

# Maintainability Report

ECE 492 – Spring 2014

Latest Revision: 12 May 2014

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## Abstract

This document presents an analysis of the LFEV-ESCM 2014 system to prove that the system can be repaired in the case of a failure in less than 1 week as specified by GPR007.

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# Executive Summary

## Introduction

In any system, failures can and will occur. The likelihood of failures and the different types of failures in the LFEV-ESCM system are documented in the Reliability Memo. Once a system fails, it needs to be repaired. A well designed system will allow for a relatively short time to restore the system to its working condition. This is measured by the Mean Time To Repair (MTTR). The Statement of Work requires the LFEV-ESCM system to have a MTTR of less than one week. This document shows how the LFEV-ESCM system meets this requirement and includes a list of spare parts to help reduce the MTTR.

## System MTTR

According to the analysis, the longest MTTR would occur if one of the battery cells failed and no spare parts were available to replace it as it would take approximately 23 days to ship and install the components. However, having the set of spare parts in the table below would allow the MTTR of the entire system to be within one week. The calculated MTTR of one week for the system passes the standard set forth by requirement GPR007.

## List of Suggested Spare Parts

Number of Suggested Spares	Description	Part No.	Manufacturer/Distributor
7	LiFePO4 3.2V 60Ah Cell	#6334	AA Portable Power Corp
1	AMS Board (config A)	N/A	N/A
1	AMS Board (config B)	N/A	N/A
1	PacMan Breakout Board	N/A	N/A
5	Discharge Fuse 200A	G3475534	Zoro Tools
1	Discharge Fuse Holder	G1878003	Zoro Tools
5	Charging Fuse 30A	576-0505030.MXP	Mouser
1	PowerLock Drain, Line 3, Gray	44W4361	Newark
1	PowerLock Source, Neutral, Blue	44W4365	Newark
1 of each	Aluminum TSV Path Components	N/A	Lafayette College Machine Shop
1	AIR	GX14CB	Gigavac
1	Charging Relay	P105CDA	Gigavac

# Detailed MTTR Analysis

## Pack Mechanical/Electrical

### Lafayette College Machined Components

MTTR (Spare Parts on hand): 1 day

MTTR (No Spare Parts): 4-7 days manufacturing time + 1 day installation = 8 days

Note: Machine shop availability varies drastically over the course of the year. Parts could be done in as little as one day if the shop demand is low or more than a week during high load periods. It is recommended to keep at least 1 spare component of the discharge path on hand in the event of a failure due to the unpredictability of the machine shop.

### PowerLock Connectors (Newark)

MTBF: 1120 Hours = 46.7 days (assuming continuous charging/discharge cycles and unplugging at each one)

MTTR (Spare Parts on hand): 1 day installation

MTTR (No Spare Parts): 15 days shipping + 1 day installation = 16 days

Note: Since the MTBF is fairly low, failures may be common depending on the usage of the battery pack. Only one spare of each powerlock connector is necessary as parts can be ordered and delivered in less time than the failure rate.

### 24V Charging Fan (Mouser)

MTTR (Spare Parts on hand): 1 day installation

MTTR (No Spare Parts): 3-4 days shipping + 1 day installation = 5 days

### AIRs and Charging Relays (Gigavac)

MTBF: 2.22 Million Hours

MTTR (Spare Parts on hand): 1 day installation

MTTR (No Spare Parts): 15 days shipping + 1 day installation = 16 days

Note: At least one spare relay of each type should be on hand in the event of a failure. Since the MTBF is so high, it is unlikely that multiple relays will break down before a new one can be ordered in, so one spare of each type should be sufficient.

**Pack Plugs and Housings (Mouser)**

MTTR (Spare Parts on hand): 1 day installation

MTTR (No Spare Parts): 3-4 days shipping + 1 day installation = 5 days

**Anderson Charging Connectors (Mouser)**

MTTR (Spare Parts on hand): 1 day installation

MTTR (No Spare Parts): 3-4 days shipping + 1 day installation = 5 days

**Charging Fuses and Holders (Mouser)**

MTTR (Spare Parts on hand): 1 day installation

MTTR (No Spare Parts): 3-4 days shipping + 1 day installation = 5 days

Note: GPR005 Requires at least 5 spare fuses of each type. A spare holder is not necessary.

**Discharging Fuses and Holder (Zoro Tools)**

MTBF: 0.080 failures/million hours  $\approx$  0 failures/week

MTTR (Spare Parts on hand): 1 day installation

MTTR (No Spare Parts): 15 days shipping + 1 day installation = 16 days

Note: GPR005 Requires at least 5 spare fuses of each type. A spare fuse holder is necessary to reduce the MTTR to under one week.

**DIN Rail Terminal Blocks (Mouser)**

MTTR (Spare Parts on hand): 1 day installation

MTTR (No Spare Parts): 3-4 days shipping + 1 day installation = 5 days

**Battery Cells (AA Portable Power Corp)**

MTBF: 3350 hours (continuous charge/discharge) = 139.6 days

MTTR (Spare Parts on hand): 1 day installation

MTTR (No Spare Parts): 22 days shipping + 1 day installation = 23 days

Note: Since the MTTR is 23 days without spare parts, it is advised to keep 7 spare cells. Since the cells in the battery pack encounter similar usage, their life cycle is likely to also end around the same time and cause all seven to fail very close to each other. Having an entire set ready to replace the dying cells will keep the MTTR under one week.

## Pack Manager

### TS-8160-4200 SBC (Technologic Systems)

MTBF: Unknown

MTTR (Spare Parts on hand): 1 day installation

MTTR (No Spare Parts): 6 days shipping + 1 day installation = 7 days

Note: No spare parts are necessary as the MTTR is 7 days, however, it is recommended to have a spare computer for development purposes if the software developer would prefer.

### PacMan Breakout Board (Advanced Circuits PCB)

MTBF: 28.3 million hours

MTTR (Spare Completed Board on hand): 1 day installation

MTTR (Individual Component Failure, No Spare Part): 4 days shipping + 1 day installation = 5 days

MTTR (Spare Parts on hand): 2 days manufacturing + 1 day installation = 3 days

MTTR (No Spare Parts): 7 days PCB and part shipping + 2 days manufacturing + 1 day installation = 10 days

Note: In order to reduce the MTTR to under one week, it is advised to keep a completed spare PacMan breakout board on hand. PCB manufacturing is the critical link as it takes at least 7 days to produce. By contrast, if a singular component on the breakout board fails, parts can be ordered from Mouser or Digikey, shipped in about 4 days, and installed in one day. At the minimum all parts necessary to build the board (including the PCB) should be available.

## AMS Boards

### AMS Boards (Advanced Circuits PCB)

MTBF: 95.8 million hours

MTTR (Spare Completed Board on hand): 1 day installation

MTTR (Individual Component Failure, No Spare Part): 4 days shipping + 1 day installation = 5 days

MTTR (Spare Parts on hand): 2 days manufacturing + 1 day installation = 3 days

MTTR (No Spare Parts): 7 days PCB and part shipping + 2 days manufacturing + 1 day installation = 10 days

Note: In order to reduce the MTTR to under one week, it is advised to keep at least one completed AMS of each cell configuration on hand. PCB manufacturing is the critical link as it takes at least 7 days to produce. By contrast, if a singular component on the breakout board fails, parts can be ordered from Mouser or Digikey, shipped in about 4 days, and installed in one day. Since the MTBF is so large, it is unlikely that two boards will fail before being able to build more space AMS boards. At the minimum all parts necessary to build the board (including the PCB) should be available.