TRUAA Network: Upgrading the Israel Seismic Network - Towards Earthquake Early Warning in Israel

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Summary

Following the recommendations of an international committee (Allen *et al.*, 2012), since October 2017 the Israeli Seismic Network (ISN) has been undergoing significant upgrades, with 120 stations being added or upgraded throughout the country and the addition of two new data centers. These enhancements are part of the TRUAA project, assigned to the Geological Survey of Israel (GSI) by the Israeli Government, to provide Earthquake Early Warning (EEW) capabilities for the state of Israel. The GSI contracted Nanometrics, supported by local contractor MSI, to deliver these upgrades through a turnkey project, including detailed design, equipment supply, and deployment of the network and two data centers.

The TRUAA network was designed and tailored by the GSI, in collaboration with the Nanometrics project team, specifically to achieve efficient and robust EEW. Several significant features comprise the backbone of this network:

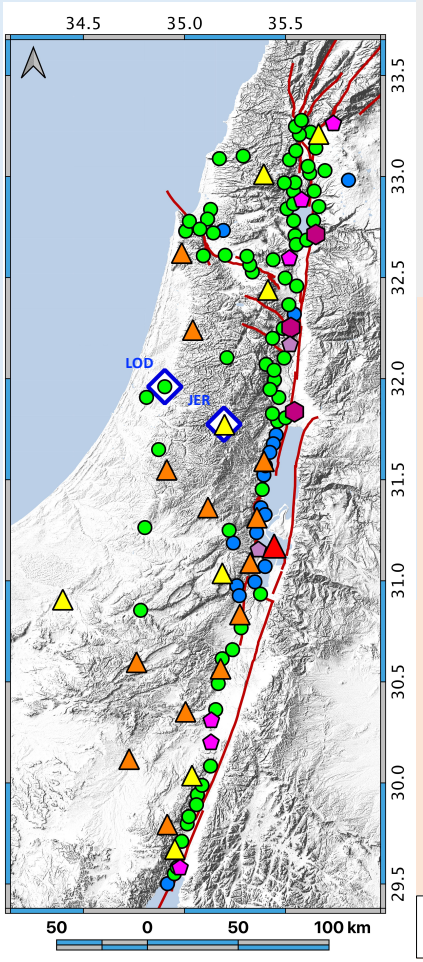
a) *coverage* - station distribution has high density (5-10 km spacing) along the two main fault systems, the Dead Sea Fault and the Carmel Fault System;

b) *instrumentation* – high quality strong motion accelerometers and broadband seismometers with modern 3 channel and 6 channel dataloggers sampling at 200sps. In addition, eight stations include co-located high quality GNSS receivers with medium-high stability short braced monuments;

c) *low latency acquisition* – data is encapsulated in small packets (< 1s), with primary routing via high speed, high capacity telemetry links (<1s latency);

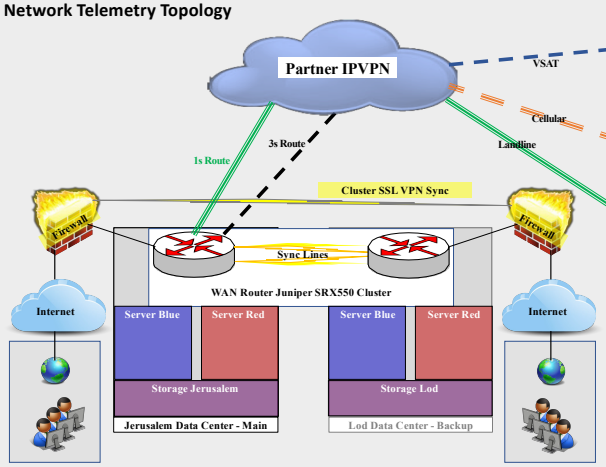
d) *robustness* – high level of redundancy throughout the system design:

- Dual active-active redundant acquisition routes from each station, each utilizing multicast streaming over an IPSec VPN tunnel, via independent high bandwidth telemetry systems
- Two active-active geographically separate data centers
- Dual active-active redundant seismic processing tool chains within each data center, implemented in a high availability protected virtual environment.

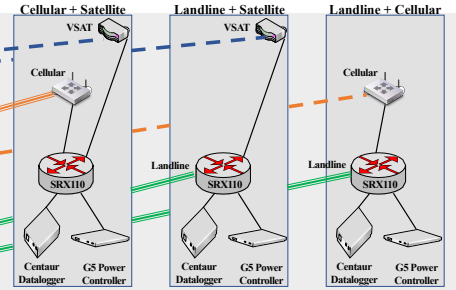


BB - broadband seismometers; SM – Strong Motion accelerometers, GNSS – Geodetic instrumentation; Ready4Inst - existing facility, as opposed to Construction; Special Construction - a 50m borehole in the southern evaporation pans of the Dead Sea; JER – Data center at the GSI, Jerusalem; LOD - Data center at the GII, Lod.

