



BRIGHAM YOUNG UNIVERSITY  
AUVSI CAPSTONE TEAM (TEAM 45)

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## Failure Modes and Effects Analysis

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# Failure Modes and Effects Analysis

## 1 Introduction

To mitigate risk of failure within the competition a Failure Modes and Effects Analysis (FMEA) was performed. Many deficiencies were found that were then corrected to an acceptable level.

## 2 Analysis

Component	Functional Purpose	Failure Mode*	Failure Effect	Failure Cause	Current Situation				Assigned Action	Improved Situation			
					S	L	D	RPN		S	L	D	RPN
RC Reciver	Communicate Manual Commands from the RC Transmittor to F4	Hardware Failure*	Mission Failure Aircraft Loiters	Poorly Connected Electrical Joint	8	1	7	56		8	1	7	56
		Transmits incornect data	Crash	Internal Code	9	1	10	90	Extensive testing prior to use**	9	1	10	90
		Loss of Connection	Mission Failure Aircraft Loiters	Interference	8	4	9	288	FFCL*** range test	8	4	3	96
RC Transmittor	Communicate Commands from the RC Pilot to the RC Reciver	Hardware Failure	Mission Failure Aircraft Loiters	Poorly Connected Electrical Joint	8	2	7	112	FFCL	8	2	3	48
		Transmits incorrect data	Crash	Settings Incorrect	9	2	6	108	FFCL	9	1	6	54
				Settings Incorrect	8	6	8	384	FFCL	8	4	3	96
		Loss of Connection	Mission Failure Aircraft Loiters	Interference	8	4	9	288	FFCL	8	4	3	96
WIFI antenna	Allow communication with groundstation over ROS network	Hardware Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42		6	1	7	42
		Loss of Connection	Mission Failure Manual Landing	Antanna Incorrectly Pointed	6	7	3	126	Assigne someone to point antenna	6	3	3	54
					6	2	7	84		6	2	7	84
Odroid	Run ROS, generate high level commands, process images, & estimate state	Hardware failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	9	1	7	63	Extensive testing prior to use	9	1	3	27
				Internal Code	9	3	6	162	Extensive testing prior to use	9	3	3	81
F4 Flight Computer & Mount	Turn high level (Odroid & RC) commands into low level servo commands	Software Failure	Crash	Poorly Connected Electrical Joint	9	3	7	189	Extensive testing prior to use	9	3	3	81
		Hardware Failure	Crash	Internal Code	4	1	10	40		4	1	10	40
Airspeed Sensor	Measure Va	Software Failure	Flight Less Smooth	Plugged Pito Tube	4	4	5	80		4	4	5	80
				High Angle of Attack	4	4	2	32		4	4	2	32
				Incorrect Mounting	4	2	2	16		4	2	2	16
		Hardware Failure	Flight Less Smooth	Poorly Connected Electrical Joint	4	1	7	28		4	1	7	28
Inertial Sense	Measure acceleration, barometter data, and magnetic heading	Software Failure	Crash	Internal Code	9	1	10	90	Extensive testing prior to use	9	1	3	27
		Inaccurate Readings	Crash	Interference	9	3	8	216	Extensive testing prior to use	9	3	3	81
		Hardware Failure	Crash	Poorly Connected Electrical Joint	9	1	7	63	Extensive testing prior to use	9	1	3	27
		Software Failure	Crash	Internal Code	9	3	10	270	Extensive testing prior to use	9	3	3	81
GPS	Measure global position	Inaccurate Readings	Crash	Interference	9	4	5	180	FFCL	9	4	4	144
		Hardware Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42		6	1	7	42
Battery	Provide current to all systems in the air	Loss of Power	Crash	Battery Not Charged Correctly	9	5	3	135	FFCL	9	5	2	90
				Chemical Mishap	9	2	3	54	Assign battery saftey officer	9	1	2	18
				Battery Degradition	9	1	1	9	FFCL	9	1	1	9
ESCs	BEC and convert digital logic PWM to high voltage/current motor inputs	Hardware Failure	Crash	Poorly Connected Electrical Joint	9	1	7	63	Extensive testing prior to use	9	1	3	27
				Overheating	10	3	5	150	Add warning to FFCL	10	2	5	100
Motors	Rotate Props	Does Not Transmit Torque	Mission Failure Glide to Safe Landing	Props Unsecured	7	8	3	168	FFCL	7	5	2	70
		Rotates the Wrong Way	Mission Does Not Start	Wires Connected Backwards	6	3	2	36		6	3	2	36
Props	Provide Thrust	Hardware Failure	Mission Failure Glide to Safe Landing	Poorly Connected Electrical Joint	7	1	7	49		7	1	7	49
		Does Not Provide Thrust	Mission Failure Glide to Safe Landing	Chipped/broken prop	7	5	3	105		7	5	3	105
Wiring	Transmit power and signals	Provides Electricity to incorrect Location	Crash	Wires Connected to Incorrect Ports	9	7	8	504	FFCL	9	3	3	81
		Does Not Transmit Electricity	Crash	Electrical Short Circuit	9	3	8	216	Shrink wrap all exposed wires	9	1	8	72
			Crash	Electrical Open Circuit	9	8	5	360	FFCL	9	8	1	72
Servos	Move control surfaces	Linkage Breaks	Crash	Poorly Assembled	9	2	8	144	Extensive testing prior to use	9	2	5	90
