Exploring the Earth

NORSAR Scientific Report No. 2-2013

# Semiannual Technical Summary

1 July – 31 December 2013

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Kjeller, June 2014

NORSAR

# 6 Technical Reports / Papers Published

## 6.1 IS37 Infrasound Station in Bardufoss, Norway

The IS37 infrasound array was initially planned to be collocated with PS28-ARCES in Karasjok, northern Norway, to gain synergy between seismic and infrasound observations. A site survey for the planned station was carried out during June/July 1998 as a cooperative effort between CTBTO/PTS and NORSAR. The site survey report proposed a 4 element array with an 18 meter diameter, 4 rosettes pipe array as Wind Noise Reduction Pipe Array (WNRPA) at each element.

During the years 2000-2006, NORSAR and the CTBTO/PTS continued discussions and planning of the array and the whole infrasound community discussed and experimented with different array configurations and different wind noise reduction systems. As a result of this a 9 element array with 18 meters pipe arrays placed within 20x20 meter fences was designed. However, the construction of fences in the area was not permitted by the municipal authorities because of possible obstruction of frequently used reindeer migration paths.

Consequently, alternative sites close to PS28 were investigated, and the municipal authorities gave positive signals for an approval. Hence, NORSAR and the CTBTO/PTS concluded a contract for the construction of IS37 in Karasjok in July 2006. However, despite intense efforts by NORSAR, permission to establish IS37 in Karasjok was rejected in a final formal meeting of the municipal community board on 14 June 2007.

NORSAR continued the work to obtain access/use of a new site for IS37. This work led to an alternative location. A promising location was found in Bardufoss, in the municipality of Målselv (Målselv Kommune), Norway, 280 km WSW of Karasjok. Several reconnaissance as well as site survey measurements were performed during 2007-2010, which resulted in a preferred location at Brannmoen, close to the small town of Bardufoss. The change of location was approved by the CTBTO PrepCom in June 2009. See Figures 6.1.1 and 6.1.2 showing the location of IS37 together with other IMS monitoring stations, and together with experimental infrasound stations in Fennoscandia.

Målselv Kommune proved to be very cooperative, and NORSAR undertook the task of developing a regulatory plan for the area (Reguleringsplan). This is a mandatory document, describing in detail the installation/construction and its consequences for the environment and society at large, and is the basis for the consideration by the authorities, prepared with the intent of leading to an approval of the proposed plans, in this case the installation of IS37. NORSAR succeeded in obtaining the final permission for the construction of IS37 at Brannmoen in December 2012.

So finally, in May 2013, after the snow had melted, NORSAR and its subcontractor started the civil works at IS37. First, the CRF (Central Recording Facility) building was constructed. Soon after a transformer and the power cable connecting the transformer with the CRF were installed. In parallel, a total length of 5.2 km of trenches from the CRF to the element sites were excavated for deployment of the power and fiber optic cables. The installation of the power and fiber optic cables was finished in August 2013. The preparations for the element sites started in June 2013 with the installation of the equipment vaults, the GPS and meteorological masts and the installation of the fences. Figure 6.1.3 shows a map of the Brannmoen site, with marks for the trenches and the 10 sites H0 – H9.

The construction work at the station continued until the end of August 2013. Soon after the construction works were finished, NORSAR started to install the station equipment at the CRF and at each element and by the end of the second week in October 2013 most of the equipment was installed and configured.

On October 19 the station started sending data from each element to Vienna (IMS-Lab) and several certification tests were performed. This resulted in the formal acceptance and certification of the station on December 19, 2013.

Figures 6.1.4 – 6.1.7 illustrates in more details the pipe arrays and the cabling of IS37.

