FROM A VERTICAL PERSPECTIVE

From before: The drone went from 0 altitude and 0↑ velocity to an altitude of 107ft ↑ in the air and moving upward at 17/ft/sec². Total vertical flight activity is discussed as follows:

12.6 sec of accelerated vertical flying ↑to be flying ↑ at 17 ft/sec, and then continuing flying ↑x 25 more seconds at constant ↑ vertical flying speed of 17 ft/sec

from a vertical distance viewpoint the effect of the flying activity listed will be that the drone will rise up

107 ft + 425 ft = to a final altitude of 532 feet and this will take (12.6 + 25 seconds) = 37.6 seconds.

Fuel use to get the drone from 0 altitude to 532 ft altitude will be
(0.217 lbs fuel/sec)x(12.6 sec) = 2.73 lbs of fuel plus (0.18 lbs fuel/sec)x(25 sec) = 4.5 lbs of fuel

Thus the drone with 1000lbs of payload and 600lbs of fuel will take off from the ground and go straight up for 37.6 seconds, burning 7.23 lbs of fuel and it will then be 532 feet up in the air.

FROM A HORIZONTAL VIEWPOINT

After the drone first moved vertically upward to an altitude of 532 feet, it then began to give itself horizontal velocity (airspeed).

From a horizontal distance traveled viewpoint
the drone traveled horizontally (327ft + 182 ft + 197 Feet) = 706 feet horizontally

Time for the drone to change from a horizontal airspeed 0f 0 to a horizontal airspeed of 60 mph was:
(14.9 sec + 3.54 sec + 2.69 sec) = 21.13 seconds.

FROM A FUEL USE VIEWPOINT

The drone was on full normal jet engine power for all of this. This is 2 jets at 850.36 HP each, total 1701 HP

(1701 HP x 0.46 lbs fuel/HP-Hr)/3600 sec/hr = 0.21 lbs fuel per second

Total vertical flying time was 37.6 sec, thus

Fuel use to get the drone from 0 altitude to 532 ft altitude will be
(0.217 lbs fuel/sec)x(12.6 sec) = 2.73 lbs of fuel plus (0.18 lbs fuel/sec)x(25 sec) = 4.5 lbs of fuel

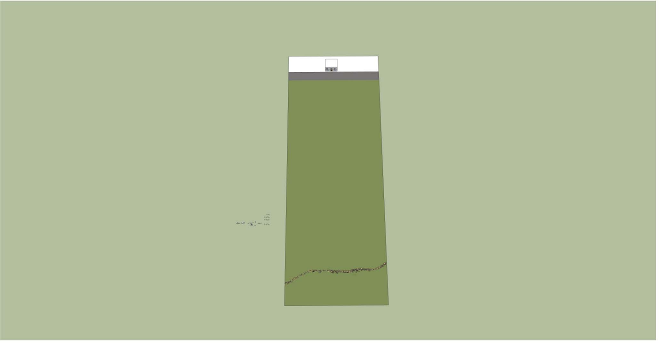
Total horizontal flying time was 21.13 seconds, thus

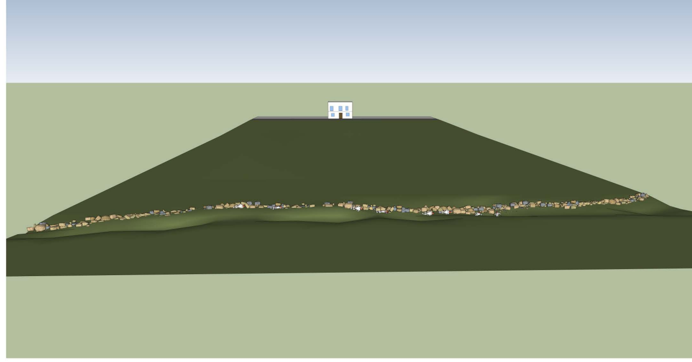
21.13 seconds x 0.21 lbs of fuel per second = 4.44 lbs of fuel

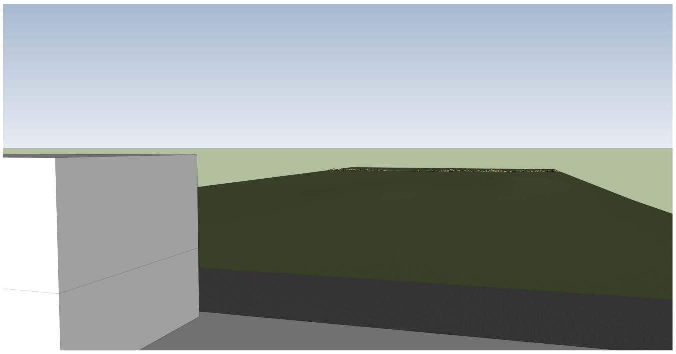
This means the deHavilland DHC-2 weighing: 3000 lbs + 1100 lbs VTOL parts + 600lbs fuel payload + 1000lbs non-fuel payload was sitting on the ground at 0 altitude and 0 horizontal airspeed, and then the drone changed its status to being (523 ft - 85.6 ft) = 437.4 feet altitude, and flying with a horizontal airspeed of 60 mph. Of note, the stall speed of the drone is 60 mph, so this means it is now in stable horizontal flight and does not need any vertical thrust to stay up in the air.

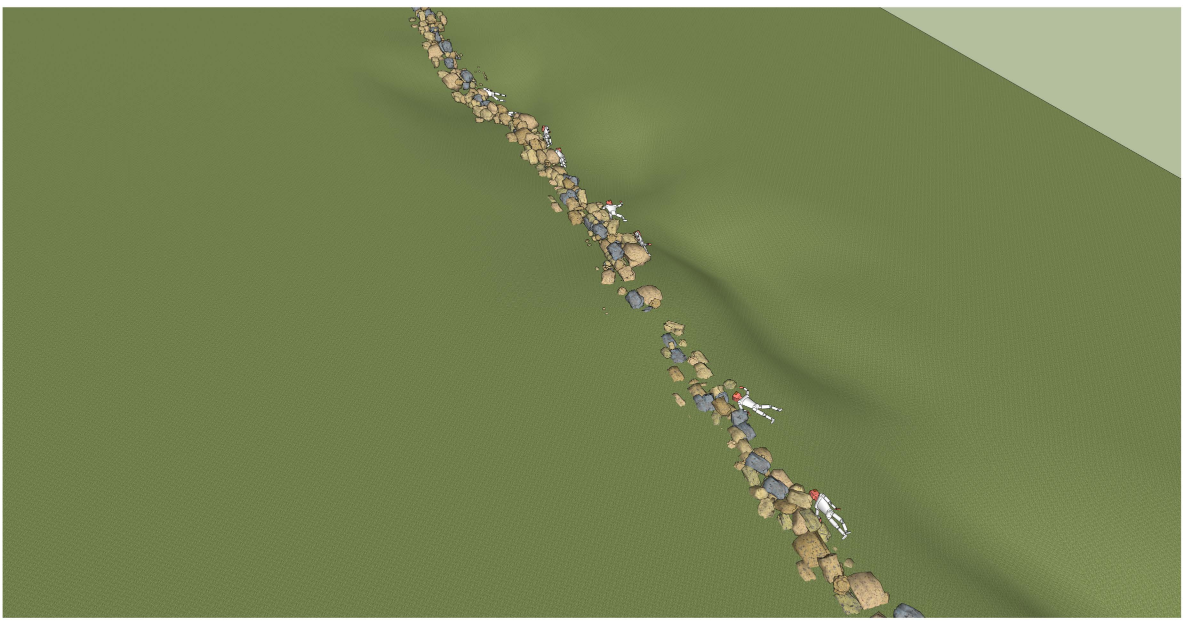
This transition of the flight status of the drone took (37.6 + 21.13) = 58.73 seconds and used up (4.5 + 4.44) = 8.94 lbs of fuel.

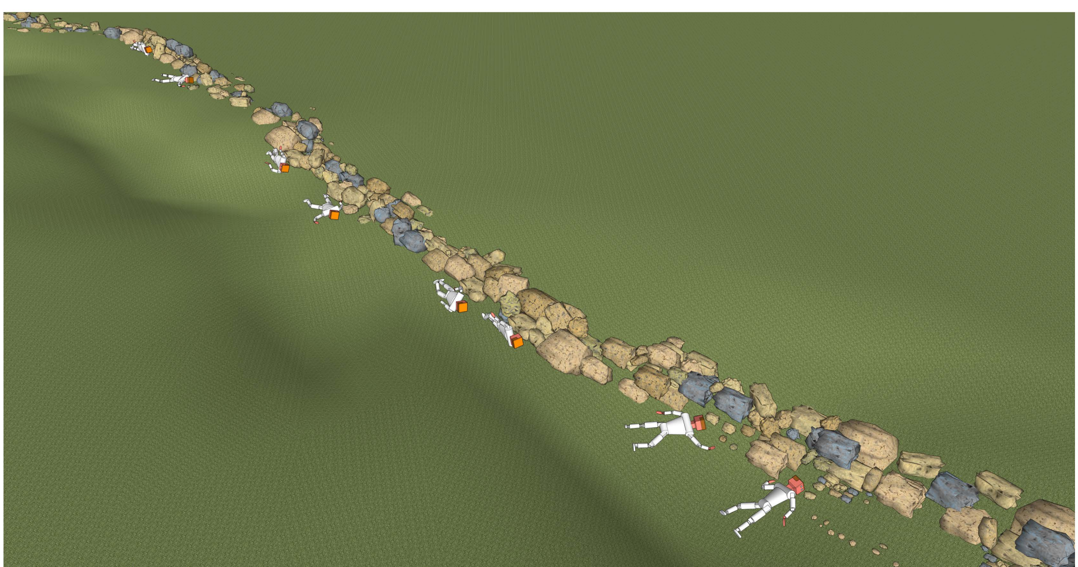

DISCLAIMER
1) Any physically real object has the potential to act in a manner that is dangerous.
2) Actions of any real object, at a minimum, should be reasonable, and also safe, and also legally allowed.
3) We advise, DO NOT MAKE any physically real object if you cannot properly control its actions.









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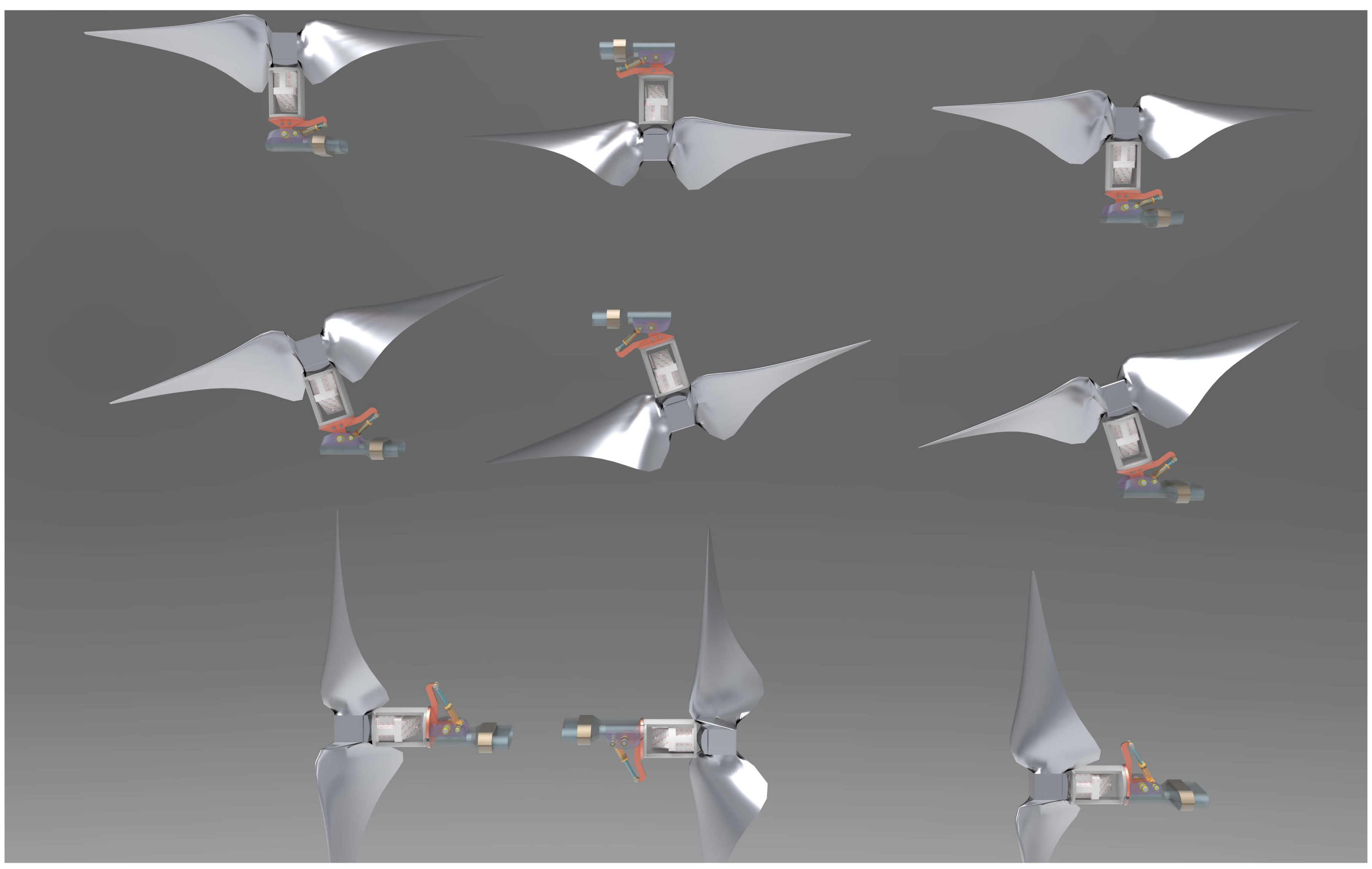
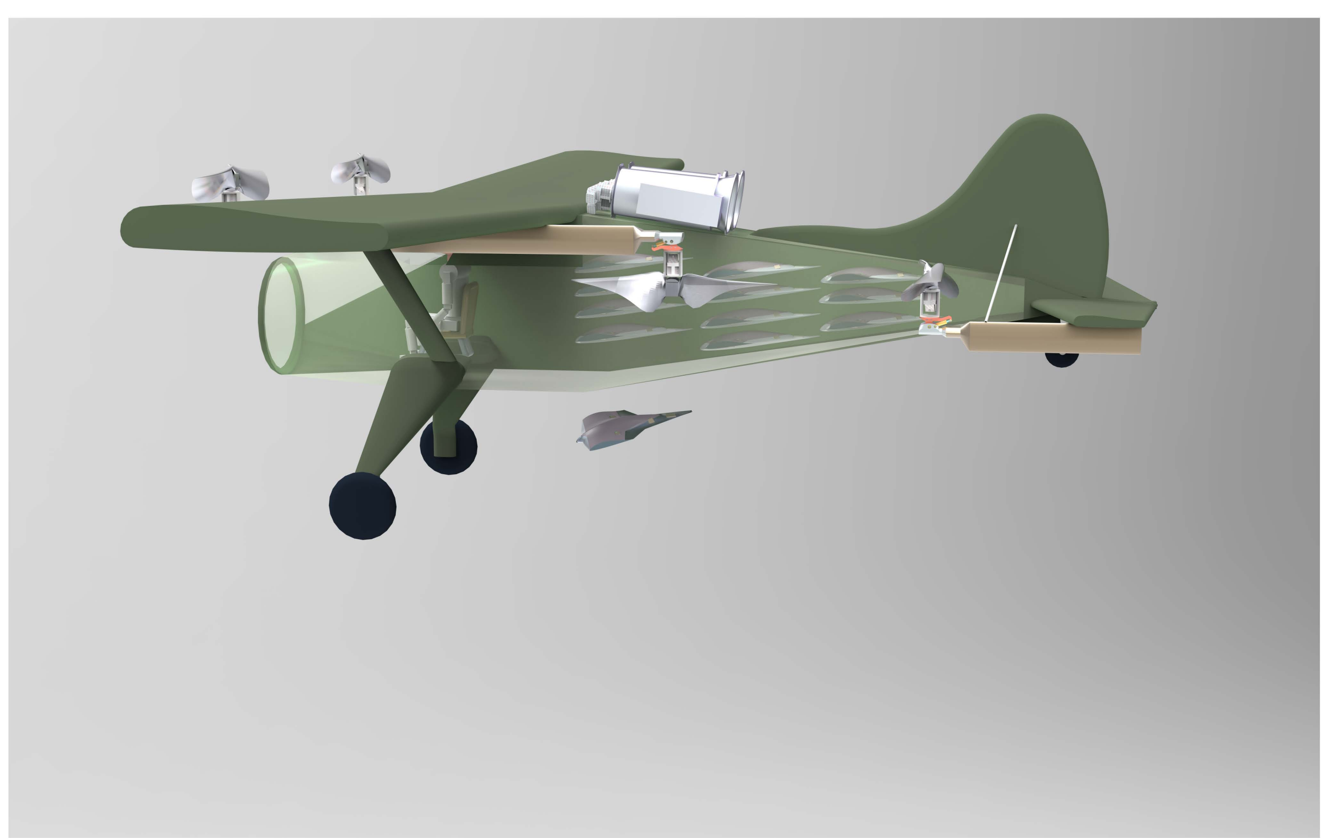
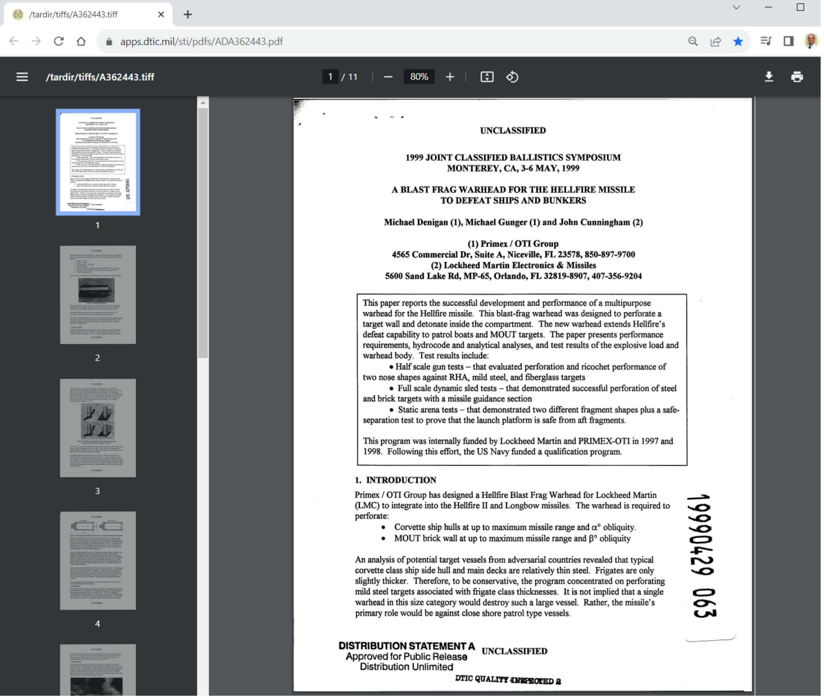
UNITED STATES ARMY







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1999 JOINT CLASSIFIED BALLISTICS SYMPOSIUM
MONTEREY, CA, 3-6 MAY, 1999

A BLAST FRAG WARHEAD FOR THE HELLFIRE MISSILE
TO DEFEAT SHIPS AND BUNKERS

Michael Denigan (1), Michael Gunger (1) and John Cunningham (2)

(1) Primex / OTI Group
4565 Commercial Dr, Suite A, Niceville, FL 23578, 850-897-9700
(2) Lockheed Martin Electronics & Missiles
5600 Sand Lake Rd, MP-65, Orlando, FL 32819-8907, 407-356-9204

This paper reports the successful development and performance of a multipurpose warhead for the Hellfire missile. This blast-frag warhead was designed to perforate a target wall and detonate inside the compartment. The new warhead extends Hellfire's defeat capability to patrol boats and MOUT targets. The paper presents performance requirements, hydrocode and analytical analyses, and test results of the explosive load and warhead body. Test results include:
- Half scale gun tests – that evaluated perforation and ricochet performance of two nose shapes against RHA, mild steel, and fiberglass targets
- Full scale dynamic sled tests – that demonstrated successful perforation of steel and brick targets with a missile guidance section
- Static arena tests – that demonstrated two different fragment shapes plus a safe-separation test to prove that the launch platform is safe from aft fragments.

This program was internally funded by Lockheed Martin and PRIMEX-OTI in 1997 and 1998. Following this effort, the US Navy funded a qualification program.

1. INTRODUCTION

Primex / OTI Group has designed a Hellfire Blast Frag Warhead for Lockheed Martin (LMC) to integrate into the Hellfire II and Longbow missiles. The warhead is required to perforate:
- Corvette ship hulls at up to maximum missile range and α° obliquity.
- MOUT brick wall at up to maximum missile range and β° obliquity

An analysis of potential target vessels from adversarial countries revealed that typical corvette class ship side hull and main decks are relatively thin steel. Frigates are only slightly thicker. Therefore, to be conservative, the program concentrated on perforating mild steel targets associated with frigate class thicknesses. It is not implied that a single warhead in this size category would destroy such a large vessel. Rather, the missile's primary role would be against close shore patrol type vessels.

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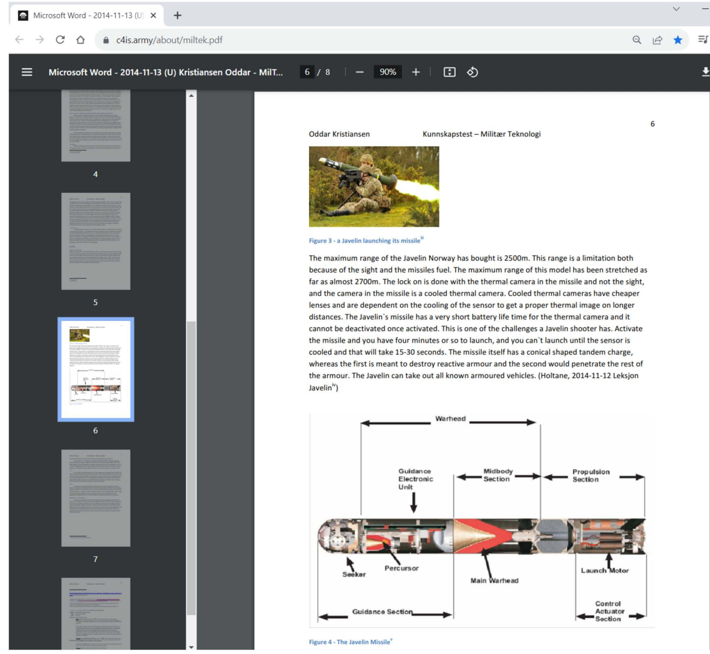
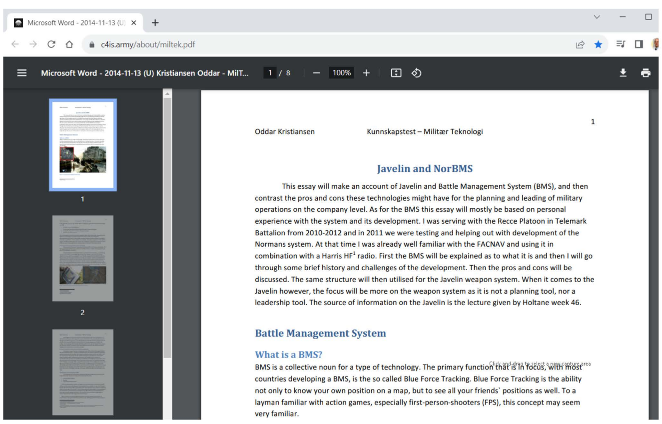


Oddar Kristiansen Kunnskapstest – Militær Teknologi 6

Figure 3 - a Javelin launching its missile[iii]

The maximum range of the Javelin Norway has bought is 2500m. This range is a limitation both because of the sight and the missiles fuel. The maximum range of this model has been stretched as far as almost 2700m. The lock on is done with the thermal camera in the missile and not the sight, and the camera in the missile is a cooled thermal camera. Cooled thermal cameras have cheaper lenses and are dependent on the cooling of the sensor to get a proper thermal image on longer distances. The Javelin`s missile has a very short battery life time for the thermal camera and it cannot be deactivated once activated. This is one of the challenges a Javelin shooter has. Activate the missile and you have four minutes or so to launch, and you can`t launch until the sensor is cooled and that will take 15-30 seconds. The missile itself has a conical shaped tandem charge, whereas the first is meant to destroy reactive armour and the second would penetrate the rest of the armour. The Javelin can take out all known armoured vehicles. (Holtane, 2014-11-12 Leksjon Javelin[iv])

Figure 4 - The Javelin Missile[v]



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Javelin and NorBMS

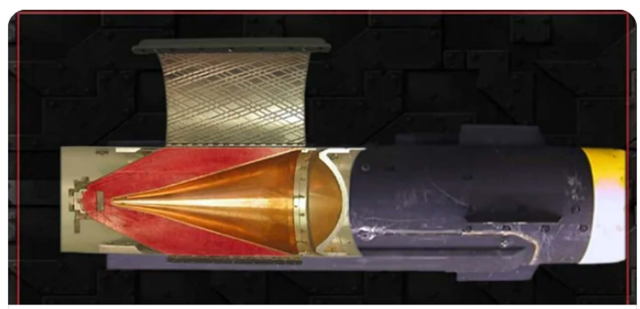
This essay will make an account of Javelin and Battle Management System (BMS), and then contrast the pros and cons these technologies might have for the planning and leading of military operations on the company level. As for the BMS this essay will mostly be based on personal experience with the system and its development. I was serving with the Recce Platoon in Telemark Battalion from 2010-2012 and in 2011 we were testing and helping out with development of the Normans system. At that time I was already well familiar with the FACNAV and using it in combination with a Harris HF[1] radio. First the BMS will be explained as to what it is and then I will go through some brief history and challenges of the development. Then the pros and cons will be discussed. The same structure will then utilised for the Javelin weapon system. When it comes to the Javelin however, the focus will be more on the weapon system as it is not a planning tool, nor a leadership tool. The source of information on the Javelin is the lecture given by Holtane week 46.

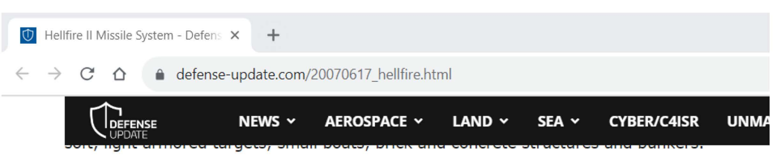
Battle Management System

What is a BMS?

BMS is a collective noun for a type of technology. The primary function that is in focus, with most countries developing a BMS, is the so called Blue Force Tracking. Blue Force Tracking is the ability not only to know your own position on a map, but to see all your friends` positions as well. To a layman familiar with action games, especially first-person-shooters (FPS), this concept may seem very familiar.

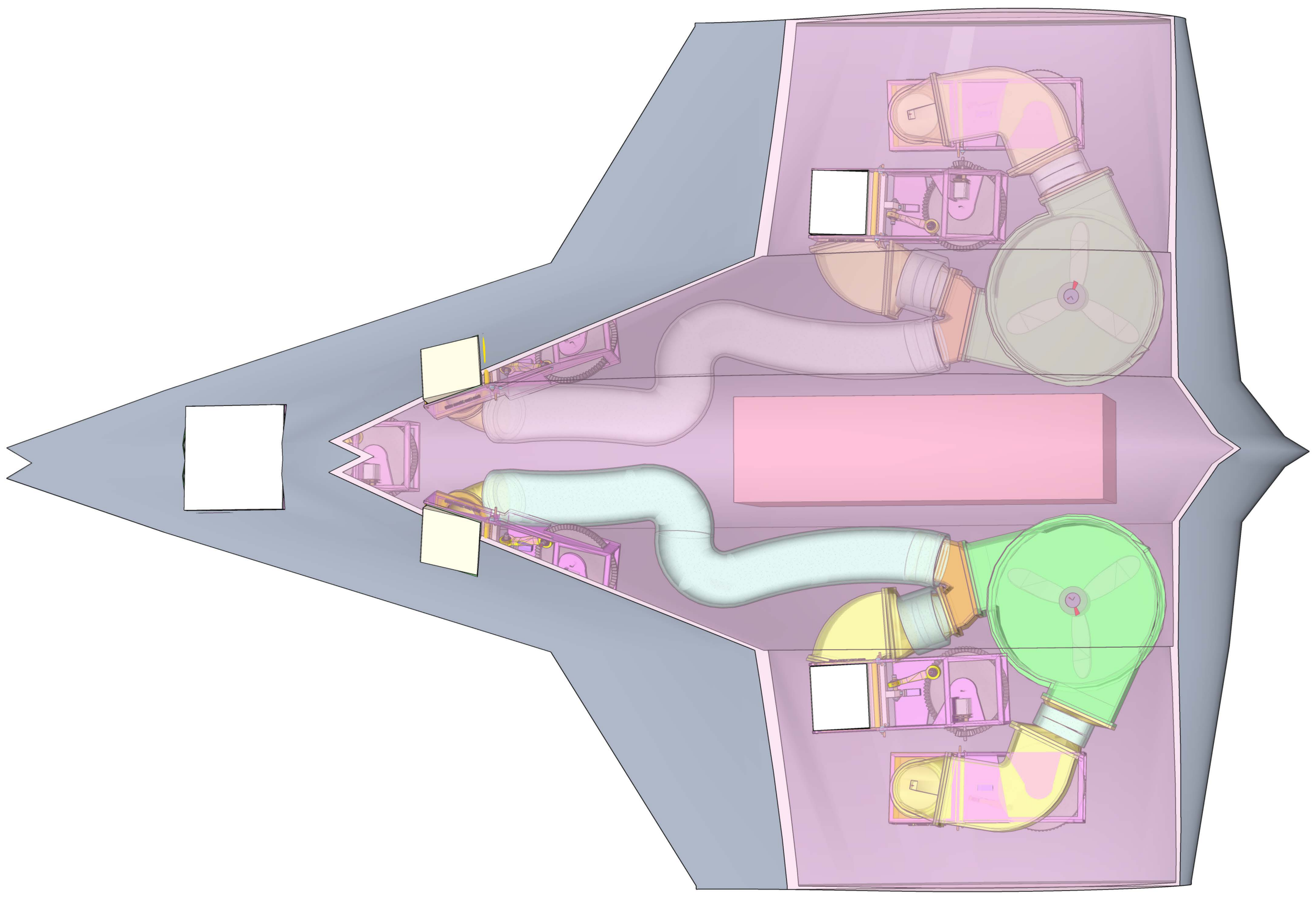
Warhead of an AGM-114K Hellfire Missile, HEAT encased in fragmentation sleeve. [808x379]

