TLAR and Engine Loss on Takeoff

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Overview

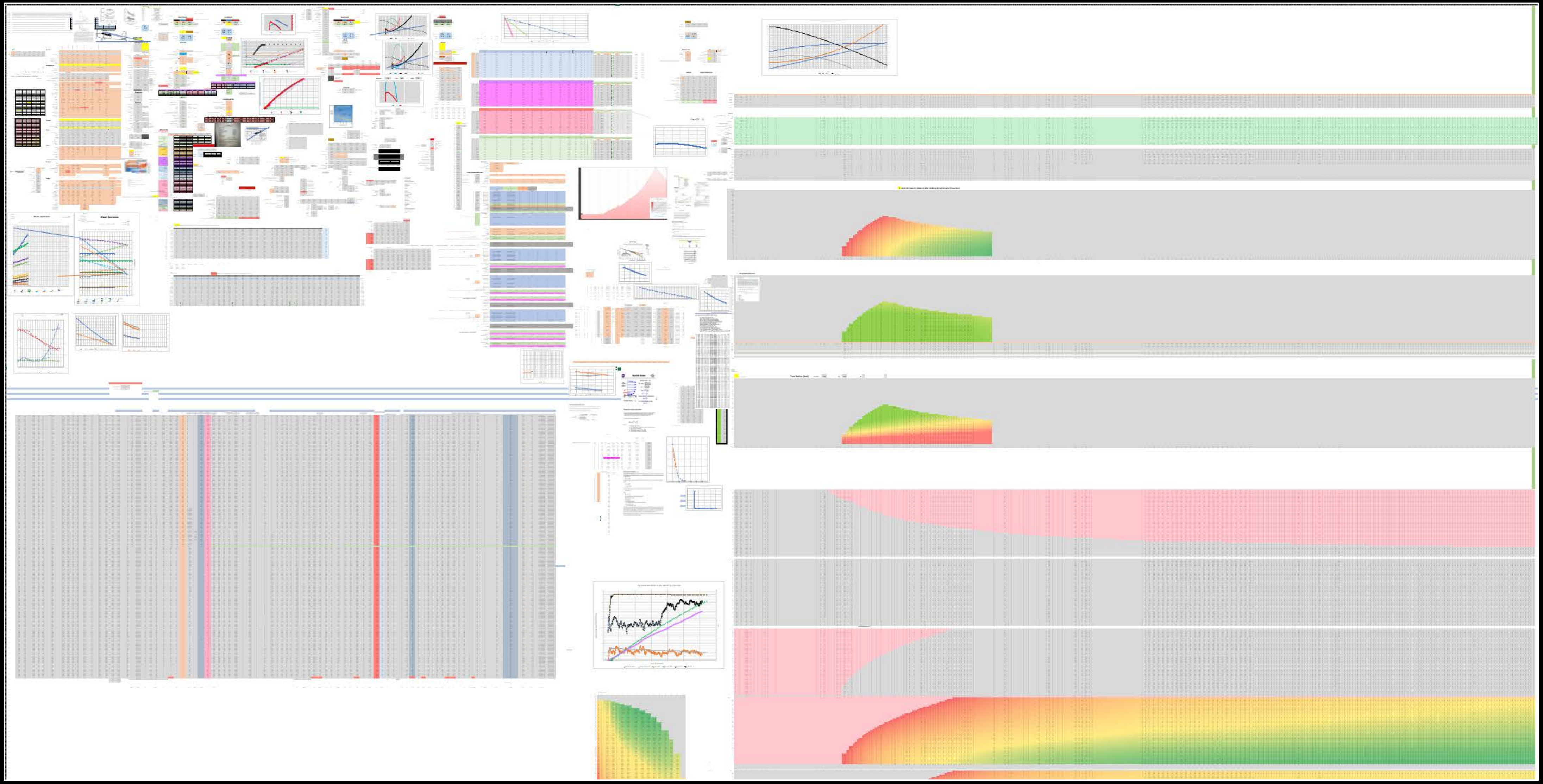
- TLAR Aircraft Performance iOS App (patent pending)
- Engine-loss on Takeoff Decision
- Turnback Geometry
- Planning for the Worst
- Flying the Turnback

TLAR born on this Backcountry takeoff in 2018

Krassel airstrip, Idaho: 1500 feet long, Trees Both Ends, 4000’ Elevation, 5400’ DA

“Can I make it?”

TLAR started as a massive Spreadsheet



TLAR now an iOS app

- “All models are wrong, some are useful.”
- ~50,000 lines of code, 1.5M lines in airfield database
- Engineering model of 37 aircraft types thus far
- Expert version has custom-aircraft build function
- All start with wing lift-drag polar

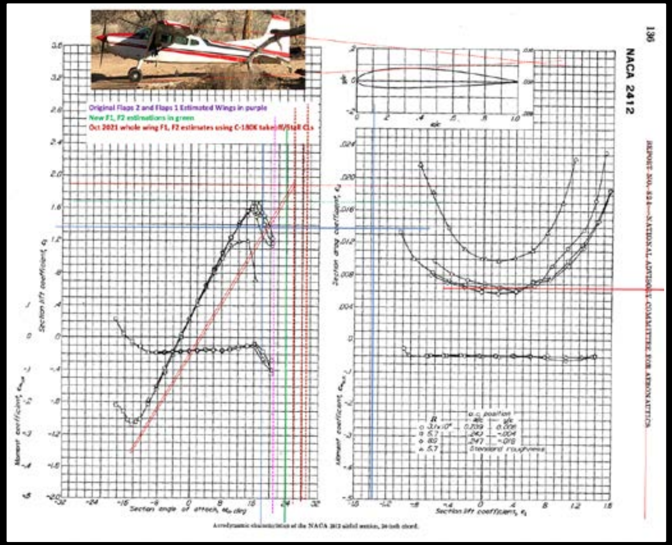
```
public func computeLift(rho: Double, v: Double, cl: Double, s: Double) -> Double{

    let lift: Double = 0.5 * rho * pow(v,2) * cl * s

    return lift

}
```

Lift equation for we nerds!



NACA 2412

TLAR Inputs / Outputs

Pilot
(Safety Margins, FPA, TDZ Length, Flaps/STOL/Brakes)

Airfield
(Lat/Long, Elev, Length, Axis, Slope, Surface, Condition)

Weather
(Winds, Temp, Pressure)

Aircraft Physics
(Altitude, Speed, Direction, Attitude)

Aircraft Aerodynamics
(Weight, Lift, Drag, Thrust)

Takeoff
(Run, Over 50, HBE)

Landing
(Roll, Over 50)

Climb
(Vx, Vy, Vz, Vcas, Vtas, Vfpm, Veco)

Cruise
(Max, %Crz, Rng, Edr)

Wing
(Vg, Vref, Vs)

Dynamic
(recomputes each second)

Effective in the Front-Country

Weather
(Pulls METARs every 10 minutes)

Navigation
(HSI, LPV-like VNAV, live Apple Maps)

Communication
(Sharable situation reports)

Airfields
(Global runway database)

Astronomical
(Time Zones, Zulu to Local conversion)

Designed for the Backcountry

Weather

(Stores all METARs, iBaro, GSL, Temp Dev, Manual Winds)

Navigation

(Mark Points, Cached Maps, World Magnetic Model 2025)

Communication

(Sharable LZs, Telemetry recording)

Landing Zones

(No runway mode, Create save and Survey LZs, STOL, Fence Height, HBE)

Astronomical

(Sun and Moon data for LZ at your ETA)

TLAR
Demo
Diamond LZ

Engine failure on Takeoff
Choosing best of bad options

OFF-AIRPORT

versus

STALL/SPIN

Commonly Held Turnback Thoughts

Are you nuts?
(I would never fly a turnback)

Minimum Altitude
(like 800 AGL)

Speed
(best glide speed)

Bank
(30 or 60 degrees)

Commonly Held Turnback Thoughts

Are you nuts?

~~(I would never fly a turnback)~~

You might from cruise altitude

Minimum Altitude

~~(like 800 AGL)~~

There isn’t one

Speed

~~(best glide speed)~~

Vref (1.3 x Vs) is better

Bank

~~(30 or 60 degrees)~~

45 is optimum

Gliding Turnback Science

Object: lose least altitude in turn
(Turn rate matters as much as descent rate)

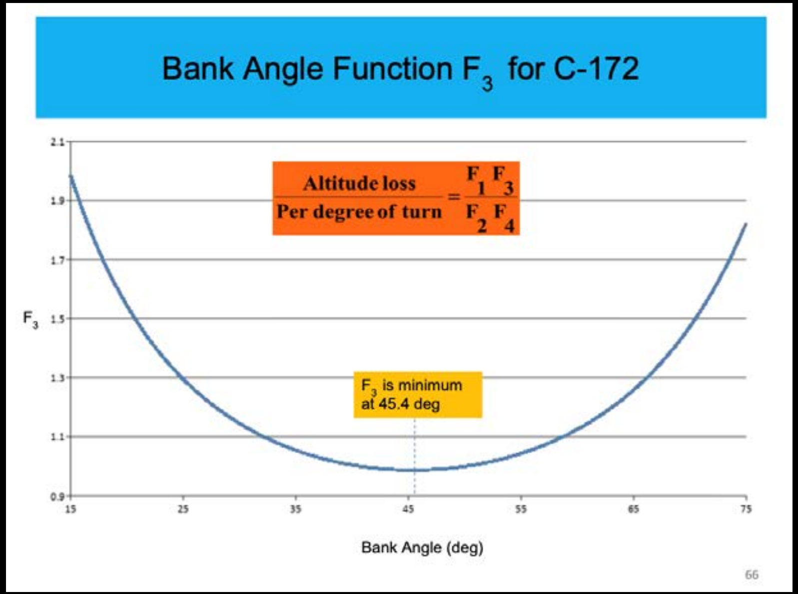
Turn rate
(1091 x TAN (Bank) / KTAS)

Descent Rate
(KTAS x Drag / Weight)

Theoretical Optimum
(45 degrees of bank @ 100% max lift, ergo @ stall, dangerous)

