



## InternPro Weekly Progress Update

Name	Email	Project Name	NDA/Non-NDA	InternPro Start Date	OPT
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### Progress

Include an itemized list of the tasks you completed this week.

#	Action Item/ Explanation	Total Time This Week (hours)
1	Research Paper on Designing and implementing GNSS RTK	3
2	Sourcing GNSS RTK Equipment Components online	3
3	Feasibility study of building a GNSS station and rover positioning	3
4	SolidWorks Installation and Setting Up	3
5	MATLAB GNSS RTK Simulation	1
6	Report Writing	1
7	Rover Design	2
8	GNSS receiver SolidWorks Design	2
9	Assembling the entire setup	2
	<b>Total hours for the week:</b>	20

### Verification Documentation:

Action Item 1: Research Paper on Designing and implementing GNSS RTK – 3 hour(s).

### Project Work Summary


- <https://www.mdpi.com/1424-8220/24/2/646>
- Designing and Testing an IoT Low-Cost PPP-RTK Augmented GNSS Location Device
- Summary of Report
  - The paper describes the design, implementation and testing of a low-cost IoT GNSS device that uses PPP-RTK corrections to achieve high-accuracy positioning.
  - The device uses a u-blox ZED-F9P GNSS receiver, a mini PC running the u-center software, and custom software to parse and transmit location data.
  - In kinematic vehicle tests, the device achieved horizontal accuracy of 7.7 cm and vertical accuracy of 5.2 cm for fixed ambiguity solutions, which were available 79.5% of the time.
- Relation to Project
  - Provides a working implementation of an IoT-connected GNSS device that could be adapted for precision agriculture applications.
  - Demonstrates the feasibility of achieving centimeter-level accuracy with low-cost GNSS hardware and commercial PPP-RTK corrections.
  - Validates the performance of PPP-RTK techniques in dynamic urban environments, which is relevant for autonomous vehicle navigation.
- Motivation for Research
  - Enable high-accuracy positioning for mass-market applications by leveraging low-cost multi-constellation GNSS receivers and PPP-RTK corrections.
  - Overcome limitations of existing RTK and PPP techniques for large-scale deployment, such as communication bandwidth constraints and long convergence times.
  - Develop an integrated IoT device that can provide real-time centimeter-level positioning data for applications like precision agriculture and autonomous vehicles.

Action Item 2: Sourcing GNSS RTK Equipment Components online – 3

hour(s).


Project Work Summary

- Relevant Links
  - <https://learn.sparkfun.com/tutorials/what-is-gps-rtk>
  - <https://learn.sparkfun.com/tutorials/how-to-build-a-diy-gnss-reference-station/all>
  - <https://pointonnav.com/news/gnss-receivers/>
  - <https://youtu.be/ieearzWTCZw>
  - <https://www.youtube.com/watch?v=Oc1LBFDj2MA&t=904s&pp=ygUIZ25zcyBydGs%3D>
- Summary of Findings
  - GNSS Antenna and Receiver: The setup requires a high-quality GNSS antenna (such as a u-blox L1/L2 antenna) and a compatible GNSS receiver (like the ZED-F9P).
  - Computing Platform: An ESP32-based system, which offers lower power consumption and simpler setup.
  - Data Transmission: The setup requires a means of transmitting correction data. An internet connection for NTRIP server functionality, using either WiFi or Ethernet.




ADD TO CART

**SparkFun GPS-RTK-SMA Breakout - ZED-F9P (Qwiic)**  
GPS-16481  
\$274.95  
★★★★☆ 18




ADD TO CART

**SparkFun GPS-RTK2 Board - ZED-F9P (Qwiic)**  
GPS-15136  
\$274.95  
★★★★☆ 21



<https://learn.sparkfun.com/tutorials/what-is-gps-rtk#ter-board>

**SparkFun MicroMod Ter Board**



**SparkFun RTK Facet L-Band**

Action Item 3: Feasibility study of building a GNSS station and rover positioning – 3 hour(s).

