Earthquake detection - location capability of the Hellenic Unified Seismological Network (HUSN) operating by the Institute of Geodynamics, National Observatory of Athens*

Dimitris Papanastassiou

Institute of Geodynamics, National Observatory of Athens, 11810 Athens, Greece
e-mail: d.papan@gein.noa.gr

ABSTRACT: The detection-location capability of the Hellenic Unified Seismological Network (HUSN) has been estimated for the period 2008-2010, which is the time that HUSN is in operation by the Institute of Geodynamics. HUSN is a network in which all Seismological Institutions of Greece, namely the Institute of Geodynamics and the Seismological Laboratories of the Universities of Thessaloniki, Athens and Patras are participate. At present HUSN is composed by 85 stations. Moreover an estimation of the future capability of the network, when 26 more stations will be connected, is performed.

The obtained results are plotted in the form of contour maps which show that the network in the examined time period has the ability to detect and locate shallow earthquakes with magnitude Ml ≥ 2.5 occurred almost in every part of Greece. When the rest 26 stations from the four Institutions will be connected to the network, the detectability-locatability of that time network will be improved considerably and will be able to detect and locate earthquakes with magnitude Ml ≥ 2.0.
Key-words: *seismic network, detection-location capability, Greece*.

ΠΕΡΙΛΗΨΗ: Στην εργασία αυτή εκτιμάται η ικανότητα ανίχνευσης και εντοπισμού σεισμών από το Σεισμολογικό δίκτυο του Γεωδυναμικού Ινστιτούτου κατά την χρονική περίοδο 2008-2010. Κατά το χρονικό αυτό διάστημα το ΕΕΣΔ – Ελληνικό Ενοποιημένο Σεισμολογικό Δίκτυο (HUSN) είναι σε λειτουργία από το Γεωδυναμικό Ινστιτούτο. Το ΕΕΣΔ είναι το δίκτυο που συνίσταται από σταθμούς που συνεισφέρουν όλοι οι Σεισμολογικοί φορείς της χώρας δηλαδή το Γεωδυναμικό Ινστιτούτο και τα Εργαστήρια Σεισμολογίας των Πανεπιστημίων της Θεσσαλονίκης, Αθηνών και Πάτρας.

Στο χρονικό διάστημα 2008-2010 το ΕΕΣΔ αποτελείται από 85 σταθμούς. Το δίκτυο αυτό είναι σε μία δυναμική κατάσταση, συνεχώς προστίθενται νέοι σταθμοί, με προοπτική να φθάσουν τους 111. Έτσι εκτιμήθηκε η ικανότητα ανίχνευσης και εντοπισμού σεισμών και για τα δύο δίκτυα, του υπάρχοντος σήμερα σε λειτουργία και του μελλοντικού. Τα αποτελέσματα έδειξαν ότι το δίκτυο των 85 σταθμών, έχει την ικανότητα να καταγράφει και να προσδιορίζει τις εστιακές παραμέτρους των σεισμών με μέγεθος ≥ 2.5, που προέρχονται σχεδόν από κάθε σημείο της χώρας. Με την προσθήκη και των 26 σταθμών το κατώτερο μέγεθος ανίχνευσης και προσδιορισμού εστιακών παραμέτρων θα μειωθεί στο 2.0 για σεισμούς που προέρχονται από κάθε σημείο του Ελληνικού χώρου.
Λέξεις-κλειδιά: *σεισμολογικό δίκτυο, ικανότητα ανίχνευσης – εντοπισμού σεισμών, Ελλάδα*.

INTRODUCTION

Seismic networks are unique tools for seismic monitoring and alarm, research on the interior of the earth, understanding the state of tectonic processes taking place in a given region, characterizing seismogenic volumes, evaluating of seismic risk in areas of high seismic activity, etc. The ability to detect events of small and medium magnitude requires the existence of an appropriately sized seismic network, consisting of a sufficient number of seismic stations featuring low noise and properly distributed.

During the 60s and 70s and after the signing between USA and USSR of the historical "Comprehensive Test Ban Treaty", large seismic networks (WWSSN) and seismic arrays (VELA, NORSAR, LASA, ALPA, CEQ, etc) were established to detect any violation of the treaty. At that time and mainly during the design and the first steps of operation of these networks, the concepts "Detection – Location Capability", "Location Accuracy" became important (Gerlach *et al*., 1966; Anglin, 1971; Berteussen & Husebye, 1972; Dean, 1972; Ringdal *et al*., 1977; Gibbons & Ringdal, 2006; Gibbons *et al*., 2007; Hafemeister, 2009; Zhang *et al*., 2009; Nanjo *et al*., 2010 and many others). In time, these ideas turned out to be essential for every seismological network and many papers were published (Evernden, 1971; Pirhonen *et al*., 1976; Suzuki & Ito, 1980, etc). For the area of Greece one should mention the works of Galanopoulos (1971), who examined the detectability of the station of Athens, Galanopoulos & Makropoulos (1981), that estimated the threshold magnitude for the area of Greece by using data of ISC bulletins and that of Papanastassiou (1989), who calculated the actual and expected detectability and location errors based on data of the first satellite network of GI.