Safety buffer
(Recommend 45 degrees of bank @ 60% of max lift or Vref = 1.3 x Vstall for turns)

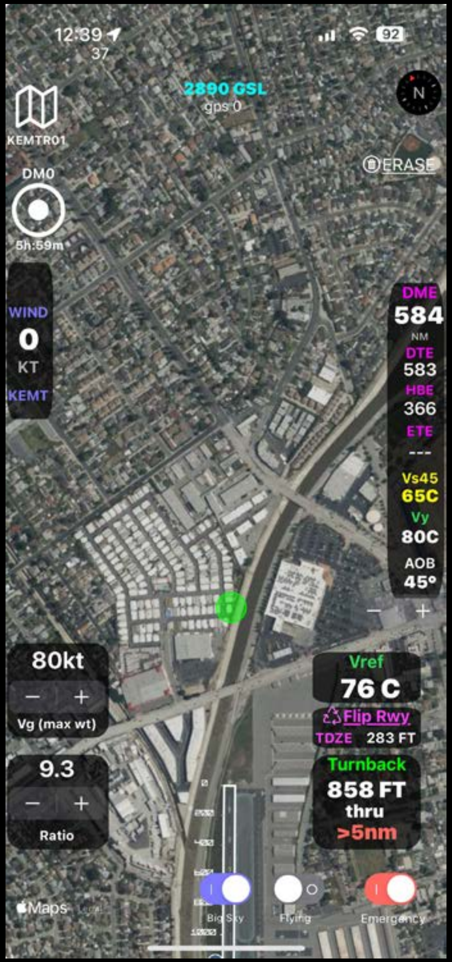
Drag is double-edged, stall is THE enemy
(Controllable drag: configuration, propeller, slip, throttle?)



Les Glatt, PhD, ATP, CFI-AI, "Single-Engine Failure after Takeoff: The Anatomy of a Turnback Maneuver," July 25, 2020. https://www.eaa.org/-/media/files/eaa/educationresources/sportaviation/2020-12-14-turnback-maneuver-anatomy.ashx

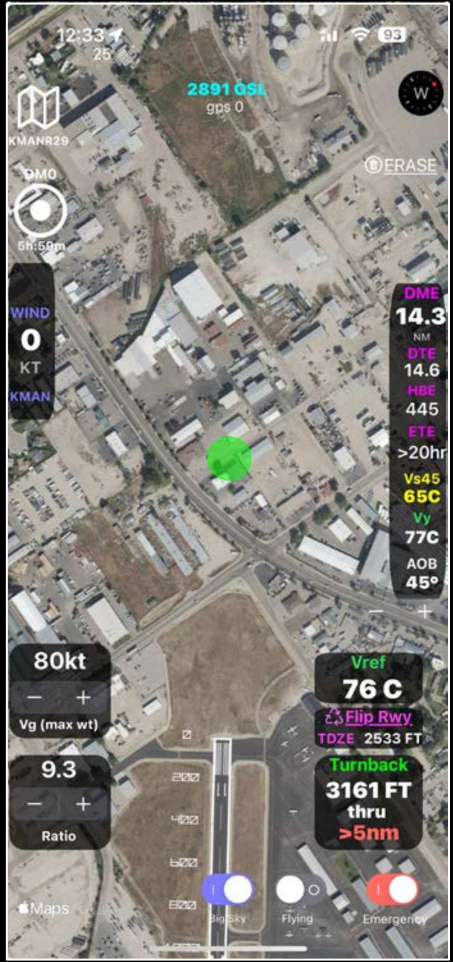
“To Turn or Not to Turn?”

What's off end of runway?



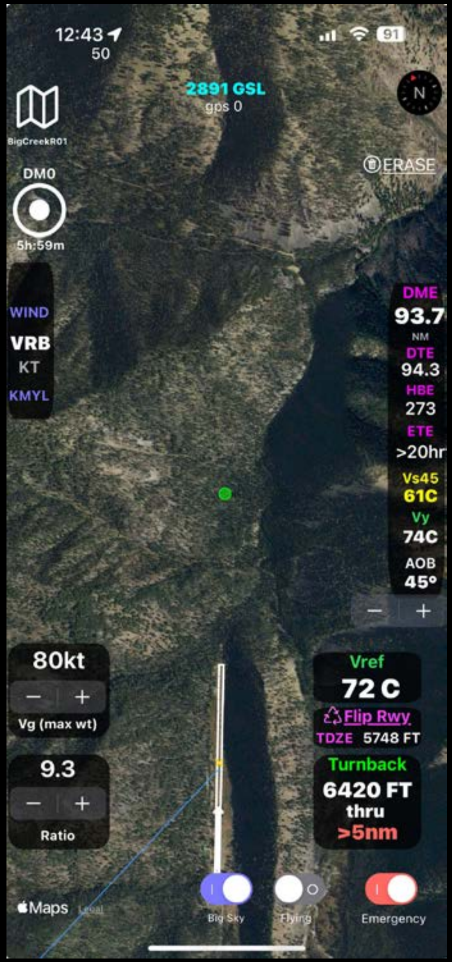
El Monte R01

Urban



KMAN R29

Mostly Urban

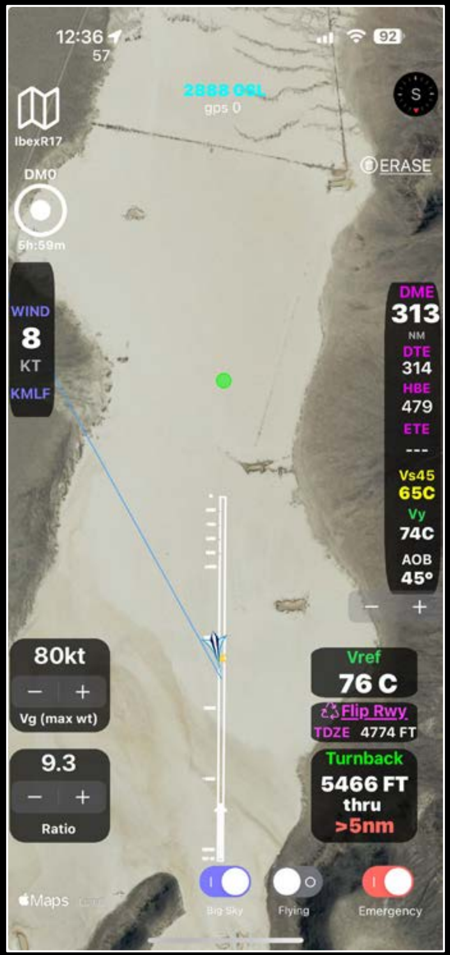


Big Creek R01

Trees/Mountain

S78 R28

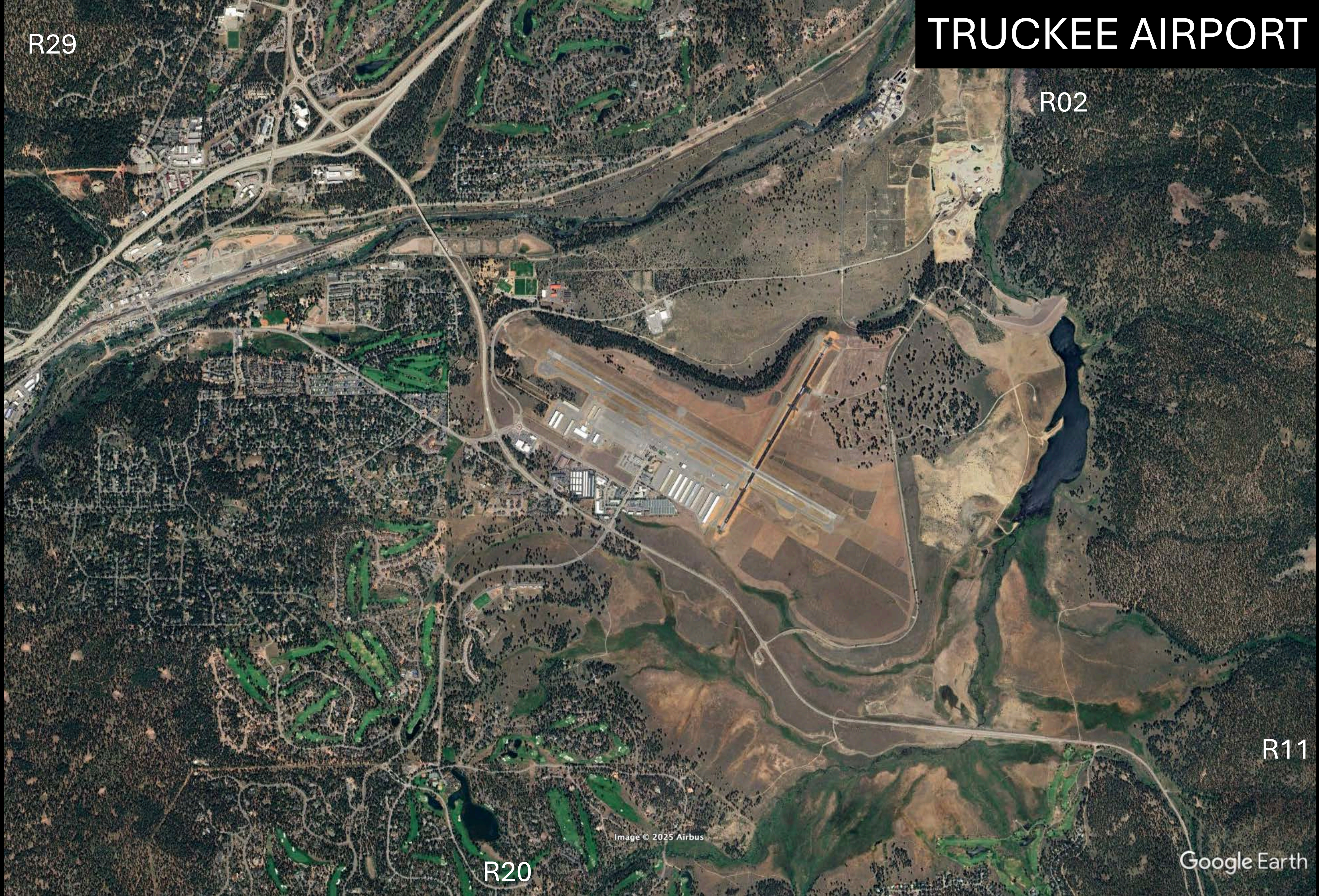
Roads/Farmland



Ibex South

Ideal!

