

POLAR TECHNOLOGY CONFERENCE

HOW IT WORKS: THE TECHNOLOGIES  
BEHIND THE REAL-TIME SOUTH POLE  
TRAVERSE TRACKING

TODD VALENTIC  
SRI INTERNATIONAL  
MARCH 24, 2015

# THE GOAL



## SOUTH POLE OVERLAND TRAVERSE UNITED STATES ANTARCTIC PROGRAM



### Elapsed Time

1 day 02:52:57

### Distance Traveled

164 km

### Distance Remaining

1506 km

### Current Location

088° 31' 51" S  
132° 00' 20" W  
2951 m

### Bearing and Speed

4° 0 km/h

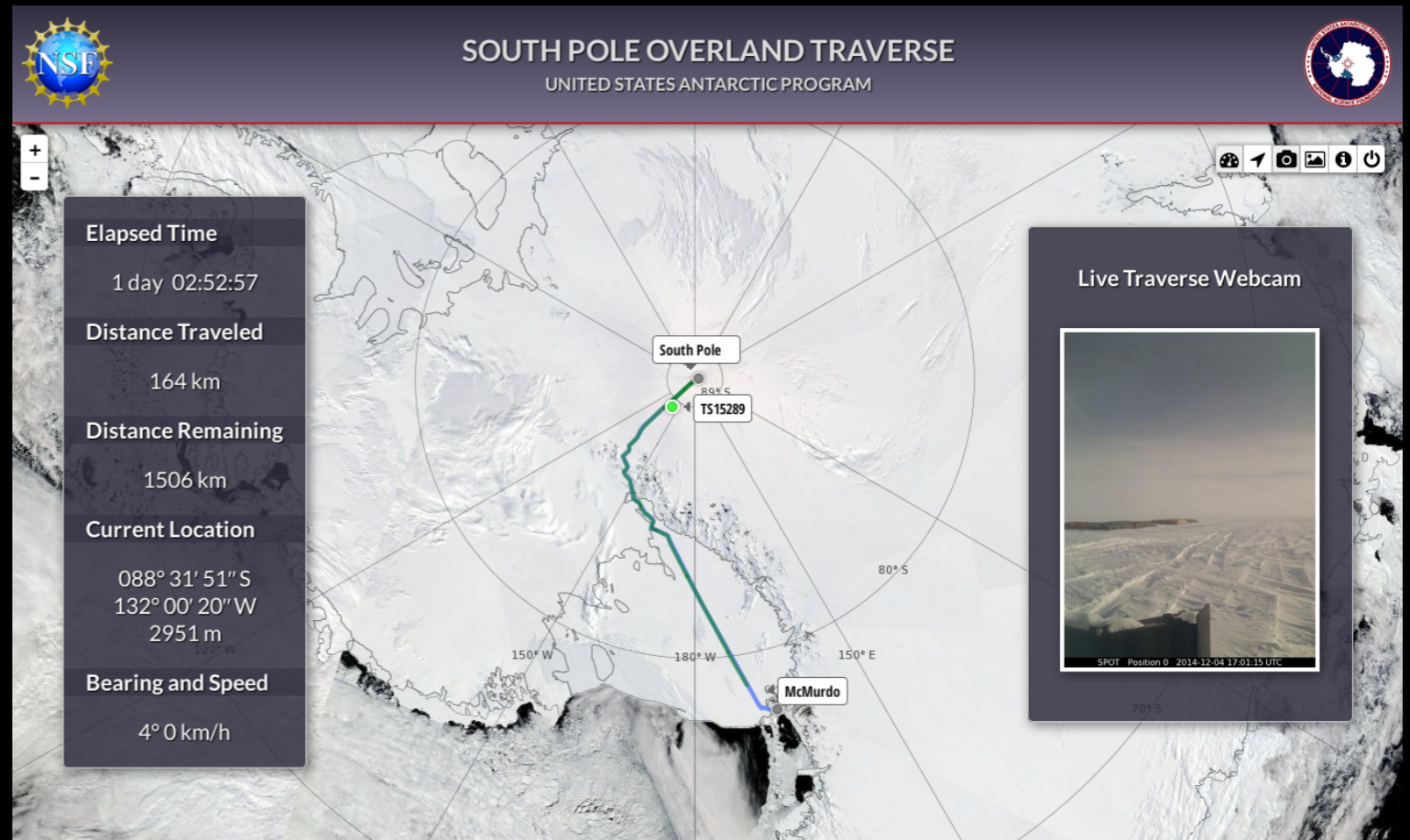
### Live Traverse Webcam



70° S

# FEATURES

- Dashboard
- Vehicle markers
- Tracks and route
- Photos and gallery
- Polar projection
- 50,000 points
- 3,000 images



Aesthetically appealing

Fast loading and smooth

Responsive (kiosk, desktop, mobile)

THE HARDWARE

# BREADCRUMB TRACKERS

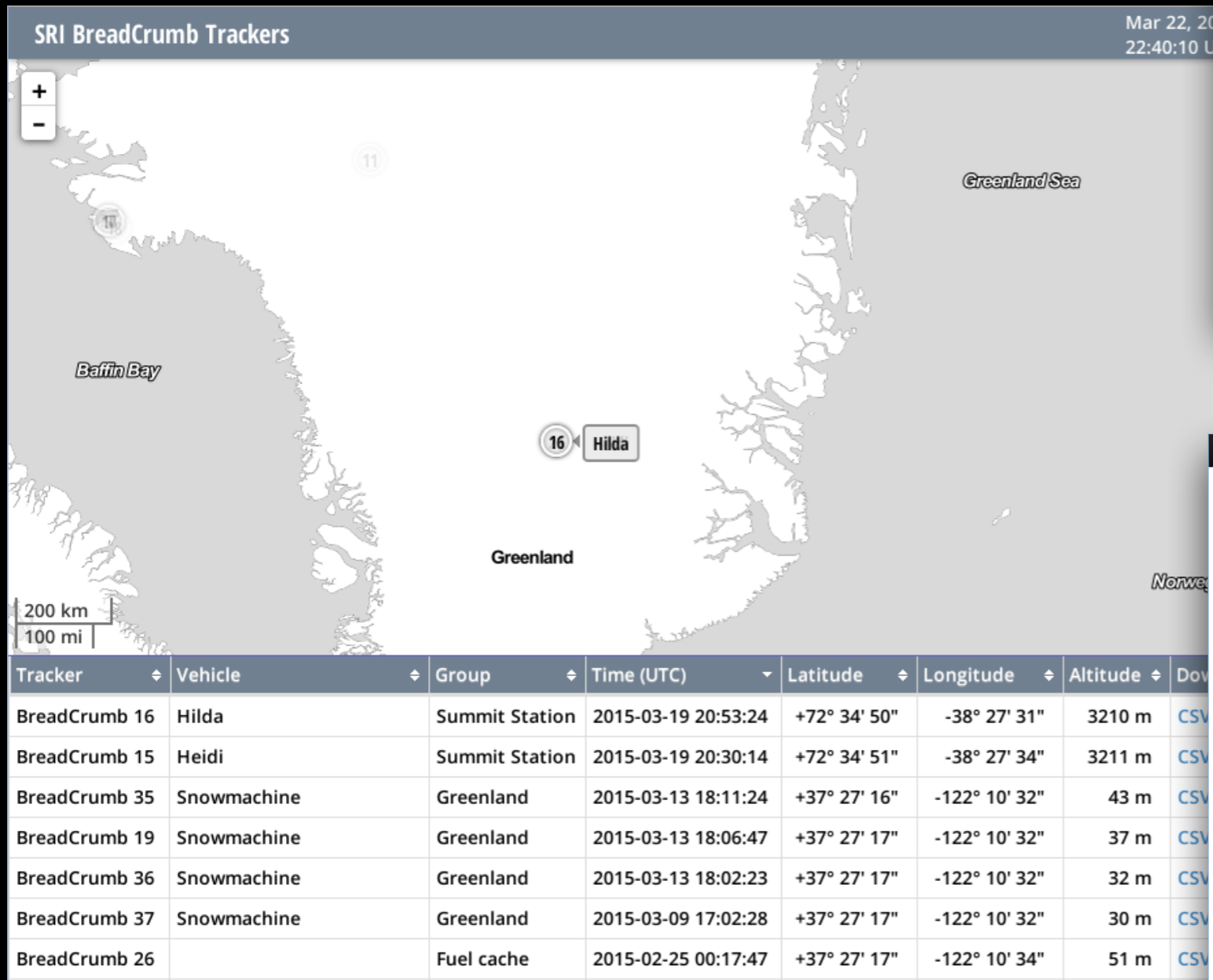
Based on the NAL 9602-LP

- 1-minute GPS updater
- Iridium SBD messages
- Dual frequency antenna
- Integrated heater, rated to -40C
- Polycarbonate case
- Proprietary data format (beware!)

