HORIZONTAL ACTIVITY

VERTICAL ACTIVITY

All 4 propellers are brought to 2658rpm
needing 11.7Nm of torque, delivering 25.35 Kgf each
Total lifting force (4x25.35) = 101.4Kg = 223.5 lbs

Drone wt at takeoff is 203lbs, vertical force available is 20lbs. Accel 20lbs on 203lbs = 3.17 ft/sec²

However, accel vertically up gives vert vel =45 ft/sec

drag at 45 ft/sec, AOA = 1.08 Lift =0 drag=2.79lbs

ave drag 0 ft/sec → 44.4 ft/sec = 2.79/2 = 1.39 lbs

Ave vertical thrust = 20lbs - 1.39 lbs = 18.61lbs

Vert accel of 18.78lbs on 203 lbs (drone wt)
= 2.95 ft/sec²

Drone is in a Nose-up Tail-down position

Direction of airflow is directly vertically down
Angle of attack (AOA) to the airflow is managed
so that Flying form is: Vertical Ascent flying only
Via AOA adjustments (as needed)
horizontal movement is kept at zero
All movement is vertical only

This condition is held for 15.3 seconds

Upper propellers thrust is made larger than
Lower propellers thrust causing a drone rotation
Drone is given a nose pitch down rotation action
Drone is rotated until the nose is 8.3 degrees
Up from horizontal

After this rotation to drone at 8.3 deg up angle
AOA = 8.3 deg
The total 223 lbs thrust becomes:

220.6 lbs forward horizontal thrust and
32.19 lbs upward vertical thrust

Initial Vertical Velocity is 0
Starting Vertical Position is 0

Time = 0 sec

After 15.3 sec of 2.95 ft/sec²
Vertical Velocity is 45 ft/sec up
Vertical travel is 343 feet straight up

Time = 15.3 sec

Vertical Forces acting on the drone are:

↓ 203lbs downward force (gravity effect)
↓ 28.8 lbs Downward force from drag because
the Wings are at a right angle to the airflow
Drag force ↓ at up velocity of 45ft/sec = 56.6lbs
Drag force ↓ at up velocity of 0 ft/sec = 0lbs
Ave drag ↓ force is 56.6/2 = 28.3 lbs

↑ 32.19 lbs upward force (propellers thrust)
↑ 13.45 lbs from lift from the horiz velocity

Total Vertical Forces on the drone are:
↓ 185.66 lbs

The drag calculation is from Google Ai
values include:
wing area 11.8 sq ft = 1.099 m²
air velocity is 45 ft/sec = 13.71 m/sec
(13.71 m/sec)² = 187.9 (m/sec)²
air density is 1.225 Kg/cubic meter
drag coefficient for a flat surface at right
angles to the air flow is 2.0

the drag equation is:
(1/2)(1.225 kg/m³)(187.9 (m/sec)²)(1.099 m²)(2.0) = 252.9N ↓
252.9 N ↓ = 56.6 lbs force ↓

HORIZONTAL ACTIVITY

At 8.3 deg of AOA (angle of attack)
of the 223lbs/thrust there is 220.6 lbs horiz thrust

220.6 lbs horiz thrust acting on drone wt 203lbs
gives horiz accel of 35 ft/sec²

This horiz accel of 35 ft/sec² only applies if the
drone horiz vel = 0
As drone horiz vel increases,
the horiz drag increases
this horiz drag acts to ↓ the horiz force available
to give a horiz accel to the drone
Thus as the drone horiz vel increases
Since the available horiz force does not increase
And the horiz drag is decreasing the amount of
horiz force that is available for horiz accel
Then
The horiz accel of the drone will decrease
as horiz vel increases

At time = 15.3 sec the drone has an ↑ prop
force of 223 lbs. When the AOA becomes
8.3 deg the ↑ prop force becomes 32.19 lbs

The horiz force goes from 0 to 200.6lbs
This horiz force starts to give the drone
a horiz accel
After 1.545 sec these horiz calculations occur.

The horiz vel = 0 gives horiz drag = 0
After 1.545 sec of horiz accel the drone has
a horiz vel of 53 ft/sec with horiz drag = 7.62 lbs

Ave horiz drag = (7.62 + 0)/2 = 3.81 lbs
Available horiz force is (220.6 lbs - 3.81 lbs) =
216.79 lbs = horiz force acting on the drone
this horiz force of 216.79 lbs gives
a horiz accel of 34.4 ft/sec²

Initial horiz vel = 0, horiz accel of 34.4 ft/sec²
applied for 1.545 sec gives a horiz vel of 53 ft/sec
horiz travel is 41.1 ft

VERTICAL ACTIVITY

Vertical climb at 2.95 ft/sec² for 15.3 seconds
The drone is at 343 ft altitude
The vertical velocity of the drone is 45 ft/sec

Vertical forces acting on the drone include:
203 lbs vertical down force (drone wt)
Drag force starts at 56.6 lbs down force, however
the drone is allowed to slow its vertical velocity
to 0 ft/sec, the drag force will be 0lbs
The average drag force is thus:
56.6 lbs/2 = 28.3 lbs vertical down force
Because of the 8.3 deg AOA, of the 223lbs total
propeller thrust, there is 32.19 lbs vertical up thrust

The horizontal thrust is accelerating the drone
horizontally, as horizontal airspeed increases
the wings begin to develop lift. The wing lift
thrust goes from 0lbs to 26.9 lbs up force

Time = 15.3 sec

The drone is allowed to move upward
for 1.545 seconds. Horiz lift from the wings goes
from 0 at horiz vel = 0 to
26.9 lbs at horiz vel = 53 ft/sec.
Ave wing lift = (26.9/2) = 13.45 lbs

Vertical force calculation is thus:
↓ of 203 lbs (drone wt)
↓ of 27.85 lbs (drag average)
↑ of 32.19 lbs (propeller up thrust from 8.3 deg AOA)
↑ of 13.45 lbs (wing lift average)

Average vertical force value on the drone
during these 1.545 seconds =
(203+27.85 ↓ force) - (32.19+13.45 ↑ force) =
net total of: 185.66 ↓ force

185.66 lbs ↓ force acting on 203lb drone gives
↓ accel of 29.4 ft/sec²

Starting with an initial ↑ velocity of 45 ft/sec
then with this ↓ accel of 29.4 ft/sec² the drone
will in 1.545 seconds go up by 34.4 ft
and at that point will have an ↓ velocity of 0.423 ft/sec

Time = 16.845 sec

The drone will be at (343 ft + 34.4ft) = 377.4 ft of altitude

HORIZONTAL ACTIVITY

VERTICAL ACTIVITY

Time = 16.845 sec

The drone is at altitude 377.4 ft
Vertical Velocity is = -0.423 ft/sec
This ↓ vert vel gives very little ↓ drag force
Down force on the drone is 203lbs (drone wt)
Up force on the drone is:
32.19 lbs (Prop thrust from 8.3 deg AOA) plus
Wing Lift from the Horiz Velocity of the drone

At time = 15.3 sec the drone has an ↑ prop force of 223 lbs. When the AOA becomes 8.3 deg the ↑ prop force becomes 32.19 lbs

When the AOA is changed to 8.3 degrees the total prop thrust of ↑ 223lbs is changed from all vertical thrust to:
a component of vertical thrust = ↑ 32.19 lbs
and
a component of horiz thrust = → 200.6 lbs

During the 1.545 sec, horiz airspeed went from 0 ft/sec → 53 ft/sec, this horiz 53 ft/sec means that ↑ force from wing lift is now ↑ 26.9 lbs

For the interval 15.3 sec → 18.845 sec
Drone↓ force is thus:
(203lbs↓ + ave drag force ↓ 28.3 lbs) -
(32.19 prop force ↑ + 26.9 lbs wing lift ↑) =
185.66 lbs total force acting in the ↓ direction

The horiz force goes from 0 to 200.6lbs
This horiz force starts to give the drone a horiz accel
After 1.545 sec these horiz calculations occur.

