



BRIGHAM YOUNG UNIVERSITY
AUVSI CAPSTONE TEAM (TEAM 45)

Failure Modes and Effects Analysis

ID	Rev.	Date	Description	Author	Checked By
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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 and 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 Receiver	Communicate Manual Commands from the RC Transmitter to F4	Hardware Failure*	Mission Failure Aircraft Loiters	Poorly Connected Electrical Joint	8	1	7	56	Extensive testing prior to use**	8	1	7	56
		Transmits incorrect data	Crash	Internal Code	9	1	10	90		9	1	10	90
		Loss of Connection	Mission Failure Aircraft Loiters	Interference	8	4	9	288		8	4	3	96
RC Transmitter	Communicate Commands from the RC Pilot to the RC Receiver	Hardware Failure	Mission Failure Aircraft Loiters	Poorly Connected Electrical Joint	8	2	7	112	FFCL*** range test	8	2	3	48
		Transmits incorrect data	Crash	Settings Incorrect	9	2	6	108		9	1	4	36
		Loss of Connection	Mission Failure Aircraft Loiters	Interference	8	6	8	384		8	4	3	96
WIFI antenna	Allow communication with ground station over ROS network	Hardware Failure	Mission Failure Manual Landing	Transmitter Battery Dead	8	4	9	288	FFCL, and laboratory debugging	8	6	3	144
		Loss of Connection	Mission Failure Manual Landing	Poorly Connected Electrical Joint	8	6	3	144		8	4	2	64
		Run ROS, generate high level commands, process images, & estimate state	Mission Failure Manual Landing	Antenna Incorrectly Pointed	6	1	7	42		6	1	7	42
Odroid	Run ROS, generate high level commands, process images, & estimate state	Hardware Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	7	3	126	Assign someone to point antenna	6	3	3	54
		Software Failure	Crash	Poorly Connected Electrical Joint	6	2	7	84		6	2	7	84
		Turn high level (Odroid & RC) commands into low level servo commands	Crash	Poorly Connected Electrical Joint	9	1	7	63		9	1	3	27
F4 Flight Computer & Mount	Turn high level (Odroid & RC) commands into low level servo commands	Software Failure	Crash	Internal Code	9	3	6	162	Extensive testing prior to use	9	3	3	81
		Hardware Failure	Crash	Poorly Connected Electrical Joint	9	3	7	189		9	3	3	81
		Software Failure	Flight Less Smooth	Internal Code	4	1	10	40		4	1	10	40
Airspeed Sensor	Measure Va	Inaccurate Readings	Flight Less Smooth	Plugged Pitot Tube	4	4	5	80		4	4	5	80
		Hardware Failure	Flight Less Smooth	High Angle of Attack	4	4	2	32		4	4	2	32
		Software Failure	Crash	Incorrect Mounting	4	2	2	16		4	2	2	16
Inertial Sense	Measure acceleration, barometer data, and magnetic heading	Hardware Failure	Flight Less Smooth	Poorly Connected Electrical Joint	4	1	7	28		4	1	7	28
		Software Failure	Crash	Internal Code	9	1	10	90		9	1	3	27
		Inaccurate Readings	Crash	Interference	9	3	8	216		9	3	3	81
GPS	Measure global position	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		9	3	3	81
		Inaccurate Readings	Crash	Interference	9	4	5	180		9	2	4	72
Battery	Provide current to all systems in the air	Hardware Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42	FFCL	6	1	7	42
		Loss of Power	Crash	Battery Not Charged Correctly	9	5	3	135		9	5	2	90
		Hardware Failure	Crash	Chemical Mishap	10	2	3	60		10	1	2	20
ESCs	BEC and convert digital logic PWM to high voltage/current motor inputs	Hardware Failure	Crash	Battery Degradation	9	1	1	9	FFCL	9	1	1	9
		Hardware Failure	Crash	Poorly Connected Electrical Joint	9	1	7	63		9	1	3	27
		Overheat	Fire and Crash	Overstressing the Motors	10	3	5	150		10	2	5	100
Motors	Rotate Props	Does Not Transmit Torque	Mission Failure Glide to Safe Landing	Props Unsecured	7	8	3	168	Add warning to FFCL	7	5	2	70
		Rotates the Wrong Way	Mission Does Not Start	Wires Connected Backwards	6	3	2	36		6	1	2	12
		Hardware Failure	Mission Failure Glide to Safe Landing	Poorly Connected Electrical Joint	7	1	7	49		7	1	7	49
Props	Provide Thrust	Does Not Provide Thrust	Mission Failure Glide to Safe Landing	Chipped/broken prop	7	5	3	105	FFCL	7	5	3	105
		Provides Electricity to Incorrect Location	Crash	Wires Connected to Incorrect Ports	9	7	8	504		9	3	3	81
		Does Not Transmit Electricity	Crash	Electrical Short Circuit	9	3	8	216		9	1	8	72
