Final Presentation - JPL SIP 2016

Alex Crawford

Jet Propulsion Laboratory
California Institute of Technology

Special Thanks

Main Assignments and Contributions

1. Electronic archival and decommissioning of research laboratories
    a. Transition of document storage from paper to electronic
    b. Compilation of key information pertaining to isotope location, amount, ownership, etc.
2. Evaluation of inexpensive Raspberry-Pi based ADS-B[1] receiver for outdoor laser safety aircraft detection
    a. Installation and secondary revisions of aircraft detection program onto Raspberry-Pi
    b. Development of custom scripts for data collection and analysis

[1]Automatic Dependent Surveillance Broadcast (Receiver)

Radiation

Decommissioning JPL Research Laboratories

- Phase two of the three-phase “Legacy Radiation Source Project”:
    a. Identify legacy sources kept in storage from past JPL research
    b. Dispose of unneeded sources
    c. Scan paper records of source location (use and storage) and isotope identities
    d. Organize decommissioning surveys for unrestricted release
    e. Convert archived records to electronic (searchable) database

Nuclear Regulatory Commission (NRC)

Title 10, Code of Federal Regulations, § 30.35

- “shall keep records of information important to the decommissioning of a facility in an identified location until the site is released for unrestricted use”
- “a list contained in a single document and updated every 2 years, of…all areas designated and formerly designated restricted areas”

Archival Process and Digitization

- Documents ranging from ~1965 to early 2000s scanned
- All documents read to pull specific information of interest for database
  - Isotope
  - Amount of isotope
  - Location of use / storage
  - Authorized user
  - Dates of authorized use
  - Corresponding UA number (documentation purposes)

Laser Safety

Laser Safety Requirements

JPL laser safety program is based on government regulations for safe laser beam operation

Organization	**Government Regulation Objective**	**Requirement**
OSHA / FDA	To ensure laser operation poses no threat to operator or personnel *Source: ANSI Z136 Series*	Eye wear, beam blocks, posted signs and controls
FAA	**Avoid exposure of flying public to laser radiation that exceeds MPE** ***Source: AC 70-1***	**Implement control measures as negotiated with FAA and defined in FAA Letter Of Determination response**
LCH	Avoid Illumination of spacecraft at unsafe laser powers *Source: DOD Instruction 3100.11*	Registration of laser with LCH
NASA LSRB	All of the above	NPR 1800.1D

Importance of Outdoor Laser Safety to FAA[2] Airspace

- In 2015 an average of 20 intentional laser strikes per day were reported in the U.S.
- Lasers can cause eye injuries or other effects that interfere with the pilot's ability to fly
  - Most dangerous during approach and landing
  - Eye injuries (*none confirmed*)
  - Flash blindness (*several confirmed cases*)
  - Laser dazzle can startle or distract pilots

[2]Federal Aviation Administration

Techniques for Avoiding Aircraft

- Observers
  - FAA only allows for aircraft up to 3 nautical miles (~18,000 ft)
  - attention span for human observers and fatigue
- Radar
- Thermal Imaging
- Transponder-Based Aircraft Detection

Transponder Based Aircraft Detection

- FAA “NextGen” ADS-B* Transmitter and Receiver System
  - Satellite based successor to radar
  - All aircraft required to carry ADS-B by 2020
  - “[transmits] information about an aircraft's [GPS] location, ground speed and other data to satellites ***once per second*** … compared to radar technology, which sweeps for position information every 5 to 12 seconds”
  - Does not require ground based interrogation to broadcast signal
- Inexpensive (self-made) receiver with an outdoor antenna tuned to 1090 MHz
  - Raspberry-pi based receiver fitted with a FlightAware USB signal receiver, 1090 MHz band-pass filter, and an antenna

Source: http://www.faa.gov/nextgen/equipadsb/ins_and_outs/

*Automatic Dependent Surveillance Broadcast

Outdoor Laser Safety System ADS-B Evaluation

- Put together hardware and install data acquisition software (Linux/Bash)
- Look over source code to understand how received signals are processed and add any needed information for data output (C)
- Write custom scripts for various data retrieval and analysis (Python & SQL):
    a. Socket_Connect_Dump.py
    b. Connect_Parse_Push.py
    c. Import_Historic_Files_SQL.py
    d. acti_Stats_Generator.py

