ADS-VTN-23G01

Installation of an IDA/GSN Geophysical Observatory in Uzbekistan

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14. ABSTRACT
A global quality seismic observatory with broadband seismometers, accelerometers, and pressure sensors, was installed with the collaboration of the Institute of Seismology, Academy of Sciences, Republic of Uzbekistan. The end result of this installation is a new GeoScope GSN (Global Seismograph Network) station that provides free and real-time access to data of significant value to verification monitoring and research. The project also opens up opportunities for U.S.-Uzbek cooperation in science and technology, paving the road for implementing U.S. Department's broader outreach initiative in Central Asia.

15. SUBJECT TERMS
Seismic Network, Seismic Monitoring, Earthquake Hazards, Real-time Seismic Data Sharing, Bilateral Agreement

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1. Summary

The overall objective was to establish global quality seismic observatory with broadband seismometers, accelerometers, and pressure sensors in Uzbekistan and to provide free and real-time access to continuous waveform data. This was accomplished. The process consisted of an initial MOU(s), a preliminary site selection and noise survey, site preparation, installation, and training of local staff. The station is operational and currently providing high-quality data that is free and open to the public. This data will be useful to the earthquake hazard monitoring agencies (such as US Geological Survey), the seismic research community, and improve understanding of waveform propagation across the region.

2. Introduction

The Central Asian region (Figure 1) is an area of considerable interest for seismic monitoring. From 1993 to 2012, the Global Seismic Network (GSN) station ABKT was in operation in Turkmenistan. Station operations stopped due a decline in support by the local host. This left a gap in coverage. As Uzbekistan is nearby, this was a logical place to install a new station.

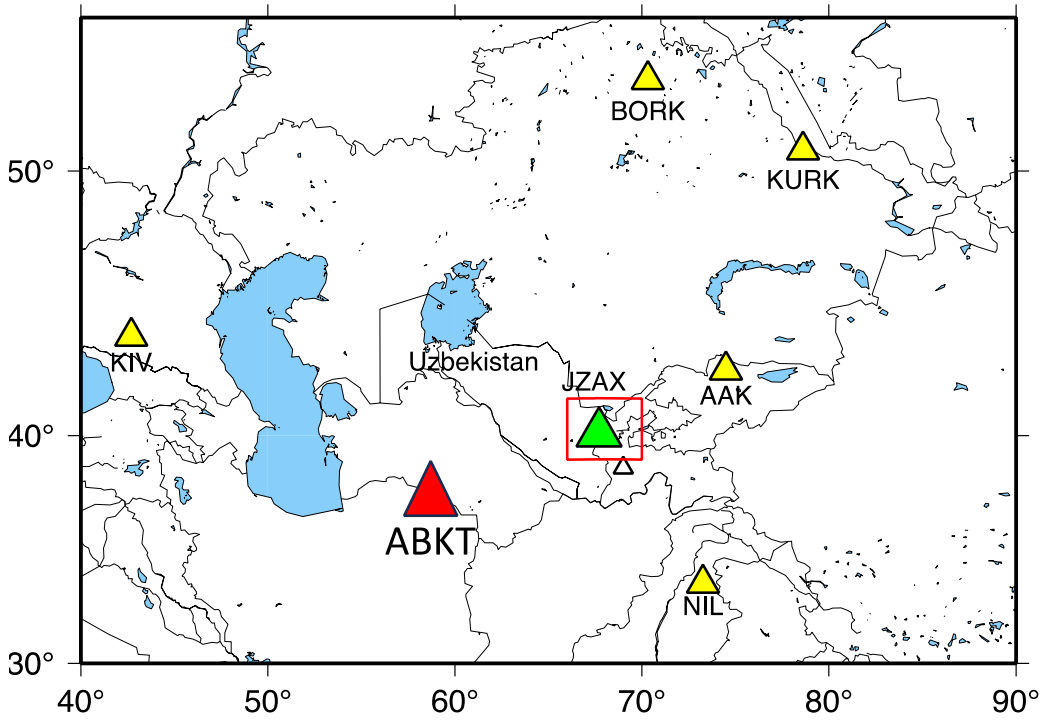


Figure 1. Location of the new Uzbek station with respect to the former station ABKT and other GSN stations in the region.

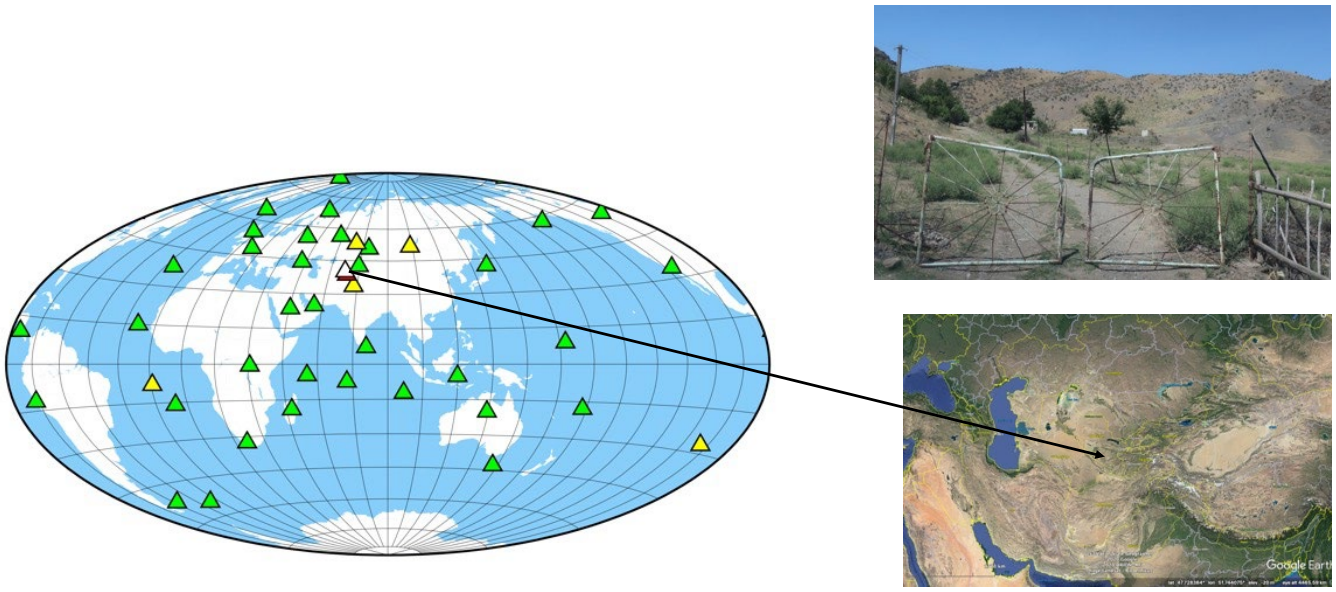


Figure 2.(left) Map if the global IDA *network. (right) Photo of gate to the station (top) and approximate location in Central Asia.*

The process of reaching out to potential hosts in Uzbekistan was started in 2012 and in 2013 an MOU was signed with the Institute of Seismology and a possible location identified. This location was visited by IDA staff in 2018 (Figure 2). However, following internal changes in the Uzbekistan government, responsibility of seismic station operation was shifted from the Institute of Seismology (which was under the Academy of Sciences) to the Ministry of Emergency Situations (MES). A second MOU was signed in 2020 between UCSD, IRIS, and MES.

Seismology and earthquake hazard is a significant concern in Uzbekistan, as the city of Tashkent was badly damaged by an earthquake in 1966 (Institute of Seismology, 1971)(Figure 3). More recently, large earthquakes have occurred in the North Tien Shan and Ferghana Valley (Mellors, 1995)(Figure 4).

