Kinemetrics, Inc.

New Developments

Date: 23-24 February, 2012

Presented at: Antelope User Group Meeting

By: Ogie Kuraica, Vice President
This presentation would be impossible without ...

- IRIS (GSN, PASSCAL, DMC, EarthScope – USArray)
- UNAVCO (EarthScope – PBO)
- IGPP, UC San Diego
- University of Alaska, Fairbanks
- Caltech, Pasadena, California
- UC Berkeley, California
- UC Los Angeles, California
- UC Santa Barbara, California
- University of Nevada, Reno
- University of Colorado, Boulder
- Columbia University, Lamont-Doherty Earth Observatory
- USGS
- ORFEUS, Holland
- Geophone, Germany
- GeoScope IPGP, France
- ZAMG, Austria
- DPC, DST, OGS: Italy
- ARSO, Slovenia
- KMA, Korea
- ERI, University of Tokyo
- Malaysian TWS, Malaysia
- ERI/J AMSTEC, Japan
- KACST/KSU/KAU, Saudi Arabia
- SQU, Oman
- GeoScience, Australia
- GeoScience, Canada
- ....and especially those with limited budgets ....
Our Background:

Scientific Instrumentation, Application, Manufacturing, and Service company

- Founded in 1969
- Headquarters, Pasadena, California - USA
- Headquarters, Quanterra, Harvard, Massachusetts – USA
- Headquarters, Metrozet, Los Angeles, California - USA
- Headquarters, BRTT, Boulder, Colorado - USA
- Headquarters, Streckeisen, Pfungen – Switzerland
- Office in Switzerland, Japan and Abu Dhabi
- Network Operation Services: 3
- Training Center: Pasadena, USA and ZAMG Vienna, Austria
Our Background cont.:

- Network of over 60 representatives worldwide
- Owned by OYO Corp. Japan, $500M/Year Sales
- 55+ Patents owned or applied by KMI & its sister group companies
- More than 100,000 instruments installed worldwide
- Leading Seismic Network and Service Company
- Truly a Global Company....
**Who We Are:**

**Kinematics, Inc.**
- Large corporation with substantial financial resources
- World leader in the manufacture of strong motion seismic sensors and dataloggers
- Lots of experience in design, installation and supporting Open-Architecture System (OAS) networks for earthquake monitoring (i.e. seismic free field, structure, GPS and metrological) around the world
- Worldwide experience in network operation
- Fiscally strong with deep support and well developed corporate infrastructure (ISO 9001-2000 **Quality Control Management** in place to ensure they meet the needs of our customers)

**Quanterra/ Streckteisen, Inc.**
- Data Acquisitions company:
- Designed *world’s 1st* digital very broadband seismograph in early 80’s
- Designed *world’s 1st* true 24-bit seismic data acquisition system in early 80’s
- Designed *world’s 1st* ultra low power 24-bit seismic data acquisition system in early 00’s
- Designed *world’s 1st* true 26-bit seismic data acquisition system in 2005.
- Excellent worldwide reputation in the manufacture of ultra-high resolution dataloggers and very broadband seismometer for weak motion seismology
Streckeisen, Pfungen - Switzerland

- The Sensor company
- Designed world’s 1st digital Very Broad-Band (VBB) seismograph in early 80’s
- STS 2.5 world’s best performance Broad-Band (BB) seismometer
- Excellent worldwide reputation in the design and manufacture of Very Broad-Band (VBB) and Broad-Band seismometer (BB) for weak motion seismology

Metrozet, Los Angeles, California - USA

- “The Sensor Company”
- New company, established in late 2005’; principals worked for NASA (JPL) on the space missions seismometers, Schlumberger...
- With NSF funding, successfully designed the NEXT generation of original Streckeisen STS-1 design, the M2166-VBB world’s 2nd Very Broadband seismometer (VBB) in early in 2010. Result: Improved the next generation of original Streckeisen STS-1 design, the M2166-VBB. Currently, the world’s best performance seismometer
- Building worldwide reputation in the design and manufacture of Very Broadband (VBB), Broadband seismometer (BB) and Strong Motion (SM) accelerometers for weak and strong motion seismology

Boulder Real Time Technologies, Inc., Colorado, - USA

- Software company
- World’s largest commercial seismic network software provider
- Designed one of the world’s first digital seismic networks (UCSD-Anza, early 80’s)
- Lots of software engineering experience, modern digital communication, information system experience, of operational experience
“inseparable right and left wheels”

**Team Work Required to Deliver Exceptional Products**

- **OSS**
  Open System and Services
  Development, Integration, Installations, support and network operations

