A history, status report, and outlook of Proj.4

@HOWARDBUTLER

Open Souce LiDAR

https://en.wikipedia.org/wiki/Map_projection

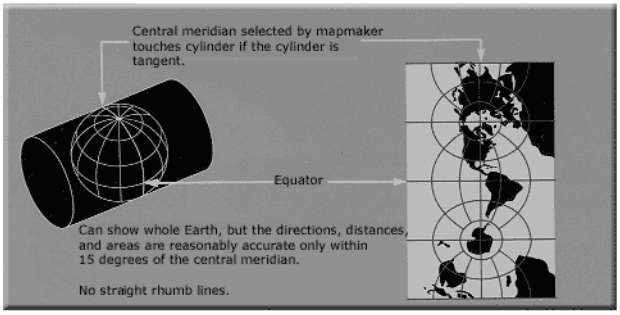
We in the geospatial software realm take a number of truisms for granted.

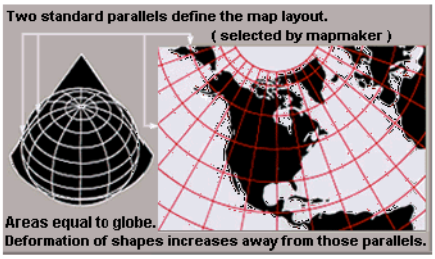
The ability to transform between coordinate systems is one of the most fundamental.

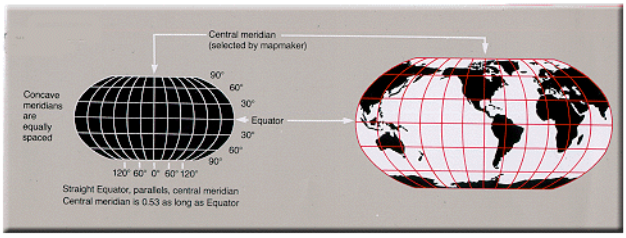
A primary challenge of geospatial software is
how to project a drawing of stuff on a round sphere onto a flat plane.

There are centuries of effort on the topic.

Some might argue that mapping software that does not concern itself with this challenge is not credible.

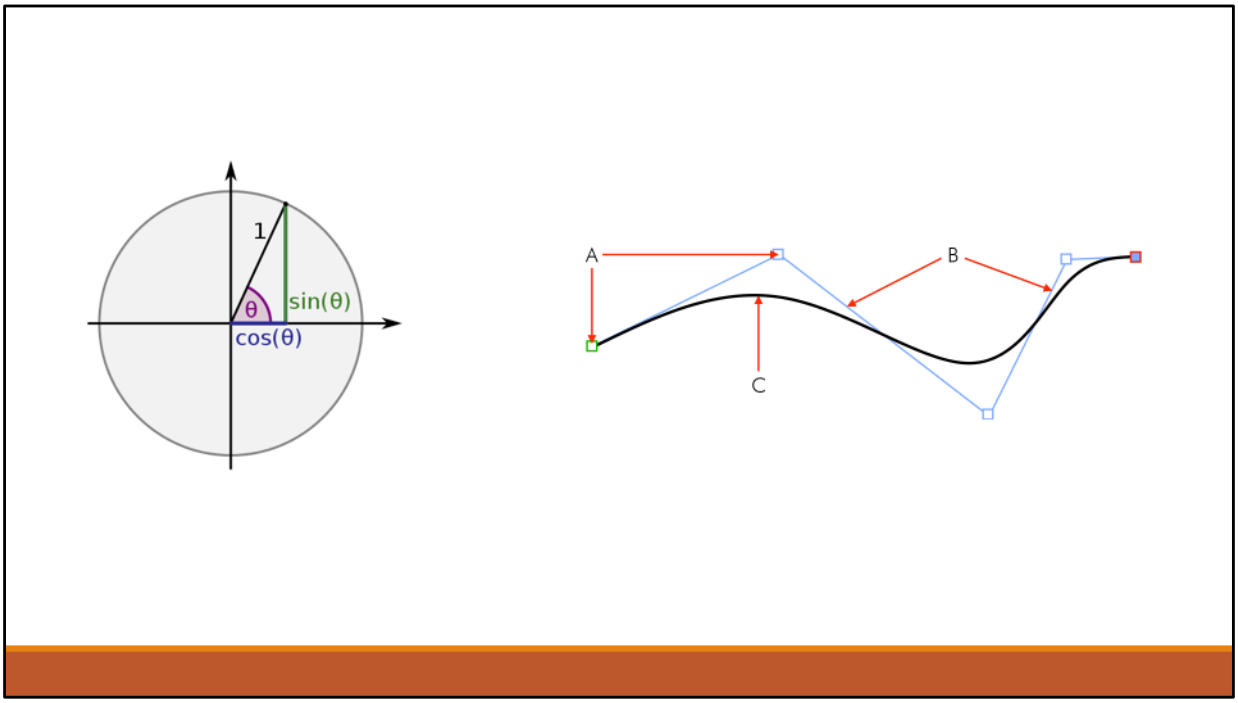






"Map Projections" poster, USGS

The ternary constraints of direction, distance, and shape loom over the mapmaker as they choose which to forgive in exchange for clear communication.



Cheap CPU cycles and efficient software
were required to support the computation of
fancy curves,
obnoxious trigonometry, and
iterative solutions required by software that does these projections.

Jerry Evenden

- 1935 - 2016
- USGS
  - Coastal and Marine 1976-1993
- San Jose State and Colorado School of Mines
- Geophysicist

In this locus, a researcher named Jerry Evenden in the Marine Geology group of USGS at Woods Hole took up the challenge of implementing the intricate math colleagues such as Snyder and Robinson collated and created in their eponymous books.

The software he wrote, PROJ, has wide and lasting impact throughout the geospatial software industry.

Today we will look back on PROJ and note Jerry's recent passing in 2016 with a remembrance.

I will describe how PROJ evolved with Frank Warmerdam's effort to become a full fledged open source project that nearly embedded itself in every open source geospatial software in some way.

I will discuss recent developments new contributors such as Kristian Evers, Thomas Knudsen, and Even Rouault have made that will keep the project moving forward for years to come.
and I will also discuss where the project is evolving.

Jerry Evenden

- 1935 - 2016
- USGS
  - Coastal and Marine 1976-1993
- San Jose State and Colorado School of Mines
- Geophysicist

Jerry knew he was going to be a scientist from age ten.

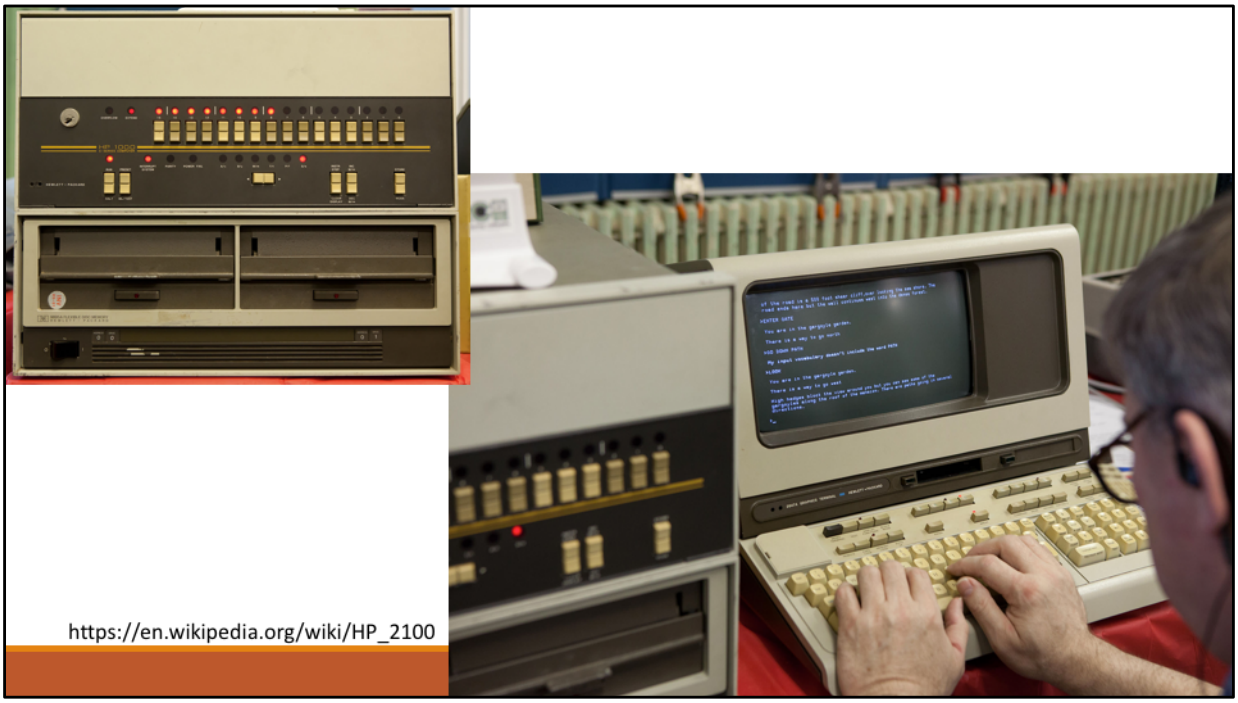
He wasn't an overly emotional person, and
he prized logical, rational thought.

Jerry met his wife Phyllis in Washington DC
where she was a park naturalist for the Park Service.

Phyllis mentioned they enjoyed
going to the pistol range together in DC
before they moved out to Denver,
where Jerry took a job doing seismic anomaly fieldwork for the USGS.