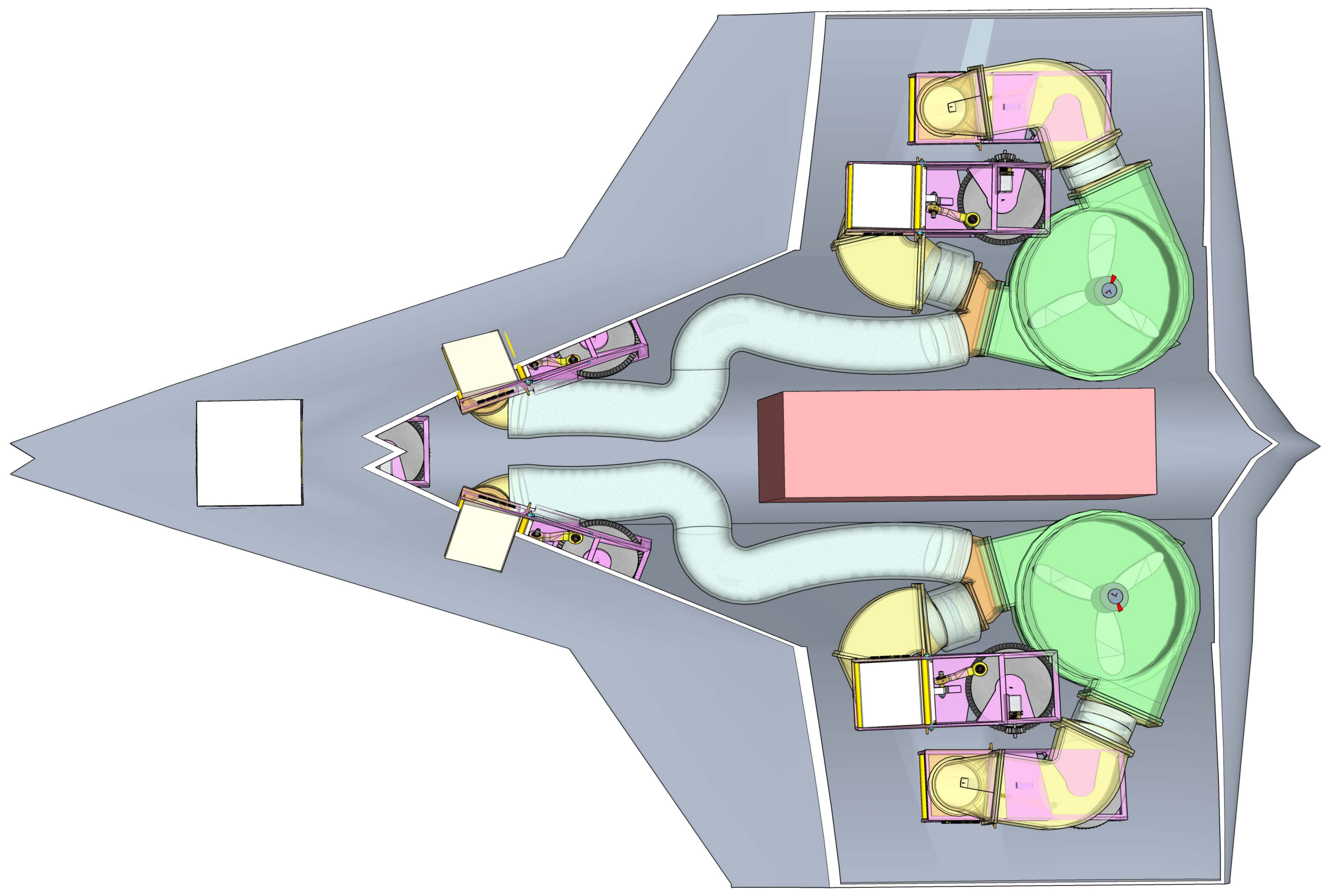


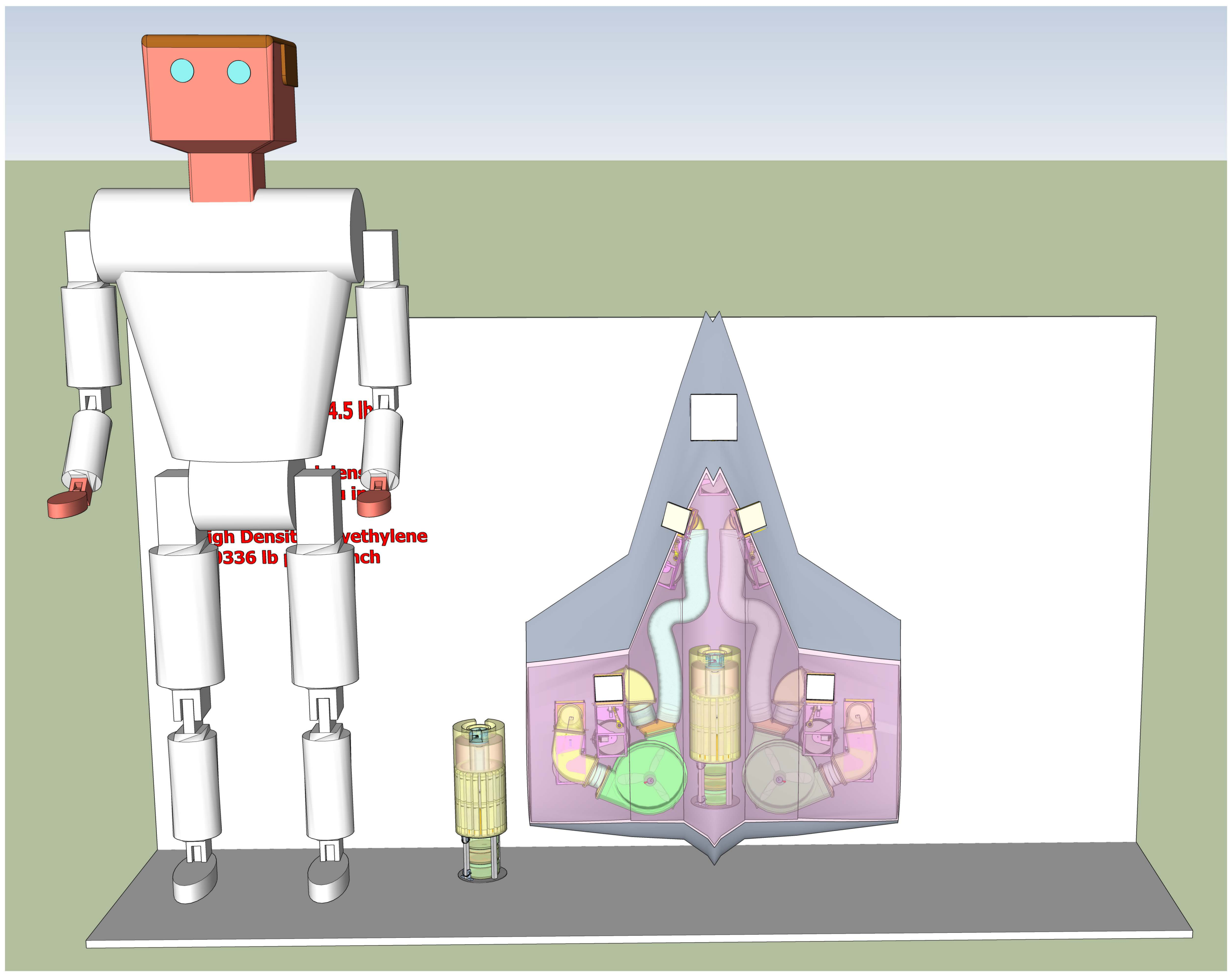


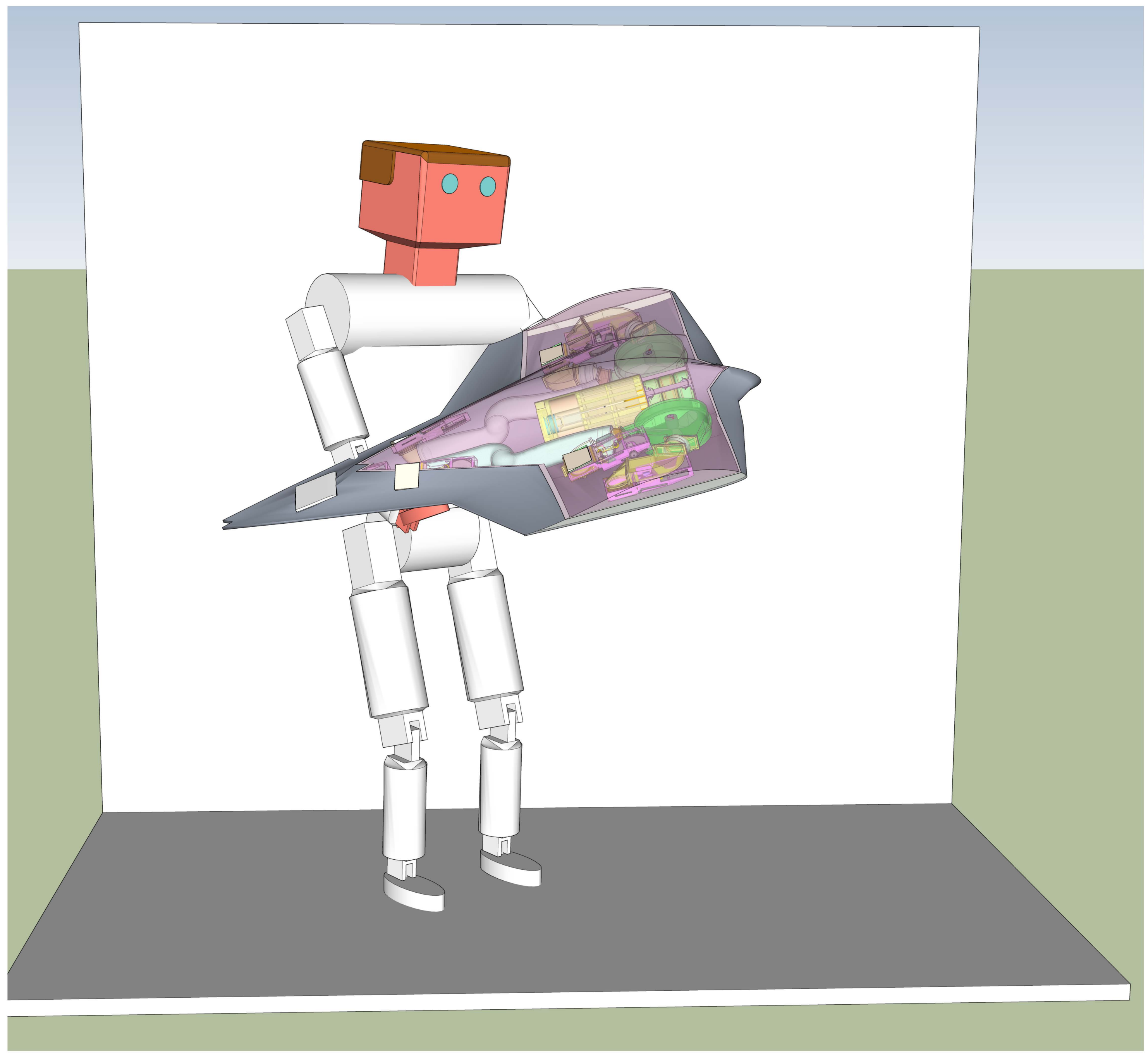
Modified HEAT Warhead

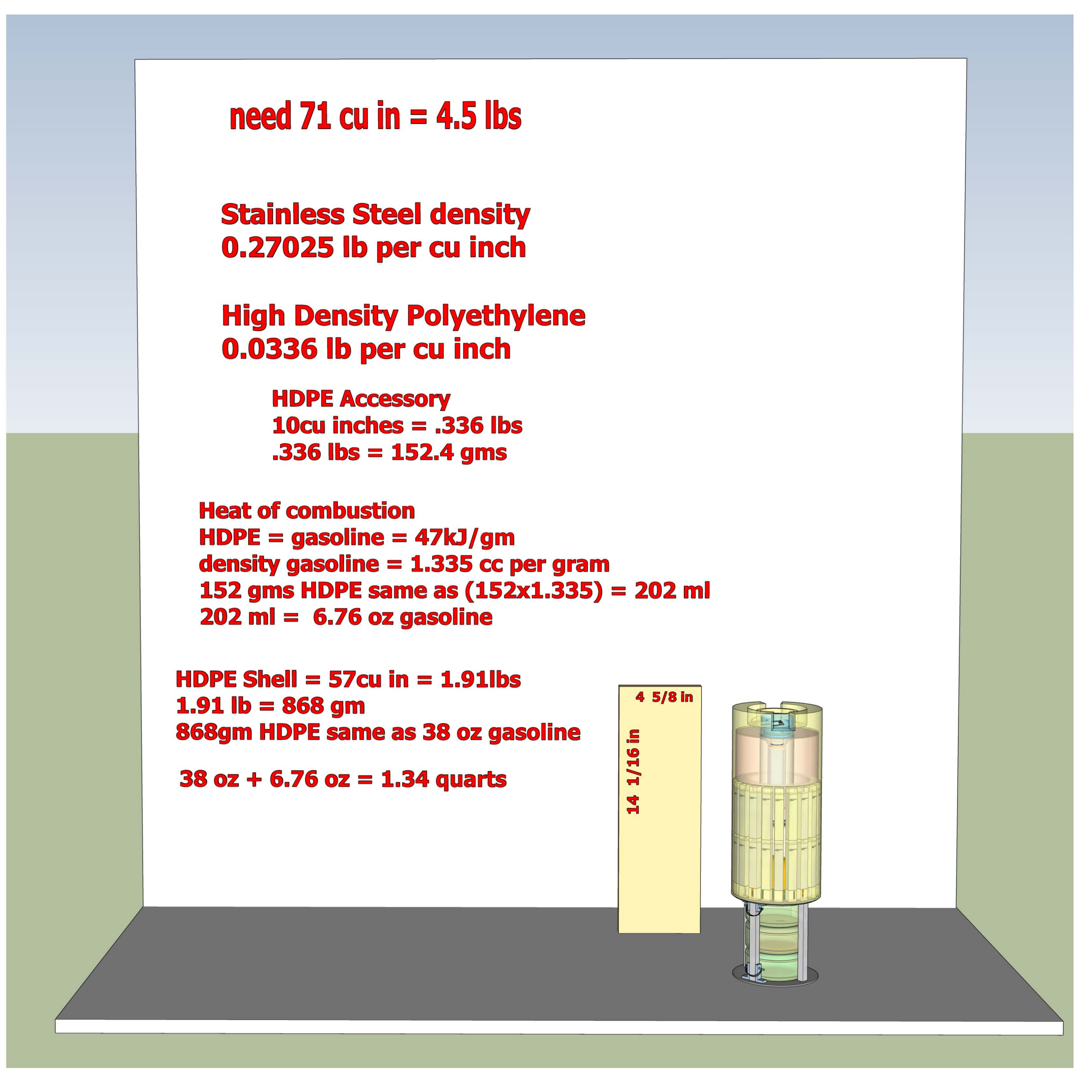
The Hellfire AGM-114K anti-tank version has been modified to improve its fragmentation capability, when engaging soft targets. The Mod-K modification, pursued by Dynetics for the Aviation & Missiles R&D and Evaluation Center, included the installation of a fragmentation sleeve placed around the shaped charge, optimizing fragment lethality against a broad target set, while minimizing degradation of shaped charge performance.



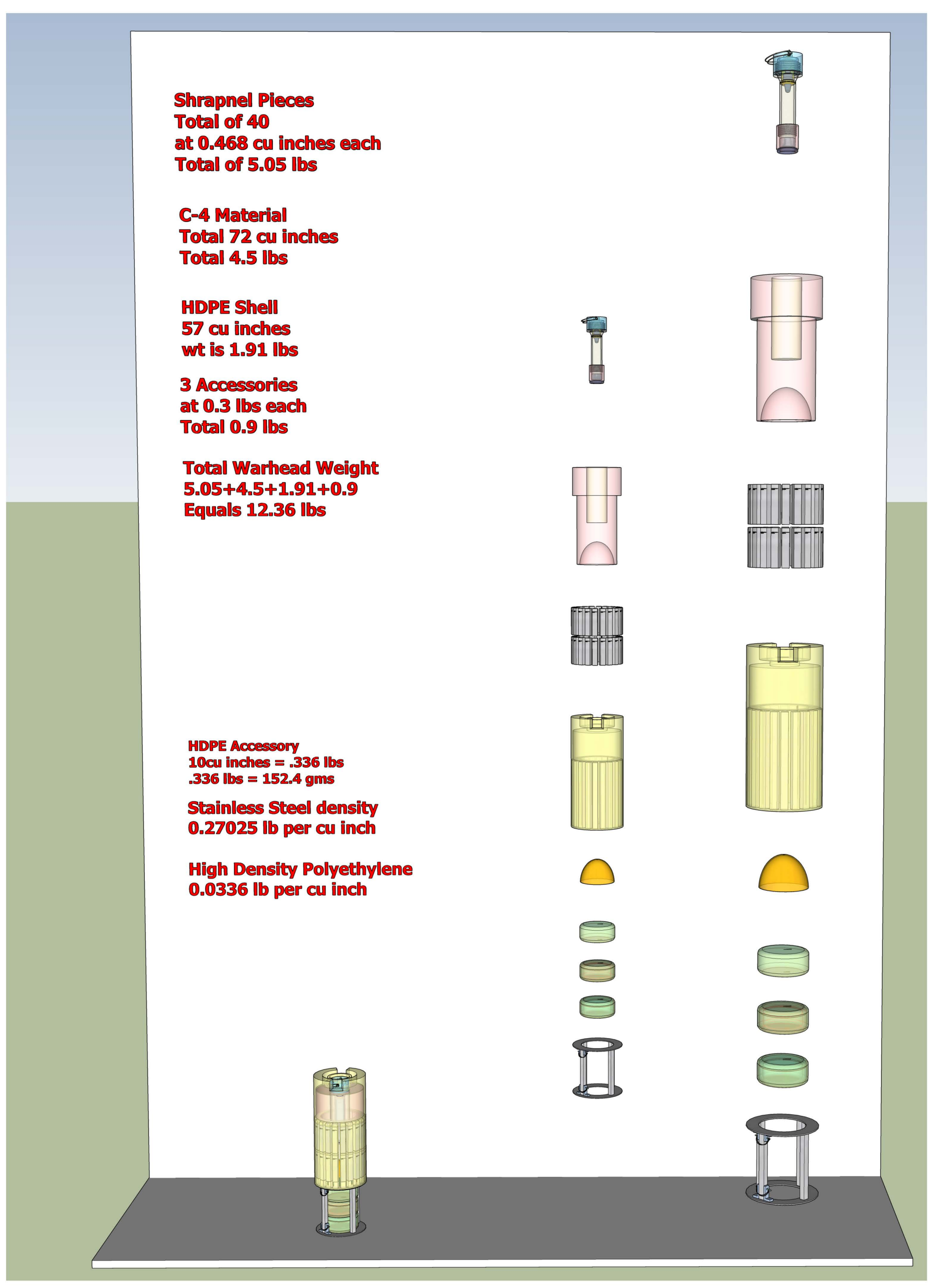




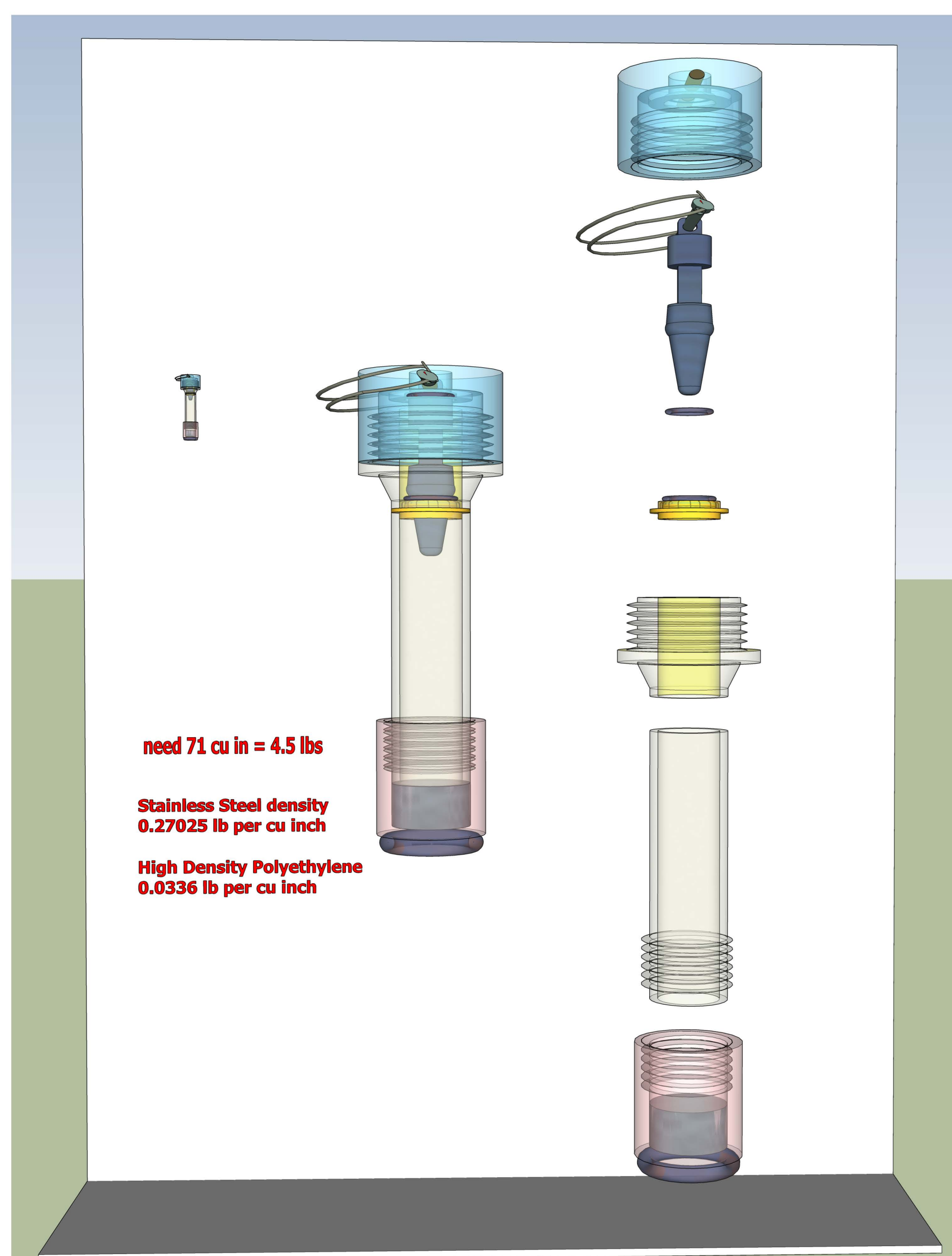




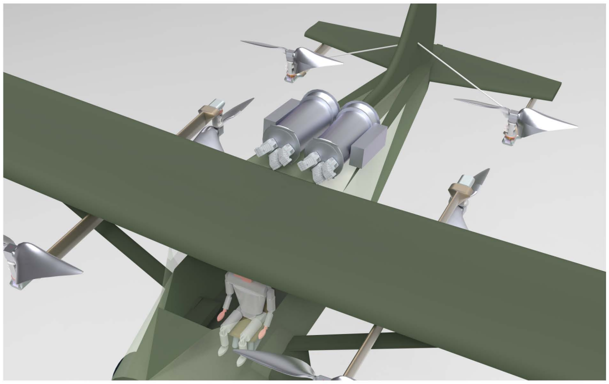
need 71 cu in = 4.5 lbs
Stainless Steel density
0.27025 lb per cu inch
High Density Polyethylene
0.0336 lb per cu inch
HDPE Accessory
10cu inches = .336 lbs
.336 lbs = 152.4 gms
Heat of combustion
HDPE = gasoline = 47kJ/gm
density gasoline = 1.335 cc per gram
152 gms HDPE same as (152x1.335) = 202 ml
202 ml = 6.76 oz gasoline
HDPE Shell = 57cu in = 1.91lbs
1.91 lb = 868 gm
868gm HDPE same as 38 oz gasoline
38 oz + 6.76 oz = 1.34 quarts
4 5/8 in
14 1/16 in

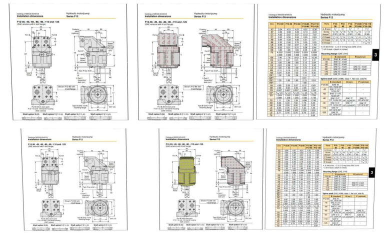


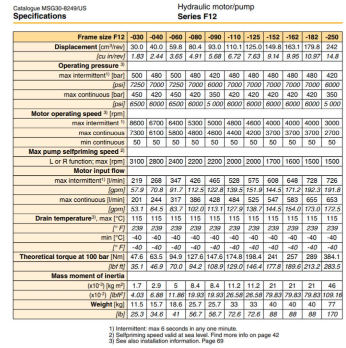
Shrapnel Pieces
Total of 40
at 0.468 cu inches each
Total of 5.05 lbs
C-4 Material
Total 72 cu inches
Total 4.5 lbs
HDPE Shell
57 cu inches
wt is 1.91 lbs
3 Accessories
at 0.3 lbs each
Total 0.9 lbs
Total Warhead Weight
5.05+4.5+1.91+0.9
Equals 12.36 lbs
HDPE Accessory
10cu inches = .336 lbs
.336 lbs = 152.4 gms
Stainless Steel density
0.27025 lb per cu inch
High Density Polyethylene
0.0336 lb per cu inch



need 71 cu in = 4.5 lbs
Stainless Steel density
0.27025 lb per cu inch
High Density Polyethylene
0.0336 lb per cu inch





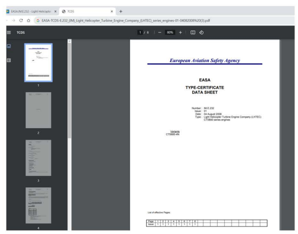


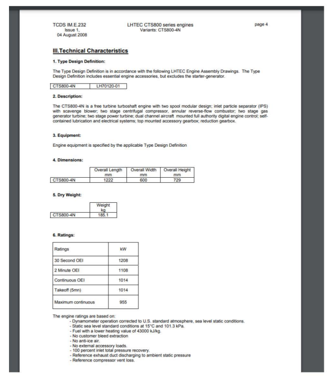
Catalogue MSG30-8249/US
Specifications

Hydraulic motor/pump
Series F12

Frame size F12	**-030**	**-040**	**-060**	**-080**	**-090**	**-110**	**-125**	**-152**	**-162**	**-182**	**-250**
Displacement [cm³/rev]	30.0	40.0	59.8	80.4	93.0	110.1	125.0	149.8	163.1	179.8	242
[cu in/rev]	*1.83*	*2.44*	*3.65*	*4.91*	*5.68*	*6.72*	*7.63*	*9.14*	*9.95*	*10.97*	*14.8*
Operating pressure 3)											
max intermittent 1) [bar]	500	480	500	480	420	480	480	480	480	480	420
[psi]	*7250*	*7000*	*7250*	*7000*	*6000*	*7000*	*7000*	*7000*	*7000*	*7000*	*6000*
max continuous [bar]	450	420	450	420	350	420	420	420	420	420	350
[psi]	*6500*	*6000*	*6500*	*6000*	*5 000*	*6000*	*6000*	*6000*	*6000*	*6000*	*5 000*
Motor operating speed 3) [rpm]											
max intermittent 1)	8600	6700	6400	5300	5000	4800	4600	4000	4000	4000	3000
max continuous	7300	6100	5800	4800	4600	4400	4200	3700	3700	3700	2700
min continuous	50	50	50	50	50	50	50	50	50	50	50
Max pump selfpriming speed 2)											
L or R function; max [rpm]	3100	2800	2400	2200	2200	2000	2000	1700	1600	1500	1500
Motor input flow											
max intermittent 1) [l/min]	219	268	347	426	465	528	575	608	648	728	726
[gpm]	*57.9*	*70.8*	*91.7*	*112.5*	*122.8*	*139.5*	*151.9*	*144.5*	*171.2*	*192.3*	*191.8*
max continuous [l/min]	201	244	317	386	428	484	525	547	583	655	653
[gpm]	*53.1*	*64.5*	*83.7*	*102.0*	*113.1*	*127.9*	*138.7*	*144.5*	*154.0*	*173.0*	*172.5*
Drain temperature 3), max [°C]	115	115	115	115	115	115	115	115	115	115	115
[° F]	*239*	*239*	*239*	*239*	*239*	*239*	*239*	*239*	*239*	*239*	*239*
min [°C]	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
[° F]	*-40*	*-40*	*-40*	*-40*	*-40*	*-40*	*-40*	*-40*	*-40*	*-40*	*-40*
Theoretical torque at 100 bar [Nm]	47.6	63.5	94.9	127.6	147.6	174.8	198.4	241	257	289	384.1
[lbf ft]	*35.1*	*46.9*	*70.0*	*94.2*	*108.9*	*129.0*	*146.4*	*177.8*	*189.6*	*213.2*	*283.5*
Mass moment of inertia											
($x10^{-3}$) [kg m²]	1.7	2.9	5	8.4	8.4	11.2	11.2	21	21	21	46
($x10^{-2}$) *[lbft²]*	*4.03*	*6.88*	*11.86*	*19.93*	*19.93*	*26.58*	*26.58*	*79.83*	*79.83*	*79.83*	*109.16*
Weight [kg]	11.5	15.7	18.6	25.7	25.7	33	33	40	40	40	77
[lb]	*25.3*	*34.6*	*41*	*56.7*	*56.7*	*72.6*	*72.6*	*88*	*88*	*88*	*170*

1) Intermittent: max 6 seconds in any one minute.
2) Selfpriming speed valid at sea level. Find more info on page 42
3) See also installation information. Page 69





TCDS IM.E.232
Issue 1,
04 August 2008

LHTEC CTS800 series engines
Variants: CTS800-4N

page 4

III.Technical Characteristics

1. Type Design Definition:

The Type Design Definition is in accordance with the following LHTEC Engine Assembly Drawings. The Type Design Definition includes essential engine accessories, but excludes the starter-generator.

CTS800-4N	LH70120-01

2. Description:

The CTS800-4N is a free turbine turboshaft engine with two spool modular design; inlet particle separator (IPS) with scavenge blower; two stage centrifugal compressor, annular reverse-flow combustor; two stage gas generator turbine; two stage power turbine; dual channel aircraft mounted full authority digital engine control; self-contained lubrication and electrical systems; top mounted accessory gearbox; reduction gearbox.

3. Equipment:

Engine equipment is specified by the applicable Type Design Definition

4. Dimensions:

	Overall Length mm	Overall Width mm	Overall Height mm
CTS800-4N	1222	600	729

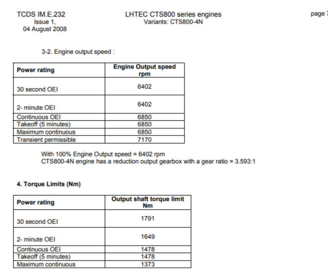
5. Dry Weight:

	Weight kg
CTS800-4N	185.1

6. Ratings:

Ratings	kW
30 Second OEI	1208
2 Minute OEI	1108
Continuous OEI	1014
Takeoff (5mn)	1014
Maximum continuous	955

The engine ratings are based on:
- Dynamometer operation corrected to U.S. standard atmosphere, sea level static conditions.
- Static sea level standard conditions at 15°C and 101.3 kPa.
- Fuel with a lower heating value of 43000 kJ/kg.
- No customer bleed extraction
- No anti-ice air.
- No external accessory loads.
- 100 percent inlet total pressure recovery.
- Reference exhaust duct discharging to ambient static pressure
- Reference compressor vent loss.



TCDS IM.E.232
Issue 1,
04 August 2008

LHTEC CTS800 series engines
Variants: CTS800-4N

page 7

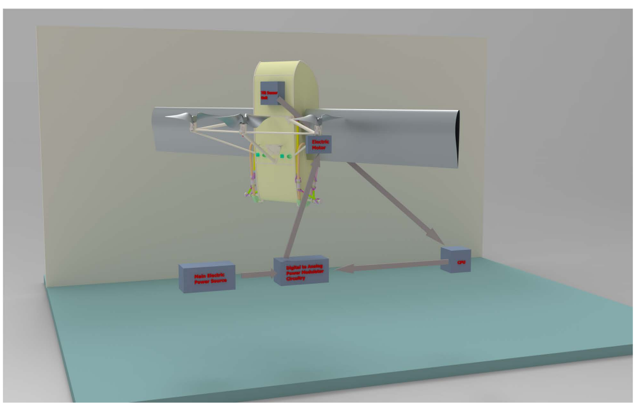
3-2. Engine output speed :

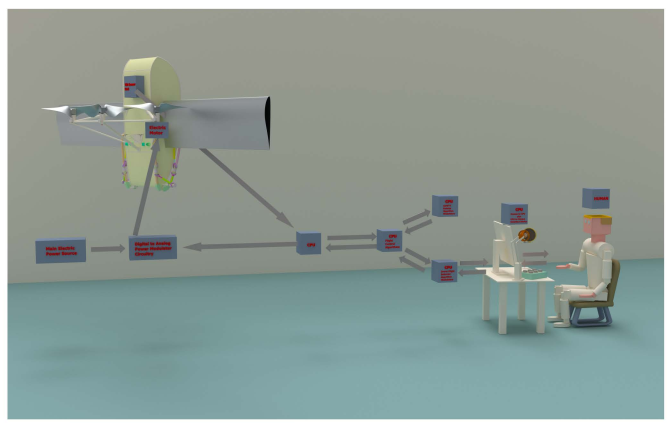
Power rating	Engine Output speed rpm
30 second OEI	6402
2- minute OEI	6402
Continuous OEI	6850
Takeoff (5 minutes)	6850
Maximum continuous	6850
Transient permissible	7170

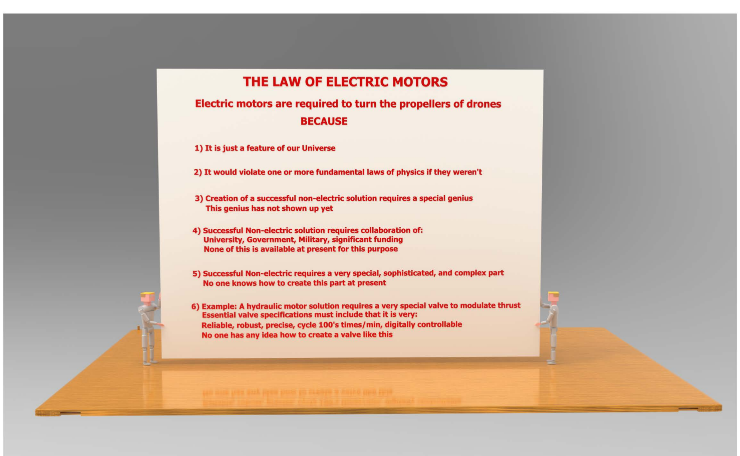
With 100% Engine Output speed = 6402 rpm
CTS800-4N engine has a reduction output gearbox with a gear ratio = 3.593:1

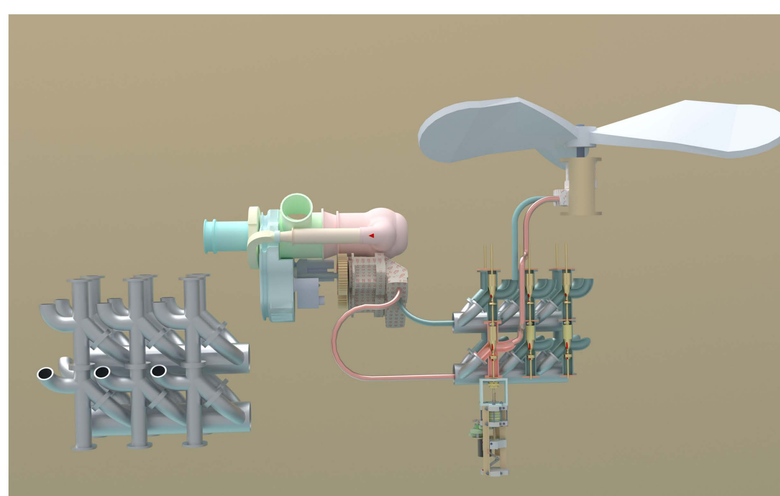
4. Torque Limits (Nm)

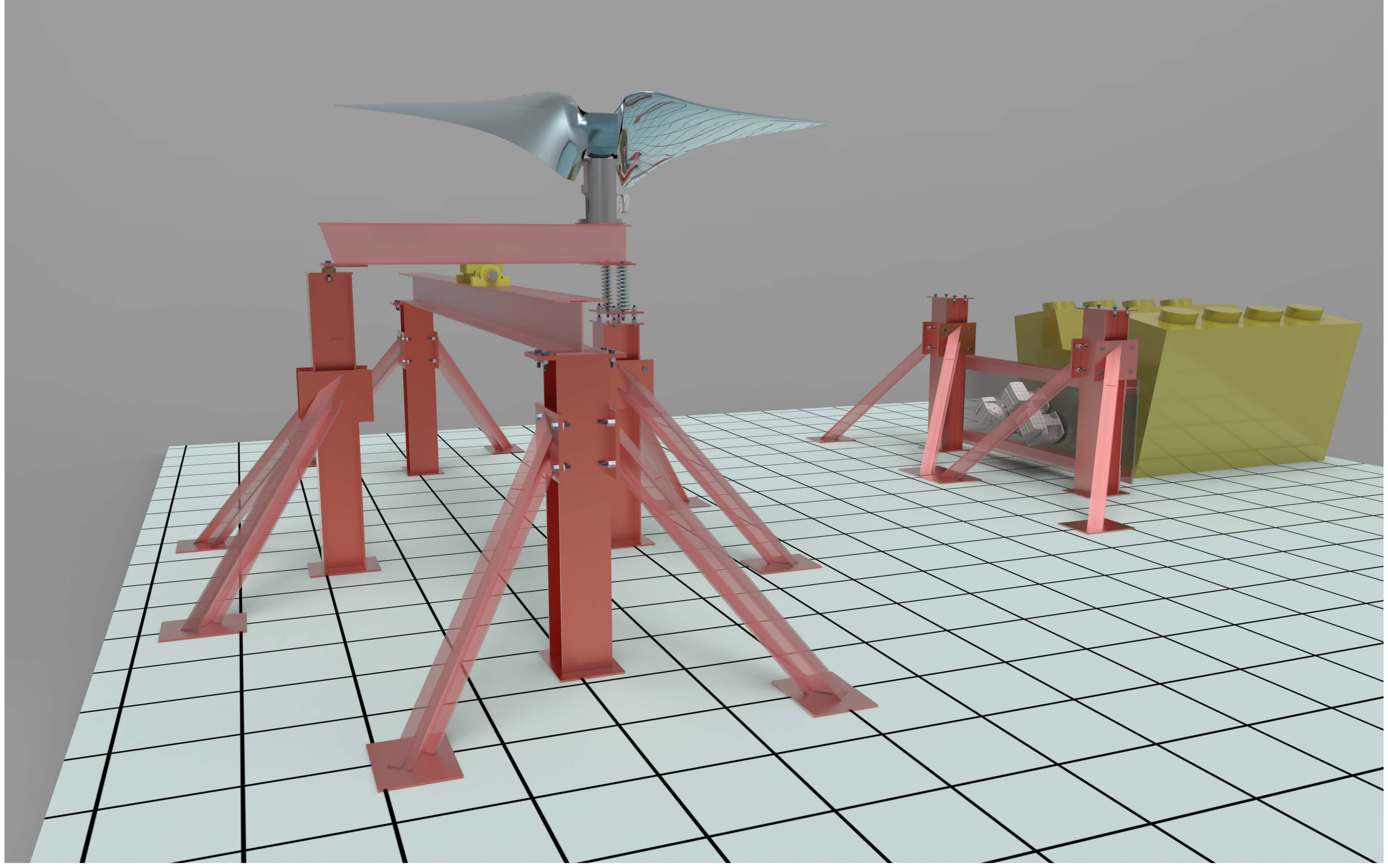
Power rating	Output shaft torque limit Nm
30 second OEI	1791
2- minute OEI	1649
Continuous OEI	1478
Takeoff (5 minutes)	1478
Maximum continuous	1373

