SUMMARY

This annual report covers TLALOCNet project (EAR-1338091) “MRI: TLALOCNet - Development of a continuous GPS-MET array in Mexico for atmospheric, climatic, and seismotectonic research in the Americas” activities for the time period from September 1, 2015 to August 31, 2016. TLALOCNet is a Collaborative Research project awarded by the National Science Foundation to UNAVCO on August 16, 2013. The project is under the direction of M. Meghan Miller, as PI, with Co-PIs, Glen Mattioli, Enrique Cabral, Chuck DeMets, and Yolande Serra. Glen Mattioli is acting as Project Director in his role as Director of Geodetic Infrastructure at UNAVCO; Karl Feaux is the Project Lead in his role as the GPS Operations Manager for the PBO, and John Galetzka is the Project Manager.

Figure 1. Combined map showing 24 operating NSF TLALOCNet and 127 operating NSF COCONet cGPS-Met stations (yellow dots), and 13 UNAM TLALOCNet contribution stations (green dots). Other sites of interest (i.e. data centers, tide gauges) are also shown (see map legend).
To date, UNAVCO field engineers have retrofitted 4 existing stations, and installed 20 new stations for the NSF component of TLALOCNet (Table 1). This concludes the number of new and refurbished stations scheduled to be built, as outlined in the construction plan in the TLALCONet MRI proposal.

<table>
<thead>
<tr>
<th>Site Code</th>
<th>Site Name</th>
<th>Status</th>
<th>Latitude</th>
<th>Longitude</th>
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Table 1. TLALOCNet cGNSS-Met station status (NSF-funded).

The TLALOCNet project also involves a 30% total-project cost-share component from the Universidad Nacional Autónoma de Mexico (UNAM). UNAM is responsible for providing daily
GPS data files to the UNAVCO archive for 13 stations shown in Table 2. At the time of this report, all but one station (TNGF), included as part of the UNAM cost-share, are delivering data to the UNAVCO archive. TNGF has been installed and is already operating but not yet delivering data to the UNAVCO because there are metadata issues that need to be resolved to allow publication of the data. We anticipate that these issues will be resolved this week and data will begin to flow from TNGF by August 31, 2016.

<table>
<thead>
<tr>
<th>Site Code</th>
<th>Site Name</th>
<th>Status</th>
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<th>Longitude</th>
</tr>
</thead>
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<td>Mexico</td>
<td>Operational – but minor data flow issues remain</td>
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</tbody>
</table>

Table 2. TLALOCNet contributing stations from the Universidad Nacional Autónoma de Mexico (cost-share).

**PROJECT STAKEHOLDERS**

The project stakeholders include the following institutional, atmospheric, solid earth, ionospheric, and data center stakeholders:

**Institutional stakeholders**

- National Science Foundation (USA)
- UNAVCO, Inc. (USA)
- Instituto de Geofísica, UNAM (México)
- Servicio Sismológico Nacional, UNAM (México)
- Centro de Ciencias de la Atmósfera, UNAM (México)
- Conacyt (México)
- Universidad de Guadalajara (México)
- Instituto de Geología, UNAM (México)
• Centro de Geociencias, UNAM (México)
• Universidad Autónoma de Ciudad Juárez (México)
• Conagua / Servicio Meteorologico Nacional (México)
• Universidad de Sonora (México)

Atmospheric Stakeholders
• David Adams, UNAM
• John Braun, University Center for Atmospheric Research
• Carlos Minjarez, Department of Physics, Universidad de Sonora
• Arthur Douglas, Creighton University
• Christopher Castro, University of Arizona
• David Gochis, NCAR
• Seth Gutman, NOAA (retired)
• Kirk L. Holub, NOAA
• E. Robert Kursinski, University of Arizona
• Rajul Pandya, UCAR
• Luis Farfan-Molina, CICESE
• Chris Watts, University of Sonora
• Marek Zreda, University of Arizona

Solid Earth Stakeholders
• Rick Bennett, University of Arizona
• Mike Brudzinski, University of Miami-Ohio
• Vladimir Kostoglodov, UNAM
• Javier Gonzalez, CICESE
• Jorge Zavala, Servicio Mareográfico Nacional, UNAM
• Carlos Valdés, Servicio Sismológico Nacional, UNAM
• Rocco Malservisi, University of South Florida
• Osvaldo Sanchez-Zamora, UNAM
• Diego Melgar, University of California-Berkeley
• Shannon Graham, University of Wisconsin-Madison
• Christina Plattner, Ludwig Maximilians University-Munich, Germany
• Mario Rebollod-Vieyra, Centro de Investigacion Cientifica de Yucatan, A.C.
• Estaban Vazquez, Universidad de Sinoloa
• Andrea Walpersdorf, LGIT, University Joseph Fourier – Grenoble, France
• Marco Guzman-Speziale, Centro de Geosciencias, UNAM
• Alejandro Gonzalez, University of California-San Diego

Ionospheric Stakeholders
• Roman Pérez, UNAM
• Tim Fuller-Rowell, CIRES, University of Colorado, SWPC, NOAA
Regional Data Center Stakeholders
• Bertha Márquez-Azúa, University of Guadalajara
• Fran Boler, UNAVCO, Regional Data Center Liaison

OPERATIONS SUMMARY
The major achievements this fiscal year include:

• Installation of eight new stations: TNIF TNCC TNLC TNGQ TNCY TNNP TNSJ and TNCN.
• Retrofit and rehabilitation of 2 older stations: PENA and GUAX.
• Addition of two real-time stations to the UNAVCO RT-GPS system: TNSJ and GUAX.

With the completion of GUAX in June 2016, the construction phase of TLALOCNet is now complete. The TLALOCNet project moves into standard operation and maintenance mode for the remaining year of the MRI award.