Inexpensive ADS-B Receiver Hardware Setup

Indoor

Raspberry Pi

USB Hub

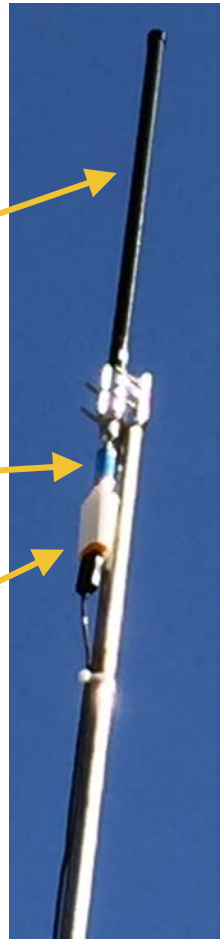
Outdoor

Antenna

Band-Pass Filter

USB Receiver

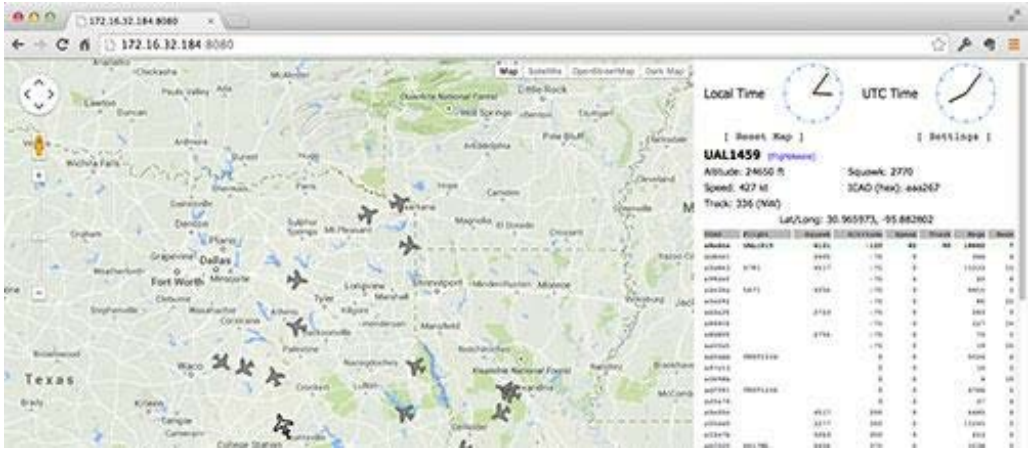
USB Extension Cable



Antenna mounted on 10 ft pole for increased visibility on Bld. 238

Data Collection

- Utilized open-source program “dump1090”
  - Collects raw data and translates binary transmission into user-readable formats
- Modified “dump1090” to include time stamp for archival purposes
  - No time stamps included because the program is designed for live-streaming



Source : https://media.readthedocs.org/pdf/adsb-decode-guide/latest/adsb-decode-guide.pdf

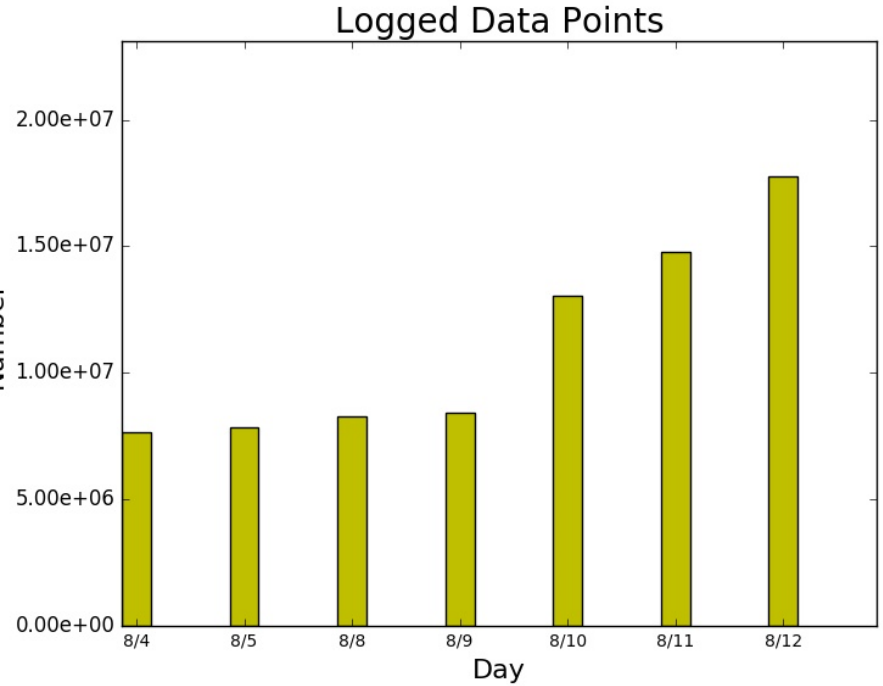
Data Collection (cont.)

