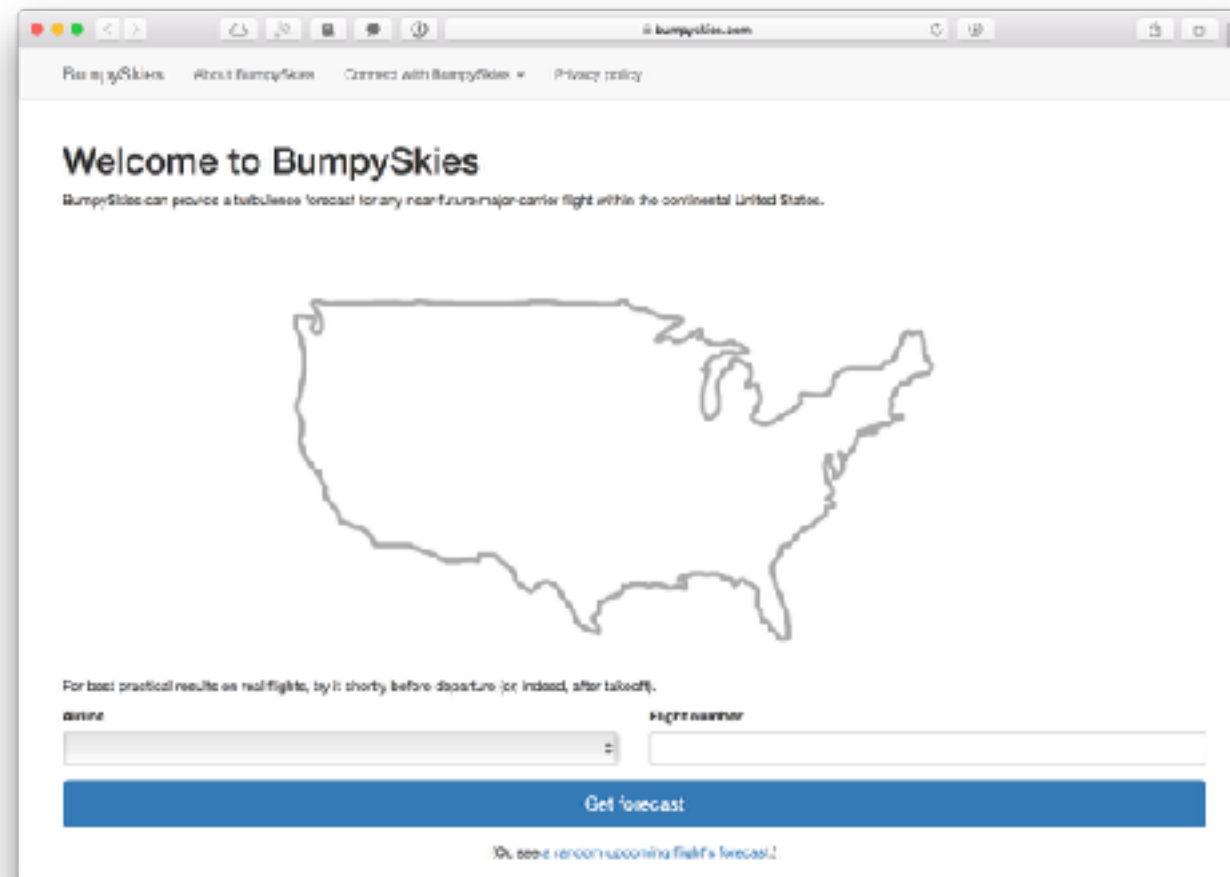


# BumpySkies: A passion-project postmortem

The Perl Conference • June 21, 2017

Jason McIntosh • @JmacDotOrg

I spent a lot of last year making



Jason McIntosh • @JmacDotOrg

this thing. It's a website called BumpySkies. It does a fraction of what I'd like it to do someday,

## SWA3350, DEN to HOU, departing 4:00 PM MDT, Jun 16

(Forecast data last collected: 2017-06-16T19:00:00 UTC)



Jason McIntosh • @JmacDotOrg

but today it can provide graphical predictions of turbulence for near-future flights over the continental US. I made it for nervous fliers like me. I think of it as a tool for demystifying flight by mitigating surprise. Turbulence prediction represents only the start of what I'd like to do, but it does it well enough that I consider it a shipped project.

So, in this project postmortem, I'll tell you about three things that went well, and three things that didn't go so well, and an ill-defined number of things that yet to earn qualitative judgment, because they haven't happened yet.

# Good thing (3 of them)

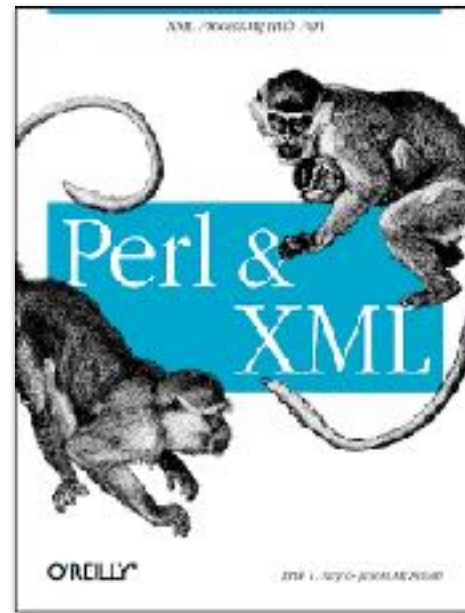
- I ask for thing
- I no ask for thing
- I thing?

For a project about managing fear, BumpySkies' development depended on my overcoming personal faults less about fear and more about misperception.

I learned that tools and resources exist outside of purely independent study, if one is willing to ask for them nicely.

I found myself able to personally succeed in tasks that I previously assumed I had no business attempting

But first I want to tell you how before I could do anything else, I had to throw away and rebuild my own sense of professional identity. See, a couple of years ago, I thought I was going to write a book.



Jason McIntosh • @JmacDotOrg

I'd done it before, or anyway as a co-author, or at least a contributor, a few times. A long time ago. I have few good memories of these experiences,



Jason McIntosh • @JmacDotOrg

all projects I agreed to when I had far more youthful enthusiasm than wisdom or even basic preparedness, but I thought this time would be different:



Jason McIntosh • @JmacDotOrg

I'd be writing by myself about a subject deeply interesting to me, and sharing things I'd learned with people who really needed it, as opposed to just documenting some computer stuff. I had the exact same thought



Jason McIntosh • @JmacDotOrg

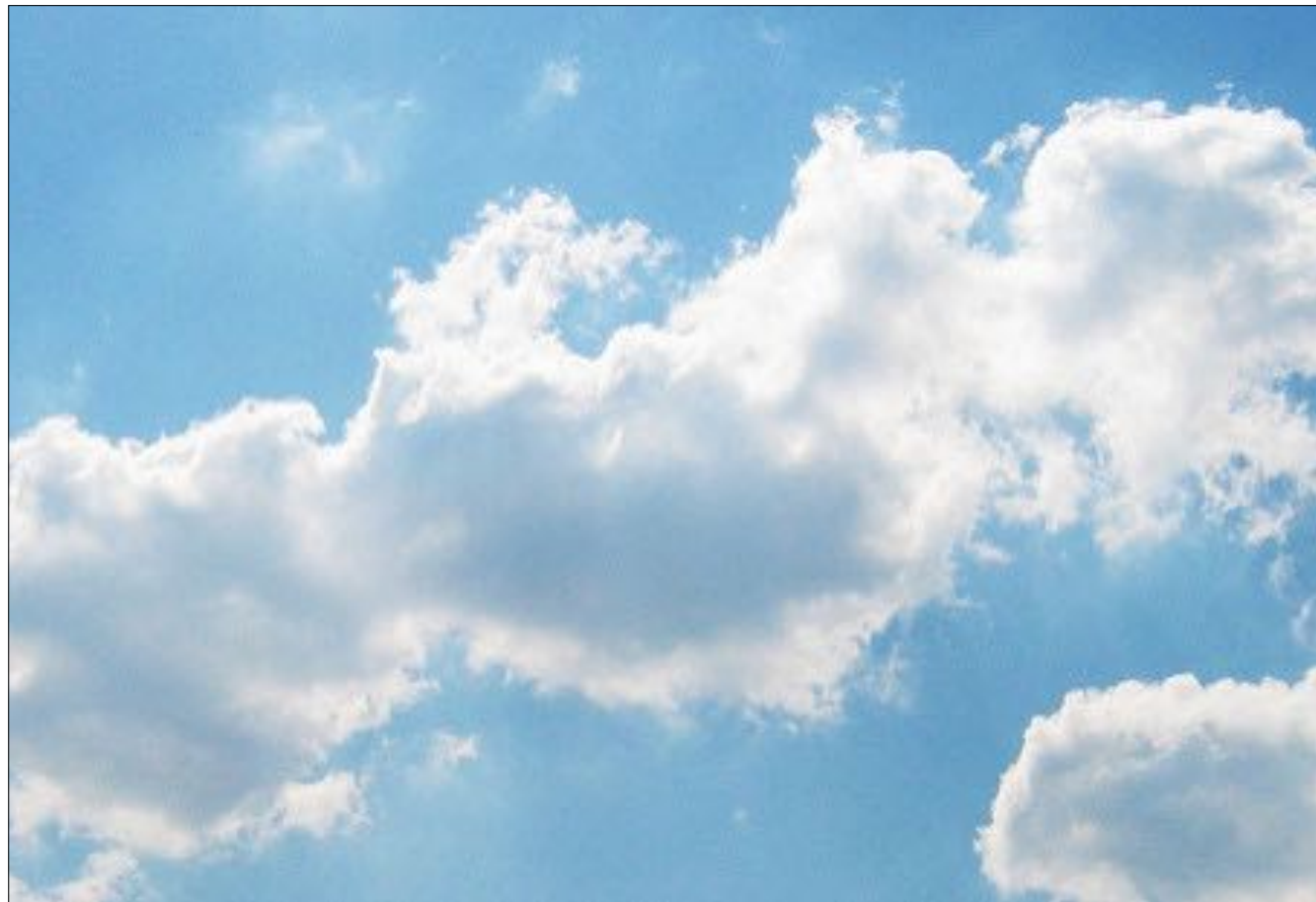
five years ago, and





Jason McIntosh • @JmacDotOrg

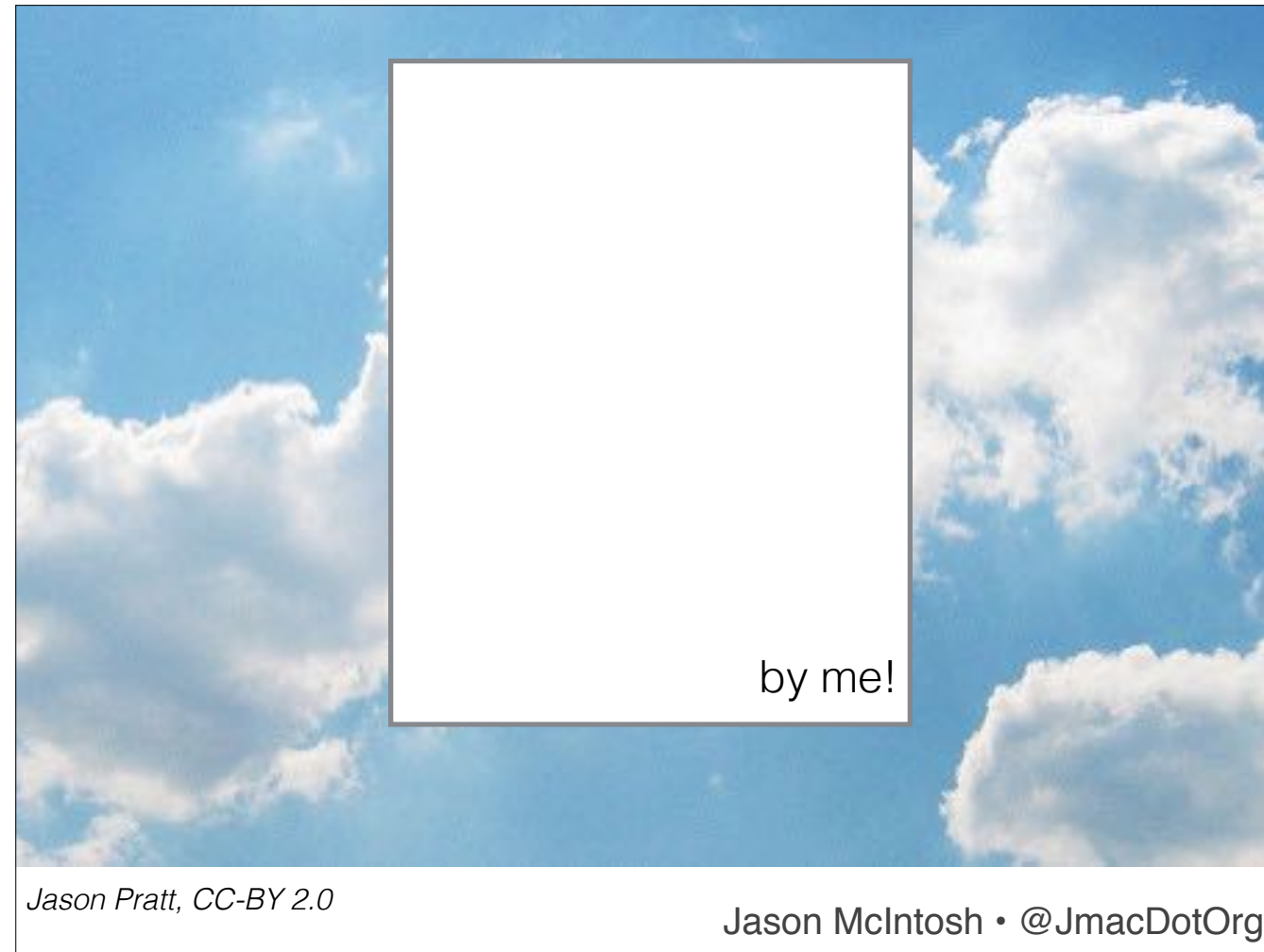
seven. In fact the thought occurred to me



*Jason Pratt, CC-BY 2.0*

Jason McIntosh • @JmacDotOrg

every time I got off an airplane, because -- my thought was —



I could sell a book



to my fellow nervous fliers about

# Flying With Your Lizard Brain



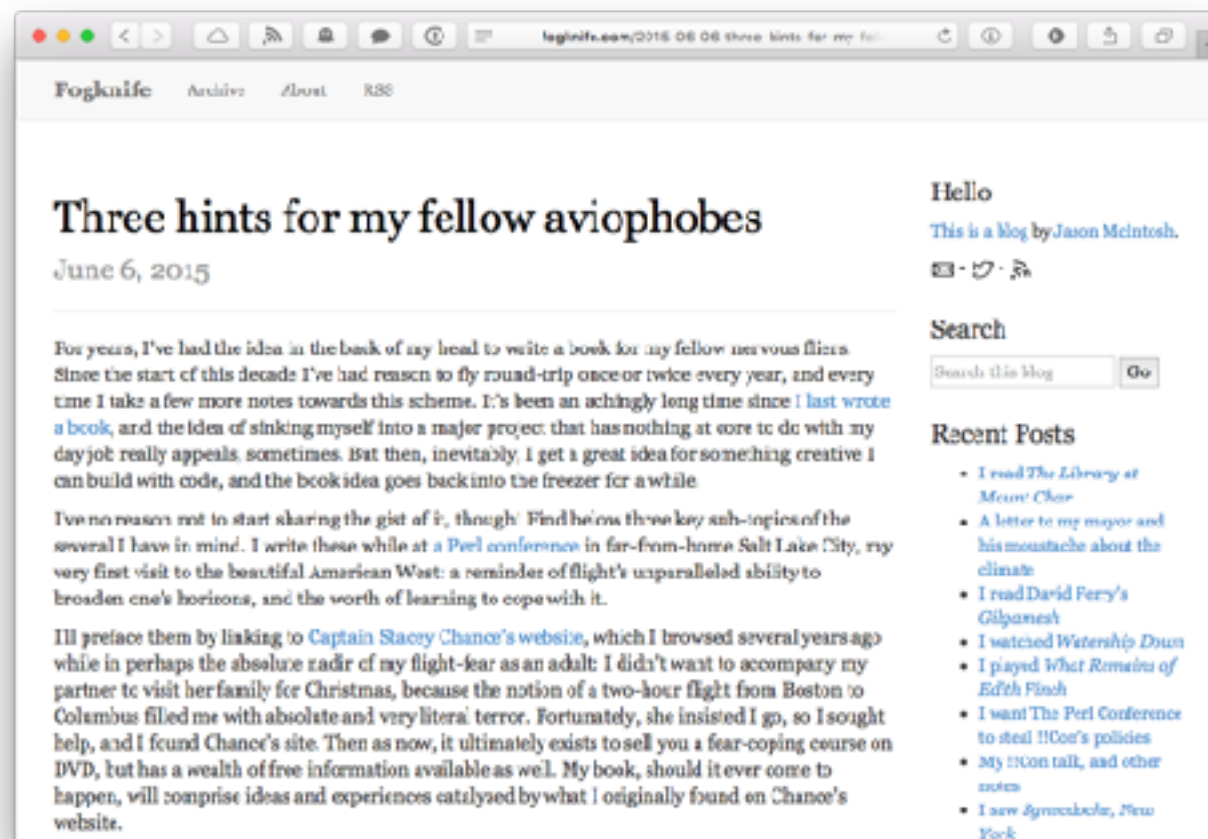
by me!

**(Vaguely working title)**

*Jason Pratt, CC-BY 2.0*

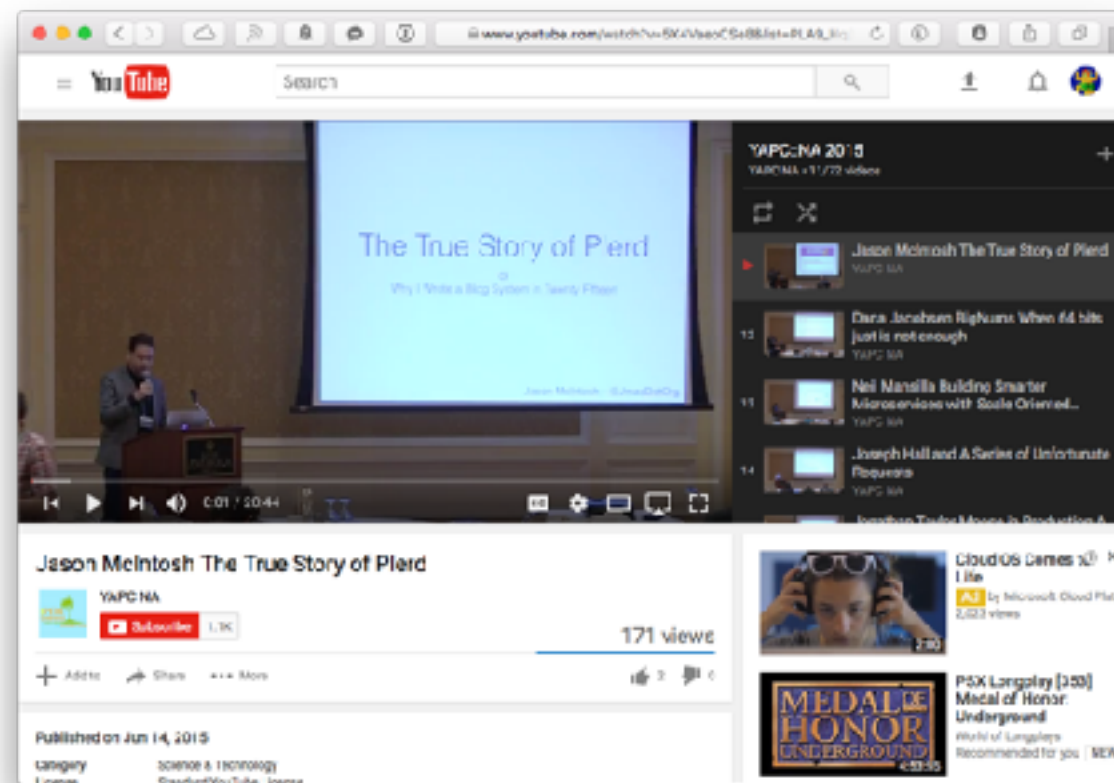
Jason McIntosh • @JmacDotOrg

all the knowledge and techniques I had gradually accrued to make the experience of commercial flight less nerve-wracking. I was never going to write that book, and I know today that I'll may never write another book about anything, ever.



Jason McIntosh • @JmacDotOrg

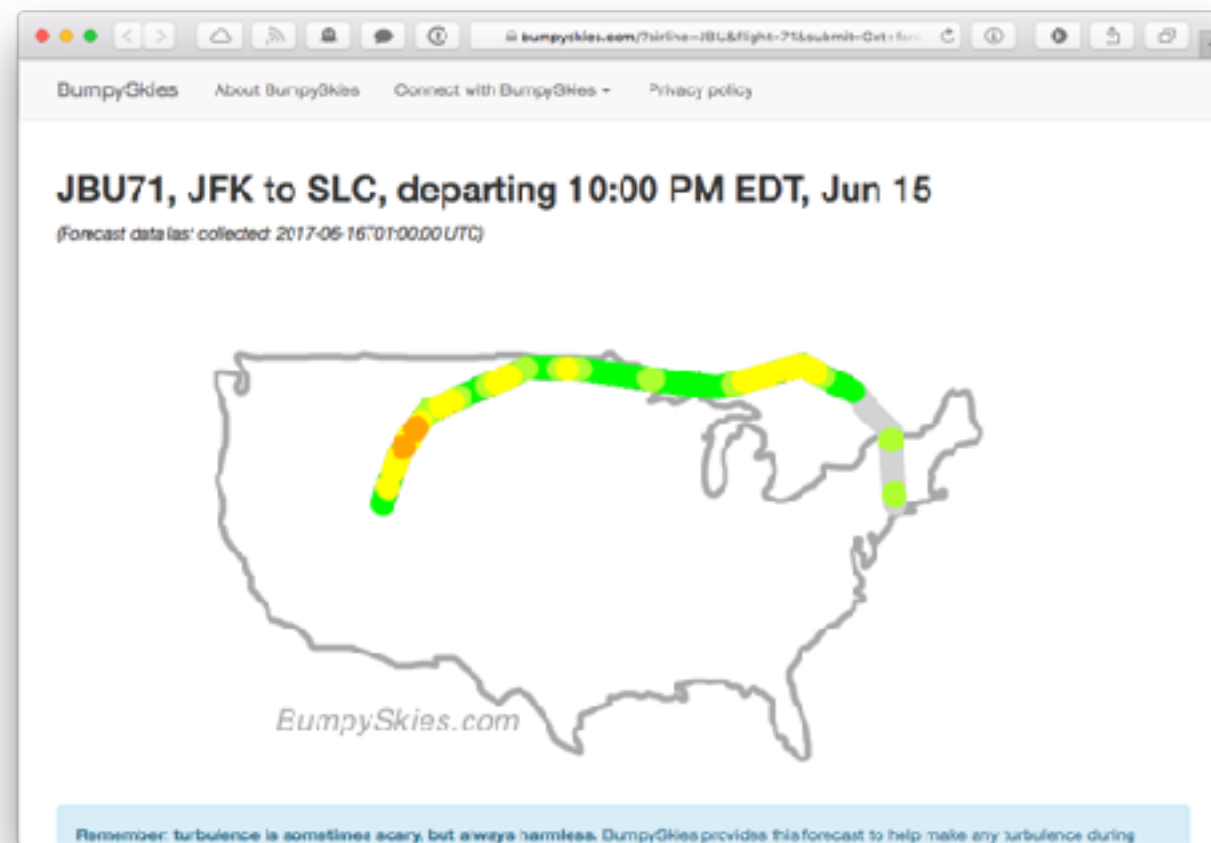
But I didn't know that when I wrote a blog post in Salt Lake City during that year's Perl Conference. I was in a very writerly mood that year.



