Lesson:
Descent Control

Objectives:

- Knowledge
    - An understanding of the aerodynamics related to glide ratio
    - An understanding of the visual effect - parallax
- Skill
    - Using the parallax effect to control the glider's descent path

Materials / Equipment

Publications

- Flight Training Manual for Gliders (Holtz)
  Lesson 5.3 – Glide Slope Control Using the Airbrakes

Simulation Files

Flight Plan

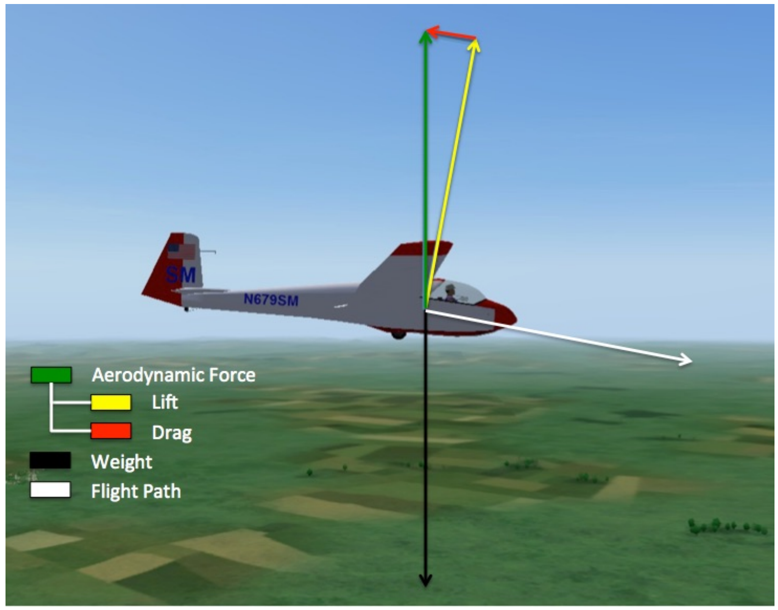
- Descent_Control.fpl

Replay

- Descent_Aerodynamics_1.rpy
- Descent_Aerodynamics_2.rpy
- Descent_Control_Demonstration.rpy
- Descent_Control_Practice.rpy (load to Flight School / Custom)
- Optimized_Descent_1.rpy
- Optimized_Descent_2.rpy
- Parallax_Demonstration.rpy

Presentation – Descent Control Aerodynamics

Before getting into the aerodynamics of descent control, a quick review of more general aerodynamic principles is in order.

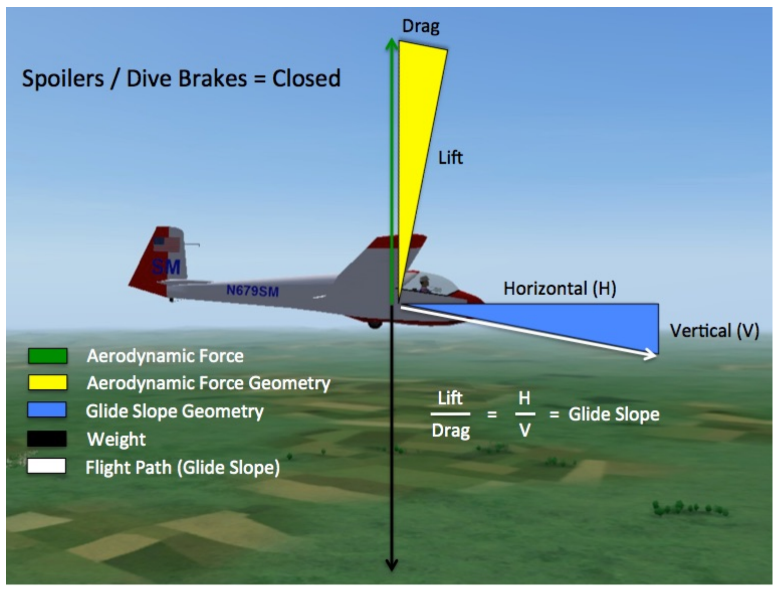


The **aerodynamic force** is defined as the sum-total of all forces acting on the glider as it moves through the air. The aerodynamic force naturally comes into equilibrium with the glider's driving force, the pull of gravity on its mass (weight).

With the glider's flight path as the frame of reference, the aerodynamic force is most often represented as two component forces:

- **Lift** acting perpendicular to the flight path
- **Drag** acting parallel to and opposite the flight path

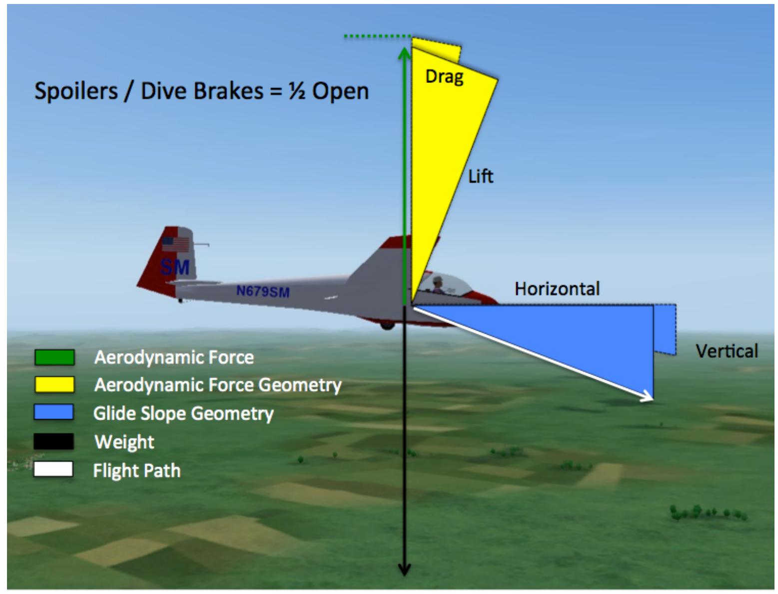
In the image at the right, the geometry of the aerodynamic force is represented as a yellow triangle. The blue triangle is an exact replica of the aerodynamic force geometry, but oriented to the glider's flight path.



What becomes clear is that the glider's ratio of lift to drag equals the ratio of its horizontal to vertical motion, i.e. its "glide slope."

So, by controlling the glider's lift-to-drag ratio, the pilot controls the aircraft's glide slope. As it turns out, this is exactly the function of a glider's dive brakes / spoilers.

In the image at the right, the glider's dive brakes have been deployed, resulting in both a decrease in lift and an increase in drag.

