

**TECHNICAL ADVISORY COMMITTEE
TO TEXNET AND BUREAU OF ECONOMIC GEOLOGY**

Meeting Minutes

Tuesday, March 26, 2024 – 11:30 a.m. to 3:30 p.m.

OPENING

The meeting of the TexNet Technical Advisory Committee was called to order at ~11:30 a.m. on Tuesday March 26, 2024.

PRESENT

Alexandros Savvaidis, Manager of TexNet

Brian Stump, Committee Chair

Mark Boyd, Committee Member (via TEAMS)

Dave Cannon, Committee Member

Chris Hillman, Committee Member

Jeff Nunn, Committee Member

Kris Nygaard, Committee Member

Aaron Velasco, Committee Member

Scott Mitchell, Committee Member

Larry French, Committee Member

Mark Shuster, Interim Director, Bureau of Economic Geology

Ken Wisian, Associate Director, Bureau of Economic Geology

Elizaveta Rybina, TexNet Admin Program Coordinator

Paul Dubois, Assistant Director, Railroad Commission of Texas (During the agenda item #8)

AGENDA FOR MARCH 26th MEETING

1. Approval of Minutes of the December 6th, 2023, meetings.
2. Introduction of new TAC Member and BEG Interim Director (15 min)
3. Update on hiring plan (15 min)
4. Lunch with the new hires (45 min, noon to 12:45pm)
5. Update on releasing M1.5+ auto-picked events (15min)
6. Operations (eq status/maintenance, resources) (30min)
7. Budget discussion (1hr)
8. Information from TRRC related to water and pressure reporting tool (15min)
9. Publications and presentations update (15 min)
10. Suggestions for the subsequent meetings (30min)

APPROVAL OF DECEMBER 6TH, 2023 MEETING MINUTES

1. Brian Stump informed Larry French, a new TAC member, that the Minutes would be posted on the TexNet website as part of an open meeting and would be accessible to the public.
2. The Committee reviewed the December 6th, 2023, Meeting Minutes with no changes being suggested; as such a motion was made to approve the Meeting Minutes and the motion unanimously approved.
3. Chris Hillman stressed the importance of keeping discussions open, as well as having all records, including texts, emails, voicemail, public for the transparency perspective, as TAC is a public entity. He also suggested having a brief open meeting training session once a year to ensure that TAC maintains the State Statute.

INTRODUCTION OF NEW TAC MEMBER AND BEG INTERIM DIRECTOR

1. TAC members and Larry French, a new TAC member, introduced themselves.
2. Mark Shuster and Ken Wisian introduced themselves to the TAC members as Interim BEG Director and Associate Director, Environmental Division, respectively.

HIRING UPDATE

1. Alexandros Savvaidis introduced the recently updated TexNet Organogram (including the extra funding – 9 FTEs) to the TAC, which reflected hiring in Field Operations, Seismic Analysts, IT, Administration, and Scientific Support:
 - Elizaveta Rybina, Admin Program Coordinator, was hired on 2/12/2024;
 - Russel Rogers and Kate Vallejo, Seismic Analysts, were hired on 2/26/2024 and 3/14/2024 respectively;
 - Emmanouil Parastatidis, Research Assistant Professor, was hired on 3/20/2024;
 - Rico Hernandez, Administrative Associate, was hired on 3/20/2024.
 - Camilo Munoz will be hired in Q2 2024.With the new and expanded state funds, several critical hires are now underway, and Alexandros Savvaidis expects to have a full TexNet group by the summer of 2024.
2. New hires, Elizaveta Rybina, Russel Rogers, Kate Vallejo, Emmanouil Parastatidis, Rico Hernandez, and Victor Salles introduced themselves to the TAC members.
3. Alexandros Savvaidis updated TAC on four finalists for the Earthquake Source Research Assistant Professor position and informed the Committee that the IT Lead position had not been filled yet, as none of the four interviewed candidates fulfilled the job requirements. Alexandros Savvaidis together with the directors of BEG leadership, Mark Shuster and Ken Wisian, decided to re-open this position as a Software Developer position, to make it more flexible with the salary range and to receive a stronger pool of applicants.

