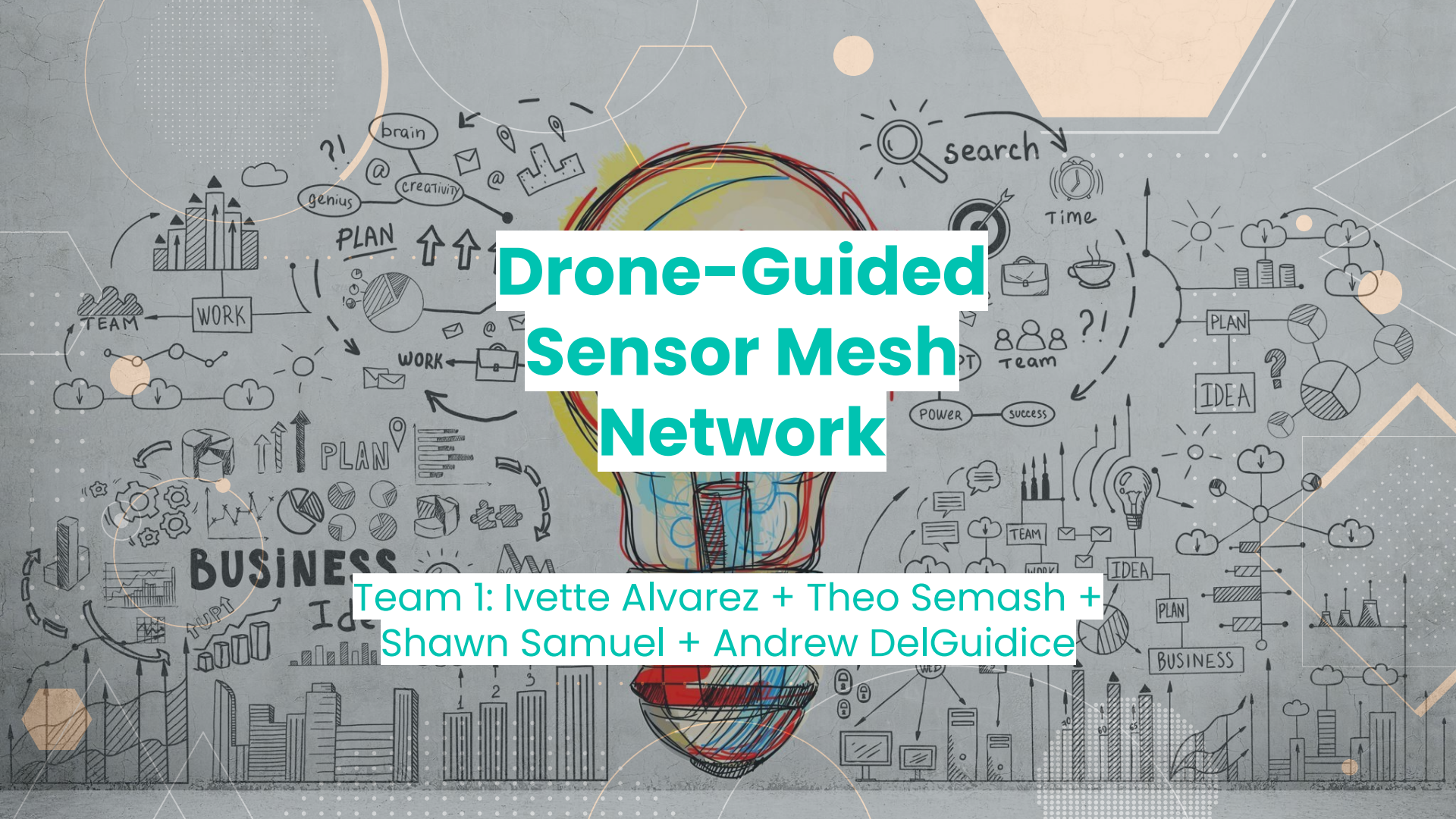


Drone-Guided Sensor Mesh Network

Team 1: Ivette Alvarez + Theo Semash + Shawn Samuel + Andrew DelGuidice



Real-World Problem: Forest Fires

- Every year there are thousands of forest fires.
- Usually the fires burn for many days before they are even detected.
- Early detection is key to being able to control and extinguish a forest fire.
- During hot + dry periods of weather is when forest fires are most likely to occur.

