ	Trimble	5700	IP-based	On-site	LV
Búðarháls	BUDH	Trimble	NetRS	IP-based	On-site	UofA
Búrfellsalda við Kárahnjúka	BALD	Trimble	NetRS	GSM	On-site	LV
Dyngjuháls	DYNC	Trimble	NetRS	IP-based	On-site	UofA
Enta	ENTA	Trimble	NetRS	IP-based	On-site	UI
Feðgar	FEDG	Trimble	NetRS	IP-based	On-site	PSU
Fimmvörðuháls	FIM2	Trimble	NetRS	GSM	On-site	UI
Fitjaás	FITC	Trimble	NetRS	IP-based	On-site	UofA
Fjórðungsalda	FJOC	Trimble	NetRS	IP-based	Main power	UofA
Flatey	FTEY	Septentrio	PolaRX2e	IP-based	On-site	NICE
Garður	GAKE	Septentrio	PolaRX2e	IP-based	Main power	NICE
Glerhaus	GLER	Trimble	NetRS	IP-based	On-site	PSU
Goðaland við Mýrdalsjökul	GOLA	Trimble	NetRS	IP-based	On-site	IMO
Grænavatn	GRVA	Trimble	NetRS	IP-based	On-site	UofA
Granastaðir	GRAN	Septentrio	PolaRX2e	IP-based	Main power	NICE
Grímsey	GMEY	Septentrio	PolaRX2e	IP-based	Main power	NICE
Grímsfjall	GFUM	Trimble	5700	IP-based	Main power	IMO
Hafrahvammagljúfur	HAHV	Trimble	NetRS	GSM	On-site	LV
Hamragarðar	HAMR	Trimble	5700	IP-based	Main power	UI
Haukadalur	HAUD	Trimble	NetRS	IP-based	Main power	UI
Háumýrar	HAUC	Trimble	NetRS	IP-based	On-site	UofA
Héðinshöfði	HEDI	Septentrio	PolaRX2e	IP-based	Main power	NICE
Heiðarsel	HEID	NN	NN	IP-based	Main power	LMI
Heklukriki	HEKR	Trimble	NetRS	IP-based	On-site	PSU
Hestalda	HESA	Trimble	5700	IP-based	Main power	PSU
Hlíðardalsskóli	HLID	Trimble	4000	Land-line	Main power	IMO
Hlíðarfjall	HLFJ	Trimble	NetRS	GSM	On-site	UofA
Höfn í Hornafirði	HOFN	NN	NN	IP-based	Main power	BGS
Hóll Tjörnesi	HOTJ	Septentrio	PolaRX2e	IP-based	Main power	NICE
Hveragerði	HVER	Trimble	4700	Land-line	Main power	IMO
Hveravellir	HVEL	Trimble	NetRS	IP-based	On-site	UofA
Innri Skúti	INSK	Trimble	NetRS	IP-based	On-site	UofA
Ísafjörður	ISAF	NN	NN	IP-based	Main power	LMI
Ísakot	ISAK	Trimble	5700	Land-line	Main power	IMO
Kálfholt í Holtum	KALT	Trimble	NetRS	IP-based	Main power	UI
Kárahnjúkar-Inntakshús	INTA	Trimble	NetRS	IP-based	Main power	LV
Kárahnjúkar-Vinnubúðir	KARV	Trimble	NetRS	IP-based	On-site	LV
Kiðagilsdrög	KIDC	Trimble	NetRS	IP-based	On-site	UofA
Kiðjaberg	KIDJ	Trimble	NetRS	IP-based	Main power	IMO
Kópasker	KOSK	Septentrio	PolaRX2e	IP-based	Main power	NICE
Krísuvík	KRIV	Trimble	NetRS	IP-based	Main power	UI
Kvíslarhóll	KVIS	Septentrio	PolaRX2e	IP-based	Main power	NICE

Continues on next page.

