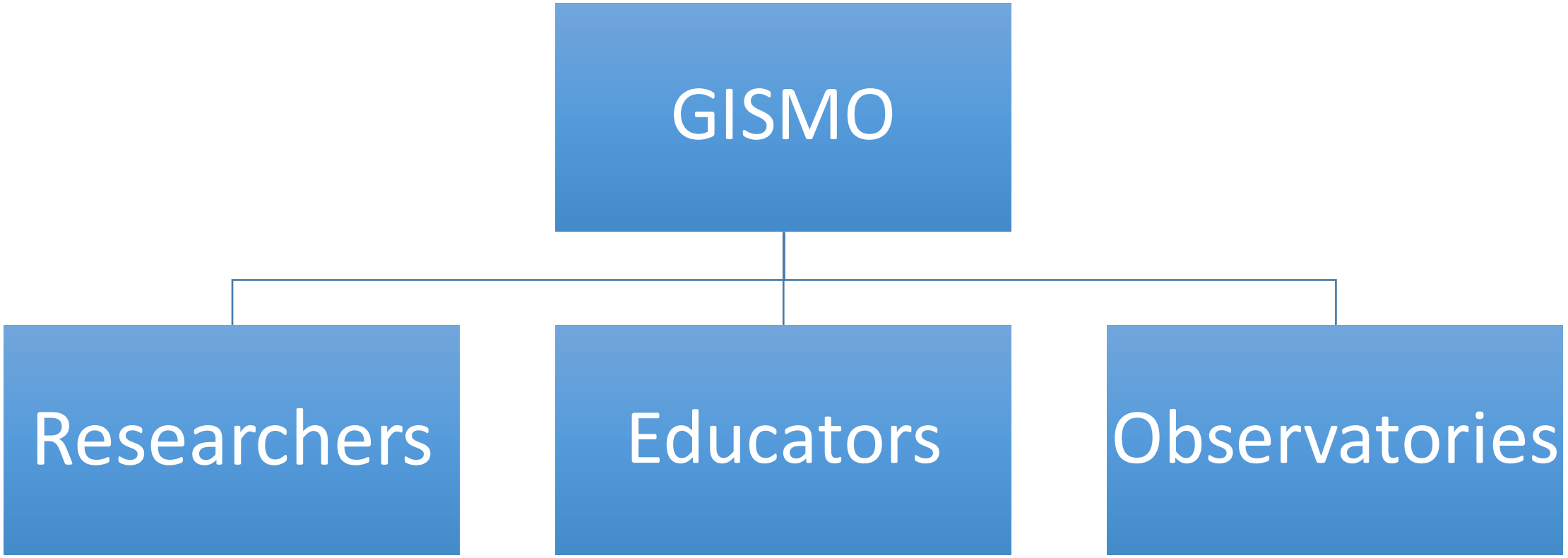
GISMO

"An object-oriented MATLAB toolbox for seismology research, teaching and monitoring"

Why am I telling you about GISMO?

- I mentioned GISMO to Armando when he asked if USF could provide any training in volcano seismology
- GISMO is used at other volcano observatories / seismic networks
- GISMO can read all INETER seismic data formats
- A platform on which we could quickly build new tools for INETER

GISMO – 3 target audiences



UAF, USF

"Antelope & MATLAB Programming", USF Fall 2014
Carl Tape at UAF

INETER

About me

specialist in designing/integrating seismic monitoring systems

- Began studying volcano-seismology in 1994
- Summer 1996: Montserrat Volcano Observatory
- 1997-1998: Systems Analyst/Programmer
- 1998-2000: Alaska Volcano Observatory developing web-based real-time monitoring tools
- 2000-2004: Lead seismologist in Montserrat. Rebuilt seismic monitoring programme.
- 2006-2013: Staff seismologist at AVO & AE(I)C designing real-time monitoring systems.
- **2013-Now: USF Professor, teaching courses in programming, seismic data analysis, time series analysis…**

Why GISMO for volcano-seismic monitoring?

