Requirements

Requirements

“utility infielder” platform

Notes

- 20/80 "good enough" solution
- consider past platforms: Lockheed MQM-105 Aquila [http://goo.gl/7SAhm], AME UAS Fury B, Boeing YCGM-121B Seek Spinner
- not just LO to only radar and IR
- satcom? bumps on top
- one hunter, one killer
- air launched?
- "Stealth" and "unprepared field" are not synonomous
- design to adapt (modularly) to several FBOs (siprnet)
- missions
    - centerline payload SDBs or other small weapons
    - icbm tracking
    - air sampling or nuclear material detection
    - can penetrate lightly defended airspace [states with possible NBC programs] AND which one can afford to actually lose
- no risk of compromise from crash
- You don't get to pick where your satellites are. An electronically steered antenna you can point at whatever satellite you want

low cost LO

- smaller - lengths of surfaces for LO
- doppler notch speeds?
- low altitude?
- buried inlet
- steered spikes - sweep angles for threat
- min apertures
- min control surfaces
- inside edges aligned, not so much outside
- "see through" OML
- RAS/RAM - structural alignment of edges
- yehudi lights
- minimal cutouts away from threat (bottom or top)
- egt over upper surface minimized
- antennae for LO

aerodynamics

- twisting strut for altitude
- top buried grid inlet with minimal distortion
- cranked kite design to play with static margin
- dropped canards on takeoff to trim pitch for high wing loading
- just above reynolds cutoff with margin
- work torsion on control surfaces
- laminar flow airfoil/wing with bump at back? (xfoil) for very high altitude loiter
- design for fast and slow? (launch instead of stall)
- manage quick pitch-up on takeoff
- basic stability until gnc online (fly with split elevons to start for directional stability?) What about lateral (roll)?
- AVL model with 6-DoF glide and powered flights (prove basic stability) maybe make Flight Gear Model

weapons

- centerline single payload bay
- b-1 upgraded rotary concept (15 or 320% increase)
- apmi mortar, gd dropped mortar?
- AEA gear

propulsion

- grid inlet for short applications?
- jato rocket assisted takeoff?
- landing/parachute gear (weight)
- uses scaneagle launch and recovery equipment?
- tilted install with toilet bowl inlet on top
- single high bypass turbofan or ducted fan (Jet Cat is high TSFC and HOT)
- hot engine melt structure
- fuel slosh
- really quiet jet
- hold the flame above 65 kft?
- Pulse Jet
    - air entrainment aft augmenter increases thrust 50% to 80%
    - can augmenter dampen noise also?
    - sources of noise? inlet? combustion chamber? nozzle?
    - aerodynamic inlet design for on-design operations
    - install above waterline to deflect noise and heat away from threat
    - harpoints with flex and growth for thermal expansion and contraction
    - supply fuel tank and line at high pressure
    - spark plug?
    - throttle valve?
    - mach and altitude variations in performance?
    - thermal management
    - heat transfer to power onboard systems?
    - air entrainment vacuum? test labs how it works?
    - engineering design specifications
    - 4 lb jet TSFC at 1.5 to 2.0 lb/lb-hr!

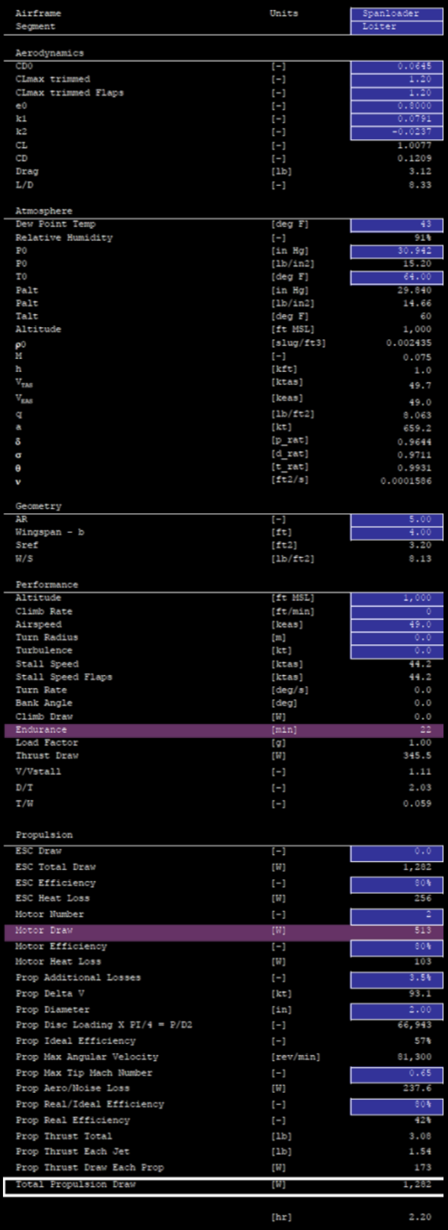
structures

- full length spar (wrap around)
- powder model parts
- OOA composites (out of autoclave)
- molds/jigs?
- sandwich construction
- minimize mechanisms
- use COTS alighting gear
- break points for logistics
- COTS (albeit oversized) landing gear

