Why Are We Still Using Tape?

--AND--

Can we do it in the Cloud?

Alan D. Hall, Operations Manager/System Owner
NOAA's Office of Satellite and Products Operations
Comprehensive Large Array Storage System (Archive)
Alan.Hall@noaa.gov

What Do I Want to Talk About?

Who am I?

Zetabyte Apocalypse

NOAA's Data Tsunami

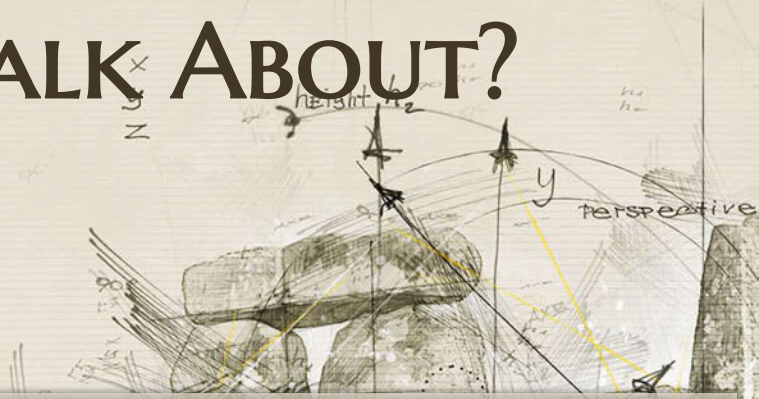
Tape Migration

The Case for Tape

Archive in the Cloud

My Estimate for Cloud

Put it all together



40+ Year IT Veteran

Wrote first program in 1976 (high school)

Distributed mini-computer systems (Data Generals)

Enterprise System Admin tools

Enterprise Ingest System

Migration of optical disks and 8mm tapes to new technology

World Meteorological Organization - Ocean Observations

Operations Manager for NOAA's Archive (CLASS)

My Storage Experience

* By Kevin586 - en.wikipedia.org: 17:32, 22. Mai 2005 . . Kevin586 (Talk) . . 976x592 (62519 Byte) (A laserdisc (left) compared with a DVD (right).), CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=9502131

Engineering Axiom

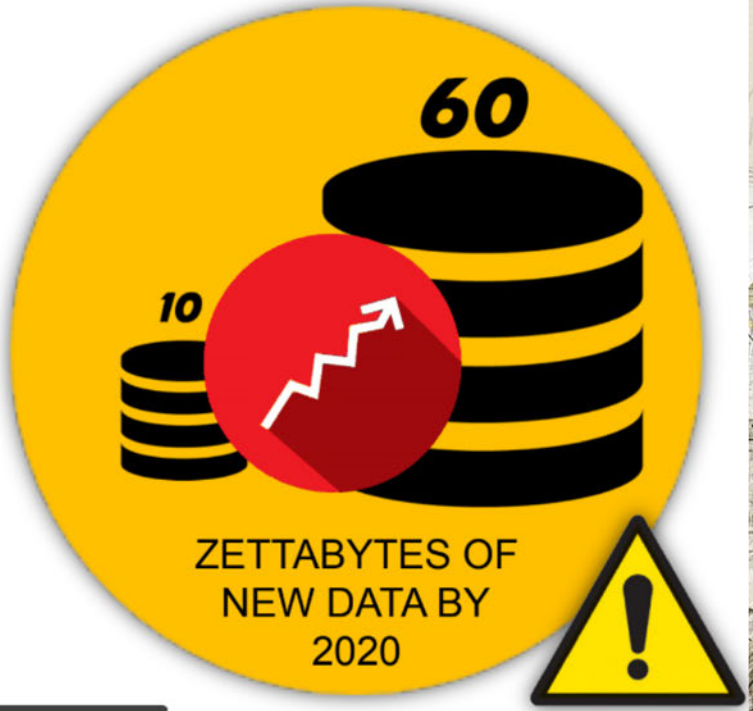
Nothing ever gets built on schedule or within budget.

Zetabyte Apocalypse

Circa 2016

- *Zettabyte Apocalypse*. In a nutshell...

=

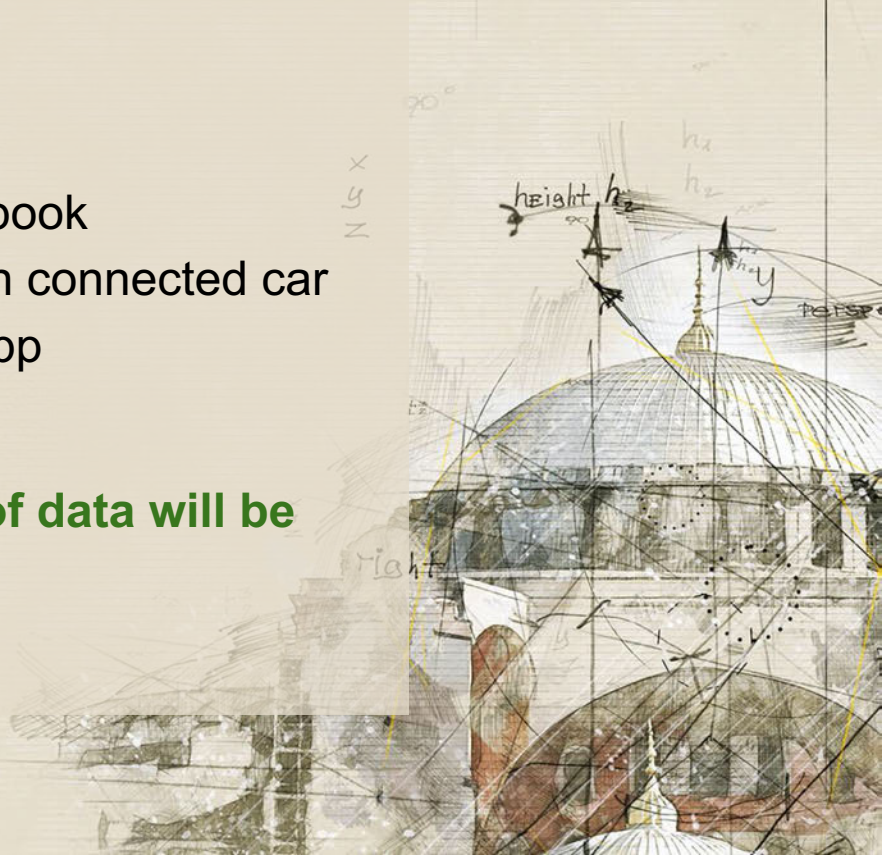


Zetabyte Apocalypse

Circa TODAY! ~170ZB Annually by 2025!

- 500 million tweets are sent
- 294 billion emails are sent
- 4 petabytes of data are created on Facebook
- 4 terabytes of data are created from each connected car
- 65 billion messages are sent on WhatsApp
- 5 billion searches are made

By 2025, it's estimated that 463 exabytes of data will be created each day globally



Source: *How Much Data is Generated Each Day?*
By Jeff Desjardins, March 13, 2019
https://www.visualcapitalist.com/how-much-data-is-generated-each-day/

Zetabyte Apocalypse

Example - Hawk-Eye Vision Processing

Hawk-Eye Electronic Line Calling - Tennis

Collects:

- Location of the ball and player
- Spin of the ball
- Speed and flight of the ball

At 300 Frames/second, Video is blended into arc-trajectories and impact ellipses

Average Rally: ~10 Seconds
Average ATP Match Duration: 2 ½ - 3 Hours

Quick Math:

4K Video
25MB/frame
300fps
7.5GB/sec
10 Cameras
750GB/sec
60 Seconds
45TB/minute

2.7PB/Hour
8.1PB/Match

NOAA's CLASS

Comprehensive Large Array Storage System

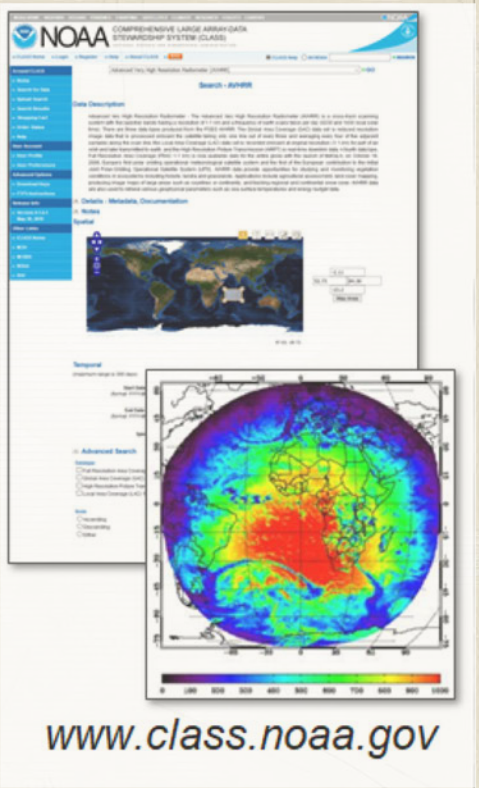
An **ARCHIVE** of environmental data and products from many sources

Users can sign-up for an account and **ORDER** by date, type, data

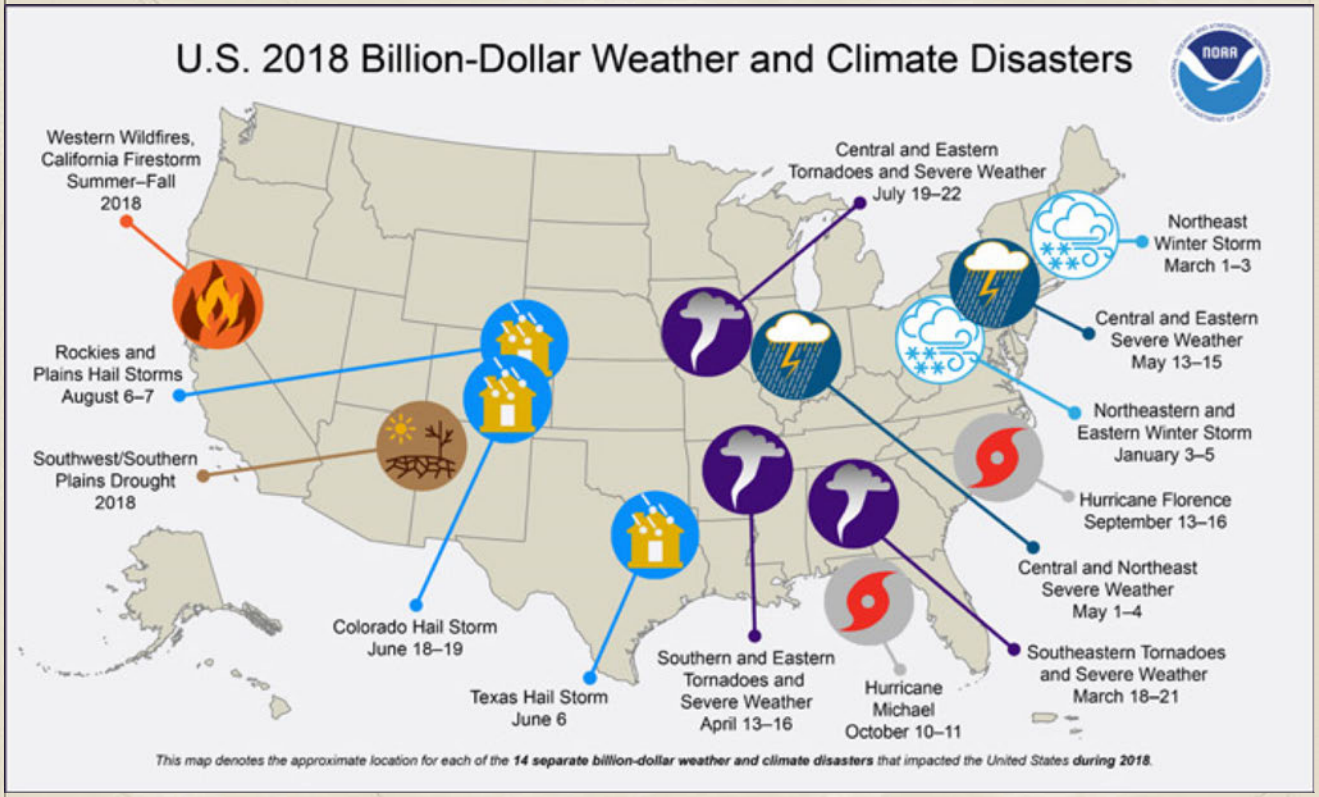
Orders are **DISEMINATED** asynchronously via HTTP and FTP