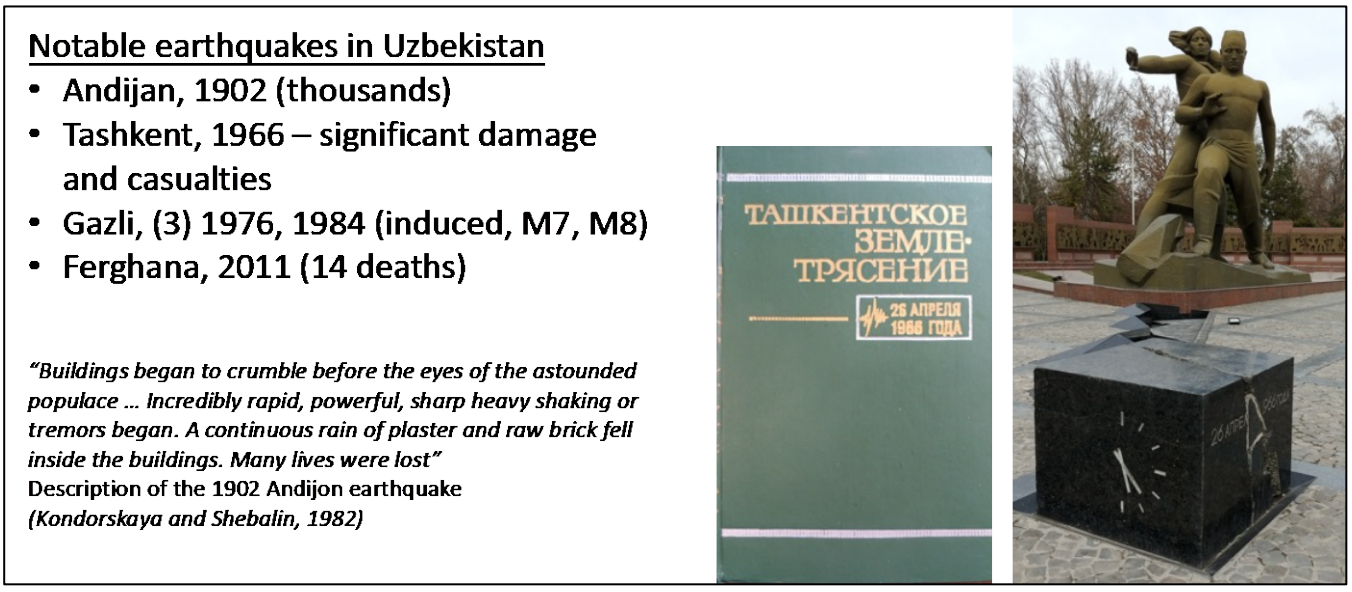


Figure 3. List of historical significant earthquakes in Uzbekistan, a book on the 1966 Tashkent earthquake, and a status commemorating the victims of the earthquake, which ocurred early in the morning.

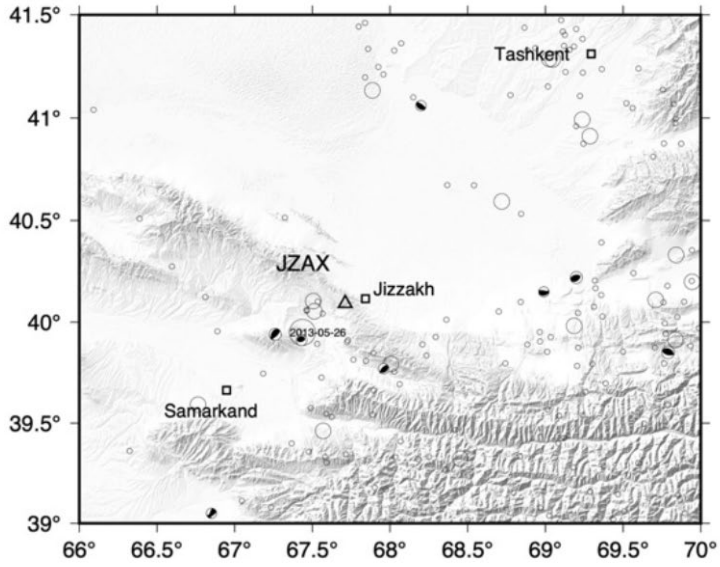


Figure 4. Map of central Uzbekistan showing the approximate location of the station and earthquakes from the ISC catalog and focal mechanisms from the CMT catalog.

3. Station selection

Station selection, preparation, and installation developed over several stages and took approximately 10 years from start to finish. Delays were caused by governmental re-organizations in Uzbekistan (transfer of the seismic network from the Uzbekistan Institute of Seismology to the Ministry of Emergency Situations) and by COVID imposed travel restrictions (Table 1).

Table 1. Approximate timeline of events in the process of establishing the GSN station at JZAX.

• 2012 – initial interactions with Uzbekistan Institute of Seismology	
• 2013 – first site (P. Davis)	
• 2018 – first signed MOU (Institute of Seismology)	
• 2018 – site visit (D. Chavez)	
• 2018 – funding from Dept. of State/AVC (V fund BAA2018, 19AQMM18P2535)	
• 2019 – equipment acquisition	
• 2018 – re-organization; Ministry of Emergency Situations	
• 2020 – 2nd signed MOU with MES	COVID impact
• 2021 – U.S. Embassy telecons	
• 2021 – equipment sent for noise survey	
• 2021 – site visit (R. Mellors)	
• 2022 – MOU addendum for site preparation	
• 2023 – site preparation complete and installation	
• May 2023, Ribbon-cutting	

Identification of partners. Initial discussions took place with the Institute of Seismology of the Academy of Sciences of Uzbekistan and an MOU was signed in April, 2018 (Appendix A), based on a selection of a site near the city of Jizzakh, which was about halfway between Tashkent and Samarkand (Figure 5 and 6). As the cooperation was new to both sides, extensive efforts were made in terms of communication, which included monthly telecons over two years, a series of remote lectures, a visit by R. Mellors in November 2021, and a joint publication (scientific poster presentation at the 2021 American Geophysical Union meeting). U.S. Embassy staff (E. Gesson) played an essential role in facilitating this collaboration and in assistance with shipping equipment.

Figure 5. (left) Location of the station with respect to the nearby town of Jizzkh and with nearby roads and railroads. Google earth photos

Figure 6. View of the station from the hillside above in 2018. The tunnel extends into the hillside.

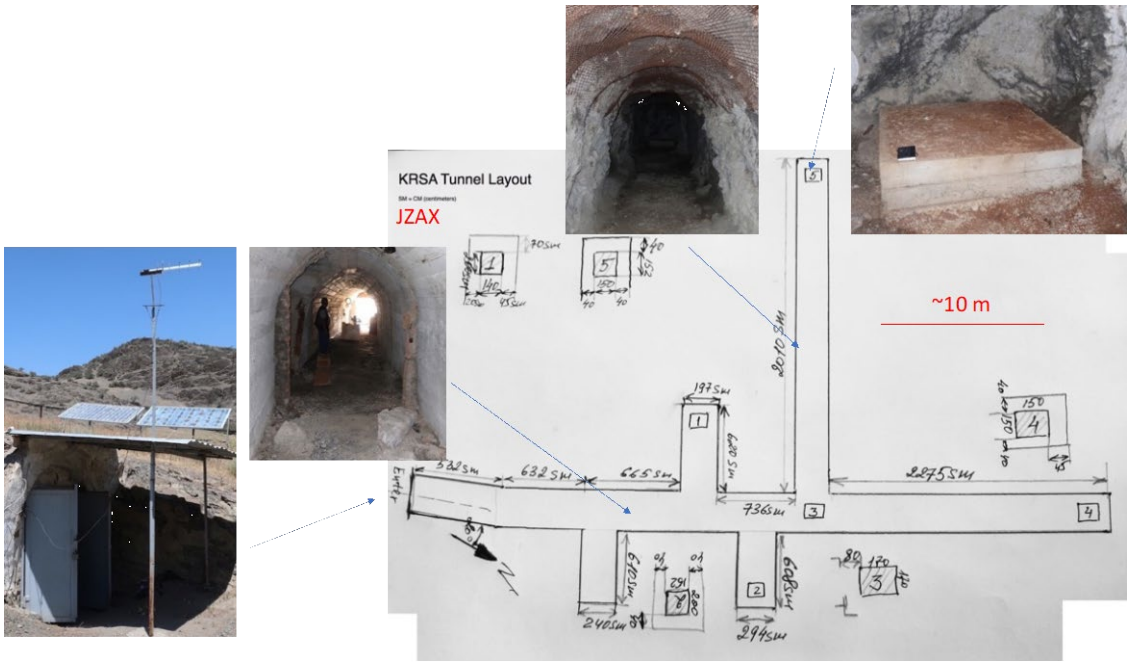


Figure 7. Initial sketch of tunnel and photographs from 2018.

Site selection and review. With the assistance of personnel from the U.S. Embassy, a series of telecons and talks were instituted between UCSD and MES, as COVID-related travel restrictions prevented in person visits. Two portable broadband sensors and associated equipment were sent in the summer of 2021 and installed by MES personnel. In additional to providing useful seismic background noise data, the installation gave MES personnel familiarity with equipment similar to the type that would be deployed in the permanent station and UCSD with the logistics of importing equipment into Uzbekistan, which has strict rules on imports. One issue is that the station is only a few km from the main transport line (road and railroad) between Tashkent and Samarkand and this creates some intermittent noise.