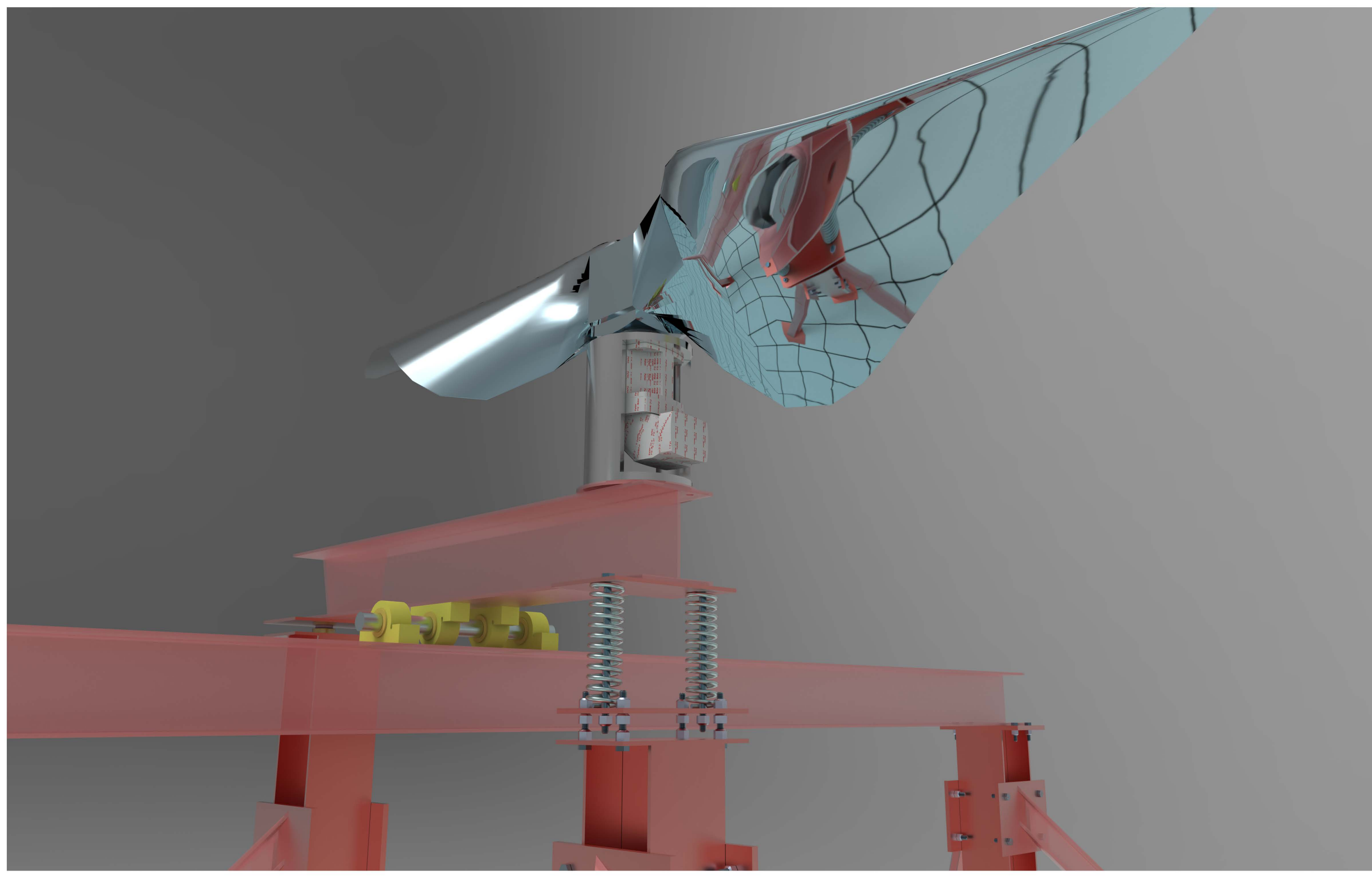


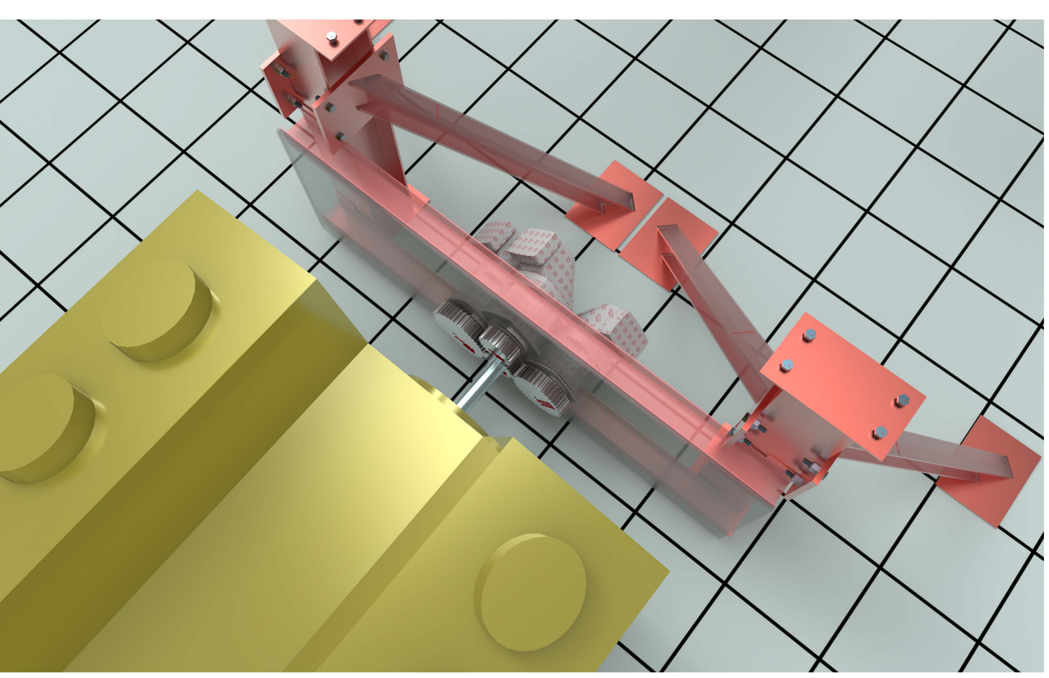


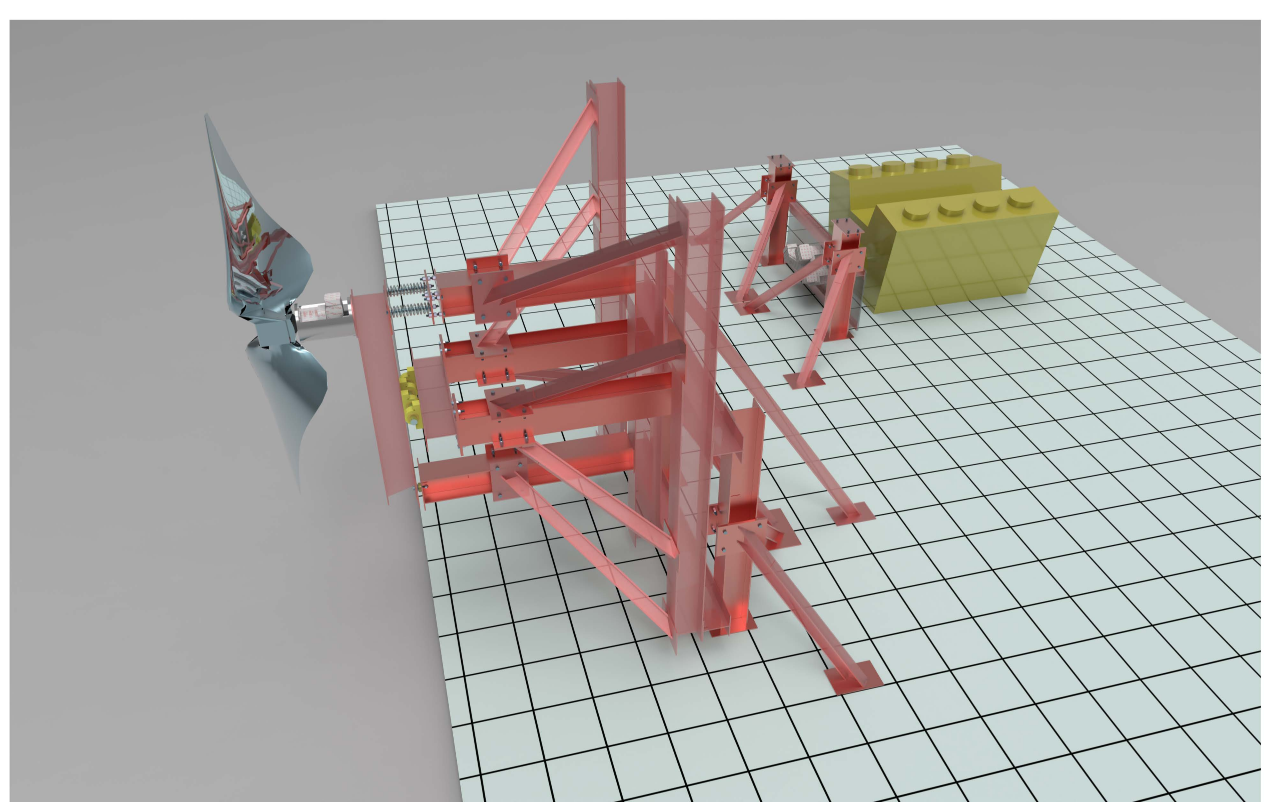


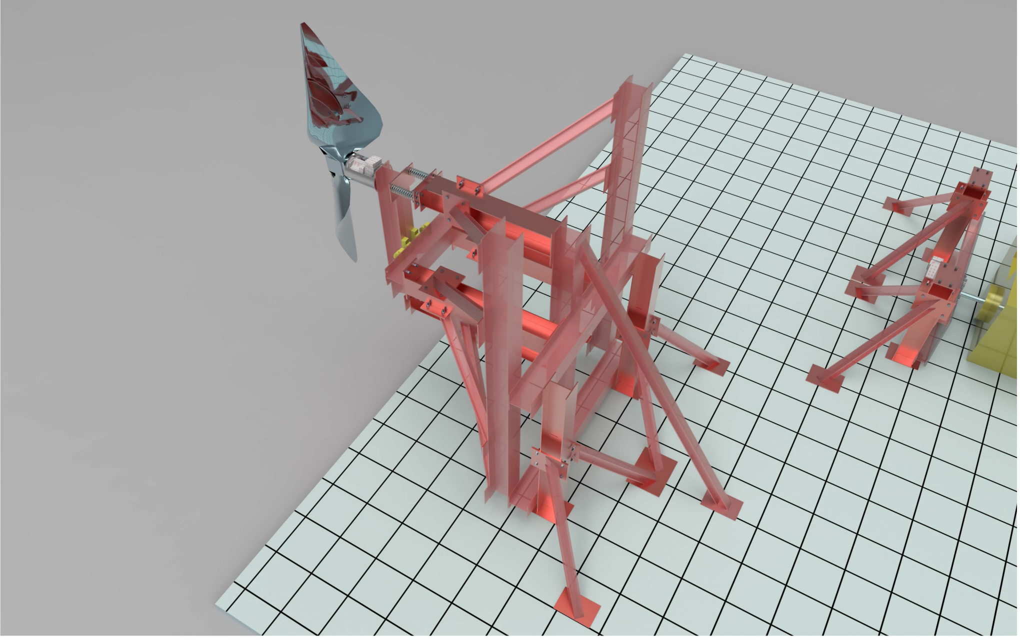


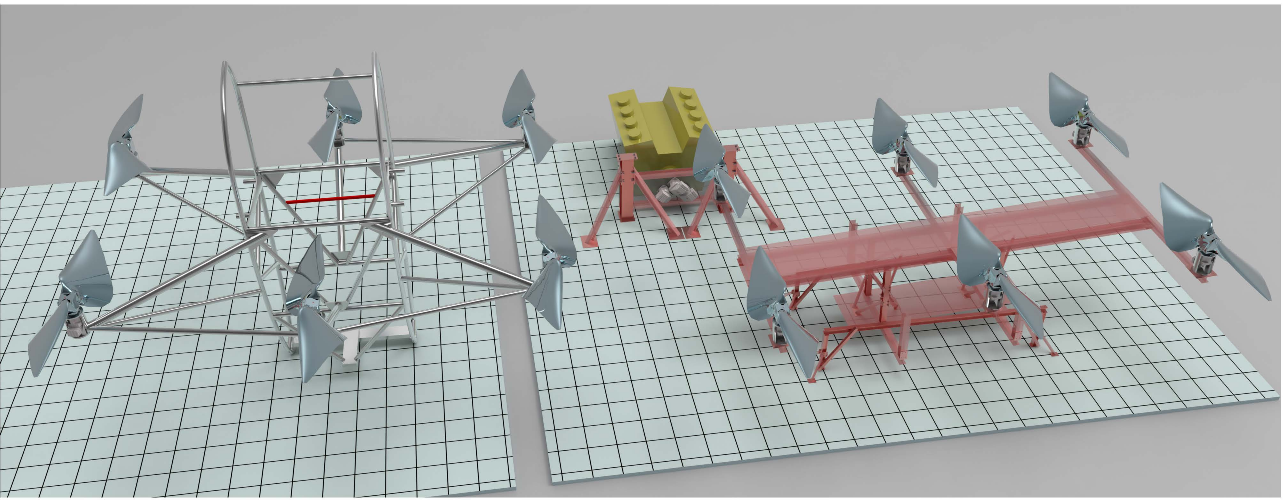


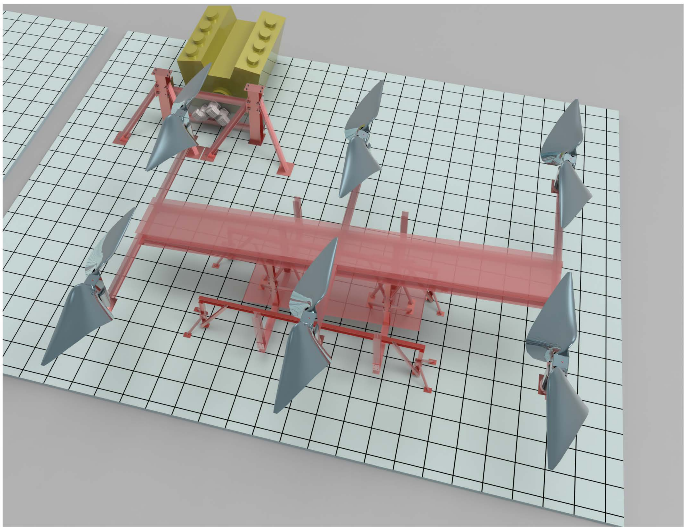


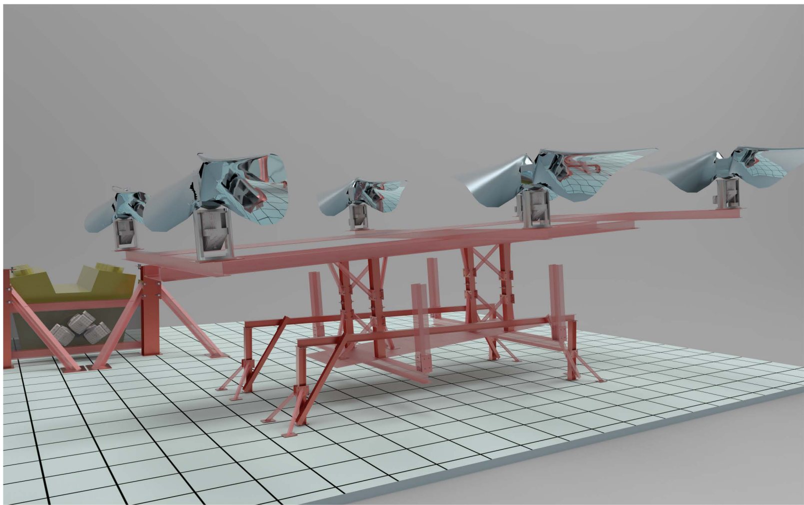


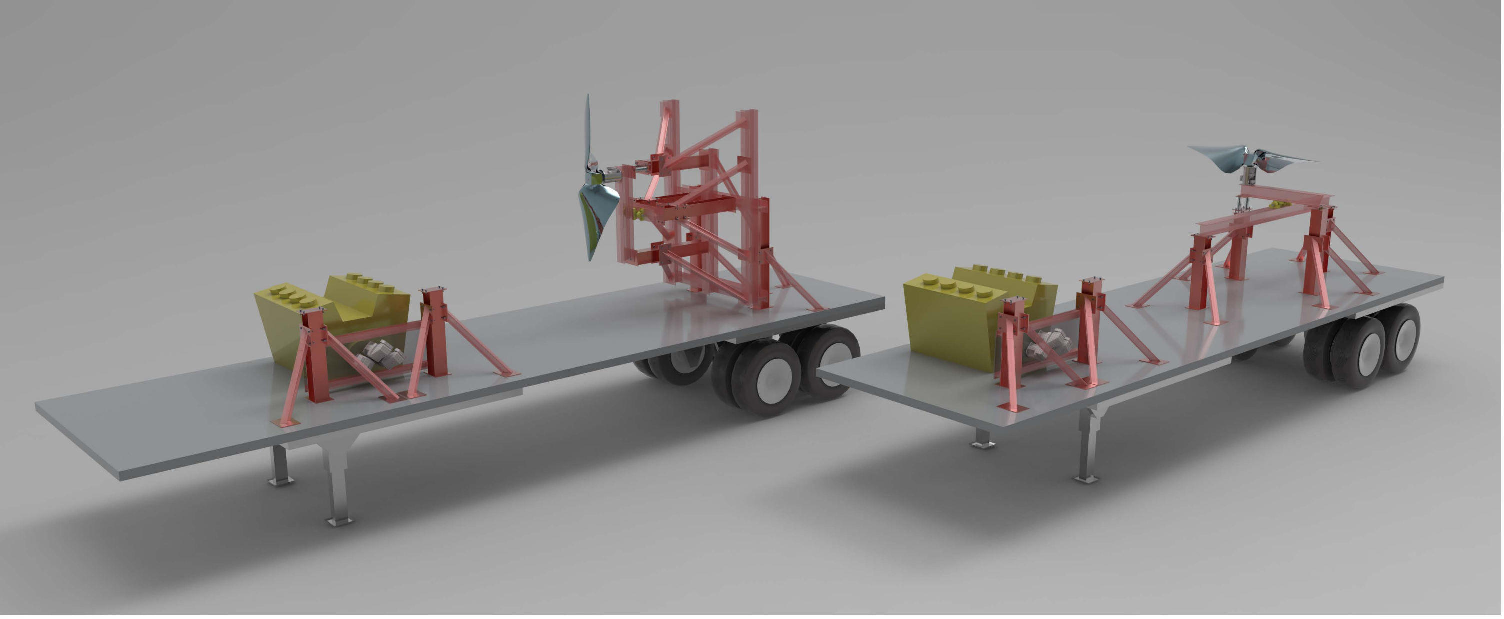


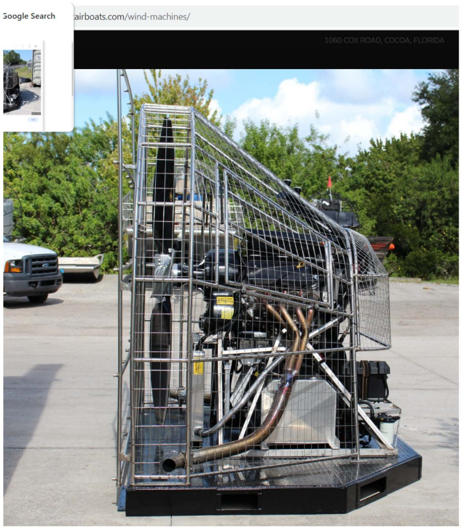


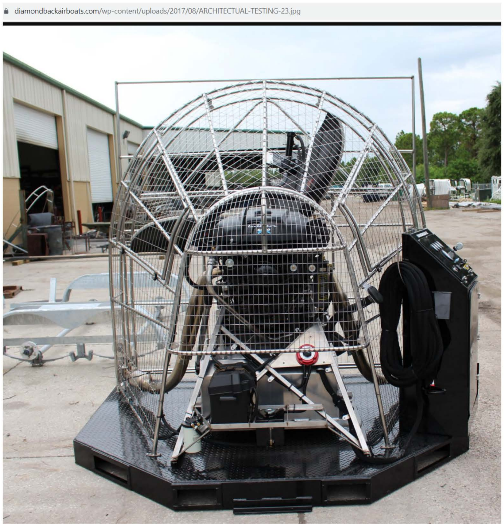









Google Search
airboats.com/wind-machines/
1060 COX ROAD, COCOA, FLORIDA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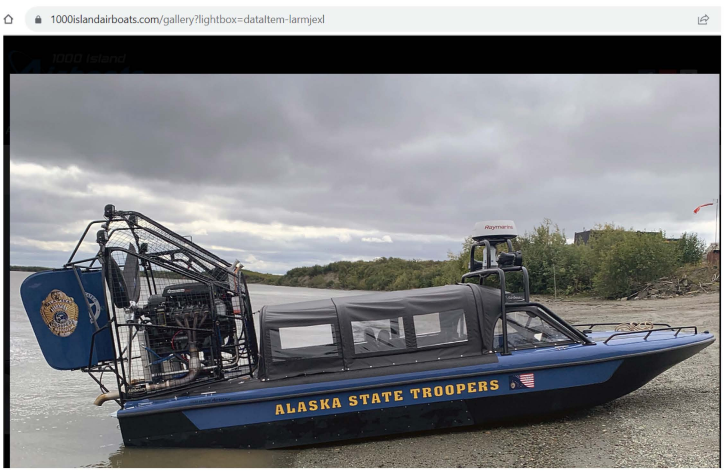
diamondbackairboats.com/wind-machines/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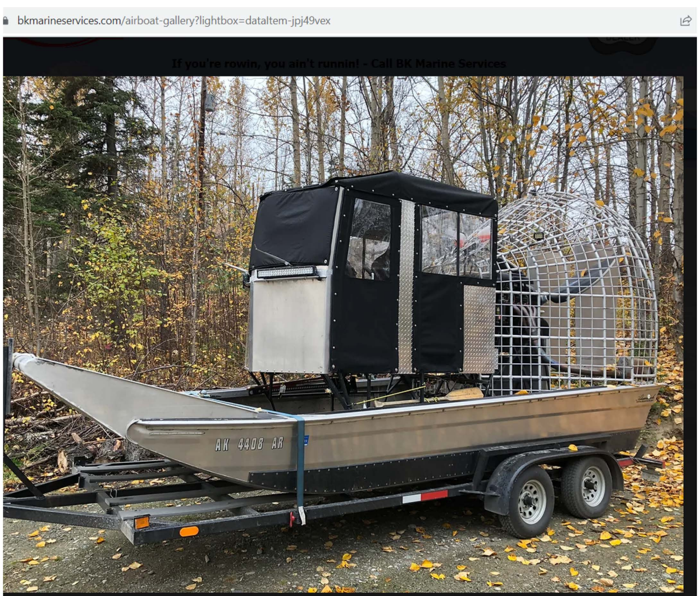
ALASKA STATE TROOPERS


bkmarineservices.com/airboat-gallery?lightbox=dataItem-jpj49vex
If you're rowin, you ain't runnin! - Call BK Marine Services
AW 4408 AR

acascoutperformancedatacomparison.pdf — mcfarlaneaviation.com/media/documents/acascoutperformancedatacomparison.pdf

World's Largest MT-Propeller Distributor

ACA Scout
Performance Specifications
2-blade & 3-blade propellers and O-360 engine.

Take-off Distance at gross weight, 1000'MSL, 55 degrees F.

- Original Hartzell 76" — 447 feet
- MT 2 Blade 83" — 342 feet [105 ' shorter than Hartzell]
- MT 3 Blade 78" — 330 feet [117 ' shorter than Hartzell]

Take-off over 50' obstacle

- Original Hartzell 76" — 701 feet
- MT 2 Blade 83" — 510 feet [191' shorter than Hartzell]
- MT 3 Blade 78" — 483 feet [218' shorter than Hartzell]

Aircraft Rate of Climb 1000' MSL at gross weight and 55F

- Original Hartzell 76" — 998 FPM
- MT 2 Blade 83" — 1201 FPM
- MT 3 Blade 78" — 1285 FPM

Propeller Weights w/spinner

- Original Hartzell 76" — 64 pounds
- MT 2 Blade 83" — 45 pounds
- MT 3-Blade 78" — 54 pounds

Propeller Static Thrust@ 1000msl & 55F

- Original Hartzell 76" — 675 pounds
- MT 2 Blade 83" — 790 pounds
- MT 3 Blade 78" — 810 pounds

RPM Restriction or Reduction

- Original Hartzell — YES
- MT 2 or 3-Blade — NO

Blade Life Limit

- Original Hartzell — YES
- MT 2 or 3-Blade — NO

Blade Water Erosion Protection

- Original Hartzell — NO
- MT 2 or 3-Blad — YES

mt-propeller

To learn more about this prop
866-717-1117
www.Flight-Resource.com

For other products
800-544-8594
www.McFarlaneAviation.com

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cessna185-2-3b-performancetestresults.pdf — mcfarlaneaviation.com/media/documents/cessna185-2-3b-performancetestresults.pdf

Flight-Resource
A Division of McFarlane
World's Largest MT-Propeller Distributor

MT Propeller Performance Test Results
Comparing
83" 2 & 3-Blade 'Expedition' Series Props
Test Plane: Cessna 185F w/ IO-520-D

Propellers Tested:

- MT 83" 2 blade 'Expedition' Series Composite Propeller
- MT 83" 3 blade 'Expedition' Series Composite Propeller
- McCauley D3A3C401 86" 3 blade aluminum propeller
- Hartzell F8468A-6R 82" 3 blade aluminum propeller

Weight:

- MT 2-blade w/spinner — 45 pounds
- MT 3-blade w/spinner — 56 pounds
- McCauley 3-blade w/spinner — 78 pounds
- Hartzell 3-blade w/spinner — 82 pounds

Static Thrust:

- MT 3-blade — 1190 pounds @2700rpm
- MT 2-blade — 1155 pounds @2700 rpm
- McCauley 3-blade — 1110 pounds @2600rpm (1090@2700)
- Hartzell 3-blade — 1055 pounds@2700 rpm

Take-off distance over 50' obstacle:

- MT 3-blade — 1297 feet
- MT 2-blade — 1352 feet
- McCauley 3-blade — 1389 feet
- Hartzell 3-blade — 1425 feet

Climb performance: (Sea level 80F)

- MT 3-blade — 1136 fpm
- MT 2-blade — 1097 fpm
- McCauley3-blade — 1080 fpm
- Hartzell 3-blade — 950 fpm

Cruise performance: (8000 feet 22"mp & 2400 rpm)

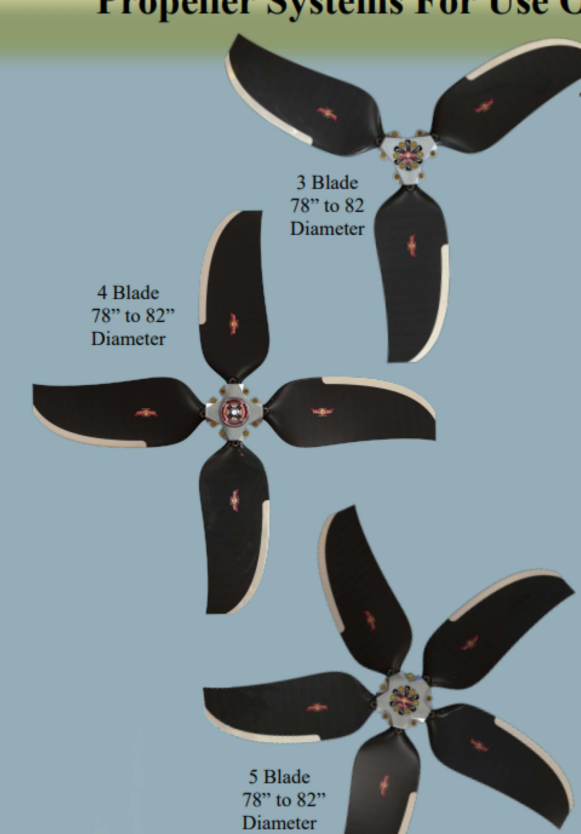
- MT 2-blade — 150 knots TAS
- MT 3-blade — 146 knots TAS
- Hartzell — 144 knots TAS
- McCauley — 143 knots TAS

NOTE: No motor mount change required with the MT!

mt-propeller

82JX blade — sensenich.com/wp-content/uploads/2018/01/Specification_Sheets_82JX_series_1505307759.pdf

82JX Series Blades
High Performance, Low Noise
Propeller Systems For Use On Reducted Engines



The 82JX Series of blades is an Xtra-wide blade for automotive engines with high ratio reduction units. Designed using completely new airfoil technology, these propellers have the optimum thickness ratio to assure you a high performance propeller.

Designed primarily for high ratio reduction units the 82JX Series has the bulldozer type push you are looking for from a Xtra-wide propeller. Coupled with our new V Hub, this propeller is a breeze to install and adjust pitch.

Recommended Combinations:

300 to 500 HP w/ 2.3 & Higher Reduction
2 Blade 78" - 82"

475 to 650 HP w/ 2.3 & Higher Reduction
GSO 480 - 540, 340+ HP
3 Blade 80" - 82"

600 to 1000+ HP w/ 2.3 & Higher Reduction
4 Blade 80" - 82"

800 to 1000+ HP w/ 2.3 & Higher Reduction
5 Blade 80" - 82"

*These are recommendations only
Your application may differ

SENSENICH

- **Carbon Fiber Construction**
- **14 Inch Wide Blade**
- **350 - 500+ Horsepower**
- **2450 Maximum RPM**
- **Reduction Applications Only**

J Series Blade Page 091317 — sensenich.com/wp-content/uploads/2018/01/Application_Guides_J-Series_Applications_1506346486.pdf

J-Series Blade Chart

Model	Description
L70JM	67"-70" propeller for most 4cyl A/C and DD Small Block V8 applications up to 200hp, 70J has a 10" maximum width, L/H rotation only.
L72JN	69"-72" faster propeller for 4, 6, and 8cyl applications up to 350hp, 72JN has a 8.5" maximum width, L/H rotation only.
L72JM	69"-72" propeller for 4, 6, and 8cyl applications up to 350hp, 72JM has a 11" maximum width, L/H rotation only.
L72JW	69"-72" propeller for 6, and 8cyl applications up to 350hp, 72JW has a 12" maximum width, L/H rotation only.
L76JW	74"-76" propeller for 6, and 8cyl applications up to 400hp, 76JW has a 12" maximum width, L/H rotation only.
L80JW	76"-80" propeller for Auto & A/C Engines with 1.8-2.3 reductions up to 500+hp, 80JW has a 12" maximum width, L/H rotation only.
L&R82JR	78"-82" propeller for Auto Engines with 2.0 and higher reductions up to 800+hp, 82JR has a 13" maximum width, and is available in L/H & R/H rotation.
L&R82JX	78"-82" propeller for Auto Engines with 2.3 and higher reductions up to 1000+hp, 82JX has a 14" maximum width, and is available in L/H & R/H rotation.

***PLEASE NOTE, J-SERIES BLADES WILL ONLY MOUNT IN CURRENT ""V" SERIES HUBS PRODUCED BY SENSENICH AND WHIRLWIND BRAND "AB" SERIES HUBS**

ENERGY FORCE POWER Calculations for DHC-2 VTOL drone

Propeller Data:

r/R	c/R	?	H/D	r	c	H	t	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	[mm]	[-]
0.0000	Spinner-		-	-	-	-	-	-
0.0500	0.1777	73.9	0.5	50.0	177.7	1088.4	21.6	interpolated
0.1000	0.3138	63.4	0.6	100.0	313.8	1254.7	38.2	interpolated
0.1500	0.4499	52.9	0.6	150.0	449.9	1246.2	54.7	interpolated
0.2000	0.4969	44.9	0.6	200.0	496.9	1252.3	60.4	interpolated
0.2500	0.4924	38.7	0.6	250.0	492.4	1258.4	59.9	interpolated
0.3000	0.4653	33.9	0.6	300.0	465.3	1266.6	56.6	interpolated
0.3500	0.4302	30.1	0.6	350.0	430.2	1274.8	52.3	Clark Y, Re=500,000
0.4000	0.3946	27.1	0.6	400.0	394.6	1286.1	48.0	interpolated
0.4500	0.3596	24.6	0.6	450.0	359.6	1294.5	43.7	interpolated
0.5000	0.3275	22.6	0.7	500.0	327.5	1307.7	39.8	interpolated
0.5500	0.2981	20.9	0.7	550.0	298.1	1319.6	36.2	interpolated
0.6000	0.2709	19.5	0.7	600.0	270.9	1335.0	32.9	interpolated
0.6500	0.2456	18.2	0.7	650.0	245.6	1342.8	29.9	Clark Y, Re=500,000
0.7000	0.2162	17.1	0.7	700.0	216.2	1353.1	26.3	interpolated
0.7500	0.1860	16.2	0.7	750.0	186.0	1369.1	22.6	interpolated
0.8000	0.1584	15.3	0.7	800.0	158.4	1375.1	19.3	interpolated
0.8500	0.1308	14.6	0.7	850.0	130.8	1391.2	15.9	interpolated
0.9000	0.1002	13.9	0.7	900.0	100.2	1399.4	12.2	interpolated
0.9500	0.0696	13.3	0.7	950.0	69.6	1411.0	8.5	interpolated
1.0000	0.0331	12.8	0.7	1000.0	33.1	1427.5	4.0	Clark Y, Re=500,000

The Geometry card

This card (Figure 8) presents the geometry of the current propeller in form of a table and a three view sketch. It also presents the distribution of the pitch to diameter ratio H/D over the radius of the propeller.

