Glideslope 2 MFD v1.0 User Documentation

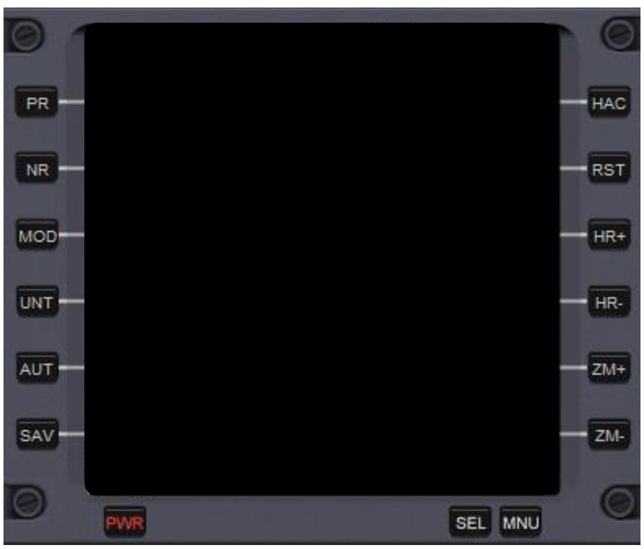
Introduction

Glideslope 2 MFD is a spacecraft reentry management tool developed for Orbiter 2010. It is an update to the original Glideslope MFD created by Chris Jeppesen (kwan3217), enhanced with new management screens, HAC geometries, updates to the algorithms and miscellaneous changes throughout.

Purpose

Glideslope 2 MFD is intended to assist the Orbiter pilot to make a safe reentry, descent, HAC turn and landing at a base and runway of their choice on Earth, or on a planet with an atmosphere. It provides vertical & horizontal situation displays and digital & tapes-formatted flight descent data to provide the pilot with the optimal situational awareness to maximize their chance of making a safe unpowered descent and landing.

Left Side MFD Button Definitions and Usage



- **PR and NR = Previous and Next Runway**
  - Selects the current runway from the configuration file (GS2.cfg).
- **MOD = Mode Select**
  - Toggles through the four primary modes: vertical situation, digital descent, tapes descent and horizontal situation.
- **UNT = Units Select**
  - Toggles Metric or US (Imperial) measurements.
- **AUT = Autopilot**
  - Toggles on/off a Basic autopilot. If your spaceship has attitude control, use that instead.
- **SAV = Save User Glideslope**
  - Creates a user saved glideslope in configuration file format, so you can set up your own reference glideslopes per spacecraft or planet, etc.

(The right side buttons will be covered later with the Horizontal Situation description)

