pcwx: Open Source Hardware and Software Camera and DAS

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What

- Open hardware and software platform for acquiring and presenting camera images and sensor data

or … more simply:

- a camera that you can plug sensors into and program to do whatever you need

Why

- Existing DAS and camera infrastructure too expensive and complicated for many applications
- No tight coupling between camera images and sensor data
- COTS products are typically closed source or barely open source

Starting Hardware Platform

- Raspberry Pi single board computer running Linux
- Pi Camera module
- Ethernet or COTS communications modules (802.11, cell, etc)

New parts

- Hardware pieces
  - enclosures
  - data acquistion boards and accessories
- Software pieces
  - data gathering
  - data processing
  - data distribution
  - data logging
  - data display

Why Raspberry Pi?

- *Large* community
- Low cost Linux computer module
  - $20 Pi A+ (1xUSB port)
  - $25 Pi B+ (4xUSB + Ethernet)
  - $35 Pi 2 (4xUSB + Ethernet + 1GB RAM)
  - $25 megapixel camera
- Low power consumption
  - Typically <1.5 watts with accessorie
- Open source, more or less

Outdoor Enclosures

- Machined plastic or aluminum
- O-ring sealed
- IP68 rated
- Configurable
- Easily modifiable for custom applications
- Easy mounting

Indoor Enclosure

- Formed aluminum
- DIN rail or wall mountable
- Access to all Raspberry PI connectors

pcwx (rev3) features

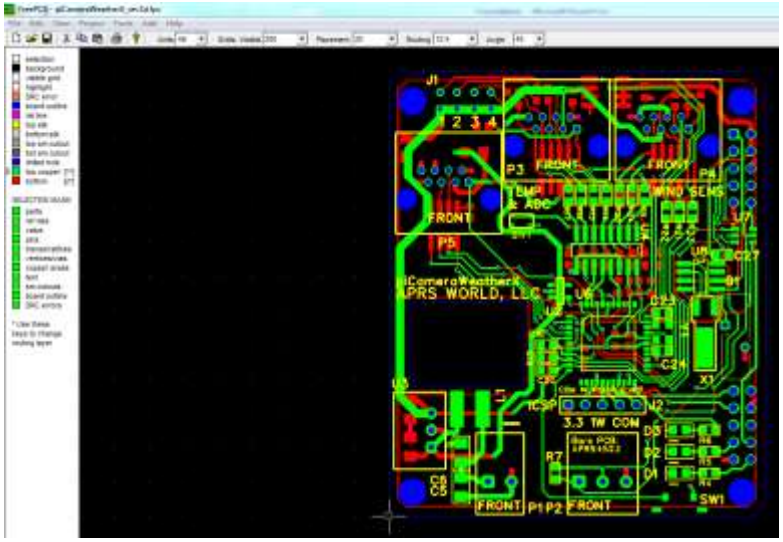
- DC input switching power supply
  - 7 to 32 VDC in
- Analog and digital inputs w/TVS
- Power control and watchdog timer for Pi
- Battery backed real time clock
- RS-485 (Modbus) port for talking to other devices

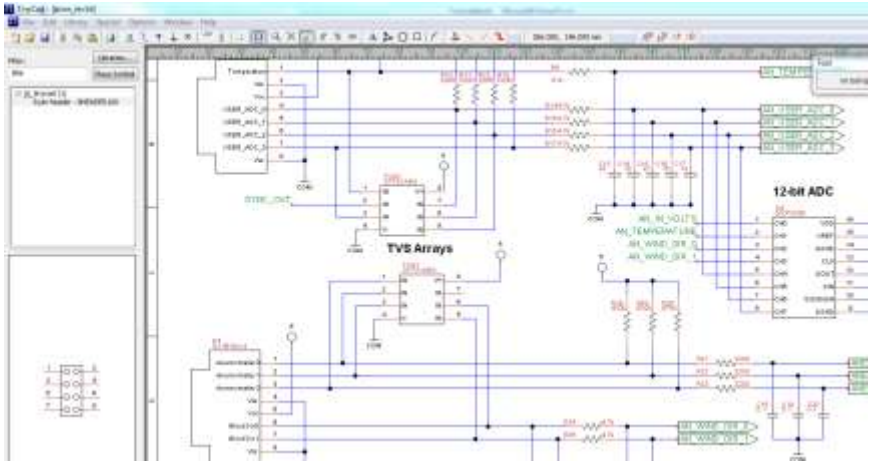
pcwx (rev3) board DAS inputs

- Counters / Hz inputs
  - 3 x 5 volt digital
    - anemometers
    - rain gauge
    - RPM
- Analog – 12-bit
  - 1 x Input voltage
    - 0 to 35VDC
  - 7 x User accessible
    - 0 to 5 volt
- Dallas 1-wire
  - field bus for low speed sensors