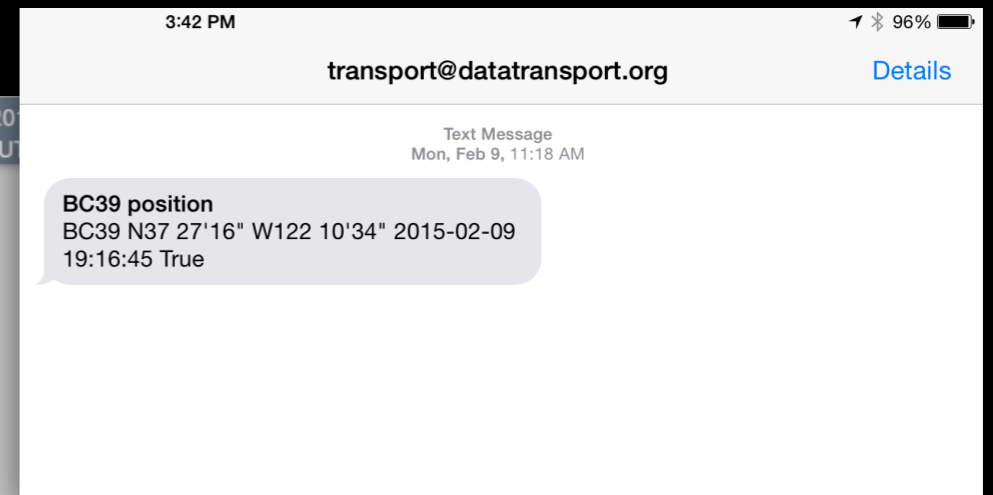


# BREADCRUMB TRACKERS

# REAL-TIME MONITORING



## MAPPING



## TEXT MESSAGES

**SRI BreadCrumb Trackers**

**Current Positions**

Tracker	Vehicle	Mission	Time (UTC)	Latitude	Longitude	Altitude
BreadCrumb 16	Hilda	Summit Station	2015-03-19 20:53:24	+72° 34' 50"	-38° 27' 31"	3210 m
BreadCrumb 15	Heidi	Summit Station	2015-03-19 20:30:14	+72° 34' 51"	-38° 27' 34"	3211 m
BreadCrumb 35	Snowmachine	Greenland	2015-03-13 18:11:24	+37° 27' 16"	-122° 10' 32"	43 m
BreadCrumb 19	Snowmachine	Greenland	2015-03-13 18:06:47	+37° 27' 17"	-122° 10' 32"	37 m
BreadCrumb 36	Snowmachine	Greenland	2015-03-13 18:02:23	+37° 27' 17"	-122° 10' 32"	32 m
BreadCrumb 37	Snowmachine	Greenland	2015-03-09 17:02:28	+37° 27' 17"	-122° 10' 32"	30 m
BreadCrumb 26		Fuel cache	2015-02-25 00:17:47	+37° 27' 17"	-122° 10' 34"	51 m
BreadCrumb 39		Fairbanks	2015-02-18 17:03:03	+64° 49' 35"	-147° 51' 18"	134 m
BreadCrumb 02	500 Nanoq	GrIT	2015-01-07 16:39:53	+36° 26' 60"	-76° 36' 14"	7 m
BreadCrumb 32	TS15289	SPOT	2014-12-22 03:56:12	-77° 50' 08"	+166° 51' 30"	12 m
BreadCrumb 12	335 Ittoqut	Summit Station	2014-12-09 16:45:39	+72° 35' 02"	-38° 26' 58"	3194 m
BreadCrumb 09	485 Qimuttuaraq	GrIT	2014-10-15 17:36:47	+76° 31' 33"	-68° 40' 54"	86 m
BreadCrumb 10	485 Kununnguaq	GrIT	2014-10-15 17:27:36	+76° 31' 33"	-68° 40' 54"	96 m
BreadCrumb 03	Tucker SnoCat	GrIT	2014-10-10 19:21:06	+76° 31' 32"	-68° 40' 53"	93 m
BreadCrumb 20	GrIT #1 snowmachine	SAGE	2014-10-03 17:38:20	+76° 32' 08"	-68° 42' 44"	79 m
BreadCrumb 14	Pisten Bully	SAGE	2014-10-03 17:05:06	+76° 31' 33"	-68° 40' 55"	108 m
BreadCrumb 17	GrIT #3 snowmachine	SAGE	2014-08-14 11:13:45	+76° 31' 32"	-68° 40' 57"	100 m
BreadCrumb 21	Archimedes snowmachine	Summit Station	2014-07-16 18:18:03	+72° 34' 50"	-38° 27' 24"	3204 m
BreadCrumb 23	Tesla snowmachine	SRI	2014-06-13 16:33:19	+67° 00' 32"	-50° 41' 48"	43 m
BreadCrumb 11	485 Nukik	GrIT	2014-05-27 13:35:37	+77° 26' 52"	-51° 05' 05"	2454 m