* Ικανότητα ανίχνευσης-προσδιορισμού σεισμών του Ελληνικού Ενοποιημένου Σεισμολογικού Δικτύου που λειτουργεί στο Γεωδυναμικό Ινστιτούτο του Εθνικού Αστεροσκοπείου Αθηνών

It is therefore necessary to evaluate the ability of a seismic network to detect seismic areas not adequately covered, and further ascertain if the network needs to be improved.

In the present work the actual performance of the network is examined in the time period of 2008-2010. This means to estimate its ability of the network, to detect earthquakes and to locate them, which means to determine the lower magnitude of events in every area of Greece for which it is possible to calculate the earthquake parameters. This period is that when the Hellenic Unified Seismological Network-HUSN is in operation. Moreover an estimation of the future capability of the network, when more stations will be connected, is performed. As the majority of the located earthquakes in the area of Greece, have depths in the crust ranging between 0 and 30Km, this depth layer was mainly examined in detail in order to have reliable results.

SEISMIC INSTRUMENTAL OBSERVATIONS BY THE INSTITUTE OF GEODYNAMICS

The Institute of Geodynamics, National Observatory of Athens (IG), is one of the oldest Institutes in Greece, operating continuously since 1893. It is the main center in Greece, for the continuing monitor of the seismicity of the country and reporting the located earthquakes to national and international authorities. It is therefore essential to give some information about its history since its beginning.

a. Pre-instrumental period

After Greece's independence the State showed its immediate interest in earthquakes. Schmidt, the first Director of the National Observatory of Athens (1825-1884), was the first to collect data about the earthquakes occurring all over Greece. He compiled detailed catalogs of earthquakes and he also described several major earthquakes of that period (like the Heliki earthquake of 26-12-1861). At that time the Observatory was combining information on earthquake occurrence with contemporary astronomical and meteorological phenomena, giving emphasis on the timing of earthquakes and not on their effects to the society and the environment. In 1893, the Seismological Institute was formed, which later on became the core of the Institute of Geodynamics.

b. Instrumental Period

At the beginning of the Institute, the first seismograph in Greece was installed, while in 1897 the first seismological network of mechanical type seismographs started to operate. In 1962 the first electromagnetic instrument started to work in Athens. However, 1965 is considered as an important date, as in that year, electromagnetic type photographic recording satellite stations were set up, comprising a network of 13 stations in 1974. In 1983 it renovated to a telemetric real time one, while in 1986 the extension with new satellite stations was realized, so by the end of 1992, 22 telemetric stations were in operation. While the establishment of new stations was always a priority, in 1996 the employment of the digital technology started and all the existing stations became by the time digital.

Moreover, the Institute, cooperates with foreign institutions (MEDNT, Geofon) from 2000 to install permanent stations in southern Aegean and since then incorporates in real time their recordings in the everyday monitoring of the seismicity of Greece. Since 1964, the initial network grew in size and extent, so that today it consists of 35 digital telemetric stations installed over the whole country plus 7 stations from international agencies cooperating with IG located in the southern Aegean and Crete.

The observational area is limited from latitudes 34°N to 42°N and longitudes 19°E to 30°E. Fig. 1 shows the operating digital stations by the Institute of Geodynamics as well as the stations belonging to collaborating foreign Institutions. In the web site http://bbnet.gein.noa.gr there is various information about the instrumentation of the network and the operating stations.

c. Hellenic Unified Seismological Network-HUSN

In addition to the Institute of Geodynamics, there are three more seismological centers in Greece, the Seismological Laboratory of the University of Athens, the Geophysical Laboratory of the University of Thessaloniki and the Seismological Laboratory of the University of Patras.

The Seismological Laboratory of the University of Athens belongs to the Department of Geophysics and Geothermy of the National and Kapodistrian University of Athens. The Laboratory first operated in 1929. The Laboratory oper-

