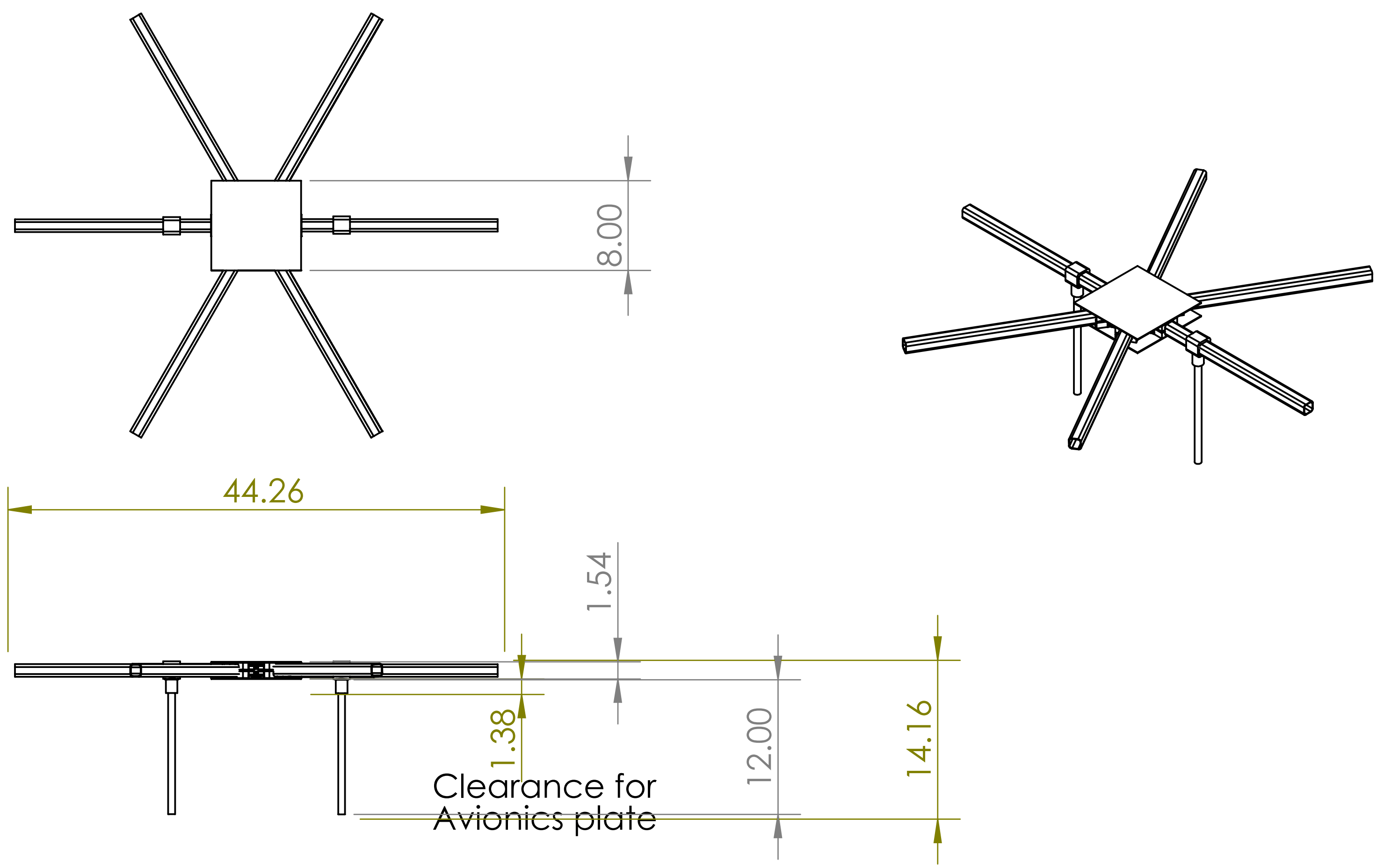
2 1

B B



A A

PROPRIETARY AND CONFIDENTIAL

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NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

SIZE	DWG. NO.	REV
A	second drone assembly	

SCALE: 1:16 WEIGHT: SHEET 1 OF 1

2 1

SOLIDWORKS Educational Product. For Instructional Use Only.

Project 6: Airdrop Solutions

Sammi Chook, Erik Maldonado, Vladimir Perez, Shashwat Sparsh

Overview: The AUVSI SUAS competition involves developing a unmanned aerial vehicle (UAV) and a ground vehicle (UGV) capable of delivering a payload to a certain locations and navigate around imaginary obstacles autonomously.

Introduction: Airdrop Solutions' is centered around the design and implementation of subsystems relevant to the Airdrop task highlighted by the competition rulebook. The subsystems would be subject to the following circumstances:

- An autonomous UGV capable of navigating relatively flat terrain and dropping a package
- *Safe* and *accurate* landing of the UGV from an altitude of ~100 ft
- UAV can be in motion

Other constraints for the subsystems were determined by UAV Forge Senior Design Project team leadership:

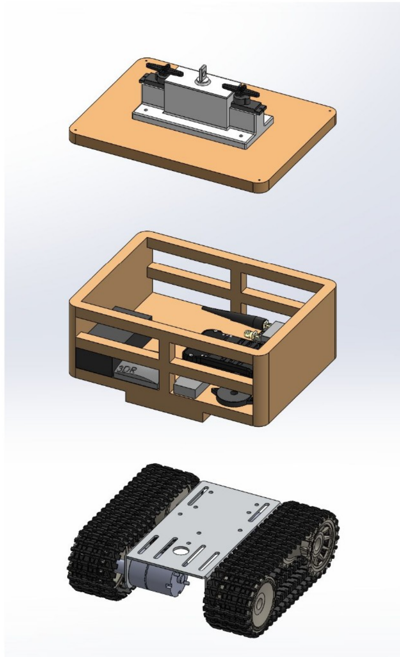
- Weight, size, and cost
- 4 wheel drive
- Guided descent drop mechanism:
  - Active Guidance: an active hybrid/closed loop control system to ensure accurate landing
  - Passive Guidance: an open loop control system based on analytical models

Objective: Design a system that will allow our UAV and UGV to execute the Air Drop task.

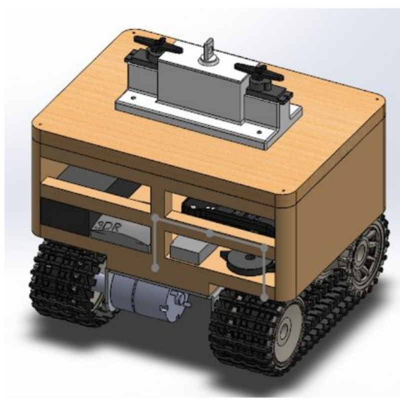
Challenge: When the UAV position is first passing the Air Drop location during the waypoint navigation task that will not require our UAV to (1) deviate from our flight path between waypoints and (2) navigate to the Air Drop location a second time.

