Preliminary Design Review

Search And Find Emergency Drone
"SAFE Drone"

Team 4
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Meet the Team Members

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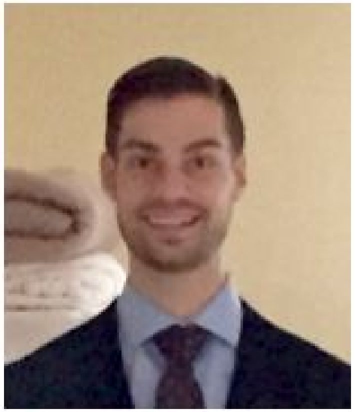


What is the problem?

- Each year, thousands of hikers get lost
- Quick emergency response in tough, wooded terrain:
  - Helicopter -- $$$
  - IR Ineffective W/Canopy
  - Not Fast Enough!
- Everybody has a cell phone
- No service in remote areas

http://www.totalcellphonerepair.com
http://piyushgaryali.blogspot.com/2011/07/lost-in-woods.html

How significant is the problem?

- At least 2000 hikers: lost every year in the US
- 519 rescue missions: The Los Angeles SAR, 2015
- Somebody has to save thrill seekers like this guy

https://www.adventure-journal.com/2013/03/the-truth-about-airbags-and-avalanche-survival/

Context: Effect on Individuals

- The longer an injured hiker is left in the woods, the more likely they are to be exposed to life-endangering threats

- Adverse Weather
- Lack of Water
- Lack of Food
- Injury
- Infection
- Mountain Lions

We NEED that quick response!

http://www.123rf.com/photo_2106565_a-close-up-on-a-big-angry-bear.html

Design Alternatives

- Helicopter Search
  - Able to scan closely to the ground
  - Expensive, hard to see through tree cover, and takes time to get to remote places

- Existing cellular network location
  - Procedures already in place to locate last position phone was connected
  - In woods, typically no cell service, though

Our Solution: Search And Find Emergency Drone

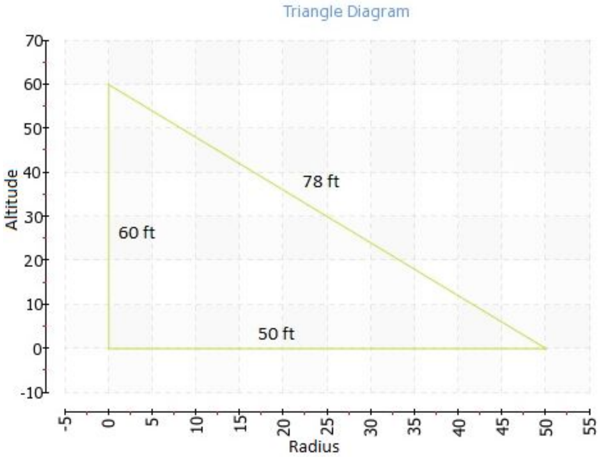
- Cell tower simulator using SDR
  - (SDR = Software Defined Radio)
- SDR flown over region using SAFE Drone
  - Quad rotor copter scans physical area
  - SDR scans airwaves
- If cell connection attempted:
  - Stores GPS coordinates
  - Return to home, relay coordinates to rescuers
- Faster deployment and search than traditional means
  - Fully autonomous: takeoff + scanning + landing
- MUCH less expensive than helicopter search

Context: Effect on Groups

- Helping search and rescue groups to find lost and possibly injured hikers
- Helps reduce cost of searches for the communities

Requirements Analysis: Specifications

- Locate the cell phone within a 50ft radius while flying at a height of 60ft (+/- 5 ft)
- Fair climate weather
    - No Precipitation
    - Calm Wind
    - Ambient Temp 35 - 85 Degrees
- Tree cover, relatively level



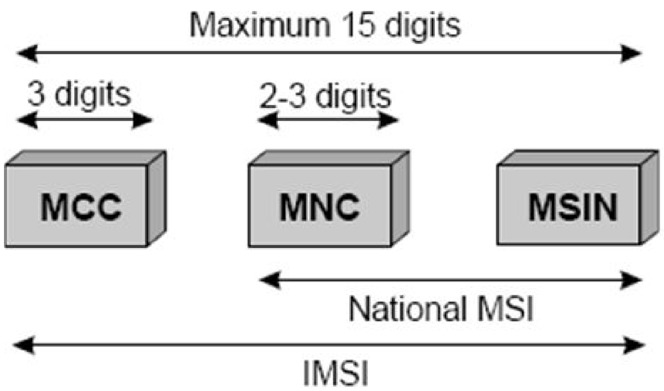
Requirements Analysis: Inputs and Outputs

