Canadian Hazards Information Service (CHIS)
and
Seismic Networks in Canada

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Canadian Hazards Information Service
Natural Resources Canada (NRCan)

Antelope Users Group meeting
Papagayo, Costa Rica
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What We Are Part Of

- Natural Resources Canada (NRCan) – federal government
  - Earth Sciences Sector
    - Geological Survey of Canada (GSC-AWCB)
      - Canadian Hazards Information Service (CHIS)
        - Earthquakes Canada
- What is CHIS involved in? – Natural Hazards
  - Earthquake Monitoring – Earthquakes Canada
  - Geomagnetic Monitoring and Space Weather Forecasting
  - Nuclear Emergency Response, e.g.mapping of radiation release
  - Tsunamis and Landslides
  - Nuclear Explosion Monitoring
  - Emergency Mapping, e.g. flood mapping
  - Emergency Management Plans for Natural Hazards
- Other groups in NRCan but outside CHIS that do more research

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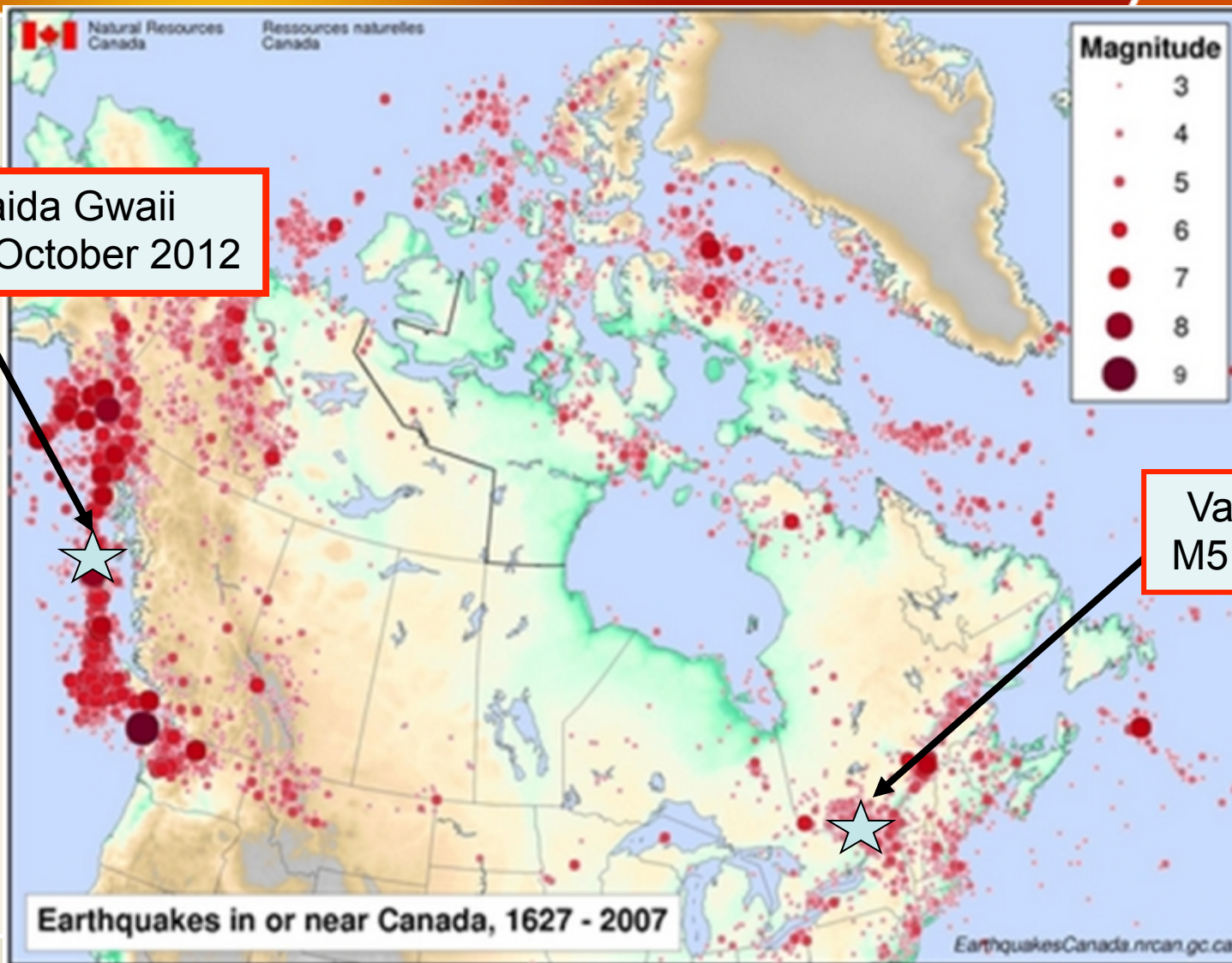
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CHIS Seismology Staff and Budgets

