**Project: SKY NET**

**Preliminary Component Specification**

**Solar Power Generator for the Mobile Control Center**

**Presented by**

**FIT**

***Presented by***

Futuristic Innovative Technologies

**FIT Participating Members:**

Andrew Thomas, Spenser Gorenflo, Connor Hill

Dhwanil Desai, Nisarg Shah, Miles Medearis, Yaya Nedd, Mariana Villalabeitia Arenas

Dylan Huss, Bria Booth, Suleyman Gokdemir

|  |  |  |
| --- | --- | --- |
| **Rev.** | **Date** | **Revision Notes** |
| 1 | 2021/09/30 | Initial Release |

***Table of Contents:***

[***1.*** ***Scope*** 5](#_Toc44315012)

[***2.*** ***Applicable Documents*** 5](#_Toc44315013)

[***3.*** ***System Requirements*** 5](#_Toc44315014)

[**3.1.** ***System Definition*** 5](#_Toc44315015)

[**3.1.1.** ***General Description*** 5](#_Toc44315016)

[***3.1.2.*** ***Operational Requirements*** 6](#_Toc44315017)

[***3.1.3.*** ***Maintenance Concept*** 6](#_Toc44315018)

[***3.1.4.*** ***Functional Analysis and System Definition*** 7](#_Toc44315019)

[***3.1.5.*** ***Allocation of Requirements*** 7](#_Toc44315020)

[***3.1.6.*** ***Functional Interfaces and Criteria*** 7](#_Toc44315021)

[***3.2.*** ***System Characteristics*** 10](#_Toc44315022)

[***3.2.1.*** ***Performance Characteristics*** 10](#_Toc44315023)

[***3.2.2.*** ***Physical Characteristics*** 11](#_Toc44315024)

[***3.2.3.*** ***Effectiveness Requirements*** 11](#_Toc44315025)

[***3.2.4.*** ***Reliability*** 11](#_Toc44315026)

[***3.2.5.*** ***Maintainability*** 11](#_Toc44315027)

[***3.2.6.*** ***Usability (Human Factors)*** 11](#_Toc44315028)

[***3.2.7.*** ***Supportability*** 11](#_Toc44315029)

[***3.2.8.*** ***Transportability / Mobility*** 12](#_Toc44315030)

[***3.2.9.*** ***Flexibility*** 12](#_Toc44315031)

[***3.2.10.*** ***Sustainability*** 12](#_Toc44315032)

[***3.2.11.*** ***Safety*** 12](#_Toc44315033)

[***3.2.12.*** ***Security*** 12](#_Toc44315034)

[***3.3.*** ***Design and Construction*** 12](#_Toc44315035)

[***3.3.1.*** ***CAD/CAM Requirements*** 12](#_Toc44315036)

[***3.3.2.*** ***Materials, Processes, and Parts*** 12](#_Toc44315037)

[***3.3.3.*** ***Mounting and Labelling*** 13](#_Toc44315038)

[***3.3.4.*** ***Electromagnetic Radiation*** 13](#_Toc44315039)

[***3.3.5.*** ***Interchangeability*** 13](#_Toc44315040)

[***3.3.6.*** ***Workmanship*** 13](#_Toc44315041)

[***3.3.7.*** ***Testability*** 13](#_Toc44315042)

[***3.3.8.*** ***Economic Feasibility*** 13](#_Toc44315043)

[***3.4.*** ***Documentation / Data*** 13](#_Toc44315044)

[***3.5.*** ***Logistics*** 13](#_Toc44315045)

[***3.5.1.*** ***Maintenance Requirements*** 13](#_Toc44315046)

[***3.5.2.*** ***Supply Support*** 14](#_Toc44315047)

[***3.5.3.*** ***Test and Support Equipment*** 14](#_Toc44315048)

[***3.5.4.*** ***Personnel and Training*** 14](#_Toc44315049)

[***3.5.5.*** ***Facilities and Equipment*** 14](#_Toc44315050)

[***3.5.6.*** ***Packaging, Handling, Storage and Transportation*** 14](#_Toc44315051)

[***3.5.7.*** ***Computer Resources*** 14](#_Toc44315052)

[***3.5.8.*** ***Technical Data*** 14](#_Toc44315053)

[***3.5.9.*** ***Customer Service*** 14](#_Toc44315054)