Project Work Summary

- Component Selection and Cost Analysis:
  - The study identified essential components for a GNSS RTK system, including a
    - high-precision GNSS antenna
    - multiple GNSS receivers (one for the base station and three for rovers)
    - a single-board computer for data processing
    - necessary accessories
- Scalability and Coverage:
  - The design incorporates four GNSS receivers - one for the base station and three for rovers.
  - This configuration is tailored for a moderate-sized farm, assuming that three robots would provide sufficient coverage for the area.
- Performance and Compatibility:
  - The selected components, particularly the SparkFun GPS-RTK-SMA Breakout (ZED-F9P) receivers, offer a balance between performance and cost-effectiveness.

- The use of L1/L2 multi-band antennas and compatible hardware ensures high-precision positioning.
- Additionally, the ESP32-based single-board computer provides adequate processing power for running the NTRIP server software
- Created an excel sheet to collect all the researched data and compiled them together to form the feasibility study for establishing the GNSS base station.

Feasibility Study

Component	Package Function	Package Link/Supplier (optional)	Specific Model Type	Quantity	Notes	Price (\$)
GNSS Antenna	Receive satellite signals	<a href="https://www.sparkfun.com/products/14979">https://www.sparkfun.com/products/14979</a>	GNSS L1/L2 Multi-Band Magnetic Mount Antenna - 5m (SP-M)	1	Chosen higher version because we might need on-off a bit.	124.5
GNSS Receiver	Process GNSS signals	<a href="https://www.sparkfun.com/products/14979">https://www.sparkfun.com/products/14979</a>	SparkFun GPS-RTK (GNSS Breakout - 2SD-FRP (Qmic))	4	I've chosen the GNSS version for its moderate pricing and good performance. One receiver is needed for the base station, while	1099.9
Antenna cable	Connect antenna to receiver	<a href="https://www.sparkfun.com/products/14979">https://www.sparkfun.com/products/14979</a>	Interface Cable - SMA Female to SMA Male (1m, RS91)	2		19.9
Single-board computer	Run NTRIP server software	<a href="https://www.sparkfun.com/products/14979">https://www.sparkfun.com/products/14979</a>	SparkFun Thing Plus - (ESP32 WHCOB (Micro))	1	The ESP32's processing power and capabilities are more than adequate to handle the task of a	122.5
Mounting hardware	Secure antenna	<a href="https://www.sparkfun.com/products/14979">https://www.sparkfun.com/products/14979</a>	GPS Antenna Ground Plane	1		14.95
Ground plane	Improve antenna performance	<a href="https://www.sparkfun.com/products/14979">https://www.sparkfun.com/products/14979</a>	GNSS Antenna Mounting Hardware	1		5.95
					Total	1583.1

**Feasibility Analysis Conclusion:** The total cost of around \$1480 is relatively low for a DIY GNSS RTK setup, making it feasible for moderate-level agricultural robotics.

**Performance:** The chosen components should provide centimeter-level accuracy, which is suitable for most agricultural applications.

**Ease of Setup:** The DIY approach requires some technical knowledge but is achievable with the provided instructions and open-source software.

**Scalability:** The setup can be expanded or upgraded as needed, providing flexibility for future improvements.

**Performance:** Regular software updates and occasional hardware checks will be necessary, but overall maintenance should be minimal.

**Power Consumption:** The system is relatively low power, making it suitable for solar power options if needed.

**Range:** The base station should provide accurate corrections within a 10km radius, which is sufficient for most farm operations.

**Compatibility:** The chosen components are widely compatible with various robotics platforms and software.

**Considerations Internet Connectivity:** Ensure reliable internet access for NTRIP server functionality, or consider the option of local corrections.

**Location:** Choose a stable mounting point with a clear sky view for optimal performance.

**Weather Protection:** The enclosure is crucial for protecting electronics in outdoor environments.

**Regulations:** Check local regulations regarding radio transmission if using the optional 915MHz radio.

**Expandability:** Consider future needs when setting up, allowing for easy integration of additional sensors or equipment.