LUNCH WITH THE NEW TEXNET HIRES

During the lunch, there was a general discussion between the TAC and the new hires. The group described their job responsibilities and how they work together responding to TexNet needs.

UPDATE ON RELEASING M1.5+ AUTO-PICKED EVENTS

Alexandros Savvaidis updated the TAC on TexNet reporting metrics:

1. As of November 1st, 2023, TexNet reports auto-picked events of M1.5+ for the Delaware Basin. Manually reviewed events are reported on the next business day or as soon as possible thereafter.
2. As of April 1st, 2024, TexNet reports auto-picked events of M1.5+ for the Eagle Ford. Manually reviewed events are reported on the next business day or as soon as possible thereafter. TexNet is reviewing the earth model for Eagle Ford. However, the Eagle Ford is a difficult area and there is not enough data yet to revise the earth model. TexNet will update TAC during the following meetings.
3. As soon as the Midland Basin seismic network density increases to a similar level as the Delaware Basin, TexNet will report auto-picked events of M1.5+.

TexNet seismic network is not yet dense enough in the Midland area. TexNet will continue mapping the seismic stations gaps in Midland Basin and will share this information with the stakeholders, industry, and RRC.

Alexandros Savvaidis reported on the recent progress regarding the use of machine learning (ML) to detect events in the Eagle Ford area. The ML approach detects as low as M1 events, which provides a better statistical sampling. He highlighted that the testing of Machine Learning (ML) approach is done in parallel with the traditional approach, which allows TexNet to increase the number of detected earthquakes. The combination of the two approaches ensures that TexNet does not miss events that are M2 and above. TexNet will publish only M1.5 threshold events.

It is important for TexNet to increase the number of stations in its network, create better earth models, and reduce location uncertainty. Alexandros Savvaidis said that TexNet would work on defining which area(s) would be the program's priority for events lower than M1.5, as the installation of additional seismometers and analysis of M1.5 events comes at the cost of additional time and resources. Currently, TexNet does not have seismic stations covering the whole Eagle Ford area. However, TexNet's observation is that seismicity is migrating in that area, and there is a need to install a few new stations, as TexNet's does not want to miss events of M2 and stronger in this area.

Mark Boyd suggested TexNet move forward with deploying more stations in Eagle Ford due to the increase of seismicity in the area.

Alexandros Savvaidis updated TAC on the number of available instruments: 10 instruments are at the warehouse and a few orders are on the way. TexNet should prioritize the deployment of the available instruments, if necessary.

OPERATIONS STATUS AND PLAN

Seismic Stations

Six new stations deployed from TexNet in 2023-Q4 and 2024-Q1:

- MB25 (Midland Basin); TexNet funded
- PB46, PB47 (Delaware Basin); TexNet funded
- PB39, PB53, PB54 (Delaware Basin); Through operators' donations

Nine new stations are deployed from Operators and data are provided to TexNet:

- CW01, GV03, MG01, OE01, SD01, SM02, SM03, SM04 (Midland Basin)
- LWM3 (Delaware Basin)

Seismic pattern

- Most of the seismicity is in North Texas Delaware Basin (increased seismicity rate)
- Seismicity increased in Eagle Ford (increased seismicity rate and highest magnitude; two M4 in 2024-Q1)
- Seismicity increased at the Midland Basin but with no high magnitude earthquakes. TexNet's highest priority in terms of deploying more stations is in the Midland area with the highest seismicity. The number of stations in Midland is acceptable, but there are still a few gaps. Having an additional 12 stations in the central part of the Midland Basin would ensure that events down to M1.5 are detected and located.

TexNet plans to deploy 4 new stations in Eagle Ford to fill the gap to the west of the current array. TexNet assesses the causal factors of seismicity by using TexNet's earthquake catalogs and Injection volumes.