- 4 offices (Ottawa, East Ottawa, Sidney, Yellowknife)

- 1.75 seismologists + 2 contractors
- 5 Scientists (plus other researchers for on-call work)
  - building codes, magnitudes, explosion monitoring, infrasound
- 4 IT specialists
- 2 Operations staff
- 9 Field technicians

- ~$500k per year plus one time "capital" requests
  - Lost $750k per year plus 3 IT staff to Shared Services Canada (consolidate IT data centres & communications)
  - Salary costs not included

Seismicity in Canada

Haida Gwaii
M7.7 October 2012

Val-des-Bois
M5 June 2010

Magnitude

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Earthquakes in or near Canada, 1627 - 2007

EarthquakesCanada.nrcan.gc.ca

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Mandate

- **Canadian Hazards Information Service Mandate**
  - **"the provision of information on the actual or probable occurrence and intensity of earthquakes".**
- From the Emergency Management Act
- Clients:
  - Federal, provincial, and territorial Emergency Management Organizations (EMOs)
  - Critical Infrastructure (CI) operators
  - Media
  - Canadian public

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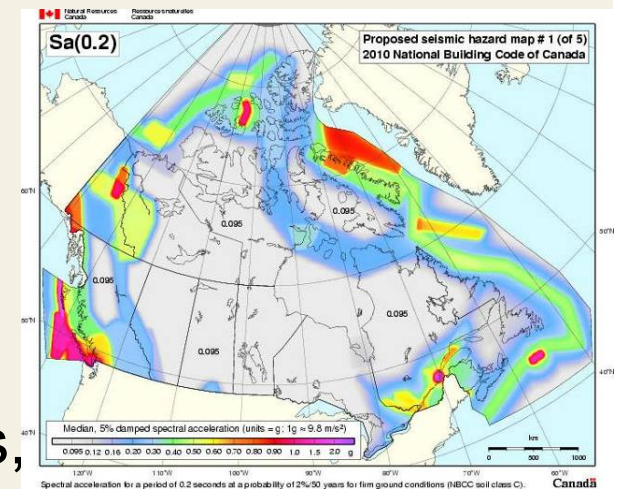
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CHIS Earthquake Responsibilities

