



BRIGHAM YOUNG UNIVERSITY
AUVSI CAPSTONE TEAM (TEAM 45)

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 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		8	1	7	56
		Transmits incorrect 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 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		8	2	3	48
		Transmits incorrect data	Crash	Settings Incorrect	9	2	6	108	FFCL	9	1	4	36
		Loss of Connection	Mission Failure Aircraft Loiters	Interference	8	6	8	384	FFCL	8	4	3	96
				Transmitter Battery Dead	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	8	6	3	144	FFCL	8	4	2	64
		Loss of Connection	Mission Failure Manual Landing	Antenna Incorrectly Pointed	6	1	7	42	Assign someone to point antenna	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	2	7	84		6	2	7	84
F4 Flight Computer & Mount	Turn high level (Odroid & RC) commands into low level servo commands	Software Failure	Crash	Poorly Connected Electrical Joint	9	1	7	63	Extensive testing prior to use	9	1	3	27
		Hardware Failure	Crash	Internal Code	9	3	6	162	Extensive testing prior to use	9	3	3	81
		Software Failure	Crash	Poorly Connected Electrical Joint	9	3	7	189	Extensive testing prior to use	9	3	3	81
Airspeed Sensor	Measure Va	Software Failure	Flight Less Smooth	Internal Code	4	1	10	40		4	1	10	40
				Plugged Pito 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
				Incorrect Mounting	4	2	2	16		4	2	2	16
Inertial Sense	Measure acceleration, barometter data, and magnetic heading	Hardware Failure	Crash	Poorly Connected Electrical Joint	4	1	7	28		4	1	7	28
		Software Failure	Crash	Internal Code	9	1	10	90	Extensive testing prior to use	9	1	3	27
		Inaccurate Readings	Crash	Interference	9	3	6	162	Extensive testing prior to use	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	Extensive testing prior to use	9	3	3	81
		Inaccurate Readings	Crash	Interference	9	4	5	180	FFCL	9	4	4	144
Battery	Provide current to all systems in the air	Hardware Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42		6	1	7	42
		Loss of Power	Crash	Battery Not Charged Correctly	9	5	3	135	FFCL	9	5	2	90
ESCs	DEC and convert digital logic PWM to high voltage/current motor inputs	Hardware Failure	Crash	Chemical Mishap	10	2	3	60	Assign battery safety officer	10	1	2	20
Motors	Rotate Props	Overheat	Fire and Crash	Battery Degradation	9	1	1	9	FFCL	9	1	1	9
				Poorly Connected Electrical Joint	9	1	7	63	Extensive testing prior to use	9	1	3	27
				Overstressing the Motors	10	3	5	150	Add warning to FFCL	10	2	5	100
				Props Unsecured	7	8	3	168	FFCL	7	5	2	70
Props	Provide Thrust	Does Not Transmit Torque	Mission Failure Glide to Safe Landing	Wires Connected Backwards	6	3	2	36	FFCL	6	1	2	12
				Mission Does Not Start	7	1	7	49		7	1	7	49
Wiring	Transmit power and signals	Does Not Provide Thrust	Mission Failure Glide to Safe Landing	Poorly Connected Electrical Joint	7	5	3	105		7	5	3	105
		Provides Electricity to Incorrect Location	Crash	Chipped/broken prop	9	7	8	504	FFCL	9	3	3	81
Servos	Move control surfaces	Does Not Transmit Electricity	Crash	Wires Connected to Incorrect Ports	9	3	8	216	Shrink wrap all exposed wires	9	1	8	72
		Linkage Breaks	Crash	Electrical Open Circuit	9	8	5	360	FFCL	9	8	1	72
				Poorly Assembled	9	2	7	126	Extensive testing prior to use	9	2	5	90
		Mechanical Limits Exceeded	Crash	Large Control Inputs at High Velocity	9	1	3	27	Train safety pilot	9	1	3	27
				Aerobatic Flight 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		9	2	5	90
Imaging System	Capture, interperate, and report ground targets								See UGV Documentation for UGV FMEA				
Control Software	Pilot aircraft autonomusly								See Imaging Documentation for Imaging FMEA				
Communication Software	Allow communication of all components								See Control Documentation for Control FMEA				
Airframe Body	Contain components, provide lift, provide stability, & respond to control inputs	Flight Characteristics Change	Crash	Icing	9	2	1	18	Only fly in good weather	9	1	1	9
				Components Move	9	5	5	225	Strap down all components	9	3	3	81
		Parts Break Off	Crash	Flight Envelop Exceeded	9	2	3	54	Train safety pilot	9	2	2	36
				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	Loss of Connection	Mission Failure Manual Landing	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
				Charger Not Connected	6	1	1	6		6	1	1	6
WiFi Router	Transmit data over ROS network between groundstations to light beam	Hardware Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42		6	1	7	42
		Software Failure	Mission Failure Manual Landing	Bug in Code	9	7	10	630	Extensive testing prior to use	9	4	3	108
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	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
Ground Power Source	Provide current to all ground systems	Software Failure	Mission Failure Manual Landing	Internal Code	6	1	10	60	Perform BPS range test	6	5	7	210
		Not Brought with Us	Mission Does Not Start	Poor Planning	4	8	4	128	FFCL	4	4	4	64
Human Operators	Give high level commands & ensure safety of flight	Mechanical Failure	Mission Failure Manual Landing	Poor Manufacturing	6	1	7	42		6	1	7	42
		Sick	Mission Does Not Start	Bacteria or Viruses	5	4	3	60		5	4	3	60
		Can Not Attend	Mission Does Not Start	Other Plans	5	1	1	5		5	1	1	5
		Sends Incorrect Commands	Crash	Poor Judgement	9	2	9	162	Extensive practice	9	1	9	81
				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: Decatbility 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 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.