The Snyder area was briefly discussed by TAC, as there is seismicity outside this area not yet covered by TexNet.

- It would be useful to have one more station in this area or a northeast to southwest "corridor" connecting Snyder with the central Midland basin, for monitoring purposes.
- Deploying a station will depend on the interest from industry or other entities in terms of gaining access to this area.

Alexandros Savvaidis informed TAC about the statistical analysis performed by TexNet which connected the seismicity in Eagle Ford with saltwater disposal. This information will also be presented at a conference this year. TAC members stressed the importance of driving monitoring and conversations with the industry regarding regulatory practices to avoid larger earthquakes. Alexandros Savvaidis proposed that TexNet use the automatic approach as an option to pick up small events related to fracking in the area.

BUDGET DISCUSSION

The TexNet Budget for 2023-2024 summarized in the following table:

Project		Year 1
Network Operations (Seismic Stations, Daily Earthquake Catalog)	56.07%	\$1,700,000.00
Seismicity Analysis (Earthquake Catalogs, Seismotectonics, Modeling and Software Evaluation)	33.52%	\$1,016,305.56
Machine Learning in Seismology	5.14%	\$155,793.27
Quality Controlled Geodatabases and Web Tools	1.92%	\$58,117.81
Analysis of Human Operations and Seismicity	1.71%	\$51,783.35
Earthquake Hazard	1.65%	\$50,000.00
	100.00%	\$3,032,000.00

Alexandros Savvaidis discussed the budget breakdown in detail in order to provide TAC with tasks, activities, and operations that are being funded under the categories listed in the above summary table. The detailed budget breakdown includes the following areas:

- Network Operations (Seismic Stations, Daily Earthquake Catalog):

The number of failing older seismometers has increased, which will continue to grow with time, as the equipment originally purchased ages. This first equipment was purchased in 2016 with a 5-year warranty. Now, as the warranty has expired, TexNet must do increasing maintenance. Currently maintenance and replacement costs are approximately \$125,000/year which is 4.1% of the total budget and are included in the “Network Operations” budget. Mark Shuster suggested splitting out the cost of maintenance and replacement in the future.

- Seismicity Analysis (Earthquake Catalogs, Seismotectonics, Modeling and Software Evaluation)
- Machine Learning in Seismology:

Machine Learning (ML) is used by the operational team. It will take some time to create a dataset to train ML to detect events for the main Oil and Gas operations areas in Texas (Permian Basin and Eagle Ford). This goal may be reached by the next biennial report.

- Quality Controlled Geodatabases and Web Tools:

The biggest part of the budget covers quality control of data, web development and earthquake catalog development.

- Analysis of Human Operations and Seismicity:
- Earthquake Hazard:

The budget covers the work on ground motion models conducted by Alexandros Savvaidis, Ellen Rathje, and their students. Alexandros would like to increase the budget on earthquake hazard to provide more tools and insights regarding ground motion models in Texas.

In connection with earthquake hazards and TexNet’s willingness to spend more resources on this problem, Dave Cannon informed TAC about a recent shutdown of a gas plant that led to significant economic and environmental losses in Permian Basin. Dave pointed out the necessity of pursuing more legislative regulation, due to the impact of the losses that have occurred.

Alexandros Savvaidis noted that TexNet has the necessary experience to monitor infrastructure. If there is interest from the industry, TexNet can deploy accelerometers in the area of concern and assess the input of ground motion on the infrastructure. Kris Nygaard and Mark Shuster agreed that it would be in everyone’s interests if TexNet puts more effort and time on assessing the earthquake hazard issue.

Brian Stump suggested that BEG, TexNet, and TAC should have a five-year strategic hazard assessment plan created and approved before next October. Chris Hillman and Scott Mitchell supported the idea of creating a strategic plan regarding economic matters, infrastructure, and safety perspectives. Jeff Nunn suggested starting with Permian Basin in order to characterize the source and path.