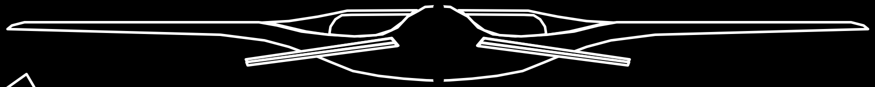
mass properties

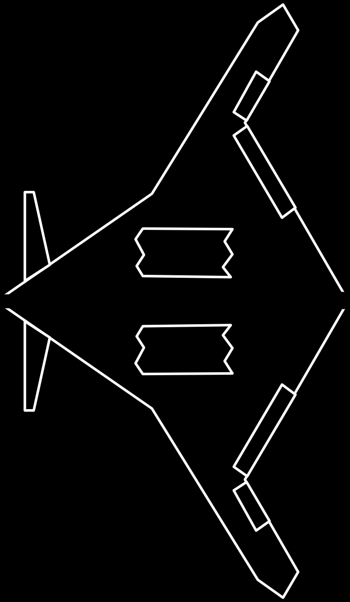
- ballast for future weight

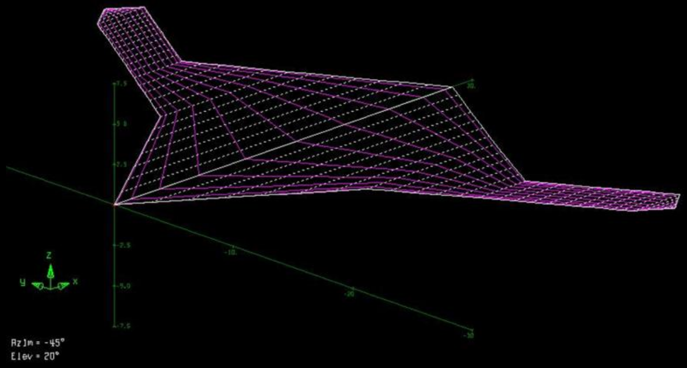
Specifications



Airframe	Units	Spanloader
Segment		Loiter
Aerodynamics		
CD0	[-]	0.0645
CLmax trimmed	[-]	1.20
CLmax trimmed Flaps	[-]	1.20
e0	[-]	0.8000
k1	[-]	0.0791
k2	[-]	-0.0237
CL	[-]	1.0077
CD	[-]	0.1209
Drag	[lb]	3.12
L/D	[-]	8.33
Atmosphere		
Dew Point Temp	[deg F]	43
Relative Humidity	[-]	91%
P0	[in Hg]	30.942
P0	[lb/in2]	15.20
T0	[deg F]	64.00
Palt	[in Hg]	29.840
Palt	[lb/in2]	14.66
Talt	[deg F]	60
Altitude	[ft MSL]	1,000
ρ0	[slug/ft3]	0.002435
M	[-]	0.075
h	[kft]	1.0
V_{TAS}	[ktas]	49.7
V_{EAS}	[keas]	49.0
q	[lb/ft2]	8.063
a	[kt]	659.2
δ	[p_rat]	0.9644
σ	[d_rat]	0.9711
θ	[t_rat]	0.9931
ν	[ft2/s]	0.0001586
Geometry		
AR	[-]	5.00
Wingspan - b	[ft]	4.00
Sref	[ft2]	3.20
W/S	[lb/ft2]	8.13
Performance		
Altitude	[ft MSL]	1,000
Climb Rate	[ft/min]	0
Airspeed	[keas]	49.0
Turn Radius	[m]	0.0
Turbulence	[kt]	0.0
Stall Speed	[ktas]	44.2
Stall Speed Flaps	[ktas]	44.2
Turn Rate	[deg/s]	0.0
Bank Angle	[deg]	0.0
Climb Draw	[W]	0.0
Endurance	[min]	22
Load Factor	[g]	1.00
Thrust Draw	[W]	345.5
V/Vstall	[-]	1.11
D/T	[-]	2.03
T/W	[-]	0.059
Propulsion		
ESC Draw	[-]	0.0
ESC Total Draw	[W]	1,282
ESC Efficiency	[-]	80%
ESC Heat Loss	[W]	256
Motor Number	[-]	2
Motor Draw	[W]	513
Motor Efficiency	[-]	80%
Motor Heat Loss	[W]	103
Prop Additional Losses	[-]	3.5%
Prop Delta V	[kt]	93.1
Prop Diameter	[in]	2.00
Prop Disc Loading X PI/4 = P/D2	[-]	66,943
Prop Ideal Efficiency	[-]	57%
Prop Max Angular Velocity	[rev/min]	81,300
Prop Max Tip Mach Number	[-]	0.65
Prop Aero/Noise Loss	[W]	237.6
Prop Real/Ideal Efficiency	[-]	80%
Prop Real Efficiency	[-]	42%
Prop Thrust Total	[lb]	3.08
Prop Thrust Each Jet	[lb]	1.54
Prop Thrust Draw Each Prop	[W]	173
Total Propulsion Draw	[W]	1,282
	[hr]	2.20

