GUARDIAN

An autonomous drone system for solving elephant-human conflict

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Worldwide Problem

- Nearly **20%** of the world's population lives in or near elephant habitats and ranges.
- Over the last 100 years, African elephant populations have declined from **3-5 million** to **0.47-0.69 million** and Asian elephant populations have declined from **100** thousand to **35-50 thousand**.

Crop-Raiding

- Main form of conflict
- Crops destroyed:
  - Wheat 65%
  - Sugarcane 21%

Economic Loss

- Small plantation
  - 200-600 pounds of food per day
  - A few thousand dollars lost per household per raid
- Large plantation
  - Palm oil and timber
  - Riau, the largest palm oil producing province in Indonesia
  - 105 million dollars lost per year

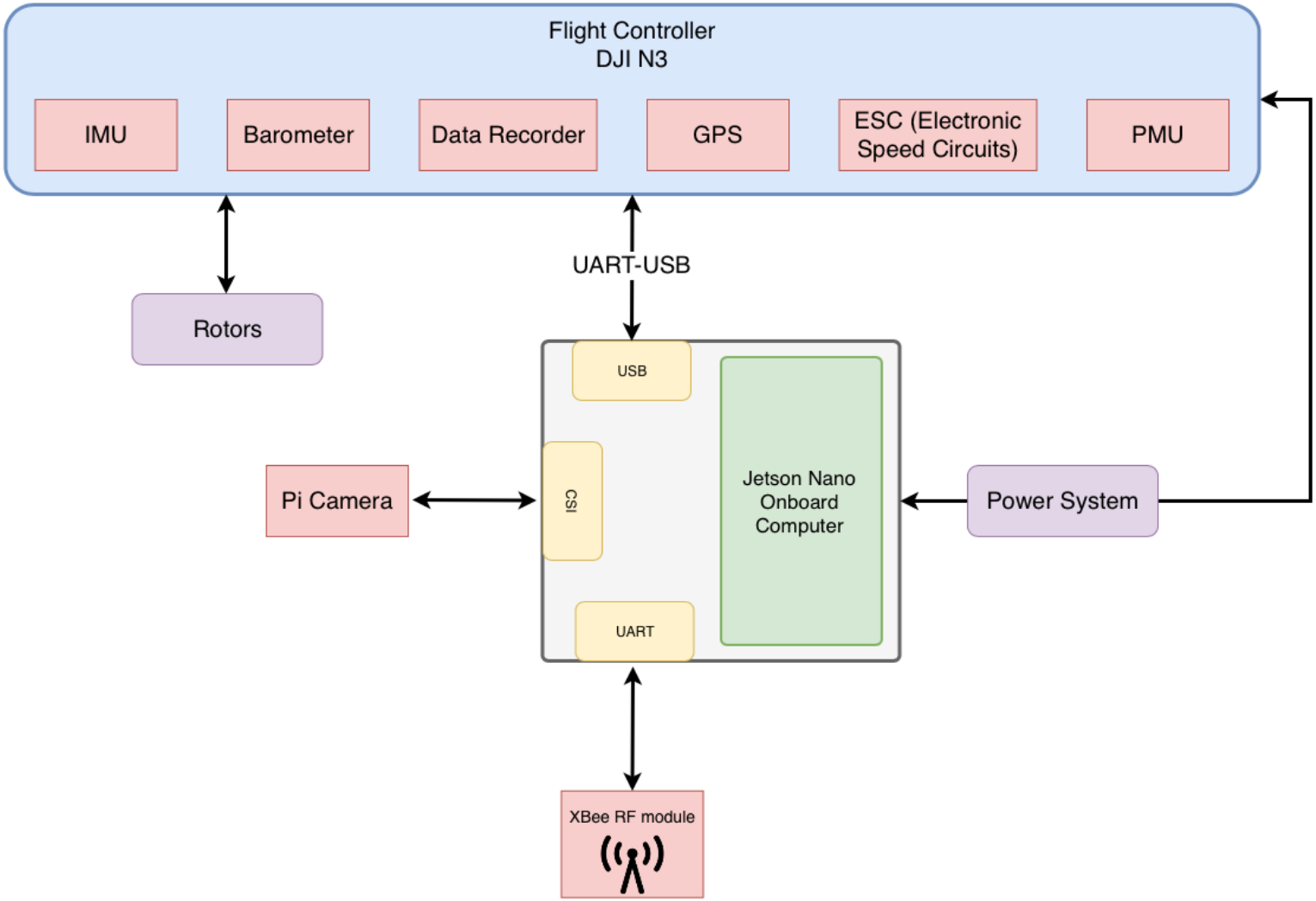
Casualty

- India
  - 100-300 humans and 40-50 elephants are killed during crop-raiding each year
- World
  - 500 people are killed by elephant each year according to National Geographic Channel documentary ***Elephant Rage***