Name	ID	Receiver type	Receiver model	Data connection	Electric power	Receiver Owner
Láguhvolar	HVOL	Trimble	4700	IP-based	On-site	IMO
Lambafell á Kili	LFEL	Trimble	NetRS	IP-based	On-site	UofA
Mjóaskarð	MJSK	Trimble	NetRS	IP-based	On-site	PSU
Móhálsadalur	MOHA	Trimble	NetRS	IP-based	Main power	UI
Mývatn	MYVA	NN	NN	IP-based	Main power	LMI
Norðurbjallar-suðurendi	NORS	Trimble	NetRS	IP-based	Main power	PSU
Nýlenda	NYLA	Trimble	NetRS	IP-based	Main power	UI
Öldufell	OFEL	Trimble	NetRS	IP-based	Main power	UI
Ölkelduháls	OLKE	Trimble	4700	GSM	On-site	IMO
Raufarhöfn	RHOF	Martec	Miraz/Ashtech	Land-line	Main power	Savoie
Reykjavík	REYK	NN	NN	IP-based	Main power	BGS
Rjúpnafell	RFEL	Trimble	NetRS	IP-based	Main power	UI
Siglufjörður	SIFJ	Septentrio	PolaRX2e	IP-based	Main power	NICE
Sarpur í Skorradal	SARP	Trimble	NetRS	IP-based	On-site	UofA
Sauðárháls	SAUD	Trimble	NetRS	IP-based	On-site	LV
Saurbær	SAUR	Trimble	NetRS	IP-based	Main power	UI
Saltvík	SAVI	Septentrio	PolaRX2e	IP-based	Main power	NICE
Selfoss flugvöllur	SELF	Trimble	NetRS	IP-based	Main power	IMO
Skógaheiði	SKOG	Trimble	NetRS	GSM	On-site	UI
Skriða	SKDA	Trimble	NetRS	GSM	On-site	UofA
Skrokkalda	SKRO	Ashtech	Z-12 CGRS	IP-based	Main power	Savoie
Sólheimaheiði	SOHO	Trimble	NetRS	IP-based	On-site	IMO
Steinsholt	STE2	Trimble	NetRS	GSM	On-site	UI
Stóra Kjalalda	STKA	Trimble	NetRS	GSM	On-site	UofA
Stórólfshvoll	STOR	Trimble	NetRS	IP-based	Main power	IMO
Vestmannaeyjar	VMEY	Trimble	4000	Land-line	Main power	IMO
Vogsósar	VOGS	Trimble	4700	IP-based	Main power	IMO
Þorvaldseyri	THEY	Trimble	4700	Land-line	Main power	IMO

Appendix IV. Cost analysis for the data connections

1. Núverandi rekstrarkostnaður við GSM og landlínumódem

Legacy

Innsleginn gildi	Útreiknuð gildi	Tímabundinn / Óviss gildi

1.1 Símakostnaður

Kenni	Nafn	Tenging	Eigandi	Kostnaður á ári	Símanúmer	Tengimöguleikar Síminn	Samant	Svæði
SOHO	Sólheimaheiði	gsm_rek	Veðurstofan	142.736 kr.	863-8661	Virðist vera 3G samband en mögulega tæpt	GPRS	M
HAHV	Hafrahvammagljúfur	gsm_rek	LV	94.579 kr.		Er á jaðri einhvers 3G sendis. Ólíklega hægt að nota 3G	GPRS	K
FIM2	Fimmvörðuháls /Baldvinsskáli	gsm_rek	HI	66.315 kr.		2G/GPRS	GPRS	M
HLFJ	Hlíðarfjall	gsm_rek	HI	82.165 kr.		Virðist vera 3G samband en mögulega tæpt	GPRS	V
OLKE	Ölkelduháls	gsm_rek	VI	95.964 kr.	890-1127	Mögulega 3G. Slitrótt samband þarna skv. Korti símans	GPRS	S
SKDA	Skriða við Eyfirðingaveg	gsm_rek	UofA	74.451 kr.		Nokkuð örugglega ekki 3G	GPRS	V
SKOG	Skógaheiði	gsm_rek	HI	64.640 kr.		Mögulega 3G. Slitrótt samband þarna skv. Korti símans	GPRS	M
STKA	Stóra Kjalalda	gsm_rek	HI	114.951 kr.	893-5771	Ekki 3G.	GPRS	H
STE2	Steinsholt	gsm_rek	HI	55.509 kr.		Ekki 3G.	GPRS	M
BALD	Búrfellsalda við Kárahnjúka	gsm_rek	LV	50.692 kr.		Er á jaðri einhvers 3G sendis. Ólíklega hægt að nota 3G	GPRS	K
ARHO	Árholt	tel_rek	Uni-Savoie	23.412 kr.	464-1102	3G	3G	N
HLID	Hlíðardalsskóli	tel_rek	VI	47.625 kr.	483-3301	Á að vera gott samband	3G	S
HVER	Hveragerði	tel_rek	VI	21.273 kr.	483-4103	Á að vera gott samband	3G	S
ISAK	Ísakot	tel_rek	VI	16.038 kr.	488-7754	Ekki 3G.	GPRS	H
THEY	Þorvaldseyri	tel_rek	VI	11.864 kr.	487-8864	Er á jaðar. Ætti að vera 3G.. annars 2G/GPRS	GPRS	M
VMEY	Vestmannaeyjar	tel_rek	VI	32.177 kr.	481-1153	Á að vera gott samband	3G	Sér ferð
RHOF	Raufarhöfn	tel_rek2	Uni-Savoie	108.010 kr.	465-1167	Virðist ekki vera. Ætla að tala við símann	GPRS	N

