

# Brigham Young University AUVSI Capstone Team (Team 45)

## Failure Modes and Effects Analysis

ID	Rev.	Date	Description	Author	Checked By
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#### Introduction 1

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.

#### Analysis 2

Component	Functional Purpose	Failure Mode*	Failure Effect	Failure Cause	Current Situation			on	Assistant Assistan		roved	Situ	ation
Component	Functional Purpose	Fallure Mode*	Failure Effect	rallule Cause	S	L	D	RPN	Assigned Action	S	L	D	RPN
RC Reciver		Hardware Failure*	Mission Failure Aircraft Loiters	Poorly Connected Electrical Joint	8	1	7	56		8	1	7	56
	Communicate Manual Commands from the RC	Transmits incorrect data	Crash	Internal Code	9	1	10	90	Extensive testing prior to use**	9		10	
	Transmittor to F4	Loss of Connection	Mission Failure Aircraft Loiters	Interference	8	4	9		FFCL*** range test	8			
		Hardware Failure	Mission Failure Aircraft Loiters	Poorly Connected Electrical Joint	8	2	7	112		8			48
		Transmits incorrect data	Crash	Settings Incorrect	9	2	6	108		9			
RC Transmittor	Communicate Commands from the RC Pilot to	Transmits mediteet data	Crush	Settings Incorrect	8	6	8		FFCL	8	4		
	the RC Reciver	Loss of Connection	Mission Failure Aircraft Loiters	Interference	8	4	9		FFCL	8			
			imission rundic rundidic Editors	Transmittor Battery Dead	8	6	3	144	FFCL	8			64
	Allow communitation with grounstation over	Hardware Failure	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	1	7	42	FFCL	6		7	
WIFI antenna	Allow communitation with grounstation over ROS network	Loss of Connection	Mission Failure Manual Landing	Antenna Incorrectly Pointed	6	7	3	126	Assign someone to point antenna	6			
	Run ROS, generate high level commands,	Loss of Connection	Mission Failure Manual Landing	Poorly Connected Electrical Joint	6	2	7	84	Assign someone to point antenna	6	2	7	84
Odroid		Hardware failure	Crash	Poorly Connected Electrical Joint  Poorly Connected Electrical Joint	9		7	63	Extensive testing prior to use	9	1	3	27
	process images, & estimate state Turn high level (Odroid & RC) commands into	Software Failure	Crash	Internal Code	9	1		162		9			
F4 Flight Computer & Mount						3	6	102	Extensive testing prior to use				
	low level servo commands	Hardware Failure	Crash	Poorly Connected Electrical Joint	9	3	7	189	Extensive testing prior to use	9	3	3	
		Software Failure	Flight Less Smooth	Internal Code	4	1	10	40		4		10	
				Plugged Pito Tube	4	4	5	80		4		5	
Airspeed Sensor	Measure Va	Inaccurate Readings	Flight Less Smooth	High Angle of Attack	4	4	2	32		4	4	2	32
				Incorrect Mounting	4	2	2	16		4		2	
		Hardware Failure	Flight Less Smooth	Poorly Connected Electrical Joint	4	1	7	28		4	1	7	28
	Measure acceleration, barometter data, and	Software Failure	Crash	Internal Code	9	1	10		Extensive testing prior to use	9	1	3	27
Inertial Sense	magnetic heading	Inaccurate Readings	Crash	Interference	9	3	8	216	Extensive testing prior to use	9	3		81
	magnetic nearing	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 Not Charged Correctly	9	5	3	135	FFCL	9	5	2	90
Battery	Provide current to all systems in the air	Loss of Power	Crash	Chemical Misshap	10	2	3	60	Assign battery saftey officer	10	1	2	20
,	, , , , , , , , , , , , , , , , , , ,			Battery Degridation	9	1	1		FFCL	9	1		9
	BEC and convert digital logic PWM to high												
ESCs	voltage/current motor inputs	Hardware Failure	Crash	Poorly Connected Electrical Joint	9	1	7	63	Extensive testing prior to use	9	1	3	27
	vortage/current motor inputs	Overheat	Fire and Crash	Oursets seize the Martin	10	2	-	150	Add	10	2	5	100
		Does Not Transmit Tourque	Mission Failure Glide to Safe Landing	Overstressing the Motors	7	3	5		Add warning to FFCL FFCI	7			