Design Specifications:
Drone-Guided Sensor Mesh Network

- Have drones that can fly through the wilderness to collect data(images, temperature, windspeed, humidity, ect.)that can help scientist monitor the presence of forest fires.
- Create a mesh-network between the drones in order to extend their communication range with a HUB that will collect the data and interpret it.
- Program drones to fly to coordinated GPS locations that will optimize their mesh network range between the target area and the HUB.
- Have an standalone power station and HUB to allow the system to be relocated to any area and stand alone in the wilderness.

Video Demonstration



5 PSSC's for the Design

01. **PCB**

Will be designed to switch power on/off from the HUB(which will be standalone and solar-powered) and provide specific power ratings to the HUB computer and indicators.

02. **ML**

The ML program will interpret the data to interpret its quality and the likelihood of a fire.

03. **Mesh Network**

After a target's GPS location is programmed to the drones, the mesh communication network will reconfigure its coordinator, router and end-point based on the positioning of each drone.

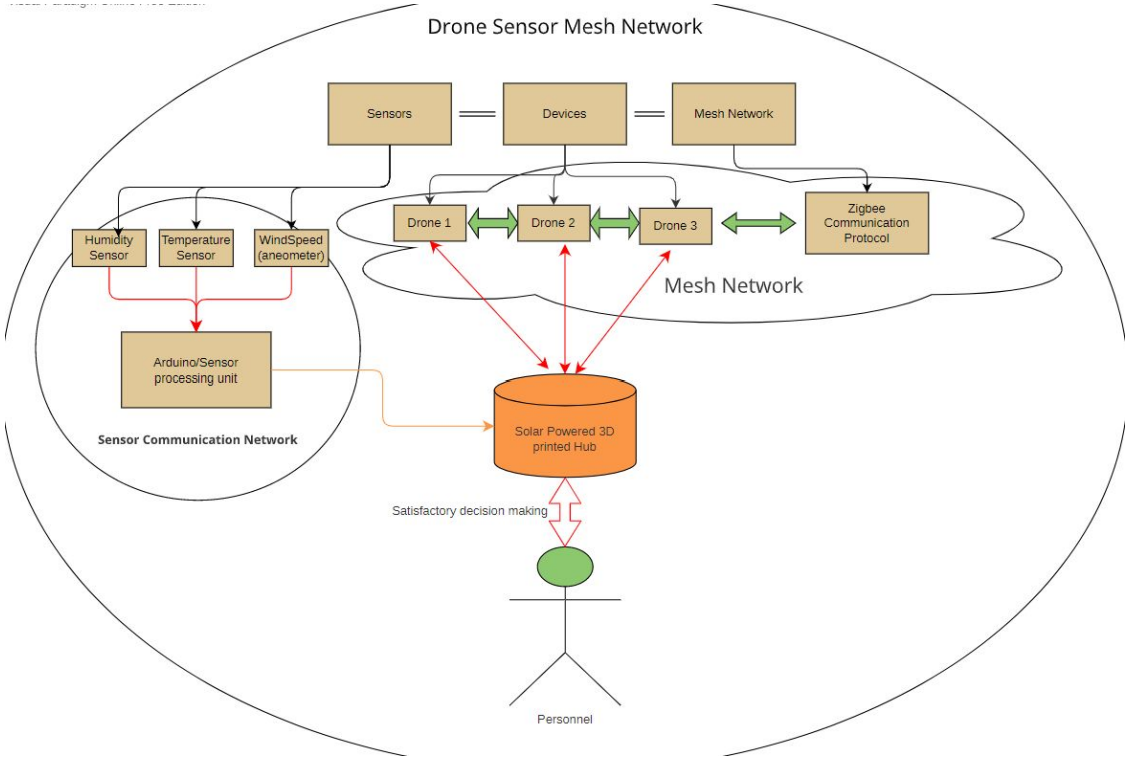
04. **Sensors**

Sensor data quality will not be compromised after installation onto the drone in order to collect accurate data not affected by drones propellers and other hardware.