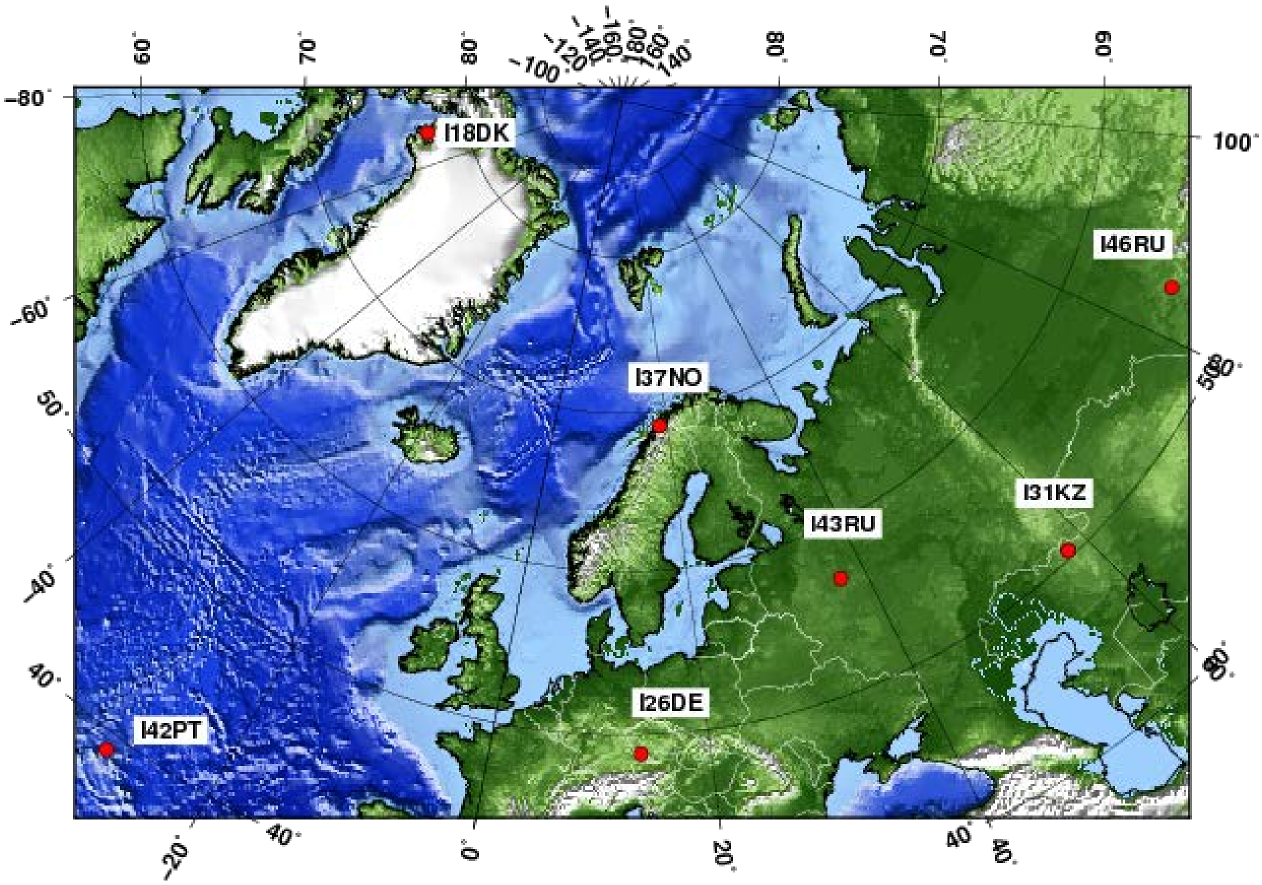


*Fig. 6.1.1 The map above shows the location of IS37 together with other operating infrasound stations in the IMS network. Although we were not able to co-locate IS37 with the seismic station PS28, the move of the station will not affect the overall coverage and performance of the IMS network. The separation from other stations in the network shown in the map is still from 1700 km to 4300 km.*