Motors	Rotate Props			Props Unsecured		8	3						
	1	Rotates the Wrong Way	Mission Does Not Start	Wires Connected Backwards	6	3	2		FFCL	6		2	
		Hardware Failure	Mission Failure Glide to Safe Landing	Poorly Connected Electrical Joint	7	1	7	49		7	1		
Props	Provide Thrust	Does Not Provide Thrust	Mission Failure Glide to Safe Landing	Chipped/broken prop	7	5	3	105		7	5		
		Provides Electricty to Incorrect Location	Crash	Wires Connected to Incorrect Ports	9	7	8	504	FFCL	9	3		
Wiring	Transmit power and signals	Does Not Transmit Electricity	Crash	Electrical Short Circuit	9	3	8	216	Shrink wrap all exposed wires	9	1		
		Does Not Transmit Electricity	Crash	Electrical Open Circuit	9	8	5		FFCL	9	8		
		Linkage Breaks	Crash Crash	Poorly Assembled	9	2	7	126	Extensive testing prior to use	9	2	5	
				Large Controll Inputs at High Velocity	9	1	3	27	Train saftey pilot	9	1	3	
		Mechanical Limits Exceeded		Aerobatic Flight Saturates Controller	9	5	8	360	Train saftey pilot	9	1	4	36
Servos		iviectianical Limits Exceeded	Clasii	Poorly Assembled	9	6	4	216	Extensive testing prior to use	9	2	4	72
Servos	Move control surfaces	Software Failure	Crash	Internal Code	9	1	10	90	Extensive testing prior to use	9	1	3	27
		Hardware Failure	Crash	Poorly Connected Electrical Joint	9	1	7	63	Extensive testing prior to use	9	1	3	27
		Internal Mechanics Broken	Crash	Overuse	9	2	5	90	, and the second	9	2	5	90
		Servo Burns Out	Crash	Overuse	9	2	5	90		9	2	5	90
UGV System	Deliver water bottle to both ground locations			See UGV Documentation for UGV FMEA		_					_	_	,
Imaging System											_		
	Capture, interperate, and report ground targets			ee Imaging Documentation for Imaging FM	FA							_	
	Capture, interperate, and report ground targets			ee Imaging Documentation for Imaging FM								_	
Control Software	Pilot aircraft autonomusly			See Control Documentation for Control FME	A	AE A					=		
				See Control Documentation for Control FME imunication Documentation for Communica	A tion FI			40	Only the in annual constant		_	1	I c
Control Software	Pilot aircraft autonomusly	Flight Characteristics Change		See Control Documentation for Control FME munication Documentation for Communica Icing	A tion FI	2	1		Only fly in good weather	9	1		
Control Software	Pilot aircraft autonomusly Allow communication of all components	Flight Characteristics Change	See Com	See Control Documentation for Control FME munication Documentation for Communica Icing Components Move	A tion FI 9 9	2 5	5	225	Strap down all components	9	3	3	81
Control Software	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide	Flight Characteristics Change	See Com	See Control Documentation for Control FME munication Documentation for Communica Icing Components Move Flight Envelop Exceeded	A tion FN 9 9	2 5 2	5 3	225 54	Strap down all components Train saftey pilot	9	3	3	81 36
Control Software Communication Software	Pilot aircraft autonomusly Allow communication of all components		See Com Crash	See Control Documentation for Control FME imunication Documentation for Communica licing Components Move Flight Envelop Exceeded Poor Manufacturing	9 9 9	2 5 2 6	5 3 7	225 54 378	Strap down all components Train saftey pilot Extensive testing prior to use	9	3 2 6	2 2	81 36 108
Control Software Communication Software	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide	Flight Characteristics Change Parts Break Off	See Com	See Control Documentation for Control FME munication Documentation for Communica Icing Components Move Flight Envelop Exceeded Poor Manufacturing Part poorly attached	9 9 9 9	2 5 2 6	5 3 7 7	225 54 378 126	Strap down all components Train saftey pilot Extensive testing prior to use FFCL	9	3 2 6	3 2 2 3	81 36 108 54