The data table presents the following columns:

- "r/R" – the radius station, normalized by propeller radius,
- "c/R" – the corresponding chord length at each station, normalized by propeller radius,
- "β" – the blade angle at the station in degrees,
- "H/D" – the local pitch to diameter ratio,
- "r" – the radius of the station in millimeters,
- "c" – the local chord length in millimeters,
- "H" – the local pitch height in millimeters,
- "t" – the local blade thickness in millimeters,
- "Airfoil" – the airfoil at each station as selected on the "Airfoils" card.

radius 350mm chord 430.2mm

circum = (2)x (350) x π = 2199 mm

velocity prop segment =

(2199mm)x 40.4 rev/sec = 88839mm/sec = 291ft/sec

radius 650mm chord 245.6mm

circum = (2)x (650) x π = 4084 mm

velocity prop segment =

(4084mm)x 40.4 rev/sec = 164993mm/sec = 541ft/sec

radius 1000mm chord 33.1mm

circum = (2)x (1000) x π = 6283.18 mm

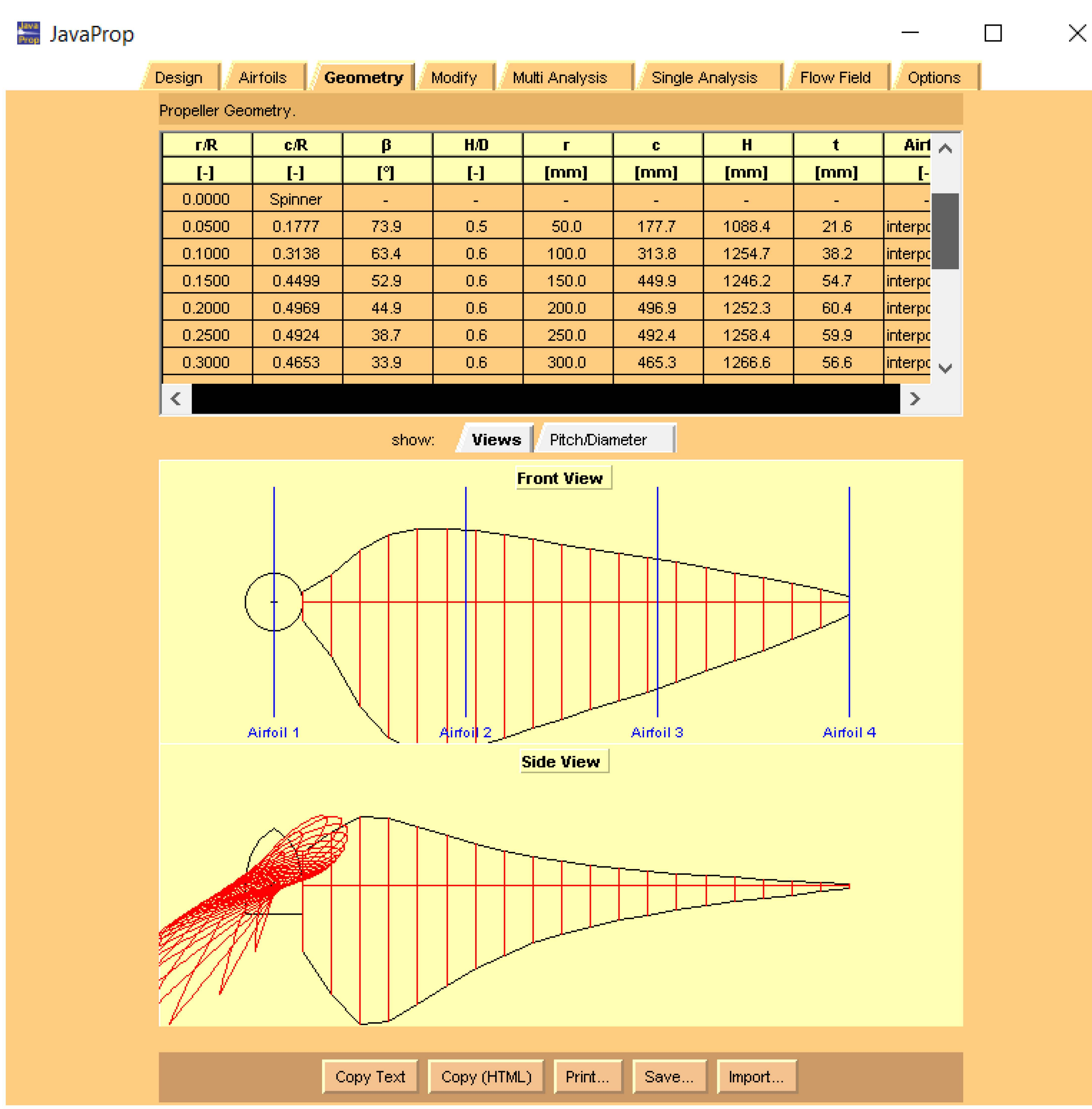
velocity prop segment =

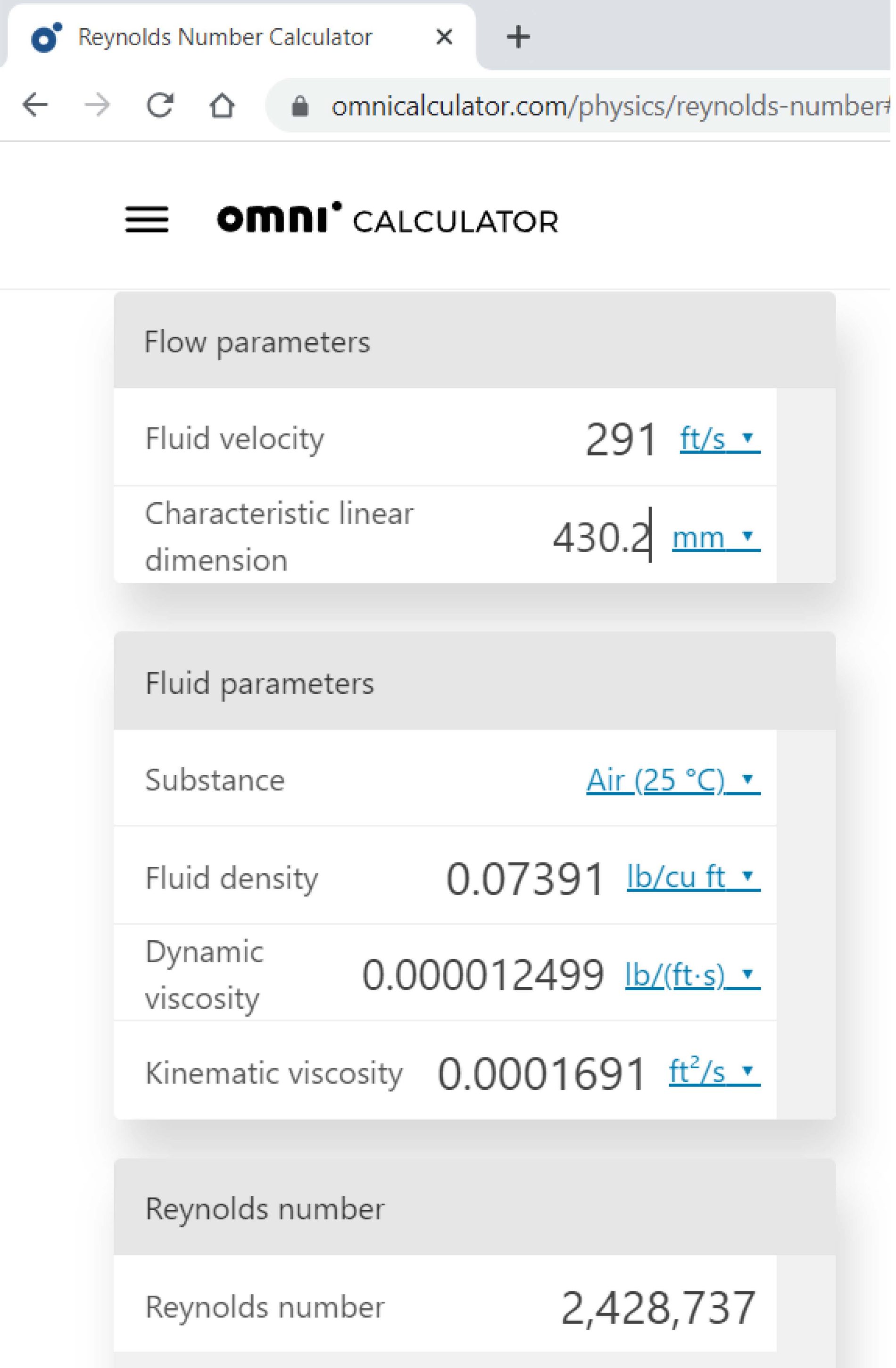
(6283.18mm)x 40.4 rev/sec = 253840mm/sec = 832.8ft/sec

Reynolds Number of Propeller (calculations):

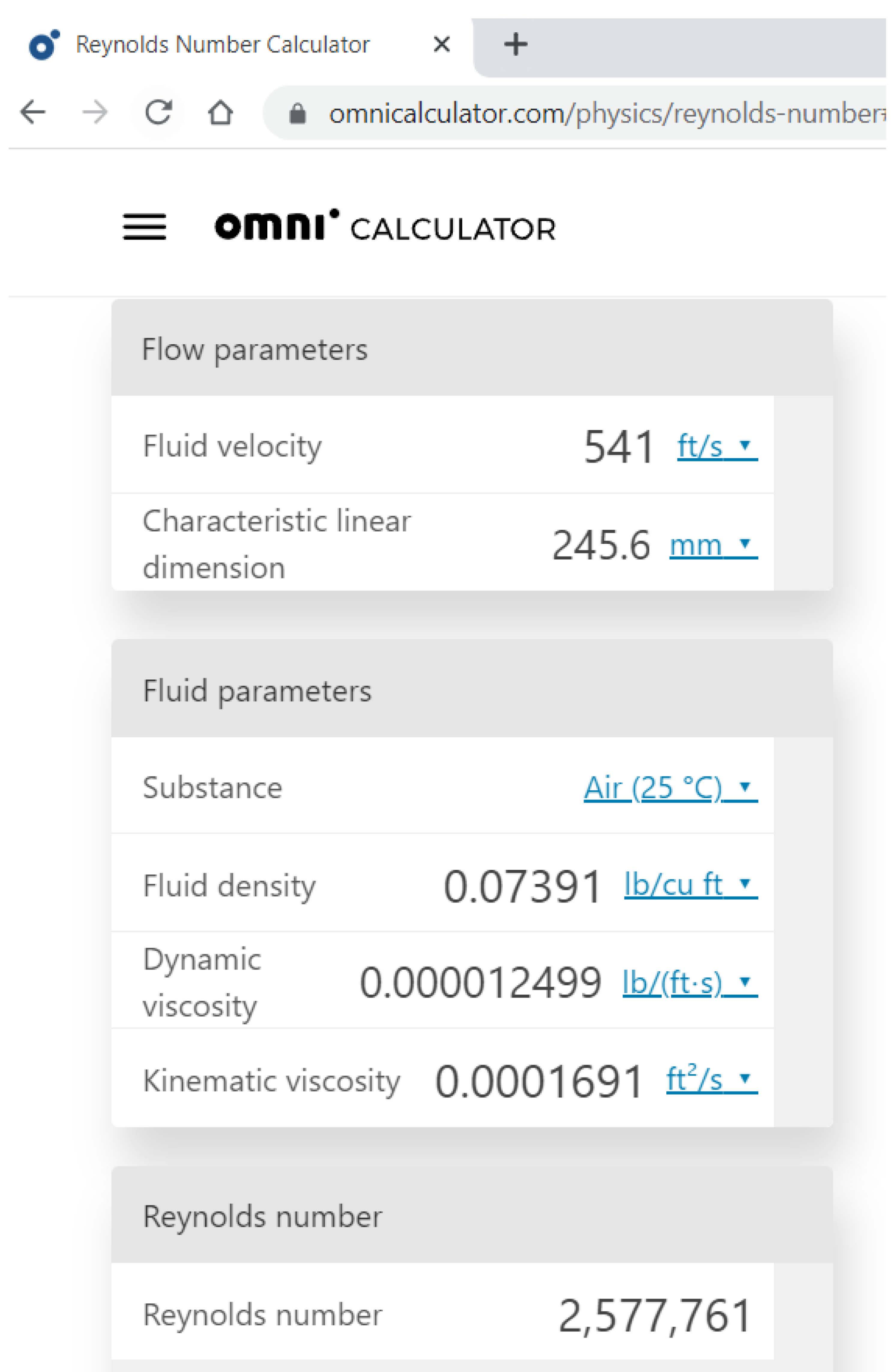
rpm = 2425

rpm/60= rev/sec 2425/60 = 40.4 rev/sec

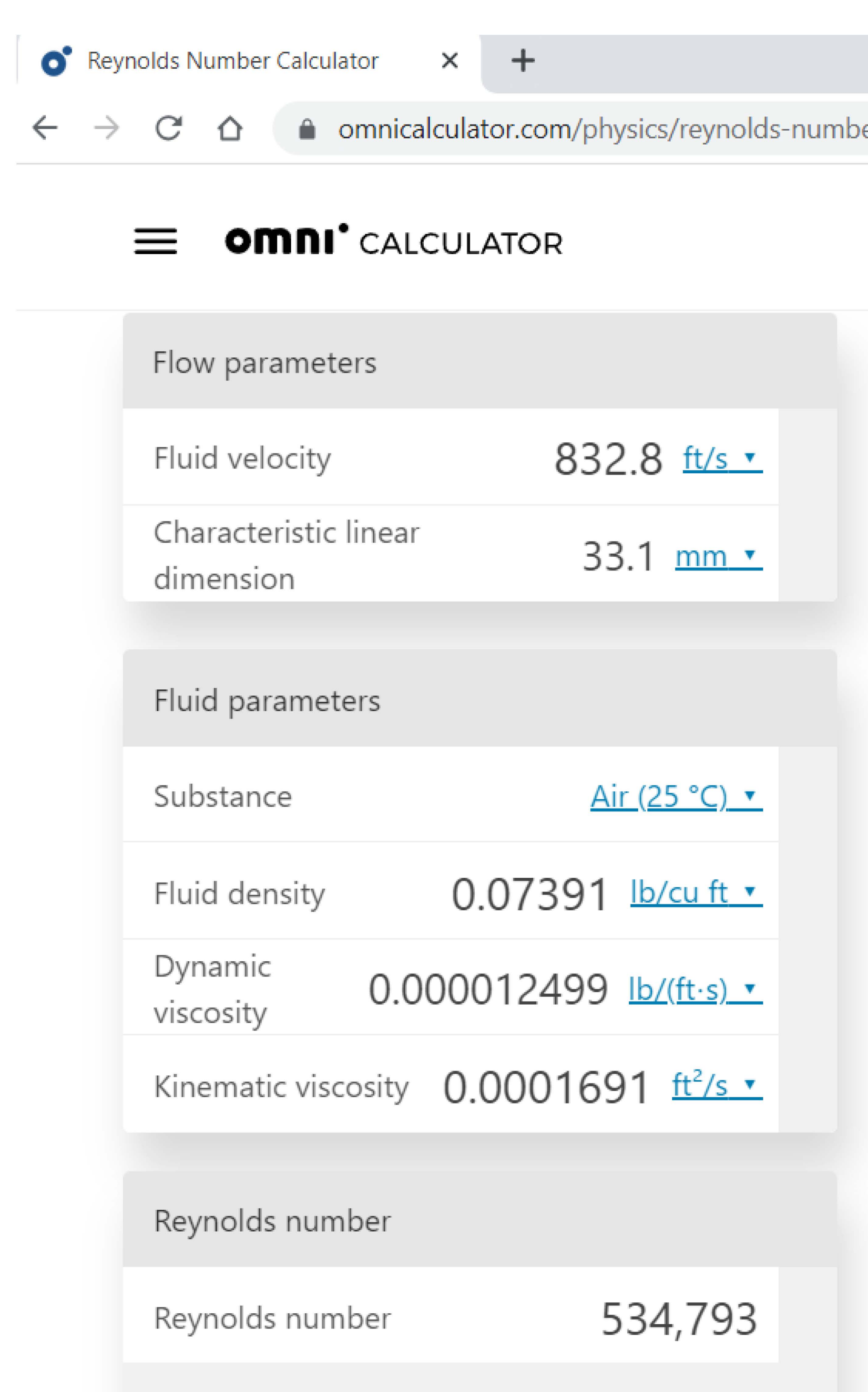




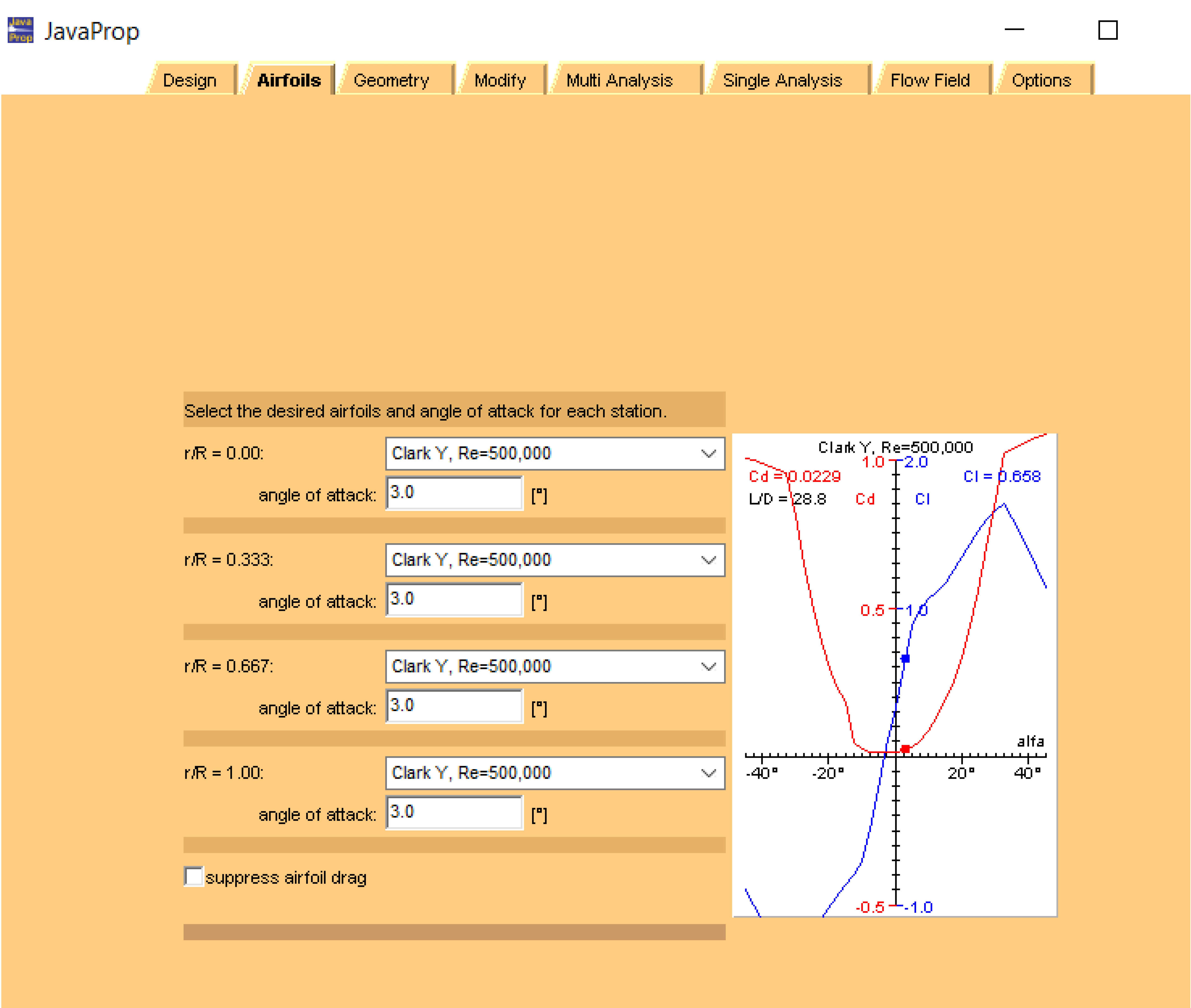
Reynolds Number Calculator
omnicalculator.com/physics/reynolds-number
omni CALCULATOR
Flow parameters
Fluid velocity 291 ft/s
Characteristic linear dimension 430.2 mm
Fluid parameters
Substance Air (25 °C)
Fluid density 0.07391 lb/cu ft
Dynamic viscosity 0.000012499 lb/(ft·s)
Kinematic viscosity 0.0001691 ft²/s
Reynolds number
Reynolds number 2,428,737



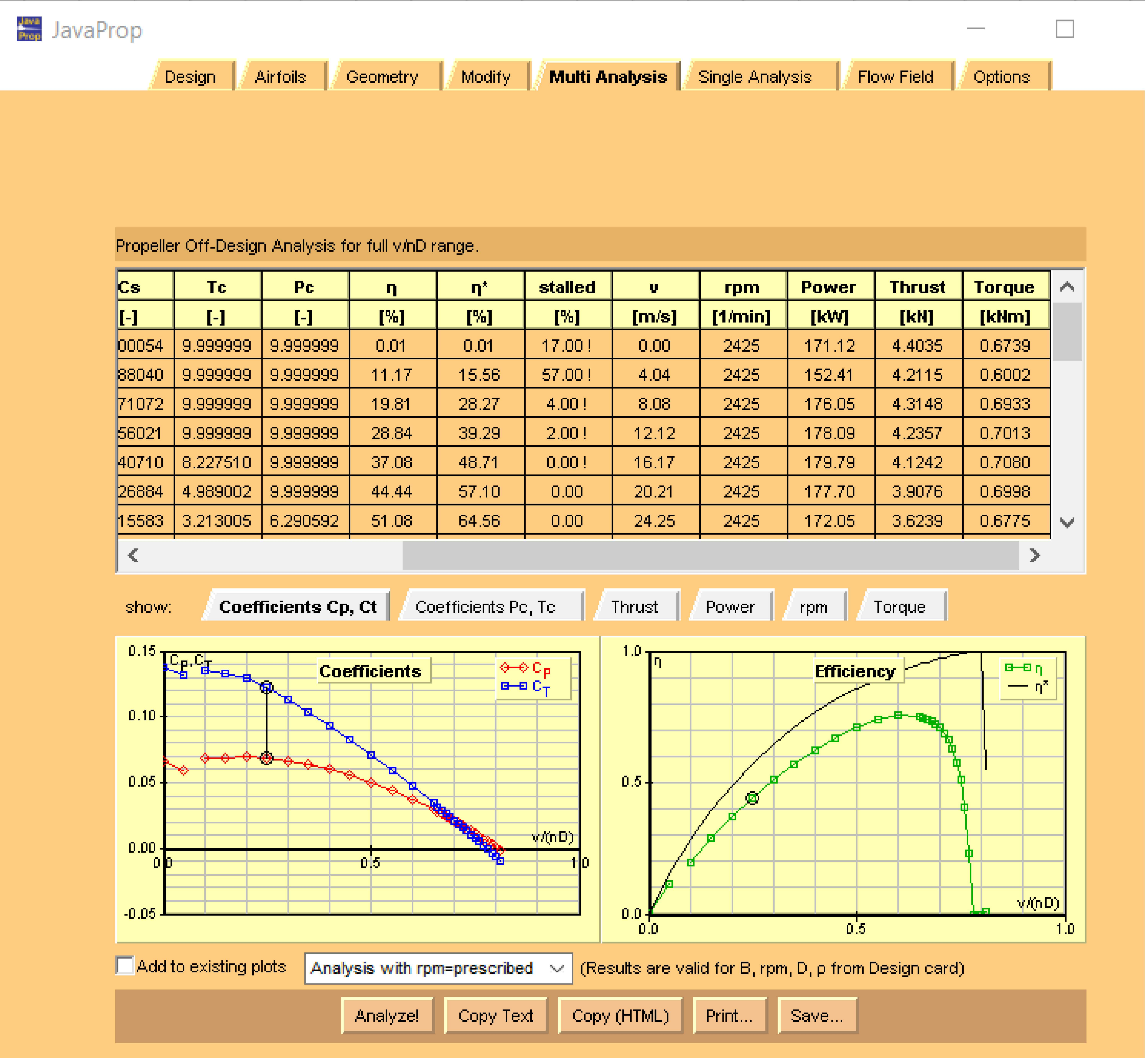
Reynolds Number Calculator
omnicalculator.com/physics/reynolds-number
omni CALCULATOR
Flow parameters
Fluid velocity 541 ft/s
Characteristic linear dimension 245.6 mm
Fluid parameters
Substance Air (25 °C)
Fluid density 0.07391 lb/cu ft
Dynamic viscosity 0.000012499 lb/(ft·s)
Kinematic viscosity 0.0001691 ft²/s
Reynolds number
Reynolds number 2,577,761



Reynolds Number Calculator
omnicalculator.com/physics/reynolds-numbe
omni CALCULATOR
Flow parameters
Fluid velocity 832.8 ft/s
Characteristic linear dimension 33.1 mm
Fluid parameters
Substance Air (25 °C)
Fluid density 0.07391 lb/cu ft
Dynamic viscosity 0.000012499 lb/(ft·s)
Kinematic viscosity 0.0001691 ft²/s
Reynolds number
Reynolds number 534,793



JavaProp
Design
Airfoils
Geometry
Modify
Multi Analysis
Single Analysis
Flow Field
Options
Select the desired airfoils and angle of attack for each station.
r/R = 0.00: Clark Y, Re=500,000
angle of attack: 3.0 [°]
r/R = 0.333: Clark Y, Re=500,000
angle of attack: 3.0 [°]
r/R = 0.667: Clark Y, Re=500,000
angle of attack: 3.0 [°]
r/R = 1.00: Clark Y, Re=500,000
angle of attack: 3.0 [°]
suppress airfoil drag
Clark Y, Re=500,000
Cd = 0.0229
L/D = 28.8
Cl = 0.658
Cd
Cl
1.0
2.0
0.5
1.0
-0.5
-1.0
alfa
-40°
-20°
20°
40°



Cs	Tc	Pc	η	η*	stalled	v	rpm	Power	Thrust	Torque
[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[kN]	[kNm]
00054	9.999999	9.999999	0.01	0.01	17.00 !	0.00	2425	171.12	4.4035	0.6739
88040	9.999999	9.999999	11.17	15.56	57.00 !	4.04	2425	152.41	4.2115	0.6002
71072	9.999999	9.999999	19.81	28.27	4.00 !	8.08	2425	176.05	4.3148	0.6933
56021	9.999999	9.999999	28.84	39.29	2.00 !	12.12	2425	178.09	4.2357	0.7013
40710	8.227510	9.999999	37.08	48.71	0.00 !	16.17	2425	179.79	4.1242	0.7080
26884	4.989002	9.999999	44.44	57.10	0.00	20.21	2425	177.70	3.9076	0.6998
15583	3.213005	6.290592	51.08	64.56	0.00	24.25	2425	172.05	3.6239	0.6775

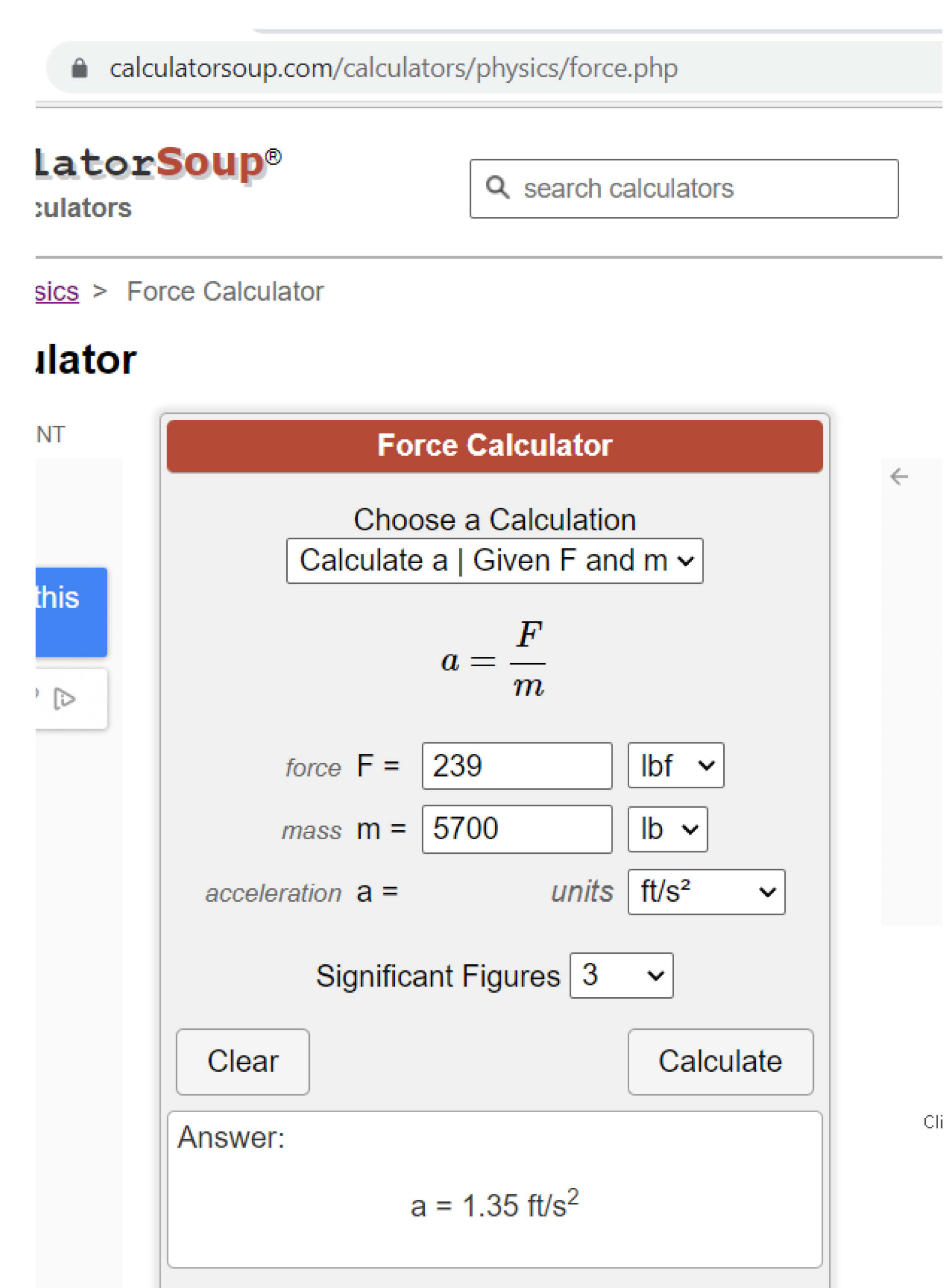
Propeller Static Thrust = 4.4035 kN 4.4035x6= 26.421 kN

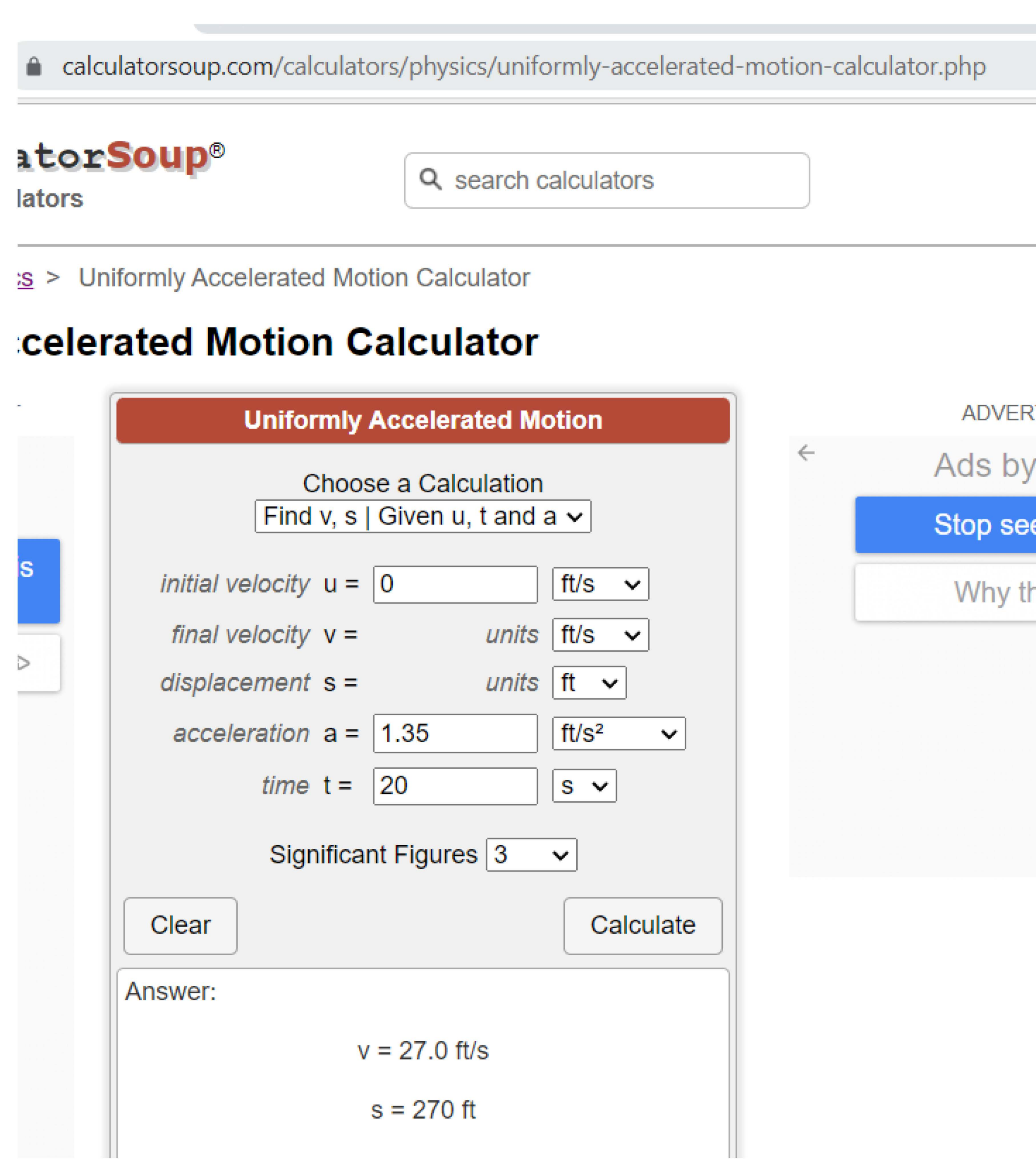
26.421 kN = 5939lbs

Drone Take-off wt (all sources) = 5700lbs

Thrust left over = 5939lbs - 5700lbs = 239 lbs

Accel of drone from 239lbs of excess force:





deHavilland DHC-2 Drone Calculations

Drone Airframe wt empty no fuel no payload = 3000lbs   Drone Take off wt all sources: 5700 lbs

Drone VTOL Components added:

Parker-Hannifin F12-125 motor #6, 33kg	33x6 =	198 kg
Parker-Hannifin F12-125 pump #2, 33kg	33x2 =	66 kg
Parker-Hannifin F12-90 pump #2, 25.7kg	25.7x2 =	51.4 kg
Parker-Hannifin VP1-128 pump #2, 27kg	27x2 =	54 kg
Carbon Fiber Propeller #6, 18kg	18x6 =	108 kg
Rolls-Royce CTS800 jet #2, 185.1kg	185.1x2 =	370.2 kg

VTOL Components total wt added: 847.6 kg   847.6 kg = 1865 lbs

Components removed: (from the original DHC-2 design)

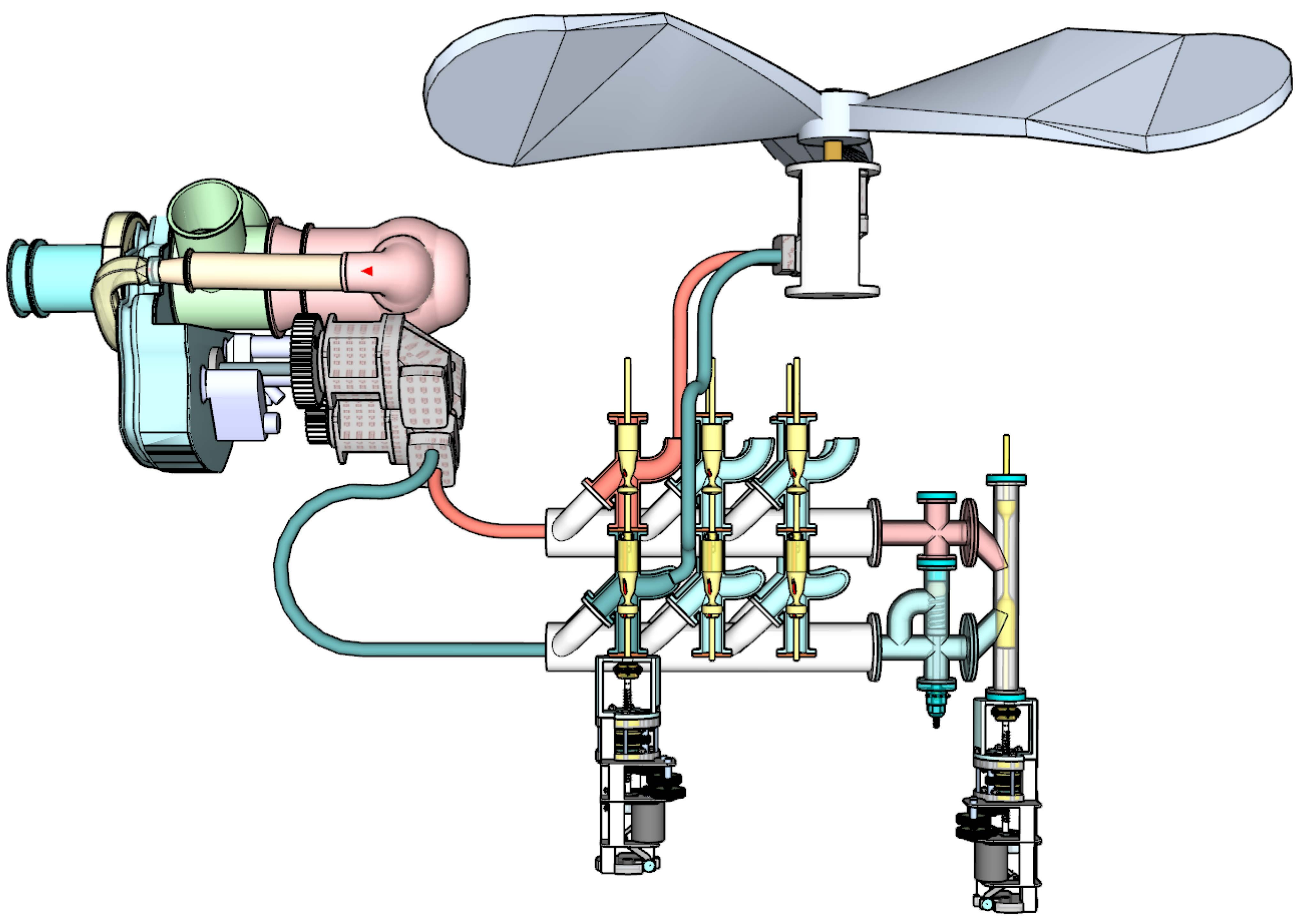
Pratt-Whitney WASP-R985 radial engine, 290kg
Hamilton Standard Metal Propeller, 59kg   (290kg + 59 kg) = 349 kg = 768 lbs