- Seismic Monitoring

- Collaboration with other agencies – data exchange

- Rapid Response for Earthquake Info

- Public Information

- Earthquake Hazard Assessment

  - Seismic hazard zoning maps

    - National Building Code

  - Advice for Critical Infrastructure

    - Hydro dams, Nuclear power plants

    - Pipelines, power transmission lines,

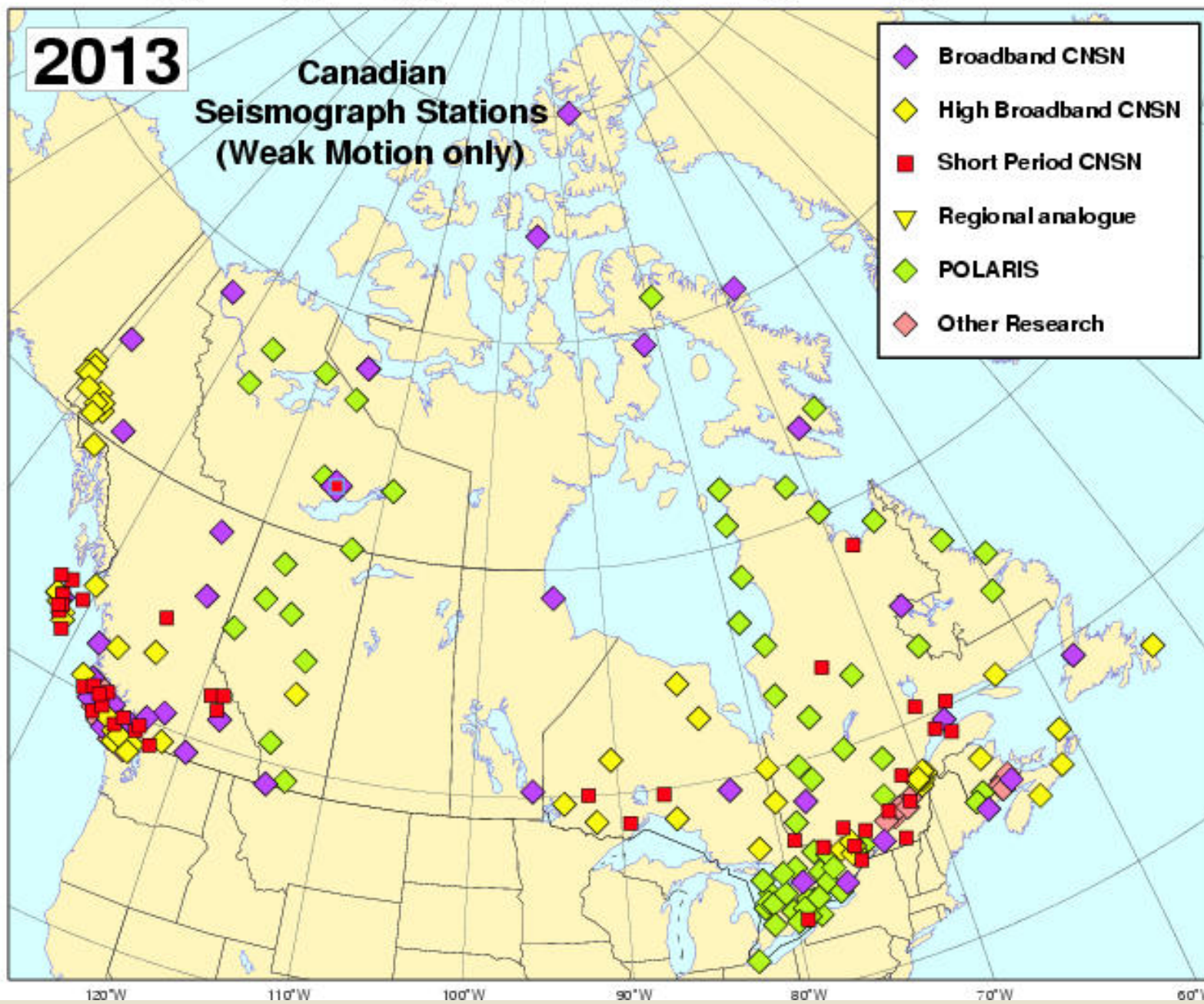Natural Resources Canada   Ressources naturelles Canada

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2013 Canadian Seismograph Stations (Weak Motion only)

Legend:
- Broadband CNSN
- High Broadband CNSN
- Short Period CNSN
- Regional analogue
- POLARIS
- Other Research

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Seismic Networks

- Continuous, real-time, weak-motion data from:
  - Canadian National Seismograph Network (CNSN)
    - ~165 Observatory-grade, permanent stations
    - network ~20 years old
    - currently seeking funding for network refreshment
  - Other special deployments within NRCan
    - ~35 temporary stations
  - University stations from POLARIS Network
    - ~60 Portable, temporary stations for research
- Strong motion monitoring
  - ~120+ stations in Canada

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Seismograph Equipment

- Equipment used in CNSN
    - **Digitizers designed in house and use CNSN protocol – cnsn2orb**
    - ~40 SPD Vertical-only Short Period sampled at 100 s/s
        - S13 seismometers
    - ~70 GD 3 Component Broadband sampled at 40 or 100 s/s
        - Guralp CMG 3ESP, 3T, 40T seismometers, STS1 seismometers
            - Various bandwidths 50Hz - 30s, 60s, 120s, 360s & NSN; 360s for STS1
        - MB2000 microbarometers for infrasound
- 3C BB Libra/Trident & Taurus digitizers (40 or 100 s/s)
    - **Apolloserver seedlink connection**
    - Guralp CMG 3ESP and Nanometrics Trillium seismometers
        - Various bandwidths 50Hz - 60s, 100s (POLARIS standard), 120s
- Yellowknife array – 18 SP & 4 BB sites, upgraded to Guralp – **CD1.1**