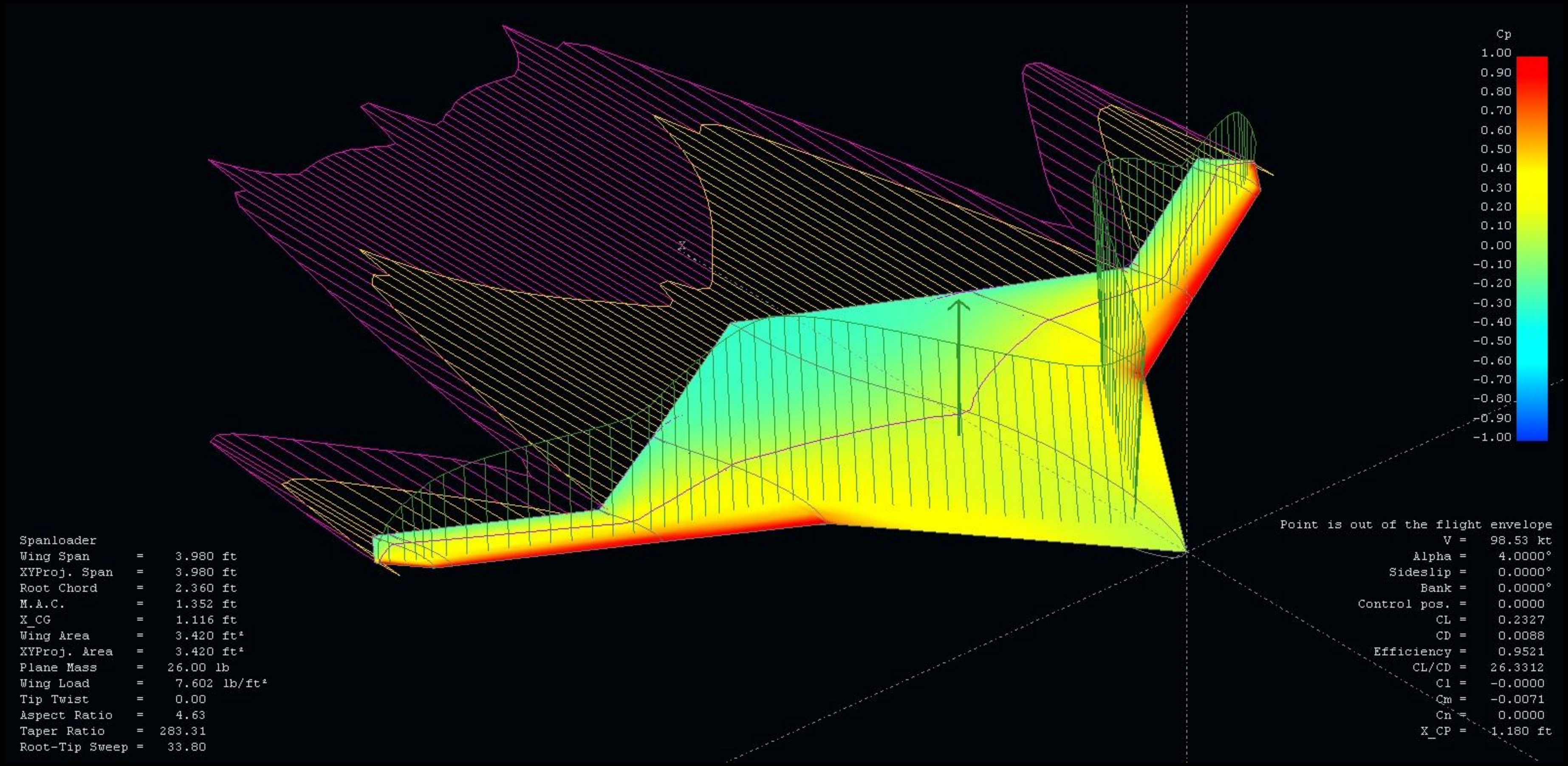






		spanloader	w35
neng		2.00	1
w/s	lb/ft2	8.00	1.80
t/w		0.20	0.20
ar		5.00	6.64
t	lb	5.20	2.60
w	lb	26.00	12.27
ve	ft/s	50.00	50.00
sref	ft2	3.25	6.81
b	ft	4.03	6.72
l/d		8.00	9.00
d	lb	3.25	1.36
throttle		0.63	0.52
cbar	ft	0.81	1.01
tsfc	lb/lb-hr	1.15	1.15
mdot	lb/hr	3.74	1.57
wf/w0		0.30	0.33
wp/w0		0.10	0.12
vst	ft/s	18.87	8.95
vcr	ft/s	24.53	11.64
range	nm	36.06	21.58
end	hr	1.47	1.85

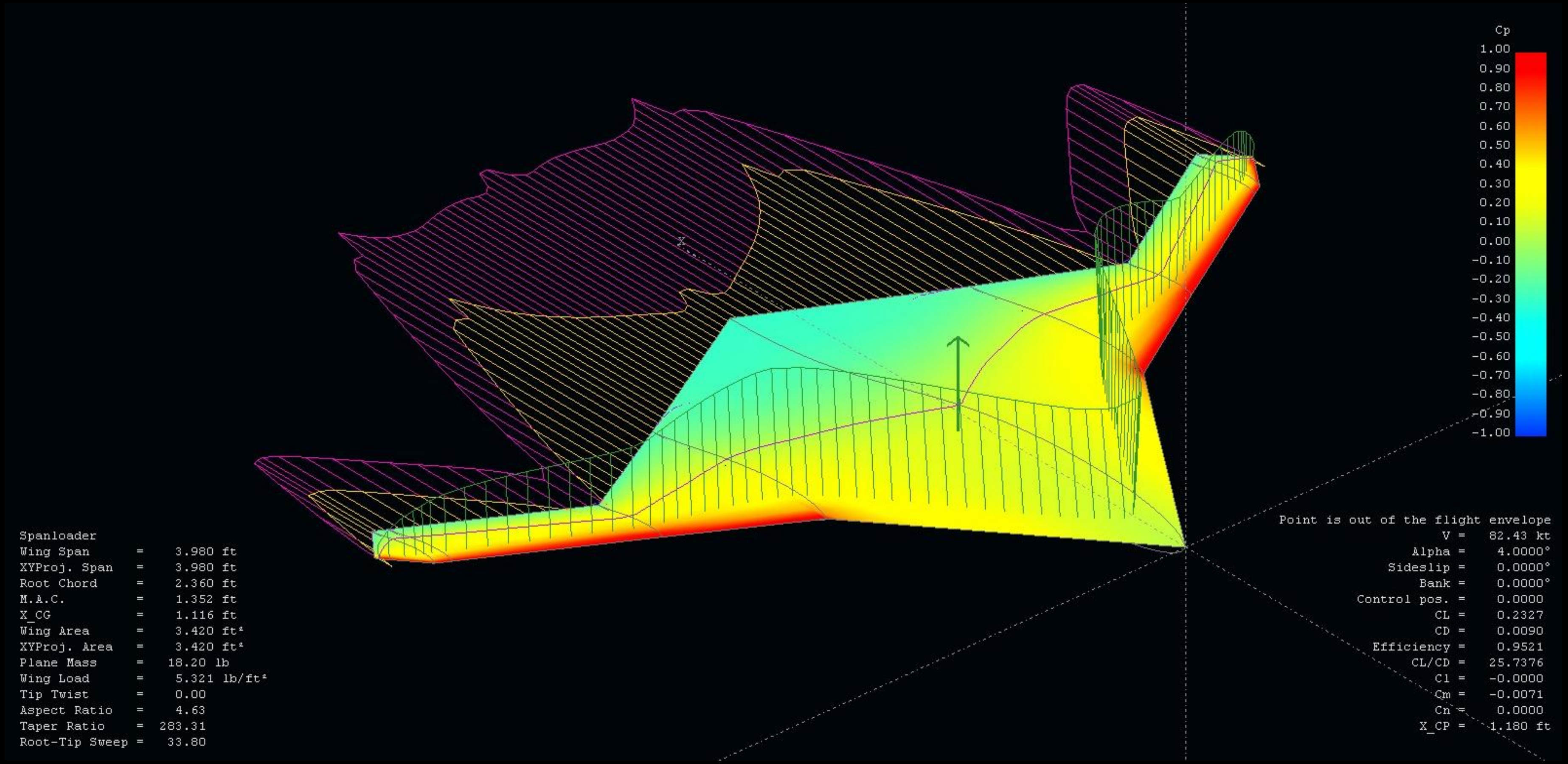
Gross Weight = 26.0 lb



```
Spanloader
Wing Span      =    3.980 ft
XYProj. Span   =    3.980 ft
Root Chord     =    2.360 ft
M.A.C.         =    1.352 ft
X_CG           =    1.116 ft
Wing Area      =    3.420 ft²
XYProj. Area   =    3.420 ft²
Plane Mass     =   26.00 lb
Wing Load      =    7.602 lb/ft²
Tip Twist      =    0.00
Aspect Ratio   =    4.63
Taper Ratio    =  283.31
Root-Tip Sweep =   33.80
```

```
Point is out of the flight envelope
                         V =   98.53 kt
                     Alpha =    4.0000°
                  Sideslip =    0.0000°
                      Bank =    0.0000°
              Control pos. =    0.0000
                        CL =    0.2327
                        CD =    0.0088
                Efficiency =    0.9521
                     CL/CD =   26.3312
                        Cl =   -0.0000
                        Cm =   -0.0071
                        Cn =    0.0000
                      X_CP =   1.180 ft
```