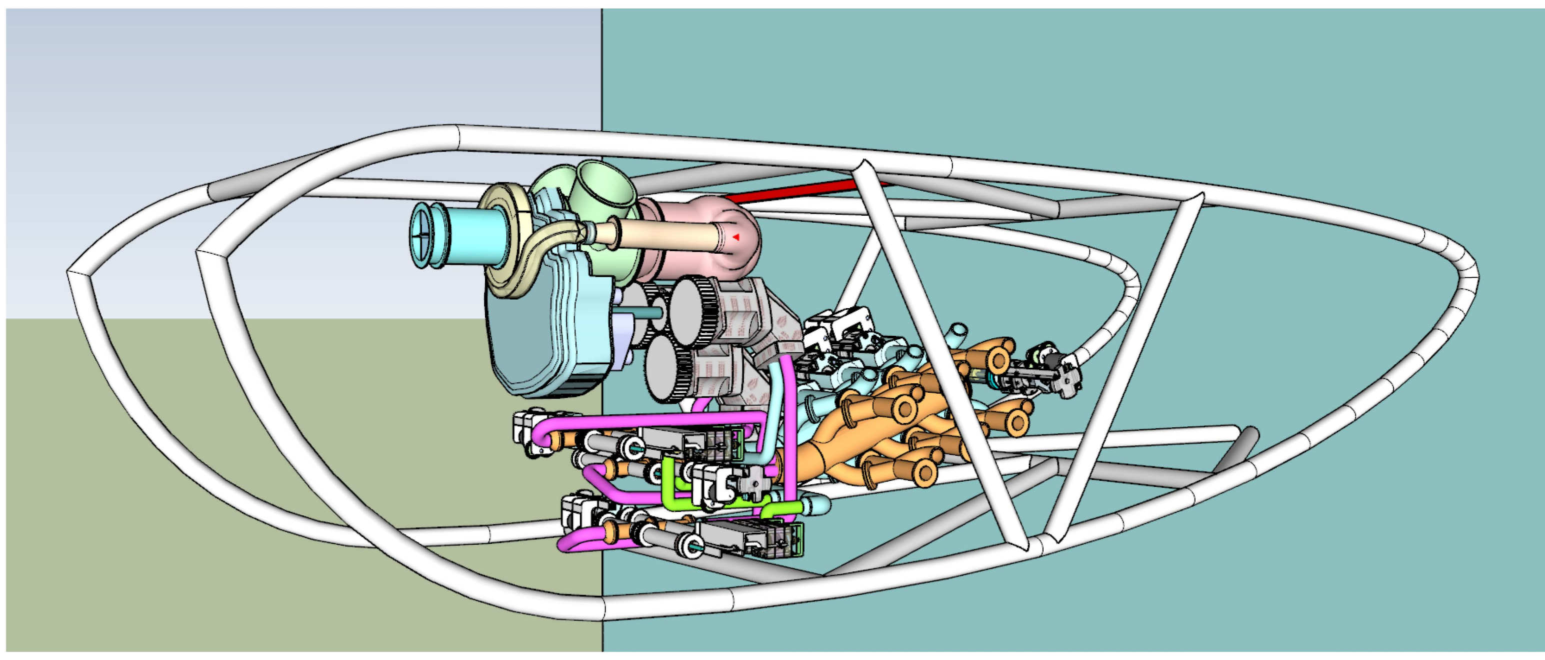
Final Wt for Drone conversion: Drone (original) 3000lb - (768 lbs) = 2232 lbs

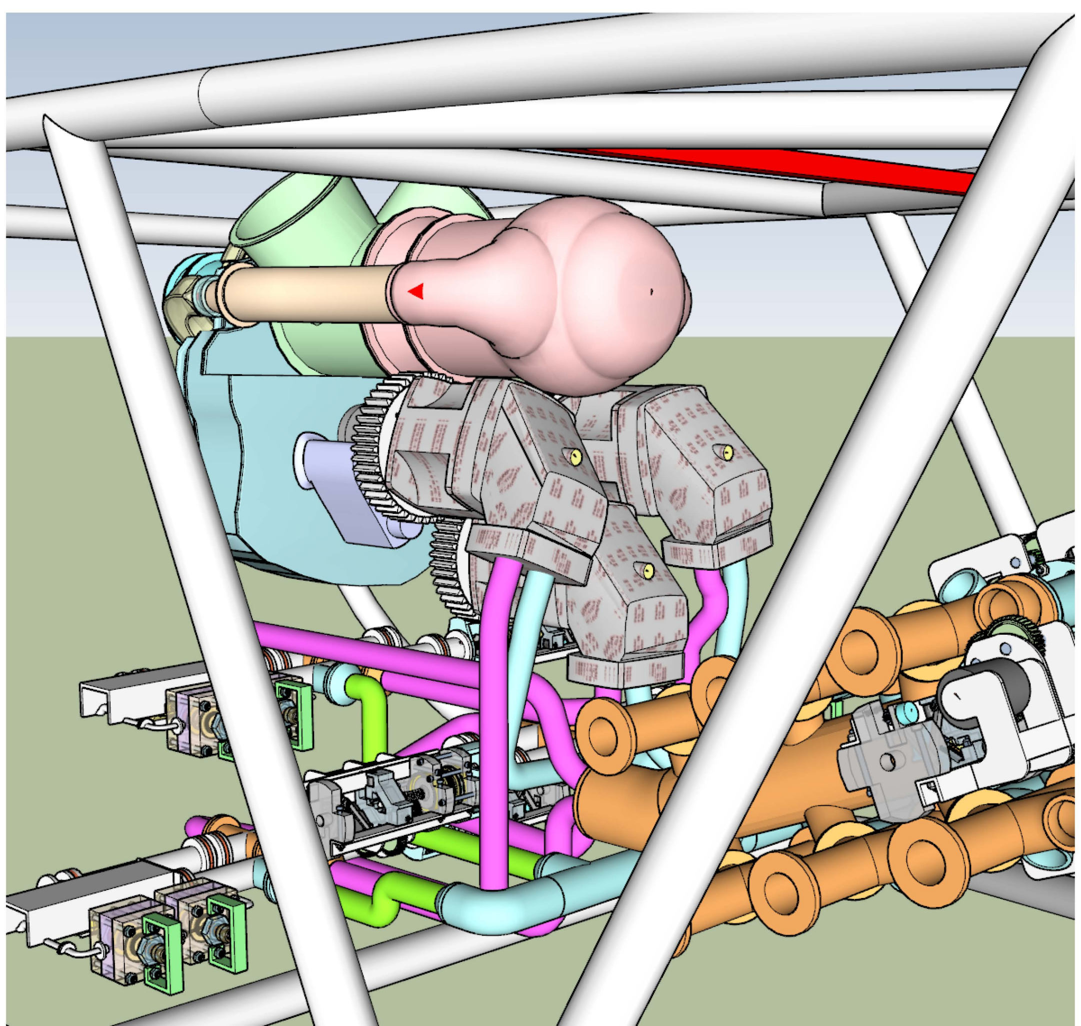
New Drone 2232 lbs + 1865 lbs (VTOL components) = 4097lbs

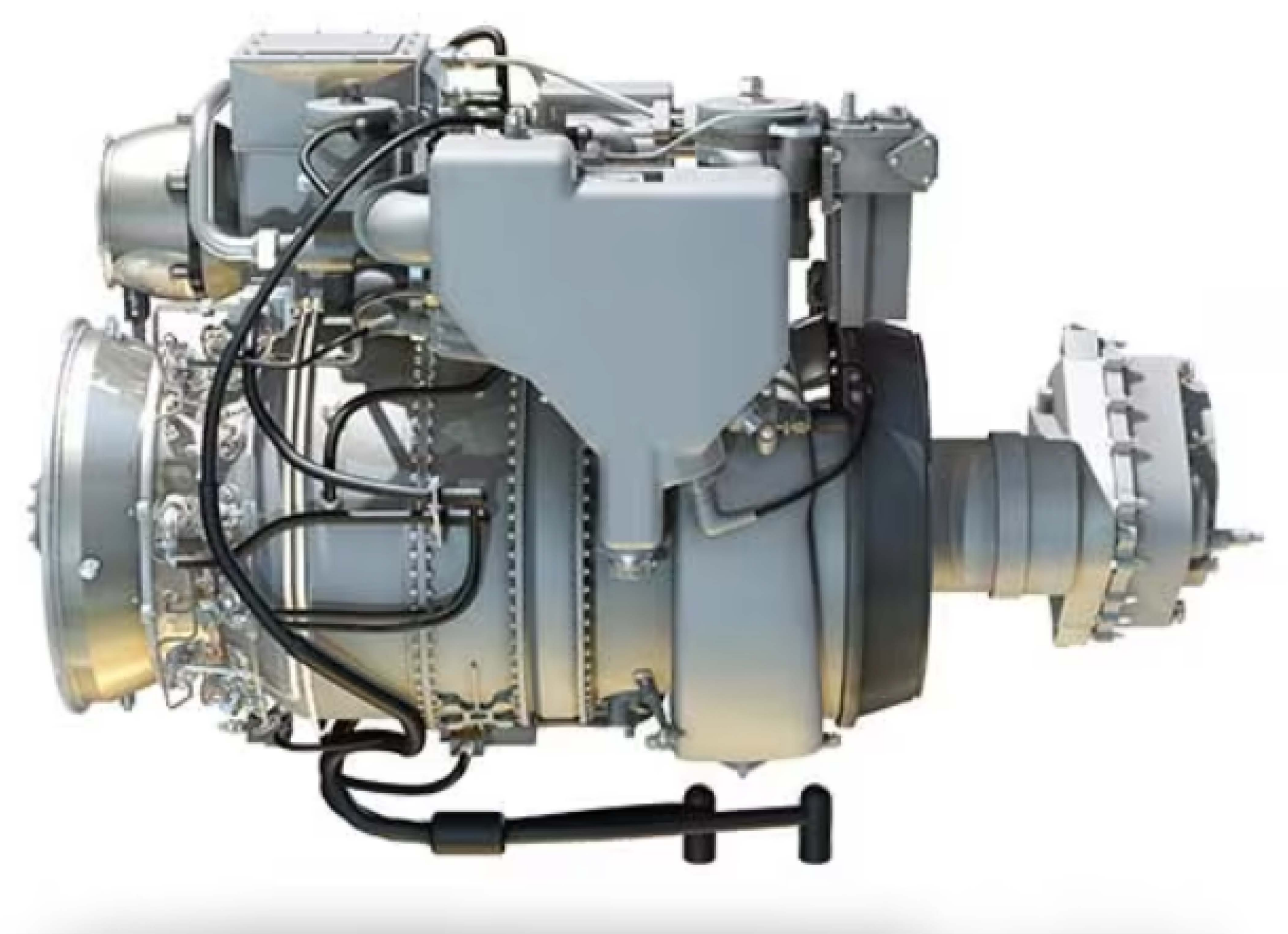
Total allowed Drone take-off wt (all sources) = 5700lbs

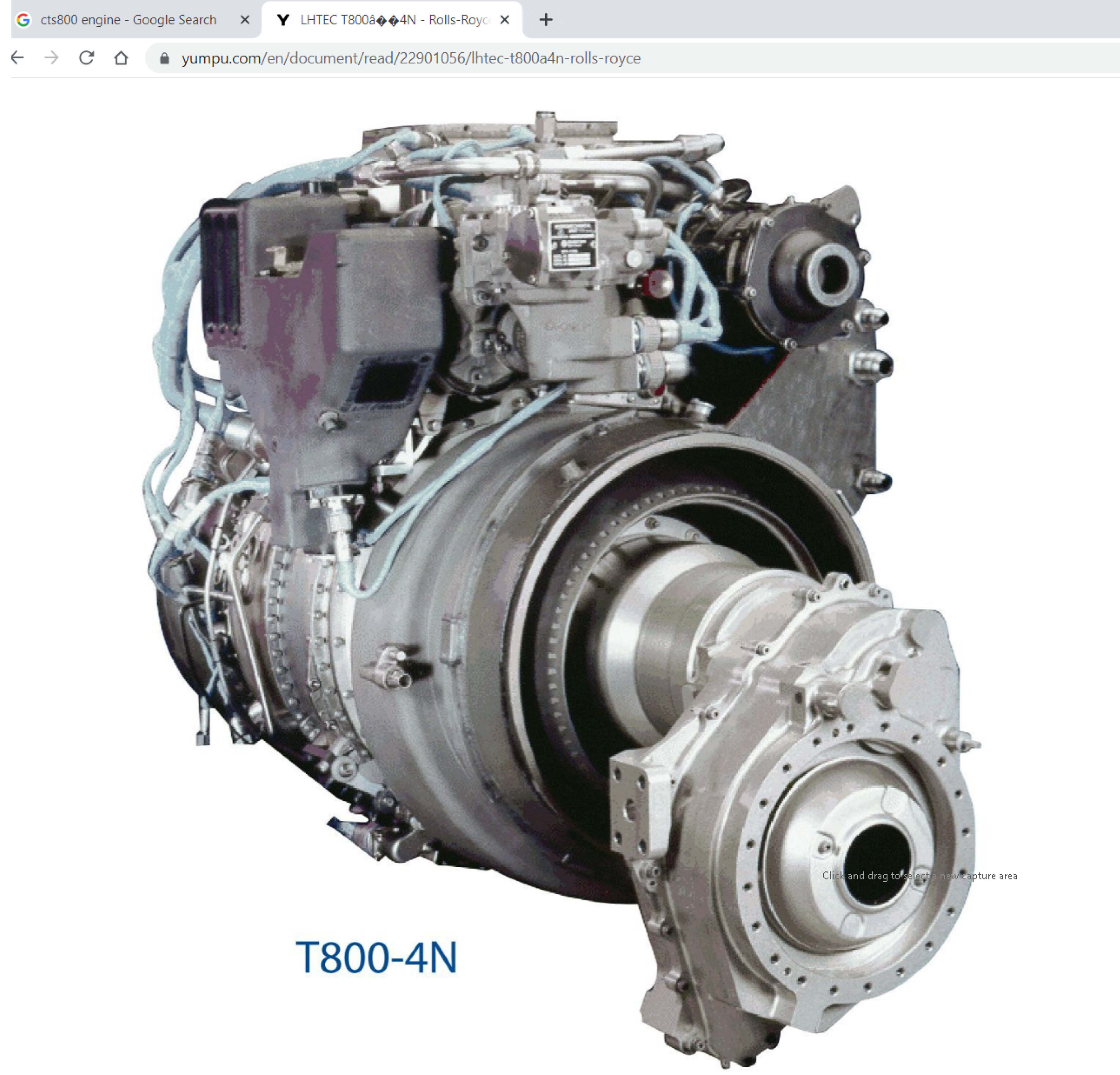
Allowed wt of (payload + fuel) = 5700lbs - 4097 lbs = 1603 lbs

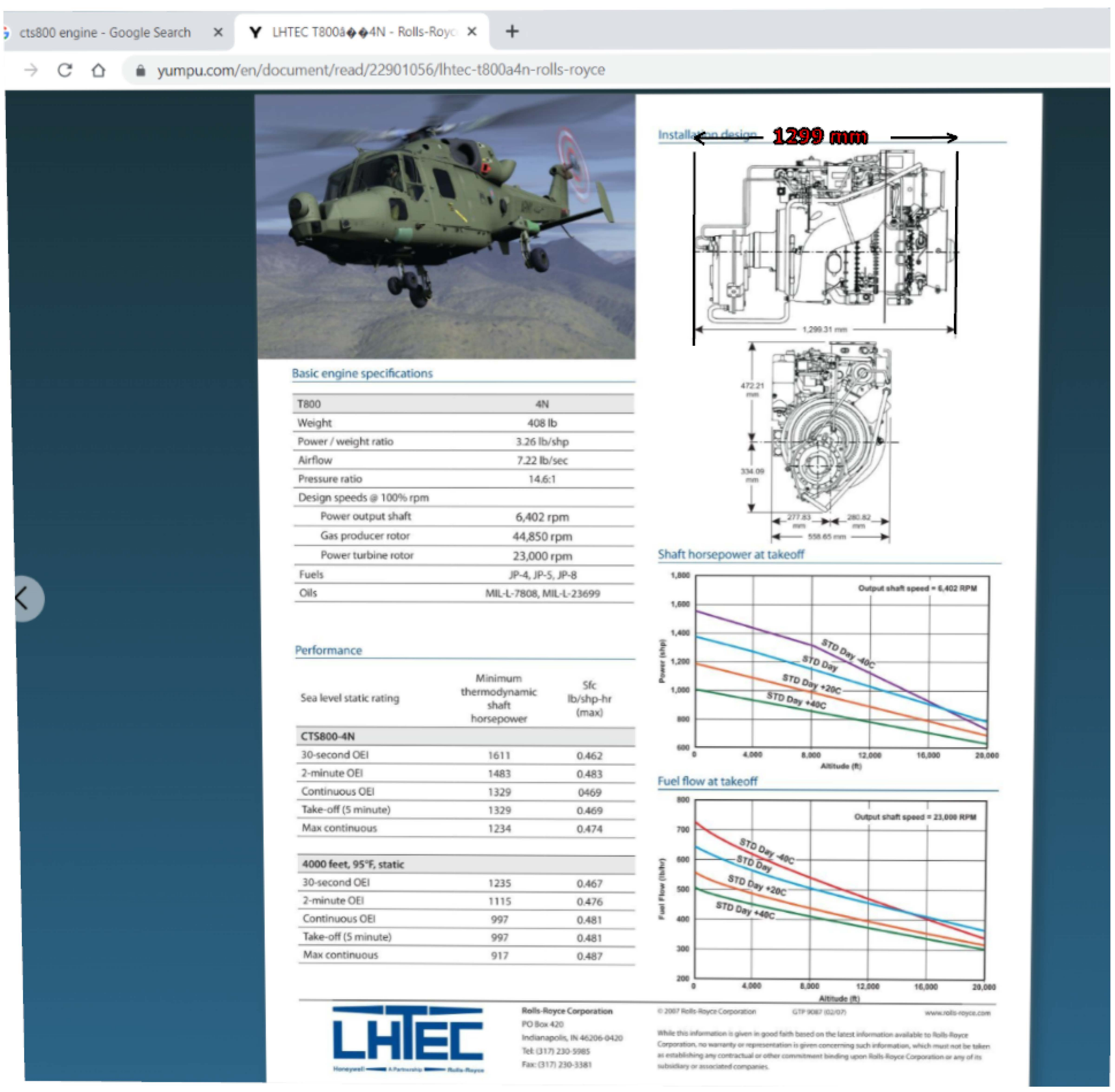












Basic engine specifications

T800	4N
Weight	408 lb
Power / weight ratio	3.26 lb/shp
Airflow	7.22 lb/sec
Pressure ratio	14.6:1
Design speeds @ 100% rpm	
Power output shaft	6,402 rpm
Gas producer rotor	44,850 rpm
Power turbine rotor	23,000 rpm
Fuels	JP-4, JP-5, JP-8
Oils	MIL-L-7808, MIL-L-23699

Performance

Sea level static rating	Minimum thermodynamic shaft horsepower	Sfc lb/shp-hr (max)
CTS800-4N		
30-second OEI	1611	0.462
2-minute OEI	1483	0.483
Continuous OEI	1329	0469
Take-off (5 minute)	1329	0.469
Max continuous	1234	0.474
4000 feet, 95°F, static		
30-second OEI	1235	0.467
2-minute OEI	1115	0.476
Continuous OEI	997	0.481
Take-off (5 minute)	997	0.481
Max continuous	917	0.487

LHTEC Honeywell — A Partnership — Rolls-Royce

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Fax: (317) 230-3381

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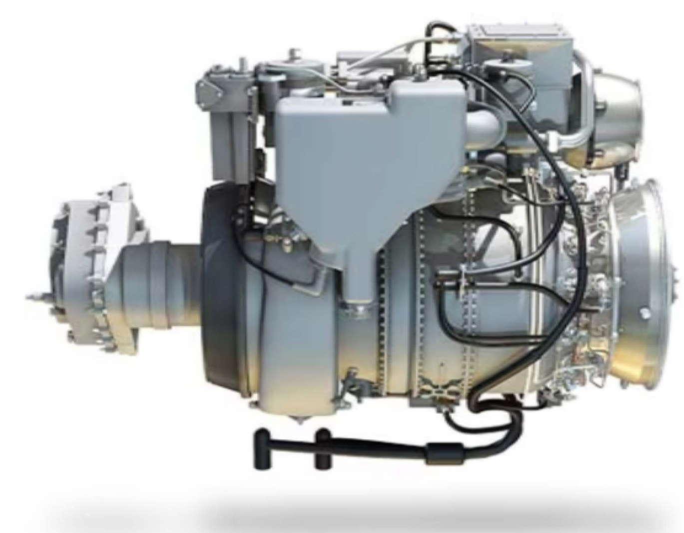
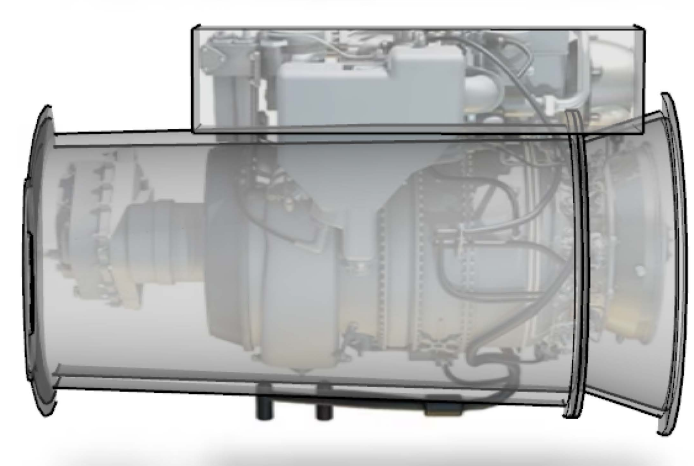
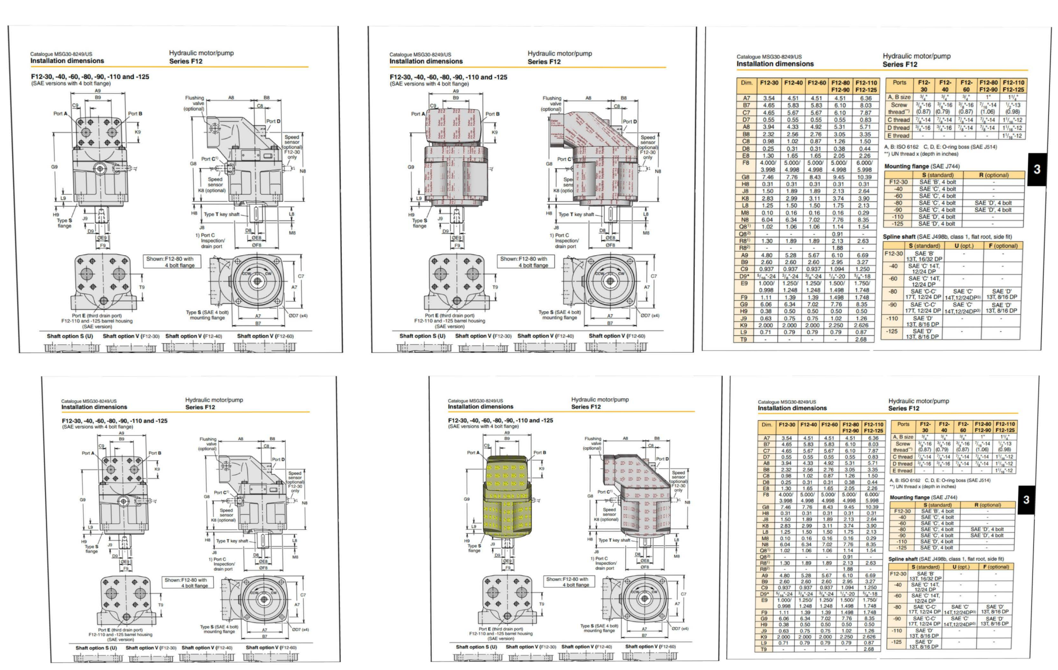
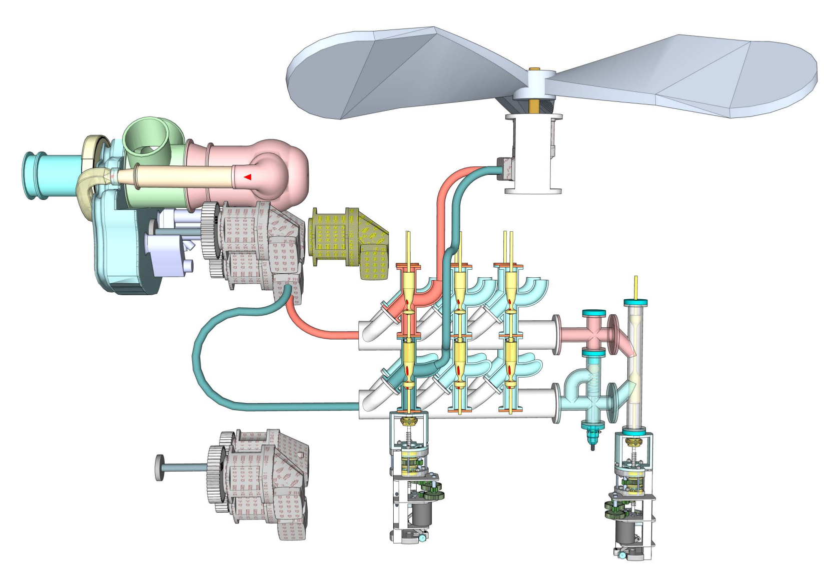
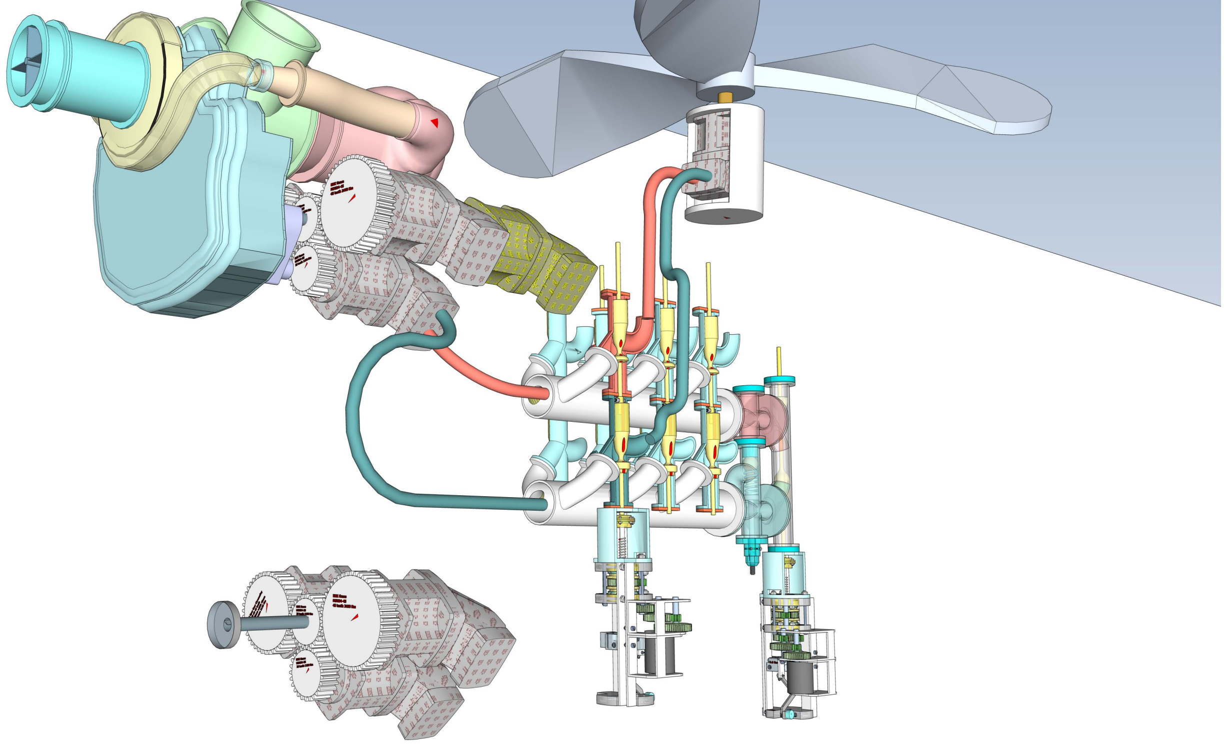
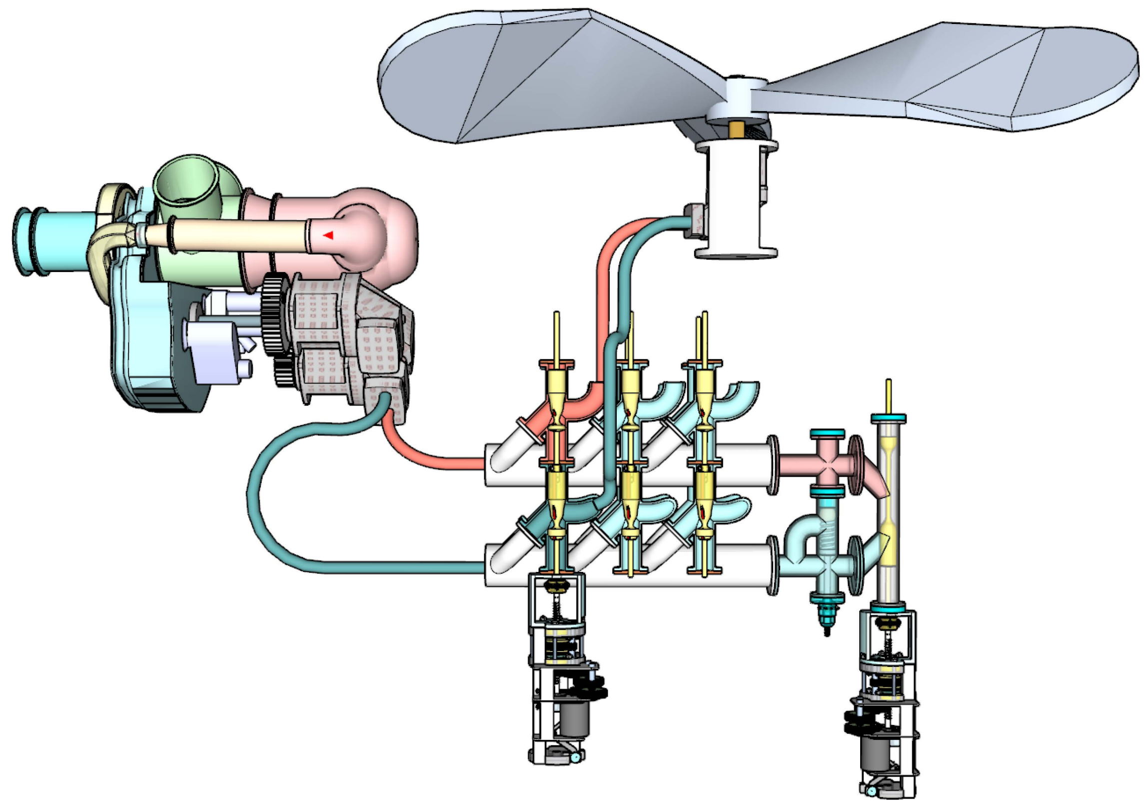


