BuddyCam

Preliminary Design Review

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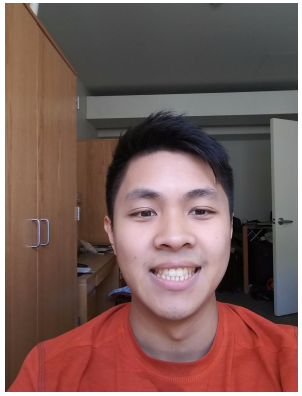
Meet the Team



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The Problem

There is a growing concern over the relationships between law enforcement officers and the public

- Shooting of unarmed civilians
- Excessive use of force
- Protests across the country
- Lack of reliable information
- Violence imposed on officers and public servants

The Problem: Improving Safety, Efficiency, and Accountability

The benefits of recording law enforcement interactions include

- Accurate reconstruction of incidents and gathering of evidence
- Decreases violence against police officers
  Increases accountability and reduces complaints against officers
- Ability to analyze recordings of many incidents and develop department wide policies to effectively address situations

Current Solutions

Body cams have seen some success, though there are limitations to their use

- Limited visibility
- First person perspective, some actions go unseen
- Movement of body leads to shaky, grainy footage
- Officers must turn them on and keep them recording

Image courtesy of *NPR.org*

Current Solutions

Mounted dash cams also have limits

- Rely on the position of vehicle
- Useful only in vehicle stops
- Limited to a fixed viewing angle

Image Courtesy of NJPublicSafetyOfficers

Our Solution

BuddyCam

Deployable Unmanned Aerial System (UAS) capable of autonomously identifying, tracking, and recording officers

- Quadcopter equipped with fixed camera
  - Aerial video capture of officer
  - Wirelessly transmit video to base station
- Base Station
  - Performs real time image processing
  - Object identification and tracking using computer vision
  - Allows UAS to move based on location of officer
  - Flight instructions sent back to UAS
  - Able to store received video

Our Solution: Perceptions and Adoption

- Reached out to UMPD
  - Phone interview with Deputy Chief Patrick Archbald
  - Believes our concept is applicable and could be useful

- Current Use
  - Larger police departments looking into drone use (LAPD)
  - Use cases in other applications: disaster relief, fire fighting support, tactical support (Aeryon Labs)

Marketability

- In the last few years, funding was provided to state and federal departments to purchase recording equipment and drones