Final Design Model

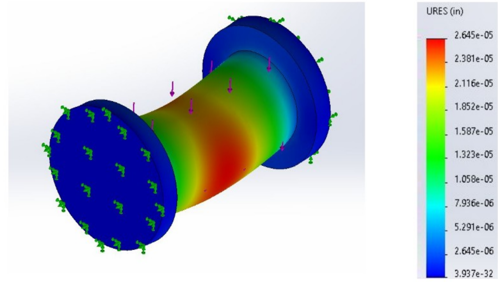
- Assembly of the UGV and Decoupler (Winch not included, attached to UAV)
- Specifications
  - Decoupling system will be screwed on top of the UAV
  - (Height, Width, Length):
    - 7.66 x 7.48 x 6.66 inches (with decoupler)
    - 5.13 x 7.48 x 6.66 inches (without decoupler)
  - Weight: ~2.5 lbs
- Cost:
  - Winch: ~$45
  - Decoupler: ~$35
  - Body + Chassis: ~$62
  - Total: ~$142



Figure(1): UGV + Decoupler Exploded View (Winch attached to UAV baseplate)

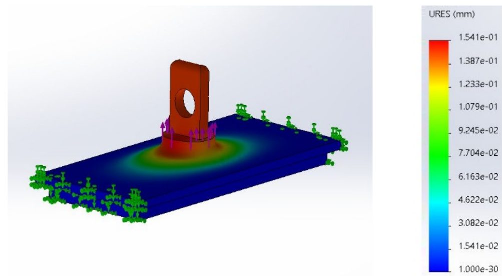


Figure(2): UGV + Decoupler



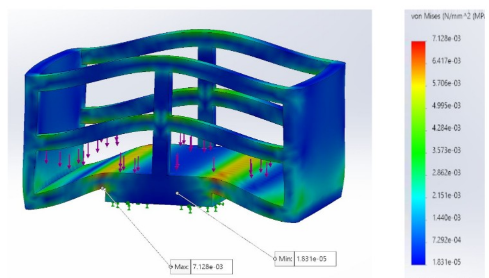
Figure(3): ABS Spool under 4 lbf load

Analysis:
Max deflection at 2.645e-5 in. under uniform solid material conditions which may not apply to 3D printed parts



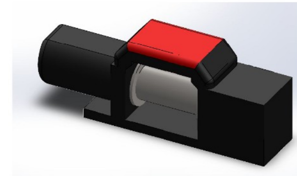
Figure(4): Polycarbonate plate under 4 lbf from payload

Analysis:
Concentrated 4 lbf at center. Based on results, max deflection of 0.154 mm and 3.37 MPa. Results well below expected 0.5mm deflection and 60 MPa yield strength.



Figure(5): Balsa wood body under 1 lbf load

Analysis:
Maximum stress of 0.007128 MPa under the rated 20 MPa based on uniform construction and weight distribution.



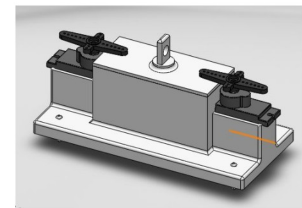
Figure(6): Winch Model

Descent System: Winch

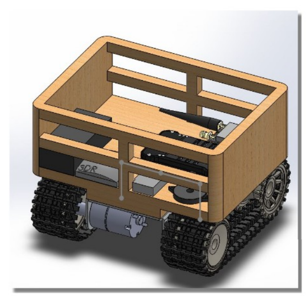
- Attached to the UAV with passive guidance system
- Manufacturable in house
- Parts:
  - Reedy Radon 2 3-Slot 3200Kv Brushed Motor, 19T
  - 3D printed spool: ABS/PLA enabling rapid prototyping
  - Fishing line: lightweight, strong

Decoupling System: Plate Release

- Cam Lock Inspiration from cabinetry construction.
- Provides a simple design for manufacturing, controlled release and lock of UGV, and better distribution of force from the payload.
- Parts
  - 3D Printed Body & Plate
    - Polycarbonate
    - Lightweight
    - Withstands loads
  - MG90S micro servo
  - 18-8 SS Button Head Screw, ½" long
  - Servo Horns (Aluminium 6061-T6): minimal deflection & lightweight



Figure(7): Plate Release Model



Figure(8): UGV Frame (without components)

UGV System: Chassis and Body

- Aluminum tank chassis with rubber treads for traction and landing recovery
- Balsa wood body frame to hold components and payload
- Parts:
  - One DC motor per tread
    - Function: Differential steering and propulsion
    - Two sprocket and idle wheels
  - Aluminum base plate attached to frame by industrial glue
  - Balsa Wood frame: lightweight and resists fracture under loads during drop based on simulations

MAE 189 Project 3: Fixed Wing Test Bed (FWTB)

Sammi Chook, Kevin Joe Kayale, Nick Norambuena, Shashwat Sparsh, Rick Meade, Jordan Louie
Department of Mechanical and Aerospace Engineering at University of California, Irvine
Sponsored by Dr. David Copp and UAV Forge

OVERVIEW

FWTB is a project team contracted by UAV Forge to design a fixed wing Unmanned Air Vehicle (UAV) that can complete certain tasks listed under AUVSI SUAS competition rulebook.

Objective: The main goal is to design, build, and fly a fixed wing aircraft that can integrate and test hardware needed for an imaging system and drop system.

Challenge: Design a fixed wing aircraft capable of carrying a 4 pound payload while still having a 20 minute flight time

EXISTING SOLUTIONS

Figure 1. Reference model aircraft.

FWTB's project follows a fixed-wing cargo plane model made by one of the team members, Jordan Louie, as the basis for designing and constructing the current aircraft. The reference plane was not built to follow any specifications or applications related to FTWB's requirements and attributes and was mainly built as a hobby craft.

SOLUTION

Calculations were done to determine the theoretical specifications of the plane. It was determined that the airframe weight could be no more than 2 ½ pounds. Due to this weight constraint, the team opted for a single wing, conventional tail, and carbon fiber spar fuselage.

HARDWARE FOR TESTING

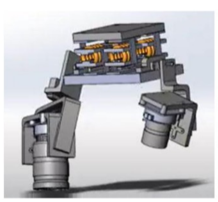


Figure 2. Imaging System

Both the imaging and parachute systems will be able to be tested on the testbed aircraft.

Figure 3. Parachute System

Figure 4. Constructed model of the aircraft.

THE AIRCRAFT

Specifications:

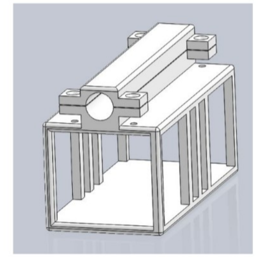
Wingspan: 8 feet
Length: 6 feet
Weight: 6 pounds without payload
Payload Capacity: 4 pounds
Maximum Takeoff Weight: 10 pounds
Maximum Flight Time Without Payload: 40 minutes
Aspect Ratio: 9.6:1
Wing Loading Without Payload: 15 oz/ft^2

Power:

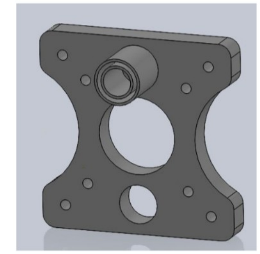
Battery: 6 cell 6600 mAh
Motor: Turnigy 300 kV
Electronic Speed Controller: Hobby King 80 Amp
Radio Receiver: Futaba R617FS
Radio Transmitter: Futaba T7C

IMPACT ON SOCIETY AND ENVIRONMENTAL CONCERNS

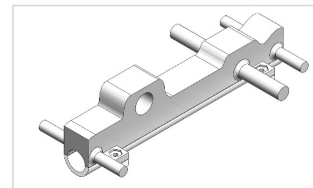
High endurance fixed wing aircraft capable of payload delivery and/or imaging will be instrumental in transporting vital goods to more remote areas for a low price. Fixed wing aircraft like the one featured above are relatively cheap to construct and operate.