Samtals 1.102.401 kr. á ári

Tafla yfir svæði

Svæði	
Mýrdalsjökull	M
Vesturland	V
Suðurland	S
Hálendi	H
Kárahnjúkar	K
Norðurland	N

1.2 Daglegur rekstur / viðvera

Forsendur

Dagleg viðvera	1	klst að meðaltali
Kostnaður við starfsmann	5.000 kr.	per klst.
Mánaðarleg viðvera	20	klst að meðaltali

Samtals 1.200.000 kr. á ári

Forsendur

Núverandi gsmkostnaður: Miðað við símakostnað síðasta árs. Þessi tala sveiflast eitthvað milli ára en er háð því hversu oft þarf að reyna / endurtaka að sækja gögn aftir á stöðvar.
Núverandi dagleg viðvera: Byggist á reynslu Matthews við að sinna stöðvunum dags daglega
Núverandi landlínu kostnaður: Fast gjald fyrir númer er 2.550 kr. + notkun

Skölun á landlínukostnaði 1.5 Reitir E17:E23

2. Kostnaður vegna kaupa á nýjum módemum

2.1 Kostnaður við innkaup á GPRS/EDGE routerum

Gengi Evru m.v ISK	160	
Grunnverð á tæki í €	250	
Grunnverð á loftnet	8.900 kr.	
Fjöldi tækja	15	
Sendingarkostnaður	40.000 kr.	Þetta er mat án raunverulegra forsenda
Grunnverð tækis	40.000 kr.	
Kostnaður við innkaup tækja	640.000 kr.	
Kostnaður við loftnet	133.500 kr.	

Samtals 733.500 kr.

2.2 Kostnaður við innkaup á 3G routerum

Grunnverð á tæki í €	365	
Grunnverð á loftnet	8.900 kr.	
Fjöldi tækja	15	
Flutningur á tækjum	40.000 kr.	Þetta er mat án raunverulegra forsenda
Grunnverð tækis	58.400 kr.	
Kostnaður við innk tækja	916.000 kr.	
Kostnaður við loftnet	133.500 kr.	

Samtals 1.009.500 kr.

Forsendur *Verð á tækjum: Eru skv. nýlegum upplýsingum úr tilboðum sem Benedikt hefur unnið*
Sendingarkostnaður: Er metin stærð. Æskilegt er að fá betri upplýsingar um þennan kostnað

3. Kostnaður við uppsetningu búnaðar

3.1 Vinnukostnaður við að skipta út módemum á stöðvum

Útseld vinna	5.000 kr.	á klst
Lengd vinnudags	15	klst að meðaltali
Fjöldi ferða	6	1 ferð per svæði. Sjá flokkun í lið 1
Kostnaður við bíl	25.000 kr.	per dag
Dagpeningur	8.750 kr.	
Samtals	**652.500 kr.**	

3.2 Vinnukostnaður við að tengjast nýjum módemum

Útseld vinna	5.000 kr.	á klst
Fjöldi tækja	15	
Vinna per tæki	1	klst að meðaltali
Samtals	**75.000 kr.**	

4. Væntur rekstrarkostnaður við GPRS/3G gagnasambönd á ári eftir breytingu

4.1 Fjarskiptakostnaður

Mánaðargjald fyrir 3 Gb tengingu	1.690 kr.	
Mánaðargjald fyrir fasta IP tölu	990 kr.	
Samtals á mánuði per stöð	2.278 kr.	15% afsl
Samtals á ári per stöð	27.336 kr.	