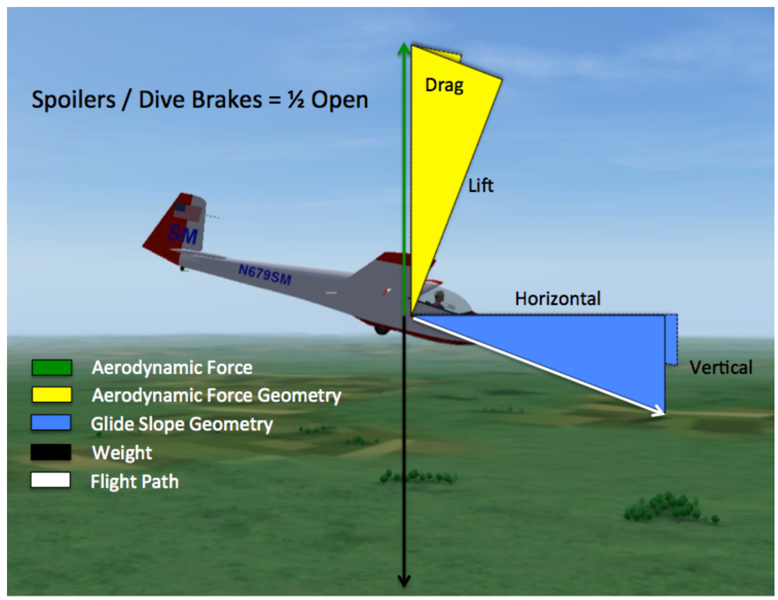


Note the resulting change in the aerodynamic force geometry.

Notice too that the aerodynamic force, generated by this new geometry, no longer equals the weight of the glider. The result is a downward acceleration, and a corresponding change in the glider's flight path.

The glider senses this change in its flight path as an increase in the angle of attack.

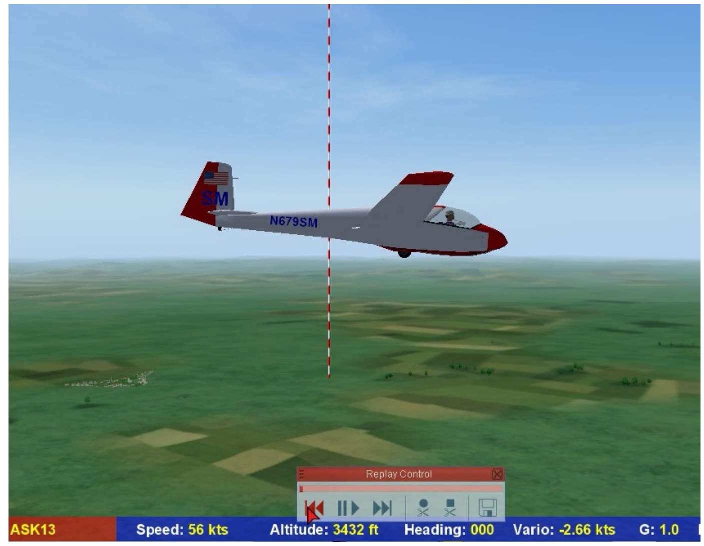
The aircraft's longitudinal stability then acts to restore (reduce) the angle of attack to its trimmed value by pitching the glider down.



With the lift vector tilted more forward, the airspeed increases. The increase in airspeed generates a corresponding increase in both lift and drag, until the aerodynamic force (lift + drag) returns to equilibrium with the weight of the glider.

Demonstration – Descent Control Aerodynamics
This demonstration is meant to help you visualize how the dive brakes alter the glider's descent profile by changing the aerodynamic force geometry (lift-to-drag ratio).

Set-up
- View Replay == Descent_Aerodynamics_1.rpy
- Reset Replay to the beginning (|<<)
- Set Replay camera OFF (F9)
- Select External glider view (F2)
- Adjust View to match the image at the right



Note: *Airspeed is measured along the glider's flight path, so it is not exactly equal to the horizontal component of the glide slope. However, for the shallow descent profiles at which gliders fly, airspeed is a close approximation of the glider's horizontal speed. As such, it can reasonably be used, along with the glider's descent rate, to calculate its glide ratio; simply divide the airspeed by the vertical speed (descent rate).*

09:01:01 – 09:01:05
As the demonstration begins, the glider is trimmed for 56 knots. It is descending at 2.66 knots with the dive brakes fully closed. Dividing the 56-knot airspeed by the 2.66-knot descent rate yields a rounded value of 21.

Note: *Glide ratios are most commonly expressed as some value over "1", so our initial glide ratio would be expressed as* ***21/1*** *(pronounced "21 to 1").*

- Press PAUSE to start
- Count to 5 (seconds)
- Press PAUSE to stop

Note: *The glider's flight path is represented by the wingtip smoke trails. To help visualize the descent profile, simply compare the flight path (smoke trails) to the horizon. This is what* ***21/1*** *looks like.*

09:01:06 – 09:01:14
The dive brakes are opened half way. The dive brake panel on the upper surface of the wing spoils (eliminates) some of the wing lift, while simultaneously introducing a substantial increase in drag; the lower dive brake panel simply adds more drag.

Primarily due to the sudden increase in drag, the glider initially slows down a couple knots, and its descent rate increases rapidly to from 2.6 knots to 9 knots. The glider senses the increased rate of descent as an increase in angle of attack, and pitches down to restore (reduce) the angle of attack to its trimmed value.

- Press PAUSE to start
- Press PAUSE to stop when the variometer (Vario) indicates **"-9.00 kts"** -- (close is good enough)

The Lift-to-Drag (glide) ratio is now 53 divided by 9, or about **6/1**; a rather dramatic departure from the 21/1 ratio experienced with the dive brakes fully closed.

Note: Changes in drag have the greatest effect on the aerodynamic force geometry, and therefore the greatest effect on glide ratio (descent profile). As we will learn in later lessons, there are a number of ways to modulate drag for the purpose of controlling the glider's descent rate. However, because dive brakes simultaneously alter both lift and drag, their use is generally more effective, at controlling the glider's descent profile, than methods that employ drag modulation only.

09:01:08 – 09:01:40
With the glider pitched further down, the lift vector has a greater horizontal component, and the glider begins to accelerate. The airspeed continues to increase, until the aerodynamic force (lift + drag) comes back into equilibrium with the weight of the glider.

As the airspeed increases, so too does parasitic drag. This additional drag further alters the aerodynamic force geometry, further increasing the descent rate. Notice the variometer value decreasing as the airspeed increases.

