Miltech Simulations U-2

U2 101 - The Basics

These characteristics combine to earn the U-2 a widely accepted title as the most difficult aircraft in the world to fly.

New to the U-2? This page shows, in pictures, what kind of aircraft it is and what to expect from the first taxi to the final stop. No switches and no procedures: Normal Procedures has the technique and the Checklists have the steps.

Note
Sim values. Performance values are measured in the sim. They may not accurately represent (nor do they intend to accurately represent) the performance of the real aircraft.

Interactive resource: Is The U-2 Spy Plane The Hardest Aircraft In The World To Land? | MythBusters

Watch first: Is The U-2 Spy Plane The Hardest Aircraft In The World To Land? (MythBusters, YouTube)

1The AircraftWhat kind of aircraft it is, and why it flies the way it does.2A Flight, Step by StepFrom the start to the stop: ground, takeoff, climb, cruise, descent and landing.3Before You FlyWhat is normal, the classic mistakes, and your first three flights.

Part 1The AircraftA very long glider with a very big jet engine.

The Short Version

Think of the U-2 as a very long glider with a very big jet engine. Almost everything strange about it comes from these six facts.

103 ftA glider's wingLots of lift and very little drag: it floats, glides and does not want to slow down or come down.

17,000 lbA huge engineThrust on an airframe of 16,230 lb empty. Light, it climbs at about 11,000 ft/min.

2 wheelsIn a lineOne main wheel and a tailwheel. The pogos fall away on takeoff; then you balance it like a bicycle.

19,500 lbHalf of it is fuelFull tanks. The aircraft you take off in and the one you land are nearly two different aircraft.

1/13Very thin airOf the sea-level air is left at 65,000 ft. The speed needle reads low and the speed band gets narrow.

0Nothing does it for youNo autothrottle, automatic spoilers, antiskid or differential brakes. The throttle is yours.

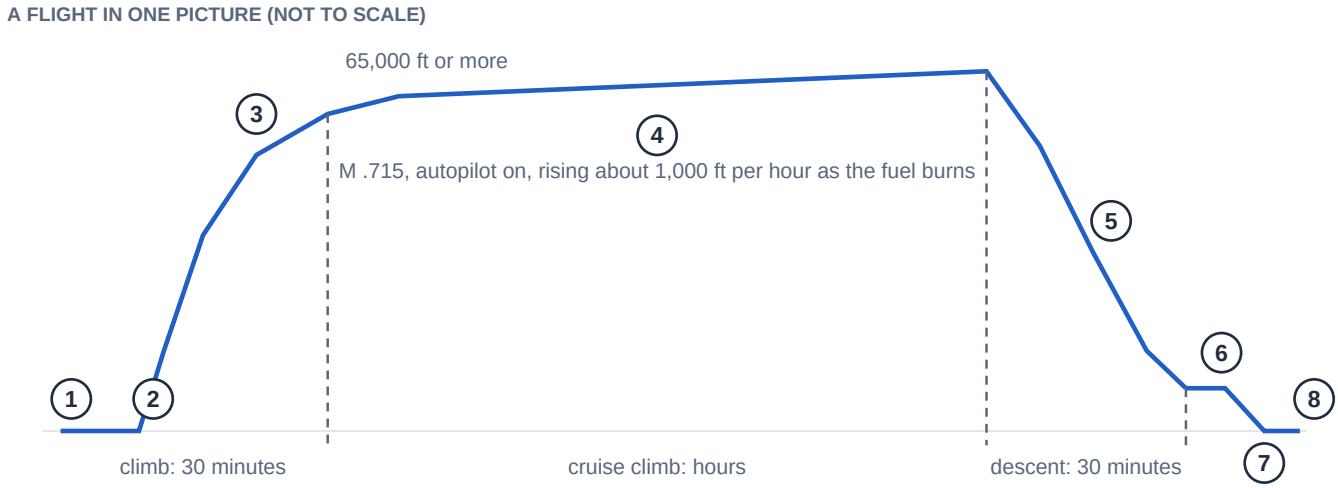


Everything the aircraft stands on, seen from the front.

1. **Main wheel**, with the tailwheel in line behind it

2. **Pogos**, 59 ft apart, gone after takeoff
3. **Wing tip skids**, 51 ft out, the only thing left to lean on

A Flight in One Picture



The numbers match the list below. Half an hour up, half an hour down, and almost all of the difficulty in the first minute and the last.

1. **Taxi.** Slow, wide turns and a lot of wing to look after.
2. **Takeoff.** 6 to 13 seconds on the runway, then a very steep climb.
3. **Climb.** Fast at first, then slower and slower. The first 40,000 ft take about 10 minutes. The last 25,000 ft take about 20 more.
4. **Cruise climb.** Hours of calm. The autopilot flies, you watch the fuel and the engine.
5. **Descent.** Gear down, everything out, throttle at idle, for about 150 NM.
6. **Pattern.** A few busy minutes at 1,500 ft and below, slowing down to landing speed.
7. **Landing.** The last 15 seconds are the hardest part of the whole flight.
8. **Rollout.** You are down, but you are still flying the wings until the aircraft stops.