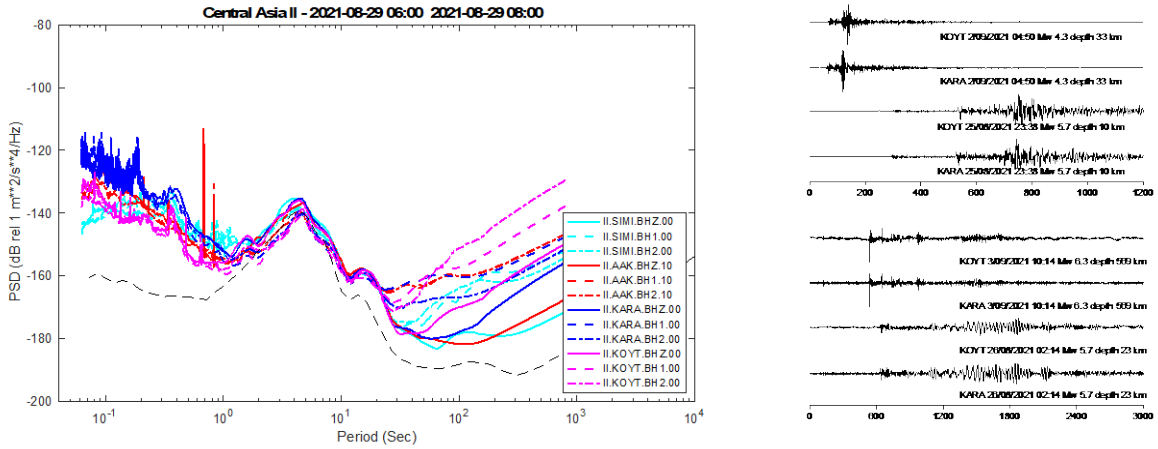


Figure 8. Results of the noise survey using data from the temporary stations KOYT and KARA. (left) Comparison of noise spectra from regional GSN stations with KOYT and KARA. (right) Example seismograms.

Station design. Based on photo and diagrams of the preferred site (Figure 7), an initial station design was developed. This was based on other IDA tunnel installations. A design review was conducted in November 2020 and several key risks were identified (Table 2).

ELECTRICAL

- Reduce AC mains voltage variability
- Replace old wiring
- New circuit minimum 16 Amps
- One AC outlet
- Add light fixtures

TUNNEL

- Add concrete flooring
- Addition of security and pier room isolation doors
- Support for cables (trays or J-hooks)
- Pier room drip shield
- General sanitation

EXTERIOR

- Installation of mast for GPS antennae and comms
- Trenching and laying of conduit as required

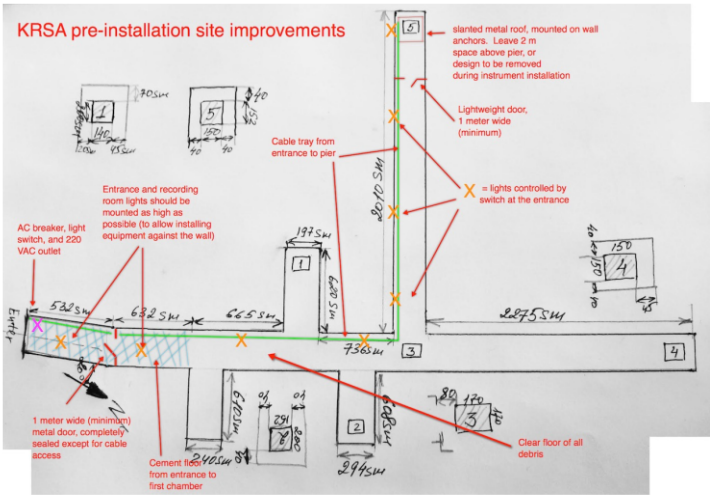


Figure 9. Schematic of existing tunnel layout with suggested improvements.

Table 2. Example of significant risks identified during design review and mitigation.

Risk	Mitigation
Pre-installation	
• Hazardous wiring	Funded site prep; pre-install visit
• Secure doors	Funded site prep; pre-install visit
• Tunnel cleanup	Funded site prep; pre-install visit
• High seismic noise	Noise survey
Installation	
• Drilling pier	Used vault sensor
Environmental	
• Water in tunnel	Tunnel lining
• Heat in summer	Insulated building with air conditioning.
Power	Double-stack of backup batteries; line conditioner
Communication	Pre-install visit; cell phone as contingency.
Long-term support	Training; collaboration

Identified risks were tunnel hazards such as water/moisture in the tunnel, location of the equipment rack, reliability of the local AC power, and installation of the sensor. Mitigation required a noise survey, extensive site preparation, and revised design considerations (such as double stack of batteries). Previous experience demonstrated that the main IDA equipment and power rack is susceptible to moisture and condensation in damp tunnels and therefore the preferred solution was to place in a separate building outside. An existing trailer was found at the site, but the floor was in poor condition (rotted wood) and our preferred solution was to establish a new building with proper environmental conditions. We also requested preparation of the tunnel itself to reduce water drippage, loose rock, and new wiring (Figure 9).

Noise survey. To assess noise levels, it was decided to conduct a noise survey at the site and an alternate location. Two portable sensors were sent to MES (via the US Embassy and these were installed for a period of several weeks by MES personnel. In addition to measuring noise levels, the survey was useful

in building teamwork between MES and UCSD, providing experience for MES with equipment similar to the future station, and with experience in shipping to Uzbekistan. The results (Figure 10) showed that noise levels at JXAX were reasonable, and a joint publication was presented at the 2021 American Geophysical Meeting (Mellors et al., 2021).

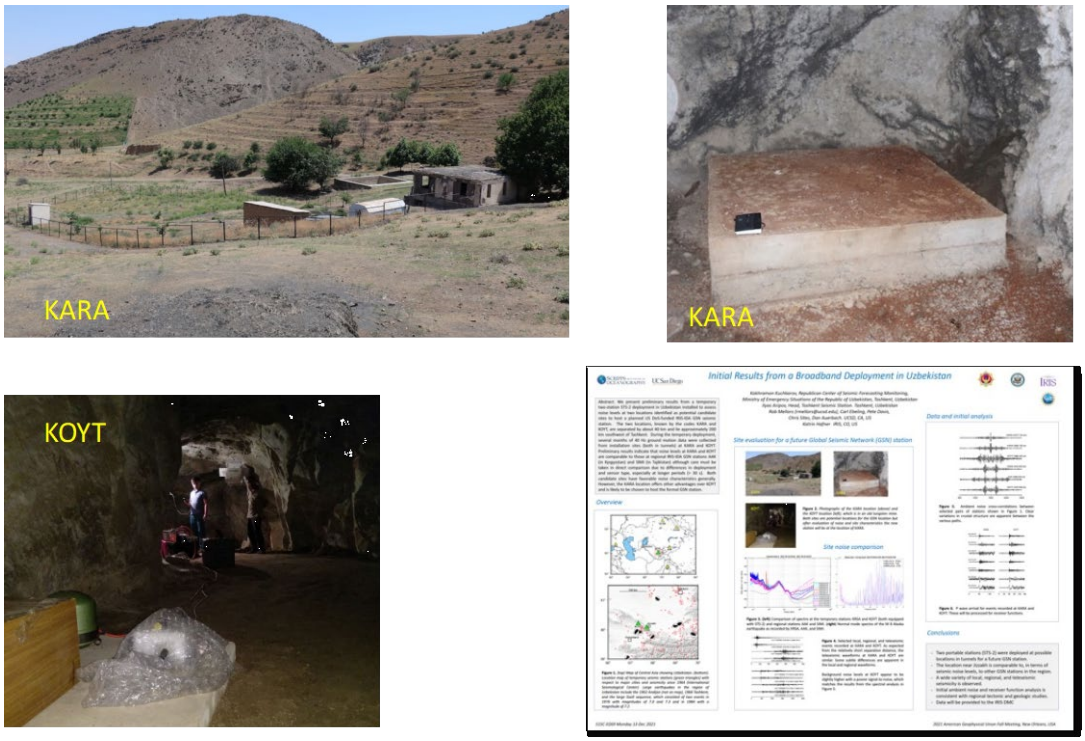


Figure 10. Photos from the site survey at the location of the station (portable station named KARA) and at a tungsten mine about 40 km to the northeast near the town of Koytash (KOYT). Lower right is the poster presented at the 2021 AGU meeting.

Sensor change. One significant change was the sensor. At the time of the original purchase, the only available very broad band (VBB) sensor was the STS-6, which is a borehole sensor. Installation of an STS-6 in a pier required drilling of a cylindrical borehole and does not always yield good results, especially in a pier with concrete of uncertain quality. By the time of the design review, the GSN standing committee had approved a new very broad-band vault sensor, the Nanometric T360 and the review committee suggested that a vault sensor would be a better solution. Accordingly, we requested a sensor swap from the Dept of State to be replaced with National Science Foundation equipment of equal value, which was approved.