Control Software Communication Software	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide	Parts Break Off	See Com Crash Crash	See Control Documentation for Control FME munication Documentation for Communica licing Components Move Flight Envelop Exceeded Poor Manufacturing Part poorly attached Junidentified Fhing Object (UFO) Impact	9 9 9 9 9 9	2 5 2 6 2	5 3 7 7 3	225 54 378 126 27	Strap down all components Train saftey pilot Extensive testing prior to use FFCL	9 9	3 2 6 2	3 2 2 3 3	81 36 108 54 27
Control Software Communication Software Airframe Body	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs	Parts Break Off Battery Dies	See Com Crash Crash Mission Failure Manual Landing	See Control Documentation for Control FME munication Documentation for Communica lcing Components Move Flight Envelop Exceeded Poor Manufacturing Part poorly attached Unidentified Flying Object (UFO) Impact Charger Not Connected	9 9 9 9 9 9 9	2 5 2 6 2 1	5 3 7 7 3	225 54 378 126 27 6	Strap down all components Train saftey pilot Extensive testing prior to use FFCL	9 9 9 9	3 2 6 2 1	3 2 2 3 3	81 36 108 54 27 6
Control Software Communication Software	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between	Parts Break Off  Battery Dies Hardware Failure	See Com Crash Crash Mission Failure Manual Landing Mission Failure Manual Landing	See Control Documentation for Control FMM ununication Documentation for Communica Licing Components Move Flight Envelope Exceeded Poor Manufacturing Part poorly attached Unidentified Plant Doctrol Flore Connected Unidentified Electrical Joint Poorly Connected Electrical Joint	9 9 9 9 9 9 9	2 5 2 6 2 1 1	5 3 7 7 3 1	225 54 378 126 27 6 42	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot	9 9 9 9 6 6	3 2 6 2 1 1	3 2 2 3 3 1	81 36 108 54 27 6 42
Control Software Communication Software Airframe Body	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs	Parts Break Off  Battery Dies Hardware Failure Software Failure	See Com Crash  Crash  Mission Failure Manual Landing Mission Failure Manual Landing Crash	See Control Documentation for Control FME munication Documentation for Communica licing Components Move Flight Envelop Exceeded Poor Manufacturing Part poorly attached Unidentified Fling Object (UFO) Impact Charger Not Connected Poorly Connected Electrical Joint Bug in Code	9 9 9 9 9 9 9	2 5 2 6 2 1 1 1	5 3 7 7 3 1 7	225 54 378 126 27 6 42 630	Strap down all components Train saftey pilot Extensive testing prior to use FFCL	9 9 9 9 6 6	3 2 6 2 1 1 1 4	3 2 2 3 3 1 7	81 36 108 54 27 6 42 108
Control Software Communication Software Airframe Body Ground stations	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WiFi router	Parts Break Off  Battery Dies Hardware Failure	See Com Crash Crash Mission Failure Manual Landing Mission Failure Manual Landing	See Control Documentation for Control FMI munication Documentation for Communica licing Components Move Flight Envelope Exceeded Poor Manufacturing Part poorly attached Unidentified Flying Object (UFO) Impact Charger Not Connected Unidentified Flying Object (UFO) impact Dorly Connected Electrical Joint Bug in Code Interference	9 9 9 9 9 9 9	2 5 2 6 2 1 1	5 3 7 7 3 1	225 54 378 126 27 6 42	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot	9 9 9 9 9 6 6 6	3 2 6 2 1 1 1 4 2	3 2 2 3 3 1	81 36 108 54 27 6 42