185.66 lbs ↓ force acting on 203lbs wt gives a ↓ accel of 29.4 ft/sec² ↓

a ↓ accel of 29.4 ft/sec² acting on wt =203 lbs with initial vel of -0.423 ft/sec acting for 1.545 sec gives a resulting Vert vel of -0.423 ft/sec
vert travel is ↑ of 34.4 ft thus new Altitude is 343 ft initial + 34.4 ft ↑ = new altitude of 377.4 ft

Time is allowed to progress x 1 sec

The horiz vel = 0 gives horiz drag = 0
After 1.545 sec of horiz accel the drone has a horiz vel of 53 ft/sec with horiz drag = 7.62 lbs

Ave horiz drag = (7.62 + 0)/2 = 3.81 lbs
Available horiz force is (220.6 lbs - 3.81 lbs) = 216.79 lbs = horiz force acting on the drone
this horiz force of 216.79 lbs gives a horiz accel of 34.4 ft/sec²

Time = 17.84 sec

At Time = 17.84 sec, Drone specs include:
horiz airspeed 85.8 ft/sec
Lift = 70.51 lbs ↑

Initial horiz vel = 0, horiz accel of 34.4 ft/sec² applied for 1.545 sec gives a horiz vel of 53 ft/sec
horiz travel is 41.1 ft

Drone ↓ forces include:
203 lbs (↓ force from Drone wt)
- 32.19 lbs (↑ force from props)
- 48.7 lbs (↑ average force from lift)

Total vertical forces acting on Drone
= 122.11 lbs ↓

HORIZONTAL ACTIVITY

For the interval 16.84 sec → 17.84 sec
the horiz story is:

horiz vel at 16.84 sec is 53 ft/sec
horiz drag at 53 ft/sec = 7.62 lbs
horiz vel at 17.84 sec is 85.5 ft/sec
horiz drag at 85.5 ft/sec is 19.85 lbs

Ave horiz drag = (7.62 lbs + 19.85 lbs) / 2
ave horiz drag = (27.44lbs) / 2 = 13.7 lbs

horiz thrust at 8.3 deg AOA = 200.6 lbs
but ave horiz drag needs to be subtracted
horiz thrust available = (200.6 lbs - 13.7 lbs)
horiz thrust available = 206.9 lbs
horiz thrust of 206.9 lbs applied to 203 lbs
give horiz accel of 32.8 ft/ sec²

initial horiz vel of 53 ft/sec given an accel
of 32.8 ft/sec² for 1 sec gives new vel of 85.8 ft/sec

horiz travel for this 1 sec is 69.4 ft

Time 0 → 15.3 sec horiz travel = 0ft

Time 15.3 sec → 16.845 sec horiz travel = 41.1 ft

Time 16.845 sec → 17.84 sec horiz travel = 69.4 ft

VERTICAL ACTIVITY

Time = 17.84sec

Drone altitude is 377.4 ft
this is the highest altitude the drone will go to
for this take off and ascent event

Lift at 53 ft/sec = 26.9 lbs
Lift at 85.8 ft/sec = 70.51 lbs
(26.9 + 70.51) = 97.41
(97.41)/2 = 48.7 lbs ave lift

This is where the 48.7 lbs ave lift value that was
used in the previous page came from

at 16.545 sec
↓ force = 185.66 lbs acting on 203 lb wt
gives ↓ accel of 29.4 ft/sec²

At 17.84 sec ↓ forces acting on the drone include:
↓ force 203 lbs (drone wt)
↑ force of 32.19 lbs (prop thrust)
↑ force of 48.7 lbs (average ↑ force of wing lift)
Total ↓ force is (203) - (32.19 + 48.7) = 122.11 lbs

122.11 lbs ↓ force acting on 203 lbs gives
↓ accel of 19.4 ft/sec²

at 17.84 sec
↓ force = 97.41 lbs acting on 203 lb wt
gives ↓ accel of 19.4 ft/sec²

Initial ↓ vert vel = -0.423 ft/sec
Time interval = 1 second
↓ accel = 19.4 ft/sec²

Result:
Drone travels ↓ by 9.98 ft
new altitude is (377.4 ft) - (9.98 ft) = 367.4 ft
Drone has now ↓ vert vel of 19.7 ft/sec

HORIZONTAL ACTIVITY

VERTICAL ACTIVITY

Time = 17.84 sec

Drone has now ↓ vert vel of 19.7 ft/sec
↓ accel = 19.4 ft/sec²

From Time = 16.84 sec to Time = 17.84 sec
Drone travelled ↓ by 9.98 ft

New Altitude is (377.4 ft - 9.98 ft) = 367.4 ft

↓ Force on the drone (at 17.84 sec) =
203.0 lbs (drone wt)
- 32.19 lbs (↑ force from props AOA)
- 48.7 lbs (↑ force from wing lift)

Total ↓ force is 122.11 lbs
122.11lbs ↓ against 203 lbs gives
↓ accel of 19.4 ft/sec² present at 17.84 sec

Time is allowed to pass by 1.645 seconds

Time = 19.485 sec

For Time 17.84 → 19.485 sec
Horiz vel was 85.8 ft/sec, lift was 70.51 lbs
Horiz vel is now 134.5 ft/sec, lift is now 173.26 lbs
(70.51 lbs + 173.26 lbs) = 243.77 lbs
(243.77 lbs) / 2 = ave lift for this interval = 121.88lbs

↓ force on the drone is:
↓ 203 lbs (drone wt) - (total ↑ wt present) =
↑ wt = 32.19 lbs prop lift + 121.88 lbs wing lift =
↑ wt total = 154.07 lbs
(↓ 203 lbs) - (↑ wt of 154.07 lbs) = ↓ 48.39 lbs
48.39 lbs ↓ acting on 203 lbs gives accel of
↓ 7.76 ft/sec²

Initial vert vel of ↓19.7 ft/sec is given an accel of
↓ 7.76 ft/sec² for time = 1.645 sec gives
new vert vel of ↓ 32.5 ft/sec with
travel during this time interval of ↓ 42.9 ft
new altitude = (367.42 ft) - (42.9 ft) = 324.42 ft

Time 0 → 15.3 sec horiz travel = 0ft

Time 15.3 sec → 16.845 sec horiz travel = 41.1 ft

Time 16.845 sec → 17.84 sec horiz travel = 69.4 ft

Starting at 17.84 sec we want horiz accel to
continue for a time interval which will cause
drone airspeed to become large enough that
total lift forces on the drone = drone wt = 203 lbs

Total ↑ forces on the drone include:
(lift from wing lift + lift from prop lift)

If we allow the horiz accel available to the drone
at 17.84 sec to occur for 1.645 sec, then
lift from all sources will total drone wt = 203 lbs

However horiz force available to create horiz
accel beyond 18.84 sec will decrease because
horiz drag will increase as horiz airspeed increases

We will need to obtain an ave horiz accel value

(203 lbs drone wt) - (32.19lbs (prop lift)) = 170.81 lbs
(wing lift at 134.5 ft/sec = 173.26 lbs)

The drone is staying at 8.3 AOA
At 17.84 sec horiz vel = 85.8 ft/sec drag = 19.85 lbs
At 134.5 ft/sec lift = 173.26 lbs, drag = 48.45 lbs

(48.45 lbs drag) + (19.85 lbs drag) = 68.3 lbs drag
(68.3 lbs drag) / 2 = ave drag = 34.15 lbs ave drag
(220.6 lbs available horiz force) - (34.15 lbs ave drag)
= 186.45 lbs horiz force available
186.45 lbs horiz force applied to 203 lbs drone wt =
horiz accel of 29.6 ft/sec²

Initial horiz vel (85.8 ft/sec)
given horiz accel 29.6 ft/sec for 1.645 sec
gives a new horiz vel of 134.5 ft/sec