Open Source

- Linux / Raspbian / node.js / etc
  - usual sources
- Acquisition scripts and ecosystem
  - APRS World's github.com
- Data acquisition hardware and firmware
  - APRS World's github.com
- Enclosures
  - APRS World's website



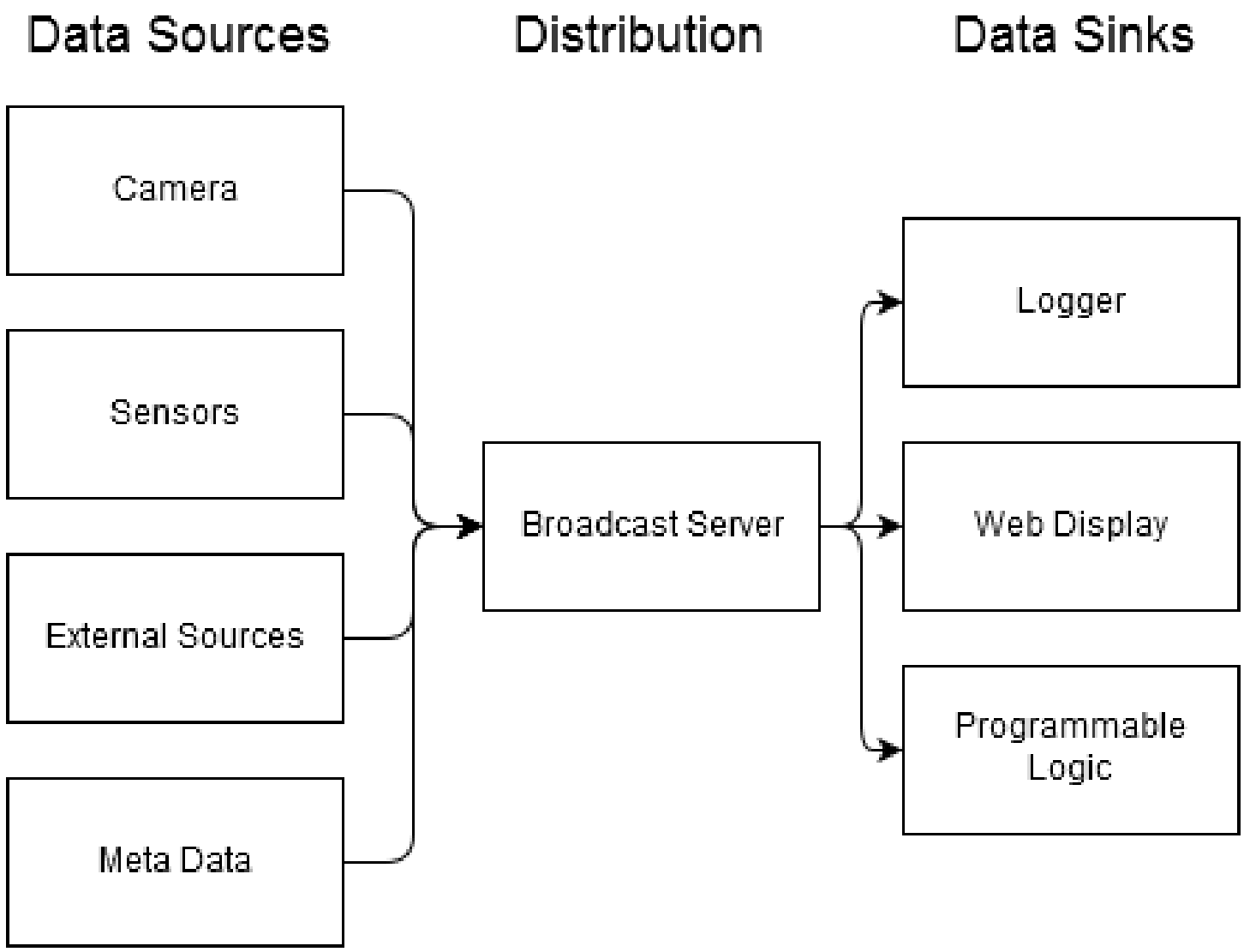


GitHub

Software

- Linux
  - Raspbian (Debian) based operating system distribution
- PHP / BASH / Python / etc
  - Modbus sensor query software
- JSON
  - Data interchange format
- node.js
  - WebSocket and Web Server