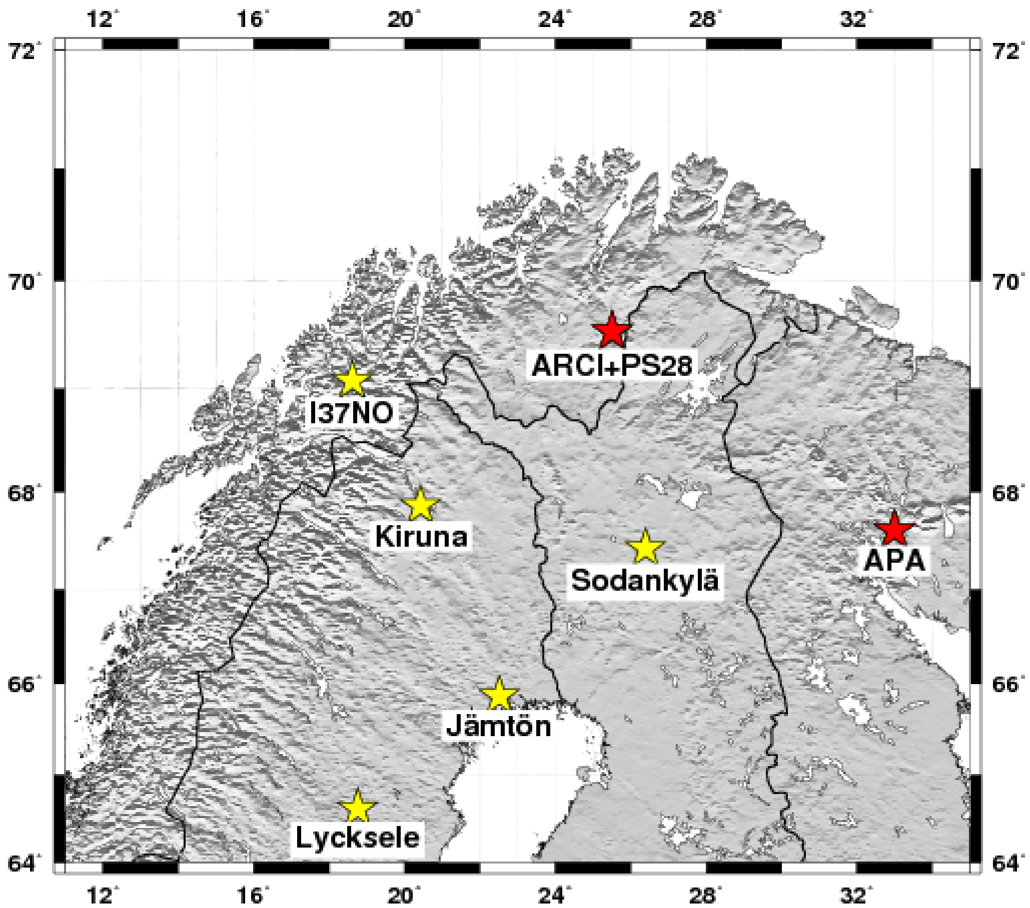


*Fig. 6.1.2 The above map shows IS37 along with other cooperating infrasound stations in northern Fennoscandia. Red diamonds indicate both seismic and infrasound sensors in an array. NORSAR cooperates with the host institutions of several permanent and experimental infrasound stations in northern Europe and exchange data for processing of interesting events. Within PS28, NORSAR operates a 4 element infrasound array with porous hoses as the noise reduction filter.*

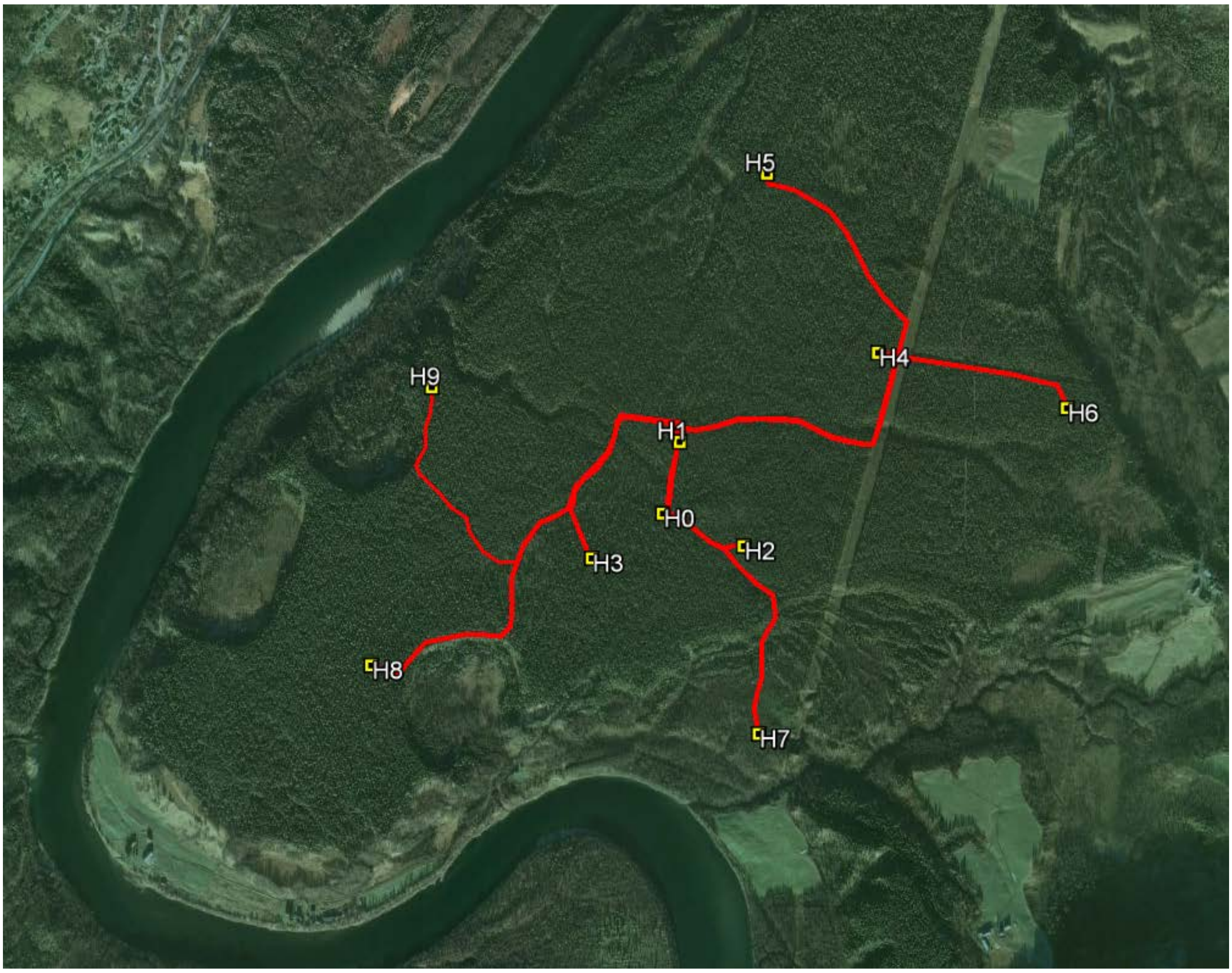


*Fig. 6.1.3 The above picture shows an aerial view of IS37. As can be seen from the picture, the area is forested with pine trees of height about 14 meters. The density of the forest varies across the area, but all sites are in places that are well protected from wind by trees. The "reguleringsplan" prevents landowners from cutting trees in an area with diameter 50 meters surrounding each of the 10 sites.*