In the 1.645 sec horiz travel is 181.2 ft

HORIZONTAL ACTIVITY

Time = 19.485 sec

horiz vel = 134.5 ft/sec
AOA = 8.3 degrees

at horiz vel = 134.5 ft/sec
Vert wing lift = 194.65 lbs
Horiz drag = 56.15 lbs

To maintain this horizontal condition:
we only need horiz thrust to be = horiz drag
thus, horiz thrust = 56.15 lbs

Take the AOA to 9.2 degrees
To obtain a horiz thrust of 56.15 lbs at this AOA
the total thrust needs to be 56.88 lbs
the vertical thrust from this total thrust at
9.2 degrees AOA will be ↑ force of 9.09 lbs
the horiz thrust will be 56.15 lbs

EXCESS POWER CALCULATION

The drone created 223 lbs thrust using
10 kW power from each of two jets
Thus 20 kW power creates 223 lbs of thrust
Thus (20,000 watts) / (223 lbs thrust) =
89.68 Watts of power needed for 1 lb of thrust
Thus if we need 56.88 lbs thrust then
(56.88 lbs) x (89.68 Watts/lb) = 5100 Watts needed

We have available 20,000 Watts to create thrust
We only need 5100 Watts to overcome horiz drag
(20,000 Watts available) - (5100 watts needed) =
14,900 Watts are available and not needed
This 14,900 Watts available is **EXCESS POWER**

VERTICAL ACTIVITY

Time = 19.485 sec

↓ Force on the drone (at 19.485 sec) =
203.0 lbs (drone wt)
- 32.19 lbs (↑ force from props AOA)
- 203.0 lbs (↑ force from wing lift)

Total vertical force on the drone is ↑32.19 lbs
↑ 32.19 lbs against 203 lbs gives
↑ accel of 5.10 ft/sec² present at 19.485 sec

vert vel is ↓ 32.5 ft/sec

There is an **ANGLE OF CLIMB** calculator
this calculator needs input of:
RATE OF CLIMB and also **VELOCITY**

The **ANGLE OF CLIMB** result is 23.73 degrees

This will give:
1) an AOA of the drone to the direction
of travel of the airflow (9.2 degrees)
2) an **ANGLE OF CLIMB** which is the angle of the
flight path of the drone to the horizontal (23.73 deg)
This means that the angle of the drone compared
to the horizontal will be (23.73 deg) + (9.2 deg)
= 32.93 deg

Time = 20.485 sec

54.3 ft/sec of ↑ vel is added to 32.5 ft/sec of ↓ vel
This means in a time interval of 1 second:
(54.3 ft ↑) + (32.5 ft ↓) = (54.3) - (32.5) = (21.63 ft ↑)
The altitude was at 324.52 ft, adding (21.63 ft ↑) =
(324.52 ft) + (21.63 ft ↑) = 346.15 ft
The overall drone vertical motion result will be:
the drone is now at an altitude of 346.15 ft

There is a **RATE OF CLIMB** from **EXCESS POWER**
calculator. You enter the drone wt (in Newtons 203 lbs = 903 N) and the excess power in Watts
The calculator gives a result that a **RATE OF CLIMB** of
54.3 ft/sec is available from this excess power of 14,900 Watts
for this weight (903 N) of drone (203 lbs = 903 N)

HORIZONTAL ACTIVITY

SUMMARY DISCUSSION

Time = 0 sec

horiz vel = (**varying slightly + or -**) due to random pertubations. Flying control actions are occuring so that (**net horiz vel remains = 0**) (**net horiz vel = 0**) means (**net horiz travel = 0**)

Time = 15.3 sec

horiz vel at this time = 0
total horiz travel at this time = 0

Time = 16.845 sec

horiz vel at this time = 53 ft/sec
total horiz travel at this time =
(0 ft) + (41.1 ft)

Time = 17.84 sec

horiz vel at this time = 85.8 ft/sec
total horiz travel at this time =
(0 ft) + (41.1 ft) + (69.4 ft)

Time = 19.485 sec

horiz vel at this time = 134.5 ft/sec
total horiz travel at this time =
(0 ft) + (41.1 ft) + (69.4 ft) + (181.2 ft)

(0ft + 41.1ft + 69.4ft + 181.2ft) = (291.7 ft)

VERTICAL ACTIVITY

SUMMARY DISCUSSION

Time = 0 sec

Start
AOA = 90 deg = (nose- up / tail - down)

Time = 15.3 sec

Altitude is 343 ft
Vert vel = 45 ft/sec
AOA changed to 8.3 deg ↑

Time = 16.845 sec

Altitude = 377.4 ft
Vert Vel = -0.423 ft/sec
AOA = 8.3 deg ↑

Time = 17.84 sec

Altitude = 367.4 ft
Vert Vel = -19.7 ft/sec
AOA = 8.3 deg ↑ to the flight path
Angle of Flight path to the horizon = 0 deg
Angle of drone to horizon = 8.3 deg ↑

Time = 19.485 sec

Altitude = 324.42 ft
Vert Vel = -32.5 ft/sec

Drone Flying Angles are changed

AOA to the flight path remains 8.3 deg ↑
Angle of Flight path to the horizon = 23.73 deg ↑
Angle of drone to horizon = 32.93 deg ↑

HORIZONTAL ACTIVITY

Time = 19.485 sec

horiz vel at this time = 134.5 ft/sec
total horiz travel at this time =
(0 ft) + (41.1 ft) + (69.4 ft) + (181.2 ft)

(0ft + 41.1ft + 69.4ft + 181.2ft) = (291.7 ft)

Time = 20.485 sec

The drone was allowed to fly at its new
Flying Angles for one second
from Time = 19.485 sec to Time = 20.485
Drone horiz vel was 134.5 ft/sec
In this one second drone horiz travel = 134.5 ft

Drone horiz travel from:
Time = 0 sec to Time = 19.485 sec =
Horiz travel total so far = (291.7 ft)
From: Time = 19.495 sec to Time = 20.485 sec
Horiz travel = 134.5 ft

From Time = 0 sec to Time = 20.485 sec
Total horiz travel for this interval =
(291.7 ft) + (134.5 ft) = 426.2 ft

From Time = 0 sec to Time = 20.485 sec
Total horiz travel for this interval =
(291.7 ft) + (134.5 ft) = 426.2 ft

Full power (10kW) from each jet = (180ml/min) x2
(20.485 sec)/(60sec/min)) = (0.341 min)
So the (20.485 sec) of ascent was (0.341 min)
(0.341 min) x (360 ml/min) = (122.76 ml of fuel)
fuel density is (0.8gm/ml)
(122.76 ml) x (0.8 gm/ml) = 98.20gm = 0.0982 kg
(0.0982 kg) x (2.2 lbs/kg) = (0.216lbs) = (3.45 oz)

So **0.216 lbs fuel** needed for the drone to go from
Stable, Stopped, On the Ground to:
Stable, Fixed Wing Flying at:
Vel = 134 ft/sec, Vert Vel = 0, Altitude = 350 ft

VERTICAL ACTIVITY

Time = 19.485 sec

Altitude = 324.42 ft
Vert Vel = -32.5 ft/sec

Drone Flying Angles are changed

AOA to the flight path remains 8.3 deg ↑
Angle of Flight path to the horizon = 23.73 deg ↑
Angle of drone to horizon = 32.93 deg ↑

Time = 20.485 sec

The effect of the new flying angles
is that 54.3 ft/sec ↑ is added to the drone

net vert vel effect is:
(54.3 ft/sec) + (-32.5 ft/sec) = vert vel 21.63 ft/sec
This new vert vel is held for one second
The drone rises up 21.63 ft