In 1976, he was offered a transfer to
Marine Geology in Woods Hole, Massachusetts.

It was there where he lived with his wife Phyllis of 51 years until his death last year in April 2016.



The offer to go to Woods Hole coincidentally timed
with the era of mini and personal computers, and
Jerry quickly started using them at USGS to solve problems.

The rapid miniaturization of computing
revolutionized sensors too, and
Jerry collaborated with many projects using them
to map the geology of the ocean floors.

Making maps that legibly covered large areas
with the results of their surveys was a challenge
for Jerry and his collaborators, and he set about the task with whatever he could find.

Jerry requisitioned three unix computers he called
Larry, Curly, and Moe to
support his software development efforts.

He wrote a map rendering software
called **MAPGEN** for vector rendering of maps, and
he combined that with a typesetting software he wrote
called **WOLF**, or Word Oriented Line Formatter,
to build a LaTeX + Scalable Vector Graphics of its day.

In support of mapping projects he was doing at the time,
he took John Synder's book and started implementing
projection transforms into what became the PROJ software library.

Jerry retired from USGS in 1993, and his software including PROJ lived online as a few tarballs
on some FTP servers until Frank Warmerdam
started to pick them up in the mid 90s

A problem with software that spans generations is
it is a product of the software culture and problems of its time.

Software design fashions change

Software tooling changes.

Software development techniques change

and each of these changes at different time scales.

Each of these causes software to atrophy in different ways too.

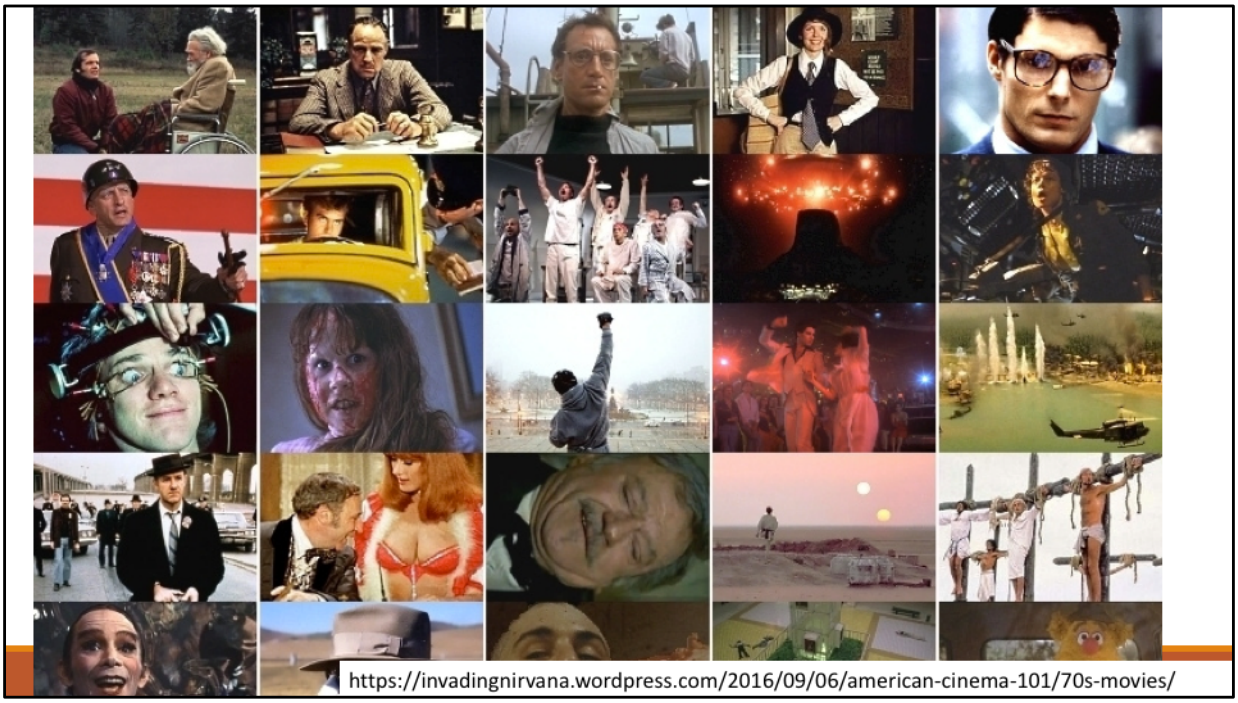
When we say an API from an ancient open source software project isn't usable,
we really mean we don't have a
software cultural literacy to translate it to today

https://en.wikipedia.org/wiki/Glenn_Miller_Orchestra

Like music from the 1940s,

https://www.flickr.com/photos/128157542@N08/16037316102

fashion from the 1950s,



or movies from the 1970s,
PROJ was software born of its culture.

That it is incidentally useful to us,
here in the future,
is a feature unique to open source software.

Open source software allows anyone
wishing to give software attention
the ability to keep it alive indefinitely.

Like an antique store record junky spinning 45s,
all that is required is for someone with enough
motivation,
enthusiasm, and
desire to keep
the software alive simply
by paying attention to it and
taking care to keep it from atrophying.

The foundation of one software civilization is the bones of another.

Software eras are more like civilizations.

Long lasting software is like art, music, or culture
that survives the transition from one civilization to another.

We might know what it does, and
we might know who made it, but
the context of how it fits with its peers, or
why certain choices were made are often lost.

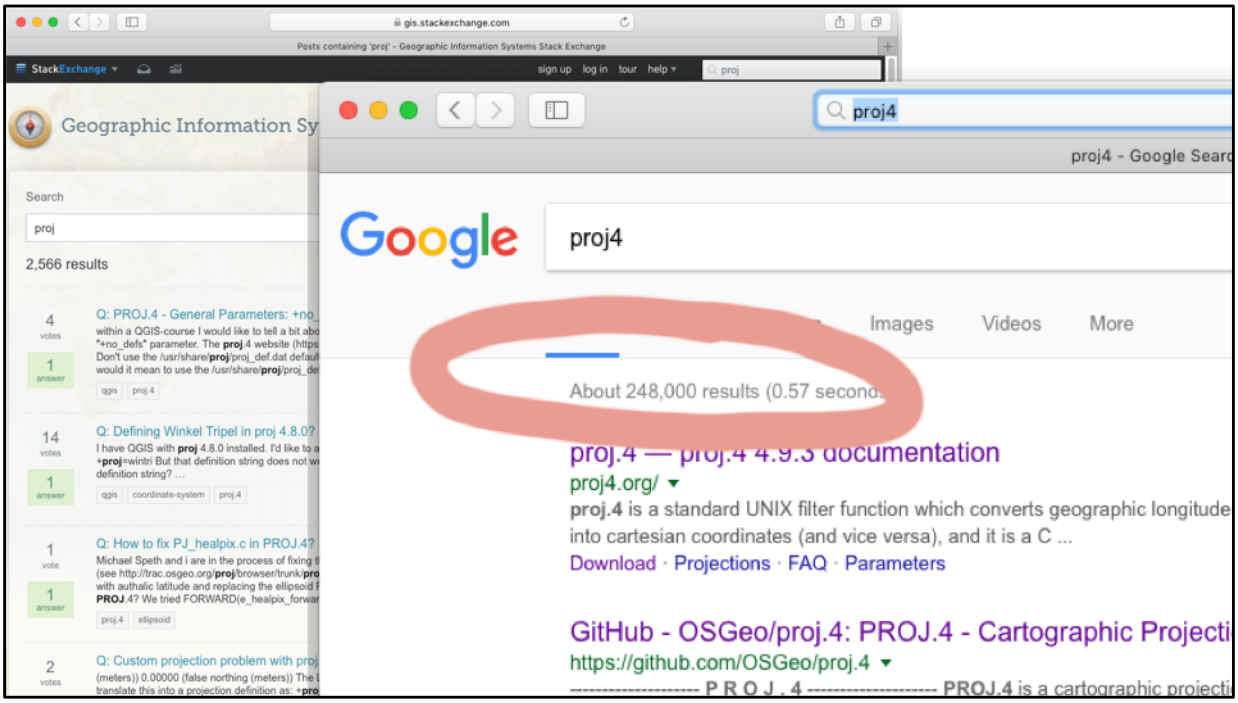
Even when something is carried forward
to a new computing future, developers who come later
end up trampling down APIs and
wrapping and stacking abstraction over them
to translate the disconnect.

PROJ was written for another computing time.

and PROJ was written for computers that don't exist today.

Did those computers even have one tenth of the computing power of the phones in our pockets today?

PROJ's API is quite natural if you are
culturally steeped in consuming 1990s
opaque object C APIs,
fume huffing macro compiler abuse,
and messy include structure
that was once organized to make things compile faster.