## MOBILE

TINCAN SBC

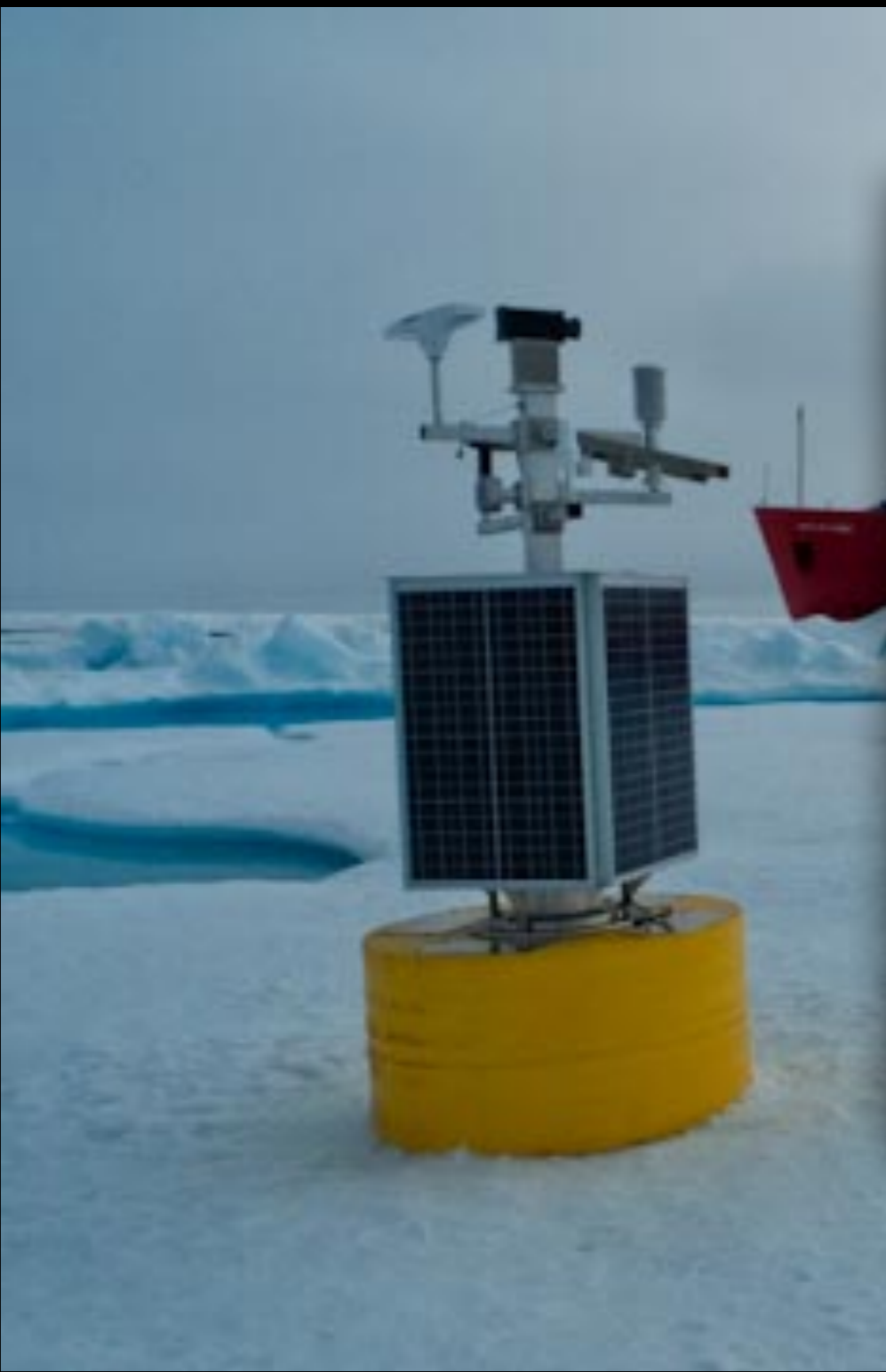
# CAMERA SYSTEM



O-BUOY 5 AND THE CCGS LOUIS S. ST.-LAURENT

TINCAN SBC

# CAMERA SYSTEM



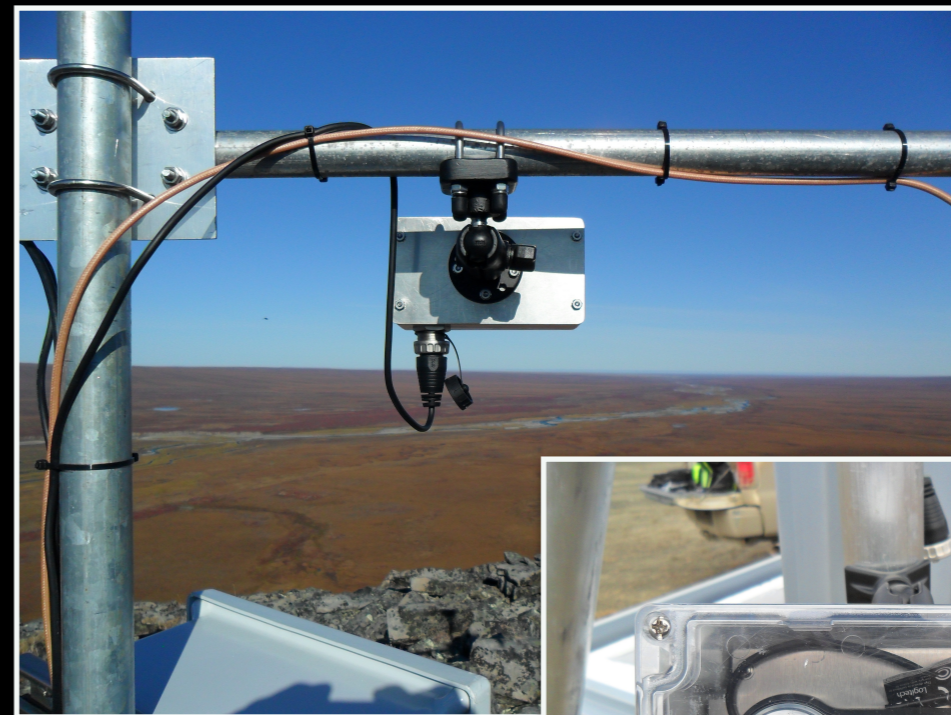
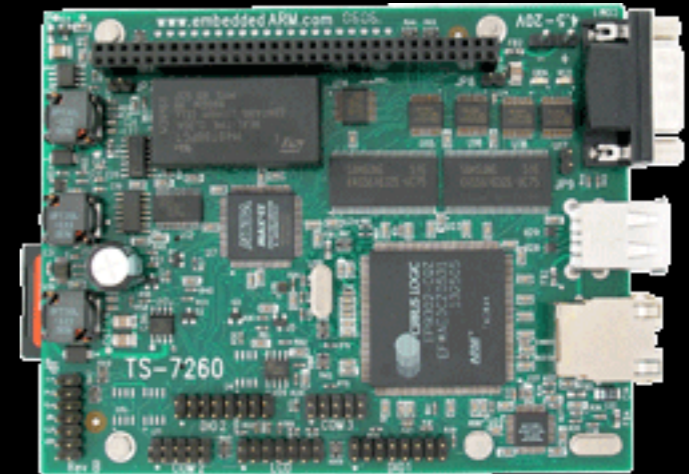


SINGLE BOARD COMPUTER

# TINCAN SBC

Based on a TS-7260

- 200MHz ARM9 CPU
- 128MB RAM / 128MB Flash
- Ethernet, USB, Serial
- DIO, ADC, SPI, Watchdog
- Low power (1W)
- Runs Linux, Python
- Data Transport applications



[http://polarpower.org/static/docs/PTC\\_2009/2009PTC\\_Valentic.pdf](http://polarpower.org/static/docs/PTC_2009/2009PTC_Valentic.pdf)

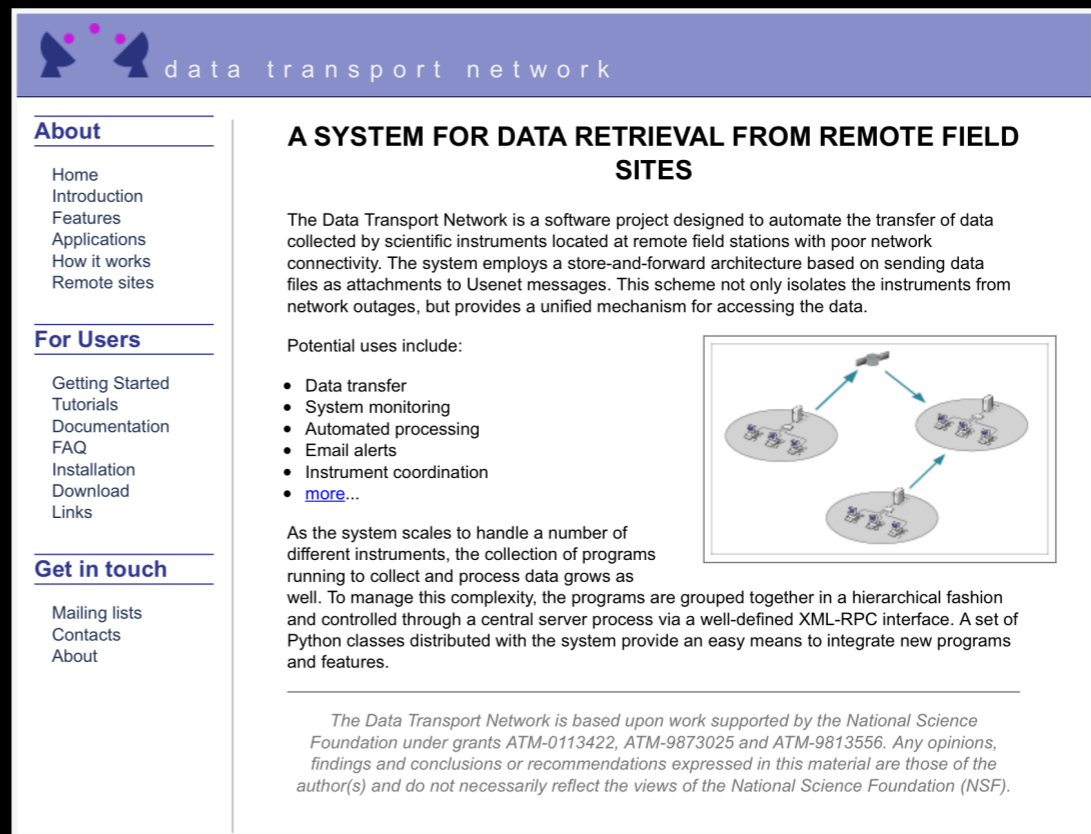
[http://polar.sri.com/polarpower.org/PTC/2012\\_pdf/PTC\\_2012\\_Valentic.pdf](http://polar.sri.com/polarpower.org/PTC/2012_pdf/PTC_2012_Valentic.pdf)