Site preparation. A site visit was made by R. Mellors to Uzbekistan in November 2021 after COVID travel restrictions were lifted (Figure 11). An examination of the existing trailer ("wagon") that existed on site showed that the floor was in poor condition and that the preferable path forward would be the construction of a new building. After iteration on the expected design, MES provided an estimate of the costs for site preparations (Figure 12).

After some negotiation, UCSD agreed to partially fund the site preparation according to our design. This required another MOU as an addendum and a request by the US ambassador to the MES director. Site preparation work started in September 2022. The major aspects were renovation of the tunnel (installation of a tiled floor, wall and ceiling lining, completely new electrical and lights, and a door to isolate air flow

from the pier). The tunnel entrance was also renovated, and a new secure door installed. Externally, a small brick building was constructed as well as some landscape improvements (Table 3). A site visit was made in February 2023 to examine the site preparation and test telemetry (Figure 13 and 14). All improvements were approved except for some needed modifications to the seismic pier. The internet connection proved suitable, and the alternate solution of cell phone telemetry was deemed unnecessary.

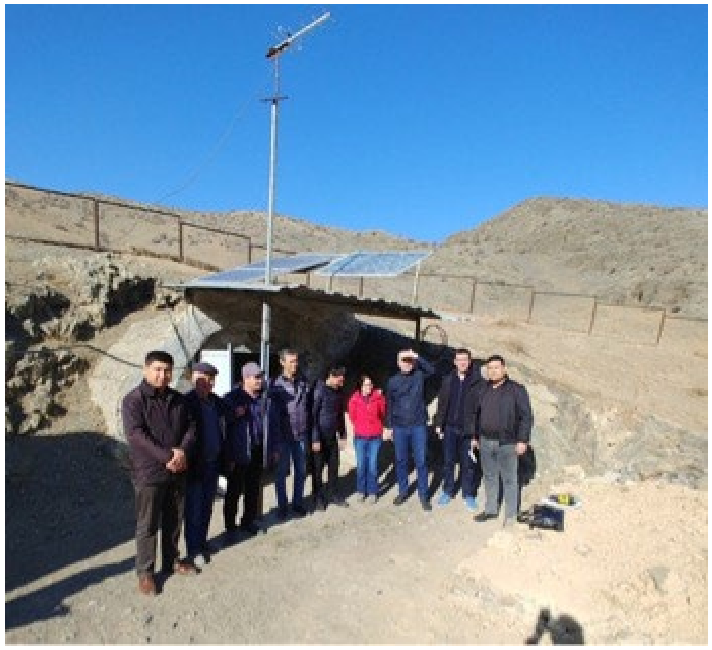
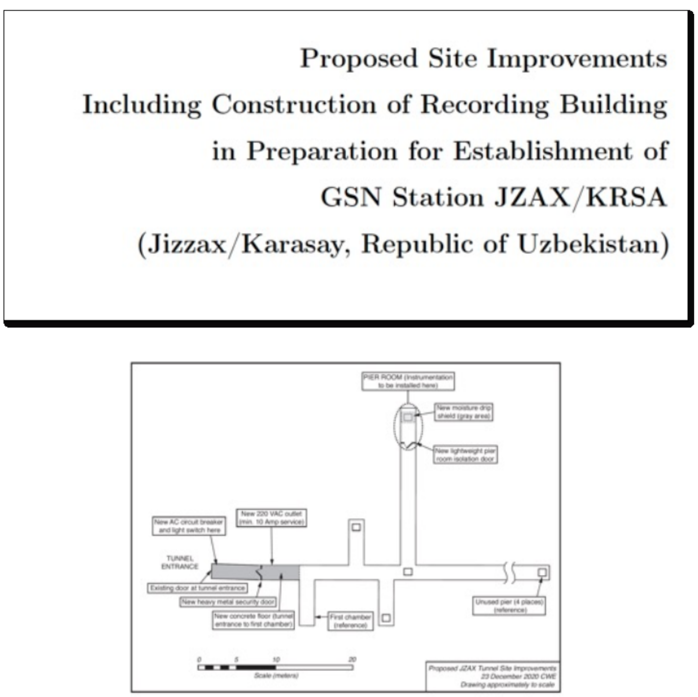
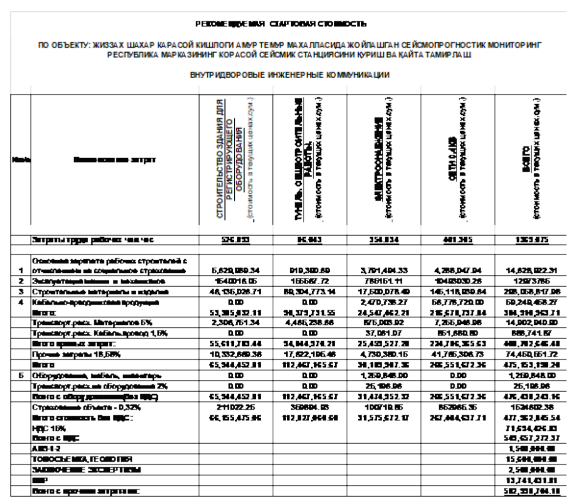


Figure 11. Photo of group that visited the JZAX site in November 2021 (US Embassy and MES).





РЕКОМЕНДУЕМАЯ СТАРТОВАЯ СТОИМОСТЬ

ПО ОБЪЕКТУ: ЖИЗЗАХ ШАХАР КАРАСОЙ КИШЛОГИ АМУР ТЕМУР МАХАЛЛАСИДА ЖОЙЛАШГАН СЕЙСМОПРОГНОСТИК МОНИТОРИНГ РЕСПУБЛИКА МАРКАЗИНИНГ КОРАСОЙ СЕЙСМИК СТАНЦИЯСИНИ ҚУРИШ ВА ҚАЙТА ТАМИРЛАШ

ВНУТРИДВОРОВЫЕ ИНЖЕНЕРНЫЕ КОММУНИКАЦИИ

[illegible]	[illegible]	СТРОИТЕЛЬСТВО ЗДАНИЯ ДЛЯ РЕГИСТРИРУЮЩЕГО ОБОРУДОВАНИЯ (стоимость в текущих ценах,сум.)	ТУННЕЛЬ, ОБЩЕСТРОИТЕЛЬНЫЕ РАБОТЫ (стоимость в текущих ценах,сум.)	ЭЛЕКТРОСНАБЖЕНИЕ (стоимость в текущих ценах,сум.)	СЕТИ 0,4 КВ (стоимость в текущих ценах,сум.)	ВСЕГО (стоимость в текущих ценах,сум.)
	Затраты труда рабочих чел.час	[illegible]	[illegible]	354.834	[illegible]	[illegible]
1	Основная зарплата рабочих строителей с отчислениями на социальное страхование	5,629,080.34	[illegible]	3,791,404.33	4,288,047.04	14,628,022.31
2	Эксплуатация машин и механизмов	1540016.05	155587.72	788151.11	10408030.26	12973785
3	Строительные материалы и изделия	48,135,026.71	89,304,773.14	17,500,078.49	145,118,030.64	298,058,817.98
4	Кабельно-проводниковая продукция	0.00	0.00	2,470,739.27	56,778,720.00	59,249,459.27
	Итого:	53,305,932.11	[illegible]	24,547,462.21	[illegible]	[illegible]
	Транспорт.расх. Материалов 5%	2,306,751.34	4,465,238.66	875,003.92	7,255,946.96	14,902,940.90
	Транспорт.расх. Кабель.провод 1,5%	0.00	0.00	37,061.07	851,680.80	888,741.87
	Итого прямых затрат:	55,611,783.44	[illegible]	25,459,527.28	[illegible]	[illegible]
	Прочие затраты 18,58%	10,332,669.36	17,622,196.46	4,730,380.16	41,765,306.73	74,450,551.72
	Итого	65,944,452.81	112,467,165.67	[illegible]	[illegible]	475,153,198.24
5	Оборудование, мебель, инвентарь	0.00	0.00	1,259,848.00	0.00	1,259,848.00
	Транспорт.расх.на оборудование 2%	0.00	0.00	25,196.96	0.00	25,196.96
	Всего с оборудованием (без НДС)	65,944,452.81	112,467,165.67	31,474,352.32	[illegible]	[illegible]
	Страхование объекта - 0,32%	211022.25	[illegible]	100718.85	[illegible]	1524602.38
	Итого стоимость без НДС:	66,155,475.06	[illegible]	31,575,072.17	[illegible]	477,362,845.54
	НДС 15%					71,634,426.83
	Всего с НДС					[illegible]
	АПП-1-2					[illegible]
	ТОПОСЪЕМКА, ГЕОЛОГИЯ					[illegible]
	ЗАКЛЮЧЕНИЕ ЭКСПЕРТИЗЫ					[illegible]
	ПИР					13,741,431.81
	Всего с прочими затратами:					[illegible]

MES cost estimate

Figure 12. (left) Example of revised plans for site preparation and (right), estimated cost table prepared by MES (in Russian and Uzebk som).