Subscriptions are available for automatic dissemination of new data

Bulk orders are available for large packages of data



NOAA's Billion $$ Problem



NOAA Needs to:

Research-to-Applications Faster

Delivery of Earth Observations Faster

-TO-

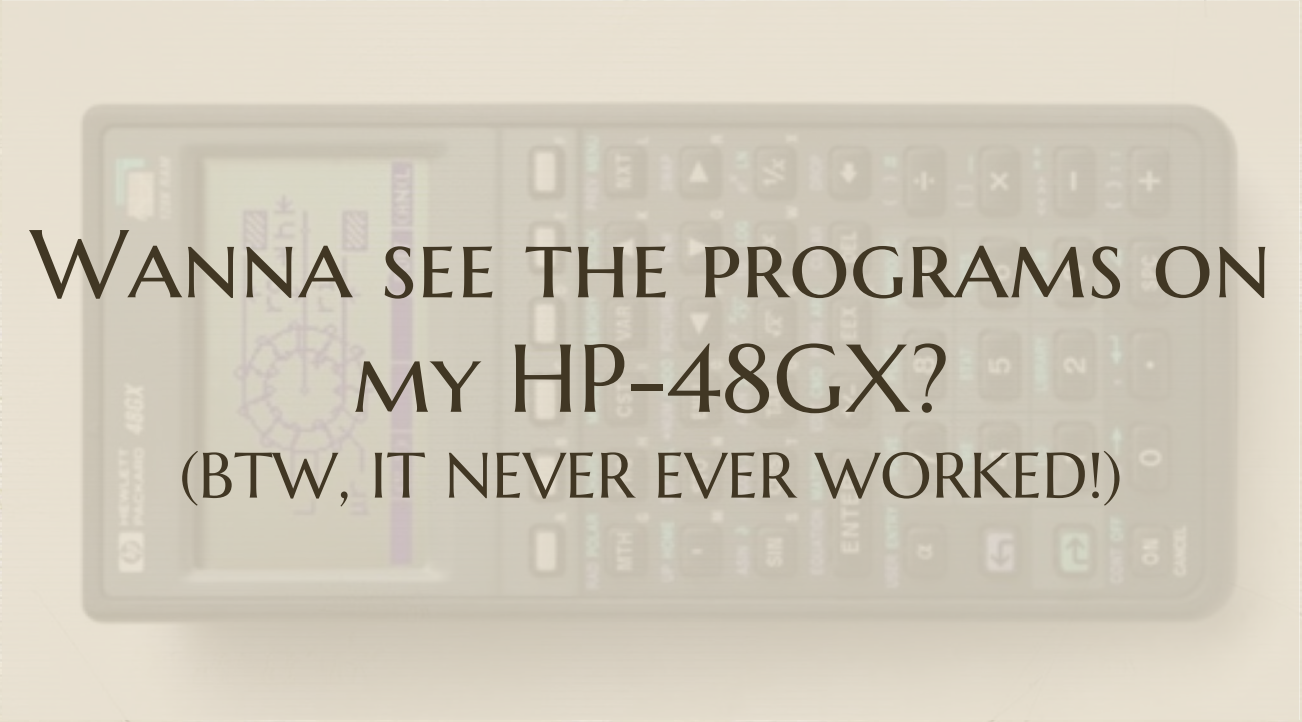
Predict Faster

Alert Faster

Protect Life and Property

The United States experienced 14 billion-dollar weather disasters in 2018, which resulted in 247 deaths and ~$91 billion in damage. (NOAA NCEI)

Engineering Pick-Up Line



Wanna see the programs on my HP-48GX?

(BTW, IT NEVER EVER WORKED!)

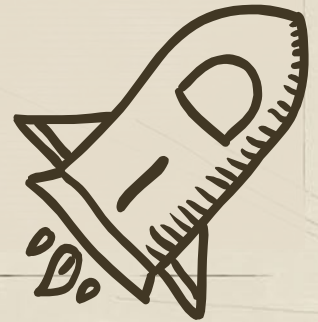
NOAA's Legacy Data

Satellites!

- ➔ ~45 satellites have been launched since the 1970's
- ➔ First Polar Orbiting Satellite launched in 1970 (POES)
- ➔ First Geostationary Satellite launched in 1975 (GOES)
- ➔ Some are still operation today

Data Generated:

MBs to a few hundred of GBs per day



NOAA's New Generation Satellites

Joint Polar Satellite System (JPSS)

➔ Suomi NPP launched 2011

➔ JPSS-1 launched in 2017

Data Generated: 3.2TB per day

Geostationary Operational Environmental Satellite (GOES-R)