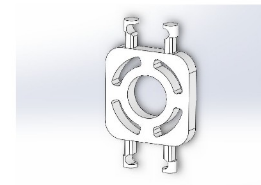
Battery Attachment



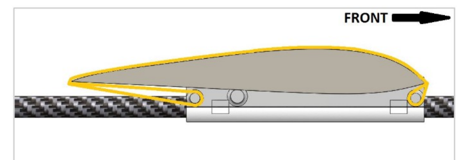
Motor Mount



Wing Attachment



Spar Holder



Future Work: The team was able to verify that the aircraft is indeed capable of flight, however the aircraft did suffer a crash. Despite crash damage, the wings, main spars, and all power components are still functional. The wing attachment mechanism needs to be redesigned to better secure the wing. Shown in Figure 3 is damage to the wing attachment mechanism sustained before the crash. This crack is presumed to be the main reason behind the crash.

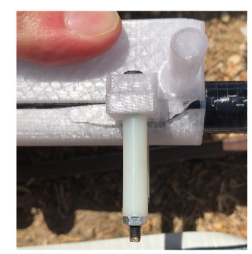
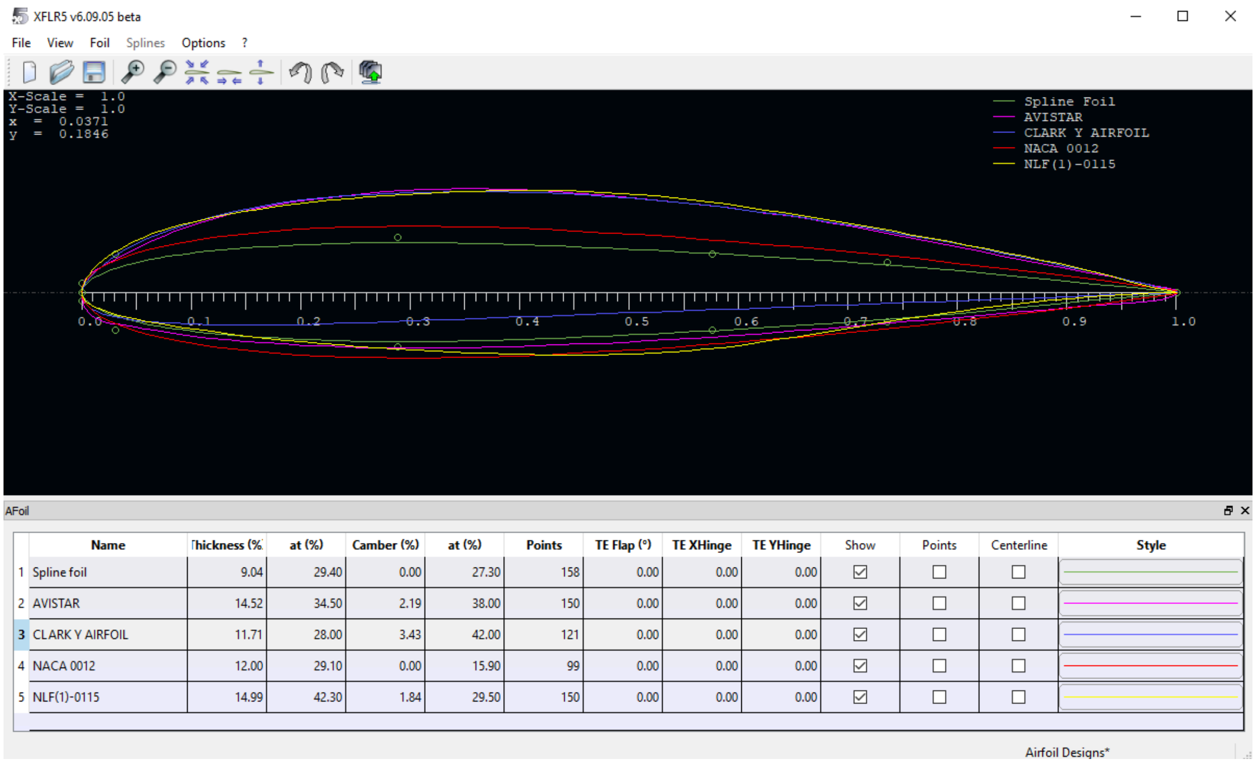


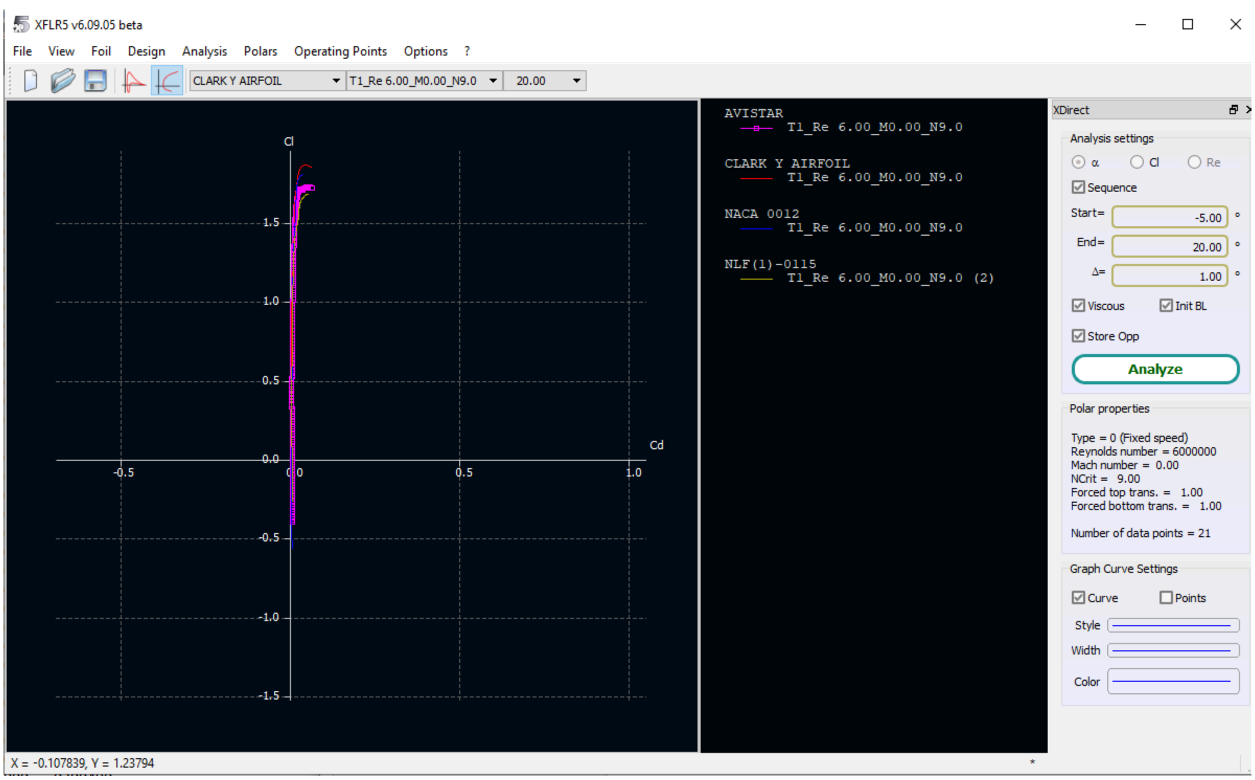
Figure 3. Wing attachment post-test flight showing a crack.