Why It Flies Like This

The long wing

A long, thin wing is what gets the U-2 to 70,000 ft. It also means the aircraft hates losing speed or height.

- **It coasts.** Close the throttle and very little happens. Clean, with the engine at idle, it comes down only about 150 - 300 ft/min from 50,000 to 30,000 ft.
- **It floats.** Close to the runway the wing gets extra help from the ground. The aircraft stays up longer than you expect, and the stall comes about 4 kt lower.
- **It is wide.** At 12 ft a bank of only 13° puts a wing tip on the runway. Small banks near the ground, always.
- **It bends.** Look out at the wing in a pull-up. It flexes with the load. That is normal.

Two aircraft in one

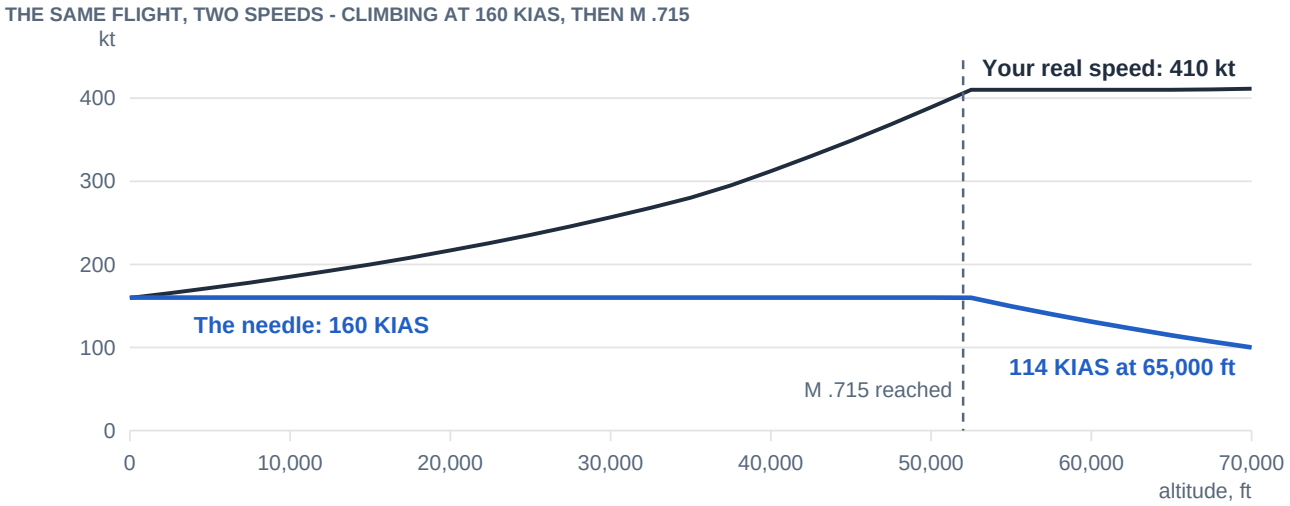
Fuel is about half the takeoff weight, so the aircraft changes character as it burns off. Know your weight before you do anything: the EFB Aircraft tab shows Gross.

Same aircraft	Heavy, about 34,500 lb	Light, about 22,500 lb
Liftoff, measured	98 KIAS, 12.5 s, 1,044 ft	76 KIAS, 6.4 s, 468 ft
Climb rate low down	about 6,000 - 8,000 ft/min	about 11,000 ft/min
Nose in the climb, measured	25 - 30° up at 135 KIAS	about 43° up at 140 KIAS
Stall, flaps up	about 95 KIAS	about 74 KIAS
Where the cruise climb settles	about 65,500 ft	about 74,000 ft

Every 100 gal of fuel is 670 lb, and about 1 kt on your landing speed.

The speed needle reads low

The wing only feels how much air hits it, and that is what the airspeed needle shows: indicated airspeed, KIAS. Up high the air is so thin that you have to go much faster for the same amount of air to arrive. So the needle and your real speed drift apart.



Standard day. Up to about 52,000 ft you hold the needle still and your real speed grows. From there you hold the Mach, your real speed stays the same and the needle falls by itself.

What to expect: from about 52,000 ft you hold Mach instead of KIAS, and the needle falls by itself: about 130 KIAS at 60,000 ft and about 115 at 65,000 ft. You have not slowed down. The MFD ground speed will show about 410 kt with no wind, while the needle reads what a light aircraft does on final.