THE SOFTWARE

# THE DATA TRANSPORT NETWORK

## SOFTWARE FRAMEWORK FOR DATA STREAMS

- Data acquisition
- Transfer of data
- Data processing
- Health monitoring
- Archiving
- Used on embedded systems and servers



The screenshot shows the website for the Data Transport Network. The header features a logo with two stylized figures and the text "data transport network". The main content area is titled "A SYSTEM FOR DATA RETRIEVAL FROM REMOTE FIELD SITES". It includes a navigation menu on the left with sections for "About", "For Users", and "Get in touch". The main text describes the system's purpose and lists potential uses such as data transfer, system monitoring, and automated processing. A diagram illustrates the network architecture with a central server and multiple remote field sites. A disclaimer at the bottom mentions funding from the National Science Foundation.

**data transport network**

### About

- Home
- Introduction
- Features
- Applications
- How it works
- Remote sites

### For Users

- Getting Started
- Tutorials
- Documentation
- FAQ
- Installation
- Download
- Links

### Get in touch

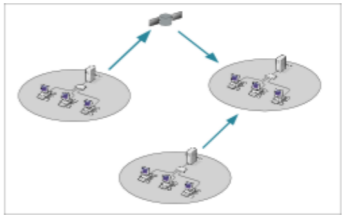
- Mailing lists
- Contacts
- About

## A SYSTEM FOR DATA RETRIEVAL FROM REMOTE FIELD SITES

The Data Transport Network is a software project designed to automate the transfer of data collected by scientific instruments located at remote field stations with poor network connectivity. The system employs a store-and-forward architecture based on sending data files as attachments to Usenet messages. This scheme not only isolates the instruments from network outages, but provides a unified mechanism for accessing the data.

Potential uses include:

- Data transfer
- System monitoring
- Automated processing
- Email alerts
- Instrument coordination
- [more...](#)



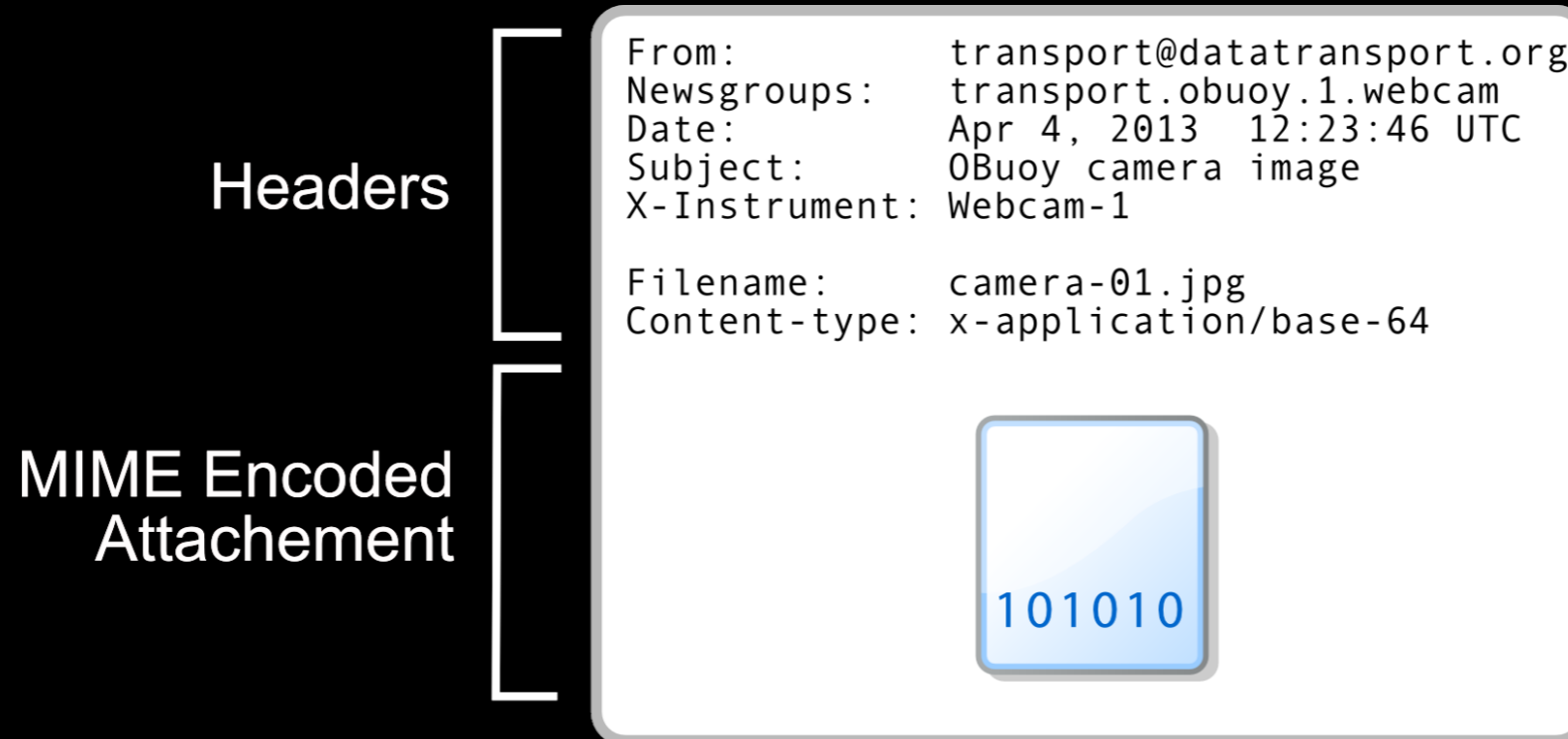
As the system scales to handle a number of different instruments, the collection of programs running to collect and process data grows as well. To manage this complexity, the programs are grouped together in a hierarchical fashion and controlled through a central server process via a well-defined XML-RPC interface. A set of Python classes distributed with the system provide an easy means to integrate new programs and features.

The Data Transport Network is based upon work supported by the National Science Foundation under grants ATM-0113422, ATM-9873025 and ATM-9813556. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation (NSF).

