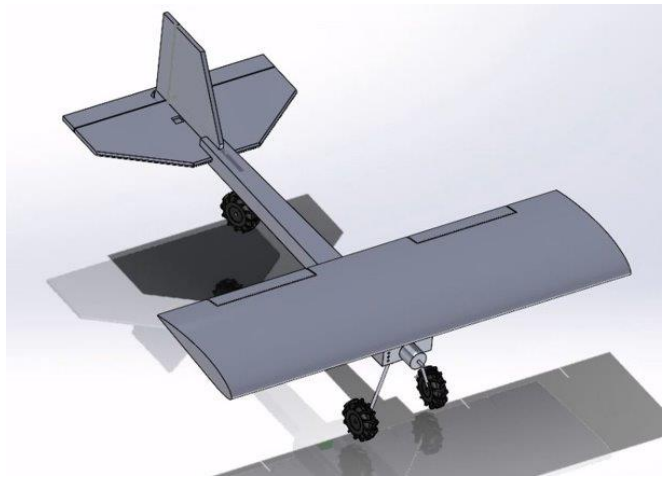

SAE Aero Initial Testing

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Special Thanks

Flagstaff Flyers

Design Requirements

Ranking	Engineering Requirements (ER)	Units
ER1	Light weight	Pounds
ER2	Increase Reliability	Percentage
ER3	Increase Durability	Percentage
ER4	Power limiter	Watts
ER5	Cargo Bay volume	Inches Cubed
ER6	Low Cost	US Dollars
ER7	Increase impact tolerance	Crashes before repair
ER8	48-inch Wingspan	Inch
ER9	Lift Forces	Pounds
ER10	Drag Forces	Pounds
ER11	Thrust	Pounds
ER12	Ground turning radius	Inches
ER13	Payload unloading time	Seconds
ER14	Low control surface slop	Degrees
ER15	Must have 4 cells or less battery for the electronics	Number of cells
ER16	Adequate servo sizing for aerodynamic forces	Ounces/inch
ER17	Must use 2.4 GHz radio control system	GHz
ER18	Must land within 200ft	Feet
ER19	Takeoff within 8 feet	Feet
ER20	Cannot exceed 55 pounds	Pounds
ER21	Optimize safety factor	Factor of Safety
ER22	Meets SAE Rules and Regulations	Percentage

Customer Requirements

Ranking	Customer Requirements
CR1	Meets the requirement of the rules
CR2	Safe design
CR3	Able to take off and land
CR4	Innovative Design
CR5	Manufacturable
CR6	Low cost
CR7	Modular compatibility
CR8	Static load capability
CR9	60 second lift-off time limit
CR10	200 feet landing distance
CR11	Payload extraction in one minute or less
CR12	Use of Lithium Polymer Batteries
CR13	Use of Power limiter (450-Watts)
CR14	Must have one cargo bay
CR15	Ability to make a turn in air
CR16	Ability to make a turn on the ground
CR17	Steering mechanism for landing gear
CR18	Must use an Electric motor
CR19	Fixed Wing
CR20	Functional failsafe for radio control systems
CR21	Must be equipped with a red arming plug
CR22	Must use model airplane safety nut
CR23	Appropriate center of gravity
CR24	Must have a radio control system

Top Level testing

Experiment/Tests	Relevant DR's
Generated Thrust Test	ER11, ER19, CR3, CR10
Generated Lift Test	ER9, ER19, CR3, CR10
Takeoff/Flight Test	ER9, ER10, ER14, ER19, CR3, CR8, CR9, CR15, CR23
Payload Test	ER5, ER13, ER21, CR11, CR14, CR23
Landing Test	ER3, ER7, ER12, ER18, CR3, CR8, CR10, CR15, CR16, CR17

Generated Thrust Test

- Questions Answered:
  - Will motor generate enough thrust for takeoff and fly?
- Equipment:
  - Thrust force testing bench
  - Electronics
- Procedure:
  - Attach motor with propeller to testing bench
  - Apply throttle at various positions
  - Record data using digital display (grams)