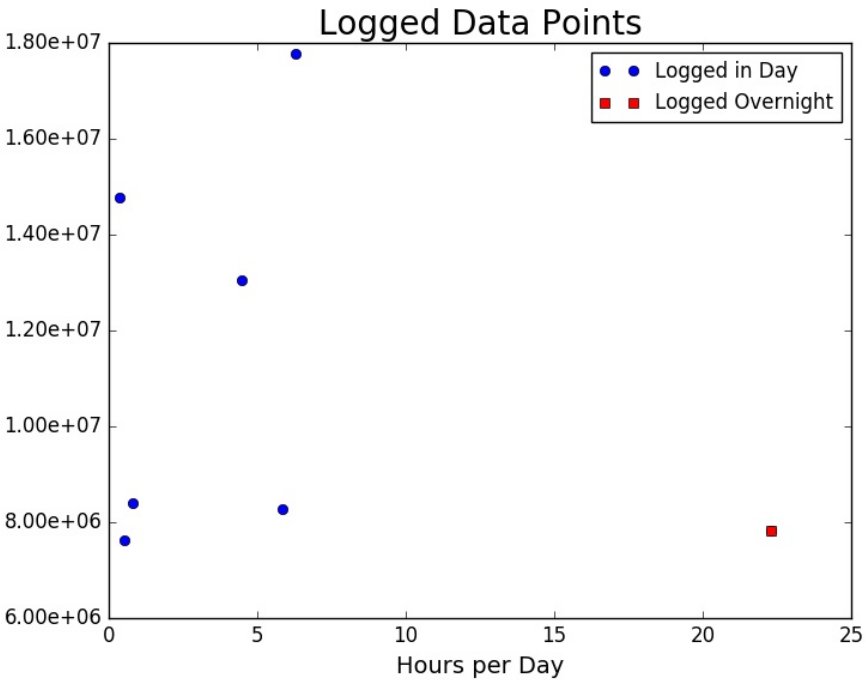
	hex	flight	lat	lon	altitude	track	speed	syst_time	syst_date
89	c0054f	ACA789	33.984344	-118.083513	1332	265	505	10:23:23.485	08/09/2016
90	a2ae06	N272BC	34.24648	-118.465061	3670	27	613	10:23:23.485	08/09/2016
91	ab0903	N81WM	33.092285	-116.357794	0	53	250	10:23:36.165	08/09/2016
92	a5dee3	ASA220	32.956833	-117.475378	7965	133	844	10:23:36.165	08/09/2016
93	7c492b	QFA7	33.193726	-116.230518	11880	89	990	10:23:36.165	08/09/2016
94	ad0e61	AAL1320	33.477585	-117.737347	3175	83	574	10:23:36.165	08/09/2016

- Standard data included in output across all versions of “dump1090”:
  - Hex ID value → unique to each aircraft
  - Latitude, Longitude, Altitude
  - Flight (ICAO) code → included for all commercial aircraft and some private aircraft
    - Non-commercial flights’ logged ICAO[3] code is inconsistent with tail number
- Used SQL to store and easily access data (for analysis) due to the amount of data being received
  - Slight data compression compared to storing data in text format or excel

[3]International Civil Aviation Organization

Amount of Data Collected





Scripts - Data Collection and Analysis

- Socket_Connect_Dump.py
  - Remotely connect to Raspberry Pi port and collect Base Station formatted data from program to extract time-stamp … [Not Used]
- Connect_Parse_Push.py
  - Access web page to extract JSON formatted data (updated by “dump1090” every second)
  - Grabs outputted data and pushes it into SQL in real time
- Import_Historic_Files_SQL.py
  - Formats text files containing data from earlier data collection technique and imports to SQL
- acti_Stats_Generator.py
  - Reads all databases to pull aircraft positional and identification information
  - Calculate slant range for each data “set” and identify unique flights within tables
  - Plot Probability Density Function (PDF) and Cumulative Density Function (CDF) of slant range
  - Identify and count unique commercial flights to plot against total flights