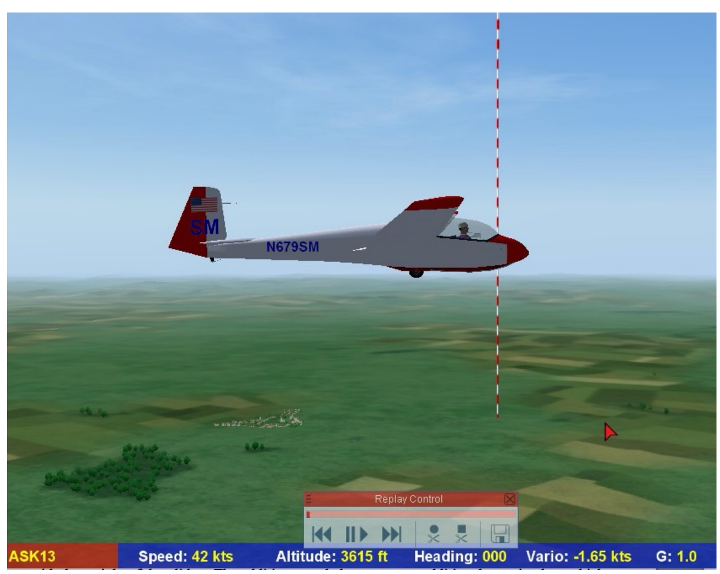
The glider eventually stabilizes at 58 knots, with a descent rate of 11.60 knots. The Lift-to-Drag (glide) ratio is now about **5/1**.

- Press PAUSE to complete the demonstration

Demonstration – Descent Control Aerodynamics
In this demonstration, the ASK-13 is trimmed to the angle of attack that produces its greatest Lift-to-Drag ratio, and therefore its best-possible glide ratio in calm air.

As the flight progress, the glider transitions through its full range of glide ratios (at this angle of attack). The dive brakes are gradually deployed from their fully closed position (glide ratio = 27/1) to their fully open position (glide ratio = 6/1).

Set-up
- View Replay==Descent_Aerodynamics_2.rpy
- Reset Replay to the beginning (|<<)
- Set Replay camera OFF (F9)
- Select External glider view (F2)
- Adjust View to match the image at the right
- Press PAUSE to begin



At any point in the demonstration, you can PAUSE and calculate the glide ratio by dividing the airspeed by the descent rate.

Parallax
While glide ratios are somewhat interesting, and provide a better understand of the vertical performance capabilities of our glider, they are not very useful for actually managing a descent profile. Fortunately, Mother Nature has provided us with everything we need to control the glider's descent.

Parallax is the difference in the apparent position of an object when viewed along two different lines of sight, and is measured by the angle between the sight lines.

As it turns out, our human eyes and brain are highly capable of quickly, and easily, detecting even small changes in angle.

Parallax, and our ability to sense it, provides the information our brains need to manage the descent of the glider.

Parallax Demonstration
This purpose of this demonstration is to help you visualize the parallax effect, i.e. how the position of an object appears to change as the line of sight to the object changes, and conversely how an object appears to remain stationary, in the absence of any angular change in the line of sight.

The glider will be approaching an imaginary window in the sky. As it does, the parallax effect will become increasingly apparent.

Set-up
- View Replay == Parallax_Demonstration.rpy
- Reset Replay to the Beginning (|<<)
- Press PAUSE (P) key to start/stop each Replay time segment

09:00:26 – 09:01:00
As the demonstration begins, the glider is still quite distant from the window. At this distance, the line-of-sight angles, to the four sides of the window, are all quite small. As such, the angular rate of change is small, and the parallax effect is not clearly obvious.

- Run the Replay to **09:01:00**

For a better idea of the change that has taken place in the preceding 34 seconds, notice the change in the size of the window as the Replay jumps back to the start.

- Reset Replay to the Beginning (|<<)

- Replay this segment, or reposition the Replay to **09:01:00**

Note: The parallax effect (the apparent movement of distance objects when viewed from different angles) is enhanced when an intermediate object is placed between the viewer and the distant object.

Try using the bottom of the yaw string as the intermediate object (parallax reference). Focus on the bottom of the yaw string, and allow your peripheral vision to sense the apparent movement of the sides of the window. Notice too, the apparent lack of movement at the center of the window.

09:01:00 – 09:02:00
As the glider gets closer to the window, the rate of change in viewing angles increases, and the apparent changes in position of the four sides of the window becomes more obvious.

- The top of the window appears to be moving up in the field of view; the bottom of the window seems to be moving down; the sides appear to be moving farther apart.
- There is little or no relative motion (zero parallax) between the bottom of the yaw string and the vertical center of the window.

Note: *In this and future lessons, this zone of "zero parallax" will be shown to represent a point of intersection. In this demonstration, it is the intersection of the glider's flight path with the vertical center of the window. Later in this lesson, it will help you visualize the glider's flight path. In a future lesson, it will represent the intersection of your glider's flight path with that of another aircraft, helping you avoid a mid-air collision.*

09:02:00 – 09:02:40
The parallax effect becomes much more obvious.

- There continues to be no relative motion between the bottom of the yaw string and the vertical center of the window. It appears likely the glider's flight path will take it through the window at that point.
- It also appears the glider will fly well over the bottom of the window, which has the appearance of moving steadily downward in the field of view.
- The glider will clearly fly under the upward-moving top of the window, and directly between the outward-moving sides of the window.

09:02:40 – 09:03:08
The glider passes through the window exactly at the vertical and horizontal points of zero-parallax (no apparent motion).

Note: *Throughout this demonstration, the pilot has also been using parallax (almost subconsciously) to control the glider's horizontal flight path (heading). Each time the vertical pole "appeared" to move to the left or right of the yaw string, the pilot would made a small turn back toward the pole.*

In the real world, however, there are very few striped poles to aid navigation. The easiest way to maintain a steady heading, in actual flight, is to select a visible object in the distance (the farther away the better), and simply keep the yaw string horizontally aligned with that object.

Visualizing the Flight Path

Another important aspect of descent control is the ability to visualize the glider's flight path.

As seen in the previous demonstration, the flight path appears to extend along an imaginary line from the pilot's eyes to a point in 3-dimensional space that appears to remain stationary in the pilot's field of view; assuming the glider's flight attitude is held steady.

If you could actually see your flight path (glide slope), it might look like the image at the right.

The glide slope appears to intersect the ground at the point of zero-parallax. During a descent, this point appears to remain stationary in the pilot's field of view.

As with airspeed control, using an intermediate visual reference (IVR) enhances the parallax effect during a descent.

For a specific airspeed, the IVR appears along the pilot's line of sight to the horizon. While flying a descent, the IVR appears along the pilot's line of sight to the point of zero parallax, i.e. along the glider's flight path.