- **ARRAY INC.**
  Information Technology
  DoD Installations, support and operation

- **BOULDER REAL TIME TECHNOLOGIES, INC.**
  System software, system design, application, system integration, IT, communication

- **KINEMETRICS, INC.**
  Sensor/digitizer manufacturing, system integration/application/installation support, Project Management, services, ISO 9000

- **METROZET INC.**
  Design of New Generation Very Broadband (VBB) Seismometers and Portable BB seismometers

- **QUANterra INC.**
  Design of ultra-high resolution Broadband (BB) seismometers

- **Streckeisen**
  Design of ultra-high performance Broadband (BB) seismometers

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  Design of ultra-high resolution Broadband (BB) seismometers

- **Streckeisen**
  Design of ultra-high performance Broadband (BB) seismometers

**Company Confidential**
Branding Strategies and Focus

Premium Brands:
- Quanterra/Streckeisen
  - VBB and BB digitizer(sensor) company
- BRTT
  - The Software company
- Metrozet Sensors
  - The Sensor Company

High Quality Brand:
- Kinemetrics
  - Strong Motion and Data Acquisition Company

Cost Effective Brand:
- EQMet
  - Competition: i.e. Reftek, Guralp, GeoSig, SysCom
Complexity Driven Community of Users:

As equipment complexity increases, end-users are in need of NOT only Products but also of *Solutions* to solve their challenges:

**Products**

**Integrated Systems**
- Deployment System (Sensor, Digitizer, Power & Communications)

**System Solution Projects**
- Building Systems
- Nuclear Power Plants
- Critical Lifelines
- Regional & National Seismic Networks
- Other Sensors

**Integrated Infrastructure Projects**
- i.e. City of Abu Dhabi project, ARAMCO etc.
Complexity Driven Market Offerings:

- **KMI Offerings:**
- **COTS Products:**
  - Q330, Basalt, STS-2, PBB-200S etc..
- **Open System and Services (OSS) Delivers:**
  - Seismic Monitoring Networks
    - Regional & National Seismic Networks
    - Infrasound
    - OBS
    - GPS
    - Customization
  - Structure Monitoring Solutions
    - Building Systems
    - Structure Health Monitoring
      - Acceleration
      - GPS
      - Displacement
      - Strain
      - Wind, Temp. Humidity
      - Corrosion
      - Etc.
    - Nuclear Power Plans
    - Critical Lifelines
    - Customization
  - Operation, Maintenance and Support
  - Since 1995 (Saudi Arabia project)
What Makes KMI a Unique Organization in our Community:

♂ Understanding of Application
  - Work in multi-disciplinary field:
    - Seismic (VBB, BB, SM, Nuclear)
    - SHO
    - OBS
    - GPS,
    - Engineering Services

♂ We are ONLY commercial company in our community that operate Seismic Networks
  - OTHER companies are equipment manufacturers

♂ Exceptional level of education of work force
  - 10+ PhD
  - Average employment 15+ years

♂ Quality Control: ISO 9001-2000

♂ Parent Company: OYO Corporation financial support
What Makes KMI a Unique Organization in our Community cont.:

**Since 2005:**

- We won ALL major projects:
  - USAArray: $15M
  - GSN: $5M
  - ANSS: $12M
  - Abu Dhabi: $30M
  - Chile: $8M
USArray:
USArray: 2013
EarthScope Instrumentation

- 3.2 km borehole into the San Andreas Fault
- 875 permanent GPS stations
- 175 borehole strainmeters
- 5 laser strainmeters
- 39 Q330HR Permanent seismic stations
- 450 Q330 based transportable seismic stations occupying 2000 sites
- 30 magneto-telluric systems
- 100 campaign GPS stations
- 2400 campaign seismic stations
USArray Data Return

6 days 100.00% Data Return
Mean Data Return - 97.37%
Median Data Return - 98.90%
USArray Data Return