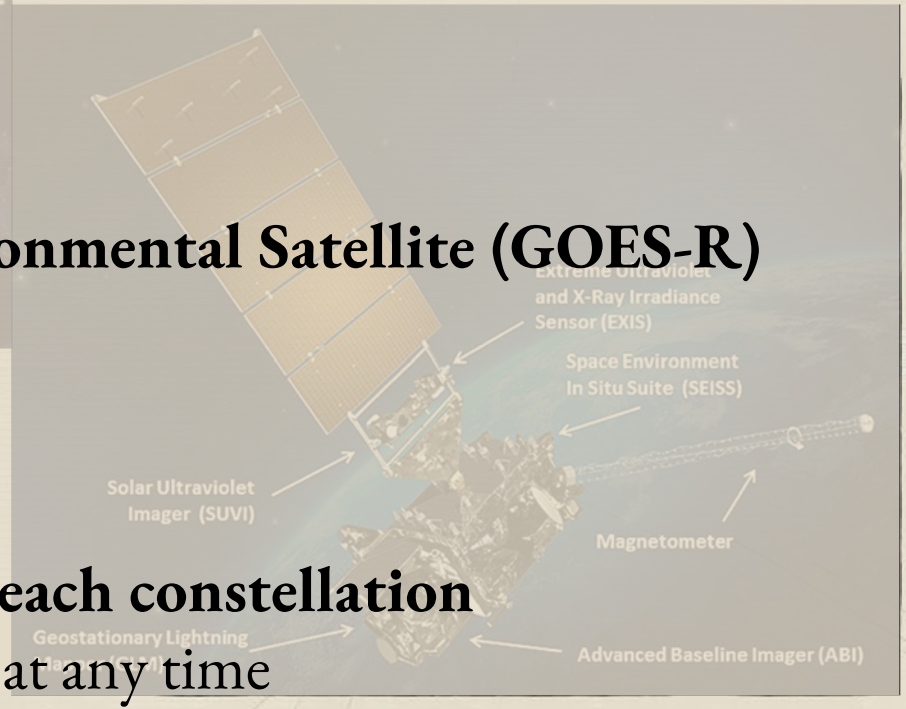
➔ GOES-16 Launched in 2016

➔ GOES-17 Launched in 2018

Data Generated: 1.4TB per day

Future Launches are planned for each constellation

Only two operational from each at any time

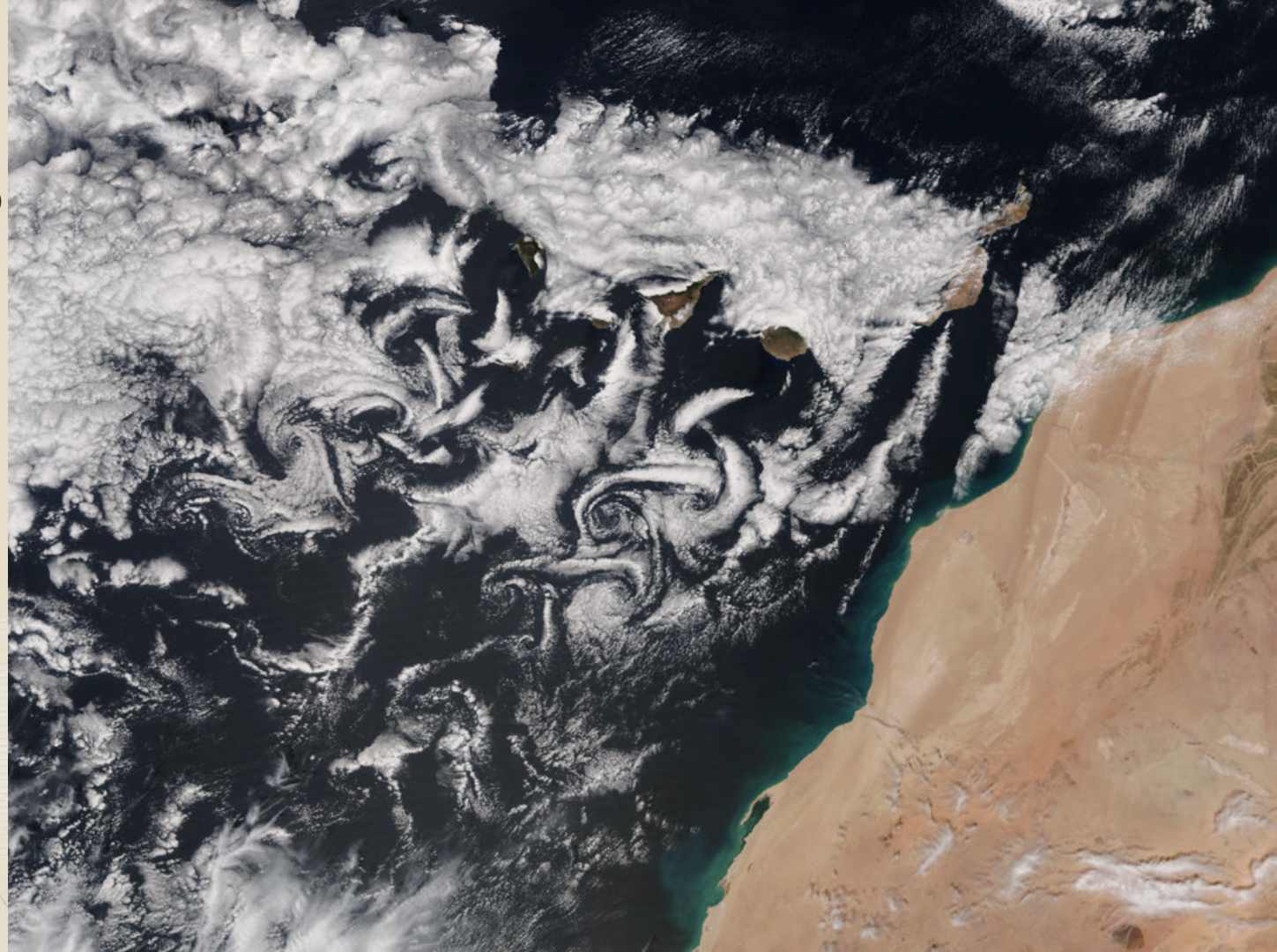


NOAA's Data Tsunami

NOAA's Data-JPSS

Joint Polar Satellite System

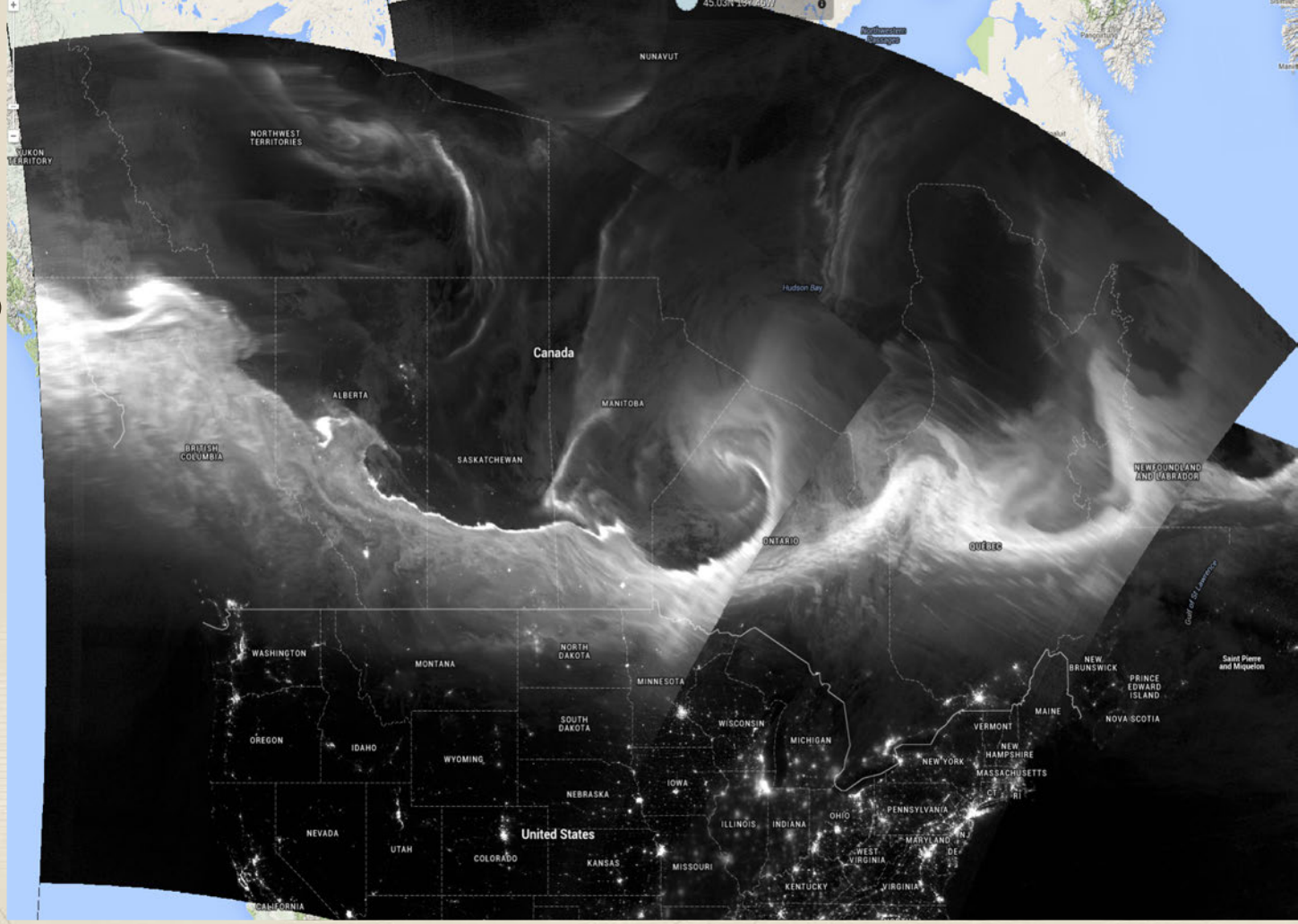
Von Karman Vortices-Canary Islands



NOAA's Data-JPSS

Joint Polar Satellite System

Aurora Borealis



NOAA's Data-GOES

Geostationary Operational Environmental Satellite

Hurricane Doria

NOAA's Data- GOES

Geostationary Operational Environmental Satellite

Wildfire Detection

Total Data Ingest

Historical Data Ingest (up to ~2009):

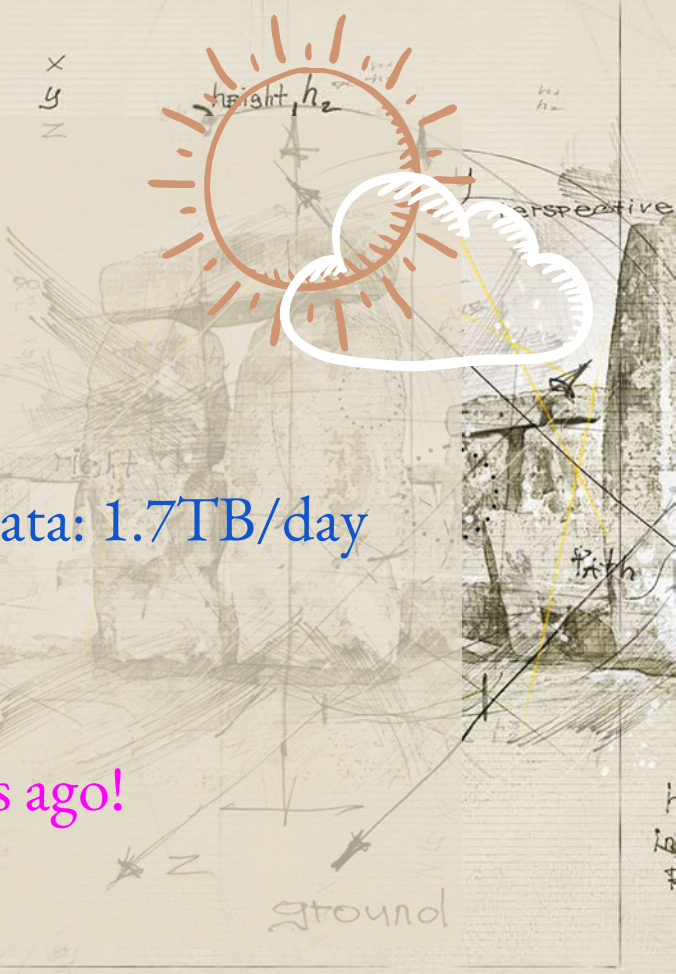
- Legacy Satellites: ~600GB/day or less

Current Data Ingest:

- Next Generation Satellites: 4.6TB/day
- Legacy/Other Satellites and Non-Satellite Data: 1.7TB/day
- Total: 6.3TB/day

Data Tsunami:

Increase of just over 10 fold from just a few years ago!



But Wait! That's Not all!

New Launches:

- Both Polar and Geostationary Launches

Other People's Data:

- New Plan! Stop launching expensive Satellites!
- Make use of Other Countries' or Commercial data
- Current Possibilities:
  - EUMETSAT METOP-SG: 4-8TB/day
  - ISRO SCATSAT: 1TB/day
- Total: ??TB/day

Increase of ?????!

Real Engineers

Wear badges so they don't forget who they are.

Wile E Coyote
ACME Engineering Services

If lost, return to me!

NOAA's Archive

The Numbers

~13PB of data stored on Spectra Logic T-Finity Libraries

Ingest: ~6.3TB/day
Dissemination: ~18TB/day

Current Annual growth: ~3PB

Two identical libraries: Separate Geographic Locations
Asheville, NC & Boulder, CO

Total of ~26PB Stored

NOTE: Data is almost NEVER deleted!

NOAA's Archive

The Deep Storage

CLASS-AVL: 84PB Capacity

10 Frame Spectra Logic T-finity Library

36 LTO-8 Tape Drives

6,940 LTO-8 Tapes
(12TB Native)

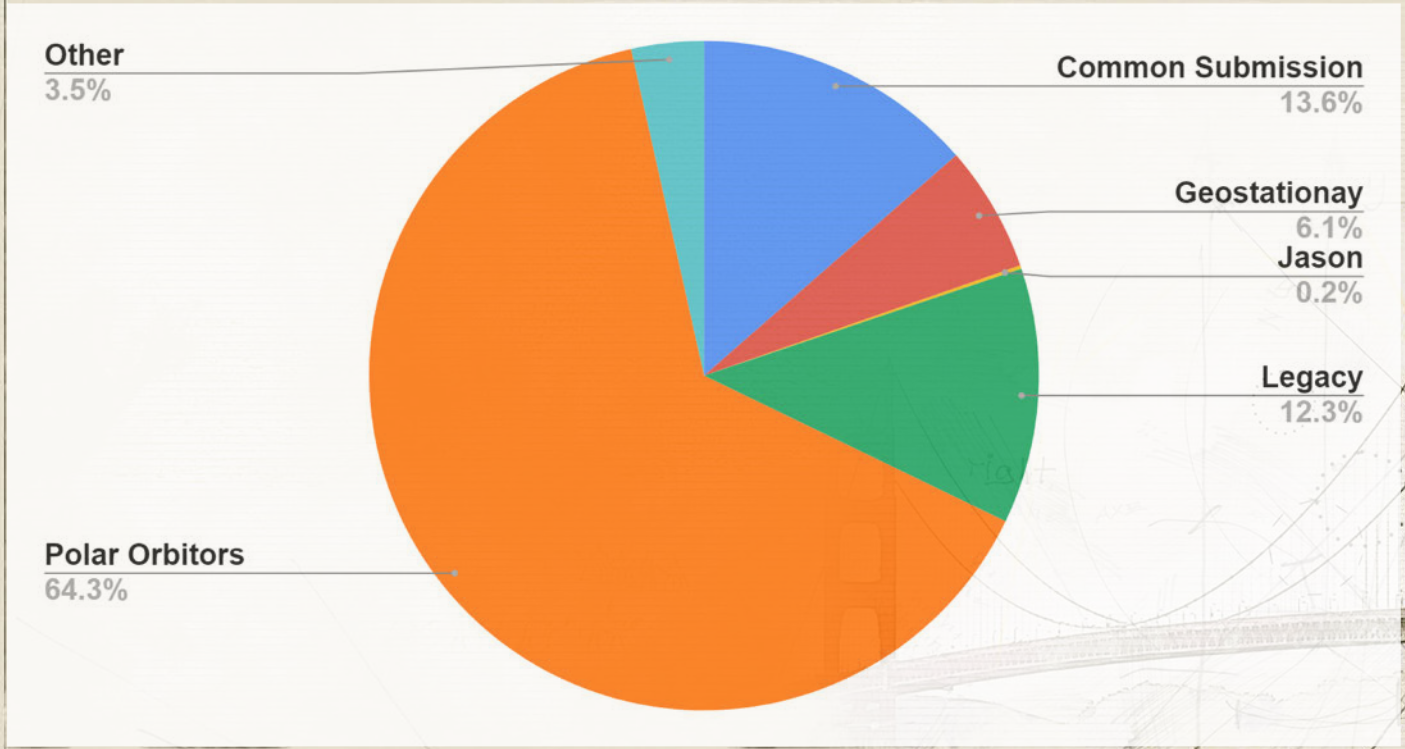
CLASS-BOU: 18PB Capacity
8 Frame Spectra Logic T-finity Library

36 LTO-6 Tape Drives

6,940 LTO-6 Tapes
(2.5TB Native)