[***3.6.*** ***Producibility*** 14](#_Toc44315055)

[***3.7.*** ***Disposability*** 15](#_Toc44315056)

[***3.8.*** ***Affordability*** 15](#_Toc44315057)

[***4.*** ***Test and Evaluation*** 15](#_Toc44315058)

[***5.*** ***Quality Assurance Provisions*** 15](#_Toc44315059)

[***6.*** ***Distribution and Customer Service*** 15](#_Toc44315060)

[***7.*** ***Notes*** 15](#_Toc44315061)

[***7.1.*** ***Acronyms*** 15](#_Toc44315062)

[***8.*** ***References*** 16](#_Toc44315063)

# ***Scope***

****This preliminary component specification has been created for educational purposes. It does not capture the full component specifications required to develop the project.

The scope of this document is to provide a preliminary list of component level requirements from a performance and feasibility perspective of a solar power generator capable of powering a AUAV Mobile Control Center

# ***Applicable Documents***

The processes and standard operating procedures referenced within this specifications document:

* 1. Military Standards

MIL-STD-499 for SYSTEM ENGINEERING MANAGEMENT (17 JUL 1969)

* 1. Federal Aviation Administration (FAA) Standards

FAA part 107 Unmanned Aircraft Systems (UAS)

# ***System Requirements***

This section covers all functional, nonfunctional, human-centered, and applicable sub-system life-cycle requirements.

## ***System Definition***

### ***General Description***

The Solar Power Generation configuration consist of an array of nine solar panels powering a total of three batteries utilizing a Power Controller unit to manage the charging loads. This unit is also capable of providing a DC Power as well as providing compatibility for an Inverter to provide AC Power as required. A preliminary layout drawing is presented in Figure 1.

