Hover MFD Manual

Version 1.1.3 *© Oliver Pola (Mythos)* *08.10.2016*

DGIV using Hover MFD over Moons Brighton Beach Pad 1

Contents

Purpose

Hover MFD is an add-on for Orbiter 2016 Space Flight Simulator © Martin Schweiger (http://orbit.medphys.ucl.ac.uk/) introducing a new multifunctional display and a universal (meant for all spacecraft) autopilot for many kinds of maneuvers that use your hover engines.

The autopilot functions are inspired by autopilots built in UGCO Arrow Freighter and DGIV © Dan Steph (http://orbiter.dansteph.com/). I wanted these functions to be available for other spacecraft and I wanted some fine tuning to be able, like having a "Level Horizon" that doesn't keep pitch and bank to zero, but only one of both.

The Hover MFD project is my way to learn how things work in outer space. So some features are built in just because I wanted to know how to do. Also there is no intention to have all done by best, most efficient or fastest algorithms, they just should work and make life in space easier.

Efficiency

Hover MFD is not designed for best fuel- or time-efficiency. Using Hover engines isn't fuel-efficient at all, because hover engine works straight against gravity and therefore much power and fuel is used to keep you just in the position you are. If you want your mission accomplished most fuel- and time-efficient, than don't use Hover MFD or keep maneuvers really short.

Requirements

Hover MFD is developed for the current Orbiter 2016 Space Flight Simulator Build Aug 28 2016 [v.160828]. Future versions will be tested when released. Appropriate version for Orbiter 2010 Build 30 Aug 2010 [v.100830] is Hover MFD 1.1.1 which will still be available on Orbithangar. Older versions will not be tested.

OrbiterSound, UCGO, DeltagliderIV and UMmu are not required but well tested.

Tested vessels are:

- Deltaglider
- DeltegliderIV
- DeltagliderXR1
- ShuttleA
- ShuttlePB
- UCGOArrowFreighter
- XR2Ravenstar
- XR5Vanguard

All other vessels should work as well, with following requirements:

- Vessel aligned to standard axes: x horizontal, y vertical, z forward
- Hover engine (of course!) thrusting down -y axis
- Main engine (optional ☺) thrusting forward z axis
- Retro engine (optional) thrusting backward -z axis

- Rotational RCS thrusters
- Linear RCS thrusters

HINT: I've read about vessels steering by main engine gimballing. This won't work with Hover MFD.

Installation

Hover MFD comes via HoverMFD.zip and you should unzip that into your Orbiter program directory. This add-on includes following files:

.\Modules\Plugin\HoverMFD.dll	add-on module
.\Doc\HoverMFD.pdf	this manual
.\Config\MFD\HoverMFD\Default.cfg	standard config file
.\Config\MFD\HoverMFD\ShuttleA.cfg	config file for ShuttleA
.\Config\MFD\HoverMFD\XR5Vanguard.cfg	config file for XR5Vanguard
.\Config\MFD\HoverMFD\UCGO\Vessels\ UCGOArrowFreighter.cfg	config file for UCGOArrowFreighter

After that go to Orbiter Launchpad → Modules and activate Miscellaneous → HoverMFD.

Update

For an update from older versions just unzip and overwrite all files. If you edited the config files, make a backup first and compare them with the new ones.

Manual standards

Some descriptions in this manual mention constant values. Most of them can now be changed via config files, so the text refers to the standard settings only. The changeable parameters are listed in chapter → Configuration files (Page 21).

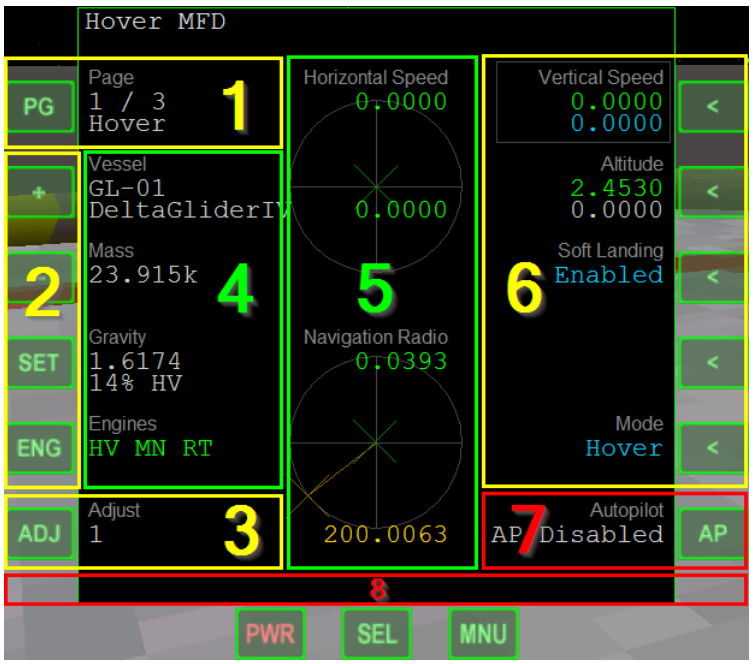
In this manual all MFD Buttons look like this:	Press the PWR Button to turn on your left or right MFD.
All keyboard input looks like:	Press G to deploy your gear before touching the ground.
All data on display:	Select the "Altitude" value and turn it to "10.0000" meter.

WARNING: There may be warnings in this document.

HINT: And there may be additional hints, tips and tricks.

Getting started

Once launched Orbiter and entered your spacecraft choose left or right MFD and press SEL (maybe more than once, when you have many modules installed and activated) and choose “HoverMFD”. You’ll see a MFD looking like this:



There are several areas on the MFD that work differently (green = display only, yellow = editing / editable, red = important).

1	Pages	Here you switch between some pages containing different information data and editable values. This area of course stays on each page and displays on which page you are.
2	Value editing	These four buttons are for editing the values in the editable value area (6). You can increase, decrease, set, engage and disengage these values. These buttons don’t belong to the data display on their right.
3	Value adjustment	In this area you can see and set how much the value editing buttons (2) increase or decrease the editable values.
4	Data display	In this data display some informational values are shown. Each page shows different values. These values can’t be edited.
5	Graphical data display	The middle area is used for some graphical, not editable information that differ from page to page.
6	Editable values	The editable values show important data and can be influenced by setting, enabling or disabling the autopilot parameters with the editing buttons (2). Each page has other values. Select a value with the < buttons.
7	Autopilot	This is the autopilot main switch. Only when AP is enabled the vessel is controlled. If turned off in unlucky situations, your vessel may crash. Other situations may demand AP turnoff immediately.
8	Error display	In the bottom line of the MFD important errors may be shown.

Buttons are described later in chapter → MFD Panel, Buttons and Keys (Page 7).

Using Hover MFD

The main idea using Hover MFD is setting up some parameters on the MFD panel and then activating the autopilot (AP). While AP is running, the current status can be watched on various informational display values. Also all AP parameters can be changed while AP is running and the vessel will then turn into new maneuvers.

Hover MFD is of course designed to control the hover engines for launch, landing and travelling. Therefore your vessel must have a hover engine, it must be set up right and you must be on surface or orbiting a planet where a hover launch / land is possible (your max engine thrust is greater than planet's gravity). Only in some situations Hover MFD makes sense to be used without using hover engines.