Control Software Communication Software Airframe Body	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WIFI router  Trasmit data over ROS network between	Parts Break Off  Battery Dies Hardware Failure Software Failure	See Com Crash  Crash  Mission Failure Manual Landing Mission Failure Manual Landing Crash	See Control Documentation for Control FME munication Documentation for Communica licing Components Move Flight Envelop Exceeded Poor Manufacturing Part poorly attached Unidentified Fling Object (UFO) Impact Charger Not Connected Poorly Connected Electrical Joint Bug in Code	9 9 9 9 9 9 9	2 5 2 6 2 1 1 1	5 3 7 7 3 1 7	225 54 378 126 27 6 42 630	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot	9 9 9 9 6 6	3 2 6 2 1 1 1 4 2	3 2 2 3 3 1 7	81 36 108 54 27 6 42 108
Control Software Communication Software Airframe Body Ground stations	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WiFi router	Parts Break Off  Battery Dies Hardware Failure Software Failure Loss of Connection	See Com Crash  Crash  Mission Failure Manual Landing Mission Failure Manual Landing Crash Mission Failure Manual Landing	See Control Documentation for Control FMI munication Documentation for Communica licing Components Move Flight Envelope Exceeded Poor Manufacturing Part poorly attached Unidentified Flying Object (UFO) Impact Charger Not Connected Unidentified Flying Object (UFO) impact Dorly Connected Electrical Joint Bug in Code Interference	9 9 9 9 9 9 9 9 9 6 6	2 5 2 6 2 1 1 7 2	5 3 7 7 3 1 7 10 7	225 54 378 126 27 6 42 630 84	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot	9 9 9 9 9 6 6 6	3 2 6 2 1 1 1 4 2	3 2 2 3 3 1 7 3	81 36 108 54 27 6 42 108 84 42
Control Software Communication Software Airframe Body Ground stations	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WIFI router  Trasmit data over ROS network between groundstations to light beam	Parts Break Off  Battery Dies Hardware Failure Software Failure Loss of Connection Hardware Failure	See Com Crash  Crash  Mission Failure Manual Landing Mission Failure Manual Landing Crash Mission Failure Manual Landing Mission Failure Manual Landing	See Control Documentation for Control FME munication Documentation for Communica licing Components Move Flight Envelop Exceeded Poor Manufacturing Part poorly attacked Poorly Attacked Poorly Attacked Poorly Connected Poorly Poorly Connected Electrical Joint Bug in Code Interference Poorly Connected Electrical Joint	9 9 9 9 9 9 9 9 6 6	2 5 2 6 2 1 1 7 2	5 3 7 7 3 1 7 10 7	225 54 378 126 27 6 42 630 84	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot	9 9 9 9 6 6 6 9	3 2 6 2 1 1 4 2	3 2 2 3 3 1 7 7 7	81 36 108 54 27 6 42 108 84 42
Control Software Communication Software Airframe Body Ground stations	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WIFI router  Trasmit data over ROS network between groundstations to light beam  Transmit data over ROS network between WIFI	Parts Break Off  Battery Dies Hardware Failure Software Failure Loss of Connection Hardware Failure Software Failure	See Com Crash  Mission Failure Manual Landing Mission Failure Manual Landing Crash Mission Failure Manual Landing Mission Failure Manual Landing Mission Failure Manual Landing Mission Failure Manual Landing	See Control Documentation for Control FMI munication Documentation for Communica licing Components Move Flight Envelope Exceeded Poor Manufacturing Part poorly attached Unidagent For Manufacturing Part poorly attached Unidagent For Manufacturing Part poorly attached Poorly Connected Floorly Connected Electrical Joint Bug in Code interference Poorly Connected Electrical Joint Interference Poorly Connected Electrical Joint Internal Code Internal Co	9 9 9 9 9 6 6 6 6 6 6	2 5 2 6 2 1 1 7 2 1	5 3 7 7 3 1 7 10 7	225 54 378 126 27 6 42 630 84 42 60	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot  Extensive testing prior to use	9 9 9 9 6 6 6 6 6	3 2 6 2 1 1 1 4 2 1 1 5	3 2 2 3 3 1 7 7 7	81 36 108 54 27 6 42 108 84 42