Frequency of Crop-Raiding

- Elephants destroy the villager's property about 5 times per year in Xishuangbanna, China

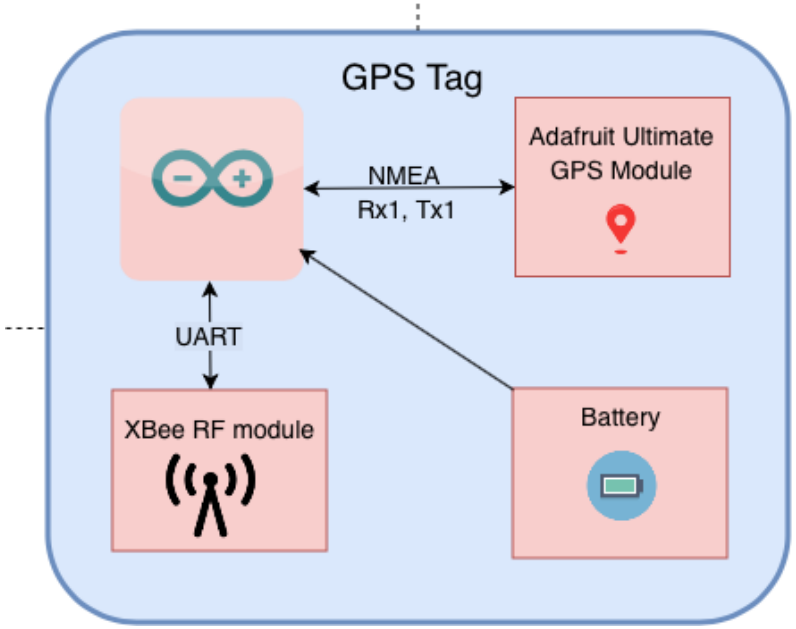
Drone High Level Design



Drones Components

- Tarot 680 Pro Hexa-copter
- DJI N3 Flight Controller
- NVIDIA Jetson Nano
- IMX219-160 IR Camera
- XBee-PRO900HP