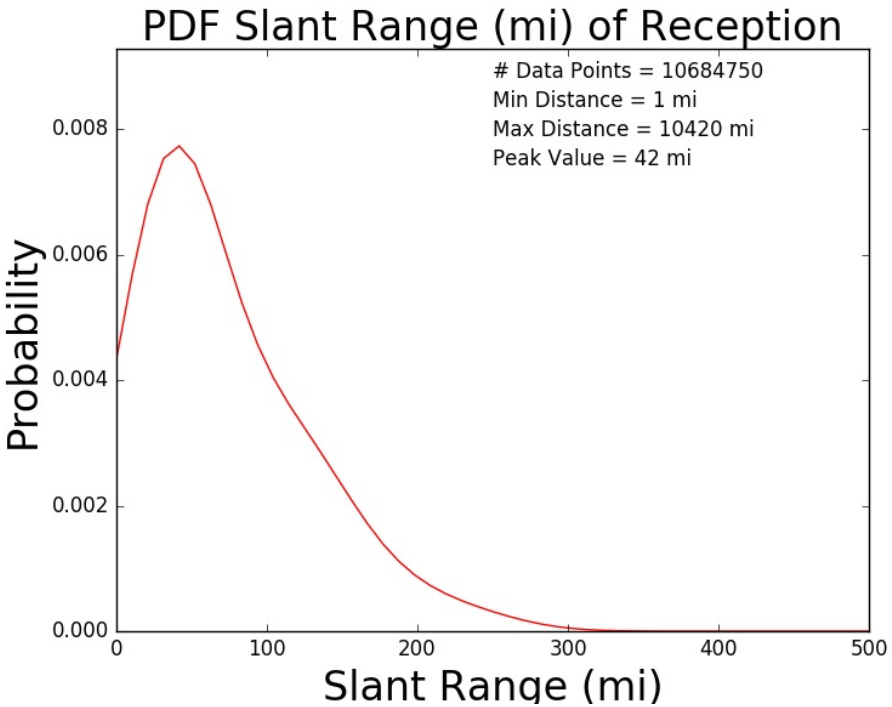
Data analysis

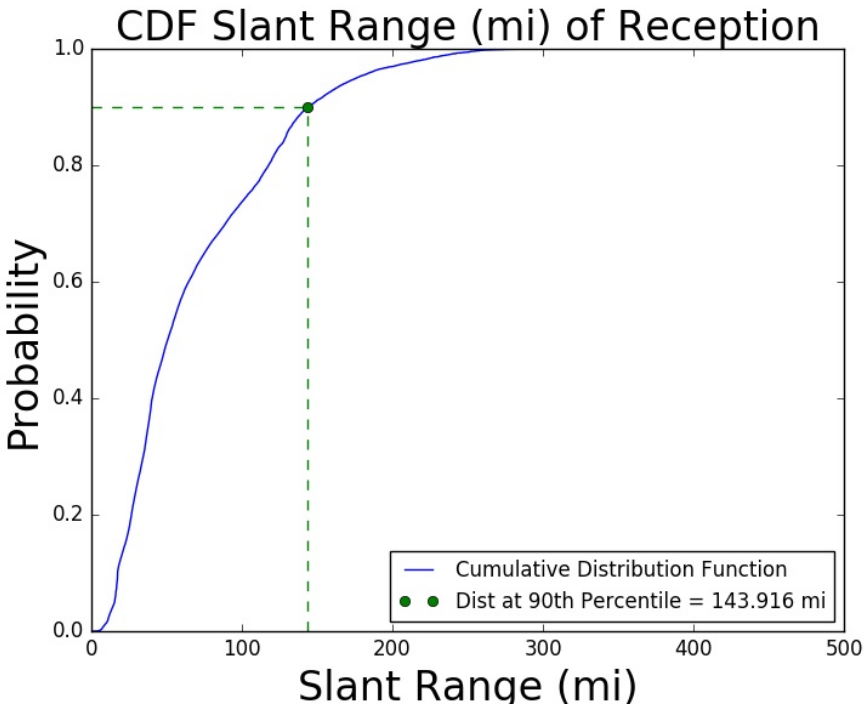
- Probability Density Function and Cumulative Density Function
  - slant range (reception distance of receiver)
- Scatter Plot
  - Count of all data points logged vs duration of log period
- Multiple Bar Chart
  - Count of unique flights per day and breakdown into commercial and other
- Determine slant range (R_{slant}) from latitude, longitude, and altitude