Data Flow


Data Sources
Distribution
Data Sinks
Camera
Sensors
External Sources
Meta Data
Broadcast Server
Logger
Web Display
Programmable Logic

Data Source: Camera

- Still: 5 megapixel (2592 x 1944 pixels)
- Video: Up to 1080p30 H.264 accelerated
- Available without IR filter for nighttime application
- Acquisition triggers:
  - periodic timer (i.e. once per minute)
  - event (i.e. RPM exceeds threshold)
- Post acquisition scripts to modify image before publishing

Data Source: Sensors

- Sensors can be attached to pcwx analog and digital inputs
- Read from Pi via Modbus
- Software scales and processes raw data values into actual units

```
$p40HC=new processAnemometer("Wind Speed","m/s",0.765,0.350,'0.1');
$pmm->addProcessor(1,$p40HC);
$p40HC=new processAnemometer("Wind Gust","m/s",0.765,0.350,'0.1');
$pmm->addProcessor(2,$p40HC);

$pRainRaw=new process("Optical Rain Gauge","counts");
$pmm->addProcessor(6,$pRainRaw);

$pVin=new processLinear("Input Voltage","volts",0.024477,0.0,'0.2');
$pmm->addProcessor(18,$pVin);
```

Data Sources: External Sources

- Remote controllers and platforms via built-in RS-485, Ethernet, USB, etc
  - Example: Inverter via Modbus/TCP
  - Example: USB RTD interface
- LAN or WAN data sources
  - Example: Barometric pressure from NOAA via HTTP / XML
  - Example: LIDAR data from elsewhere on the site
- Reduces sensor duplication and associated costs

Data Source: Meta Data

- Internal system health parameters
  - Examples: disk space available, memory usage, CPU temperature
- Sensor information
  - Example: Sensor serial numbers and calibration data
  - Example: GPS time server accuracy
- User input
  - Example: notes from operator

```
top - 08:09:38 up 33 days, 22:16,  4 users,  load average: 0.28, 0.27, 0.18
Tasks: 223 total,   1 running, 222 sleeping,   0 stopped,   0 zombie
Cpu(s):  0.1%us,  0.0%sy,  0.0%ni, 99.8%id,  0.0%wa,  0.0%hi,  0.1%si,  0.0%st
Mem:   4117516k total,  3988756k used,   128760k free,   451356k buffers
Swap:  3229024k total,     1408k used,  3227616k free,  2792348k cached
```

Data Distribution: wsBroadcast

- Accepts data
  - TCP & UDP & WebSockets
- Broadcasts to all connected clients
  - WebSockets
  - HTTP
- Web server for static and dynamic content
- Small application written in node.js (JavaScript)
- Can run locally on Pi or on central servers