On-going and other upcoming work includes:

• Maximize the number of stations providing high-rate data streams in real time.
• Add meteorological instruments to contributing stations if budget allows.
• Improve network-monitoring tools to assist managers and engineers in station maintenance.

Site and Schedule Changes
Several site and schedule changes were made this fiscal year, including:

• TNLC was substituted for a nearby existing station called PURI which was determined a high security risk.
• TNCC in Michoacan replaced PZUL which had poor cell coverage.
• TNIF and TNCN in Michoacan replaced unsuitable existing stations elsewhere on the central Pacific coast intended for upgrade.
• TNCY, TNNP, and TNSJ in Oaxaca replaced unsuitable existing stations in Oaxaca intended for upgrade.
• The GUAX upgrade shifted from February to June 2016 because of permitting delays as well as fieldwork scheduling conflicts.

Regional Data Center
The TLALOCNet RDC system continues to operate at the University of Guadalajara storing and distributing data from the 37 core TLALOCNet stations, and about 30 community stations from across Mexico. Stations from various universities, partners and agencies in Mexico are expected to be added to the TLALOCNet RDC as they come online.
SCIENTIFIC PRODUCTS: ACTIVITIES, SUBMITTED MANUSCRIPTS, AND ABSTRACTS

Hurricane Patricia struck the coast of Jalisco at the end of October 2015 as a category 5 hurricane. TNCM was directly in the path and about 2 km inland, but suffered damage to its Vaisala met pack in a way that also corrupted data on the NetR9 receiver during the height of the event. Dr. John Braun (UCAR) and Dr. Enrique Cabral (UNAM) initiated a UNAVCO data event response for stations from Baja California to Central America.

On June 27, 2016, an M 5.7 earthquake in Oaxaca triggered a minor UNAVCO data event response to download high sample rate data (5 Hz) from the nearest five NSF-funded TLALOCNet stations.

Chuck DeMets, Enrique Cabral, and colleagues might have identified the first evidence of slow slip activity below the coast of Jalisco. To better resolve these subtle movements they have asked the TLALOCNet PIs for the installation of three additional GPS-only stations to complement existing cGPS infrastructure in the region if the budget allows. Budget analysis for these additional stations is currently underway by project staff.

The 2016 North American monsoon is currently underway and will once again be well measured using the seven TLALOCNet stations in northwestern Mexico as well as those of other stakeholder institutions.

Submitted Manuscripts and Abstracts


**DATA SUMMARY**

UNAVCO currently archives standard 15 sec hourly data files from 24 UNAVCO-built GPS-Met stations, and 13 UNAM contribution GPS-Met stations. Additionally, there are currently 15 TLALOCNet stations delivering high-rate, low-latency (1 Hz, < 2.5 s) data streams in real-time via the Networked Transport of RTCM via Internet Protocol (NTRIP).

**BUDGET AND SCHEDULE**

Including open commitments (project manager salary, travel to support remaining scope, and the purchase of remaining project hardware), the TLALOCNet expenditures through the end of June 2016 were **$1,145,493**. With a June 2016 project budget (34 months since beginning of project) of **$1,211,739**, the project is under budget and operating with a **5.5%** positive cost variance. UNAVCO management is working with the TLALOCNet PIs to determine how to spend any available project funds.

UNAVCO engineering staff installed three cGNSS-Met stations in the first year, 11 stations in the second year, and 10 stations in the third year of the TLALOCNet project. Since the project manager was not hired until the 8th month of FY2014, the optimistic 2-year installation schedule was not met. UNAM installed four cost-share stations in the first year, seven more in the second year, and two in the third year of the project. All data from the UNAM contributing stations are delivered via daily ftp to the UNAVCO data archive. Additional project milestones are shown in the detailed project schedule below (Figure 2).
Figure 2. Complete TLALOCNet project schedule.

EDUCATION, OUTREACH, AND COMMUNITY ENGAGEMENT

TLALOCNet representatives gave talks and/or presented posters at a handful of functions during the year, including:

- One poster presented at Sismo85 in Mexico City in September, 2015.
- Two posters presented at the annual meeting of the Unión Geofísica Mexicana in Puerto Vallarta in November 2015.
- Two posters presented at the Fall 2015 AGU meeting in San Francisco.
- Gilles Arefuille (meteorology professor at U. de Colima) and Lenin Avila (geophysics postdoc at CICESE) joined the TLALOCNet installation team in November and December 2015 to participate in construction of several GPS-Met stations in Oaxaca and Guerrero.
- In January 2016, John Galetzka gave a TLALOCNet progress report at CICESE in Ensenada.
• Enrique Cabral, Karl Feaux and Chris Walls participated in a UCMexus (http://ucmexus.ucr.edu) workshop in April 2016 at SIO/UC San Diego focused on developing the basis for long-term scientific and infrastructure proposals for the Monsoon region of Northwestern Mexico and the Southwestern United States, based on GPS-Met infrastructure.

• In support of UCMexus, TLALOCNet loaned Dr. Jennifer Haase (SIO) a Vaisala WXT-520 met pack for installation at a GPS station in San Felipe, Baja California (TSFX) for the duration of the 2016 monsoon.

Now that network installation is complete we anticipate that special sessions at AGU and RAUGM will be developed by the PIs to highlight TLALOCNet infrastructure and data.

**PROJECT CONCERNS**

As indicated in above, TLALOCNet is appropriately under budget by about 5.5%. We will closely watch spending for the remainder of the project to ensure that the budget does not become a concern.

Despite a possible failure of a Trimble NetR9 at TNIF receiver due to the heat and humidity, the other Trimble NetR9 receivers appear to be working well in the harsh climates of Mexico.