Control Software Communication Software Airframe Body Ground stations WIFI Router	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WIFI router  Trasmit data over ROS network between groundstations to light beam	Parts Break Off  Battery Dies Hardware Failure Software Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure	See Com Crash  Mission Failure Manual Landing Mission Failure Manual Landing Crash Mission Failure Manual Landing	See Control Documentation for Control FMI munication Documentation for Communica Long Components Move Flight Envelope Exceeded Poor Manufacturing Part poorly attached Unident Fiving noblect (UFO) Impact Control	4 tion FM 9 9 9 9 9 9 6 6 6 6 6 6 6 6	2 5 2 6 2 1 1 7 2 1 1 8	5 3 7 7 3 1 7 10 7 7 10 7	225 54 378 126 27 6 42 630 84 42 60 336	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot  Extensive testing prior to use	9 9 9 9 6 6 6 6 6 6	3 2 6 2 1 1 1 4 2 1 1 5	3 2 2 3 3 1 7 7 7 7 10	81 36 108 54 27 6 42 108 84 42 60 210
Control Software Communication Software Airframe Body Ground stations WIFI Router WIFI Light Beam	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WiFI router  Trasmit data over ROS network between groundstations to light beam  Transmit data over ROS network between wiFI router and the WiFI antenna on the aircraft	Parts Break Off  Battery Dies Hardware Failure Software Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Software Failure Loss of Connection Hardware Failure	See Com Crash  Crash  Mission Failure Manual Landing	See Control Documentation for Control FMM munication Documentation for Communica Licing Components Move Flight Envelope Exceeded Poor Manufacturing Part poorly attached Unidentified Flying Object (UFO) Impact Charger (Songer Licina) Floring Object (UFO) Impact Charger (Songer Licina) Floring Object (UFO) Impact Charger (Songer Licina) Joint Bug in Code Interference Poorly Connected Electrical Joint Internal Code Interference Poorly Connected Electrical Joint Internal Code Interference Poorly Connected Electrical Joint Internal Code	9 9 9 9 9 6 6 6 6 6 6 6 6 6	2 5 2 6 2 1 1 7 2 1 1 8 1	5 3 7 7 3 1 7 10 7 7 10 7 7	225 54 378 126 27 6 42 630 84 42 60 336 42	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot Extensive testing prior to use Extensive testing prior to use Perform BPS range test	9 9 9 9 9 6 6 6 6 6 6 6	3 2 6 2 1 1 1 4 2 1 5 1	3 2 2 3 3 1 7 7 3 7 7 10 7 7	81 36 108 54 27 6 42 108 84 42 60 210 42 60
Control Software Communication Software Airframe Body Ground stations WIFI Router	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WIFI router  Trasmit data over ROS network between groundstations to light beam  Transmit data over ROS network between WIFI	Parts Break Off  Battery Dies Hardware Failure Software Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Software Failure Noftware Failure Noftware Failure Not Brought with Us	See Com Crash  Crash  Mission Failure Manual Landing Mission Failure Manual Landing Crash Mission Failure Manual Landing Mission Des Not Start	See Control Documentation for Control FME munication Documentation for Communica licing Components Move Flight Envelop Exceeded Poor Manufacturing Part poorly attached Unidentified Flying Object (UFO) Impact Charger Not Connected Poorly Connected Electrical Joint Bug in Code Interference Poorly Connected Electrical Joint Internal Code	A tion FN 9 9 9 9 9 6 6 6 6 6 6 6 6 6 4	2 5 2 6 2 1 1 7 2 1 8 1 8	5 3 7 7 3 1 7 10 7 7 10 7 7 10 7	225 54 378 126 27 6 42 630 84 42 60 336 42 60 128	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot  Extensive testing prior to use	9 9 9 9 9 6 6 6 6 6 6 6 6	3 2 6 2 1 1 4 2 1 1 5 1 1 4	3 2 2 3 3 1 7 7 7 7 100 7 7 7	81 36 108 54 27 6 42 108 84 42 60 21 60 64