Kenni	Kostnaður
SOHO	27.336 kr.
STKA	27.336 kr.
OLKE	27.336 kr.
HAHV	27.336 kr.
HLFJ	27.336 kr.
SKDA	27.336 kr.
FIM2	27.336 kr.
SKOG	27.336 kr.
STE2	27.336 kr.
BALD	27.336 kr.
ARHO	27.336 kr.
HLID	27.336 kr.
HVER	27.336 kr.
ISAK	27.336 kr.
THEY	27.336 kr.
VMEY	27.336 kr.
RHOF	27.336 kr.
Samtals	**464.712 kr.** á ári

4.2 Daglegur rekstur / viðvera

Dagleg viðvera	0.5	klst að meðaltali
Kostnaður við starfsmann	5.000 kr.	per klst.
Mánaðarleg viðvera	10	klst að meðaltali
Samtals	**600.000 kr.**	á ári

Forsendur *Mánaðargjald: Hér er gert ráð fyrir því að mánaðarlegt gjald fyrir gagnatengingu sé það sama, hvort sem um er að ræða GPRS eða 3G*
Dagleg viðvera: Gert er ráð fyrir því að dagleg rekstrarviðvera minnki með nýjum tækjum. Hóflega er gert ráð fyrir 50% minni viðveru en getur vel minnkað meira

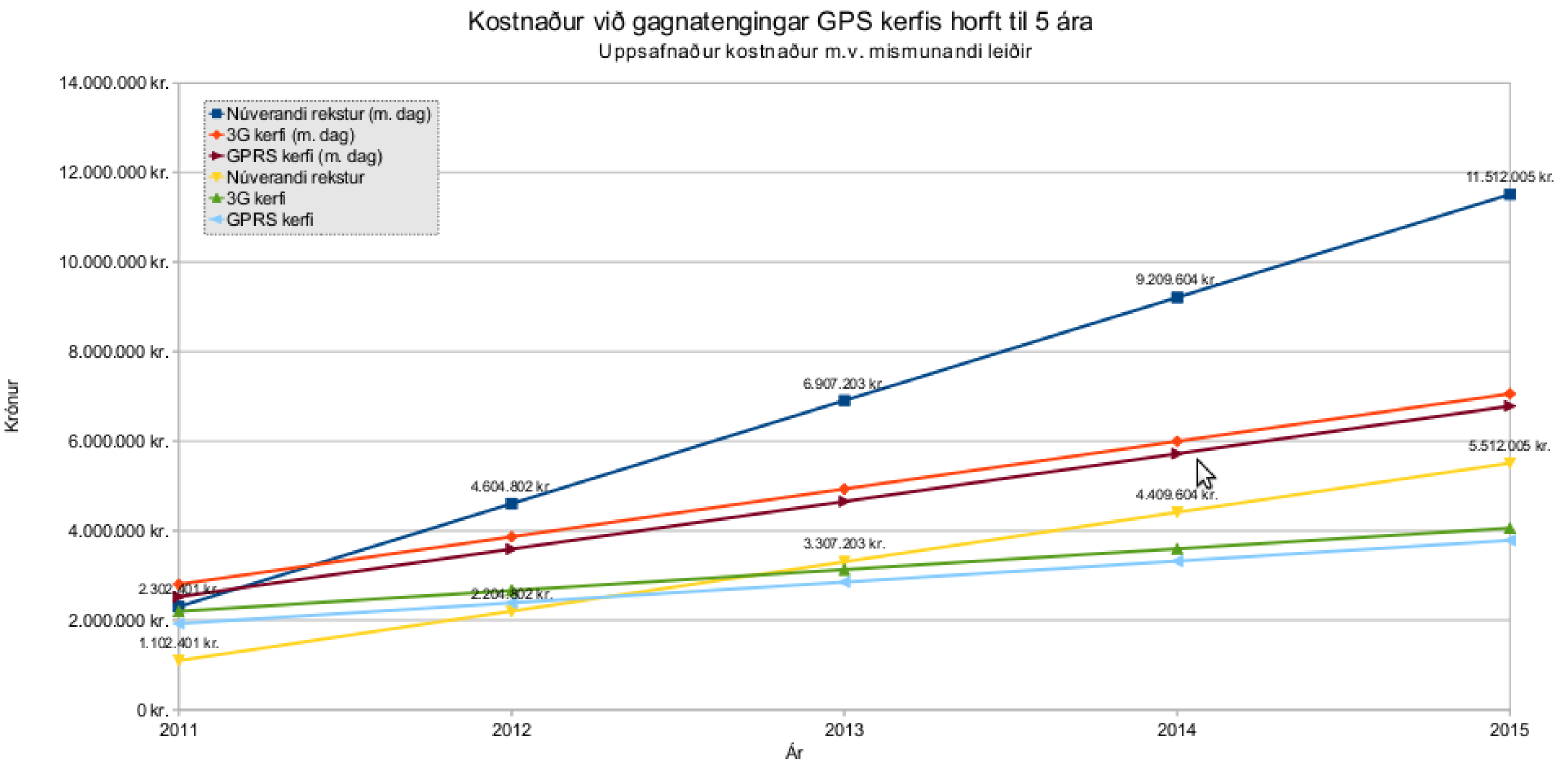
5. Núllpunktsgreining – Uppsafnaður kostnaður