The speed band closes up

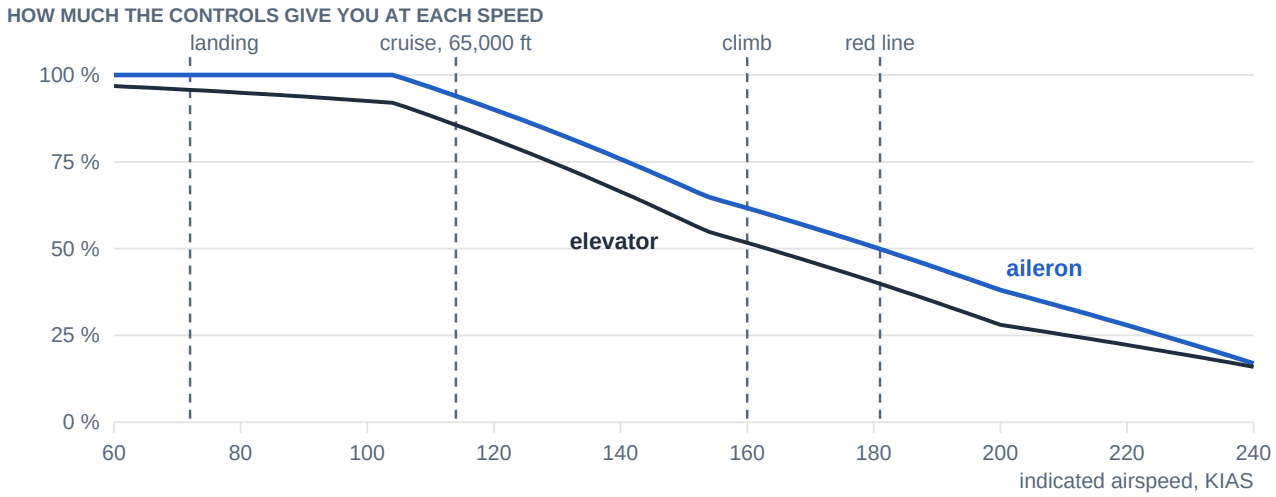
Two things limit your speed: the stall below you and the red line above you. Low down they are far apart. Up high the red line comes down to meet you, because it is set by Mach. Pilots call the top of this picture the coffin corner.

How narrow, and what to do about it: see **The Coffin Corner** below.

- **At the top of a cruise climb** you have about 7 kt to the red line and about 13 kt to the stall. You can stay there for hours with the autopilot on, but nothing you do up here should be sudden.
- **The red line gap hardly changes.** It is about 7 kt whatever you weigh.
- **The stall gap does.** It depends on how high you are for your weight. Each extra 1,000 ft takes about 3 kt off it. Do not try to force the aircraft higher than it wants to go. Wait for the fuel to burn off.
- **No warning from the wing.** In the sim there is no Mach buffet, and up here no tone sounds before the stall. See High-Altitude Handling.

Controls: soft, stiff, soft

The harder the air pushes on the control surfaces, the less they move. So the controls are at their best on the approach and in the cruise, where the indicated speed is low, and get stiff in between.



From the U-2S flight model: the share of the low-speed control effect left at each indicated airspeed. The rudder is not shown.

- **The yoke has a long way to go:** 120° each way. Turn it past about 38° and a roll spoiler pops up on that wing, so the roll rate jumps.
- **The trim is slow:** about 1° every 3 seconds. Plan ahead and do not wait for it.
- **At 240 KIAS,** the red line with gust control UP, the controls are nearly solid: less than a fifth of their effect is left.

Part 2A Flight, Step by StepWhat to expect from the first taxi to the final stop.

Starting the Aircraft

There are three ways to get the U-2 ready to fly. The Quick Start Guide takes you through each one.

1Runway startReady at onceStart your flight on the runway: engine running, avionics up, INS aligned.2EFB presetUp to 3 minutesAlready parked: EFB **Set up aircraft**, *Ready for takeoff* or *Ready for taxi*.3Cold and Dark startAbout 5 minutesStart on a parking spot with everything off and set it all up yourself.

On the Ground

The U-2 taxies like a bus with a 103 ft plank on the roof.

- **It will not move at idle.** Bring the power up to about 78 % N2 until it rolls, then back to idle. Once it is rolling it keeps rolling.

- **It turns wide.** The tailwheel answers half a second after the pedals. Full pedal gives a 189 ft radius, so a U-turn needs about 380 ft of tarmac, and about 480 ft for the wing tips. Start every turn early.
- **One brake.** Either pedal brakes the main wheel. You cannot steer with the brakes, and there is no antiskid.
- **Wait for the crew.** On the runway, stop and hold still. A pickup brings two technicians to pull the pogo pins. Go before they finish and the pogos stay on after liftoff.

Takeoff

Forget the long, patient takeoff roll of a jet. Full throttle and it is gone.

- **The airspeed reads zero at first.** In the logged run it stayed near zero until about 18 kt over the ground. That is normal.
- **Watch for the pogos.** They fall away one after the other between 60 and 88 KIAS. From that moment there is nothing under the wings. Keep them level with the aileron.
- **Be ready for the climb.** It feels like the nose is pointing at the sky, because it nearly is: 25 - 30° heavy, over 40° light. Hold the speed with the nose and stay on the PFD.
- **Light, you run out of pattern very quickly.** At 11,000 ft/min you pass 1,500 ft about 10 seconds after liftoff.
- **Do not lower the nose suddenly.** The speed runs away at once. The AIRSPEED lamp comes on at 180 KIAS.