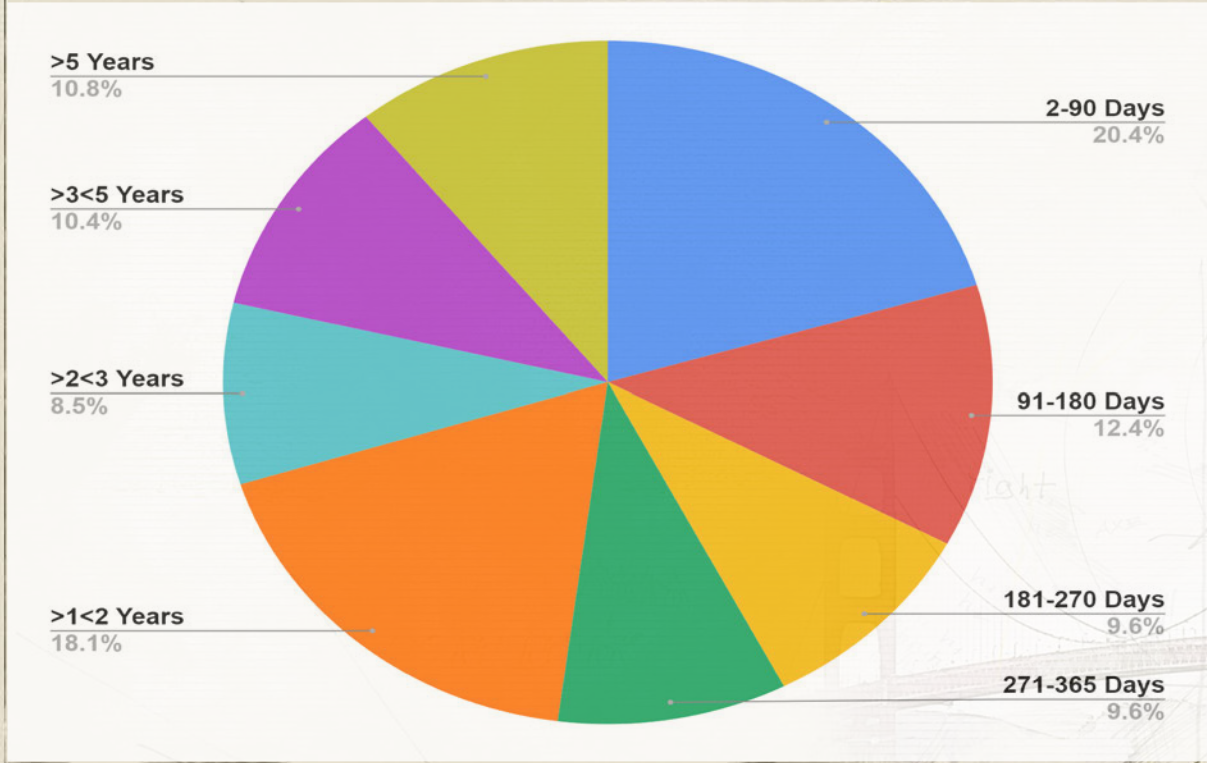
NOAA's Archive

Total Archive of ~13PB: Bytes



NOAA's Archive

Data Stats - Dissemination Age

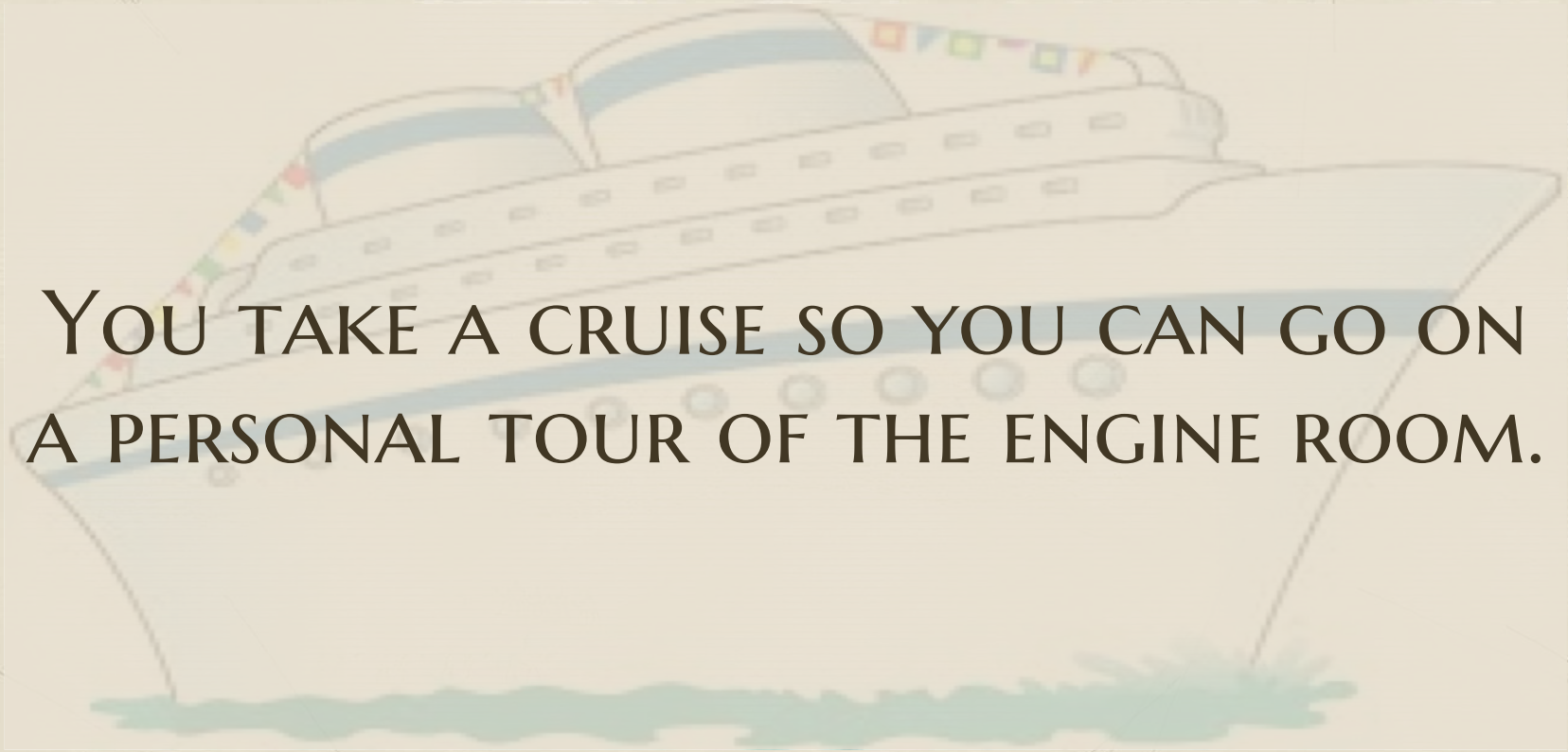


83.7% of data is delivered at Ingest via subscriptions

More than 50% of data is delivered within the first year after Ingest

Significant Wx events and Research drives data retrievals that are over 3 years old

You Might Be an Engineer if...



You take a cruise so you can go on a personal tour of the engine room.

NOAA's Archive

Tape Migration

CLASS-AVL: From 18PB (LTO-6) to 84PB (LTO-8)

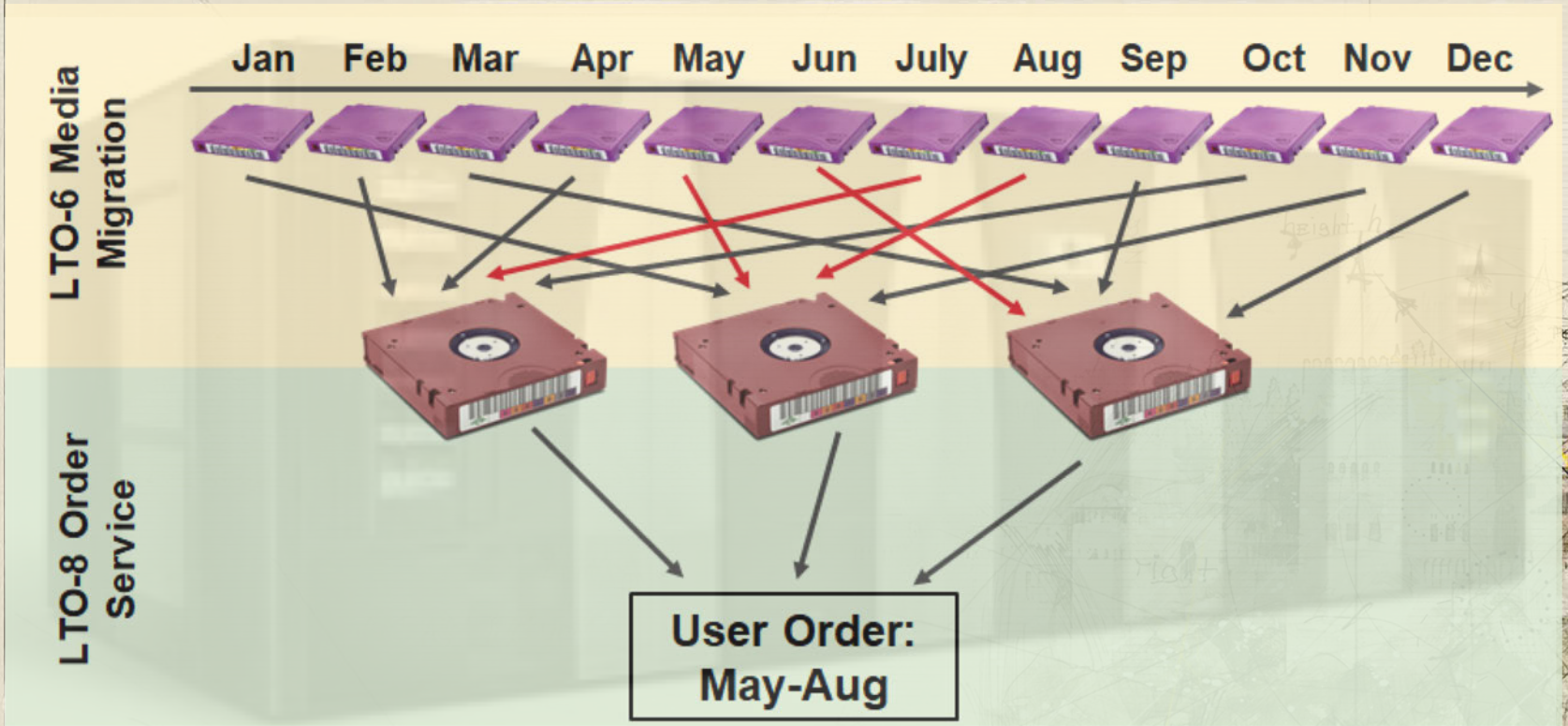
- Completed LTO-6 to LTO-8 Migration
- Cost: ~$900K
- Operations were shifted to CLASS-BOU
  - CLASS-AVL dedicated to Migration
  - Only new data was written to tape in CLASS-AVL

Challenge: Optimized Retrieval

- Retrieval from archive is by date: Example order May-Aug
- Migration planned for optimal retrieval by date