New altitude is 346.15 ft

On arriving at this new altitude,
some Drone Flying Angles are changed

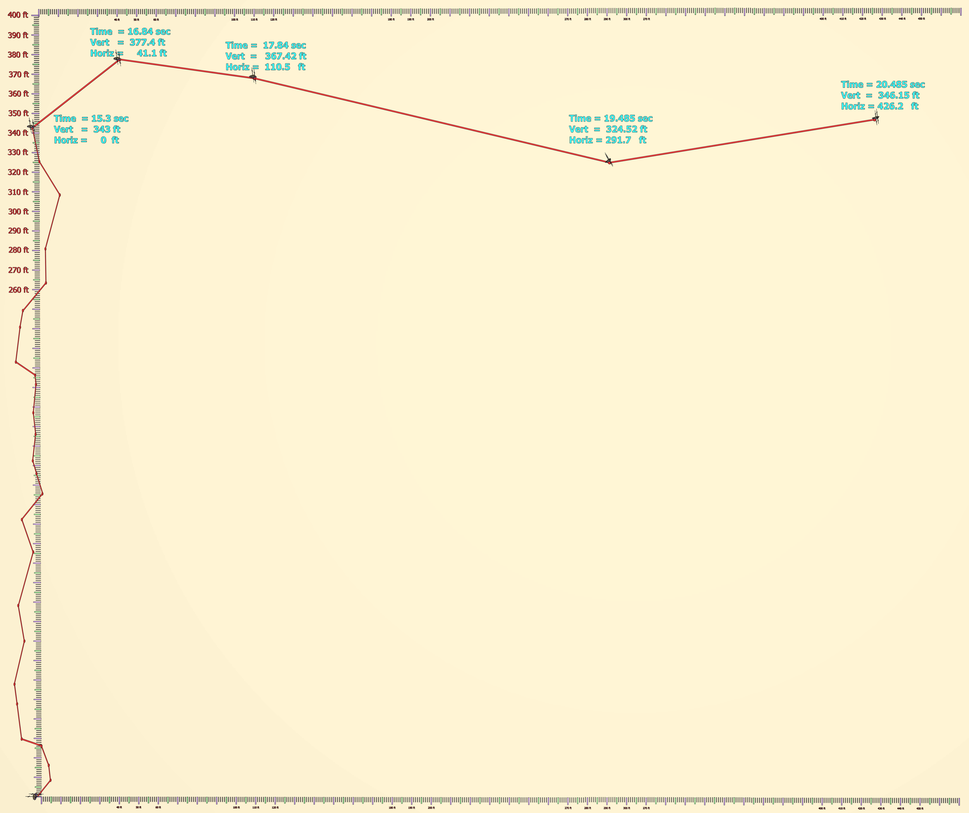
AOA to the flight path remains 8.3 deg ↑
Angle of Flight path to the horizon = 0 deg
Angle of drone to horizon = 8.3 deg ↑

The drone is now in **Stable Fixed Wing Flying**

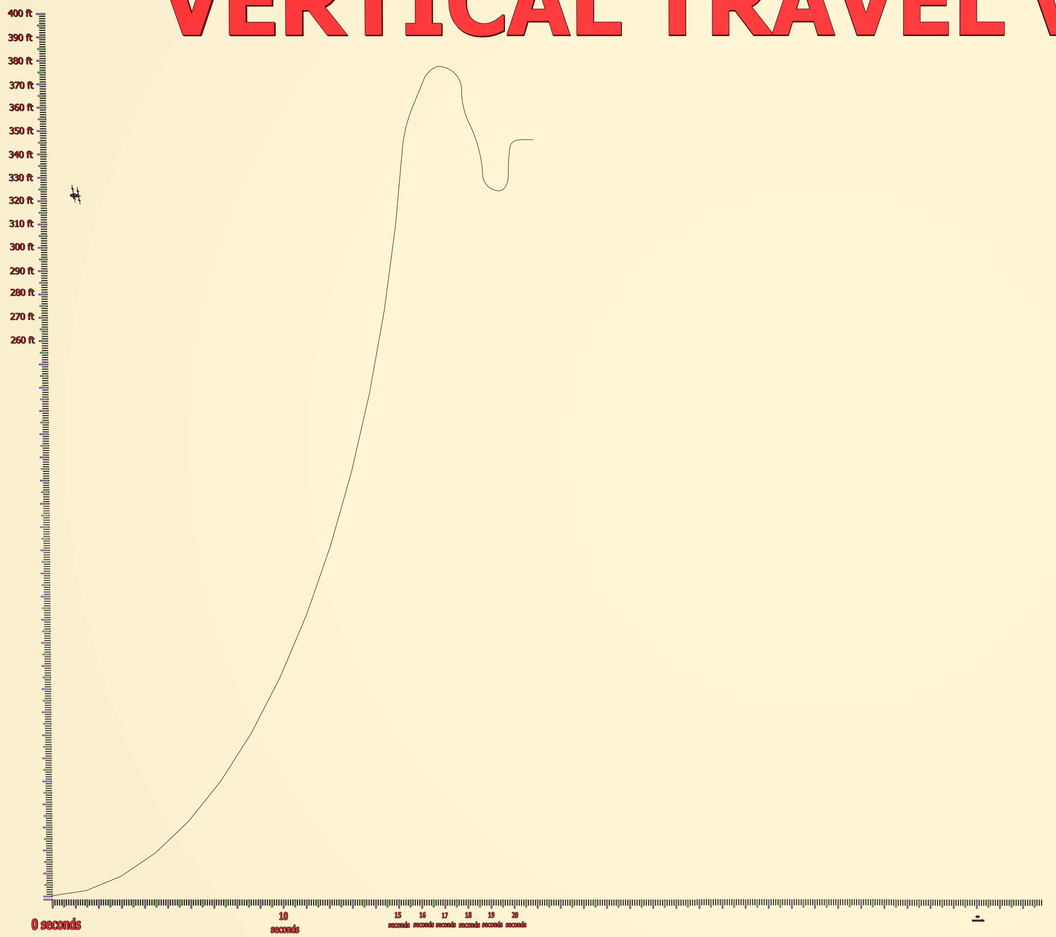
sum of lift from all sources = wt of drone
vert vel = 0
horiz vel is 134.5 ft/sec and not changing
Total thrust is adjusted so that:
horiz thrust = horiz drag = 56.15 lbs
At an AOA of 8.3 deg, 56.15 lbs of horiz thrust
needs **Total Thrust to be 56.88 lbs**

56.88 lbs total thrust = 5100 Watts power
power from the jets is reduced so that
Total Output Power from the jets = 5100 watts