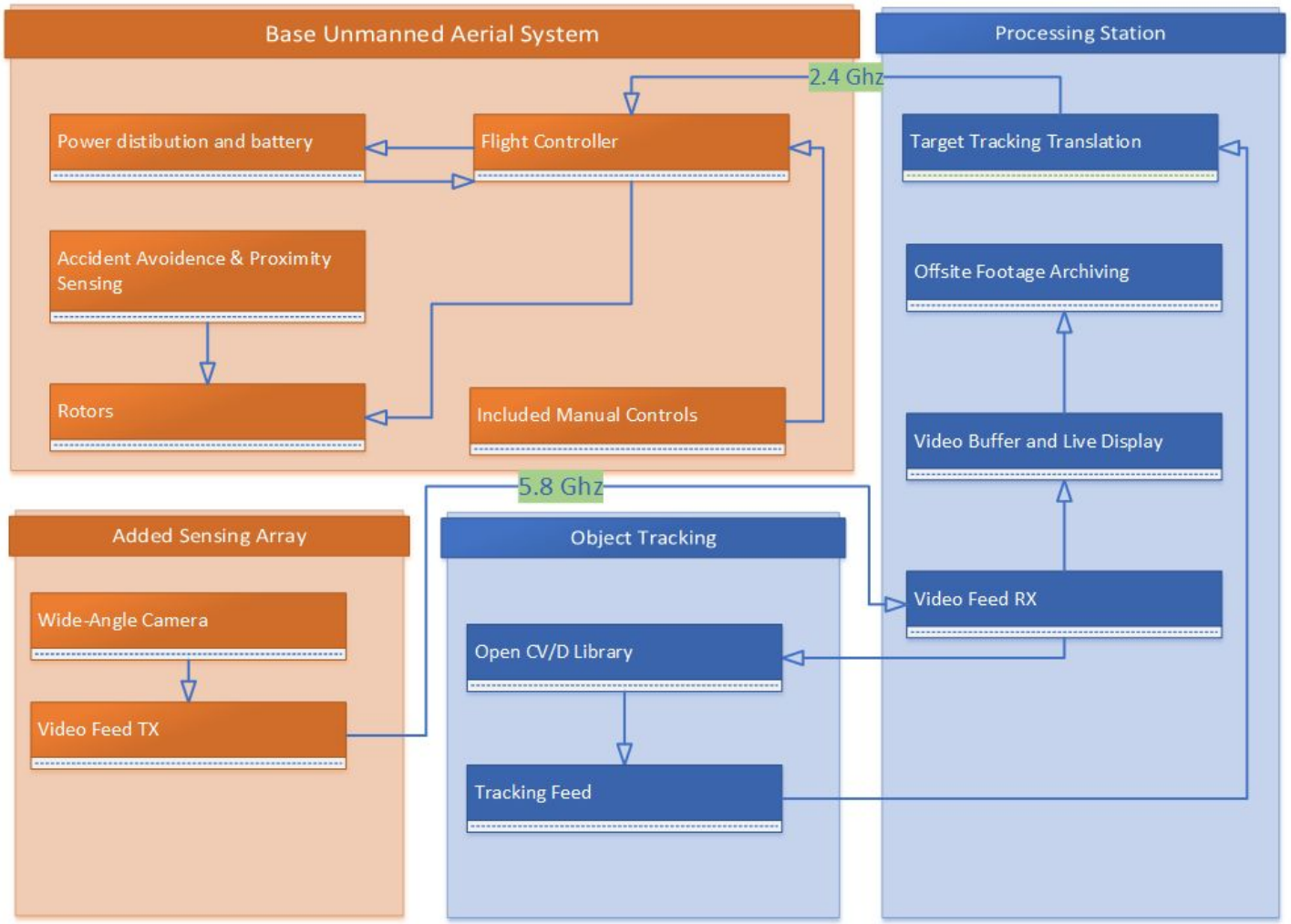
- This trend increases each year
  - 347 public safety departments in ~6 years (2009-2016)
  - Most purchased in 2016

Image courtesy of *90.5 WESA*

Requirements Analysis: Specifications

- Fully autonomous after lift-off
- Track and keep subject in frame
  - maximum of 1.6 s out of frame
- Maintain minimum height of 8 ft after initial lift-off, variance of 2 ft
- Maintain line of sight of subject within a radial distance of 15-20 ft
- Operate and record for at least 10 minutes
- Max operational distance from base station 0.25 miles

Our Solution: Block Diagram



Technical Breakdown - Unmanned Aerial System (UAS)

Requirements

- Maintain stable altitude with less than 2 foot variance
- Transmit analog video feed of scene
- Maintain communications with base station at a distance of 0.25 miles

Image courtesy of *New Atlas*

Implementation

- 3DR IRIS+ Drone
- Acro Naze32 Flight controller
- 5.8 GHz analog video transmitter
- Wide angle fixed position camera
- 2.4 GHz UAS control receiver