Climb

Hold 160 KIAS and the aircraft goes up like a rocket, then slowly runs out of breath.

Climb rate at 34,000 lb (estimate)	Sea level	20,000	40,000	55,000	65,000 ft
ft/min	7,750	5,000	2,600	1,400	300

- **Above about 45,000 ft the engine needs watching.** Full throttle above about 55,000 ft runs into the EGT limit, so you trim the power with the vernier to hold 650 - 725 °C.
- **From about 52,000 ft fly the Mach:** M .715, with the autopilot if you like. The needle starts to fall, as shown above.
- **Do not push the nose over.** Below 1 g the AMAD oil pump uncovers and you get a warning at once.
- **Rough air low down?** GUST CONTROL UP takes load off the wing and moves the red line up to 241 KIAS, below 43,000 ft.

Cruise

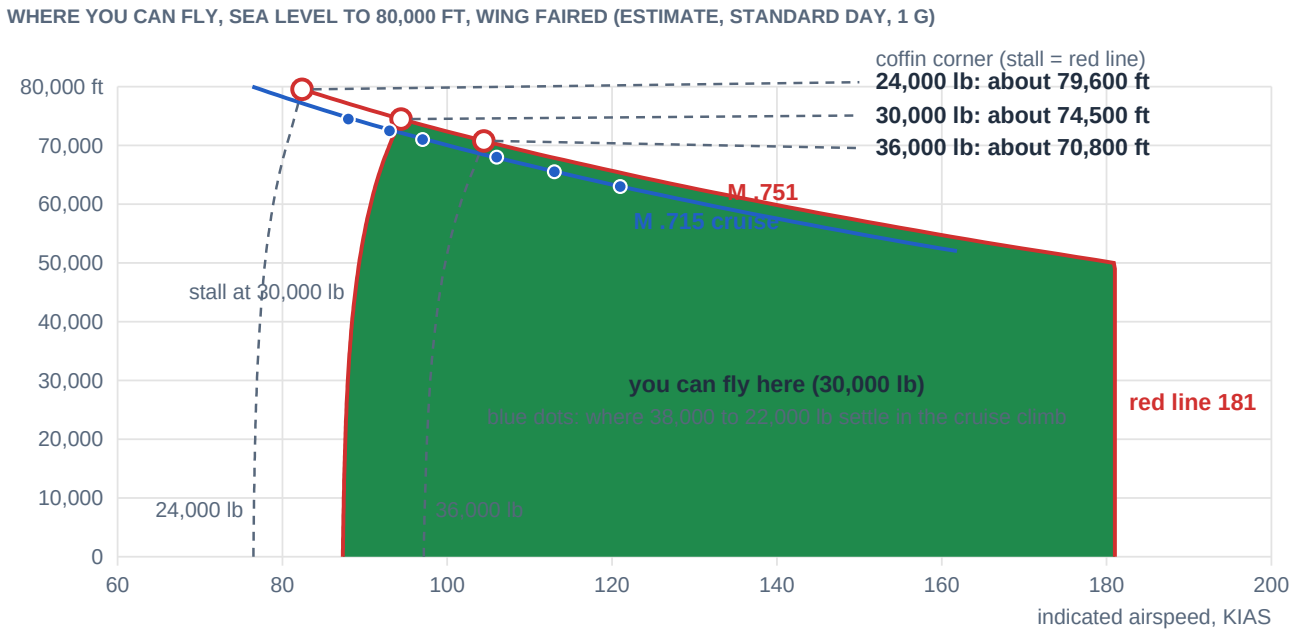
This is where the U-2 is happiest. It is also the quietest part of the job.

- **You do not level off.** With the engine at climb power and the autopilot holding M .715, the aircraft rises about 1,000 ft per hour as the fuel burns.
- **The autopilot flies the aircraft, you fly the engine.** It never touches the throttle. Keep the EGT at 650 - 725 °C with the vernier.
- **Be gentle.** Small, slow inputs, then wait and see. The aircraft is in the narrow band and the trim is slow.

- **Turns are enormous.** At 410 kt and 15° of bank the circle has a radius of about 9 NM, and a U-turn takes about 4 minutes.
- **Turbulence can trip the autopilot.** Above 60,000 ft moderate turbulence switches off all three axes. Switch each one ON again.
- **Watch the balance.** If the autopilot is holding aileron, one wing is heavier. Move fuel across, see CRUISE TRIM AND BALANCE.