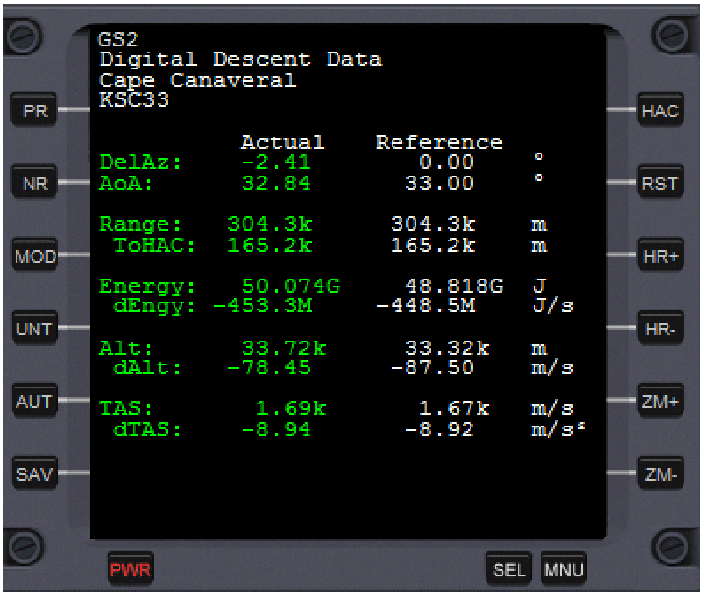
Vertical Situation Mode

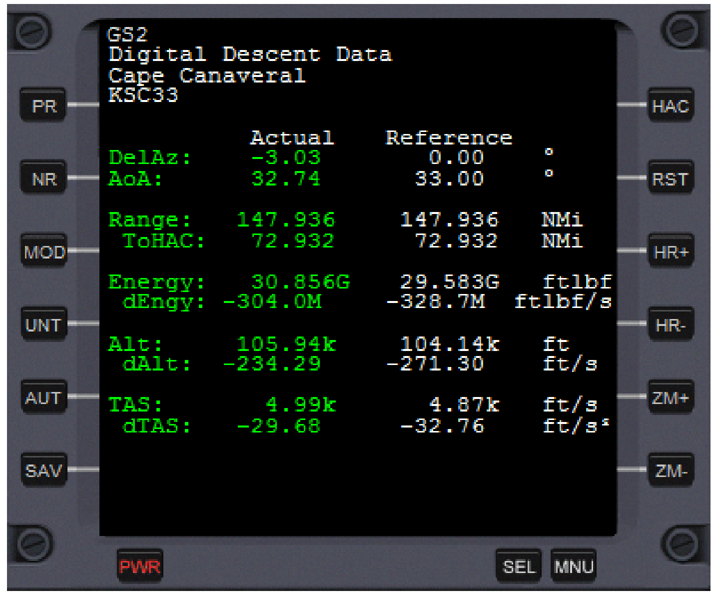
This mode shows a trace of your true air speed (green) and altitude (yellow) plotted against range from the runway. The bright traces are your live data and the duller traces are the reference glideslope you are trying to recreate. For the actual values, use the Digital Descent Data or Tapes Descent screens, but this is useful for overall situational awareness.

The display screen will auto-scale with range to base. If you enable it whilst still in orbit, you will see a bright horizontal yellow and green line indicating your orbital range from base (e.g. 200km to several million km), and your orbital velocity. As you descend towards the atmosphere, you will see the yellow trace come down the glideslope towards the entry point. (Visual note – the maximum airspeed is also aligned with the entry interface altitude for Earth, so you get a pleasing visual indication of the track of the spaceship relative to the entry interface, before the true airspeed trace is strictly needed.)

For interest, in the screenshot here, where we are in the late stage of the main descent pre-HAC, you can see the notch in the altitude reference glideslope. This corresponds with the pre-HAC stabilization point where we want to un-stall the wing and get ready to enter the HAC turn.

Digital Descent Data Mode

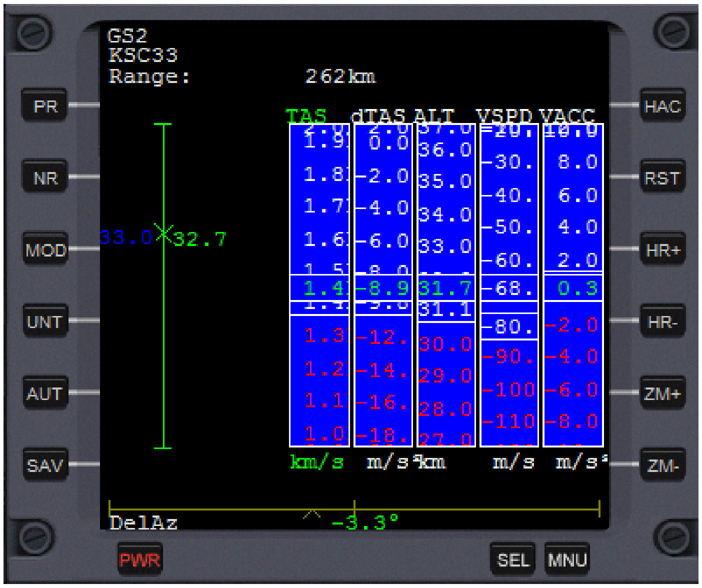




This mode shows the critical descent parameters you need to focus on. These two screenshots show the units in metric mode and in US (Imperial) mode as toggles by pressing the UNT key. The actuals will be in green (ideal), red (low) or white (high). Reference is always in white.