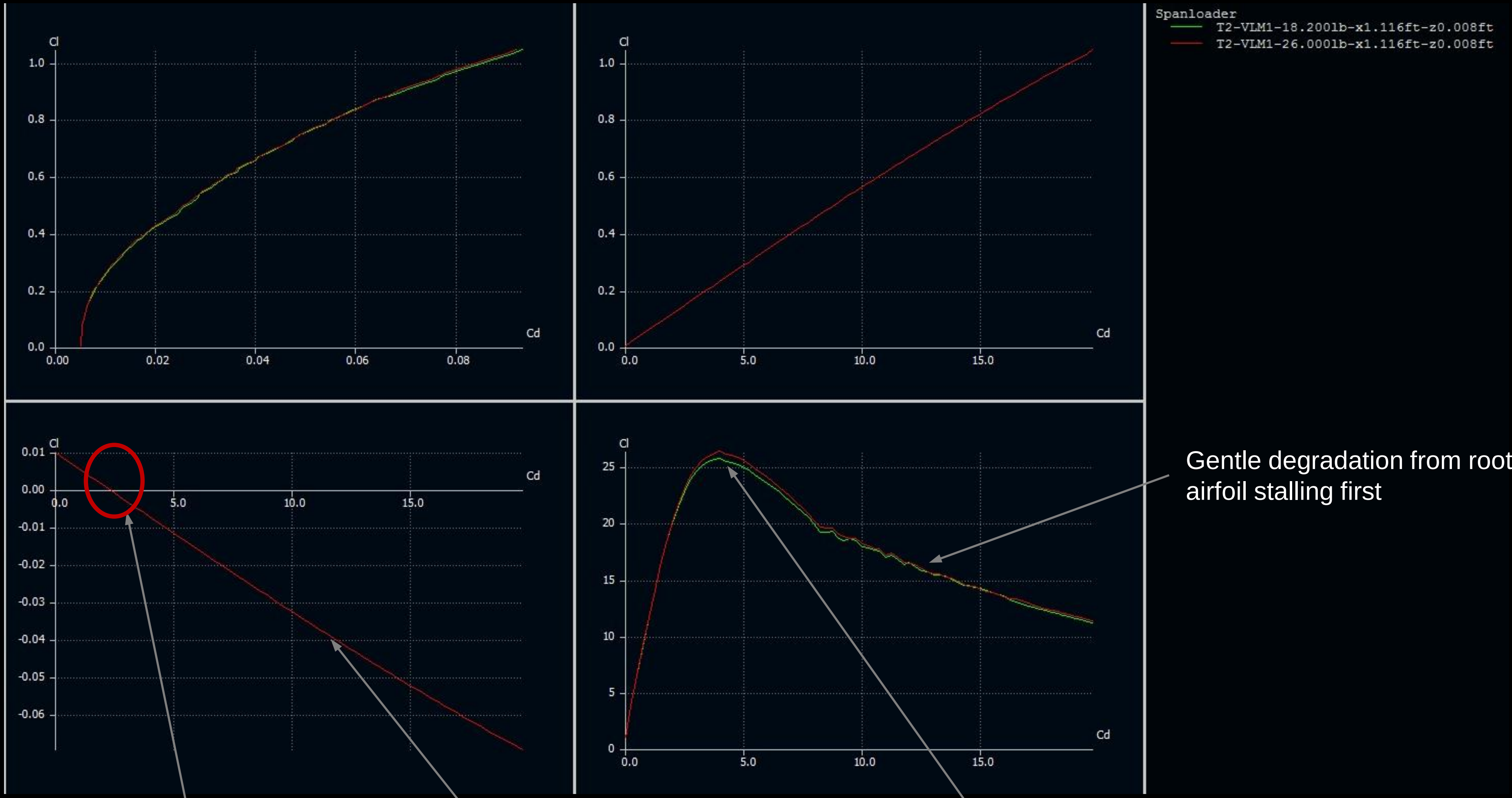
Gross Weight = 18.2 lb



```
Spanloader
Wing Span      =    3.980 ft
XYProj. Span   =    3.980 ft
Root Chord     =    2.360 ft
M.A.C.         =    1.352 ft
X_CG           =    1.116 ft
Wing Area      =    3.420 ft²
XYProj. Area   =    3.420 ft²
Plane Mass     =   18.20 lb
Wing Load      =    5.321 lb/ft²
Tip Twist      =    0.00
Aspect Ratio   =    4.63
Taper Ratio    =  283.31
Root-Tip Sweep =   33.80
```

```
Point is out of the flight envelope
                     V =   82.43 kt
                 Alpha =    4.0000°
              Sideslip =    0.0000°
                  Bank =    0.0000°
          Control pos. =    0.0000
                    CL =    0.2327
                    CD =    0.0090
            Efficiency =    0.9521
                 CL/CD =   25.7376
                    Cl =   -0.0000
                    Cm =   -0.0071
                    Cn =    0.0000
                  X_CP =   1.180 ft
```