Components of a seismic monitoring program

1. Seismic network
2. Data acquisition & event detection system
3. Alarm systems (earthquake, swarm, tremor, pyroclastic flows, lahars)
   - Alternatively a 24-hour Operations Room
4. Real-time data visualization systems (e.g. for rapid alarm response)
5. Catalog production / analyst review of data
6. Advanced analysis system
7. Data archival system / data management solution
8. Diagnostic monitoring & alarms to monitor all other software systems
9. Information to observatory staff, civil defence, aviation authorities, media, public etc.

Step 1. Choose “off the shelf” software

Data acquisition / event detection frameworks (modular)

- SeisComP3
- Earthworm
- Antelope*

Catalog production systems

- Seisan
- SWARM
- Antelope*

* Antelope is expensive. Everything else is free!

Step 2: Build custom software

- Typically each observatory develops their own custom software for things like:
  - Visualization of catalog data, e.g. maps, event counts, energy release rates, b-values, magnitude of completeness
  - Detecting swarms
  - Detecting tremor
  - Plotting RSAM data
  - Locating debris flows
  - Match filtering / cross-correlation studies
  - Web-based spectrograms
  - Instrument correction
- MATLAB is often the language they choose
- GISMO is a MATLAB toolbox that can do many of these things / support others
- ObsPy is an excellent alternative

Components of a seismic monitoring program

1. Seismic network - modern hardware is excellent
2. Data acquisition & event detection system – Earthworm, SeisComP3, Antelope
3. Alarm systems (earthquake, swarm, tremor, pyroclastic flows, lahars) – Earthworm & SeisComP3?
4. Real-time data visualization systems (e.g. for rapid alarm response) – SWARM, RSAM
5. Catalog production / analyst review of data – Seisan, SeisComP3, Antelope
6. Advanced analysis system – GISMO, ObsPy, Antelope
7. Data archival system / data management solution
8. Diagnostic monitoring & alarms to monitor all other software systems
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Typical volcano observatory setup

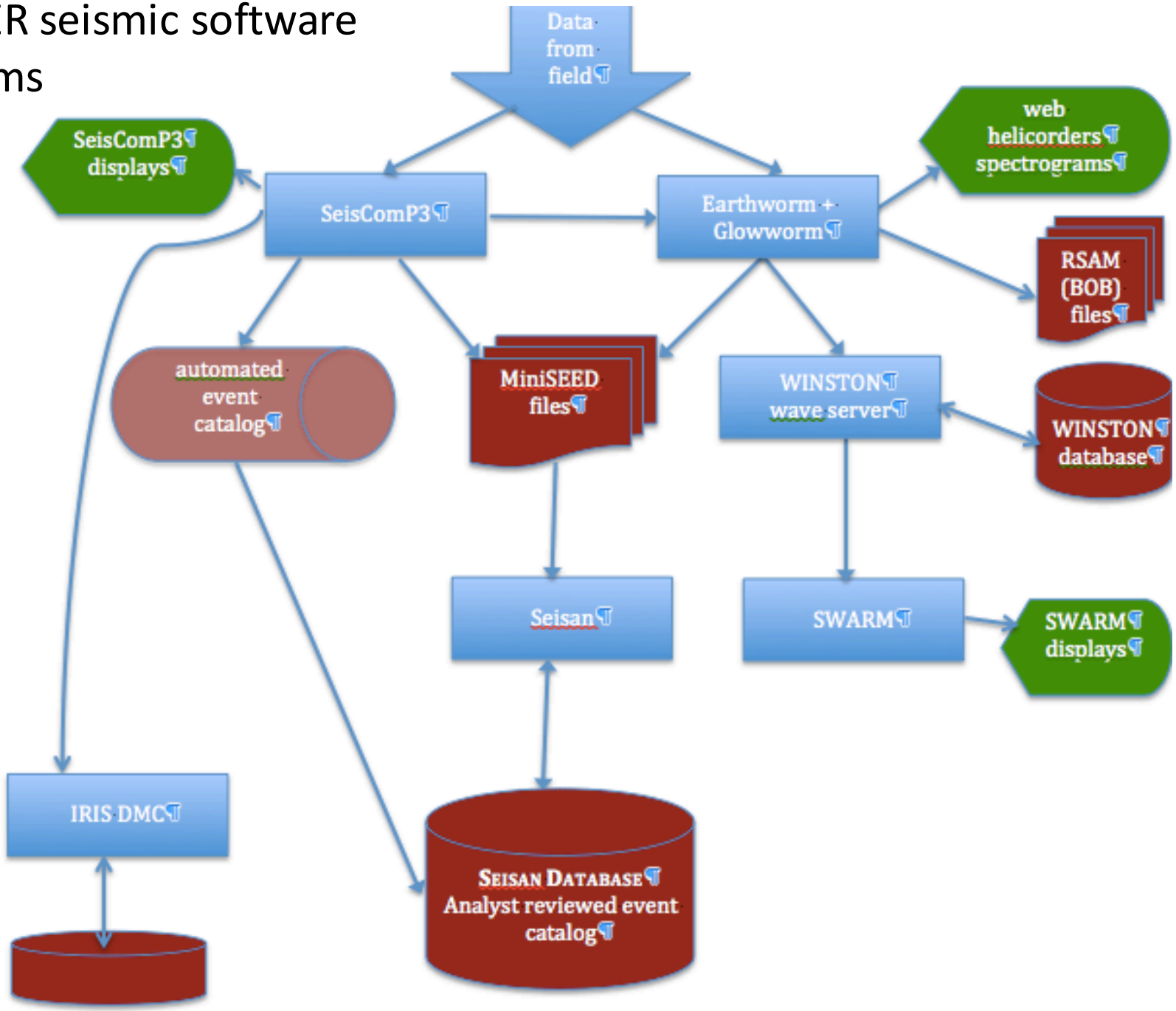
- Earthworm/Glowworm for data acquisition, subnet triggering, web-based helicorders & spectrograms
- Seisan for catalog production
- Winston & SWARM for analysis of continuous seismic data

