



***The Rings Corporation***  
***Because the sky is full of stars***

# **SuborbMFD v2.1 User Manual**

*Optimize your suborbital Flights!*

By Laserpithium

*September 2007*

# Introduction

Thank you for having purchased Rings Corporation's new SuborbMFD v2.1. With our new software, you be able to perform very accurate suborbital flights, to save propellant, and thus to lower your operational costs.

A brief history of SuborbMFD:

**- 1 September 2005: first version (SuborbMFD 1.0).**

**- 5 March 2006: SuborbMFD 2.0:**

- Perform now "orbit to ground" suborbital flights, and not only "ground to ground" suborbital flights.
- Allow course-corrections.
- Allow retargeting.
- Corrector's algorithm reworked.
- Bug fix: new way to estimates the Dv produced by the engines of the spacecraft. The accuracy is now good for every type of vessel.
- Several small bugs fixed.
- New documentation

**- 16 September 2007: SuborbMFD 2.1:**

- "Orbit to Ground" flights now optimized.
- Compatible main engines / Hovers.
- Several parts of the code rewritten, for better efficiency.
- Natively in two languages, English or French.
- Several small bugs fixed.
- Compiled for Orbiter 060929 (Orbiter 2006 P1)

## What is SuborbMFD ?

SuborbMFD is an MFD developed by Rings Corporation, and dedicated to work with Martin Schweiger' Orbiter Space Flight Simulator version 060929 (O2k6P1). You can download this amazing simulator here:

[www.medphys.ucl.ac.uk/~martins/orbit.html](http://www.medphys.ucl.ac.uk/~martins/orbit.html)

The present release of SuborbMFD is designed to allow you to perform **suborbital flights on celestial body without atmosphere** (for example, on the Moon. Tests show that it works quite well on Mars too).

Take a ship of yours, still on its launch pad or already in orbit, and with a single initial burn reach the location you want on the ground of the same body. Choose a destination located on the same body, and SuborbMFD will compute for you the most economical trajectory (as far as propellant is concerned), which allows you, with a single initial burn, to join your destination by doing a suborbital flight.

**NEW**

With v2.1, the trajectory is optimized too in case of flights “Orbit to Ground”

Important considerations:

- If you are landed on a body with an atmosphere, SuborbMFD will work but its results will be wrong because of the drag due to the atmosphere, which is for the moment not taken into account. In this release, SuborbMFD works only on body without atmosphere.

Rings Corporation declines all responsibilities if the use of SuborbMFD v2.1 on a body with atmosphere leads you to a crash. In particular, no damages of any kind may be claimed.

**NEW**

Since v2.1, the burn may be performed with the hovers.

The minimum-altitude security concept:

In “Grounded” mode, SuborbMFD computes for you the most economical trajectory. But if your actual location and your destination are almost at the opposite one another, the result of this optimization-process is a trajectory almost tangent to the surface of the body.

Thus, an altitude of security is defined in SuborbMFD: SuborbMFD computes the most economical trajectory whose maximum altitude at least equals a minimum-security value.

By default, this value is fixed to 40 km. You are free to change it for any value greater than 1 km.

That doesn’t mean that your maximum altitude will equal this value, but that your maximum altitude can’t be lower than this value.

**NEW**

Since v2.1, SuborbMFD exists natively in two languages: English (default) or French.

To choose the language, open the file *SuborbMFD.cfg* located in the *Config* folder with the notepad, and change the value of the bit in front of the tag LANGUAGE, and restart Orbiter.

## Installing SuborbMFD

This operation must be performed only by someone having a diploma in Spacecrafts' Computers and Software Management. Once more, The Rings Corporation declines all responsibilities in every circumstance if some unauthorized technicians of yours perform the installation operation.

To install your new SuborbMFD v2.1:

Just unzip the package you have downloaded into your main Orbiter folder.

This package contains the plugin (*SuborbMFD.dll*), a configuration file (*SuborbMFD.cfg*), and this documentation.

Do not forget to activate SuborbMFD in the launchpad before using it.