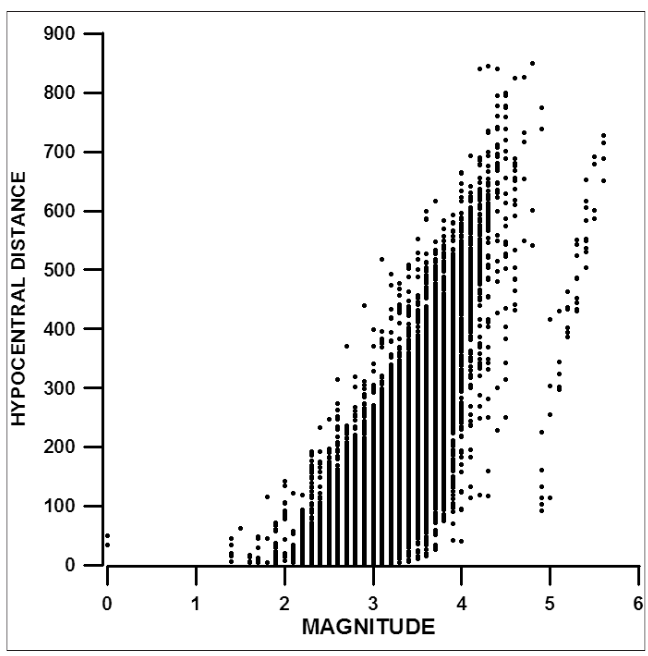

Fig. 1. Plot between the magnitude and the hypocentral distance of the located earthquakes.

ates twenty (20) stations organized in three digital telemetric networks: CORNET, VOLNET and ATHENET in the areas of the gulf of Corinth, central Greece and around Athens in an area of 100km radius. The Laboratory of Geophysics of the Aristotle University of Thessaloniki was established in 1976. Today, the telemetric seismological network of the Laboratory of Geophysics of the Aristotle University of Thessaloniki consists of twenty eight (28) stations. The stations are installed in northern Greece as well as in the north Aegean and Ionian sea. The University of Patras Seismological Laboratory (UPSL) started operating in 1990. The Patras Seismological Lab Seismic Network (PATNET) covers the wider Western Greece area and the Peloponnese. It consists of twenty one (21) stations. Information for the networks of the above Institutions is provided at the web sites: http://dggsl.geol.uoa.gr, http://geophysics.geo.auth.gr/ss/ and http://seismo.geology.upatras.gr respectively.

By the beginning of 2005, a national project was launched, named: "Hellenic Unified Seismological Network-HUSN", financed by the Ministry of Development (EPAN 4.5) that intended to unify the Seismological networks of the Greek Institutions, which by the end of 2007, began to give the first results.

More specifically, this project made possible the successful interconnection of the seismological networks of the four Institutions for more detailed and precise recording of the seismic activity of the broader area of Greece, the unified calculation of seismic parameters, the publication of common announcements of the occurrence of strong earthquakes, the compilation of a national bulletin of earthquakes and more generally the qualitative upgrading of seismological data and seismological research. Basic action of the project is the upgrade of the seismological institutions, their unification with common software and the support of IG-NOA as main coordinating institution. At the same time, it created a new automatic system of recording, processing and presentation in real time the seismicity of the broader area of Greece.

In this way it created the conditions for:

- direct, detailed and more reliable information for the state and public,
- common observations of the seismicity and exchange of all available elements between the institutions
- collection of data for research and possibility of their direct disposal in the scientific community and - more precisely a detailed study of the seismicity of the country.

All the signals, from the agreed stations of the partners, are collected by the IG in its central facilities at Thissio and are retransmitted to them. Every partner receives signals from the rest of the partners. This procedure is taking place in real time. At present, 85 digital signals are gathered by IG, 35 belong to the IG, 22 are coming from Thessaloniki, 12 from Patras, 9 from Athens and 7 from the international agencies cooperating with IG. The data are analyzed routinely in detail by the staff of IG, producing a daily report of the located earthquakes in the broader area of Greece, while every month a monthly bulletin is produced. The earthquake listings are distributed regularly all over the world to several Seismological centres and Universities, as well as to different Organizations and Libraries.

Fig. 2 shows the present situation of HUSN as it is operated by the Institute of Geodynamics.

METHODOLOGY

The knowledge of the detection-location capability is a very important aspect for a seismic network, not only during its design but also during its operation. This term means the ability of the network to detect and locate any earthquake (to determine the earthquake parameters) which occurs in the observational area with magnitude larger than a threshold magnitude M_T and coordinates x, y, z. There are several factors affecting the detection capability of a seismological network: the non homogeneous geographical distribution of the stations, their different sensitivity, stations located in islands have higher background noise in comparison with those in mountainous regions and that the spatial distribution of the earthquakes inside the observational area is not uniform.

Different methods address this problem, like those based on the signal to noise ratio (SNR) (Lacoss, 1969; Harley, 1971), on the comparison of the performance of the network in comparison with a reference system (Aki, 1965; Ringdal, 1976) or directly from the appearance of the network (Ringdal, 1975; Matsumura, 1984; Papanastassiou & Matsumura, 1987).

