SAE Aero Micro Design:
Presentation 1

NAU Capstone 2019-2020
The Prop Dogs
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9/17/2019

Corbin

Project Description: SAE Aero

- The SAE Aero Design competition provides Engineering students with real life design problems.
- There are three different competitions within SAE Aero.
  - Advanced, Regular, and Micro
- Each design has different evaluations: Design, Presentation, and MP
- The Micro design consists of a small mobile plane that can
  - Carry the highest payload fraction possible
  - Pursue the lowest empty weight possible
- Faculty Advisor: Dr. John Tester

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Literature Review

- **Design, performance evaluation and optimization of a UAV [1]**

  This source evaluated aerodynamic characteristics and efficiency of the airfoil section, the wing, and the full configuration of a small uav. Provides many useful equations to be used when designing our system.

- **Fox and McDonald's Introduction to Fluid Mechanics, 8th ed [2]**

  A study of the laws of fluid mechanics, more precisely, boundary conditions and air foils. Will be useful when comparing prototypes to our final product.

- **Design and assembly of an experimental fixed wing remote controlled glider plane [3]**

  This source developed an airframe and interfaced it with radio controlled remote, then embedded an on-board micro controller on the glider airframe.

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State of the Art Design (SOTA): 2019 SAE Aero Micro Winner

Xi'an Jiaotong University [4]

- 8th - Design
- 4th - Oral Presentation
- 1st - Mission Performance

Design	Presentation	Mission Performance	Penalties	Total
32.5943	44.9000	57.9746	-0.0	135.469

Eli

State of the Art Design (SOTA): 2019 SAE Aero Micro American Winner

Wright State University [4]

- 1st in Design
- 11th in Presentation
- 6th in Mission Performance

Design	Presentation	Mission Performance	Penalties	Total
41.9185	36.9000	20.2716	-0.5	98.5901

Eli

Customer Requirements (CRs)

2020 Collegiate Design Series
SAE Aero Design Rules

	Customer Requirements
1	Gross Weight Limit (10 lbs)
2	In-flight radio control (2.4 GHz) w/ fail safe
3	wheeled landing gear steering mechanism
4	Payload cannot aid frame integrity
5	Payload attached w/ metal hardware
6	Electric motor/Servo
7	Red arming plug
8	3 cell 2200mAh lithium polymer battery
9	gyroscopic assist allowed
10	ASTM D1785 PVC Payload weights
11	Hand launch
12	12.125 in X 3.625 in X 13.875 in container
13	3 min assembly
14	1 min to energize, check, and launch
15	fly for 400-foot leg of a flight circuit
16	cost within budget
17	durable and robust design
18	reliable design
19	safe to operate

Non-ER Competition Requirements
Aircraft Identification
Empty CG Marking and Drawing Req.
Non-metal propeller
No lead
Battery-only stored energy
Secure linkages
Clevis keepers
Servo load analysis
Battery protection from protrusions
Gearbox allowed
Multiple motors, props, ducted fans allowed
Payload included in gross weight

Zach

Engineering Requirements (ERs)

-Customer Requirements

-Determine metric to evaluate and measure each CR

-Each CR must be measured by at least 1 ER

Frequency (GHz)
Power (Watts)
Weight (lbs)
Time (seconds)
Capacity (mAh)
Storage Volume (in^3)
Length (inch)
Current (Amperes)

Angle (deg)
Acceleration (feet/second^2)
Angular Velocity (degrees/sec)
Angular Speed (rpm)
Lift (lb)
Thrust (lb)
Cost ($)
Toughness (in*lb/in^2)

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Quality Function Deployment (QFD): CRs vs. ERs