<http://datatransport.org>

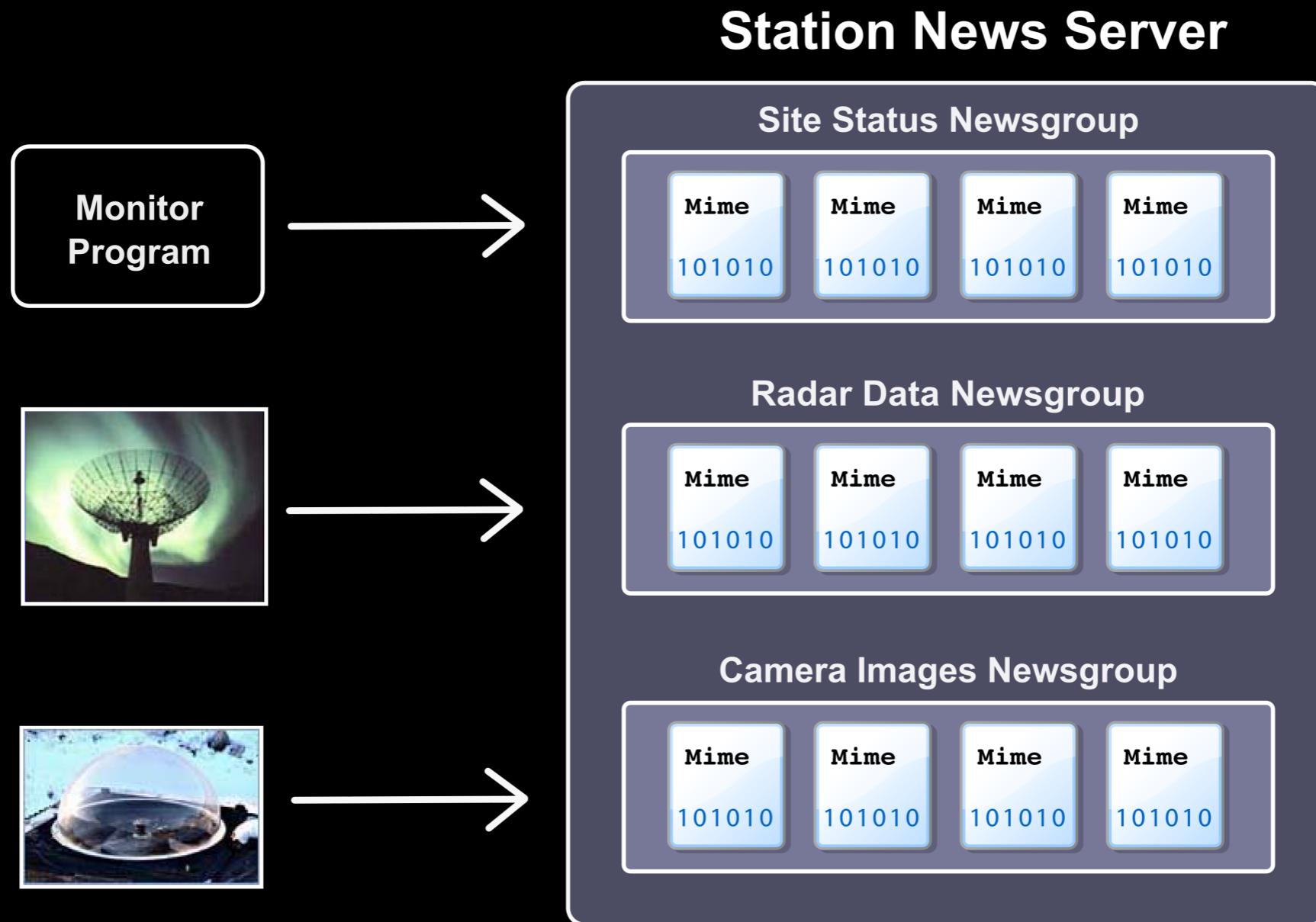
## HOW IT WORKS

# USENET MESSAGES

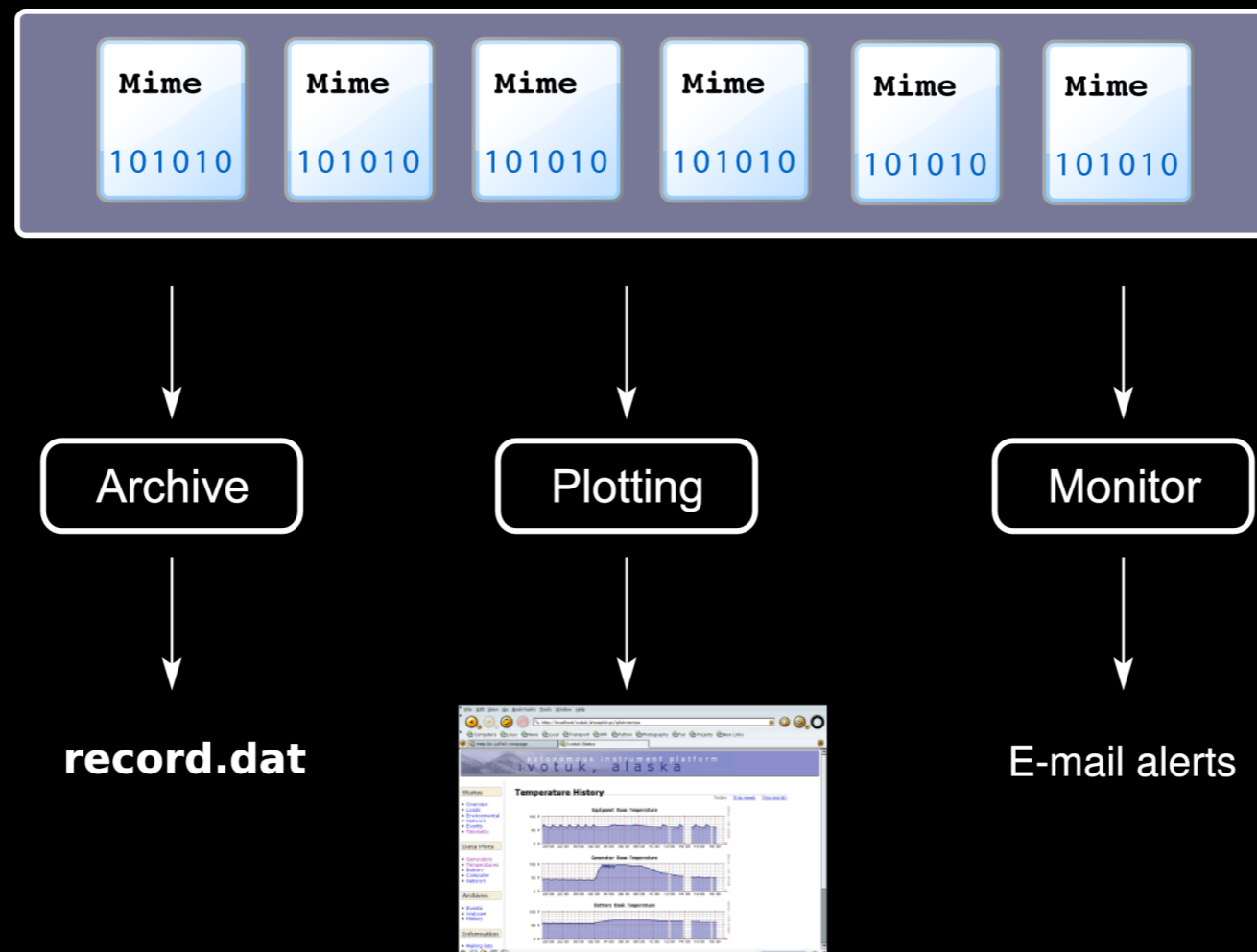


- Data files are sent as attachments
- Headers provide metadata
- Any type day data can be sent (text, images, binaries ,etc)