The indicated timeline for working on the strategic plan would allow TAC and TexNet to assess the initial budget and discuss it in detail with Legislature in January 2025, as well as to include it in the next biennial budget. This plan should include risk component, goals, resources, accomplishments, and discussions with legislature to get additional funding for TexNet. It would be also helpful to have RRC regulate how the industry responds to seismic events.

Alexandros Savvaidis will work on the hazard and risk assessment; however, it would be more efficient to hire someone dedicated to specifically work on the hazard and risk assessment. Alexandros Savvaidis will contact Mark Petersen (USGS) to participate in the next TexNet TAC Meeting and provide insights of the USGS hazard assessment.

Kris Nygard pointed out that the conversation about having a strategic hazard and risk assessment plan is a step forward to forming risk management strategies and proposed making a motion in terms of pursuing initiative for the Permian Basin. A motion was made, seconded and unanimously approved.

PUBLICATIONS AND PRESENTATIONS UPDATE

Published

1. Breton C., Shensky M., and Savvaidis A., (2024). Induced Seismicity Data Prep: Automate data processing and data set production in Texas and New Mexico using Python and ArcGIS Pro tools. Interpretation (2024) 12 (2): SC1–SC7, <https://doi.org/10.1190/int-2023-0013.1>
2. Chen, Y., Savvaidis, A., Saad, O. M., Huang, G.-C.D., Siervo, D., O’Sullivan, V., McCabe, C., Uku, B., Fleck, P., Burke, G., et al. (2024). TXED: The Texas Earthquake Dataset for AI, Seismological Research Letters (2024) 95 (3): 2013–2022, <https://doi.org/10.1785/0220230327>
3. Chen, Y., Zhou M., and Abma R., (2024) Revisiting two notable methods for improving the deblending performance of marine towed-streamer acquisition, Geophysics (2024) 89 (3): P33–P45, <https://doi.org/10.1190/GEO2022-0621.1>
4. Dommissé, R., (2024). Constraining Faults and Stratigraphic Zones in Shale and Tight Oil Basins via 3D Geocellular Models, Geoenergy Science and Engineering, Volume 240, 212991, <https://doi.org/10.1016/j.geoen.2024.212991> (Accepted for publication).
5. Huang, G.-C.D., Chen Y., and Savvaidis, A. (2024). Complex Seismotectonic Characteristics in the Midland Basin of Texas: Constrained by Seismicity and Earthquake Source Mechanisms, Seismological Research Letters (2024) 95 (3): 1870–1884, <https://doi.org/10.1785/0220230269>
6. Saad, O.M., Helmy, I., Mohammed, M., Savvaidis, A., Chatterjee, A., and Chen, Y., 2024, Deep Learning Peak Ground Acceleration Prediction Using Single-Station Waveforms: IEEE Transactions on Geoscience and Remote Sensing, vol. 62, pp. 1-13, 2024, <http://dx.doi.org/10.1109/TGRS.2024.3367725>
7. Lee, J., Chen, Y., Dommissé, R., Huang, G.-C.D., and Savvaidis, A. (2024) Basin-scale prediction of S-wave Sonic Logs using Machine Learning techniques from conventional logs. Geophysical Prospecting, 1–23, <https://doi.org/10.1111/1365-2478.13527>
8. Chen, Y., Savvaidis, A., Saad, O.M., Siervo, D., Huang, G.-C.D., Chen, Y., Grigoratos, I., Fomel, S., and Breton, C. (2024) Thousands of Induced Earthquakes per Month in West Texas Detected Using EQCCT. Geosciences, 14, 114, <https://doi.org/10.3390/geosciences14050114>