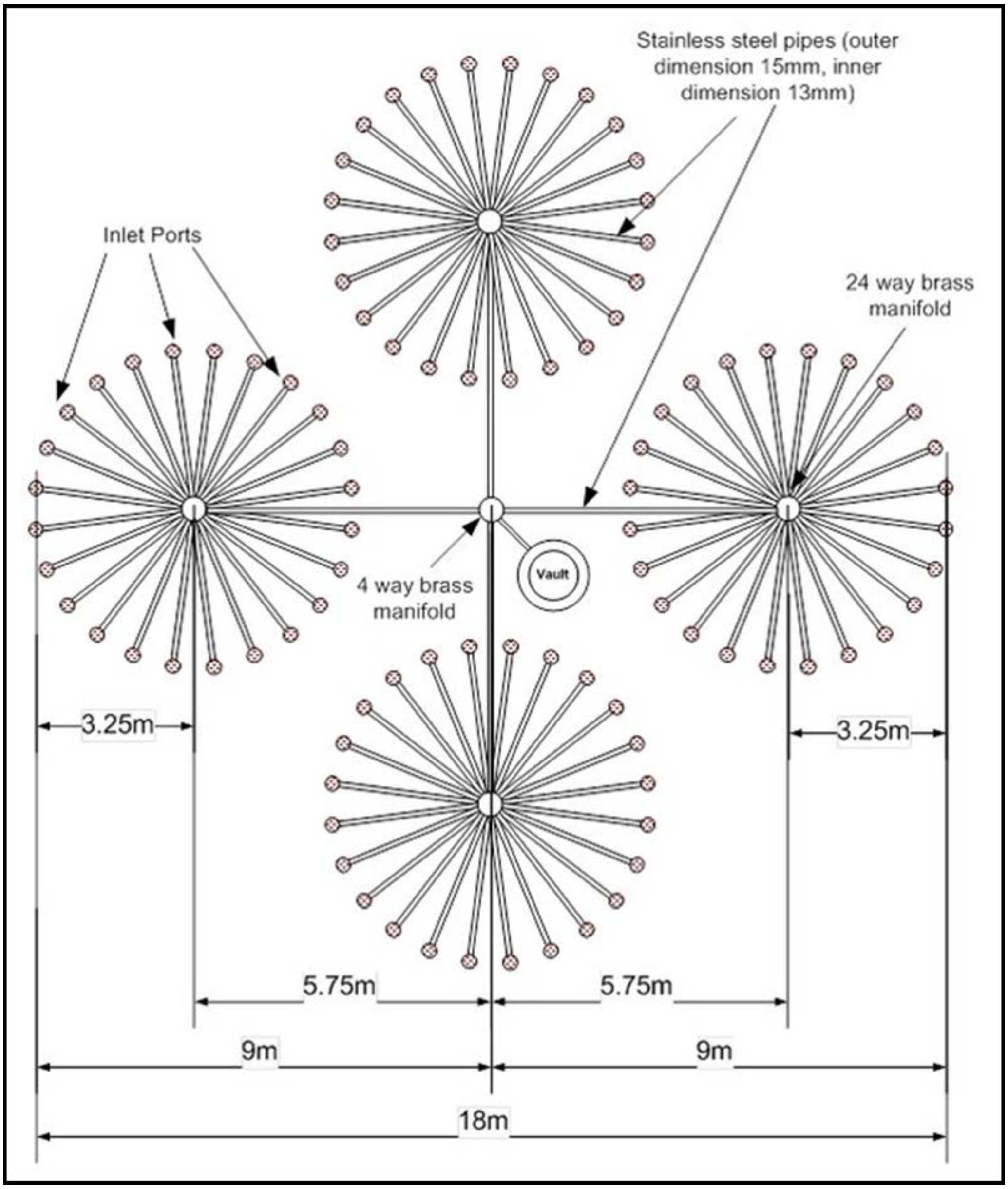


*Fig. 6.1.4 Each of the 10 sites has a 18 meter wide wind noise reduction system consisting of stainless steel pipes with diameter 15 mm. The figure above shows the layout of the pipes and the 96 inlet ports. The MB2005 microbarometer is inside a shallow vault in the center of the site. All the 10 sites are protected by a 2 meter high fence of dimension 20 by 20 meters.*

*Fig. 6.1.5 The picture shows the pipe array system during installation.*

*Fig. 6.1.6 The picture above shows the pipe array system, the fence and the CRF in the background.*