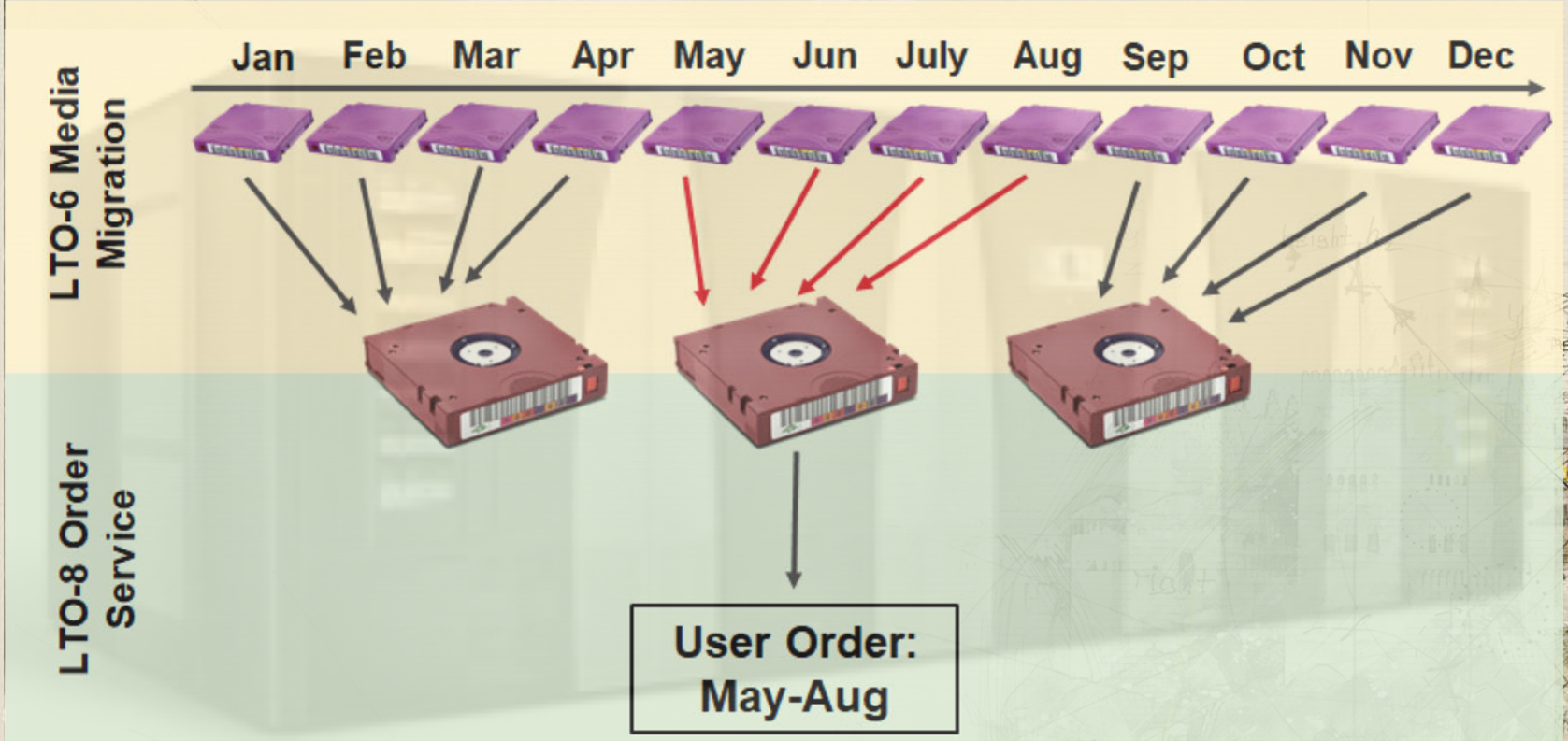
NOAA's Archive

Tape Migration: Automated Repack – Brute Force



NOAA's Archive

Tape Migration: Repack Optimized for Date Retrieval



NOAA's Archive

Tape Migration Challenge: Maximize Space

LTO-6: 2.5TB

~~LTO-8: 12TB~~

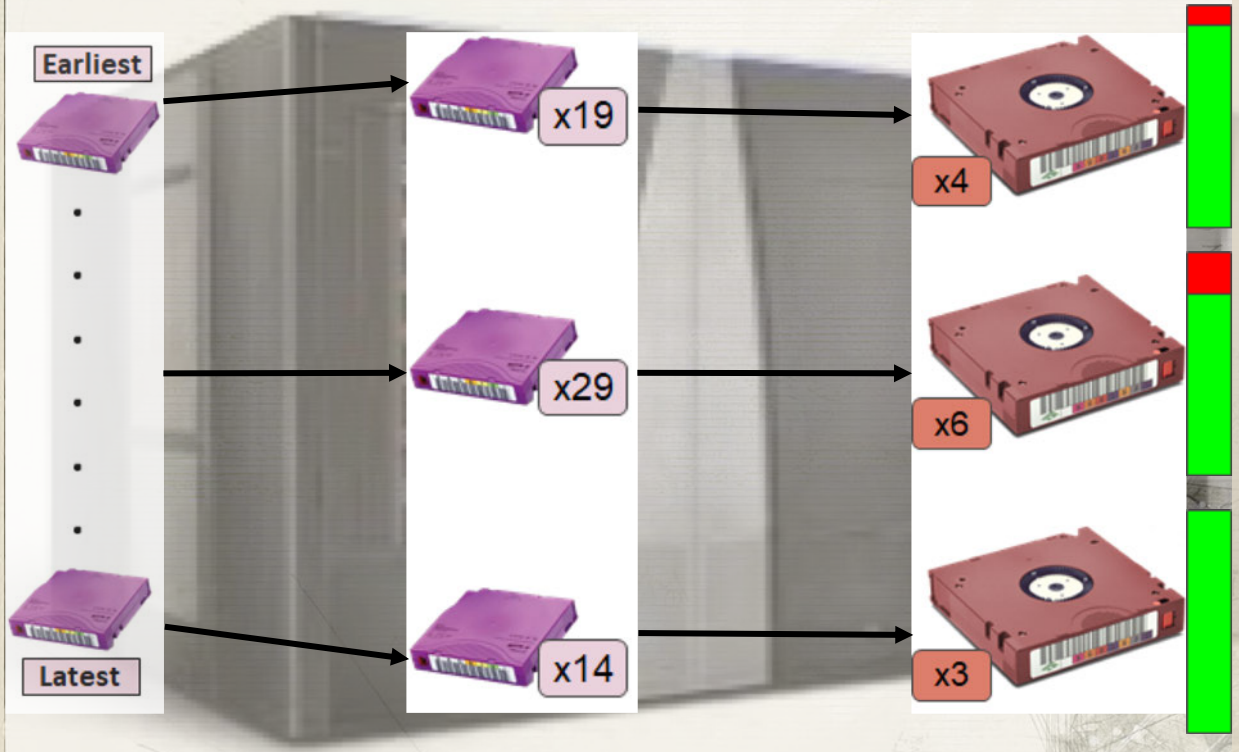
LTO-6 (2.5 TBs)	LTO-6 (2.5 TBs)	LTO-6 (2.5 TBs)	LTO-6 (2.5 TBs)	Unused (2TB)

The Goal:

Minimizing unused space on the destination tapes

NOAA's Archive

Tape Migration: Maximize Space: Grouping

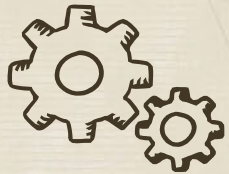


Grouping both **Source** (LTO-6) and **Destination** (LTO-8) tapes maximizes tape utilization

Unused Portion of Tape: **1.4%Avg**

NOAA's Archive

Tape Migration: Details



Operations Shifted to Writing LTO-8 **Dec 12, 2018**
Migration Started: **Jan 22, 2019** Completed: **July 5, 2019**
165 Days; Avg: **67**TBs/day; Total: **11.1PB**

384.3M Files; ~**2.3M** files/day (Lots of small files)
19.7 LTO-8/day**; 3,230** LTO-6 Migrated to **782** LTO-8 (4:1 Ratio)

Verification (checksums) Completed **Aug 20, 2019**

NO TAPE ERRORS!

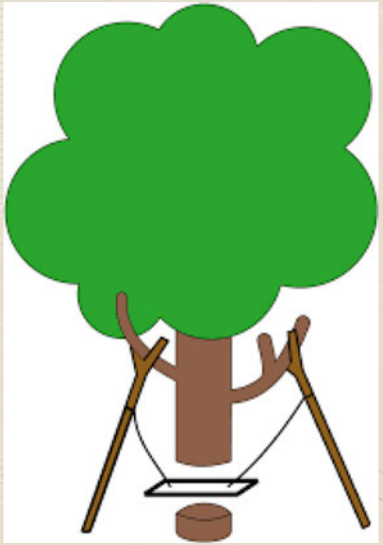
Earliest manufacture date of the LTO-6 media: May 2013

You Might Be an Engineer if...

you see a good design and still have to change it.

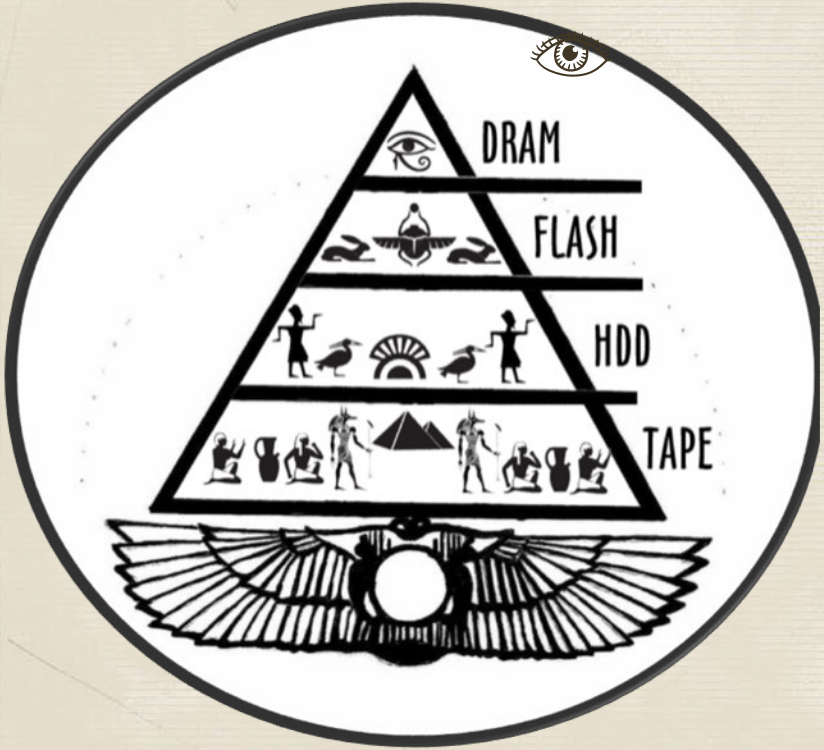
Before Engineering Prototype

After Engineering

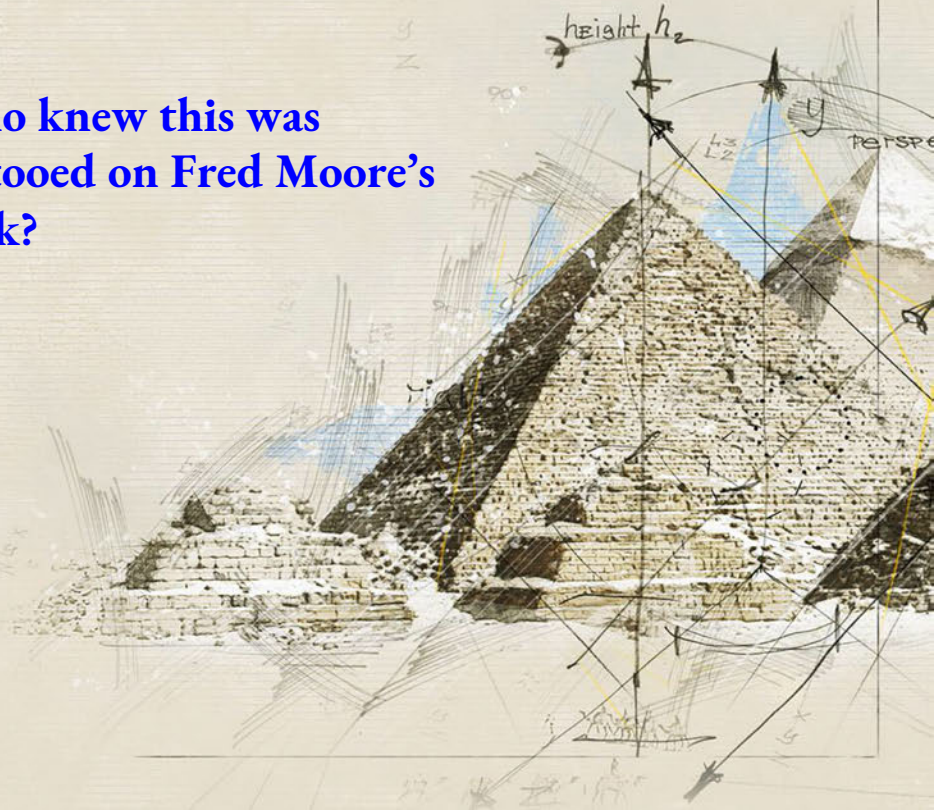


The Case for Tape

Storage Pyramid – Original Before Google

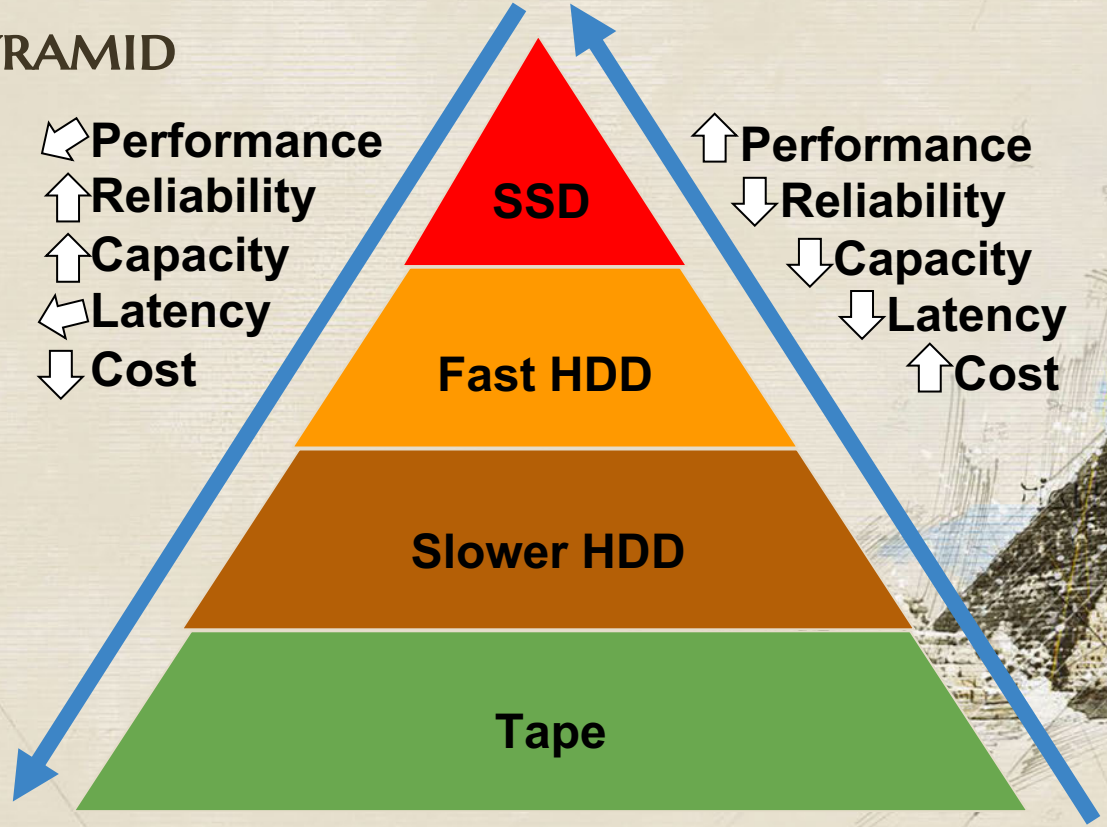


Who knew this was tattooed on Fred Moore's back?



The Case for Tape

Storage Pyramid



The Case for Tape

What if it's all on Spinning Disk?

How much Disk do we need?

USING TAPE?"