The Coffin Corner

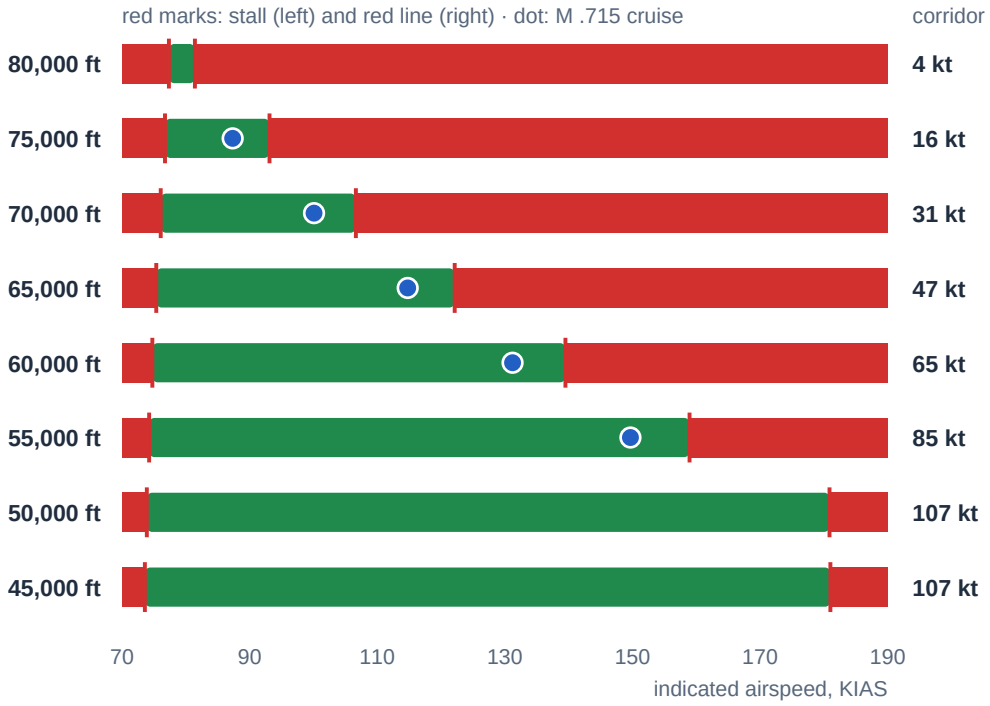
Up high the U-2 flies in a corridor only about 20 kt wide. Below it the wing stalls. Above it you pass the Mach red line. Pilots call the top of that corridor the coffin corner.



Green: where you can fly at 30,000 lb. Dashed: the stall at 24,000 and 36,000 lb. The red line is 181 KIAS up to about 49,500 ft, then Mach .751. Where a stall line meets the red line (open circle) is the coffin corner for that weight: about 70,800 ft at 36,000 lb, 74,500 ft at 30,000 lb and 79,600 ft at 24,000 lb. The dots on the blue line show where each weight settles in the cruise climb, about 7,000 ft below its corner.

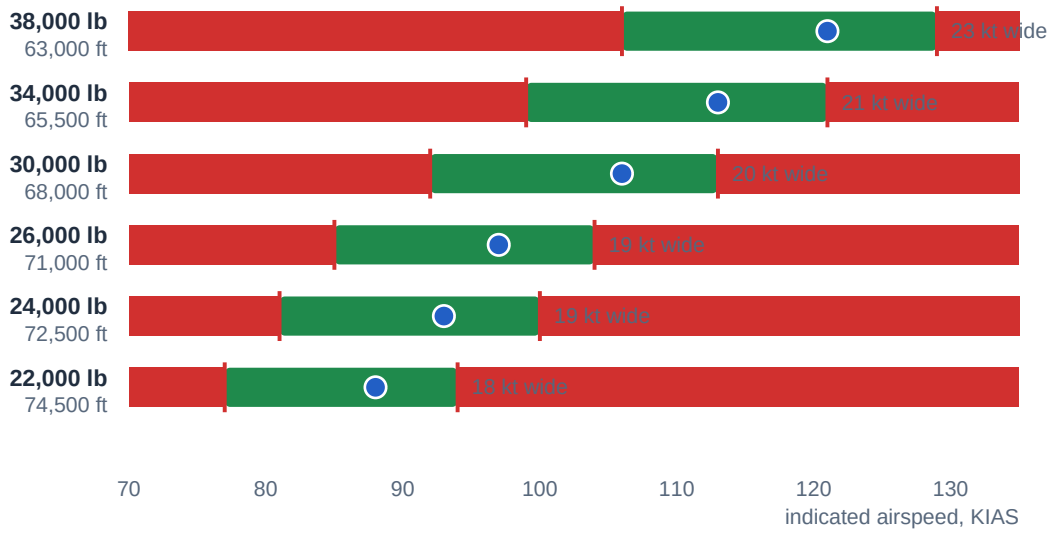
- **Two limits, coming together.** The stall stays near the same indicated speed as you climb (it creeps up a few knots). The red line is set by Mach .751, so its indicated speed falls fast above 50,000 ft: 159 KIAS at 55,000 ft, about 140 at 60,000, 122 at 65,000, about 107 at 70,000.
- **Higher is narrower.** At one weight, each extra 1,000 ft takes about 3 kt off the room to the stall. In the cruise climb the aircraft only goes up as the fuel burns off and it gets lighter, so the corridor stays about 18 - 23 kt wide all the way up (see the table).
- **The small gap is on top.** At M .715 the red line is only 6 - 8 kt above you. The stall is 11 - 15 kt below. Most mistakes up here are too fast, not too slow.