Airfoil Design

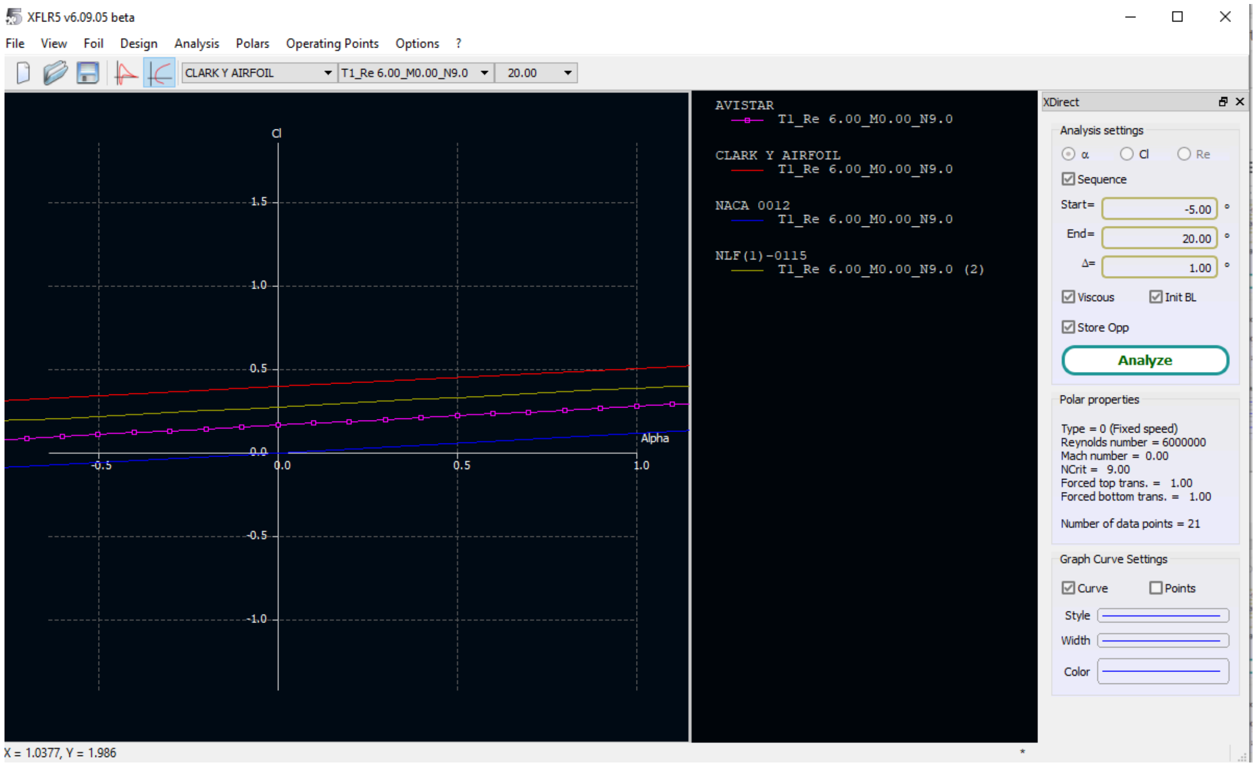


	Name	Thickness (%	at (%)	Camber (%)	at (%)	Points	TE Flap (°)	TE XHinge	TE YHinge	Show	Points	Centerline	Style
1	Spline foil	9.04	29.40	0.00	27.30	158	0.00	0.00	0.00	☑	☐	☐	
2	AVISTAR	14.52	34.50	2.19	38.00	150	0.00	0.00	0.00	☑	☐	☐	
3	CLARK Y AIRFOIL	11.71	28.00	3.43	42.00	121	0.00	0.00	0.00	☑	☐	☐	
4	NACA 0012	12.00	29.10	0.00	15.90	99	0.00	0.00	0.00	☑	☐	☐	
5	NLF(1)-0115	14.99	42.30	1.84	29.50	150	0.00	0.00	0.00	☑	☐	☐	

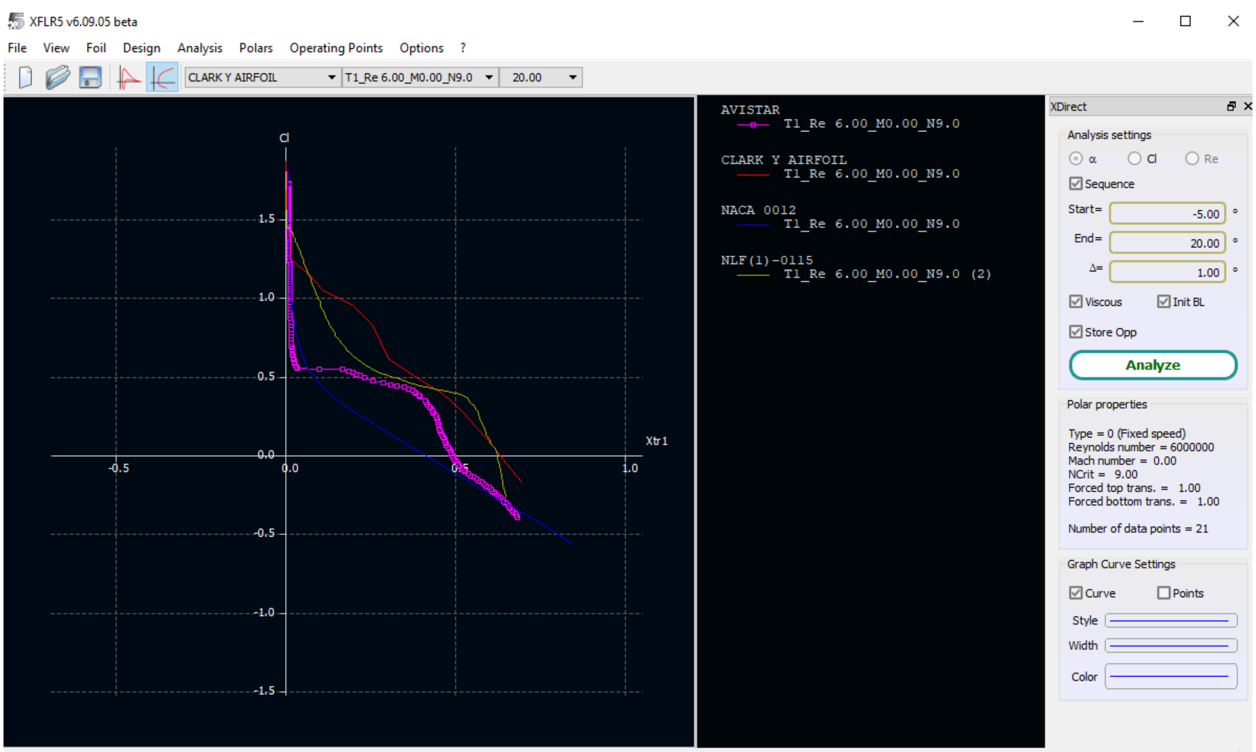
Cl vs Cd



Cl vs Alpha



Cl vs Xtr.