Note: What you use for an intermediate visual reference, and the IVR's relative position to a distant reference (the horizon for airspeed control; the point of zero parallax for descent control) will vary with the features of the glider, your seating position, etc.

The examples used here are specific to the ASK-13 in Condor, but the concepts apply to any glider.

Interestingly, the same IVR used to maintain the pitch attitude (angle of attack) associated with a specific airspeed, can also be used to control the flight path of the glider during a descent, at that same angle of attack.

The pairs of images on the following pages help make this point.

In the image at the right, the glider is flying at 42 knots. This is the airspeed (angle of attack) at which the ASK-13 achieves its best glide ratio in calm air.

Airspeed is a function of angle of attack, which by definition, is a relationship to the glider's flight path.

The pilot's line of sight to the horizon appears to pass through the top edge of the tape securing the yaw string. This is the IVR for the pitch attitude (angle of attack) that results in a 42-knot airspeed with the dive brakes closed.

In the image to the left, the pilot has altered the descent profile by opening the dive brakes.

The pitch attitude has changed, but the angle of attack (glider's relationship to the flight path) has been maintained by the pitch trim system.

As it turns out, the pilot's line of sight through the 42-knot airspeed IVR (top edge of the yaw string tape) is a reasonably accurate representation of the glider's flight path at the 42-knot angle of attack.

The following pairs of images provide three other IVRs for controlling the ASK-13's descent, at the angles of attack associated with various airspeeds.

At the right, the glider is flying at 38 knots, dive brakes closed. The IVR splits the distance between the bottom of yaw string and the top of the instrument panel.

At the left, the glider is flying at the 38-knot angle of attack with the dive brakes partially deployed. Sighting through the IVR helps the pilot visualize the glide path.

The image at the right has the glider pitched to achieve 47 knots, dive brakes closed. The IVR is ½ way up the yaw string.

The glider at the left is descending (dive brakes partially open) at the 47-knot angle of attack.

The 56-knot airspeed IVR is the top of the yaw string.

In a descent, the same IVR represents the flight path at the 56-knot angle of attack.

TLAR – That Looks About Right
Another important skill in descent control is the ability to recognize what a "normal" glide slope looks like.

Different gliders have different performance capabilities, so what looks right in one glider may not work well in another.

The ability to recognize what "looks about right" comes with experience, and the ability to quickly accumulate experience is one of the many advantages of incorporating simulation into your flight training. As you practice making controlled descents, in this and future lessons, your experience base will grow, and your ability to quickly and easily recognize a viable descent profile will become second nature.

The following series of images will help you get a jumpstart on developing a sense of what "looks about right" from the cockpit of Condor's ASK-13. For each scenario, the approach speed is 42 knots. The 42-knot IVR is the top edge of the yaw string tape. **The line of sight through the IVR indicates the glider's flight path**. The intended touchdown point is the approach (near) end of the runway.

Let's start with the appearance of a normal approach slope in the ASK-13.

The dive brakes are about ½ open, so the pilot has the option to steepen or flatten the descent profile as needed.

TLAR – This Looks About Right

In the image at the right, the glider is higher than normal. The approach end of the runway appears to be moving down in the pilot's field of view (relative to the IVR), but the situation is still manageable. By further opening the dive brakes, the pilot can steepen the descent profile, and still arrive at the approach end of the runway as intended.

TLHBM – This Looks High but Manageable

In this scenario, the current flight path would have the glider touching down somewhere near the far end of the runway. Full dive brake deployment would probably allow for a landing somewhere around mid-field, but at this point in the approach, a landing near the approach end of the runway is pretty much out of the question.

TLWTH – This Looks Way Too High

In this image, the glider is higher than normal, but the flight path is too steep. Unless corrected, the decent profile would result in a landing short of the runway.

The situation is still manageable by flattening the descent profile (closing the dive brakes as needed).

TLHBTS – This Looks High but Too Steep

The glide slope here is too shallow. The dive brakes are ½ open, so the pilot has some margin for error should the glider descend any lower.

While this approach will probably end well, it is not optimal.

The wise move at this point would be to fully close the dive brakes, and keep them closed until the descent profile returns to normal (TLAR).

TLLBM – This Looks Low but Manageable

This approach may still be salvageable, but the pilot has left himself with very little margin for error. If closing the dive brakes didn't do the trick, the pilot's natural tendency would be to pitch up to make the sight picture "look" normal. The resulting increase in angle of attack would produce an exponential increase in induced drag, and actually cause the glider to descend more quickly.

TLUL – This Looks Uncomfortably Low

There is no way this glider makes it to the runway.

Situations like this are almost always preceded by a series of poor decisions, and unless the chain of poor decision-making ends here, this situation is about to go from bad to worse.

To make the best of this bad situation, our intrepid pilot needs to:

1. Completely give up on the idea of making it to the runway
2. Commit to the safest possible landing short of the runway

TLLSSTUB – This Looks Like Somebody Should Take Up Bowling

Demonstration – Descent Control
In this demonstration, you will see how parallax is used to determine whether the glider is maintaining a flight path to the desired point in 3-dimensional space, and how the dive brakes can be modulated, as needed, to maintain the necessary descent profile.

*Note: The term "**aim point**" is often used to describe the point in 3-dimensional space where we intend our glide to terminate.*

Set-up
- View Replay == Descent_Control_Demonstration.rpy
- Reset Replay to the Beginning (<<)
- Press PAUSE (P) key to start/stop each Replay time segment

Note: To help visualize the IVR on each leg of the demonstration, use your mouse to place the red cursor arrow on the IVR (e.g. @ 42 knots, place the cursor on the yaw string at the top edge of the tape).

Note: The pilot's line of sight, through the IVR, is the glider's flight path.

09:00:50 – 09:01:50
The glider is trimmed to 42 knots, the speed (angle of attack) at which the ASK-13 achieves its best (flattest) glide in calm air. The IVR (intermediate visual reference) for 42 knots is the top edge of the yaw string tape. The aim point is the vertical and horizontal center of the window.

Note: As with airspeed control, reference to the horizon plays an important role in descent control.
- *Objects that appear to be on the horizon are at the same altitude as the glider.*
- *Objects that appear to be above the horizon are higher than the glider.*
- *Objects that appear to be below the horizon are below the glider.*

*With these facts in hand, we can make the following determinations at **09:01:50** in the demonstration:*
- *The horizon appears to intersect the window at about 2/3 of its height.*
  If the glider were passing through the window at this point in time, it would pass through at that 2/3 point.
- *The top of the window is higher than the glider.*
  A descent over the top of the window is already out of the question.
- *The vertical center of the window is below the glider.*
  The glider still has the potential to pass through the window at that point, but time will tell.
- *The bottom of the window is well below the glider.*
  There is an even better chance the glider will clear that obstacle, but that is still not guaranteed at this point.