Control Software Communication Software Airframe Body Ground stations WIFI Router WIFI Light Beam	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WiFI router  Trasmit data over ROS network between groundstations to light beam  Transmit data over ROS network between wiFI router and the WiFI antenna on the aircraft	Parts Break Off  Battery Dies Hardware Failure Software Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Software Failure Loss of Connection Hardware Failure	See Com Crash  Crash  Mission Failure Manual Landing Mission Does Not Start Mission Failure Manual Landing Mission Does Not Start	See Control Documentation for Control FME munication Documentation for Communica licing Components Move Flight Envelop Exceeded Poor Manufacturing Part poorly attached Unidentified Flying Object (UFO) Impact Charger Not Connected Unidentified Flying Object (UFO) Impact Charger Not Connected Poorly Connected Electrical Joint Bug in Code Interference Poorly Connected Electrical Joint Internal Code Internal Code Internal Code Poor Panning Poor Manufacturing	9 9 9 9 9 9 6 6 6 6 6 6 6 6 6 6 6 6 6 6	2 5 2 6 2 1 1 7 2 1 1 8 1 1 8 1	5 3 7 7 3 1 7 10 7 7 10 7 7 10 4 7	225 54 378 126 27 6 42 630 84 42 60 336 42 60 128	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot Extensive testing prior to use Extensive testing prior to use Perform BPS range test	9 9 9 9 6 6 6 6 6 6 6 6	3 2 6 2 1 1 1 4 2 1 1 5 1 1 4 1 4 1 1	3 2 2 3 3 1 7 7 7 7 10 7 7 7 7 7 7	81 36 108 54 277 6 6 42 108 84 42 210 60 64 42
Control Software Communication Software Airframe Body Ground stations WIFI Router WIFI Light Beam Ground Power Source	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WiFi router  Trasmit data over ROS network between groundstations to light beam  Transmit data over ROS network between wiFi router and the WiFi antenna on the aircraft  Provide current to all ground systems	Parts Break Off  Battery Dies Hardware Failure Software Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Software Failure Not Brought with Us Mechanical Failure Sick	Crash  Crash  Crash  Mission Failure Manual Landing Mission Dees Not Start Mission Failure Manual Landing Mission Failure Manual Landing Mission Dees Not Start	See Control Documentation for Control FME munication Documentation for Communica Licing Components Move Components Move Flight Envelop Exceeded Poor Manufacturing Part poorly attached Unidentified Flying Object (UFO) Impact Charger Not Connected Charger Not Connected Bug in Code Interference Poorly Connected Electrical Joint Intermal Code Poor Planning Poor Manufacturing Bacteria or Viruses	9 9 9 9 9 9 6 6 6 6 6 6 6 6 6 5 5	2 5 2 6 2 1 1 7 7 2 1 1 8 1 1 8 1 1 8 1	5 3 7 7 3 1 7 10 7 7 10 7 7 10 4 7 3	225 54 378 126 27 6 42 630 84 42 60 336 42 60 128 42 60	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot Extensive testing prior to use Extensive testing prior to use Perform BPS range test	9 9 9 9 6 6 6 6 6 6 6 6 6 6 5	3 2 6 2 1 1 1 4 2 1 1 1 5 1 1 4 1 1 4 1 1 1 1 1 1 1 1 1 1	3 2 2 3 3 3 1 7 7 7 100 7 7 7 100 4 7 3	81 36 108 54 27 6 42 108 84 42 60 210 60 64 42 60