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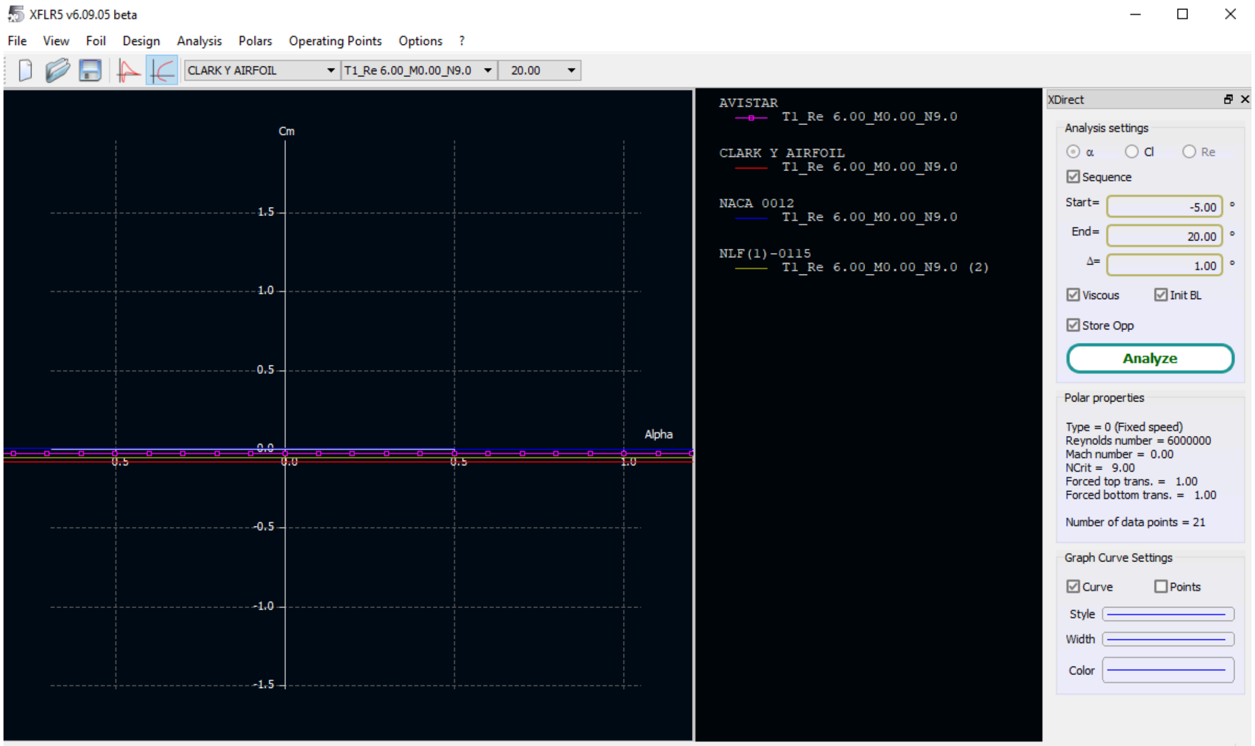
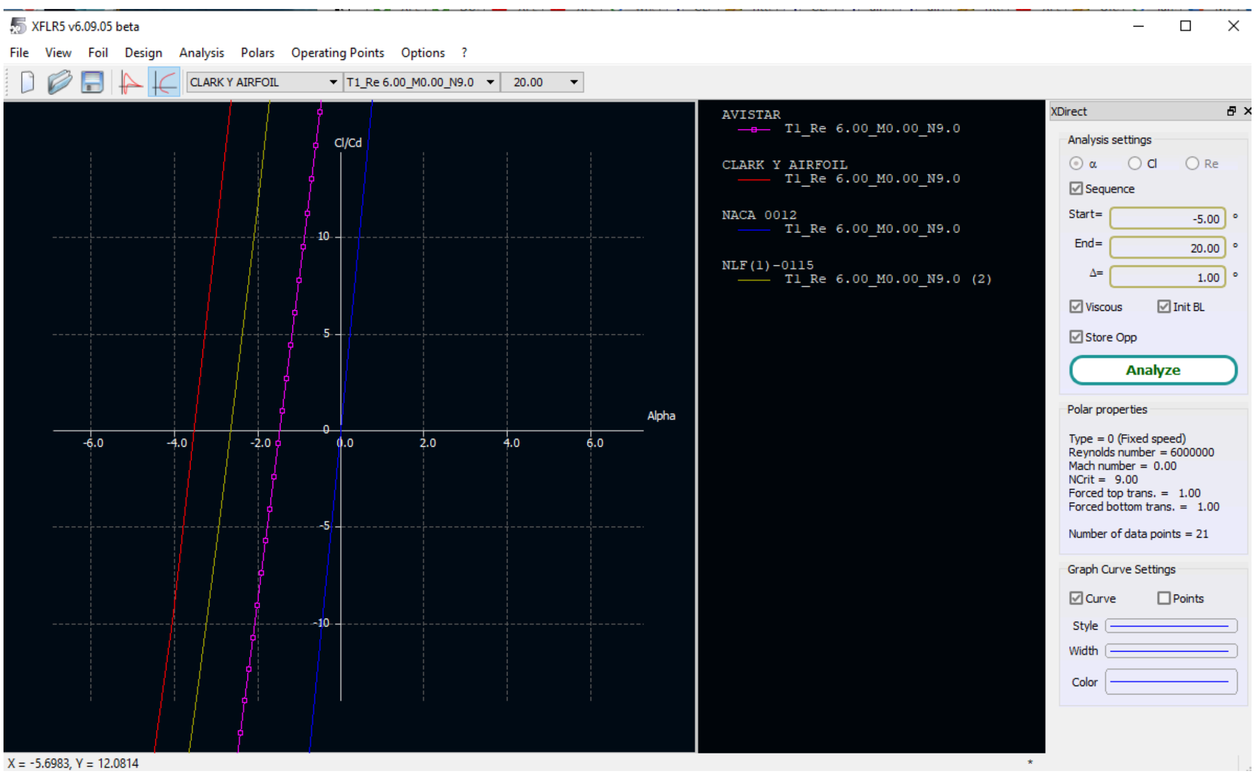
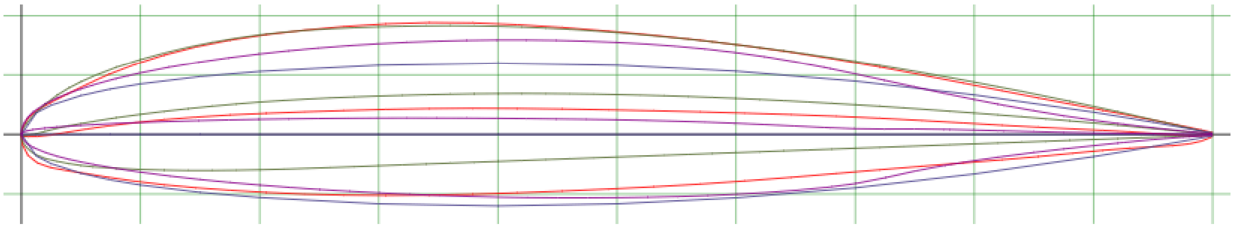
Cm vs Alpha