**Conclusion:** This DIY GNSS RTK setup appears feasible for moderate-level agricultural robotics applications. It offers a good balance of cost, performance, and flexibility. The total investment is relatively low compared to commercial systems, while still providing the necessary accuracy for most significant tasks. The modular nature of the setup allows for future upgrades or modifications as needs change or technology advances.

Action Item 4: SolidWorks Installation and Setting Up - 3 hour(s).

## Project Work Summary

- Now that we have completed the feasibility study based on the hardware and component requirements, we also need to verify if the rover's design can accommodate the GNSS receiver.
- To evaluate if the rover design can accommodate a GNSS receiver, I needed to use SolidWorks for 3D modeling and analysis.
- I reviewed the installation manual for SolidWorks, based on the Student Edition Key (SEK) serial number provided through the EPICS program's licensed version.
- I successfully installed SolidWorks on my PC and activated the licensed version using the provided Student Edition Key (SEK).

Topic: Solidworks License

Solidworks License: 2024-2025

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canvas.asu.edu/courses/189652/pages/solidworks-license?module\_item\_id=14769217

Solidworks2024-2025.pdf

ASU Ira A. Fulton Schools of Engineering  
Arizona State University

**HOW TO DOWNLOAD & INSTALL SOLIDWORKS ENGINEERING KITS**

1. Uninstall any/all previous versions
2. Go to [www.solidworks.com/SEK](http://www.solidworks.com/SEK)
3. Use SEK-ID = **XSEK12** and enter in the form
4. Choose '2024' for the most recent version
5. You will then be asked to enter your Student ID Number:

**Your Student ID Number is: 9020 0086 84**

Action Item 5: MATLAB GNSS RTK Simulation – 1 hour(s).

### Project Work Summary

- Before getting into hardware of buying the GNSS RTK and other agricultural robot, we could simulate and understand some of the difficulties faced in implementing a real world application.
- MATLAB does contain 'gpsSensor' and 'gnssSensor' objects for simulating the GPS and GNSS receivers, but how realistically it could incorporate the inaccuracies in the measurements is still needs to be researched.
- Further research is needed in finding if there is a way to simulate the GNSS RTK in MATLAB or perhaps any other coding language like Python or ROS 2.

Action Item 6: Report Writing – 1 hour(s).

### Report Writing

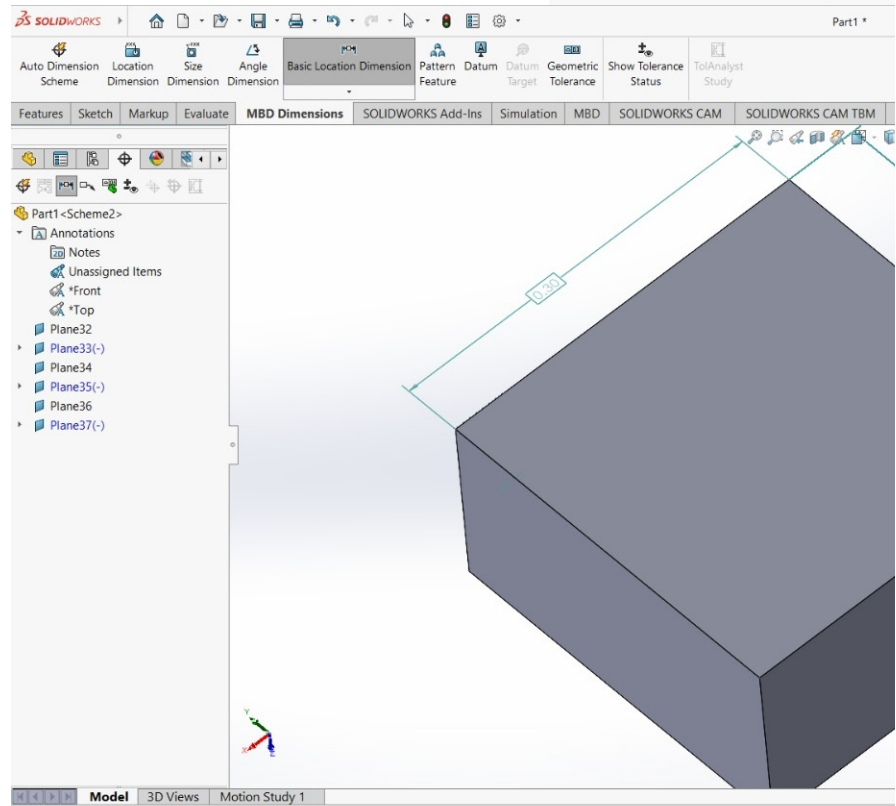
- Compiled all the contents for the entire week and documented it in the word document.
- Organized screenshot, relevant links and documented contents to write for the weekly progress.
- Described all the action items in detail and wrote it as per the requirements.