Control Software Communication Software Airframe Body Ground stations WIFI Router WIFI Light Beam	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WIFI router  Trasmit data over ROS network between groundstations to light beam  Transmit data over ROS network between WIFI router and the WIFI antenna on the aircraft  Provide current to all ground systems  Give high level commands & ensure saftey of	Parts Break Off  Battery Dies Hardware Failure Software Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Software Failure Noftware Failure Noftware Failure Not Brought with Us	Crash  Crash  Mission Failure Manual Landing Mission Dees Not Start Mission Does Not Start Mission Does Not Start Mission Does Not Start	See Control Documentation for Control FMI munication Documentation for Communica licing Components Move Flight Envelope Exceeded Poor Manufacturing Part poorly attached Unidentified Flying Object (UFO) impact Changer Not Connected Foorly Connected Electrical Joint Bug in Code interference Poorly Connected Electrical Joint Internal Code Interference Poorly Connected Electrical Joint Internal Code Interference Poorly Connected Electrical Joint Internal Code Poor Planning Poorly Connected Electrical Joint Internal Code Poor Planning Bacteria or Viruses Other Plans Bacteria or Viruses Other Plans	9 9 9 9 9 9 6 6 6 6 6 6 6 6 6 5 5 5	2 5 2 6 2 1 1 1 7 7 2 1 1 8 1 1 1 8 1 1 8 1 1 8 1 1 8 1 8 1	5 3 7 7 3 1 1 7 10 7 7 10 7 7 10 4 7 7	225 54 378 126 27 6 42 630 84 42 60 336 42 60 128 42 60 5	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot Extensive testing prior to use Extensive testing prior to use Perform BPS range test	9 9 9 9 6 6 6 6 6 6 6 6 6 6 6 6 6 5 5 5 5	3 2 6 2 1 1 1 4 2 1 1 1 5 1 1 4 1 1 4 1 1 1 1 4 1 1 1 1 1	3 2 2 3 3 1 7 7 100 7 7 7 100 4 7 3 1	81 36 108 54 277 6 42 108 84 42 60 64 42 60 54 54 54 60 64 60 54 54 60 60 60 60 60 60 60 60 60 60
Control Software Communication Software Airframe Body Ground stations WIFI Router WIFI Light Beam Ground Power Source	Pilot aircraft autonomusly Allow communication of all components  Contain components, provide lift, provide stability, & respond to control inputs  Transmit high level commands between operators and WiFi router  Trasmit data over ROS network between groundstations to light beam  Transmit data over ROS network between wiFi router and the WiFi antenna on the aircraft  Provide current to all ground systems	Parts Break Off  Battery Dies Hardware Failure Software Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Loss of Connection Hardware Failure Software Failure Not Brought with Us Mechanical Failure Sick	Crash  Crash  Crash  Mission Failure Manual Landing Mission Dees Not Start Mission Failure Manual Landing Mission Failure Manual Landing Mission Dees Not Start	See Control Documentation for Control FME munication Documentation for Communica Licing Components Move Components Move Flight Envelop Exceeded Poor Manufacturing Part poorly attached Unidentified Flying Object (UFO) Impact Charger Not Connected Charger Not Connected Bug in Code Interference Poorly Connected Electrical Joint Intermal Code Poor Planning Poor Manufacturing Bacteria or Viruses	9 9 9 9 9 9 6 6 6 6 6 6 6 6 6 5 5	2 5 2 6 2 1 1 7 2 1 1 1 8 1 1 1 8 1 1 1 2 1 1 1 2 1 1 1 1	5 3 7 7 3 1 7 10 7 7 10 7 7 10 4 7 3	225 54 378 126 27 6 42 630 84 42 60 128 42 60 5 162	Strap down all components Train saftey pilot Extensive testing prior to use FFCL Train saftey pilot Extensive testing prior to use Extensive testing prior to use Perform BPS range test	9 9 9 9 6 6 6 6 6 6 6 6 6 6 5	3 2 6 2 1 1 1 4 2 1 1 1 5 1 1 4 1 1 4 1 1 1 1 1 1 1 1 1 1	3 2 2 3 3 1 7 7 100 7 7 7 100 4 7 3 1	81 36 108 54 277 6 42 108 84 42 60 64 42 60 54 54 54 60 64 60 54 54 60 60 60 60 60 60 60 60 60 60

S: Severity of failure effect
L: Likelihood of failure occurring
D: Dectability of cause before failure occurs
RPN: Risk Priority number (S\*L\*D)

<sup>\*</sup> 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.



### 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.