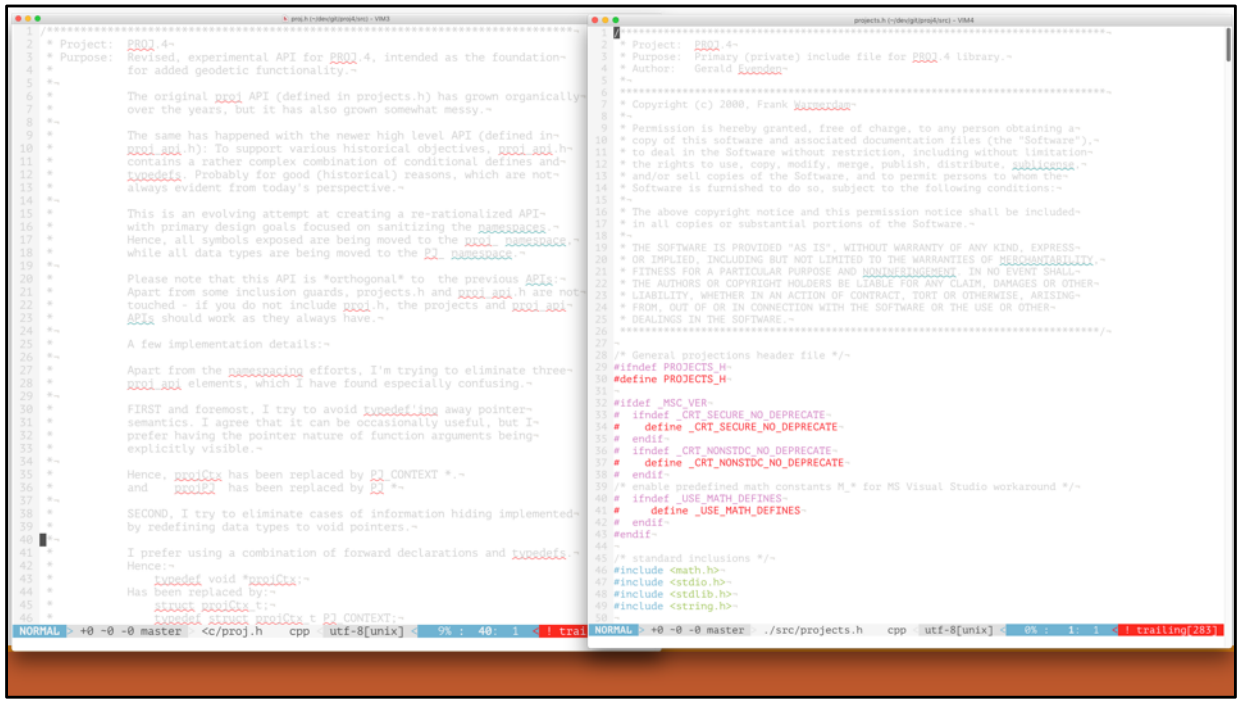


PROJ was written before there was StackOverflow,

before Google,

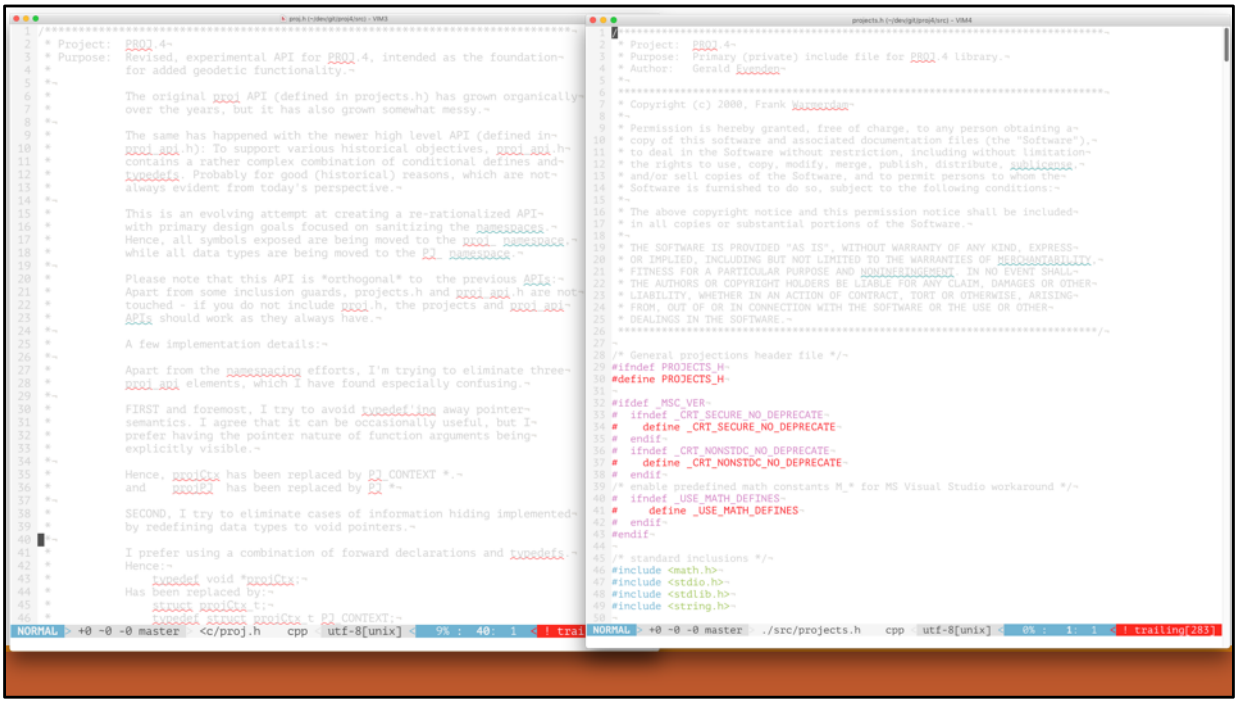
and before Usenet.

Programming in the 1980s and 90s
wasn't the simple pasting of error messages
into a search engine as it is now



The C programming language,
which PROJ is written in,
was still somewhat new when Jerry started writing PROJ in it.

Unix and C were just about ten years old,
and which tools would survive
the test of time was still in doubt.

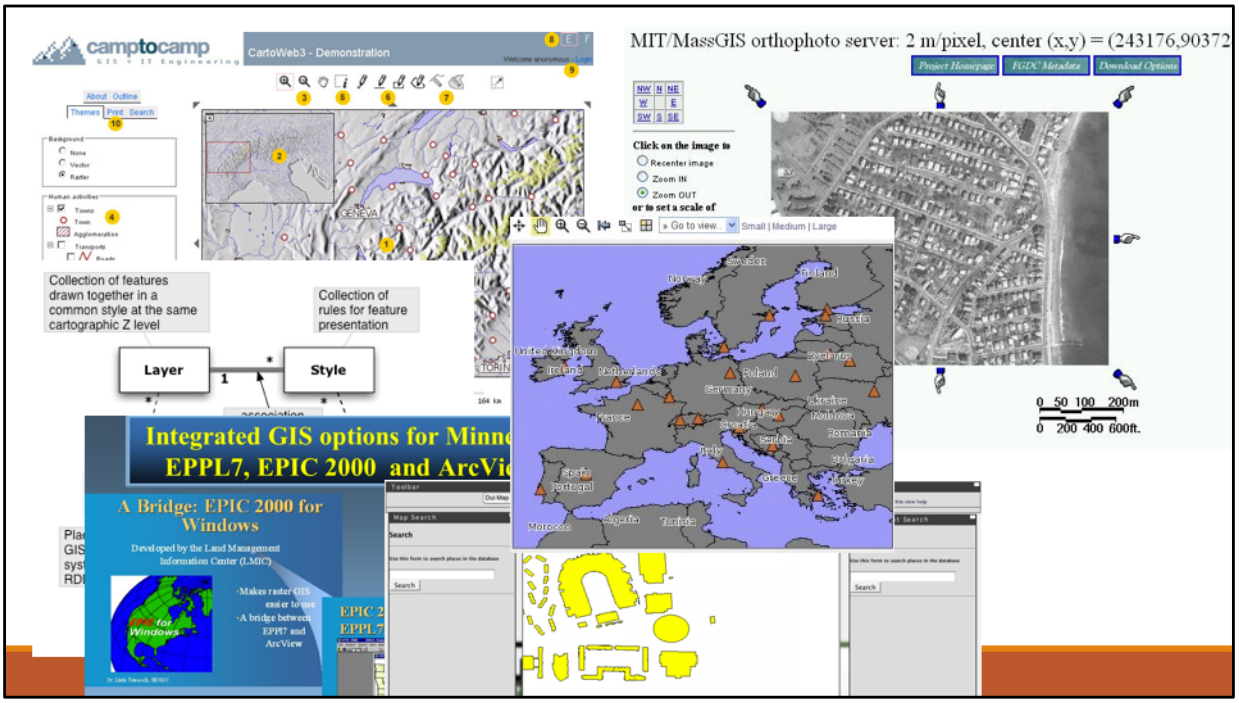


The C programming language helped
smooth over many rough parts as a system language,
but connection of tools like PROJ
to others was still very challenging with C in the 1980s and 90s.

Assumed API norms that are common today weren't settled

Hardware constraints of
memory, cpu, and storage
meant program efficiency often overshadowed

ease of code reading,
ease of integration,
or ease of reuse.