Results – Thrust

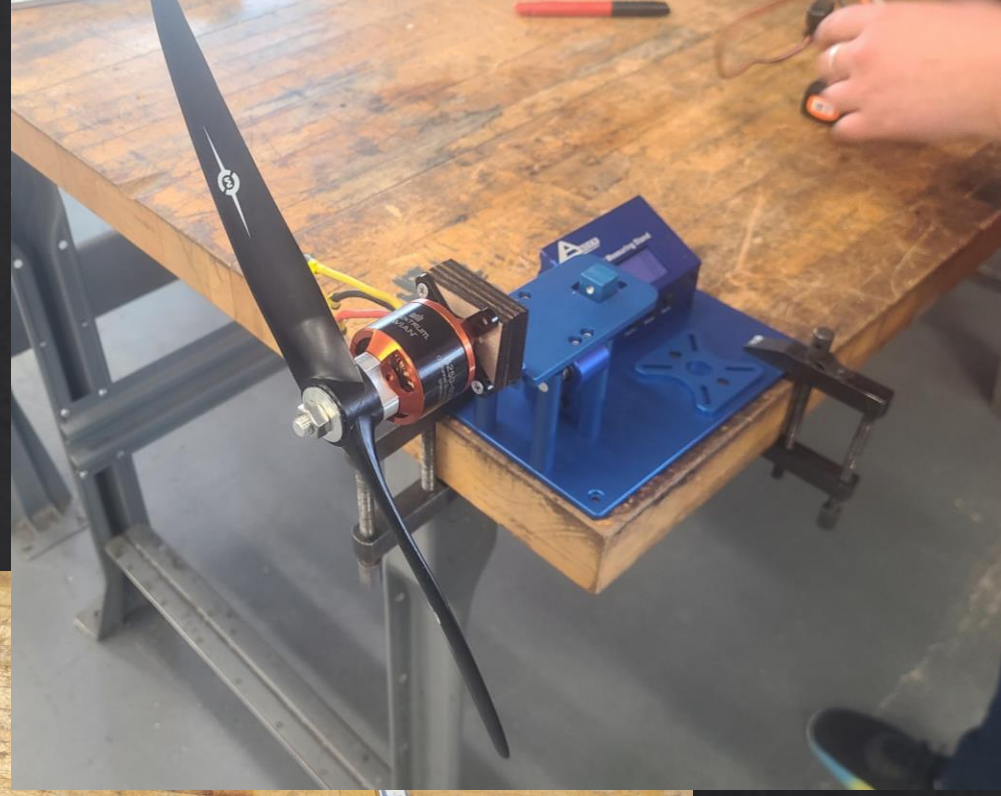
- Three different tests
- 3 cell lithium battery – fully charged

