SPACECAD 5

ROCKET DESIGN SOFTWARE

USER MANUAL

Version 1.0 (November 2011)

For latest updates and information please visit our homepage at http://www.spacecad.com/

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1 Preface

Congratulations for choosing SpaceCAD! SpaceCAD lets you design and simulate your own model rocket designs - from launch to landing. It's the perfect solution when you also want to build your rocket and make it fly.

This is what you can do with SpaceCAD:

- **Build your own rockets** and go beyond manufacturer kits
- Be prepared for **varying launch conditions**
- Construct **complex rocket designs** with multiple recovery systems
- Become **level certified**
- Never worry about the **safety** of your rockets anymore

When you get a new kit, you are curious: How high will it fly? That's probably also the first question you'll get at the range. And: How fast does fly?

With SpaceCAD, that's easy to find out. And if you have an altimeter and know how high your rocket flew, you can use that information to find out the real coefficient of drag (CD) value in SpaceCAD, no additional software is required.

But maybe you don't want to buy a kit – and rather design your own rocket. To try things out, put an altimeter in there or an egg to see if you also have the skills to take part in the Team America Rocketry Challenge (TARC). That's when you want to design a rocket from scratch, and you want to make sure that it flies stable.

With SpaceCAD, you can use elements from the large parts database to put your rocket together – that's a lot easier than entering the data by hand.

Maybe you also have some cool fin design ideas. And then you need a little help when you are ready to build your rocket: you need a fin pattern printout, a fin guide to find out where to put these three fins so that they are at the correct location. That's one of the things that come with every kit, so you can expect to have them with your rocket design software as well, and SpaceCAD has them.

2 Installation & Setup

This chapter gives you a short overview on how to get SpaceCAD, install it and enter license information.

Before you install the software, make sure that each computer in your network meets the minimum system requirements. A computer running Windows usually meets these requirements:

- Windows XP, Windows Vista, Windows 7
- Screen resolution 1024x768 or higher

2.1 Where to find this guide

When you install SpaceCAD, the electronic version of this manual is installed on your computer. To access these electronic documents, follow these steps:

1. On the Microsoft Windows taskbar, click Start.
2. Select Programs -> SpaceCAD.
3. Select a document from the drop-down list.

The electronic documents are in PDF file format and can be opened with Adobe Reader software that you can download from http://get.adobe.com/reader/.

2.2 Getting SpaceCAD

There are two ways of getting SpaceCAD: Either you downloaded from our website at www.spacecad.com or you bought it through one of our resellers.

We suggest that you always use the latest version from the website to install SpaceCAD, even if you ordered the CD. Sometimes, these versions lag behind a bit. Your license key is valid for the downloaded version and the CD version.

Pass it on! If you have the SpaceCAD CD, you can also give it to your friends and co-flyers – but please without the license key. Thank you for spreading the word!

2.3 Installing SpaceCAD

To install SpaceCAD on your computer, follow these steps:

1. Make sure you are logged in with administrator privileges
2. For electronic delivery orders, download the installer file by downloading the "trial version" of SpaceCAD from www.spacecad.com. For shipments that came with a CD or Flash License, insert the CD or flash drive into your machine.
3. Double-click on the installation file (sc5setup.exe) that you downloaded or that came on your installation CD or flash drive.
4. Run the installer, answering the questions that appear on the screen.
   Note: The default folder location is based on your system configuration and should not be changed.
5. Click Finish.

You should now have a SpaceCAD shortcut on your desktop and a SpaceCAD listing in your Start Menu. Launch SpaceCAD and you can see that you have a 30 day trial active.

Note: When installing the software on the Microsoft Vista / Windows 7 operating system, one system security alert is displayed. Click Allow to enable the installation process.

2.4 Entering Licensing Information

When you install SpaceCAD, it will always install the 30-day trial version. You'll have to enter the licensing key to remove the 30-day restriction.

Start SpaceCAD. If your trial period has not expired, click on the "License SpaceCAD" button in the trial information dialog that appears. Or, if your trial period has expired, click on "Enter License Info…" in the expired license dialog that appears.

If your license information email is available copy the license information out of the email to the Windows clipboard. Then, paste the license information OR type the information into the license information form EXACTLY as it appears in your customer letter.

2.5 Setting up SpaceCAD

SpaceCAD automatically takes the localization information from your computer’s defaults. However, you can change those settings through the options dialog which is available in the Tools-menu (Tools->options).