Jason McIntosh • @JmacDotOrg

I gave a talk about a blogging platform I had made, and with my lizard brain freshly hoarse from

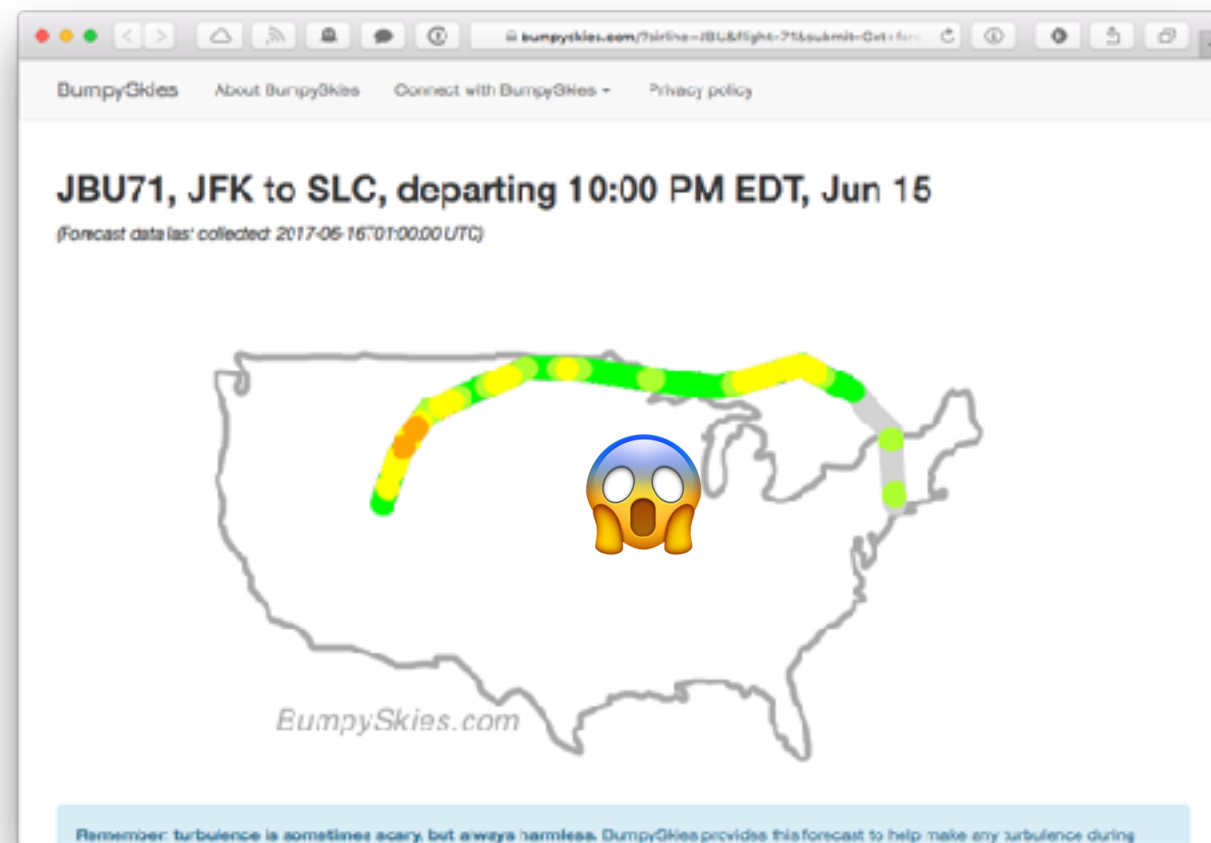




Jason McIntosh • @JmacDotOrg

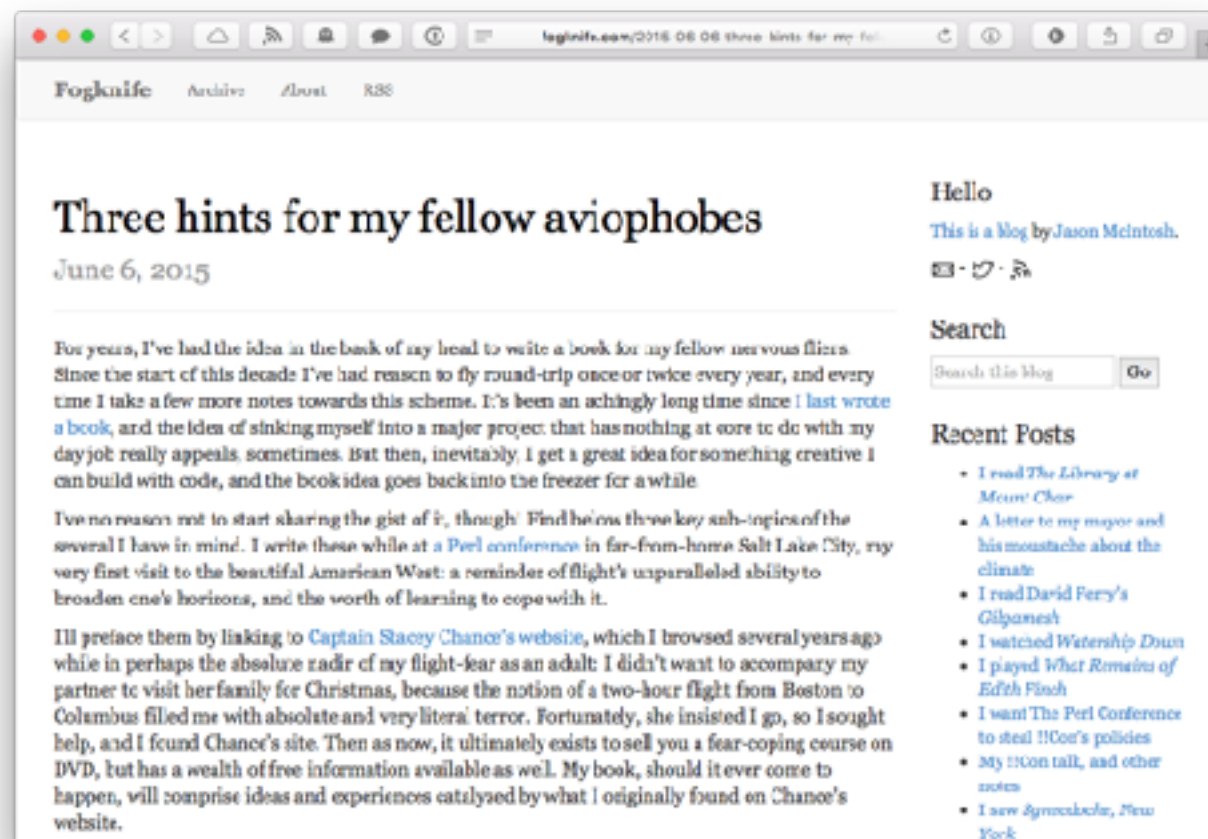
screaming all through the





Jason McIntosh • @JmacDotOrg

cross-continental flight, things seemed to align such that



Jason McIntosh • @JmacDotOrg

I couldn't not see my post as the nut graf of a much larger work. I was right — but not in the way I thought. My flights to and from Salt Lake City were the first I'd made on an aircraft



Jason McIntosh • @JmacDotOrg

with in-cabin Wi-Fi. Not knowing what else to do with it, I spent the whole time

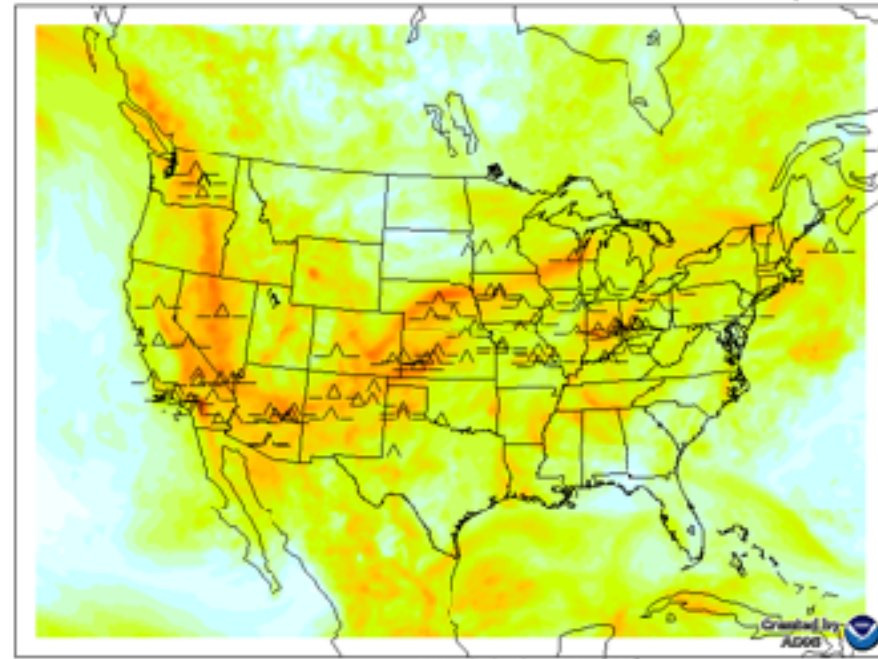


Jason McIntosh • @JmacDotOrg

posting continuously on Twitter as a distraction while my jet pinballed over heartland turbulence and my friends encouraged me and brands engaged with me and that was pretty great. I also had the novel experience of

# GTG - Max combined intensity (1000 ft. MSL to FL500)

00 hr forecast valid 2300 UTC Fri 28 Apr 2017



Eddy Dissipation Rate (EDR)  
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

Turb PREP Symbols

Smooth  
Smooth-Light

Light  
Light-Moderate

Moderate  
Moderate-Severe

Severe  
Extreme

Jason McIntosh • @JmacDotOrg

reading NOAA's turbulence maps even as the jet I rode tore straight through its various bright orange doom-blobs, and while I still hated every minute of it, I could feel my terror lessened by seeing it reduced from



Jason McIntosh • @JmacDotOrg

an unknown horror tearing at my fragile craft to



Jason McIntosh • @JmacDotOrg

a finite phenomenon whose discrete borders fit on a tiny phone screen. By the time of my next long-haul flights, some months later,



Jason McIntosh • @JmacDotOrg

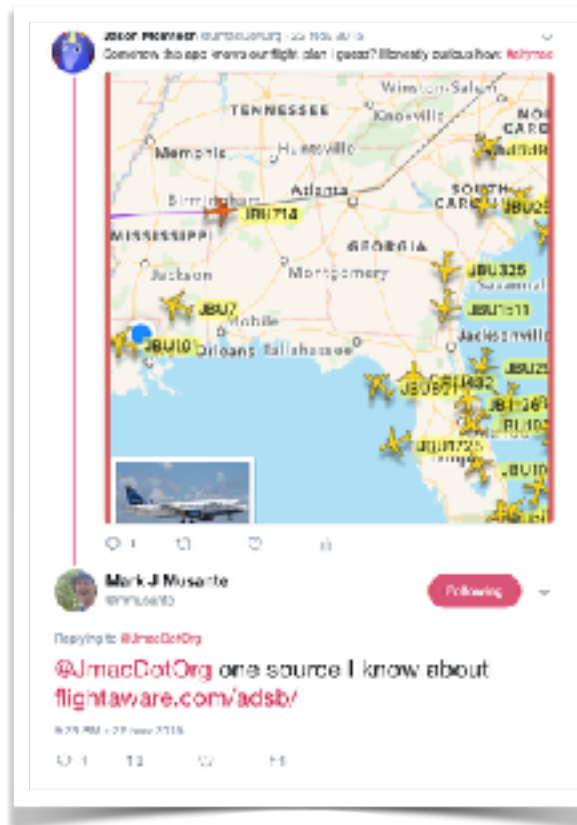
I had discovered plane-tracking mobile apps like FlightRadar, which, yes, do work splendidly while airborne. And this led to the true pivot in my thinking about how I could best help my fellow aviophobes, and it was a literal pivot,





Jason McIntosh • @JmacDotOrg

which is to say this left turn over Atlanta, which FlightRadar somehow plotted ahead of my plane's current position. I paused in my mid-air tweet-gibbering to



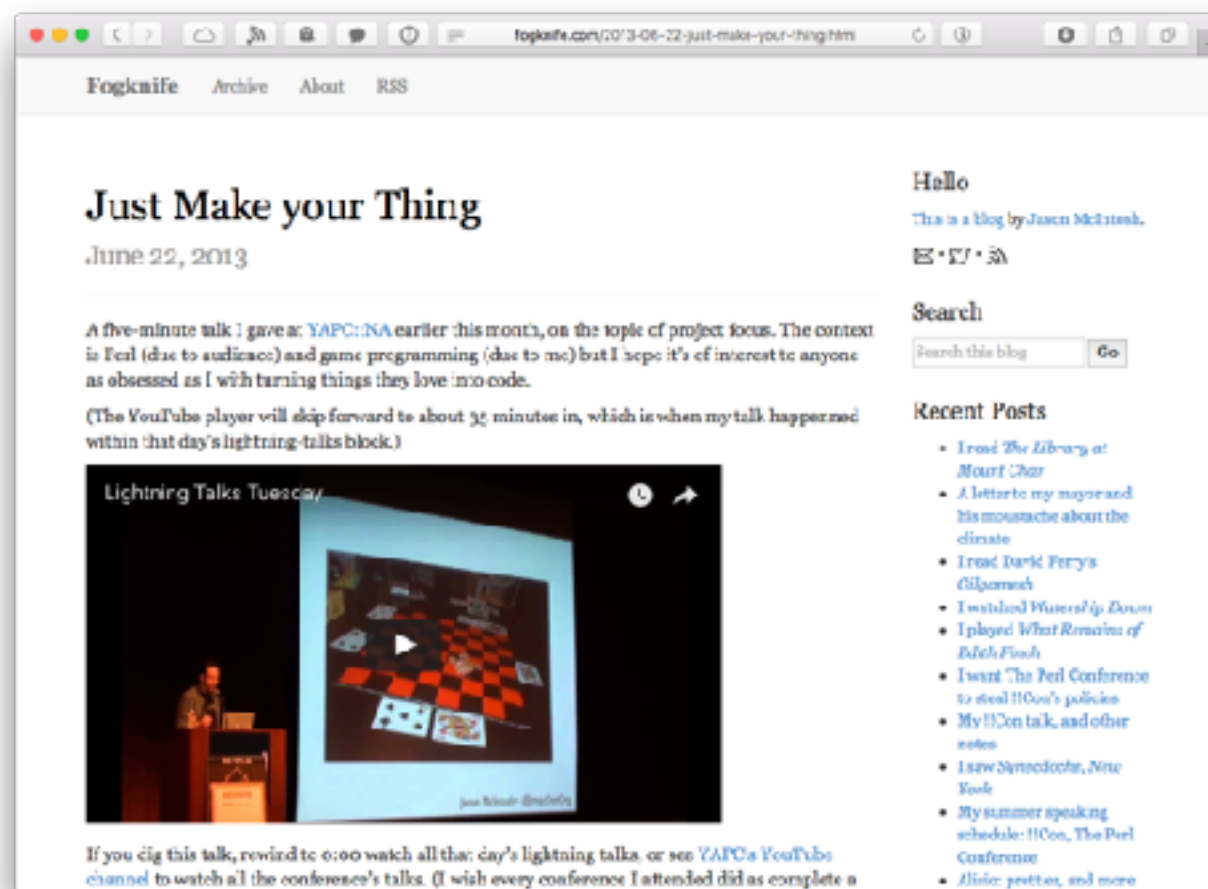
Jason McIntosh • @JmacDotOrg

ask out loud how this was possible, and my friend Mark said that it might have something to do with



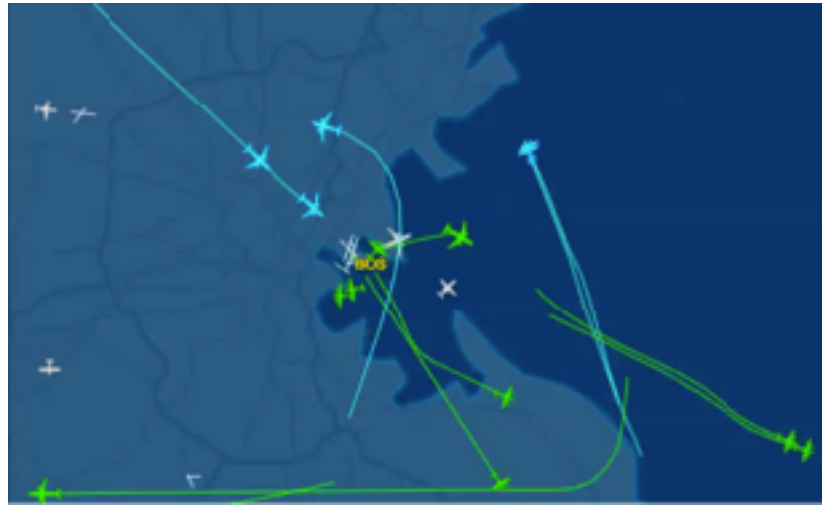
Jason McIntosh • @JmacDotOrg

this crowdsourced plane-tracking project that another service called FlightAware runs. And so my plane continued on to Logan, but before it landed I knew I'd just started a new journey.



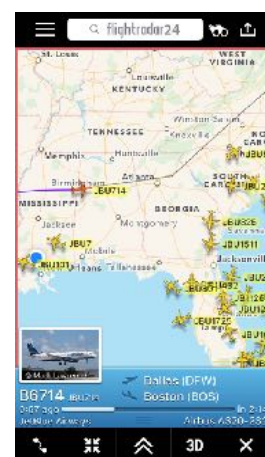
Jason McIntosh • @JmacDotOrg

I gave a lightning talk, my first Perl Conference talk, in 2013 called "Just Make Your Thing" where I set out the case that, in software, purposeful tools, however rough around the edges, can bring at least as much value to the world than the most beautifully architected abstraction layers.

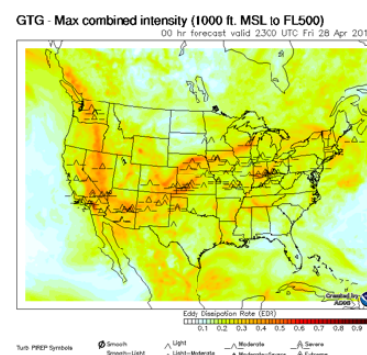


Jason McIntosh • @JmacDotOrg

And as my plane juddered through the clouds over Massachusetts Bay I saw my long assumptions of just repackaging my knowledge as text, even though I love text, as the less vital abstraction here. My time would be much better spent building a tool, one that that would somehow mix these disparate mobile-technology magics into syncretic software that would directly demystify flight for the fearful.



+



=

!!

Jason McIntosh • @JmacDotOrg

Years overdue and thousands of feet high, the discarded pages of my outdated identity as an author fluttered into the sea. I landed in Boston a fully self-cognizant toolmaker, and I knew what my next tool had to be. Even as I deplaned back into my home city, I found myself in gloriously unknown territory, and of course I had to spend some time going about it all wrong.



Jason McIntosh • @JmacDotOrg

One of the dangers of working freelance,



Jason McIntosh • @JmacDotOrg

as I have done for the last decade, is the temptation to start viewing yourself the way that your clients tend to do:





*(it me)*

Jason McIntosh • @JmacDotOrg

as a wizard, ensconced in your high tower, with only



Jason McIntosh • @JmacDotOrg

your grimoire and



Jason McIntosh • @JmacDotOrg

your Palantir, working in beautiful isolation to



Jason McIntosh • @JmacDotOrg

bend reality to match your will. The danger lurks in how this view can feel quite accurate -- 90 percent of the time.



Jason McIntosh • @JmacDotOrg

But sealing yourself off like this all the time can block even the most experienced hacker from realizing some of their best work, which requires not just showing up at conferences and such



Jason McIntosh • @JmacDotOrg

but truly venturing outside one's comfort zone, taking the initiative to reach out and ask for knowledge, access, or perspective that will never come through a mere search query.



Jason McIntosh • @JmacDotOrg

When I began working on BumpySkies, though, I wasn't a big believer in any of that. So I retreated into my workshop,



Jason McIntosh • @JmacDotOrg

assuming that I could apply





Jason McIntosh • @JmacDotOrg

all my usual methods of isolated study and experimentation until the day I



Jason McIntosh • @JmacDotOrg

shipped



Jason McIntosh • @JmacDotOrg

just as I would with

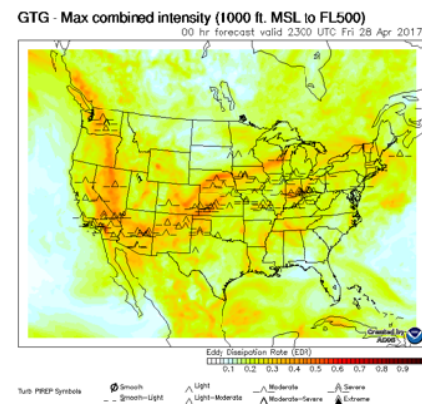


Jason McIntosh • @JmacDotOrg

any client-driven task.

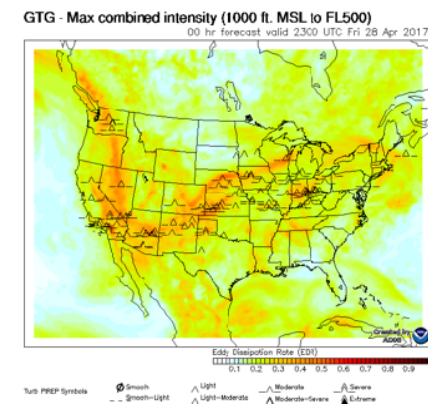
Jason McIntosh • @JmacDotOrg

Obviously I would need access to two data sources:



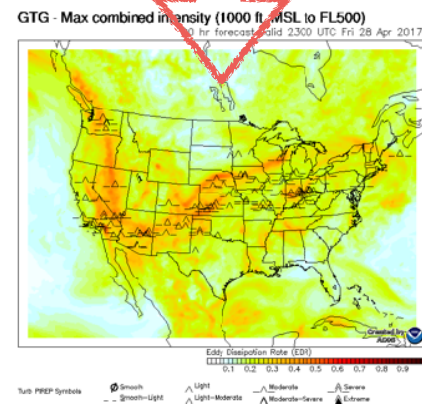
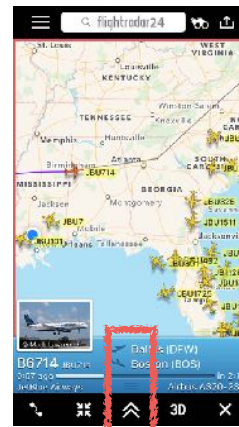
Jason McIntosh • @JmacDotOrg

One for weather conditions,



Jason McIntosh • @JmacDotOrg

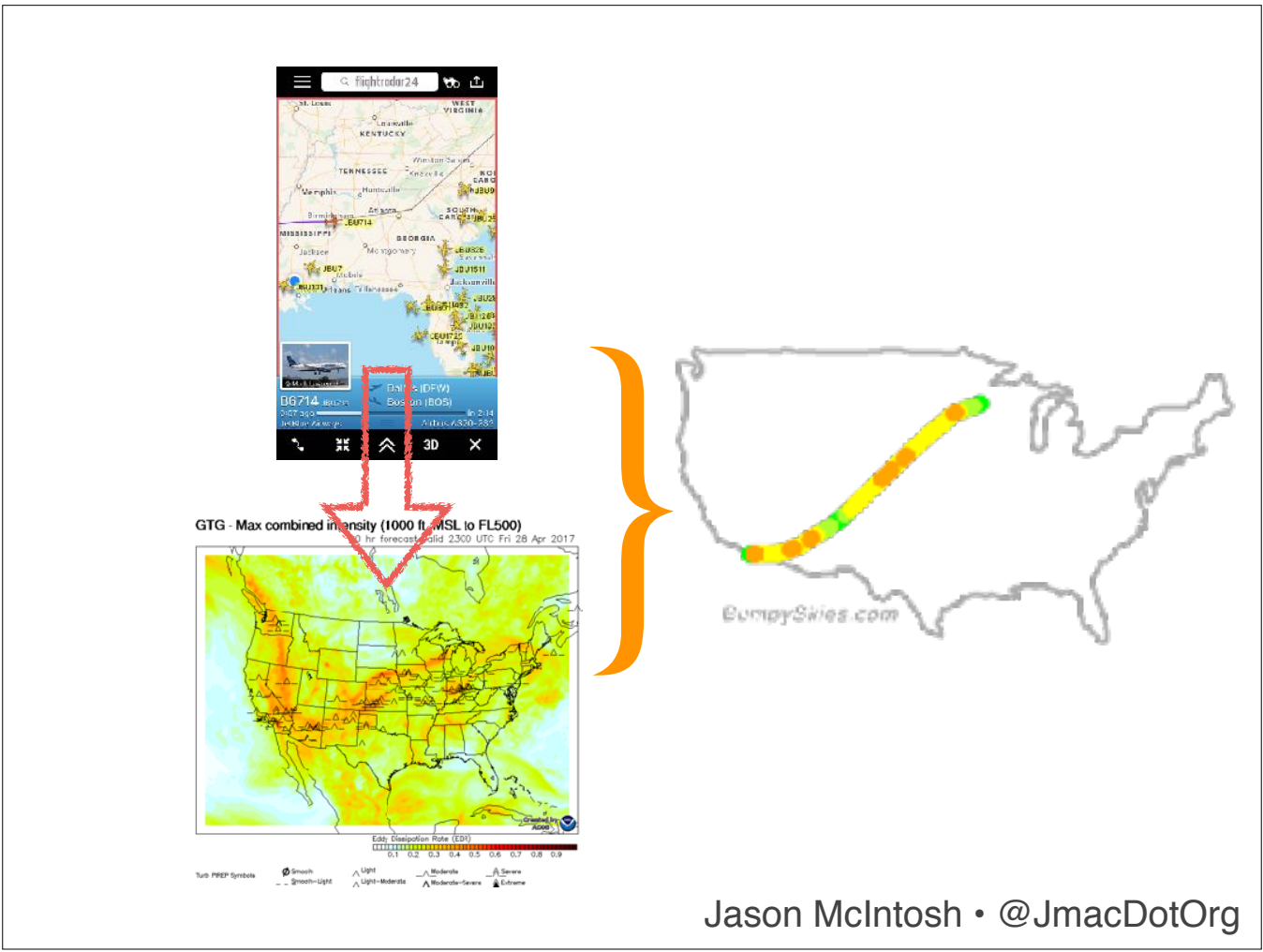
and one for flight routes. My idea being that for a given flight,



Jason McIntosh • @JmacDotOrg

I'd just run the latter through the former





and show you the numbers, somehow. And my natural introverted starting point was: let's find the public APIs! Surely there are public APIs!