Inputs:

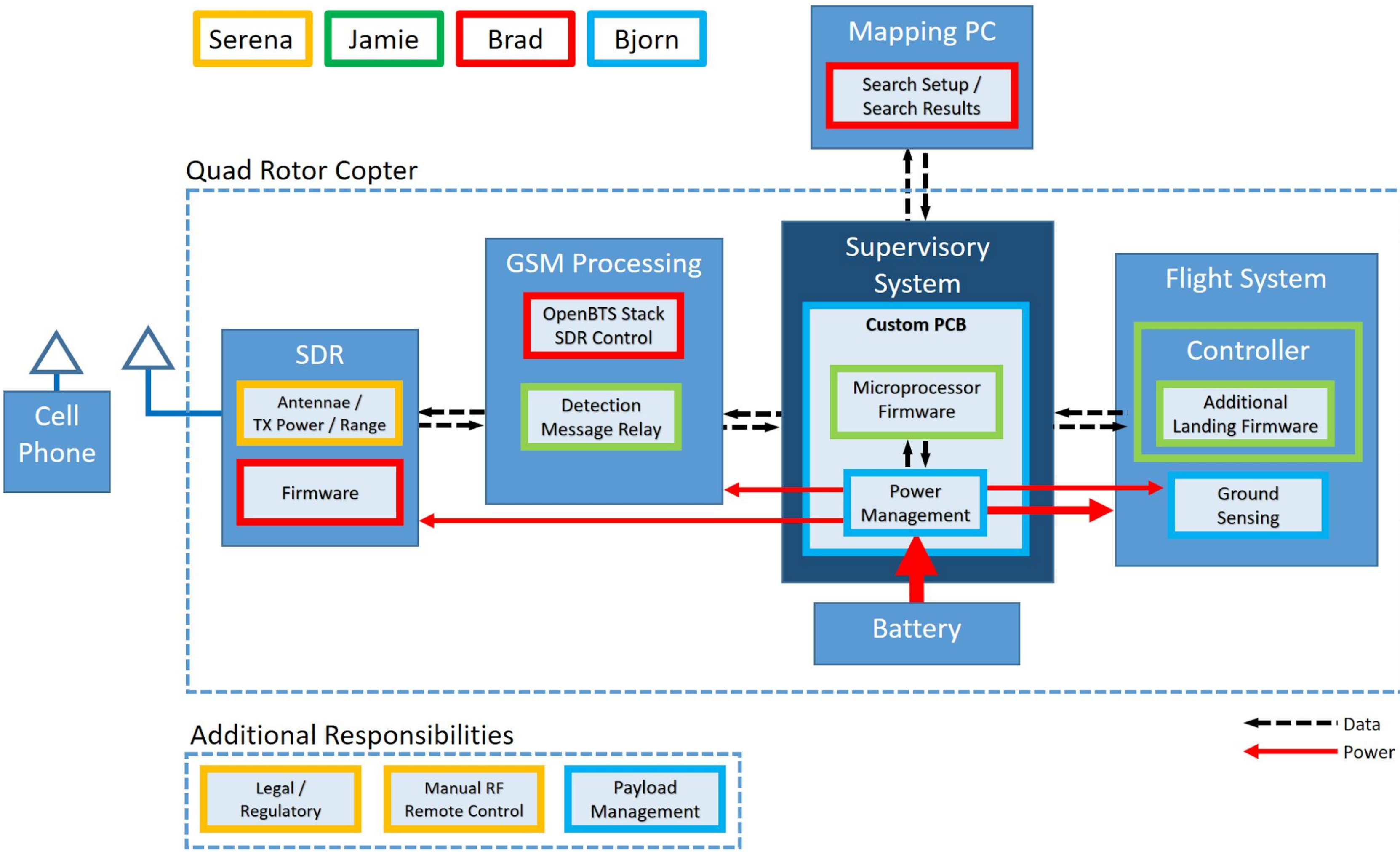
- Area to search
- Altitude
- IMSI

Outputs:

- GPS coordinates of drone when IMSI is found
- Area searched



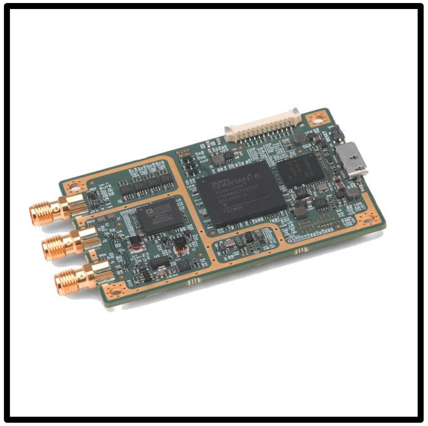
Our Solution: Block Diagram



Block 1: Software Defined Radio

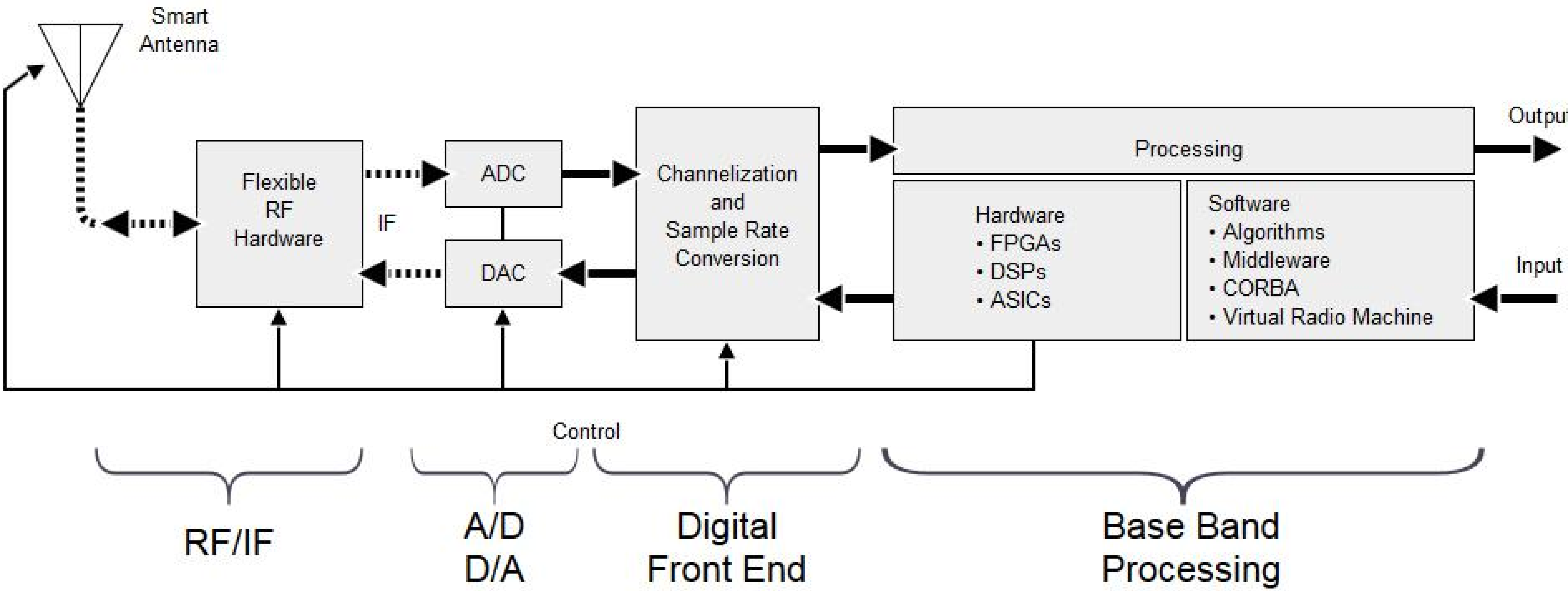
- Light Weight
- Power Efficient
- High Output
- Tunable Bands
  - 850 MHz
  - 900 MHz
- Signal Processing
- Both options have 2 channels to transmit, receive at same time
- bladeRF x40 cheaper

bladeRF X40
Weight: 80g
Size: 3.5” x 5.0"
Output: +6 dBm



Ettus Research B200 - mini
Weight: 24g
Size: 2.0” x 3.3”
Output: +10 dBm

Block 1: Software Defined Radio



Source: https://www.annapmicro.com/solutions/sw-defined-radio/

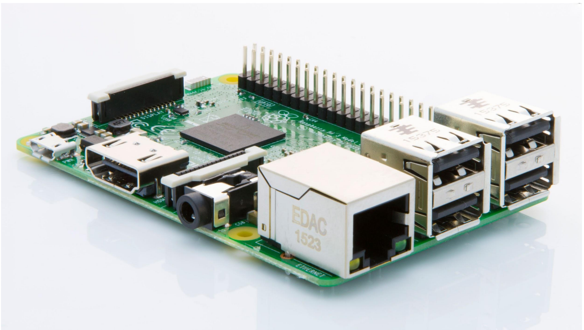
Block 2: Software Defined Radio - Antenna