Table 3. Timeline of last year of work.

- 2022/2023: Additional monthly telecoms
- Site preparation discussions (assisted by a site visit from K. Mackey, MSU).
- MES reluctant to implement all improvements due to cost; UCSD offered to defray some of the costs.
- This required agreement by the MES director.
- After a meeting between the U.S. ambassador and the MES director, an MOU was signed (August 2022) and funds sent to MES.
- October 2022: work started, first shipment of station equipment
- February 2023: R. Mellors and D. Auerbach visit site to evaluate progress and test communications link.
- March/April 2023: UCSD field engineers install station.
- May 2023: Official ribbon-cutting (attended by Ambassador, MES deputy director, and myself)
- May 2023 R. Mellors visits Tashkent again on return from Kazakhstan.

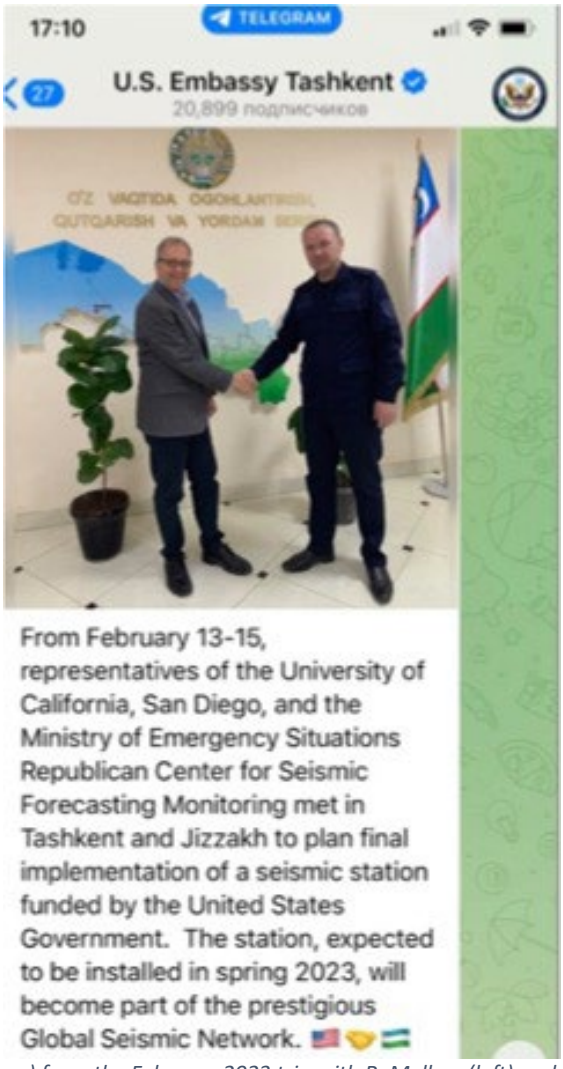


Figure 13. Photo (via US Embassy telegram) from the February 2023 trip with R. Mellors (left) and the director of the MES seismic center, K. Kakramon.

Figure 14. Photo of newly constructed station building (left) and tunnel (right) showing improvement (before tunnel photo shown for comparison).

Site installation. Equipment and installation tools were sent in two shipments (Table 4) via the Embassy and delivered to the site by MES. A team of three UCSD field engineers performed the installation in late March 2023. The installation went smoothly, with no major problems (Figures 15). A ribbon-cutting ceremony that attended by an assistant director of the MES and the U.S. Ambassador was held in early May (Figure 16 and 17).

Figure 15. A). Seismic pier with seismic sensors (uncovered for clarity). B) View of seismic vault showing sensors and digitizers (at left). C) Outside of vault door. D) Looking down tunnel towards entrance (from inspection trip). E) Outside of tunnel. GPS antenna at top.

Figure 16. A) Recording room building from outside. B) Equipment rack (and laptop showing seismogram). C) Battery backup.

Figure 17. The facility was inaugurated by U.S. Ambassador Jonathan Henick and the Deputy Minister of MES, Muhitdinov Muhtar, who cut a ribbon to mark the occasion on May 3. From U.S. Embassy telegram channel (https://t.me/s/USAUzbekistan)

Host training and continued cooperation. A key aspect of new stations is ensuring that the host organization has adequate training to continue station operation. Training was performed during installation and after the ribbon-cutting ceremony. MES staff successfully replaced a failed GPS antenna in late May, which may have been due to lightning.

Table 4. Significant equipment (value > $1,000) currently installed in Uzbekistan as part of the JZAX seismic station. Bold indicates high-value. Asterisks (*) indicate the equipment was part of an equipment exchange (equal value) between Dept. of State and National Science Foundation (NSF) (executed 8/31/2022). The STS2.5 and the T360 were exchanged for an STS6 sensor (#206104) which was originally purchased using Dept of State funds.

Serial number	Description
	Steel – Equipment Rack, 19" Schroff
	Transformer – Topaz Isolation
STL1911LPC48205	Computer – Stealth PC - LPC-480G4FS
STL1911LPC78266	Computer – Stealth PC - LPC-480G4FS
7176	**Geophysical Intrument – Quanterra Q330-00 HR seismic system**
7184	**Geophysical Intrument – Quanterra Q330-00 HR seismic system**
192245	**Geophysical Instrument – STS-2.5 Broadband Seismometer**
170235	Geophysical Instrument – STS-2.5 Sensor Interface Host Box
N/A	Cable – STS-2.5 Sensor to Host Box Cable
N/A	Cable – STS-2.5 Host Box to Q330-10 Sensor A Cable
120346	**Geophysical Instrument – STS-2.5 Broadband Seismometer***
110413	Geophysical Instrument – STS-2.5 Sensor Interface Host Box
N/A	Cable – STS-2.5 Sensor to Host Box Cable
N/A	Cable – STS-2.5 Host Box to Q330-10 Sensor A Cable
133	**Geophysical Instrument – Trillium T360 – SV Seismometer***
N/A	Cable – T360 Cable
19370007	Integrated Power System – NewMar IPS-48-11
9172	Geophysical Instrument – Episensor ES-T (Isolated Supply Option) Accelerometer – FBA ES-T-ISO
N/A	Cable – Episensor (ISO) to Q330-00 Sensor B Cable
7567802	Geophysical Instrument – Setra Barometer Model 270 / cable
N/A	Battery – Lifeline/Concorde non-spillable lead acid – GPL-31T (4)

4. Results, Conclusions, and Suggestions for Future Work

Significant results were 1) the establishment of a new global quality seismic station and 2) initiation of a new partnership with the main seismic monitoring agency in Uzbekistan. In addition to the scientific objectives, we believe this cooperation contributed to the long term U.S. Uzbekistan partnership and has contributed to the development of other projects related to seismic monitoring and earthquakes hazard mitigation (https://uz.usembassy.gov/global-seismic-network-station/).

Data from the station is provided to the EarthScope Data Management Center (DMC) and openly available (network code II, station name JZAX). Some analyses, as part of routine station data quality control, has been conducted (Figures 18, 19 and 20) and the data quality looks good, with overall low background noise levels and comparable with other stations in the region.

The host agency (MES) is in the process of upgrading the Uzbekistan seismic network, which serves mainly for earthquake monitoring and seismic hazard. Initial discussions with MES indicate that they might be willing to make this data available, which would greatly improve the resolution of any regional seismic velocity or attenuation models. A second possibility would be the installation of additional stations, either temporary or permanent, in the northwest of the country, which is expected to be extremely seismically quiet. Other possibilities are exchange visits or encouraging cooperation between neighboring counties.

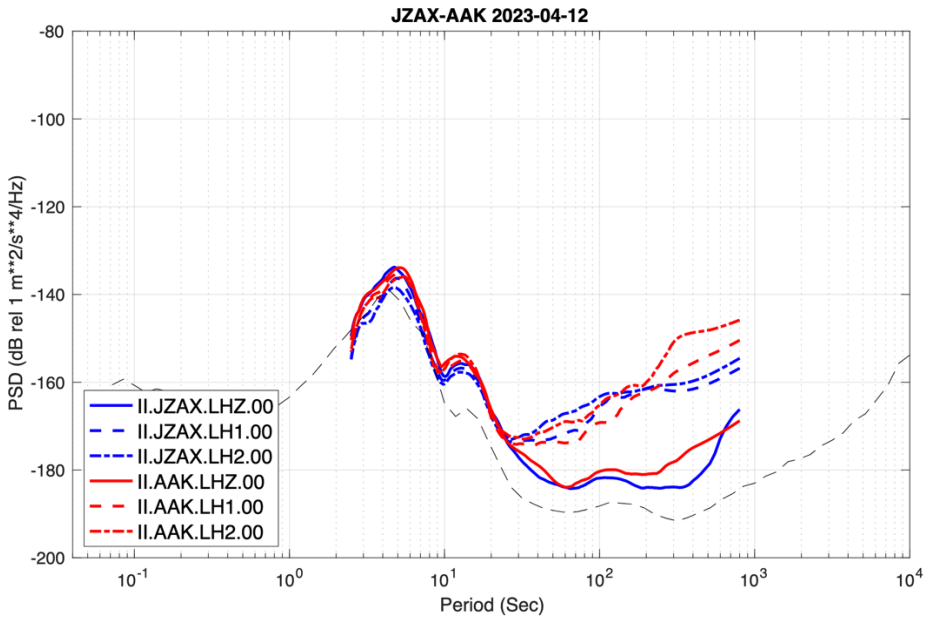


Figure 18. Power spectral plots of the station JZAX (blue) with the IDA station AAK (red).