Jason McIntosh • @JmacDotOrg

I started with the flight plans, and to my surprise



Jason McIntosh • @JmacDotOrg

I didn't find any obvious APIs offered by the FAA, even though I had a notion that flight plans were public information. I did quickly find a commercial API



### Pricing

Total queries per month	Class 1	Class 2	Class 3	Class 4
1 - 9,999	\$0.0120	\$0.0079	\$0.0020	\$0.0008
10,000 - 24,999	\$0.0070	\$0.0046	\$0.0012	\$0.0005
25,000 - 49,999	\$0.0060	\$0.0040	\$0.0010	\$0.0004
50,000 - 99,999	\$0.0050	\$0.0033	\$0.0008	\$0.0003
100,000 - 249,999	\$0.0040	\$0.0026	\$0.0007	\$0.0003
250,000 - 999,999	\$0.0030	\$0.0020	\$0.0005	\$0.0002
1,000,000 - 4,999,999	\$0.0020	\$0.0013	\$0.0003	\$0.0001
More than 5,000,000?	<a href="#">Contact FlightAware</a>			

Jason McIntosh • @JmacDotOrg

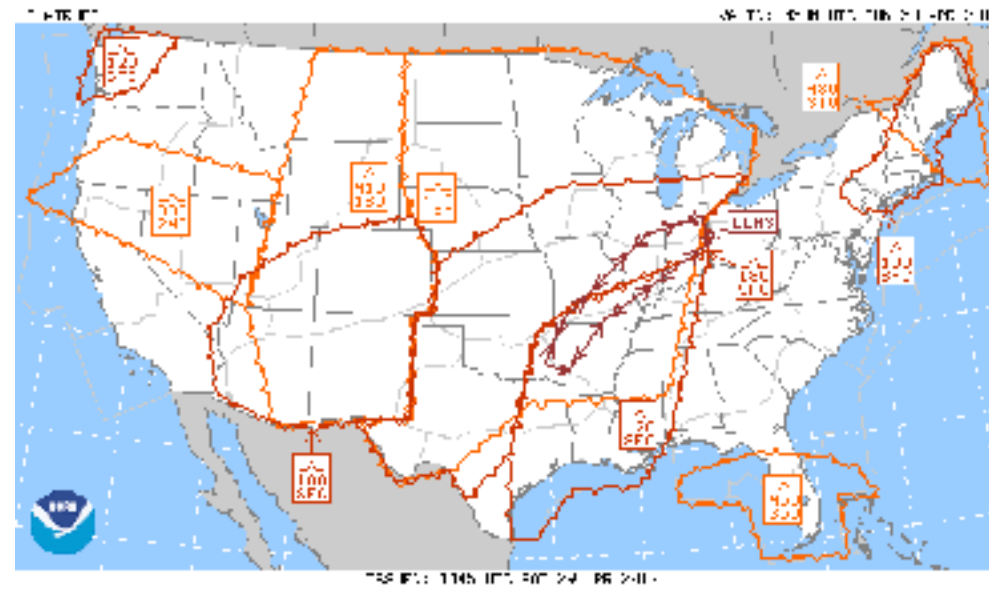
the low low price of two tenths a cent per query. OK, well: so noted. Put that aside for now.



Jason McIntosh • @JmacDotOrg

NOAA! They have public APIs! One even involves air turbulence!

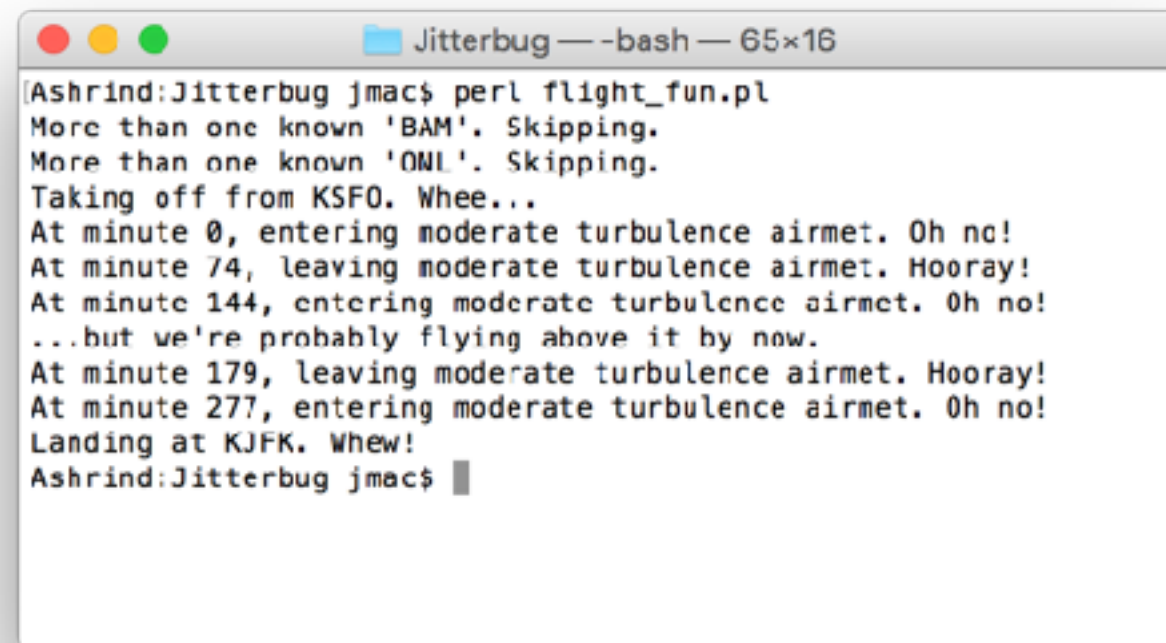




Jason McIntosh • @JmacDotOrg

AIRMETs look like this. They're big old irregular polyhedra floating in the air, with floors and ceilings defined at certain altitudes. They define a 3D space that contain an increased likelihood of atmospheric conditions for aircraft passing through them, including turbulence. Sounds perfect!

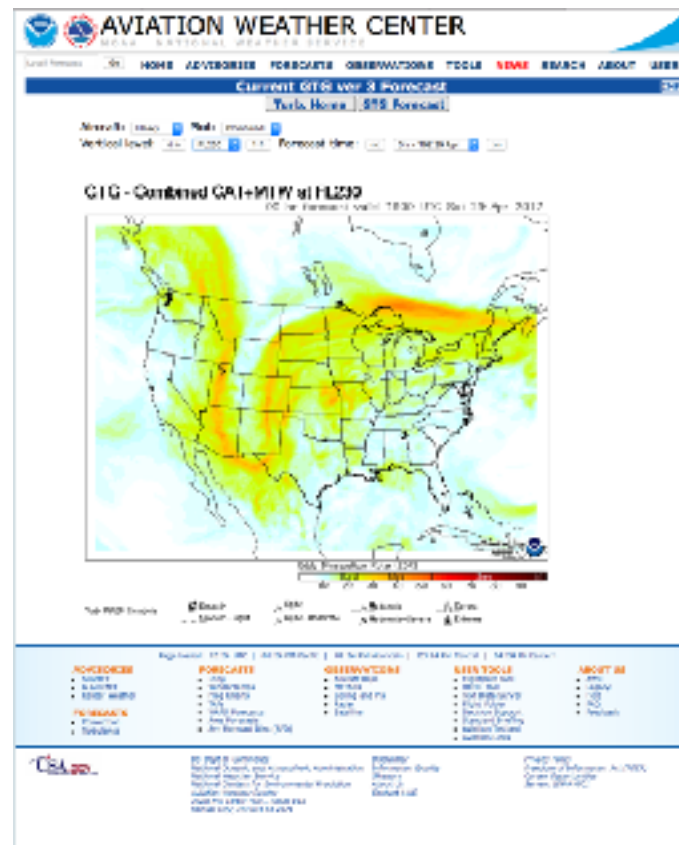




```
Jitterbug — -bash — 65x16
[Ashrind:Jitterbug jmac$ perl flight_fun.pl
More than one known 'BAM'. Skipping.
More than one known 'ONL'. Skipping.
Taking off from KSFO. Whee...
At minute 0, entering moderate turbulence airmet. Oh no!
At minute 74, leaving moderate turbulence airmet. Hooray!
At minute 144, entering moderate turbulence airmet. Oh no!
...but we're probably flying above it by now.
At minute 179, leaving moderate turbulence airmet. Hooray!
At minute 277, entering moderate turbulence airmet. Oh no!
Landing at KJFK. Whew!
Ashrind:Jitterbug jmac$
```

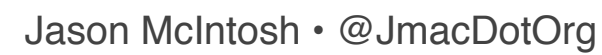
Jason McIntosh • @JmacDotOrg

And I drafted a prototype out of it! And some friends tested it, but it was clearly too broad to be a useful predictor of anything from a passenger's perspective.



Jason McIntosh • @JmacDotOrg

What I wanted was something like this, NOAA's graphical turbulence display, which I've used as part of my own pre-flight meditation for many years. And friends, I sunk many serious hours into the puzzle of downloading and analyzing these images, pixel by pixel,



before I even began to consider the possibility of doing something with those contact links down at the bottom.



Jason McIntosh • @JmacDotOrg

Now, my wife is a public servant -- that's her on the left. She works as a librarian for the U.S. Navy. And upon hearing my image-analysis woes, she said:

**AVIATION WEATHER CENTER**  
NOAA NATIONAL AVIATION SERVICE

Send Feedback [Home](#) [Advisories](#) [Forecasts](#) [Observations](#) [Tools](#) [News](#) [Weather](#) [About](#) [Help](#)

**Contact Us**


To send us a message please complete the form below and click Send Message. NOTE: If this form does not work, send email to: [acft@noaa.gov](mailto:acft@noaa.gov)

**Name \***

**Enter your email address \***

**Subject \***

**Message \***

**MESSAGE CAPTCHA FOR PREVENT OF SPAM IMAGES \***  


---

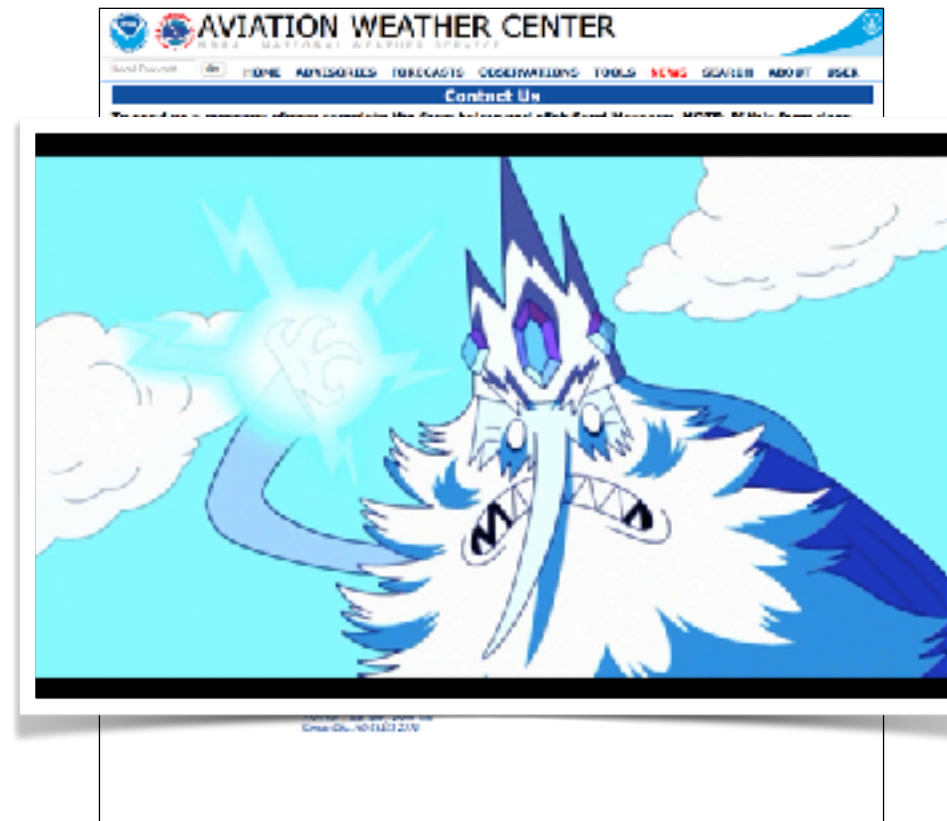
Page Number: 11-11-2010 | 11-11-2010 | 11-11-2010 | 11-11-2010 | 11-11-2010

<b>ADVISORIES</b> <ul style="list-style-type: none"> <li>• COTR</li> <li>• COTR</li> <li>• COTR</li> </ul>	<b>FORECASTS</b> <ul style="list-style-type: none"> <li>• Data</li> <li>• Data</li> <li>• Data</li> </ul>	<b>GENERAL WEATHER</b> <ul style="list-style-type: none"> <li>• Weather Data</li> <li>• Weather Data</li> <li>• Weather Data</li> </ul>	<b>USER TOOLS</b> <ul style="list-style-type: none"> <li>• FlightPath Tool</li> <li>• FlightPath Tool</li> <li>• FlightPath Tool</li> </ul>	<b>ABOUT US</b> <ul style="list-style-type: none"> <li>• About Us</li> <li>• About Us</li> <li>• About Us</li> </ul>
---	--	--	--	---

**CONTACT US**  
 11-11-2010 | 11-11-2010 | 11-11-2010 | 11-11-2010 | 11-11-2010

Jason McIntosh • @JmacDotOrg

you know, that contact form is probably monitored by someone who cares deeply about their work, seldom hears honest curiosity about it, and who would be absolutely delighted to hear from a member of the taxpaying public for whom they ostensibly labor. This struck me as counterintuitive, given my own



Jason McIntosh • @JmacDotOrg

typical private-sector response to unsolicited requests for my attention from strangers,



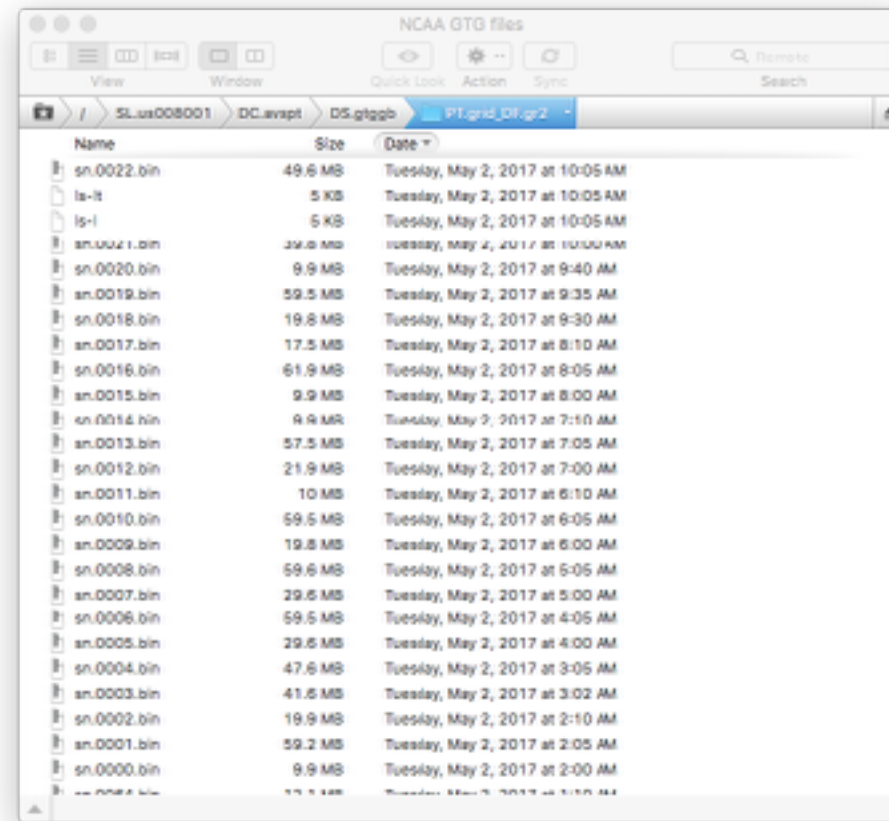
Jason McIntosh • @JmacDotOrg

but I like to think I know when to defer to experts.

Jason McIntosh • @JmacDotOrg

And so I filled out that contact form. Feeling optimistic about the AIRMET API, I asked if they made their graphical turbulence data available in some plain text format. XML, maybe JSON. And I got a response almost immediately. And they said: JSON or XML files? Yeah, sorry, we don't have any data like that.





Jason McIntosh • @JmacDotOrg

But we do have an anonymous FTP directory full of up-to-the minute weather data using a format that meteorologists use called GRIB, and here is all the information you need to get at it. Would that be useful? And I said:



Jason McIntosh • @JmacDotOrg

I'll will let you know. And so I retreated to my tower



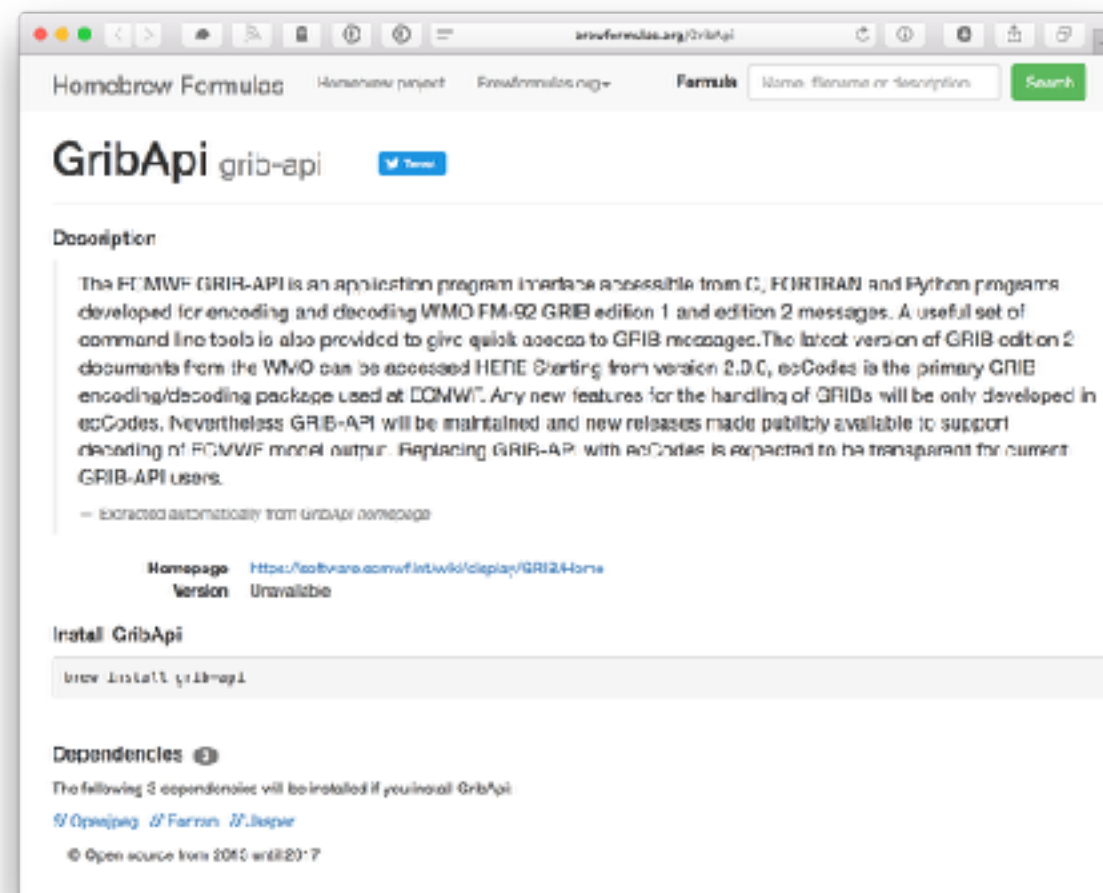
Jason McIntosh • @JmacDotOrg

which that particular afternoon was actually the Blue State coffee house in Allston, Massachusetts and there did work I've no doubt most anyone in this room could have done, and I had a great deal of fun. Does there already exist



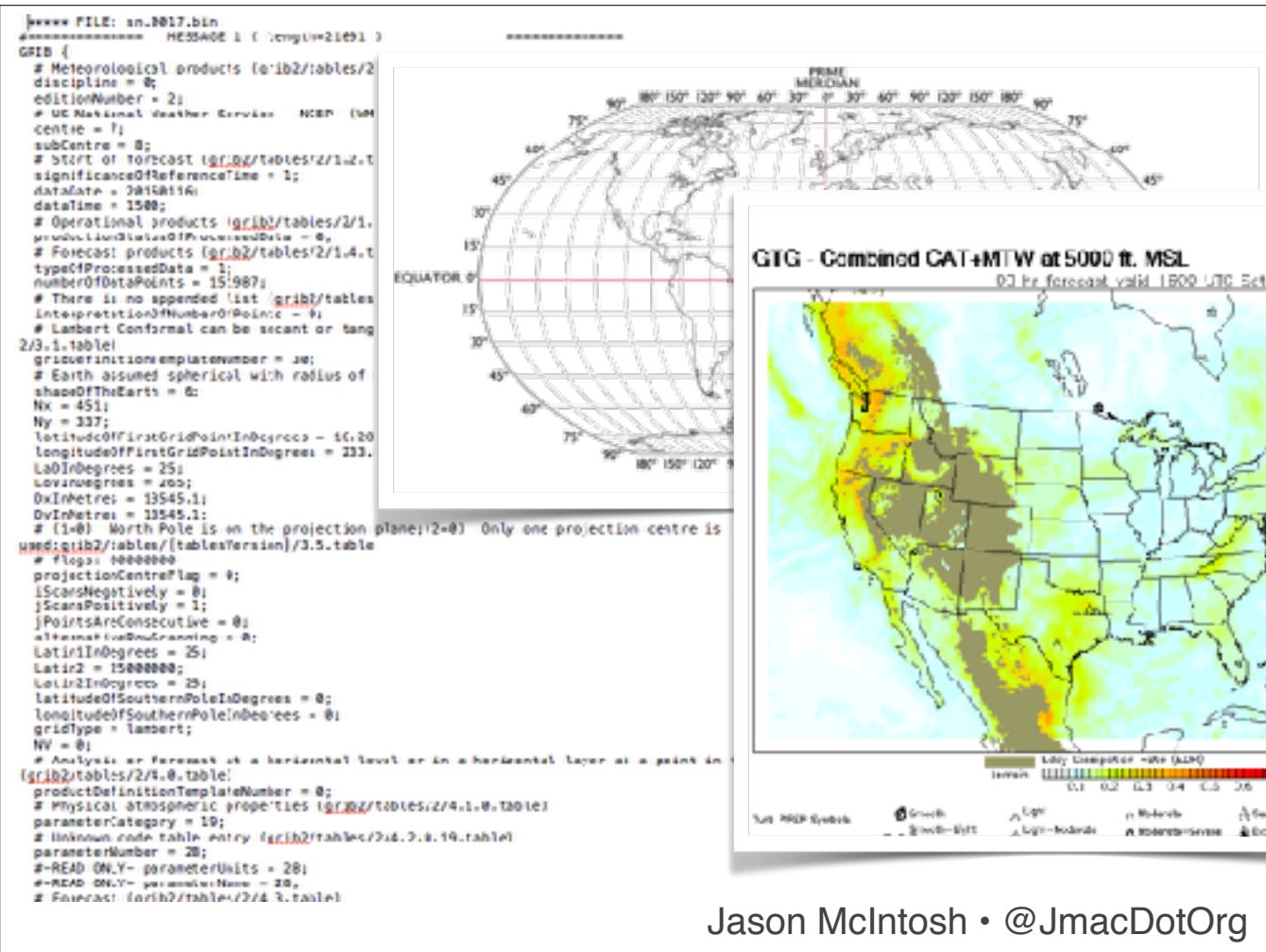
Jason McIntosh • @JmacDotOrg

a suite of open-source tools specifically for working with GRIB data? Yes. Was it already



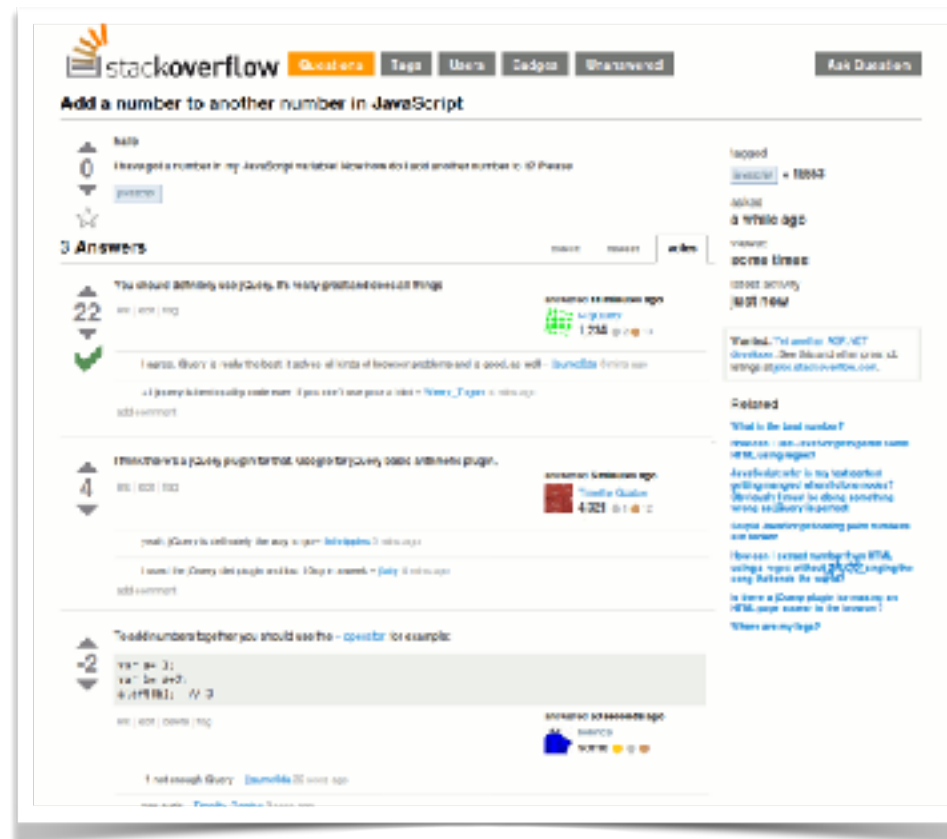
Jason McIntosh • @JmacDotOrg

packaged up for macOS Homebrew? Yes. Did it feel indescribably refreshing to work with open source tools that processed data



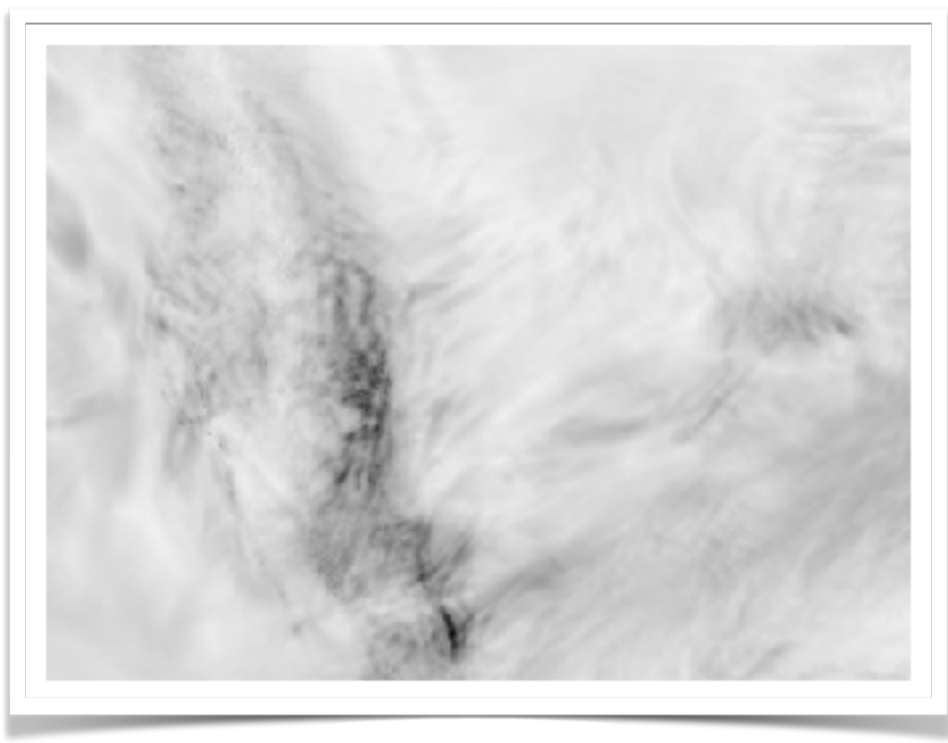
Jason McIntosh • @JmacDotOrg

for a purpose more focused than data-processing's own sake, as so often feels like the foundation of my career? GOD YES. And my discovery of this territory would have been impossible had I not jumped the track and contacted someone from outside of



Jason McIntosh • @JmacDotOrg

my usual sphere. And so I ended up that afternoon



Jason McIntosh • @JmacDotOrg

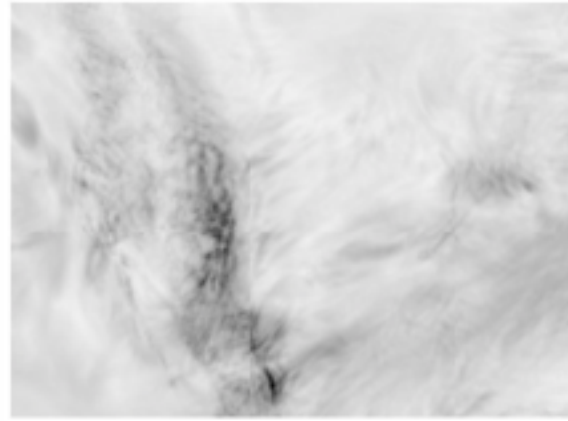
with this. And I felt jubilant! And I





**Jason McIntosh**  
@JmacDotOrg

Jitterbug progress. Hello, beautiful. [Special note to Facebook friends: this is not an ultrasound. Sorry!]