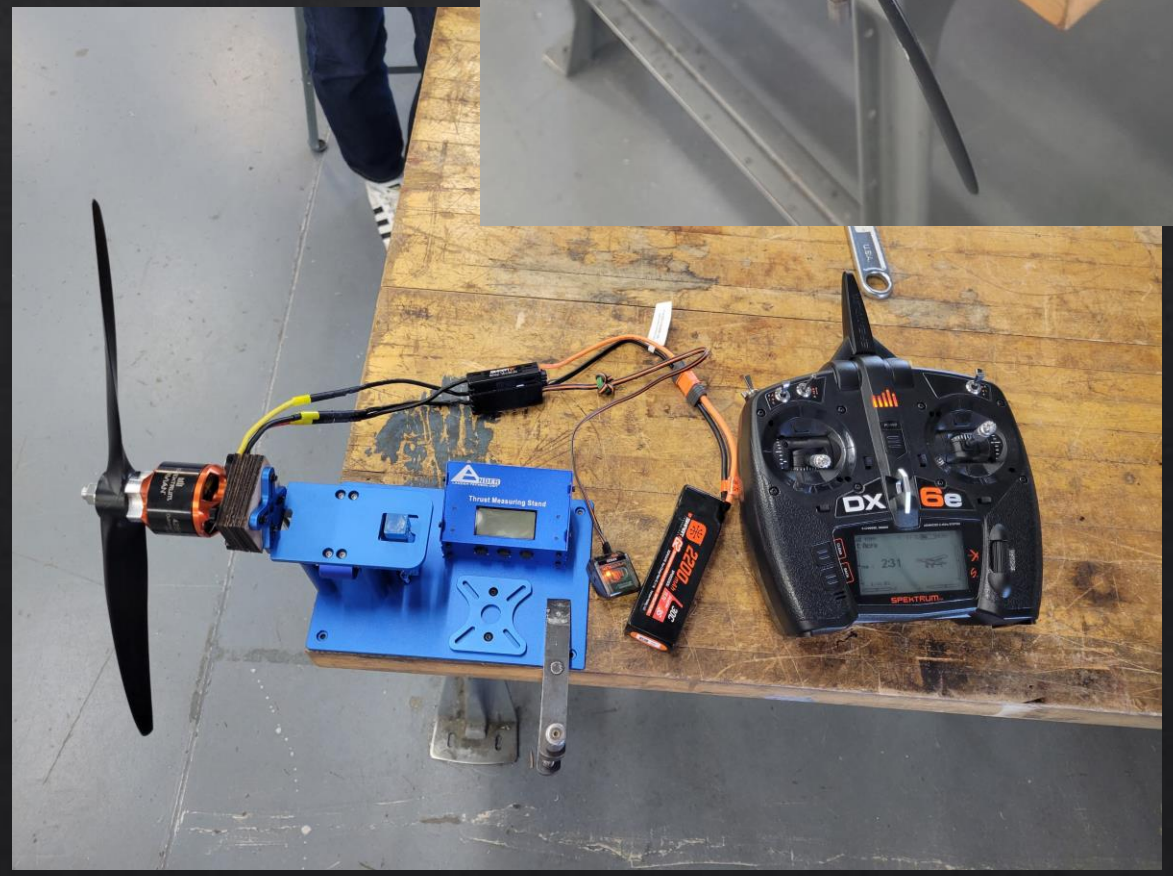
- 25% - 138 g - .304 lb

- 50% - 554.33 g – 1.22 lb

- 75% - 1326.33 g – 2.92 lb

- 100% - 1850 g – 4.07 lb





Takeoff/Flight Test

- Questions Answered:
  - Can the plane take off
  - Distance to takeoff
  - Takeoff/flight stability
- Equipment:
  - Plane
  - Controller
- Procedure:
  - Professional Flagstaff Flyers member assigned to fly plane
  - Safe runway to fly in
  - Visually assess takeoff and flight of plane

Results – Take off

Results – Flight

Landing Test

- Questions Answered:
  - Landing gear stability
  - Assess landing gear damage
  - Can the landing gear withstand impact
  - Landing distance
- Equipment:
  - Plane
  - Controller
- Procedure:
  - Find safe runway to land in
  - Professional Flagstaff Flyer as pilot
  - Attempt to land after successful flight path
  - Iterate landing gear if damaged

Results – Landing

Payload Test

- Questions Answered:
  - Can plane takeoff with payload: Yes
  - Payload loading time: needs to be under 60 seconds
- Equipment:
  - Payload
  - Plane
  - Controller
- Procedures:
  - Land plane in runway
  - Secure payload to load into plane
  - Try to takeoff within 60 seconds from start of process

Generated Lift Test

- Questions Answered:
  - Will plane generate enough lift to fly: Yes
  - What wind speeds will it generate enough lift to take off
- Equipment:
  - Arduino Uno with Anemometer
  - Thrust force testing bench
  - Plane
  - Tie down straps
  - 2X4 wood
  - Vehicle
- Procedure:
  - Plane secured on top of vehicle
  - Thrust testing bench attached to bottom of plane and secured to vehicle
  - Driver proceeds to drive down road at set speeds
  - Team member records anemometer live data
  - Other team member records load cell data at corresponding wind speeds