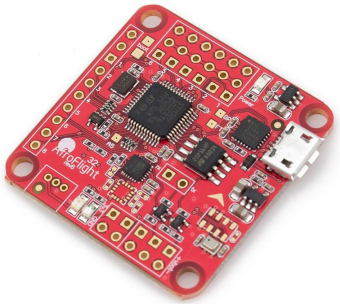


Image courtesy of *NextFPV*

Image courtesy of *Amazon*

Technical Breakdown - Processing System

Requirements

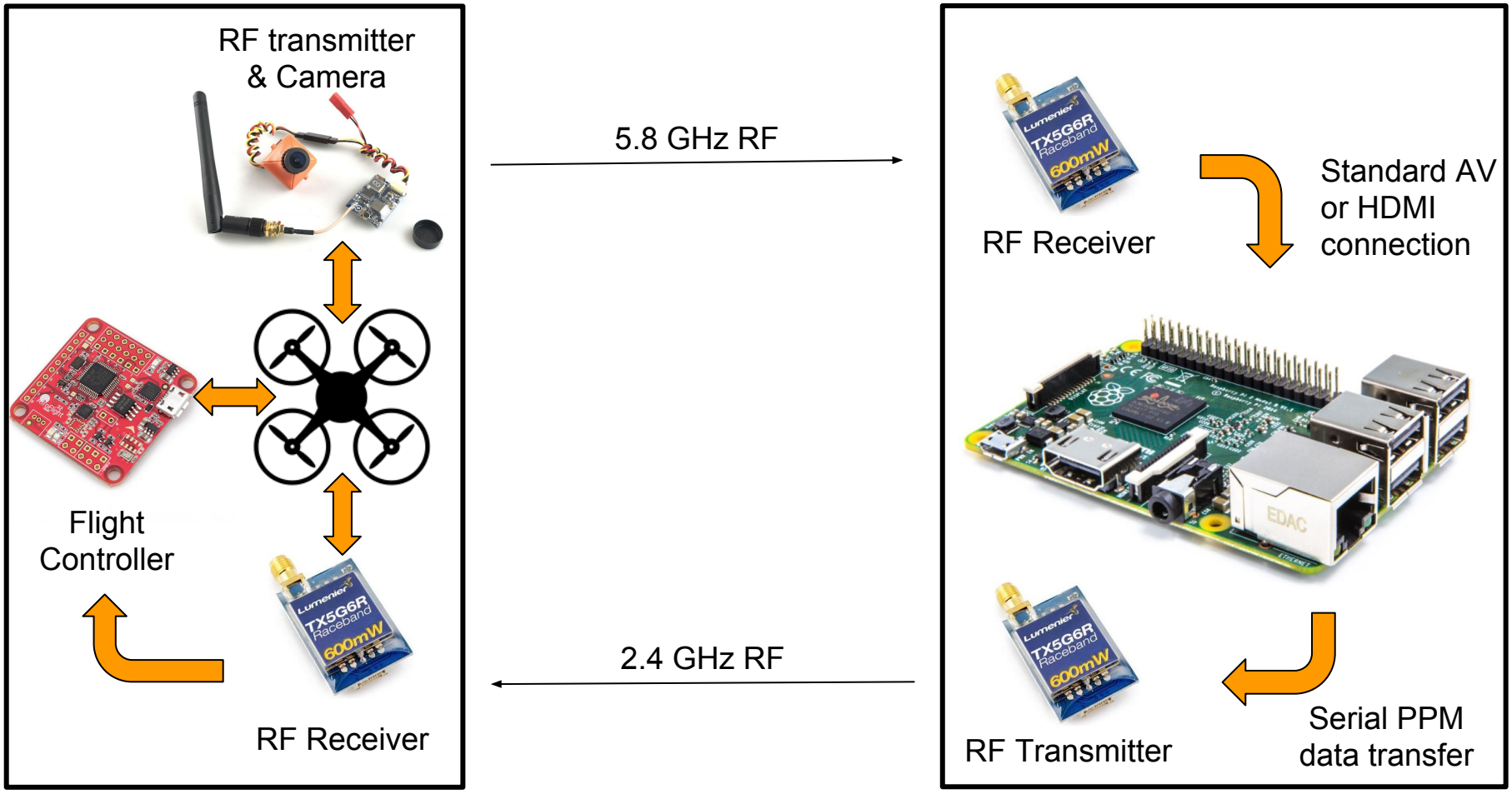
- Receive video footage transmitted by UAS
- Recognize and actively track location of a subject as they move through frame
- Translate image tracking to flight controls and transmit to UAS
- Record up to 10 minutes of scene

Implementation

- 5.8 GHz analog video receiver
- Raspberry Pi
- 2.4 GHz UAS control transmitter
- Storage device - hard drive and/or cloud storage