## Using SuborbMFD v2.1

Depending whether you are grounded (**“Grounded” mode**) or not (**“Not grounded” mode**) when you launch SuborbMFD, different algorithms will be used.

In both cases, the first window will collect the coordinates of your target. These coordinates can be of two types:

- Enter directly the name of the base you want to go.
- Enter the destination you wish, by giving to SuborbMFD its latitude (counted positively to the North) and its longitude (counted positively to the East).

The Rings Corporation's SuborbMFD v2.1 will then provide you key information to perform a burn which will lead you right on your target.

- If you are grounded, this information will be displayed on the same page. The provided indications to perform the burn are:

- Heading (in degrees)
- Pitch (in degrees)
- DeltaV (m/s)

- If you are not grounded, only the deltaV you need to reach your destination will be displayed. You will have to go to another page (page “2/2”) to know in which direction you must perform the burn. The latter contains a moving target you have to center to be in the good position.

- You can choose which type of engines you will use (main engine or hover engine), with the button ENG, or shift+E.

### Important considerations:

In the “Not Grounded” mode, if you are very close from your target, the display may become unstable.

## Display's description

SuborbMFD is divided into two modes, "Grounded" (you are actually landed and planning a departure from the ground) and "Not Grounded" (you are already in orbit or performing a suborbital flight).

To navigate from one mode to another, use the "SWT" command, or shift+S.

### Important consideration:

When, in the "Grounded" mode, you click on "SWT", you will be able to reach the "Not Grounded" mode only if you are no more landed. And it will not be possible to go back in "Grounded" mode until you are once again landed.

The same way, if you are in "Not grounded" mode, it's only possible to reach the "Grounded" mode if you are landed.

Be cautious not to change from one mode to the other one while performing a burn, you may lose information and then perform a bad burn.

### 1. "Grounded" mode (since v1.0).

The display provides 4 kinds of information, grouped by color.

```
Suborbital Launch MFD/Grounded

Position          Target
Moon             Moon
Lat:+41.13        Lat:-15.00
Lng:-33.44        Lng:+56.00

Security Alt: 40.0 km
Engine : Main

Heading : +102°
Velocity Vector : +12° (+0°)
hMax : 191.1 km
vTan : 1392 m/s

DeltaV : 1631 m/s
Pitch : 19° (0°)
```

- **In green, your actual location.** SuborbMFD displays the name of the body where you are located, then the latitude (counted positively to the North), and your longitude (counted positively to the East).

Just under, SuborbMFD displays the current value of the security altitude. Be aware that these coordinates are not automatically updated. Especially, if you decide to run another scenario without exiting the launchpad, **you will have to update manually your location** by clicking on the RST (reset) button.

- **In yellow, your target.** You can choose a target by two ways: by choosing a base thanks to the button “TGT” (target), or by defining a point on the body by its latitude (button “LAT”) and its longitude (button “LNG”).  
Remember the convention: latitudes are counted positively to the North, and longitudes are counted positively to the East.
- **The blue group presents the results of the calculus.**
  - **Heading** is the heading you have to take for the launch. Be aware that because of the sphericity of celestial bodies, your heading will slightly changed during the burn. So, **this heading is the one you have to take at the beginning of the launch.** Do not try to maintain it during all the burn, a small change of your heading will necessarily occur during the launch because of the sphericity of the body.
  - **Velocity Vector** is the angle between the velocity vector (represented by a + in a circle) and the horizon. The first number is the computed value you have to maintain during all the burn. The second number into brackets is your actual velocity-vector angle. Your job consists in making these two numbers equal during all the burn.  
However, because it's more intuitive and easier to work with the pitch of the spacecraft rather than the velocity vector angle, **SuborbMFD provides you the equivalent information pitch-related.** (See white group).
  - **hMax** is the value of the maximum altitude you will reach during your flight, if you perform a perfect burn.
  - **vTan** is the value of the tangential speed at the top of the trajectory (that is when the altitude reaches *hMax*), if you perform a perfect burn.
- **Finally, the white group is the most important one.** It provides you useful information to perform a good burn.
  - **Dv** is the deltaV you need to achieve the computed trajectory.
  - **Pitch** provides you information in order to help you to maintain your velocity-vector angle at the good position.  
The first number is the pitch you have to maintain according to the calculator. The second number into brackets is your actual pitch. Your job consists in making these two numbers equal during all the burn.  
During the burn, the value of the first number will change. Actually, this value is the result of the calculus made by a corrector to allow you, just by working on the pitch, to maintain the good velocity vector angle. For the one who are interested in automatics, I use here a double-loops corrector, with one pure proportional loop and a second proportional-integral loop for more accuracy.