				Large Control Inputs at High Velocity	9	1	3	27	Train safety pilot	9	1	3	27
		Mechanical Limits Exceeded	Crash	Aerobatic Flight that Saturates Controller	9	5	8	360	Train safety pilot	9	1	4	36
		Software Failure	Crash	Poorly Assembled	9	6	4	216	Extensive testing prior to use	9	2	4	72
		Hardware Failure	Crash	Internal Code	9	1	10	90	Extensive testing prior to use	9	1	3	27
		Internal Mechanics Broken	Crash	Poorly Connected Electrical Joint	9	1	7	63	Extensive testing prior to use	9	1	3	27
UGV System	Deliver water bottle to both ground locations	Servo Burns Out	Crash	Overuse	9	2	5	90	Train safety pilot	9	2	5	90
					9	2	5	90	Train safety pilot	9	2	5	90
Imaging System	Capture, interperate, and report ground targets	See Imaging Documentation for Imaging FMEA											
Control Software	Pilot aircraft autonomously	See Control Documentation for Control FMEA											
Communication Software	Allow communication of all components	See Communication Documentation for Communication FMEA											
Airframe Body	Contain components, provide lift, provide stability, & respond to control inputs	Flight Charicotics Change	Crash	Icing	9	1	1	9	Only fly in good weather	9	1	1	9
				Components Move	9	5	5	225	Strap down all components	9	3	3	81
				Flight Envelop Exceeded	9	2	3	54	Train safety pilot	9	2	2	36
		Parts Breaks Off	Crash	Poor Manufacturing	9	6	7	378	Extensive testing prior to use	9	6	2	108
Ground stations	Transmit high level commands between operators and WIFI router			Part poorly Attached	9	2	7	126	FFCL	9	2	3	54
				Unidentified Flying Object (UFO) Impact	9	1	3	27	Train safety pilot	9	1	3	27
		Battery Dies	Mission Failure Manual Landing	Charger Not Connected	6	1	1	6		6	1	1	6
		Hardware Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42		6	1	7	42
WIFI Router	Trasmit data over ROS network between groundstations to light beam	Software Failure	Crash	Bug in Code	9	7	10	630	Extensive testing prior to use	9	4	3	108
		Loss of Connection	Mission Failure Manual Landing	Interference	6	2	7	84		6	2	7	84
		Hardware Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42		6	1	7	42
		Software Failure	Mission Failure Manual Landing	Internal Code	6	1	10	60		6	1	10	60
WIFI Light Beam	Transmit data over ROS network between WIFI router and the WIFI antenna on the aircraft	Loss of Connection	Mission Failure Manual Landing	Interference	6	8	7	336	Perform BPS bange test	6	5	7	210
		Hardware Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42		6	1	7	42
		Software Failure	Mission Failure Manual Landing	Internal Code	6	1	10	60		6	1	10	60
					6	1	10	60		6	1	10	60
Ground Power Source	Provide current to all ground systems	Not Brought with Us	Mission Does Not Start	Poor Planning	5	10	4	200	FFCL	5	3	4	60
		Mechanical Failure	Mission Failure Manual Landing	Poor Manufacturing	6	1	7	42		6	1	7	42
Human Operators	Give high level commands & ensure saftey of flight	Sick	Mission Does Not Start	Bacteria or Viruses	5	3	3	45		5	3	3	45
		Can Not Attend	Mission Does Not Start	Other Plans	5	1	1	5		5	1	1	5
				Crash	9	2	9	162	Extensive practice	9	1	9	81
		Sends Incorrect Commands	Crash	Poor Understanding of System	9	2	5	90	Extensive practice	9	1	5	45

\* In this analysis "Hardware Failure" refers only to electrical hardware (e.g. USB port breaks or soldering fails)

\*\* FFCL is the Field Flight Checklist to which we will add items to test and do before flight

\*\*\* Extensive testing before use refers to extensive flight tests before the competition.

We currently perform flight tests a couple times a week.

S: Severity of failure effect

L: Likelihood of failure occurring

D: Detectability of cause before failure occurs

RPN: Risk Priority number (S\*L\*D)

### 3 Discussion

As can be seen from this analysis, most of the concerning issues were addressed. We are now confident in our ability to fly a failure free mission with the exception of one issues: we continue to see communication drop out for a couple systems. We do not completely understand this issue. It seems to be location dependent and caused by interfering signals. It does not usually affect our missions, but it's risk priority number (RPN) is high enough that we would like to address it. We will perform tests in several locations to see if we can identify the root cause and solution to these communication issues. We would like to be confident that this issue will not arise at the competition.