For a network operated for a significant time period, its performance could be obtained by combining the individual detection-loction capability of every single station. Specifically, for every station a plot between the magnitude and the hypocentral distance of the located earthquakes was made (Fig. 3). By this for a given magnitude M_T the maximum hypocentral distance of location is derived. In order to calculate the location probability of the whole network, the ob-

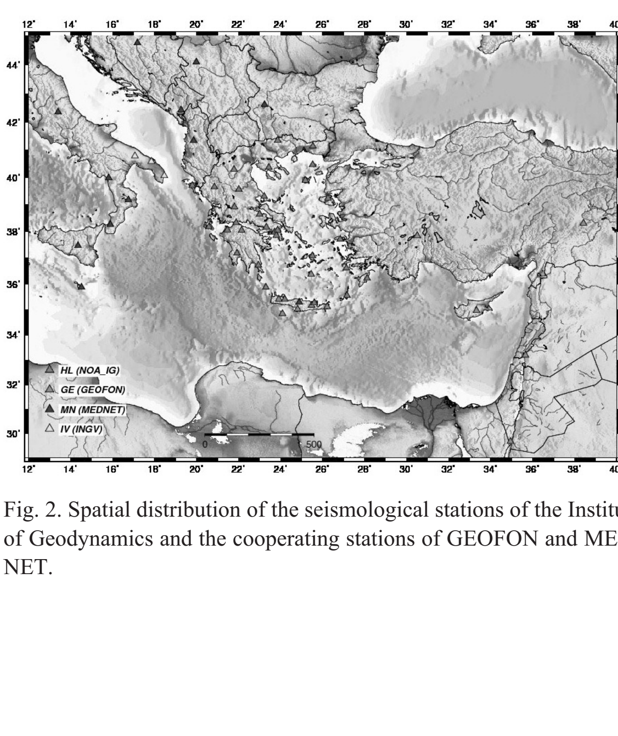

Fig. 2. Spatial distribution of the seismological stations of the Institute of Geodynamics and the cooperating stations of GEOFON and MEDNET.

servational area has been divided into small, 10km by 10km shells. In every shell, an earthquake with fixed magnitude M_T occurs at different depths. Then the location probability P of the network is calculated, under the condition that the earthquake must be detected by more than 2 stations. So,

$$P(M_T, X) = 1.0 - (P_0+P_1+P_2)$$

X represents the position of the earthquake and P_n the probability that the earthquake could be detected at only n stations as follows:

$$P_0= (1-p_1)\,(1-p_{p2})\ldots(1-p_N)$$

$$P_1= p_1\,(1-p_2)\,(1-p_3)\ldots(1-p_N) + \ldots + p_N\,(1-p_1)\,(1-p_2)\ldots(1-p_{N-1})$$

$$P_2= p_1\,p_2\,(1-p_3)\,(1-p_2)\ldots(1-p_N) + \ldots + p_{N-1}\,p_N\,(1-p_1)\ldots(1-p_{N-2})$$

n is the total number of the stations operating in the network and p_N the detection probability of the N station.

The results are shown as three dimensional maps. The curves define the area inside which all the occurring earthquakes, with magnitude greater than the threshold value and appropriate depth, could be not only detected but also located with a probability greater than 90%.

The detectability-locatability of the current configuration of the HUS network (85 stations, Table 1) for the time period 2008-2010, for different depth windows and for was examined. The obtained results are given in Figs 4 and 5.

Moreover, the expected detectability-locatability of the future configuration of the HUSN, when all the available station (111 in total, Table 1) will be connected was also examined but for threshold magnitudes Ml=2.5 and 2.0 (Figs 6 and 7).

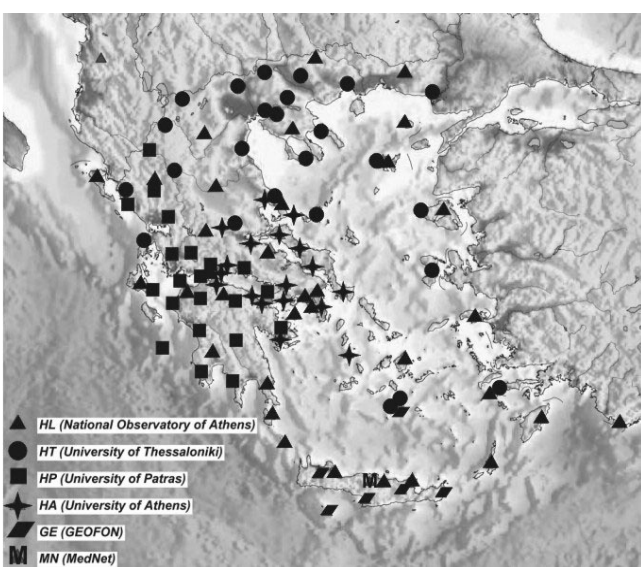

Fig. 3. Spatial distribution of the seismological stations of the HUN Hellenic Unified Seismological Network. Different information about the stations are given in Table 1.