Action Item 7: Rover Design – 2 hour(s).

### Project Work Summary

- We need to first design the rover so that we could attach the GNSS receiver to understand if it could accommodate the receiver within the body.
- We do not need a highly defined structure of the rover for the understanding purpose, hence a basic cuboid with 30x30x15 cm preliminary design for the rover is chosen.
- Opened the SolidWorks and chose the front plane. Then chose the sketch option to create a 30x30 square plane. Extruded the shape

to form the cuboid robot.

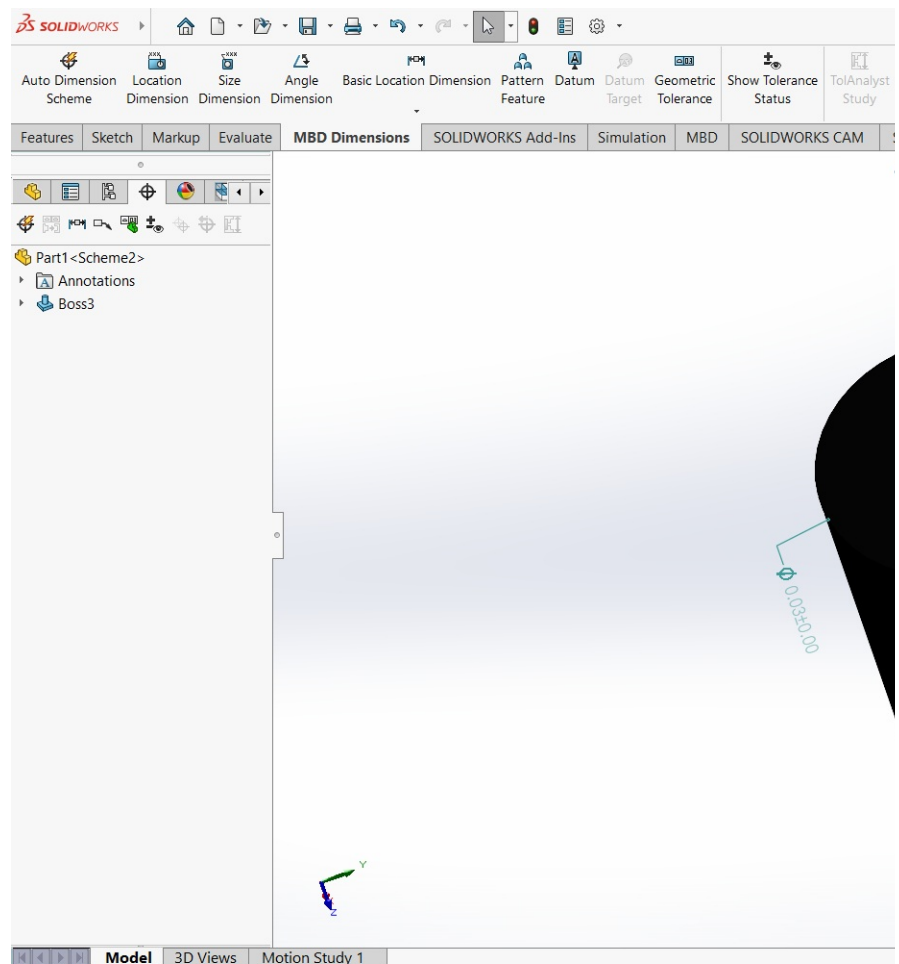


- Select one or more faces and then a text location.
- 

Action Item 8: GNSS receiver SolidWorks Design – 2 hour(s).