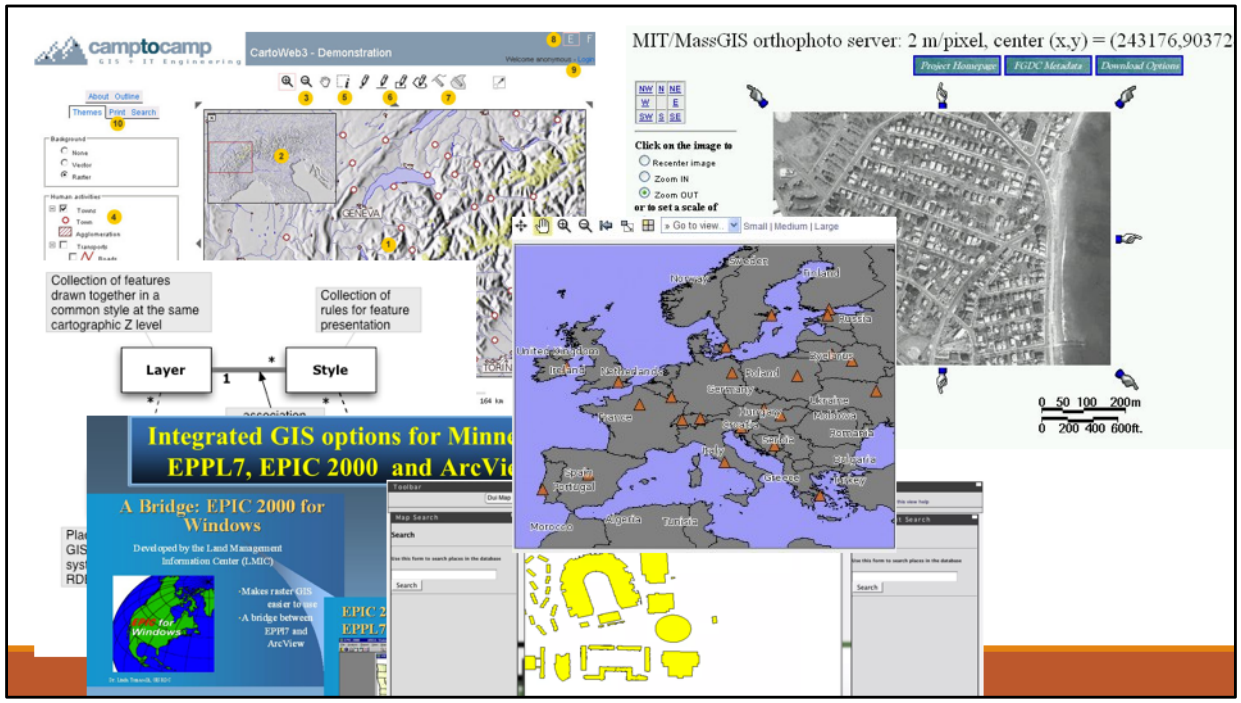


Successful open source software has a longevity problem.

Authors don't optimize today's creations
with the expectation that they will
survive the culture that produced them.

Here's a list of geospatial cultural dead ends
I've contributed to or used in the past:

OpenEV.
FWTools.
OGDI.
KaMap.
CartoWeb.
MIT OrthoServer.
Zope Cartographic Objects
You might remember some of these names.
It took me a while to come up with them actually,
but I know I contributed many hours to more than a few of them.



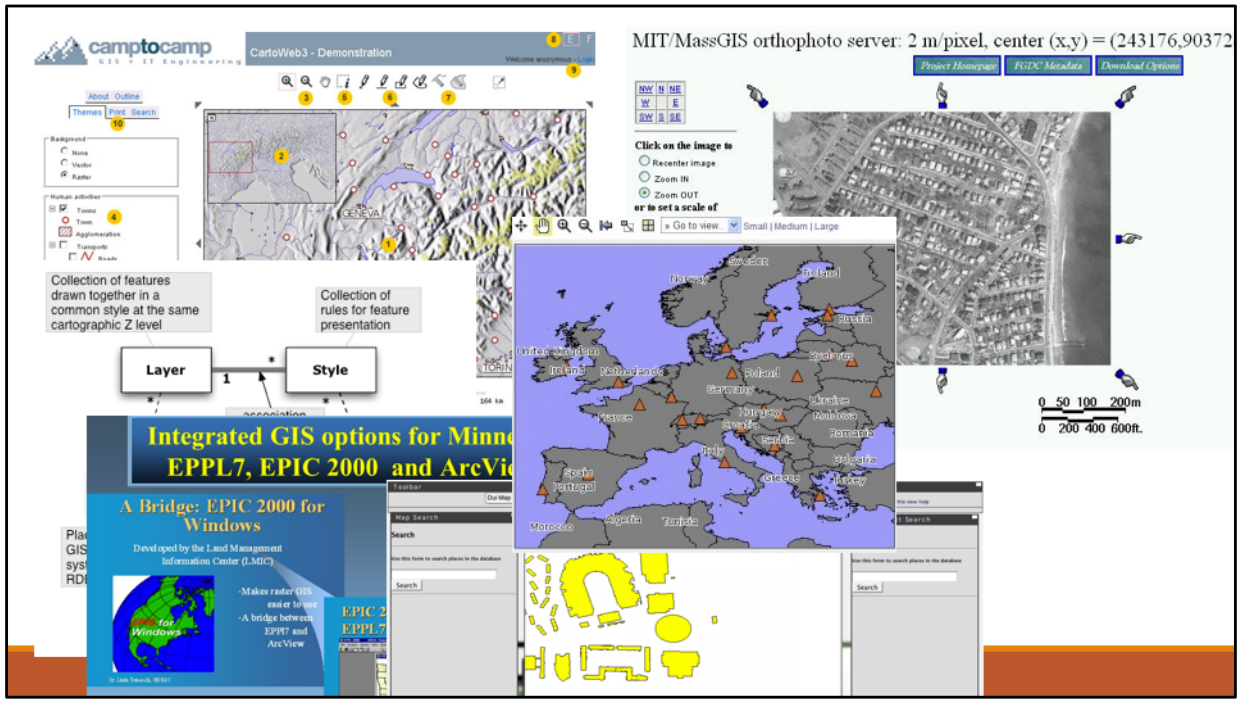
They're just gone to the ether,
and no one pays any attention to them anymore.

The problems they solved might be no longer relevant

The problems they solved are done better solved by modern tools

The project's majordomo moved to more
interesting problems, and no one has stepped into their place.

My own attic includes a bunch of ridiculously
named stuff you've never heard of
based on technologies you've forgotten:
PySDE. Hobutools. PyTerra. libLAS.



Attention is life for open source software, and
it is gone for each of these.
Without attention, these tools faded into dust
with aspects of the problems they addressed
being resolved in the context of a new development cultures.

PROJ is a software too critical to
our geospatial ecosystem to let wither,
even if that means we need to translate it
into today's development culture.

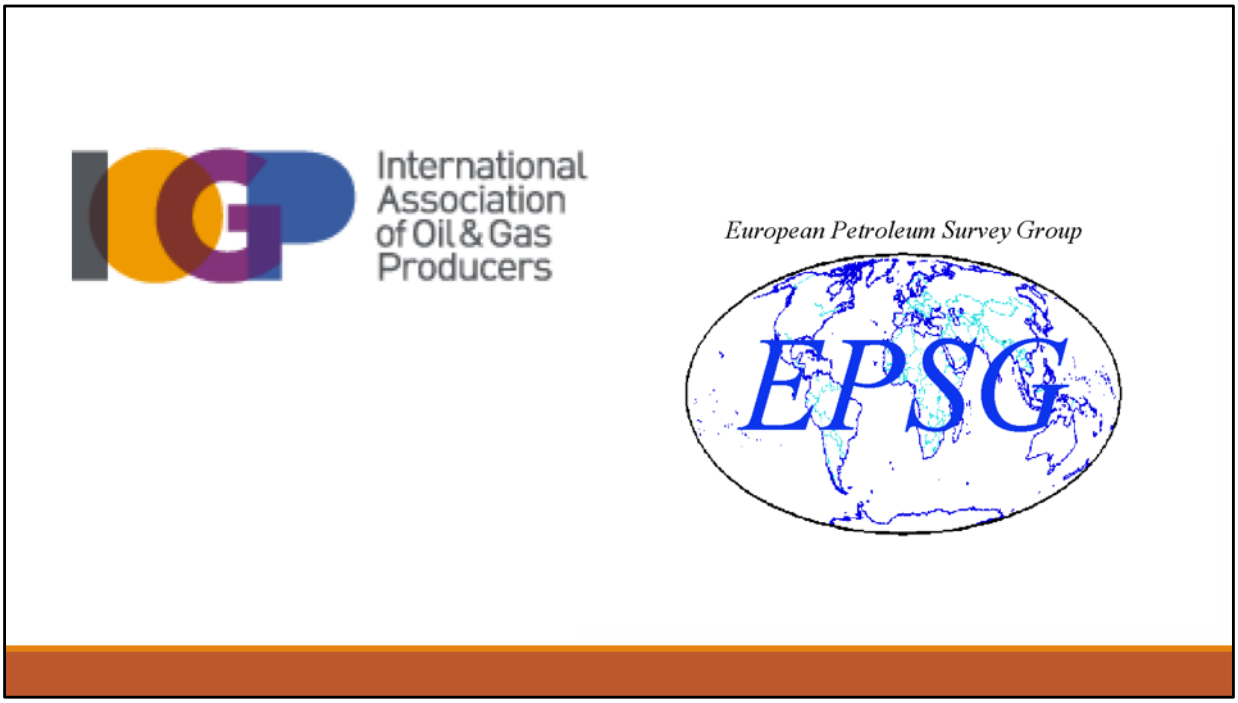
PROJ, however, wasn't designed in
1983 for 2017's computing problems.
It was designed in 1983 for 1983's problems.

The funny thing is PROJ has already
jumped this gap once before.
In 1998, nearly five years after Jerry retired from the USGS,
Frank Warmerdam started using PROJ
to provide coordinate system transformation
for one of those now dead projects -- OGDI.