## 2. “Not grounded” mode (since v2.0).

This mode is divided into two pages, page 1/2 and page 2/2. To switch from one page to the other one, use the command “PG”, or shift+P.

### 2.1. Page “1/2”

```
Suborbital Launch MFD/Not Grounded

Position          Target
Moon              Moon
Lat:-29.88        Lat:+70.00
Lng:+38.29        Lng:+23.00

Security Alt: 10.0 km
Alt above target: 5.0 km
Engine : Hovers

Dv : 1660.5 m/s

1/2
```

- **The green and yellow groups:**

This is in this page you arrive when you launch SuborbMFD in “Not Grounded” mode.

The purpose of this page is to allow you, as the in the “Grounded” mode, to choose your target. The green and the yellow groups work the same way as they do in “Not Grounded” mode (see above). For instance, you still may choose a target by its name, or by its equatorial coordinates.

However, new information appears: the altitude above target “Alt above target”. This is the altitude, in km, you want to be above your target. It is very useful to fly a few km above your target, in order to have margins to land safely. That allows saving a lot of propellant.

By default, this altitude is fixed to 5 km. You are free to change it for any positive value (in km) thanks to the button “ABV” or shift+B

- **The white group** indicates, as in the “Grounded” mode, the total Dv you need to reach your target. Each time-step, SuborbMFD performs a new calculus taking into account your new position on your orbit. For this reason, this value varies with time.

You are free to perform the burn whenever you want, but it’s better to wait until the value of Dv begins to rise: that means that the actual value is the smallest one, and by performing the burn at this moment you will save a lot of propellant.

## 2.2. Page “2/2”

This page gives you information on how to perform the burn: which duration and in which direction.



- **The direction:** in order to be in the good position, you have to rotate your spacecraft in order to put the cross symbol “+” right in the middle of the grid. Be aware that to provide more accuracy, the sensibility raises as you get close from the middle of the grid. For this reason, it may be difficult to put the cross symbol just in the right position. The three ellipses are here to help you:  
The smallest one (C1) symbolizes a 5 degrees error.  
The second one (C2) symbolizes a 10 degrees error.  
The third one (C3) symbolizes a 45 degrees error.  
To perform an efficient burn, the cross symbol must be located within C1.
- **The duration:** under the chart giving the direction, the value of Dv you need to reach your target is once more indicated. Burn to make this value as close from zero as possible.  
As SuborbMFD updates every time-step this value according to your new position, this value will change with time. In general rule, when this value is greater than 20 m/s, a new burn will be needed to reach a good accuracy.

Note that the values of Dv indicated in pages “1/2” and “2/2” are the same.

## List of the commands

- Launch SuborbMFD with “shift+F”.
- “TGT” or “shift + T”: choose a target by its name.
- “LAT” or “shift+L”: choose a latitude, counted positively to the North.
- “LNG” or “shift+N”: choose a longitude, counted positively to the East.
- “ALT” or “shift+Z”: choose a value for the security-altitude. Enter value in km.
- “ABV” or “shift+B”: choose at which altitude you want to pass above your target. Enter value in km.
- “RST” or “shift+R”: reset SuborbMFD to your new location. For the moment, if you run SuborbMFD during a scenario and if, after that, you run another scenario without exiting the launchpad, SuborbMFD will display the same information than during the previous scenario, and will not see that you are perhaps on another planet.  
Update your new situation by clicking on “RST”.
- “SWT” or “shift+S”: switch you from “Grounded” to “Not grounded” mode or the contrary, if such an operation is relevant.
- “ENG” or “Shift+E”: toggle between main engine and hover (under the conditions that these engines exist on your current spacecraft).
- “PG” or “shift+P”: when in “Not grounded” mode, switch you from the main page (choice of the target) to the burn page (take the good attitude) or the contrary.