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Canada

Strong Motion Monitoring

- ~100 Internet Accelerometers
  - ia2orb for data access
- Some Nanometrics Titan
  - At Libra or Taurus weak-motion sites
- ~20 Kinemetrics Altus Etna
  - Non-realtime
- Future – increase in strong motion co-located strong motion stations

The National Strong Motion Network Map

Telecommunications Network

- Acquisition of continuous, real-time CNSN data requires operation of a national telecommunications network (SeisWAN) involving 30+ VSAT satellite links, UHF/VHF radio, spread-spectrum radio, dedicated telephone/modem links, cell modems, T1 links, Frame Relay links, and the Internet.

- Heterogeneous on purpose!

- ~60 Nanometrics Libra stations in CNSN and POLARIS use Carina Hub for master earth station and NAQS software which is then converted to CNSN protocol. To be replaced with ApolloServer and SeedLink feed.

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CHIS Data Centres

Two data centres: Ottawa, Sidney

- Parallel, Independent Operation
- Redundant Systems & Communications
- Change control procedures
    - 2 man rule, in-house ticket tracking system, partial use of GIT
- Operate on a 24x7 basis with on-call IT systems staff

- Legacy systems – Sparc/Solaris with in-house software
- New systems – Intel/Linux CentOS with Antelope & Nanometrics software
- Acquire, process and archive over 5 GB/day of waveform data
- Waveform Archive (~20 TB and growing) – sync'd between data centres
    - Channel or station day files, internal or mini-seed format
- National Earthquake DataBase (catalog), Ingres RDBMS moving to postgres
- Automatic and analyst reviewed processes to locate earthquakes

Canada

Collaboration with Other Agencies – Data Exchange

- Forward real-time data from 10 IMS stations to CTBTO in Vienna (under contract with SLA's)

- Disseminate Wave Form and Earthquake data to other agencies and researchers including:
    - Tsunami Warning Centres
    - USGS
    - IRIS
    - US Regional Networks
- Import and export via various formats
    - CD1.x, orb2orb, earthworm, seedlink, NMXP/ NP, etc

- Earthquake Catalog
    - Sent to ISC when complete
    - Bulletins from US networks imported via Antelope
    - Working towards better real-time integration with USGS