Atmospheric flight is not main purpose of Hover MFD. It may work when hover engine is still strong enough (on earth most vessel engines are not).

HINT: Check if your vessel has hover doors that must be opened, before using hover. While they're closed, Hover MFD may think there is no hover engine or it's too small. In worst case the vessel reports fully functional thrust values but just ignores thrust level input (stock DG does so).

With the right parameter setup the autopilot can

- Launch in hover style (e.g. from pad)
- Landing in hover style (e.g. on pad)
- Apply desired vertical speed (up or down)
- Slow downward vertical speed automatically for soft touchdown
- Maintain specific altitude
- Keep horizon level (standard) or any other pitch and bank
- Turn to desired heading
- Turn nose into horizontal airspeed direction (or relative to)
- Turn to NAV signal (or relative to)
- Travel to NAV target by main- and retro-engine
- Travel to NAV target by hover-engine with pitch/bank control
- Maintain or capture center position over NAV signal (any kind)
- Taxi from pad to pad (or any other NAV)
- Use coordinates or base names instead of NAV signal

Multi-vessel and multi-MFD

Hover MFD supports being used by multiple vessels and MFDs at same time. Each MFD in one vessel can show different pages, select other values and use other adjustment values. All vessel data and autopilot parameters are the same for each MFD within one vessel. Each vessel's active autopilot will continue its work when control is switched to other vessels. Multiple auto piloted vessels are possible.

MFD Panel, Buttons and Keys

The different areas of the Hover MFD panel are described in chapter → Getting started (Page 5).

Hover MFD's main panel looks like this (you can look up button labels by pressing MNU button):

All buttons can be used by left mouse button, right mouse button (in generic cockpit only) or keyboard shortcuts. Upper left button PG switches through all pages. The left buttons below are for editing the selected value on the right side. One of the five values is selected by its < button. The grey frame around the value data shows the selected value for editing (here: "Vertical Speed"). The lower right button AP is the main switch for the autopilot.

In Orbiter all keyboard shortcuts are combined with left shift ↑ when the left MFD is used and right shift ↑ when the right MFD is used. As far as I know in further internal or external MFDs no keyboard shortcut is possible.

The SET button now doesn't reuse the previous AP value anymore. You now can just type the new wanted value. If you want the previous value to be copied to the input box, you can change this behavior in the config file by defining "ReUseValueForSet = TRUE".

In the input-box "Enter Value" you may use dotted input values with m, k, M, G or T suffix to specify your dimension / precision.

Right click on the SET button or key V will now use not the previous AP value but the belonging vessel data readout as suggestion in the input-box. This makes it easier to keep your vessel in current state (altitude, pitch or any other numeric value).

Button overview

Button	Label	Keyboard	Function
PG (left mouse)	Page select	↑ + P	Switch to next page or to first, if already on last page
PG (right)	Page select	↑ + O	Switch to previous page or to last one, if already on first page
	Page select	↑ + F5 – F8	Switch directly to page 1 – 4
+ (left) / - (right)	Value up	↑ + F / U	Increase selected value by "Adjust" value or switch mode-style values
- (left) / + (right)	Value down	↑ + D / Y	Decrease selected value by "Adjust" value or switch mode-style values (Key Y on English / US / standard keyboard, Z on German keyboard)
SET (left)	Set value	↑ + S	Show an input-box for editing the value (accept by Enter or cancel by Esc)
SET (right)	Set value	↑ + V	The input-box will contain the current vessel readout for setting (not current AP value)
ENG	Engage/Disengage	↑ + E	Engage / enable value or disengage / disable, if engaged already
ADJ (left)	Adjustment	↑ + J	Increase adjustment value
ADJ (right)	Adjustment	↑ + H	Decrease adjustment value
<	Select value 1 – 5	↑ + 1 – 5	Select the value aside for editing
AP	Autopilot	↑ + A	Engage / disengage autopilot

Adjustment

The adjustment value is controlled by the ADJ button or ↑ + J / H keys. You can go backward by keyboard or right mouse button, otherwise use the button six times to get one step back.

The possible adjustment values are:

1m → 10m → 100m → 1 (standard) → 10 → 100 → 1k

1m (e.g. millimeter) is the lowest precision in display, although autopilot won't reach this precision. 1k is max adjustment value, because height uses the greatest values in Hover MFD autopilot that is meant for transfer to heights about 10 – 20 km. Go higher with prograde main burns.

If you still need a greater parameter setup, use the SET button. This will support typing values with m, k, M, G and T suffix.

Not all values accept all adjustments like angles ignoring greater than 360.

Color code

For better readability display data is colored with these colors and meanings:

Grey	Grey value labels give the numbers a name.
White	Informational data where no great changes are expected or the values can't go below zero and also editable, but not active parameters are displayed white.
Light blue	If autopilot is active, all active parameters are painted light blue. These are the ones that control your vessel right this moment.
Purple	All only potential active parameters are painted purple. They can become active, if other settings change their state. All parameters are only potential active, if AP main switch is off. Then the purple values show the state "what if autopilot gets turned on".
Green	Positive (and maybe turning negative) values are green. Other good values are green also.
Orange	Orange values are negative or bad values.
Red	Error messages are red as usual.

HINT: There are some more dependencies between the autopilot parameters than all depending on main switch only. Some values depend on other values to be in a specific mode. Most values depend on control over desired engine being allowed on engine page. The idea is to show dependent values in the state that will apply, if dependency is satisfied. If you want a value to be controlled and it's white: turn it on! If it's purple: check dependencies! If it's blue: it's ok.

Autopilot main switch

When autopilot is turned on, all standard programs (level horizon, hold alt, pro grade, retro grade, +/- normal) will be turned off and the RCS thrusters (rotational / linear) are reset. Usually hover engines are set to an appropriate level immediately.

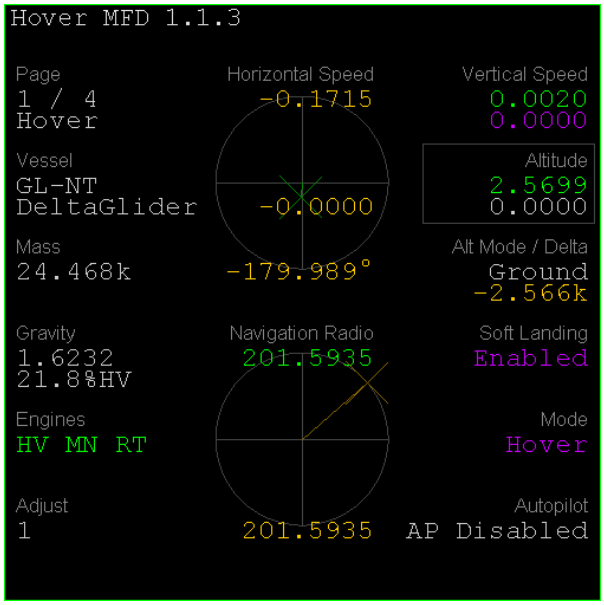
HINT: If you want to use built-in level horizon, start autopilot, disengage pitch and bank control (or rotational RCS at all) and then re-engage the standard level horizon. Hover MFD won't touch this again until next AP off/on.