- **DelAz = Delta Azimuth**
  - Indicates your groundtrack bearing offset to the next waypoint. There are three waypoints on the descent: the entry to the HAC (WP1), the exit from the HAC (WP2) and the touchdown point (TDP). During the main descent, you are tracking to WP1. In the HAC, WP2. On final, TDP.
- **AoA = Angle of Attack, or Alpha**
  - This is your wing angle relative to airflow, and critical for lift / stall and vertical descent control.
  - Try to pay close attention to this as you come down the main descent through the highest heat phase, adjusting by half-degrees to keep your vertical speed (dALT) where you need it.
- **Range, ToHAC = Range to TDP, and Range to HAC entry**
  - Indicates your range to touchdown point, and additionally the range to HAC on the main descent. As range to HAC comes down to say 50km to go, ensure you have the Horizontal Situation up for the HAC.
- **Energy, dEngy = Total Spaceship Energy, and Delta Energy (rate of change of energy over time)**
  - Sum of gravitational potential energy (PE) and kinetic energy (KE). Use this to keep your overall energy situation under control, and to track the delta energy to trend it towards reference.
- **Alt, dAlt = Altitude, and Delta Altitude (Vertical Speed)**
  - Keep an eye on your altitude and rate of change, relative to reference. If everything is in the green, then watch dALT and keep that close to the reference by adjusting AoA up and down 0.5 degrees at a time.
- **TAS, dTAS = True Air Speed, and Delta True Air Speed**
  - You need to get your TAS down to around 800 m/s before HAC entry. Slow down faster by presenting more resistance to the airflow – i.e. raising your AoA. But balance this with the increasing vertical speed. Trend both air speed and altitude to keep your total energy in the green (high and slow / low and fast are both easily correctable).

Tapes Descent Mode



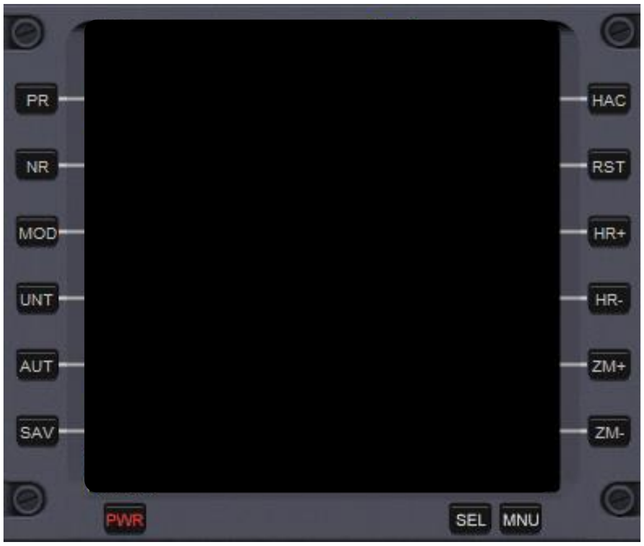
This is an alternative display of the reentry data, mimicking a more analog cockpit if you prefer your data in that format. You have similar data to the Digital Descent Data Mode, but treat this more as a visual way to fly the descent rather than focus on the numbers so much.

- Range
  - Simple range to base measurement
- Vertical pointer line
  - Angle of Attack data, with the reference in blue on the left, and the current on the right (color-coded white, red or green for high, low or nominal).
- Horizontal pointer line
  - Delta Azimuth data, showing deviation to the desired track
- TAS tape
  - True Air Speed tape, showing current speed in the middle and the reference speed on the tape
- dTAS tape
  - Delta True Air Speed, showing rate of change of airspeed
- ALT tape
  - Altitude tape, showing current altitude
- VSPD tape
  - Vertical Speed (or delta Altitude), showing rate of change of altitude
- VACC tape
  - Vertical Acceleration tape, showing rate of change of VSPD

This mode is retained for historical reasons, as it was the primary data interface for the original Glideslope, but the Digital Descent Data is now the preferred mode for this information.

Right Side MFD Button Definitions and Usage

Before describing the Horizontal Situation modes, we need to introduce the right side MFD buttons:



- **HAC = Heading Alignment Circle Geometry Selection**
    - Toggles through four HAC modes: left-entry closed HAC, left-entry open HAC, right-entry closed HAC and right entry open HAC. These modes govern the positioning of the HAC, where you enter and exit, and whether or not you need to do a full lap before exiting the HAC or not.
- **RST = Heading Alignment Circle Reset**
    - Resets the HAC settings back to default geometry, HAC radius and Auto-Zoom. Useful to allow you to play with various settings and then quickly reset back to normal.
- **HR+ = Heading Alignment Circle Radius Increase**
    - Increases the size of the HAC and the distance of the final approach. Useful when you are high energy (particularly high speed so you cannot pull a tight turn). This mode has a reset at 3x the HAC radius, so you do not increase the HAC turn without limit!
- **HR- = Heading Alignment Circle Radius Decrease**
    - Decreases the size of the HAC and shortens the final approach. Useful for low energy situations, where you cannot afford to do the full circle, or you want to tighten the approach as much as possible to a straight-in landing. This mode shrinks the HAC radius as tight as 500m (fly it “open”) and the final to 8km to allow a minimal final line-up before landing.
- **ZM+, ZM- = Manual Zoom In and Out**
    - By default this mode will auto-zoom appropriate to your range to touchdown. These buttons override the auto-zoom and allow you to lock it to your preferred zoom. This is useful in certain recovery situations where you want to see a broader view of the HAC, or where you want to zoom in to see a more close view of your flight path relative to the HAC.

Horizontal Situation Mode

This mode presents your horizontal situation relative to the HAC turn and final approach to landing. The display elements are as follows:

- **Runway, Phase, HAC size, HAC entry, HAC open/closed**
  - Runway name is obvious (in this case Kennedy runway 33)
  - Phase is “Descent” for the Main Descent to the HAC, “On HAC” when flying the HAC, and “On Final” for the final approach to landing.
- **DelAz, Range**
  - Delta Azimuth and Range as on the Digital Descent Display
- **(Descent phase only) HAC WP1 Range and Bearing:**
  - Range to the HAC entry (Waypoint 1), and absolute bearing to fly.
- **(On HAC phase only) HAC WP2 Range and Arc:**
  - Range to the HAC exit (Waypoint 2), and arc in degrees to fly round the circle. (Note – for closed geometry HAC approaches, the initial arc will be greater than 360 degrees).
- **(On final phase only) PAPI Range and XRange:**
  - Range to the Precision Approach Path Indicator in flight distance and in crossrange. The crossrange is useful for tacking alignment towards the runway.
- **Main yellow track**
  - Reference horizontal flight path, HAC, final ending at the runway itself.
- **Green track and Green Cross indicators**
  - Current track and predictions for the next minute, based on bank angle and turn rate
- **Horizontal pointer**
  - Delta Azimuth presented visually
- **Vertical Pointer**
  - Glideslope angle, desired in blue on the left, actual on the right. (Useful for final stage of the HAC turn, into the final approach. Ideally it should rise from below 10 degrees to 20 degrees as you complete the HAC turn).

HAC Geometries on the Horizontal Situation Mode

These four example screens show the four HAC geometries, selected with the HAC button.

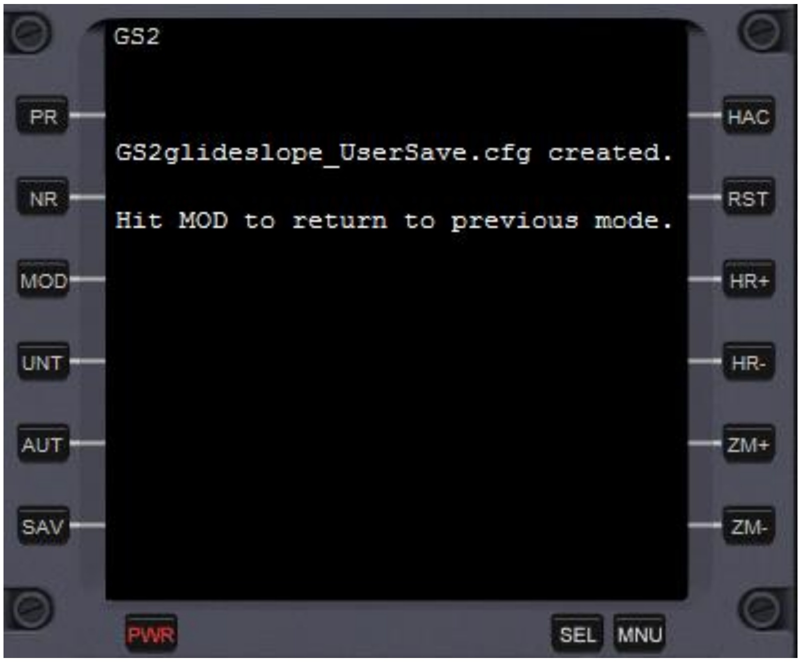
- **Left-Closed (L-C)**
  - You will fly the rest of the approach to the HAC entry point (WP1), left turn into the HAC, do a full lap and then exit at the top of final (WP2) for landing. Range to base is the remainder of your approach to WP1, a full lap of the HAC, the arc range from WP1 to WP2, and the final distance to touchdown.
- **Left-Open (L-O)**
  - Opening the HAC removes the requirement to fly the full circle. Use this mode when you are low energy. Range is now just range to WP1, arc to WP2, final to touchdown.
- **Right-Closed (R-C)**
  - Right entry moves the HAC position to the far side of the runway. Useful for high energy, where you want more space to slow down pre-HAC entry.
- **Right-Open (R-O)**
  - Same as L-O, removing the requirement to fly the full lap.