LIKE

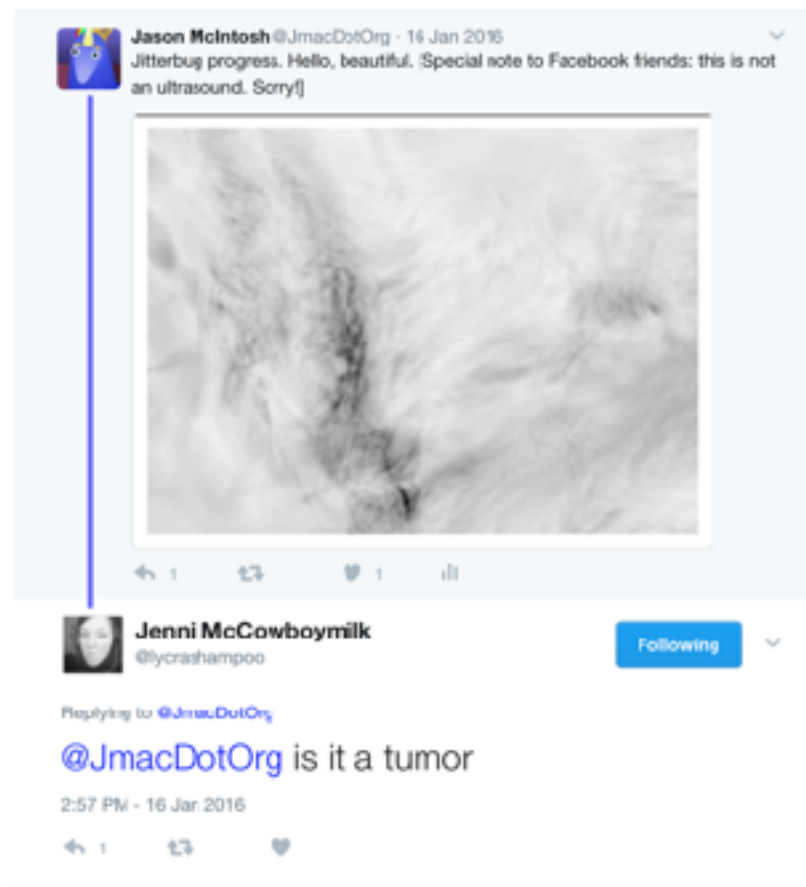
1



2:50 PM - 16 Jan 2016

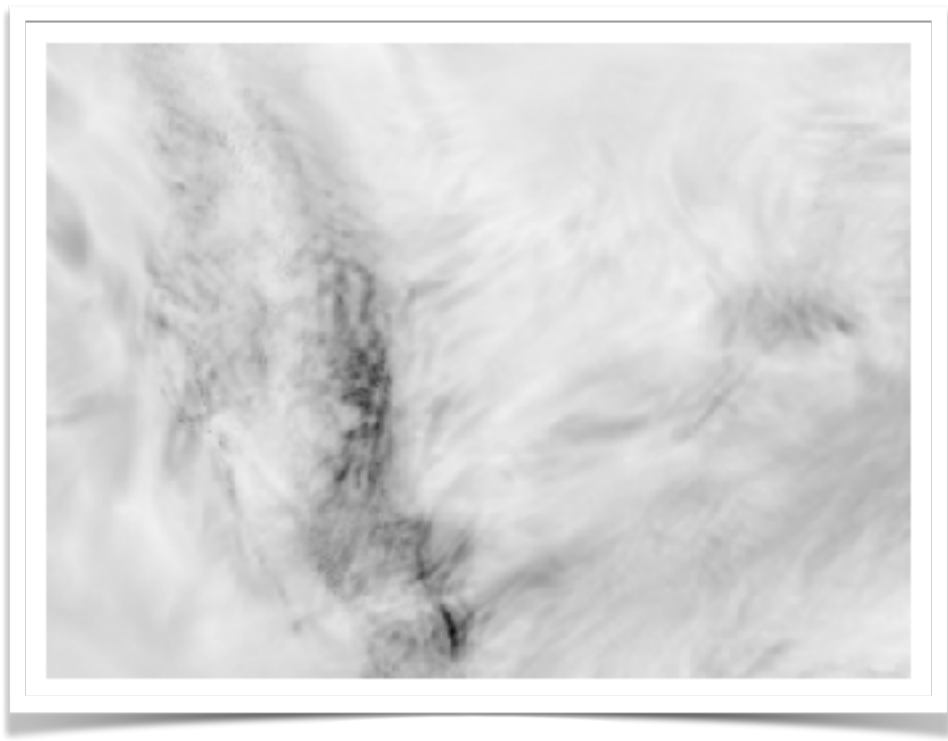
Jason McIntosh • @JmacDotOrg

posted it to Twitter! Jitterbug being an early code name for the project. And my friend Jenni said



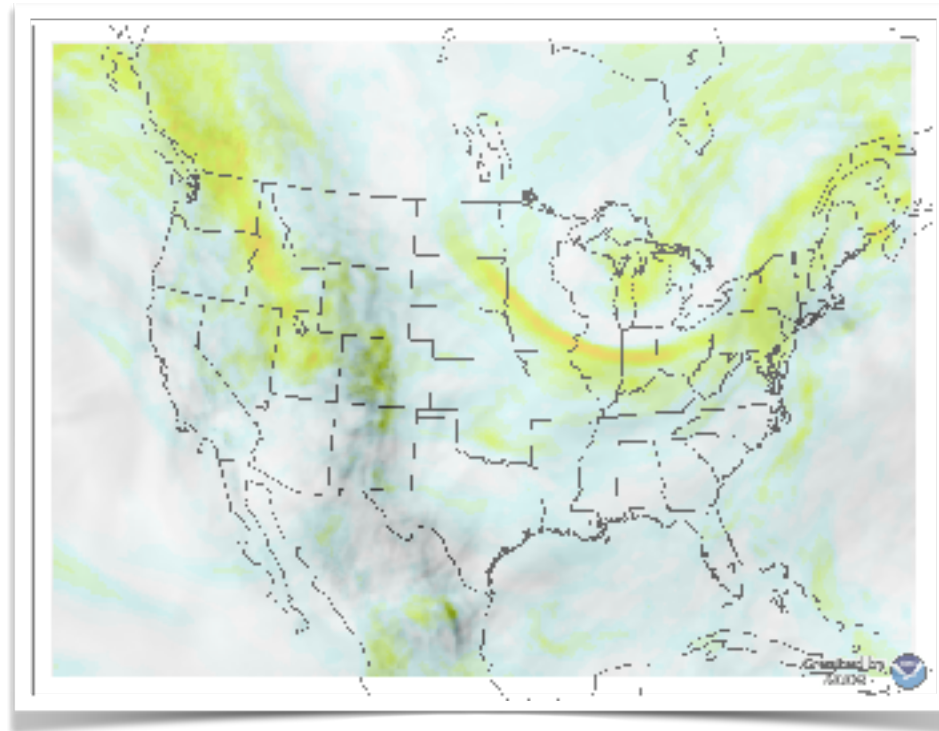
Jason McIntosh • @JmacDotOrg

"Is it a tumor" and I was like No, Jenni, but yeah okay I didn't really provide any context so that's fair but no!



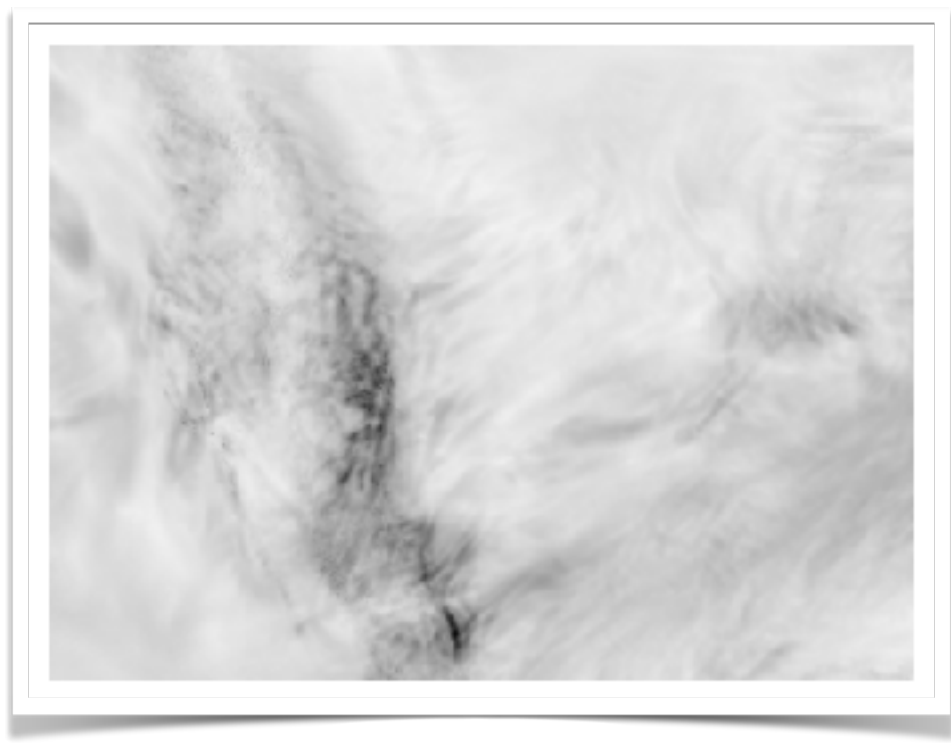
Jason McIntosh • @JmacDotOrg

It's CONUS!



Jason McIntosh • @JmacDotOrg

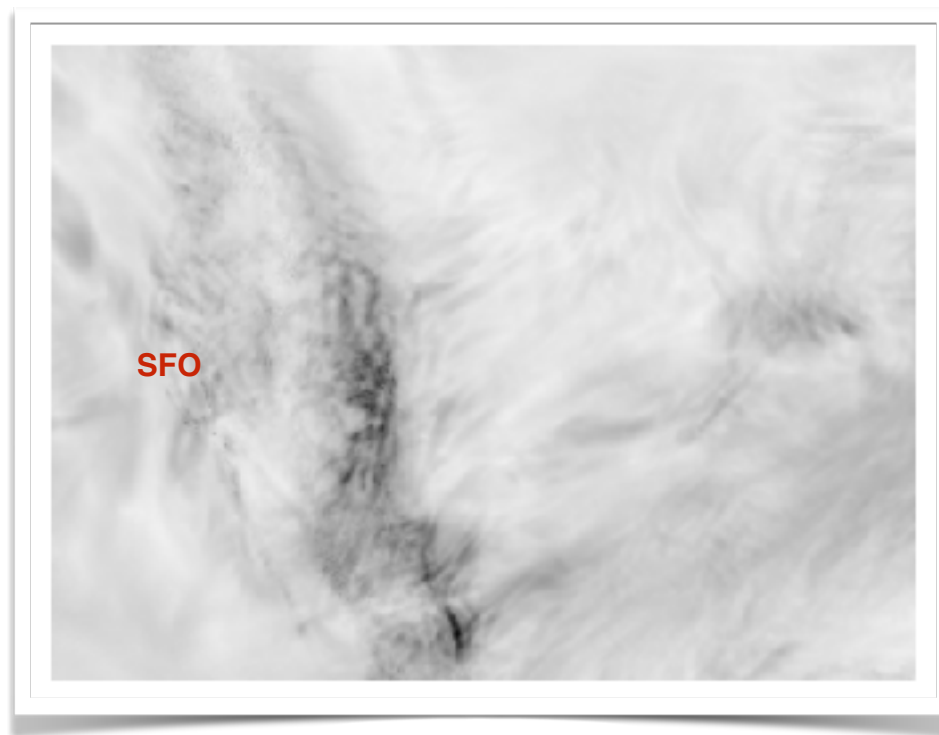
It's the continental United States or rather a slice of the atmosphere above it, or rather a forecast of clear-air turbulence intensities at a particular altitude at a particular minute on January 16, 2016.



Jason McIntosh • @JmacDotOrg

I was able to read the data well enough to create this image. This is the moment where I knew this project had potential. Which left the problem of the airplanes. I had enough that, given

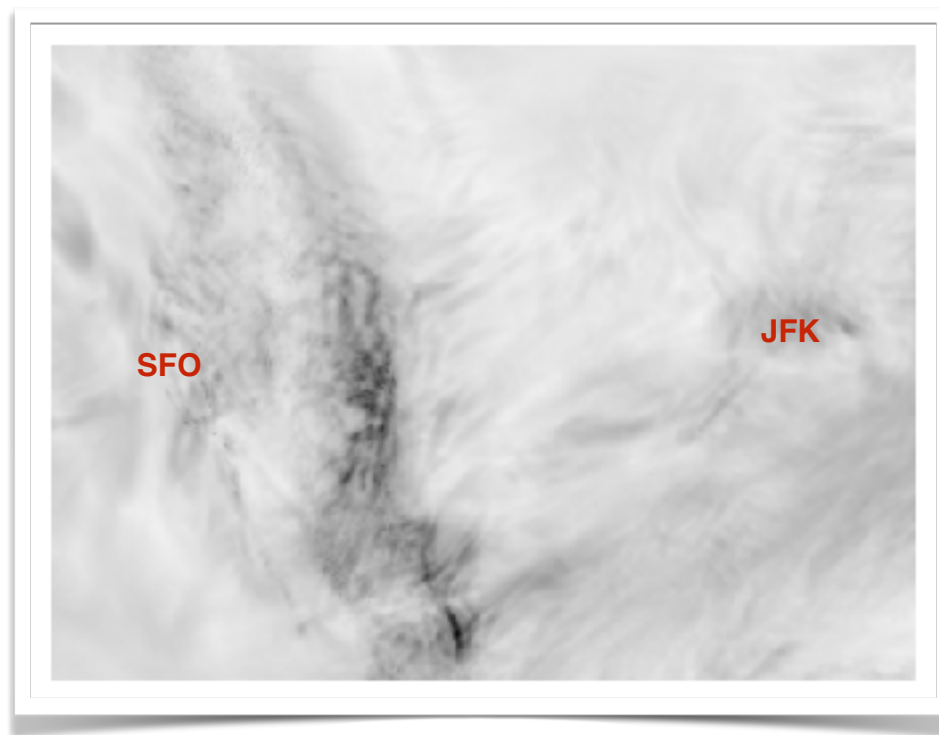
JetBlue flight 616, SFO-JFK, typical path



Jason McIntosh • @JmacDotOrg

takeoff and

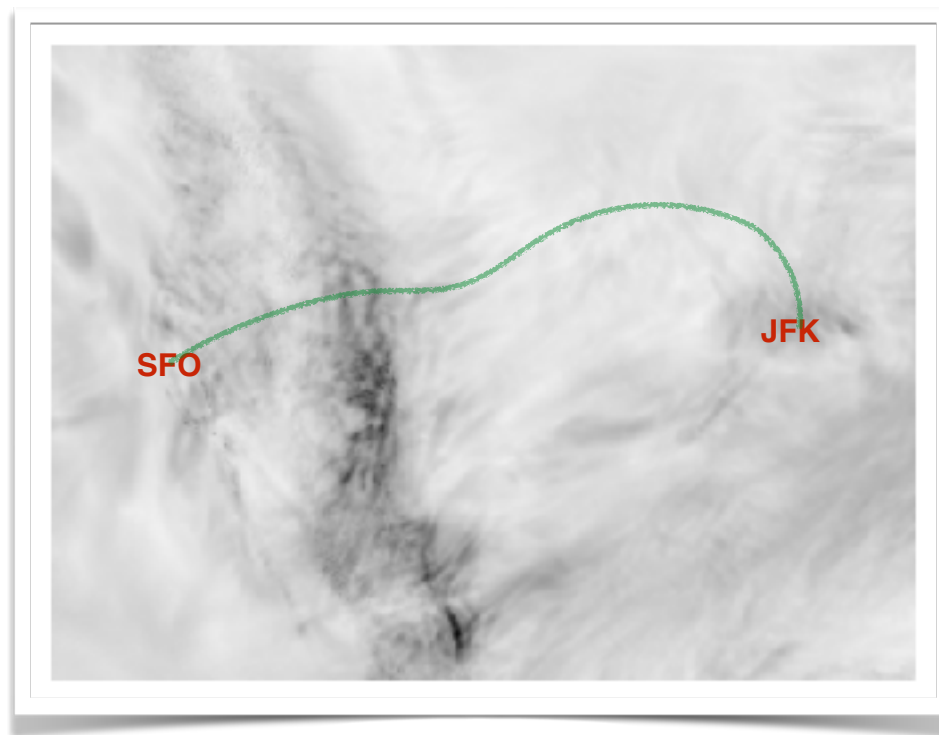
JetBlue flight 616, SFO-JFK, typical path



Jason McIntosh • @JmacDotOrg

landing times and

## JetBlue flight 616, SFO-JFK, typical path

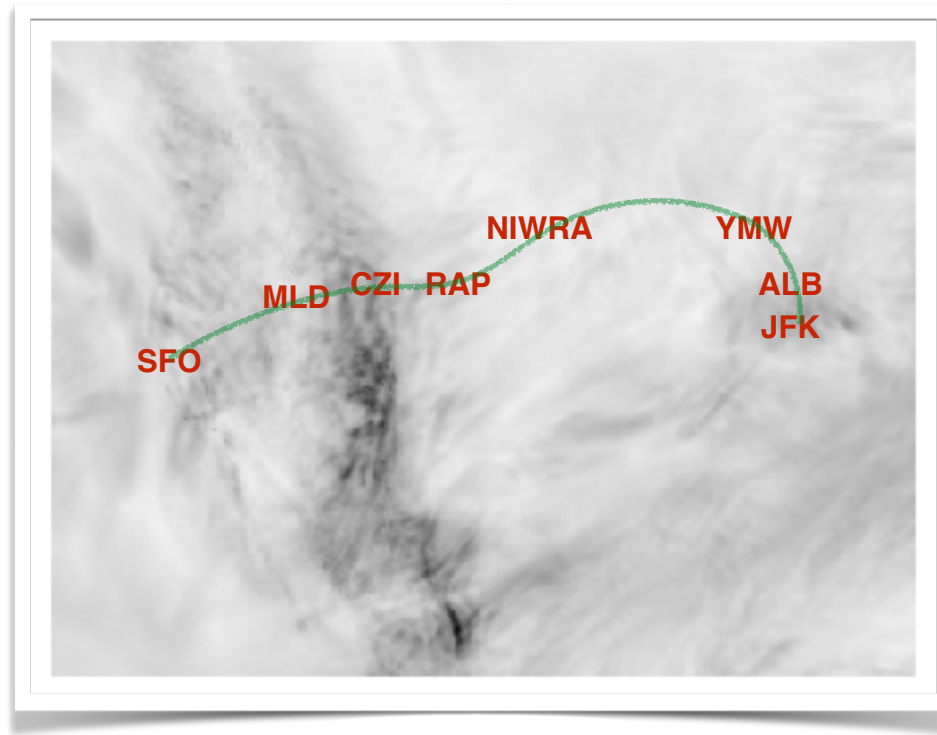


Jason McIntosh • @JmacDotOrg

a line of



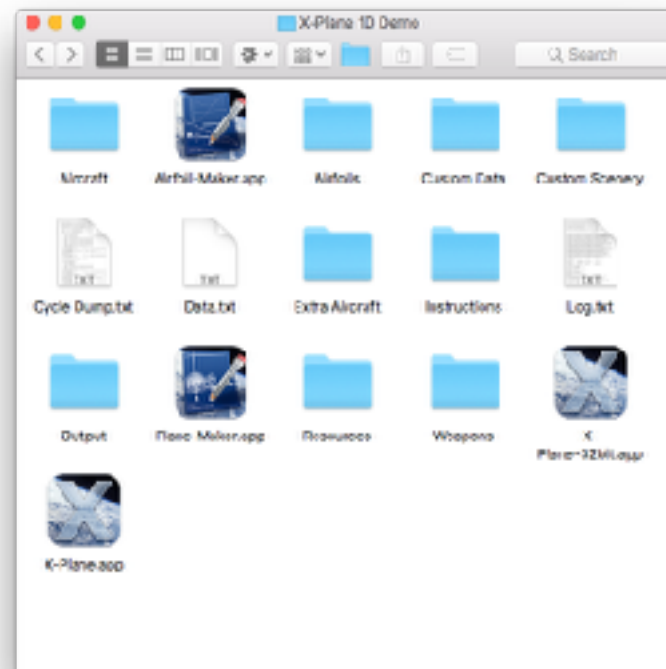
## JetBlue flight 616, SFO-JFK, typical path



Jason McIntosh • @JmacDotOrg

navigational fixes I could estimate what conditions surrounded the plane at any given point on its journey. But asking users to look up and type in nav codes of their upcoming flight, versus just a flight number, was a non-starter.

As an aside: I learned a lot about aeronautical navigation points for this project, and how there's no good public database of them all, but you can fake it well enough by



Jason McIntosh • @JmacDotOrg

downloading the free trial of the super-nerdy X-Plane flight simulator and raiding





Jason McIntosh • @JmacDotOrg

Back to my tower, which I wasn't ready to leave again, just yet.

jmacdotorgmyflightawareMy AlertsEGYPTUSAUSDTIMEOUT

All

Search for flight, lat, airport, or city

Track

+1-800-715-8570

Chat

LIVE FLIGHT TRACKINGPRODUCTSADS-BPHOTOSSQUAWKSDISCUSSIONSABOUTCONTACT

# Flight Tracking and Flight Status API

Harness FlightAware's infrastructure to build an awesome aviation app using FlighXML.