Image courtesy of *The Pi Hut*

Interfacing and Communication



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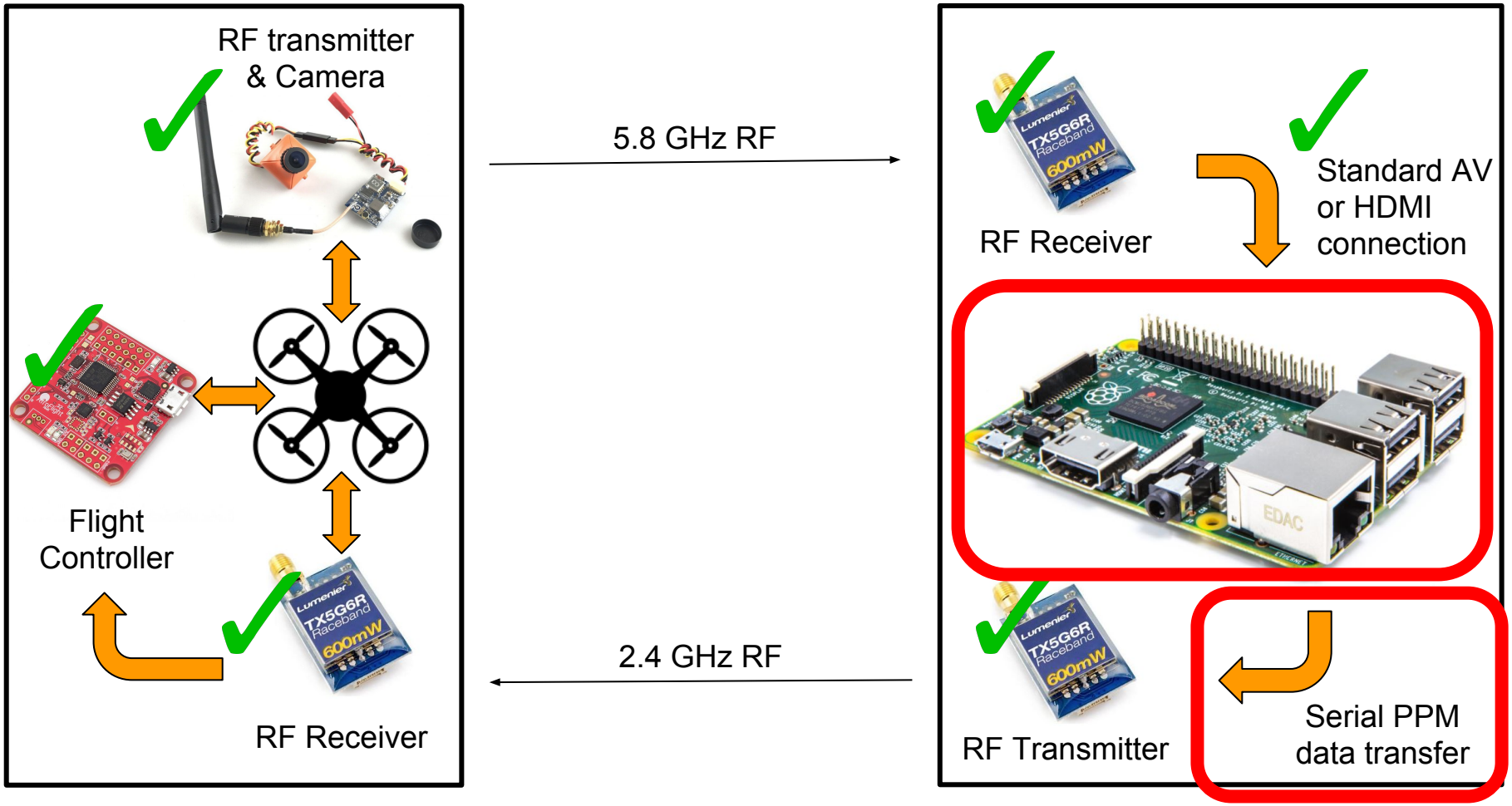
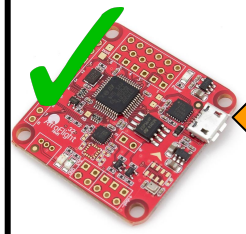


Interfacing and Communication

RF transmitter & Camera



Flight Controller

RF Receiver

5.8 GHz RF

Latency

Transmission ~ <1ms
Calculation ~ 10ms
PPM delay ~15ms
receiver output ~ 5ms
motors/ESC ~ 50ms
video processing ~ ?