## Tutorial: From Brighton Beach to Moonbase Alpha

- Start the scenario "Brighton Beach" from the folder "Deltaglider".
- Open SuborbMFD on one MFD and MapMFD on the other.
- On SuborbMFD, click on "TGT" and enter "Moonbase Alpha". For the one who do not have this add-on installed, enter a point somewhere on the moon by clicking on "LAT" and "LNG", or choose another base.
- On MapMFD, target Moonbase Alpha.
- Switch off MapMFD and switch on SurfaceMFD.
- Once you have the clearance for lift off, push up slightly the hoover. Maintain a vertical speed of a few m/s, and run the HLevel autopilot.
- Thanks to the RCS in rotation mode, turn the Deltaglider to have your heading equal to the computed value on SuborbMFD (blue group).
- Once this goal is achieved, push the hoover to full thrust during a few seconds, until your vertical velocity reaches about 50 m/s.
- Kill the thrust, and before your vertical speed drops under zero, take the pitch indicated in the white group. The two numbers have to be equal.
- When your vertical velocity reaches 0 on SurfaceMFD, apply max thrust to the main engines. Try to maintain your pitch (number into brackets) equal to the pitch calculated by the corrector (first number). The first seconds are a bit tricky, because the value computed by the corrector may change very fast. Try to do your best. When the value of the pitch begins to be stable, you will see that your velocity vector angle (blue group, number into brackets) is very close from the computed one (which, I say it again, is the real important thing. The pitch is just a way to reach this goal).
- When the  $Dv$  indicator reaches 0 on the white group, kill thrust. You can see on the SurfaceMFD that you are on a direct way to Moonbase Alpha.
- Wait to be at mid-course from Moonbase Alpha, and there switch to "Not Grounded" mode by clicking on "SWT". We will now perform a mid-course correction.
- Check that Moonbase Alpha is entered as a target (it should be the case), choose at which altitude you want to fly above Moonbase Alpha to be able to land safely ("ABV"), and then look at the value of  $Dv$  (white group). If the value drops, we will wait for it to rise before performing the burn (we want to be sure to make the burn when  $Dv$  is minimum). If  $Dv$  is already rising, perform the burn now.
- To perform the burn, go to page "2/2" by clicking on "PG". Rotate the ship to have the cross-symbol within the smallest circle, and fire until  $Dv$  reaches 0.
- You should reach now Moonbase Alpha directly. Break and land.
- Once grounded, you must reset SuborbMFD to your new location by clicking on "RST".

## Known bugs and future features

Known bugs: none.

Any suggestions or comments about this add-on are welcome. You can join me at [laser@laserpithium.fr](mailto:laser@laserpithium.fr)

## Thanks to...

- Dr Martin Schweiger, for having created this wonderful space simulator.
- Robert B. Denny, for having created AttitudeMFD and having released his source code on Orbithangar with his MFD. I didn't use his code in my MFD, but it helps me a lot to understand how the Orbiter's API works.
- All the Orbiter community for its amazing work around Orbiter.
- Karl Friedrich Gauss (1777-1855) for having found some of the equations which are implemented in the "Not Grounded" module.

## Copyright and other legal stuff

This add-on is a freeware, and thus you have to take it "as it".  
I cannot be considered responsible for any damage it may create. Use it at your own risks.

Furthermore, you are not allowed to earn money with this add-on or with any kind of package containing this add-on.

You are free to distribute it as long as the package contains all its original components (that is *SuborbMFD.dll*, *SuborbMFD.cfg* and this documentation). You are not allowed to modify any components of this package.

Enjoy!

Laserpithium,  
The Rings Corporation's CEO  
September 16<sup>th</sup>, 2007