85% is official performance goal

number of active stations
USArray: Organization Summary

34 Team Members

- **Management:** 2.0
  - 2.5 office
  - 2.5 field team

- **Recon:** 5.0
  - 5.0 office
  - 5.0 field team

- **Construction:** 4.0
  - 1 office
  - 3 field crew

- **Installation:** 4.0
  - 4 field crew

- **Service:** 4.0
  - 4 field crew

- **Removal:** 3.0
  - 3 field crew

- **Support Facilities:** 12.0
  - AOF NM Tech 6
  - ANF UCSD 6

- **20 Installation/ Month**
Client: Abu Dhabi Municipality

Project: Seismic Risk Assessment and Loss Estimation

- Seismic Hazard Assessment and Seismic Zoning of Abu Dhabi Municipality (ADM)
- Site Amplifications and Microzonation
- Seismic Design Code
- Seismic Risk Analysis for 4 Critical Importance Life Lines
- Seismic Risk Analysis of 4 Critical structures
- Structural Health Monitoring for 4 Unique Structure
- Permanent Real-time 30 station Accelerograph Network
- Permanent Real-time Seismic Monitoring Network
- Ground Motion Estimation Maps (i.e. Shake Maps)
- 3D Seismic simulation Model to Simulate Long Period Seismic Waves
- Seismic Performance and Risk of ADM Tall Buildings
- Seismic Risk Assessment and Loss Estimation
- Seismic Data Base and GIS Shell for Management, Maintenance, and Modification of Seismic Database Products

KMI Largest project.

Status: Implementation Phase
Q330S+

- Leverages on Quanterra’s extensive experience in ultra-reliable seismic systems design, and combines sampling up to 1kHz with ultra-high low-frequency resolution.

- Crossover of the Q330 and Q330HR performances
  - Typical ~138dB wideband RMS, Low-frequency may exceed 145dB

- Sampling rates: 1000, 500, 250, 200, 100, 50, 40, 20, 10, 1.

- 2 PC/MAC/linux-formatted removable USB media, up to 256GB each.

- No need for any additional software for file transfer or data read.

- All unit operative -40 to +70C.
NEW Developments!

**QUANTERRA Q330S+**

**General Description**
The Q330S+ is the newest member of the world-standard Q30 family, and is an advanced 3 or 6 channel broad-band, high resolution seismic system incorporating Quanterra's proven IP networking technology into a very low-power field package. The Q330S+ leverages Quanterra's extensive experience in ultra-reliable seismic systems design, and combines sampling up to 1kHz with ultra-high low-frequency resolution.

**Telemetry...**

...and Local Recording

**Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channels</td>
<td>3, optional 6-channel</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>Typical -130dB wideband RMS</td>
</tr>
<tr>
<td>Low-frequency</td>
<td>may exceed 145dB</td>
</tr>
<tr>
<td>Format</td>
<td>32-bit integer, Level 2 compressed 1-second packets</td>
</tr>
<tr>
<td>Input Range</td>
<td>40V P-P at gain=1</td>
</tr>
<tr>
<td>Gain</td>
<td>Selectable per channel group: 1, 8, 32</td>
</tr>
<tr>
<td>Filtering</td>
<td>Linear or Minimum Phase FIR</td>
</tr>
<tr>
<td>Sample Rate</td>
<td>1000, 500, 250, 100, 50, 40, 20, 10, 1 Other rates available</td>
</tr>
<tr>
<td>Time Base</td>
<td>Precision TCXO, locked to GPS, No adjustment</td>
</tr>
<tr>
<td>Telemetry (real-time)</td>
<td>Full Duplex, low-latency efficient positive acknowledgment with sensor control, UDP/IP over serial and Ethernet. Burst or continuous. Operates with custom application software</td>
</tr>
<tr>
<td>Data storage and retrieval</td>
<td>3 PC/UX/MAC-formatted removable USB media, 16G each (128G in development), Industry-standard Standard HTTP, FTP, and SSH servers for remote retrieval</td>
</tr>
<tr>
<td>Temperature</td>
<td>Fully specified -50 to +70C</td>
</tr>
<tr>
<td>Sensor Control</td>
<td>Calibrate: step, low-TID site, or random. Recorder, on-command</td>
</tr>
<tr>
<td>Operational Data</td>
<td>Temp, U.C., voltage, GPS status, Survey boom position (4 chan)</td>
</tr>
<tr>
<td>Memory</td>
<td>128MB RAM standard</td>
</tr>
<tr>
<td>Network</td>
<td>Dual Ethernet (10BT &amp; 10/100BT)</td>
</tr>
<tr>
<td>Serial Ports</td>
<td>1 console port up to 115K baud</td>
</tr>
<tr>
<td>Media</td>
<td>Dual USB up to 330G total, follower, -40 to 70C rated media available</td>
</tr>
<tr>
<td>Power</td>
<td>12VDC nominal</td>
</tr>
<tr>
<td>Physical</td>
<td>Sealed, Aluminum, 17 X 4 X 6 in, 10 lb. Rubber standoffs, External visible status and field indicators</td>
</tr>
</tbody>
</table>

Q330S+ QUANterra, INC. 2 Shaker Rd, Ste. F 200, Shirley, MA 01464, USA 978-425-2100

PRELIMINARY SPECIFICATIONS, SUBJECT TO CHANGE
Rev B.
NEW Developments!