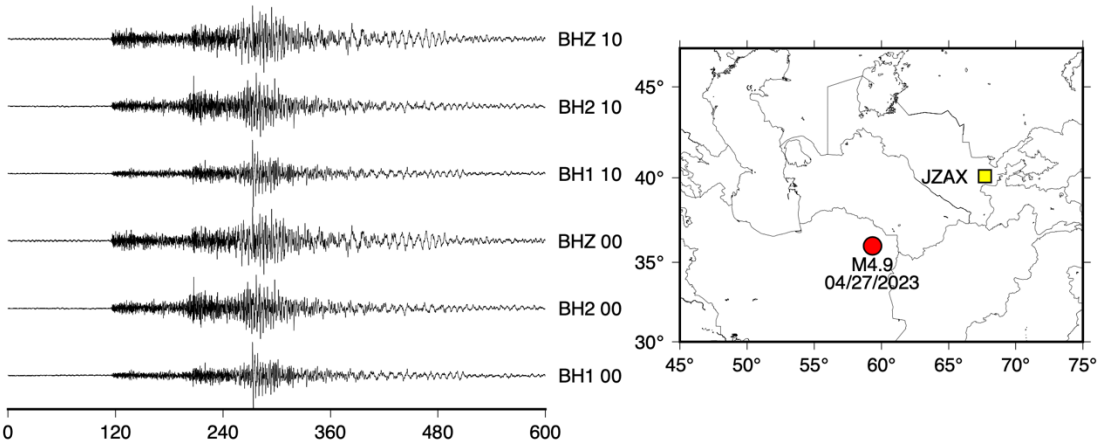


Figure 19. Example seismogram for the T360 sensor ("00") and the STS2.5 ("10") for a regional earthquake.

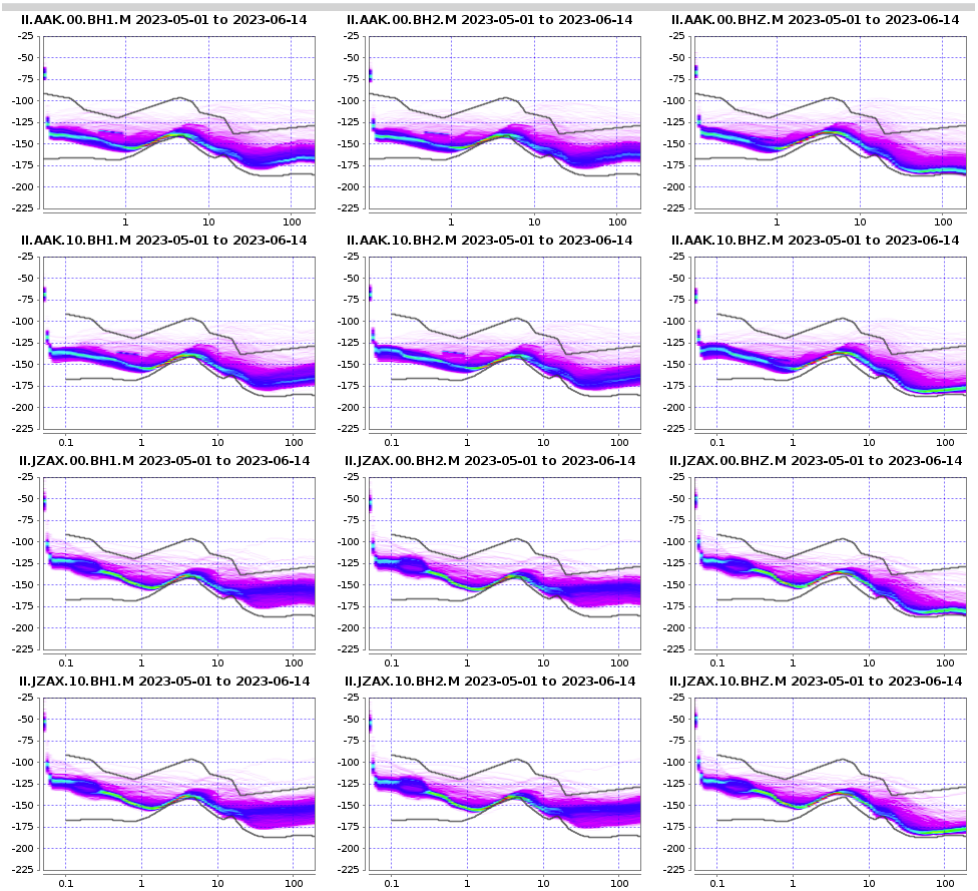


Figure 20 Comparison of AAK and JZAK for six weeks between May 1 and June 16 2023. The left two columns are horizontal sensors, and the rightmost column is the vertical. Each Station has two seismometers. The plot can be updated, or individual panel images grabbed here

5. Acknowledgments.

This project would not have been possible without contributions from many people. Elizabeth Gesson of the U.S. Embassy in Tashkent played an invaluable role in leading and managing the collaboration between UCSD and MES and this project could not have been completed without her assistance. Ekaterina Biryukova and Jakhongir Mavlany also provided invaluable assistance, as did the U.S. Embassy logistics and shipping team. Glen Offield aided in station design. David Chavez conducted an initial site survey and assisted in the installation. Kevin Mackey of the Michigan State University added valuable insights in a site preparation survey. Finally, we wish to thank the staff of the Ministry of Emergency Situation's Republican Center for Seismic Forecasting Monitoring of Uzbekistan for their collaboration, assistance, and hospitality. We thank the U.S. Dept of State (Award 19AQMM18P2535) and the U. S. National Science Foundation (SAGE Facility CSA EAR-2310069) for support.

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https://uz.usembassy.gov/global-seismic-network-station/ [accessed on June 16, 2023].

Robert J Mellors1, Kakhramon Kuchkarov, Ilyas Aripov, Carl W Ebeling, Peter Davis, Chris Sites and Katrin Hafner, Initial results from a broadband deployment in Uzbekistan, S15C-0269

Mellors, Robert, 1995, Two studies in central Asian seismology: A teleseismic study of the Pamir/Hindu Kush seismic zone and analysis of data from the Kyrgyzstan broadband seismic network, Ph.D thesis, Indiana University, 224 pages.