# NEWSGROUPS HOLD MESSAGES



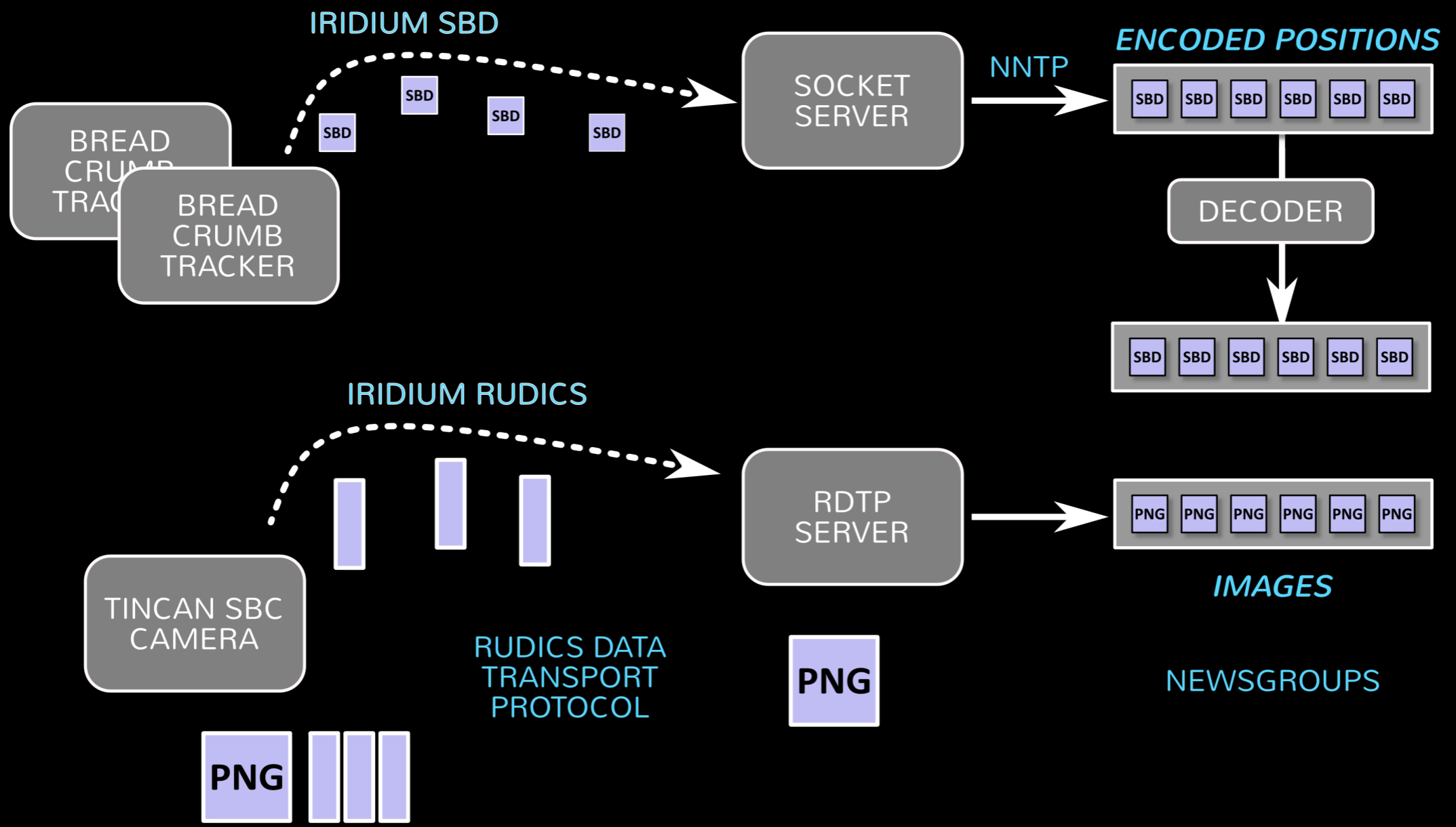
# PUBLISH AND SUBSCRIBE



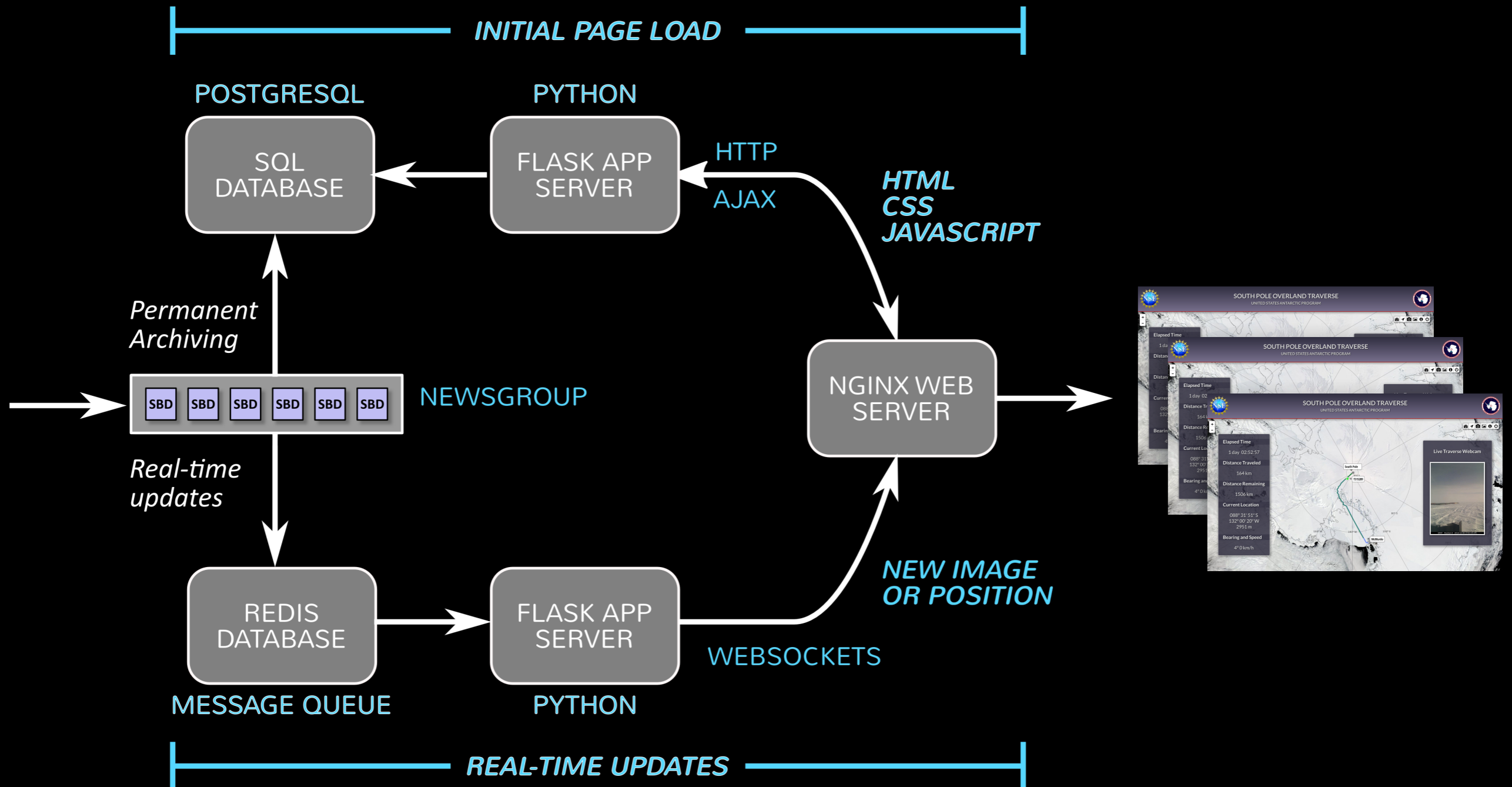
- Single producer and many consumers
- Copies of data are accessed
- Short term history, automatic expiration (2 weeks)
- Market place for data

DATA TRANSPORT

# FIELD TO SERVER



# WEB SERVER ARCHITECTURE





THE WEB PAGE

# USER INTERFACE LAYER

# APPLICATION ARCHITECTURE

[FACEBOOK.GITHUB.IO/REACT](https://facebook.github.io/react)  
[FACEBOOK.GITHUB.IO/FLUX](https://facebook.github.io/flux)  
[GITHUB.COM/SPOIKE/REFLUXJS](https://github.com/spoike/refluxjs)

The screenshot shows the React website homepage. At the top left is the React logo and the word "React". To the right are navigation links: "DOCS", "SUPPORT", "DOWNLOAD", "BLOG", and "GITHUB". The main heading is "React" in a large, light blue font, followed by the tagline "A JAVASCRIPT LIBRARY FOR BUILDING USER INTERFACES". Below this are two prominent buttons: "Get Started" and "Download React v0.13.1". The page is divided into three columns, each with a heading and a paragraph of text.

