

Reference Number	Related Requirement	Failure Mode	Type of Failure	Cause of Failure	Effect of Failure	Before			Mitigation of Failure	After		
						Likelihood	Criticality	RPN		Likelihood	Criticality	RPN
1a	1.1.3	uSD card not present	Operator Error	uSD card is not inserted into the receptacle	System will be unable to log data to a uSD card for storage and off-loading	0.50	9	4.50	Go into an error state when uSD is not detected. Prompt user to override by storing data on backup flash storage - notify them that doing so will dramatically limit their deployment time	0.50	7	3.50
1b	1.1.3	uSD card is broken	Hardware Failure	The uSD card is damaged and inoperable	System will be unable to log data to a uSD card for storage and off-loading.	0.10	9	0.90	Go into an error state when uSD is not detected. Prompt user to override by storing data on backup flash storage - notify them that doing so will dramatically limit their deployment time.	0.10	9	0.90
					Depending on the physical damage to the card, an electrical short may develop, leading to excess heating and power draw	0.10	9	0.90	Protect the SD card with a strong receptacle. Have fuses that can limit the current drawn in the event of a short circuit	0.05	9	0.45
1c	1.1.3	Secondary flash storage is non-operable	Hardware Failure	The SPI bus is having electrical issues, or CS line is not set correctly	System will be unable to log data to the backup storage system in the event of an error on the uSD card.	0.10	3	0.30	Proper installation of the secondary flash chip during assembly. Ensure that the proper CS line is selected in the code when initializing the device. Ensure that there is no damage to the board Warn user of fault in secondary flash storage	0.10	2	0.20
				The flash chip is physically damaged	A short may develop, leading to excess heating and power draw	0.05	8	0.40	0.05	8	0.40	
2	1.1.10	The power switch is non-operable	Hardware Failure	The switch is melted and locked into a certain setting. Debris or corrosion jammed the switch into its current settings	The system will be unable to turn on	0.01	10	0.10	Ensure that components are protected during use by strong case. Ensure that components are able to withstand intended soldering conditions (especially temperature)	0.01	10	0.10
				The system will be unable to turn off	0.01	1	0.01	Ensure that power connections are easily removable - remove connections in event of failure	0.01	1	0.01	

3	3.1.11	The battery does not charge when plugged into USB power	Hardware Failure	Internal failure of the IC. Faulty connections	The system will be unable to charge the battery by itself	0.10	1	0.10	Ensure that the battery is easily removable and an external charger is available for it	0.10	1	0.10	
	3.1.11			Physical damage to the charging IC	A short may develop, leading to excess heating and power draw	0.01	1	0.01	Have fuses on the board that can limit the current drawn in the event of a short circuit. Protect the IC from physical damage with a case	0.01	1	0.01	
4a	1.1.2	The GPS does not receive a valid satellite fix	Radio Failure	The radio antenna does not have a clear LOS to the sky	The system will be unable to locate itself in geographic coordinates	0.90	5	4.50	Ensure that the GPS radio antenna has a clear line of sight to the sky. Ensure that antenna is clear of concrete or metal obstructions.	0.01	5	0.05	
	1.1.2				The system will not be able to coordinate the system time to UTC reported by satellites	0.90	2	1.80	Allow the user to overwrite the current RTC setting via UI.	0.90	1	0.90	
4b	1.1.2	The GPS does not send or receive data to the microcontroller	Software Failure	The GPS firmware has crashed due to a buffer overflow error	The system will not be able locate itself in geographic coordinates	0.40	5	2.00	Integrate a software reset function for the GPS radio Adjust the GPS report rate and baud rate to be more stable	0.40	2	0.80	
					The system will not be able to coordinate the system time to UTC reported by satellites	0.40	2	0.80	Allow the user to overwrite the current RTC setting via UI.	0.40	1	0.40	
5a	3.2.7	The microcontroller does not broadcast a WiFi Access Point station	Radio Failure	The radio antenna is not properly connected to the surface mount connector		0.60	5	3.00	Ensure that the antenna connectors are securely mounted to any board connectors. Minimize cycle times of plugging/unplugging the connectors to maximize usable lifespan	0.20	5	1.00	
	2.2.7			The radio antenna is mounted inside a RF-blocking material		0.10	5	0.50	Ensure that the enclosure is non-RF-blocking, or the antenna is mounted externally	0.10	5	0.50	
			Hardware Failure	The WiFi PHY hardware inside the microcontroller fails to initialize		0.05	5	0.25	Ensure that the microcontroller is not damaged and does not exceed its maximum operating limits for power, temperature, humidity, etc.	0.05	5	0.25	
			Software Failure	The WiFi PHY firmware inside the microcontroller crashes		0.05	5	0.25	Ensure that the microcontroller code does not crash due to run-time errors and the web server cannot be disrupted easily. Implement a software check that resets the system after a hanging failure.	0.01	5	0.05	
				The WiFi AP is not initialized with the correct settings		0.30	5	1.50	Ensure that the configuration file is written to the microcontroller SPIFFS storage. Ensure that the WIFI_DEBUG compile flag is flipped when firmware is flashed	0.10	5	0.50	