"WHY ARE WE STILL

13PB + (3PB/yr*3Yrs)=22PB for Archive

Ingest/Dissemination/Overhead: 2PB

Minimum of 24PB * 2copies = **48PB Usable**

Two Geographic Locations

Disk Cost is 155/TB/yr*48,000=**$7.4M/yr**

5yr Lifecycle Refresh

Plus Maintenance/Facilities/Communications Costs: **~$26M/3yrs**

TOTAL

Over 3 yrs

Interpolated Estimate based on actual annualized purchases

Current

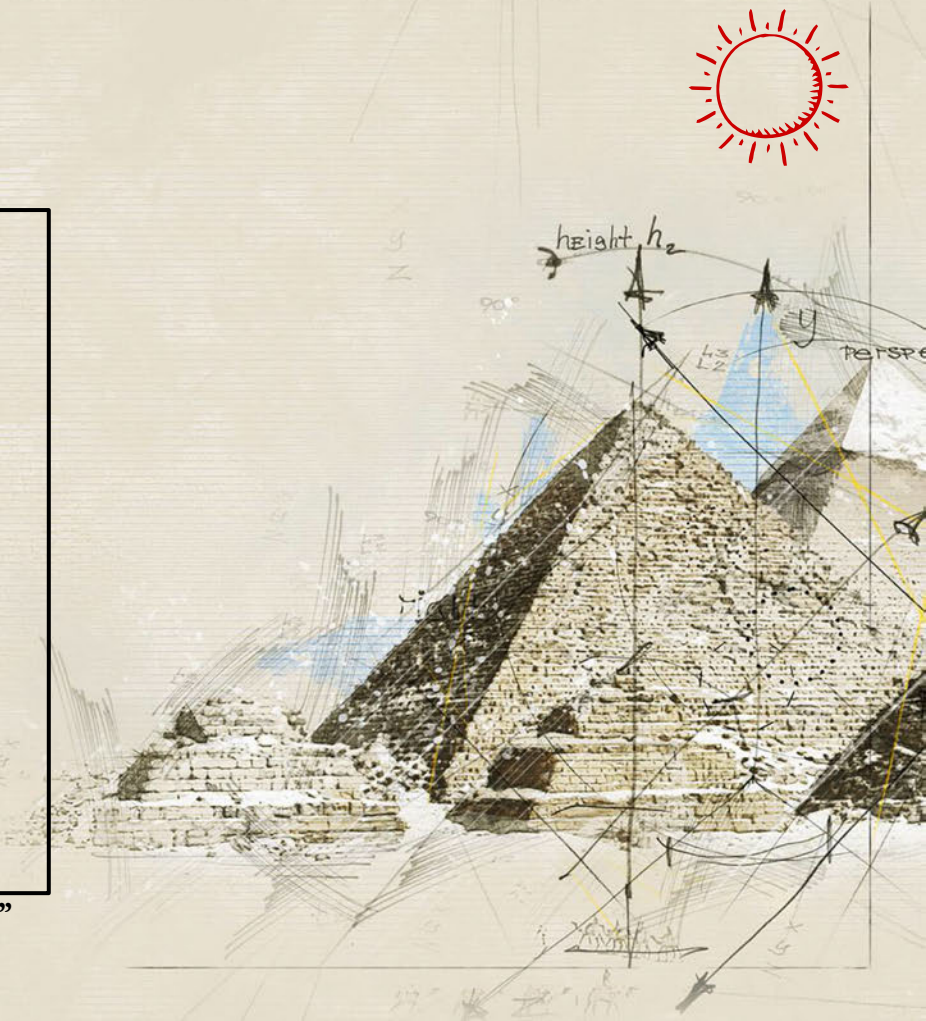
implementation

The Case for Tape

The facts about Tape

The Way It Is (Modern Tape Era)

- Surpassed HDDs Reliability (BER)
- Data Rates >2x Faster Than HDDs
- Media Life 30+ Years
- Exabyte+ (1x1018) Libraries
- RAIT, RAO and TAOS Arrive (Perf.)
- Lowest Energy Consumption and TCO
- Intelligent Robotics, Smart cartridges
- No Known Recording Limits



Fred Moore, STS2019 "Moving from Storage Hype to Storage Reality"

The Case for Tape

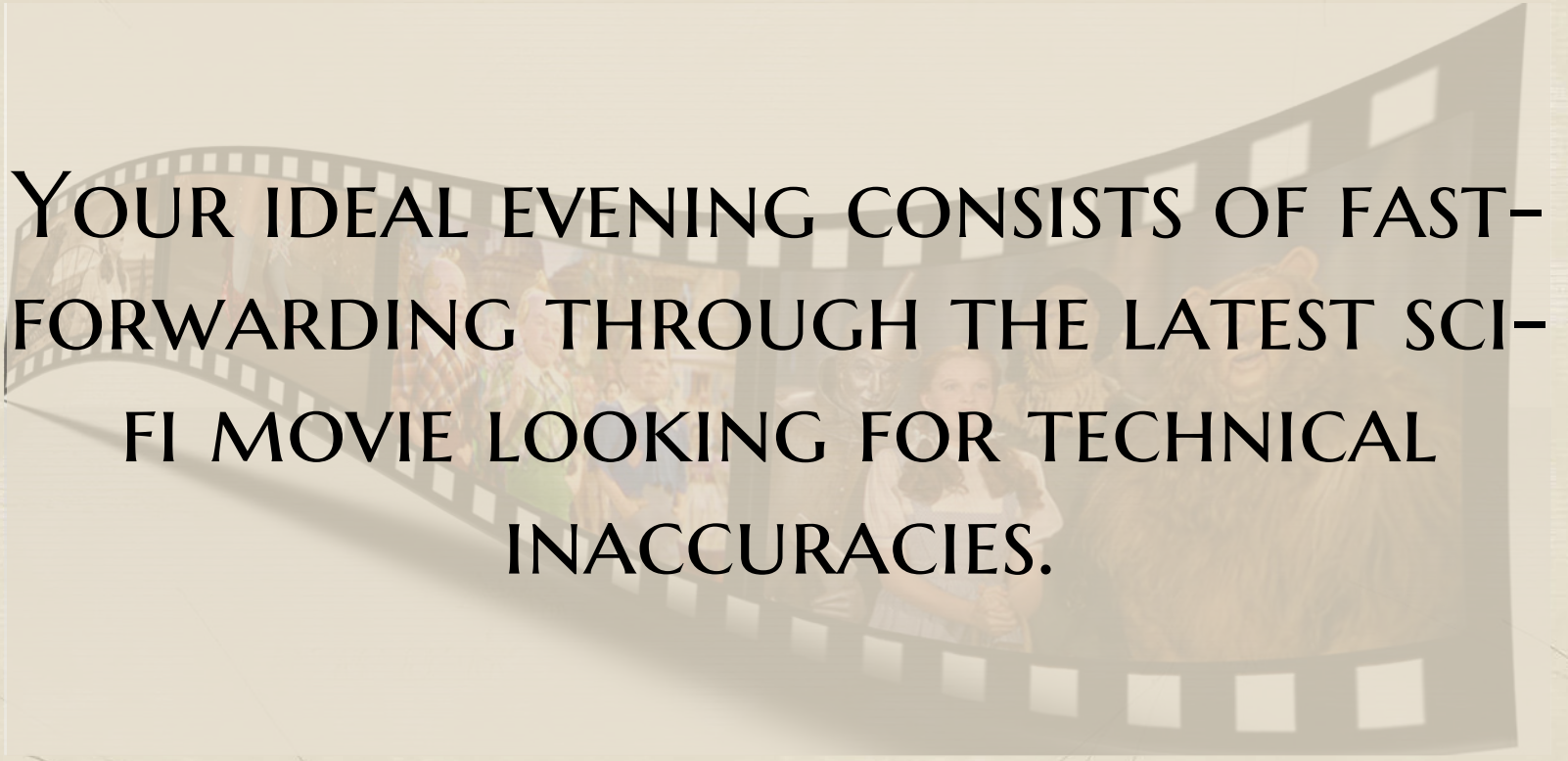
Case Closed!

Given that:

- ★ Most of our data is accessed infrequently after the first year
- ★ Spinning disk is cost prohibitive and not as reliable
- ★ Tape is the most reliable; lowest TCO; and fast retrievals

TAPE WINS!

You Might Be an Engineer if...



Your ideal evening consists of fast-forwarding through the latest sci-fi movie looking for technical inaccuracies.

The Cloud

An Industry Estimate

Matt Star
Spectra Logic
STS2019: “Rub Some Math On It”

20 PB local copy and backup copy in the cloud

- Ten year running total, $11,313,320
- Cloud Storage cost for 10 years $6.3 million
- No Retrieval Pipe cost ($2.86 million)
- No Cloud Out charges ($2.33 million)

- On prem copy for 10 years $3.94 million
- Cloud, Second copy $6.292 million
- Total for two copy 10.2 million

The Cloud

My Example

13PB to upload over a year

Growth at 3PB annually

Dark copy almost **NEVER** accessed

- ➔ Bad Tape (damaged by over zealous robot)
- ➔ Catastrophic Recall (Asheville is a smoking hole)

On-Prem still primary for servicing

The Cloud

Rub Some Math On It (YMMV)

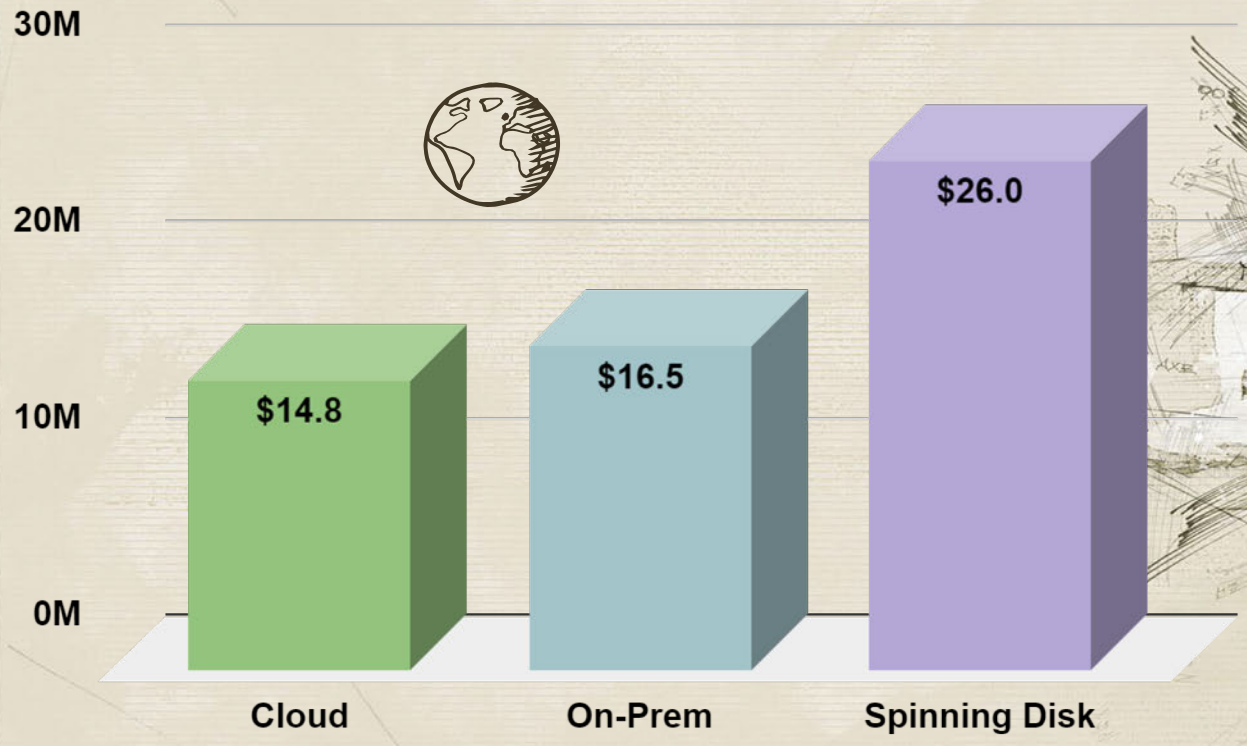
Budget Summary	Cloud	On-Prem	3Yr Savings 24.3PB
Direct Costs*	$7,120,011	$9,405,609	$2,285,597
Cloud Storage (AWS)	$3,147,200	$0	($3,147,200)
Tech Refresh	$4,616,355	$7,122,000	$2,[illegible]45
Totals	$14,883,566	$16,527,[illegible]09	$1,644,042

Budget Sur				
Direct				
Tech				
Budget Sur				
Direct [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cloud Storage (AWS)	$575,754	$1,187,640	$1,383,806	$3,147,200
Tech Refresh	$1,171,020	$2,164,200	$1,281,135	$4,616,355
Total	$4,789,774	$5,360,220	$4,733,572	$14,883,566