VDAP deploys these tools

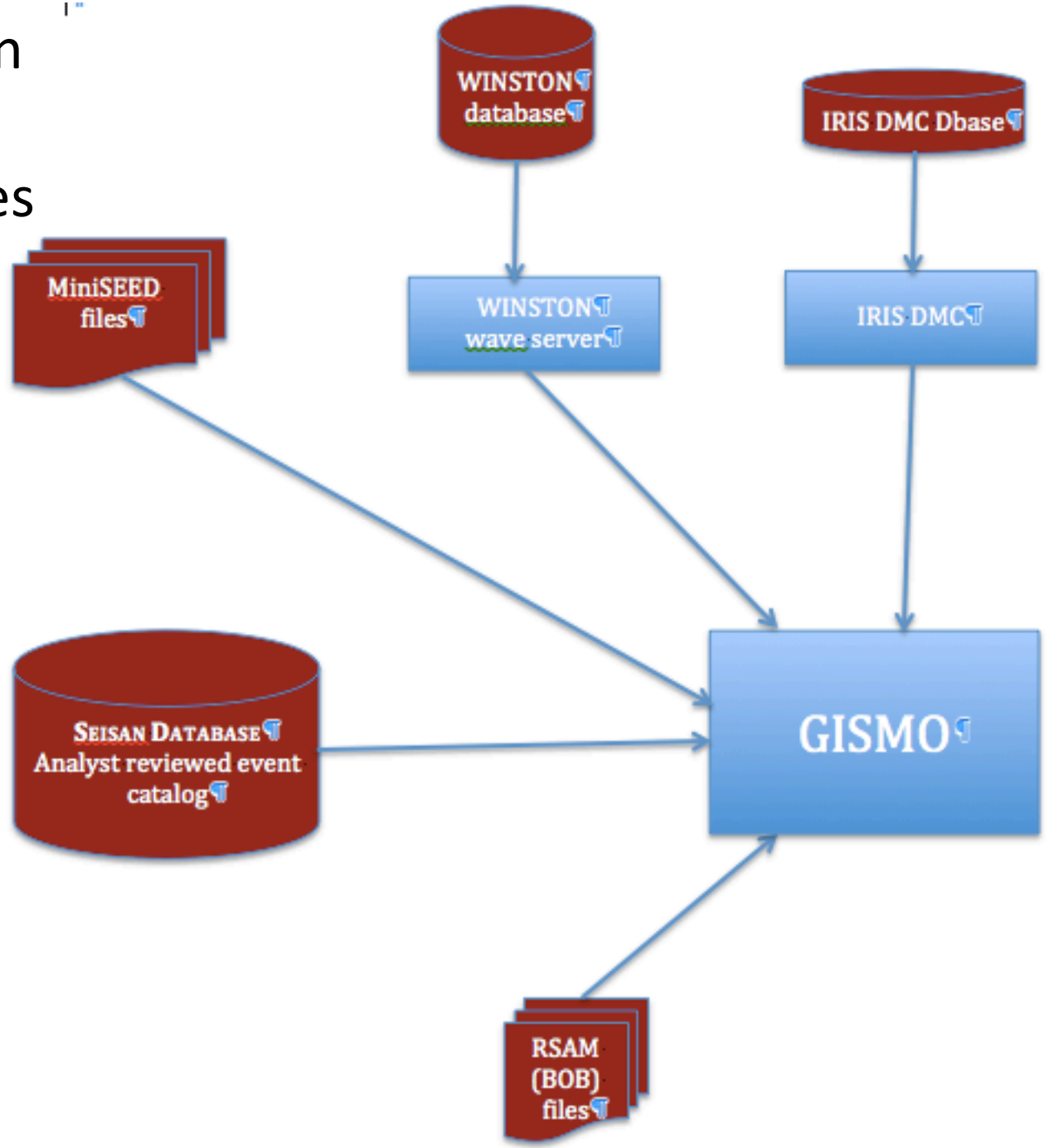
→A community of observatories who can share expertise