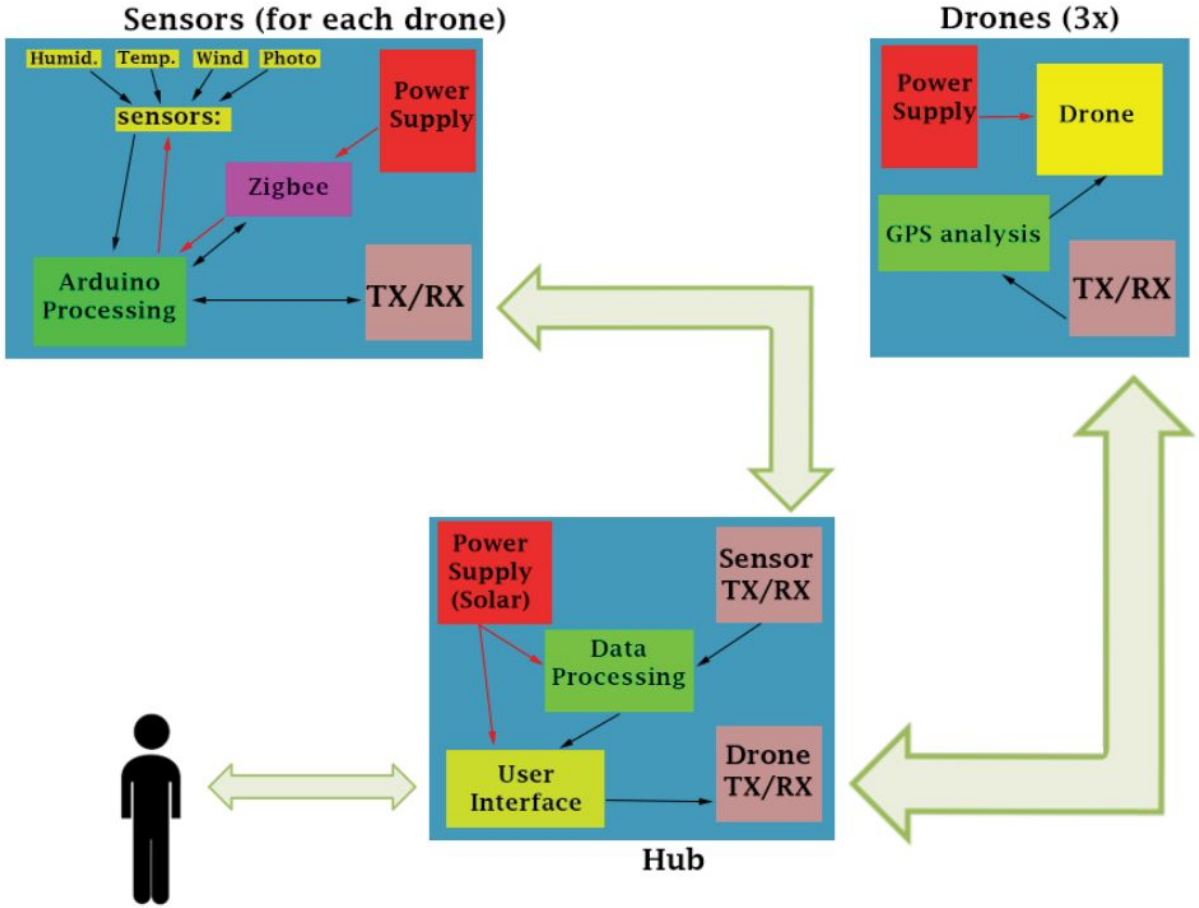
05. **GPS Coordination**

Drones can coordinate their flight control path with one another to determine which one should fly to the target location and where the others should be positioned to create a strong connection between the target and the HUB.