Get your FlightAware API key

View API activity and billing history

### PHP

```
// get flight status on flight
// GDSRRR
$param = array(
    "flight" => "GDSRRR",
    "radius" => 1,
    "offset" => 0 );

$result = $client->
    >flightInfo($param);
```

### JavaScript (with jQuery)

```
// get aviation weather (ADSRD)
$.ajax({
    url: 'http://api.flightaware.com/adsr',
    data: { 'airport': 'EGYPT' },
    dataType: 'jsonp',
    jsonp: 'jsonp_callback',
    xhrFields: { withCredentials:
        true }
});
```

### Ruby

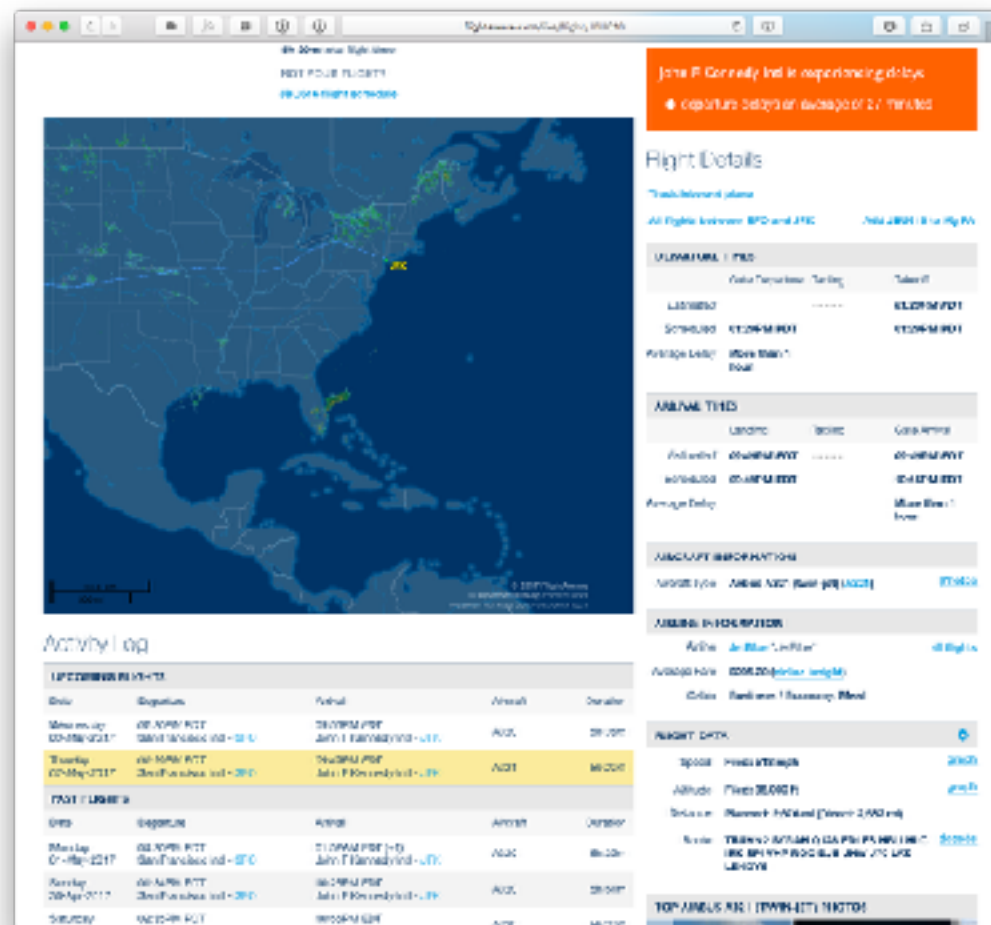
```
# get tracking data on flight
on route to SFO
result =
    client.request(:url =>
        'http://api.flightaware.com/adsr',
        :method => 'GET',
        :params => {
            :airport => 'EGYPT',
            :offset => 0
        }
    )
```

### Python

```
# Get the flight status for
EGYPT
result =
    api.flightaware.flight('EGYPT', 10,
        1, 0)
print result
```

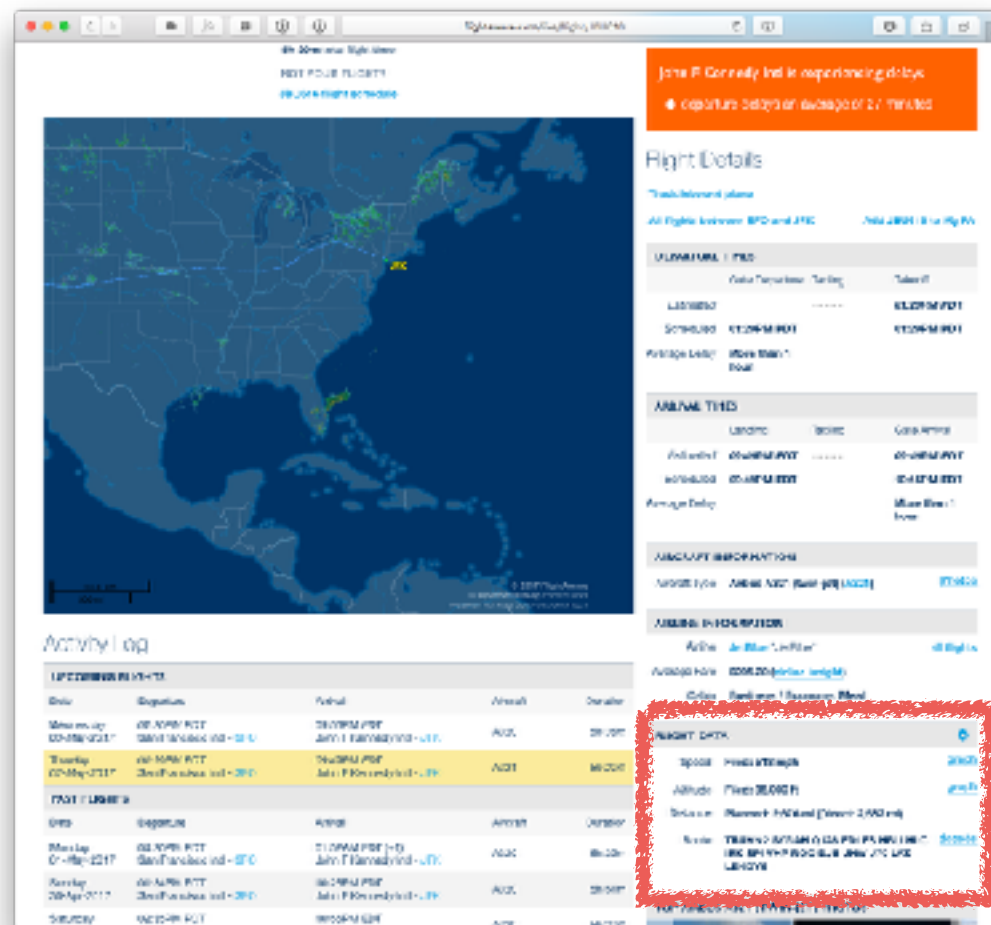
Jason McIntosh • @JmacDotOrg

I returned to my old friends at FlightAware, they of the commercial API, and... well.



Jason McIntosh • @JmacDotOrg

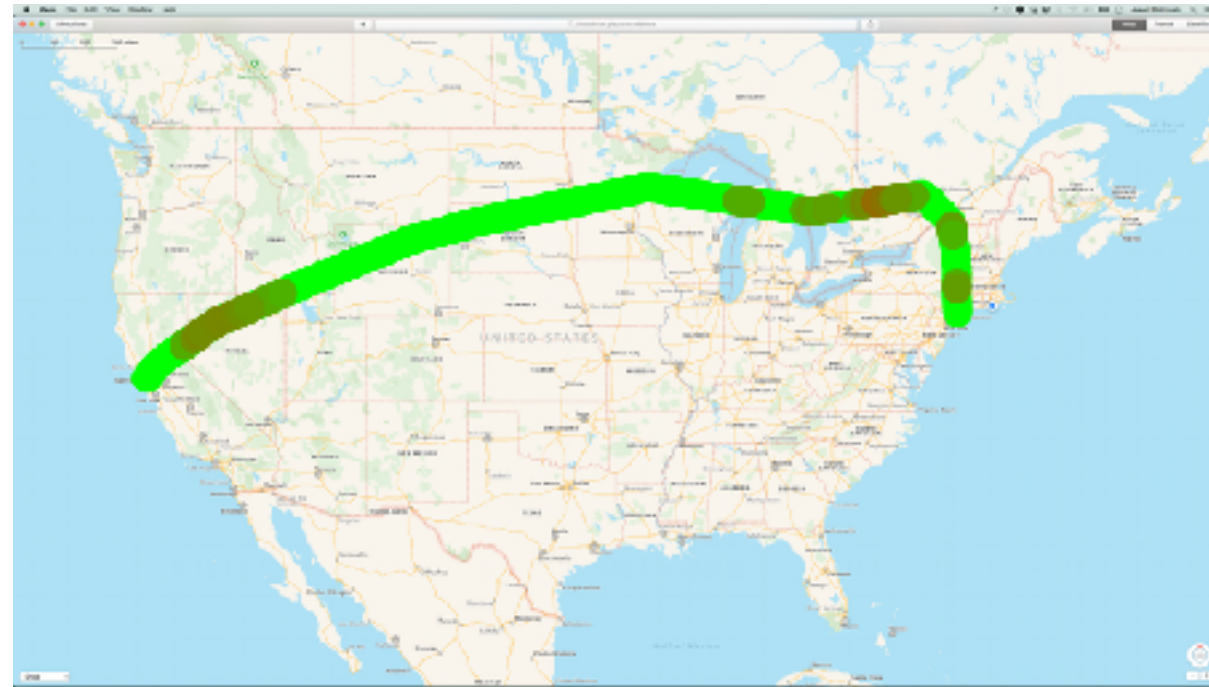
built a screen-scraper of their webapp, which among other things turns flight numbers



Jason McIntosh • @JmacDotOrg

into nav paths. This would not scale to production, but it did let me complete

## JetBlue flight 616, SFO-JFK, June 5, 2016



Jason McIntosh • @JmacDotOrg

my proof of concept, of which me and some friends were the only users. (And yes, that's plotted against an Apple Maps screengrab. It was there, and it was good enough.) But now progress slowed down.





(xkcd 979)

Jason McIntosh • @JmacDotOrg

"Never have I felt so close to another soul", writes Randal Munroe in XKCD 979, "..."

Naturally I wasn't the only jerk on the internet who wanted FAA data, and indeed found many instances of people asking, but no clear answers. I did find some tantalizing, almost rumor-level pointers in multiple years-old forum posts



**`https://www.fly.faa.gov/ASDI/asdi.html`**



Jason McIntosh • @JmacDotOrg

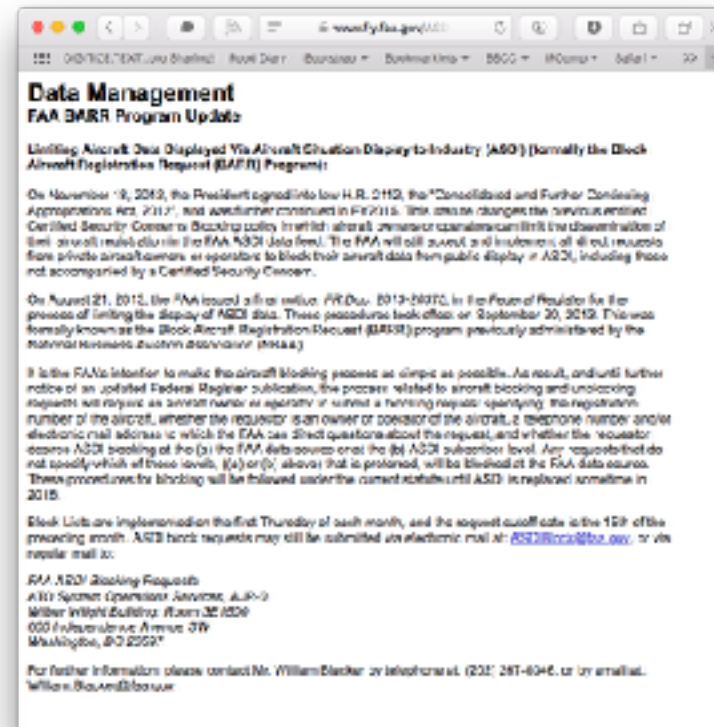
that all linked to the same URL, and clearly there

**`https://www.fly.faa.gov/ASDI/asdi.html`**

Jason McIntosh • @JmacDotOrg

used to be a website there, but now it just held

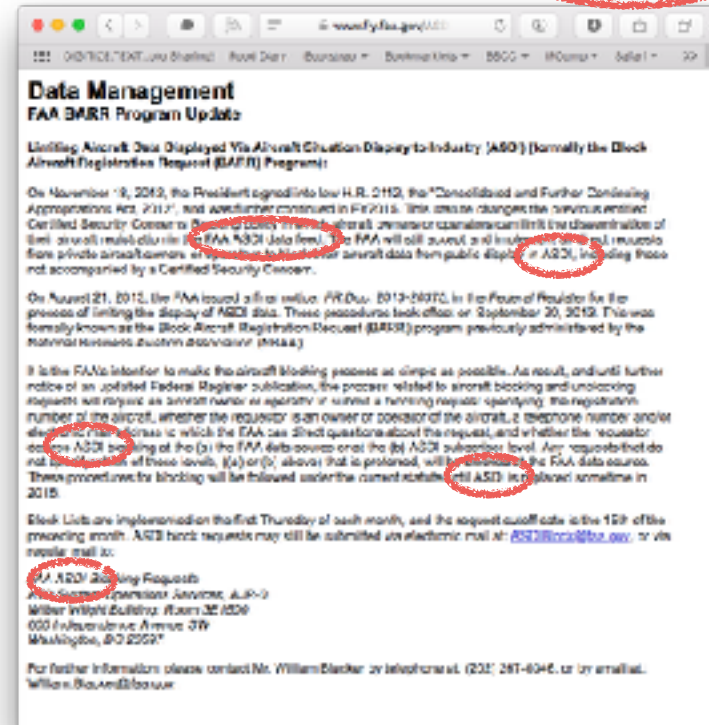
<https://www.fly.faa.gov/ASDI/asdi.html>



Jason McIntosh • @JmacDotOrg

a 2011 press release describing a random policy change, like a fading concert flier tacked to an old warehouse. However, it had an acronym I hadn't seen before:

<https://www.fly.faa.gov/ASDI/asdi.html>



Jason McIntosh • @JmacDotOrg

ASDI, and a reference to something called the FAA ASDI data feed. That gave me another handle to search on. And I found, for example,

Class	London	Company	Firstname	Lastname	Email	Phone1
Class 1	Yes	ARINC, Incorporated	Jeannine	Hendricks	jh@arinc.com	410-266-4560
Class 1	Yes	ARINC, Incorporated	Kevin	Traub	ktraub@arinc.com	410-266-2380
Class 1	Yes	Aviation Data Systems	Andy	Green	green@fboweb.com	407-323-4697
Class 1	Yes	Aviation Data Systems	Andy	Green	ag@ads.aero	407-323-4697
Class 1		Embry Riddle Aeronautical University Center for Applied ATM Research	John	Pesce	Pescej@erau.edu	386-226-7437
Class 1		Embry Riddle Aeronautical University Center for Applied ATM Research	John	Pesce	Pescej@erau.edu	386-226-7437
Class 1	Yes	FlyteComm Inc.	Maurice	Bailey	mbailey@flytecomm.com	650-404-8100
Class 1	Yes	FlyteComm Inc.	Maurice	Bailey	mbailey@flytecomm.com	650-404-8100
Class 1		IT&T (ERA)	Bill	Colligan	bcolligan@erabeyondradar.com	703-637-7250
Class 1		Metron, Inc.	Miro	Lehky	lehky@metronaviation.com	
Class 1		OAG Worldwide Inc.	Melinda	Breitman	mbreitman@oag.com	630-515-3934
Class 1		OAG Worldwide Inc.	Graham	Mockett	graham.mockett@oag.com	
Class 1		OAG Worldwide Inc.	Stephen	Bray	stephenbray@oag.com	
Class 1	Yes	Passur Aerospace, Inc. (Megadata)	Jeff	Devaney	jeffdevaney@passur.com	631-589-6800
Class 1	Yes	Passur Aerospace, Inc. (Megadata)	Ron	Dunsky	rondunsky@passur.com	631-589-6800
Class 1	Yes	RLM Software Inc. (FlightView)	Jim	Steinberg	jimsteinberg@flightview.com	617-787-4200
Class 1	Yes	Sabre, Inc.	Beth	Conord	beth.conord@sabre.com	301-634-8210
Class 1	Yes	Sabre, Inc.	John	Cheng	john.cheng@sabre.com	301-634-8214
Class 1		Sabre, Inc.	John	Cheng	john.cheng@sabre.com	301-634-8214
Class 1		Sabre, Inc.	Beth	Conord	beth.conord@sabre.com	301-634-8210
Class 1		Sensis Corporation, Syracuse	Dan	London	dan.london@sensis.com	315-445-5721
Class 1	Yes	WSI Corporation, Atlanta	Mark D.	Miller	mmiller@wsi.com	978-983-6711
Class 1	Yes	WSI Corporation, Boston	Mark D.	Miller	mmiller@wsi.com	978-983-6711
Class 2		Aerospace Engineering and Research Associates	Kathy	Bolin	kathy@freeflight.com 3	301-459-4484
Class 2		Air Routing International LP	Jim	Rouse	jim.rouse@argis.com	713-430-7072
Class 2		Air Routing International LP	Greg	Murray	greg.murray@argis.com	
Class 2		AIRNAV Systems	Andre	Brandao	acrb@airnavsystems.com	619-330-2482
Class 2		ARINC, Incorporated	Jeannine	Hendricks	jh@arinc.com	410-266-4560
Class 2		ARINC, Incorporated	Kevin	Traub	ktraub@arinc.com	410-266-2380
Class 2		Ascent Technology Inc	Alan	Hartstone	alanh@ascent.com	617-395-4815
Class 2		ATAC Corporation	Charles	Winkelman	cew@atac.com	408-736-2822
Class 2		Austin Digital, Inc	Ben	Prager	bap@ausdig.com	512-452-8178
Class 2		Bruel & Kjaer (formerly Lochard)	Robert	Brodecky	robert.brodecky@lochard.com	866-240-8307
Class 2		Bruel&Kjaer	Robert	Brodecky	robert.brodecky@lochard.com	866-240-8307
Class 2		Business Aviation Technology	Greg	Johnson	greg@onesky.com	877-293-4019
Class 2		Camp Systems International, Inc.	Steve E	Attard	sattard@campsystems.com	631-588-3200
Class 2		Conductive Technology Corporation	Jeff	Kennedy	jeffk@conducivetech.com	503-445-4236
Class 2		Conductive Technology Corporation	Shuchi	Agrawal		972-973-5801
Class 2		Conductive Technology Corporation	Michael	Crozier	crozier@conducivetech.com	503-445-4233
Class 2		DFW International Airport	Michael	McCrary	mmccrary@dfwairport.com	
Class 2		FlightAware	Daniel	Baker	dbaker@flightaware.com	800-713-8570
Class 2		FlightAware	Daniel	Baker	dbaker@flightaware.com	800-713-8570
Class 2		Honeywell Global Data Center	Kerry	Hodnett	kerry.hodnett@honeywell.com	425-895-6855
Class 2		Honeywell Global Data Center	James	Harvey	james.harvey@honeywell.com	425-885-8974
Class 2		Honeywell Global Data Center	George	Risinger	george.risinger@honeywell.com	425-885-8629
Class 2		Honeywell Technology Solutions Inc.	Alan	Morgan	alan.morgan@honeywell.com	979-693-2683
Class 2		Honeywell Technology Solutions Inc.	David	Dougherty	daviddougherty2@honeywell.com	303-682-9140
Class 2		Lennoc Development B.V.	Bert	van den Brinkvanden	brink@lennoc.com	310-575-468720

Jason McIntosh • @JmacDotOrg

this document listing users of ASDI — whatever it was — which included

Class	London	Company	Firstname	Lastname	Email	Phone1
Class 1	Yes	ARINC, Incorporated	Jeannine	Hendricks	jh@arinc.com	410-266-4560
Class1	Yes	ARINC, Incorporated	Kevin	Traub	ktraub@arinc.com	410-266-2380
Class 1	Yes	Aviation Data Systems	Andy	Green	green@fboweb.com	407-323-4697
Class 1	Yes	Aviation Data Systems	Andy	Green	ag@ads.aero	407-323-4697
Class 1		Embry Riddle Aeronautical University Center for Applied ATM Research	John	Pesce	Pescej@erau.edu	386-226-7437
Class 1		Embry Riddle Aeronautical University Center for Applied ATM Research	John	Pesce	Pescej@erau.edu	386-226-7437
Class 1	Yes	FlyteComm Inc.	Maurice	Bailey	mbailey@flytecomm.com	650-404-8100
Class 1	Yes	FlyteComm Inc.	Maurice	Bailey	mbailey@flytecomm.com	650-404-8100
Class 1		IT&T (ERA)	Bill	Colligan	bcolligan@erabeyondradar.com	703-637-7250
Class 1		Metron, Inc.	Miro	Lehky	lehky@metronaviation.com	
Class 1		OAG Worldwide Inc.	Melinda	Breitman	mbreitman@oag.com	630-515-3934
Class 1		OAG Worldwide Inc.	Graham	Mockett	graham.mockett@oag.com	
Class 1		OAG Worldwide Inc.	Stephen	Bray	stephenbray@oag.com	
Class 1	Yes	Passur Aerospace, Inc. (Megadata)	Jeff	Devaney	jeffdevaney@passur.com	631-589-6800
Class 1	Yes	Passur Aerospace, Inc. (Megadata)	Ron	Dunsky	rondunsky@passur.com	631-589-6800
Class 1	Yes	RLM Software Inc. (FlightView)	Jim	Steinberg	jimsteinberg@flightview.com	617-787-4200
Class 1	Yes	Sabre, Inc.	Beth	Conord	beth.conord@sabre.com	301-634-8210
Class 1	Yes	Sabre, Inc.	John	Cheng	john.cheng@sabre.com	301-634-8214
Class 1		Sabre, Inc.	John	Cheng	john.cheng@sabre.com	301-634-8214
Class 1		Sabre, Inc.	Beth	Conord	beth.conord@sabre.com	301-634-8210
Class 1		Sensis Corporation, Syracuse	Dan	London	dan.london@sensis.com	315-445-5721
Class 1	Yes	WSI Corporation, Atlanta	Mark D.	Miller	mmiller@wsi.com	978-983-6711
Class 1	Yes	WSI Corporation, Boston	Mark D.	Miller	mmiller@wsi.com	978-983-6711
Class 2		Aerospace Engineering and Research Associates	Kathy	Bolin	kathy@freeflight.com 3	301-459-4484
Class 2		Air Routing International LP	Jim	Rouse	jim.rouse@argis.com	713-430-7072
Class 2		Air Routing International LP	Greg	Murray	greg.murray@argis.com	
Class 2		AIRNAV Systems	Andre	Brandao	acrb@airnavsystems.com	619-330-2482
Class 2		ARINC, Incorporated	Jeannine	Hendricks	jh@arinc.com	410-266-4560
Class 2		ARINC, Incorporated	Kevin	Traub	ktraub@arinc.com	410-266-2380
Class 2		Ascent Technology Inc	Alan	Hartstone	alanh@ascent.com	617-395-4815
Class 2		ATAC Corporation	Charles	Winkelman	cew@atac.com	408-736-2822
Class 2		Austin Digital, Inc	Ben	Prager	bap@ausdig.com	512-452-8178
Class 2		BrueI & Kjaer (formerly Lochar)	Robert	Brodecky	robert.brodecky@lochard.com	866-240-8307
Class 2		BrueI & Kjaer	Robert	Brodecky	robert.brodecky@lochard.com	866-240-8307
Class 2		Business Aviation Technology	Greg	Johnson	greg@onesky.com	877-293-4019
Class 2		Camp Systems International, Inc.	Steve E	Attard	sattard@campsystems.com	631-588-3200
Class 2		Conductive Technology Corporation	Jeff	Kennedy	jeffk@conducivetech.com	503-445-4236
Class 2		Conductive Technology Corporation	Shuchi	Agrawal		972-973-5801
Class 2		Conductive Technology Corporation	Michael	Crozier	crozierm@conducivetech.com	503-445-4233
Class 2		FlightAware	Daniel	Baker	dbaker@flightaware.com	800-713-8570
Class 2		FlightAware	Daniel	Baker	dbaker@flightaware.com	800-713-8570
Class 2		Honeywell Global Data Center	James	Harvey	james.harvey@honeywell.com	425-885-8974
Class 2		Honeywell Global Data Center	George	Risinger	george.risinger@honeywell.com	425-885-8629
Class 2		Honeywell Technology Solutions Inc.	Alan	Morgan	alan.morgan@honeywell.com	979-693-2683
Class 2		Honeywell Technology Solutions Inc.	David	Dougherty	daviddougherty2@honeywell.com	303-682-9140
Class 2		Lennoc Development B.V.	Bert	van den Brinkvanden	brink@lennoc.com	310-575-468720