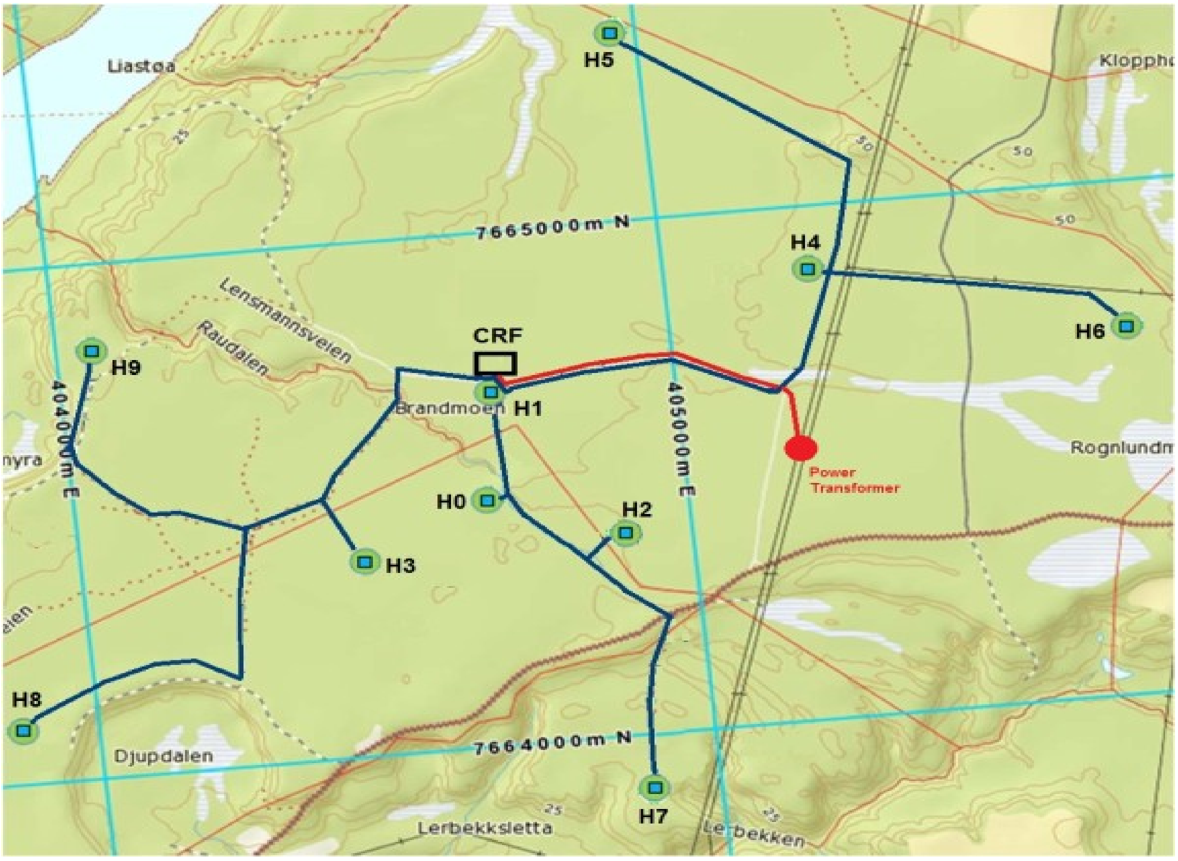


*Fig. 6.1.7 The station receives mains power from a 22 kVAC to 415 VAC transformer indicated with a red dot. Power lines on poles connect the station CRF to mains power. At the CRF a UPS provides 230 VAC to a central cabinet, where AC/DC converters give 48 VDC to each of the 10 remote sites. Approximately 5200 meters of trenches connect the 10 sites to the CRF. In the trenches are one copper cable for each of the sites, and one PVC pipe for fiber optic cable. So there is one power cable and one fiber cable to each of the points. Each site has power cable and fiber connected directly to the CRF, not via any other site. For H1, there is additionally one extra power cable for heating of the meteorological equipment.*

From the CRF to each of the 10 sites there are at least 60 cm deep trenches which house continuous PVC conduits and armored power cables; one conduit and one power cable for each site. Fiber cables with 12 fibers were blown from the CRF to each of the sites through the conduits. Six of the fibers have connectors, so 4 fibers are available as backup.

Figures 6.1.8 and 6.1.9 show schematic and photo views of the remote sites H0 – H9, and give an explanation to the pit installations. Each pit has an Uponor manhole which houses major electronic equipment.