TRUCKEE AIRPORT



Can you fly a low-altitude engine-out gliding turnback under extreme stress without stalling?

Have you practiced?

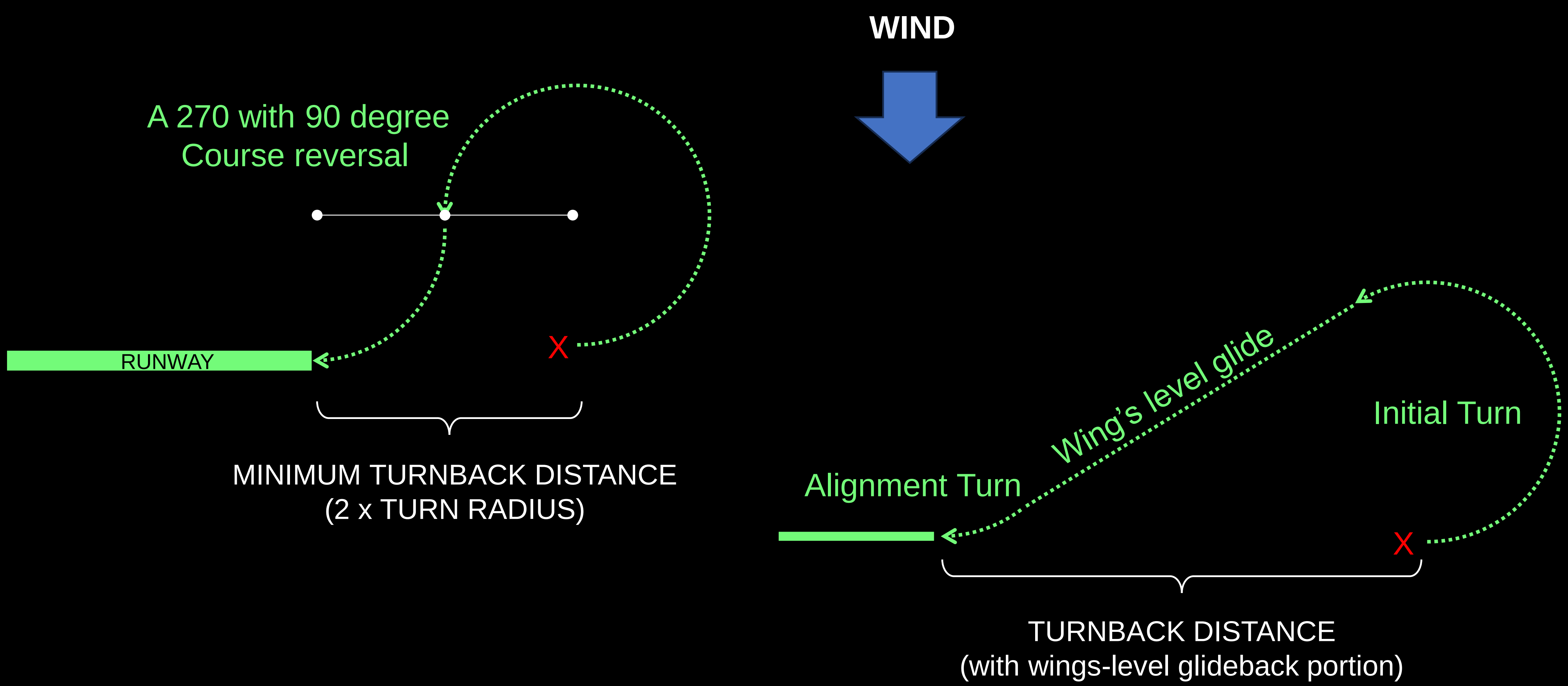
https://www.youtube.com/watch?v=_ZM0KNcZZ6c

If engine fails after takeoff, your initial decision was

	Turnback Possible	Turnback Not Possible
Decide to turnback	GOOD	BAD
Decide not to turnback	BAD if wanted turnback, but thought could not GOOD if plan was no turnback	GOOD

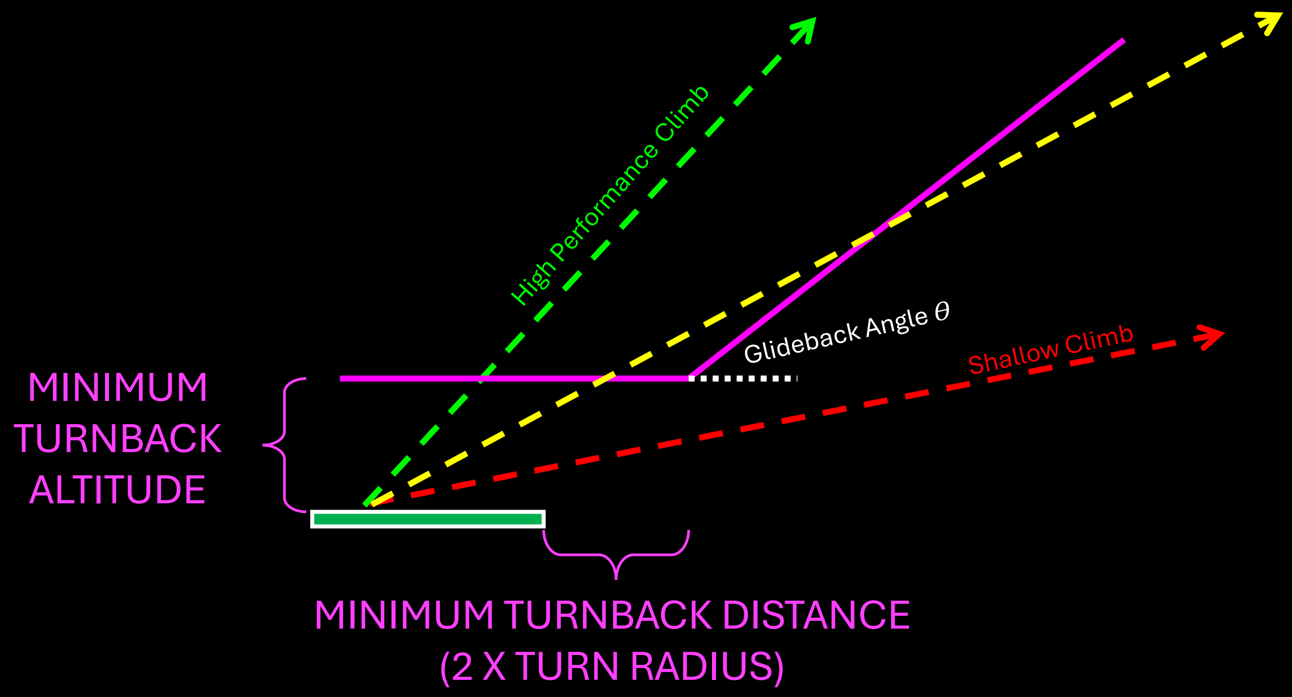
But, how do you know if you can make it?