5b	3.2.7	The microcontroller does not connect to a WiFi network	Radio Failure	The radio antenna is not properly connected to the surface mount connector	The system will not be able to connect to outside devices and users will not be able to configure the device remotely	0.60	5	3.00	Ensure that the antenna connectors are securely mounted to any board connectors. Minimize cycle times of plugging/unplugging the connectors to maximize usable lifespan	0.20	5	1.00
	2.2.7			The radio antenna is mounted inside a RF-blocking material		0.10	5	0.50	Ensure that the enclosure is non-RF-blocking, or the antenna is mounted externally	0.10	5	0.50
			Hardware Failure	The WiFi PHY hardware inside the microcontroller fails to initialize		0.05	5	0.25	Ensure that the microcontroller is not damaged and does not exceed its maximum operating limits for power, temperature, humidity, etc.	0.05	5	0.25
			Software Failure	The WiFi PHY firmware inside the microcontroller crashes		0.05	5	0.25	Ensure that the microcontroller code does not crash due to run-time errors and the web server cannot be disrupted easily. Implement a software check that resets the system after a hanging failure.	0.01	5	0.05
				The WiFi connection is not initialized with the correct settings		0.30	5	1.50	Ensure that the configuration file is written to the microcontroller SPIFFS storage. Ensure that the settings within the configuration file are correct. Ensure that the WIFI_DEBUG compile flag is flipped when firmware is flashed	0.10	5	0.50
6	3.2.2	The I2C devices are not initialized properly	Hardware Failure	A solder joint is not connected properly to one or multiple devices	The IMU, magnetometer, and/or battery gauge will not be functional	0.05	10	0.50	Ensure that the device is properly assembled and tested before deployment	0.05	10	0.50
				One or more devices has physically broken		0.01	10	0.10	Ensure that the device is properly protected by a drop-resistant case. Ensure that the device is stored in accordance with manufacturer recommendations	0.01	10	0.10
			Software Failure	The I2C bus is not properly initialized on the device		0.30	10	3.00	Ensure that the SDA and SCL pins are properly set in the board configuration file. Ensure that "Wire.begin((int) SDA, (int) SCL);" is called before I2C sensor initialization begins	0.01	10	0.10
				One or more devices have reached a soft failure state		0.05	10	0.50	Have the microcontroller be able to soft reset each device. Notify the user of failure modes and advise them to hard restart the device	0.05	3	0.15

7	1.1.12	The device is not put into a diagnostic mode when a USB cable is inserted	Hardware Failure	One or more of the resistors in the sense divider are not the correct value	The device will not enter the appropriate mode for programming and debugging during development	0.01	3	0.03	Ensure that the board is assembled with the appropriate parts and that the connections are secure	0.01	3	0.03
8a	1.1.14	The NeoPixel LED does not come on during system start	Hardware Failure	The MOSFET enabling current flow to the component may not be open	The NeoPixel will not come on and provide useful information to the user	0.20	1	0.20	Check that the NEOPIXEL_EN line is LOW (0V)	0.20	1	0.20
	3.2.2			A solder joint is not connected properly to the NeoPixel or related components		0.10	1	0.10	Ensure that the device is properly assembled and tested before deployment	0.05	1	0.05
				One or multiple LEDs within the NeoPixel are burned out		0.30	1	0.30	Ensure that the current-limiting resistor to the NeoPixel is greater than to equal to the value specified in the schematic	0.05	1	0.05
8b	1.1.14	The NeoPixel LED does not display the proper colors	Hardware Failure	One or multiple LEDs within the NeoPixel are burned out	This may provide the user with incorrect or false information, depending on the color scheme	0.30	1	0.30	Ensure that the current-limiting resistor to the NeoPixel is greater than to equal to the value specified in the schematic	0.05	1	0.05
			Software Failure	The color values provided to the NeoPixel color() function are not in GRB format		0.05	1	0.05	Ensure that the colors specified in the firmware are in the proper color format	0.01	1	0.01
9	1.1.3	The diagnostic file logger does not initialize properly	Operator Error	uSD card is not inserted into the receptacle	System will be unable to log data to a uSD card for storage and off-loading	0.50	9	4.50	Go into an error state when uSD is not detected. Prompt user to override by storing data on backup flash storage - notify them that doing so will dramatically limit their deployment time	0.50	7	3.50
			Software Failure	The CS line is not properly selected in the firmware		0.01	9	0.09	Ensure that the SD_CS variable in the firmware is properly configured to the schematic. Go into an error state and prompt the user to override by storing data on backup flash storage - notify them that doing so will dramatically limit the deployment time	0.01	7	0.07