7. Appendix A. AGU poster.

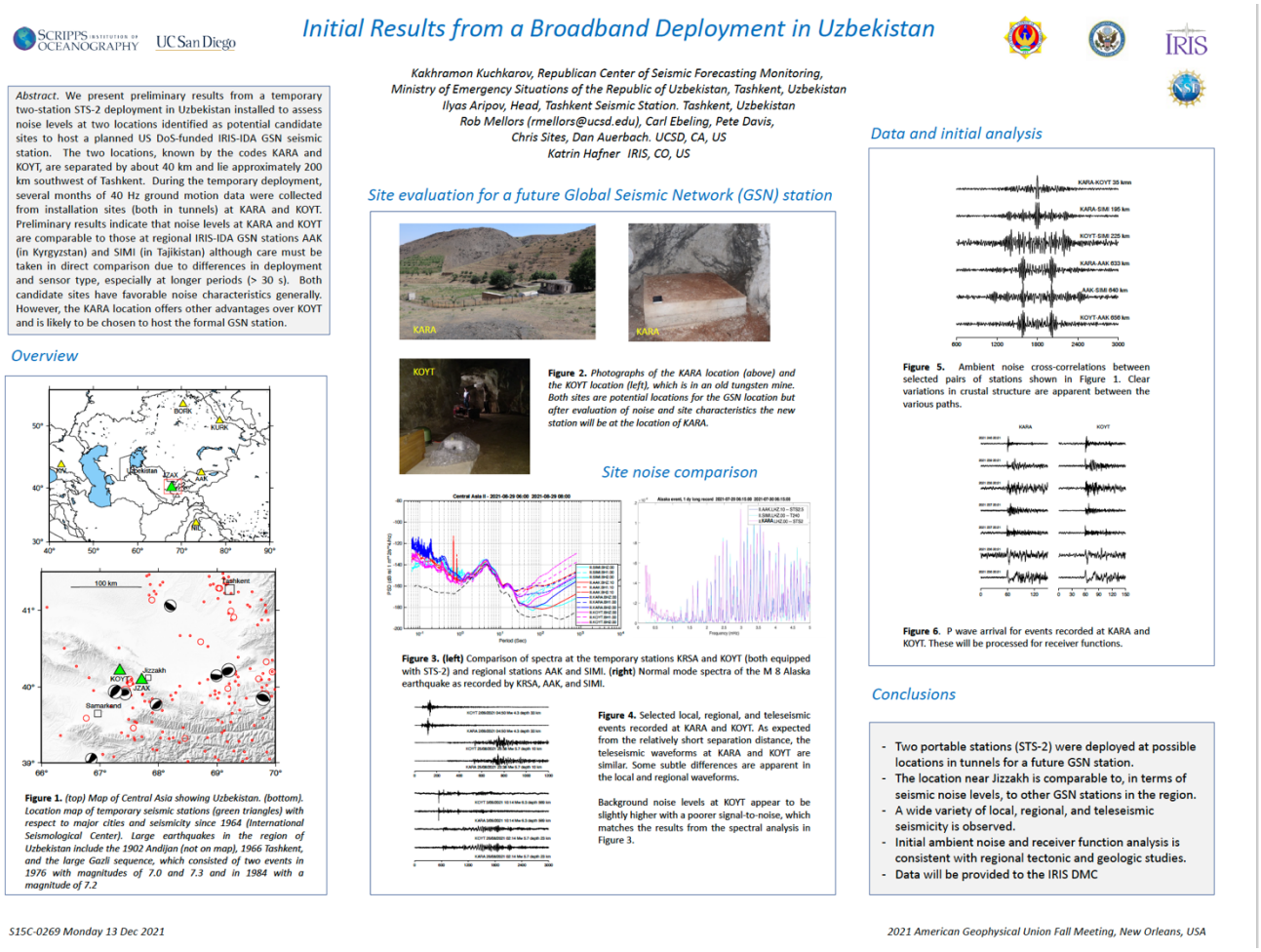
American Geophysical Union Fall Meeting, 2021

S15C-0269 Initial results from a broadband deployment in Uzbekistan

Robert J Mellors1, Kakhramon Kuchkarov2, Ilyas Aripov3, Carl W Ebeling4, Peter Davis4, Chris Sites4 and Katrin Hafner5, (1)University of California San Diego, Scripps Institution of Oceanography, La Jolla, United States, (2)Republican Center of Seismic Forecasting Monitoring, Tashkent, Uzbekistan, (3)Tashkent Seismic Station, Tashkent, Uzbekistan, (4)Scripps Institution of Oceanography, IGPP, La Jolla, CA, United States, (5)IRIS, Longmont, CO, United States

Abstract. We present results from a small temporary broadband deployment in Uzbekistan. The objectives of the deployment were to assess noise levels for a proposed future IRIS/IDA GSN seismic station funded by the US Dept. of State. The location is approximately 200 km southwest of Tashkent in a slightly mountainous setting. The full GSN station will have a very broad band sensor, a broad band seismometer, and a strong motion instrument. To obtain a preliminary noise evaluation, an STS-2

seismometer was deployed in a tunnel and several weeks of data have been collected. Preliminary evaluation shows noise levels comparable to regional IRIS/IDA stations AAK in Kyrgyzstan and SIMI in Tajikistan although signals from a railroad approximately 2 away are evident. A wide variety of regional seismic signals are recorded including from the Hindu Kush/Pamir seismic zones, the Tien Shan, and the Caspian/Caucasus. We expect to show ambient noise correlation and receiver function analysis.



8. Appendix B. 2018 MOU

Initial MOU signed with the Institute of Seismology, Academy of Sciences of Uzbekistan.

AGREEMENT

BETWEEN THE INSTITUTE OF SEISMOLOGY ACADEMY OF SCIENCES OF UZBEKISTAN AND THE INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS, UNIVERSITY OF CALIFORNIA - SAN DIEGO ON SCIENTIFIC AND TECHNICAL COOPERATION IN THE FIELD OF EARTHQUAKE MONITORING

The Institute of Seismology of the Academy of Sciences of the Republic of Uzbekistan and the Institute of Geophysics and Planetary Physics, University of California of the United States of America San Diego, hereinafter referred to as the "Parties":

- Considering the critical importance of seismic monitoring systems to risk management alert frameworks in reducing the effects of earthquakes, and to seismic hazard assessment and the benefit of international co---operation in improving the efficiency of determining catastrophic earthquake parameters;
- Based on the prospects for the development. of the technological capabilities the open global seismographic network (Global Seismographic Network, hereinafter GSN), supported by the United States National Science Foundation through a non--- profit consortium (Incorporated Research Institutions for Seismology, hereinafter IRIS) and the Institute of Seismology Academy of Sciences of the Republic of Uzbekistan, responsible for monitoring the regional seismicity;
- On the basis of the provisions of the Agreement between the Government of the Republic of Uzbekistan and the Government of the United States of America on scientific and technical cooperation signed on December 2, 2010 it is agreed as follows:

ARTICLE 1

Terms of the agreement

Both parties agree to cooperate on improving warning efficiency of strong earthquake risk management agencies, and on the development of an experimental facility for seismological research, and have concluded this Agreement to establish and jointly operate the seismographic station "Karasai", located in the Jizzax district of Jizzax region of Uzbekistan, and herein after referred to as "JZAX".

ARTICLE 2

Rights of each party

Both parties have the right to unrestricted access to JZAX data via telemetry channels. The national network of seismic monitoring of the Republic of Uzbekistan has unrestricted access to IRIS data seismographic stations located on the territory of Central Asia in real time. JZAX data will be made available to the international community through the IRIS seismological data management system.

ARTICLE 3

Responsibilities of the Institute of Geophysics and Planetary Physics University of California, San Diego

- Shall provide the delivery, installation and commissioning of equipment necessary for seismographic observations, including hardware and software for data acquisition;
- Shall pay all costs associated with shipping, customs procedures, furnishing, installation and commissioning the equipment at the station;
- Shall provide all necessary spare parts of the equipment required for the operation of the station Shall provide training to the staff of the Institute of Seismology of the Academy of Sciences of the Republic of Uzbekistan on the operation of technological equipment;
- Is responsible for monitoring and managing via telemetry control the technical condition of the equipment and, if necessary, to quickly resolve issues required to maintain station functionality.

ARTICLE 4

Responsibilities of the Institute of Seismology Academy of Sciences of the Republic of Uzbekistan

Institute of Seismology of the Academy of Sciences of the Republic of Uzbekistan:

- Is responsible for obtaining the permission for performing site repairs, for installation of the station equipment and for the transmission of seismic data through a communications provider of the Republic of Uzbekistan to the IRIS Data Management Center and the Analytical Center of the Institute of Seismology of the Academy of Sciences of the Republic of Uzbekistan, in accordance with the laws of the Republic of Uzbekistan;
- Is responsible for the staffing and maintenance of the station, for the guaranteed timely receipt of data, and to quickly respond to the IRIS staff requests for diagnostic tests;
- Is responsible for ensuring the physical security of the equipment installed at station JZAX.

ARTICLE 5

Special conditions

This agreement does not provide for the transmission of confidential or secret information, and does not give rise to any obligation of the parties to allocate funds.

ARTICLE 6

The procedure for making changes and amendments

Upon mutual agreement, this Agreement may be modified and amended provided all changes are in writing and shall form an integral part of this Agreement.

ARTICLE 7

Term of Agreement

This Agreement shall enter into force on the day of its signing. This Agreement shall remain in force for five (5) years and shall be automatically extended for an additional five (5) years, unless either Party provides the other written notice that it does not wish to renew the agreement at least six (6) months prior to the expiry of the five year period.

Either Party may terminate this Agreement at any time with six (6) months written notice to the other Party.

ARTICLE 8

Resolution of disputes

In case of a dispute concerning the interpretation or application of this Agreement, the Parties shall resolve them through negotiations and consultations.

Signed at Sk+SAN DIEGO + CA " USA " 6 APRIL 2018, in two original copies, each in Russian and English languages. In the event of discrepancies in t translations the English text shall prevail.