Jason McIntosh • @JmacDotOrg

my friends at FlightAware. OK: right track. I'd also seen mention of this

Class	London	Company	Firstname	Lastname	Email	Phone1
Class 1	Yes	ARINC, Incorporated	Jeannine	Hendricks	jh@arinc.com	410-266-4560
Class 1	Yes	ARINC, Incorporated	Kevin	Traub	ktraub@arinc.com	410-266-2380
Class 1	Yes	Aviation Data Systems	Andy	Green	green@fboweb.com	407-323-4697
Class 1	Yes	Aviation Data Systems	Andy	Green	ag@ads.aero	407-323-4697
Class 1		Embry Riddle Aeronautical University Center for Applied ATM Research	John	Pesce	Pescej@erau.edu	386-226-7437
Class 1		Embry Riddle Aeronautical University Center for Applied ATM Research	John	Pesce	Pescej@erau.edu	386-226-7437
Class 1	Yes	FlyteComm Inc.	Maurice	Bailey	mbailey@flytecomm.com	650-404-8100
Class 1	Yes	FlyteComm Inc.	Maurice	Bailey	mbailey@flytecomm.com	650-404-8100
Class 1		IT&T (ERA)	Bill	Colligan	bcolligan@erabeyondradar.com	703-637-7250
Class 1		Metron, Inc.	Miro	Lehky	lehky@metronaviation.com	
Class 1		OAG Worldwide Inc.	Melinda	Breitman	mbreitman@oag.com	630-515-3934
Class 1		OAG Worldwide Inc.	Graham	Mockett	graham.mockett@oag.com	
Class 1		OAG Worldwide Inc.	Stephen	Bray	stephenbray@oag.com	
Class 1	Yes	Passur Aerospace, Inc. (Megadata)	Jeff	Devaney	jeffdevaney@passur.com	631-589-6800
Class 1	Yes	Passur Aerospace, Inc. (Megadata)	Ron	Dunsky	rondunsky@passur.com	631-589-6800
Class 1	Yes	RLM Software Inc. (FlightView)	Jim	Steinberg	jimsteinberg@flightview.com	617-787-4200
Class 1	Yes	Sabre, Inc.	Beth	Conord	beth.conord@sabre.com	301-634-8210
Class 1	Yes	Sabre, Inc.	John	Cheng	john.cheng@sabre.com	301-634-8214
Class 1		Sabre, Inc.	John	Cheng	john.cheng@sabre.com	301-634-8214
Class 1		Sabre, Inc.	Beth	Conord	beth.conord@sabre.com	301-634-8210
Class 1		Sensis Corporation, Syracuse	Dan	London	dan.london@sensis.com	315-445-5721
Class 1	Yes	WSI Corporation, Atlanta	Mark D.	Miller	mmiller@wsi.com	978-983-6711
Class 1	Yes	WSI Corporation, Boston	Mark D.	Miller	mmiller@wsi.com	978-983-6711
Class 2		Aerospace Engineering and Research Associates	Kathy	Bolin	kathy@freeflight.com 3	301-459-4484
Class 2		Air Routing International LP	Jim	Rouse	jim.rouse@argis.com	713-430-7072
Class 2		Air Routing International LP	Greg	Murray	greg.murray@argis.com	
Class 2		AIRNAV Systems	Andre	Brandao	acrb@airnavsystems.com	619-330-2482
Class 2		ARINC, Incorporated	Jeannine	Hendricks	jh@arinc.com	410-266-4560
Class 2		ARINC, Incorporated	Kevin	Traub	ktraub@arinc.com	410-266-2380
Class 2		Ascent Technology Inc	Alan	Hartstone	alanh@ascent.com	617-395-4815
Class 2		ATAC Corporation	Charles	Winkelman	cew@atac.com	408-736-2822
Class 2		Austin Digital, Inc	Ben	Prager	bap@ausdig.com	512-452-8178
Class 2		BrueI & Kjaer (formerly Lochard)	Robert	Brodecky	robert.brodecky@lochard.com	866-240-8307
Class 2		BrueI & Kjaer	Robert	Brodecky	robert.brodecky@lochard.com	866-240-8307
Class 2		Business Aviation Technology	Greg	Johnson	greg@onesky.com	877-293-4019
Class 2		Camp Systems International, Inc.	Steve E	Attard	sattard@campsystems.com	631-588-3200
Class 2		Conductive Technology Corporation	Jeff	Kennedy	jeffk@conducivetech.com	503-445-4236
Class 2		Conductive Technology Corporation	Shuchi	Agrawal		972-973-5801
Class 2		Conductive Technology Corporation	Michael	Crozier	crozierm@conducivetech.com	503-445-4233
Class 2		FlightAware	Daniel	Baker	dbaker@flightaware.com	800-713-8570
Class 2		FlightAware	Daniel	Baker	dbaker@flightaware.com	800-713-8570
Class 2		Honeywell Global Data Center	James	Harvey	james.harvey@honeywell.com	425-885-8974
Class 2		Honeywell Global Data Center	George	Risinger	george.risinger@honeywell.com	425-885-8629
Class 2		Honeywell Technology Solutions Inc.	Alan	Morgan	alan.morgan@honeywell.com	979-693-2683
Class 2		Honeywell Technology Solutions Inc.	David	Dougherty	daviddougherty2@honeywell.com	303-682-9140
Class 2		Lennox Development B.V.	Bert	van den Brinkvanden	brink@lennox.com	310-575-468720

Jason McIntosh • @JmacDotOrg

Class 1 versus Class 2 designation, which would come in handy later. Finally I found



**ASDI Contact Information**

**FAA contact information:**

Contact the FAA ASDI Program Office at [asdi-program-office@faa.gov](mailto:asdi-program-office@faa.gov)

**FAA TEMS Operations Help Desk contact information:**

To report a data outage with your operational ASDI connection, 24x7 call TEMS Operations Help Desk: (609) 485-9601. The Operations Help Desk staff can verify normal server functioning. Please follow-up ALL calls with an email describing the problem to: [9-ACT-ASDI@faa.gov](mailto:9-ACT-ASDI@faa.gov)

To report all other questions and issues other than loss of service, (for example; data questions), send an email to [9-ACT-ASDI@faa.gov](mailto:9-ACT-ASDI@faa.gov).

Jason McIntosh • @JmacDotOrg

this PDF, sitting in a directory containing no index files, and on an FAA website



Jason McIntosh • @JmacDotOrg

otherwise dedicated to flight delays. That search engines had indexed it bespoke a dignified past for the document,

**ASDI Contact Information**

**FAA contact information:**

Contact the FAA ASDI Program Office at [asdi-program-office@faa.gov](mailto:asdi-program-office@faa.gov)

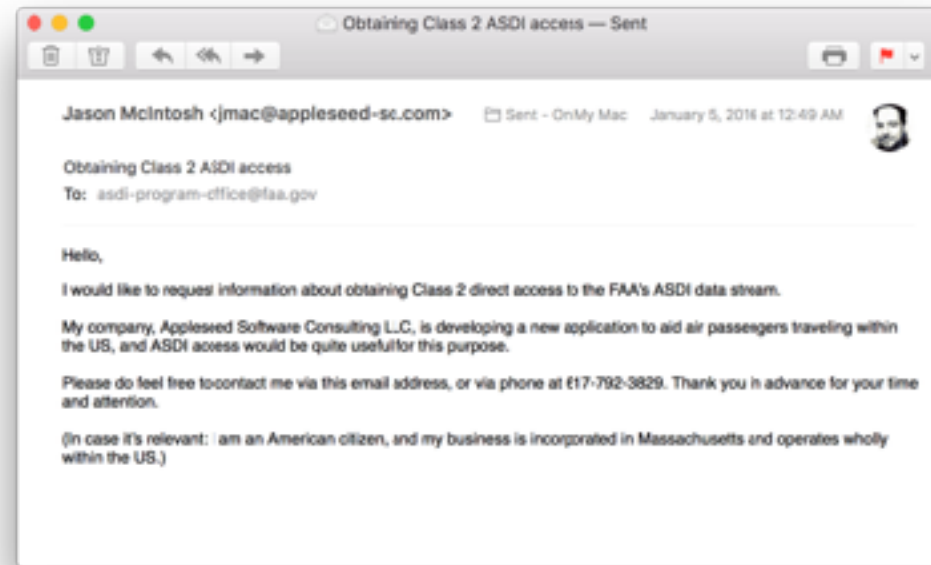
**FAA TFMS Operations Help Desk contact information:**

To report a data outage with your operational ASDI connection, 24x7 call TFMS Operations Help Desk: (609) 485-9601. The Operations Help Desk staff can verify normal server functioning. Please follow-up ALL calls with an email describing the problem to: [9-ACT-ASDI@faa.gov](mailto:9-ACT-ASDI@faa.gov)

To report all other questions and issues other than loss of service, (for example; data questions), send an email to [9-ACT-ASDI@faa.gov](mailto:9-ACT-ASDI@faa.gov).

Jason McIntosh • @JmacDotOrg

and I could only assume its continued existence an organizational oversight. I didn't let that stop me. I had learned my lesson earlier. I wrote the email address printed on it. Like a tourist speaking from a phrasebook, I pieced together vocabulary I had encountered but not necessarily fully understood, and I said



Jason McIntosh • @JmacDotOrg

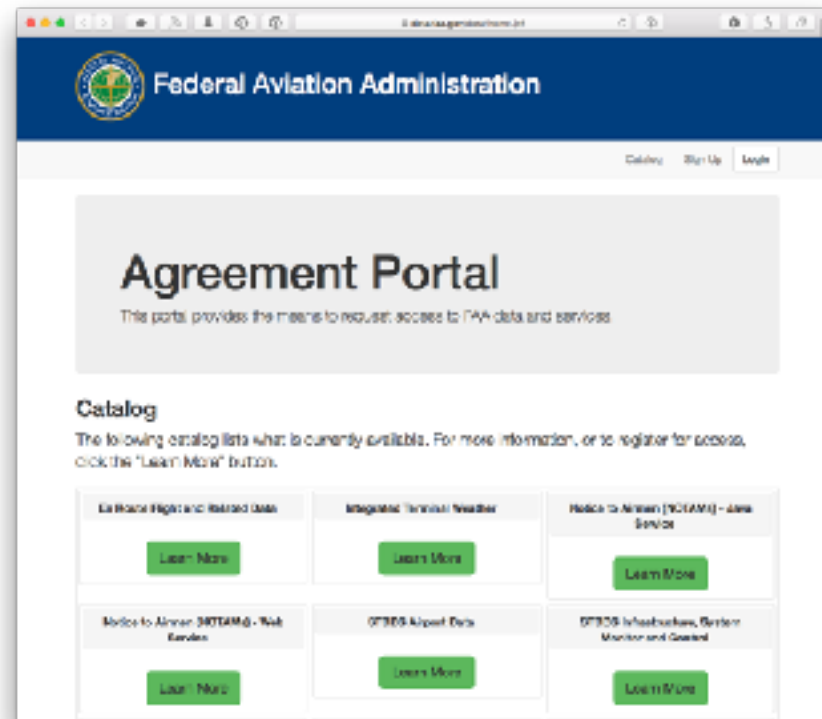
"Hello, I would like to request information about obtaining Class 2 direct access to the FAA's ASDI data stream." A week later I got a response. And it said: ASDI! We've retired that. Have you checked

**`https://data.faa.gov`**

Jason McIntosh • @JmacDotOrg

data.faa.gov? You know, the website we have that is

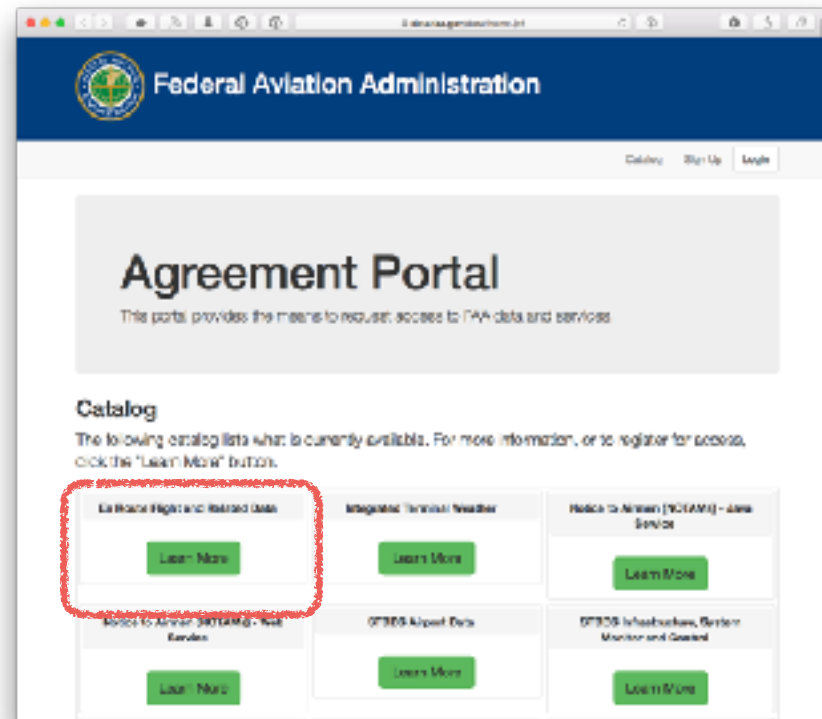
**https://data.faa.gov**



Jason McIntosh • @JmacDotOrg

covered in giant green buttons, the very first one of which is labeled

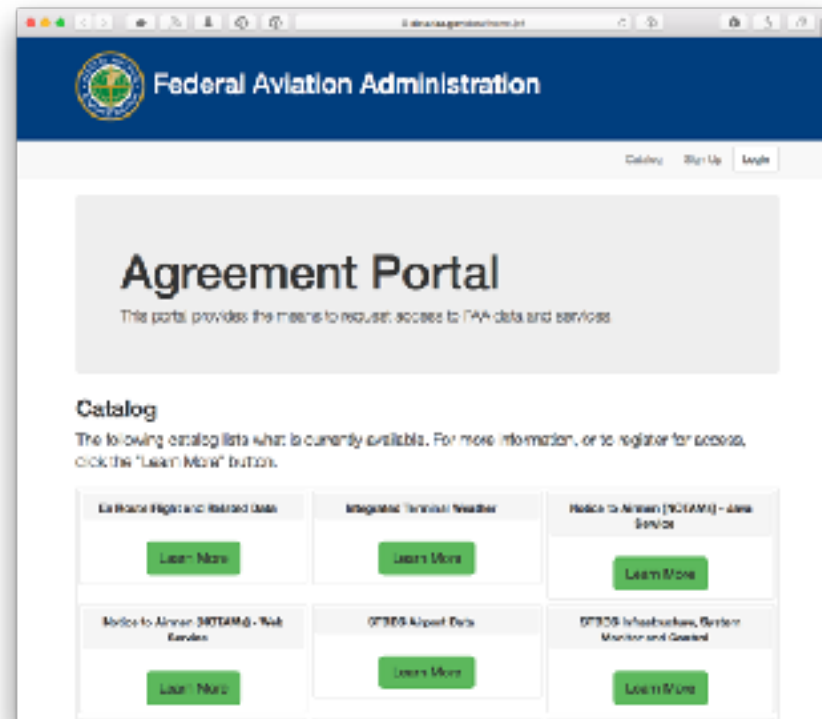
**https://data.faa.gov**



Jason McIntosh • @JmacDotOrg

En Route Flight and Related Data? And I said: How is your robots.txt file...

**https://data.faa.gov**



Jason McIntosh • @JmacDotOrg

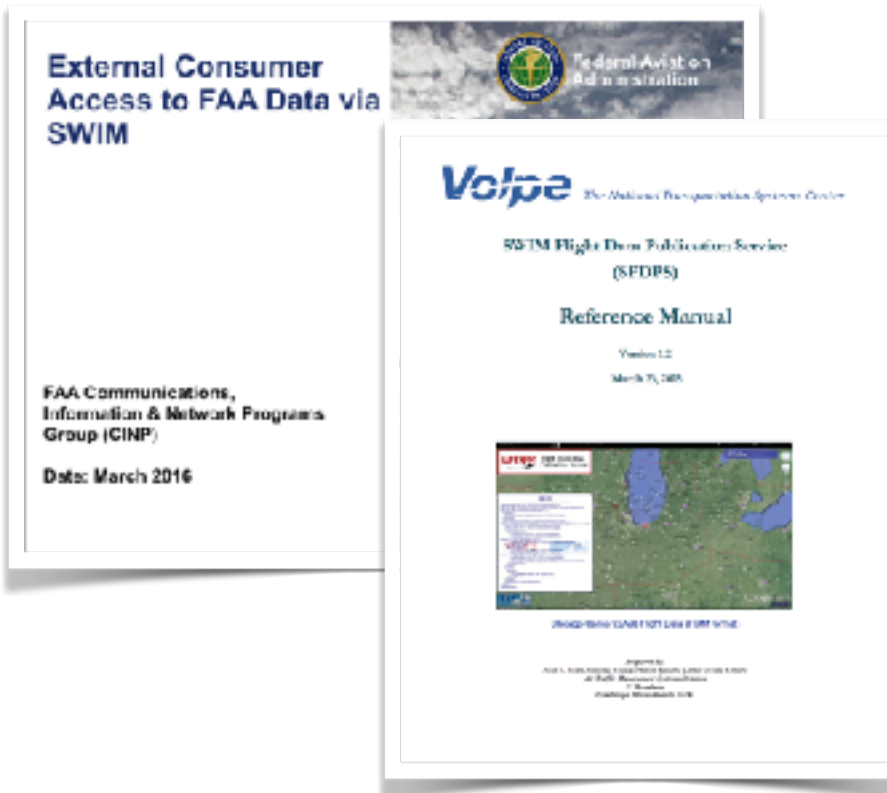
You know what... never mind. \*Thank you.\* And friends, I hit that button.





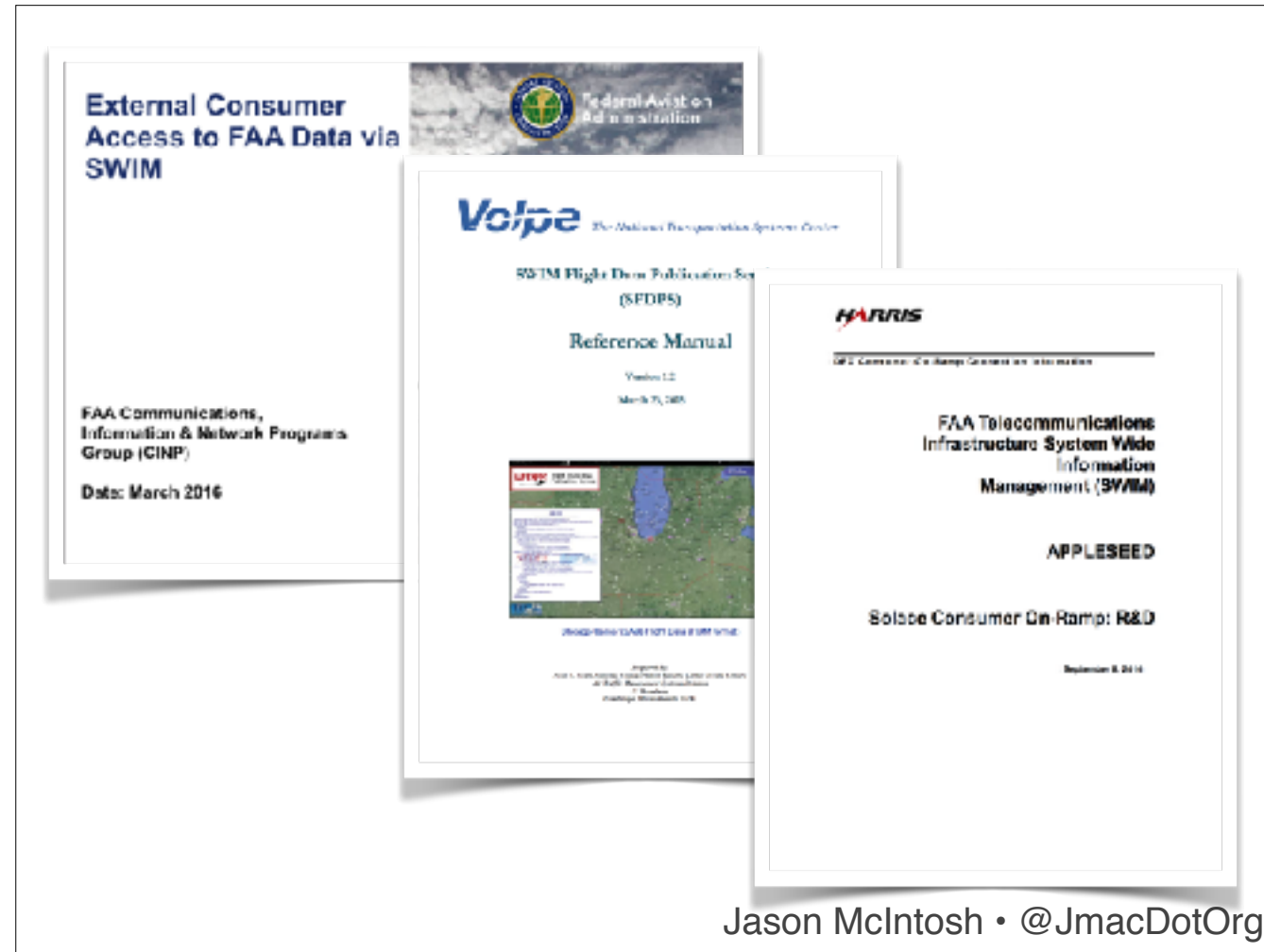
Jason McIntosh • @JmacDotOrg

At this point, about three months had passed since that bank to port over Atlanta, and now I found myself set up with my own assigned contact at the FAA,



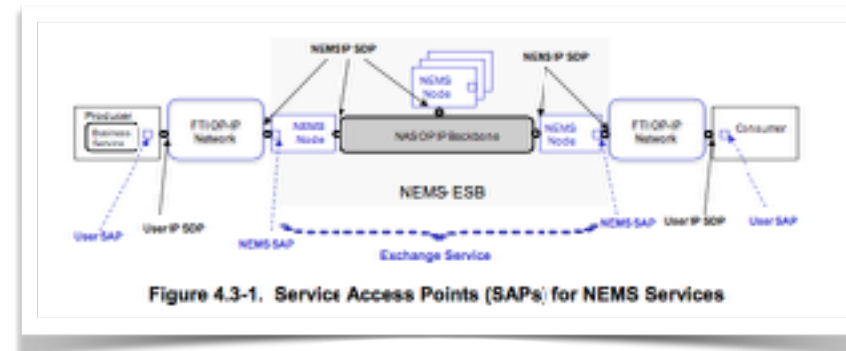
Jason McIntosh • @JmacDotOrg

as well as a passel of documents about hooking in to the administration's flight-data firehose. And here, for the first time in this project,



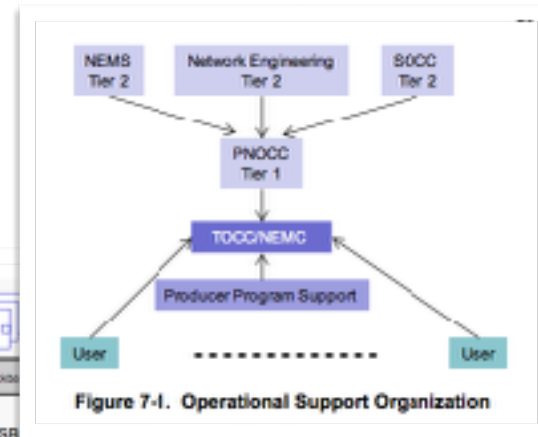
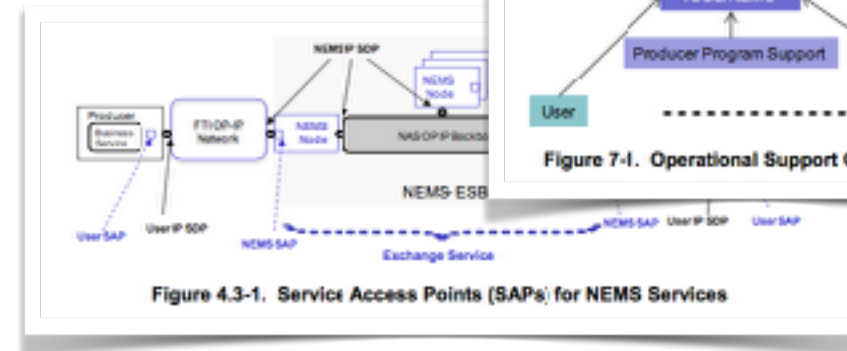
Jason McIntosh • @JmacDotOrg

I faced an obstacle I could neither code nor question my way around.