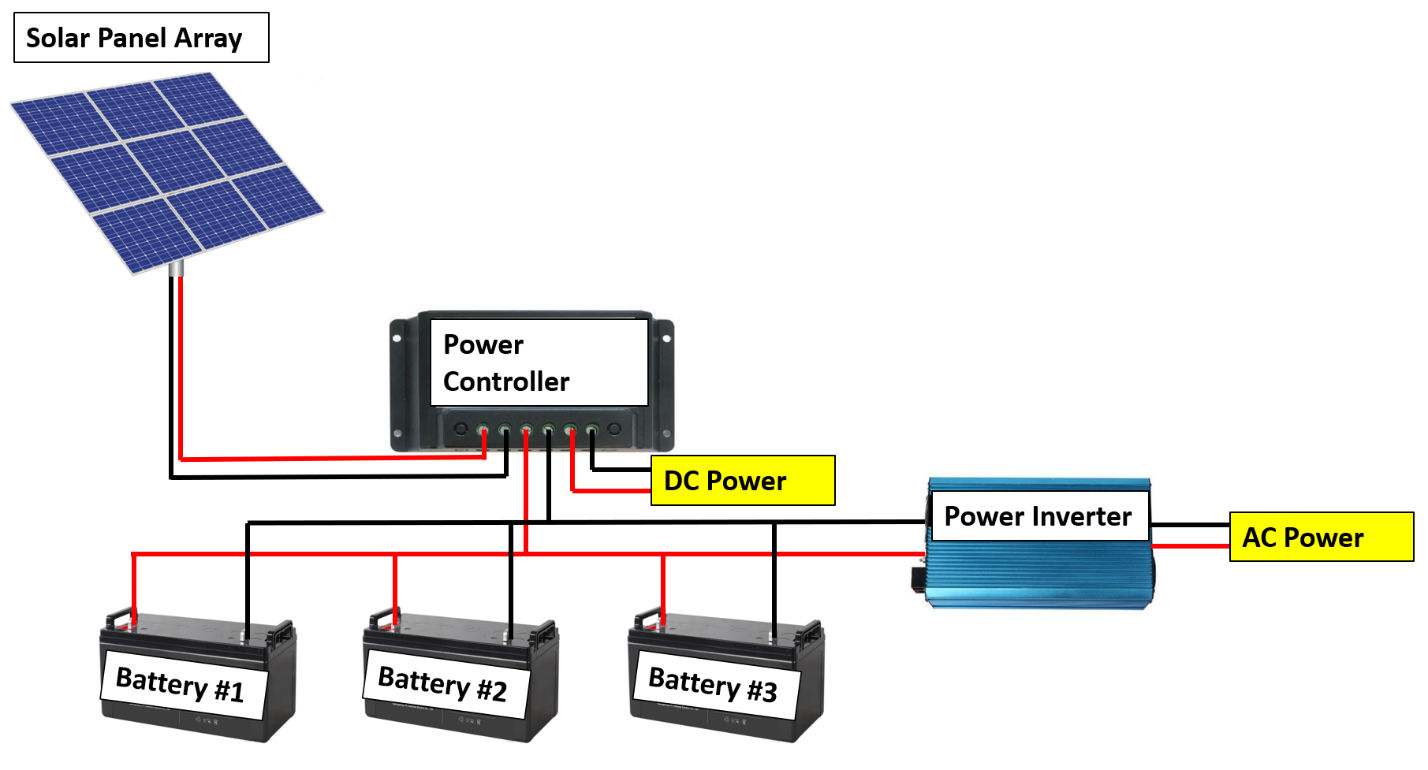


Figure 1: Solar Power Generator Schematic

### ***Operational Requirements***

(Need, Mission, Use Profile, Distribution, Life Cycle)

The MS-275 is too provide power to the MCC. The solar panels will be attached to the trailer. The trailer will have a Universal Hitch that can be connected to the MCC. The MCC will be able to run wires to the MS-275 so that it can receive the stored power and run all the equipment during the mission life cycle.

All are recyclable at the end of the project lifecycle.

### ***Maintenance Concept***

The MCC Solar Power generator does not require maintenance in the way of a hardware system. The hardware comes equipped with an automatic Mobile Solar system and provides a 5 year warranty for the inverter, 7 year warranty for the batteries, 25 year warranty on the solar panels and 5 year warranty on the charge controller.

### ***Functional Analysis and System Definition***

On average, constant satellite communications require about 4.8 kWh per day. FIT will assume a usage of 39.6 kWh per day to account for AUAV communications, internet connectivity, and general Mobile Command Center power usage.

|  |  |  |  |
| --- | --- | --- | --- |
| **Equipment** | **Power (W)** | **Usage Per Day (Hour)** | **Energy Usage (kWh)** |
| Communications (Antenna/Internet) | 200 | 24 | 4.8 |
| Lights | 100 | 24 | 2.4 |
| Computers/Workstation | 1000 | 24 | 24 |
| Air Conditioning | 700 | 12 | 8.4 |
| **Totals** | **2000** | **84** | **39.6** |

Table 1. Breakdown of components in MCC and their Power Consumption

Comms: The communications power usage is 200 W. This number was derived from different power requirements of antenna, satellite, GPS, and internet. These would all be run for 24 hours giving the energy usage of 4.8 kWh.

Lights: Lighting energy usage was calculated assuming the use of 2 LED flat panel troffer lights each requiring 50W.

Computer/Workstation: In the Mobile Command Center there would be two computer workstations. Based on findings online of similar equipment, each computer was estimated to require 700 W of power. As the workstations would be run for 24 hours the total energy usage would be 24 kWh to run both computer stations.

A/C: Mobile Command Center requires at least a 10,000 BTU A/C unit to cool off the electronics while maintaining a suitable temperature for the operators. A standard 10,000 BTU A/C unit utilized in RVs has a power draw of 700W continuously.

After doing research on various battery types, FIT has elected to use a lead-acid battery type for the solar power generator. Lithium-ion as well as absorbed glass mat (AGM) batteries were available however lead-acid was the most commercially available and most cost-effective option.

FIT chose to select Mobile Solar brand solar generators. These products all come bundled with batteries, solar panels, and trailers for mobility. The analysis below compares some of the solar powered generator options available. Based on the specifications provided and chart data below, the Mobile Solar MS-275 is the most beneficial option. It has a battery capacity of 30 kWh; it can harvest up to 22.5 kWh\* daily with 9 solar panels and the nominal power output is 8kW.

\*22.5 kWh harvested daily assumes an average of 7 hours of sunlight per day and peak direct sun hours would be approximately 3 - 4 / daily. \*

Due to the required power consumption and the requirement to have the Mobile Command Center operating 24/7, two batteries would be required to make purely solar power generation feasible. One battery constantly in use while the secondary battery charges. FIT recommends the use of three batteries however, to mitigate any risks that may occur with battery failure.