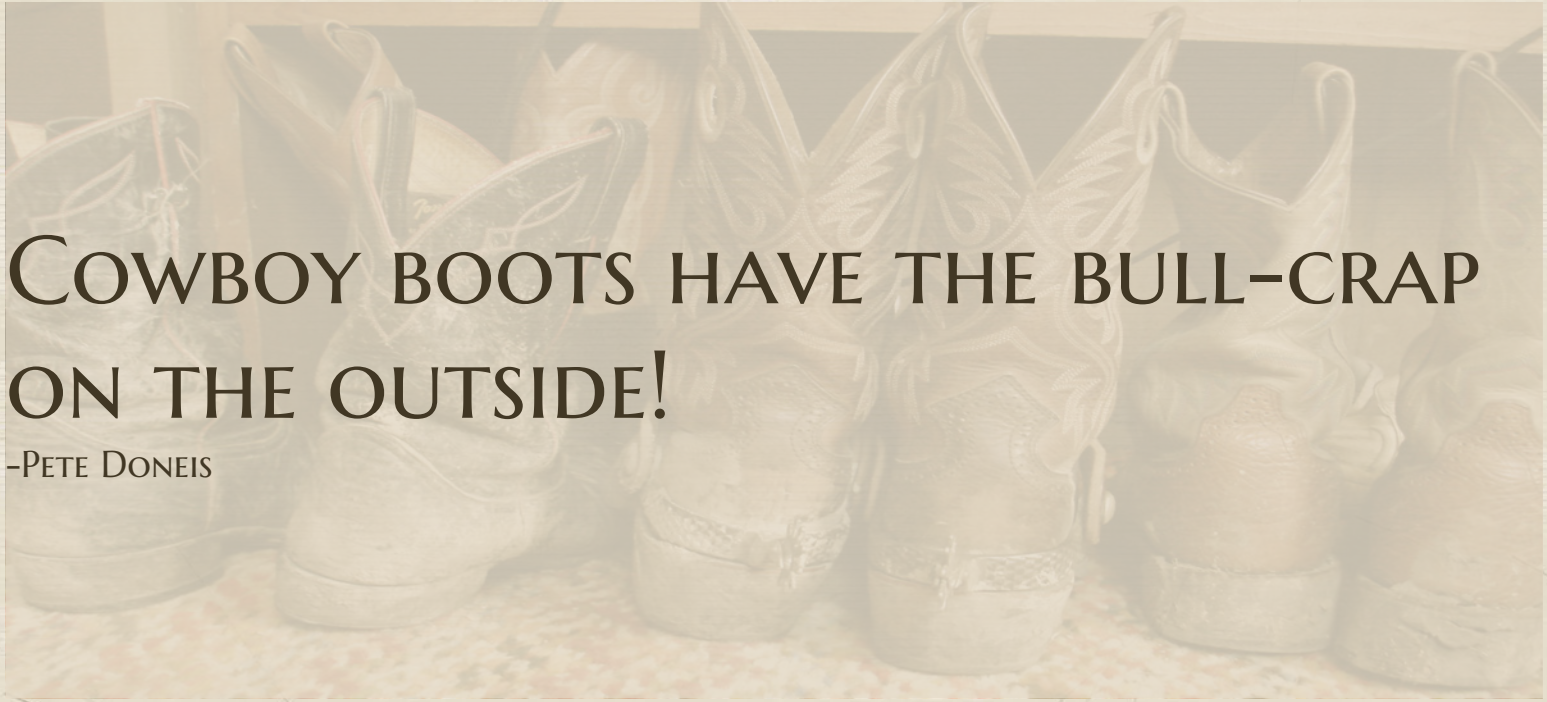
*Maintenance Contracts; Facilities; Communications

Put it all together

My Estimates!!



What is the difference between engineer boots and cowboy boots?



Cowboy boots have the bull-crap on the outside!

-Pete Doneis

Thank You!

I deny everything in this presentation! 😋

Backup Slides

Zetabyte Apocalypse

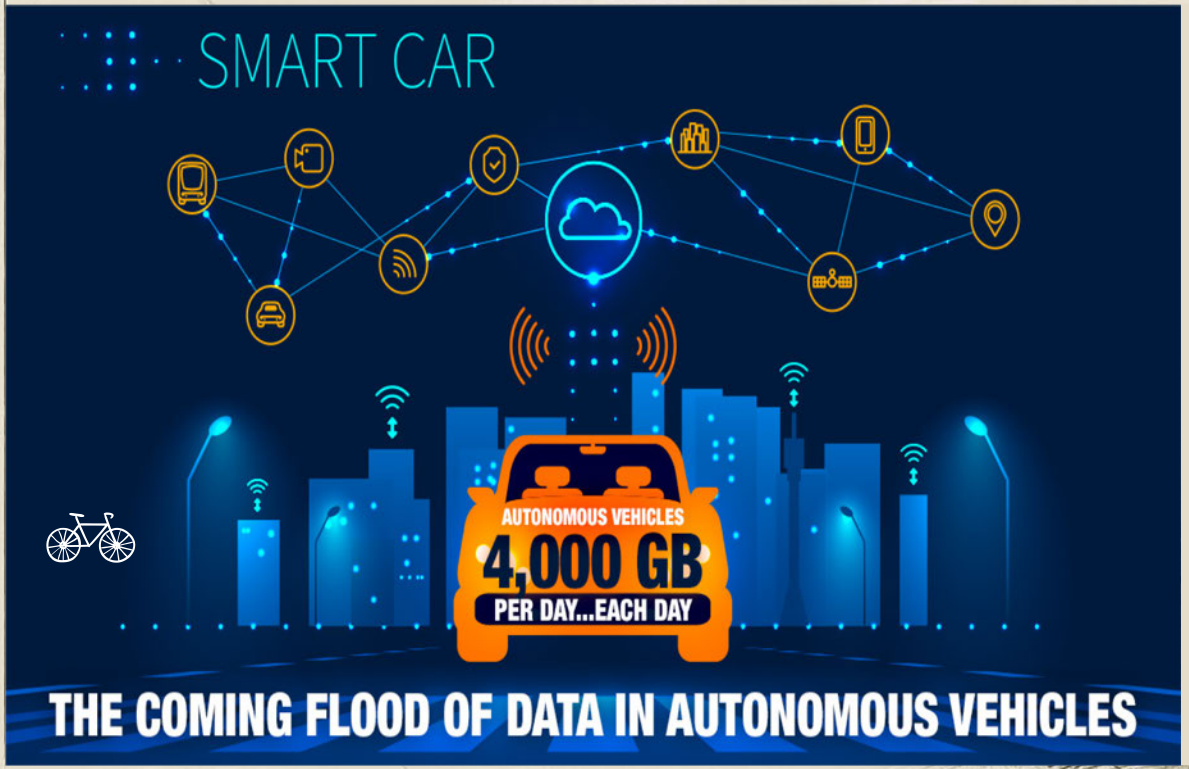
Circa TODAY!

https://wearesocial.com/blog/2019/01/digital-2019-global-internet-use-accelerates

https://www.visualcapitalist.com/what-happens-in-an-internet-minute-in-2019/

Zetabyte Apocalypse

Example – Autonomous Cars



Quick Math: By 2020

10 Million Autonomous Cars
4TB/Day * 10M

Level 2 Autonomous Driving

40PB/Day

Level 3 and above would generate much more data!

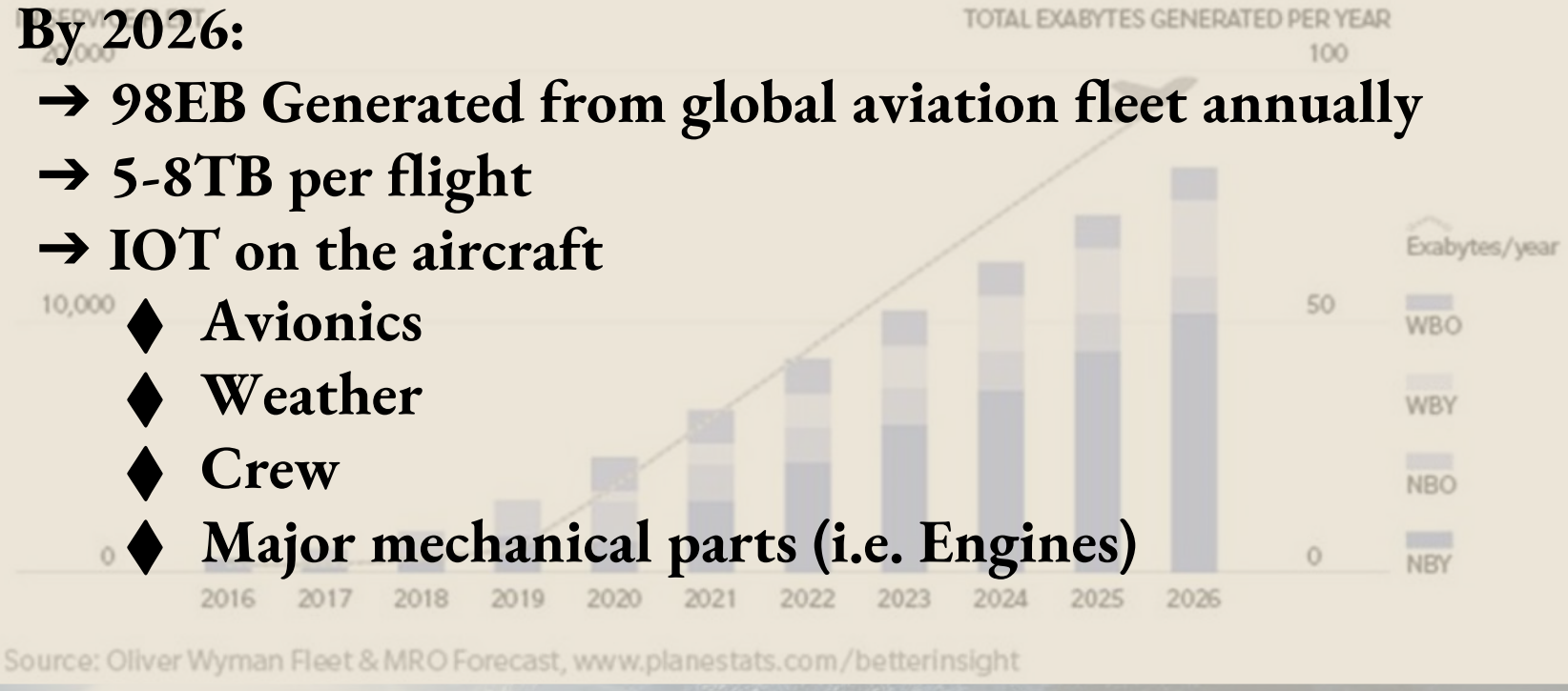
https://www.unicomengineering.com/blog/the-key-to-autonomous-driving-the-5g-network/
https://www.businesswire.com/news/home/20180831005410/en/U.S.-Autonomous-Car-Market-2018-20

Zetabyte Apocalypse

Example – Aviation

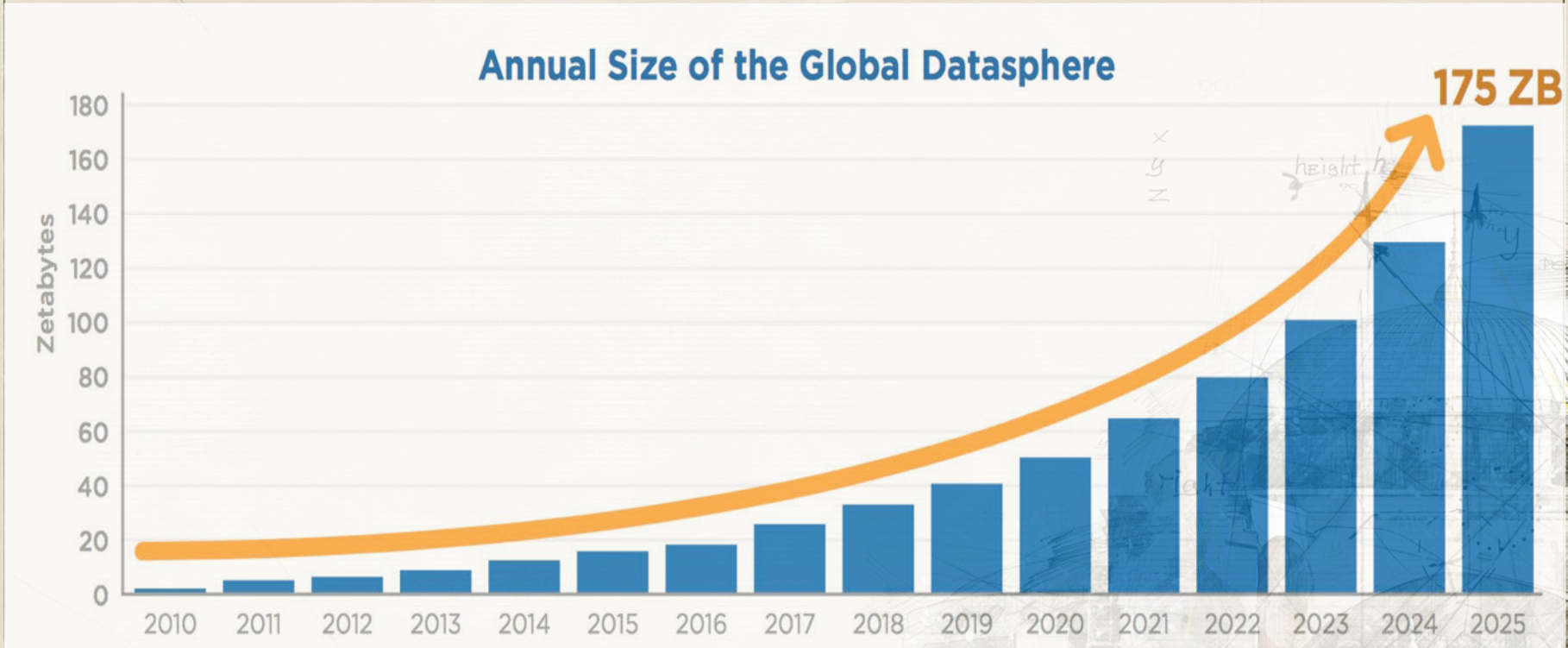
By 2026:

- ➔ **98EB Generated from global aviation fleet annually**
- ➔ **5-8TB per flight**
- ➔ **IOT on the aircraft**
  - ♦ **Avionics**
  - ♦ **Weather**
  - ♦ **Crew**
  - ♦ **Major mechanical parts (i.e. Engines)**



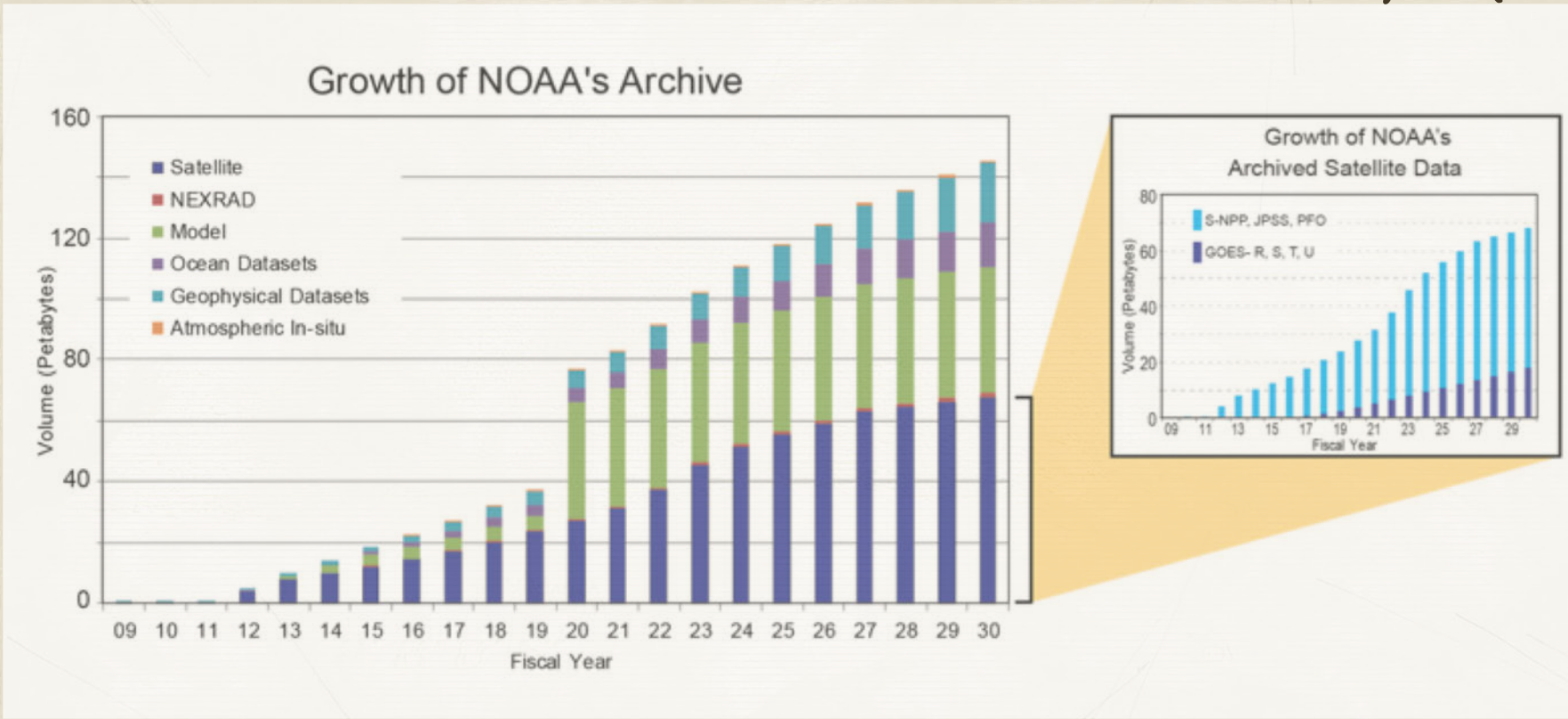
Zetabyte Apocalypse

Circa TODAY!



https://www.storagenewsletter.com/2018/11/28/global-datasphere-from-33zb-in-2018-to-175zb-by-2025/

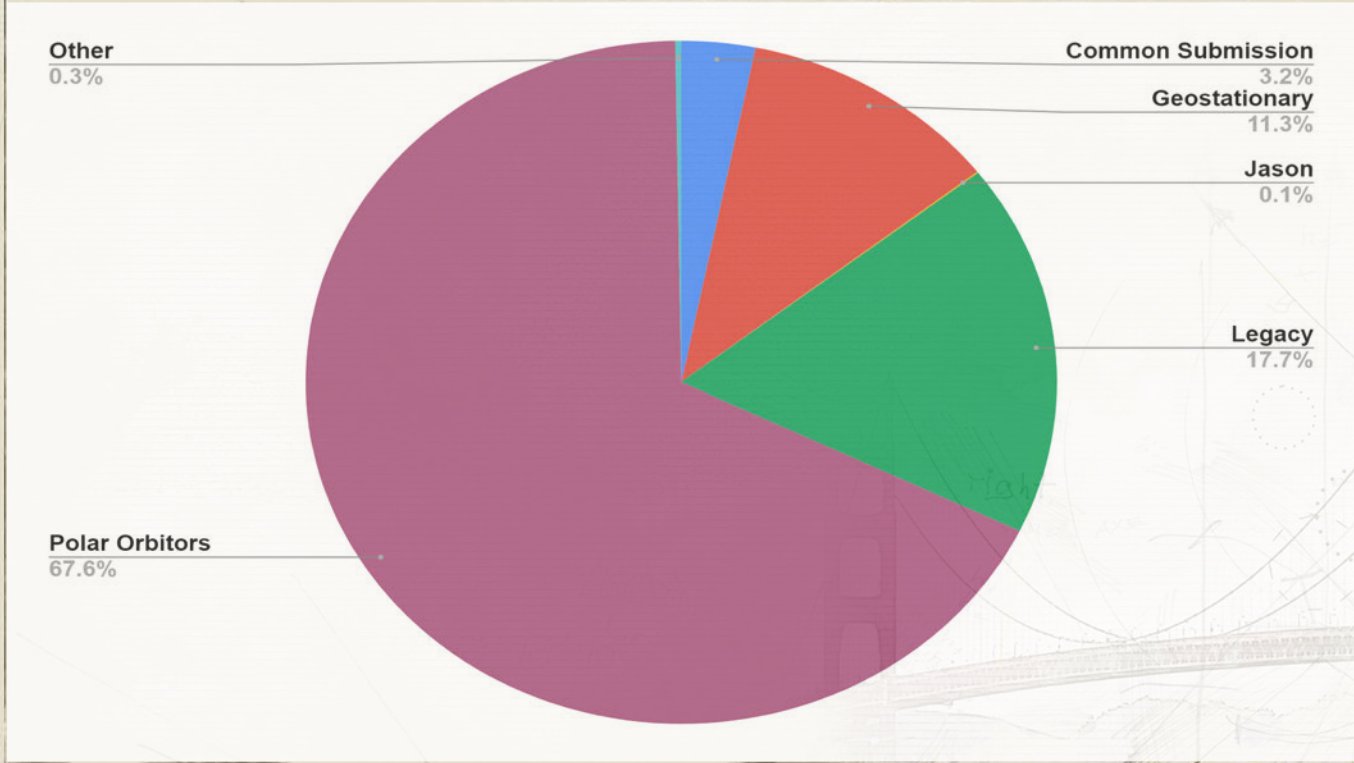
Data Growth (Circa 2016)

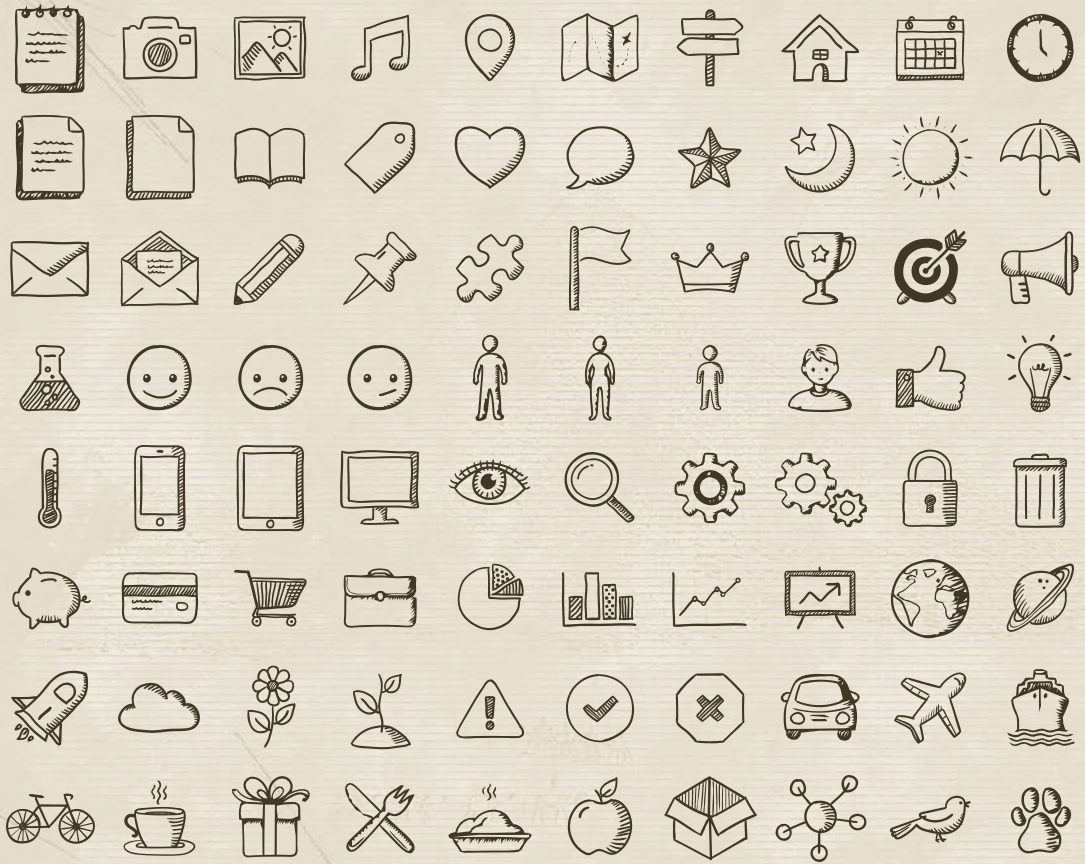


http://www.dlib.org/dlib/november16/peng/11peng.print.html

NOAA's Archive

Dissemination Over Last 12 Months - Bytes





SlidesCarnival icons are editable shapes.

This means that you can:

- Resize them without losing quality.
- Change fill color and opacity.
- Change line color, width and style.

Isn't that nice? :)

Examples:

Now you can use any emoji as an icon!
And of course it resizes without losing quality.

How? Follow Google instructions
https://twitter.com/googledocs/status/730087240156643328

and many more...