AT 22,000 LB: THE CORRIDOR FROM 45,000 TO 80,000 FT (ESTIMATE, STANDARD DAY, 1 G)



Every row is one altitude at the same weight, 22,000 lb, the weight near the end of a long mission. Green is where you can fly, between the stall (left red mark) and the red line (right red mark). Only the altitude changes: the stall creeps up a few knots and the red line comes down fast. At 80,000 ft only a few knots are left, and M .715 is already slower than the stall (no dot): the coffin corner for 22,000 lb is at about 82,000 ft. At 30,000 lb the corridor closes at about 74,500 ft. Below about 50,000 ft the red line is 181 KIAS.

THE CORRIDOR AT YOUR CRUISE-CLIMB ALTITUDE (ESTIMATE, STANDARD DAY, 1 G)



Green: where you can fly. Red lines: the stall (left) and the Mach .751 red line (right). Dot: M .715, the cruise speed. Each weight settles at its own altitude, so the corridor stays about 18 - 23 kt wide.

Where the corner itself is

The chart shows where the two lines meet: at about 69,500 ft at 38,000 lb, 70,800 ft at 36,000 lb, 74,500 ft at 30,000 lb, 79,500 ft at 24,000 lb and 82,000 ft at 22,000 lb. That is about 7,000 ft above where the engine can take you at each weight, so in a normal cruise climb you never reach it.

You can get closer by pulling up (a zoom) or by forcing the climb at a lower speed: do not.

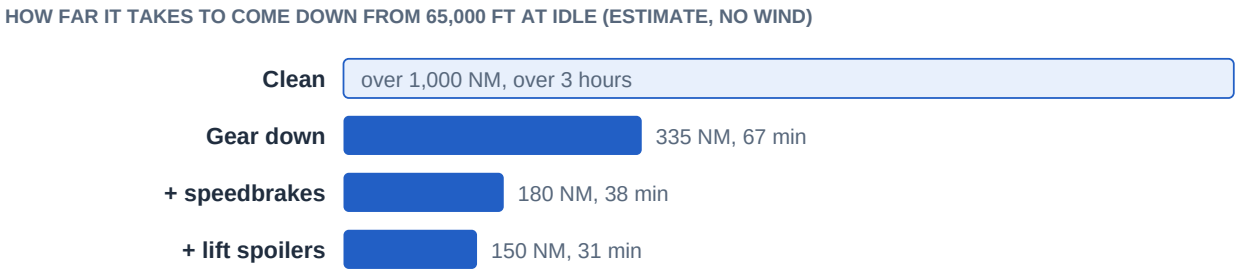
What makes the corridor narrower

- **Bank.** A turn raises the stall: about 7 % at 30° of bank. At M .715 a level turn at about 40° of bank stalls the wing, at every weight (see the table). The AFCS turns at 15°, at most 25°. By hand, keep to the same.
- **Gust control UP.** It raises the stall speed and above 43,000 ft it does not raise the red line. Keep it FAIRED in the cruise.
- **Lift spoilers up.** They add 2 kt to the stall.
- **Turbulence.** A gust changes your speed by several knots in a second, in the narrow band that is most of the margin. Above 60,000 ft moderate turbulence switches off the autopilot. Hold the attitude gently and let the speed settle.
- **On the fast side you get warnings.** The red bar on the PFD and SFD speed tapes, the Mach digits turning red, MACH RATE when you will reach M .75 within 5 seconds, and AIRCRAFT OVERSPEED past the red line. The drag starts to rise at about M .65 and climbs quickly past .75, so the aircraft resists a runaway.
- **On the slow side you get almost nothing.** In the sim there is no Mach buffet, and up here no stall tone: the AOA gauge reads low because it corrects for Mach, the tones start at .70 and the wing lets go at about .60. The AFCS MACH and ALT modes give way before the stall, but by hand it is up to you.
- **Too fast?** Nose up a little, or a touch of throttle back. Correct at once.
- **Too slow?** Lower the nose gently and let the speed come back. Do not pull. The red line is not far away.
- **A warmer day** does not move these KIAS numbers at a given altitude. It puts your cruise climb lower, where the corridor is wider.

More: Flying the U-2S → High-Altitude Handling.

Descent

Getting a glider down from 65,000 ft takes planning. Gear down at 65,000 ft is not a mistake: it is the first thing you do, and the gear has no speed limit.



Each bar adds to the one above it. Without the gear this wing barely comes down at all.