Drag Polar: Trimmed Plots



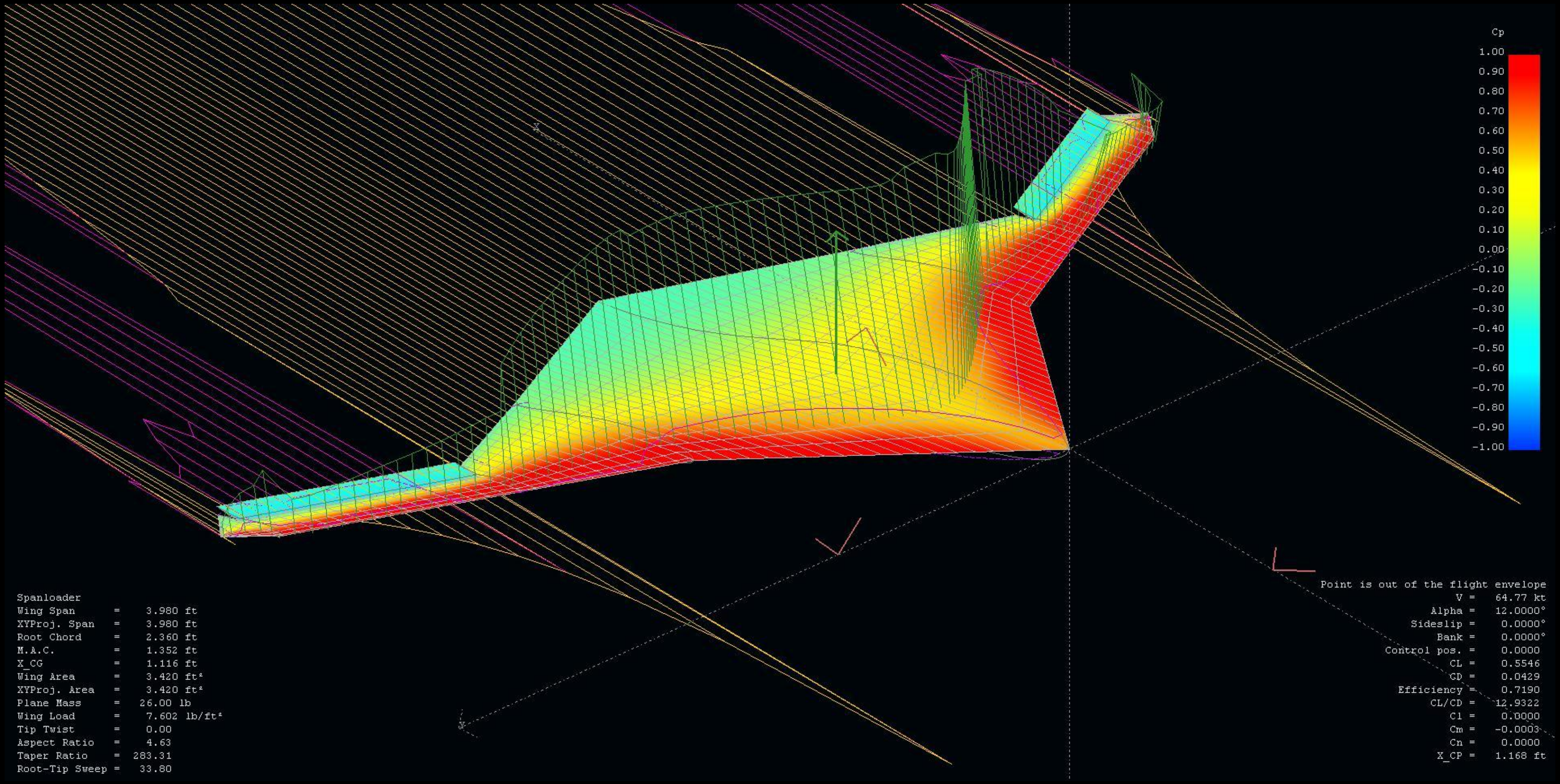
Gentle degradation from root airfoil stalling first

Trims at 4 deg AoA

Negative Cm slope static longitudinal stability

Max Glide Ratio 26:1 at 4 deg trim point!

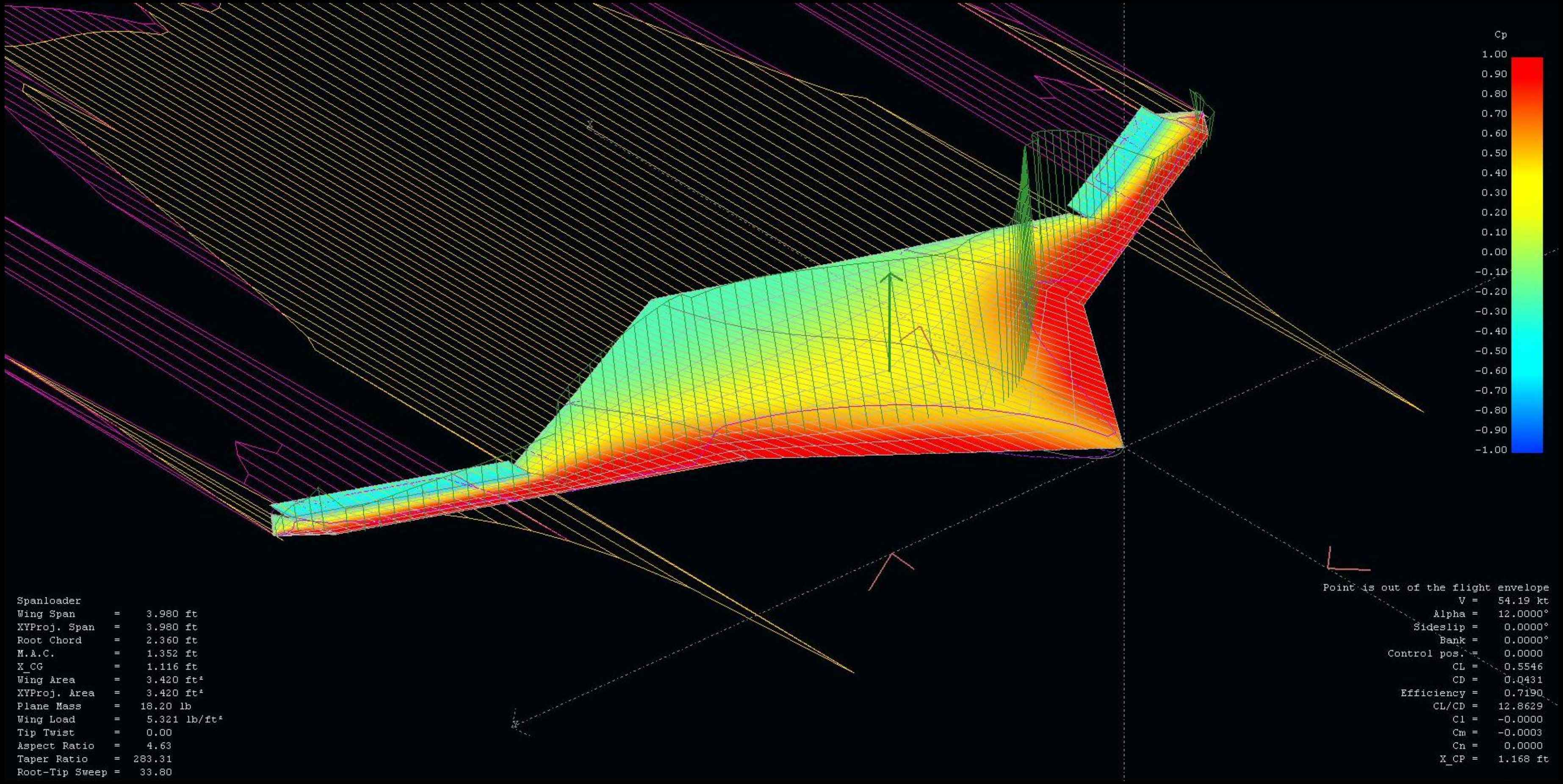
Gross Weight = 26.0 lb, dElv = -15 deg



```
Spanloader
Wing Span       =    3.980 ft
XYProj. Span    =    3.980 ft
Root Chord      =    2.360 ft
M.A.C.          =    1.352 ft
X_CG            =    1.116 ft
Wing Area       =    3.420 ft²
XYProj. Area    =    3.420 ft²
Plane Mass      =   26.00 lb
Wing Load       =    7.602 lb/ft²
Tip Twist       =    0.00
Aspect Ratio    =    4.63
Taper Ratio     =  283.31
Root-Tip Sweep  =   33.80
```

```
Point is out of the flight envelope
                        V =   64.77 kt
                    Alpha =   12.0000°
                 Sideslip =    0.0000°
                     Bank =    0.0000°
             Control pos. =    0.0000
                       CL =    0.5546
                       CD =    0.0429
               Efficiency =    0.7190
                    CL/CD =   12.9322
                       Cl =    0.0000
                       Cm =   -0.0003
                       Cn =    0.0000
                     X_CP =   1.168 ft
```