Can you make it? Track Geometry

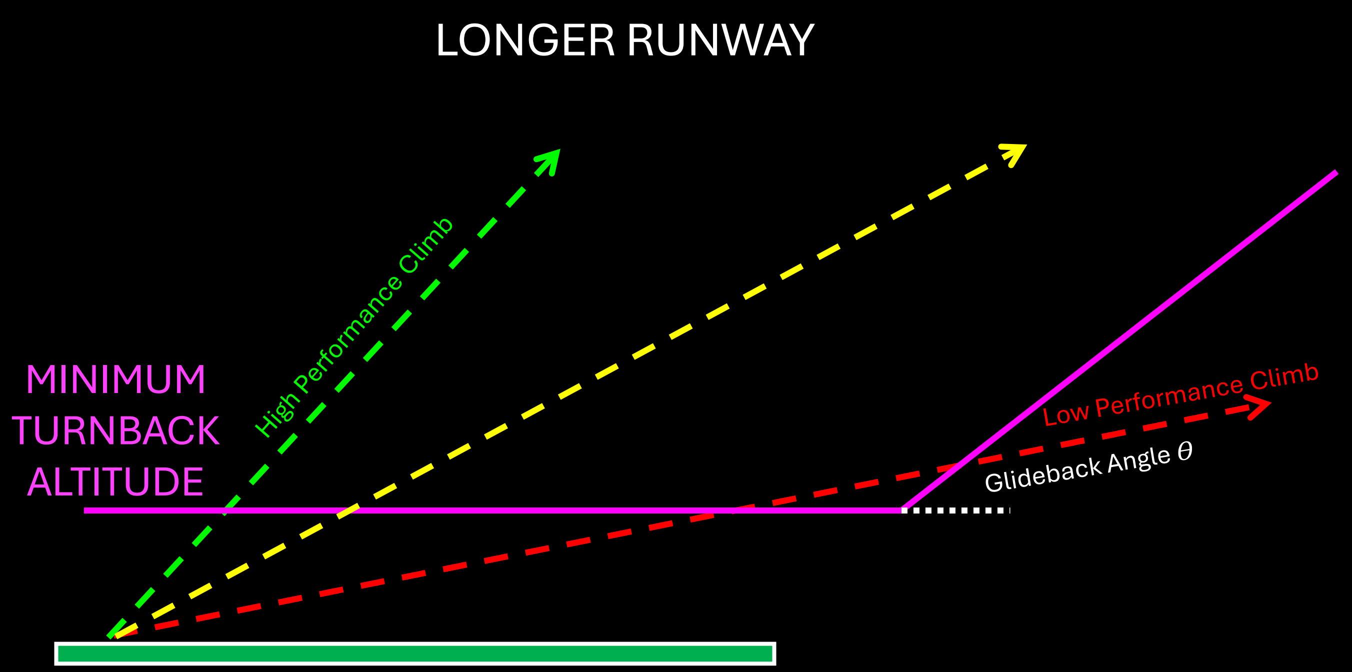


Can you make it? Vertical Geometry

ABOVE MAGENTA LINE, TURNBACK IS POSSIBLE
BELOW MAGENTA LINE, TURNBACK IS NOT

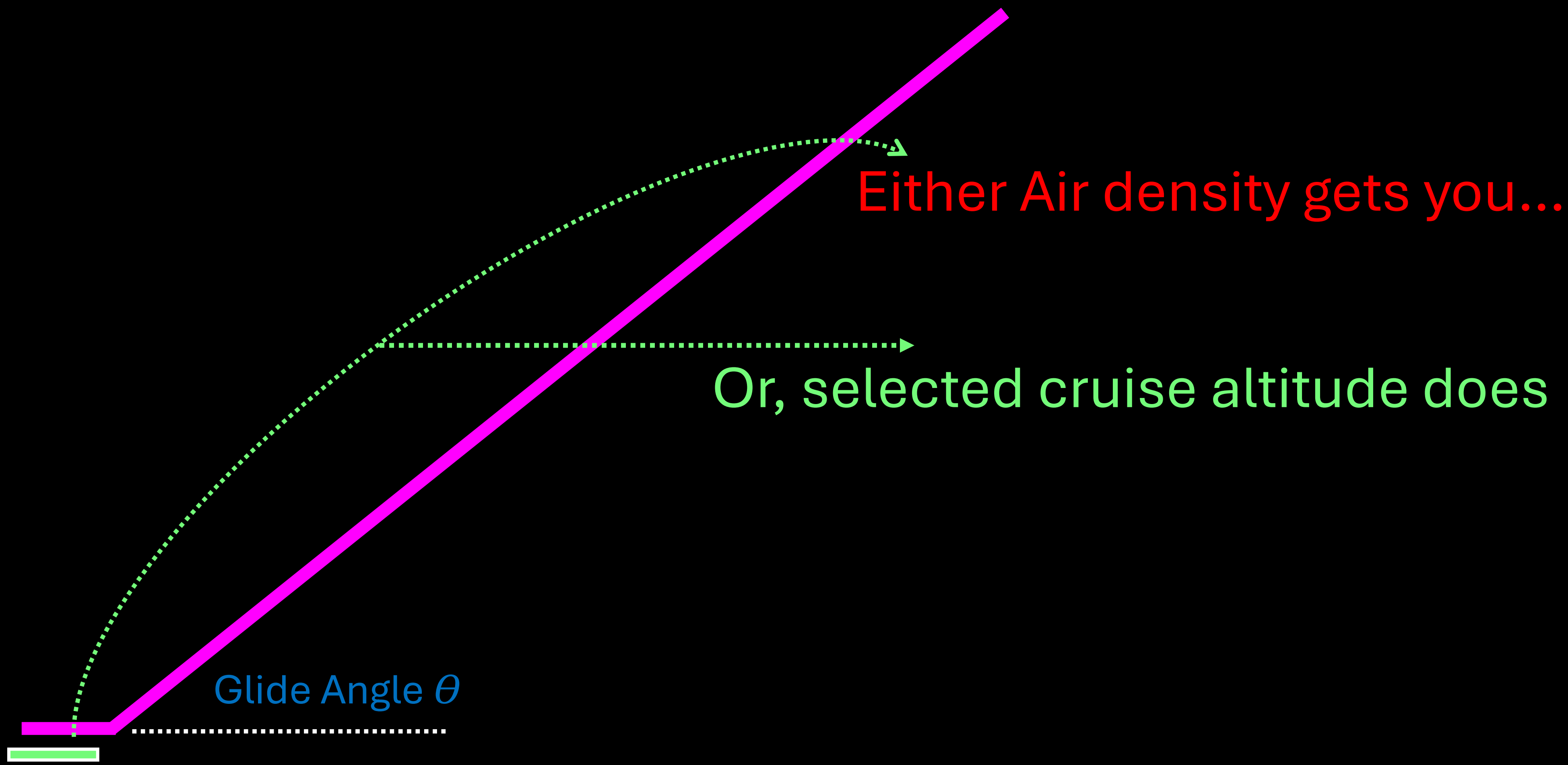


Can you make it? Runway Length



CLIMB PERFORMANCE, RUNWAY LENGTH, ALTITUDE LOST IN TURNBACK, AND GLIDEBACK DESCENT ANGLE DETERMINE TURNBACK POTENTIAL

Can you make it? Eventually…no



Can you make it? Variables

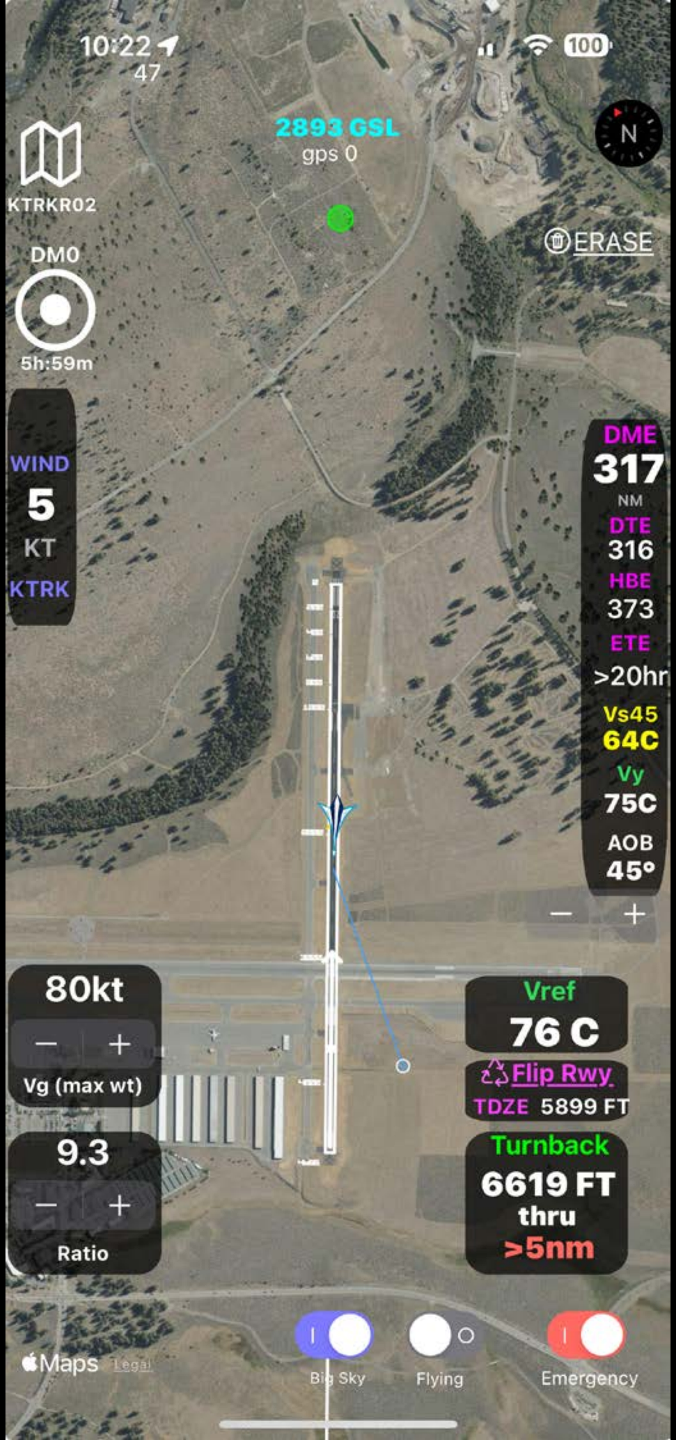
Runway(s)
(Length, Surface, Slope, Elevation)

Weather
(Temperature, Pressure, Wind)

Aircraft
(Weight, Motor, Prop, Aerodynamics)

Pilot
(Climb Profile, Startle, Bank Angle, Glide speed/AoA, Prop/Flap Configuration)

Turnback Planning Demo Truckee

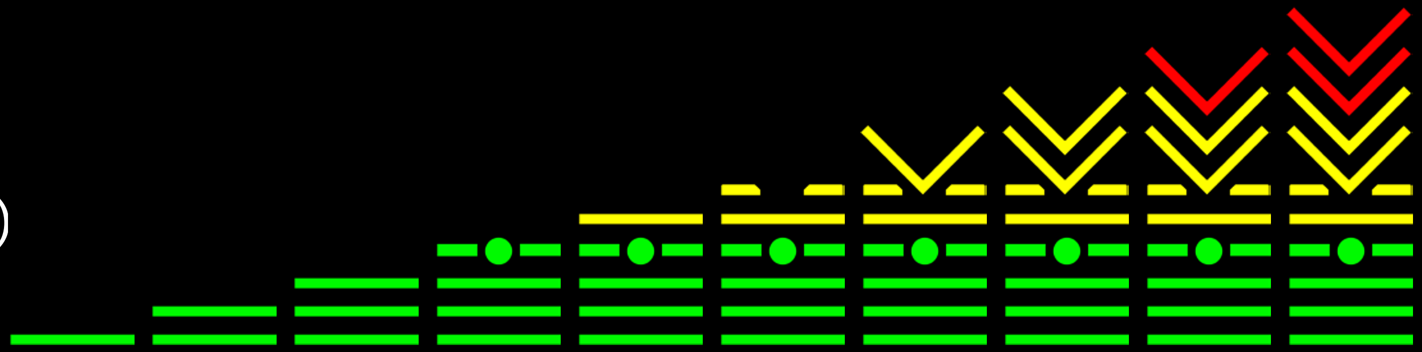


There is no *one* altitude from which your airplane can execute a turnback.