DISCUSSION-CONCLUSIONS

The obtained results show that during the current period 2008-2010, shallow earthquakes with depth ≤ 30Km and magnitude Ml ≥ 3.0 could be detected and located within almost all the observational area (Fig. 4). The existence of sufficient stations along the western Greece, Crete, Corinth gulf, southern and north Aegean permits the good monitoring of nearly all the earthquake prone areas of Greece. All the earthquakes with magnitude greater than this threshold value and appropriate depth could be detected and accurately located. This network for this threshold magnitude has a gap in the region of Cyclades, meaning that earthquakes of that or lower magnitudes originated from this area, although being detectable, they were not efficiently located. For smaller mag-

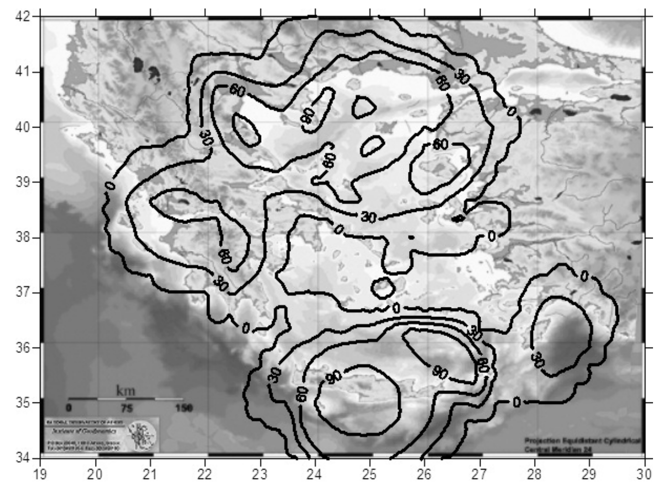

Fig. 4. Detection-location capability of the Hellenic Unified Seismological Network consisting of 85 stations, for the period 2008-2010. Contours show the maximum depths where earthquakes with magnitudes greater than Ml=3.0 are detected and located.

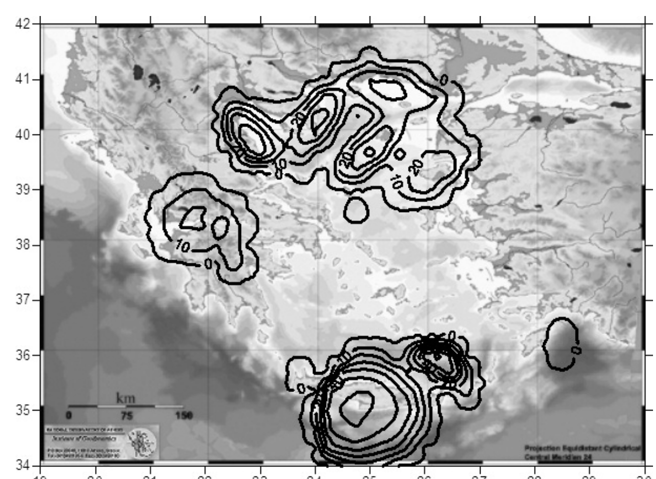

Fig. 5. Detection-location capability of the Hellenic Unified Seismological Network consisting of 85 stations, for the period 2008-2010. Contours show the different depths inside which earthquakes with magnitudes greater than Ml=2.5 are detected and located.

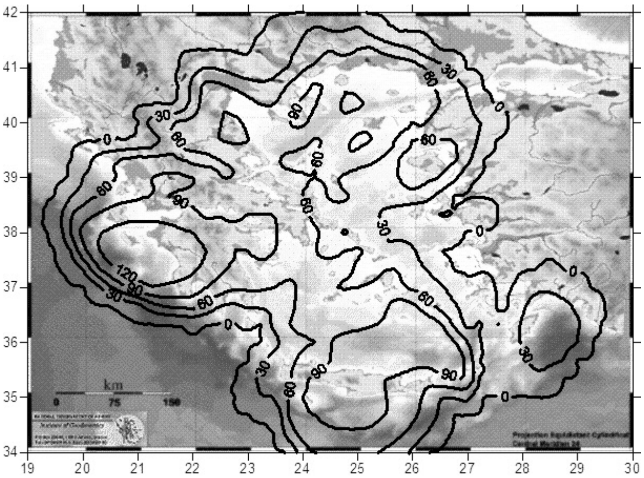

Fig. 6. Expected detection-location capability of the Hellenic Unified Seismological Network when the existing 111 stations will connect. Contours show the different depths inside which earthquakes with magnitudes greater than Ml=2.5 will be detected and located.