Wiring	Transmit power and signals	Does Not Transmit Electricity	Crash	Electrical Open Circuit	9	8	5	360	Shrink wrap all exposed wires	9	8	1	72
		Linkage Breaks	Crash	Poorly Assembled	9	2	7	126		9	2	5	90
		Mechanical Limits Exceeded	Crash	Large Control Inputs at High Velocity	9	1	3	27		9	1	3	27
Servos	Move control surfaces	Software Failure	Crash	Aerobatic Flight Saturates Controller	9	5	8	360	Train safety pilot	9	1	4	36
		Hardware Failure	Crash	Poorly Assembled	9	6	4	216		9	2	4	72
		Internal Mechanics Broken	Crash	Internal Code	9	1	10	90		9	1	3	27
UGV System	Deliver water bottle to both ground locations	Servo Burns Out	Crash	Overuse	9	2	5	90	Extensive testing prior to use	9	1	3	27
		Imaging System	Capture, interpret, and report ground targets	See UGV Documentation for UGV FMEA	9	2	5	90		9	2	5	90
		Control Software	Pilot aircraft autonomously	See Imaging Documentation for Imaging FMEA	9	2	5	90		9	2	5	90
Imaging System	Capture, interpret, and report ground targets	Communication Software	Allow communication of all components	See Control Documentation for Control FMEA	9	2	5	90	See Communication Documentation for Communication FMEA	9	2	5	90
		Flight Characteristics Change	Crash	Iceing	9	2	1	18		9	1	1	9
		Parts Break Off	Crash	Components Move	9	5	5	225		9	3	3	81
Airframe Body	Contain components, provide lift, provide stability, & respond to control inputs	Battery Dies	Mission Failure Manual Landing	Flight Envelope Exceeded	9	2	3	54	Strap down all components	9	2	2	36
		Hardware Failure	Mission Failure Manual Landing	Poor Manufacturing	9	6	7	378		9	6	2	108
		Software Failure	Crash	Part poorly attached	9	2	7	126		9	2	3	54
Ground stations	Transmit high level commands between operators and WIFI router	Loss of Connection	Mission Failure Manual Landing	Unidentified Flying Object (UFO) Impact	9	1	3	27	Train safety pilot	9	1	3	27
		Hardware Failure	Mission Failure Manual Landing	Charger Not Connected	6	1	1	6		6	1	1	6
		Software Failure	Crash	Poorly Connected Electrical Joint	6	1	7	42		6	1	7	42
WIFI Router	Transmit data over ROS network between groundstations to light beam	Loss of Connection	Mission Failure Manual Landing	Bug in Code	9	7	10	630	Extensive testing prior to use	9	4	3	108
		Hardware Failure	Mission Failure Manual Landing	Interference	6	2	7	84		6	2	7	84
		Software Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42		6	1	7	42
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	Internal Code	6	1	10	60	Laboratory debugging	6	1	10	60
		Hardware Failure	Mission Failure Manual Landing	Interference	6	8	7	336		6	5	7	210
		Software Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42		6	1	7	42
Ground Power Source	Provide current to all ground systems	Not Brought with Us	Mission Does Not Start	Internal Code	6	1	10	60	FFCL	6	1	10	60
		Mechanical Failure	Mission Failure Manual Landing	Poor Planning	4	8	4	128		4	4	4	64
		Sick	Mission Does Not Start	Poor Manufacturing	6	1	7	42		6	1	7	42
Human Operators	Give high level commands & ensure safety of flight	Can Not Attend	Mission Does Not Start	Bacteria or Viruses	5	4	3	60	Other Plans	5	4	3	60
		Sends Incorrect Commands	Crash	Poor Judgement	9	2	9	162		9	1	9	81
		Crash	Crash	Poor Understanding of System	9	2	5	90		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: Decatibility 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 issue: we continue to see communication drop out for a couple systems. We do not completely understand why this is happening. It seems to be somewhat location dependent and occurs randomly. It does not usually affect our missions, but it's risk priority number (RPN) is high enough that we wanted to address it. We have since performed tests in several locations to see if we can identify the root cause and solution to these communication issues. We have found that the GPS drop out issues occur less frequently than previously expected. As such, it's RPN is within acceptable levels. We are still experiencing communication drop in the remote control signal and the WIFI signal. We would like to be confident that this issue will not arise at the competition and so are performing laboratory testing to find a way to fix these issues.