Disengaging autopilot will reset RCS, standard programs are not touched. Main and Retro Engine are set to zero. Hover engine remains at its last level, so you usually can disengage AP for short without falling down.

Only when a touchdown is realized, autopilot will be automatically disengaged after a few seconds.

MFD Pages

Page 1: Hover



The "Hover" page displays basic information and all you need to put your vessel into a hover (control VS or altitude).

"Vessel"

First line shows the name, second line the type of your vessel.

"Mass"

This is your vessel mass [kg] (24k kg is 24 metric tons).

"Gravity"

First line is gravity [m/s²] (screenshot from moon), second line shows the calculated level of hover engine to work against that gravity. Over 90% of hover thrust this value goes orange because then only 10% are left for gaining vertical speed and your launch will be very slow.

"Engines"

Fully functional engines show green in fist line, problematically ones (if there is no such engine at all or the hover / retro doors are closed) switch to second line in orange. The engines are hover (HV), main (MN) and retro (RT).

"Horizontal Speed"

This graphical indicator shows the direction and amount of your horizontal speed. Horizontal is all that is not vertical, so this is the speed over ground in X (wings) or Z (nose/tail) axis. The line from the center of the circle to the green X shows the direction of your speed relative to your nose. An upward pointer means you are flying forward (this feels best). The upper value is the Z axis amount and will go orange, if you fly backwards. The value below the center shows the X axis amount, green for right, orange for left. The circle border means 1 m/s, so only at lower speed the pointer is inside for fine tuning your position.

The bottom angle is the airspeed direction relative to your nose direction. This shows an exact angle value for the graphical pointer.

The plane of reference is fixed to the horizon, so naming the axes wings and nose/tail is only true for zero pitch and bank. If you pitch or bank, the graph won't change but only flip x when upside down.

"Navigation Radio"

When in range of the radio / NAV signals set up in COM/NAV MFD, this graphical display shows the direction and distance to NAV1 (green) and NAV2 (orange). For smaller distances than 50 m (nearly pad radius) the pointer stays within the circle.

If you set up a target base (see → "Hdg Target"), it will also be drawn in grey.

The possible three values are the distances to NAV1 (green), NAV2 (orange) and base (grey).

"Vertical Speed"

The first line shows the current vertical speed, green for upward, orange for downward. The editable value in second line is the wanted vertical speed. This control is always enabled. Vertical Speed is often abbreviated by VS.

"Altitude"

This parameter shows the current and wanted altitude at vessel center (so it will be > 0 above ground when landed). This is either altitude above ground level or relative to mean body radius, depending on "Alt Mode". Altitude control isn't enabled by default. Set the wanted value and enable it by ENG button. Autopilot will internally override "Vertical Speed" value then, but use its absolute amount as maximum. If "Vertical Speed" is "0", a maximum of +/-1 m/s is used.

"Alt Mode / Delta"

This mode switch lets you choose how altitude is measured. First line contains the "Alt Mode":

"Ground"	Per default altitude is measured above ground level. This is good for landing and taxiing around. Also it will let your vessel follow ground slopes when hovering with some speed at constant altitude.
"Mean Rad"	Each celestial body has heights and depths and thus different radius readings for each location. In this mode altitude is not given in radius (like the Orbit MFD switch would) but +/- this mean radius (a negative value at your base is not unusual). If you hover around at a constant value above the mean radius this would again be a constant radius value and therefor would make you move on a perfect sphere around the body center, ignoring all the changes in ground elevation. This is a good setting for high altitude flights, where occasional hover boosts to follow that mountain slope would just annoy you, especially near orbital speed.

Second line reads the "Alt Delta", the difference between alternative mode value and current. When you are in "Ground" mode and "Alt Delta" reads a positive value you know that ground level is above mean radius. This value will be added when you switch modes (you can turn this off in config file).

WARNING: Be careful in "Ground" mode and not hovering at fast speed just above the ground. The reactivity for slopes is somewhat slow.

"Soft Landing"

This is a feature for automatically reducing downward vertical speed for smooth touchdown.

"Mode"

This main AP mode describes how to handle pitch and bank and how engines are used to counter gravity.

"Hover"	Standard is "Hover" mode, which is designed for pitch and bank to be zeroed, so hover thrust is always pointing directly against gravity. You can override pitch and bank at your own risk.
"Heli"	In the "Heli" mode pitch and bank are meant to gain horizontal speed while the vertical part of the thrust vector still counters gravity. Therefor thrust will rise with pitch and bank to a max angle where thrust is 100% and vertical portion still counters gravity. At that point would be no thrust reserve to control upward VS, so the internal max angle is only 80% of that absolute max angle (changeable in config file). Setting up AP pitch / bank to higher values will be ignored and max angle is used instead.
"Tailsit"	That highly requested mode works almost like "Heli" mode with steering by pitch/bank and all that, but it's using main engine instead of hover engine. Doing that all axes get rearranged, so tailsitter's standard orientation with nose up to the sky and main engine towards the ground (formerly known as pitch 90, bank swapping, heading spinning) is then renumbered (pitch 0, bank somewhat 0, heading to where your downside points).

Here is an overview showing typical positions of your vessel in the different modes:

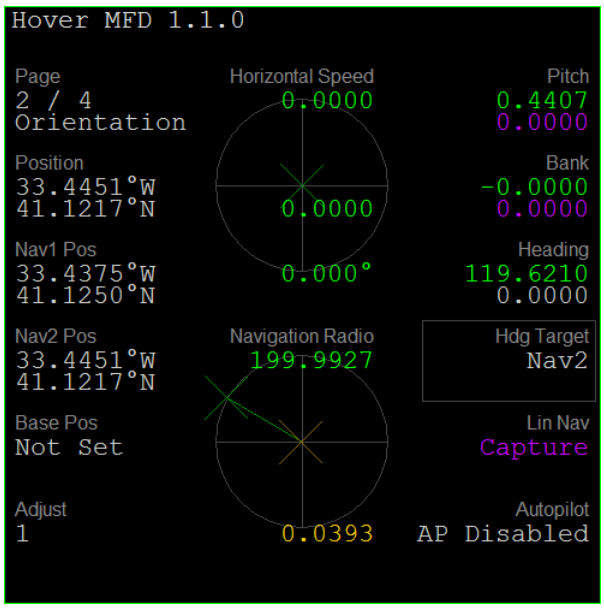
	hovering	accelerating	decelerating
Hover			
Heli			
Tailsit			

WARNING: The higher pitch / bank in "Hover" mode the harder AP can reach desired VS and maintain altitude. At some angle AP will reduce (!) thrust, because engine can't help against gravity anymore and the horizontal acceleration is not a wanted effect – crash is imminent!

HINT: You may also turn of rotational AP control in "Heli" mode and pitch / bank manually (maybe to reach absolute max angle) but you have to stop rotation before 100% thrust is reached. The higher the needed thrust to counter gravity (look at "Gravity" saying "x% HV"), the smaller is your max angle.

WARNING: If there is no need for hover VS thrust, "Heli" will put you to a pitch or bank but with no thrust there will be no effect on horizontal speed. This has to be watched when you are on target approach coming from deorbit burn and still have orbital speed.

Page 2: Orientation



The "Orientation" page is for rotational RCS control. Since heading control is for navigation purpose, this page contains the necessary navigation data.