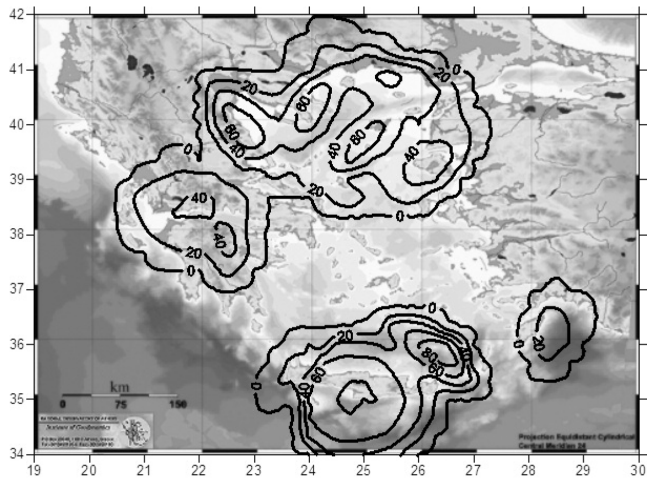

Fig. 7. Expected detection-location capability of the Hellenic Unified Seismological Network when the existing 111 stations will connect. Contours show the different depths inside which earthquakes with magnitudes greater than Ml=2.0 will be detected and located.

TABLE 1

List of all the operating seismological stations in Greece, by the four institutions. HL is for the stations of the Institute of Geodymanics, HL/GEOFON and HL/MEDNET are the cooperating stations between the Institute of Geodymanics, GEOFON and MEDNET respectively, HT, HA and HP are for the stations of the Universities of Thessaloniki, Athens and Patras respectively. The star (*) next to the name of the Institution, indicate station not yet connected with the HUSN. The rest, are the stations contributed at present to HUSN.

STATION		**NETWORK**	**NAME**	**LATITUDE ˚N**	**LONGITUDE ˚E**	**HEIGHT m**	**SEISMOMETER**	**DATA LOGGER**
1	ANKY	HL	ANTIKYTHERA	35.8670	23.3012	143	CMG-3ESPC/60	PS6-SC
2	APE	HL	APEIRANTHOS	37.0727	25.5230	608	STS-2	PS6-SC
3	ARG	HL	ARCHANGELOS	36.2135	28.1212	148	LE-3D/20	DR24-SC
4	ATH	HL	ATHENS OBSERVATORY	37.9738	23.7176	93	STS-2	DR24-SC
5	EVR	HL	KARPENISI	38.9165	21.8105	1037	CMG-3ESPC/60	DR24-SC
6	IACM	HL	HERAKLEIO	35.3058	25.0709	45	STS-2 & CMG-5T	PS6-SC
7	ITM	HL	ITHOMI	37.1787	21.9252	423	LE-3D/20	DR24-SC
8	JAN	HL	JANNINA	39.6561	20.8487	526	CMG-3ESPC/60	DR24-SC
9	KARP	HL	KARPATHOS	35.5471	27.1610	524	STS-2	DR24-SC
10	KEK	HL	KERKYRA	39.7127	19.7962	227	STS-2	DR24-SC
11	KSL	HL	KASTELORIZO	36.1500	29.5833	100	Le3D/20	PS6-SC
12	KLV	HL	KALAVRYTA	38.0437	22.1504	758	STS-2	PS6-SC
13	KYTH	HL	KYTHERA	36.2800	23.0360	458	S-13	DR24-SC
14	KZN	HL	KOZANI	40.3033	21.7820	791	STS-2	DR24-SC
15	LIA	HL	LIMNOS	39.8972	25.1805	67	CMG-3ESPC/60	DR24-SC
16	LKR	HL	ATALANTI	38.6495	22.9988	185	CMG-40T/30	DR24-SC
17	NEO	HL	NEOCHORI	39.3056	23.2218	510	LE-3D/20	DR24-SC
18	NISR	HL	NISYROS	36.6106	27.1309	48	LE-3D/20	PS6-SC
19	NPS	HL	NEAPOLIS	35.2613	25.6103	288	LE-3D/20	DR24-SC
20	NVR	HL	NEVROKOPI	41.3484	23.8651	627	CMG-3ESPC/60	DR24-SC
21	PLG	HL	POLYGYROS	40.3714	23.4438	590	LE-3D/20	DR24-SC
22	PRK	HL	AGIA PARASKEVI	39.2456	26.2649	130	STS-2	DR24-SC
23	PSA1	HL	PSATHOPYRGOS	38.3253	21.8837	3	Le3D/20	PS6-SC
24	PTL	HL	PENTELI	38.0473	23.8638	500	LE-3D/20	PS6-SC
25	RDO	HL	GRATINI	41.1450	25.5355	116	CMG-3ESPC/60	DR24-SC
26	RLS	HL	RIOLOS	38.0558	21.4647	97	LE-3D/20	DR24-SC
27	SMG	HL	SAMOS	37.7042	26.8377	348	TRILLIUM 120	PS6-SC
28	SMTH	HL	SAMOTHRAKI	40.4709	25.5304	365	CMG-3ESPC/60	PS6-SC
29	THL	HL	KLOKOTOS	39.5646	22.0144	86	STS-2	DR24-SC
30	VAM	HL	VAMOS	35.4070	24.1997	225	LE-3D/20	DR24-SC
31	VLI	HL	VELLIES	36.7180	22.9468	220	CMG-3ESPC/60	PS6-SC
32	VLS	HL	VALSAMATA	38.1768	20.5886	402	LE-3D/20	DR24-SC
33	VLY	HL	VOULA	37.8524	23.7942	256	LE-3D/20	PS6-SC
34	NAIG	HL	AIGINA	37.7585	23.4887	221	S-13	DR24-SC