Jason McIntosh • @JmacDotOrg

The FAA requires that organizations seeking this data



Jason McIntosh • @JmacDotOrg

first establish a permanent site-to-site VPN connection

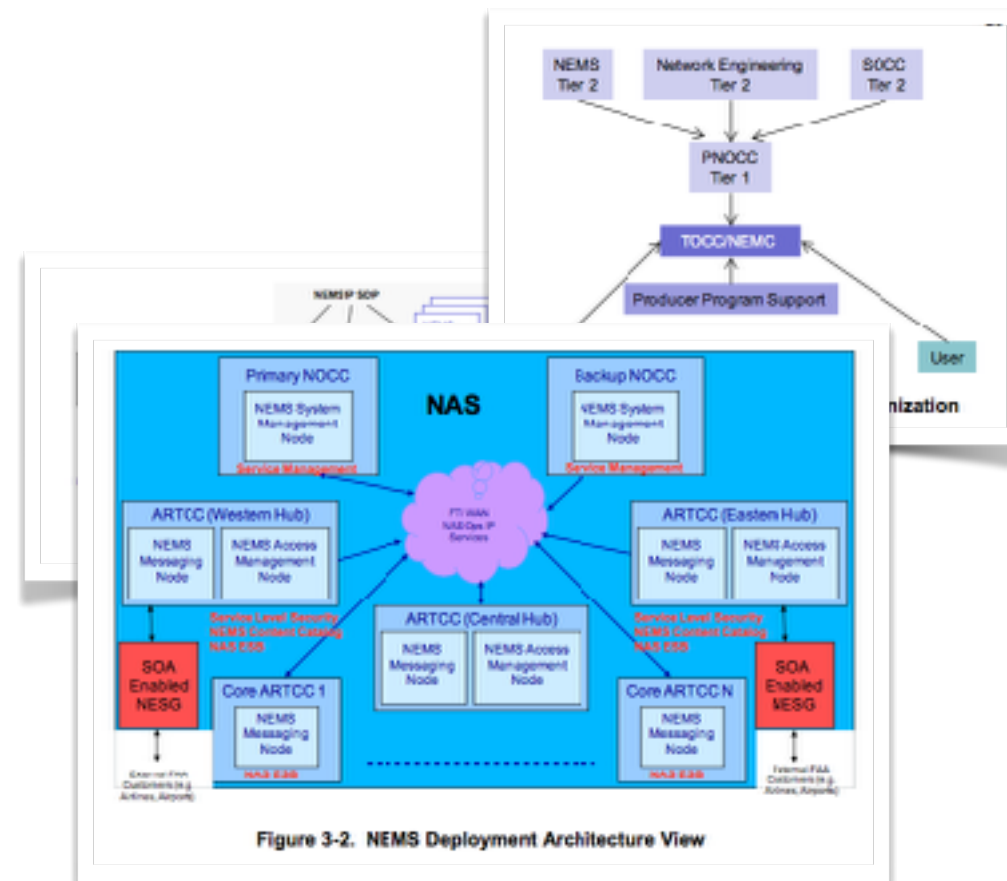
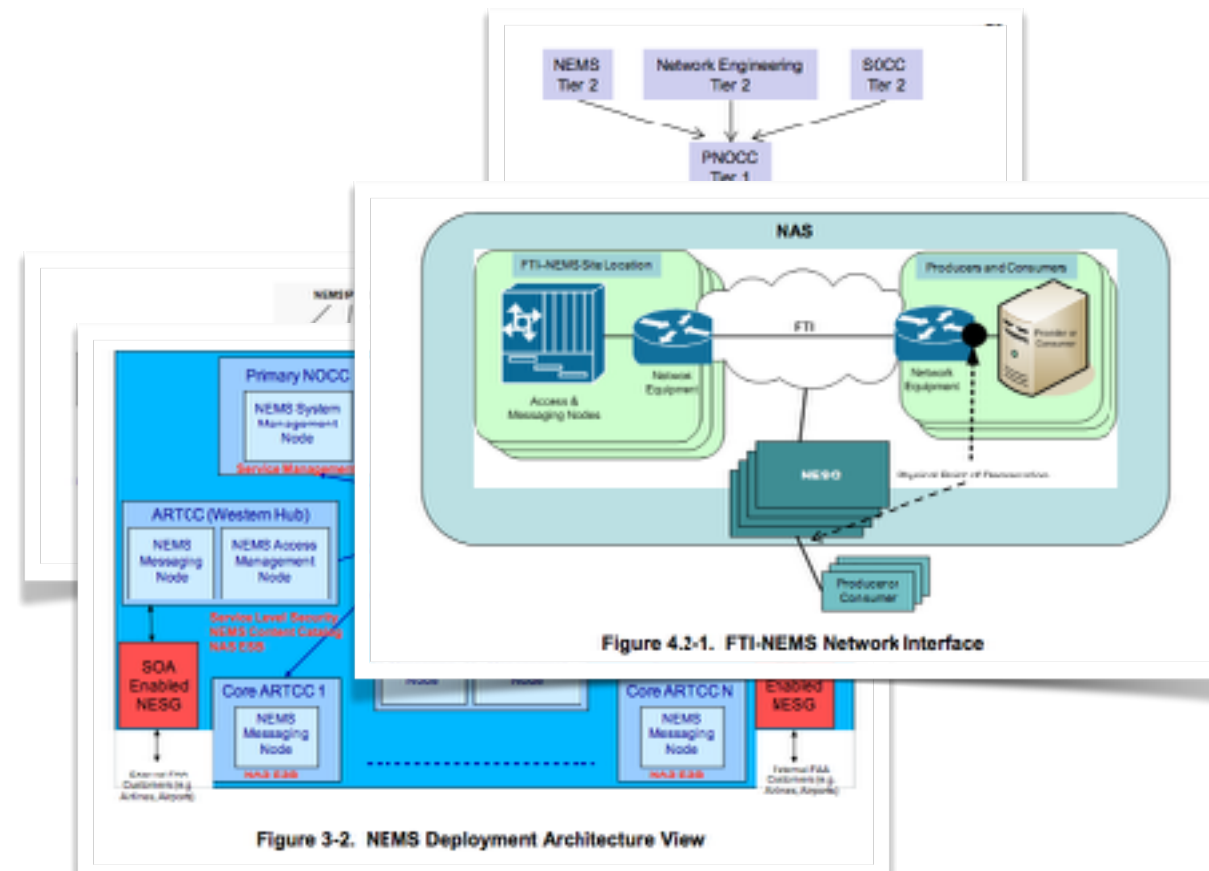


Figure 3-2. NEMS Deployment Architecture View

Jason McIntosh • @JmacDotOrg

between some machine under their control



Jason McIntosh • @JmacDotOrg

and the FAA's own internal network. Now, I barely know how the internet works,

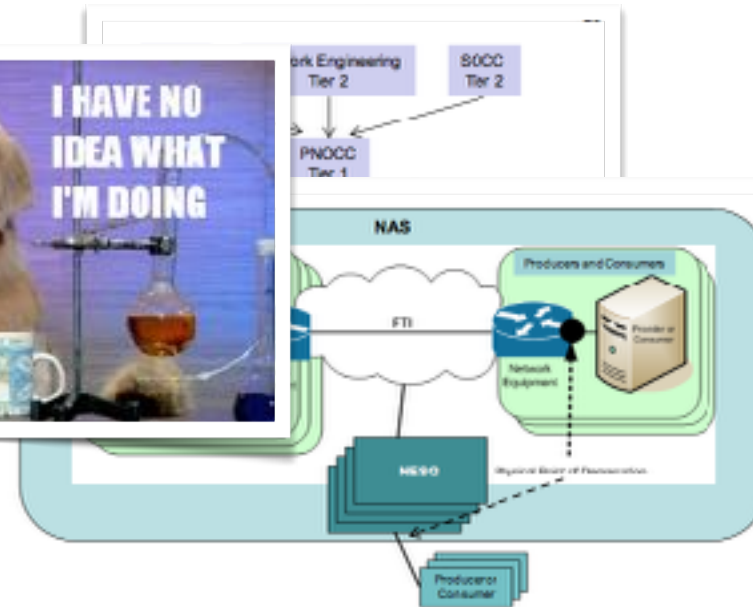


Figure 4.2-1. FTI-NEMS Network Interface

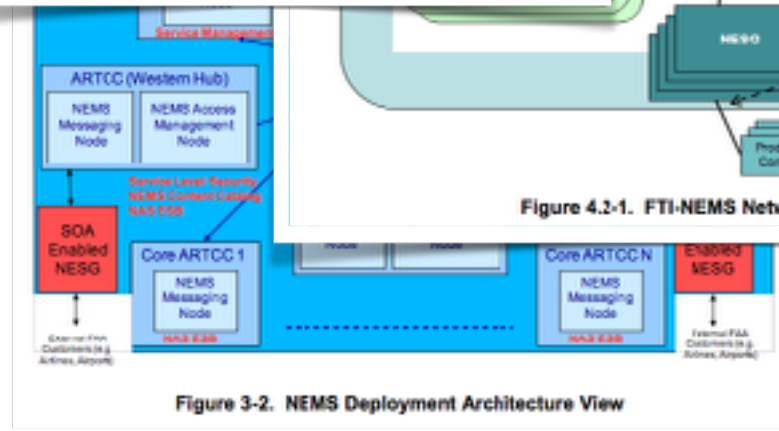


Figure 3-2. NEMS Deployment Architecture View

Jason McIntosh • @JmacDotOrg

and I didn't know anything at all about VPNs. in my experience heretofore, VPNs are only a vaguely annoying hurdle that certain of my business clients insist I leap over before





Jason McIntosh • @JmacDotOrg

I could SSH in and see why Apache had crashed this time.

Jason McIntosh • @JmacDotOrg

Site-to-site VPN connections, I swiftly learned, are something much more intimate than this remote-client sort of relationship,



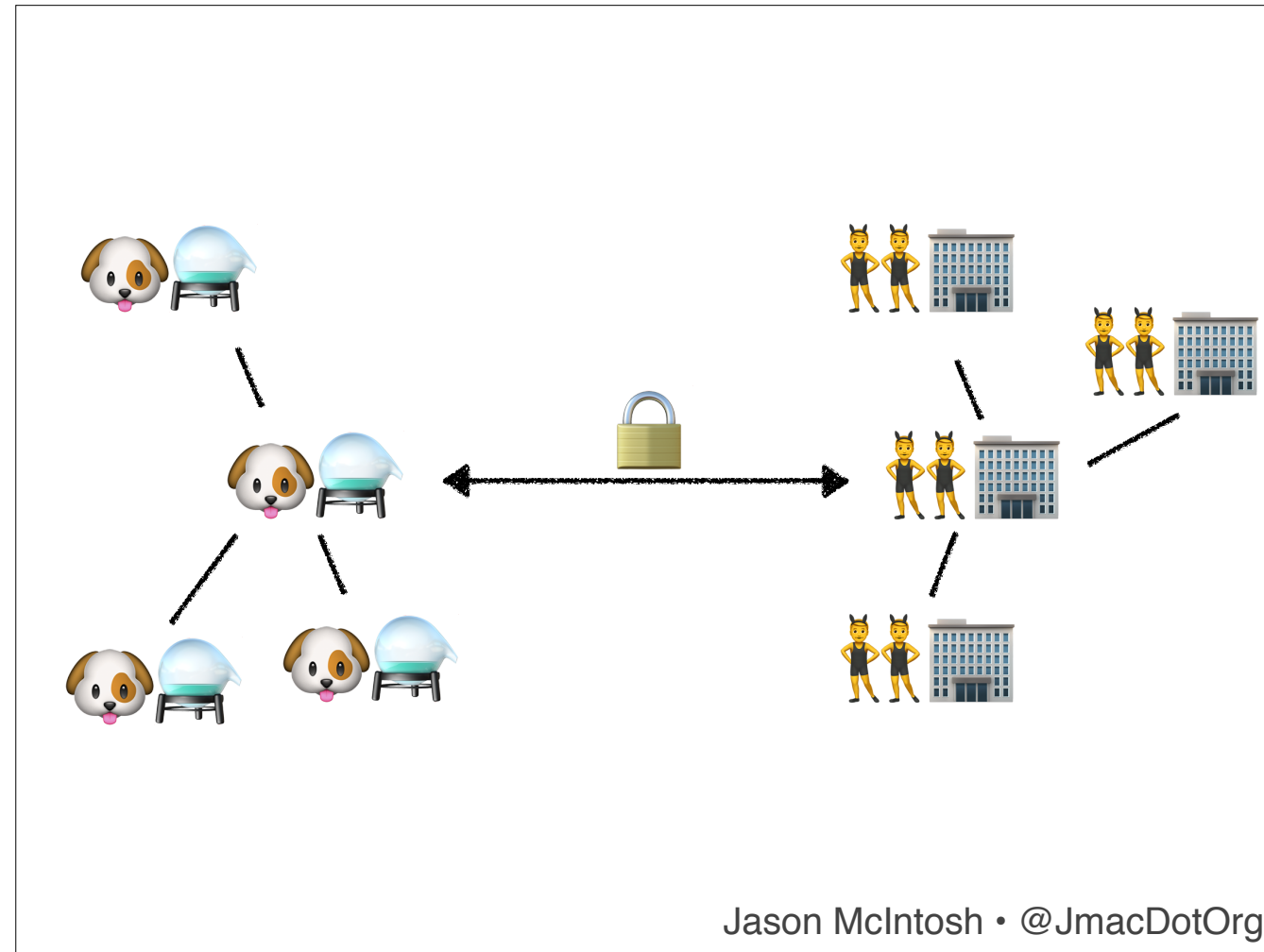
Jason McIntosh • @JmacDotOrg

establishing an encrypted tunnel between

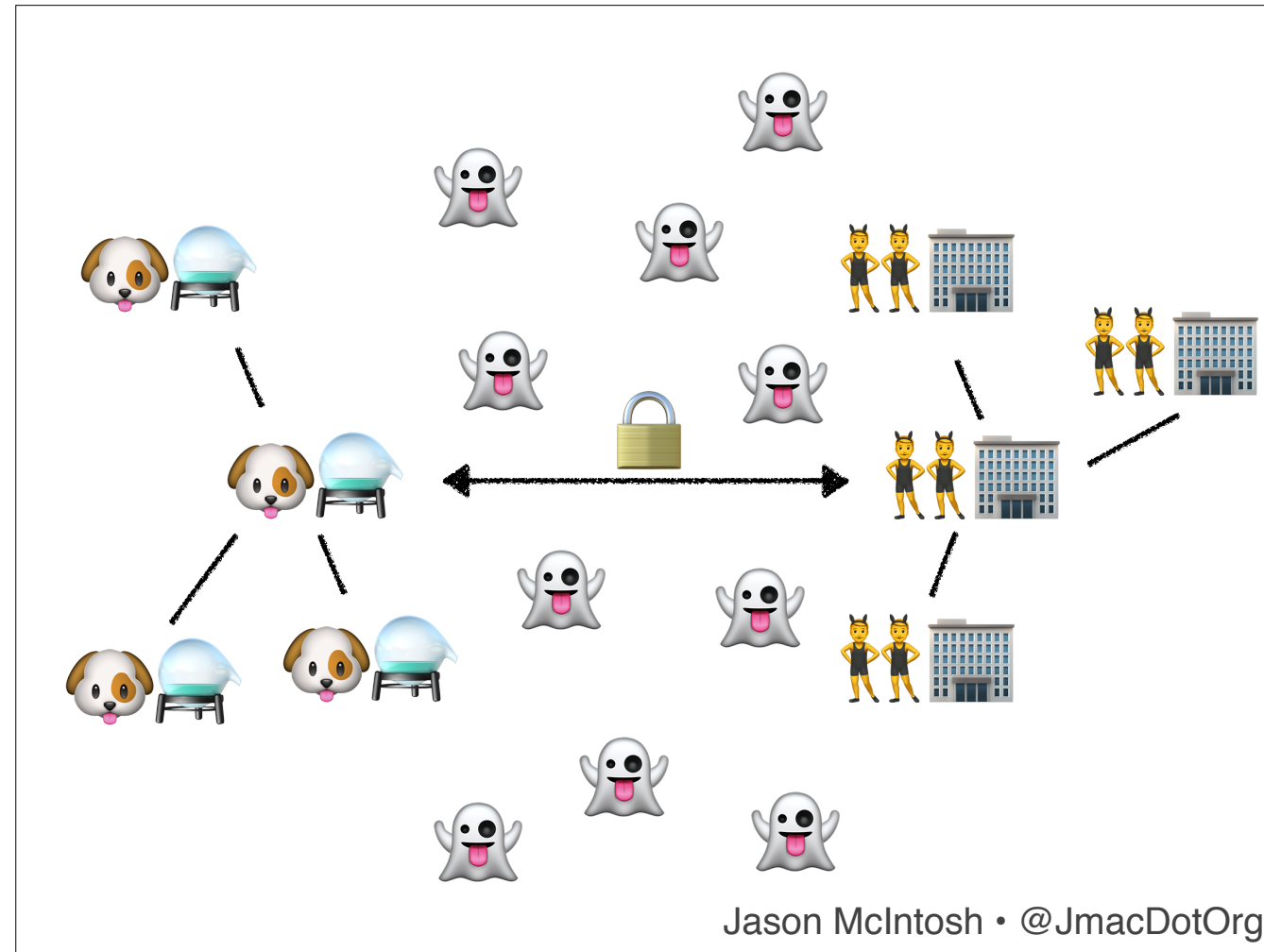


Jason McIntosh • @JmacDotOrg

two routers that see each other as peers, and typically used to securely connect a single organization's



geographically disparate subnetworks over

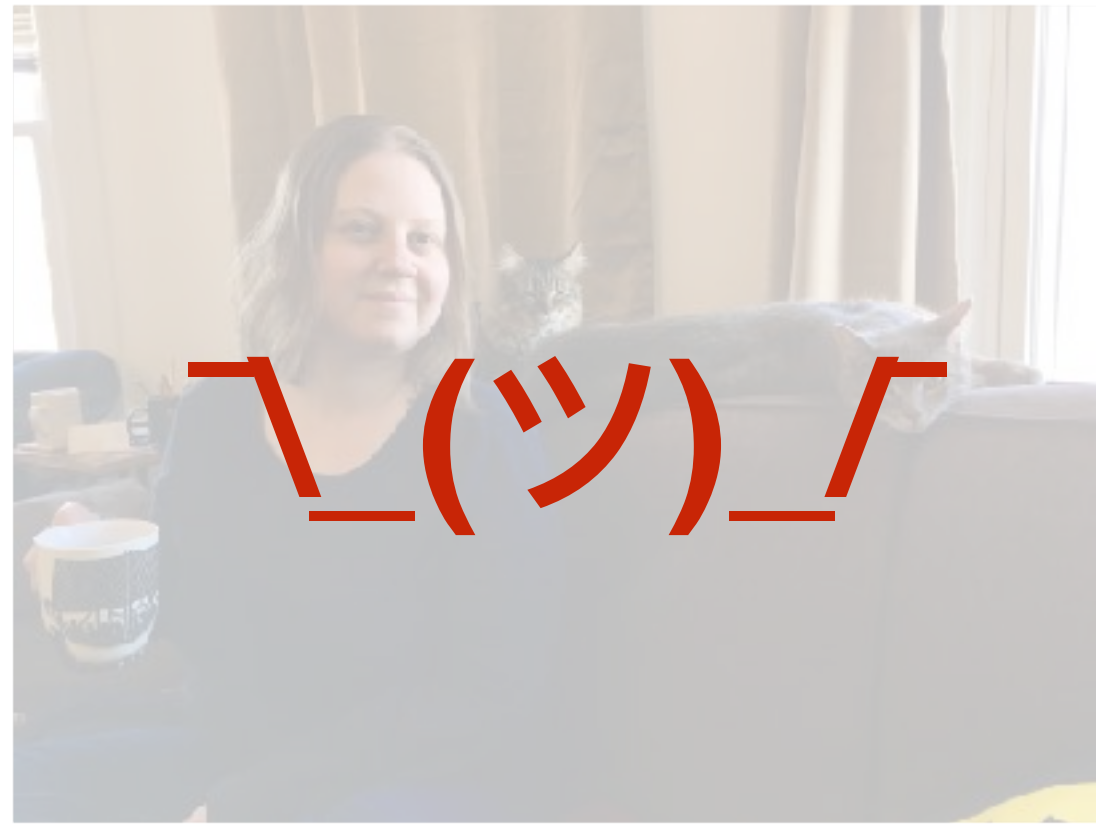


the insecure internet. So, as a prerequisite for something I saw as a public API, a site-to-site VPN struck me as a little weird. One colleague of mine, upon hearing about it, compared the requirement to inviting a dinner guest over on the condition that they come in through your bedroom window. It's just not a commonly encountered phenomenon, at least not in the open-source world,



Jason McIntosh • @JmacDotOrg

and when I used my shiny new super-power of asking for help,



Jason McIntosh • @JmacDotOrg

I got nothing. None of my colleagues knew how to implement this. I continued to get very little results when





Jason McIntosh • @JmacDotOrg

I decided to start spending some money on the problem, hiring other consultants to help. While I did have some insightful conversations, the problem still stumped every professional in my vicinity who was willing to consider the problem.



Jason McIntosh • @JmacDotOrg

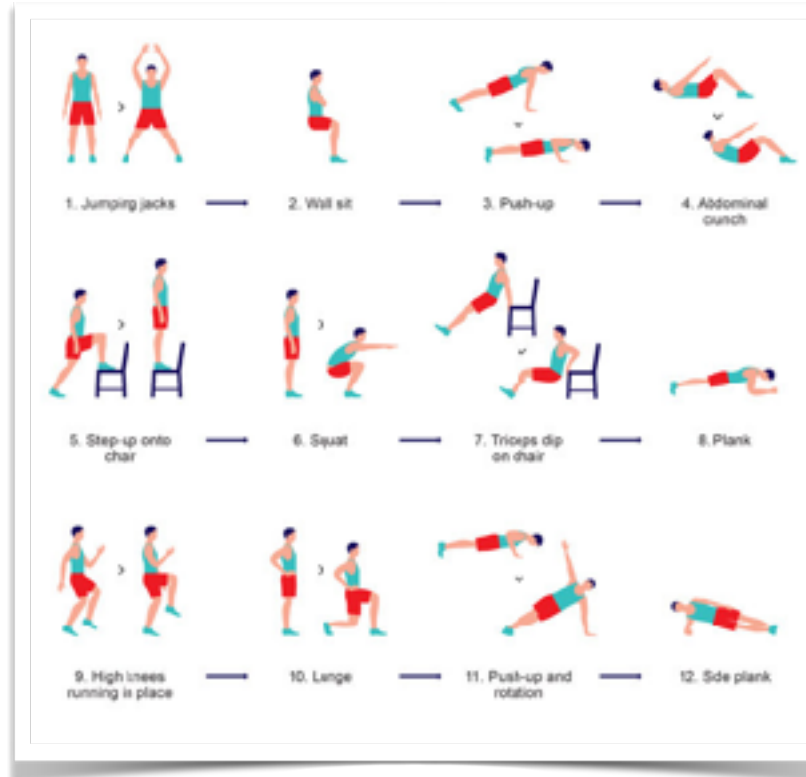
At my talk a couple of years ago about blogging, I mentioned as an aside how in recent years I've taken up regular exercise. I had a twofold reason for it.

500	
BOSTON	
(City or Town making this return)	
557	
REGISTERED NUMBER	
INTOSH	
5	DATE OF BIRTH
JANUARY 16, 1974	
MONTH (SPELL OUT) DAY YEAR	
INTOSH	
LAST	
8	AGE AT TIME OF THIS BIRTH
43	
MC INTOSH	
MARRIED	
12	AGE AT TIME OF THIS BIRTH
42	
ASSET	MASS. 02025
WN	STATE

VOID IF ALTERED OR F

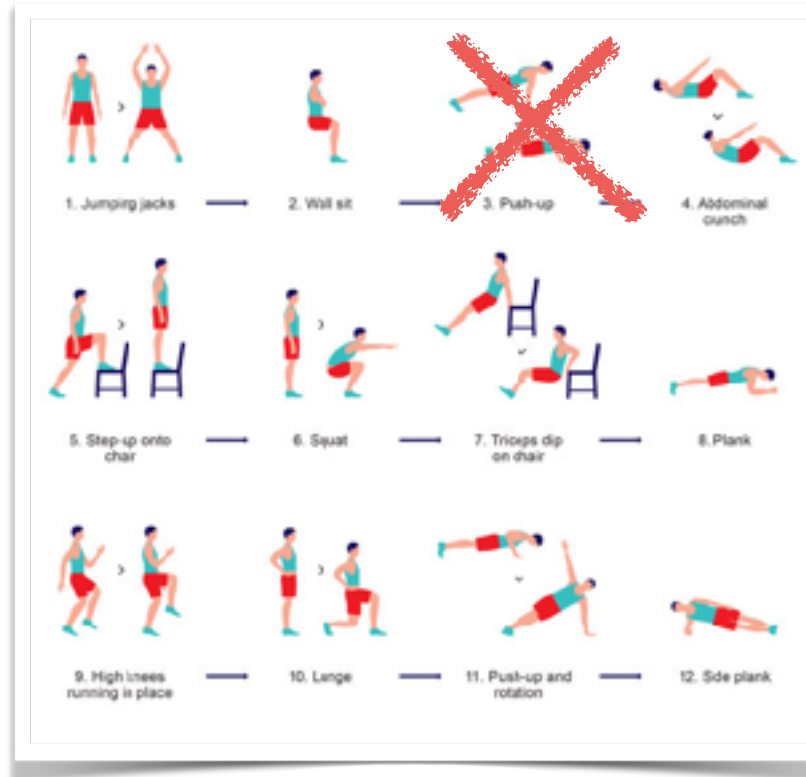
Jason McIntosh • @JmacDotOrg

On the one hand, due to both age and dicey genetics, I'd stopped receiving daily well-being for free every morning.



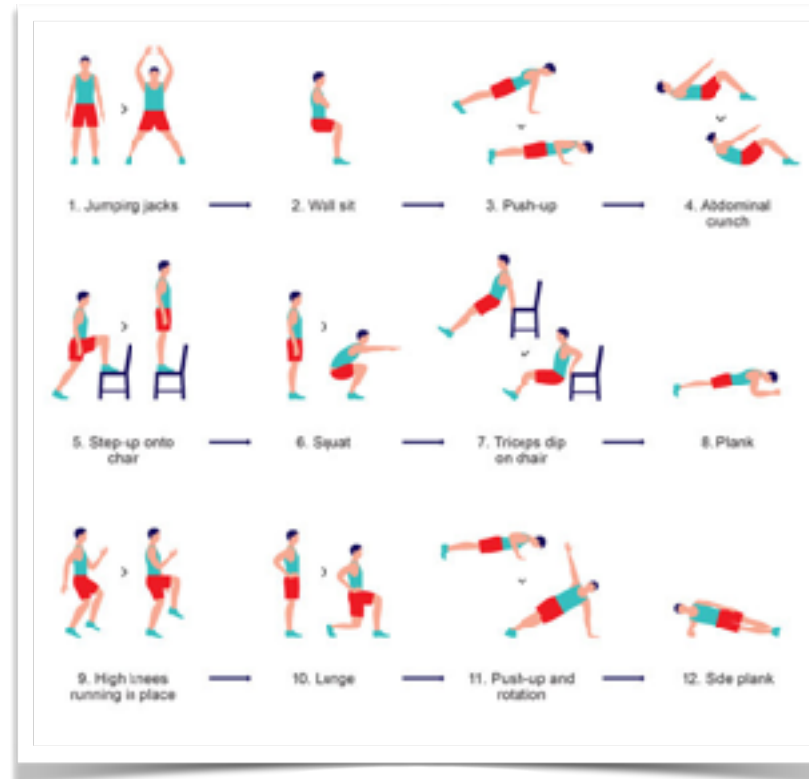
Jason McIntosh • @JmacDotOrg

More to the point though, new scientific and technological developments, like the standardized seven-minute workout and the panoply of web and mobile apps that implement it, made high-intensity workouts much more feasible for an otherwise extremely lazy and antisocial person.