HAC Radius and Zoom Adjustment on the Horizontal Situation Mode

You can grow or shrink the HAC radius size to meet your flight conditions and energy state. In this example, the HAC has been reduced to 8km radius and the final approach also reduced. As this happens, the HAC center is repositioned closer to the runway, on the assumption that you want a smaller HAC because you are unable to fly the regular HAC. As you shrink the HAC, you will see a new flight vector to the recalculated WP1 entry point. In this example, you will see we need to roll left and correct our track almost 29 degrees to handle the much smaller HAC turn. Normally, you would adjust the HAC radius in small steps, adjusting your flight direction a few degrees to reacquire the new WP1 waypoint.

You can also manually override and adjust the screen zoom, if you want to see more of the big picture (i.e. zoom out), or more of the predicted track for the next minute or two (zoom right in). If you want to reset everything back to default (default geometry, auto-zoom, HAC radius), then hit the RST button.

Save User Glide Slope Data



If you want to review your last descent and landing after exiting the Orbiter simulator, hit SAV. This writes a file GS2glideslope_UserSave.cfg into the Config\MFD\GS2 directory. If that approach was awesome enough that you would like to make it your new glideslope for that vehicle or planet, or even if you want to use it to see how close you can recreate your previous approach, you can use this config file directly as input to Glideslope for your next flight. You do this by setting up the GS2.cfg PREFS to point to UserSave, or rename your glideslope to your choice of name to avoid it being overwritten. For details on the configuration files, please see the next page.

Glideslope 2 Configuration Settings

You have extensive ability to configure Glideslope 2 through configuration files. Find them in Config\MFD\GS2 in your Orbiter directory tree. The base distribution has a master config file, GS2.cfg, and a number of glideslope config files of format GS2glideslope_{name}.cfg.

The GS2.cfg file

GS2.cfg defines the bases, runways and preferences for Glideslope 2. The default GS2.cfg has extensive comments to help you format it correctly. This is a summary of those comments:

Blank rows and rows starting with semicolons are ignored. Every other line needs to start with either BASE, RUNWAY or PREFS. The BASE definition specifies a name for the surface base and its longitude and latitude. Example:

```
BASE "Cape Canaveral" -80.675 +28.5208
```

(You get this information from the respective surface base definition file for the planet).

The RUNWAY definition specifies a runway name, runway near and far end offsets, runway PAPI offsets and VASI offsets. Example:

```
RUNWAY "Cape Canaveral" "KSC33" -8220 -600 -12670 -3155 -2000 671
RUNWAY "Cape Canaveral" "KSC15" -12670 -3155 -8220 -600 -2000 671
```

The runway must reference a previously defined surface base (i.e. BASE “Cape Canaveral”… must exist before RUNWAY “Cape Canaveral” … lines will be recognized). The runway name is something you have to create yourself, as for some reason this is not in the main surface base definition files (this is a main reason Glideslope 2 reads this from a separate file). The runway offsets (e.g. -8220 -600 -12670 -3155 for KSC33) come from the End1 and End2 definitions in the surface base file (parameters 1 and 3 from End1, and the same for End2). The PAPI and VASI information comes from the RUNWAYLIGHTS block for your runway. If not present, -2000 and +500 work just fine. (Glideslope uses the PAPI point to mark the end of the 20-degree final glideslope, and the VASI point to mark the touchdown point. A PAPI of -2000 targets the main glideslope 2km from the foot of the runway, and marks the point you do the pre-flare for a soft landing. A VASI of +671 puts the touchdown point 671m down the runway.)