Approx. 80ms system latency + video processing time

2.4 GHz RF

RF Receiver

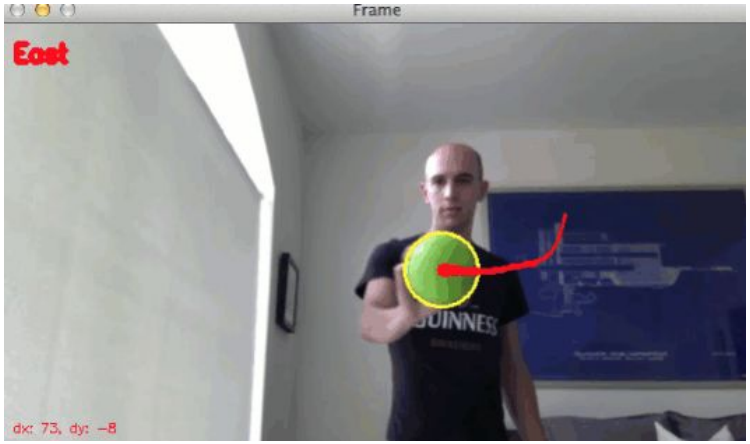
Standard AV or HDMI connection

RF Transmitter

Serial PPM data transfer

Technical Breakdown - Image Processing

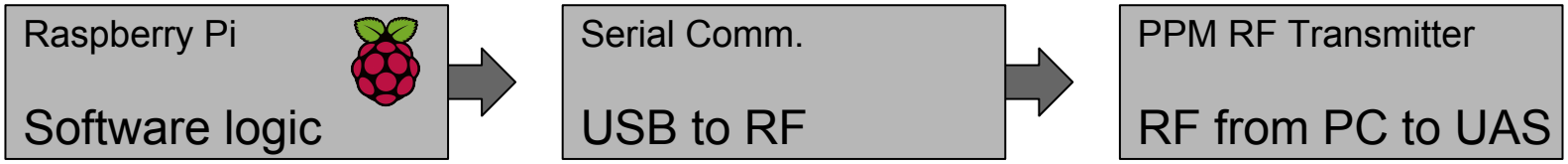
Subject will be identified and tracked through use of image processing tools



OpenCV
Dlib

} Running on Raspberry Pi with python bindings

Interfacing RF transmitter with RPi



Feedback logic received from image processing will direct the UAS to move or rotate according to the location of the subject in the video frame

Pulse-position modulation (PPM)

Bits are transmitted through use of a single pulse in one of 2^M time shifts

Image courtesy of *Spy-Copter*

Proportional-integral-derivative (PID)

Closed-loop control system that adjusts throttle level inputs based on set parameters and calculated error feedback

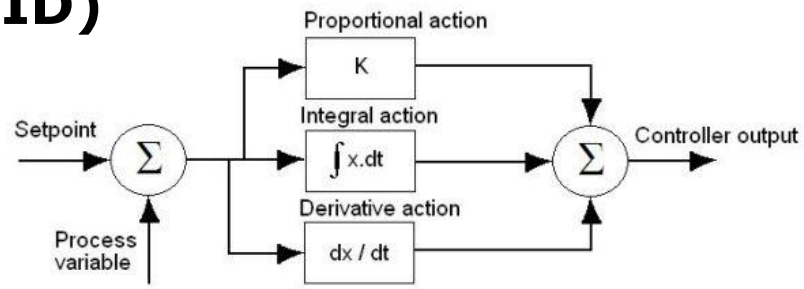
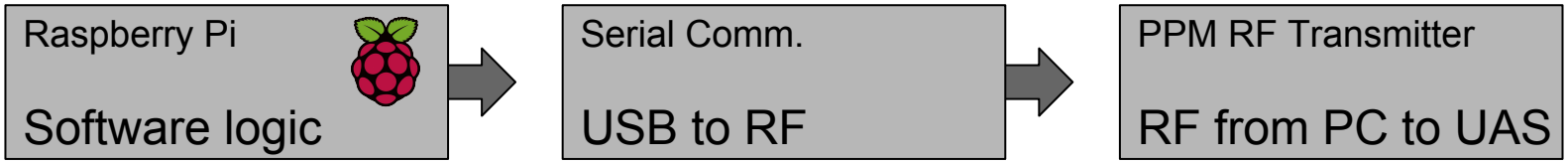