Land off-field

Maneuver
(avoid obstacles)

Pitch
(Speed flyers: flaps up V_{REF} (not Vg))
(AoA flyers: green donut if calibrated)
DO NOT STALL



Troubleshoot
(Mags, Mixture, Fuel, time permitting)

Radio call
(Traffic conflict, time permitting)

Transition
(landing attitude, flaps *when touchdown assured)*

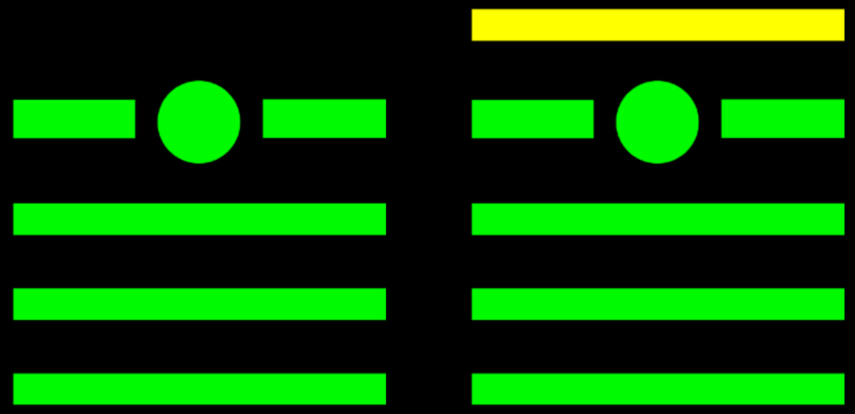
Or Turnback

Pitch

(Speed flyers: flaps up V_{REF} (not Vg): constant speed, variable AoA)
(AoA flyers: green donut if calibrated: constant AoA, variable speed)

Turn into wind

(45^{o} bank best, >180^{o} + turn)
DO NOT STALL



Drag as required

(Flaps, prop pitch, slip, throttle?)

Troubleshoot

(Mags, Mixture, Fuel, time permitting)

Radio call

(Traffic conflict, time permitting)

TLAR Turback Test Flight March 22, 2024

- Caldwell Airport, Idaho (KEUL)
  - Takeoff Runway 12 turnback 30
- Glasair Sportsman
  - 210 HP IO-390
  - Taildragger with 8.50 x 6 Tires and no wheel pants
  - 80" 3-Bladed Composite Hartzel Constant Speed Prop
  - 1830 lb GW (solo, no cargo except emergency equipment, 21 gal fuel)
- Conditions
  - Runway 12 TDZE 2412 msl
  - VFR, Temp 19C, Pressure 29.76, DA 3629', Surface Wind 050/12
- Profile
  - Vy climb-out (78 KCAS)
  - Idle power, flaps 20 degrees to simulate windmilling prop drag
  - Vref turnback and glide (71 KCAS)

Two failed attempts


MIXTURE
CABIN HEAT
FUEL

Lessons Learned

Wind!

(Wind <10 knots helpful; more than that: expect to fail)
(Overshoots, undershoots, too steep, too shallow, high groundspeed landings etc)

Training flaps

(Mimic windmilling drag, but negative training for stall margin / turn rate)

Coarse pitch!

(Large influence on glide)

Gliding 45 degree bank

(Not natural, hard to average)

Time

(Turnback maneuver happens fast!)

Math works

(Surprised how predicted matches actual, unless garbage-in garbage-out)

Take-aways

TLAR
(Does a lot of stuff)

Have a plan
(Train to your plan)

Make a Decision
(Stall risk v Off-field obstacle risk)

DO NOT STALL

Where to Find Me

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501.231.2794

flightlead@tlarpilot.com

This Brief

TLARpilot.com

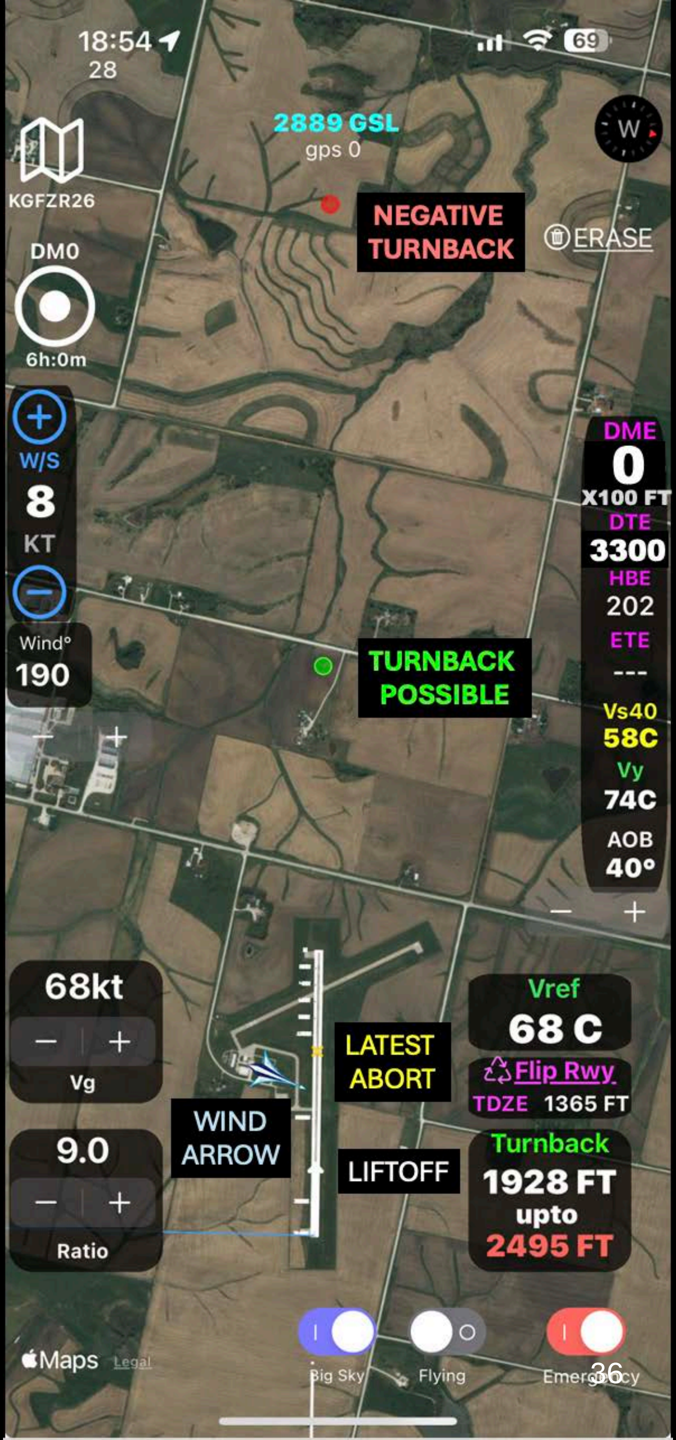
TLAR

Back Up Slides

TLAR iOS App

Patent Pending

Runs on:
iPhone X and higher
iPads with cellular (GPS)
“old” devices no go



TLAR vs Foreflight/Garmin Pilot

TLAR

(Exquisite aircraft performance, VNAV)

(Basic navigation only)

Foreflight and Pilot

(Exquisite navigation, traffic, weather hazards)

(Almost no aircraft performance)

Minimum Required Data Entry

Pilot

None

Airfield

None

Weather

None

Aircraft Physics

None

Aircraft Aerodynamics

Pick a plane, set weight and fuel

Customizable

Pilot
Set Preferences

Airfields
Global database, make or survey one

Weather
(METARs, iOS Sensors, Manual Entry)

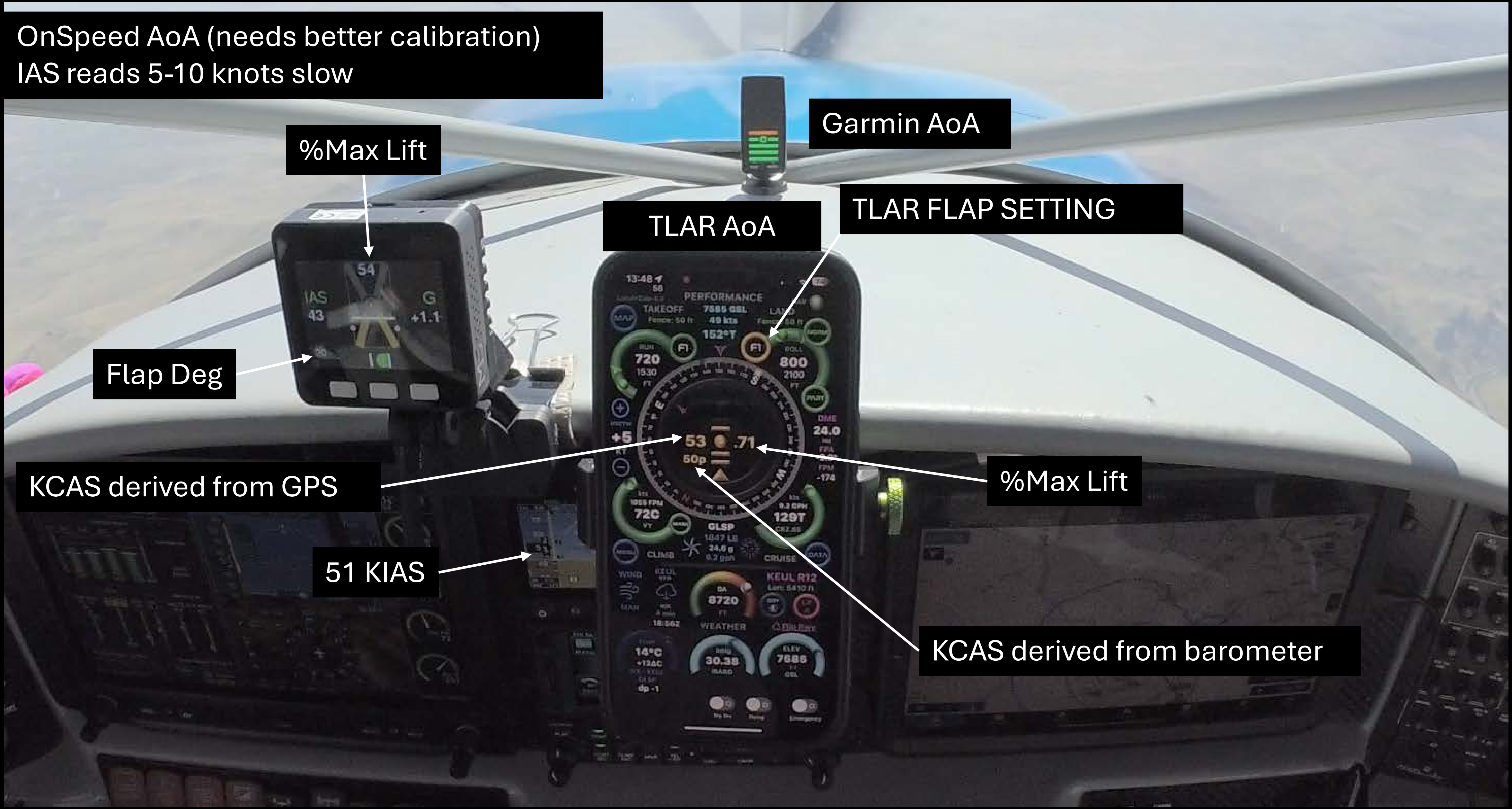
Aircraft Physics
iOS for now….EFIS integration in future