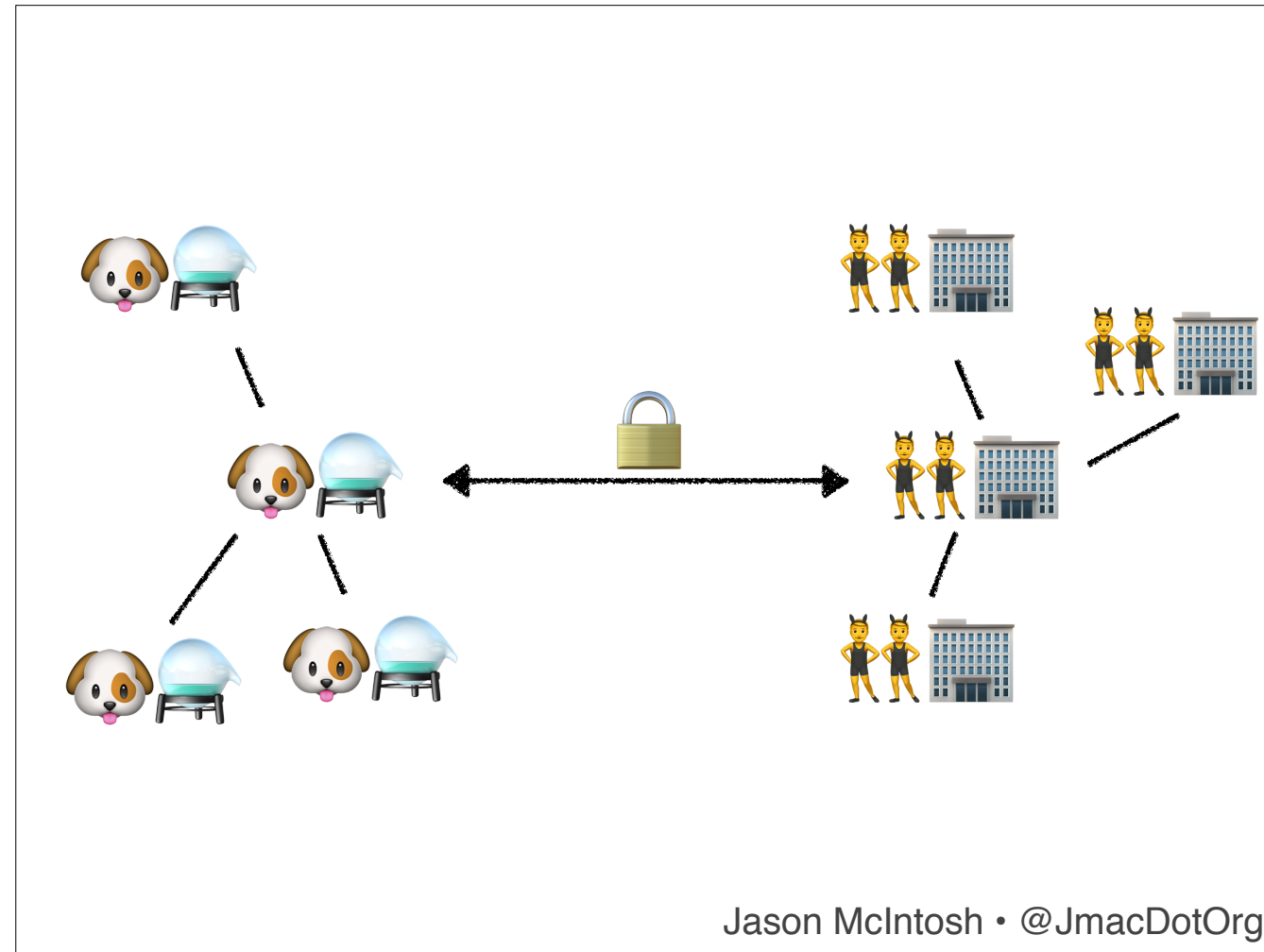
Jason McIntosh • @JmacDotOrg

My whole life up until then, I assumed that I couldn't do push-ups. That, I don't know, I just lacked the ineffable sinew for it, somehow, like how some of my friends can't eat cilantro.



Jason McIntosh • @JmacDotOrg

But as soon as I reached a sweet-spot intersection of personal motivation and technological affordance, I found that I could do push-ups just fine, decades of denial to the contrary. And even though it took until the summer of 2015 for the penny to drop, I do believe that that experience helped me to question how accurate it was that



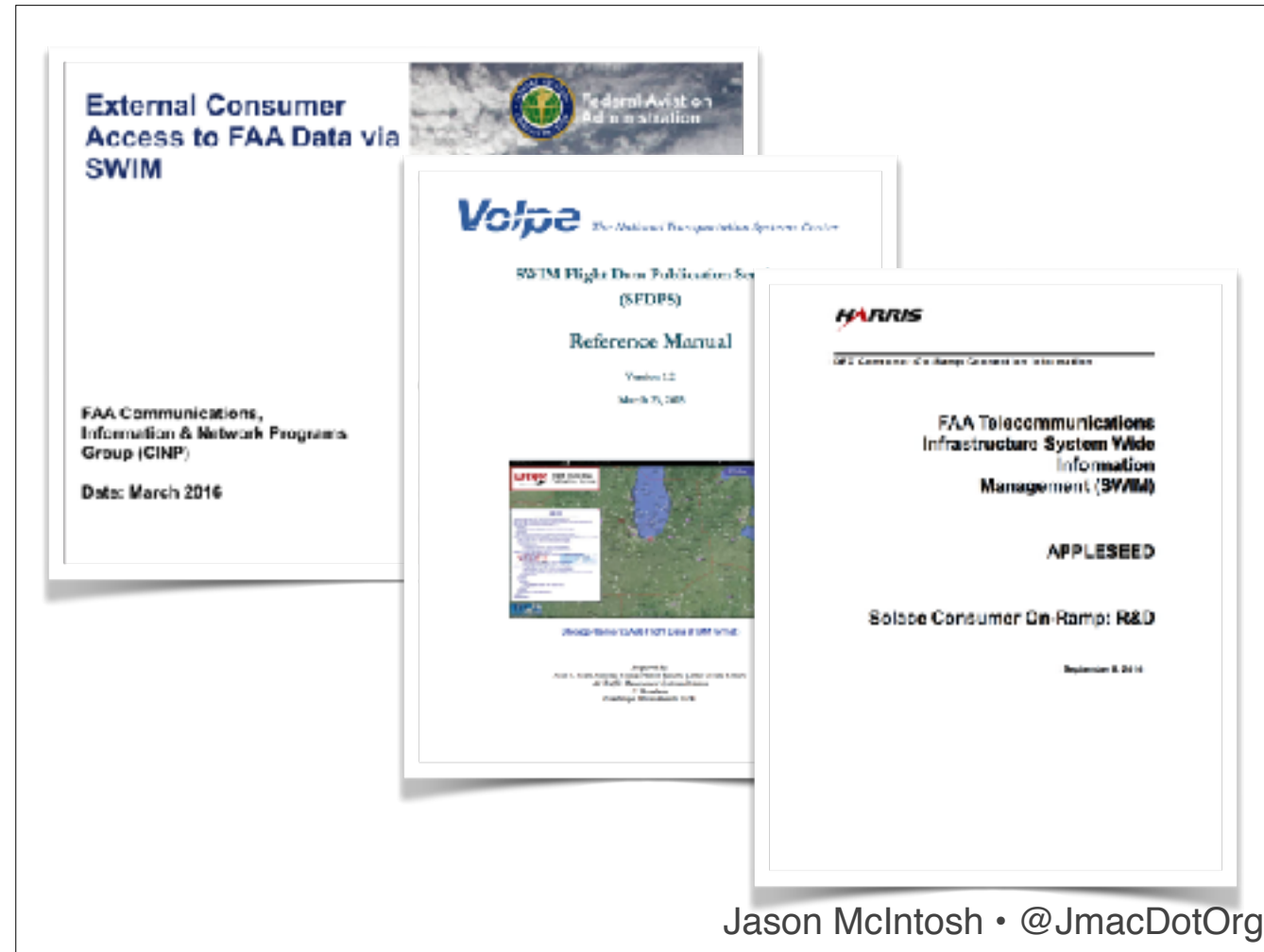
I just couldn't "do" network engineering. What if -- here was a crazy thought -- what if I took just a little that money I tried to spend on consulting, as good an idea as that was at the time -- blocked out two weeks, and taught myself how to do this? Well, I'll tell you right now,



Jason McIntosh • @JmacDotOrg

I still barely have any idea what a VPN is, but I can also tell you that this didn't stop me.





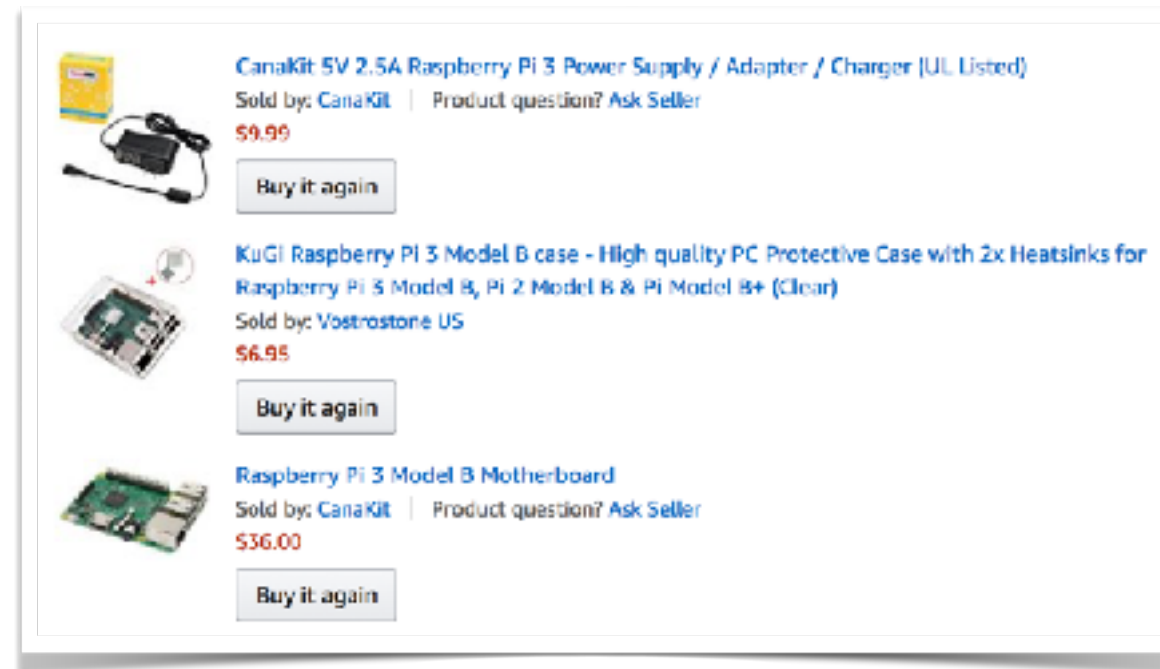
Jason McIntosh • @JmacDotOrg

In all their documentation, the FAA assumed that you-the-outsider would use dedicated, aye, Cisco-branded hardware as your end of the site-to-site VPN tunnel. Fine. So be it!



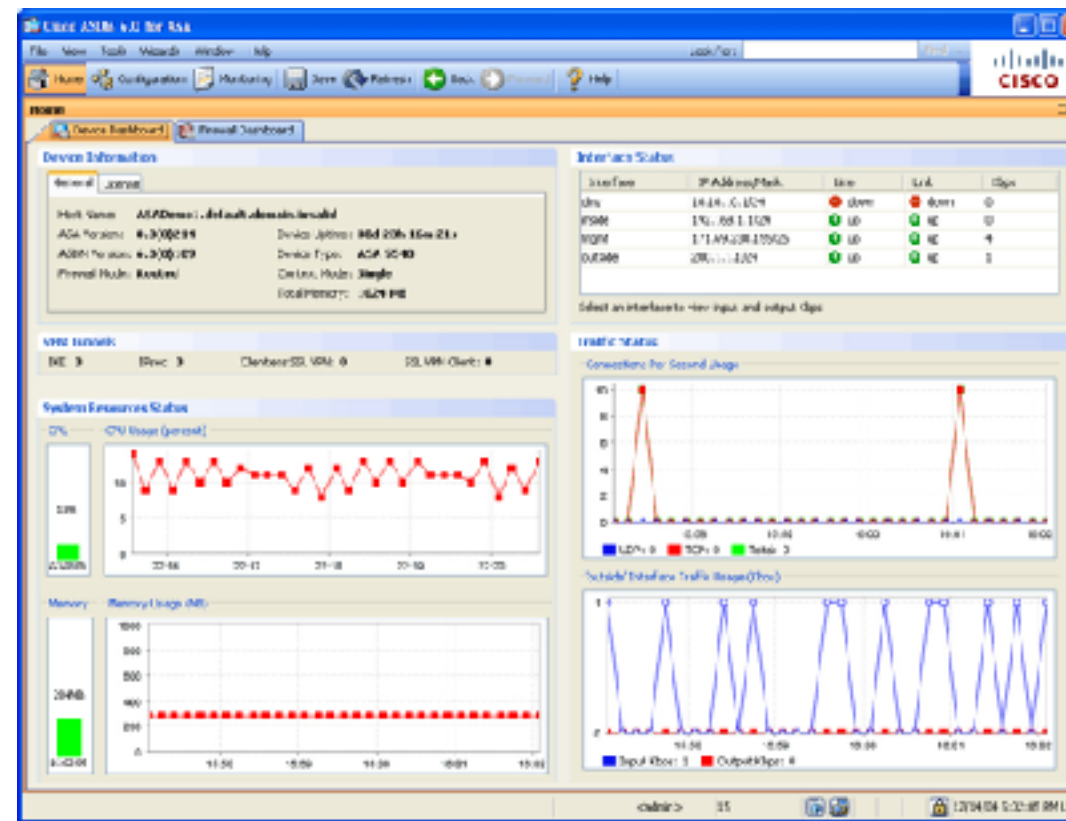
Jason McIntosh • @JmacDotOrg

After some time banging around on Amazon, I bought Cisco's cheapest network appliance that had "site-to-site VPN" written on the box,



Jason McIntosh • @JmacDotOrg

and I bought a raspberry Pi to use as a development server to which I had physical access. and I bought a static IP address for my little office,



Jason McIntosh • @JmacDotOrg

And using the box's Java-GUI wizard which causes my laptop's fans to switch to jet-turbine mode, I got, after two weeks, that Raspberry Pi to talk to the FAA. And after two more weeks, I managed to translate the state of that Cisco box into

```

jmac— mic@eddy: ~ — ssh eddy — 80x50
File Edit Options Buffer Tools Conf Help
ipsec.conf — strongSwan IPsec configuration file

# basic configuration

config setup
    # strictipsetting=yes
    # uniqueids = no

# Add connections here.

conn %default:
    #
    ikelifetime=10m
    #
    keylifetime=1440m
    #
    keylifetime=20m
    keylifetime=60m
    rekeymargin=3m
    keyingtries=%forever
    keyexchange=ikev1
    authby=secret

# left = se, eddy, the linode
# right = bellerus's ASA
conn bellerus-asa-ikev1
    left=48.33.04.44
    leftid=48.33.04.44
    leftsubnet=192.168.229.0/11
    right=99.133.36.39
    rightid=99.133.36.39
    rightsubnet=192.168.1.5/32
    auto=add
    ikem=esp156-sha1-molp136 # Diffie-Hellman Group 1
    esp=esp156-sha1-molp124 # Diffie-Hellman Group 2
    keyexchange=ikev1
    rightauthcert=ikev1
    dedaction=restart
    closeaction=restart
    keyingtries=%forever

conn fas=fas
    also=fas-base
    rightsubnet=155.178.172.194/26
    rightid=155.178.172.1
    rightid=155.178.172.1

conn fas=fas
    also=fas-base
    rightsubnet=155.178.68.32/17
    rightid=155.178.68.32/17

#Mikrotik: ipsec.conf  Type: 1.1  [conf:ikev1] -----
Makefile: file is write protected

```

Jason McIntosh • @JmacDotOrg

a nice, clean Strongswan configuration file running on one of my beautiful, silent, invisible Linodes, which is all I really wanted eight months prior. Both the Pi and the router sit unplugged in places of honor on my office shelf today,

**SWA3350, DEN to HOU, departing 4:00 PM MDT, Jun 16**

(Forecast data last collected: 2017-06-16T19:00:00 UTC)



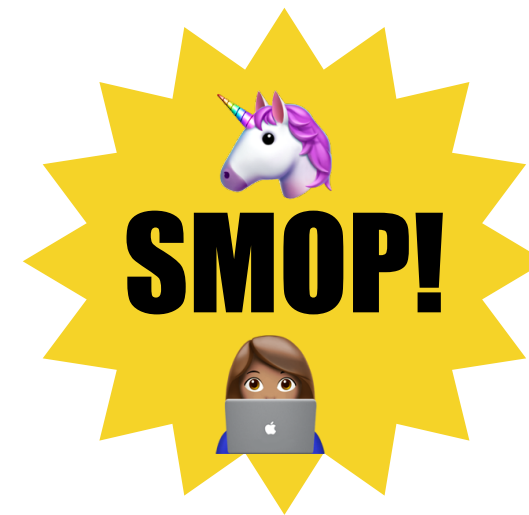
Jason McIntosh • @JmacDotOrg

And all that brings it around to where the whole project rests today. So what didn't go well? Obviously, it took too long. A one-page web application that draws lines over a map of a single country shouldn't have taken most of a year to build, and while I could further dig into reasons why, I find far more interesting the problem that I can't eat my own dogfood here.



Jason McIntosh • @JmacDotOrg

That inspiration struck while I sat literally in-flight makes for a subtly crucial point, one I was blind to during those initial months of subsequent and entirely ground-based work,

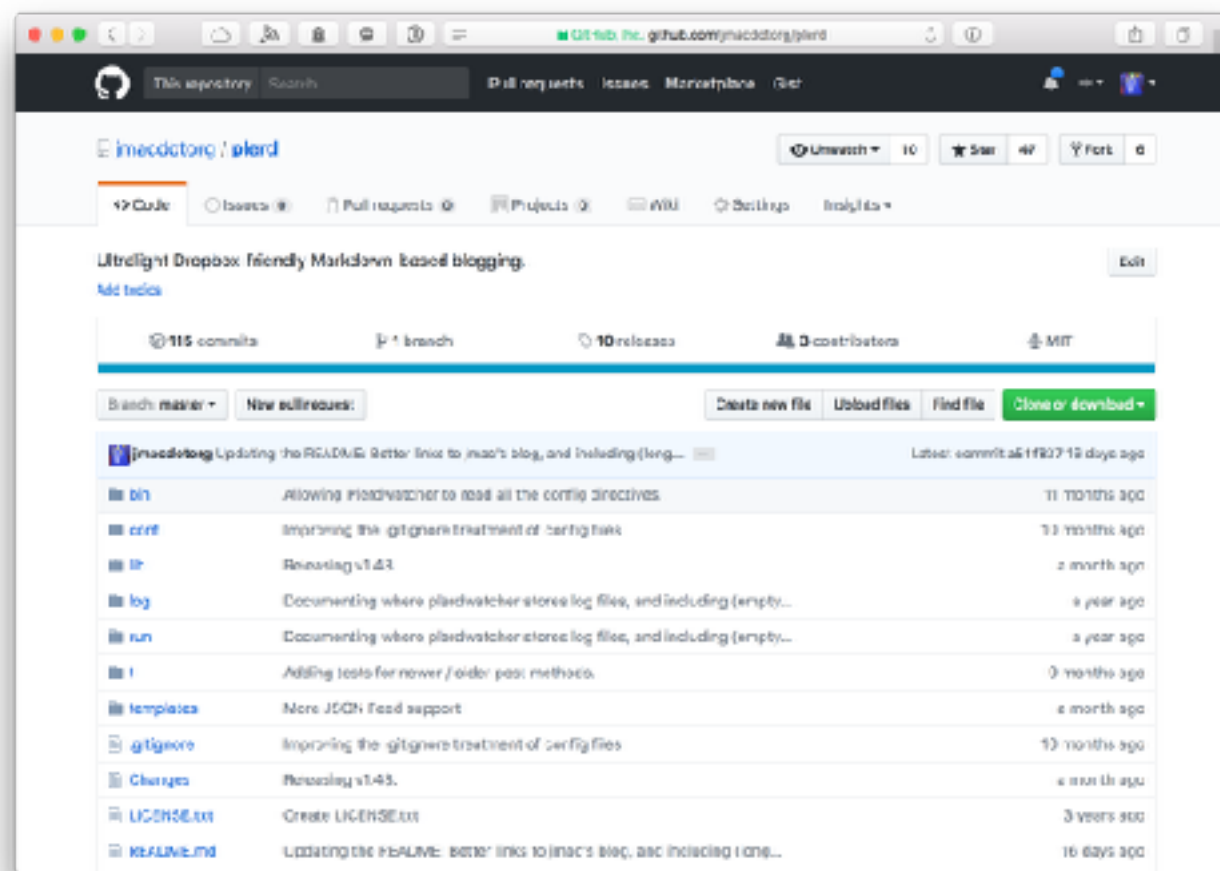


Jason McIntosh • @JmacDotOrg

when I was able to pretend that, my goals firmly established, the rest was a simple matter of programming.







Jason McIntosh • @JmacDotOrg

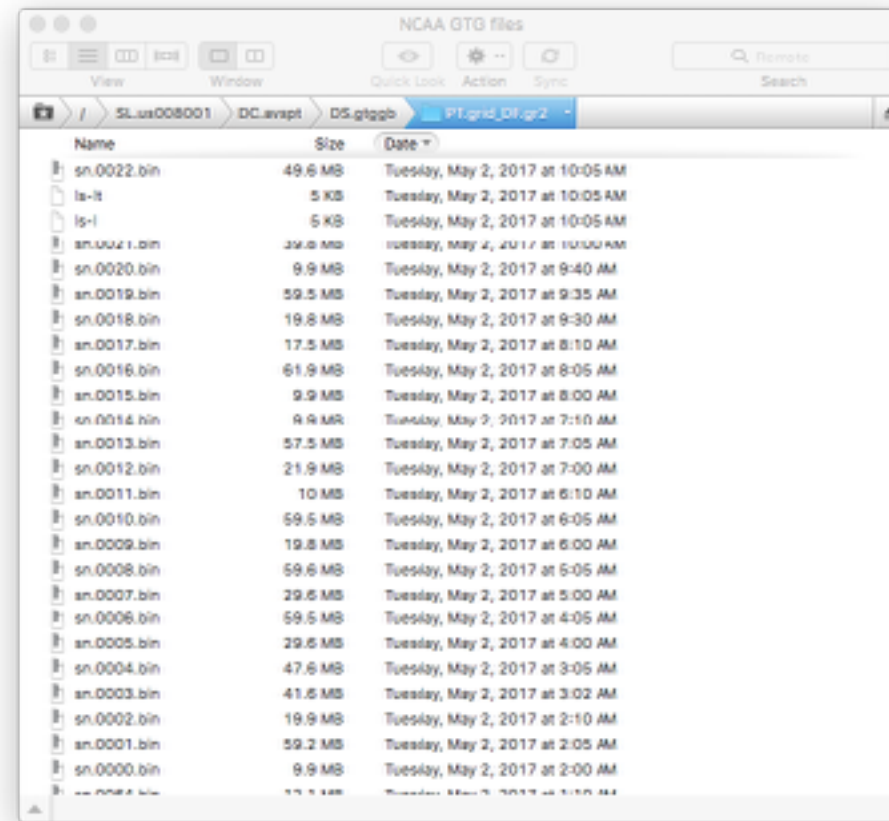
Compare this to Plerd, my blogging platform, and my most successful self-started open-source project. Colleagues and I use it several times per month, across multiple contexts, and this more than any Github star count or whatnot has driven me to make it the best tool that I can.

There's no getting around the fact that passion projects work best when their builder can also become their most fanatical user — but in BumpySkies' case, that just isn't possible, and that will always be a diminishing factor.



Jason McIntosh • @JmacDotOrg

But thirdly, and most worryingly, the project's dependencies have become more precarious through no action of my own. I have concerns now about its future viability which didn't seem worth my trouble in late 2015. In particular, those two data sources it relies on depend in turn on American tax dollars, shared through transparent, government-funded science that increasingly feels itself subject to a new kind of turbulence.



Jason McIntosh • @JmacDotOrg

Eighteen months ago I wondered if using an anonymous FTP server outside of my control would give me problems later on; today, \*click\* I wonder if assuming the continued existence of publicly funded meterological science is folly. I hope not.



But so far I don't have any reason to bail out. In retrospect I find Bumpy Skies absolutely worth the effort I've put into it so far, and with climate change all but guaranteeing that air travel will become only more turbulent, \*click\* I see this tool as itself a source of comfort in an uncertain future.



*Jason Pratt, CC-BY 2.0*

Jason McIntosh • @JmacDotOrg

And yet I'm not sure what to do with BumpySkies next. I'd like to add more features, like mapping cloud cover, for flyers like me who like to see the ground. Honestly, I'd also like it to generate income somehow, but that's truly flying far afield of my own expertise.

So I end with an appeal: if you or someone you know might like to speak with me about where this technology could go next, and for whom, please do look me up. I'm willing to travel, if I have to.





# Thank You

*Jason Pratt, CC-BY 2.0*

Jason McIntosh • @JmacDotOrg

Thank you very much.