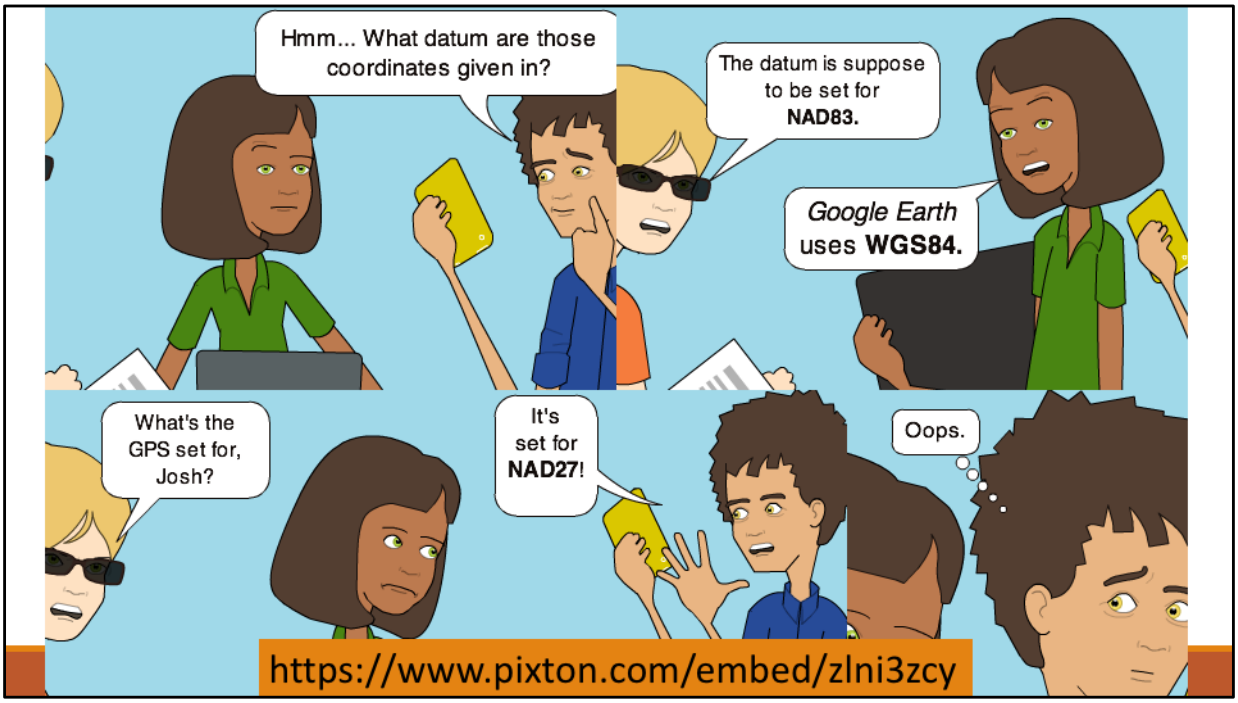
Frank had been using **another**
USGS created coordinate system library
that few probably remember -- GCTP, but
he liked PROJ's description language
and the open source GRASS software project
had already integrated PROJ to give him a head start.

It was a simple thing that made him choose PROJ
-- GRASS had already integrated it --
but it reverberated our entire industry as
Frank used it as the basis for a software stack
that soon included
libgeotiff, shapelib, and ultimately GDAL.

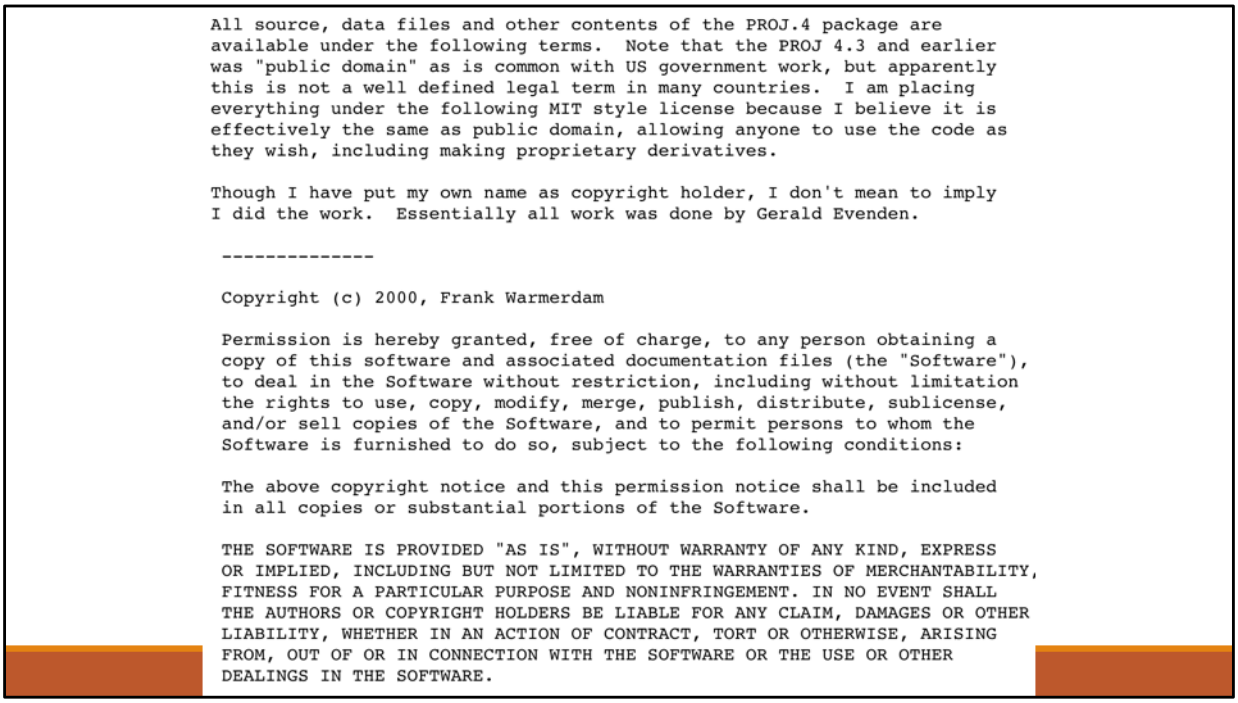
When Frank started contributed, PROJ had
a coordinate system definition language and
many implemented transformations, but
it was still missing a number of pieces to make it
a complete transformation library.



It was missing the EPSG database,
one with which we are now all so
familiar to provide a dictionary of transform parameters.



It was missing the ability to transform
between datums other than NAD83 and NAD27.



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All source, data files and other contents of the PROJ.4 package are
available under the following terms.  Note that the PROJ 4.3 and earlier
was "public domain" as is common with US government work, but apparently
this is not a well defined legal term in many countries.  I am placing
everything under the following MIT style license because I believe it is
effectively the same as public domain, allowing anyone to use the code as
they wish, including making proprietary derivatives.

Though I have put my own name as copyright holder, I don't mean to imply
I did the work.  Essentially all work was done by Gerald Evenden.

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It was missing an open source software license,
tests, and a revision control system --
cornerstone tenets of all open source projects.

- Thread safety
- API
- EPSG
- Pivot datum shifting
- License
- Mailing list
- Bug fixes

Frank built up PROJ's capabilities to include
support for the EPSG database through distribution
of CSV files in specially designated directories,
and he enabled PROJ to apply datum transformations
by pivoting through the WGS84 ellipsoid.

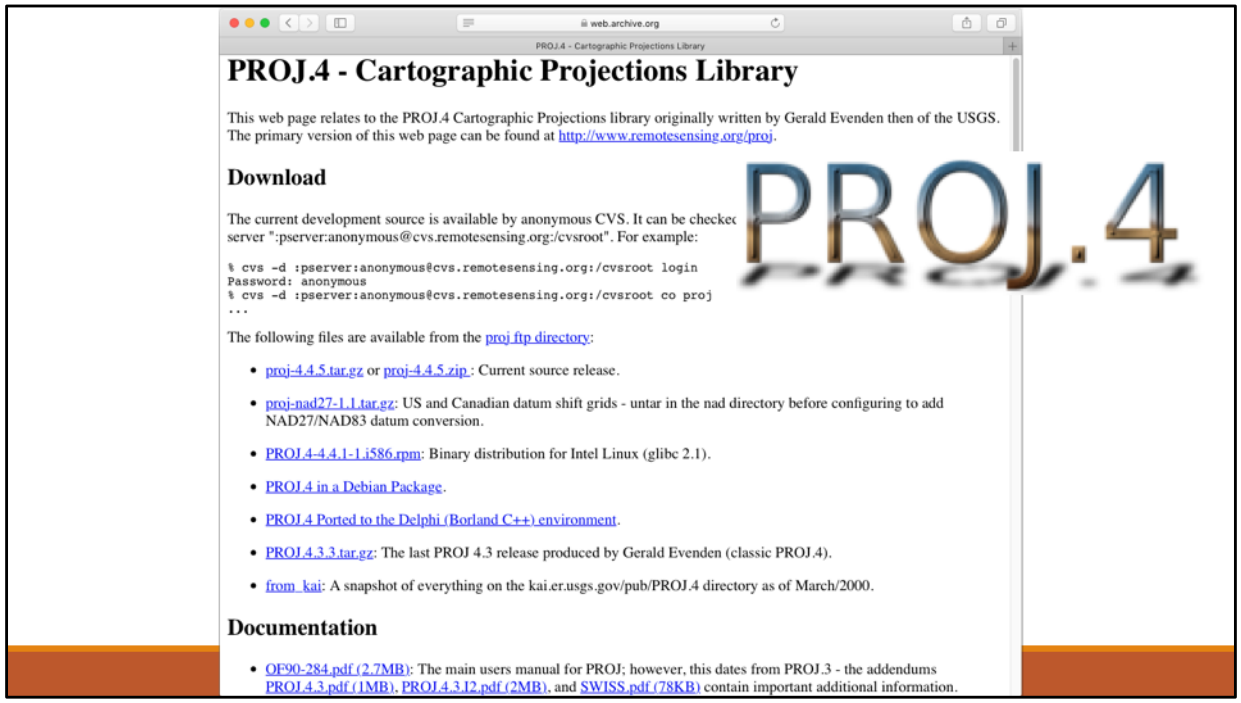
He coordinated the addition of modern features such as thread safety,
error contexts, integration tests, and Makefiles
and he assigned a true open source software license.