Image courtesy of *Process-Control*

Interfacing RF transmitter with RPi



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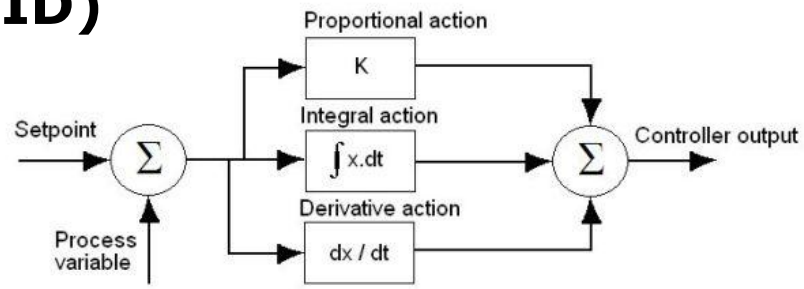
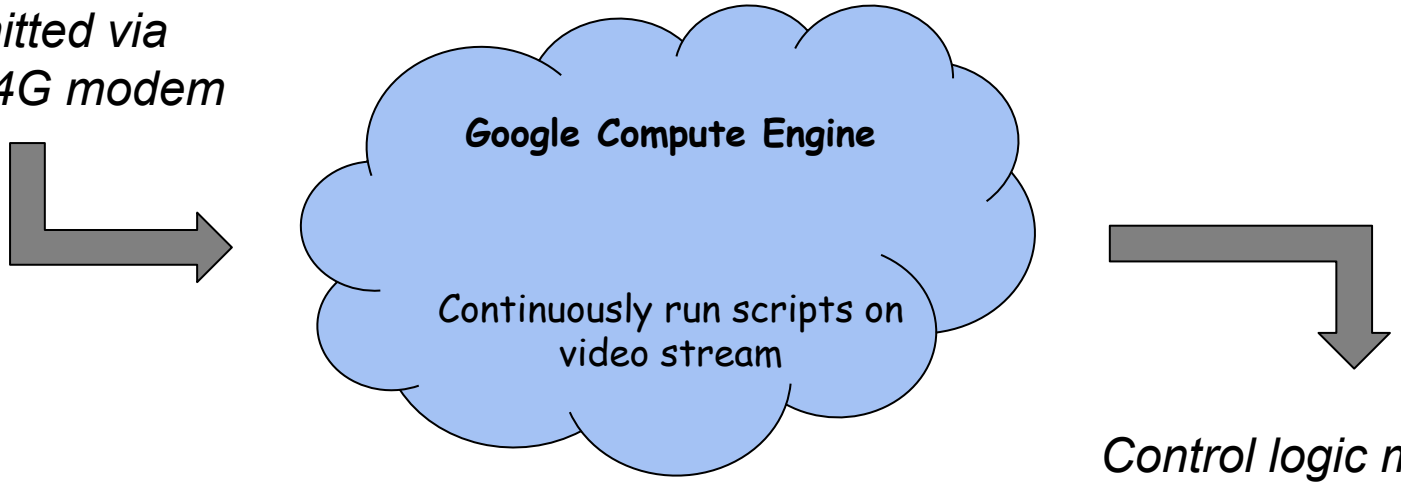