Gross Weight = 18.2 lb, dElv = -15 deg



```
Spanloader
Wing Span      =    3.980 ft
XYProj. Span   =    3.980 ft
Root Chord     =    2.360 ft
M.A.C.         =    1.352 ft
X_CG           =    1.116 ft
Wing Area      =    3.420 ft²
XYProj. Area   =    3.420 ft²
Plane Mass     =   18.20 lb
Wing Load      =    5.321 lb/ft²
Tip Twist      =    0.00
Aspect Ratio   =    4.63
Taper Ratio    =  283.31
Root-Tip Sweep =   33.80
```

```
Point is out of the flight envelope
                V =   54.19 kt
            Alpha =   12.0000°
         Sideslip =    0.0000°
             Bank =    0.0000°
     Control pos. =    0.0000
               CL =    0.5546
               CD =    0.0431
       Efficiency =    0.7190
            CL/CD =   12.8629
               Cl =   -0.0000
               Cm =   -0.0003
               Cn =    0.0000
             X_CP =   1.168 ft
```

Launch Trade Study

	Description	Pros	Cons
CTOL – Static Gear	Fixed tricycle gear. Use COTS wheels/axels (RC industry). Requires grass or dirt strip runway (~500 ft).	- Design already exists - Lowest technical risk	- Requires prepared runway (est. 500 ft.) - Obscures sensor view - Performance Reduction - Parasitic Drag Hit - Increase in RF Signature
CTOL – Retractable Gear	Fixed tricycle gear. Use COTS wheels/axels (RC industry). Requires grass or dirt strip runway (~500 ft).	- Sky Spirit designed with retracts in mind	- Requires some NRE (design already started) - Landing gear mechanism (complexity = cost) - Runway needs to be good quality
CTOL – Dolly or Cart	Drop away tricycle gear. Use COTS wheels/axels (RC industry). Requires grass or dirt strip runway (500 ft).	- Lowers aircraft weight	- Extra Loose components - Additional step in launch process & logistics
Pneumatic Launch Rail	Large wheeled launch rail (possibly on trailer).	- Repeatable launch - No Pilot training required - No prepared runway required	- Large logistical footprint - Requires significant NRE (unless we can buy one somewhere) - Mechanical reliability?
High/Push Start on Rail	Low friction Guide Rail laid on ground (in sections). Rides on rail until lift off. No active components. Aircraft relies on own engine to accelerate (helped out by a "high start" and/or push).	- Simple design compared to Pneumatic Launch Rail - Does not require prepared runway - Guide rail could float on water if need be	- Still Requires significant length (shorted than conventional Take Off though) - Requires some NRE
Sling Launch	Aircraft is spun on a tether until it reaches climb-out velocity and then it is released.	- Does not require prepared runway - Potentially lowers aircraft weight - Can choose release speed and direction - quick deployment	- New, unproven concept - Requires Significant NRE

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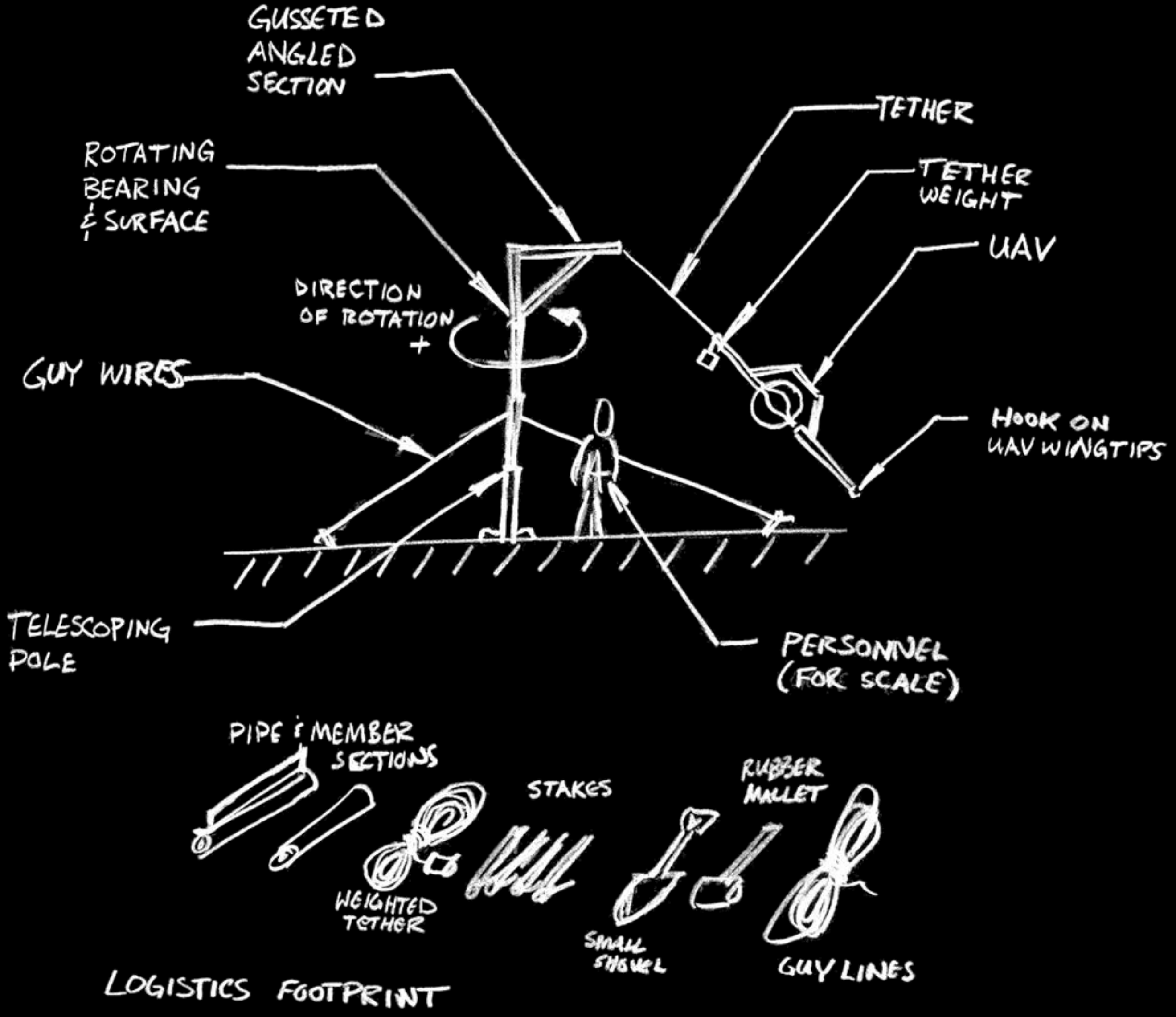
Recovery Trade Study