As Frank continued pushing the software forward,
Jerry participated on PROJ's open source mailing list
chiming in with knowledge,
history, and
opinions about the scope of the project.

- Thread safety
- API
- EPSG
- Pivot datum shifting
- License
- Mailing list
- Bug fixes

Jerry's original vision for PROJ did not include
things like datum shifts, but the practical desires
of software developers looking to include
the capability from a single software library carried forward.

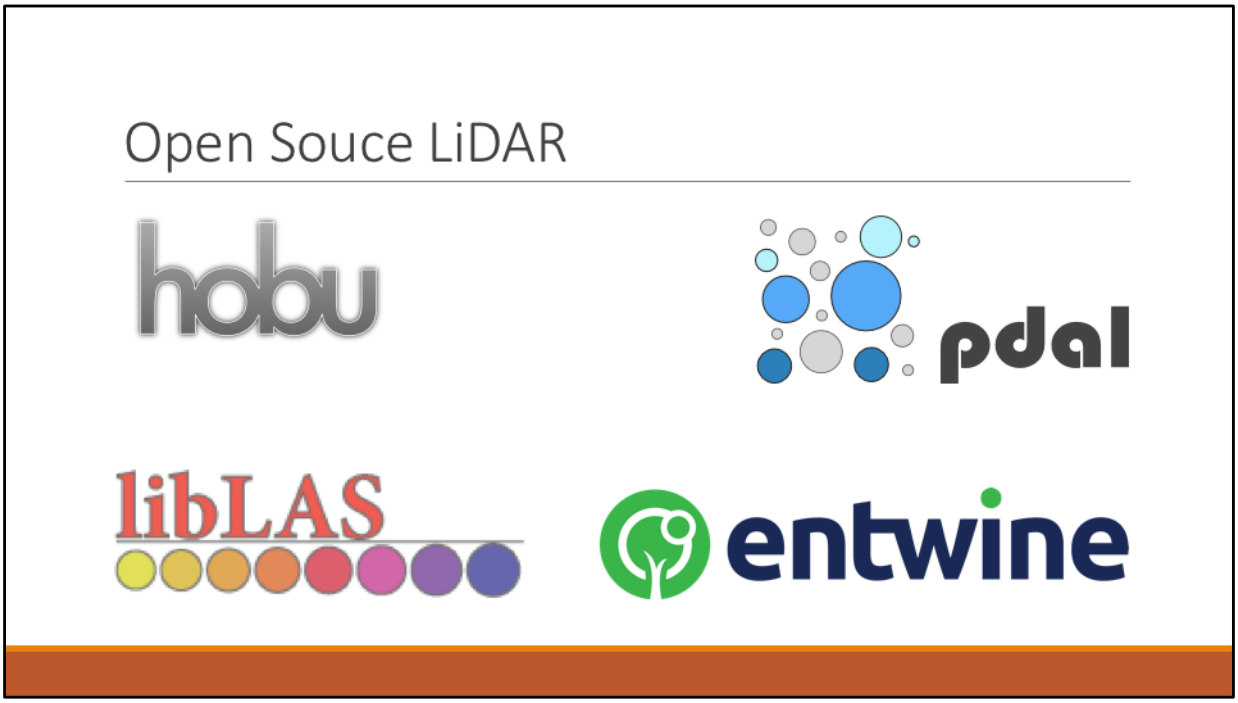
Throughout the 2000s, PROJ continued to improve
in capability and reach, with its success culminating
in other developers porting PROJ to different
computing platforms such as Java, JavaScript, and .NET.



Frank kept PROJ chugging along until about 2011
when he answered a Google recruiter email.
He eventually moved on to PlanetLabs, and
has been busy there ever since bootstrapping
their massive data processing backend.

Planet uses PROJ, GDAL and other open source software
Frank pioneered with the goal of capturing a 3m resolution
satellite photo of the entire earth, every day.
They are well on their way to achieving that too,
with over 100 micro satellites now capturing data.

Frank's moving on caused PROJ languished a bit.
The bug tracker continued to fill up with items,
including security issues,
but releases stagnated.



My company, Hobu, Inc., writes LiDAR software called PDAL, which is very dependent upon the ability to transform between different coordinate systems.

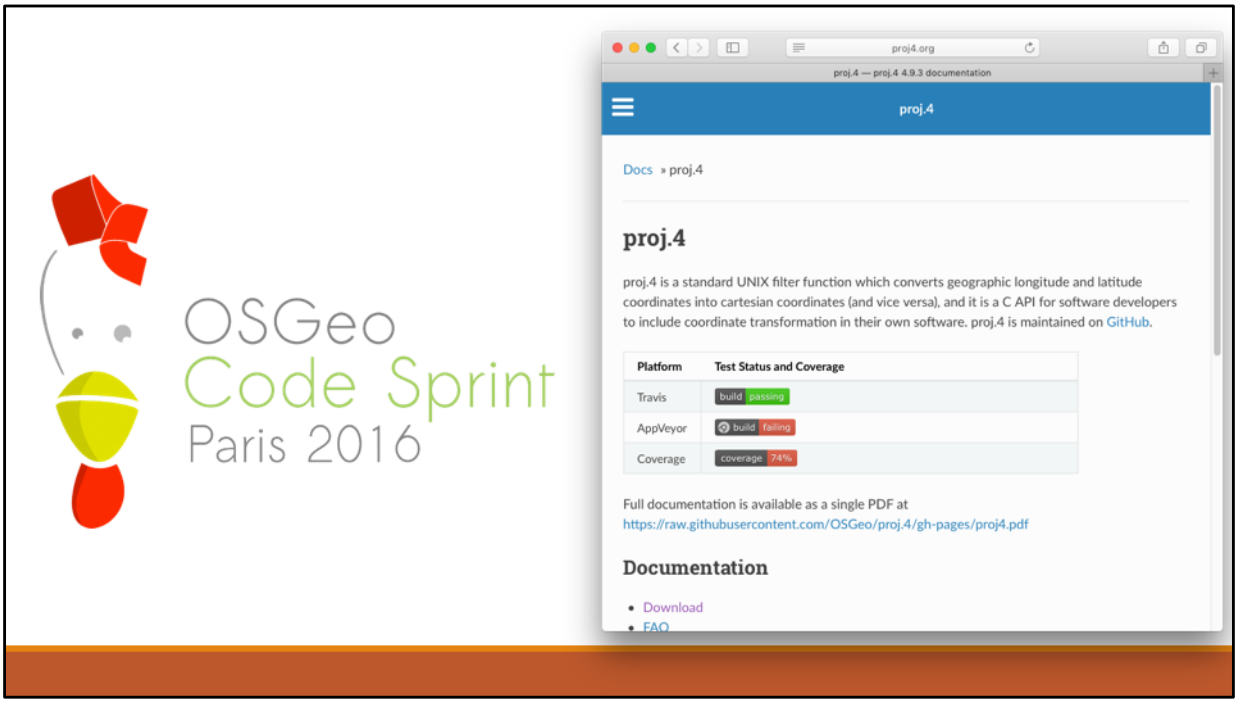
I took it upon myself to take on the task of applying and shepherding fixes in the bug repository and organizing an approximately annual release process.

I don't know very much about the intricacies of coordinate transformations, but I do know plenty about shepherding open source software, issuing releases, and keeping the train moving.

With that experience, I started to organize and issue roughly annual releases to collect and squash bugs, patch any security items, and include small new features.

After a few releases, it was clear to me that the documentation infrastructure for PROJ was terribly deficient.

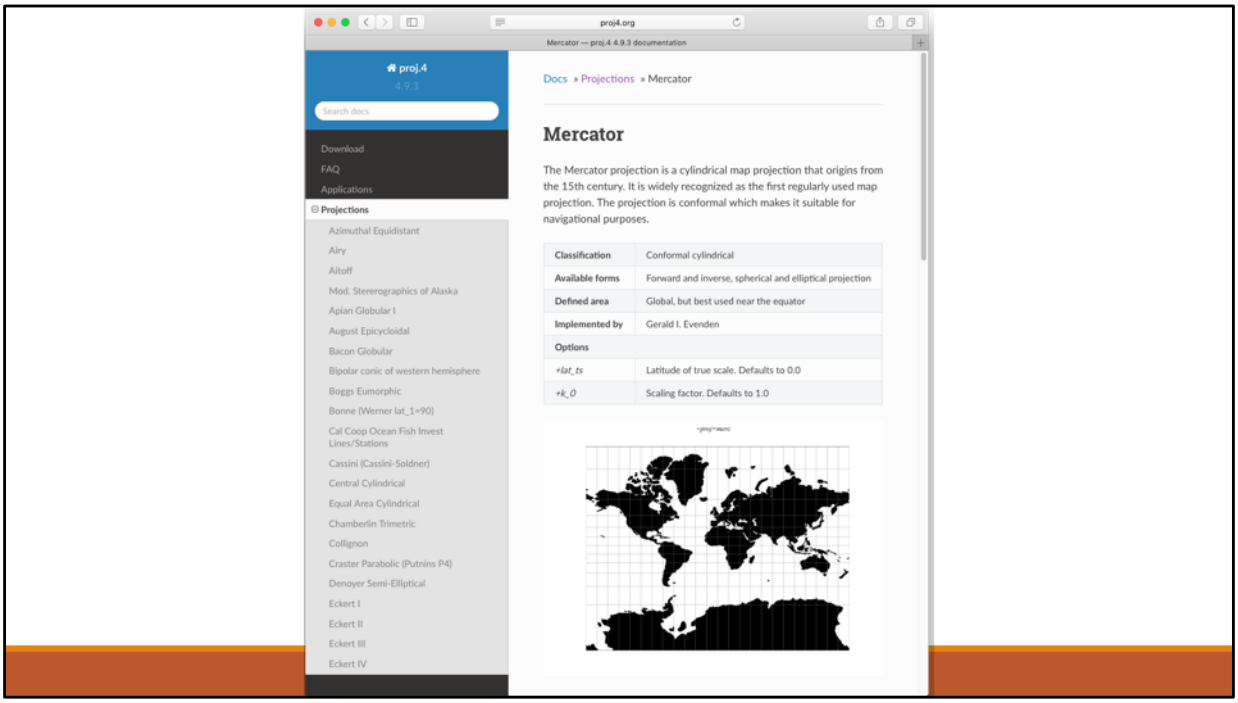
There were a couple of very old PDFs that Jerry had written while he was still working at USGS available online, bits and pieces of unorganized wiki pages spread across about three generations of project infrastructure, and some light source-tree documentation.