To support reaching navigational target by linear RCS this site also offers the "Lin Nav" mode.

"Position"

Here your current position in longitude and latitude is shown.

"Nav1 Pos"

This shows the position of NAV1 signal, if it's in range.

"Nav2 Pos"

This is NAV2 position.

"Base Pos"

This is the position of the selected base. To select a base go to "Hdg Target", set it to "Base" and press the SET button (see → "Hdg Target").

"Horizontal Speed"

It's the same like on first "Hover" page.

"Navigation Radio"

It's the same like on first "Hover" page.

"Pitch"

Here your current pitch (nose up / down) is displayed and can be set to another wanted value than zero. You also can leave pitch uncontrolled by disabling this value.

"Bank"

This works like "Pitch" but for the bank angle (wings level).

"Heading"

Your heading is the nose direction relative to planet's (moon's) North Pole. This isn't controlled by default and can be enabled to take this under autopilot control.

"Hdg Target" (Heading Target)

This is a mode style value (edited by + and – buttons) for the heading. Its enabled-state is linked to "Heading". Other features of Hover MFD depend on a proper target to be set and enabled (distance and speed control to reach that target). There are four different modes:

"True Hdg"	The heading is meant as absolute compass heading
"Hor. Spd"	Horizontal speed direction is counted as 0° – Only for speed > 1 m/s
"Nav1"	Turn your nose towards NAV1 signal (0°) – Only for ranges > 50 m
"Nav2"	Turn your nose towards NAV2 signal (0°) – Only for ranges > 50 m
"Base"	Turn your nose towards selected base (0°) – Only for ranges > 50 m (Use the SET button to enter a base)

Even the "Hor. Spd" and "Nav" modes accept all angles from 0° to 360° of course. So you can turn your main engine into horizontal speed direction for braking by setting "Hor. Spd" and 180°.

"Hor. Spd" mode works for 1 m/s (speed indicator outer circle) and above to avoid spinning around while minimal speed changes result in maximal direction changes.

"Nav" and "Base" modes are limited to ranges of 50m (outer circle of "Navigation Radio" indicator) and above. If heading was nice before, it would stay nearly optimal on last approach without further control. Otherwise if corrections are needed, it's often too late and would result in spinning around while passing your target. So close to target "Lin Nav" is meant for last corrections to reach the exact position.

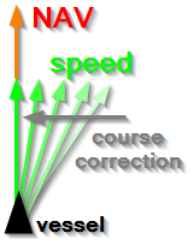
If there is no NAV signal / base set, setting the "Nav" / "Base" mode results in autopilot maintaining current heading. It still will "kill rotation".

To select a base set “Hdg Target” to “Base” and then press the SET button. An input-box will appear and you may enter following data to set up a base position:

Input	Example	Description
<Base Name>	Cape Canaveral	The base is selected by its name. It has to be on current surface.
<Base Name> <Pad Nr>	Brighton Beach 1	One of the base’s pads is selected by its number (starting with 1)
<Base Name> 0	Brighton Beach 0	The first not occupied pad of that base is selected
<Long><W/E> <Lat><N/S>	12.34E 56.78S	Any Longitude and Latitude can be entered by degree and orientation-letter
<Long> <Lat>	12.34 -56.78	Longitude and Latitude can be entered by degree numbers only (W and S would be negative)

HINT: Long / Lat input with letters can be swapped and Lat, Long be entered. Due to technical needs it is also possible to enter “O” for “E” like on German compass (Osten).

“Lin Nav” (Linear Navigation)



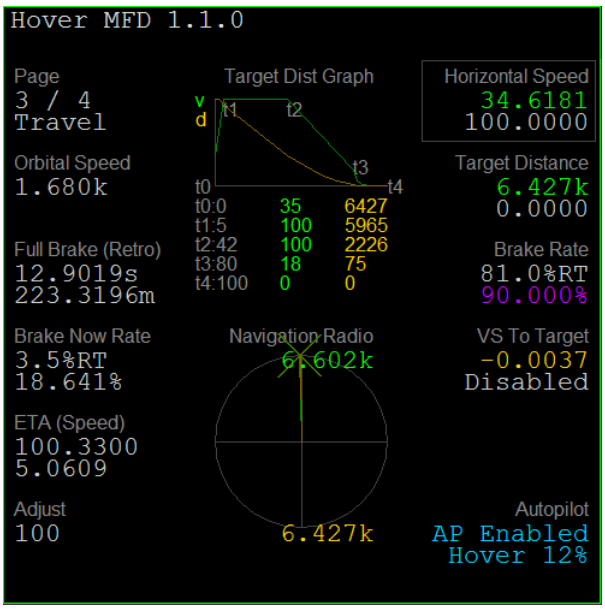
If this mode-style feature is enabled (by default), it will use linear RCS thrusters for additional corrections to reach NAV position. By nature it only works when “Hdg Target” is set to “Nav1/2” or “Base” and active. At relative heading 0° or 180° any pitch is allowed for “Lin Nav” to work, bank is free at +/- 90° otherwise absolute pitch and bank are limited to < 5°. Another limit for working “Lin Nav” is desired heading has to be reached about +/- 10°. If enabled, there are three modes:

“Course”	Only course corrections are made (the wanted airspeed vector is a projection of your current airspeed on the target vector, so your overall speed shouldn’t change a lot)
“Capture” (default)	This works like “Course” until you come within 50 m (navigation indicator circle) range. Then the overall horizontal speed is controlled as a function of distance. This will automatically slow you down and stop over center of target (pad). Speed has to be very slow already before reaching 50 m distance for linear RCS to handle it.
“Taxi”	This controls overall speed even outside 50 m distance by deceleration and acceleration. Since speed is controlled by linear RCS it’s only useful for short distances and slow speed.

HINT: If within the +/- 10° tolerance of target heading the course correction is more urgent than heading control, heading may overshoot. If it goes over 10° on other side, course correction will stop and rotation changes direction. This may happen repeatedly and you slinger around target heading. To stop this, disengage “Lin Nav” until target heading is reached or use vessels “Kill Rotation” manually. On the other hand it is in fact more important that you fly into right direction than to have nose pointing to it.

Page 3: Travel

This page contains data for traveling across the surface to reach the position of NAV signal / base or for launching to orbit. You can control the horizontal speed, the speed elements (x, z) that remain when vertical speed (y) is not concerned (→Page 1: Hover is for that).



In standard "Hover" mode main and retro engines are used to control your travel speed. In "Heli" mode the speed is controlled by horizontal elements of hover thrust reached by pitch and bank steering. The functionality in "Heli" mode is the same that in previous version 1.0.2 was called "Heli Nav" (Linear Navigation in "Heli" mode).

Like "Lin Nav" it only works when "Hdg Target" is set to "Nav1/2" or "Base" and active. Absolute pitch and bank are limited to < 5° in "Hover" mode only. Another working limit is desired heading has to be reached about +/- 2°.

"Orbital Speed"

The orbital speed is the speed that is needed to be in circular orbit at current altitude. Being in circular orbit would mean no hover thrust would be needed to maintain altitude. So you have to watch to stay far below this speed, if you want to be in a hover state where the AP controls are designed for and work best. Of course reaching orbit may be what you want and the purpose of Hover MFD ends here.