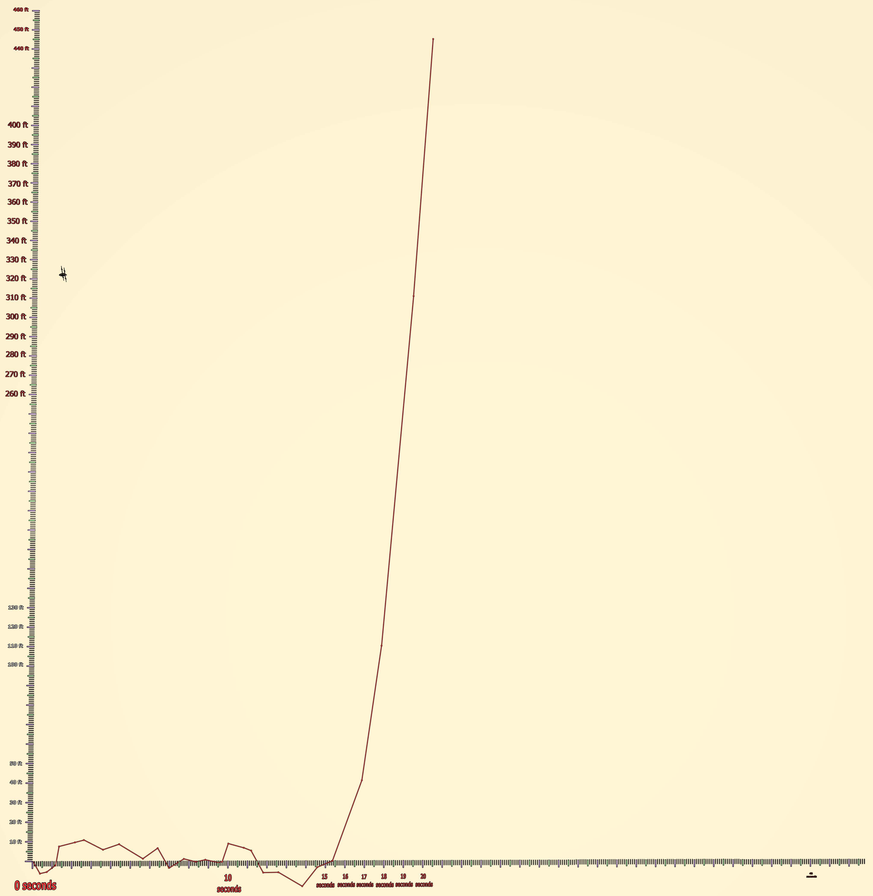
HORIZONTAL TRAVEL vs VERTICAL TRAVEL



VERTICAL TRAVEL vs TIME



HORIZONTAL TRAVEL vs TIME



DesignFOIL V7 Shareware (Please support and share)

File Edit Airfoil TOOLS_geometry TOOLS_analysis TOOLS_Wing Help

How To Use DesignFOIL

Step #1:

Select a new airfoil from the Airfoil menu.

Step #2:

Use the Tools menus to modify, alter, or analyze your airfoil (Standard Version cannot run analysis).

Step #3:

When you're finished, store it permanently in the MyAirfoils window or save it to disk. Or export to Excel. If you have paid for the CAD Export features, then you can send it directly to select CAD packages!

☐ Don't Show This Window Ever Again!

Close

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If you find DesignFOIL V7 useful, please consider supporting to help cover monthly hosting costs and development time. Thank you and please tell your friends about DesignFOIL.

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Link For Airfoil Primer on Kindle

Note: This window is always visible.

DesignFOIL V7 Shareware (Please support and share)

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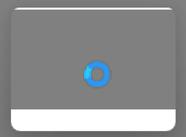

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DesignFOIL V7 SHAREWARE SUPPORT

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Airfoil Construction Parameters (COMMON)

Point Distribution: Dense Endpoints
Number Of Points: 71
Thickness Increments: 1.00
Coordinate Values: X/C: 0.00 Y/C: 0.00
Construction Method: Standard NACA
Draw Elements: Surface Points, Camber Lines
Normalized Chordlength?: Normalize to 1.0

HELP

Standard Atmosphere Model

INPUTS

ALTITUDE: 358 (FEET)
REF. LENGTH: 2.5 (FEET)
FLIGHT SPEED: 134.5 (Feet Per Second) Help Convert

Help

UNITS
(•) FEET
( ) METERS

PUSH TO UPDATE ALL VALUES

RESULTING ATMOSPHERIC AND PERFORMANCE VALUES

DENSITY: 0.002352 (Slugs Per Cubic Foot)
PRESSURE: 2088.99 (Pounds Per Square Foot); 0.987 (Atmospheres)
TEMPERATURE: 57.72 (Degrees Fahrenheit); 517.4 (Degrees Rankine)
SPEED OF SOUND: 1115.1 (Feet Per Second); 760.3 (Miles Per Hour); 660.7 (Knots)
VISCOSITY: 3.73004525e-7 (lb-sec / Foot^2)

REYNOLDS NUMBER: 2120324
MACH NUMBER: 0.1206
DYNAMIC PRESSURE (Q): 21.2750 (Pounds Per Square Foot)
CRITICAL CP (where Sonic flow appears): -45.79
FRICTION COEFFICIENT (Assuming Laminar): 0.0009
FRICTION COEFFICIENT (Assuming Turbulent): 0.0039

WingCrafter(tm): Wing Layout & Preliminary Performance Tool

Flow Conditions | Wing Layout | ANALYZE | Stall Speeds / W/S | CFD Export/Slice | Wing Imp/Exp

Wing Analysis Options
Assume elliptical lift degradation
Oswald Efficiency Factor: 0.8

Root-Airfoil Angle Of Attack
9.200 Degrees
Set To ZERO

NOTE: Stall is not predicted with this tool.

BUILD / ANALYZE

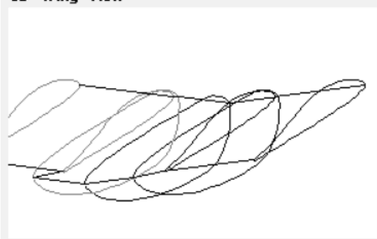
Drag RESULTS

Frictional Drag:	4.46 Pounds	Frictional Cd*S	0.21
Induced Drag:	37.90 Pounds	Induced Cd*S	1.78
TOTAL DRAG:	56.15 Pounds	TOTAL Cd*S	2.64
Frictional Cd:	0.0177		
Induced Cd:	0.1505		
TOTAL Cd:	0.2229		

Lift RESULTS
Total Lift Force (LBS): 194.65
Total Lift Coefficient: 0.773
L/D: 3.47

Moment RESULTS
Total Pitching Moment: 10.58 FootPounds
Moment Coefficient: 0.015
( ) Referenced to Root Quarter Chord
( ) Referenced to Root Nose
(•) No Transfer (Debugging Only)

3D Wing View



Y-Axis View Rotation (not AOA)

Z-Axis View Rotation
(Drag box with left mouse button to zoom)