During the OSGeo Paris Code Sprint in 2016,
I embarked on improving PROJ's infrastructure
to allow the project to start to treat the documentation
just like it was treating the code.

After the Paris effort, every commit to the repository
now regenerates the entire projct website,
including a single PDF with its entire contents --
approximately 135 pages long.

Other contributors such as
Kristian Evers,
Julien Moquet, and
Elliot Sales de Andrade
saw the website effort and started working
to pull forward content and port those PDFs of Jerry's into



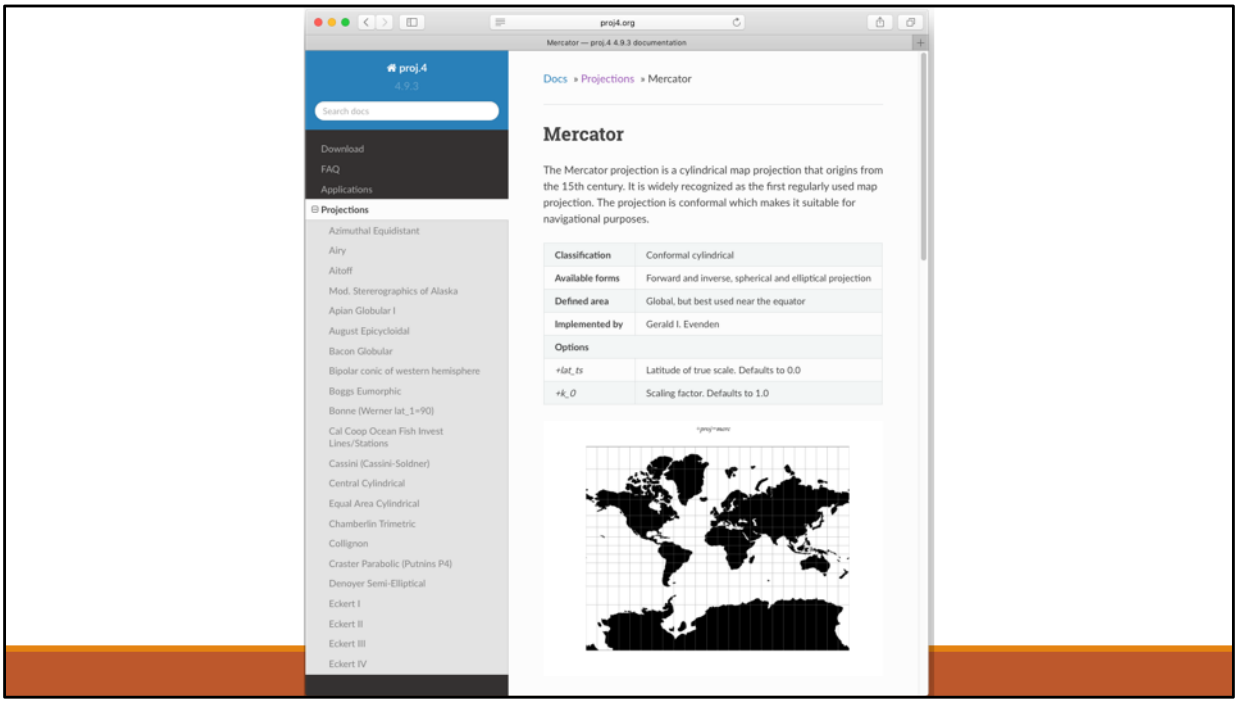
a corpus of supported projections,

clear equations for forward and inverse methods

a nice representative graphic showing what each projection might look like

and some notes on usage and caveats.

After implementing the Sphinx documentation system
and coordinating a spiffy new URL for the website,
proj4.org was enabled, and
we worked to pull down all of the old,
misleading, and out-of-date bits spread throughout the internet.



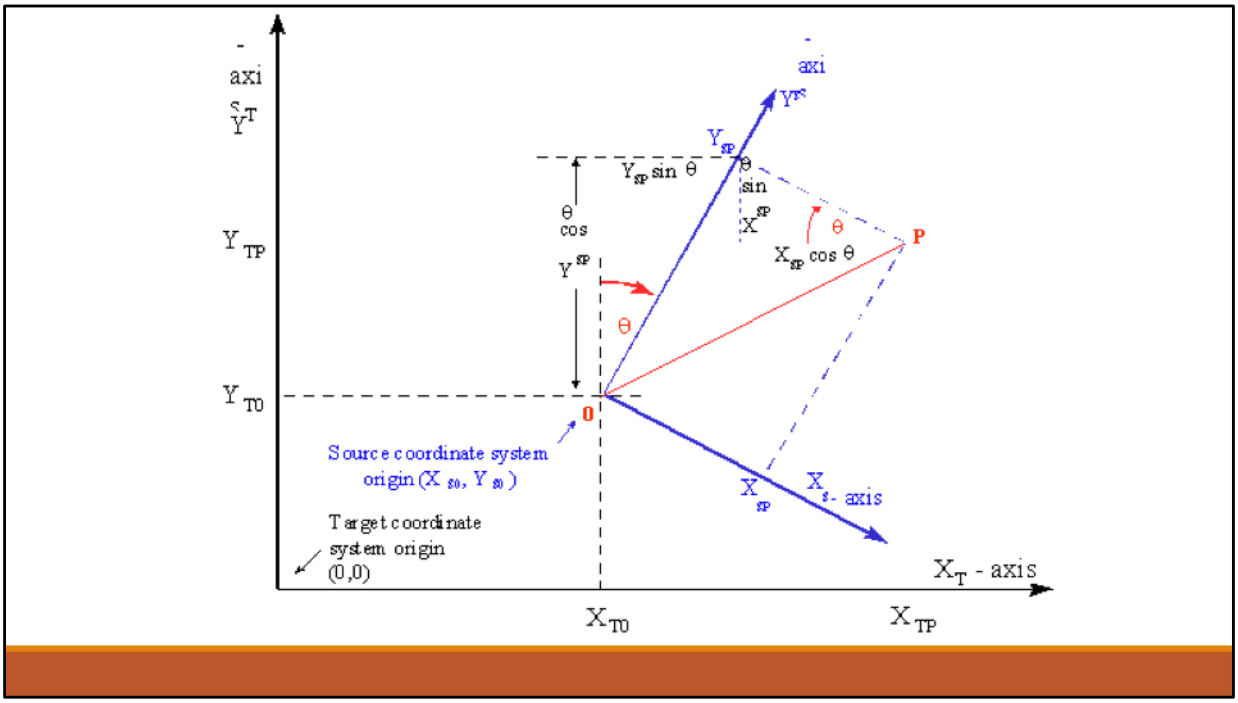
There's still plenty of work to do.

Most of the 130+ projection methods PROJ
supports need their documentation completed.