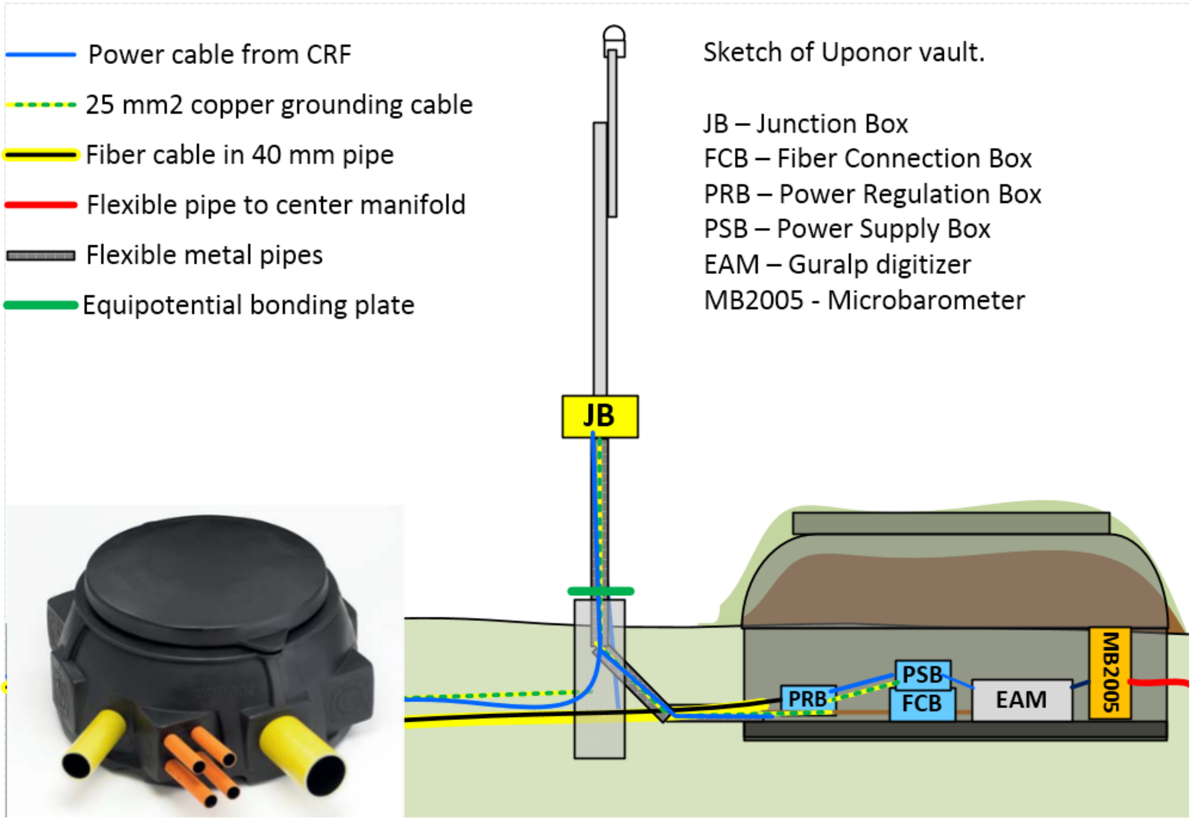


*Fig. 6.1.8 The figure above is a principle sketch of the Uponor cable well that contains pit equipment. The manhole is 60 cm high, and about 20 cm is above surface. A 5 cm layer of concrete is added in the bottom for additional weight, and covered by epoxy.*