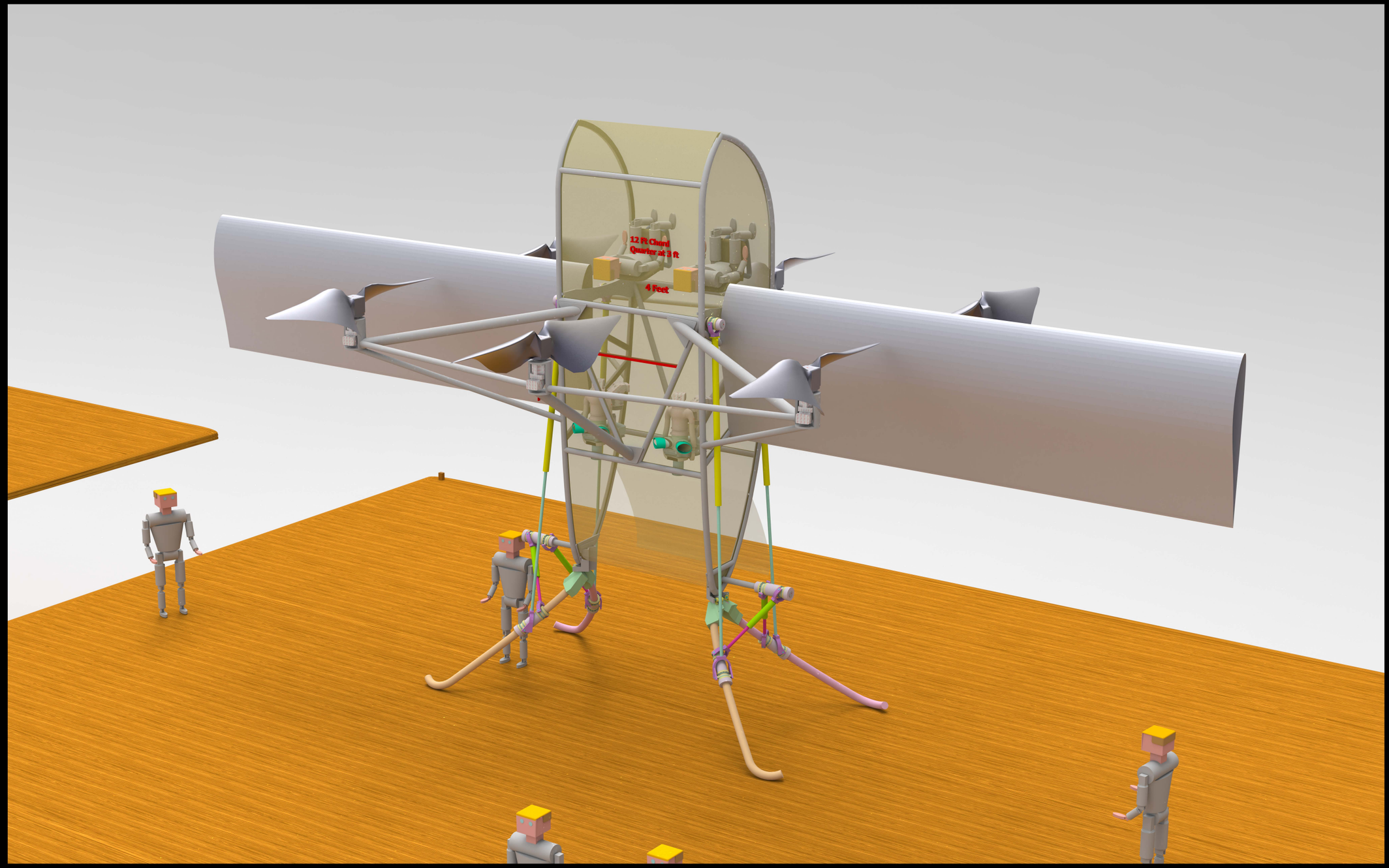
RESET

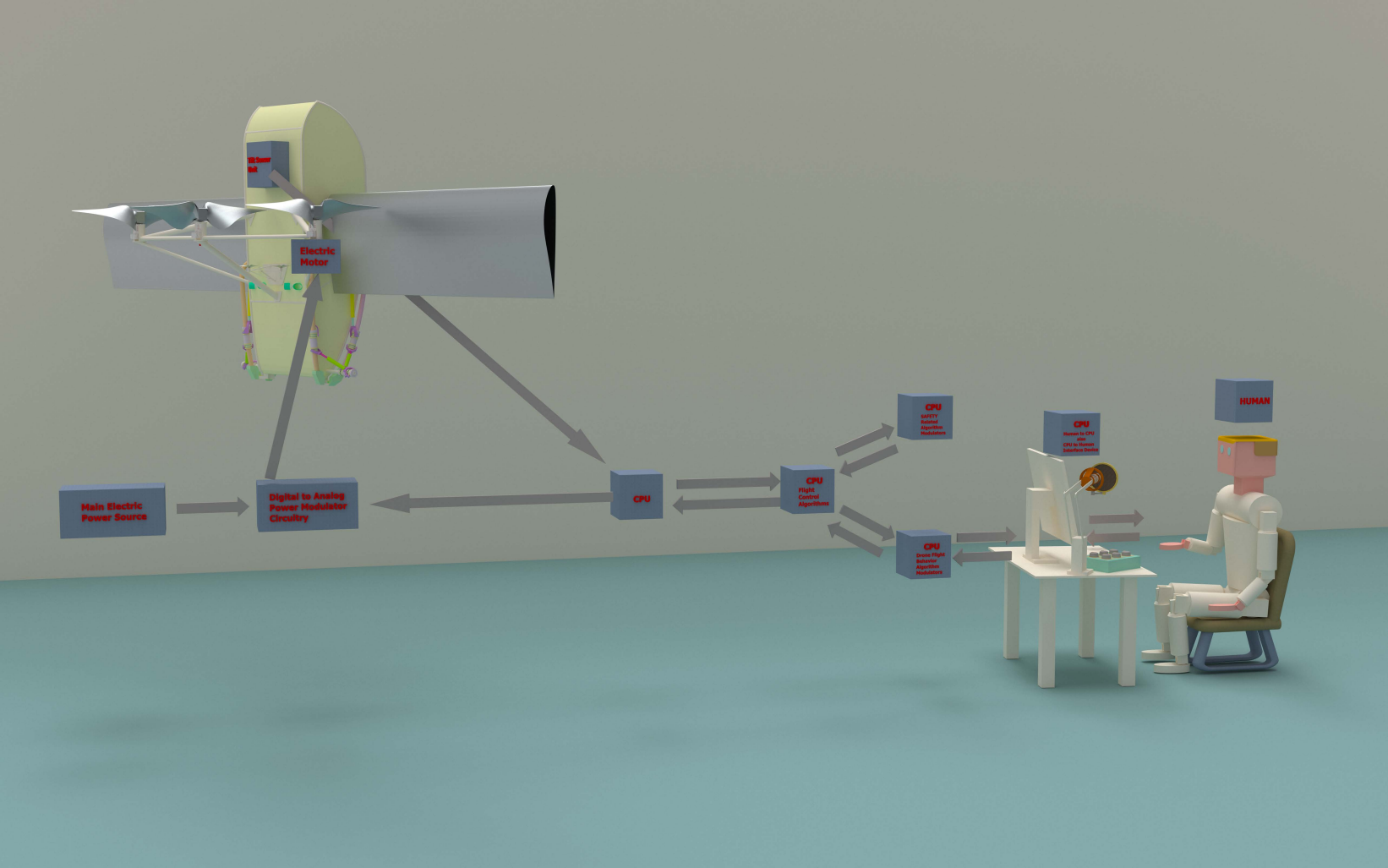
WING LAYOUT NAME
Heavy Lift Drone v4

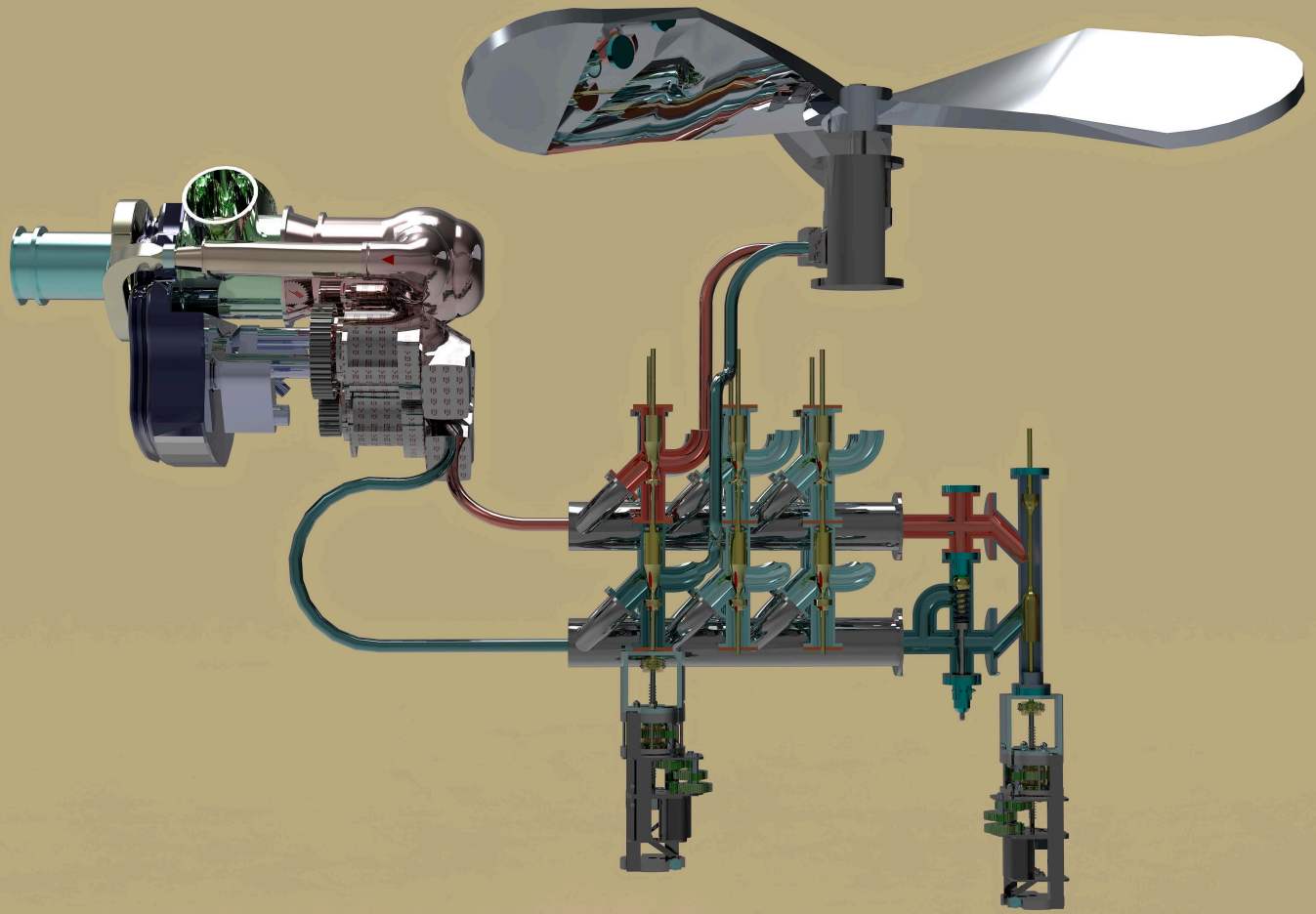
BUILD / ANALYZE

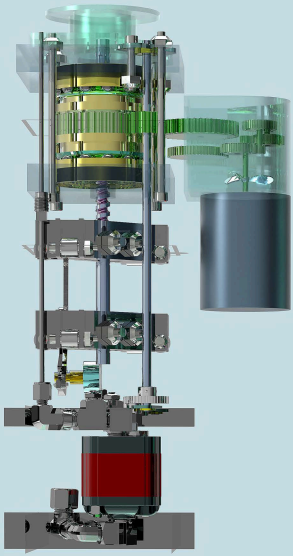
NOTE: Stall is not predicted with this tool.

Help Close


12 Ft Chord
Quarter at 3 ft
4 Feet


Electric Motor
Main Electric Power Source
Digital to Analog Power Modulator Circuitry
CPU
CPU
Flight Control Algorithms
CPU
SAFETY Related Algorithm Modulators
CPU
Drone Flight Behavior Algorithm Modulators
CPU
HUMAN





coefficient of friction Hallite Hythane 181

The exact coefficient of friction for **Hallite Hythane 181** is not a single fixed value but rather a performance characteristic that varies depending on the specific application, surface finish, lubrication, pressure, and temperature.

Hallite promotes Hythane 181 as a material with **low friction** properties, particularly when used in dynamic sealing applications, to provide efficient and long-lasting performance in hydraulic and pneumatic systems. The material data sheets do not typically list a single coefficient of friction value but rather highlight the operating conditions (e.g., maximum speed 1 m/sec, temperature range -45°C to 110°C, max pressure 400 bar) under which their seals perform optimally.

For general engineering purposes, the dynamic (kinetic) coefficient of friction for polyurethane on steel in typical applications can range widely, often between **0.2 and 2.5** when unlubricated. However, in properly lubricated hydraulic systems using Hythane 181 seals, the dynamic coefficient of friction is typically much lower, around **0.06** (on a steel surface with a specified roughness).

To obtain precise data for a specific scenario, you would need to conduct application-specific testing or contact the manufacturer, Hallite Seals, directly with your detailed operating parameters.

drag force calculation for an airfoil at 90 degrees to the airflow

AI Overview

The drag force on an airfoil at a 90-degree angle of attack can be calculated **using the standard drag equation**, but requires using the specific **drag coefficient (C_d) for an airfoil in this orientation**.

Drag Force Equation

The general drag equation is:

$$F_D = \frac{1}{2} \times \rho \times V^2 \times A \times C_d$$

Where:

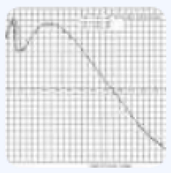
- F_D = Drag Force (in Newtons, N, in SI units)
- ρ = Density of the fluid (e.g., air density, approx. 1.225 kg/m³ at sea level)
- V = Flow velocity (airspeed) (in m/s)
- A = Reference area (the frontal area of the airfoil perpendicular to the flow)
- C_d = Drag coefficient (dimensionless)

Key Considerations at 90 Degrees Angle of Attack

At a 90-degree angle of attack, an airfoil behaves much like a bluff body (an object with a non-streamlined shape).

- **Drag Coefficient (C_d)**: For an airfoil section (2D), the drag coefficient at a 90-degree angle of attack is approximately **2.0**. This value is similar to that of a flat plate normal to the flow and is significantly higher than the low C_d values airfoils exhibit at typical flight angles (around 0.1).