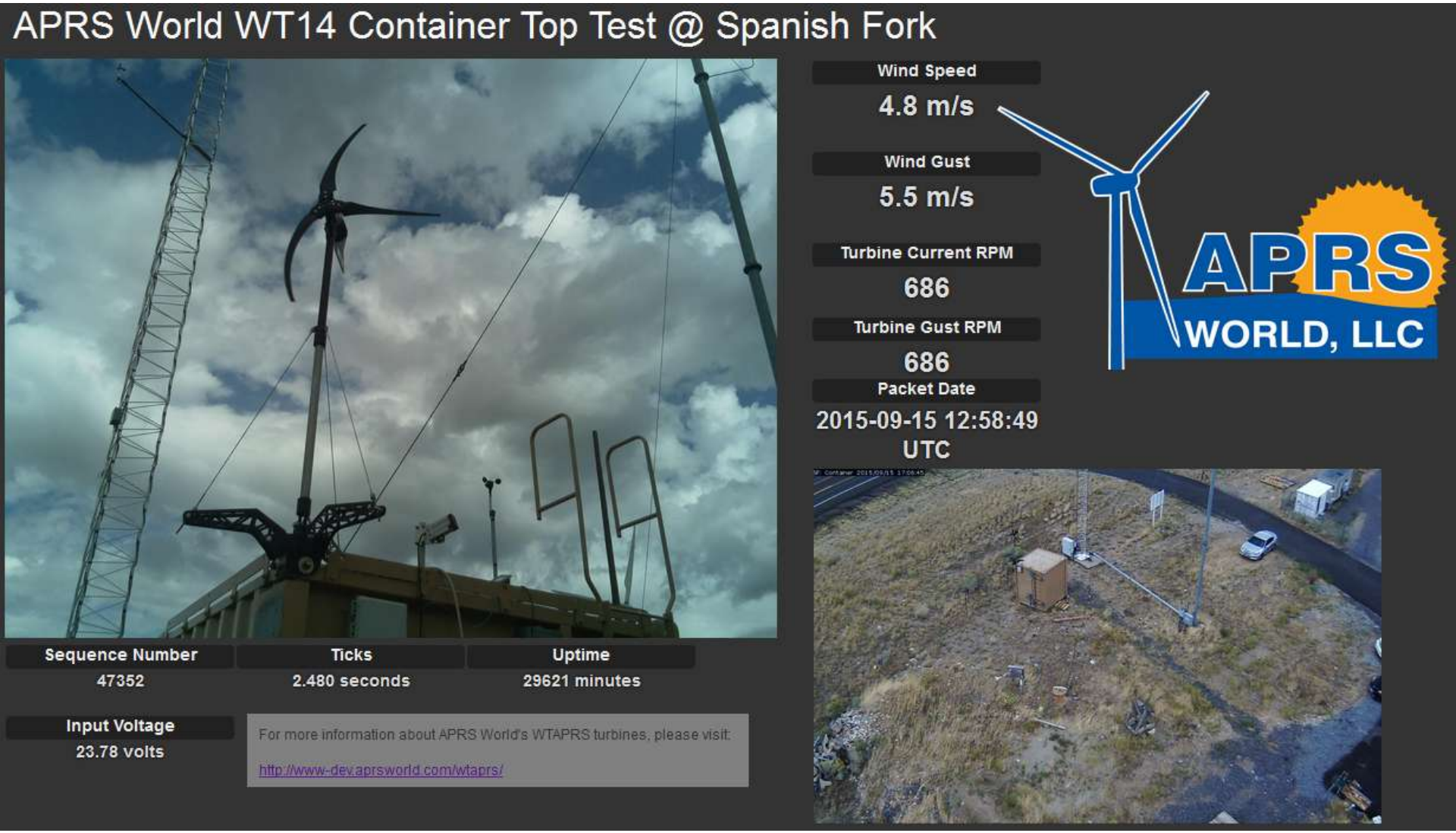
Data Sink: Logger

- Record time series data
  - Example: Files
  - Example: Relational database on outside computer
- Multiple loggers can be running, so data can automatically be sent to multiple places
  - off-site backup