	Customer Requirements	Customer Weights	Frequency (GHz)	Power (Watts)	Weight (lbs)	Time (seconds)	Capacity (mAh)	Storage Volume (in^3)	Length (inch)	Current (Amperes)	Angle (deg)	Acceleration (feet/second^2)	Angular Velocity (degrees/sec)	Angular Speed (rpm)	Lift (lb)	Thrust (lb)	Cost ($)	Toughness (in*lb/in^2)
			Engineering Requirements															
1	Gross Weight Limit (10 lbs)	5	1	3	9	1	1	3	3	1	1	1	1	1	1	9	3	3
2	In-flight radio control (2.4 GHz) w/ fail safe	5	9	1	1	3	1	1	1	3	1	1	3	1	1	1	3	1
3	wheeled landing gear steering mechanism	4	1	1	1	1	1	1	9	1	3	1	1	1	1	1	3	3
4	Payload cannot aid frame integrity	3	1	1	9	1	1	9	3	1	1	1	1	1	1	3	1	9
5	Payload attached w/ metal hardware	3	1	1	9	1	1	3	3	1	1	1	1	1	1	3	1	1
6	Electric motor/Servo	4	3	9	9	1	9	1	1	9	1	9	9	9	9	9	3	3
7	Red arming plug	5	1	9	1	1	1	1	1	9	1	1	1	1	9	9	1	1
8	3 cell 2200mAh lithium polymer battery	5	1	9	9	1	9	9	3	9	1	1	1	1	3	3	3	1
9	gyroscopic assist allowed	2	1	1	3	1	1	3	3	1	9	1	9	1	1	1	3	3
10	ASTM D1785 PVC Payload weights	4	1	1	9	1	1	9	9	1	1	1	1	1	1	9	1	3
11	Hand launch	4	1	9	9	3	1	1	9	1	9	9	9	9	9	9	1	3
12	12.125 in X 3.625 in X 13.875 in container	5	1	1	3	9	1	9	9	1	1	1	1	1	3	3	1	3
13	3 min assembly	4	1	1	3	9	1	3	3	1	1	1	1	1	1	1	1	9
14	1 min to energize, check, and launch	4	1	1	3	9	1	1	3	9	1	1	1	1	1	1	1	3
15	fly for 400-foot leg of a flight circuit	3	1	9	9	3	3	9	9	1	9	3	3	9	3	3	1	1
16	cost within budget	3	3	9	9	1	3	1	3	1	1	9	1	3	9	9	9	3
17	durable and robust design	4	1	3	9	1	1	3	3	1	1	3	1	1	3	1	9	9
18	reliable design	5	9	9	3	3	9	3	9	9	9	9	3	3	9	9	1	3
19	safe to operate	5	9	9	1	1	9	1	3	3	1	3	1	1	3	3	1	1
	Absolute Technical Importance		211	367	421	215	241	283	353	281	197	229	183	181	289	365	183	245
	Relative Technical Importance		12	2	1	11	9	6	4	7	13	10	15	16	5	3	14	8

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QFD: ERs vs. ERs

Engineering Requirements	Frequency (GHz)	Power (Watts)	Weight (lbs)	Time (seconds)	Capacity (mAh)	Storage Volume (in^3)	Length (inch)	Current (Amperes)	Angle (deg)	Acceleration (feet/second^2)	Angular Velocity (degrees/sec)	Angular Speed (rpm)	Lift (lb)	Thrust (lb)	Cost ($)	Toughness (in*lb/in^2)
Frequency (GHz)																
Power (Watts)	1															
Weight (lbs)	1	9														
Time (seconds)	1	3	1													
Capacity (mAh)	1	3	1	3												
Storage Volume (in^3)	1	1	3	1	3											
Length (inch)	1	1	3	1	1	9										
Current (Amperes)	1	3	1	1	9	1	1									
Angle (deg)	1	1	1	1	1	1	1	1								
Acceleration (feet/second^2)	3	9	9	3	1	9	3	3	1							
Angular Velocity (degrees/sec)	1	1	3	3	1	3	3	1	3	1						
Angular Speed (rpm)	3	9	1	3	3	1	1	3	1	1	1					
Lift (lb)	1	9	3	1	1	3	3	1	9	9	1	1				
Thrust (lb)	1	9	9	1	1	3	9	1	9	9	1	3	9			
Cost ($)	1	3	9	3	9	1	1	1	1	3	1	1	1	1		
Toughness (in*lb/in^2)	1	1	9	1	1	3	3	1	1	9	1	1	1	1	3	

Customer Requirements

Customer Weights

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Competition Benchmarking

Legend	
A	SAE Aero Micro 2014-2015 NAU
B	SAE Aero Micro 2016-2017 NAU
C	SAE Aero Micro 2018-2019 NAU
D	SAE Aero Micro 2018 Puerto Rico Results
E	SAE Aero Micro 2019 University of Minnesota
F	SAE Aero Micro 2015 Montana State University
G	SAE Aero Micro 2019 Xi'an Jiaotong Univ First Place
H	SAE Aero Micro 2019 Acharya Institute of Technology
I	SAE Aero Micro 2019 Wright State Univ 6

	Competitor Benchmarking				
Customer Requirements	1 Poor	2	3 Acceptable	4	5 Excellent
Gross Weight Limit (10 lbs)	E,C	D,B	F	H	G
In-flight radio control (2.4 GHz) w/ fail safe	C	E,B	D	H	G
wheeled landing gear steering mechanism	D,E,C	F		H	G
Payload cannot aid frame integrity	D,E,C,B		F	H	G
Payload attached w/ metal hardware	D,E,C,B	D,F,H			G
Electric motor/Servo	E,C	D,B	H	F	G
Red arming plug	E,C	D,B	F	H	G
3 cell 2200mAh lithium polymer battery	E,C	D,B	F	H	G
gyroscopic assist allowed	H,C	E,B	D,F		G
ASTM D1785 PVC Payload weights	C	D,B	E,F,H	G	
Hand launch	E,C	D,B	F,G		
12.125 in X 3.625 in X 13.875 in container	H, B	F, C	G	E	I
3 min assembly	H, B	F, C	G	E	I,D
1 min to energize, check, and launch	H, B	F, C	G	E	D
fly for 400-foot leg of a flight circuit	F, H	C, B	G	E	
cost within budget			A,B,C,D,E,F,G,H,I		
durable and robust design	H	F, C, B	G	E	D
reliable design	H	C, B	F, G	E	I,D
safe to operate	H	E, C	D, G, B		

Eli

Budget

Expenses	Cost
Entry Fees	$1050
Prototypes	$200
Final Design Materials *	$650
Travel	$100

*Final Design Material Expenses include;
Servo motor, propeller, fuselage, airfoil/ wings, wiring, etc.