- **Reference Area (A)**: Since the airfoil is perpendicular to the airflow, the relevant area is the **frontal area** (chord length multiplied by the wingspan for a 3D wing, or just the chord length for a 2D section analysis).

Ask Us - Airfoils at High Angle of Attack - Aerospaceweb.org



Nov 15, 2003 — It is therefore not surprising that the lift curve shown above also indicates ...

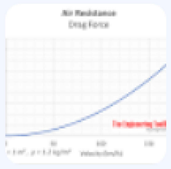
Aerospaceweb

DRAG FORCE CALCULATION - UTRGV Faculty Web

"Drag is the component of force on a body acting parallel to the direction of relative...

The University of Texas Rio Grand...

Drag Coefficient - The Engineering ToolBox



Drag Coefficient. Drag Coefficient. The drag coefficient quantifies the drag or resistance of...

The Engineering ToolBox

Show all

drag force calculation for an airfoil at 90 degrees to the airflow

- **Reference Area (A)**: Since the airfoil is perpendicular to the airflow, the relevant area is the **frontal area** (chord length multiplied by the wingspan for a 3D wing, or just the chord length for a 2D section analysis).
- **Lift Force**: At 90 degrees angle of attack, the lift force generated by the airfoil drops to approximately zero.

Calculation Steps

1. **Determine Fluid Properties**: Find the density (ρ) of the air at the relevant altitude and temperature.
2. **Measure Velocity**: Get the free-stream velocity (V) of the airflow.
3. **Define Reference Area**: Calculate the frontal area (A) presented to the flow. For a standard wing, this would be the span multiplied by the chord.
4. **Use the Drag Coefficient**: Use $C_d \approx 2.0$ for a 90-degree angle of attack.
5. **Calculate the Drag Force**: Plug all values into the drag equation to find F_D.

Dive deeper in AI Mode

Give an example of calculating drag force at 90 degrees

The drag force calculation for an example **airfoil yields 306.25 Newtons**.

Step 1: Define Parameters and Formula

We use the drag equation to calculate the force D, assuming standard sea-level air density (ρ), a velocity (V), a specific reference area (A), and the drag coefficient ($C_d \approx 2.0$) for a 90-degree angle of attack.

The formula is:

$$D = \frac{1}{2} \times \rho \times V^2 \times A \times C_d$$

Click and drag to select a new capture area

We assume the following values for this example:

- Fluid Density (ρ): $1.225\,\text{kg/m}^3$
- Airspeed (V): $50\,\text{m/s}$
- Frontal Area (A): $0.1\,\text{m}^2$

2

We assume the following values for this example:

- Fluid Density (ρ): $1.225\,\text{kg/m}^3$
- Airspeed (V): $50\,\text{m/s}$
- Frontal Area (A): $0.1\,\text{m}^2$
- Drag Coefficient (C_d): 2.0

Step 2: Substitute Values and Calculate

Substitute the assumed values into the drag equation and solve for the drag force D:

$$D = \frac{1}{2} \times 1.225\,\text{kg/m}^3 \times (50\,\text{m/s})^2 \times 0.1\,\text{m}^2 \times 2.0$$

$$D = 0.5 \times 1.225 \times 2500 \times 0.1 \times 2.0$$

$$D = 306.25\,\text{N}$$

Answer:

The calculated drag force for an airfoil with a $0.1\,\text{m}^2$ frontal area moving at $50\,\text{m/s}$ at a 90-degree angle of attack is **306.25 Newtons**.