09:01:50 – 09:03:10
As the glider approaches the window, the pilot monitors the position of the IVR relative to the aim point. The lack of relative motion between these two visual references indicates the glider's flight path should take it directly through the aim point; and indeed it does.

Note: If you visually project the flight path through and beyond the IVR, the point at which the flight path appears to intersect the ground is logically where the glider would land. Accordingly, the glider would over-fly all points on the ground that appear to be below the IVR (e.g. the row of trees just above the glider's instrument panel), and would land short of any point appearing to be above the IVR.

09:03:10 – 09:04:00
The glider miraculously gains an additional 1500 feet of altitude, begins a left turn toward another window in the distance, and is stabilized at 42 knots. This airspeed corresponds to the best possible glide ratio in the ASK-13, and therefore the highest probability of reaching the window. Sighting through the 42-knot IVR (top edge of the yaw string tape), the initial indication is that the glider will pass just over the top of the window.

09:04:00 – 09:05:15
The pilot continues to fly at the best glide airspeed, looking for any change in the relative positions of the window and the flight path (IVR). As the glider gets closer, the window appears to be moving downward relative to the IRV, confirming the earlier assertion the glider would overfly the window.

09:05:15 – 09:06:00
The pilot opens the dive brakes to steepen the glide slope and modulates the dive brake control to position the IVR onto the vertical center of the window. Since the IVR represents the glider's flight path, the pilot has essentially directed the glider to descent through that point.

09:06:00 – 09:06:45
To experiment a little, the pilot opens the dive brakes to further steepen the glide slope, resulting in a flight path that would clearly take the glider under the window, and then adjusts the dive brakes as needed to ensure a descent through the window.

09:06:45 – 09:08:25
As the descent continues, the pilot makes a series of small adjustments to the dive brake setting; keeping the IVR vertically centered in the window. Small heading adjustments keep the IVR near the horizontal center of the window.

09:08:25 – 09:09:30
After passing through the second window, the pilot closes the dive brakes, reestablishes a normal 42-knot glide attitude, miraculously gains another 1500 feet of altitude, and turns left toward the next window.

09:09:30 – 09:10:30
To demonstrate that this IVR-based technique will work at any airspeed, the pilot accelerates the glider to 56 knots and sets the trim to hold the 56-knot pitch attitude.

The pitch attitude for 56 knots has the top of the yaw string on the horizon. This is the 56-knot IVR.
- Place the red cursor arrow at the top of the yaw string to help visualize the 56-knot IVR.

09:10:30 – 09:11:10
The pilot continues the 56-knot glide with dive brakes closed and monitors the position of the IVR relative to the window. Again, the relative position of the IVR, and the apparent downward movement of the window in the pilot's field of view, both indicate this descent profile would result in the glider overflying the window.

09:11:10 – 09:13:00
The pilot opens the dive brake to steepen the descent, adjusting the dive brake control as needed to keep the IVR centered vertically in the window, and making small heading changes (turns) as needed to keep the glider horizontally centered on the window.

Note: ***When the IVR is not vertically where you want it, there is a strong tendency to make the sight picture look right by pitching the glider using the stick. Initially this seems to work, but it soon becomes clear that pitching the glider does little to change the actual descent profile.***

The key to effective descent control is to

1. ***allow the glider's longitudinal stability to maintain the trimmed angle of attack (the pilot makes no pitch changes with the stick)***
2. ***control the descent profile (as indicated by the IVR) with dive brake control inputs only***

This technique requires disciplined practice. It is not intuitive.

09:13:00 – 09:15:15
After successfully descending through another window, the pilot closes the dive brakes, turns left to a heading that will intercept the extended centerline of Runway 27 at Murska Sobota, and initiates an airspeed change to 47 knots (the target speed for the final segment of this demonstration). Once on the extended centerline, the pilot turns right to align with the runway.

Note: *The pole on the runway, and the one beyond it, are both located on the extended centerline of the runway. The poles appear to align when the glider is also on the runway's extended centerline; another parallax effect.*

The IVR for 47 knots is the vertical midpoint of the yaw string.

- Place the red cursor arrow at the midpoint of the yaw string to help visualize the 47-knot IVR.

The current position of the 47-knot IVR is indicating the glider will not only overfly the approach end of the runway, but the entire airport was well. In fact, unless something changes, the flight will likely terminate in the light-colored field about 2 miles beyond the airport.

09:15:15 – 09:17:05
The objective of this final segment is to control the glider's descent to the approach (near) end of the runway.

The pilot opens the dive brakes to steepen the descent profile, aligns the IVR with the approach end of the runway, and modulates the dive brakes as needed to gracefully bring the glider down to the perfect position from which to begin the actual landing.

Note: *The landing approach requires that the pilot simultaneously manage the horizontal and vertical flight path to the runway. In both dimensions, the parallax effect enables the pilot to quickly recognize and correct any deviations from the desired flight path.*

Exercise - Descent Control Skills Development

Set-up

- Select Free Flight
- Load User Flight Plan == Descent_Control.fpl
- Start Flight
- Press "J" to make the turn points visible
- Press "ESC"
- Select "Ready for Flight"

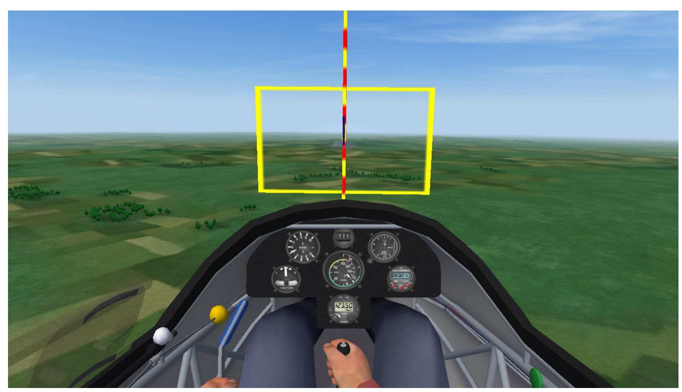
Play by Play

1. As you fly toward the red/white pole, stabilize the glider's airspeed at 42 knots.

2. After passing the red/white pole, direct the glider's flight path to the center of the window by holding the yaw string horizontally within the sides of the window, and holding the 42-knot IVR (top edge of the yaw string tape) on the vertical center of the window.

   Only very small control inputs are required. The closer you get to the window, the easier it is to keep everything centered.