"Full Brake"

A full brake will be applying full thrust to the opposite direction of horizontal speed from now until full stop. The values show you the time in first line and the distance in second line such full brake would need. In brackets the label shows what type of engine would be used for that.

Retro	The retro engine will be used for braking when horizontal speed angle is > -90° and < 90°, 0° would be best (you fly forward).
Main	The main engine will be used at horizontal speed angle < -90° and > 90°, 180° would be best (fly backward). Since main engine is usually more powerful it may be useful to turn to 180° for shorter braking time and distance.
Heli	In "Heli" mode a full stop would be applied by pitch up with maximum angle (reduced for safety) where vertical speed can still be maintained.

"Brake Now Rate"

Instead of a full brake this values show how much thrust or "Brake Rate" would be needed, if you start braking from now on until your target is reached and your speed gets zeroed simultaneously. Of course this only works when "Hdg Target" is set to "Nav1/2" or "Base" and active. Also you have to be flying towards your target and not away from it so there is need for a braking phase.

First line is the needed thrust for main (MN) or retro (RT) engine. This will be colored orange above 90%. In "Heli" mode first line shows the needed pitch, colored orange above 95% of reduced max angle. Second line shows the corresponding "Brake Rate" in percentage of maximum speed able to brake.

"ETA" (Estimated Time to Arrival)

This gives you the relative estimated time to arrival at currently selected "Hdg Tagret" ("Nav1/2" or "Base" and active). This depends on your current speed, the wanted travel speed and the capabilities of your thrusters. This will already calculate and display, even if your travel settings aren't active yet to show you the "what if" of your inactive settings.

First line gives you the overall time until your vessel will stop right over the selected target. Additional time to go down from some remaining altitude is not going into this calculation in this Version of Hover MFD.

In second line you will see the time you will stay in current stage before next stage is entered. There may be up to 5 stages that are named in the ETA label:

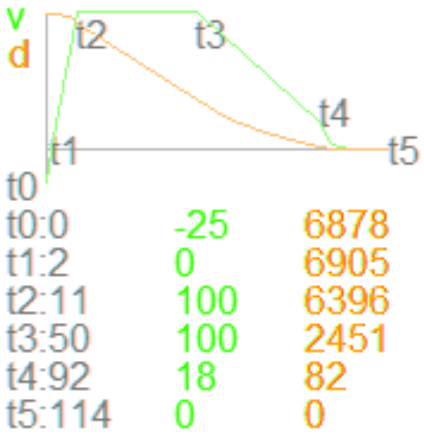
Zero	If your speed is pointing away from target, it will be counted negative. The "Zero" stage will stop this movement, while of course the distance will still grow in this stage. The speed is counted only in z-axis, so after this stage your overall horizontal speed may not be zero, if there is some lateral speed in x-axis.
Speed	This stage is used to get speed until the "Horizontal Speed" setting is reached.
Wait	After reaching your wanted speed it can be maintained until calculations say it's time to start braking. So in this stage you are waiting for this to happen.
Brake	Depending on current speed and the thrusters that will be used for braking Hover MFD calculates at what distance the deceleration or braking should start. This stage is within this distance and you will notice the thrusters starting.
Near	If only constant deceleration in braking stage would be used, of course you can reach target and zero speed simultaneously. But at this point suddenly this (in most cases very high) deceleration has to be stopped very abrupt. For a smoother arrival you will notice a short growth of deceleration at certain near distance. But then the deceleration will reduce with time. Thus all three will be zeroed at arrival: distance, speed and thrust.

"Target Dist Graph"

This is a graphical representation of the possible stages (see previous section) towards the set target. Again this only works when "Hdg Target" is set to "Nav1/2" or "Base" and active. It's also necessary to activate "Horizontal Speed" and "Target Distance" for this prediction to happen, but it will already display when these are inactive.

The coordinate system will show time in x-axis where the points of a stage change are labeled along the graph. In y-axis speed v (green) and distance d (red) are shown. Below the graph a table lists the corresponding overall values for time (grey), speed (green) and distance (red).

Your current situation is always labeled “t0” and later stage changes are called “t1”, “t2” and so forth. If you already are in a later stage, there will be fewer stages to come, so the arrival time will not always be labeled “t5” but maybe a smaller number.



Let’s examine this readout on the left. Here we can see all 5 possible stages. At current time t0 we are at a distance of 6878 m and a speed of 25 m/s away from target. It will take 2 s to stop movement at t1 and the distance will grow to 6905 m meanwhile. Then “Horizontal Speed” tells us we want to travel at 100 m/s. This speed will be reached at t2 after another 9 s or after 11 s from now and at a distance of 6396 m. At that constant speed we will travel until a distance of 2451 m at t3 (50 s from now) where braking starts. Speed will then be reduced to 18 m/s at 82 m distance at t4 (92 s). There the smoother deceleration of “Near” stage will go until full stop and target will be reached at t5 (114 s).

HINT: You may also notice that speed is gained between t0 and t2 much faster by main engine than reduced between t3 and t4 (t5) by retro engine. It will be vice versa when “Heading” is set to “180” and your nose pointing away from target using main for braking.

WARNING: All these values may not be very exact. The Hover MFD AP only reacts on current situation and the wanted speed and direction. AP does not know about the future and coming stages for now. All these predictions are only calculated for display. The stages are only achieved by controlling the wanted speed and then AP will react always slightly too late. To encounter this lazy AP you should reduce “Brake Rate” and thereby add more thrust reserve for error corrections.

“Navigation Radio”

It’s the same like on first “Hover” page.

“Horizontal Speed”

All functionality of “Travel” Page is dependent on “Horizontal Speed” to be active. Set it to exact or maximum speed you want to be travelling. If only this control is activated, your current speed is increased or reduced to the exact given value. If also “Target Distance” is activated, this speed would be used at maximum speed on the approach to your target. Without “Target Distance” activated there will be no braking thrust to stop at the set target (see → “Hdg Target”).

“Target Distance”

If you want to start braking thrust in time to stop exactly at the set target, you must set “Target Distance” to “0” and active. If you set up higher distances, you will not stop at an exactly defined coordinate but just at the given distance regardless of the direction. This may be helpful if the target pad is occupied or if your target NAV is a vessel you want to follow but not to crash in.

"Brake Rate"

The "Brake Rate" determines how hard the braking phase will be when a "Hdg Target" is set and "Horizontal Speed" with "Target Distance" activated. In dependency to your vessels thrust, current speed and distance to your target a maximum speed able to brake is calculated. To aim 100% of that max speed would mean to wait or even accelerate to the perfect moment to start a "Full Brake". This may work theoretically but actually you will always overshoot this perfect moment and then you would need more than 100% thrust to correct this. So Hover MFD usually aims only 90% of that max speed (which corresponds to 81% braking thrust level) and some thrust reserve can be used to correct errors. You may change this "Brake Rate" from 90% to your desired percentage of max speed.

Above the "Brake Rate" parameter the corresponding thrust level of main (MN) or retro (RT) engine is displayed. Above 90% this gets critical and will be painted orange. In "Heli" mode not the thrust level but the pitch angle is displayed. This will be considered critical above 95% of reduced max angle.

By right-clicking the SET button the "Brake Now Rate" will be offered for input.