Based on the required power to sustain the MCC (roughly 40 kWh), it is feasible to use the MS-275 solar powered generator accompanied by a minimum of two batteries for this purpose.

FIT alternatively recommends use of Mobile Solar products with larger battery capacities. Products such as the MS-400 Series have larger batteries, larger inverter outputs and alternative gas-powered backup generators in case of a failure.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Product | Battery | Battery Capacity (kWh) | Harvest (kWh)/day | Power Output (kW) | Number of Panels | Average- Price |
| Tesla Power Wall 2￼ | Lithium-ion | 13.5 | 15 | 5 | 6 | $20,000 |
| Mobile Solar MS-200 | Acid | 20 | 15 | 3.6 | 6 | $24,955 |
| Mobile Solar MS-225 | Acid | 25 | 15 | 8 | 6 | $29,990 |
| Mobile Solar MS-275 | Acid | 30 | 22.5 | 8 | 9 | $34,975 |

Table 2. Breakdown of the different specifications of each generator.

Figure 2. Price of Generators

Figure 2 shows the price variation of each Generator Type. Tesla power wall is the cheapest while MS-275 is the most expensive.

Figure 3. Power Output vs Price

Figure 3 shows the power output for each generator when compared to the price. MS-225 and MS-275 have the same power output at 8kW where MS-225 is another option with lowest power output 3.6kW.

Figure 4. Battery Capacity (kWh)

Figure 4 gives a visual representation of each Generators Battery Capacity. MS-275 has the highest battery capacity at 30 kWh.

Figure 5. Battery Capacity (kWh) vs. Price

Figure 5 shows the battery capacity for each generator type compared to the price of the generator type. MS-225 has the best battery capacity to price ratio but has less capacity than MS-275 model.

### ***Allocation of Requirements***

Component requirements are to be developed through allocation, apportionment, or derivation.

### ***Functional Interfaces and Criteria***

Table 3 summarizes the COTS products identified through the system and sub-system requirements. These components are to electronically interface with and power the Mobile Command Center.

|  |  |
| --- | --- |
| **Component** | **Model** |
| Photovoltaic Solar Panels | 350-watt LG monocrystalline modules (or Equal) |
| Charge Controller | 80A Outback Power Charge Controller (or Equal) |
| Battery | Lead-Acid  20hr Rate: 627AH @ 48Vdc (30kWh)  Rated: 2,000 cycles @ 80% DOD (or Equal) |
| AC/DC Power Inverter | 8kW rated / 16kW surge  120/240Vac 60Hz single phase |

Table 3: Summary of COTS products

## ***System Characteristics***

### ***Performance Characteristics***

No additional performance characteristics requirements have been identified.

### ***Physical Characteristics***

* + - 1. Solar panels shall be attached to roof of MS-275 two-axle trailer via bolts.
      2. The mounting holes shall be 5/8” [15.875 mm] in diameter.
      3. The mounting holes centers shall be inset 0.50” [12.7 mm] from each of the corners in both directions.
      4. The mounting assembly shall be mounted on an 18” [457 mm] x 18” [457 mm] x 1” [25.4 mm] thick machinery vibration pads.
      5. Nuts shall be welded to the underside of the assembly plate at each bolt hole for replacement of topside components without removing assembly plate.
      6. Trailer shall have a universal hitch so that it can be hooked to military and civilian vehicles
      7. Trailer weight shall not exceed 8,000 lbs.

### ***Effectiveness Requirements***

No additional effectiveness requirements been identified.

### ***Reliability***

3.2.4.1 The solar panels will be able to run 24/7 for the length of the mission

3.2.4.2 The mean time to repair (MTTR) the solar panel will less than 8 hours

3.2.4.3 The Mobile Command Center will be able to function effectively in all climates and terrains

3.2.4.4 There will be backups of key components in case there is a failure during a critical point in the mission

### ***Maintainability***

No additional maintainability requirements have been identified.

### ***Usability (Human Factors)***

3.2.6.1 All equipment shall have adequate usage documentation so that anyone using it can fully operate the Mobile Command Center to the full extent of its capabilities

3.2.6.2 Before working in the field, each person who will be working in the MCC shall complete the two-hour training course

### ***Supportability***

No additional supportability requirements have been identified.