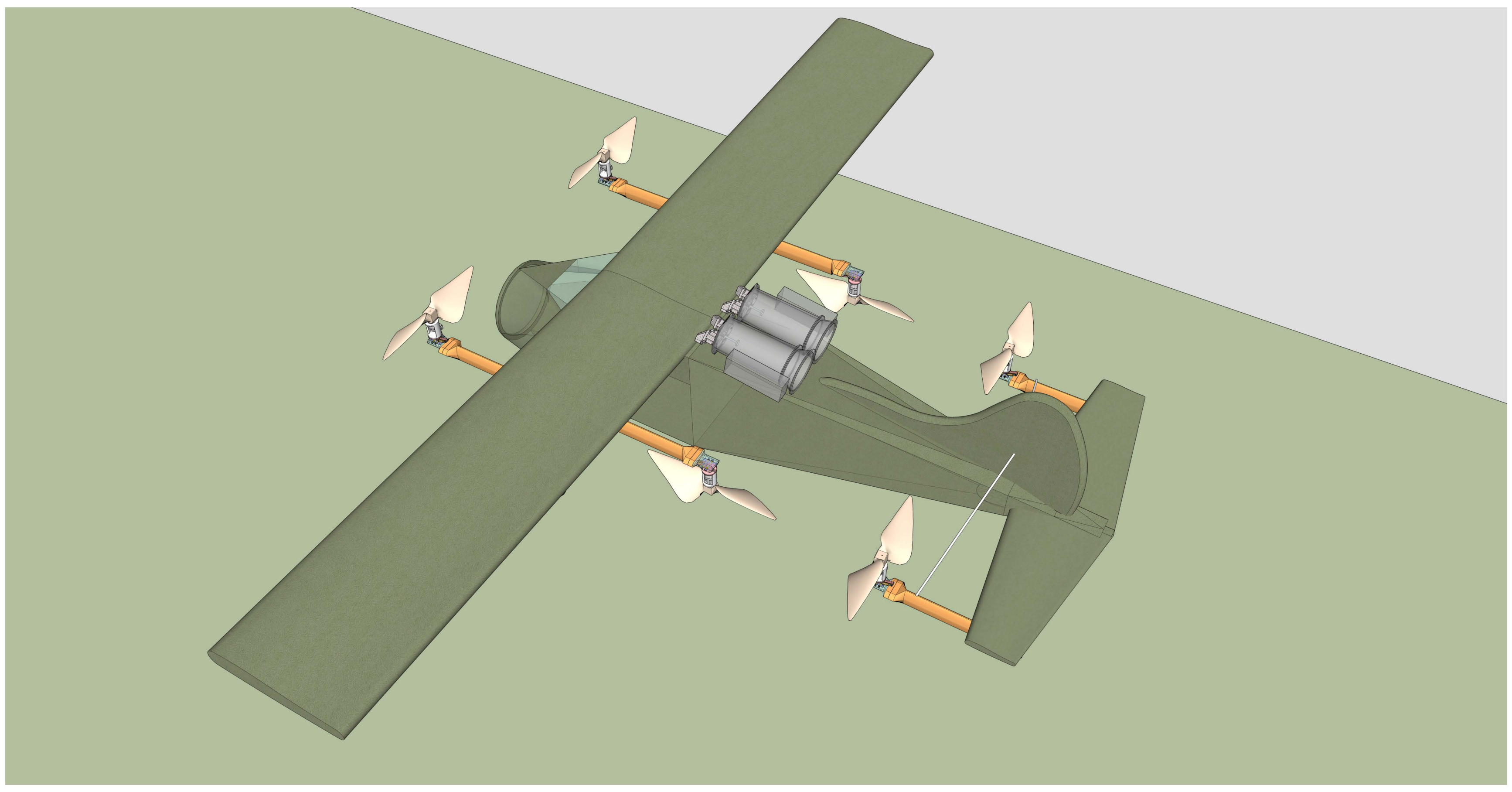


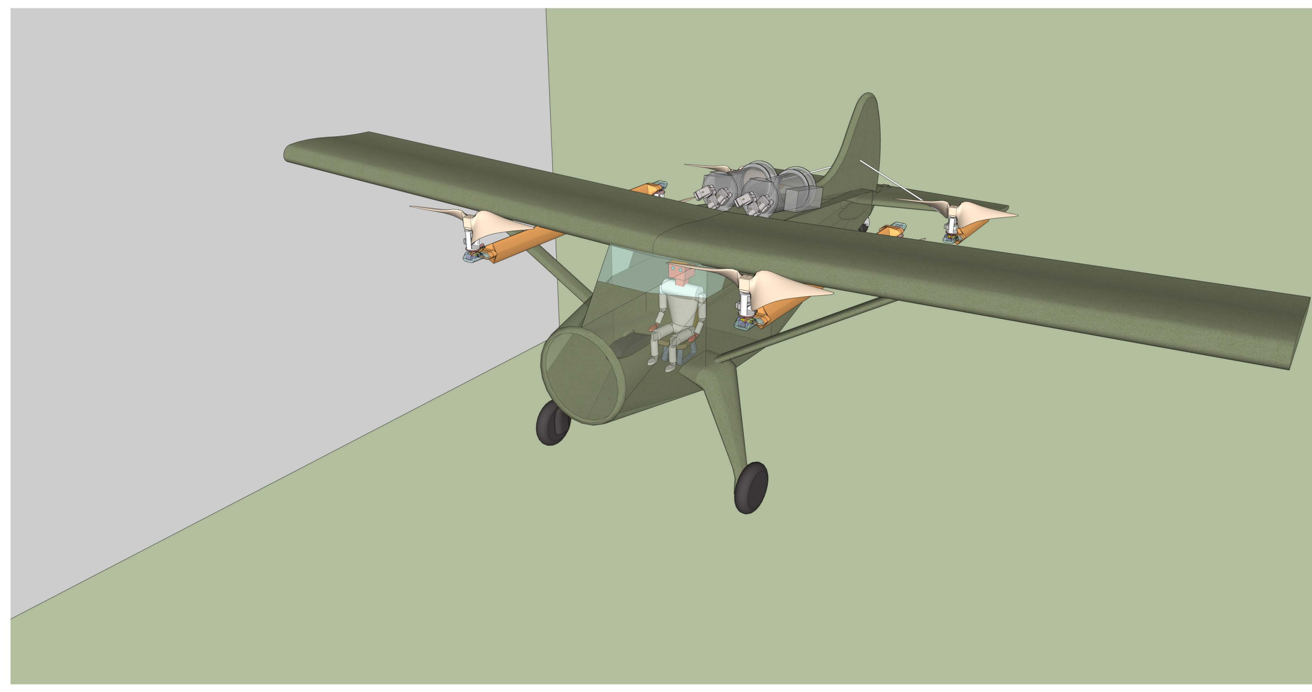


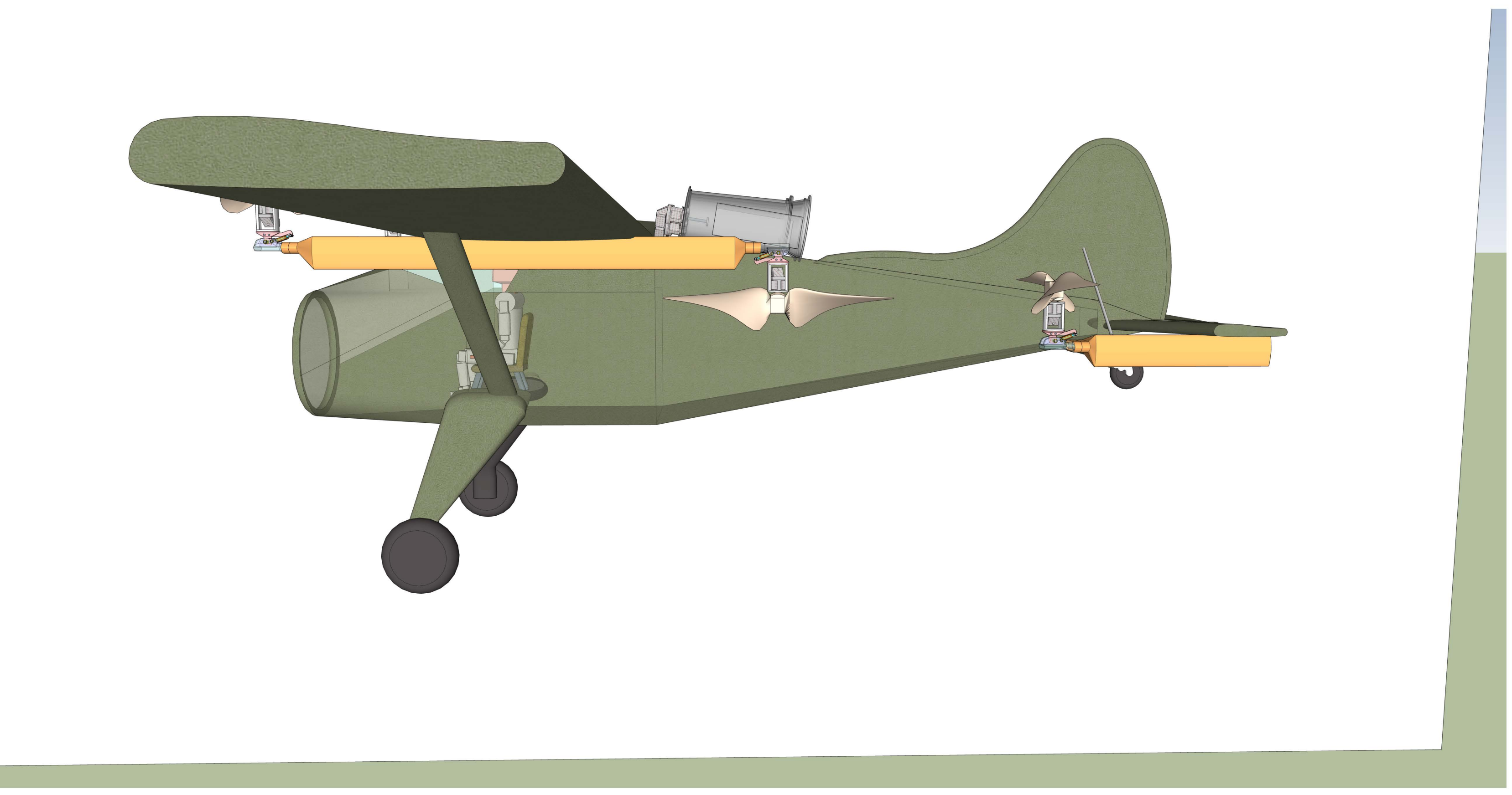


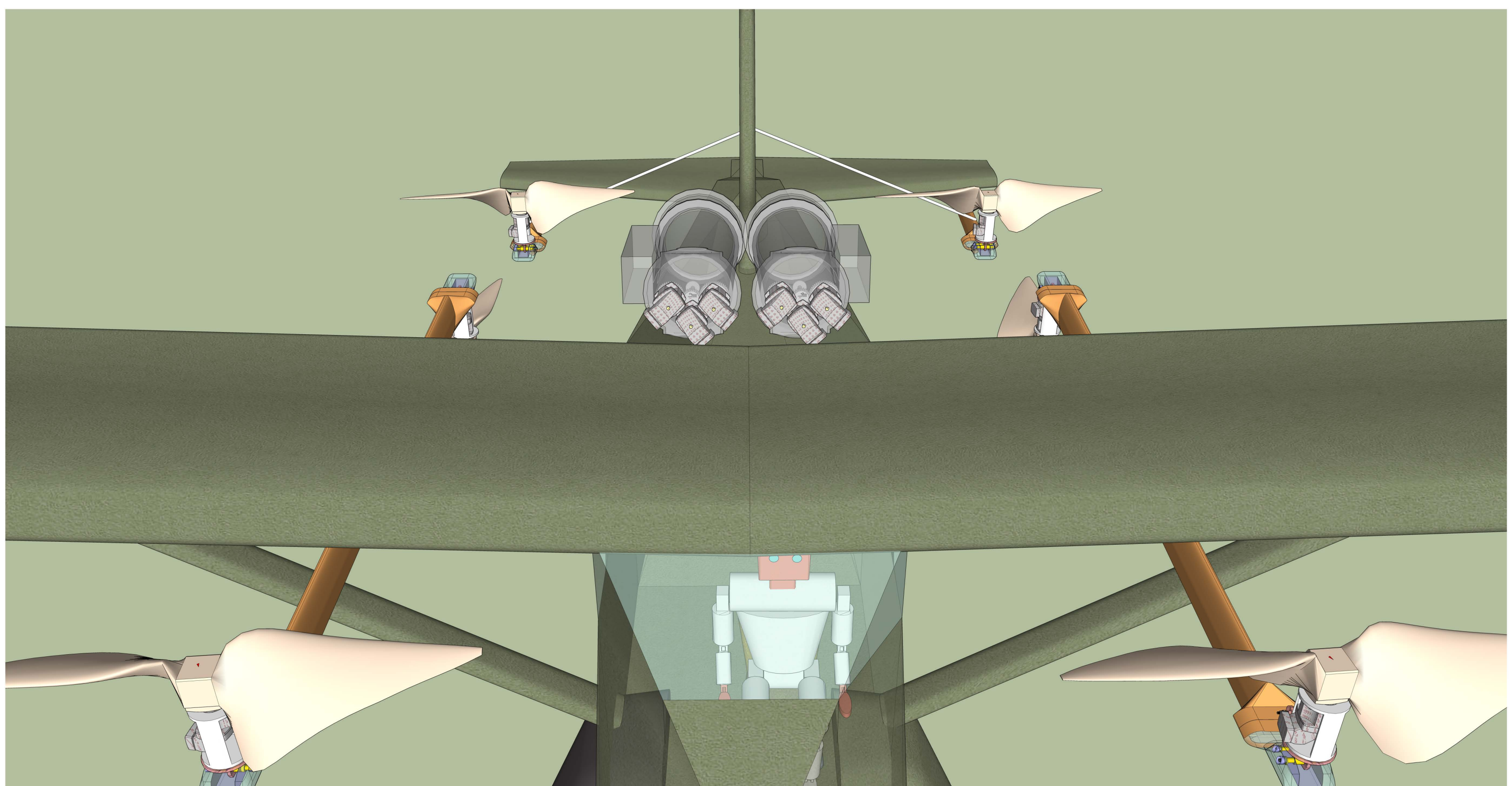












Catalogue MSG30-8249/US

Hydraulic motor/pump
Series F11/F12

Basic formulas for hydraulic motors

Flow (q)

$$q = \frac{D \times n}{1000 \times \eta_v} \text{ [l/min]}$$

Torque (M)

$$M = \frac{D \times \Delta p \times \eta_{hm}}{63} \text{ [Nm]}$$

Power (P)

$$P = \frac{q \times \Delta p \times \eta_t}{600} \text{ [kW]}$$

D - displacement [cm³/rev]
n - shaft speed [rpm]
η_v - volumetric efficiency
Δp - differential pressure [bar] (between inlet and outlet)
η_{hm} - mechanical efficiency
η_t - overall efficiency ($\eta_t = \eta_v \times \eta_{hm}$)

Basic formulas for hydraulic pumps

Flow (q)

$$q = \frac{D \times n \times \eta_v}{1000} \text{ [l/min]}$$

Torque (M)

$$M = \frac{D \times \Delta p}{63 \times \eta_{hm}} \text{ [Nm]}$$

Power (P)

$$P = \frac{q \times \Delta p}{600 \times \eta_t} \text{ [kW]}$$

D - displacement [cm³/rev]
n - shaft speed [rpm]
η_v - volumetric efficiency
Δp - differential pressure [bar] (between inlet and outlet)
η_{hm} - mechanical efficiency
η_t - overall efficiency ($\eta_t = \eta_v \times \eta_{hm}$)

Conversion factors

1 kg	2.20 lb
1 N	0.225 lbf
1 Nm	0.738 lbf ft
1 bar	14.5 psi
1 l	0.264 US gallon
1 cm^3	0.061 cu in
1 mm	0.039 in
1°C	$^5/_9$(°F-32)
1 kW	1.34 hp

Conversion factors

1 lb	0.454 kg
1 lbf	4.448 N
1 lbf ft	1.356 Nm
1 psi	0.068948 bar
1 US gallon	3.785 l
1 cu in	16.387 cm^3
1 in	25.4 mm
1°F	$^9/_5$°C + 32
1 hp	0.7457 kW

Motor Calculations

F12-125 motor D=125
note: will use P instead of ΔP for pressure
will use Pwr instead of P for power

One motor q=125x2425/1000x0.9 = 272.8 L/min

For 6 motors, 272.8x6 = 1637 L/min

Moving terms: P= M(torque Nm)x63/125x0.9

Thus P= 673.9Nmx63/125x0.9 = 377.3 Bar

Pump Calculations

There are 2 of CTS-800 engines, running 2 pumps each.

Total needed flow is 1637 L/min, thus per engine is needed 1637/2 = 818.5 L/min

Each CTS-800 runs 2 pumps, the F12-125 at 4200rpm giving 472 L/min. Still needing 818.5-472 = 346.5 L/min

F12-125 Pump max rpm is 4200. Normal RPM of output of RR CTS-800 is 6402

Use gear reduction of 4200/6402 to get pump rpm to 4200

F12-125 Pump flow = q =125*4200*0.9/1000 = 472 L/min

M for F12-125 is 125x377.3/63*0.9 = 831.8 Nm at the pump, but at the jet it is (4200/6402)x904 = 545.6 Nm

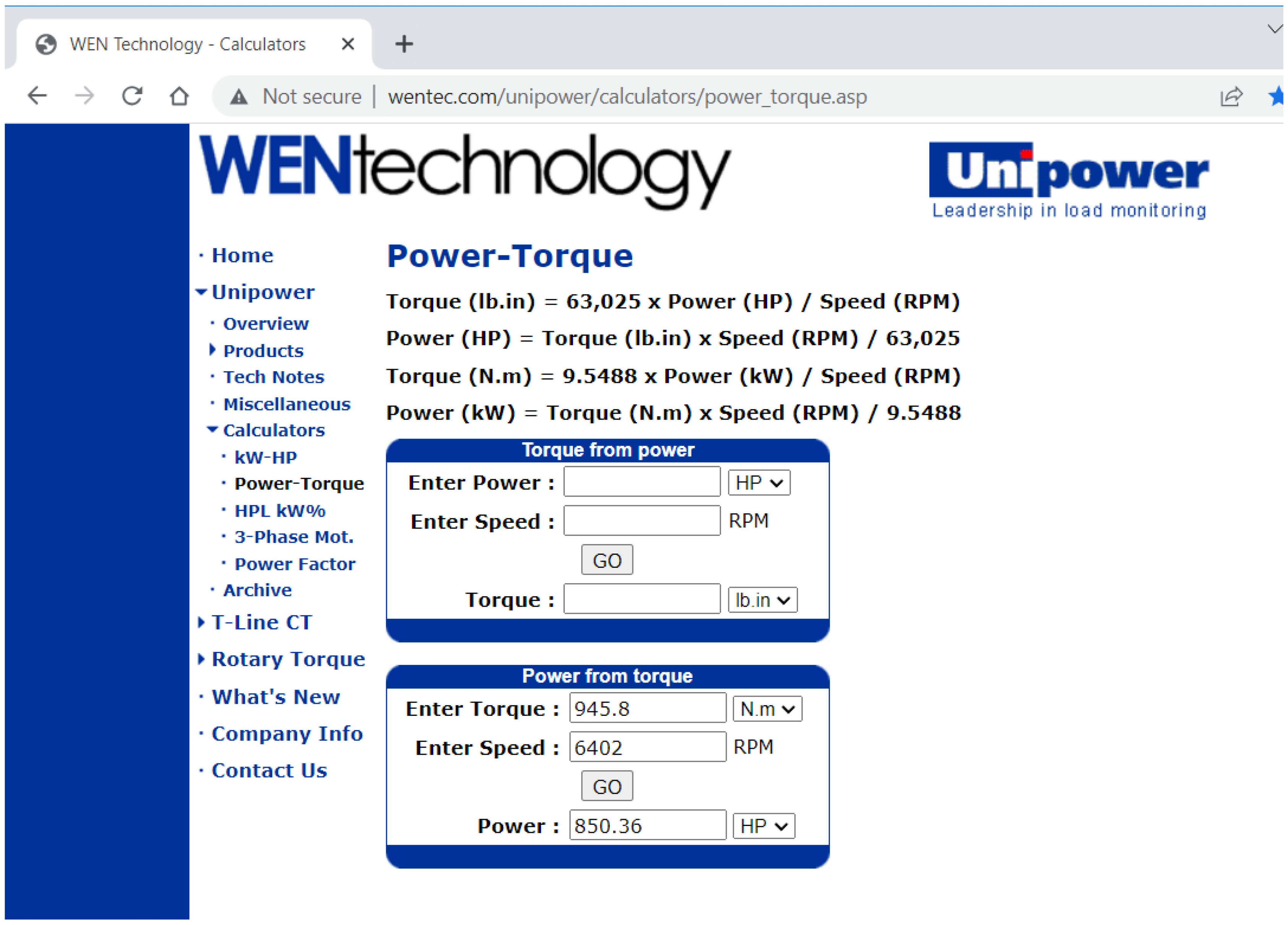
Max Nm from the jet is 1373Nm. Thus remaining is 1373 Nm - 545.6Nm = 827.4 Nm

F12-90 pump, rpm max is 4600 rpm F12-90 is the second pump, running at 4140 rpm giving 346.5 L/min.

F12-90 pump torque = 93x377.3/63x0.9 = 619 Nm at pump. At engine, will be (4140/6402)x619 = 400.2 Nm

Thus total Nm for each jet engine is (F12-125) 545.6 + (F12-80) 400.2 = 545.6+400.2 = 945.8 Nm

Fuel Calculations



WEN Technology - Calculators

wentec.com/unipower/calculators/power_torque.asp

WENtechnology

Unipower Leadership in load monitoring

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- What's New
- Company Info
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Power-Torque

Torque (lb.in) = 63,025 x Power (HP) / Speed (RPM)

Power (HP) = Torque (lb.in) x Speed (RPM) / 63,025

Torque (N.m) = 9.5488 x Power (kW) / Speed (RPM)

Power (kW) = Torque (N.m) x Speed (RPM) / 9.5488

Torque from power

Enter Power : [ ] HP

Enter Speed : [ ] RPM

GO

Torque : [ ] lb.in

Power from torque

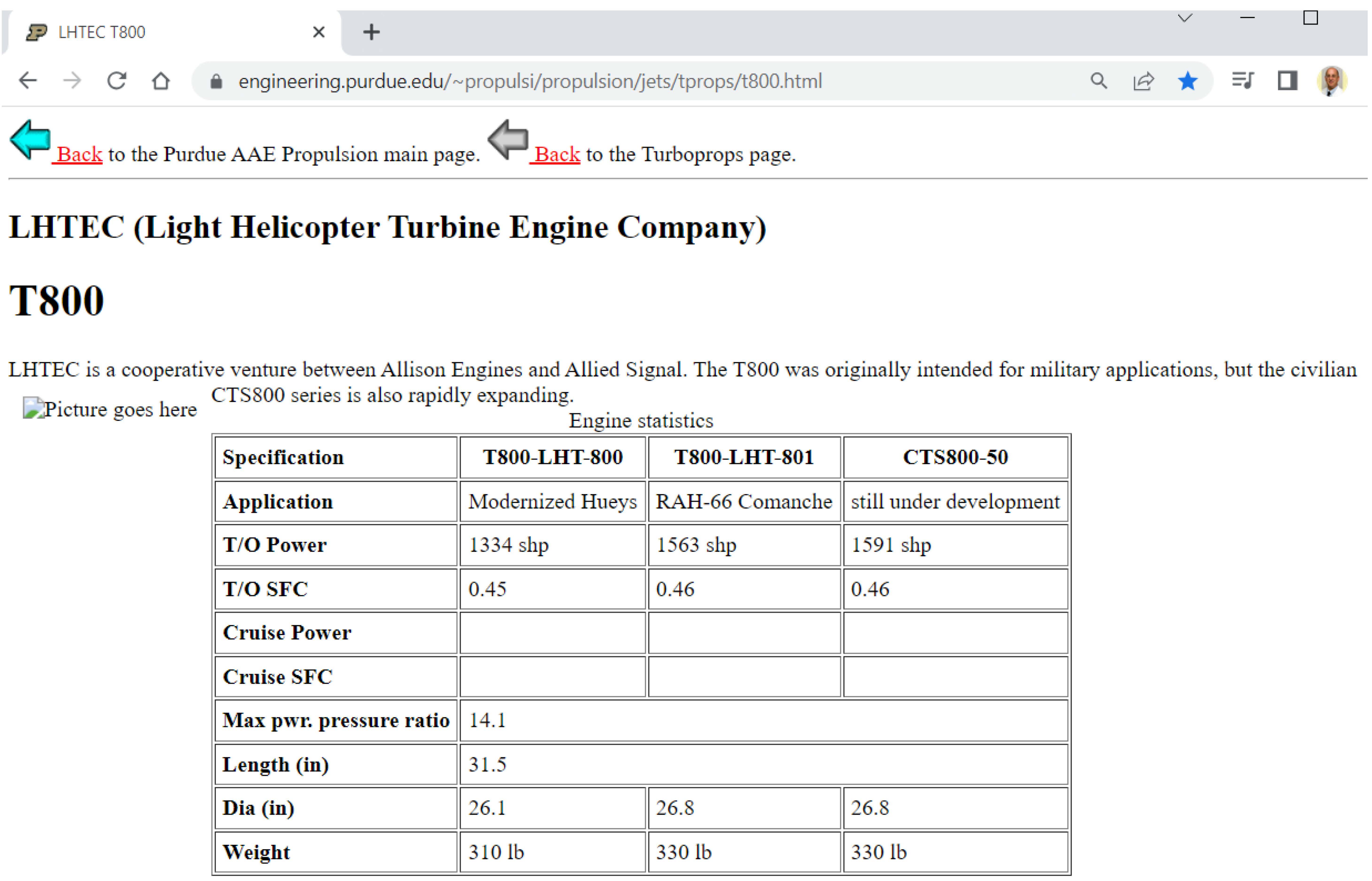
Enter Torque : 945.8 N.m

Enter Speed : 6402 RPM

GO

Power : 850.36 HP

945.8 Nm running at 6402 rpm gives power of 850.36 HP (per engine), and 1701 total HP (for both engines)



LHTEC T800

engineering.purdue.edu/~propulsi/propulsion/jets/tprops/t800.html

Back to the Purdue AAE Propulsion main page. Back to the Turboprops page.

LHTEC (Light Helicopter Turbine Engine Company)

T800

LHTEC is a cooperative venture between Allison Engines and Allied Signal. The T800 was originally intended for military applications, but the civilian CTS800 series is also rapidly expanding.

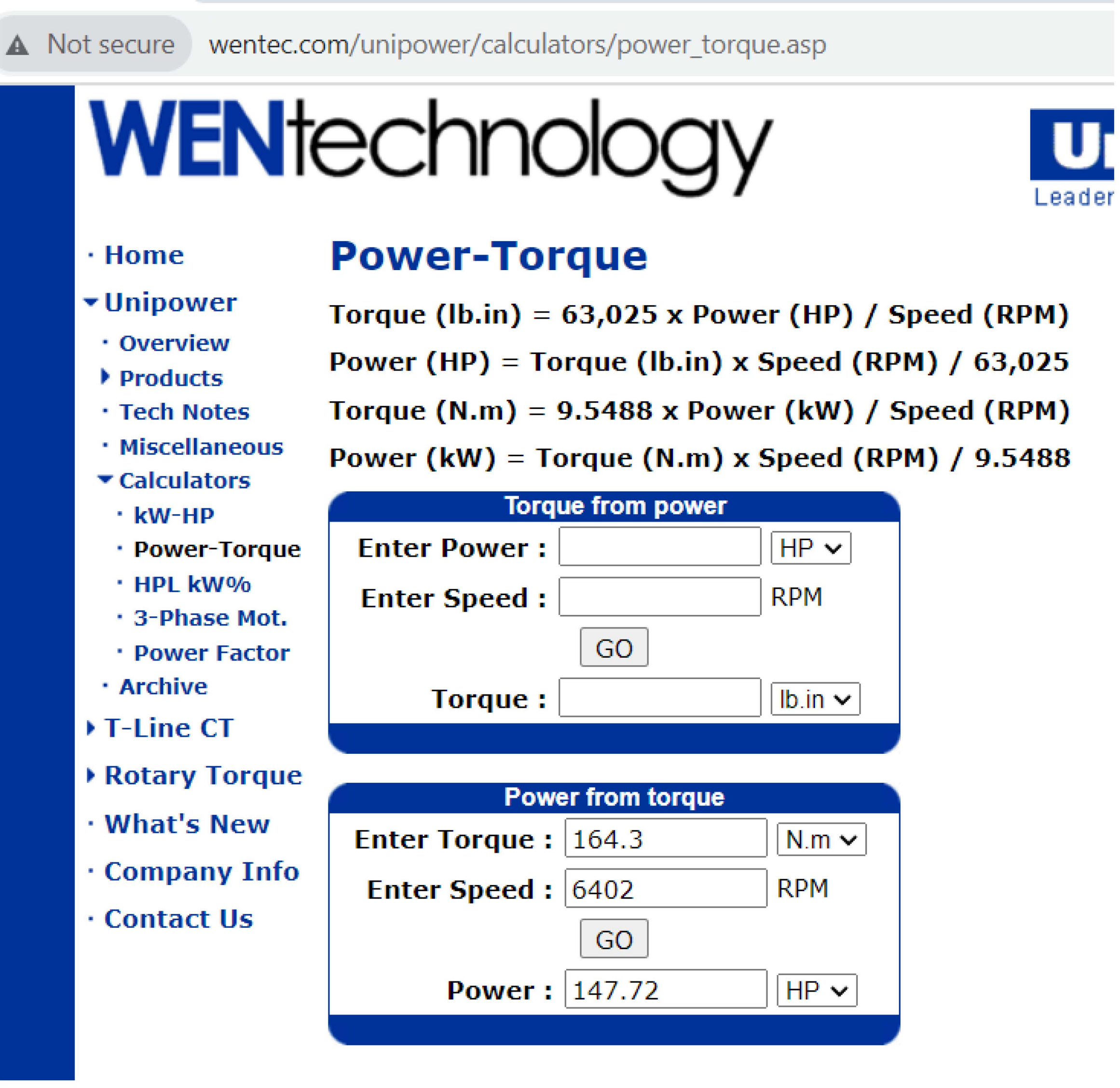
Picture goes here

Engine statistics

Specification	T800-LHT-800	T800-LHT-801	CTS800-50
Application	Modernized Hueys	RAH-66 Comanche	still under development
T/O Power	1334 shp	1563 shp	1591 shp
T/O SFC	0.45	0.46	0.46
Cruise Power			
Cruise SFC			
Max pwr. pressure ratio	14.1		
Length (in)	31.5		
Dia (in)	26.1	26.8	26.8
Weight	310 lb	330 lb	330 lb

SFC (Specific Fuel Consumption) for CTS-800 is 0.46 lbs fuel/HP-Hour

1701 HP x 0.46 lb fuel/HP-Hr = 783 lb/hr or 783/3600 = 0.217 lbs/fuel per second to lift off the drone



147.72 HP x 2 Propellers = 295.4 HP

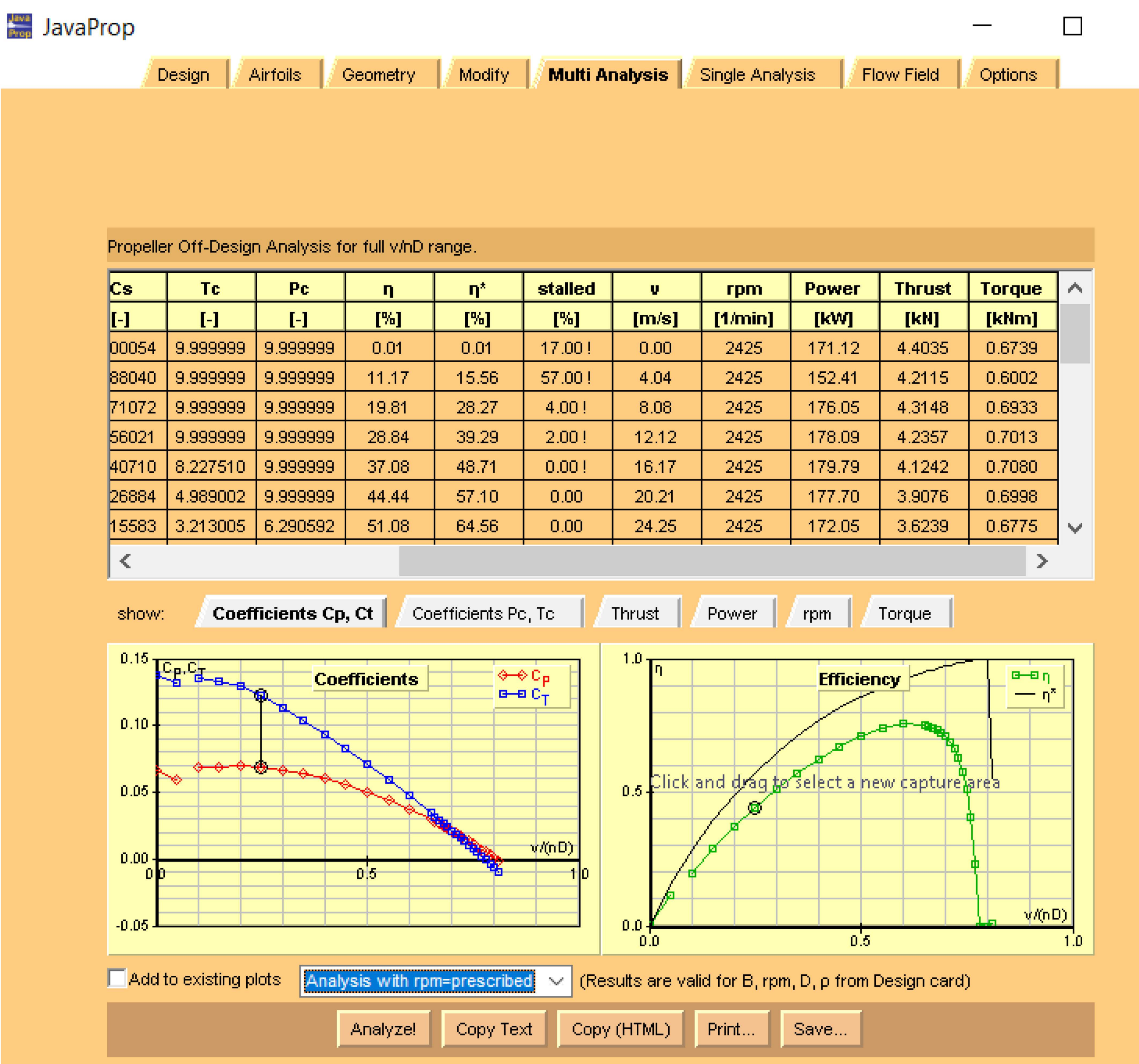
295 HP x 0.46 Lbs fuel/HP-Hr = 136 lbs fuel/hour

Planning take-off fuel load = 600 lbs

Consider safety margin flying time = 3 hours

3hrs x 136 lbs fuel/Hr = 408 lbs fuel, range = 124 mph x 3 = 372 miles

TRANSITION FROM VTOL FLYING TO FIXED WING FLYING



Cs	Tc	Pc	η	η*	stalled	v	rpm	Power	Thrust	Torque
[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[kN]	[kNm]
00054	9.999999	9.999999	0.01	0.01	17.00 !	0.00	2425	171.12	4.4035	0.6739
88040	9.999999	9.999999	11.17	15.56	57.00 !	4.04	2425	152.41	4.2115	0.6002
71072	9.999999	9.999999	19.81	28.27	4.00 !	8.08	2425	176.05	4.3148	0.6933
56021	9.999999	9.999999	28.84	39.29	2.00 !	12.12	2425	178.09	4.2357	0.7013
40710	8.227510	9.999999	37.08	48.71	0.00 !	16.17	2425	179.79	4.1242	0.7080
26884	4.989002	9.999999	44.44	57.10	0.00	20.21	2425	177.70	3.9076	0.6998
15583	3.213005	6.290592	51.08	64.56	0.00	24.25	2425	172.05	3.6239	0.6775

Drone wt (all sources) = 5700 lbs

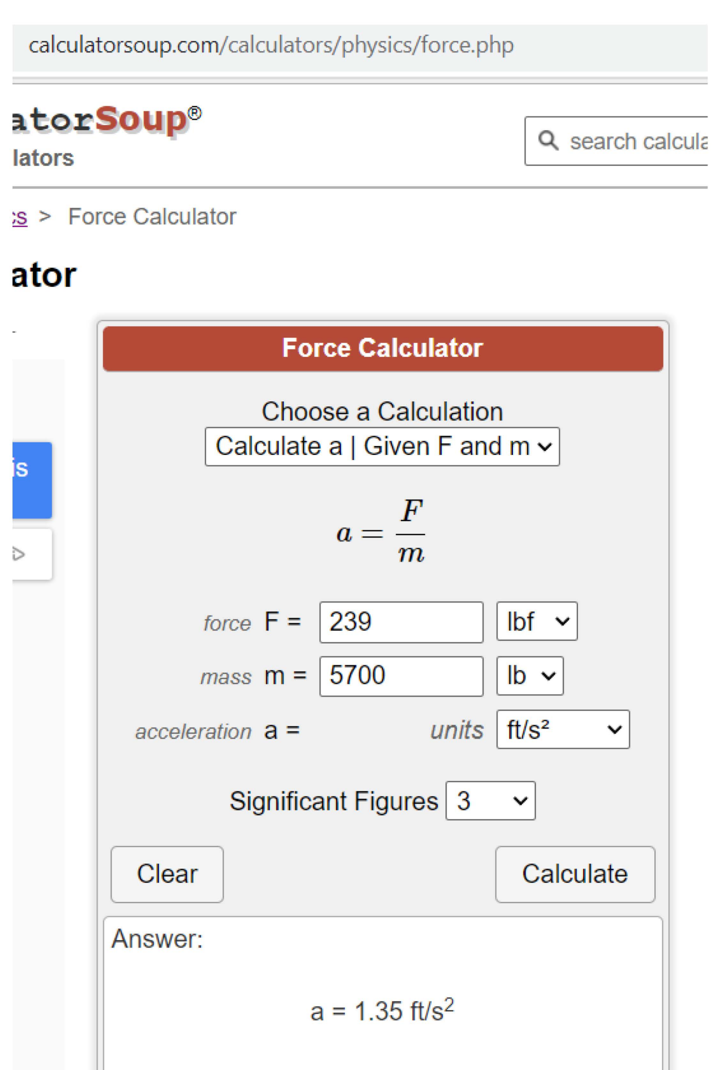
From Javaprop

Rpm = 2425 Thrust = 4.4035 kN (4.4035)x(6) = 26.421 kN

26.421 kN = 5939lbs

5939 lbs - 5700 lbs = 239 lbs thrust in excess

From Acceleration Calculator



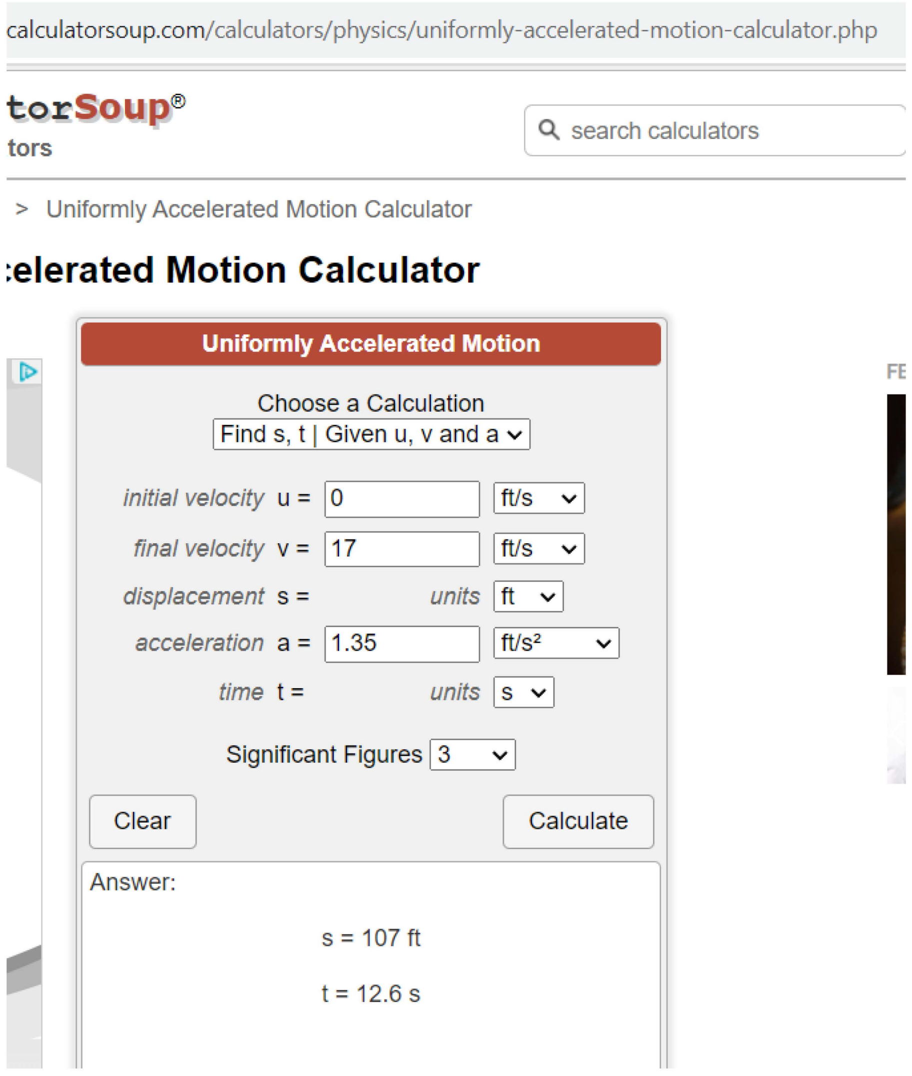
		Landplane (5,100 lb)	Skiplane (5,100 lb) / Seaplane (5,090 lb)
Max. True Level Speed			
Sea Level	mph (kmh)	156 (251)	144 (232)
5,000 ft.	mph (kmh)	163 (262)	151 (243)
True Cruising Speed (300 BHP)			
Sea Level	mph (kmh)	136 (219)	123 (198)
5,000 ft.	mph (kmh)	143 (230)	127 (204)
Economic True Cruising Speed (240 BHP)			
Sea Level	mph (kmh)	125 (201)	110 (177)
5,000 ft.	mph (kmh)	130 (209)	114 (183)
Stalling Speed (I.A.S.)			
Flaps up	mph (kmh)	60 (96)	60 (96)
Flaps "Landing"	mph (kmh)	45 (72)	45 (72)
Take-off distance to clear 50 ft. obstacle			
(Flaps "Take-off", still air ICAO technique)	ft. (m)	1,250 (381)	1,610 (491)
Landing distance over 50 ft. obstacle			
(Flaps "Landing", still air ICAO technique)	ft. (m)	1,250 (381)	1,510 (460)
Initial Rate of Climb (T.O. Power)			
Flaps up	fpm (m/sec)	1,020 (5.2)	920 (5)
Flaps "Take-off"	fpm (m/sec)	730 (3.7)	650 (3.3)
Service Ceiling	ft. (m)	18,000 (5490)	15,750 (4800)

40

Click and drag to select a new capture area

We will limit max upward velocity to 1020 ft/min = 17 ft/sec

Up accel at 1.35 ft/sec² initial vel = 0, final vel = 17 ft/sec



Thus, stay at 1.35 ft/sec² x 12.6 sec rising up 107 ft

To remain at an upward velocity of 17 ft/sec, we need to decrease thrust to be = wt of drone we understand there will be resistance (drag) forces opposing the upward velocity and the thrust needs to actually be (drone wt) + (drag forces), but we will state these forces should be low and we will not include them.