Glide ratio vs Alpha





Open full size plan in new window

Open paginated plan in new window

Download PDF file

SVG image as text file

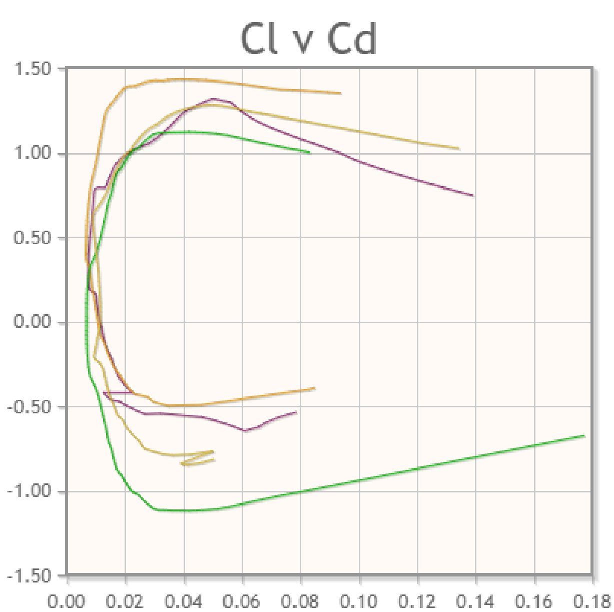
2032c-il - 20-32(Add airfoil

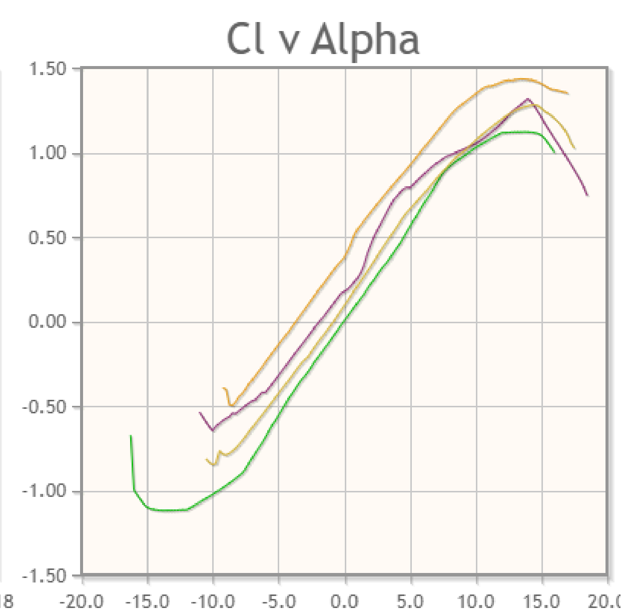
Clear all

(avistar-il) AVISTAR	Hobbico R/C Avistar trainer airfoil Max thickness 14.5% at 34.2% chord Max camber 2.3% at 37.9% chord	Remove Airfoil details Airfoil plotter
(clarky-il) CLARK Y AIRFOIL	CLARK Y airfoil Max thickness 11.7% at 28% chord Max camber 3.4% at 42% chord	Remove Airfoil details Airfoil plotter
(naca001264-il) NACA 0012-64	NACA 0012-64 airfoil Max thickness 12% at 40% chord Max camber 0% at 0% chord	Remove Airfoil details Airfoil plotter
(hsnlf213-il) HSNLF(1)-0213 AIRFOIL	NASA/Langley HSNLF(1)-0213 high speed natural laminar flow airfoil Max thickness 13.3% at 42.4% chord Max camber 1.4% at 32.4% chord	Remove Airfoil details Airfoil plotter

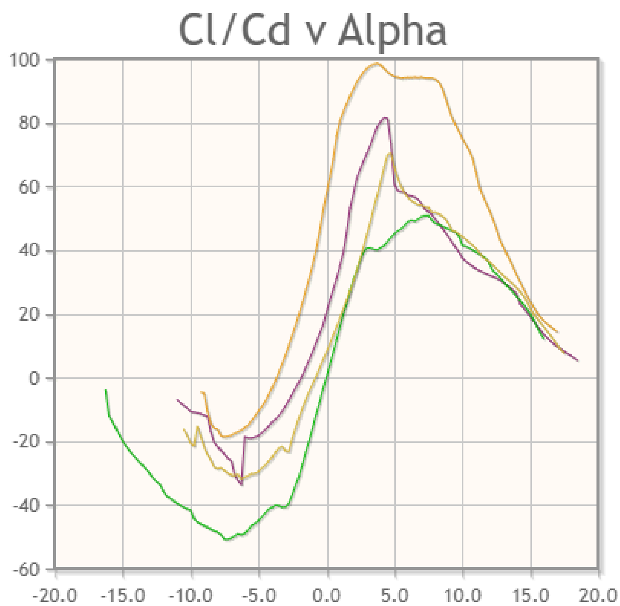
Graph Color Key

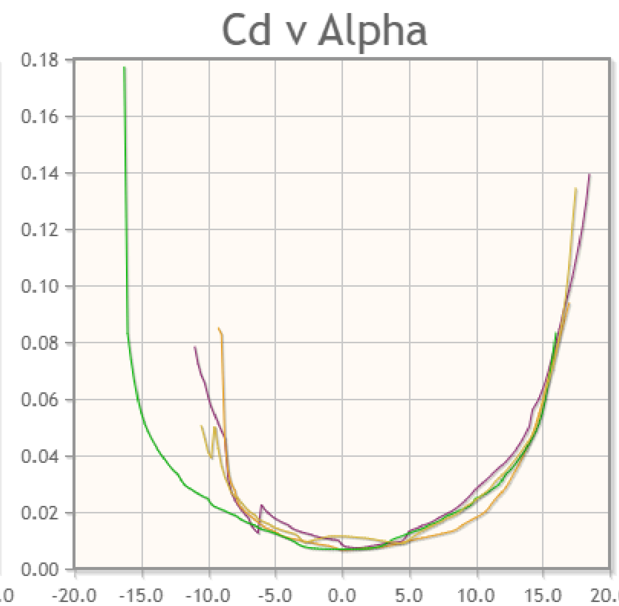
O = Avistar
O = Clark Y
O = Symmetric
O = Laminar

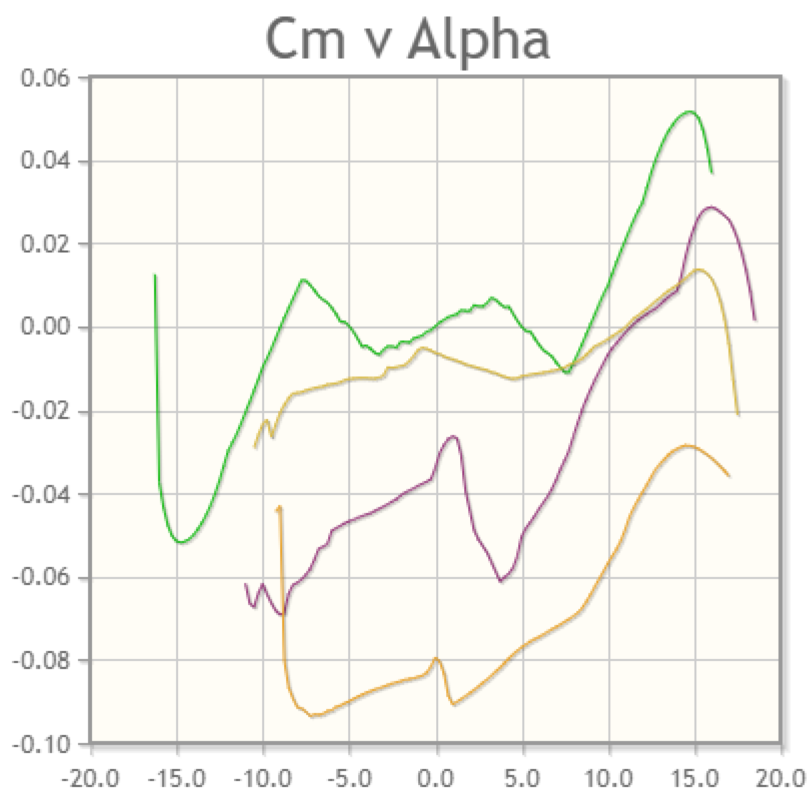




- Clark Y -> highest coefficient of lift for coefficient of drag, highest coefficient of lift for aoa