35	XRY	HL	XRYSI	34.8748	25.6943	21	S-13	DR24-SC
36	GVD	HL/GEOFON	GAVDOS	34.8392	24.0873	180	STS-2	Q-4120-M
37	KARN	HL/GEOFON	KARANOS	35.4019	23.9174	420	STS-2	Q-4120-M
38	LAST	HL/GEOFON	LASITHI	35.1611	25.4786	870	FBA-EST/10.0	PS6-SC
39	SANT	HL/GEOFON	SANTORINI	36.3710	25.4590	540	STS-2	PS6-SC
40	SIVA	HL/GEOFON	SIVAS	35.0175	24.8100	95	STS-2	Q-420-M
41	ZKR	HL/GEOFON	ZAKROS	35.1147	26.2170	270	STS-2	Q-4120-M
42	IDI	HL/MEDNET	ANOGEIA	35.2880	24.890	750	STS-1	Q52K
43	AGG	HT	AGIOS GEORGIOS	39.0211	22.3360	622	CMG-3ESP/100	TRIDENT
44	ALN	HT	ALEXANDROUPOLI	40.8957	26.0497	110	CMG-3ESP/100	TRIDENT
45	AOS	HT	ALONISOS	39.1700	23.8800	200	CMG-3ESP/100	TAURUS
46	CHOS	HT	CHIOS	38.3868	26.0506	854	CMG-3ESP/100	TRIDENT
47	FNA	HT	FLORINA	40.7818	21.3835	750	CMG-3ESP/100	HRD24
48	GRG	HT	GRIVA	40.9558	22.4029	600	CMG-3ESP/100	TRIDENT
49	HORT	HT	HORTIATIS	40.5978	23.0995	925	CMG-3ESP/100	TRIDENT
50	IGT	HT	IGOUMENITSA	39.5315	20.3299	270	CMG-3ESP/100	HRD24
51	KAVA	HT	KAVALA	40.9941	24.5119	95	CMG-3ESP/100	TAURUS
52	KNT	HT	KENTRIKO	41.1620	22.8980	380	CMG-3ESP/100	HRD24
53	LIT	HT	LITOCHORO	40.1003	22.4893	568	CMG-3ESP/100	TAURUS
54	LKD2	HT	LEFKADA	38.7889	20.6578	485	CMG-3ESP/100	TRIDENT
55	LOS	HT*	LEMNOS	39.9330	25.0810	460	S-13	TRIDENT
56	MEV	HT*	METSOVO	39.7850	21.2290	1500	S-13	TRIDENT
57	NEST	HT	NESTORIO	40.4147	21.0489	1056	TRILLIUM 120	TAURUS
58	NIS1	HT	NISYROS	36.6023	27.1782	378	CMG-3ESP/100	TAURUS
59	OUR	HT	OURANOUPOLIS	40.3340	23.9820	60	CMG-3ESP/100	TRIDENT
60	PAIG	HT	PALIOURI	39.9363	23.6768	213	CMG-3ESP/100	TRIDENT
61	SIGR	HT	SIGRI	39.2114	25.8553	92	CMG-3ESP/100	TRIDENT
62	SOH	HT	SOCHOS	40.8206	23.3556	728	TRILLIUM 120	TAURUS
63	SRS	HT	SERRES	41.1086	23.5846	321	CMG-3ESP/100	TRIDENT
64	THE	HT	THESSALONIKI UNIV.	40.6319	22.9628	124	CMG-3ESP/100	TRIDENT
65	THR1	HT*	THIRA	36.3712	25.4597	522	S-13	TRIDENT
66	THR2	HT	THIRA, VOURVOULOS	36.4469	25.4354	220	S-13	TRIDENT
67	THR3	HT*	THIRA, NEA KAMMENI	36.4091	25.4008	71	S-13	TRIDENT
68	THR5	HT*	THIRA, KERA	36.4172	25.3479	180	S-13	TRIDENT
69	THR6	HT*	THIRA, AKROTIRI	36.3562	25.3975	119	S-13	TRIDENT
70	XOR	HT	XORICHTI	39.3660	23.1920	500	CMG-3ESP/100	TAURUS
71	ATHU	HA	ATHENS UNIVERSITY	37.9665	23.7845	308	CMG-40T/60	REF72A
72	ACOR	HA	ACROKORINTHOS	37.8902	22.8692	437	CMG-40T/30	REF72A
73	ATAL	HA*	ATALANTI	38.6926	23.0213	290	CMG-40T/60	REF130
74	AXAR	HA	AXARNES	38.7664	22.6590	406	CMG-40T/30	CMG-DM24
75	DESF	HA	DESFINA	38.4127	22.5321	750	CMG-40T/30	CMG-DM24
76	DIDY	HA*	DIDYMA	37.4765	23.2118	1036	CMG-3ESPC/60	REF72A
77	ERET	HA*	ERETRIA	38.4423	23.8064	810	LE-3D/5	REF72A
78	FYTO	HA*	FYTOKO	39.4086	22.9396	192	CMG-40T/30	CMG-DM24
79	KALE	HA	KALITHEA	38.3911	22.1398	760	CMG-40T/60	REF130
80	LAKA	HA*	LAKA	38.2401	21.9785	505	CMG-3T/120	REF130
81	LTRA	HA*	LOUTRAKI	37.9754	22.9766	100	CMG-40T	CMG-DM24
82	MAKR	HA	MAKRAKOMI	39.0132	22.1317	532	CMG-40T/30	REF130
83	MRKA	HA	MARKATES	38.7058	23.5875	424	CMG-40T/30	CMG-DM24
84	MRMA	HA*	MARMARI	38.0573	24.3792	300	CMG-40T/30	CMG-DM24
85	SERI	HA*	SERIFOS	37.1707	24.4871	100	CMG-40T/30	CMG-DM24
86	SKIA	HA	SKIATHOS	39.1665	23.4661	325	CMG-40T/30	REF130
87	SMIA	HA	SIMIA	38.8791	23.2090	448	CMG-40T/30	CMG-DM24
88	THAL	HA*	THALERO	38.0372	22.6631	129	CMG-40T/30	REF72A
89	TRIZ	HA*	TRIZONIA	38.3655	22.0726	57	CMG-40T/30	REF72A
90	VILL	HA*	VILLIA	38.1642	23.3122	650	CMG-40T/30	REF72A
91	AMT	HP	AMALIAS	37.5324	21.7089	482	TRILLIUM 40	TRIDENT
92	AXS	HP*	ARAXOS	38.1962	21.3763	102	CMG-3T/360	TRIDENT
93	DDN	HP*	DODNI	39.5314	20.8449	1110	KS2000M	TRIDENT
94	DID	HP	DIDYMA	37.5063	23.2368	525	TRILLIUM 40	TRIDENT
95	DRO	HP	DROSIA	37.9522	21.7111	471	TRILLIUM 120	TRIDENT
96	DSF	HP	DESFINA	38.4112	22.5271	701	TRILLIUM 40	TRIDENT
97	DSL	HP*	DIASELO	39.1338	21.0964	525	KS2000M	TRIDENT
98	DYR	HP*	DYROS	36.7622	22.3337	428	TRILLIUM 40	TRIDENT
99	EFP	HP	EFPALIO	38.4269	21.9058	135	TRILLIUM 40	TRIDENT
100	GUR	HP	GOURA	37.9363	22.3423	1080	TRILLIUM 40	TRIDENT
101	KFL	HP*	KEFALONIA	38.1096	20.7880	264	S-13	TRIDENT