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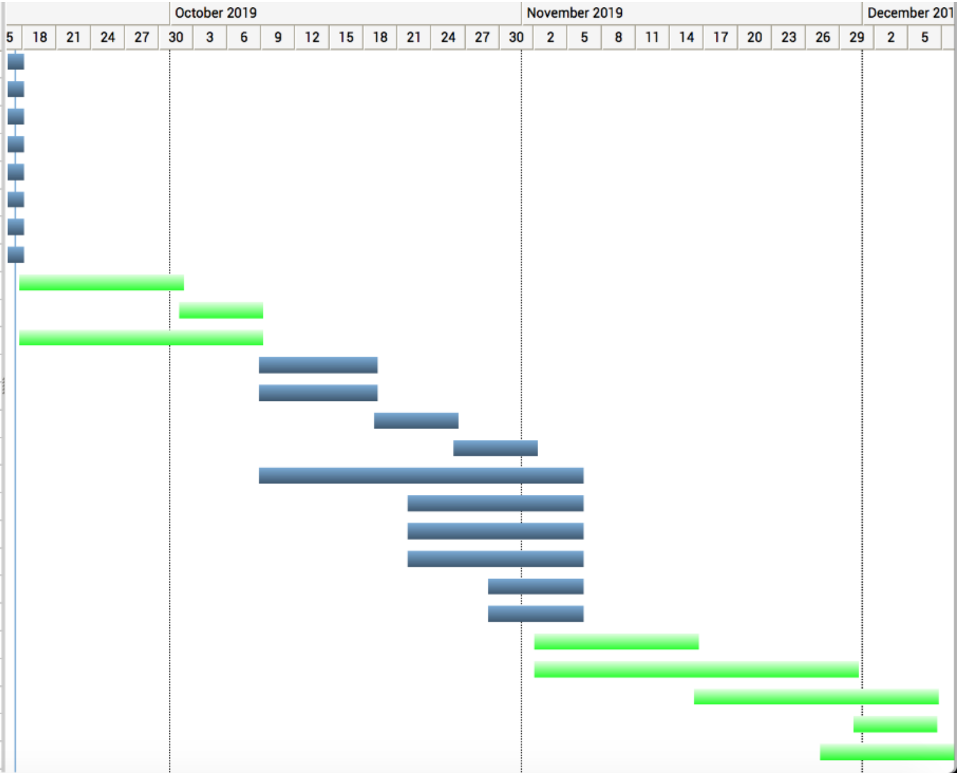
Schedule

Name	Duration	Start	Finish
Customer Needs	2days	09/16/2019	09/17/2019
Engineering Requirements	2days	09/16/2019	09/17/2019
Project Description	2days	09/16/2019	09/17/2019
Background	2days	09/16/2019	09/17/2019
Literature Review	2days	09/16/2019	09/17/2019
Schedule	2days	09/16/2019	09/17/2019
Budget	2days	09/16/2019	09/17/2019
Benchmarking	2days	09/16/2019	09/17/2019
Concept Generation	11days	09/17/2019	10/01/2019
Concept Evaluation	6days	10/01/2019	10/08/2019
Budget Planning	16days	09/17/2019	10/08/2019
Prototype	9days	10/08/2019	10/18/2019
Preliminary Report	9days	10/08/2019	10/18/2019
Analyses Team Memo	6days	10/18/2019	10/25/2019
Website Check 1	6days	10/25/2019	11/01/2019
CAD package	21days	10/08/2019	11/05/2019
BOM	12days	10/21/2019	11/05/2019
Design Validation	12days	10/21/2019	11/05/2019
Design Requirements	12days	10/21/2019	11/05/2019
Schedule for next Semester	7days	10/28/2019	11/05/2019
Budget for next Semester	7days	10/28/2019	11/05/2019
Final Report	11days?	11/01/2019	11/15/2019
Final BOM/Cad package	21days?	11/01/2019	11/29/2019
Final Prototype	16days?	11/15/2019	12/06/2019
Website check 2	6days?	11/29/2019	12/06/2019
Analytical report	11days?	11/26/2019	12/10/2019



Corbin

References

[1] S. G. Kontogiannis and J. A. Ekaterinaris, “Design, performance evaluation and optimization of a UAV,” *Aerospace Science and Technology*, vol. 29, no. 1, pp. 339–350, 2013.

[2] R. W. Fox, A. T. McDonald, and P. J. Pritchard, *Introduction to fluid mechanics*. New Delhi, India: J. Wiley, 2012.

[3] S. Khatoon and D. Gupta, “Design and Assembly of an Experimental Fixed Wing Remote Controlled Glider Plane,” *Applied Mechanics and Materials*, vol. 110-116, pp. 1582–1588, 2011.

[4] Sae.org. (2019). [online] Available at: https://www.sae.org/binaries/content/assets/cm/content/attend/2019/student-events/aero/west/2019_microclassresults---aerowest.pdf [Accessed 16 Sep. 2019].