Block Diagram



SUB-SYSTEMS


Sensors (for each drone)
Humid.
Temp.
Wind
Photo
sensors:
Power Supply
Zigbee
Arduino Processing
TX/RX
Drones (3x)
Power Supply
Drone
GPS analysis
TX/RX
Power Supply (Solar)
Sensor TX/RX
Data Processing
User Interface
Drone TX/RX
Hub

Engineering Requirements

Adaptability

- The design will be able to demonstrate its ability to work under 3 different target locations.

Energy

- HUB battery life(mAh) compared to device consumption(mA) will not exceed at ratio of 1:4 in order to allow for 15 minutes of testing/demonstration.

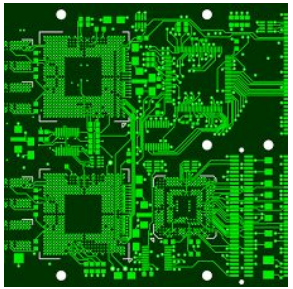
Accuracy

- Drones relative GPS location will be within 3 yards of desired relative location.



Skills + Tools to Create the Design

Raspberry Pi



Andrew+Theo

- DIGI XBEE Wireless Mesh Communication Modules(XCTU) will be used to relay sensor data from Arduino microcontroller.

Ivette

- PCB design and electronic power consumption for drone equipment and the HUB.

Shawn

- Raspberry Pi programming + Drone Flight Controller Programming.

Whole Team

- GPS calculations and mathematical derivations for optimal flight path



Name + Description	Quantity	Total Price
Wind Speed Sensor: This sensor is small and lightweight and uses heated filament to calculate wind speed.	3	$54.00
Temperature/Humidity Sensor: This sensor is small and light weight and will configure well with arduino.	3	$12.00
Camera Sensor: This sensor is small and would work with arduino like the other sensors.	3	$78.00
Arduino Nano: This will be used to gather sensor information and connect to the zigbee.	3	$75.00
Xbee Mesh Kit 3: includes antennas, modules and header boards.	2	$200.00
Raspberry Pi: Small SBC device for flight control program and data acquisition.	1	$129.00
Grove Connectors: Used to connect Xbee module to Arduino Nano.	4	$8.00
Solar Panel + Battery: Isolated Power Supply for the HUB	1	$65.00
LiPo Batteries: Lightweight rechargeable battery for Xbee module on the drone.	3	$7.00
Lipo Battery Adapter: Used to transport power from the battery into USB on Xbee.	3	$6.00
Drones- Parrot Anafi Base: GPS and codeable drone that can carry substantial external weight.	3	$1500.00

Budgeting

Base Total: $2134.00

After tax+Shipping: $2372.00

*Initial plan is to buy one drone and the seek additional funding of $1000.00 in the future

Design Validation Tests

Phase 1

Establish GPS coordinate flight path with one drone directed by the HUB. Simulate mesh communication network as if they are installed onto three drones and confirm sensor data acquisition at the HUB.

Phase 2

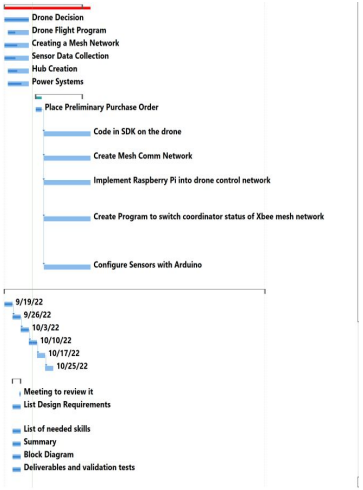
Now reconfigure the HUB to communicate GPS coordinates to three drones. Implement recognition into drones as to which one will take off first.