Aircraft Aerodynamics
Design your own plane

TLAR Projects/Ideas on the list

- iOS-derived CAS, Winds, and AOA (beta)
- HUD mode
- EFIS integration via bluetooth
- Simplified GUI
- Multi-runway turnback
- Multi-engine, float-plane, turbo-props
- Aviation-charts
- Terrain awareness
- Near real time weather (Digital ATIS, web-based ASOS?)
- Altitude winds
- AI performance calibration
- Airfield database improvements (ongoing)

TLAR IAS and AOA Test Flight 10 Apr 2025

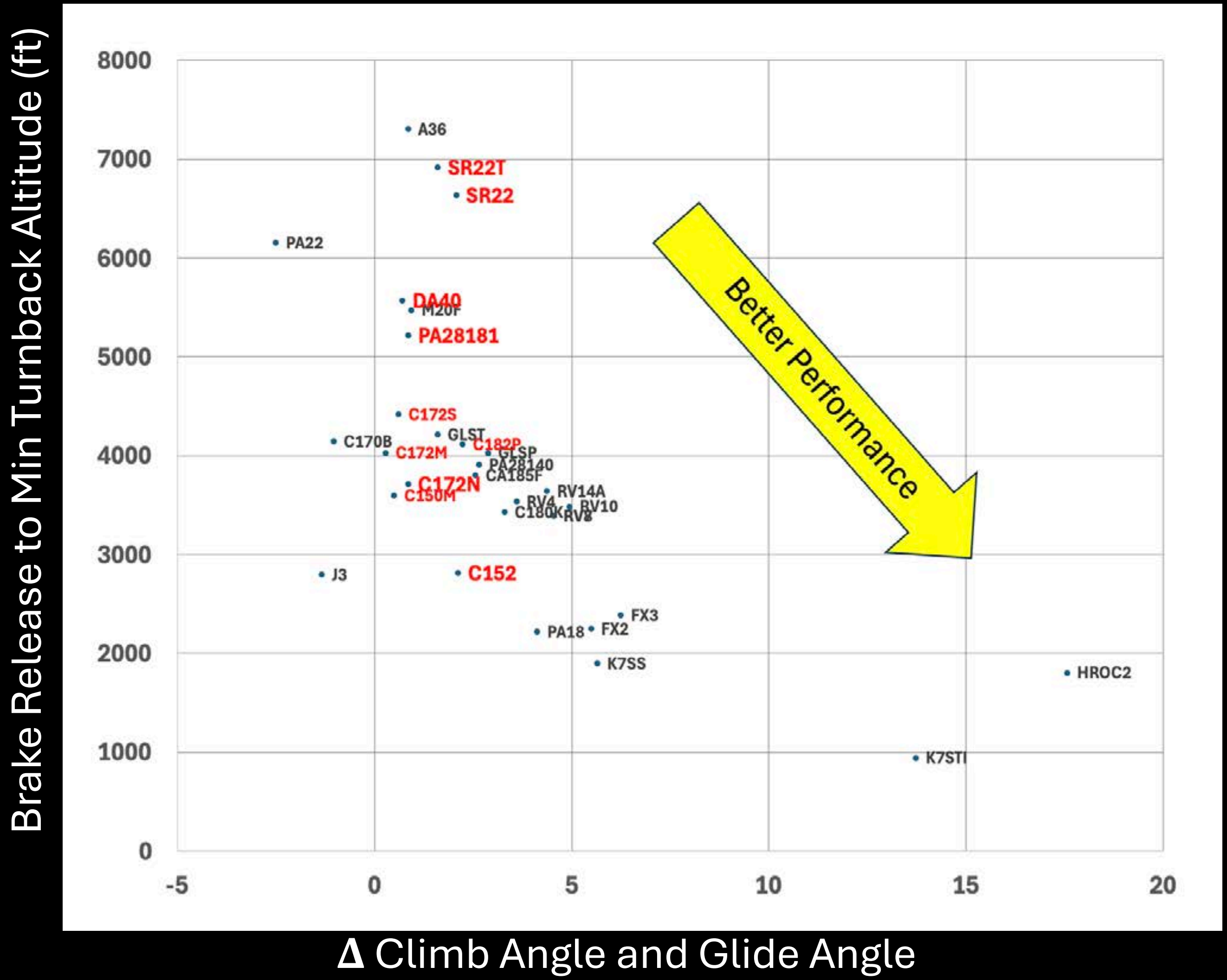



DATE: 4/19/25
TIME: 12:52:58
SPEED: 65 KT

Turnback Test Videos
KEUL in Oct 2023, Sportsman
FL17 in Fall 2023, RV4


12:31
24
LTE
63 GSL
FL17R01
DM
WIND
5
KT
KVPS
DME
0
x100 FT
DTE
3132
HBE
219
ETE
16s
Vs45
57C
Vy
102C
AOB
45°
Vref
62 C
Flip Rwy
TDZE 62 FT
Turnback
318 FT
30.516258
-86.438579
402ft / 360
-681 fpm
Prop Drag
0.000
Maps
Big Sky
Flying
Emergency
DYNON AVIONICS
EFIS-D10A
INSTANTANEOUS VERTICAL SPEED
FT/MIN
X100
MANIFOLD PRESSURE
FUEL
LEFT
RIGHT
ALT

Turnback DNA of 33 planes in TLAR



"The Math"

After a little algebra, the resulting expression for the altitude loss per degree of turn is given by

$$\frac{dh}{d\theta} = \left(\frac{\pi}{180}\right)\frac{F_1 F_3}{F_2 F_4} \qquad (5)$$

We have grouped the parameters in the above equation in such a manner that they are essentially independent of each other. We define the F_i's as follows:

(a) $F_1 = \left(\frac{4}{g}\right)\frac{W}{S}$ is the aircraft wing loading function, where g is the Earth's gravitational acceleration, W the aircraft weight, and S the wing area in ft^2

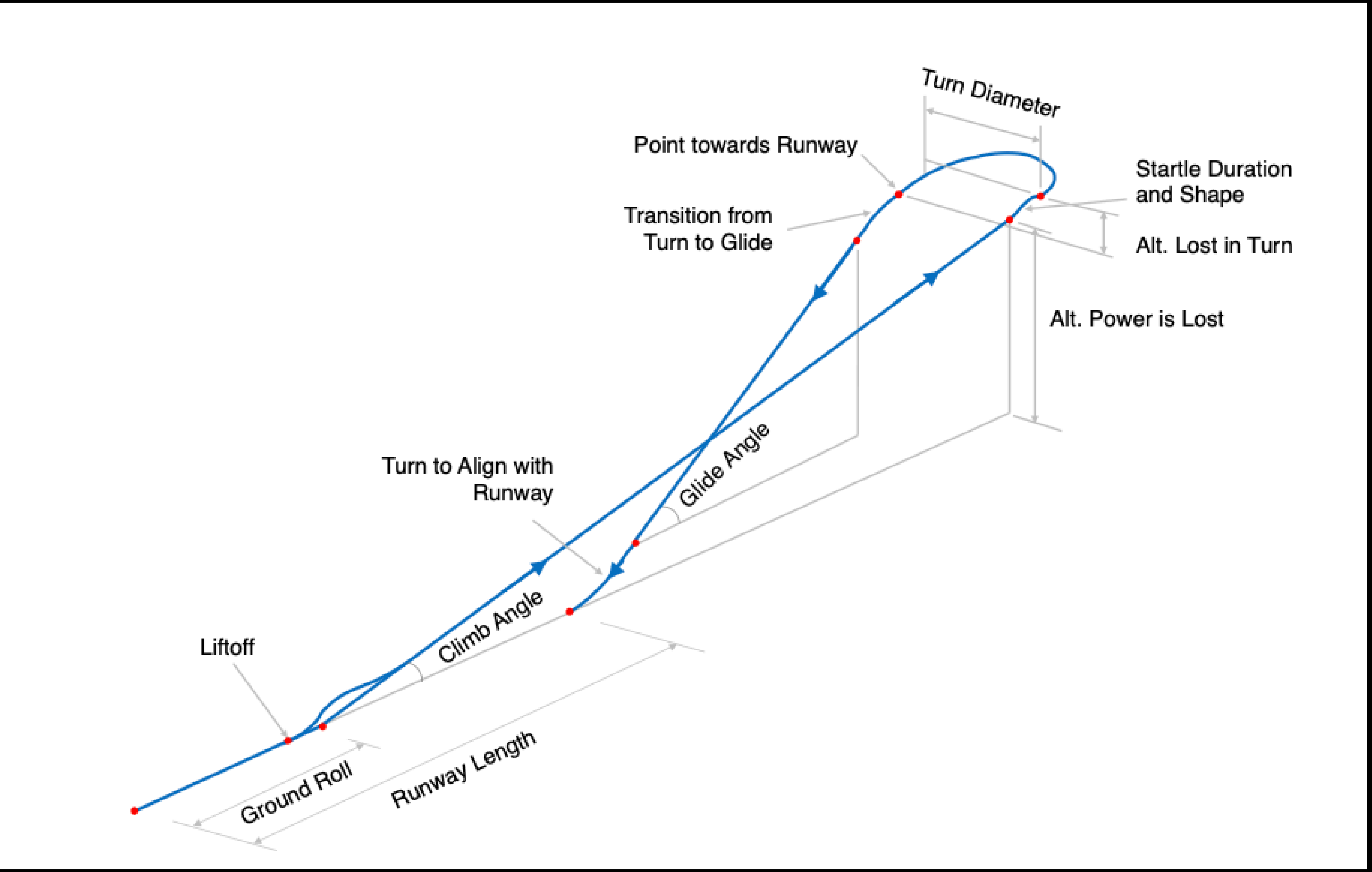
(b) $F_2 = \rho$ is the air density, units are in $slugs/ft^3$ (i.e., sea-level density is $0.002378\ slugs/ft^3$)