102	KNS	HP	KONITSA	40.0596	20.7592	1092	KS2000M	TRIDENT
103	LTK	HP	LOUTRAKI	38.0228	22.9673	408	CMG-3T	TRIDENT
104	PDO	HP	PRODROMOS	38.5986	21.1833	227	CMG-3T	TRIDENT
105	PVO	HP*	PARAVOLA	38.6167	21.5259	188	S-13	TRIDENT
106	PYL	HP	PYLOS	36.8955	21.7420	220	CMG-3T	TRIDENT
107	RGA	HP*	PARGA	39.3212	20.3544	610	KS2000M	TRIDENT
108	SFD	HP	STROFADES	37.2512	21.0165	45	TRILLIUM 120	TRIDENT
109	UPR	HP*	PATRAS UNIVERSITY	38.2836	21.7864	138	TRILLIUM 40	TRIDENT
110	VLX	HP	VLACHOKERASIA	37.3703	22.3793	1031	TRILLIUM 40	TRIDENT
111	VTN	HP*	VYTINEIKA	37.9166	21.1856	50	S-13	TRIDENT

nitudes Ml ≥ 2.5, earthquakes having epicenters in the north Aegean, Corinth gulf and Crete, where there are enough stations, could be detected and located (Fig. 5).

HUS network is in dynamic stage. More stations belonging to the contributing Institutions are going to connect in the coming time. It is obvious that when all the existing in Greece 111 stations will be operating within HUSN, the detectability-locatability of this future network, will be improved considerably due not only to the installation of more stations but also to the quality of these digital broad-band stations. This is also shown in Figs 6 and 7 where the expected detectability – locatability of the the HUS network of 111 station was estimated. It is obvious that that network will be able to detect and locate all the shallow earthquakes with magnitudes greater than 2.0 all over the country.

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