Network Telemetry Topology

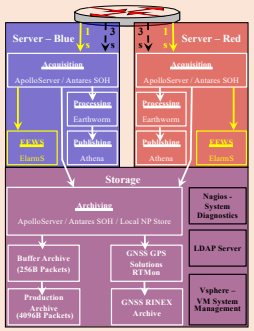


All data streams are routed through the Partner Virtual Routing and Forwarding (VRF) Network (Partner IPVPN) to the main datahub. In addition to the main data acquisition topology, the power controller generates asynchronous SNMP Traps to alert of system status events. These Traps are sent to the NMX Nagios network monitoring systems at each datacenter using unicast addressing.



The three telemetry route options are presented: Landline + Cellular, Landline + Satellite, and Cellular + Satellite. Seismic, Geodetic and SOH channels are recorded and streamed by the Centaur Datalogger. The Centaur forwards each data packet to the Juniper SRX110 Gateway twice, using two multicast streamers, each assigned to one of the two telemetry routes. If available, Landline is used for the fast route (green lines). Otherwise, Cellular is used for the fast route.

Datacenter and Dataflow



Both acquisition servers receive both the 1s (yellow) and 3s (black dashed) streams. The data is forwarded to critical path EEW modules for real-time processing (yellow arrows), and to the Archiving module for archiving and distribution to non-critical path clients (in white). Data arriving to the DCs via the backup slower routes are acknowledged, but do not proceed into the real-time processing unless packets from the fast route fail to arrive. The main and secondary datacenters are identical.

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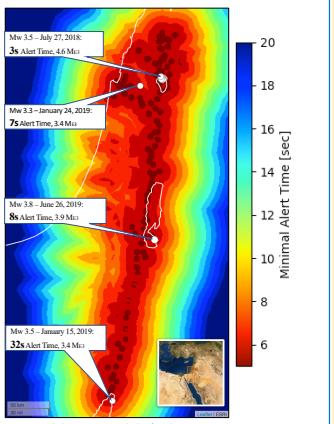
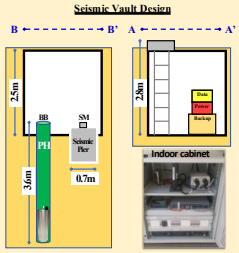
EEWS Performance

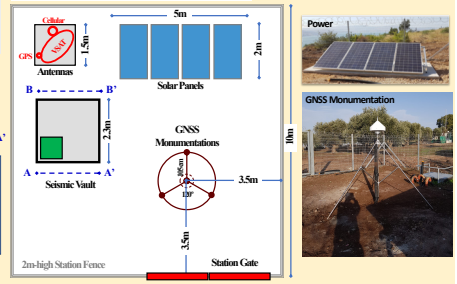


EEW module is UC Berkeley's ElarmS. It is a point source network-based algorithm, requiring at least 4 stations for alert. The TRUAA implementation is based on ElarmS3, with 4 redundant instances operating in parallel – one on each server, fed real-time waveform data by the corresponding ACQUISITION ApolloServer. Four Decision Modules, merge the alerts into one single alert and forward it to the Home Front Command (HFC), which is responsible for dissemination of the alert to the public.

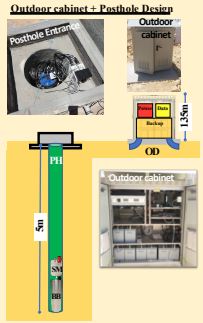
Above, alert time is calculated as the time between origin time and the issuance of an EQ alert to the HFC. It is calculated here according to the full planned network topology with 120 stations in place. Assume here: 6km/s for P velocity, 10km depth, packet size of 0.86s, minimal time of 2 packets, telemetry latency of 1s, and processing time of 1s.

Field Station Design





Seismic Vaults and Outdoor cabinet + Posthole (OD+PH): Above - Map view of a typical BB+SM+GNSS (or SM+GNSS) new construction station layout; some components are omitted depending on station specifications; Upper Left - A-A' and B-B' cross sections for the BB+SM new construction station; in the SM only case there is no posthole; Right - cross-section of a typical OD cabinet + PH station design. Note, that there are other custom station designs, tailored to meet site-specific requirements.



- Many of the insights and solutions used for this network may be applied to the design of new real-time seismic networks or the upgrade of existing real-time seismic networks, especially those with a mandate to provide EEW capabilities.
- At this time, both data centers and over 100 stations are operational. The system is currently being commissioned, with initial early warning operation targeted for early 2020.