Customer Requirement	CR met? (√ or ×)	Client Acceptable (√ or ×)
CR1 Meets the requirements of the rules	×	
CR2 Safe design	√	
CR3 Able to take off and land	√	
CR4 Innovative design	√	
CR5 Manufacturable	√	
CR6 Low cost	√	
CR7 Modular compatibility	√	
CR8 Static load capability	√	
CR9 60 Second lift-off time limit	√	
CR10 200 feet landing distance	√	
CR11 Payload extraction in one minute or less	√	
CR12 Use of Lithium Polymer Batteries	√	
CR13 Use of Power limiter (450-Watt)	√	
CR14 Must have one cargo bay	√	
CR15 Ability to make a turn in air	√	
CR16 Ability to make a turn on the ground	×	
CR17 Sterring mechanism for landing gear	×	
CR18 Must use an Eletric motor	√	
CR19 Fixed Wing	√	
CR20 Functional failsafe for radio control systems	√	
CR21 Must be equipped with a red arming plug	×	
CR22 Must use model airplane safety nut	×	
CR23 Appropriate center of gravity	√	
CR24 Must have a radio control system	√	

CR Summary

Red: Testing results
Blue: Evaluating results

- Most of requirements met
- Still a few requirements are not met
- We will continue working and improve it

Engineering Requirement	Target	Tolerance	Met?	Client Acceptable?
Light weight	55(Pounds)	+∞	Y	
Increase Reliability	100 (Percent)	±0	Y	
Increase Durability	100 (Percent)	±0	Y	
Power limiter			Y	
Cargo Bay volume	6*6*4(Cubed inches)	0	Y	
Low Cost	1500(Dollars)	-500	Y	
Increase impact tolerance			Y	
48 inch Wing Span	48 (inches)	±1inch	Y	
Lift Forces				
Drag Forces				
Thrust				
Ground turning radius			N	
Payload unloading time				
Low control surface slop				
Must have 4 cells or less battery for the electronics	4 (Number of cells)	±0	Y	
Adequate servo sizing for aerodynamic forces			Y	
Must use 2.4 GHz radio control system	2.4 (GHz)	0	Y	
Must land within 200ft	200 (ft)		Y	
Takeoff within 8 feet	8 (feet)	-1 feet	N	
Cannot exceed 55 pounds	55 (pounds)	+∞	Y	
Optimize safety factor				
Meets SAE Rules and Regulations	100 (percent)	±0		

ER Summary

- Still some requirements are not meet
- Some testing results have not been obtained
- To meet all the requirements, lots of changes should be made

QFD

- All the Customers requirements and Engineering Requirements are from this QFD.
- QFD gives each demand a different proportion.
- Compared with the test results, the main target that has not been achieved is the takeoff distance.

	Light weight	Increase Reliability	Increase Durability	Power limiter	Cargo Bay volume	Low Cost	Increase impact tolerance	48 inch Wing Span	Lift Forces	Drag Forces	Thrust	Ground turning radius	Payload unloading time	Low control surface slop	Must have 4 cells or less battery for the electr	Adequit servo sizing for aerodynamic forces	Must use 2.4 GHz radio control system	Must land within 200ft	Takeoff within 8 feet	Cannot exceed 55 pounds	Optimize saftey factor	Meets SAE Rules and Regulations
Light weight																						
Increase Reliability																						
Increase Durability		1		1																		
Low Cost	3			3			1															
Increase impact tolerance	1		9																			
Optimize saftey factor	1	3	3	3			9							1	1							
Meets SAE Rules and Regulations				9	3	1		9				9	9	9	9	9	9	9				