React

A JAVASCRIPT LIBRARY FOR BUILDING USER INTERFACES

Get Started Download React v0.13.1

### JUST THE UI

Lots of people use React as the V in MVC. Since React makes no assumptions about the rest of your technology stack, it's easy to try it out on a small feature in an existing project.

### VIRTUAL DOM

React uses a *virtual DOM* diff implementation for ultra-high performance. It can also render on the server using Node.js — no heavy browser DOM required.

### DATA FLOW

React implements one-way reactive data flow which reduces boilerplate and is easier to reason about than traditional data binding.

The screenshot shows the Flux website homepage. At the top left is the Flux logo and the word "Flux". To the right are navigation links: "DOCS", "SUPPORT", and "GITHUB". The main heading is "Flux" in a large, white font, followed by the tagline "APPLICATION ARCHITECTURE FOR BUILDING USER INTERFACES". Below this is a paragraph of text describing Flux. At the bottom, there is a video player showing a presentation slide.

Flux

APPLICATION ARCHITECTURE FOR BUILDING USER INTERFACES

Flux is the application architecture that Facebook uses for building client-side web applications. It complements React's composable view components by utilizing a unidirectional data flow. It's more of a pattern rather than a formal framework, and you can start using Flux immediately without a lot of new code.

PLAYLIST | 26 / 42 Hacker Way: Rethinking Web App Development ... YouTube

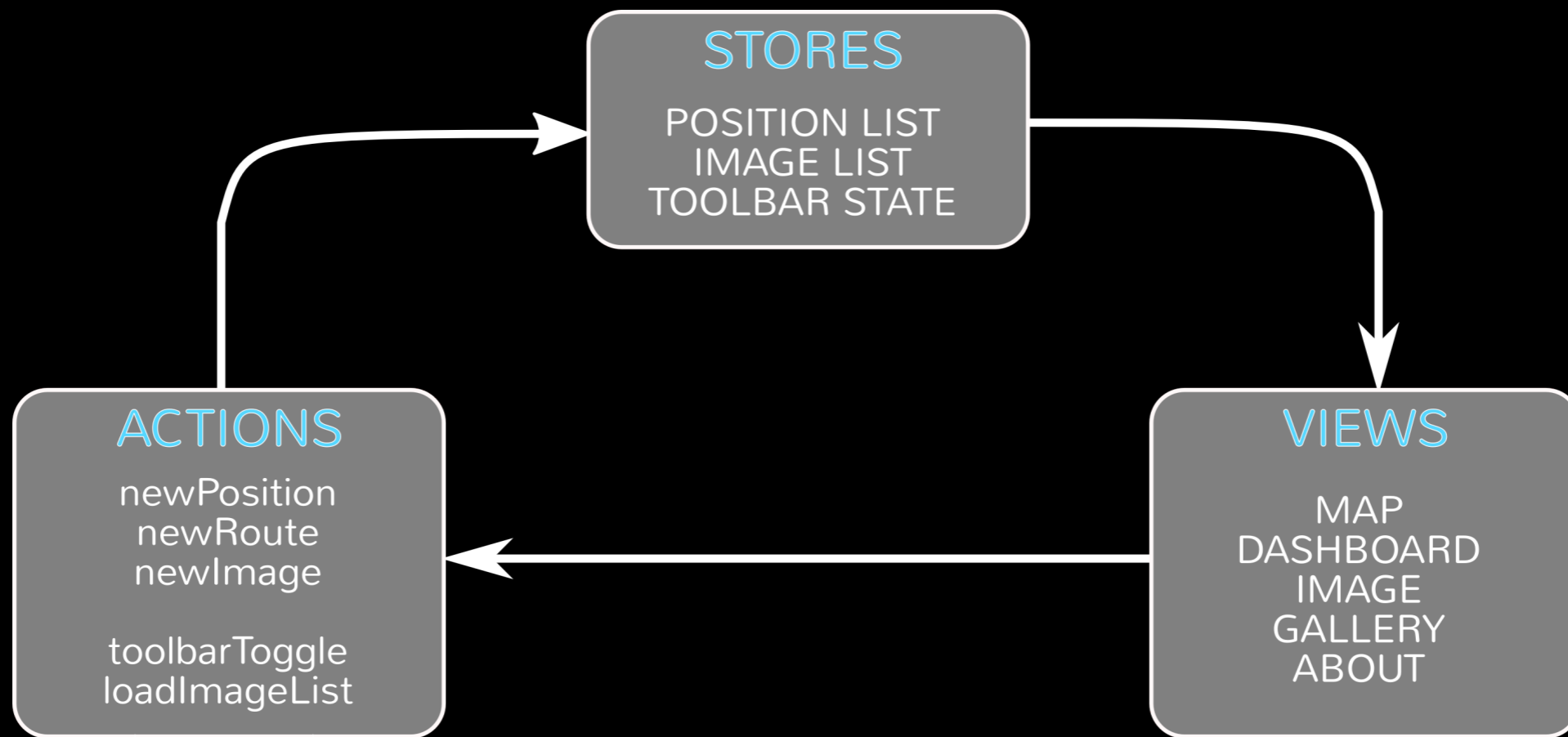
IDEAL: ALWAYS RE-RENDER

```
{ text: "message 1" }  
{ text: "message 2" }  
{ text: "message 3" }
```

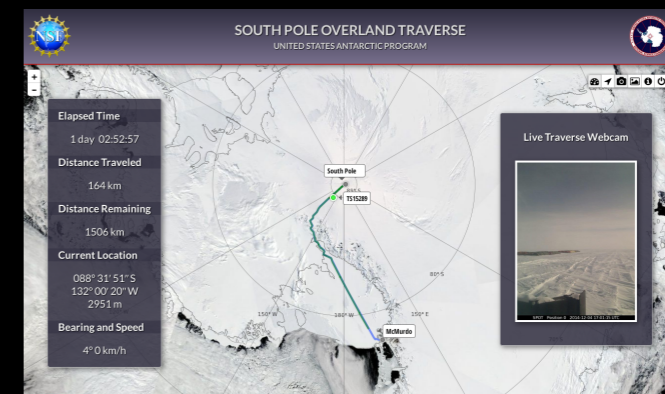
```
<li>  
  <div>message 1</div>  
  <div>message 2</div>  
  <div>message 3</div>  
</li>
```

# WEB CLIENT ARCHITECTURE

ONE WAY DATA FLOW



NEW IMAGE  
NEW GPS POSITION  
VIA WEBSOCKETS



# CLIENT MAPPING TOOLS



Star 10,049 Tweet Follow 12.5K followers Like 5.4k

An Open-Source JavaScript Library for Mobile-Friendly Interactive Maps

Overview Features **Tutorials** API Download Plugins Blog GitHub Twitter Forum

## Leaflet Features

Leaflet doesn't try to do everything for everyone. Instead it focuses on making *the basic things work perfectly*. It should still satisfy the needs of the vast majority of map apps developers while being easily extended by [third-party plugins](#).