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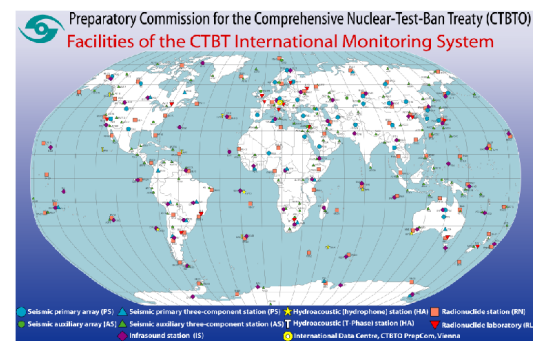
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Rapid Response for Earthquake Info and Public Information
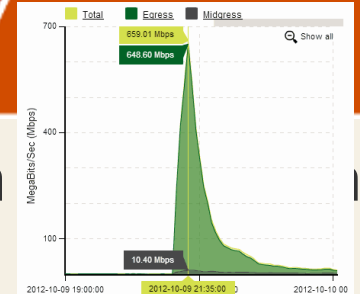
- 24x7 on-call seismologists provide rapid information earthquake location, magnitude, aftershocks
- Earthquake reports, maps & lists @ www.earthquakescanda.ca, DYFI
- Tweet automatic and reviewed earthquake notifications on Twitter
  - English: @CANADAquakes, Français: @CANADAseisme
- AEneas (Automated Event Notification and Eq Alert Service)
  - Alerts Customized for client's facilities and thresholds
    - sent via email, scp, SMS, ftp, fax
  - Eg: send "STOP/SLOW TRAINS" alerts to railways within minutes
- Earthquake alerts to Multi-Agency Situational Awareness System (MASAS) using open standards, e.g. Common Alerting Protocol (CAP)
  - sharing of location-based situational awareness information and alerts between issuers, first responders & emergency management agencies
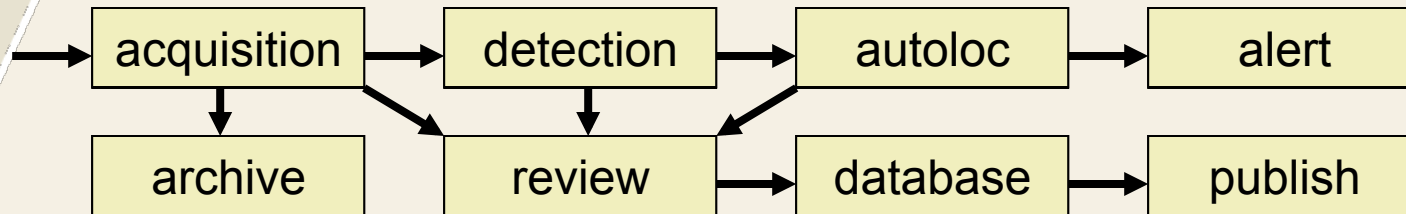
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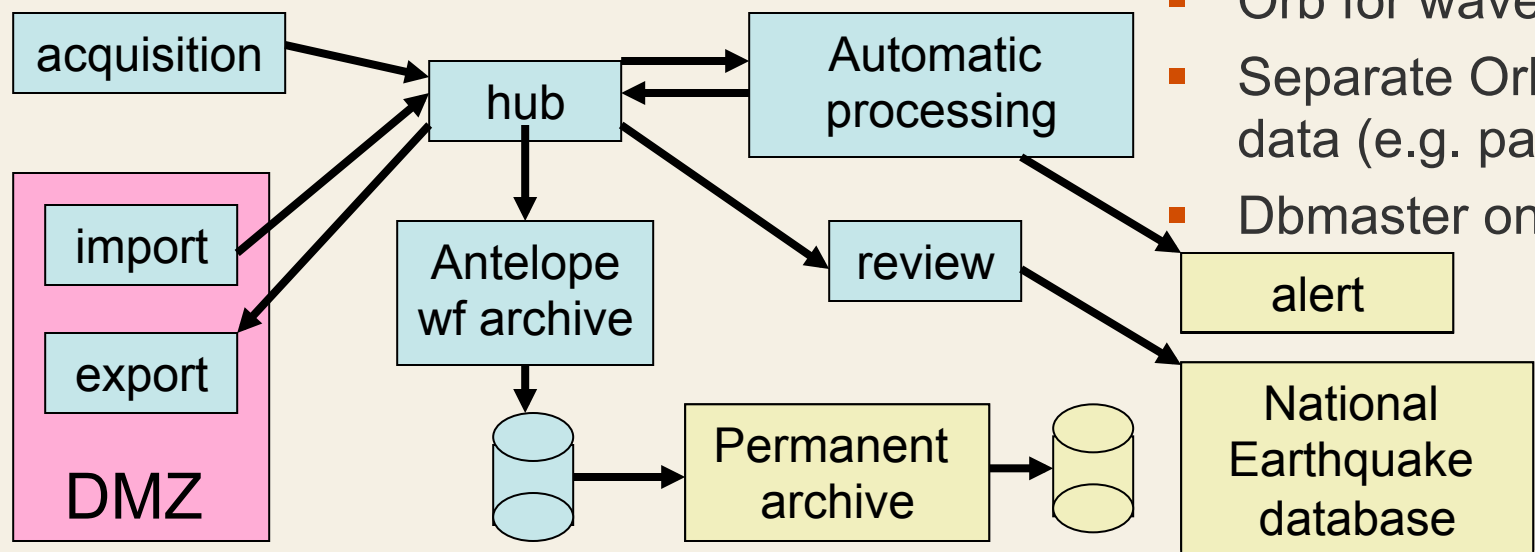Natural Resources Canada   Ressources naturelles Canada

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Processing System

- Legacy Data Processing System – developed in-house

```
→ acquisition → detection → autoloc → alert
      ↓             ↓          ↘
   archive → review → database → publish
```

- Current Antelope 4.x System – all on one computer

- New Antelope 5.2 System – partially implemented

- Orb for waveform
- Separate Orb for other data (e.g. parametric)
- Dbmaster on select zones

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6. Network Operations Meetings

- Weekly seismology group meeting in Sidney.
- Weekly station meeting (Sidney & Ottawa)
- Bi-monthly analyst meeting (Sidney & Ottawa)

8. Network Obligations

- Serve the people of Canada
- Significant event response
- Waveform archiving
- Catalogue (ML, Mw, MbLg, MN)
  - Bldg code (seismic zoning regions/maps)
  - Research

t do THEY want?