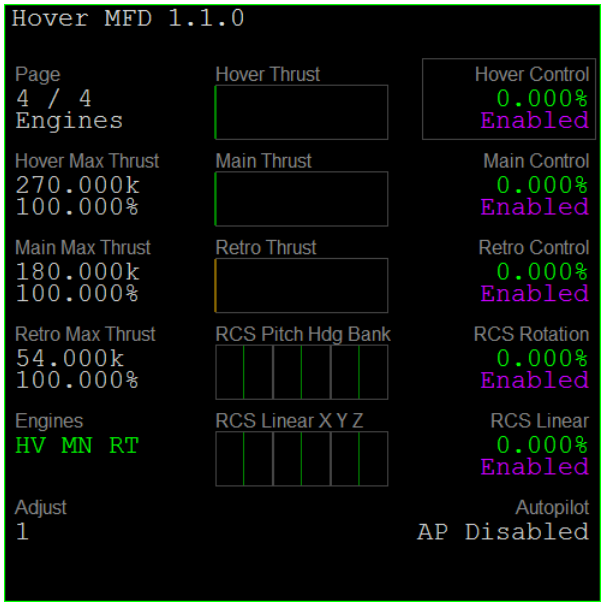
"VS To Target" (Vertical Speed To Target)

If this feature is activated, all vertical speed settings are overwritten so that in the time of calculated overall ETA the altitude is reduced from current to twice the altitude of touchdown. You should activate this for a good looking landing. First line gives you a reading of current VS, second line is the calculated VS that the AP will try to match.

HINT: Please remind that there is no downward thrust so negative VS can only be reached, if your vessel will fall down by itself. You should set "Horizontal Speed" below "Orbital Speed" and consult Map MFD to check you will touchdown nearby the target just by current orbit.

Page 4: Engines

The "Engines" page shows the power and state of your thruster engines. Here are the main switches for each engine. If they are disabled, the engine is not under autopilot control and will not be touched at all.



"Hover Max Thrust"

This is the maximum thrust force [N = kgm/s²]. Divide it by the mass and subtract the planet's gravity and you'll get the maximum possible vertical acceleration. The percentage shows the efficiency of that engine, which may be reduced within atmosphere.

"Main Max Thrust"

This is the maximum thrust force [N] and efficiency of your main engine.

"Retro Max Thrust"

This is the maximum thrust force [N] and efficiency of your retro engine.

"Engines"

This is the same display like on first "Hover" page to check, if your engine setup is ok.

"Hover Thrust"

This bar shows the current level of hover thrust (0% - 100%).

"Main Thrust"

This bar is the graphical representation of the current main thrust level.

"Retro Thrust"

And this is the retro thrust level bar. Because retro engines direction is negative this bar is orange.

"RCS Pitch Hdg Bank"

These three bars show the current level of rotational RCS thrusters for pitch, bank and heading. Orange color means downward, left yaw or left roll.

"RCS Linear X Y Z"

Here are the three bars for linear RCS thrust level. The axes are X: wings level, Y: vertical, Z: forward. The negative directions left, downward or backward are drawn in orange.

"Hover Control"

The current percentage of hover thrust level is displayed and the enabled-state lets AP take control over hover engine. If control is disabled, AP won't use hover engine at all.

"Main Control"

This works like "Hover Control" but for the main engine.

"Retro Control"

This works like "Hover Control" but for the retro engine.

"RCS Rotation"

If enabled, autopilot can take control over rotational RCS thrusters. The displayed percentage is an overall percentage of all three directions and says "100%", if only one direction is at full thrust and "141%" for two axes at full thrust. This may be fixed later.

"RCS Linear"

This is like "RCS Rotation" but for linear RCS thrusters.

Configuration files

In your orbiters config folder resides Hover MFD's folder for config files ".\Config\MFD\HoverMFD\". There will be one default config file "Default.cfg" and some vessel specific config files.

Within the files some optional features can be chosen and autopilots parameters can be set up to react more aggressive or rather slow depending on your vessels movement (although mass and other factors are taken for calculation already).

Reading the configuration appears for each vessel when Hover MFD is opened within for the first time in your simulation session. First all options are set to standard values, so if there is no config file at all, every parameter is defined. Then "Default.cfg" is loaded and overwrites all parameters it contains. After default setup Hover MFD will look for a file named like the class of your vessel. Then again only the contained options are loaded and all others keep the value from "Default.cfg" or MFD standards.

HINT: If you are within a "Deltaglider" (check scenario editor or file to get the full class name and path), then the file should be ".\Config\MFD\HoverMFD\Deltaglider.cfg". For an UGCO Arrow Freighter (full path is "UCGO\Vessels\UCGOArrowFreighter") the config file should be ".\Config\MFD\HoverMFD\UCGO\Vessels\UCGOArrowFreighter.cfg".

Within the configuration files you may define these general options:

Parameter	*Type*	*Default*	*Description*
AltModeConversion	Bool	TRUE	When "FALSE" switching "Alt Mode" will not add the "Alt Delta" to AP target altitude
HorizontalSpeedRadius	Float	1.0	This is the outer radius of the horizontal speed indicator, within no heading corrections are made for "Hdg Target" = "Hor. Spd"
IndicatorUpsideDownFlip	Bool	TRUE	Set "FALSE" to have indicators ignore your bank. Default is to flip x axis when upside down
LoadApEnabledFromScenario	Bool	FALSE	When "TRUE" AP will be enabled directly after scenario load, if it was on while saving
NavTargetRadius	Float	50.0	This is the outer radius of the NAV indicator, within no heading corrections are made for NAV "Hdg Target" and it's used for "Lin Nav" Mode "Capture"
ReUseValueForSet	Bool	FALSE	If you press SET button and you want the input box to contain the current value, then put this to "TRUE"
Timer	Float	0.1	This defines how often [s] values are calculated and AP takes control

HINT: If you set the "Timer" option to "0.0", the calculations will be made every timestep (this would be about "0.01" or less. This is of course not problematic but also not necessary.

Here are some options about autopilots functional limits:

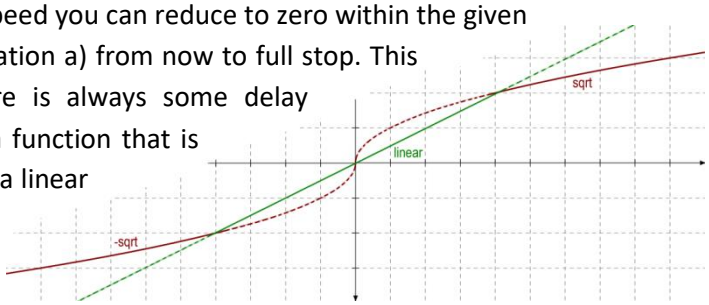
Parameter	Type	Default	Description
HeliMaxAngle	Float	0.8	The max angle flying in “Heli” mode is where 100% hover thrust is applied and the vertical portion counters gravity. This factor reduces the angle to have some reserve for VS and applying pitch and bank same time.
HeliNavHeadingTolerance	Float	20.0	For “Tavel” to work in “Heli” mode desired heading has to be reached +/- this value to apply horizontal speed
LinNavBankFreeTolerance	Float	5.0	“Lin Nav” works in a bank free zone at relative target heading +/- 90° +/- this value
LinNavBankLimit	Float	5.0	Otherwise “Lin Nav” is limited to work at bank +/- this one
LinNavHeadingAVelLimit	Float	0.3	Max angular velocity for “Lin Nav” heading condition
LinNavHeadingPriority	Float	2.0	To check whether RCS Lin or RCS Rot has to be applied (RCS thrusters can’t do both at same time), the greater of both is preferred, where Rot is multiplied by this value
LinNavHeadingTolerance	Float	10.0	For “Lin Nav” desired heading has to be reached +/- this value to apply linear corrections
LinNavPitchFreeTolerance	Float	5.0	“Lin Nav” works in a pitch free zone at relative target heading 0° / 180° +/- this value
LinNavPitchLimit	Float	5.0	Otherwise “Lin Nav” is limited to work at pitch +/- this one
TravelBankFreeTolerance	Float	5.0	“Travel” in “Hover” mode works in a bank free zone at relative target heading +/- 90° +/- this value
TravelBankLimit	Float	5.0	Otherwise “Travel” in “Hover” mode is limited to work at bank +/- this one
TravelNavHeadingAVelLimit	Float	0.2	Max angular velocity for “Travel” heading condition
TravelNavHeadingTolerance	Float	2.0	For “Travel” to work in “Hover” mode desired heading has to be reached +/- this value to apply horizontal speed
TravelPitchFreeTolerance	Float	5.0	“Travel” in “Hover” mode works in a pitch free zone at relative target heading 0° / 180° +/- this value
TravelPitchLimit	Float	5.0	Otherwise “Travel” in “Hover” mode is limited to work at pitch +/- this one

For the following thrust calculating factors that you may need to change for some vessels you have to know that applied thrust is calculated with such formula:

wanted_speed = **FactorVRate** * SqrtLike(2 * max_acceleration * (target_position – current_position), **FactorVLin**)

thruster_level = **FactorAccel** * (wanted_speed – current_speed) * vessel_dependent_calculated_factor

v = Sqrt(2*a*s) would be the maximum speed you can reduce to zero within the given range (s), if you apply full thrust (acceleration a) from now to full stop. This would be **FactorVRate** = 1. Since there is always some delay **FactorVRate** has to be < 1. SqrtLike is a function that is defined for < 0 of course and switches to a linear function with a pitch of **FactorVLin** when close to target, otherwise it would be too steep.



This means you can control the speed the vessel will aim to go from current position to target position by **FactorVRate**, greater factors for more speed. Fine tuning close to target is done by **FactorVLin**, also greater factor for more speed. And by **FactorAccel** you can define how much acceleration is used to reach that speed sooner or later.

HINT: If you set FactorVRate to let's say 0.9 (90%), the targeted speed will be 90% of the maximum speed able to brake and the resulting constant thrust in deceleration phase will be the square of that, in this case 0.9^2=0.81 (81%).

Parameter	Type	Default	Description
HeliAccel	Float	0.30	FactorAccel for "Heli" linear corrections – result is not a thrust but pitch / bank
HeliVLin	Float	0.01	FactorVLin for "Heli" linear corrections – result is not a thrust but pitch / bank
HeliVRate	Float	0.80	FactorVRate for "Heli" linear corrections – result is not a thrust but pitch / bank
HoverAccel	Float	1.00	FactorAccel for hover thrust
HoverVLin	Float	0.10	FactorVLin for hover thrust
HoverVRate	Float	0.80	FactorVRate for hover thrust
MainAccel	Float	1.00	FactorAccel for main thrust
MainVLin	Float	0.05	FactorVLin for main thrust
MainVRate	Float	0.90	FactorVRate for main thrust
RcsLinAccel	Float	1.00	FactorAccel for linear RCS
RcsLinVLin	Float	0.30	FactorVLin for linear RCS
RcsLinVRate	Float	0.80	FactorVRate for linear RCS
RcsRotAccel	Float	1.00	FactorAccel for rotational RCS
RcsRotVLin	Float	0.05	FactorVLin for rotational RCS
RcsRotVRate	Float	0.80	FactorVRate for rotational RCS
RetroAccel	Float	1.00	FactorAccel for retro thrust
RetroVLin	Float	0.05	FactorVLin for retro thrust
RetroVRate	Float	0.90	FactorVRate for retro thrust

HINT: These thrusting factors were necessary to be changed for ShuttleA, XR5Vanguard and UCGOArrowFreighter, so there are specific configuration files delivered with the setup file HoverMFD.zip.

Standard checklists

I'll now explain some standard maneuvers and how Hover MFD is set up to help you.

Hover launch to low orbit

Condition: Your vessel is on surface, powered on, fueled up etc.

- Calculate the necessary heading for your orbit
- Check engines and gear are operational (hover doors open, hydraulic pressure)
- Select one Orbit MFD and set PRJ to "SHP" and DST to show "ApA" and "PeA"
- Select one Hover MFD and page "Hover"
- Make sure "Gravity" is below "100% HV"
- Set "Vertical Speed" to about +10 m/s
- Leave "Altitude" disengaged (we'll use main engine and watch ApA)
- Select page "Orientation"
- If you feel safe (small vessels), already set some pitch (+10°)
- Engage heading control and set to calculated angle
- Set "Hdg Target" to "True Hdg"
- Engage AP and watch your vessel launching
- Raise gear
- Slowly apply some main thrust
- Set pitch to appropriate value (+10° is ok for DG 10km Moon orbit)
- Apply full main thrust
- Switch to "Hover" page, wait for AP saying "free fall" (hover engine is set off because VS is now fully taken by main engine due to pitch)
- Switch to "Engines" page and disengage "Hover Control" (we don't need hover engine from now on)
- Watch Orbit MFD and cut off main engine when "ApA" reaches your desired height
- Switch to "Orientation" page and set pitch to 0°
- Wait for Orbit MFD "ApT" coming close to zero and apply main thrust until your orbit gets circular
- Well done! Turn off AP before starting other programs or time acceleration > 10x

Deorbit and touchdown

Condition: Your vessel is orbiting the desired planet and you already used some base-approach / align program to set up your path directly over desired base.

- Use COM/NAV MFD and set NAV1 to a wide range signal from target base (VOR / XPDR)
- Set NAV2 to the short range frequency for landing pad (VTOL)
- Or set up BASE to <Base Name> <Pad Nr>