Með daglegum rekstri

	Núverandi rekstur (m. dag)	3G kerfi (m. dag)	GPRS kerfi (m. dag)
2011	2.302.401 kr.	2.801.712 kr.	2.525.712 kr.
2012	4.604.802 kr.	3.866.424 kr.	3.590.424 kr.
2013	6.907.203 kr.	4.931.136 kr.	4.655.136 kr.
2014	9.209.604 kr.	5.995.848 kr.	5.719.848 kr.
2015	11.512.005 kr.	7.060.560 kr.	6.784.560 kr.

Án daglegs reksturs

	Núverandi rekstur	3G kerfi	GPRS kerfi
2011	1.102.401 kr.	2.201.712 kr.	1.925.712 kr.
2012	2.204.802 kr.	2.666.424 kr.	2.390.424 kr.
2013	3.307.203 kr.	3.131.136 kr.	2.855.136 kr.
2014	4.409.604 kr.	3.595.848 kr.	3.319.848 kr.
2015	5.512.005 kr.	4.060.560 kr.	3.784.560 kr.



Appendix V. Coordinates for recommended national network and volcano monitoring stations

Table 21 shows the recommended national network stations and their coordinates; and Table 22 shows recommended volcano monitoring stations.

Table 21. Recommended survey stations for the national network.

Station	Long	Lat	Station	Long	Lat
npt1	-15.20642	64.4508	**npt16**	-17.24630	65.17312
npt2	-15.05605	64.55604	**npt17**	-18.54895	65.12665
npt3	-15.18196	65.36541	**npt18**	-19.53111	65.48415
npt4	-15.00638	66.16931	**npt19**	-23.55854	64.54175
npt5	-15.57130	65.58866	**npt20**	-20.04121	65.01076
npt6	-13.42498	65.02483	**npt21**	-20.50432	64.43608
npt7	-17.35947	64.03207	**npt22**	-21.44779	65.06326
npt8	-18.05285	64.08170	**npt23**	-21.41141	65.42512
npt9	-19.30974	63.5163	**npt24**	-23.59436	65.36261
npt10	-19.06619	63.55602	**npt25**	-21.06515	65.12445
npt11	-18.42963	64.11020	**npt26**	-15.08436	64.33260
npt12	-17.43742	64.42728	**npt27**	-16.06003	65.21525
npt13	-18.33622	64.03898	**npt28**	-16.17950	65.02399
npt14	-16.39679	65.03619	**npt29**	-16.05412	65.33843
npt15	-18.56736	63.50631	**npt30**	-16.56045	65.24412

Table 22. Recommended monitoring stations for volcanic activity.