### Available Map Layers

- Tile layers
- Markers
- Popups
- Vector layers: polylines, polygons, circles, rectangles, circle markers
- GeoJSON layers
- Image overlays
- WMS layers

### Visual Features

- Zoom animation (for all layers, including tile layers, markers and vector layers)
- Panning animation
- Smooth continuous zoom on modern mobile devices
- Tile and popup fade animation
- Very nice default design for markers, popups and other map controls
- Retina resolution support for tile layers and markers

### Map Controls


- Zoom buttons
- Attribution
- Layer switcher
- Scale



### Browser Support

On Desktop

# POLAR STEREOGRAPHIC PROJECTION

# MAP TILE SERVER

Data Discovery ▾ Data Centers ▾ Community ▾ Science Disciplines ▾SearchLogin with URS!



## EOSDIS

NASA'S EARTH OBSERVING SYSTEM  
DATA AND INFORMATION SYSTEM

Search

Home **About EOSDIS** Data Our Community User Resources Labs Wiki Register

EOSDIS Project Performance Science System Description Interfaces Requirements News Internal Account Request

**EOSDIS Components**

- Common Metadata Repository (CMR)
  - [EOSDIS Data Centers](#)
- EOS Clearing House (ECHO)
- ESDIS Metrics System (EMS)
- Global Imagery Browse Services (GIBS)**
  - [Available Imagery Products](#)
  - [Technical Information / Wiki](#)
  - [Blog](#)
- LANCE
  - [EOS Networks](#)
  - [Science Investigator-led Processing Systems \(SIPS\)](#)

Home » [About EOSDIS](#) » [Science System Description](#) » [EOSDIS Components](#)

## Global Imagery Browse Services (GIBS)

Share/Send Print


### Introduction


The Global Imagery Browse Services (GIBS) system is a core EOSDIS component which provides a scalable, responsive, highly available, and community standards based set of imagery services. These services are designed with the goal of advancing user interactions with EOSDIS' inter-disciplinary data through enhanced visual representation and discovery. These advancements are realized in the following ways:

- [Improved Approachability & Extended Reach](#) - Imagery greatly improves the usability of NASA Earth science data to new communities and improves cross-disciplinary data discovery through full-resolution, "no boundaries" (or "granule-free") interaction patterns.
- [Cohesive Approach to Imagery](#) - As a core EOSDIS component, GIBS integrates with other core EOSDIS systems, components, and processes to provide a primary, authoritative source for EOSDIS imagery.
- [Improved Cross-Discipline Research](#) - GIBS leverages science expertise and interoperable standards to provide science-based products that enhance cross-discipline discovery and analysis.

# POLAR STEREOGRAPHIC PROJECTION

# MAP TILE SERVER

 **EARTHDATA** Data Discovery ▾ Data Centers ▾ Community ▾ Science Disciplines ▾

 **EOSDIS**  
NASA'S EARTH OBSERVING SYSTEM  
DATA AND INFORMATION SYSTEM

[Home](#) **About EOSDIS** Data Our Community User Resources

[EOSDIS Project](#) [Performance](#) [Science System Description](#)

**EOSDIS Components**

- Common Metadata Repository (CMR)
  - [EOSDIS Data Centers](#)
- EOS Clearing House (ECHO)
- ESDIS Metrics System (EMS)
- Global Imagery Browse Services (GIBS)**
  - [Available Imagery Products](#)
  - [Technical Information / Wiki](#)
  - [Blog](#)
- LANCE
  - [EOS Networks](#)
  - [Science Investigator-led Processing Systems \(SIPS\)](#)

Home » About EOSDIS

## Global Imagery Browse Services (GIBS)

### Introduction

The Global Imagery Browse Services (GIBS) is available, and co-located with other EOSDIS systems, and interactions with other EOSDIS systems are realized in the following ways:

1. [Improved Accessibility](#) - GIBS provides a single, authoritative source for EOSDIS imagery, making it easier for communities to find and use the data.
2. [Cohesive Approach to Imagery](#) - As a core EOSDIS component, GIBS integrates with other core EOSDIS systems, components, and processes to provide a primary, authoritative source for EOSDIS imagery.
3. [Improved Cross-Discipline Research](#) - GIBS leverages science expertise and interoperable standards to provide science-based products that enhance cross-discipline discovery and analysis.

[Leaflet](#) [NASA EOSDIS GIBS](#) [View Source](#)

# OPEN-SOURCE PROJECTS

The image displays three overlapping screenshots of GitHub repository pages, illustrating various open-source projects. The top-most screenshot shows the repository for **nasa-gibs / gibs-web-examples**, which has 80 commits and 21 stars. The middle screenshot shows the repository for **Leaflet / Leaflet**, a JavaScript library for mobile-friendly maps, with 3,578 commits and 10,049 stars. The bottom-most screenshot shows the repository for **facebook / react**, a declarative, efficient, and flexible JavaScript library for building user interfaces, with 3,971 commits, 11 branches, 25 releases, 336 contributors, and 18,409 stars. The React page also shows a list of recent commits, including a merge pull request from MaximAbramchuck and a commit from spicyj.

**GitHub** This repository Search Explore Features Enterprise Blog Sign up Sign in

**nasa-gibs / gibs-web-examples** Watch 8 Star 21 Fork 7

Examples of using GIBS with various...  
80 commits

branch: release

Version bump  
mike-mcgann authored on Jan 9

bin CSS/JS lint re...  
bing Removed proto...  
cesium Changing days...  
deploy Version bump...  
google Removed proto...  
leaflet Removed proto...  
openlayers Upgrade to ope...  
openlayers2 Removed proto...  
.gitignore Linting for JS/C...  
travis.yml Travis config...

**GitHub** This repository Search Explore Features Enterprise Blog Sign up Sign in

**Leaflet / Leaflet** Watch 573 Star 10,049 Fork 1,819

JavaScript library for mobile-friend...  
3,578 commits

branch: master

Merge pull request #3303 from Trufi/pant...  
mourner authored 4 days ago

build Use standa...  
debug restore tog...  
dist Stricter sel...  
spec Merge bran...  
src Merge pull...  
.eslintrc add indent...  
.gitignore add publish...  
.npmignore Add .npmig...  
.travis.yml Changed d...  
CHANGELOG.md add 1.0.7.2...

**GitHub** This repository Search Explore Features Enterprise Blog Sign up Sign in

**facebook / react** Watch 1,252 Star 18,409 Fork 2,458

A declarative, efficient, and flexible JavaScript library for building user interfaces. <http://facebook.github.io/react/>

3,971 commits 11 branches 25 releases 336 contributors

branch: master react / +

Merge pull request #3475 from MaximAbramchuck/patch-1 ...  
spicyj authored a day ago latest commit 5dee15273f

bin	Fix module option parsing of jsx command	11 days ago
docs	Merge pull request #3442 from spicyj/kill-initializeTouchEvent	3 days ago
examples	Add missing semicolon	a day ago
gem-react-source	BSD + PATENTS	5 months ago
grunt	Remove perf folder	5 days ago
jest	lint from root	a month ago
npm-jsx_orphaned_brackets_t...	jsx_orphaned_brackets_transformer v1.0.1	11 days ago
npm-react-tools	Documents that JSX tool is transforming files with .js extension (and...	2 months ago
npm-react	Bump version so we can get back to work	12 days ago
scripts	AUTHORS	2 years ago

Code  
Issues 413  
Pull requests 112  
Wiki  
Pulse  
Graphs

HTTPS clone URL  
`https://github.com/face`  
You can clone with [HTTPS](#) or [Subversion](#).

Download ZIP

# MAKING THE PAGE FAST

- Minimize number downloads from web server - use modern tooling such as WebPack to create a single bundle
- Snapshot table in database, updated via triggers
- Proper SQL indexing, schema and queries
- Smart caching and DOM management in client
- Line smoothing and marker grouping