Data Sink: wsWebDisplay

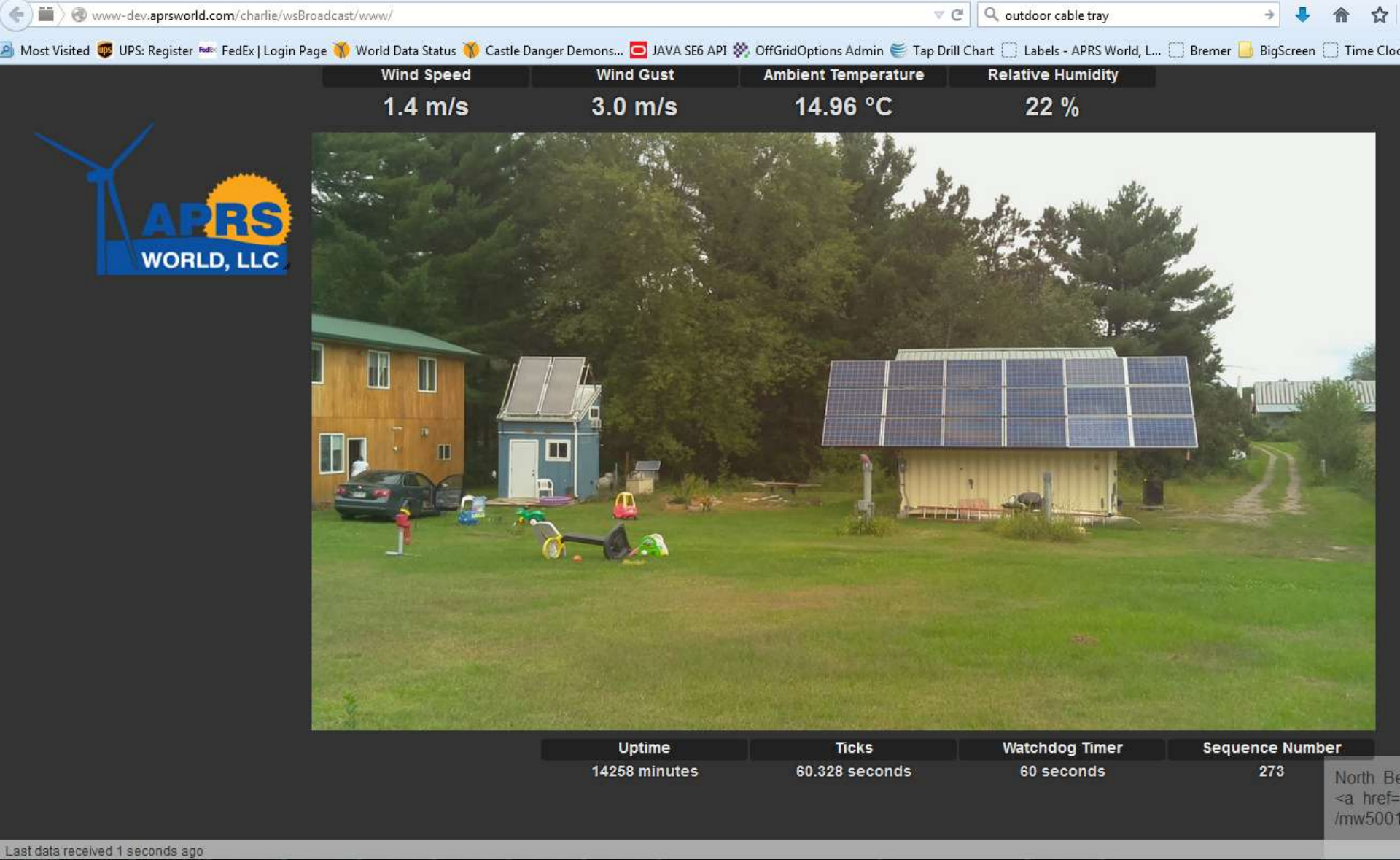
- Web front end for displaying data and images
- Completely configurable in web browser
- Can display data from many sources
- Pushed to web browser using WebSockets
- Runs entirely in web browser using HTML and JavaScript
- Works without Internet connection

Data Sink: demo building wsWebDisplay application



Temporary URL: http://www-dev.aprsworld.com/charlie/wsBroadcast/www/

Data Sink: wsWebDisplay Example



Data Sink: Programmable Logic

- Automated programmable logic for control
  - Example: e-mail when fault occurs
  - Example: cycle power to crashed device

Status

- Outdoor Enclosure
  - stable and well tested
  - in production
- Indoor Enclosure
  - starting beta testing
- pcwx DAS / control board
  - on revision 3
  - stable and functional
  - adding firmware features
  - ready for production
- Software stack
  - in development

Outdoor Test Locations

- Alaska
  - Bering Glacier @ Alaska Earthquake Center
  - Deadhorse / Haul Road test
  - Fairbanks @ APRS World
  - Valdez @ Copper Valley Telecom
- Antarctica (soon)
- Minnesota
  - Fremont @ APRS World
  - Goodview @ individual
  - Minnesota City @ APRS World
- North Carolina (soon)
  - Beech Mountain @ Appalachian State University
- Utah
  - Spanish Fork @ APRS World @ Windward
- Virginia
  - Wallops Island @ NASA Employee
- Wisconsin
  - Madeline Island @ APRS World
  - North Bend @ individual