	Description	*Pros*	*Cons*
CTOL – Static Gear	Fixed Tricycle gear configuration. Use COTS wheels/axels (RC industry). Requires grass or dirt strip runway (est. 500 ft long).	- Design already exists - Lowest technical risk	- Requires prepared runway (est. 500 ft.) - Obscures sensor view - Performance Reduction - Parasitic Drag Hit - Increase in RF Signature
CTOL – Retractable Gear	Retractable Tricycle gear configuration. Use COTS wheels/axels (RC industry). Requires grass or dirt strip runway (est. 500 ft long).	- Sky Spirit designed with retracts in mind	- Requires some NRE (design already started) - Landing gear mechanism (complexity = cost)
CTOL – Static Skids	Fixed TBD skid configuration. Requires grass or dirt strip runway (est. 100 ft long).	- Requires shorter runway than wheels - Possibly easier to implement Auto-Land	- Requires some NRE - Possible greater potential for damage on landing - Performance Reduction - Parasitic Drag Hit
CTOL – Retractable Skids	Retractable TBD skid configuration. Requires grass or dirt strip runway (~ 100 ft).	- Requires shorter runway than wheels - Possibly easier to implement Auto-Land	- Requires some NRE - Possible greater potential for damage on landing - Alighting gear mechanism (complexity =
Fly into a "Net"	Hanging Net of TBD design will catch the UAV as it flies into it. The engine will probably have to be turned off before impact.	- Does not require prepared runway	- High risk of damage to the UAV during recovery - Larger logistical footprint compared to conventional Landing
Sky Hook	Similar to the Boeing Scan Eagle design with appropriate tweaks to work with Sky Spirit.	- Does not require prepared runway - Quick recovery (saved time)	- Difficult to modify Sky Spirit to this configuration (may require significant NRE and changes) - Larger logistical footprint compared to
Deep Stall	Flight controller maintains the aircraft in deep stall (wings level) and performs a near-vertical landing. May require shock absorbers/airbags under aircraft.	- No one else is doing this on our class of UAV or bigger - If successful we might attract R&D funding for further development.	- Requires significant NRE on the flight controller - Requires some NRE for shock absorbers
Ballistic Chute	Aircraft deploys a parachute when it arrives over landing zone.	- Known method from Target Drones - Chute delpoys over landing zone - Low risk	- Tangled in chute - Space for pyro deployment device - Heavy

Launch & Recovery: Trade Study Weighted

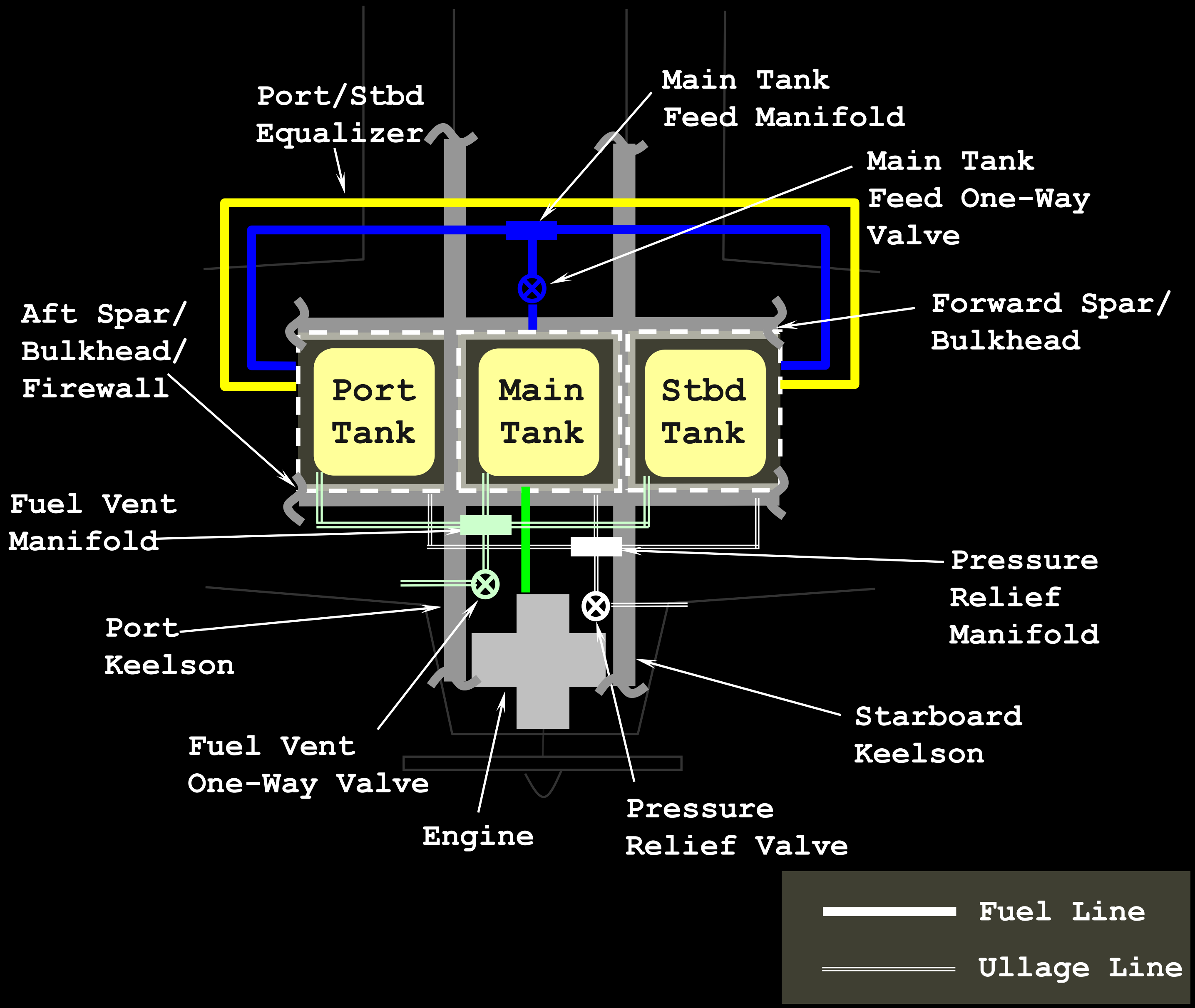
		Logistics Foot Print	Min Training/Skill	Low Cost	Minimum NRE	Mech Reliability	Repeatable	Min Weight	Min Impact to Useful Volume	Sensor Obscuration	Minimum Reqmts on Deployment Area	Average - Unweighted	Average - Unweighted	Average - Weighted	Average - Weighted
	Weighting	1	1	3	2	1	1	1	1	3	1				
Launch	**CTOL – Static Gear**	5	1	5	5	5	5	4	3	1	1	3.5	**92%**	52	**91%**
	CTOL – Retractable Gear	5	1	4	4	3	5	3	1	5	1	3.2	**84%**	54	**95%**
	CTOL – Dolly or Cart	4	1	4	4	4	4	5	3	5	1	3.5	**92%**	57	**100%**
	Pneumatic Launch Rail	1	3	1	1	2	5	5	4	5	5	3.2	**84%**	45	**79%**
	High/Push Start on Rail	3	3	3	3	4	4	5	4	5	4	3.8	**100%**	57	**100%**
	Sling Launch	3	2	3	1	2	3	4	3	5	5	3.1	**82%**	48	**84%**
Recovery	**CTOL – Static Gear**	5	1	5	5	4	5	4	3	1	1	3.4	**97%**	51	**94%**
	CTOL – Retractable Gear	5	1	4	4	3	5	3	1	5	1	3.2	**91%**	54	**100%**
	CTOL – Static Skids	5	1	5	3	5	4	4	4	1	2	3.4	**97%**	49	**91%**
	CTOL – Retractable Skids	5	1	4	3	4	4	3	2	5	2	3.3	**94%**	54	**100%**
	Net	2	4	3	2	3	3	4	4	5	5	3.5	**100%**	53	**98%**
	Sky Hook	2	4	3	1	3	3	3	4	5	5	3.3	**94%**	50	**93%**
	Deep Stall	5	5	3	1	2	2	3	4	5	5	3.5	**100%**	52	**96%**
	Ballistic Chute	3	5	3	1	5	5	2	1	5	5	3.5	**100%**	52	**96%**