→Each does not have to reinvent the wheel

INETER seismic software systems



GISMO can read in all these types of data produced by INETER



GISMO can read…

- Waveform data
  - Miniseed, SAC & Seisan files
  - Seisan (WAV) databases
  - IRIS DMC (via irisfetch)
  - Earthworm & Winston waveservers
  - CSS3.0 (e.g. Antelope) databases
- Catalog data
  - Hypoellipse (Hypoinverse soon…)
  - Seisan S-file (REA) databases
  - Events from IRIS DMC (via irisfetch)
  - CSS3.0 (e.g. Antelope) databases
- Instrument corrections
  - SAC pole-zero files
- RSAM (BOB) binary files

What is the point?

- Writing code to load lots of different waveform and catalog data formats (e.g. Seisan, Miniseed, SAC, hypoellipse, CSS3.0) and from a variety of sources (e.g. Earthworm/Winston waveservers, Antelope databases, Seisan databases, SDS, IRIS DMC …) is the biggest barrier for seismologists trying to write code to analyze data.
- GISMO eliminates this barrier. Reduces the cost of data analysis / research.
- Only a few lines of code needed…

Objections

1. MATLAB is expensive
   - There is a free version of MATLAB called “Octave”
   - Your time is expensive. Software that saves your time – and allows you to rapidly respond to seismic/volcanic emergencies is valuable
2. MATLAB is slow
   - Well-written MATLAB code is almost as fast as C or Fortran. But it is 10+ times faster to write & easier to debug
   - Computers are 1000 times faster than 20 years ago. Biggest cost is your time writing code, not computer time running code.
3. I’d rather use Excel!
   - Excel is great for financial spreadsheets. But it is not good at all for scientific data analysis. Analyses are limited. Graphs are poor. Excel is not extendable. *Work is not repeatable!* Getting data into and out of Excel is a nightmare. Tip: do not use Excel

We have ObsPy. So why GISMO?

- ObsPy is a similar project with greater resources
- We all like ObsPy (I use it for teaching, research too)
- Python is free!