Image courtesy of *Process-Control*

Design Alternatives

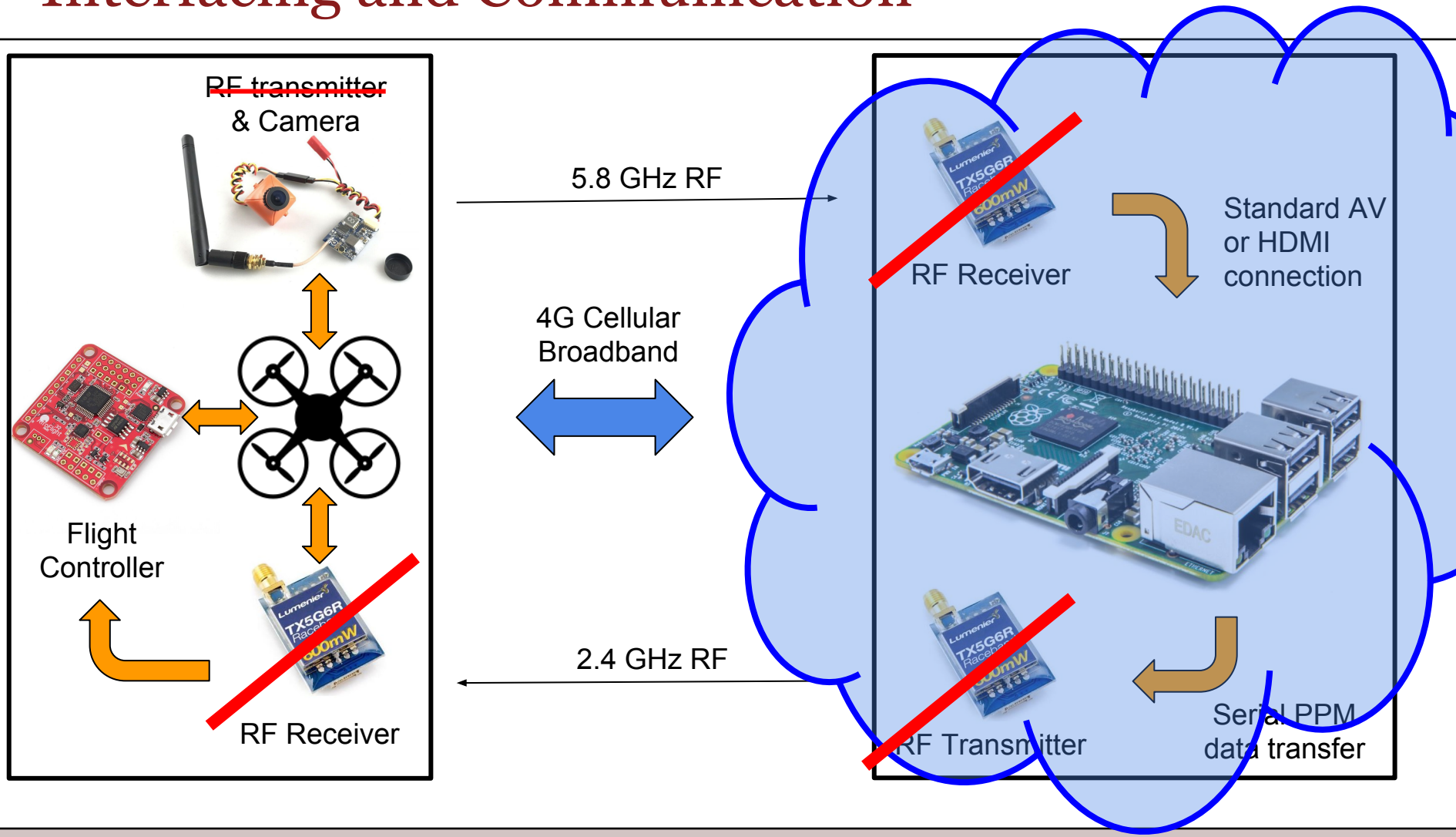
Employ Google Cloud Platform's Compute Engine for the task of image processing functions

Live video feed transmitted via onboard 4G modem



Control logic movement commands via 4G to UAS flight controller

Interfacing and Communication



Off-board Processing System vs Cloud Computing System

- Easier access to internet/storage
- Physical access to control override
- Weight constraints
- Power constraints
- Don’t have to use 4G modem

- Less complexity in terms of wireless transmission
- No distance tether to the ground processing unit
- Possibly higher processing speed

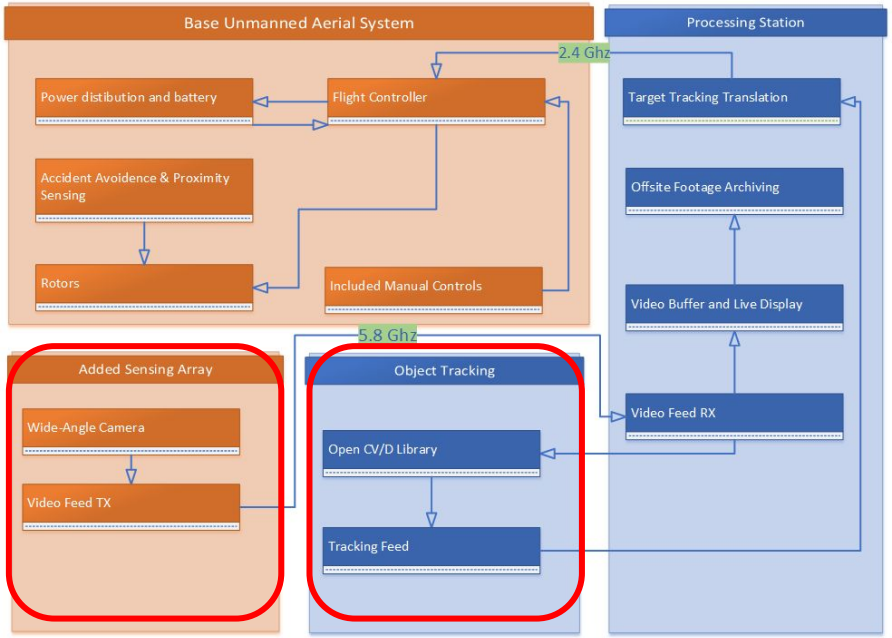
Total system latency?