Manuscripts under review

1. Chen, Y., Savvaidis, A., et al., 2024, Deep learning for P-wave first-motion polarity determination and its application in focal mechanism inversion, submitted to SRL.
2. Chen, Y., Savvaidis, A., Saad, O.M., Huang G.-C.D., and Siervo, D., 2024, Real-time monitoring in Texas using highly precise deep learning phase pickers, submitted to Earth and Space Science.
3. Chen, Y., Saad, O.M., Savvaidis, A., Huang, G.-C.D., Chen, Y.F., Li, H., and Zanjani, F.A. 2024, Deep learning for P-wave first-motion polarity determination and its application in focal mechanism inversion, submitted to IEEE Transactions on Geoscience and Remote Sensing.
4. Huang G.-C.D., Chen Y., and Savvaidis, A., 2023. Complex seismogenic structures in the Midland Basin as constrained by induced seismicity and earthquake source mechanisms, submitted to SRL.
5. Huang, G.-C. D. and Savvaidis, A., 2023 Reactivated Seismogenic Faults and Earthquake Source Mechanisms in the Snyder Area of Texas, submitted to SRL.
6. Saad, O.M., Savvaidis, A., and Chen, Y., 2024, Transfer Learning for Seismic Phase Picking in Texas, submitted to SRL.
7. Simeonova, G., Eisner, L., Waheed, U., Savvaidis, A., and Hanafy, S., 2024, S-wave velocity model of Texas based on joint inversion of interferometry and P-wave receiver functions, submitted to SRL.

Presentations

1. Chen et al., 2023. A Texas earthquake dataset for seismological artificial intelligence, Dec, 15th , 2023, San Francisco, AGU Fall meeting, Poster.
2. Chen et al., 2024. Deep learning for DAS denoising, March, 09th, 2024, Houston, BP America.
3. Chen et al., 2024. Benchmark dataset and framework accelerate research, Mar, 12th , 2024, Houston, Saudi Aramco.
4. Chen et al., 2024. Real-Time Earthquake Forecasting in China Using AI, May 26th , Chiba, Japan Geoscience Union.
5. Chen et al., 2024. Tuning a passive-seismic phase picker using TXED, June 11th , Oslo, EAGE.
6. DeShon, H., et al., 2024. Using Converted Phases to Investigate Induced Seismicity in the Midland Basin, Texas, April 27th, 2024, Anchorage, Alaska, SSA.
7. Dommissse, R., Update on Permian Basin 3D Velocity Model, SWS AAPG Annual Meeting, Apr. 27 - Apr. 30, 2024, Abilene, Texas.
8. Lee, J., Chen, Y., Dommissse, R., Savvaidis, A. 2024. Rock Physics Attribute Analysis for Identifying Brittle Zones in Upper Delaware Basin Formations. International Meeting for Applied Geoscience & Energy 2024. (Submitted)
9. Lee, J., Dommissse, R., Savvaidis, A. 2024. Constructing a Comprehensive 3D S-Wave Velocity Model of the Delaware Basin. International Meeting for Applied Geoscience & Energy 2024. (Submitted)
10. Pandel B., E. Rathje, A. Savvaidis and A. Kottke, Stochastic Inversions of Source, Path, and Site Parameters for West Texas Earthquakes. April 27th, 2024, Anchorage, Alaska, SSA
11. Parastatidis, E., Hildyard, M., Pytharouli, S., Savvaidis, A. 2024. Study of the effect of pre-existing fractures in the reservoir on the potential for induced seismicity for hydro storage dam projects. International Meeting for Applied Geoscience & Energy 2024. (Submitted)
12. Savvaidis and Grigoratos, 2024. Causal assessment of anthropogenic seismicity in Texas and New Mexico, June 11th, Oslo, EAGE.
13. Savvaidis et al., 2024. Earthquake swarms of complex seismotectonic features in West Texas, USA. March, 19th 2024, Vienna, EGU.
14. Savvaidis et al., 2024. Seismicity Triggering in the North Delaware Basin, West Texas, USA. April 27th, 2024, Anchorage, Alaska, SSA.
15. Zanjani A., DeShon H., and A. Savvaidis, 2024. Spatiotemporal Evolution of Induced Earthquakes in the Southern Delaware Basin, Reeves-Pecos, West Texas. April 27th, 2024, Anchorage, Alaska, SSA.