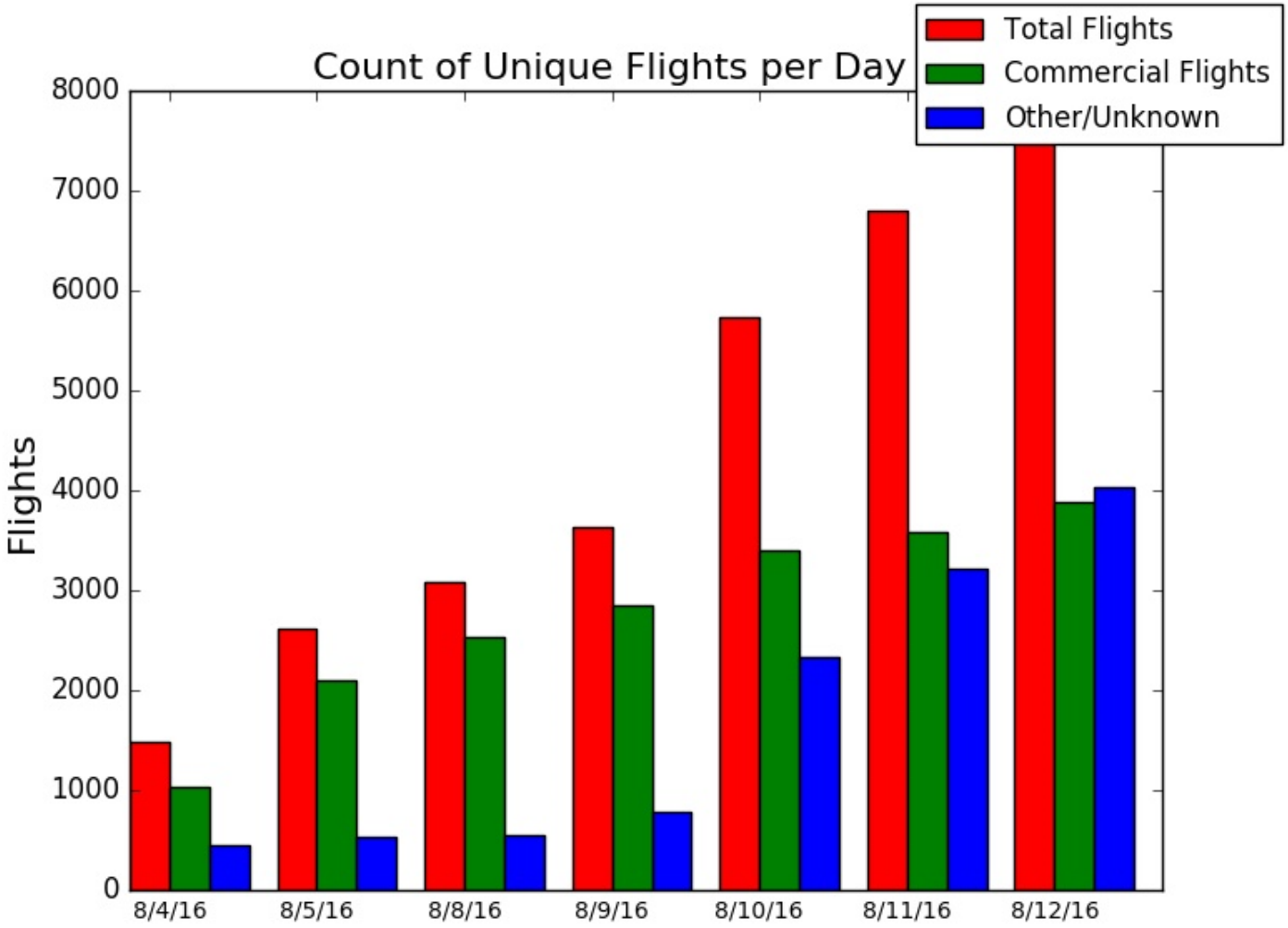
$$D_{short} = 2\sqrt{\sin\left[\frac{lat_1 - lat_2}{2}\right]^2 + \cos(lat_1)\cos(lat_2)\sin\left[\frac{lon_1 - lon_2}{2}\right]^2}$$

$$R_{slant} = \sqrt{alt^2 + {D_{short}}^2}$$

Range Distance Statistics of Receiver






Count of Unique Flights per Day
Total Flights
Commercial Flights
Other/Unknown
Flights
0
1000
2000
3000
4000
5000
6000
7000
8000
8/4/16
8/5/16
8/8/16
8/9/16
8/10/16
8/11/16
8/12/16

Summary and Conclusions

Compile single comprehensive document of historic information useful to the decommissioning of radioisotopes in JPL

- Scan archived documents and write important information to single excel database
- Assembly of information into queried Access database (part 3 of project) will be completed by Marc