Launch & Recovery: Tether Method

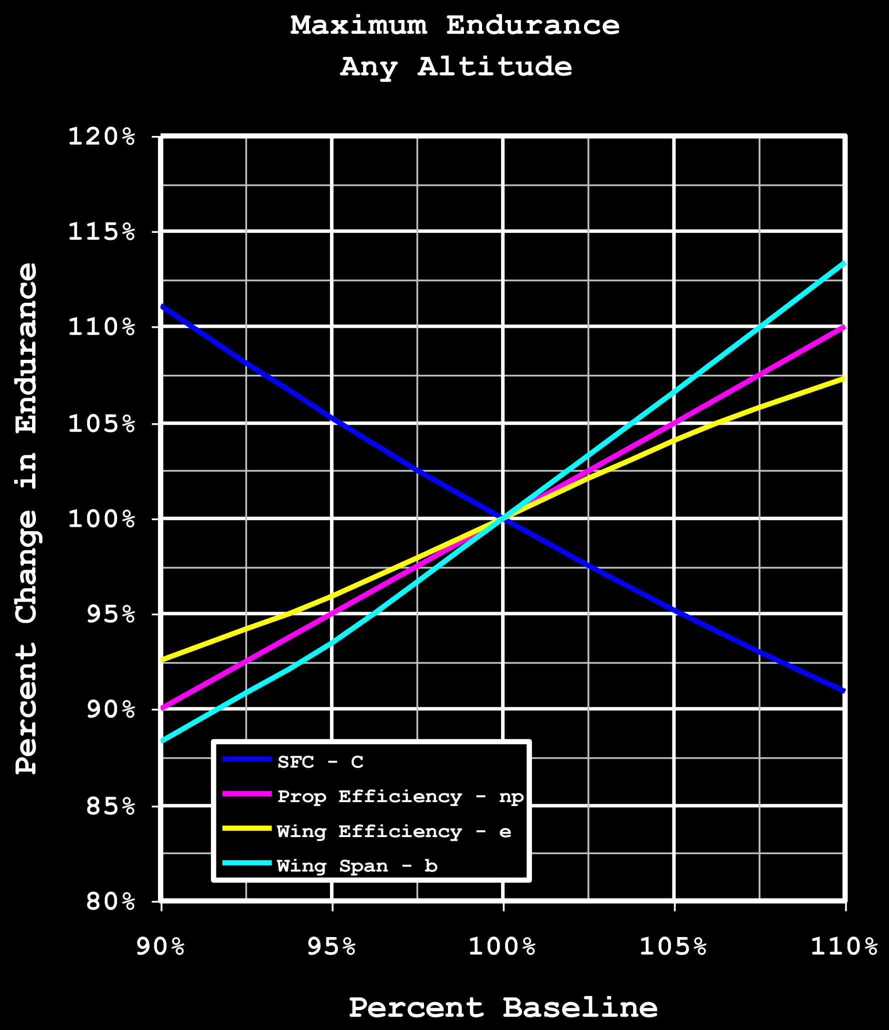


Fuel System: Concept Schematic

- *Bladders/Seals in Each Bay*
- *Foam Baffling*
  - Does Not Wick Fuel
  - Inert
- *Pressure Relief Manifold with Threshold Pressure for All Tanks*
- *System Operates at Atmospheric Pressure*
- *One-Way Valve to Feed Main Tank*
  - Manifolded to Reduce Unequal Fuel Flow From Outboard Tanks



Sensitivity Study: Endurance



- *Answer*
  - Larger Span and Smaller SFC, Prop and Wing Efficiencies are Better
  - Altitude Independent
- *Assumptions*
  - Parasitic Drag Buildup with Form Factor Method
  - Used Average Dynamic Pressure for Entire Segment
  - Loiter for Prop at 87% Max L/D
- *Sensitivities*
  - Drivers in Order of Impact:
    - *- Wing Span*
    - *- SFC*
    - *- Prop Efficiency*
    - *- Wing Efficiency*
  - Drivers are Close in Overall Impact
- *Alternatives*
  - Cross Check with Incremental Calculations