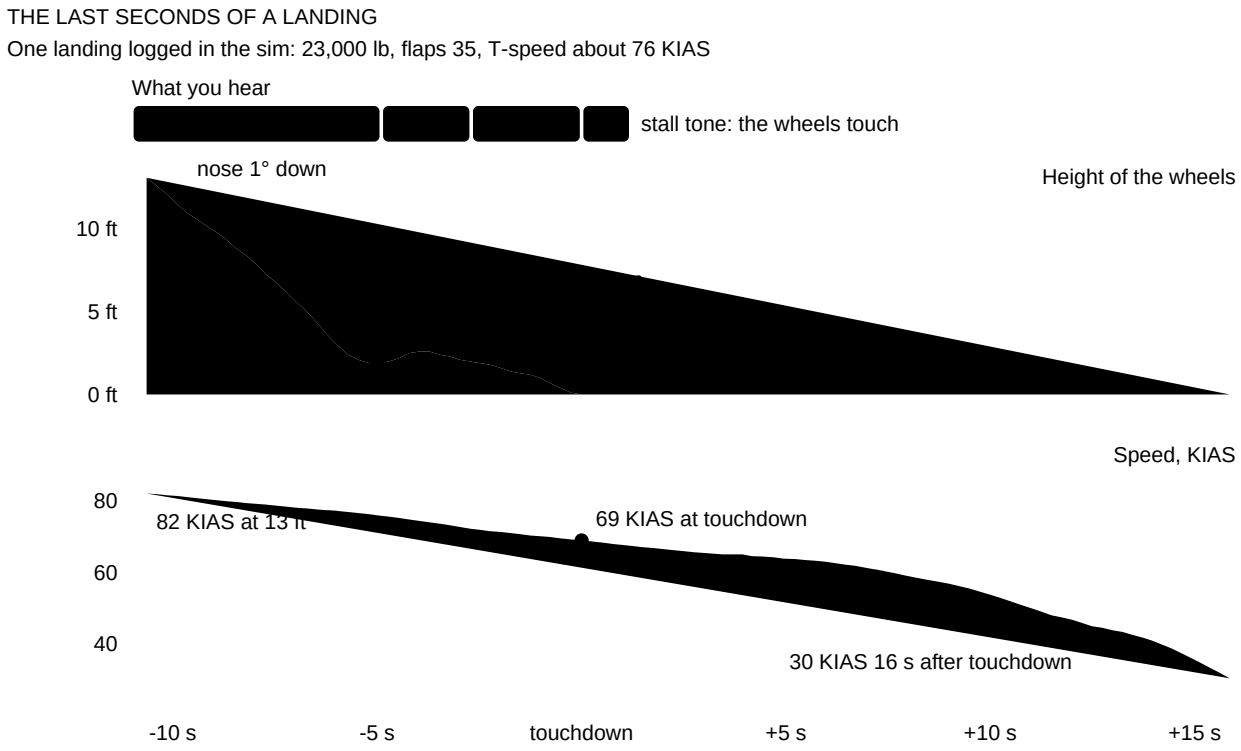
- **Start early.** About 2.4 NM for every 1,000 ft you have to lose, so about 150 NM from 63,000 ft, plus extra for a tailwind.
- **Expect about 1,700 - 2,500 ft/min** with everything out.
- **The engine stays busy.** Flight idle up high is still about 81 - 85 % N2. It is not stuck.
- **The needle comes back up** as you descend, the opposite of the climb. Below 53,000 ft you fly 160 KIAS again.

- **Clean up in time.** The lift spoilers and gust control have to be sorted out before the pattern, and the flap lever is locked while gust control is UP.

The Landing

This is the part the U-2 is famous for. In most aircraft you land with speed to spare, on wheels spread wide. Here you land at the edge of the stall, in the same slightly nose-up attitude the aircraft has on the ground, so that the main wheel and tailwheel touch together, and then you balance on them.

On final expect the nose a few degrees **down**, about 90 KIAS and 600 - 700 ft/min with the throttle at idle, flaps 35 and the speedbrakes out (measured). Then, in the last 10 seconds, everything happens at once:



One logged landing. The tones are placed for that weight by the AOA system: steady at T-speed, fast beeps about 4 kt below it, the stall tone about 7 kt below it.

- **You are lower than you think.** In this landing the wheels were 2 ft above the runway five seconds before they touched. In the U-2 you fly it down to a couple of feet, not to a flare height.
- **The speed falls by itself,** a little over 1 kt per second. You only hold the height and wait. Every knot too fast at the threshold is about another second of float and over 100 ft of runway.
- **Listen.** Slow beeps, steady tone at T-speed, fast beeps about 4 kt below it, high stall tone about 7 kt below it. The stall tone is where the wheels should touch.
- **The mobile helps.** With the chase car on, a second pilot calls your height: "ten... five... two... one", and "left rudder" or "right rudder" if you drift. Height is hard to judge from the cockpit, so trust the calls.
- **The nose comes up slowly,** from about 1° down to about 3.5° up, over the last 10 seconds. If the aircraft touches on the main wheel first it can pitch up and fly again.

Caution
Press the SPOILER button at touchdown. Nothing deploys by itself. Without the lift spoilers the wing

keeps flying and the aircraft will not stay down.

It is not over until it stops

- **Keep flying the wings.** Left alone, a wing goes down in a few seconds. Keep working the aileron all the way down the runway. It gets weaker as you slow.
- **In the logged landing** the aircraft was down to 30 KIAS 16 seconds after touchdown.
- **One wing tip will settle on the runway** at the end. That is what the skid is for.
- **Stop straight ahead and stay there.** About a minute later the crew arrives, fits the pogos and levels the aircraft, in about half a minute. The pogos wait for the crew, however long they take.