What's the drag coefficient of an airfoil at other angles of attack?

The drag coefficient (C_d) of an airfoil varies significantly with the angle of attack (AoA). It is **minimal at low AoA, increases gradually with increasing AoA, and then rises sharply after the stall angle, eventually reaching a maximum of approximately 2.0 at 90 degrees**.

General Trends and Values

The specific C_d values depend heavily on the airfoil shape (camber, thickness), Reynolds number, and whether it's a 2D airfoil section or a 3D wing (which has induced drag).

- **Low Angles of Attack (Cruise/Efficient Flight):** In the normal operating range (typically -5° to 10°), the C_d is very low and relatively constant due to smooth, attached airflow (laminar or turbulent boundary layer).
  - **Typical C_d range:** 0.005 to 0.02.
- **Stall Angle of Attack (Critical AoA):** As the angle increases (typically between 12° and 18° for most airfoils), the lift coefficient reaches its maximum, and flow separation begins to occur more significantly over the upper surface. The drag coefficient starts to increase rapidly here.
  - **Typical C_d range at stall:** 0.1 to 0.25 (highly variable depending on airfoil).
- **Post-Stall (High Angles):** Beyond the stall angle, the airflow separates completely, the lift drops rapidly, and the airfoil acts as a bluff body. The drag coefficient increases dramatically as the large wake region behind the airfoil generates significant pressure

20 sites

Ask Us - Airfoils at Hig
Attack - Aerospacewe
Nov 15, 2003 — Flat pla
aerodynamics predict t
Aerospaceweb

How an Airfoil's Angle
Creates Lift and Drag
Feb 28, 2022 — Key Tal
Airfoils produce flow ra
Cadence

Inclination Effects on
Research Center - NA
Jul 27, 2022 — On this
of Attack. As a wing mo
NASA (.gov)

I have pages here that are discussions of other topics that intrigue me.

I think they are really cool topics and they interest me just simply to imagine how things would be if the ideas in these topics were brought into existence.

Of course, I would like a budget to let me create everything I think of, but, alas, that special power is handed out very sparingly over the ages to a very few people.

But I would suggest, read the topics, if they grab a'hold of you and you start bringing them into reality....well..... I'm with ya' at least in spirit.

DARPA Lift Challenge Discussion

Update from 11-25-25: Hello everyone, when I first was thinking about this DARPA Lift Challenge, it did not seem to me there would be any method to get a drone that weighs only 55lbs to have a power source that could generate enough kW to run a group of propellers where this group of propellers ... Continue reading

https://pistonrobot.com

what is the range of the rpm variations that are used to maintain stable hover of a 42 inch propelle...

Which response do you prefer?

You're giving feedback on a new version of AI Mode.

Response A

To maintain a stable hover for a 42-inch propeller providing 49 lbs (approx. 22.2 kg) of thrust, the operational RPM typically stays **between 1,200 and 1,800 RPM**. Because drone flight controllers maintain stability by rapidly varying motor speed, the range of these variations—known as the control authority—usually operates within **±5% to ±15%** of the base hover RPM.

Hover RPM Dynamics for 42" Propellers

For heavy-lift drones using ultra-large propellers (36–42 inches), the target is high thrust at low rotational speeds to maximize efficiency

I prefer this response

Response B

For a 42-inch propeller generating 49 lbs (approx. 22.2 kg) of thrust, the operating range to maintain a stable hover typically falls between 1,200 and 1,800 RPM, depending on the specific propeller pitch and air density.

RPM Characteristics for Large Props

- Operating Range: Ultra-large propellers (40–42 inches) are designed for heavy-lift industrial platforms and typically operate at very low RPMs to maximize static thrust efficiency. While specific 42-inch data can vary by manufacturer, comparable 40-inch

I prefer this response

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Hover RPM Dynamics for 42" Propellers

For heavy-lift drones using ultra-large propellers (36–42 inches), the target is high thrust at low rotational speeds to maximize efficiency and minimize tip-speed noise.

- **Base Hover RPM:** A 40–42 inch propeller typically reaches approximately 49 lbs of thrust in the **1,300 to 1,600 RPM** range, depending on its pitch.
- **Safe Operating Limits:** Manufacturers like T-Motor and Xoar recommend a maximum operating range of up to **2,600–4,000 RPM** for propellers of this size, though they are most efficient at much lower speeds.
- **Tip Speed Constraint:** Large propellers are limited by tip speed; at 2,000 RPM, the tips of a 42-inch propeller travel at approximately 250 mph. Staying below **0.8 Mach** is critical for stability and efficiency.

RPM Variation Range for Stability

I prefer this response

For a 42-inch propeller generating 49 lbs (approx. 22.2 kg) of thrust, the operating range to maintain a stable hover typically falls between 1,200 and 1,800 RPM, depending on the specific propeller pitch and air density.

RPM Characteristics for Large Props

- Operating Range: Ultra-large propellers (40–42 inches) are designed for heavy-lift industrial platforms and typically operate at very low RPMs to maximize static thrust efficiency. While specific 42-inch data can vary by manufacturer, comparable 40-inch propellers are rated for a maximum of 4,000 RPM but hover far lower, often between 1,000 and 2,000 RPM.
- Thrust to RPM Relationship: For large-diameter props, thrust increases significantly with relatively small changes in speed. Because thrust is proportional to the square of RPM, a large 42-inch blade requires only minor speed adjustments to maintain stability.
- Stability Variations: To maintain a stable hover in a quadcopter, the flight controller makes micro-adjustments to these RPMs. For a heavy-lift drone, these variations typically stay within ±5–10% of the hover RPM to counteract environmental factors like wind or minor weight shifts.

Performance Examples

Large industrial setups often utilize low-KV motors (e.g., 30–50 KV) to

I prefer this response

recommend a maximum operating range of up to **2,600–4,000 RPM** for propellers of this size, though they are most efficient at much lower speeds.

- **Tip Speed Constraint:** Large propellers are limited by tip speed; at 2,000 RPM, the tips of a 42-inch propeller travel at approximately 250 mph. Staying below **0.8 Mach** is critical for stability and efficiency.

RPM Variation Range for Stability

The "variations" used by the flight controller to maintain level hover are not static but occur hundreds of times per second.

- **Control Margin:** For a stable hover, drones are typically designed to hover at **40–60% throttle**. This provides a "buffer" of RPM variations to counter wind or off-center weight.
- **Thrust-to-RPM Relationship:** Thrust increases with the **square of the RPM**. To achieve a 10% increase in thrust for a sudden stability correction, the flight controller only needs to increase the RPM by approximately **4.8%**.
- **Typical Variation Bandwidth:** In a standard hover, you can expect the RPM to fluctuate within a window of **±100 to ±200 RPM** around the base speed to maintain precise attitude control.

inch blade requires only minor speed adjustments to maintain stability.

- Stability Variations: To maintain a stable hover in a quadcopter, the flight controller makes micro-adjustments to these RPMs. For a heavy-lift drone, these variations typically stay within ±5–10% of the hover RPM to counteract environmental factors like wind or minor weight shifts.

Performance Examples

Large industrial setups often utilize low-KV motors (e.g., 30–50 KV) to drive these propellers at high torque and low speed.

- 40x10 Propeller: Known to provide massive static thrust at "extremely low RPMs" for platforms in the 50–100 kg weight class.
- 36x11.5 Propeller: Recommended operating range is 1,000–2,600 RPM, producing up to 37 kg (81 lbs) of thrust per pair.
- 64x20 Propeller: Larger 64-inch systems hover at even lower speeds, typically requiring higher voltages (up to 400V) to manage the massive torque.

I prefer this response
I prefer this response

Help Us to Get Born