Cl/Cd v Alpha
100
80
60
40
20
0
-20
-40
-60
-20.0 -15.0 -10.0 -5.0 0.0 5.0 10.0 15.0 20.0


Cd v Alpha
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-20.0 -15.0 -10.0 -5.0 0.0 5.0 10.0 15.0


Cm v Alpha
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-20.0 -15.0 -10.0 -5.0 0.0 5.0 10.0 15.0 20.0

eCalc - Propeller Calculator
all data without guarantee - Accuracy: /-15%

Project Name: Fixed-Wing Test-Bed Config Alpha

(c) by Solution for All - 7.25.000, 12.4.2021

Airplane	Units	Values
# of Motors:		1
All-up Weight:	g	2722
	oz	96
Wing Area:	in²	1152
Wing Load:	g/dm²	37
	oz/ft²	12.1
Cubic Wing Load:		4.2
est. Stall Speed:	km/h	29
	mph	18
est. Speed (level):	km/h	108
	mph	67
est. Speed (vertical):	km/h	76
	mph	47
est. rate of climb:	m/s	21.2
	ft/min	4165

Propeller	Units	APC Electric E (0°) 17" x 10.0"
# Blades:		2
Static Thrust:	g	7592
	oz	267.8
Revolutions*:	rpm	7578
Stall Thrust:	g	-
	oz	-
avail.Thrust @ Flight Sp	g@km/h	7592 @ 0
	oz@mph	267.8 @ 0
Pitch Speed:	km/h	116
	mph	72
specific Thrust:	g/W	4.48
	oz/W	0.16

Battery	Units	LiPo 8000mAh - 30/45C
Configuration:		8S1P
Load:	C	7.45
Voltage:	V	28.6
Rated Voltage:	V	29.6
Energy:	Wh	236.8
Total Capacity:	mAh	8000
max. discharge:		0.85
Used Capacity:	mAh	6800
min. Flight Time:	min	6.8
Mixed Flight Time:	min	23.2
Weight:	g	1608
	oz	56.7

Motor @ Maximum	Units	Turnigy G160-290 (290)
Gear Ratio:	: 1	1
Weight:	g	649
	oz	22.9
Current:	A	59.62
Voltage:	V	28.45
Revolutions*:	rpm	7578
electric Power:	W	1696.1
mech. Power:	W	1574.1
Efficiency:	%	92.8
est. Temperature:	°C	49
	°F	120

Total Drive	Units	Values
Drive Weight:	g	2626
	oz	92.6
Power-Weight:	W/kg	648
	W/lb	294
Thrust-Weight:	: 1	2.79
Current @ max:	A	59.62
P(in) @ max:	W	1764.7
P(out) @ max:	W	1574.1
Efficiency @ ma	%	89.2

Controller	Type	max 100A
Current:	A cont.	100
	A max	100
Weight:	g	130
	oz	4.6
Battery extension Wire:		AWG10=5.27mm²
Length:	mm	0
	inch	0
Motor extension Wire:		AWG10=5.27mm²
Length:	mm	0
	inch	0

all data without guarantee - Accuracy: +/-10%

propCalc - Propeller Calculator

News | Toolbox | Easy View | Help | Submit Specs | Language: english

General	Model Weight: 2722 g incl. Drive / 96 oz	# of Motors: 1 (on same Battery)	Wingspan: 2438.4 mm / 96 inch	Wing Area: 74.32 dm² / 1152 in²	Drag: simplified / 0.03 Cd	Field Elevation: 500 m.ASL / 1640 ft.ASL	Air Temperature: 25 °C / 77 °F	Pressure (QNH): 1013 hPa / 29.91 inHg
Battery Cell	Type (Cont. / max. C) - charge state: LiPo 8000mAh - 30/45C - normal	Configuration: 8 S 1 P	Cell Capacity: 8000 mAh / 8000 mAh total	max. discharge: 85%	Resistance: 0.0021 Ohm	Voltage: 3.7 V	C-Rate: 30 C cont. / 45 C max	Weight: 201 g / 7.1 oz
Controller	Type - Timing: max 100A - normal	Current: 100 A cont. / 100 A max	Resistance: 0.0025 Ohm	Weight: 130 g / 4.6 oz	Battery extension Wire: AWG10=5.27mm²	Length: 0 mm / 0 inch	Motor extension Wire: AWG10=5.27mm²	Length: 0 mm / 0 inch
Motor	Manufacturer - Type (Kv) - Cooling: Turnigy - G160-290 (290) / good / search...	KV (w/o torque): 290 rpm/V / Prop-Kv-Wizard	no-load Current: 1 A @ 10 V	Limit (up to 15s): 78 A	Resistance: 0.022 Ohm	Case Length: 66 mm / 2.6 inch	# mag. Poles: 10	Weight: 649 g / 22.9 oz
Propeller	Type - yoke twist: APC Electric E - 0°	Diameter: 17 inch / 431.8 mm	Pitch: 10.0 inch / 254 mm	# Blades: 2	PConst / TConst: 1.08 / 1.0	Gear Ratio: 1 : 1	Flight Speed: 0 km/h / 0 mph	calculate

Load: | Mixed Flight Time: | Current: | est. Temperature: | Thrust-Weight: | Pitch Speed:

Result Link: https://www.ecalc.ch/motorcalc.php?ecalc&lang=er

Remarks:

Battery		**Motor @ Optimum Efficiency**		**Motor @ Maximum**		**Propeller**		**Total Drive**		**Airplane**	
Load:	7.45 C	Current:	37.18 A	Current:	59.62 A	Static Thrust:	7592 g	Drive Weight:	2626 g	All-up Weight:	2722 g
Voltage:	28.60 V	Voltage:	28.88 V	Voltage:	28.45 V		267.8 oz		92.6 oz		96 oz
Rated Voltage:	29.60 V	Revolutions*:	7860 rpm	Revolutions*:	7578 rpm	Revolutions*:	7578 rpm	Power-Weight:	648 W/kg	Wing Load:	37 g/dm²
Energy:	236.8 Wh	electric Power:	1074.0 W	electric Power:	1696.1 W	Stall Thrust:	- g		294 W/lb		12.1 oz/ft²
Total Capacity:	8000 mAh	mech. Power:	1005.2 W	mech. Power:	1574.1 W		- oz	Thrust-Weight:	2.79 : 1	Cubic Wing Load:	4.2
Used Capacity:	6800 mAh	Efficiency:	93.6 %	Efficiency:	92.8 %	avail. Thrust @ 0 km/h:	7592 g	Current @ max:	59.62 A	est. Stall Speed:	29 km/h
min. Flight Time:	6.8 min			est. Temperature:	49 °C	avail. Thrust @ 0 mph:	267.8 oz	P(in) @ max:	1764.7 W		18 mph
Mixed Flight Time:	23.2 min				120 °F	Pitch Speed:	116 km/h	P(out) @ max:	1574.1 W	est. Speed (level):	108 km/h