- Use Map MFD, set target base and enable TRK
- Check your path goes straight over target base
- Wait for your target base to switch from one border of map to opposite border (you are now exact half an orbit away from base)
- Wait some more time until you passed about one map quadrant
- You are now ready for deorbit burn, we'll do this by Hover MFD
- Switch to Hover MFD, page "Hover"
- Set "Vertical Speed" to about -40 m/s
- Make sure "Soft Landing" is enabled
- Switch to "Orientation" page
- Check pitch and bank enabled and at 0°
- Enable heading control and set to 180°
- Switch "Hdg Target" to "Hor. Spd"
- Check all values on "Engines" page are enabled
- Engage AP (you'll level horizon and turn your main engine into airspeed direction for braking)
- Leave AP enabled, switch from Hover MFD to Orbit MFD (other MFD shows Map)
- Watch Orbit MFD and apply full main thrust until "PeA" falls slightly below zero
- Watch Map MFD and smoothly use main / retro thrust to put the "landing spot" slightly beyond target base
- Switch back to Hover MFD, leave Map MFD open
- Disengage AP while you accelerate time more than 10x
- Set heading to 0°, if you rather fly forward
- Wait until you get a signal for NAV1, if you didn't set BASE
- Set heading to 180°, "Hor. Spd" mode
- Set heading to 180°, "Nav1" or "Base" mode (should be nearly the same)
- Go to "Travel" Page, set "Horizontal Speed" to current speed and active, "Target Distance" to "0" and active, "VS To Target" to active
- Watch "Horizontal Speed" indicator, x value (z is forward/back) should be close to zero
- For small x let RCS do linear corrections by setting "Lin Nav" to "Course" or "Capture" and enabled
- For larger x values disable "Lin Nav", turn heading to 90° or 270° (to pull speed indicator in that direction), set "Travel" → "Horizontal Speed" to "0" and active, but deactivate "Target Distance"
- When x reaches "0" set back heading to "180", "Travel" → "Horizontal Speed" to current and "Target Distance" to "0" and active
- When in range of Nav2 (pad) you may turn "Hdg. Mode" to "Nav2" 0° or let it be at "Base" and "180"
- Lower gear, when near target
- Lean back and watch a smooth touchdown

Known Issues

- Hover MFD state of active vessel only is saved to scenario / current file
- Gravity and orbital speed for small moons only slightly improved (Phobos)
- Sometimes negative VS with altitude set don't make you launch although it was meant to be treated as positive also (noticed mostly within atmosphere) – Workaround: Set it to positive value
- The "Travel" functionality in "Hover" mode by main and retro engine is vulnerable to x-axis course deviation – Workaround: Use "Travel" in "Heli" mode
- The "Travel" mode will overshoot target sometimes
- "Travel" mode AP will be a little bit off calculated ETA

Planned features

- More automatic launch and landing features
- Rocket-Mode (set pitch but hold position by dependent hover- and main-levels, up to 90° pitch while hovering with main engine "ready for rocket style launch")

Version history

1.1.3 – 08.10.2016

- New setting "Alt Mode / Delta" on page 1 lets you switch between altitude measured above ground level (default) or mean radius (don't follow the slopes when flying high), the "Alt Delta" value will be added while switching modes
- Reworked "VS To Target" for surface elevation of target, changed display to current and target VS value
- Horizontal speed is now using ground speed instead of airspeed (manual always said ground speed, but there has been no ground speed hence no difference in Orbiter 2010)
- Workaround for Orbiter [v.160828] issue with SetAttitudeRotLevel (_V(0, 0, 0)), setting every axis separately to zero

1.1.2 – 06.09.2016

- Compiled for Orbiter 2016
- Using new altitude reading over ground instead of mean radius
- Fixed drawing rectangles so left coordinate is always less than right coordinate, 2010 version was more forgiving

1.1.1 – 15.06.2014

- Set up base with pad number "0" to get the first one that is not occupied
- Fixed text size in D3D9 client
- Introducing Tailsit mode (beta version) that uses main engine only, with pitch/bank steering almost like Heli mode

1.1.0 – 20.01.2014

- New “Travel” page for horizontal speed control
- Main and retro engine control
- Engines are checked for their thrust direction and then dynamically assigned for usage (main engine can be treated as it would be hover, if it is currently aligned in y-axis)
- Additional thruster groups (like auxiliary pod in ShuttleA) can be used to replace a missing one (ShuttleA has no retro) or to support other groups
- Engine thrust is now calculated by sum of each thruster in group (technically using thruster handles instead of engine types)
- By the above method reduced thrust under atmospheric pressure can be read before any thrust is applied
- Rotational RCS thrusters are now also checked and the resulting torque and angular acceleration are calculated
- “Gravity” and “Orbital Speed” are titled “(weak)” and drawn orange when nearest surface body is not the one with most gravitational influence (e.g. Phobos)
- “Hdg Mode” now labeled “Hdg Target” to show its important role as a target for other navigational features
- Set up base by name or Lat/Long as “Hdg Target” in new “Base” mode
- Reduced to a single timer value (doesn’t hurt to calculate other values more often)
- Right click on SET button uses current vessel data readout
- Use keyboard ↑ + F5 – F8 to switch directly to page 1 – 4
- “Travel” page has replaced functionality from “Heli Nav” and “Approach” mode, so these were removed

1.0.2 – 17.06.2012

- Heli mode for steering by pitch/bank
- Using heli mode for linear navigation, if activated
- Exact calculation of max speed to be zeroed by thrusters until reaching target
- New “Approach” mode for linear navigation watching this max speed
- Default and vessel specific config files
- Hover thrust adapted to reduction within atmosphere
- Thrust efficiency is shown on engines page
- State of current vessel with active Hover MFD is written to scenario file
- Reference plane for “Horizontal Speed” and “Vertical Speed” is now fixed to the horizontal plane rather than wings plane
- More pitch allowed for “Lin Nav” when relative heading near 0° / 180°, more bank for +/- 90°
- Time acceleration limited to 10x
- Purple color now marks the only potential active parameters, check dependencies to make them active – blue are only actually working AP settings
- Engine page physically correct labels “Max Thrust” (not “Power”)
- Some source code cleanups
- Now tested with XR fleet also

1.0.1 – 05.05.2012

- Compiled in release config (sorry guys for that debug config mistake)
- Implemented a module class with “clbk” methods rather than “opc” callbacks

1.0.0 – 02.05.2012

- Hover engine control
- Rotational RCS control
- Linear RCS control
- Manage vertical speed
- Maintain altitude
- Soft landing
- Autopilot self-turnoff after landing
- Manage pitch, bank, heading (true heading, speed relative, NAV relative)
- Hover-Mode (designed for zero pitch and bank only)
- Linear course corrections to NAV
- Linear X and Z control for pad center positioning and taxiing
- Airspeed and NAV indicators
- Engine level bars

Links

Orbiter Space Flight Simulator	http://orbit.medphys.ucl.ac.uk/
Orbiter Forum	http://www.orbiter-forum.com/
Orbit Hangar Mods (Add-ons for Orbiter)	http://orbithangar.com/
Orbiter 2010 HoverMFD 1.0.0: Launch-Taxi-Landing (Video)	http://youtu.be/X9zPhNLd7qw
Orbiter 2010 HoverMFD 1.0.2: Earth Heli Taxi (Video)	http://youtu.be/wM5lHUaAXJk
Orbiter 2010 HoverMFD 1.0.2: Arrow-Heli-Approach (Video)	http://youtu.be/MBO1fMbEqnk
Orbiter 2010 HoverMFD 1.1.0: Travel Approach (Video)	http://youtu.be/a_L--KlDo1g
Orbiter 2010 HoverMFD 1.1.0: Pod Thrusters (Video)	http://youtu.be/xcaFzxcTfwY
Orbiter 2010 HoverMFD 1.1.1: Tailsitter (Video)	http://youtu.be/AO-y6A9B8Uc

Thanks

I would like to say thank you to all forum users for all their support in feedback, comments, problem solving, new ideas and insistence, especially to: Keatah, Ripley, NukeET, C3PO, CaptBlanc, Donamy, blixel, Interceptor, perseus

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