JavaProp

Design | Airfoils | Geometry | Modify | **Multi Analysis** | Single Analysis | Flow Field | Options

Propeller Off-Design Analysis for full v/nD range.

Cs	Tc	Pc	η	η*	stalled	v	rpm	Power	Thrust	Torque
[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[kN]	[kNm]
00054	9.999999	9.999999	0.01	0.01	17.00 !	0.00	2280	142.23	3.8927	0.5957
88040	9.999999	9.999999	11.17	15.56	57.00 !	3.80	2280	126.67	3.7229	0.5305
71072	9.999999	9.999999	19.81	28.27	4.00 !	7.60	2280	146.32	3.8143	0.6128
56021	9.999999	9.999999	28.84	39.29	2.00 !	11.40	2280	148.01	3.7443	0.6199
40710	8.227510	9.999999	37.08	48.71	0.00 !	15.20	2280	149.43	3.6458	0.6259
26884	4.989002	9.999999	44.44	57.10	0.00	19.00	2280	147.70	3.4543	0.6186
15583	3.213005	6.290592	51.08	64.56	0.00	22.80	2280	143.00	3.2034	0.5989

Drone wt (all sources) = 5700 lbs = 23.35 kN

23.35 kN/6 = 3.89 kN needed per prop

From Javaprop

2280 rpm Thrust = 3.892 kN m = 595.7 Nm

F12-125 motor q = 125x2280x0.9/1000 = 257 L/min 257 L/min x 6 = 1542 L/min needed

We are using 2 jets, so 1542/2 = 771 L/min per jet

ΔP = 595.7x63/125x0.9 = 333.6 Bar max ΔP for the VP1-128 variable output pump is 350 Bar

Pump #1 F12-125 limited to max rpm of 4200 q=125x4200x0.9/1000 = 472 L/min

771 L/min - 472 L/min = 299 L/min

m for F12-125 = 125x333.6/63x0.9 = 735.4 Nm at the pump

m at the jet is (4200/6402)x735.4 = 483 Nm at the jet

Pump #2, the F12-90 will not be used for this, it will be turning, but it will be in bypass mode

Pump #3, the VP1-128 will be used to create the remaining needed flow of 299 L/min

STANDARD CONDITIONS

4.10.1 GENERAL

		Landplane (5,100 lb)	Skiplane (5,100 lb) Seaplane (5,090 lb)
Max. True Level Speed			
Sea Level	mph (kmh)	156 (251)	144 (232)
5,000 ft.	mph (kmh)	163 (262)	151 (243)
True Cruising Speed (300 BHP)			
Sea Level	mph (kmh)	136 (219)	123 (198)
5,000 ft.	mph (kmh)	143 (230)	127 (204)
Economic True Cruising Speed (240 BHP)			
Sea Level	mph (kmh)	125 (201)	110 (177)
5,000 ft.	mph (kmh)	130 (209)	114 (183)
Stalling Speed (I.A.S.)			
Flaps up	mph (kmh)	60 (96)	60 (96)
Flaps "Landing"	mph (kmh)	45 (72)	45 (72)
Take-off distance to clear 50 ft. obstacle (Flaps "Take-off", still air ICAO technique)	ft. (m)	1,250 (381)	1,610 (491)
Landing distance over 50 ft. obstacle (Flaps "Landing", still air ICAO technique)	ft. (m)	1,250 (381)	1,510 (460)
Initial Rate of Climb (T.O. Power)			
Flaps up	fpm (m/sec)	1,020 (5.2)	920 (5)
Flaps "Take-off"	fpm (m/sec)	730 (3.7)	650 (3.3)
Service Ceiling	ft. (m)	18,000 (5490)	15,750 (4800)

page from the DHC-2 manual

120 Hp = 89 kW   125 mph = 55.8 meters/sec   55.21 m/s = 123.51 mph

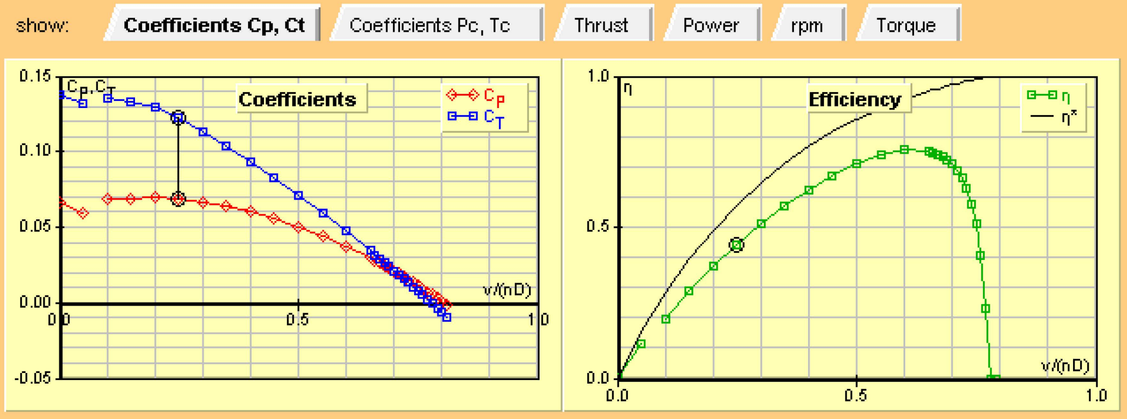
JavaProp

Design | Airfoils | Geometry | Modify | **Multi Analysis** | Single Analysis | Flow Field | Options

Propeller Off-Design Analysis for full v/nD range.

07148	2.156830	3.780986	57.04	71.06	0.00	23.07	1977	89.000	2.2010	429.86
02240	1.486973	2.385785	62.33	76.67	0.00	26.89	2017	89.000	2.0626	421.37
02120	1.039340	1.552989	66.93	81.49	0.00	31.03	2069	89.000	1.9195	410.83
08817	0.726643	1.026826	70.77	85.63	0.00	35.62	2137	89.000	1.7682	397.67
25411	0.500846	0.679478	73.71	89.19	0.00	40.88	2230	89.000	1.6049	381.19
56879	0.333879	0.442388	75.47	92.25	0.00	47.16	2358	89.000	1.4243	360.42
12907	0.207605	0.275802	75.27	94.86	0.00	55.21	2548	89.000	1.2135	333.56
48635	0.186090	0.248631	74.85	95.34	0.00	57.15	2598	89.000	1.1656	327.18
86473	0.165610	0.223117	74.23	95.81	0.00	59.25	2653	89.000	1.1150	320.36

show: **Coefficients Cp, Ct** | Coefficients Pc, Tc | Thrust | Power | rpm | Torque



Add to existing plots   Analysis with P=prescribed   (Results are valid for B, rpm, D, ρ from Design card)

Analyze! | Copy Text | Copy (HTML) | Print... | Save...

From JavaProp

55.21 m/s 2548 rpm 89 kW

1.21 kN 333.56 Nm 2548 rpm = mach 0.783

F12-125 motor

q = 125x2548x0.9/1000 = 287 L/min

P = 333.56x63/125x0.9 = 187 Bar

VP1-128 Pump

Rpm = 287x1000/128x0.9 = 2492 rpm

m = 128x187/63x0.9 = 422.1Nm for pump

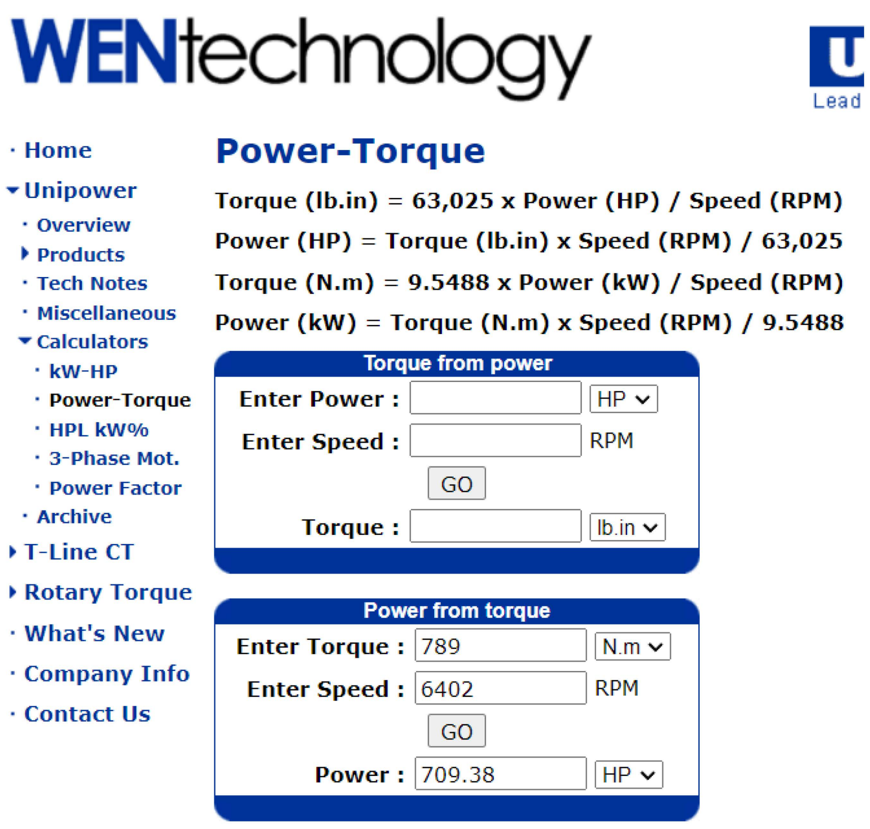
for jet m = (2492/6402)x422.1 = 164.3 Nm

Rpm for the VP1-128 = 299x1000/128x0.9 = 2595 rpm   max rpm for the VP1-128 is 3000 rpm

m for VP1-128 = 128x333.6/63x0.9 = 735.4 Nm at the pump

m at the jet = (2595/6402)x735.4 = 306 Nm at the jet

Total Nm per jet = (Pump #1) 483 Nm + (Pump #3) 306 Nm = 789 Nm



Thus to fly upward
at a steady + vertical velocity of 17 ft/sec needs 709.38 HP per jet

709.38 HP/jet x 2 jets = 1419 HP

1419 HP x 0.46 lbs fuel/Hr-HP = 653 lbs/Hr

653 Lbs fuel/Hr/3600 sec/Hr = 0.18 lbs fuel per second

Thus, to rise the drone up in the air from a starting + vertical velocity to 17 ft/sec and then stay rising upward at a steady + vertical velocity will need as follows:

0+ft/sec↑ to 17 ft/sec↑, needs 12.6 seconds, the drone will be 107 feet in the air

Maintaining a ↑vert velocity for 25 seconds will need 25 seconds of time,
and will rise the drone another 425 feet

0 fts/sec↑ to 17ft/sec↑ in 12.6 sec needs (from before) 850.36 HP per jet

850 HP/jet x 2 jets = 1701 HP, and (1701 Hp x 0.46 lbs fuel/hr-Hp)/3600 sec/hr) = 0.217 lbs fuel/sec

Maintaining a steady upward velocity of 17 ft/sec needs 709.38 HP per jet and 1419 HP for 2 jets

(1419 HP x 0.46 lbs fuel/HP-Hr)/3600 sec/hr = 0.18 lbs fuel/sec

Thus flying from 0 altitude and 0↑ velocity to an altitude of 107ft in the air and moving upward at 17/ft/sec^2
taking 12.6 sec and then flying ↑ at 17 ft/sec x 25 more seconds the drone will rise up
107 ft + 425 ft = to a final altitude of 532 feet and this will take (12.6 + 25 seconds) = 37.6 seconds.

Fuel use will be (0.217 lbs fuel/sec)x(12.6 sec) = 2.73 lbs of fuel
plus (0.18 lbs fuel/sec)x(25 sec) = 4.5 lbs of fuel

Thus the drone with 1000lbs of payload and 600lbs of fuel will take off from the ground and go straight up for 37.6 seconds, burning 7.23 lbs of fuel and it will then be 532 feet up in the air.

TRANSITION OF DRONE

FROM HORIZ AIRSPEED = 0 TO HORIZ AIRSPEED = 125MPH

Important to understand, there are tilt rotors on the drone, thus the thrust output of the propellers can be adjusted to 100% vertical thrust down to 100% horizontal thrust towards the tail of the drone, and values in between where some of the thrust is directed as vertical thrust down and the rest of the thrust is directed as horizontal thrust towards the back of the drone.

Another important point to understand is that as the horizontal thrust increases the horizontal airspeed of the drone, the fixed wings of the drone will begin to create upward thrust (lift) and this upward thrust will act to decrease the amount of gravitational down force acting on the drone to pull it downward.

		Landplane (5,100 lb)	Skiplane (5,100 lb) Seaplane (5,090 lb)
Max. True Level Speed			
Sea Level	mph (kmh)	156 (251)	144 (232)
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Landing distance over 50 ft. obstacle (Flaps "Landing", still air ICAO technique)	ft. (m)	1,250 (381)	1,510 (460)
Initial Rate of Climb (T.O. Power)			
Flaps up	fpm (m/sec)	1,020 (5.2)	920 (5)
Flaps "Take-off"	fpm (m/sec)	730 (3.7)	650 (3.3)
Service Ceiling	ft. (m)	18,000 (5490)	15,750 (4800)

40

Click and drag to select a new capture area

from the DHC-2 flight manual

The lift of the wings is related to the square of the airspeed. The stalling speed of the drone is listed as 60 mph. Thus at 60 mph the lift from the wings is = to the weight of the drone = 5700lbs. We understand the stall speed is listed in the DHC-2 manual for a plane weight of 5100 lbs, and we are applying this to a plane wt of 5700 lbs, we feel this does not introduce too much of an error.

Thus to calculate the airspeed where the lift is ½ the weight of the drone, we can use this equation:

$(60mph)^2/(½\ lift\ mph)^2 = 2$, rearranging terms, $(½\ lift\ mph)^2 = (60)^2/2 = 1800$

and $\sqrt{1800}$ = ½ lift mph = 42 mph, we will use 40 mph

The same math can be used on 40 mph to find the mph where the lift from the wings is ¼ of the weight of the drone, $= (\sqrt{(40)^2})/2 = \sqrt{800} = 28$

we will use 30mph

We will bring the plane to stable level fixed wing flying in 4 steps.

Step 1) the plane moves directly upward to an altitude of 532 feet

Step 2) the plane adds horizontal airspeed up to 30 mph

Step 3) the plane adds additional horizontal airspeed to go from 30 mph to 40 mph

Step 4) the plane adds additional horizontal airspeed to go from 40 mph to 60 mph

The 2 jet engines remain at their full power the whole time. Total thrust from the six propellers remains at 5939 lbs the whole time. This 5939 lbs of thrust is allocated between vertical thrust and horizontal thrust through use of the tilt rotor function present for all of the six propellers.

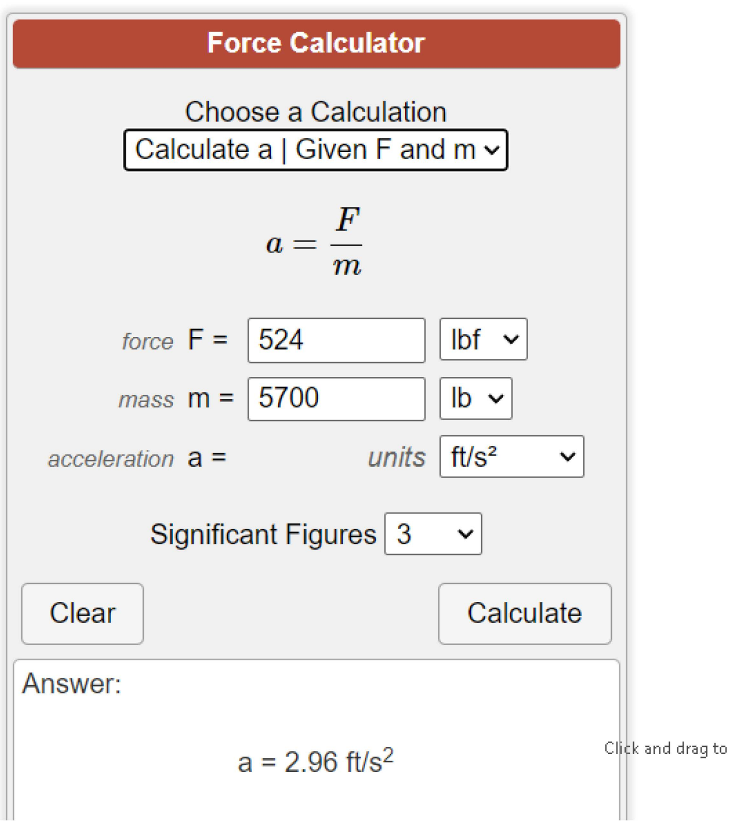
We have already discussed how the drone rose up in the air to an altitude of 523 feet.

Horizontal airspeed from 0 mph to 30 mph

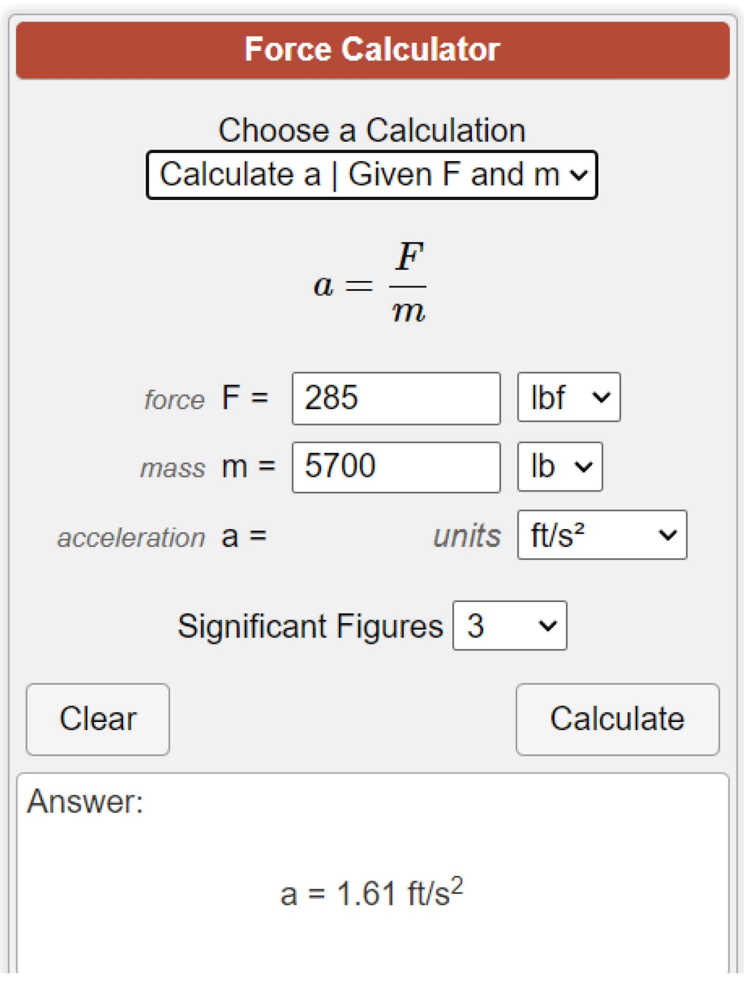
The rotors are tilted so that vertical thrust is 5415 lbs. ↓ force on the drone is 285 lbs.

Note: ↓ force is force pulling the drone down toward the ground,
↑ force is force pushing the drone up, → force is horizontal force pushing the drone flying forward

→ force on the drone is (285 + 239) = 524 lbs →, accel → is 2.96 ft/sec²

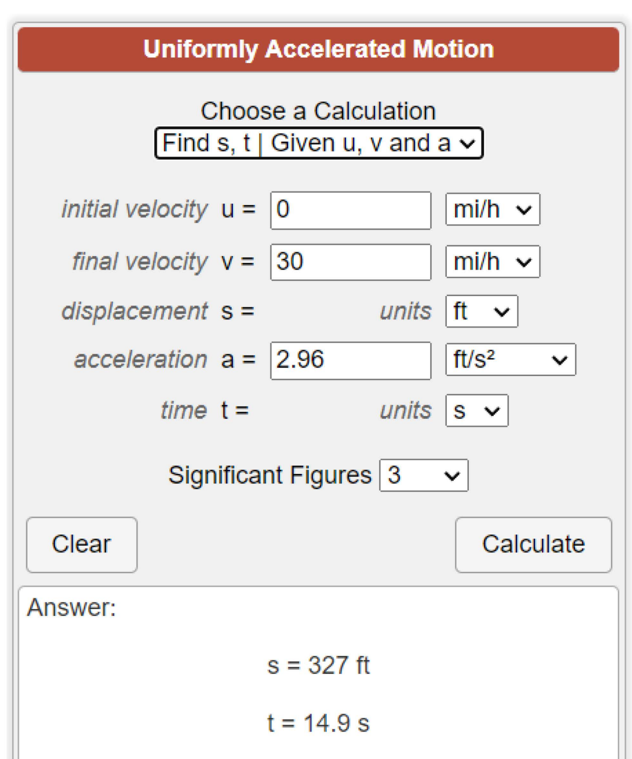


↓ force on the drone is 285 lbs



↓ accel on the drone is 1.61 ft/sec²↓, or -1.61 ft/sec²

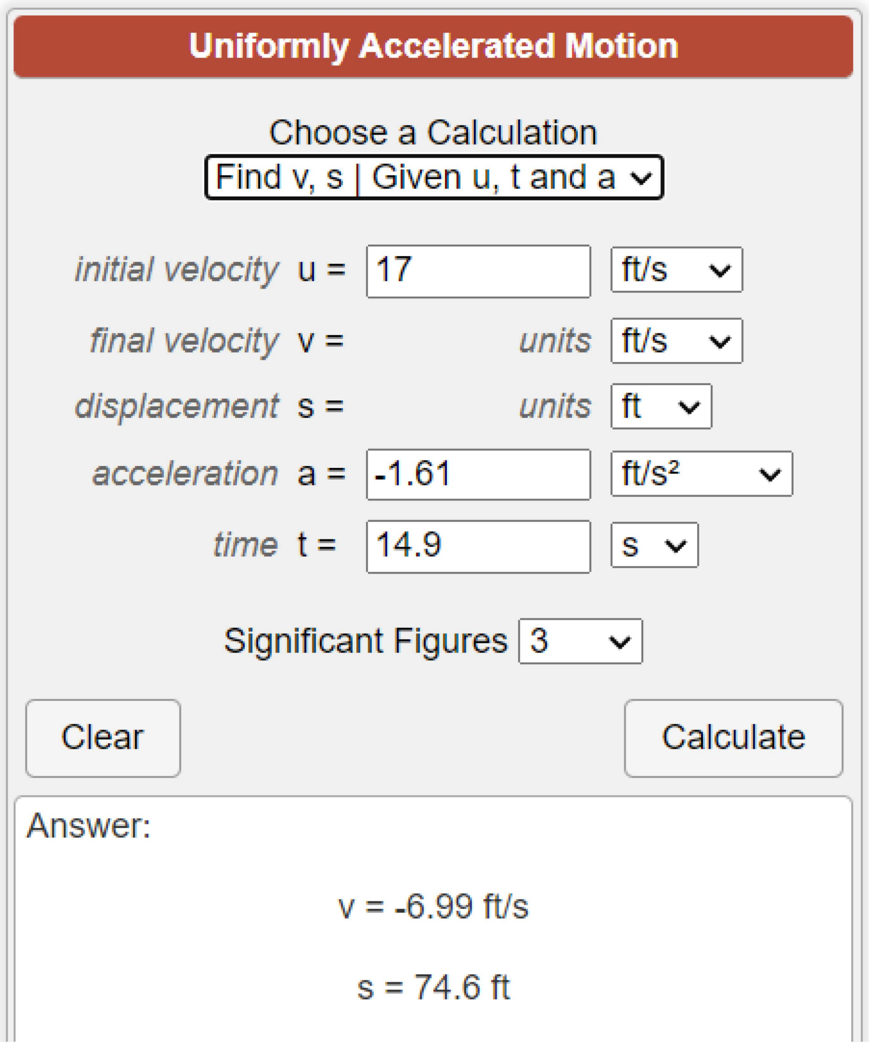
Travel horizontally is:



Remember, when the drone arrives to 532 feet altitude it is traveling up at 17 ft/sec

Remember it took 14.9 sec for the drone to go from airspeed 0 to airspeed 30 mph

For the 0 mph to 30 mph airspeed change, the vertical component follows:



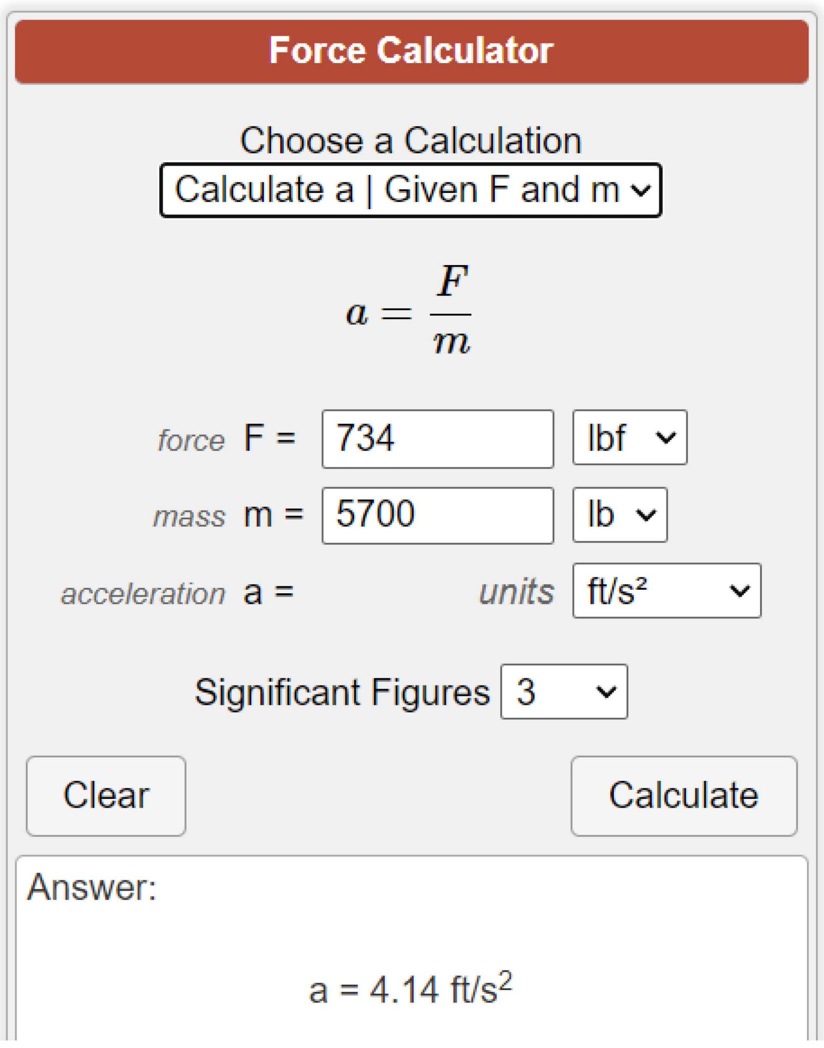
Now that the drone has an airspeed of 30mph, the wings are giving it lift equal to ¼ of its weight. The ↓ force on the drone is now ¾ of its weight. ¾ x 5700 lbs is 4275 lbs

From Javaprop, at 30 mph, keeping the prop torque the same at 673.9 Nm, the thrust from the prop is 3.925 kN per prop. 3.925 x 6 = 23.55 kN = 5294 lbs

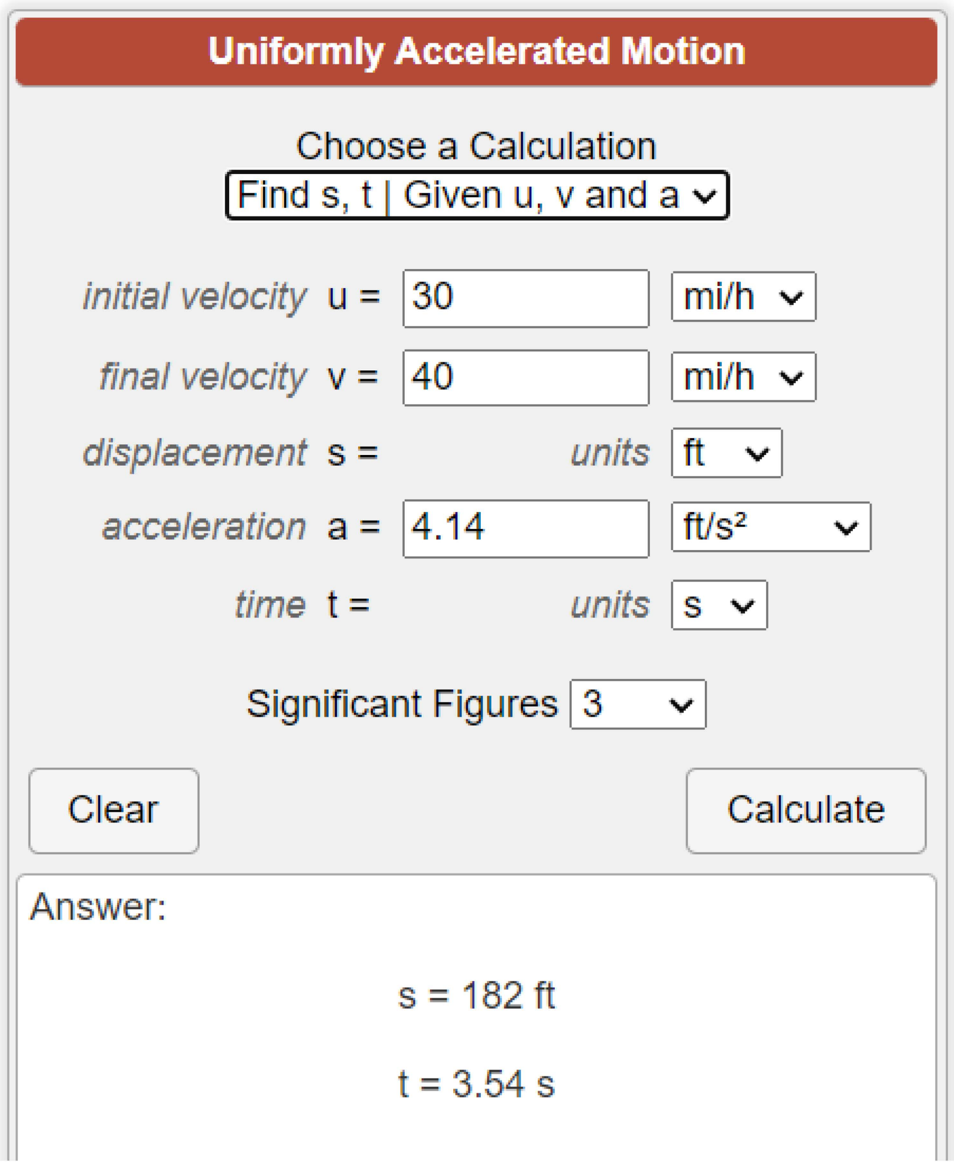
↑ thrust is adjusted so there is a net + ↑ thrust on the drone of 285 lbs. ↓ force will be drone wt of 4275 lbs

Final ↑ thrust will be 4275lbs + 285 lbs = 4560 lbs

Total thrust is 5294 lbs, 5294 lbs - 4560 lbs ↑ thrust leaves remaining 734 lbs of → thrust



To go from 30 mph to 40 mph airspeed with accel = 4.14 ft/sec²



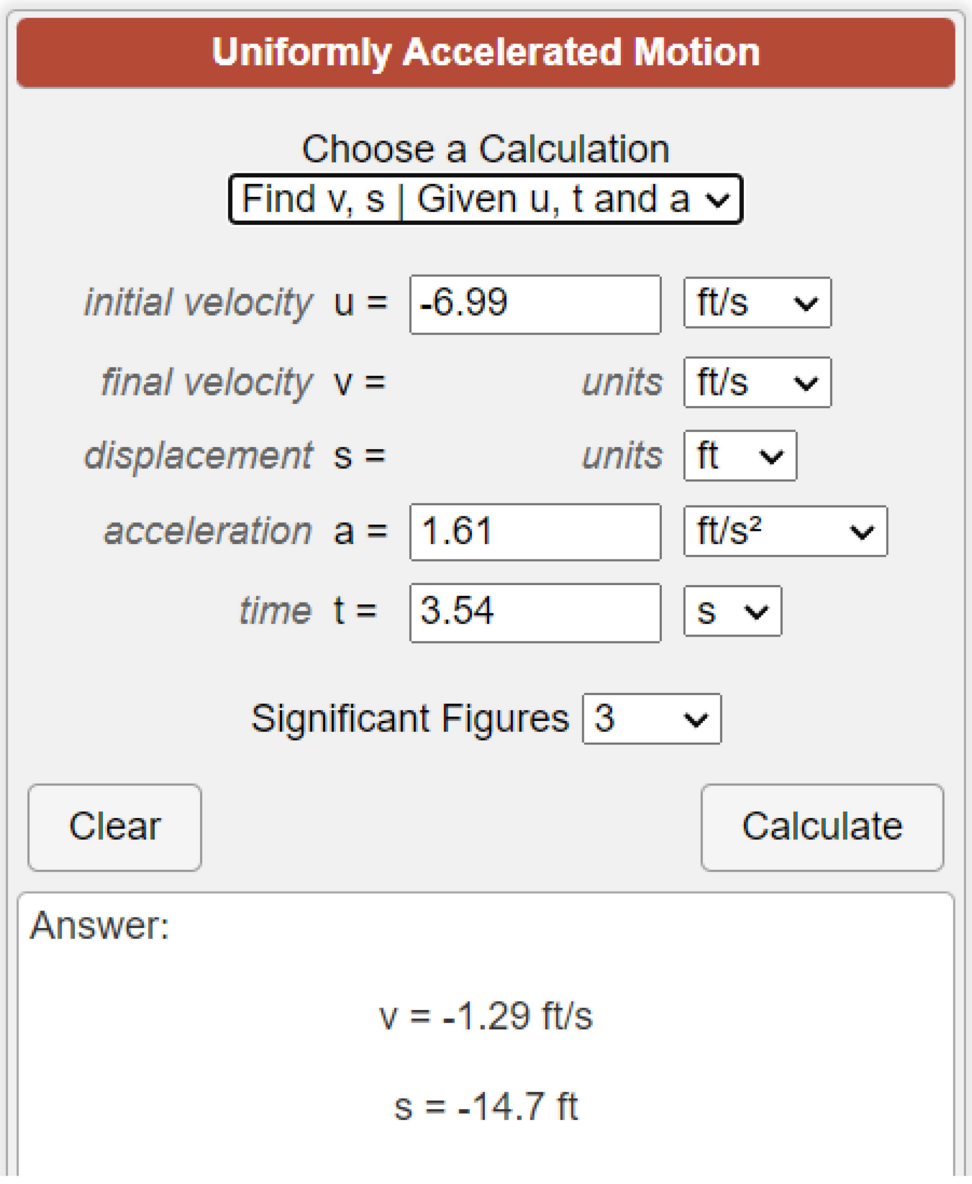
Thus, from the horizontal viewpoint, the drone going from 30 mph to 40 mph will travel a horizontal distance of 182 feet and it will take 3.54 sec to get to 40 mph

When the drone went from 0 airspeed to 30 mph airspeed, there was a vertical component that occurred.
When the drone achieved an airspeed of 30 mph,
the drone will have dropped down vertically 74 feet and will have a ↓ vertical velocity of 6.99 ft/sec,
which is also written as -6.99 ft/sec.