Weight:	1608 g	
	56.7 oz	

Wattmeter readings

Current:	59.62 A
Voltage:	28.6 V
Power:	1705.1 W

	72 mph
Tip Speed:	617 km/h
	383 mph
specific Thrust:	4.48 g/W
	0.16 oz/W

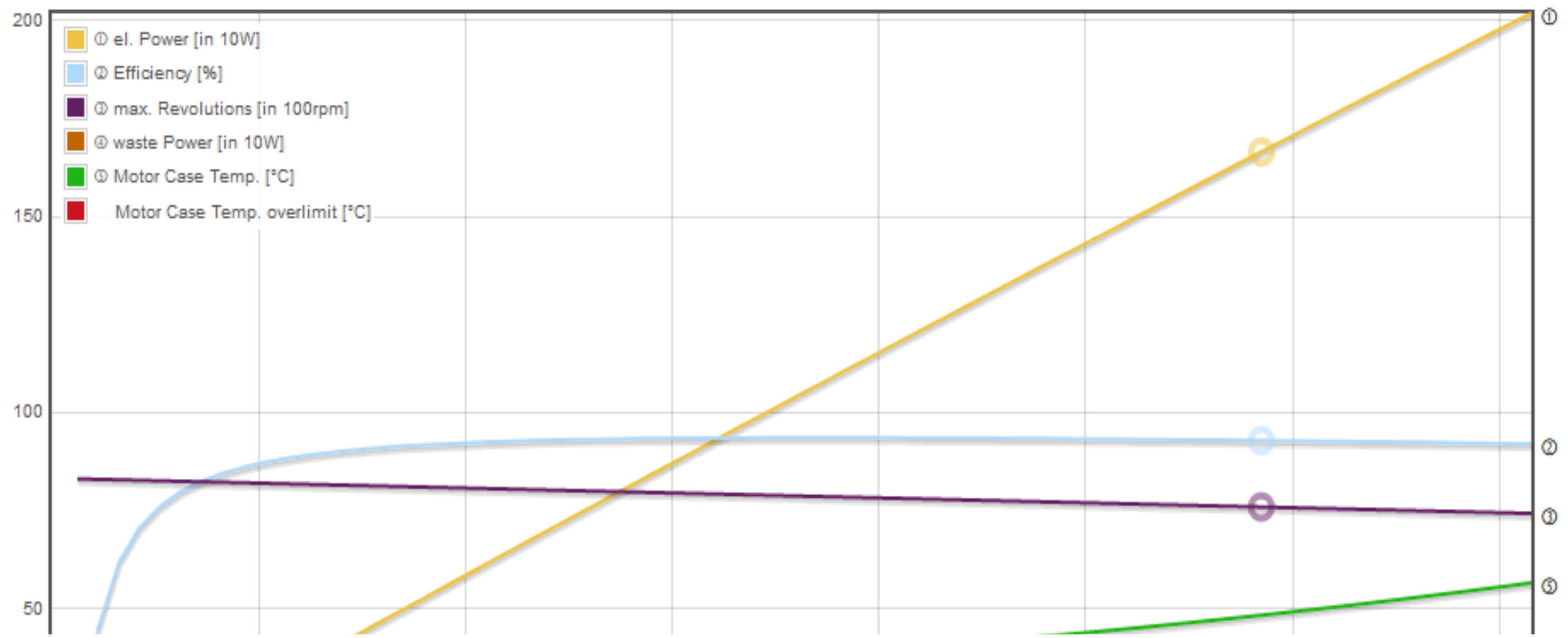
Efficiency @ max:	89.2 %
Torque:	1.98 Nm
	1.46 lbf.ft

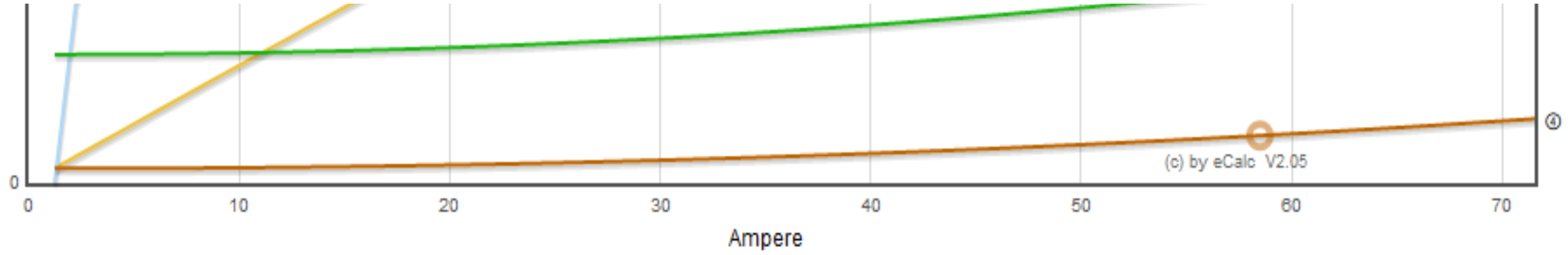
	67 mph
est. Speed (vertical):	76 km/h
	47 mph
est. rate of climb:	21.2 m/s
	4165 ft/min

Motor Partial Load

Propeller	Throttle	Current (DC)	Voltage (DC)	el. Power	Efficiency	Thrust		Spec. Thrust		Pitch Speed		Speed (level)		Motor Run Time
rpm	%	A	V	W	%	g	oz	g/W	oz/W	km/h	mph	km/h	mph	(85%) min
1000	12	0.2	29.6	7.0	51.3	132	4.7	18.8	0.66	15	9	-	-	1712.2
1500	18	0.6	29.6	17.6	69.2	297	10.5	16.9	0.60	23	14	-	-	683.8
2000	25	1.2	29.6	36.6	79.1	529	18.7	14.5	0.51	30	19	-	-	329.6
2500	31	2.3	29.6	66.7	84.7	826	29.1	12.4	0.44	38	24	-	-	180.5
3000	37	3.8	29.5	110.9	88.0	1190	42.0	10.7	0.38	46	28	43	27	108.4
3500	43	5.9	29.5	172.2	90.0	1619	57.1	9.4	0.33	53	33	50	31	69.7
4000	50	8.6	29.5	253.5	91.3	2115	74.6	8.3	0.29	61	38	57	35	47.3
4500	56	12.2	29.4	357.9	92.1	2677	94.4	7.5	0.26	69	43	64	40	33.4
5000	63	16.7	29.3	488.4	92.5	3305	116.6	6.8	0.24	76	47	71	44	24.4
5500	**70**	**22.3**	**29.2**	**648.1**	**92.8**	**3999**	**141.1**	**6.2**	**0.22**	**84**	**52**	**79**	**49**	**18.3**
6000	**77**	**29.0**	**29.1**	**840.2**	**93.0**	**4759**	**167.9**	**5.7**	**0.20**	**91**	**57**	**86**	**53**	**14.1**
6500	**84**	**37.0**	**29.0**	**1067.8**	**93.0**	**5585**	**197.0**	**5.2**	**0.18**	**99**	**62**	**93**	**58**	**11.0**
										107	66	100	62	8.8
										114	71	107	66	7.1
										116	72	108	67	6.8

Motor Characteristic at Full Throttle





0
0
10
20
30
40
50
60
70
Ampere
(c) by eCalc V2.05

n&weight=2722&wingspan=2438.4&calc=auw&motornumber=1&warea=74.32&elev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Current Research:

https://youtu.be/Ap72AvPILys

Flight Tests:

https://youtu.be/ud40HQ99TWY

https://youtu.be/rfiTyWSTaKw

Static Thrust Test (Pusher Test Bed):

https://youtu.be/pcXGhXoKhb8