10	1.1.8	Tertiary flash storage (SPIFFS) is not initialized	Hardware Failure	The SPI bus is having electrical issues, or CS line is not set correctly. The microcontroller may be physically damaged	System will be unable to load settings from the on-board configuration file.	0.10	9	0.90	Automatically backup configuration settings to the secondary flash storage device - load if there is an error. Warn user of fault in tertiary flash storage	0.01	9 0.09
				System will be unable to load webpage information for serving the dashboard and UI	0.10	1	0.10	Backup the web server information to secondary flash storage - load if there is an error. Warn user of fault in tertiary flash storage	0.01	1 0.01	
			Software Failure	The SPIFFS memory registers may not be initialized	System will be unable to load settings from the on-board configuration file.	0.10	9	0.90	Automatically backup configuration settings to the secondary flash storage device - load if there is an error. Warn user of fault in tertiary flash storage Ensure that the filesystem image has been flashed to the device	0.01	9 0.09
				System will be unable to load webpage information for serving the dashboard and UI	0.10	1	0.10	Backup the web server information to secondary flash storage - load if there is an error. Ensure that the filesystem image has been flashed to the device Warn user of fault in tertiary flash storage	0.01	1 0.01	
11	1.2.12	The logging interval timer does not initialize	Software Failure	The timer configuration settings may not be correctly set	The system will be unable to log at the user-specified interval	0.05	10	0.50	Extensively test the configuration parameters before deployment	0.01	10 0.10
12a	1.1.8	The configuration file cannot be loaded from tertiary storage	Hardware Failure	The SPI bus is having electrical issues, or CS line is not set correctly. The microcontroller may be physically damaged	The user configuration settings will be unable to be loaded	0.10	9	0.90	Automatically backup configuration settings to the secondary flash storage device - load if there is an error. Warn user of fault in tertiary flash storage	0.01	9 0.09
				The configuration file may not be loaded into the SPIFFS memory registers		0.60	9	5.40	Ensure that the filesystem image is flashed to the device before deployment	0.50	9 4.50
			Software Failure	The configuration file name may not be set properly in the firmware		0.10	9	0.90	Ensure that the configuration file name is constant and consistent throughout the firmware	0.01	9 0.09
				A configuration setting has a line length greater than the maximum line length (127)		0.01	4	0.04	Ensure that each line in the configuration file does not exceed 127 characters	0.01	4 0.04

Failure Mode Analysis Report											
Failure ID	Failure Description	Failure Type	Failure Symptoms			Failure Mechanism			Mitigation and Recovery		
			Severity	Impact	Probability	Mechanism Type	Severity	Impact	Mitigation Type	Severity	Impact
12b	1.1.8 A configuration parameter is not loaded properly	Software Failure	The configuration parameter in the file does not match that being checked for in the loadConfigurations function	The incorrectly labeled configuration(s) will be unable to load	0.30	2	0.60	Ensure that each configuration setting name matches that in the loadConfigurations function Warn the user that an unknown configuration parameter was detected using the diagnostic logger	0.15	2	0.30
			The type of parameter does not match that specified in the loadConfigurations function	The incorrectly typed configuration(s) will not load properly The device may enter into a crashing failure state	0.30	8	2.40	Ensure that the configuration settings type matches that in the loadConfigurations function Log every configuration parameter loaded so the user may find a bad type, if a crashing error occurs	0.15	8	1.20
13	1.3.10 The microcontroller's internal RTC is not able to synchronize properly	Radio Failure	The GPS does not have a valid fix to the satellite constellation	The on-board report time will not be synchronized to UTC, rather it will be in terms of time since power-on	0.80	2	1.60	Attempt to synchronize the RTC every minute Advise the user of the synchronization status by using the diagnostic logs	0.80	1	0.80
		Software Failure	The RTC synchronizes to the GPS time, but incorrectly counts the milliseconds between updates	The on-board report time will not be correct. For instance, the time may be 2023-02-23T09:00:00.120000 where the clock is misreporting the 2 minutes that have passed.	0.90	9	8.10	Regulararly update the RTC milliseconds in the main loop execution	0.01	9	0.09
14	1.1.3 The data logger does not initialize	Operator Error	uSD card is not inserted into the receptacle	System will be unable to log data to a uSD card for storage and off-loading	0.50	9	4.50	Go into an error state when uSD is not detected. Prompt user to override by storing data on backup flash storage - notify them that doing so will dramatically limit their deployment time	0.50	7	3.50
		Hardware Failure	The uSD card is damaged and inoperable	System will be unable to log data to a uSD card for storage and off-loading.	0.10	9	0.90	Go into an error state when uSD is not detected. Prompt user to override by storing data on backup flash storage - notify them that doing so will dramatically limit their deployment time.	0.10	9	0.90
				Depending on the physical damage to the card, an electrical short may develop, leading to excess heating and power draw	0.10	9	0.90	Protect the SD card with a strong receptacle. Have fuses that can limit the current drawn in the event of a short circuit	0.05	9	0.45
		Software Failure	The CS line is not properly selected in the firmware	System will be unable to log data to a uSD card for storage and off-loading	0.01	9	0.09	Ensure that the SD_CS variable in the firmware is properly configured to the schematic. Go into an error state and prompt the user to override by storing data on backup flash storage - notify them that doing so will dramatically limit the deployment time	0.01	7	0.07
			The maximum number of data logs have been created	System will be unable to log data to a uSD card for storage and off-loading	0.01	9	0.09	Set the maximum number of log files absurdly high Well before reaching the maximum limit, warn the user about the potential failure and prompt them to clear the data	0.01	9	0.09