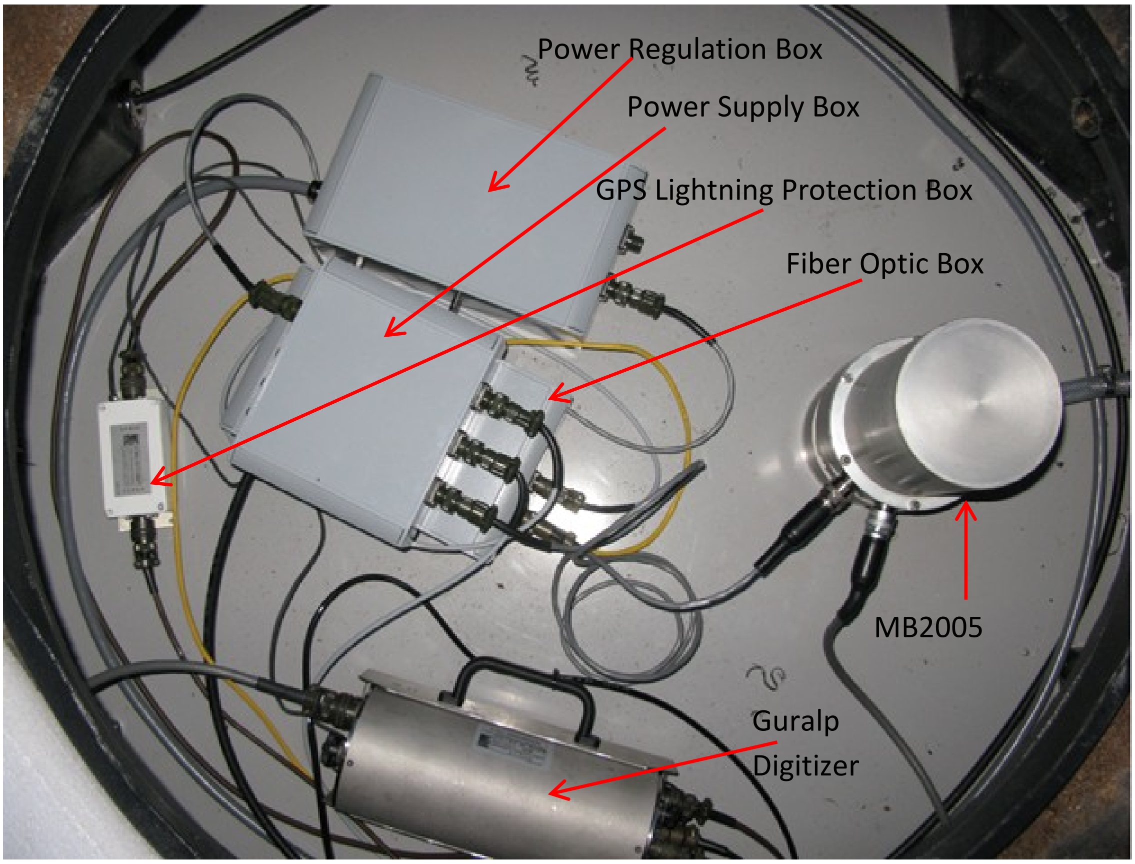


*Fig. 6.1.9 Equipment installed inside IS37 vaults. The inside bottom of the tank has a 5 cm layer of concrete topped with epoxy coating. The vault houses a MB2005 microbarometer, a Güralp digitizer model CMG-DM24S3AM, and a Güralp GPS lightning protection box. The two power boxes with power conditioning and lightning protection and a fiber optic communication box are NORSAR custom made products. The fiber optic communication has the Luxcom OM-101 Ethernet converter and the fiber splice assembly.*

Figure 6.1.10 show a block diagram of the IS37 power system. The UPS contains an Eltek Flatpack 2 power system with Smartpack 2 controller and 12*77Ah SAFT Evolion batteries. For each of the 10 remote sites, the CRF has a web controlled power switch, AC/DC converters and lightning protection. There is one buried power cable to each of the 10 remote sites, which again have lightning protection and DC/DC converters.

The length of the buried cables ranges from 100 to 1500 meters. The cable is of type Nexans EKKJ 1 kV 4x6/6 mm2 shielded cable. 25 mm2 grounding wires are connected to 2 meter deep copper spears in each end, as well as to the shield of the power cable.

A test showed that the UPS provided power to the whole system for 87 hours, including two large PCs used for data acquisition. The UPS sends e-mail alarms to operators, so that the PCs can optionally be switched off using the web controlled power switch. The rest of the system can then be operated for 5-6 days. The test also showed that the batteries reached full capacity after 7 hours of charging. Each of the 12 batteries can be monitored, and one battery can be exchanged with new, without interruption of the system. Each battery delivers 56 Volts when fully charged, and the system automatically shuts down if voltage drops below 43 Volts.