### Project Work Summary

- Research some online sources for the available GNSS receivers for the rover to get a reasonable estimate of the GNSS receiver's dimensions.
- The dimensions for the receiver was found to be 3cm diameter cylinder with a height of 5 cm.
- Opened the SolidWorks and sketched a 3 cm diameter circle and the base plane and extruded the circle to form the rough diagram of the sensor.
- Effectively I created the rough diagram to successfully compare the dimensions of the rover and receiver through SolidWorks.

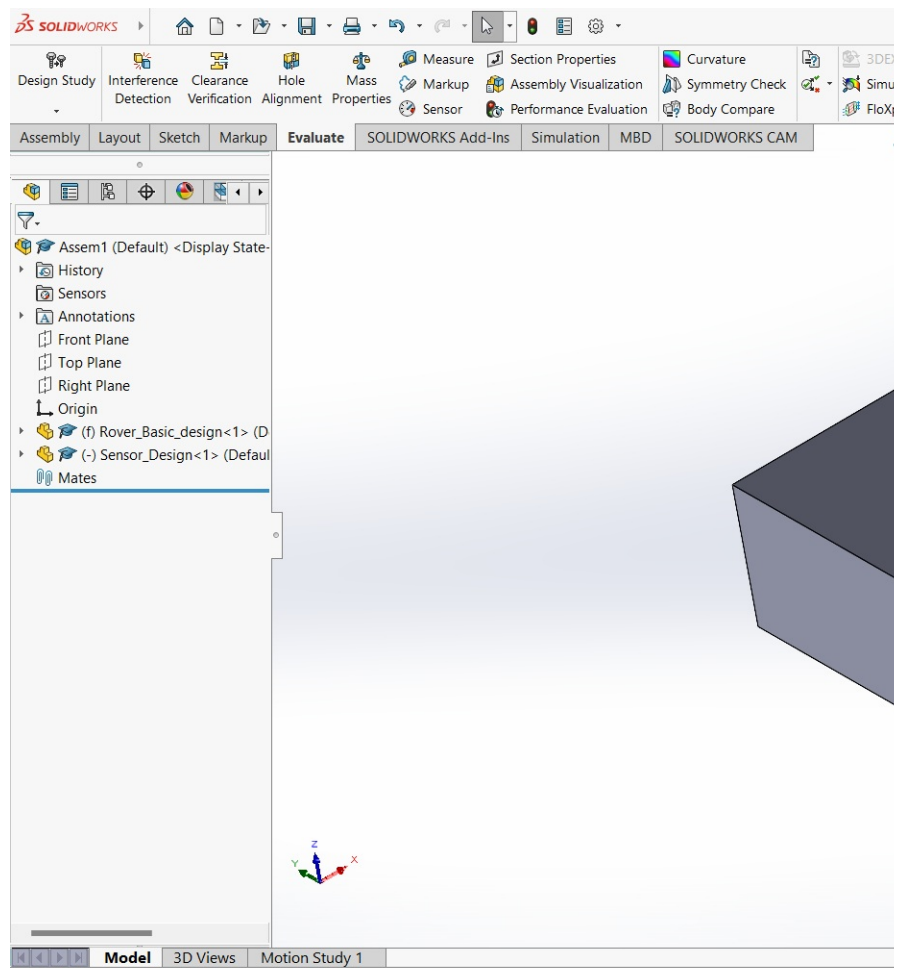


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Action Item 9: Assembling the entire setup – 2 hour(s).

### Project Work Summary

- Now that I have created both the shapes of the rover and sensor in the SolidWork, I then have to assemble them together to find if the receiver goes well with the rover.
- So I opened the assemble feature of the SolidWorks and added both the structures together to the SolidWorks and used the Mate option to mate them together.
- Effectively I have attached the sensor to the design of the rover and it almost seems perfect from the preliminary design but further work is needed to better estimate the effectiveness.



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