TAC appreciated TexNet's research group going to conferences, as it is important to have feedback from the scientific community.

INFORMATION FROM TRRC RELATED TO WATER AND PRESSURE REPORTING TOOL

Paul Dubois, Assistant Director, Railroad Commission (RRC) of Texas joined the meeting. He and TAC members introduced themselves. TAC welcomed Paul.

1. Alexandros Savvaidis updated TAC on the collaboration between TexNet and RRC that resulted in the creation of Injection/Pressure Reporting Tool, a web injection tool used by operators in Delaware and Midland Basins on a voluntary basis.
2. Paul Dubois informed TAC about two Notice to Operators (NTOs) issued by RRC. He appreciated the work that TexNet has done for RRC. TexNet was able to quickly create a web interface that has been helpful to RRC. RRC, in a joint effort with TexNet, are finalizing updates for the web injection tool. An updated version of the tool should be available by the end of March 2024. It will allow operators to submit the information requested by the recent NTO.
3. Paul Dubois informed TAC about a discussion between RRC and a software company regarding creating a middleware application solution that would facilitate data uploading between TexNet and industry operators. The status of this project is unknown at the moment. Alexandros Savvaidis brought to the attention of TAC and Paul Dubois the fact that this company works directly with its customers, and the fact TexNet cannot give access

to a third-party company. In order to upload data, each operator that has a permit would have to give the company access to their data.

4. Paul Dubois also mentioned that RRC is working on a legislative appropriation request, so RRC could handle this task directly. RRC's IT Department is exploring options for direct submission of data as well. Paul updated the TAC that the RRC is working on having data be reported on a regulatory basis.
5. RRC is modernizing technology and moving data into a cloud-based system, which could be used by RRC, BEG, and other selected contractors.
6. Commissioner Wright holds a series of meetings with operators related to pressure and seismicity issues, as it is important to have this data managed for seismicity and formation pressure concerns.
7. RRC is aware of seismic concerns related to carbon storage.

CISR'S REQUEST FOR A MEETING WITH TAC

Brian Stump informed TAC about his communication with a CISR representative, who expressed a desire to meet with TAC.

TAC members agreed to invite several CISR representatives to the annual TAC meeting in December, which is subject to public record. Prior to the meeting with CISR, TAC members expressed a need to have clarity on CISR's mission and objectives.

SUGGESTED TOPIC FOR NEXT MEETING

Possible topics that were suggested for discussion at the next meeting were proposed as follows:

1. Mark Shuster proposed to invite a provost representative to the next TAC meeting.
2. Jeff Nunn suggested discussing the next peer review.
3. Mark Boyd suggested discussing extra funding for the next two years on reporting the seismicity due to the increased number of events.
4. Alexandros Savvaidis suggested discussing the Earthquake hazard plan.
5. Biennial report table of contents (Biennial report is due in December 2024).
6. Update on hiring plan.
7. Update on releasing M1.5+ auto-picked events.
8. Operations (status/maintenance, resources).
9. Budget discussion.
10. Publications and presentations update.
11. Suggestions for the subsequent meetings.

ADJOURNMENT

Meeting was adjourned at ~3:30 pm by Brian Stump, Committee Chair

Minutes submitted by: Elizaveta Rybina, TexNet

Minutes reviewed by: Alexandros Savvaidis, TexNet

Minutes approved on June 25th, 2024, by:

Brian Stump, Committee Chair

Mark Boyd, Committee Member

Dave Cannon, Committee Member

Chris Hillman, Committee Member (via Zoom)

Jeff Nunn, Committee Member

Kris Nygaard, Committee Member (via Zoom)

Aaron Velasco, Committee Member

Scott Mitchell, Committee Member (via Zoom)

Larry French, Committee Member (via Zoom)