While the drone was going from airspeed 30 mph to airspeed 40 mph, there was also an effect on its status with respect to vertical.

At 30 mph, the vertical status of the drone is that it was lower down by 74.6 feet and it had a negative vertical velocity of -6.99 ft/sec.

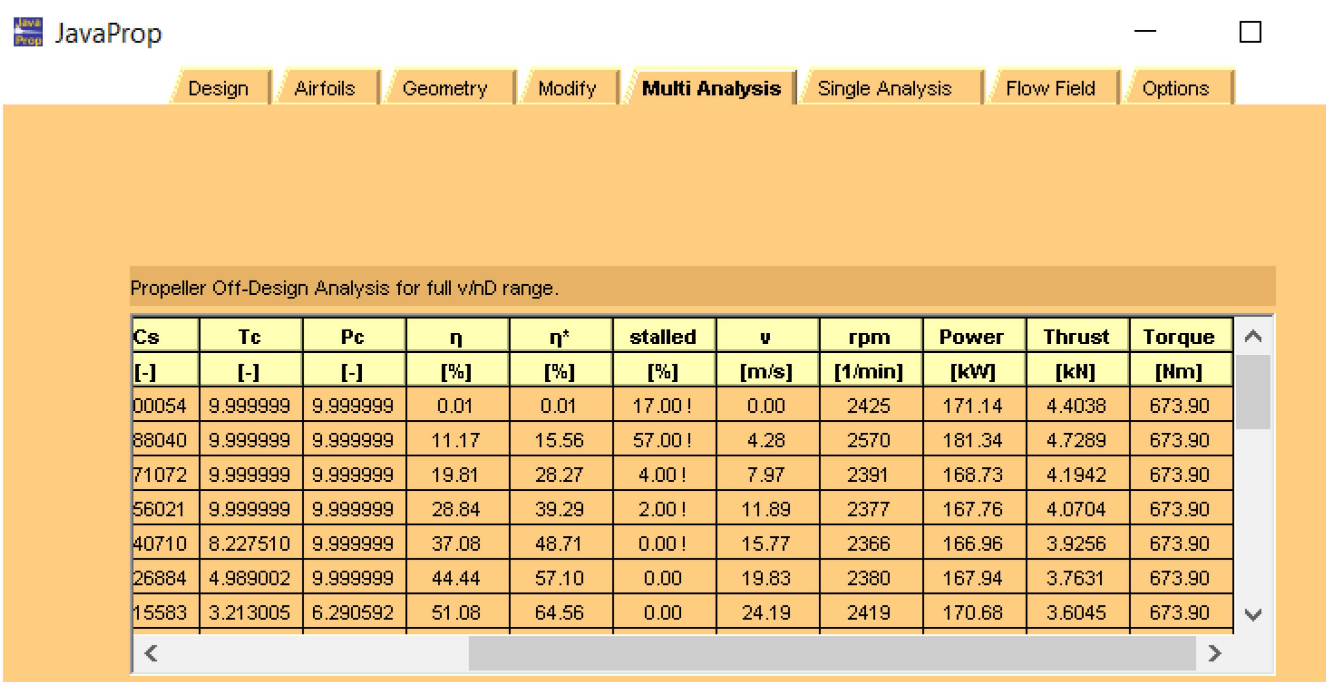
At 30 mph, the tilt rotors were adjusted so that the vertical thrust was equal to:
the ↓ directed weight of the drone plus 285 lbs. The ↓directed weight of the drone was equal to its mass derived weight (5700 lbs) - (¼ of 5700lbs) which is the upward thrust (lift) on it from its wings because it has an airspeed. The net upward directed thrust was 285 lbs. And 285 lbs of ↑ directed thrust on the drone with mass 5700 lbs will give it an ↑ directed acceleration of 1.61 ft/sec²



Thus while going from an airspeed of 30 mph to an airspeed of 40 mph, the drone went vertically ↓ by 14.7 feet and its ↓ directed velocity went from 6.99 ft/sec ↓ to 1.29 ft/sec ↓

At an airspeed of 40 mph, the wings of the drone provide an ↑ directed force (lift) of ½ of the wt of the drone. 5700lbs/2 = a ↓ weight of 2850 lbs

At 40 mph from Javaprop, keeping the propeller torque at 673.9 Nm at 40 mph = 17.8 m/sec prop thrust is 3.76 kN 3.76x6 = 22.56 kN = 5071 lbs of thrust available.



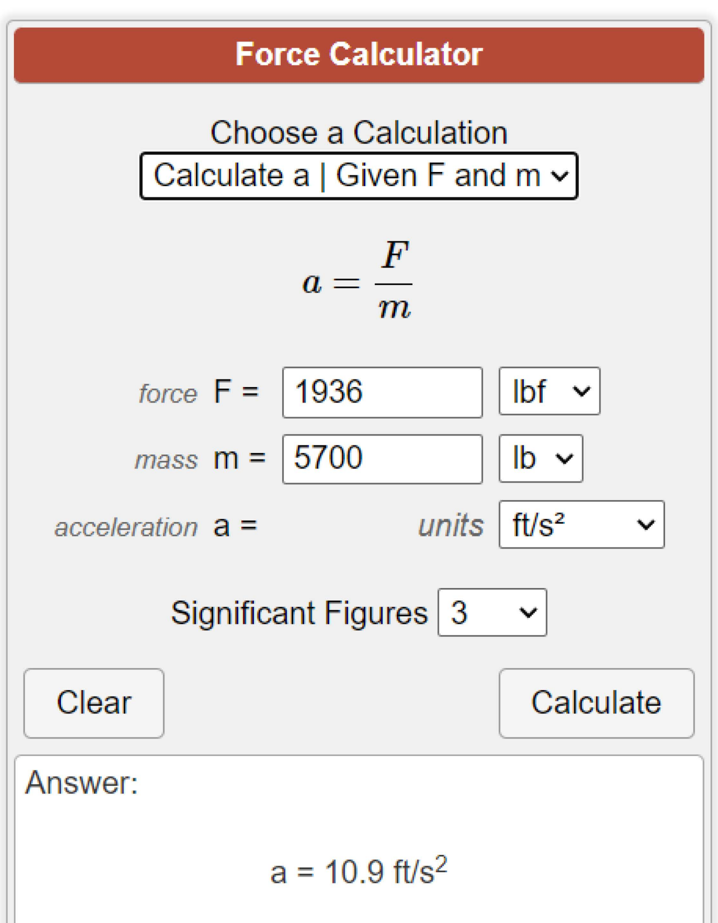
Propeller Off-Design Analysis for full v/nD range.

Cs	Tc	Pc	η	η*	stalled	v	rpm	Power	Thrust	Torque
[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[kN]	[Nm]
00054	9.999999	9.999999	0.01	0.01	17.00 !	0.00	2425	171.14	4.4038	673.90
88040	9.999999	9.999999	11.17	15.56	57.00 !	4.28	2570	181.34	4.7289	673.90
71072	9.999999	9.999999	19.81	28.27	4.00 !	7.97	2391	168.73	4.1942	673.90
56021	9.999999	9.999999	28.84	39.29	2.00 !	11.89	2377	167.76	4.0704	673.90
40710	8.227510	9.999999	37.08	48.71	0.00 !	15.77	2366	166.96	3.9256	673.90
26884	4.989002	9.999999	44.44	57.10	0.00	19.83	2380	167.94	3.7631	673.90
15583	3.213005	6.290592	51.08	64.56	0.00	24.19	2419	170.68	3.6045	673.90

The tilt rotors are adjusted so that the vertical ↑ thrust applied to the drone is equal to its ↓ directed wt of:
(5700/2) = 2850 lbs + an added 285lbs of ↑ force

This is 2850+285 = 3135 lbs of ↑ thrust.

Thrust available for → directed force is thus the total thrust of 5071 lbs - the 3135 lbs used for ↑ directed thrust.
5071lbs - 3135 lbs = 1936 lbs thrust as → directed force



Thus the drone can be accelerated from 40 mph to 60 mph using 1936 lbs of → directed force. This results in an → directed acceleration of 10.9 ft/sec²

FROM A VERTICAL PERSPECTIVE

From before: The drone went from 0 altitude and 0↑ velocity to an altitude of 107ft ↑ in the air and moving upward at 17/ft/sec². Total vertical flight activity is discussed as follows:

12.6 sec of accelerated vertical flying ↑to be flying ↑ at 17 ft/sec, and then continuing flying ↑x 25 more seconds at constant ↑ vertical flying speed of 17 ft/sec

from a vertical distance viewpoint the effect of the flying activity listed will be that the drone will rise up

107 ft + 425 ft = to a final altitude of 532 feet and this will take (12.6 + 25 seconds) = 37.6 seconds.

Fuel use to get the drone from 0 altitude to 532 ft altitude will be
(0.217 lbs fuel/sec)x(12.6 sec) = 2.73 lbs of fuel plus (0.18 lbs fuel/sec)x(25 sec) = 4.5 lbs of fuel

Thus the drone with 1000lbs of payload and 600lbs of fuel will take off from the ground and go straight up for 37.6 seconds, burning 7.23 lbs of fuel and it will then be 532 feet up in the air.

FROM A HORIZONTAL VIEWPOINT

After the drone first moved vertically upward to an altitude of 532 feet, it then began to give itself horizontal velocity (airspeed).

From a horizontal distance traveled viewpoint
the drone traveled horizontally (327ft + 182 ft + 197 Feet) = 706 feet horizontally

Time for the drone to change from a horizontal airspeed 0f 0 to a horizontal airspeed of 60 mph was:
(14.9 sec + 3.54 sec + 2.69 sec) = 21.13 seconds.

FROM A FUEL USE VIEWPOINT

The drone was on full normal jet engine power for all of this. This is 2 jets at 850.36 HP each, total 1701 HP

(1701 HP x 0.46 lbs fuel/HP-Hr)/3600 sec/hr = 0.21 lbs fuel per second

Total vertical flying time was 37.6 sec, thus

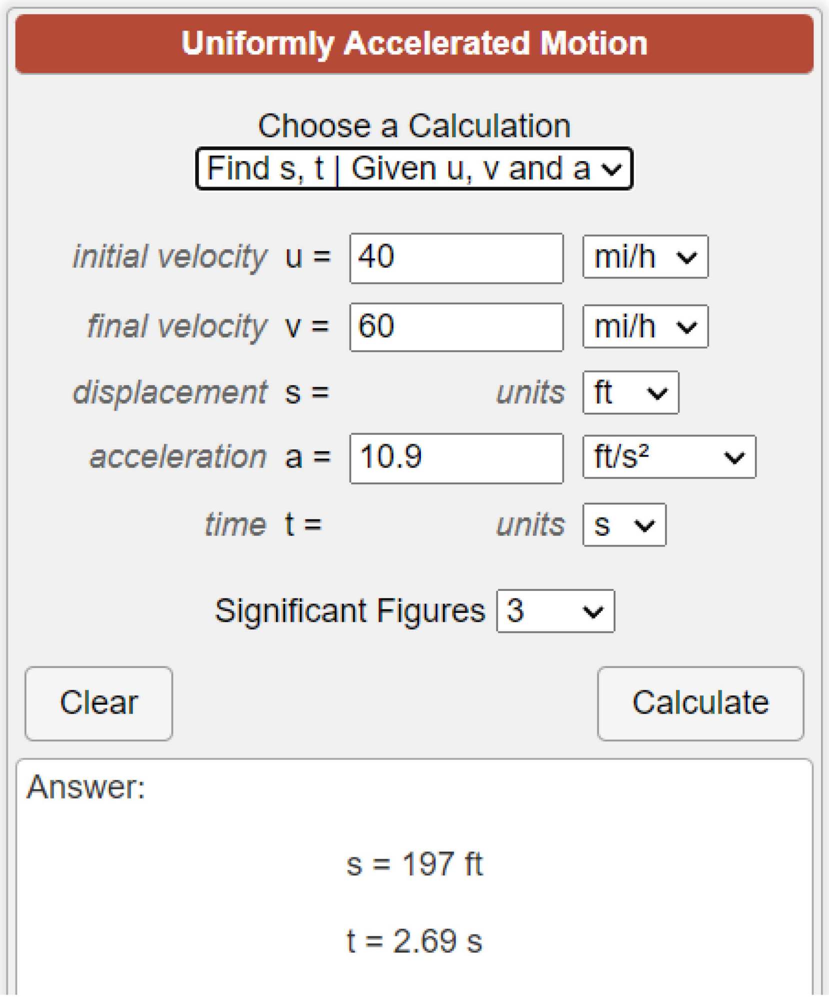
Fuel use to get the drone from 0 altitude to 532 ft altitude will be
(0.217 lbs fuel/sec)x(12.6 sec) = 2.73 lbs of fuel plus (0.18 lbs fuel/sec)x(25 sec) = 4.5 lbs of fuel

Total horizontal flying time was 21.13 seconds, thus

21.13 seconds x 0.21 lbs of fuel per second = 4.44 lbs of fuel

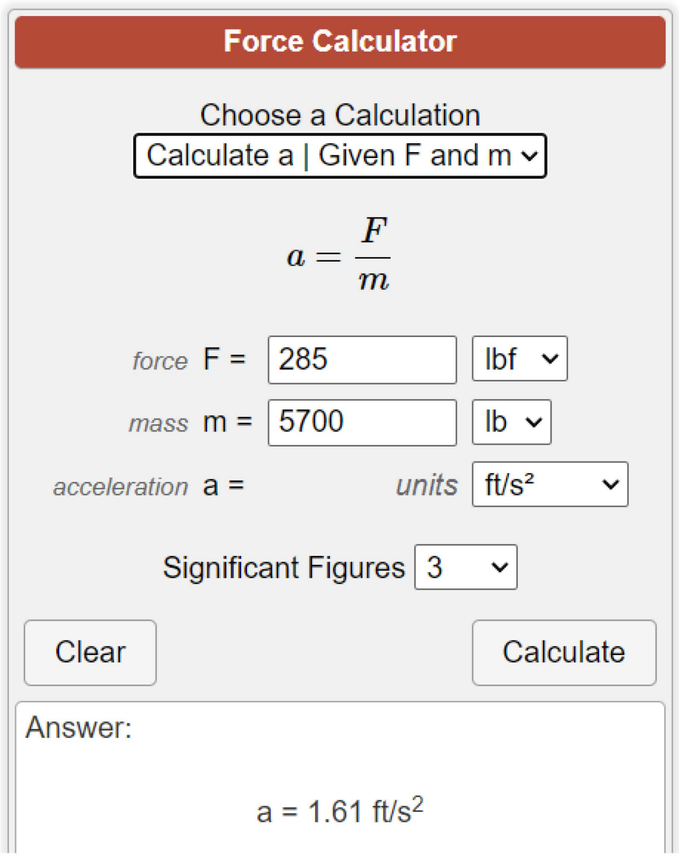
This means the deHavilland DHC-2 weighing: 3000 lbs + 1100 lbs VTOL parts + 600lbs fuel payload + 1000lbs non-fuel payload was sitting on the ground at 0 altitude and 0 horizontal airspeed, and then the drone changed its status to being (523 ft - 85.6 ft) = 437.4 feet altitude, and flying with a horizontal airspeed of 60 mph. Of note, the stall speed of the drone is 60 mph, so this means it is now in stable horizontal flight and does not need any vertical thrust to stay up in the air.

This transition of the flight status of the drone took (37.6 + 21.13) = 58.73 seconds and used up (4.5 + 4.44) = 8.94 lbs of fuel.

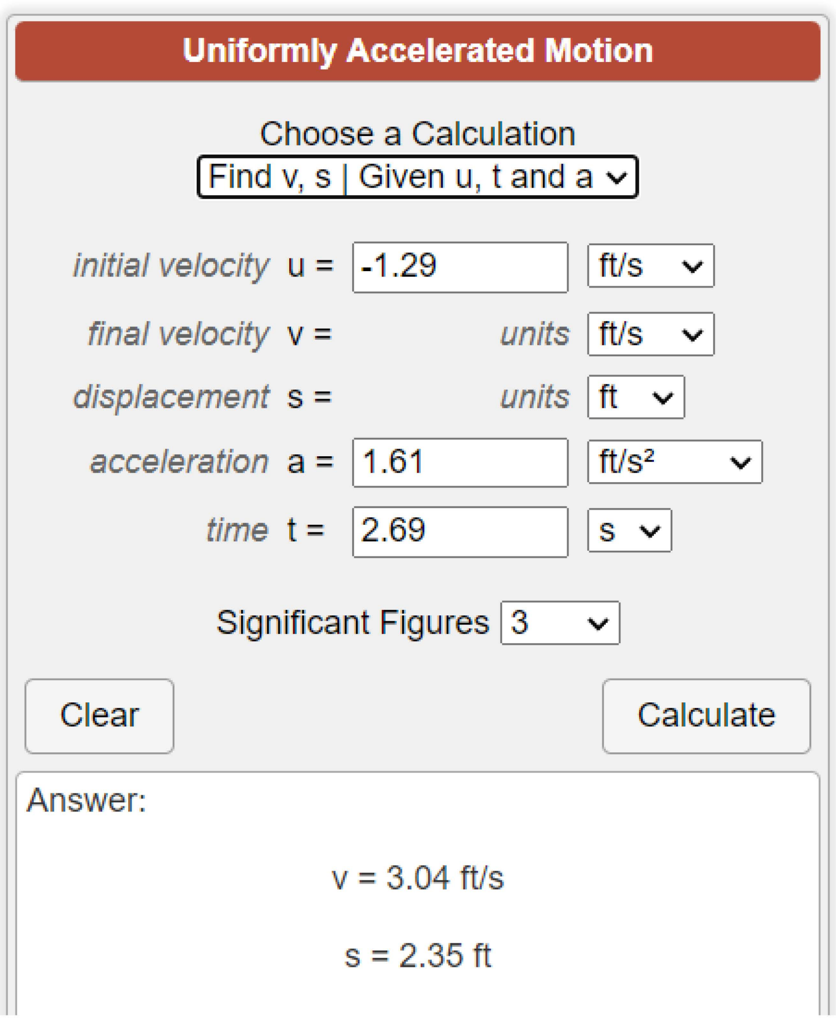


From the horizontal viewpoint, thus, the drone will change from an → airspeed of 40 mph to an airspeed of 60mph over a time of 2.69 seconds and it will travel in the → direction a distance of 197 feet.

With respect to the vertical viewpoint, again the drone is given a net ↑ force of 285 lbs in excess of its gravity directed ↓ force, so that it has an ↑ directed acceleration of 1.61 ft/sec²



The drone in going from 0 mph airspeed to 30 mph airspeed had a ↓ directed drop of 74.6 feet. In going from 30 mph airspeed to 40 mph airspeed, it had a ↓ directed drop of 14 feet.



From the vertical viewpoint, the drone in going from 40 mph airspeed up to 60 mph airspeed had a ↑ vertical ascent of 2.35 feet and when it arrived at 60 mph airspeed it had an ↑ directed vertical velocity of 3.04 ft/sec

The vertical related summary then is that the drone as it went from a horizontal airspeed of 0 mph to 60 mph had a vertical ↓ directed drop in altitude of (74.6 ft + 14 ft) = 88.6 ft directed ↓ down. It then had in the last 2.69 seconds a vertical ↑ directed ascent of 3.04 feet.

The net result is that the drone had a vertical drop of 85.6 feet.

From a horizontal viewpoint the drone traveled horizontally (327ft + 182 ft + 197 Feet) = 706 feet horizontally

Time for the drone to change from 0 horizontal airspeed to 60 mph horizontal airspeed was:
(14.9 sec + 3.54 sec + 2.69 sec) = 21.13 seconds.

The drone was on full normal jet engine power for all of this. This is 2 jets at 850.36 HP each, total 1701 HP

(1701 HP x 0.46 lbs fuel/HP-Hr)/3600 sec/hr = 0.21 lbs fuel per second

21.13 seconds x 0.21 lbs of fuel per second = 4.44 lbs of fuel

CAN THE DRONE FLY AT ITS RECOMMENDED MAX AIRSPEED OF 143 MPH

From the DHC-2 manual (section 4.10.1) the max airspeed for the drone at its max AUW (All Up Weight, the manual defines AUW as the weight of the drone and everything in it). The manual uses an AUW of 5100lbs, but Viking is listed as upgrading the DHC-2 to a max AUW of 6000lbs

The manual lists that it takes 300hp to fly the DHC-2 at 143 mph. We will do this with the drone using two propellers at 150 hp each. 150 hp is 112 kW. 143 mph is 63.92 m/sec

From JavaProp, rpm 2864, airspeed 63.97 m/sec, thrust 1.2996 kN, torque 373.42 Nm

Motor for the two props is the F12-125. q=125x2864/1000x0.9 = 398 L/min

Motor Bar = 373.42x63/125x0.9 = 209.1 Bar

Pump #1 is F12-90, Pump #2 is VP1-128 F12-90 at 4140rpm q=346.5 L/min

F12-90 m= 93x209.1/63x0.9 = 343 Nm at the pump. At jet is (4140/6402)x343 = 222 Nm at jet

Flow needed is 398, so VP1-128 supplies (398-346.5) = 51.5 L/min

VP1-128 is variable displacement, it is running at 3000 rpm Disp= 51.5x1000x0.9/3000 = 15.45 cm^3/rev

Vp1-128 m= 15.45x209.1/63x0.9 = 57 Nm at the pump. At jet is (3000/6402)x57 = 27 Nm at jet

222 Nm at 6402 rpm is 199.6 hp, 27 Nm at 6402 rpm is 24 hp. (199.6 hp+24 hp) = 223.6 hp per jet

Total jet torque load at the jet per jet is (222+27 Nm) at 6402 rpm which is 223.6 Hp per jet.

223.6 Hp per jet x 2 jets = 447.2 Hp to fly the drone at its recommended max airspeed of 143 mph

447.2 hp x 0.46 lbs fuel/Hr-Hp is 205.7 lbs fuel/hr to fly at 143 mph.

Remembering it is 136 lbs fuel/hr to fly the drone at is listed best cruising airspeed of 125 mph

CAN THE DRONE DO DRONE FLYING AT ALTITUDE OF 13000 FT ?

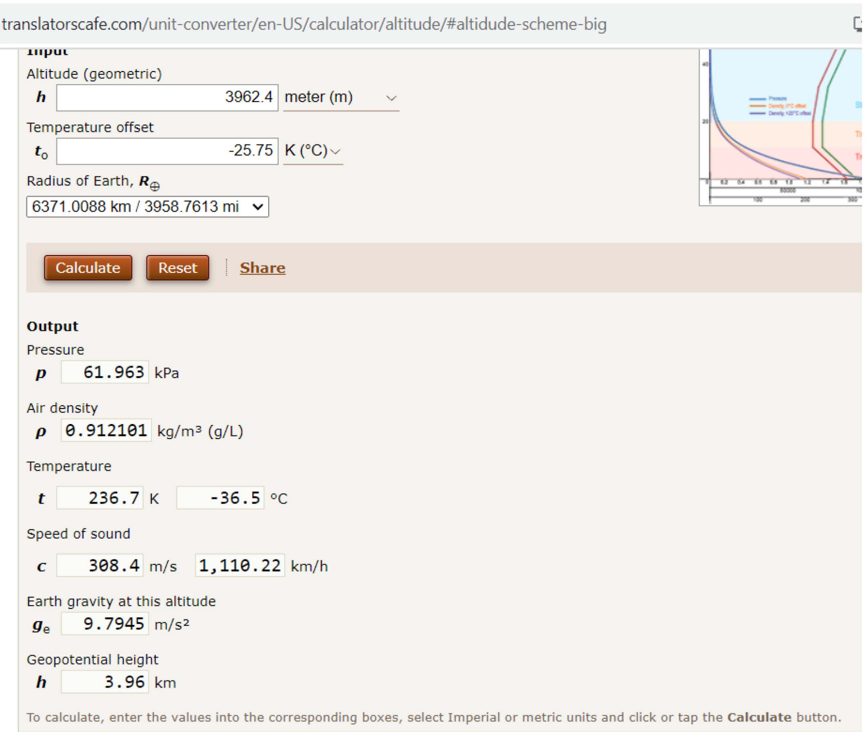
We took the drone to Gunnison, Colorado for a year for feasibility, safety, and algorithm testing

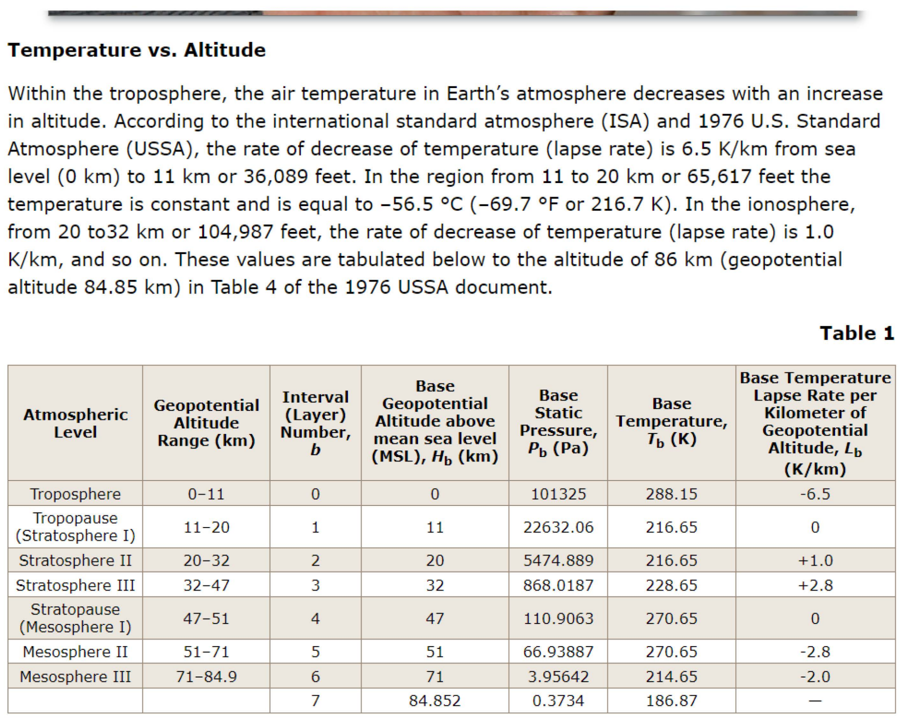
During time intervals when the science and safety teams were analyzing and compiling data, the pilots were told to spend time with the drone doing flying, take-offs, and landings.

In one YouTube we discussed the pilots flying in valleys that lead up to peaks. In Gunnison, some peaks are at 12000 ft altitude. Valleys floors leading to the peak began at 5000ft altitude

The question is whether the VTOL system of the drone could do drone flying at these altitudes

Air parameters at 13000ft altitude must be established and sent to JavaProp to eval the propellers



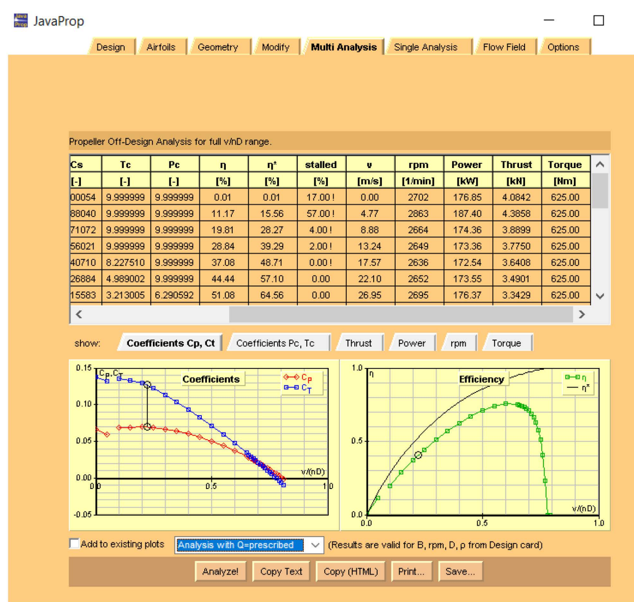


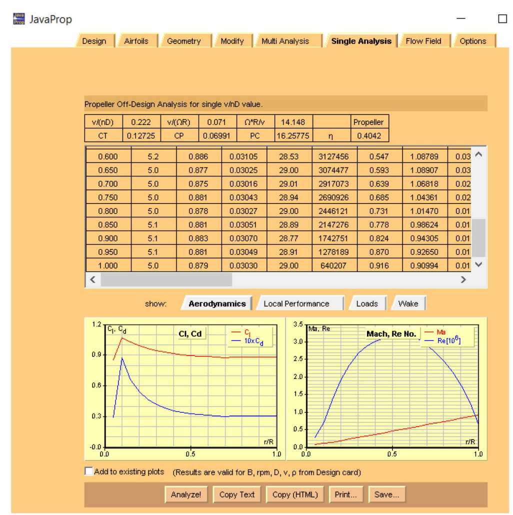
Temperature vs. Altitude

Within the troposphere, the air temperature in Earth's atmosphere decreases with an increase in altitude. According to the international standard atmosphere (ISA) and 1976 U.S. Standard Atmosphere (USSA), the rate of decrease of temperature (lapse rate) is 6.5 K/km from sea level (0 km) to 11 km or 36,089 feet. In the region from 11 to 20 km or 65,617 feet the temperature is constant and is equal to −56.5 °C (−69.7 °F or 216.7 K). In the ionosphere, from 20 to32 km or 104,987 feet, the rate of decrease of temperature (lapse rate) is 1.0 K/km, and so on. These values are tabulated below to the altitude of 86 km (geopotential altitude 84.85 km) in Table 4 of the 1976 USSA document.

Table 1

Atmospheric Level	Geopotential Altitude Range (km)	Interval (Layer) Number, b	Base Geopotential Altitude above mean sea level (MSL), H_b (km)	Base Static Pressure, P_b (Pa)	Base Temperature, T_b (K)	Base Temperature Lapse Rate per Kilometer of Geopotential Altitude, L_b (K/km)
Troposphere	0–11	0	0	101325	288.15	-6.5
Tropopause (Stratosphere I)	11–20	1	11	22632.06	216.65	0
Stratosphere II	20–32	2	20	5474.889	216.65	+1.0
Stratosphere III	32–47	3	32	868.0187	228.65	+2.8
Stratopause (Mesosphere I)	47–51	4	47	110.9063	270.65	0
Mesosphere II	51–71	5	51	66.93887	270.65	-2.8
Mesosphere III	71–84.9	6	71	3.95642	214.65	-2.0
		7	84.852	0.3734	186.87	—





JavaProp 2702 rpm, 0 airspeed, thrust 4.0842 kN, torque 625 Nm, 4.0842x6 = 24.5052 kN = 5508 lbs

F12-125 motor Bar = 625x63/125x0.9 = 350 Bar max Bar for the VP1-128 pump is 350 Bar

There are 3 pumps, F12-125 at 4200rpm, F12-90 at 4140rpm, VP1-128 at 3000rpm

Flow from F12-125 is 125x4200x0.9/1000 = 472.5 L/min
Flow from F12-90 is 93x4140x0.9/1000 = 346.5 L/min
Flow from VP1-128 is 125x3000x0.9/1000 = 345.6 L/min

472.5+346.5+345.6 = 1164.6 L/min per jet

1164.6 x 2 = 2329 L/min from two jets

2329 L/min total/6 propellers = 388 L/min per propeller

propeller rpm = 388x1000x0.9/125 = 2793 rpm

We have available 2793 rpm and we will use 2702 rpm to keep the Bar value ok for the VP1-128

Drone with 1600lbs payload (fuel+non-fuel) weighs 5700lbs. Thrust at 13000ft altitude is 5508 lbs

Allowing 200lbs of excess thrust for flying upward, drone wt must be 5508 lbs - 200lbs = 5308lbs

Thus drone flying is possible at 13000 ft altitude if the total drone weight is 5308 lbs or less.

Drone weight with no payload is 4097 lbs.

(5308 lbs allowed total wt - 4097 lbs drone weight) = 1211 lbs for (fuel+non-fuel payload)

this means to fly at 13000ft altitude the (fuel+non-fuel) payload wt

needs to be kept to 1211 lbs instead of 1600 lbs.