Quad-band Cellular Duck Antenna (SMA connector)

- GSM : 880 to 960MHz
- 0.5g
- Compatible with bladeRF X40
- Omni-directional
- One to transmit
- One to receive

Block 3: GSM Processing

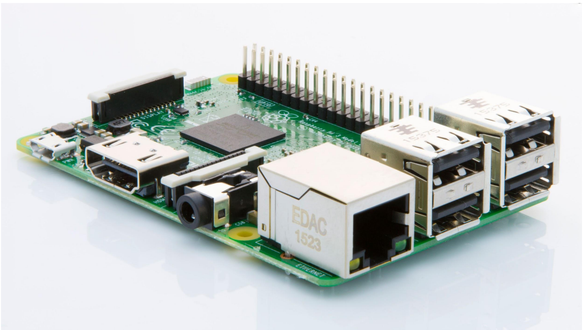
- Control SDR Transceiver
- Capture & Identify Cellular IMSI
- Notify supervisor if signal/IMSI found
- Other Communication/Processing as needed



Raspberry Pi 3 Model B

Block 3: GSM Processing

- Linux OS
- SDR Driver/Controller
- Base Transceiver Station Software
  - GSM Protocol
  - IMSI Identification
- I/O Pin Communications



Raspberry Pi 3 Model B

Block 4: Flight Hardware

Flight Structure

- Frame / motors re-used from SDP 2015
- Payload a delicate balance between lift capability and battery capacity
- Frame targeted at industrial / research use

Block 4: Flight Hardware

Flight Controller

- Commercial unit designed by leading manufacture
- Abstracts complex motor/flight control
- Significant upgrade from SDP 2015

Hardware (open source)

- 32bit Cortex M4
- Onboard barometer, gyros/accelerometers
- External GPS/Compass, expansion ports

Software (open source)

- Real-time OS, developed with autopilot in mind
- MAVLink protocol for in-flight modifications

Block 5: Supervisory System

Q: Why another processor?
A: System control requires higher reliability
A: Analog sensing would require PCB anyway
...

Monitoring and control for power management:

- Battery usage algorithms to assure return energy
- Relays power on/off commands to subsystems
- Set waypoint of flight controller when battery critical

Acts on phone detection signal from processing block:

- Pulls/stores GPS coordinates from flight controller.
- Set waypoint of flight controller to return home

Block 6: Power

- Target 60’ Canopies
- Propeller/Motor Selection
  - Flight Time
  - PWR consumption
  - Payload
    - ➢ Battery, SDR, FLT Controller, RPi, etc.