But:

- So much seismology code already written in MATLAB, rewriting it all in Python is impractical (think Fortran77)
- We still need a good seismology toolbox in MATLAB

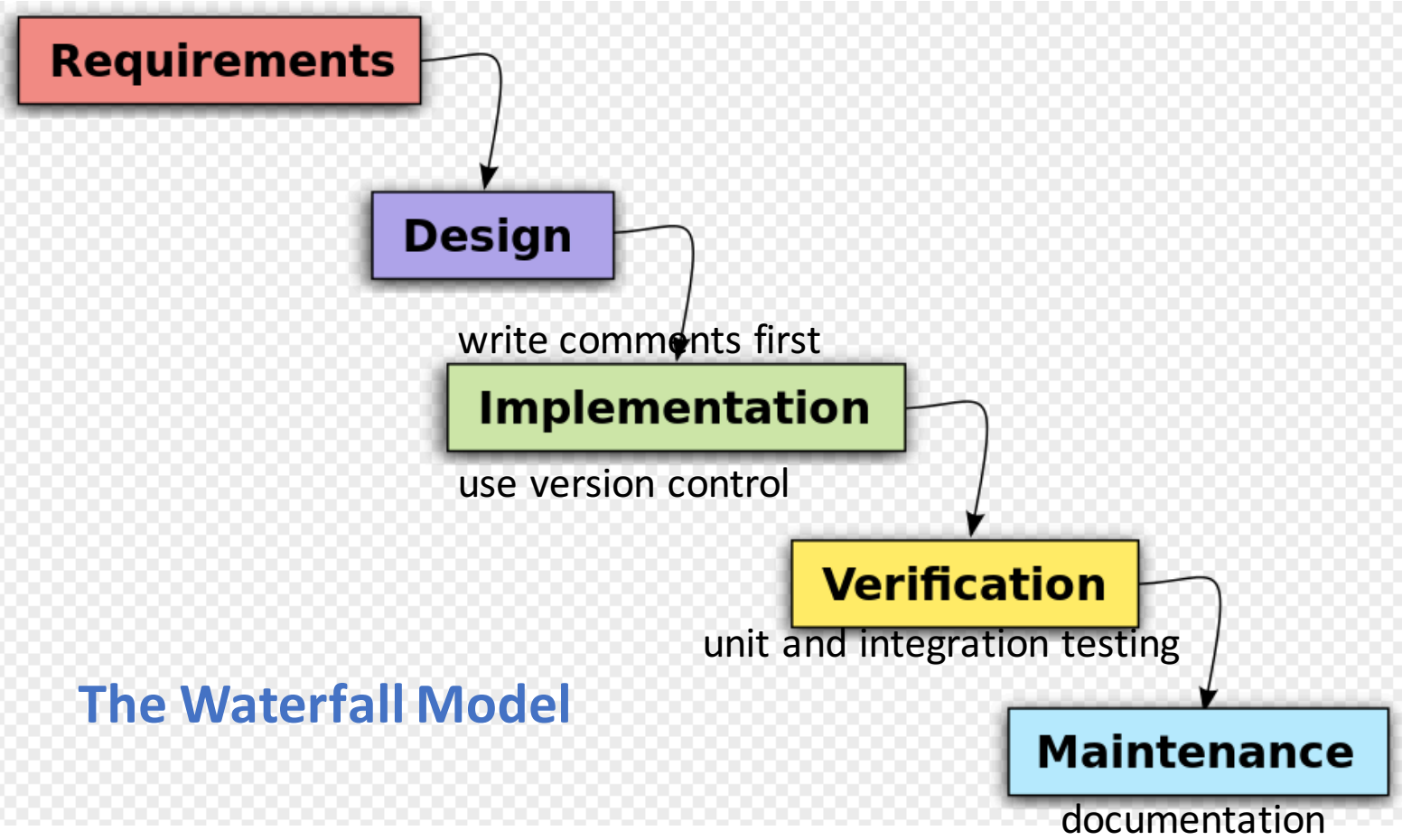
GISMO is community code

- Used by over 300 people worldwide since 2009
- Led by Celso Reyes & Glenn Thompson
- Contributions encouraged…this is how GISMO can grow and improve…

GISMO Timeline

- 2004-2006 Celso Reyes develops first version of ”The Waveform Suite”. Object-oriented.
- 2008 Celso & Mike West package other classes and contributed codes around The Waveform Suite. This package is called GISMO.
- 2011 Catalog class added by Glenn. No longer just waveform data.
- 2015 Lisa Kempler (MathWorks) contacts Mike, Celso, Glenn about GISMO. MathWorks wants to see this project go forward.
- 2015 (Fall) Glenn takes over GISMO. Migrated from Google Code to GitHub. Celso rejoins effort. Begin to add documentation, unit tests.