We currently consider the off-board processing ground unit to be an effective and feasible approach.

Proposed MDR Deliverables

Demonstration of video processing on Raspberry Pi

- Stationary camera
- OpenCV processing on RPi connected to a camera
- Object recognition & tracking in frame



MDR Deliverable: Team Roles

All

Wireless transmission of analog video from board camera to Raspberry Pi, using RF.

Saswati & Joseph

Object recognition through use of Raspberry Pi, image processing python libraries

Kyle & Steven

Object tracking through use of Raspberry Pi, image processing python libraries

Budget Breakdown

Component	Approximate Price
NAZE32 Flight Controller	$25
Raspberry Pi	$35
Generic Board Camera	$5
Video TX/RX	$30/$50
2.4 Ghz Transmitter	$50
PCTx Device	varies / multiple components

Additional Ideas

- UAS with moving Gimbal
- IR camera to allow for low light scenarios

Image courtesy of *AltiGator*

Image Courtesy of YTIMG

Thank you

Questions

Legal Considerations

Laws surrounding unmanned aerial vehicles vary state to state…

Massachusetts - Bill S. 1349 seeks to outlaw drones equipped with weapons. Facial recognition, and biometric matching technology would be limited to ongoing criminal cases.

- This does not seem to apply to our project or the use of our project by law enforcement or first responders

FAA Regulations -

- Drone must be registered if it weighs > 0.55 pounds **UNLESS** its use complies with Section 336 of Public Law 112-95.
- Remote pilot airman certificate is needed for commercial use
- Must yield right of way to manned aircraft at all times
- Must keep aircraft in line of sight at all times
- UAS must be under 55 lbs
- Must follow community-based safety guidelines
- Must provide advanced notification to airports and air traffic control to fly drones within five miles of an airport

Section 336 of Public Law 112-95

Section 336 also prohibits the FAA from promulgating "any rule or regulation regarding a model aircraft, or an aircraft being developed as a model aircraft" if the following statutory requirements are met:

- the aircraft is flown strictly for hobby or recreational use;
- the aircraft is operated in accordance with a community-based set of safety guidelines and within the programming of a nationwide community-based organization;
- the aircraft is limited to not more than 55 pounds unless otherwise certified through a design, construction, inspection, flight test, and operational safety program administered by a community-based organization;
- the aircraft is operated in a manner that does not interfere with and gives way to any manned aircraft; and
- when flown within 5 miles of an airport, the operator of the aircraft provides the airport operator and the airport air traffic control tower … with prior notice of the operation….

FAA Drone Guidelines

	Fly for Fun	Fly for Work
Pilot Requirements	No pilot requirements	Must have Remote Pilot Airman Certificate Must be 16 years old Must pass TSA vetting
Aircraft Requirements	Unless exclusively operated in compliance with Section 336 of Public Law 112-95 (*Special Rule for Model Aircraft*), the aircraft must be registered if over 0.55 lbs.	Must be less than 55 lbs. Must be registered if over 0.55 lbs. (online) Must undergo pre-flight check to ensure UAS is in condition for safe operation
Location Requirements	5 miles from airports without prior notification to airport and air traffic control	Class G airspace*
Operating Rules	Must ALWAYS yield right of way to manned aircraft Must keep the aircraft in sight (visual line-of-sight) UAS must be under 55 lbs. Must follow community-based safety guidelines	Must keep the aircraft in sight (visual line-of-sight)* Must fly under 400 feet* Must fly during the day*

Possible Issues We May Encounter

- Range/reliability of transmission, both for control and video
- Limited to more open testing areas, weather-permitting

Negative Societal Effects

- Video recording raises concerns of privacy, both for police and civilians.
- Heavier reliance and trust of technology, which some people may take issue with.

Additional Notes

UAS
Motors
Electronic Speed Controllers
Power Distribution Board
Battery
Flight Controller
Camera
Video Transmitter (& antenna)
Controls receiver (& antenna)
Onboard Proximity Sensors (optional)

Processing System
Raspberry Pi
Video Receiver
Control Transmitter
Video Display
Storage Device

Ideas
Onboard Proximity Sensors
Manual control override at processor
Stand alone button to control start/stop

First Steps
Get video processing working on RPi
- object tracking with opencv

Interface between tracking and drone movement