(c) $F_3 = \frac{1}{2\sin\Phi\sqrt{\cos\Phi^2 + (D/L)^2}}$ is defined as the "Bank Angle Function", with Φ the bank angle, and D/L is the inverse of the lift to drag ratio flown in the turn

(d) $F_4 = C_L\left(\frac{L}{D}\right)$ is defined as the "Aerodynamic Function", and only depends on angle-of-attack

Les Glatt, PhD, ATP, CFI-AI, "Single-Engine Failure after Takeoff: The Anatomy of a Turnback Maneuver," July 25, 2020.
https://www.eaa.org/-/media/files/eaa/educationresources/sportaviation/2020-12-14-turnback-maneuver-anatomy.ashx

Worst “It Depends” Scenario in GA



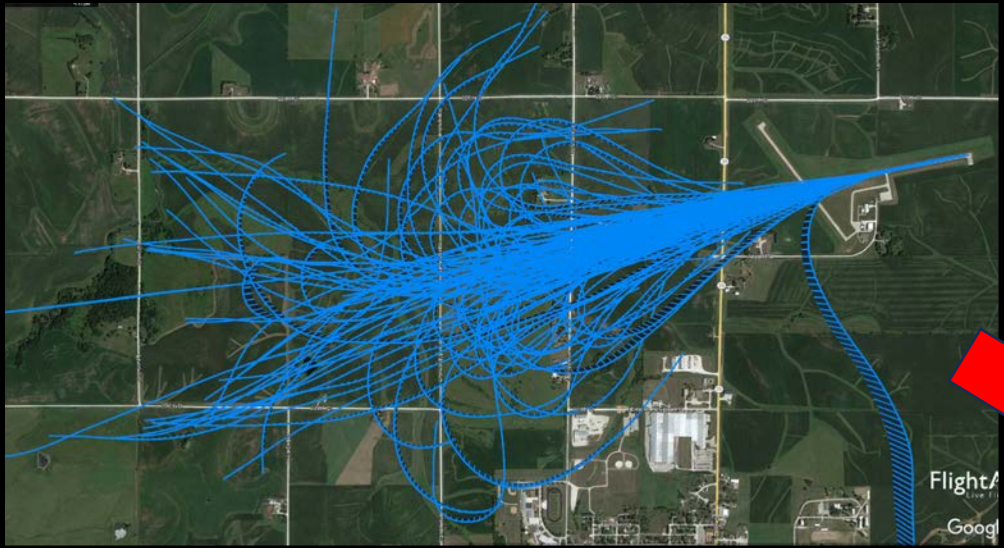
Video

There’s an app for that

Survey: 1000 Participants (100 CFI's)

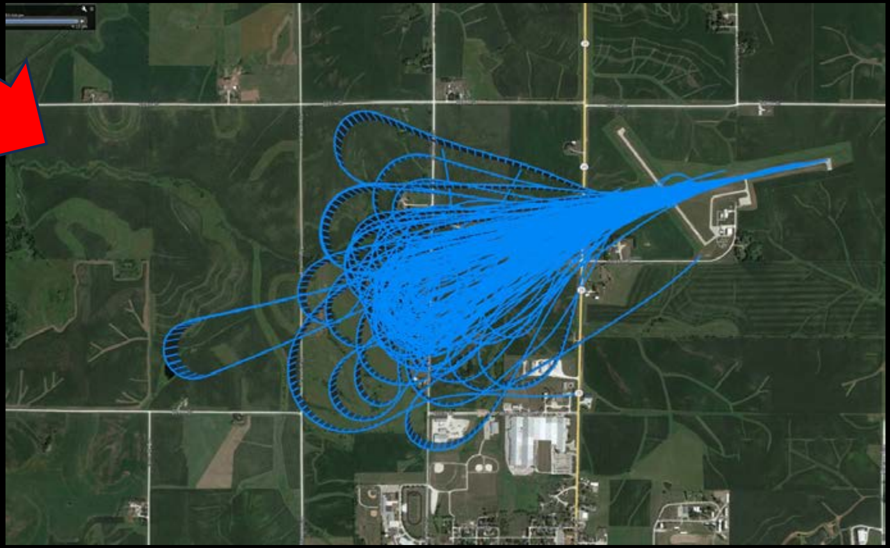
- 800-1000' AGL — The altitude most pilots thought they can return to the runway (75% confidence)
- 95% — Number of pilots that said they could return at ***some*** altitude
  - "I have a minimum altitude to turn back"
- 5% — Number of pilots that said they could not return at ***any*** altitude
  - "Are you nuts?"

2022 EAA Simulator Study Results



Before Training
46% Turned Back
12% Made the Airport
or Runway

After Training
61% Made the Airport or
Runway



Flight Maneuvers Training

- AC 61-89D recommendation since 2018
- AOA Recovery
- 45° Banked gliding turn
- Gliding maneuvering
- 45° banked gliding turn: to an accelerated stall
- Actual engine-out glides to baseline your aircraft

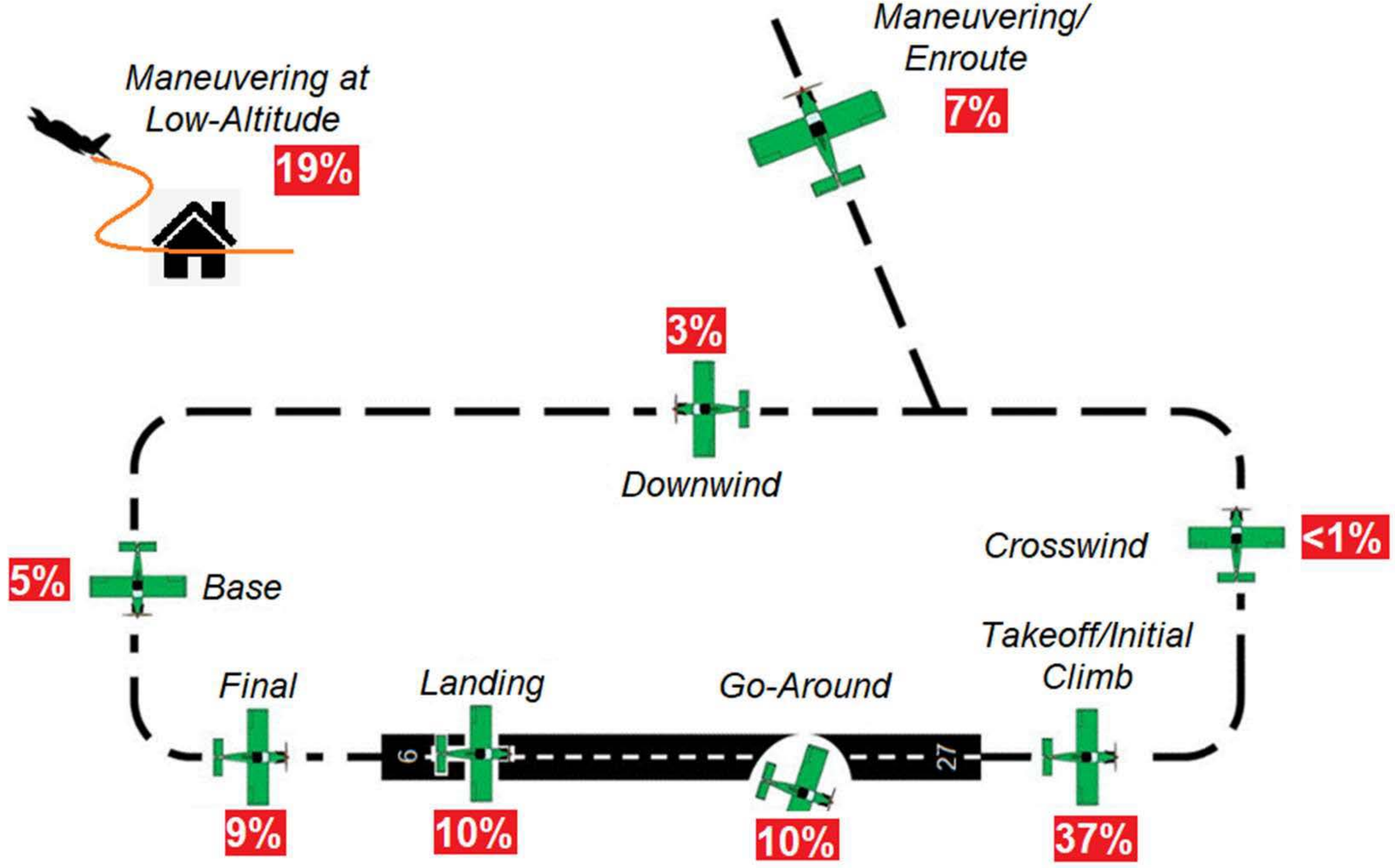
High Altitude

- 180+ Power-off approach
- Low-altitude turnback practice
- Residual thrust and type of prop
  - Use of “drag” Flaps to mimic engine shutdown drag

Low Altitude

Draft Teaching Guide

Location of Stall/Spin Accidents 2011-2020



SOURCE: https://data.ntsb.gov/avdata/avall.zip

Stall and AOA

Stall/Spin kills pilots attempting a turnback

"LOC is the number one root cause of fatalities in GA. More than 25 percent of GA fatal accidents occur during the maneuvering phase of flight. Of those accidents, half involve stall/spin scenarios." – AC 61-98D

None of us know our stall speed

What is it in 23 degrees of bank at mid-gross weight with half flaps?