Click on the “Localization” tab to change the measurement system. If you prefer inches and feet, please use “U.S.”, if you prefer meters; please use “metric” system.

You can also change SpaceCAD’s user interface language and set the default units which are used when no unit information is given in an input field.

3 Getting Started: Step-by-step

Some words on the philosophy of SpaceCAD: Just like any other model rocket software – and just like in real life – you build your model rocket by assembling different sub-parts together, e.g. a nose cone, then a body tube, etc. It's not different in SpaceCAD. To enter parachutes and such, you can use the general "weight" object.

3.1 Designing your rockets

SpaceCAD knows these types of objects:

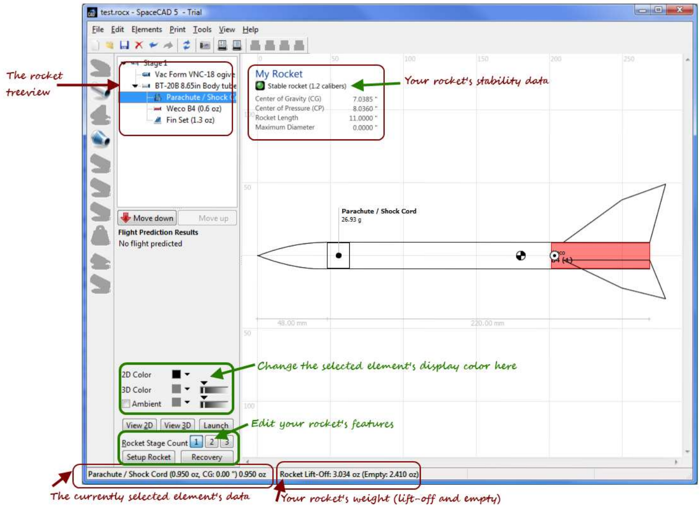
- Nose cones
- Body tubes
- Transitions (to connect two body tubes of different diameter)
- Inside Tubes (these tubes are inside of other tubes and are attached to the outer tube with centering rings)
- Fins
- Bulkheads (to connect two body tubes of the same diameter, or to be used for partitioning a tube)
- Centering Rings
- Weights (a general object that allows you to enter any type of weight at any position of your model rocket)
- Launch lugs (that will connect your rocket's fuselage to the launch rail)
- Motor mounts / Engines (which power your rocket)

After you have launched SpaceCAD, you are immediately presented with the startup screen. You can immediately start designing your rockets.

The best way to get started with SpaceCAD is to open the example file in the "My Rockets" directory, and play around with it.

You can edit the rocket elements by double-clicking on the treeview in the upper left corner of the screen, or you can add elements using the buttons. Also, you can copy/paste elements. They are automatically appended to the rocket.

You can move the elements in the treeview (except the nose cone) by clicking and dragging. Try it out!



3.1.1 Screen output

All the time you edit the data of your model rocket, you can see the values change:

- **Lift-Off weight** is the weight of your model rocket on the launch pad
- Empty weight is the weight of your model rocket with burned-out engines (the empty engines are still in the model rocket!)
- The length of your model rocket
- The **Center of Gravity** (CG) at launch and at burnout (designated with an arrow)
- The **Center of Pressure** (CP) of your model rocket
- The **stability** of your model rocket – either your model rocket is unstable, stable, or over stable. Details on CG and CP can be found in the chapter about the basics of model rocketry calculation.

3.1.2 Setup your rocket

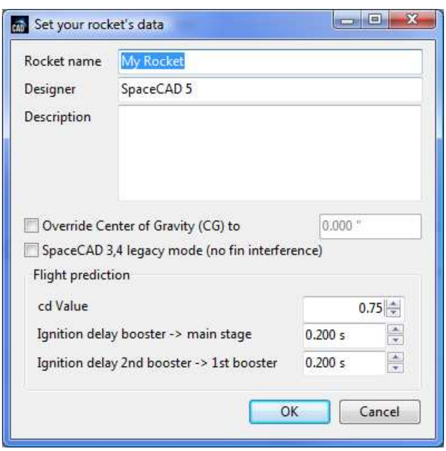
You can setup your rocket by clicking on the “setup rocket” button. You can select the number of stages by clicking on the numbered buttons.

This is the rocket setup dialog. You can give your rocket a name, which will be the displayed one. You can enter the designer (your name) and a short description.