Volcano	Location 1 - Long	Location 1 - Lat	Location 2 - Long	Location 2 - Lat
Karfla	-16.73335	65.74765	-16.76728	65.68775
Askja	-16.72617	65.06772	-16.56382	65.00918
Kverkfjöll	-16.63283	64.74712	-16.69080	64.67143
Snæfell	-15.65807	64.79598	-15.43263	64.83478
Öræfajökull	-16.64192	63.91548	-16.85677	63.99125
Hofsjökull	-18.79700	64.63860	-19.19983	64.79663
Vöttur	-17.12442	64.25973		

Appendix VI. Overview map for the CGPS network

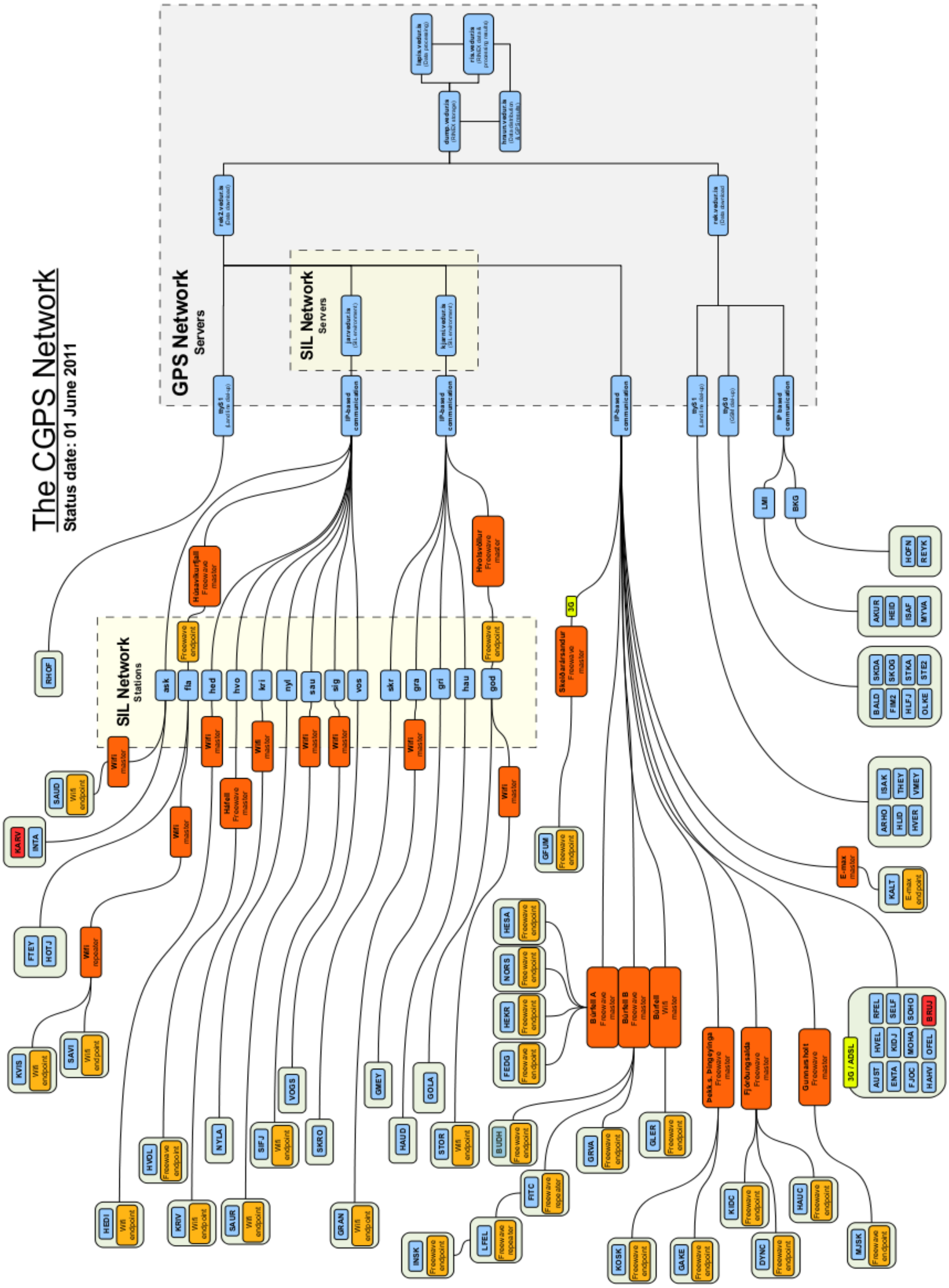


Figure 7. Overview map for the CGPS network

An A1-size pdf-version of the map is available at the Icelandic Meteorological office upon request.