S. S. Husamiddinov
Director of the Institute of Seism
Academy of Sciences
Republic of Uzbekistan

Peter Davis
Inst. Of Geophysics & Planetary
Physics University of California — San
Diego Unite States of America

9. Appendix C. 2020 MOU

AGREEMENT

between the Republican Center of seismic forecasting monitoring of the Ministry of Emergency Situations of the Republic of Uzbekistan and the Institute of Geophysics and Planetary Physics University of California of the United States of America on scientific and technical cooperation in the field of earthquake monitoring

The Republican Center of seismic forecasting monitoring (hereinafter RCSFM) of the Ministry of Emergency Situations of the Republic of Uzbekistan and the Institute of Geophysics and Planetary Physics University of California of the United States of America, (hereinafter - IGPP) referred to as the "Parties":

a) Considering the importance of seismicity monitoring systems for alerting risk management structures, reducing the effects of major earthquakes, assessing seismic hazard and the high efficiency of international cooperation in increasing the efficiency of determining the characteristics of catastrophic earthquakes;

b) Based on the prospects for the development of technological capabilities of the open Global Seismographic Network (hereinafter - GSN), supported by the USA National Science Foundation through the non-profit consortium (Incorporated Research Institutions for Seismology, hereinafter – IRIS) and the Republican Center of seismic forecasting monitoring of the Ministry of Emergency Situations of the Republic of Uzbekistan, responsible for seismicity monitoring in the republic;

c) Based on the provisions of the Agreement between the Government of the Republic of Uzbekistan and the Government of the United States of America, on scientific and technical cooperation of December 2, 2010 agreed the following:

ARTICLE 1

Subject of Agreement

Parties, in order to cooperate to increase the efficiency of warning of strong earthquakes in risk management structures and development of the experimental base of seismological studies, have concluded this Agreement on establishment of a point of seismographic observations and its joint operation at the "Karasai" seismic station (code "JZAX"), which is located in the territory of the Jizzakh region.

ARTICLE 2
Rights of each parties

Parties have the right to access the "Karasai" seismic station via telemetric communication channels, which will also be available to the global seismological community through the IRIS Data Management System.

The National Network of Seismic Monitoring of the Republic of Uzbekistan gets direct access to real-time data from IRIS seismographic stations located in Central Asia.

ARTICLE 3
Duties of the Republican Center of seismic forecasting monitoring of the Ministry of Emergency Situations of the Republic of Uzbekistan

The Republican Center of seismic forecasting monitoring of the Ministry of Emergency Situations of the Republic of Uzbekistan:

1.1. is duty for obtaining permission to arrange, install seismographic equipment and transmit surveillance data through the communications operator of the Republic of Uzbekistan to the IRIS monitoring center and the Urgent Reporting Service of the RCSFM in accordance with the legislation of the Republic of Uzbekistan;

1.2. appoints a responsible operator and station maintenance for guaranteed data acquisition, quickly responds to requests from IRIS personnel regarding equipment diagnostics;

1.3. ensures the safety of equipment at the point of seismographic registration.

ARTICLE 4
Duties of the Institute of Geophysics and Planetary Physics University of California of the United States of America

Institute of Geophysics and Planetary Physics University of California:

1.1. provides delivery, installation and commissioning of a set of equipment for seismographic observations, including hardware and software for receiving and accumulating data;

1.2. makes payment of all costs associated with the transportation of goods by customs procedures, arrangement, installation and commissioning of necessary equipment at the station;

1.3. provides the supply of equipment spare parts required for station operation;

1.4. provides training for the personnel of the RCSFM in the amount of 2 people on the operation of the seismic and communication equipment at the seismic station and works to identify opportunities for RCSFM personnel to receive training on modern information technologies for the collection, storage and processing of seismological data;

1.5. performs telemetric monitoring of the technical condition of equipment and, if necessary, quickly solves issues of restoration of station functionality.

ARTICLE 5
Special conditions

This Agreement does not provide for the transfer of confidential or secret information and does not give rise to any Parties financial commitment.

ARTICLE 6
The procedure for making changes and amendments

By mutual Agreement of the Parties, this Agreement may be amended and supplemented in writing by the relevant protocols, which are an integral part of this Agreement.

ARTICLE 7
Term of Agreement

This Agreement shall enter into force on the day of its signing.

This Agreement shall remain in force for 5 (five) years and automatically renews for the next 5 (five) years, unless one of the Parties notifies the other Parties in writing that she does not wish to renew the Agreement, at least 6 months before the expiration of the five-year period.

This Agreement may be terminated at any time, by any of the Parties 6 (six) months after the written notification is sent to the other Parties.

ARTICLE 8
Resolution of disputes

In case of disagreement regarding interpretation or applying the provisions of this Agreement, the Parties authorize them through negotiations and consultations.

Signed on 2020 in two original copies, each in English and Russian, the text in English being prevailing in case of disagreement in the interpretation of the provisions of this Agreement.

10. Appendix D. 2022 MOU supplement

PROTOCOL

On amendments to the Agreement between the Republican Center for Seismic Forecasting Monitoring of the Ministry of Emergency Situations of the Republic of Uzbekistan and the Institute of Geophysics and Planetary Physics, University of California, United States of America, on scientific and technical cooperation in the field of earthquake monitoring dated October 15, 2020

The Republican Center for Seismic Forecasting Monitoring of the Ministry of Emergency Situations of the Republic of Uzbekistan (hereinafter referred to as RCSFM MES RU) and the Institute of Geophysics and Planetary Physics, University of California San Diego of the United States of America (hereinafter referred to as the IGPP), hereinafter referred to as the "Parties", in accordance with Article 6 of the Agreement signed between the RCSFM and the IGPP in October 2020, agreed on the following:

Article 1

Add the following amendments:

"Amend Article 1 with new paragraphs with the following content:

*"In order to improve conditions at the **Karasai** seismic station, IGPP will provide one-time financial support to the RCSFM MES RU to cover the costs of the site preparation before installing equipment for the GSN station by IGPP.";*

"Equipment will include (but not be limited to) seismic sensors, digitizers, an equipment rack with electrical transformers, computers, internet equipment, and various special power and data cables."

Article 2

Supplement Articles 4.1 and 4.2 with the following:

"Article 4.1 Organization of Construction Work and Costs"

1. IGPP covers the following expenses for:

*1.1.Tunnel improvements at seismic station **Karasai** to provide the best environment for GSN equipment.*

1.2. Construction of a new building as close as possible to the tunnel entrance and suitable for GSN equipment into the tunnel and suitable for GSN station equipment.

1.3. Upgrades to the electrical power in the tunnel suitable for GSN equipment.

1.4. Upgrades to the power supply to the Karasai seismic station site.

2. The funds provided by IGPP will not exceed US $55,000 (fifty-five thousand US dollars only). Any change must be mutually agreed upon by both parties.

3. 100 % of the funds will be provided in advance of the beginning of construction.

4. RCSFM MES RU will be responsible for the implementations and construction of the improvements and the building, for purchase of necessary materials, and for any required permits and approvals.

5. IGPP will provide designs and guidance for the buildings and improvements.

6. During implementation and construction, RCSFM MES RU will inform IGPP of progress and of any significant changes that may be necessary. As needed, IGPP would be able to send field engineers to review and advise. These trips would be funded by IGPP.

7. The improvements and any building will be the property of RCSFM MES RU.

8. All equipment provided by IGPP is and will remain the property of the United States Government unless mutually agreed otherwise.

9. IGPP will use the following banking information when arranging the transfer of funds to the MES:

Bank name: Central Bank of the Republic of Uzbekistan. Address: 6, Islam Karimov street, Tashkent 100001 Uzbekistan;

Bank SWIFT code: CBUZUZ22;

Beneficiary Name: RCSFM MES RU;

Beneficiary account number: 4900 1084 0262 6970 1510 0175 001.

"Article 4.2 Organization of Training Courses and Exchange of Experience"

1. Organize training courses in the field of seismicity and seismic hazard monitoring (online or offline).

2. Invite leading scientists and researchers from IGPP to RCSFM MES RU for the exchange of experience in the field of seismic monitoring. IGPP will pay their own travel and all other expenses.

3. Organize short-term training courses in the field of earthquake monitoring for specialists of the RCSFM MES RU at IGPP. Uzbekistan will cover travel and all other expenses for travel of RCSFM MES RU specialists.

Article 3

1. This Protocol shall enter into force on the date of its signing and is valid until the termination of the Agreement.

2. Signed on "18" July 2022 in two original copies, each in English and Russian, the text in English being prevailing in case of disagreement in the interpretation of the provisions of this Protocol.

For the Republican Center for Seismic Forecasting Monitoring of the Ministry of Emergency Situations of the Republic of Uzbekistan

K.I. Kuchkarov

For the Institute of Geophysics and Planetary Physics, University of California, United States of America

Endorsed by the Incorporated Research Institutions for Seismology (IRIS), managing organization of SAGE (Seismological Facilities for the Advancement of Geophysical Research)

Robert Woodward