Public
- Earthquake location & magnitude as fast as possible.
- What is the chance of aftershocks?
- When is the next big earthquake?

Engineers
- Input to building code
- Expected velocity & accelerations at a given lat & lon.

Research
- Waveform archive
- Earthquake catalogue
- All available magnitudes for incorporation into catalogue.
- Access to tools to manipulate wfs and catalogue database.

Products

- Waveforms
- Earthquake catalogue
- Metadata
- Web pages for significant events (< 1 hr)
  - Earthquake location (map & time, lat, lon, depth, mag)
  - Earthquake distribution in region
  - Largest earthquakes in region (where & when)

Desired, but not yet in use with Antelope:
  - "Shaking map"
  - MTs
  - Focal mechanisms (P-nodal from first motions)

10. Building Catalogue

- Real-time solutions drive analyst review
- Dbcentral/Dbloc2
    - genloc
    - Assoc with external catalogues (RT Bulletin acquisition)
    - Event flags: Blasts, Locals, Teleseisms, Induced, rockburst (want to move to international std designations – whatever they are!)
- Catalogue available through the web
    - Research, engineers, public

Building catalogues (cont.)

- Essentially have two orthoganal catalogues
  - East & West
- Reconfiguring to allow processing on each catalogue from either office.
- Acts as a backup for each catalogue.
- Keeps daily processing sane so that analysts in each office can process their respective catalogue as a single system without being burdened by the review for the other catalogue.
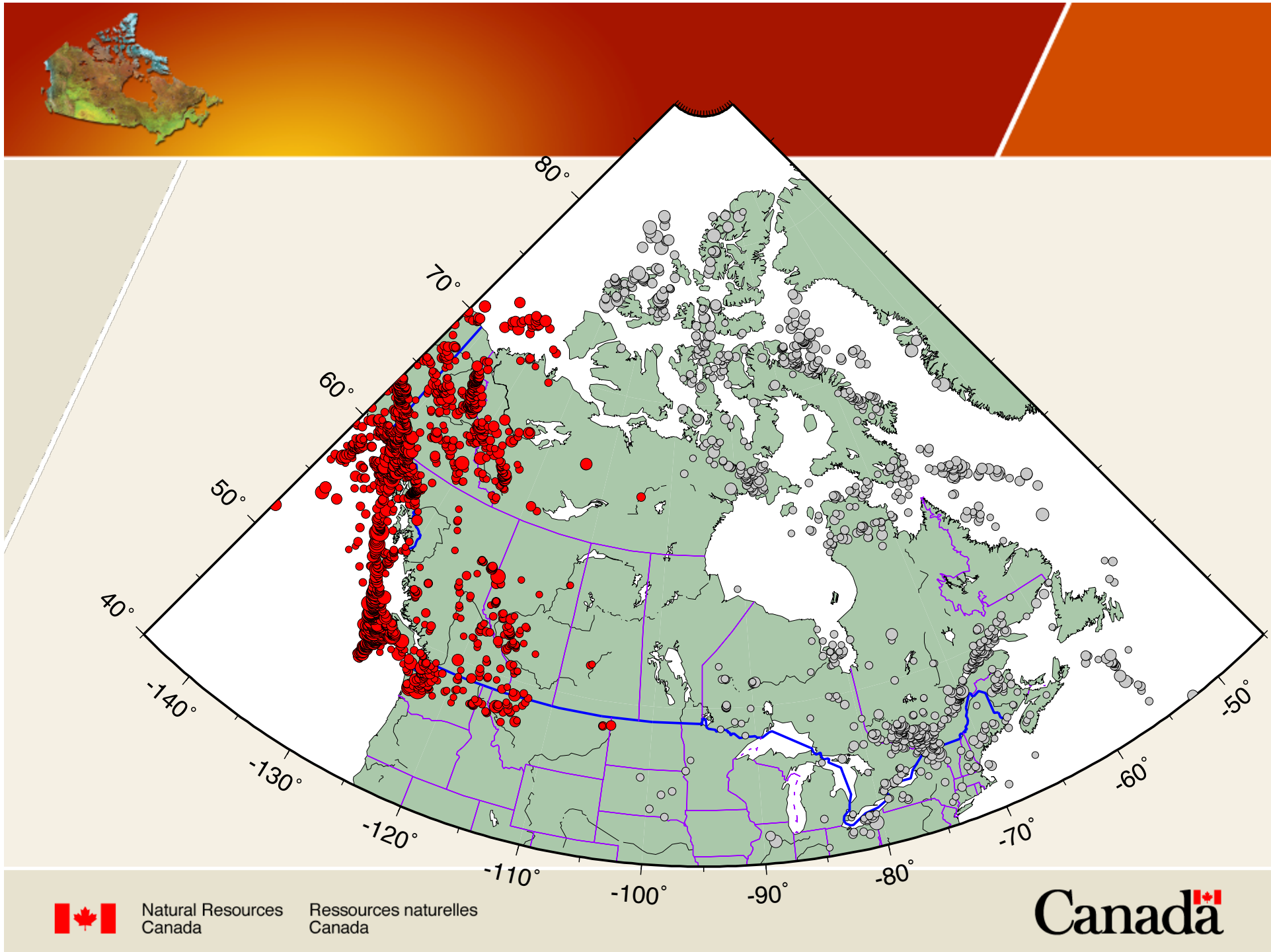- Create read-only catalogue for web/research use.