Phase 3

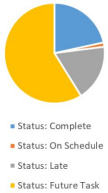
Synthesize the drone flight path coordination with the mesh communication network and implement machine learning to indicate quality of the data received. Test all 5 PSSC’s and evaluate design success.

Responsibilities- Gantt Chart

	Task Name	Duration	Start	Finish	Predecessors	Resource Names	Cost	% Complete
	Research	49 days	Tue 9/20/22	Fri 11/25/22		drone	$750.00	23%
	Drone Decision	15 days	Tue 9/20/22	Mon 10/10/22		Deshawn,Ivette	$0.00	100%
	Drone Flight Program	12 days	Fri 9/23/22	Mon 10/10/22		Deshawn,Ivette	$0.00	35%
	Creating a Mesh Netwo	15 days	Tue 9/20/22	Mon 10/10/22		Andrew,Deshawn	$0.00	60%
	Sensor Data Collection	15 days	Tue 9/20/22	Mon 10/10/22		Andrew	$0.00	50%
	Hub Creation	12 days	Fri 9/23/22	Mon 10/10/22		Theodore	$0.00	50%
	Power Systems	12 days	Fri 9/23/22	Mon 10/10/22		Ivette,Theodore	$0.00	65%
	Phase 1	30 days	Mon 10/17/22	Fri 11/25/22			$0.00	100%
	Place Preliminary Purchase Order	5 days	Mon 10/17/22	Fri 10/21/22		Andrew,Ivette	$0.00	100%
	Code in SDK on the drone	30 days	Mon 10/24/22	Fri 12/2/22	9	Deshawn	$0.00	0%
	Create Mesh Comm Network	30 days	Mon 10/24/22	Fri 12/2/22	9	Andrew, Theodore	$0.00	0%
	Implement Raspberry Pi into drone control network	30 days	Mon 10/24/22	Fri 12/2/22	9	Deshawn, Theodore	$0.00	0%
	Create Program to switch coordinator status of Xbee mesh network	30 days	Mon 10/24/22	Fri 12/2/22	9	Andrew, Deshawn, Ivette, Theodore	$0.00	0%
	Configure Sensors with Arduino	30 days	Mon 10/24/22	Fri 12/2/22	9	Ivette	$0.00	0%
	Weekly Report	160 days	Tue 9/20/22	Mon 5/1/23			$2,600.00	37%
	9/19/22	5 days	Tue 9/20/22	Mon 9/26/22		Theodore	$0.00	100%
	9/26/22	5 days	Tue 9/27/22	Mon 10/3/22	16	Ivette	$0.00	100%
	10/3/22	5 days	Tue 10/4/22	Mon 10/10/22	17		$0.00	100%
	10/10/22	5 days	Tue 10/11/22	Mon 10/17/22	18		$0.00	100%
	10/17/22	5 days	Tue 10/18/22	Mon 10/24/22	19		$0.00	0%
	10/25/22	5 days	Tue 10/25/22	Mon 10/31/22	20		$0.00	0%
	Problem Definition	5 days	Tue 9/27/22	Mon 10/3/22			$0.00	100%
	Meeting to review it	1 day	Mon 10/3/22	Mon 10/3/22			$0.00	100%
	List Design Requirements	5 days	Tue 9/27/22	Mon 10/3/22		Ivette,Deshawn	$0.00	100%
	List of needed skills	5 days	Tue 9/27/22	Mon 10/3/22		Ivette	$0.00	100%
	Summary	5 days	Tue 9/27/22	Mon 10/3/22		Theodore	$0.00	100%
	Block Diagram	5 days	Tue 9/27/22	Mon 10/3/22		Deshawn	$0.00	100%
	Deliverables and validation tests	5 days	Tue 9/27/22	Mon 10/3/22		Deshawn, Theodore	$0.00	100%



CRITICAL TASKS



A task is critical if there is no room in the schedule for it to slip.