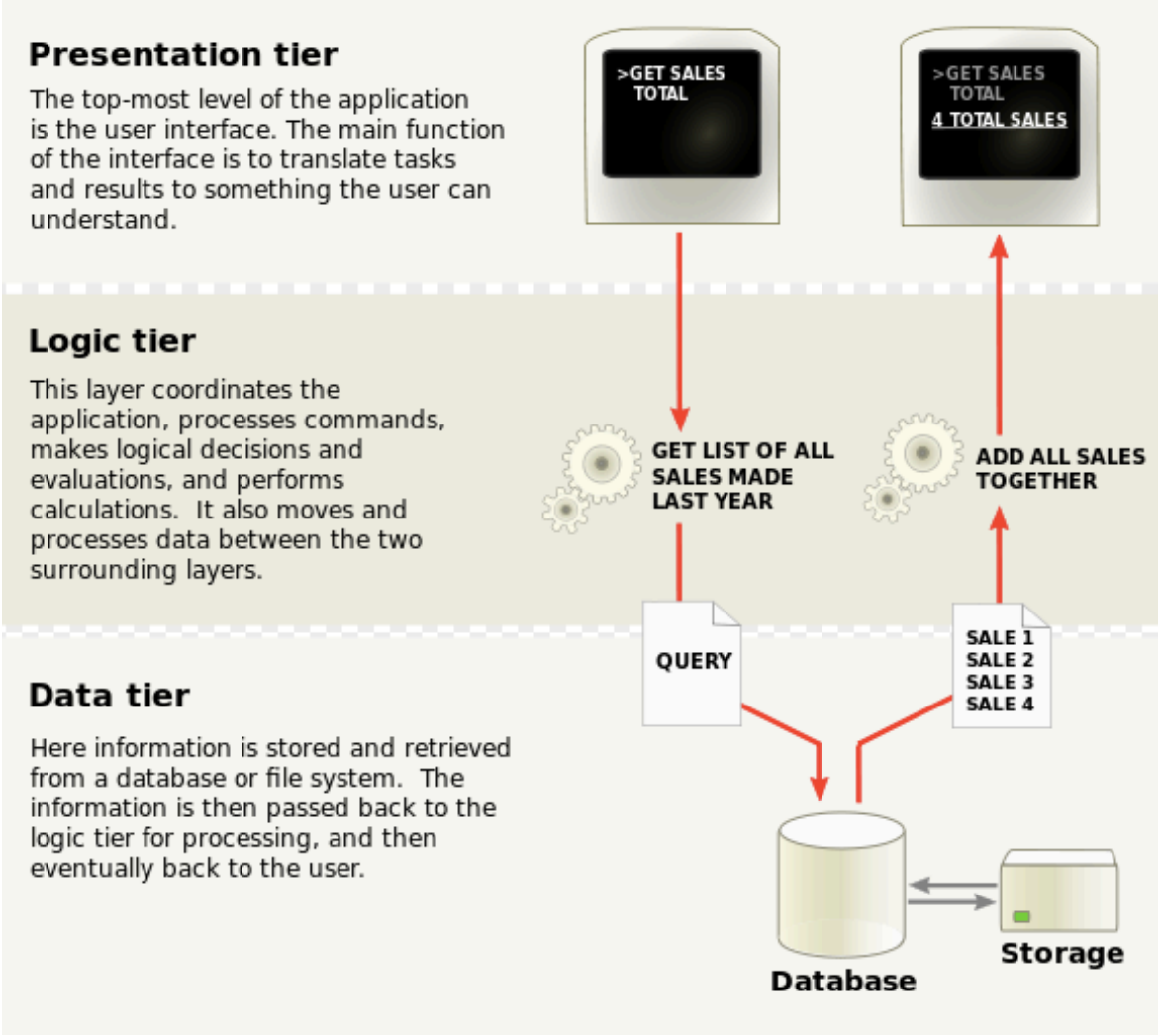
Software development



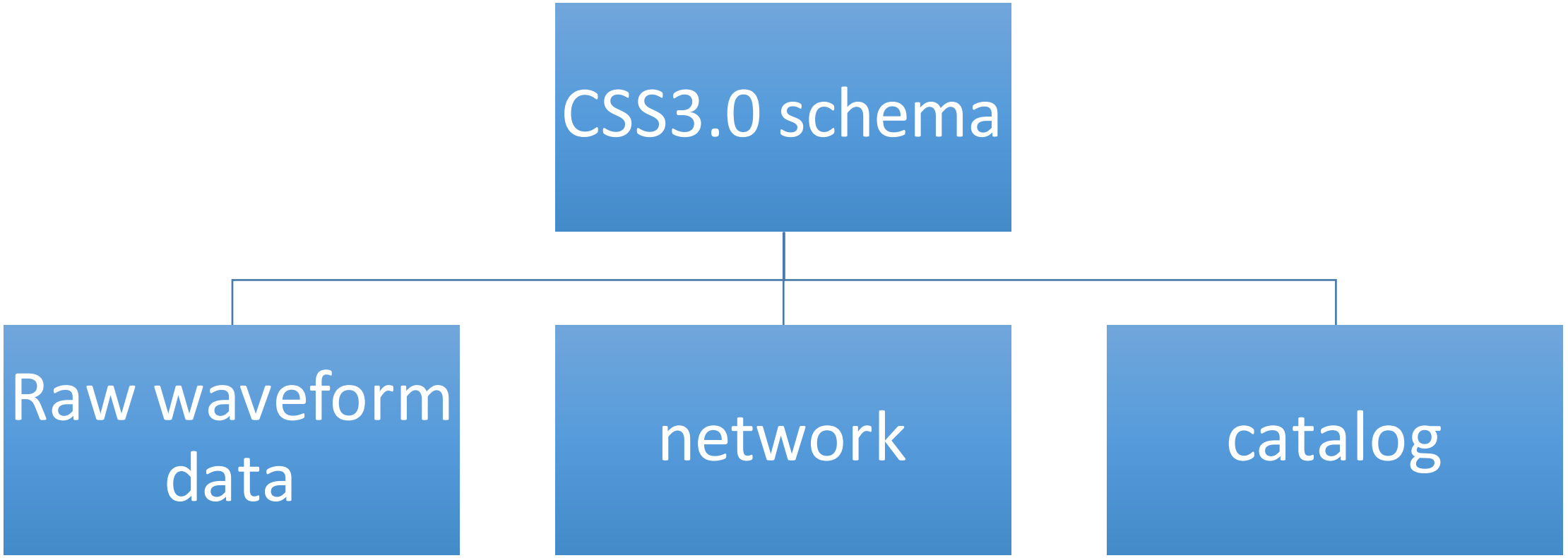
Project Management (e.g. Asana, Gannter)

Multi-tiered applications

- As we move to big data, we need scalable workflows
  - Database-driven
- Abstraction: User does not need to know details of data storage