3. The window on this flight segment is centered directly on the ASK-13's best glide (42-knot) descent profile. The glider is trimmed for 42 knots, so it should simply fly itself through the vertical center of the window. All you need to do is make small heading changes (turns) to keep the glider moving toward the window.



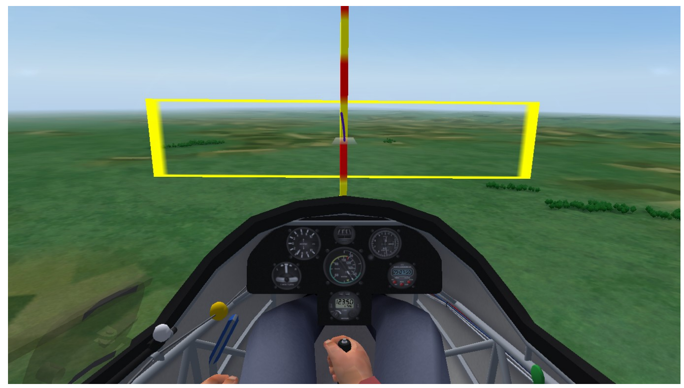
4. As you approach the window, notice how everything around the aim point (center of the window) "appears" to be moving (parallax effect), but that the aim point appears stationary.
   - Objects above your flight path appear to be moving up
   - Objects below your flight path appear to be moving down
   - Objects to either side of your flight path appear to be moving farther to that side
   - Objects on your flight path have no apparent movement

5. After flying through the window
   - Press the "Q" key one time to gain altitude
   - Turn left
   - Head toward the next window

6. As you approach the second window, maintain a 42-knot glide with the dive brakes closed. The relative position of the IVR will indicate a flight path that will take the glider over the top of the window, and the window will gradually, and more obviously, appear to move down in your field of view.

7. At your discretion (when you think the glide slope to the center of the window "looks about right"), open the dive brakes and begin modulating (opening, closing) them as needed to keep the IVR (top edge of the yaw string tape) between the top and bottom of the window.

   Do not make any pitch inputs using the stick. The glider will pitch slightly with each change in dive brake setting. That's OK. The glider's longitudinal (pitch) stability is simply acting to maintain the glider's trimmed angle of attack.



   As you get closer to the window, modulate the dive brakes to hold the IVR on the aim point (the vertical center the window).

8. After flying through the 2^{nd} window,
   - Close the dive brakes
   - Stabilize the glider, wings-level, at 42 knots
   - Press the "Q" key one time to gain altitude
   - Turn left
   - Head toward the next window

9. Establish and stabilize a 56-knot descent toward the window with the dive brakes closed.

   The relative position of the 56-knot IVR (top of the yaw string) will indicate that your flight path will again take the glider over the top of the window.

   Parallax will give the window the appearance of moving down in your field of view.

10. At your discretion, open the dive brakes. Control your descent through the window using only dive brake control inputs.

11. After flying through the 3rd window,
    - Close the dive brakes
    - Stabilize the glider, wings-level, at 47 knots
    - Turn left to a heading of 10-20 degrees left of the airport

12. Maintain this heading until the red/yellow pole on the runway begins to align with the red/white window pole beyond the airport.

    Then turn right to line up with the runway.

Note: The pole on the runway and the one beyond it are located on the extended centerline of the runway. When the poles appear to align, it is because the glider is on the extended centerline as well.

Note: In the real world, there are no poles to help us align with the runway, but we can still use parallax to align the glider's flight path to the runway heading.

- *Press "J" to make the poles disappear*

With the glider on the extended centerline, the runway appears to be vertical. If the runway appears slanted, e.g. to the left, the glider is to the left of the extended centerline. Fly to the right of the runway until it appears to be vertical. Then turn to line up with the runway.

13. The 47-knot IVR is the middle of the yaw string. At your discretion, begin your descent to the approach end of the runway.

14. Maintain your 47-knot descent profile by holding the IVR on the approach end of the runway.

    Maintain runway alignment (stay on the extended centerline of the runway) by making small turns. The runway should appear to be a vertical trapezoid.

Exercise - Descent Control Practice

Introduction
This exercise provides the opportunity to repeatedly make controlled descents to the runway, at various airspeeds.

Set-up
- Select Flight School
- Select Custom
- Select Descent_Control_Practice

Demonstration – Descent Control Practice
This demonstration begins with the glider located about 2.5 miles from the approach end of the runway, on the extended centerline (final approach), and about 1800 feet above the airport. Relative to the runway, this represents an 8.5 / 1 glide ratio, well within the ASK-13's performance capability.

- Select View Lesson

09:11:00 – 09:11:20
The glider is initially trimmed to 42 knots.

09:11:20 – 09:11:50
The pilot selects 47 knots as the approach airspeed, establishes that airspeed by pitching down, and then trims the glider to hold the target airspeed.

09:11:50 – 09:12:30
The dive brakes are opened to initiate the descent. The 47-knot IVR (middle of the yaw string) is placed on the aim point (approach end of the runway) using only dive brake control inputs.

09:12:30 – 09:14:30
The pilot continues to modulate the dive brakes, as needed, to maintain the desired descent profile (glide slope).

To return to the Flight School panel
- Press ESC
- Select Exit Lesson
- Select OK

Exercise – Descent Control Practice
As in the previous demonstration, this exercise places the glider about 2.5 miles from the approach end of the runway, on the extended centerline (final approach), and about 1800 feet above the airport. The initial trimmed airspeed is 42 knots.

Set-up
From the Flight School / Custom panel
- Select Try Lesson

Directions
Execute a series of descents to the approach end of the runway using various airspeeds.

For each approach:
1. Select the target airspeed for the approach
2. Pitch as needed to establish the target speed
3. Trim the glider to fly hands off at the target speed
4. Using a line of sight to the horizon, determine the IVR (intermediate visual reference) for the target speed
5. Modulate the dive brakes (only) to control the glider's descent to the runway
6. Use parallax to recognize and correct any deviation of the IVR from the aim point (approach end of the runway)

If you have trouble finding the runway or remaining on the extended centerline
- Press "J" to make the navigation poles visible

Don't worry about landing the glider. Landing is a later lesson.

To begin each exercise
- Press "ESC"
- Select "Ready for Flight"

To end each exercise and return to the Flight School panel
- Press ESC
- Select Exit Lesson
- Select OK

Exercise – Stretching a Glide
This exercise is designed to convince you that a glide cannot be extended by pitching the glider up to make the sight picture look normal.

Scenario
You are on a final glide to your home airport. Your approach airspeed is right where you want it, and the descent profile is looking good. You are almost to the runway when, suddenly, you enter an area of strong sink (a downdraft). You immediately close the dive brakes, but the glider continues to descend at an alarming rate and the ground seems to be rushing up at you.