Learn more about managing your project's critical path.

Name	Start	Finish	% Complete	Remaining Work	Resource Names
Place Preliminary Purchase Order	Wed 10/19/22	Wed 10/26/22	50%	48 hrs	Andrew,Ivette
Practice flying drone with weight	Thu 10/27/22	Fri 11/4/22	0%	224 hrs	Andrew,Deshawn, Ivette,Theodore
Code in SDK on the drone	Mon 11/7/22	Wed 11/9/22	0%	24 hrs	Deshawn
Create Mesh Comm Network	Tue 11/1/22	Wed 11/9/22	0%	112 hrs	Andrew,Theodore
Implement Raspberry Pi into drone control network	Thu 10/27/22	Mon 10/31/22	0%	48 hrs	Deshawn,Theodor e
Create Program to switch coordinator status of Xbee mesh network	Thu 11/10/22	Fri 11/18/22	0%	224 hrs	Andrew,Deshawn, Ivette,Theodore
Configure Sensors with Arduino	Thu 10/27/22	Mon 10/31/22	0%	24 hrs	Ivette
10/17/22	Tue 10/18/22	Mon 10/24/22	50%	0 hrs	
10/25/22	Tue 10/25/22	Mon 10/31/22	0%	0 hrs	
<New Task>	Tue 11/1/22	Mon 11/7/22	0%	0 hrs	
Formal Design Report	Mon 10/10/22	Mon 10/24/22	60%	0 hrs	
Project Readiness Presentation	Fri 10/7/22	Thu 12/1/22	15%	1,088 hrs	Andrew,Deshawn, Ivette,Theodore
Design Validation Presentation	Thu 12/1/22	Wed 3/15/23	0%	2,400 hrs	Andrew,Deshawn, Ivette,Theodore
Final Product Presentation	Wed 3/15/23	Mon 5/1/23	0%	1,088 hrs	Andrew,Deshawn, Ivette,Theodore

Alternative Design Considerations

- Building our own drone with the use of Pixhawk flight controller. This would allow for project specific functions, however it is expensive unless we found a resale deal.
- GPS header integrated into the Xbee Mesh Kit.
- PCB battery switch implemented on to the drones for additional battery power supply.
- Camera sensor if the drones on-board camera can’t be used for image data.





Testing Safety/Considerations

Area requirements:

- Between 30 -50 yards of dry and open airspace.
- Clear of obstacles that could damage the drone.
- Follow all UAV regulations in the area.
- Area is secure of civilian interference or motor vehicles.

Ethical Considerations:

- Data acquired is used to assist wildland firefighters.
- Data should be accurate to assist them in safe operations.



Electrical Safety:

Many layers of power connections will be involved in the drones and at the HUB. It will be important to mitigate risks of short circuits that could cause fire or damage to components. Also, when making adjustments to the design all systems should be powered off to eliminate risk of electrocution.

Design Summary

The design processes main focus is to have a functioning mesh communication on moving drones.

Success=

- The drones can be transported to an area of interest
- The drones will be able to re-route the data from one another with a change of target location.
- The HUB will be able to collect data and execute satisfactory commands.

Signature of Approval

DocuSigned by:



DF14690ABAE6456...

DocuSigned by:

Deshawn Samuel

1B0F93299515462...

DocuSigned by:

Andrew DelGuidice

6BF29E4348804D6...

DocuSigned by:

Ivette Alvarez

9F0EE28A7B96410...

DocuSigned by:

Tomas Materdey

B077405424714F1...

Resources

https://www.digi.com/products/embedded-systems/digi-xbee/rf-modules/2-4-ghz-rf-modules/xbee3-digimesh-2-4#support

https://data.fs.usda.gov/geodata/

https://developer.parrot.com/docs/airsdk/general/overview.html