**Q330S+**

- Shipped first 21 units with STS-2.5’s to China in July.
- We currently have an additional backlog of over 200 units and more orders expected.

Total Harmonic Distortion of 3 channels Q330S+ (using Quanterra Supertonal Signal Source) indicates -122 dB, and -119dB SNR

16 of the Q330S+ units for China
NEW Developments!

Metrozet VBB Development: M2166-VBB

- Most quiet seismometer in the world
- Next generation of STS-1 class
- Several Installations in US : Harvard, ASL, etc.
- Will install a demonstration unit in the French (GSN) Geoscope Network in the fall.
- The results from the data obtained from the installation of the unit at ASL have been presented by ASL at the recent IRIS Instrumentation Symposium and are creating considerable interest in the community.
- Responded to USGS request for GSN upgrade.
- Number of units shipped to USGS in Dec 2011
- More units to be delivered (other customers) in 2012
NEW Developments!

**VIE**

**Vault Interface Enclosure**

- USAArray demonstrated improved network data return to almost 99% after implementation of the VIE.

- 16x16x8” Enclosure, hangs inside vault.
  - IP68, 0.5” Lexan Clear lid, bulletproof!

- Q330 interfaces converted to industrial standard connections;
  - IDC flat ribbon, RJ 45.

- Custom power regulation circuit
  - Faultfree switchover to alkaline backup battery
  - Signalling via existing data channels for power SOH
  - Sensor power regulation, filtered power for Q330 and Baler
  - High efficiency regulation, load shedding/mode switch on backup power
  - Independent fault isolation of powered devices.

- Station Integration
  - Integration of new Baler44CT, Environmental sensor
  - Simplified Data collection via new Baler44
  - Reset power cycle for comms equipment
  - Remotely controlled power interrupt for sensor
  - Monitor and signalling of pump operation

- Protected housing for electronics and auxiliary equipment-allowing better flexibility and increased reliability.
  - Allows economical packaging choices for small ancillary devices
  - Protects commercial modems, charge controllers and circuit boards.
  - Simplifies troubleshooting, acts as a field replaceable unit.

- Uniform cabling for installation
  - MS style connectors, molded termination

- Commercial production in large runs; Enclosure, cables, PCB, testing, etc
  - Custom cable fabrication, custom metal, factory assembly and testing.
NEW Developments!

Metrozet PBB Development:

PBB - 200S

We start delivery of NEW Portable Broad Band Seismometer.

- Units have been successfully tested at Harvard and ASL
- The units show greatly improved glitch performance – “After the expected few days, they have settled in with essentially no, or rare, significant glitch production.” (Joe Steim)
- The basic sensor noise performance outperforms sensors of such class
- More….Separate presentation…
NEW Developments!

Benefits to You:
- More high fidelity data at a better price
- Lower sensor self-noise than comparable sensors
- Rugged design protects your sensors from damage
- Eliminate non-linearity caused by shipping and handling
- Easy to handle
- Water-tight IP68 housing

Key Features:
- NLNM performance over a broad frequency range
- Genuine warless baseplate w/complete electrical isolation and an EMI/RFI shield
- 50g-rated mass lock
- Remote diagnostics and operation
- Very reliable connectors and cabling

The figure below shows a typical Self Noise Spectra

PBB-200S Specifications

<table>
<thead>
<tr>
<th>Sensor Technology</th>
<th>Velocity Output</th>
<th>PBB-200S Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triaxial, orthogonal feedback sensor</td>
<td>Industry-standard 40V peak-to-peak, matched to Quanterra data logger input, Z, North, and East</td>
<td></td>
</tr>
<tr>
<td>with temperature-compensated leaf spring</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shock Survival</th>
<th>Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass lock allows more than 50g shocks with no degradation of linearity or hysteresis</td>
<td>120 seconds to 50 Hz, pole/zero data provided</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Self-noise</th>
<th>Mass Position Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below NLNM 30 seconds to 8 Hz</td>
<td>Independent, orthogonal mass position outputs for each sensor</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500 V/m, factory trimmed to 0.25%</td>
<td>Available; compatible with Quanterra data logger for remote network diagnostics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cross-axis Sensitivity</th>
<th>Host Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.2%</td>
<td>Included with each unit; isolates more than 95% of total power from the sensor elements for improved performance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass Centering</th>
<th>Serial Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard local and remote operations</td>
<td>Available RS-232 for local or remote operation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Leveling</th>
<th>Power Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bubble level and locking feet</td>
<td>1W typical from isolated 9-36V input</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alignment</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision straight edge on housing</td>
<td>Pressure sealed IP68 sensor housing with true warless baseplate, EMI/RFI shield</td>
</tr>
</tbody>
</table>
STX-2.5 Post/Borehole and OBS Design