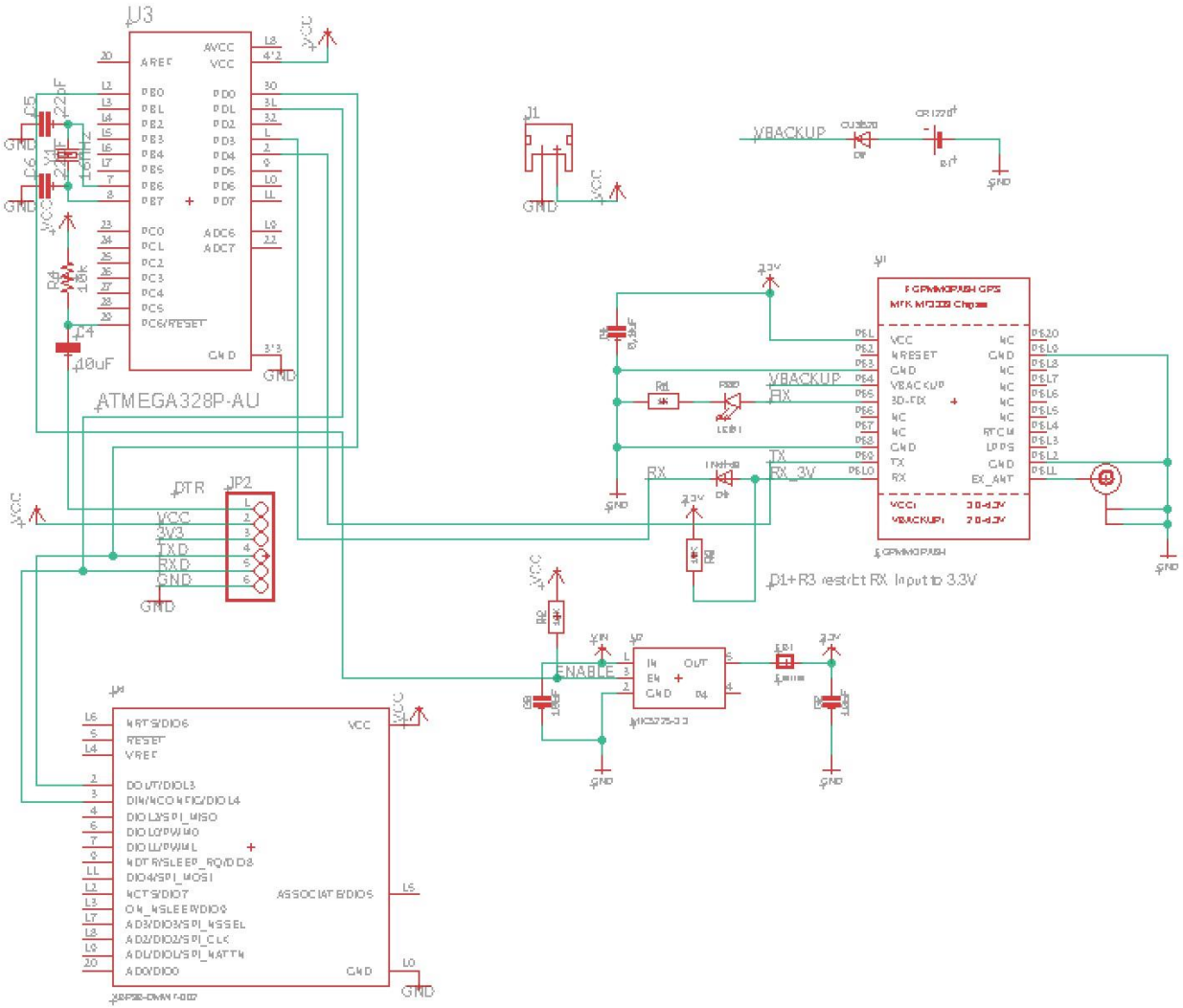
GPS Tags High Level Design



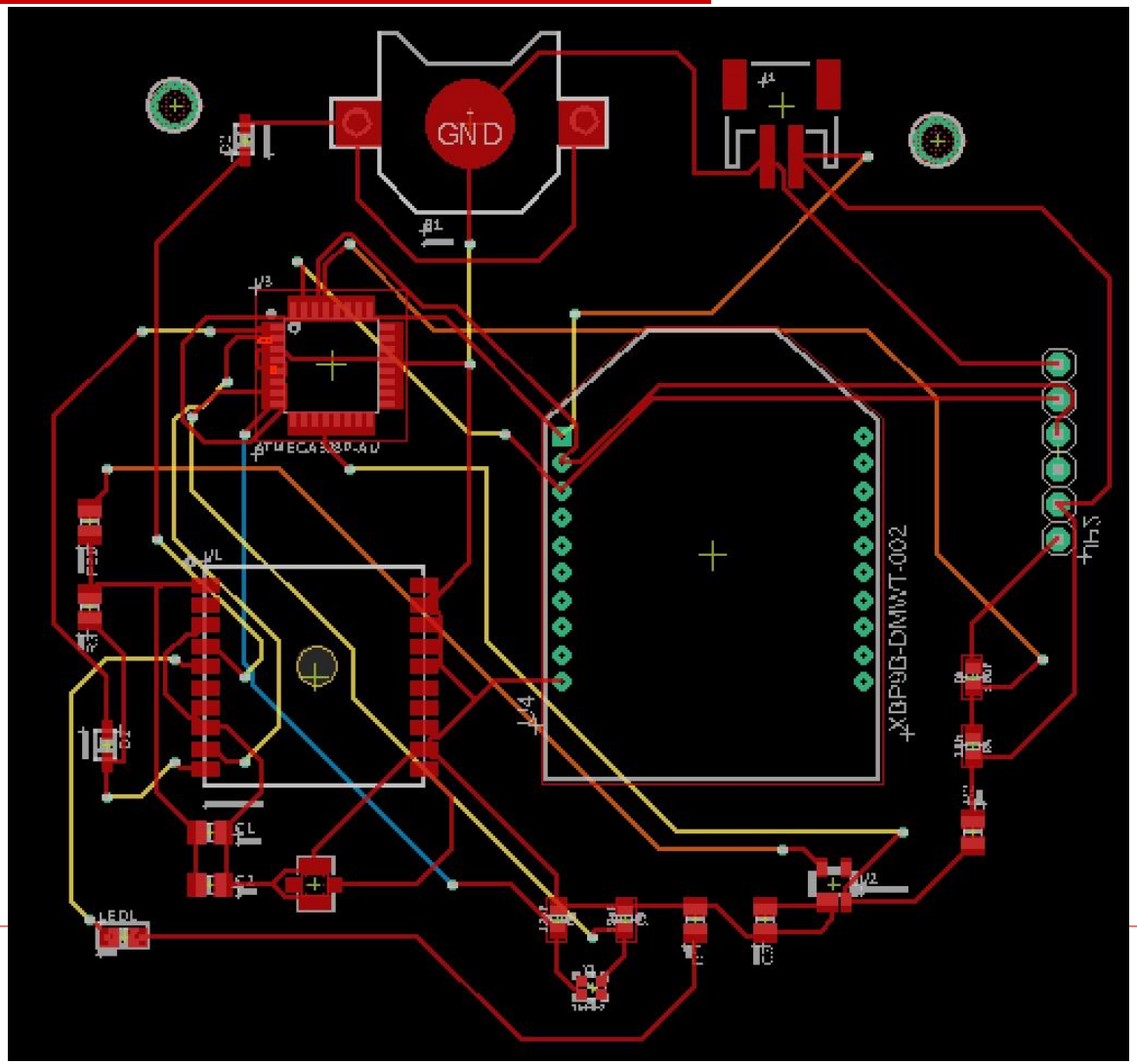
GPS Tags Components

- XBee-PRO900HP
- FGPMMOPA6H GPS
- Atmega328P-AU

PCB (GPS Tags) Schematic

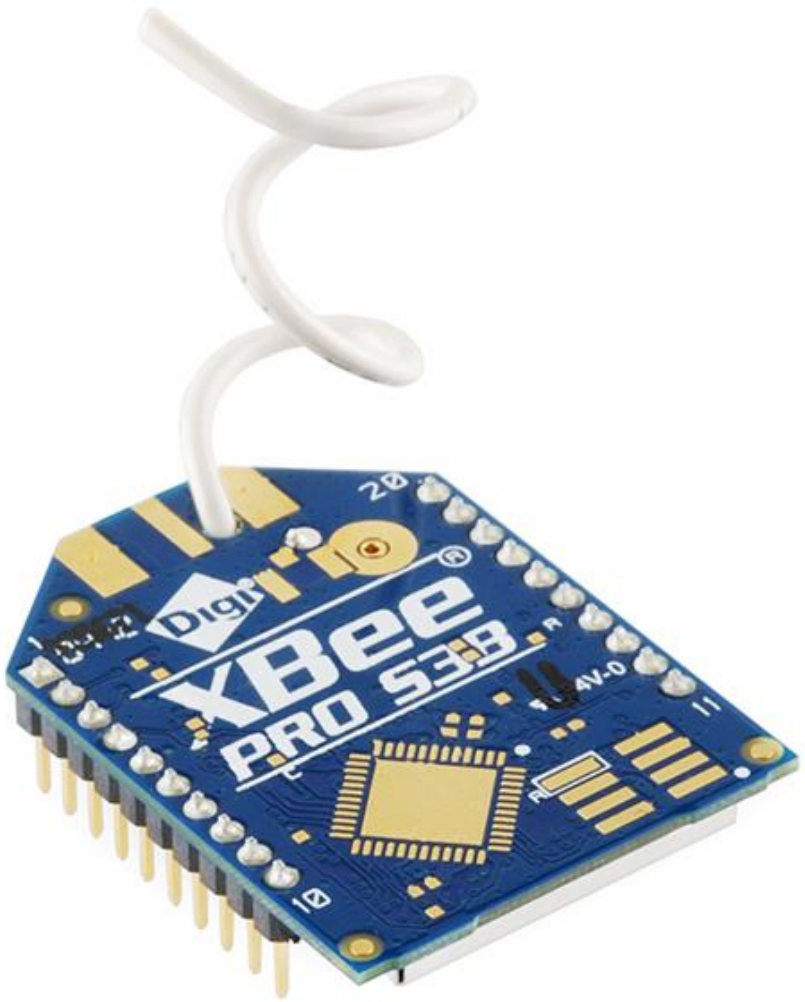


PCB (GPS Tags) Board



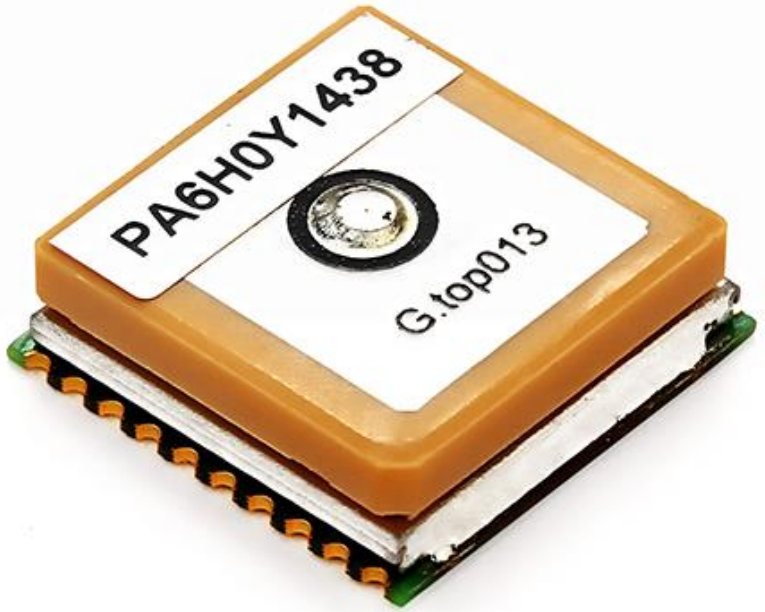
XBee-PRO900HP

- Frequency: 900MHz
- Ideal range:
  - 10 kb/s: 9 miles (15.5 km)
  - 200 kb/s: 4 miles (6.5 km)
  - (with 2.1 dB dipole antennas)
- Supply voltage: 3.3V
- Transmit current: 290 mA max
- Receive current: 29 mA typical
- Sleep current: 2.5 µA
- Interface: UART



FGPMMOPA6H GPS

- Update rate: 1 to 10 Hz
- Position Accuracy: < 3 meters
- Velocity Accuracy: 0.1 meters/s
- Warm/cold start: 34 seconds
- Supply voltage: 3.3V
- Tracking current: 20mA
- Interface: UART



Atmega328P-AU

- Speed: 20 MHz
- Operating Voltage: 1.8 - 5.5V
- Power Consumption at 1MHz: 1.8V, 25C
- Active Mode: 0.2mA
- Power-down Mode: 0.1µA
- Power-save Mode: 0.75µA (Including 32kHz RTC)