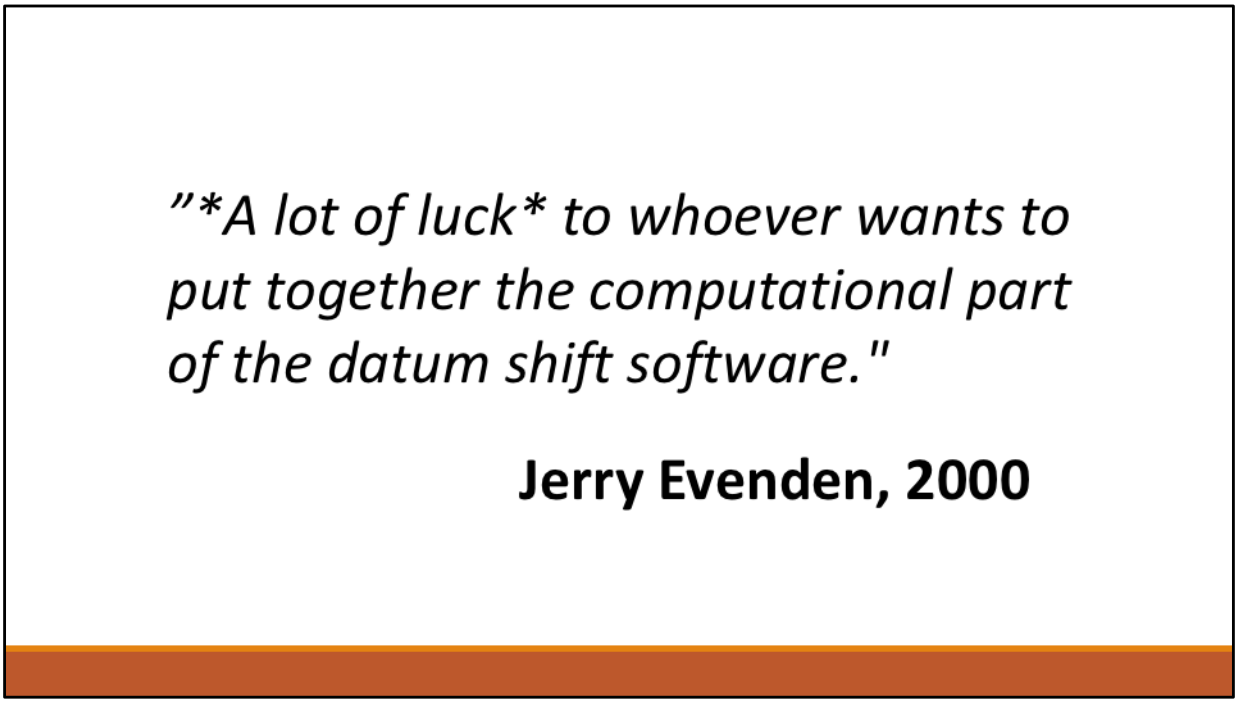
Some of that information still resides in Jerry's old PDFs,
and meticulous effort is required to verify the equations
in those documents match the math in the actual software.

Even so, the new website is a dramatic improvement
over the previous situation, and
documentation infrastructure is critically important
to a software project like PROJ with a multi-generational lifespan.

All it took to improve the situation was attention.



Seeing renewed interest in PROJ after the website refactoring,
Kristian Evers and Thomas Knudsen
of the Danish Agency for Data Supply and Efficiency,
which is kind of like the Danish equivalent of the US Geological Survey, embarked in 2016 on an effort
to bring a formalized approach to datum transformations to PROJ



As Jerry said,

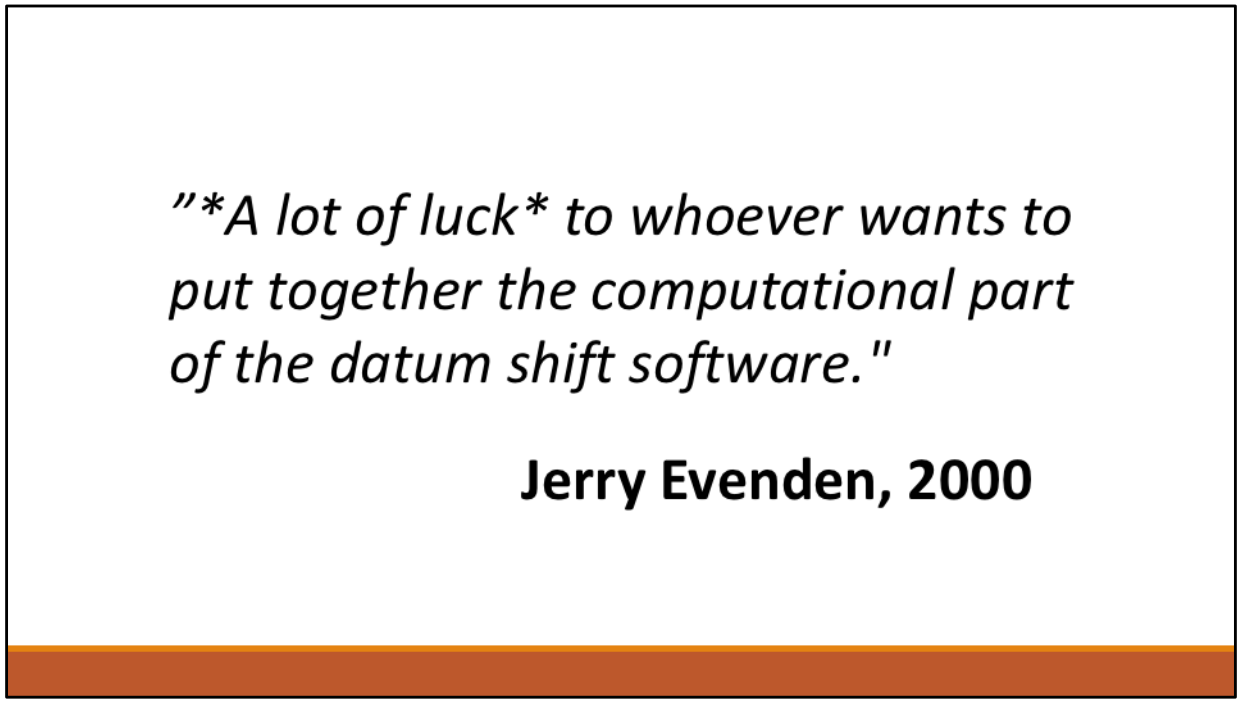
"A lot of luck to whoever want to put together the computational part of the datum shift software."

Thomas is a long-time contributor to PROJ, and his first contribution was in 1999.

It was a massive undertaking.

Thomas and Kristian started by porting a library called
trlib,
originally written by the Danish agency in Algol in 1961.

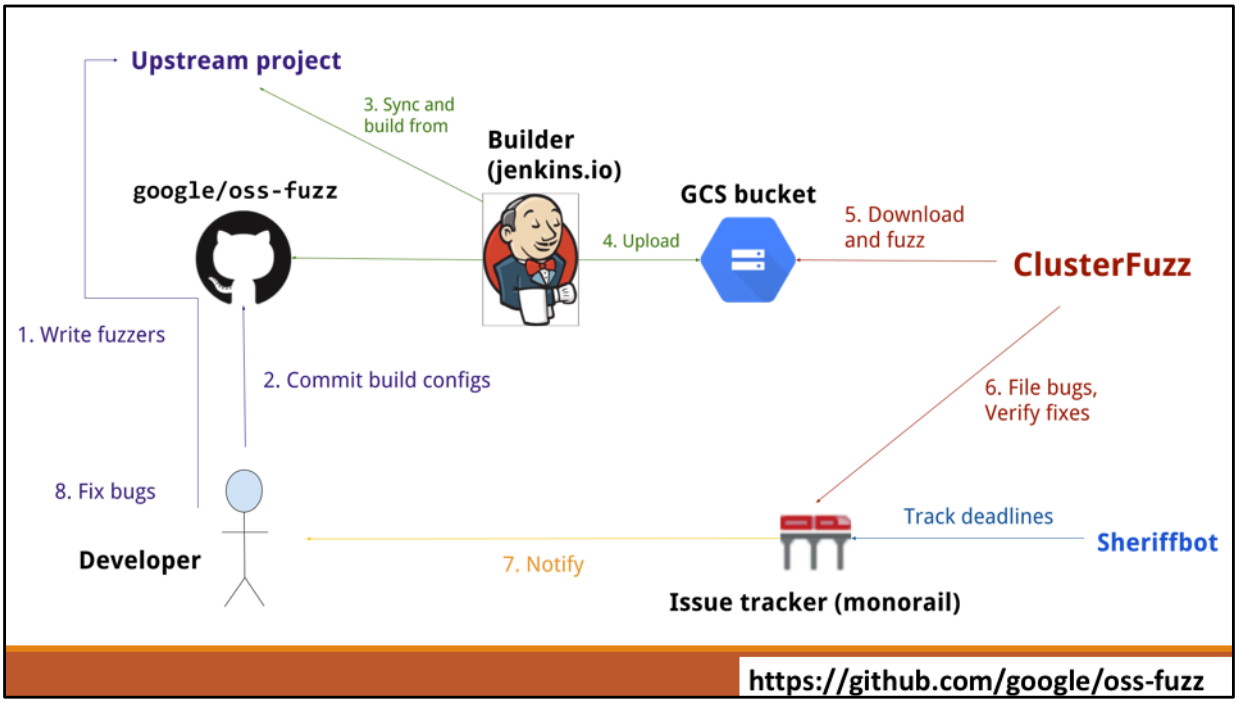
The end result is new versions of PROJ will support
14-parameter, time-dependent shifting, and
users will be able to create their own shifts
using Thomas' generic transformation pipelines.



Thomas and Kristian targeted PROJ for this contribution for a couple of slightly selfish reasons --

PROJ is the most widely used coordinate system transformation library, and their hope was wider availability of transformation pipelines will mean broader support of their precision needs flowing back toward them in commercial software.
It's the virtuous circle of open source.

More attention begets more attention.



Even Rouault recently submitted PROJ to the Google Open Source Software Fuzz project. Fuzz clones the PROJ software repository every day,
builds it, and runs tests designed to highlight

buffer overflows,
uninitialized memory,
and exploitable assertions.

When Fuzz finds something, it automatically creates a bug report in a private repository for developers to fix. After a month, that bug report becomes public.

Even has also been using this capability for improving the security hardening of GDAL project too.

For projects such as GDAL and PROJ, tools like Fuzz keep them relevant and safe in today's harsh computing environment. This is especially true in situations where code written in 1983 potentially processes random input over the internet.

Thanks Jerry!

Jerry's initial development and Frank's maintenance made the library an indispensable tool in most geospatial people's toolkits, whether they use it explicitly from the command line, or embedded in software that hides it from them.

New contributions from people like Thomas and Kristian and Evan will keep it going for an unpredictably long future.

Thanks Jerry for letting all of us use PROJ, which has and will continue to impact the world by providing the math to compute where we are.