Test Site: Alaska @ Bering Glacier

https://youtu.be/H4gGgiLEr3c

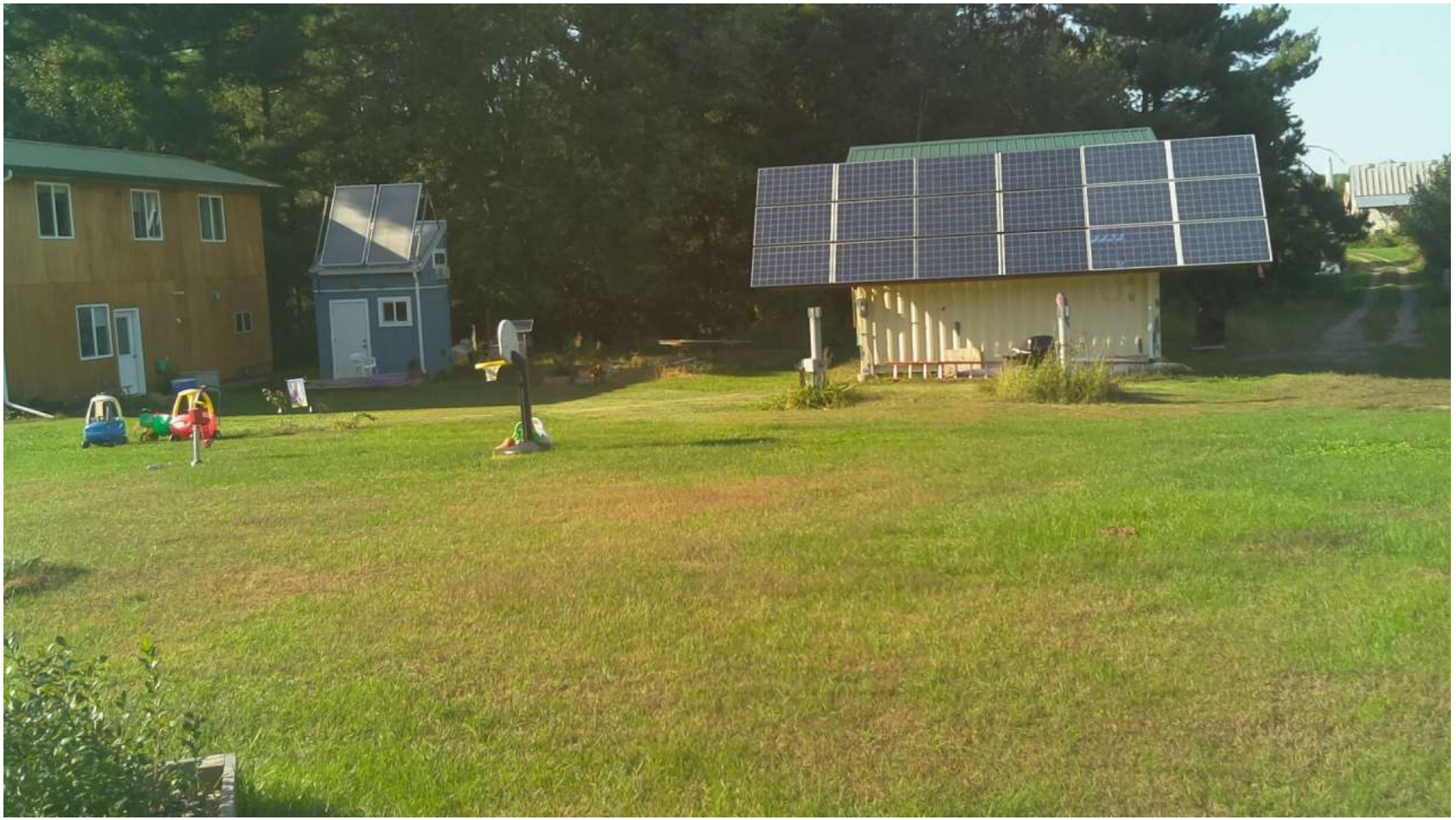
Test: Alaska @ Deadhorse / Haul Road

Test Site: Alaska @ Fairbanks

Test Site: Alaska @ Valdez

Test Site: Utah @ Spanish Fork

Test Site: Wisconsin @ North Bend



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