Parts - Drone

- Tarot 680 Pro Frame
  - Tarot 4108 High-Power Brushless Motor
  - HobbyWing XRotor 40A-OPTO-ESC
- Processor: NVIDIA Jetson Nano
- Flight Controller: DJI N3
- Sensors:
  - IMX219-160IR Camera
  - XBee-PRO900HP
- Gartpot 4S 75C LiPo Battery

NVIDIA Jetson Nano

- ARM Cortex-A57 (4 cores)
- 128 cores NVIDIA Maxwell GPU
- Clock speed:
  - CPU: 1.5 GHz
  - GPU: 900 MHz
- Power:
  - Requirement: 5V (4A)
  - Consumption: 10 W
- Peripheral Interfaces: CSI, UART, USB, GPIO
- Serves as an onboard processor on drone

IMX219-160IR

- Resolution: 3280 x 2464
- Angle of View (diagonal): 160 degree
- Night vision:
  - No IR filter installed
  - Two infrared LEDs
- Power requirement: 3.3 V
- Interface: CSI
- Interfaced with Nano through OpenCV API

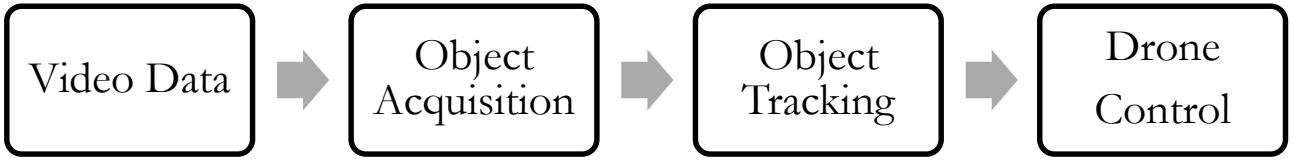
DJI N3 Flight Controller

- Dual IMU Redundancy
  - 8GB Black Box
- GNSS-Compass
- PMU
- 3S-12S LiPo Battery Supply
- M Pin
  - ESC PWM Port for Motor
- API Port
  - UART
- S-Bus Port
  - RC Receiver

DJI Onboard SDK

- Installed in Jetson Nano
- Interface for DJI N3
- Flight actions
  - Roll/Yow/Pitch/Throttle
- Aircraft state data
  - Direction
  - GPS Coordinate
  - Altitude
- Automate herding process

Computer Vision Software Flow



- Object acquisition is performed using a neural network detection model
- Optical flow is used for real-time elephant tracking
- Localization data is then fed into a control algorithm to effectively herd the elephant away

Timeline

- Fall quarter achievements
  - Successful prototyping of the GPS tag
  - Successful sending and receiving coordinates and other data between tag, base station and drone
  - Successful implementation of AI object detection on Nvidia Nano
- Winter quarter objectives
  - Print out the PCB for GPS tags
  - Finish calibration and test flight the drone
  - Develop autopilot program for the drone with DJI SDK
  - Computer vision software development

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