The PREFS definition specifies your choice of start mode for the left, right and external MFD’s, the Units, the default runway, and your glideslope file. Example:

```
PREFS 3 1 4 METRIC "KSC33" XR
```

The first three numbers are the default starting modes for the screens (1 = vertical situation, 2 = tapes, 3 = digital descent and 4 = horizontal situation). The next entry is US or METRIC, to select the starting unit-preference. The next is the default runway (must refer to a RUNWAY line above). Finally is the glideslope name. In this example, the XR name triggers Glideslope 2 to look for GS2glideslope_XR.cfg for the reference glide slope data.

Glideslope is hardcoded to 64 bases, and 128 runways. (It’s easy to increase if you need it, so long as you send me your proposed GS2.cfg file with all the new base definitions so I can roll into the main distro!!)

The GS2glideslope_{name}.cfg file

The last parameter of the PREFS line in GS2.cfg specifies the reference glide slope configuration file. The main distribution comes with three sample glideslopes for XR, Shuttle and DG spacecraft. If you hit SAV after a landing, you will generate a GS2glideslope_UserSave.cfg as well.

You are free to create any number of glideslopes matching this naming format, for different spaceships and situations (e.g. landing a DG-IV to Olympus Base on Mars). Just fly the approach, save your glideslope, rename it to your preferred name (e.g. GS2glideslope_DGIV_Mars.cfg) and reference it from the master GS2.cfg to activate it.

The glide slope format ignores blank lines and semicolon comments. The active components are UNITS, BEGIN GLIDESLOPE and END GLIDESLOPE. Between BEGIN GLIDESLOPE and END GLIDESLOPE, you put up to 256 rows of glide slope waypoints.

UNITS definition is similar to the GS2.cfg – US or METRIC. It sets the units for the glideslope. Note – you can set a glideslope with METRIC units and then display in US units, or vice-versa as you wish. I.e. the UNITS setting here is only to define the glideslope waypoints.

The glide slope data is rows of five numbers, with an optional trailing comment: range, altitude, true air speed, vertical speed and AoA.

The SAV function creates data in this same format. You may edit the values as you prefer, to smooth out any imperfections in your flight, or to drive the reference to achieve something different (e.g. fly at zero vertical airspeed for 40KM before the HAC entry, or hit the HAC much higher). Basically, you can set it up as you wish!

Author's Comments and Recognitions

My name is Andrew Stokes (ADSWNJ) and I have been flying the Orbiter for a couple of years now. It is a truly fascinating simulator, which invites you to engage at any level from casual to deeply technical. From my early days of getting a Delta Glider into orbit, to doing the first landings on the Moon and Mars, and to doing rendezvous with space stations and orbiting bases, to executing deep space voyages out to Saturn and Neptune, it's been an addictive pastime. Dr Martin Schweiger – thank you sir for an amazing platform that has created this community.

At each level of understanding, you can generally figure it out in a few hours to a point of basic competence, but mastering each activity takes a lot longer. In all my journeys, mastering the unpowered descent and landing was my hardest challenge. In January 2012, TMac3000 posted "My first unpowered landing", and the comments from Jarvitä, Tommy and PhantomCruiser inspired me to want to do better. I have used the excellent Glideslope 1 from Chris Jeppesen (kwan3217) for a long time, and I was fascinated to look at the source code he released. I've coded off and on for much of my adult life, on many technologies and levels (assembler on mainframes and VAX to X-Windows on Unix, and Win 32 on Windows). I wanted to get into addon development for Orbiter, and this seemed as good as anywhere to start!

So, with great respect and recognition to Chris's original code, which took me many weeks to figure out how it worked, I now offer back Glideslope 2 to the community, complete with source code. To the casual end-users, I hope that this gives you a greater feeling of control for your reentries and landings back on Earth. To the developers or potential developers, hopefully this source code will inspire you to understand how it works and go build something even more awesome from the bones of this code.

Finally, I would like to thank my fellow addon developers, spacecraft designers, graphics clients, MFD's and scenarios, and the scores of rocket scientists and physicists (in the truest sense of the word) who contribute to the forums and make them great places to learn.

Cheers, Andrew
December 2012