If It Stalls

Well away from the ground the U-2's stall is not frightening. The nose comes down by itself, and the roll and yaw stay under control. Lower the nose a little more, level the wings and let the speed come back. With the stall strips in, a wing drops. With them out, as they are from 24° of flap, the wings stay level.

What makes it dangerous is where it happens:

- **In the flare:** if the stall tone comes while you are still several feet up, the aircraft will drop in. Above 750 ft/min at touchdown the gear is damaged (with crash damage on).
- **In a turn:** the stall speed goes up about 7 % at 30° of bank, so about 5 kt at landing speed. Keep to 30° in the pattern.
- **Close to the ground:** a dropped wing soon becomes a wing tip on the runway, and at speed that can throw the aircraft around.
- **Up high:** no tone warns you. The autopilot's MACH and ALT modes give way before the stall, but by hand it is up to you. Lower the nose gently: the red line is not far away.

Part 3Before You FlyThe surprises, the mistakes and a plan for your first flights.

That Is Normal

These all look like faults the first time you see them.

What you see	Why
The aircraft stays put at idle	It needs a burst of power to get rolling, about 78 % N2.
The AOA indexer is lit on the ramp	The AOA reads about .65 at the two-point attitude.
The airspeed reads zero early in the takeoff roll	It starts reading at about 18 kt.
The pogos fell off	That is their job. The crew fits them again after landing.
The nose is 30° or more above the horizon	That is the climb attitude on this much thrust.
The oil quantity drops to about 8.5 qt in the climb	The reading swings with the climb and comes back. The oil itself does not change.
The needle falls above 52,000 ft	You are holding Mach. Your real speed has not changed.

What you see	Why
The AOA shows only .15 to .40 in the cruise	The gauge corrects for Mach. Fly the Mach, not the AOA.
The altitude keeps creeping up	That is the cruise climb.
The throttle does not follow the autopilot	There is no autothrottle.
The cabin altitude reads about 29,000 ft at 70,000 ft	The cabin only holds 3.88 psi, which is why you stay on oxygen.
The trim keeps running after the autopilot goes off	The autopilot can take the trim past its stops, and it runs back at the normal slow rate.
Idle up high is about 81 - 85 % N2	That is flight idle. Near 70,000 ft it eases to about 81 %.
The gear is down at 65,000 ft	It is your biggest source of drag on the way down.
A wing tip rests on the runway after landing	With no pogos, the aircraft has to lean on something.

Classic Mistakes

Mistake	What happens	Fix
Not binding the lift spoilers	You touch down and cannot kill the lift	Bind **Toggle water rudder** before you fly, see Keybinds Guide
Rolling before the crew has finished	The pogos stay on after liftoff	Wait for "ground crew clear".
Forgetting the wings when the pogos go	A wing drops on the runway	Have aileron ready from 60 KIAS
Lowering the nose in the climb	The speed runs past 180 KIAS in seconds	Small pitch changes, and bring the power back if you need to level off
Staying at full throttle up high	EGT HIGH from about 55,000 ft	Vernier to 650 - 725 °C from about 45,000 ft
Big inputs at altitude	A roll spoiler pops and the speed moves	Small and slow, then wait
Forcing it higher when heavy	The stall gap closes by about 3 kt per 1,000 ft	Let the fuel burn off
Starting down too late	You arrive thousands of feet high	Start about 150 NM out, gear down first
Crossing the threshold fast or high	A long float, and maybe no runway left	T-speed, 10 ft at most, throttle idle
Flaring too high	The stall tone comes early and it drops in	Fly it down to 2 - 3 ft, then hold it there
Touching main wheel first	The nose pitches up and it flies again	Both wheels together, in the two-point attitude

Mistake	What happens	Fix
Relaxing after touchdown	A wing goes down and the aircraft swings	Aileron and rudder until it stops

Your Recommended First Three Flights

1CircuitsStart on the runway with about 500 gal: at least 70 in the sump, the rest equally in the two inboards, with the outboards empty. With the default equipment that is about 23,600 lb and a T-speed of about 77 KIAS. Keep the chase car on and wait for the crew. Take off, and start bringing the power back as soon as you are flying: 1,500 ft comes very quickly at this weight. Fly the pattern, land, stop and let the crew fit the pogos.The pattern is in Normal Procedures. Set yourself a light target: both wheels together on the centreline, wings level to the stop.

2A trip to the topLoad about 900 gal and climb all the way. Watch the needle fall past 52,000 ft, set MACH on the autopilot and spend half an hour in the cruise getting a feel for the engine and the speed band.About an hour and a half. You should land under 24,300 lb, so your normal landing still works. Check the weight on the way down.

3The real thingNow start from Cold and Dark with the Quick Start Guide and the Checklists.

Related pages: Normal Procedures - Flying the U-2S · High Altitude and the Cruise Climb · Angle of Attack (AOA) · Speedbrakes and Lift Spoilers · Checklists

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