Set-up
- Select Flight School
- Select Custom
- Select Descent_Control_Practice
- Select Try Lesson
- Press "ESC"
- Select "Ready for Flight"

Directions
As the flight begins, the glider is trimmed for 42 knots.

Open the dive brakes and modulate them, as needed, to execute a normal descent to the runway.

As the chronometer (instrument panel clock) reaches **09:14:30**, fully deploy the dive brakes to simulate entry into an area of strong sink (a downdraft). Then try to reach the runway using pitch inputs only.

Because pitching the glider up makes it appear as though the runway is no longer moving up in your field of view, your natural tendency will be to pull back on the stick. Initially, that seems to work, but it soon becomes clear that pitching up has actually made things worse; in fact, the glider's descent rate is increasing.

By this time, the ground is getting uncomfortably close, and the tendency to pull back on the stick becomes even greater, as you attempt to steer the glider away from the ground. However, the sink rate increases even further as the induced drag increases exponentially with angle of attack. Quite often, this last increase in angle of attack will exceed critical, leading to a stall and loss of control.

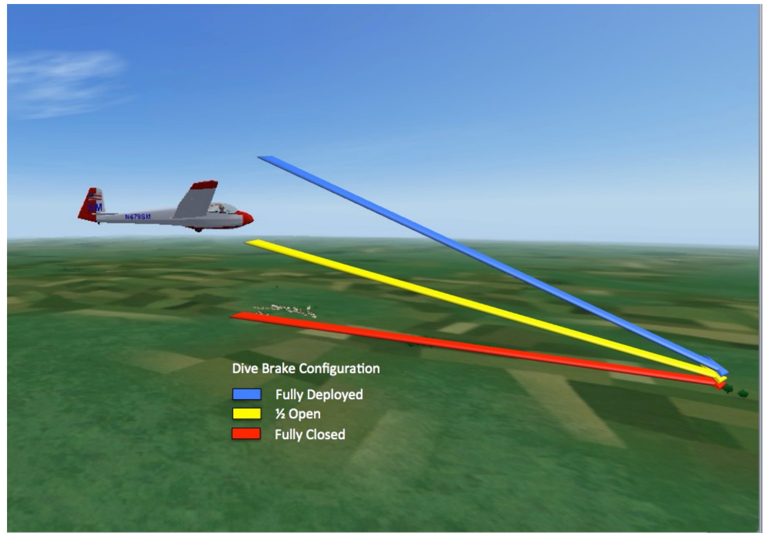
Fly the scenario as often as you like. Once you hit the sinking air at 09:14:30, nothing you can do with pitch inputs is going to get you to the runway. That realization is the very important point of this exercise.

The Safest Way Out
As soon as you realize the glider is not going to make it to the runway, maintain flying airspeed, and land the glider, under control, in the best place you can. Do not try to "stretch" your glide to the runway! That strategy almost always ends really badly.

Optimizing your Descent Profile
Up to this point in the lesson, the technique for controlling the glider's descent has been to maintain a glide path by using parallax to keep the IVR on the aim point of the approach. This technique works as long as the glider is flown within its glide performance envelope.

The diagram at the right shows the glide performance envelope for the ASK-13 when flown at the angle of attack associated with a 42-knot airspeed. The envelope is bounded by the 27/1 glide ratio (red; dive brakes fully closed) and the 6/1 glide ratio (blue; dive brakes fully deployed).

Note: Glide ratios in the image are exaggerated for effect.



While it is possible to descend to an aim point using any profile within the glider's descent performance envelope, taking a "middle of the road" approach is considered best practice.

On any good soaring day, there exist both horizontal and vertical variations in the movement of air mass. Rising air (lift) allows us to soar, but that which goes up must come down, so where there is lift, there is usually sink (descending air) nearby. Gusting winds and wind gradient (wind speed decreasing with altitude) can have immediate and dramatic effects on the lift being generated by the wings, with correspondingly dramatic effects on the glider's descent rate.

A controlled descent to the ground requires that the pilot compensate for the effects of air mass movement on the glider's descent profile. The glider's effective descent rate is the combination of its horizontal and vertical movement through the air, and the horizontal and vertical movement of the air mass itself. For example, if the glider were to encounter rising air during the landing approach, the pilot would need to increase the glider's descent rate through the air to maintain the overall rate of descent. If the glider were to encounter sinking air, the pilot would need to decrease the glider's descent rate to compensate.

However, if the dive brakes were already fully open, there would be no way (at this point in the syllabus) to further compensate for an encounter with rising air. Likewise, with the dive brakes fully closed, the effects of sinking air could not be countered.

As such, the optimum descent profile has the dive brakes (spoilers) ½ open. In this configuration, if the glider encounters sinking air, the pilot can compensate by closing the dive brakes. If the glider enters rising air, the dive brakes could be opened further.

The optimum descent control technique seeks to not only hold the IVR on the aim point, but also maintain a ½ dive brake configuration as a contingency.

By definition then, the **optimum descent profile** is characterized by:

1. IVR aligned with the aim point of the approach
2. ½ open dive brake configuration

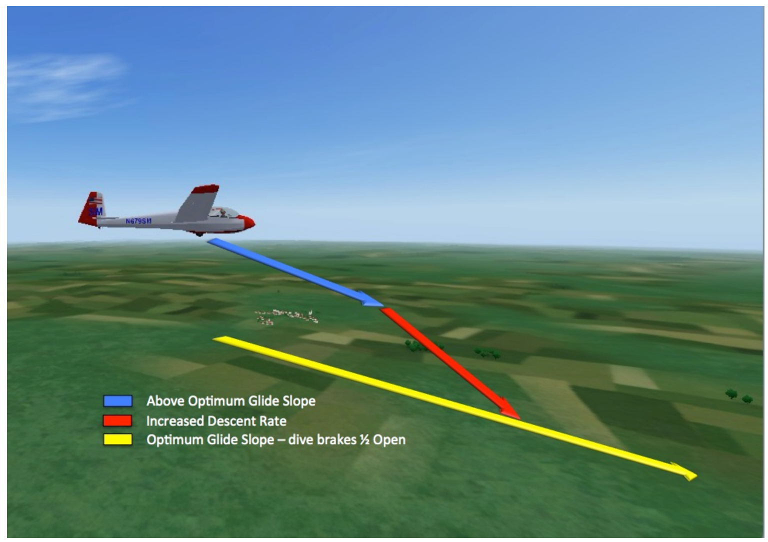
Demonstration – Optimizing a High Descent Profile

Set-up

- View Replay == Optimized_Descent_1.rpy
- Reset Replay to the Beginning (<<)
- Press PAUSE (P) key to start/stop each Replay time segment

09:03:42 – 09:03:58
As the demonstration begins, the glider is on a long, straight-in final approach, trimmed for a 42-knot angle of attack. The aim point is the approach end of the runway. The 42-knot IVR (top edge of the yaw string tape) is indicating the current descent profile would result in a landing well beyond the airport.