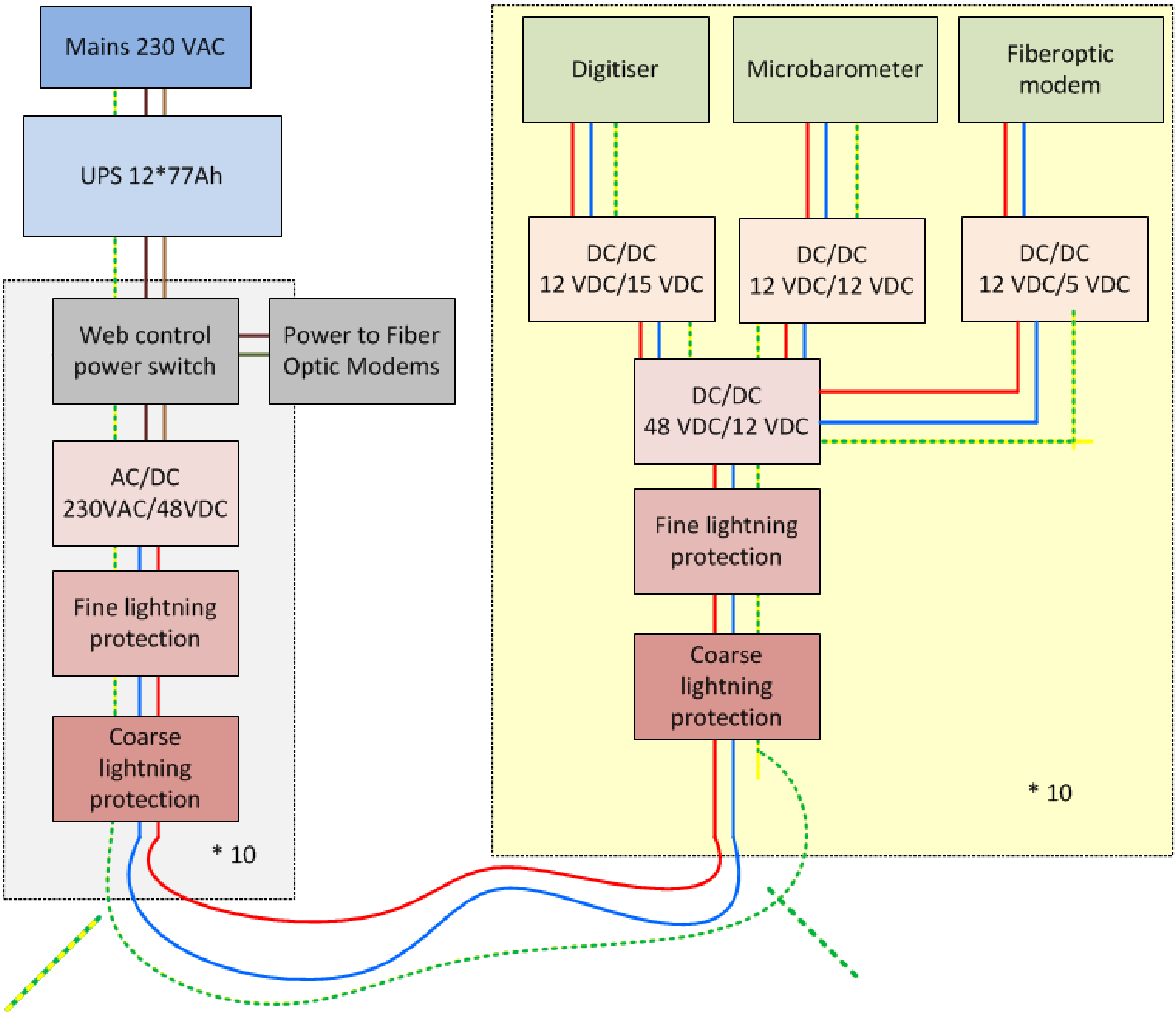


*Fig 6.1.10 Block diagram for the power system at IS37.*

The communication between the CRF and the remote pits is over single mode fiber cables with Luxcom OM-101 Ethernet converters in each end. Between the CRF and the NDC is a VPN connection over internet provided by DirectConnect. See Figure 6.1.11. The internet connection is utilized at site H7. Between H7 and CRF we use one pair of fibers from the fiber cable and Luxcom OM-101 Ethernet converters in each end. The VPN connection is handled by a CISCO ASA router at the CRF. All IP based units in the CRF are connected to this link via the Ethernet switch. The two PCs have two Ethernet interfaces. One of them is connected to the Ethernet switch. The other is connected to a GSM router, NetModule NB1600, which provides VPN connection to the NDC.

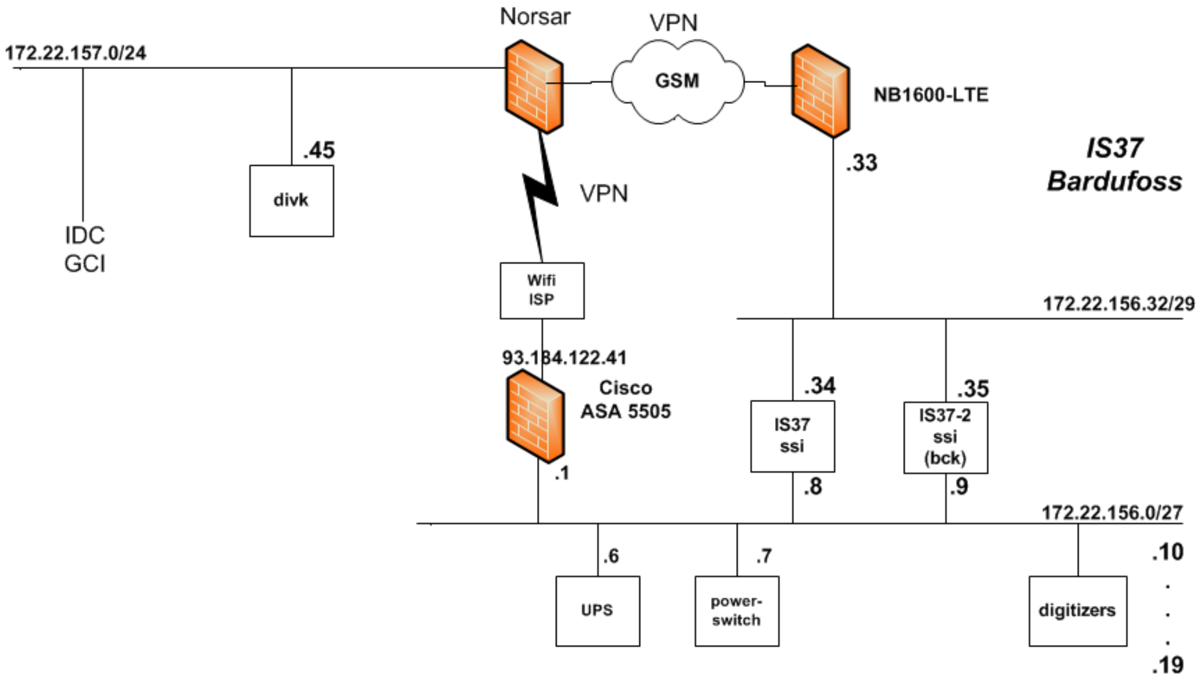


*Fig. 6.1.11 The figure above shows a schematic of the IP configuration of IS37.*

NORSAR is utilizing the feature of multiple sample rates from the Güralp digitizer. The sensors are thus sampled with 20 Hz for CD1.1 data to the IDC. Additionally, we collect data with 40 Hz sample rate for NDC use. All data are transmitted to the NDC and from there, only 20 Hz data are forwarded to the IDC.

We plan to change all sensor cables of the array to be able to additionally record absolute pressure.

Data received at the NDC are stored in an easily accessible data base of Unix files, and NORSAR keeps all its seismic and infrasound array data online on disk storage. In the same data base are also all data from all arrays, since the start of digital data acquisition from the large aperture NORSAR array in 1970.

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