Stall-warning

ALL our planes have a stall-warning system

Angle of Attack (AOA) systems are superior IMHO

Eliminates guessing, will make you a better pilot

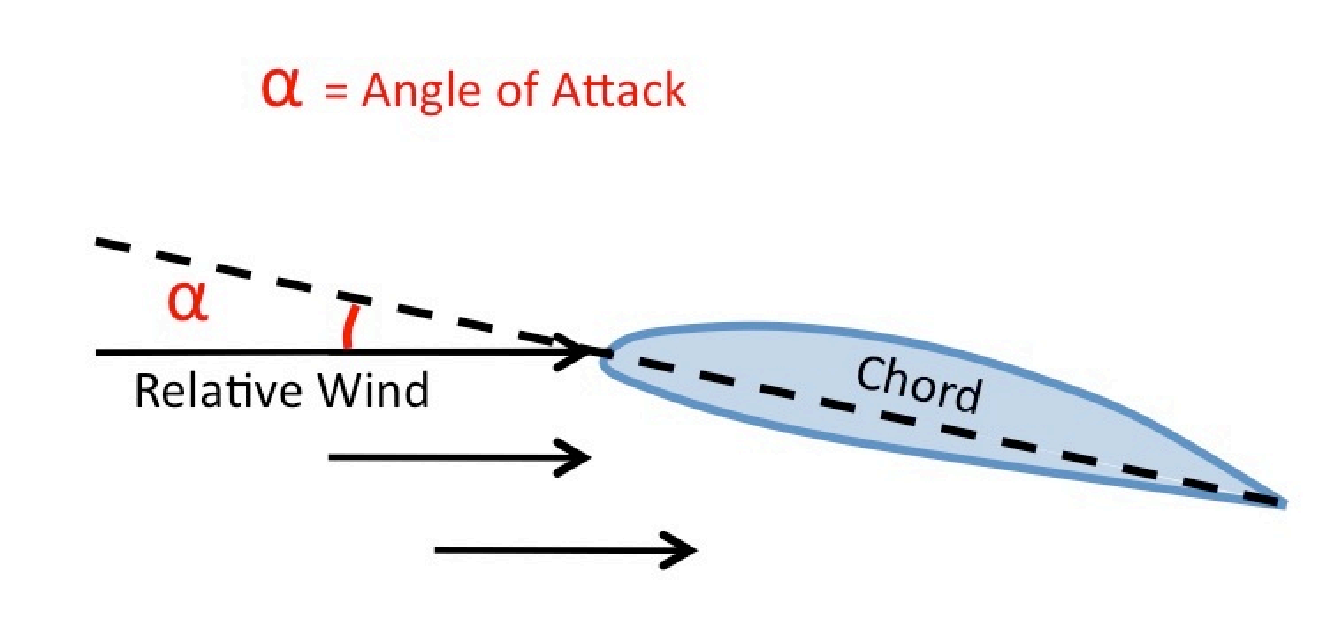
Cessna 172S Flaps Up Stall Speeds

Stall Speeds	N																			
GW	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3	3.2	3.4	3.6	3.8
1800	**0**	18	26	31	36	**40**	44	48	51	54	**57**	60	62	65	67	70	72	74	77	**79**
1850	0	18	26	32	37	41	45	48	52	55	58	61	63	66	68	71	73	75	78	80
1900	0	19	26	32	37	41	45	49	52	56	59	61	64	67	69	72	74	76	79	81
1950	0	19	27	33	38	42	46	50	53	56	59	62	65	68	70	73	75	77	80	82
2000	0	19	27	33	38	43	47	50	54	57	60	63	66	69	71	74	76	78	81	83
2050	0	19	27	33	38	43	47	51	54	58	61	64	67	69	72	75	77	79	82	84
2100	0	19	28	34	39	44	48	52	55	58	62	65	67	70	73	75	78	80	83	85
2150	0	20	28	34	39	44	48	52	56	59	62	65	68	71	74	76	79	81	84	86
2200	0	20	28	35	40	45	49	53	56	60	63	66	69	72	75	77	80	82	85	87
2250	0	20	29	35	40	45	49	53	57	60	64	67	70	73	75	78	81	83	86	88
2300	0	20	29	35	41	46	50	54	58	61	64	68	71	74	76	79	82	84	86	89
2350	0	21	29	36	41	46	50	55	58	62	65	68	71	74	77	80	82	85	87	90
2400	0	21	29	36	42	47	51	55	59	62	66	69	72	75	78	81	83	86	88	91
2450	0	21	30	36	42	47	52	56	60	63	67	70	73	76	79	81	84	87	89	92
2500	0	21	30	37	43	48	52	56	60	64	67	70	74	77	80	82	85	88	90	93
2550	0	21	30	37	43	**48**	53	57	61	64	**68**	71	74	77	80	83	86	89	91	94
2600	0	22	31	38	43	48	53	57	61	65	69	72	75	78	81	84	87	89	92	94
2650	**0**	22	31	38	44	49	54	58	62	66	69	73	76	79	82	85	88	90	93	**95**

N is g-loading, GW in pounds, speeds KCAS, Green shaded area is “normal” operating envelope, Blue boxes are the only speeds provided by POH

AERO FACTS

- Wings do NOT stall at a speed
- Wings stall at an angle of attack
- The stall angle of attack is constant[1]
- The stall angle of attack does not change based on weight, bank angle, g-load, or speed



[1] For any given flap/slat setting

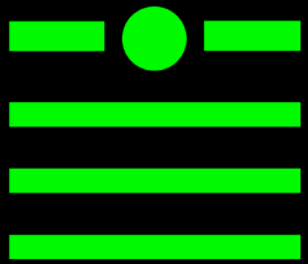
Cessna 172S Flaps Up Stall Angle of Attack

Stall AoA	N																			
GW	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3	3.2	3.4	3.6	3.8
1800	**16**	16	16	16	16	**16**	16	16	16	16	**16**	16	16	16	16	16	16	16	16	**16**
1850	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
1900	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
1950	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2000	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2050	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2100	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2150	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2200	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2250	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2300	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2350	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2400	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2450	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2500	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2550	16	16	16	16	16	**16**	16	16	16	16	**16**	16	16	16	16	16	16	16	16	16
2600	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2650	**16**	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	**16**

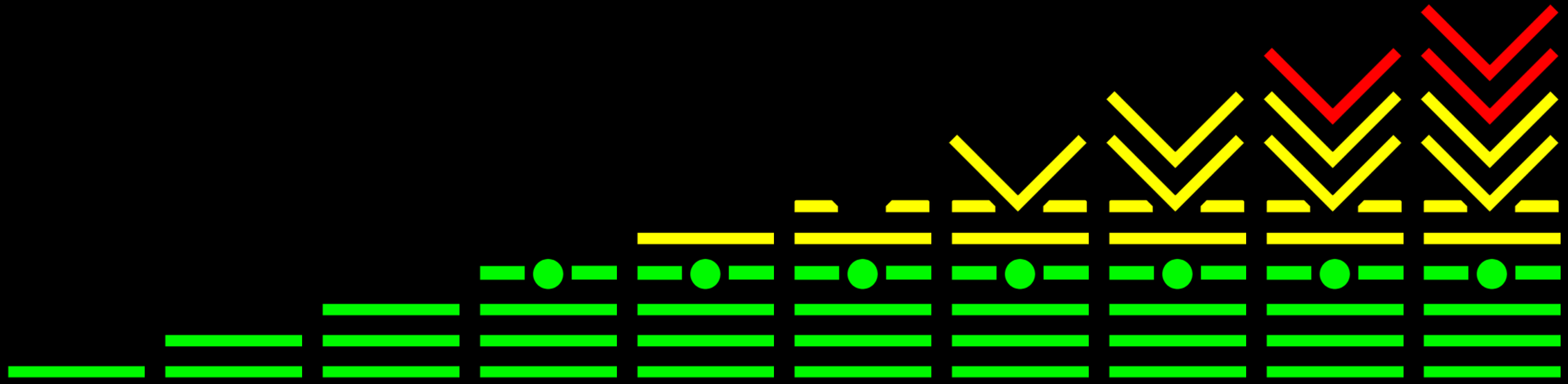
N is g-loading, GW in pounds, AoA in degrees, Green shaded area is "normal" operating envelope

What is “On Speed”?

- **It’s a speed/GW/g-load, that corresponds to 60% AoA**
  - Small range: ± 2 – 2 ½ kts at 1 g
- Wing is working at **60%** capacity
- It’s the AoA for approach
- It’s the AoA for maximum sustained turn rate
- It’s the AoA for maximum endurance glide



AoA Displays (Garmin top, OnSpeed bottom)

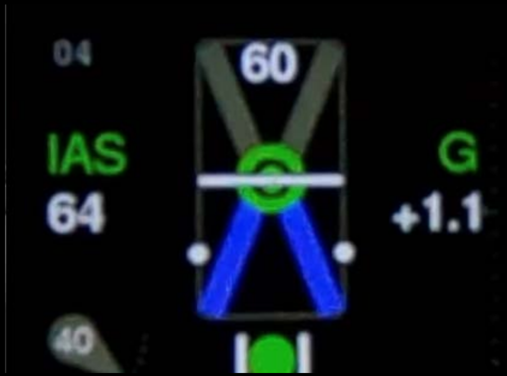


L/D Max

“On Speed”

Tones/beeps get progressively more “scary”

Stall



Mike “Vac” Vaccaro

- Retired USAF Lieutenant Colonel
- F-4, F-15 pilot
- Fighter Weapons School instructor
- Test pilot
- Multiple combat deployments
- Civilian instructor since 1983
- Current airline pilot
- Part of the FlyONSPEED team

    -EAA Founder’s Innovation Prize 1st Place 2018

    -EAA Founder’s Innovation Prize Grand Champion 2021

Jeff “Jefe” Brown

- Retired USAF Colonel
- C-130 pilot
- Multiple deployments
- USAF Weapons School graduate
- Civilian CMEL pilot & EAB repairman
- Homebuilder (Glasair Sportsman)
- Currently a Senior Analyst for the Rand Corporation
- Coder behind the TLAR app