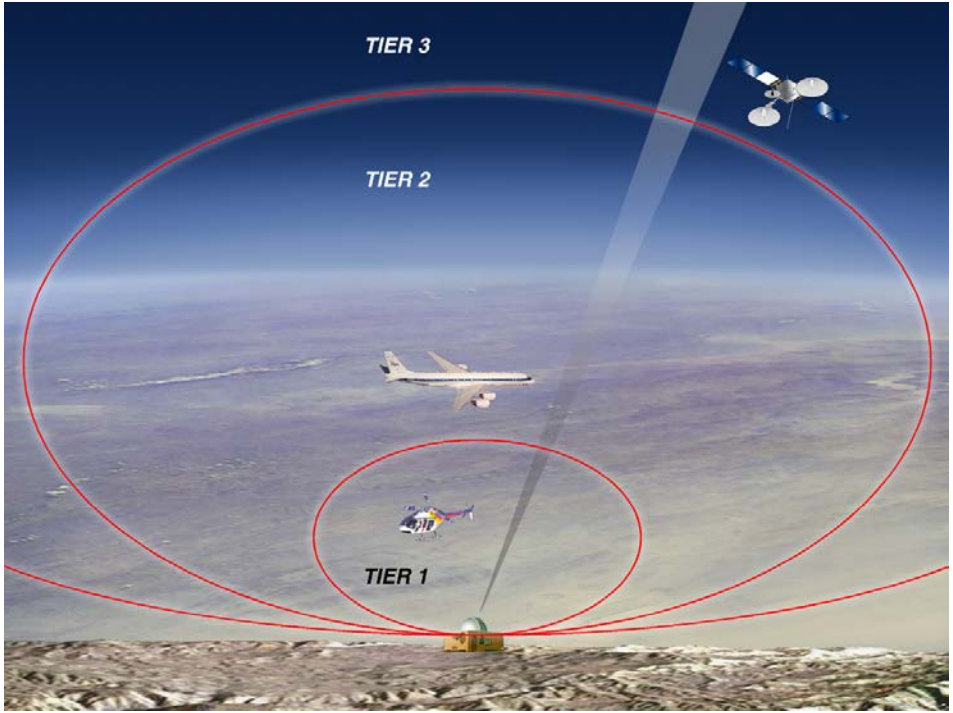
In real-time, collect data from Raspberry-Pi ADS-B receiver, transfer data to SQL, and compile statistics pertaining to receiver effectiveness

- Data was successfully collected and transferred to SQL in real-time
- Statistics compiled after data collection - difficult to generate graphs of entire data set (~34 GB)
- System ran without trouble for about a month until the hardware was disconnected prematurely
    - New SD card has been inserted to determine where problem lies
- Future work:
    - Compare data to FAA air traffic data
    - Antenna relocation to Table Mountain Facility (TMF) for testing
    - Additional statistics (i.e. distribution of flights by azimuthal and elevation position)