09:03:58 – 09:04:28
The pilot initiates a descent by opening the dive brake, and employs the first method for determining whether the glider is on the optimum descent profile.



Method 1:

- Position the dive brakes ½ open and allow the glider's pitch attitude to stabilize.
- Note the position of the IVR relative to the aim point.

  If the IVR is above the aim point, the glider is above the optimum glide slope.

09:04:28 – 09:04:48
The pilot employs the second method for determining whether the glider is on the optimum descent profile.

Method 2:

- Deploy the dive brakes to the extent required to hold the IVR on the aim point.
- Note the position of the dive brake control.

  If the dive brake control is deployed more than ½ way, the glider is above the optimum glide slope.

09:04:48 – 09:05:47
Having determined the glider is above the optimum glide slope, the pilot initiates a more rapid descent by fully deploying the dive brakes. The idea is to intercept and then maintain the optimum profile.

As the glider descends, the pilot monitors the sight picture, using TLAR to determine when the glider has intercepted the optimum profile.

09:05:47 – 09:06:10
TLAR. The pilot returns the dive brake control to the ½ open position, and the IVR settles onto the aim point. By definition, the glider is now on the **optimum glide slope**.

Note: Either of the two methods, described above, can be used to determine the position of the glider relative to the optimum glide slope. It is not necessary to use both.

Note: At any point during the previous descent, the pilot could have performed an intermediate check on the position of the glider relative to the optimum glide slope. If the glider was still too high, the dive brakes could have again been fully deployed until TLAR. If the glider was too low, techniques used in the following demonstration could have been employed.

Demonstration – Optimizing a Low Descent Profile

Set-up

- View Replay == Optimized_Descent_2.rpy
- Reset Replay to the Beginning (<<)
- Press PAUSE (P) key to start/stop each Replay time segment

09:04:29 – 09:04:30

As the demonstration begins, the glider is on a long, straight-in final approach, trimmed for a 42-knot angle of attack. The aim point is the approach end of the runway. The IVR (top edge of the yaw string tape) is indicating the current descent profile would result in a landing short of the airport.

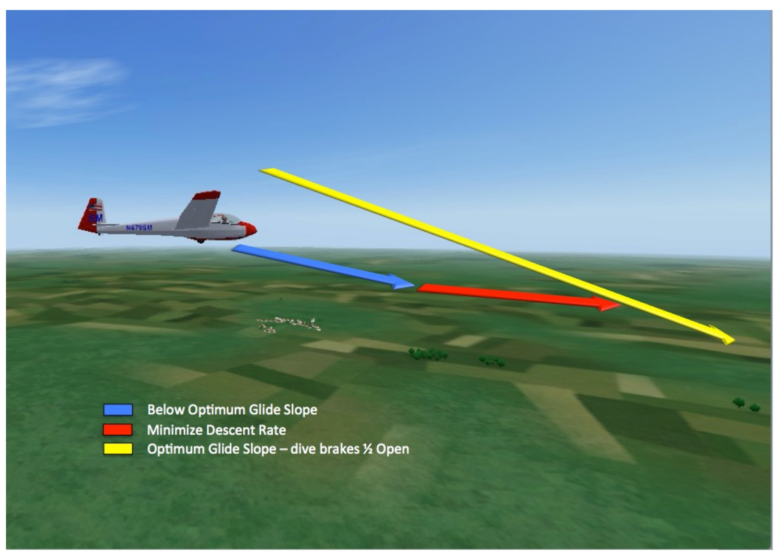
09:04:30 – 09:05:20

The pilot employs the first method (described in the previous demonstration) for determining whether the glider is on the optimum descent profile.

The IVR appears to be below the aim point, indicating the glider is below the optimum glide slope.

09:05:20 – 09:05:40

The pilot employs the second method for determining whether the glider is on the optimum descent profile.



09:05:40 – 09:06:05

Having determined the glider to be below the optimum glide slope, the pilot fully closes the dive brakes to minimize the descent rate, thereby establishing a flight path that will intersect the optimum descent profile.

As the glide continues, the pilot monitors the sight picture, waiting for TLAR.

09:06:05 – 09:06:10

TLAR. The pilot moves the dive brake control to the ½ open position and the IVR settles onto the aim point. The glider is on the optimum glide slope.

Exercise – Optimizing the Descent Profile
This exercise lets you practice the techniques needed to establish and maintain an optimal descent profile, i.e. ½ dive brake deployment with the IVR on the aim point of the approach. It also helps develop your TLAR skills. You will gradually get better at recognizing the position of the glider relative to the optimum glide slope.

Set-up

- Select Flight School
- Select Custom
- Select Descent_Control_Practice
- Select Try Lesson
- Press "ESC"
- Select "Ready for Flight"

Directions
As each flight begins, the glider is trimmed for 42 knots, and is already located on the optimum glide slope. That means you could simply open the dive brakes ½ way, let the pitch attitude stabilize, watch the IVR settle onto the aim point, and allow the glider to pretty much fly an optimized descent profile all by itself.

Instead:

1. Position the glider above or below the optimal glide slope:
   - Above: Fly the first minute + 30 seconds of the flight with the dive brakes closed
   - Below: Fly the first minute of the flight with the dive brakes fully deployed

2. Once in position, use one of the following 2 methods to determine the glider's position relative to the optimal glide slope.

   Method 1:
   - Position the dive brakes ½ open and allow the glider's pitch attitude to stabilize.
   - Note the position of the IVR relative to the aim point.

     If the IVR is above the aim point, the glider is above the optimum glide slope.
     If the IVR is below the aim point, the glider is below the optimum glide slope.

   Method 2:
   - Deploy the dive brakes to the extent required to hold the IVR on the aim point.
   - Note the position of the dive brake control.

     If the dive brake control is deployed more than ½ way, the glider is above the optimum glide slope.
     If the dive brake control is deployed less than ½ way, the glider is below the optimum glide slope.

3. Deploy the dive brakes as needed to intercept the optimal glide slope.

4. When the descent path to the aim point "looks about right" (TLAR), use one of the two **methods** to determine whether you are right.
   - If you are, congratulations!
   - If not, repeat steps 3 and 4.

5. Practice intercepting the optimal glide slope, from above and below, using different trimmed airspeeds.