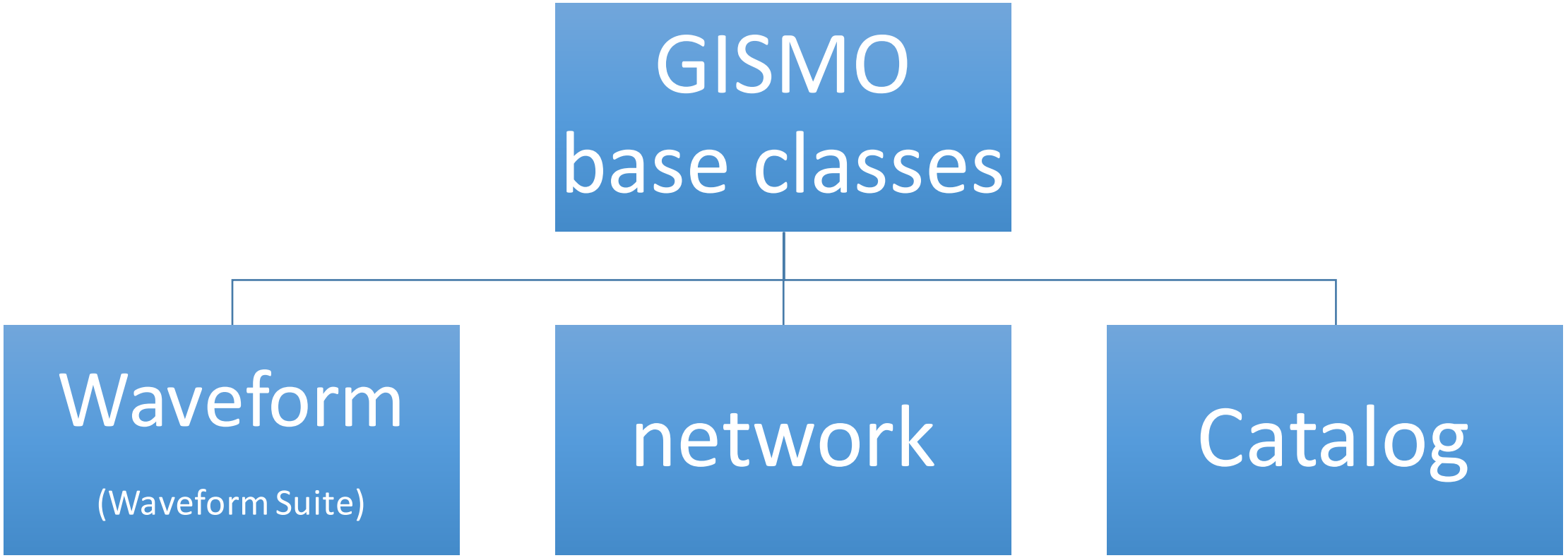


CSS3.0 database – 3 parts



- Antelope provides APIs in C, Fortran, Perl, PhP, MATLAB, Python which provide abstraction
- Antelope provides applications (e.g. dbpick, dbloc2, dbevents) built on this abstraction
- Easy to build own applications

GISMO – 3 parts



GISMO provides abstraction. You only need to know how to manipulation base classes (data types). Do not need to know how these are stored / retrieved.

Foundation of a good seismic toolbox

1. Must be object-oriented
2. Use abstraction so users do not need to know write data storage / format specific code
3. Base classes to describe main different types of seismic data
   - waveform
   - Catalog
   - Network
     - Sites
     - Instrument responses
4. Import/export functions to read/write common seismic data formats and data sources

Then adding functionality becomes easy.

GISMO is closest MATLAB toolbox to meeting these goals

Short-term targets

1. Stabilize GISMO, create new release
   - Fix issues, e.g. with waveform/load_antelope
   - Add unit tests
   - Internal consistency (helicorder -> drumplot)
2. Document
   - wiki
3. Adapt GISMO for volcano monitoring
   - INETER training next week
   - Miniseed data, Earthworm/Winston waveservers, RSAM data, Seisan catalogs
4. Publicize
   - Present at IRIS Workshop
5. Interface with ObsPy
   - Move waveform/Catalog objects easily between them

The GISMO project on github.com

Website:
https://geoscience-community-codes.github.io/GISMO/

Code repository:
https://github.com/geoscience-community-codes/GISMO

Wiki:
https://github.com/geoscience-community-codes/GISMO/wiki

Issue Tracker:
https://github.com/geoscience-community-codes/GISMO/issues

Applications built on GISMO

- AVO spectrograms http://www.aeic.alaska.edu/spectrograms/
  - Fastest way to browse large continuous seismic datasets
  - Versions of this in Montserrat, Cascades, Hawaii, NEIC