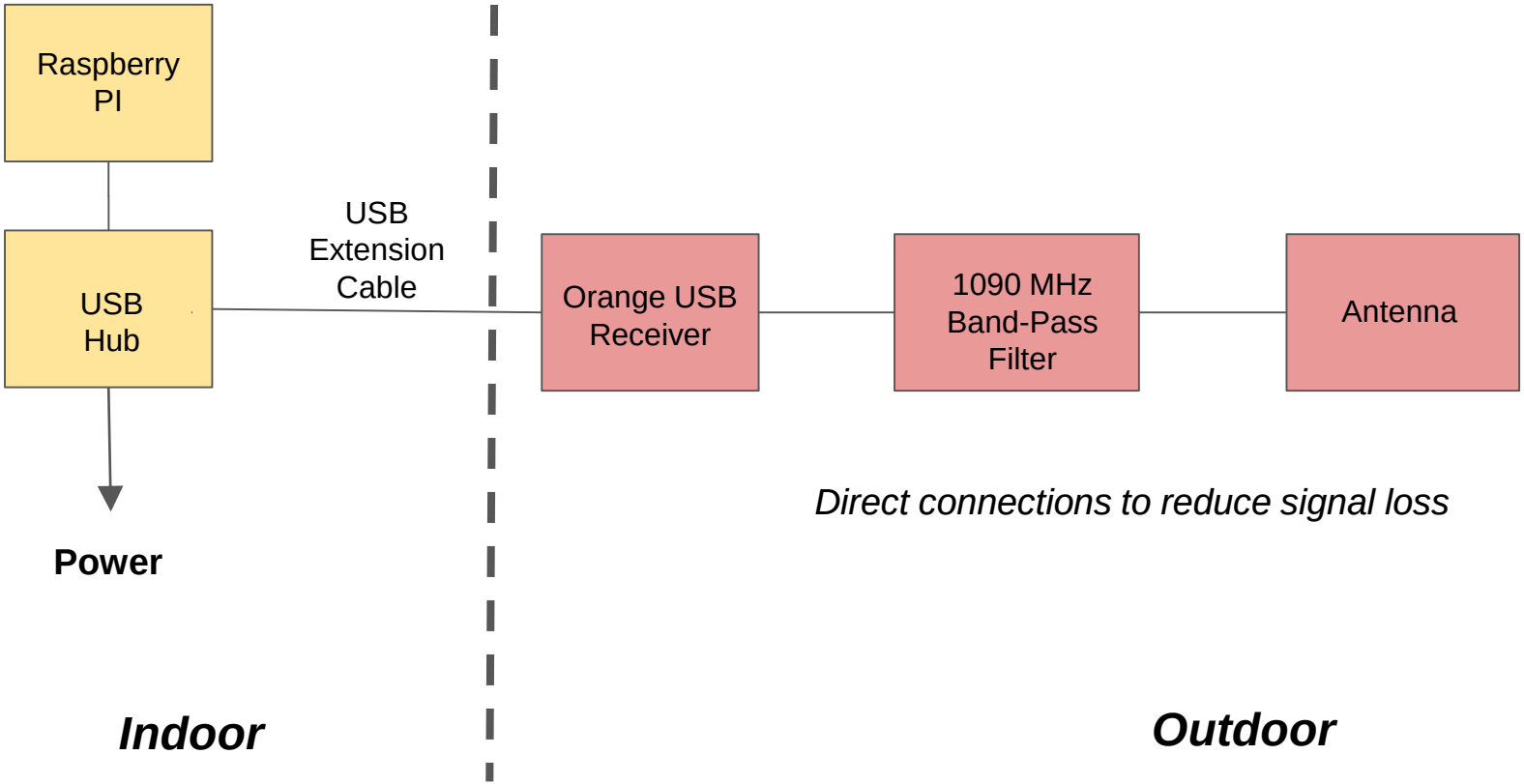
Backup Slides

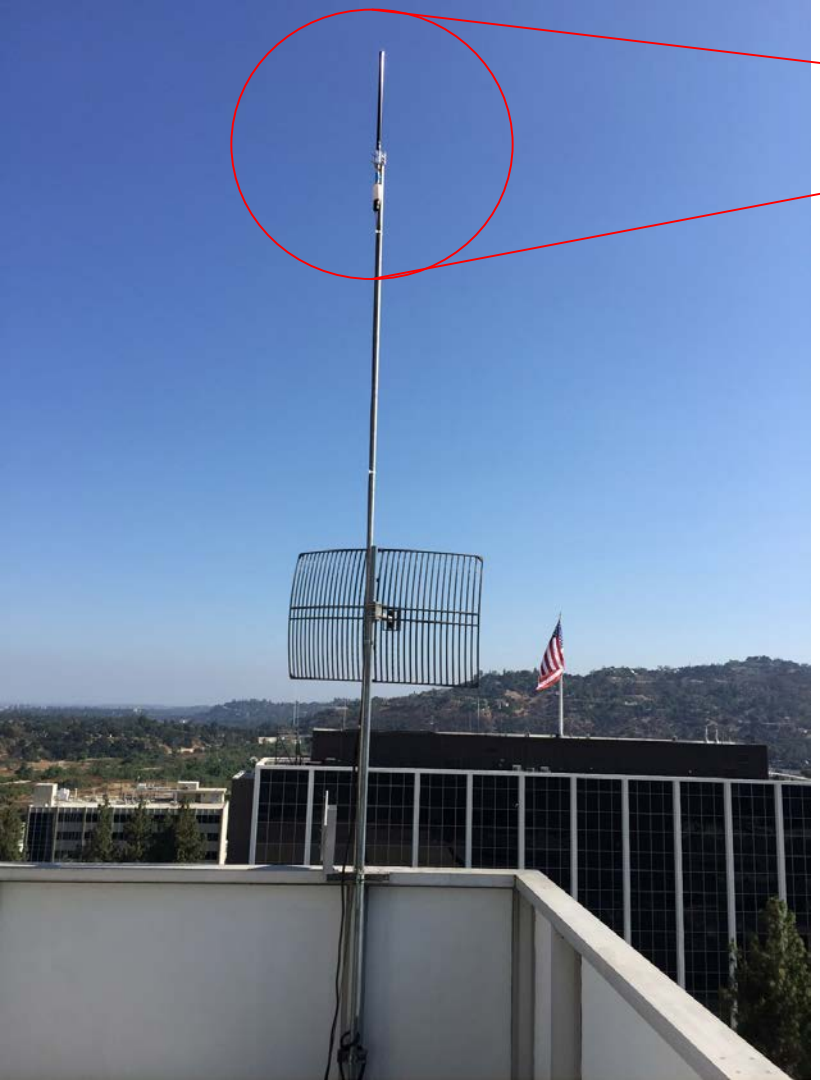
OCTL Three-Tier Laser Safety Strategy

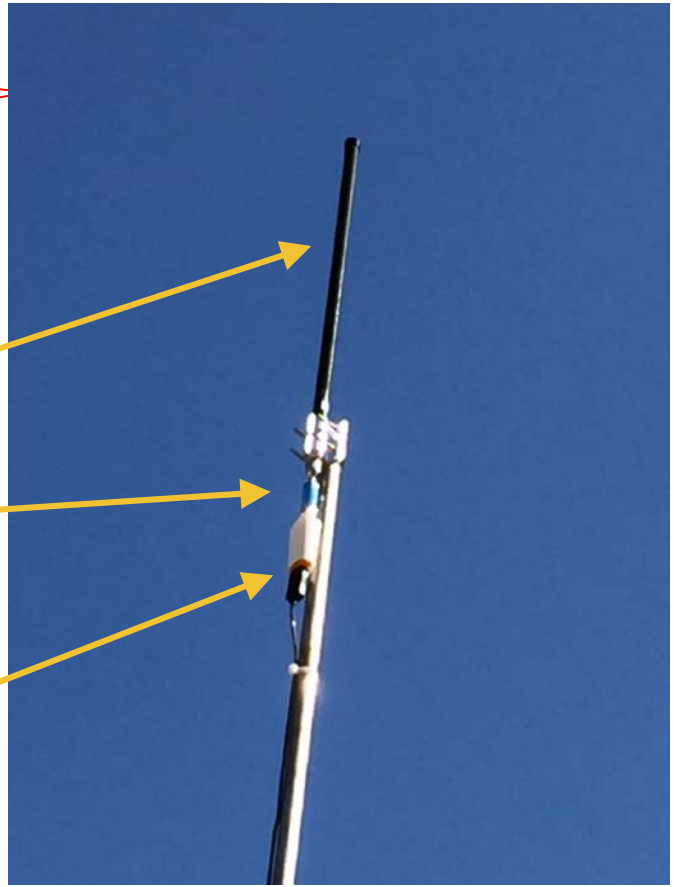
- Navigable Airspace (>400 feet)
- Tier 1 – FAA controlled region ranging up to 3.4 km
- Tier 2 – FAA controlled ellipsoidal region ranging to 20 km at zenith, and 58 km at 20° elevation
- Near-Earth Space
- Tier 3 – Laser Clearinghouse (STRATCOM) region extends from near-Earth to ranges of geo-stationary and elliptical orbiting satellites



Hardware … what is the R-Pi?







Mounted on 10 ft pole on roof of building 238

Examples of Data Headers:

squawk	flight	messages	track	lon	altitude	vert_rate	hex	validposition	mlat	validtrack	lat	seen	speed
0		7	0	0	26825	0	acf207	0	0	0	0	0	0
0	N11GG	34	131	-117.591995	2050	1344	a02a77	1	0	1	33.877441	0	114
0	CPZ6058	70	265	-116.824241	21750	-2176	a19e61	1	0	1	33.978058	0	355
2070		68	0	0	31000	0	a23877	0	0	0	0	2	0
0		21	0	0	3600	0	a8d0e2	0	0	0	0	13	0
0		48	0	0	17200	0	aa7a3c	0	0	0	0	0	0

hex	flight	lat	lon	altitude	track	speed	syst_time	syst_date
a097e9	UAL1923	33.491638	-117.817767	2414	114	501	07:22:20.702	08/08/2016
abf2c2	SWA403	32.652832	-117.257739	3129	100	546	07:22:20.702	08/08/2016
a07b3e	AAL2453	33.664018	-118.408756	3221	109	598	07:22:20.702	08/08/2016
a0428a	AAL118	33.644932	-118.264103	4051	90	661	07:22:20.703	08/08/2016
a48ba6	EJA392P	32.835526	-116.968689	5437	46	590	07:22:20.703	08/08/2016
abbbc7	VRD352	33.152252	-117.794916	5132	311	700	07:22:20.703	08/08/2016