Legend
- A SAE Aero Micro 2021
- B Hangar 9 Pulse XT
- C UMX Turbo Timber

Customer Needs	Customer Weights (1: worst-5: Best)	Light weight	Increase Reliability	Increase Durability	Power limiter	Cargo Bay volume	Low Cost	Increase impact tolerance	48 inch Wing Span	Lift Forces	Drag Forces	Thrust	Ground turning radius	Payload unloading time	Low control surface slop	Must have 4 cells or less battery for the electr	Adequit servo sizing for aerodynamic forces	Must use 2.4 GHz radio control system	Must land within 200ft	Takeoff within 8 feet	Cannot exceed 55 pounds	Optimize saftey factor	Meets SAE Rules and Regulations	1 Poor	2	3 Acceptable	4	5 Excellent
		Technical Requirements (1-3-9)																						Customer Opinion Survey				
Meets the requirements of the rules	5	1	1	1	9	9	1	9	9	3	3	3	9	9	9	9	9	9	9	9	9	9	9				BC	A
Safe design	5	1	3	3	9			3							9		9					9	9					ABC
Able to take off and land	5	9	9	9	3					9	9	9			9		9				3	1	3					ABC
Innovative design	2		3	3			1	3		3	3	3			3		1				1	3	3		C	AB		
Manufacturable	3	3	1	1	3	1	9	3		3	3	3			1	3	3	3				9				A	B	C
Low cost	4	3			3		9	9							1	3	3	3							ABC			
Modular compatibility	1		3				1	3					1		3				1	1		1	3		A	BC		
Static load capability	5	9	9	3		9	1							9							9	3	3					ABC
60 Second lift-off time limit	5	3								9	9	9					9			9								ABC
200 feet landing distance	5	3								9	9	9					9		9									ABC
Payload extraction in one minute or less	5					9								9										C				AB
Use of Lithium Polymer Batteries	5		3	3	3		3									9	1	1				1	3				C	AB
Use of Power limiter (450-Watt)	5		3	3	9		1					3					3	3				9	3	ABC				
Must have one cargo bay	5					9								9									3					ABC
Ability to make a turn in air	5									9	9	9			3		9	3					3					ABC
Ability to make a turn on the ground	5												9										9					ABC
Stering mechanism for landing gear	5	3				1	3						9		3		9						9					ABC
Must use an Eletric motor	5				3		3					9				3							9					ABC
Fixed Wing	5		1	1						3	3	3		1	3		1		3	9		9	9					ABC
Functional failsafe for radio control systems	5																		3				9					ABC
Must be equipped with a red arming plug	5																						9	C				AB
Must use model airplane safety nut	5																						9					ABC
Appropritate center of gravity	5	3				1			1												1		9					ABC
Must have a radio control system	5															1	1	9										ABC
Technical Requirement Units		pounds	Percentage	Percentage	Watts	Inches cubed	US dollars	Crashes before repair	Inch	Pounds	Pounds	pounds	Inches	Seconds	Degrees	Number of cells	ounces/inch	GHz	Feet	Feet	pounds	Factor of Saftey	Percentage					
Technical Requirement Targets		55	100	100		6*6*4	1500		48							4		2.4	200	8	55		100					
Absolute Technical Importance		181	151	124	201	193	153	114	50	225	225	285	136	185	196	131	368	146	121	136	112	230	549					
Relative Technical Importance		11	13	18	7	9	12	20	22	6	5	3	16	10	8	17	2	14	19	15	21	4	1					

Why some requirements are not met?

- ·Due to the unbalanced weight of the fuselage, we added some counterweight modules to balance the weight of the aircraft, which led to a rise in the total weight and extended the takeoff distance.
- ·The area of the tail rudder is not enough to realize the ground steering of the aircraft, and there is no steering device on the landing gear.
- · Some parts are not easy to purchase (such as safety nuts). We have searched for purchase channels on the Internet for many times, but no results have been achieved.
- · Due to the weather, some tests were not carried out as scheduled. We need to select a suitable date for further tests to get the final results.

Future plans

- Finish testing
  - How much cargo can we hold
  - Lift forces
- Ugrads
- Learn to fly ourselves
- Go until it breaks