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11. Local and Remote Archive Features

- Wf archive of CA data in CA format

- Rt waveform archive in miniseed. ~60 day depth for event analysis (90+ days would be ideal).

- Catalogue in Ingres, flat "Loon" files, and antelope datascope db.

- External wf data NOT archived – retrieved from IRIS

12. Other Products

- Significant event pages
- Tremor events (Honn Kao)
- MT's (Honn Kao)
- Strong Motion Maps (Andreas Rosenberger)

Short Term Needs/Challenges

- Coordinating operations across two distant offices (Sidney, BC & Ottawa, ON) with differing driving factors and hence differing priorities.
  - Event analysis in antelope
  - metadata
- Re-vamping or adding schema tables to legacy (Ingres) database to enable the proper mapping to antelope dbbuild & instr responses for properly formatted dataless SEED.
- Bringing Nanometrics data directly into Antelope.
- Difficulties: no on-site computer support for the western office seismic group.
- Difficulties: Shared Services Canada is taking over operational support for all computers. It will be interesting to see what this will look like for the seismic network. Stay tuned.
- Analysts – 2 staff, 2 contract (not enough)

13. Research Tools

- Sac
- Matlab
- Dbxcor
- Fpfit
- focmec

14. Vision - 5 years

- Mini-SEED wf archive
- All wf data archived at IRIS
- Metadata produced routinely and correctly (getting closer!)
- Historical metadata in correct antelope format (getting closer)
- Entire earthquake catalogue in antelope format for use with antelope research tools.
- Storing local modifications (pf files, velocity models, etc.) through config_sourcetree.
- Real-time shaking maps (acceleration map with data from strong motion instruments)
- Real-time MT estimates
- Catalogue routine
  - Daily review
  - Daily wf scan for missed events
  - Teleseismic arrivals determined by x-correlation (fast and consistent).
  - Monthly review
    - need to be much more efficient at the daily review stage in order to find time to get this done

- FM catalogue
- Cascadia catalogue (events sorted by tectonic plate location)
- Various other catalogues for operational and research purposes
- 6 month or yearly release (snapshot) of reviewed seismic catalogue – archive these snapshots
- Full access to antelope based version of the historical wf and catalogue archive to the in-house research group.
- In house antelope based development done in a generic manner and submitted to contrib.
- Monthly metrics.
- Web development (transition from Ingress based web data to Postgres and/or antelope based web data)
- USArray coming to the Yukon: increase wf acquisition & analysis.