### ***Transportability / Mobility***

3.2.8.1 The MS-275 will have a Universal Hitch so that it can be hooked up to any military or civilian vehicle

3.2.8.2 MS-275 is on a two-axle trailer that allows travel over any terrain

3.2.8.3 MCC will be an all-terrain vehicle that can tow the MS-275 through any necessary environment

### ***Flexibility***

No additional flexibility requirements have been identified.

### ***Sustainability***

No additional sustainability requirements have been identified.

### ***Safety***

No additional safety requirements have been identified.

### ***Security***

3.2.12.1 All doors will be locked when not in use

3.2.12.2 All windows will be locked from the inside

3.2.12.3 All computers/workstations will be password encrypted

## ***Design and Construction***

### ***CAD/CAM Requirements***

No additional CAD/CAM requirements have been identified.

### ***Materials, Processes, and Parts***

* + - 1. The trailer shall be fabricated from 6061 aluminum.
      2. The attachment bolts and nuts shall be fabricated from 18-8 stainless steel.
      3. Wiring shall use listed components.
      4. Wiring shall be insulated.
      5. Wire insulation shall have an FT-1 Flame Rating
      6. Wire insulation shall be UV resistant.

### ***Mounting and Labelling***

No additional mounting and labelling requirements have been identified.

### ***Electromagnetic Radiation***

No additional electromagnetic radiation labelling requirements have been identified.

### ***Interchangeability***

No additional requirements identified for this class of requirement.

### ***Workmanship***

* + - 1. The solar panels shall be mounted on an angle optimized for maximum solar light efficiency.
      2. Electrical wiring shall be bundled where possible.
      3. Batteries shall be mounted on an exterior bay within the MCC away from direct sunlight and elements.

### ***Testability***

No additional testability requirements have been identified.

### ***Economic Feasibility***

3.3.8.1. COTS materials will be researched and tested to see if any are a cheaper but more viable option.

## ***Documentation / Data***

No additional documentation / data requirements have been identified.

## ***Logistics***

### ***Maintenance Requirements***

* + - 1. Maintenance and inspection plans to be revised to include terminals bolt tightness checks on monthly intervals.

### ***Supply Support***

No additional supply support requirements have been identified.

### ***Test and Support Equipment***

No additional test and support equipment requirements have been identified.

### ***Personnel and Training***

3.5.4.1 All personnel shall pass training course in controlled environment before being able to work in the field

3.5.4.2 Any driver must have applicable license

### ***Facilities and Equipment***

No additional facilities and equipment requirements have been identified.

### ***Packaging, Handling, Storage and Transportation***

No additional packaging, handling, storage and transportation requirements subsystem have been identified.

### ***Computer Resources***

No additional computer resources requirements have been identified.

### ***Technical Data***

No additional technical data requirements have been identified.

### ***Customer Service***

No additional producibility requirements have been identified.

## ***Producibility***

No additional producibility requirements have been identified.

## ***Disposability***

No additional disposability requirements have been identified.

## ***Affordability***

No additional affordability requirements have been identified.

# ***Test and Evaluation***

No additional testing and evaluation requirements have been identified.

# ***Quality Assurance Provisions***

No additional quality assurance provisions requirements have been identified.

# ***Distribution and Customer Service***

No additional distribution and customer service requirements have been identified.

# ***Notes***

## ***Acronyms***

|  |  |
| --- | --- |
| AUAV | Autonomous Unmanned Aerial Vehicle |
| BIT | Built-In-Test |
| DLTV | Day-light television |
| FAA | Federal Aviation Administration |
| FLIR | Forward Looking Infrared |
| GPS | Global Positioning System |
| MCC | Mobile Command Center |
| MS | Mobile Solar |
| MTBF | Mean Time Between Failure |
| MTTR | Mean Time to Repair |
| NMEA | National Maritime Electronics Association |
| SAE | Society of Automotive Engineers |
| TCU | Turbocharger Control Unit |
| UAV | Unmanned Aerial Vehicle |
| V | Volts |
| VDC | Volts Direct-Current |

# ***References***

*Mobile Solar Generators; MS-Series Specifications*

*Project SKYNET Design Dossier Rev 12 December 9, 2021*

*Project SKYNET System Specification Rev 1 December 9, 2021*

*Project SKYNET Subsystem Specification Rev 0 December 9, 2021*