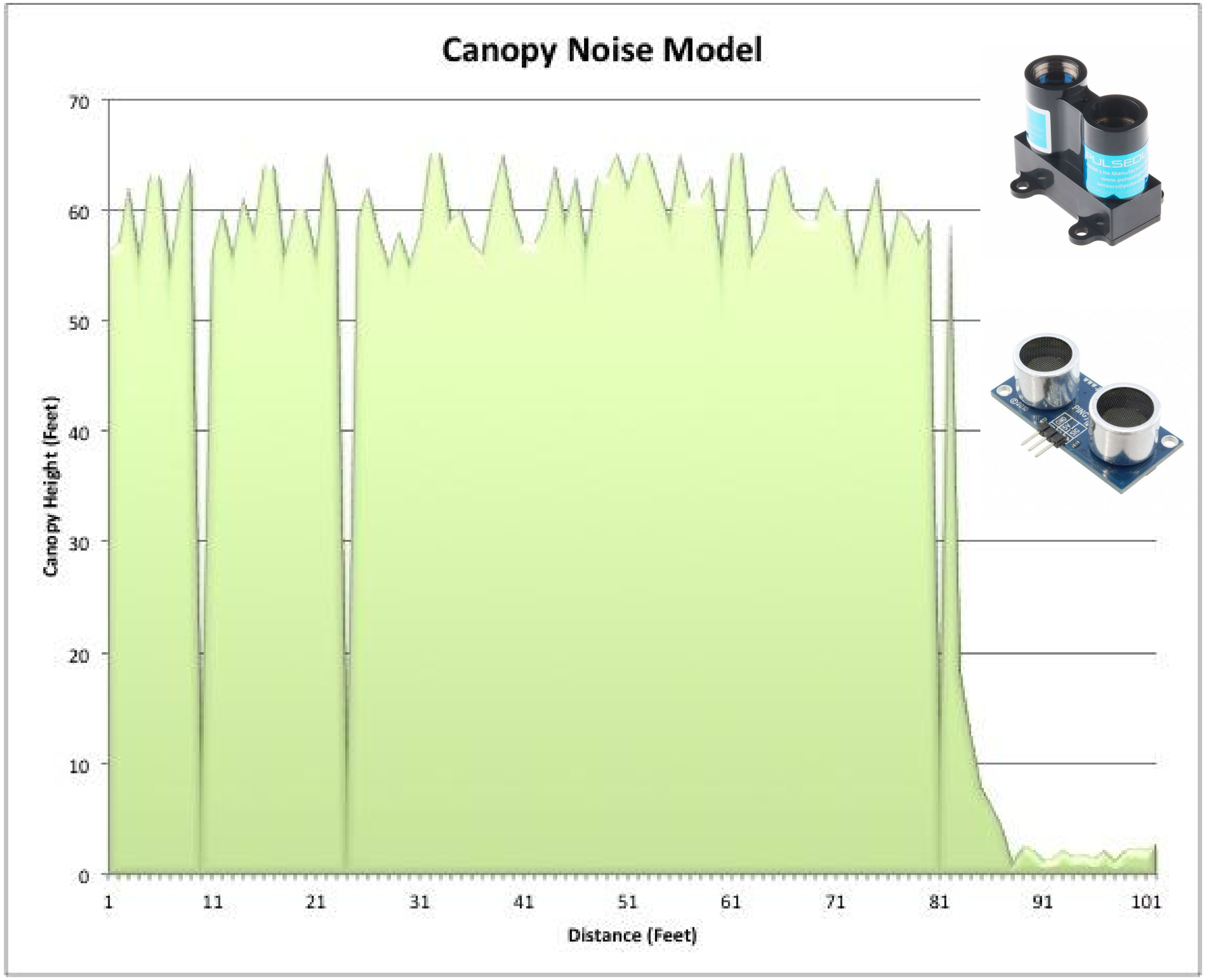
```
Pc=  600;            %Payload Capacity (grams)
n=  4;               %Num of Motors
m=  900;             %the weight of the craft itself (g)
ThPercent=  0.5;     %Hover Throttle percent 50%

MotorThrust = (Pc+m) / (n*ThPercent);
MotorThrust = 750 g
```

- Battery/Current Monitoring algorithms
- Main/Aux Battery power selection
  - Drawback -- weight increase
- PCB -- Onboard Power integration

http://www.hobbyking.com/hobbyking/store/__15311__Turnigy_2200mAh_3S_20C_Lipo_Pack_AU_Warehouse_.html?gclid=CIaqi9y_z88CFYhbhgodCF4Ptg

Block 7: Landing Sensory



Landing Feedback Sensor

- LIDAR ($150)
- Ultrasonic ($5)
- 130' vs 9' range

Terrain Avoidance

- Projected dual-use of landing sensory for Canopy Navigation
- Able to avoid a 10' Canopy std dev

http://www.digikey.com/product-detail/en/sparkfun-electronics/SEN-14032/1568-1437-ND/6204382
http://www.digikey.com/product-detail/en/parallax-inc/28015/28015-ND/1774419

Million Dollar Questions

How can we do this *legally* (without breaking FCC rules)?

- Target European band: a U.S. licensed band
- Technician class amateur radio license

How can we do this *considerately* (without disrupting service)?

Multi-layered approach depending on goals:

- Minimized transmit power and/or use of anechoic chamber
- Tower not presented as active
- Setup as non-US/unknown provider

How can we do this *practically* (and still show that it works)?

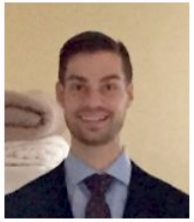
- Testing at full power in remote areas only
- For Demo: locally at low power, or present a demo. video

Proposed MDR Deliverables

- Manual RF control of the drone that doesn't interfere with SDR

- Able to alert supervisory system upon IMSI identification

- Supervisory micro software functions complete: control flight waypoints, poll GPS



- Landing/Distance sensory able to detect distance accurately

Thank You

Questions?

Sources / Extra Slides / Extra Info

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