- Streckeisen/Metrozet/Quanterra development
- In response to needs for a future Post/Borehole deployment and OBS opportunities we are developing a Post Hole package based on the STS 2.5 units.
- An initial gimbal structure has been designed, fabricated and integrated with an STS-2.5 sensor deck within a conventional STS-2.5 package. Testing of this has begun.
- An improved mechanical design has been completed and submitted for mechanical fabrication.
- A concept design for a pressure-isolated 5.5” diameter cylindrical housing for a gimbaled STS-2.5 is developed.
- First installation in OBS installation early summer 2012
NEW Developments!

**OBS Station**

- Based on proven design
- Started with Woods Hole Oceanographic institution (WHOI)
- Moved to UCSD Design
- Operational in many installations worldwide including in US OBS pool

**The Short-Period OBS.** The instrument is ~ 1m in height. Carries a 3-component 3.5 Hz geophone and a hydrophone. 9 month battery life.

**Strong-Motion/Broad-Band OBS.** EpiSensor/STS-2.5, Differential Pressure Gauge. Max deployment duration is 1 year.
**OBS Station and New Improvements**

- New design to support our current project in Caspian sea
- To support Cable and Autonomous operation
- WHOI OBS design incorporates the Q330 and PB14/44 since early 2000.
- New Design will incorporate Gimbal structure for the STS-2.5 sensor deck.
- New timing system to allow aging < 3.0e-10/month
NEW Developments!

OBS Station

New Design: Q330 and Baler-44; All electronics in Al pressure housings; Syntactic foam floatation.
NEW Developments!

**OBS Station**

- To support Cable and Autonomous operation

New Autonomous OBS Design: STS-2.5, Q330 and Baler-44; All electronics in Al pressure housings; Syntactic foam floatation.
NEW Developments!

EQ Early Warning and Basalt

- Basalt modes of communication
  - Through Ethernet Port
  - Using Serial Port
- The packet size is 1 second and cannot be made smaller.
- Basalt basic latency for normal operations is 1-2 seconds.
- However, there is a way to get real-time data through a serial link:
  - Samples with essentially “no latency” on a “sample by sample” basis and data could be GPS tag tagged (DFS Option.)
  - Telemetry lossless data is not guaranteed, since getting every sample through a serial link with no latency precludes all the good stuff needed for lossless data telemetry.
- More in the next Presentation
NEW Developments!

E. Early Warning: Basalt & GPS

- Accelerometer
  - Double integrations is always challenge
- Geodetic quality GPS provides direct displacement
- Required: Accelerograph and Geodetic quality GPS co-location
  - Basalt & Trimble GPS NetR9
- Basalt to provide:
  - GPS physical interfaces
- Basalt to provide onboard Data Processing
  - 2 data streams and to Derive a good displacement time series
- Antelope Data Center to collect packetized info, visualize and to disseminate info to stakeholders
  - Command and Control
NEW Developments!

New Line - EqMet: TSA-SMA

Low Cost Strong Motion IP Accelerograph that incorporates exceptional performance Metrozet TSA-100S accelerometer (Non-MEMS sensor) and with built-in GPS timing

TSA-100S sensors have noise floor of 22 nano-g/root Hz @ 1 Hz (seismic grade)

Market:

- Noisy, lower-grade Strong Motion sites (deployments)
- Target product coming from Guralp, GeoSig, Reftek; especially those who use MEMS sensor (Current Low-cost products based on industrial-grade MEMS sensors are 20 - 40 dB worse from TSA-100S)
- Target Selling Price <$5,000

Time Scale & Costs

<table>
<thead>
<tr>
<th>Month</th>
<th>FY11</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>FY11</td>
</tr>
<tr>
<td>Sept</td>
<td>FY11</td>
</tr>
<tr>
<td>Oct</td>
<td>FY11</td>
</tr>
</tbody>
</table>

Design Finished and Given to Production for Manufacturing
Production Units Available
First Delivery to Taiwan

Development & Other Risks

- Production Cost Containment to meet Target Selling Price
- Market acceptance....
- Is there traditional Strong Motion Market?