Sometimes you have a completely designed rocket. That's when you can enter the data you have measured for the center of gravity (it's the balancing point of your model rocket) using "Override CG".

You can also set up flight prediction values:

- You can set the cd-value (which is usually around 0.75) and the descent rate of your model rocket (this is to calculate the parachute diameter for your model).
- You can select the **ignition delay** between the stages, and adjust the time when the engine is ejected
- The ignition delay can also be **negative**, which allows firing stage 2 while stage 1 is still burning.



3.1.3 Rocket display (2D, 3D)

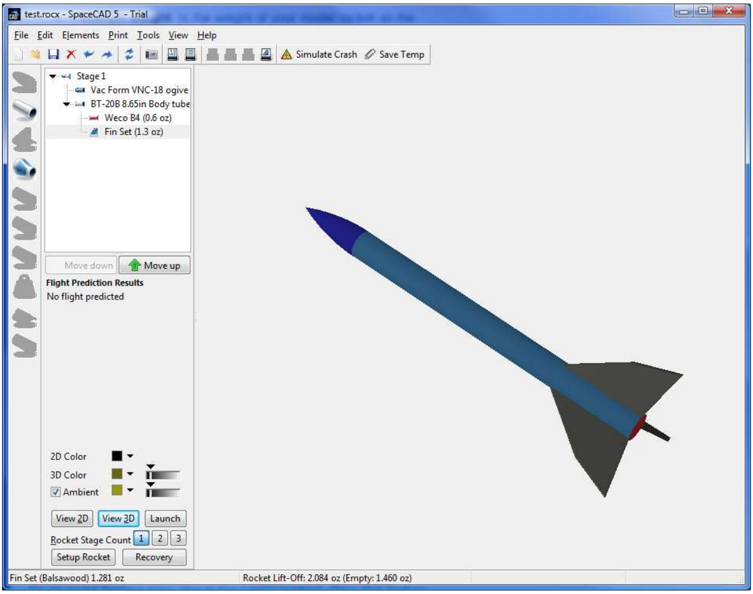
You can select how SpaceCAD displays your rocket by clicking on the "View 2D" or "View 3D" button. You can launch the rocket by clicking on "launch". This will display the flight prediction graph.

In 2D and flight prediction mode, you can use these mouse commands to zoom:

- Left click + move → zoom in
- Right click → zoom out

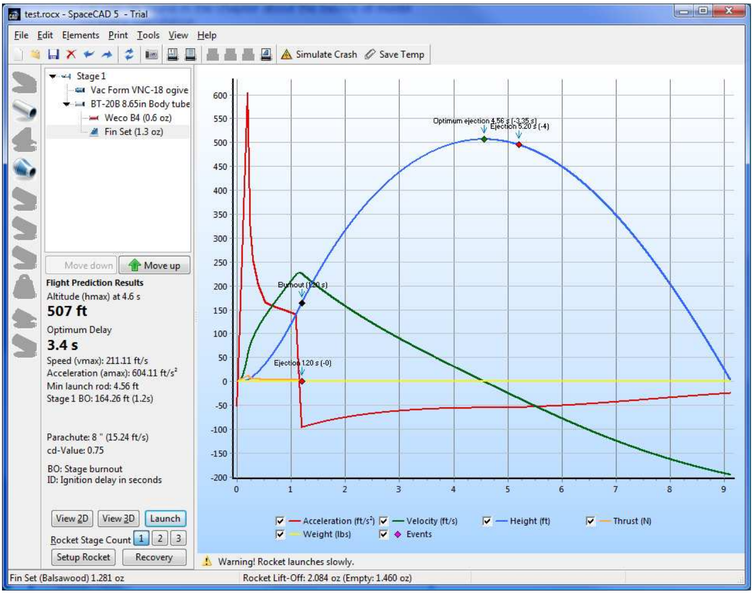
In 3D mode, you can use these:

- Mouse wheel to zoom in / out or right mouse and up/down movements
- Left mouse + move to rotate



3.1.4 Flight prediction

Clicking on the flight prediciton tab executes SpaceCAD's flight prediction of your model rocket. The flight prediction screen is displayed – with the graph of your model rocket's flight. Please note that SpaceCAD assumes that your model rocket will fly straight in the air at a 90° angle, and the display of height, velo city, and acceleration show the variation through time (the x-axis displays the time).



SpaceCAD displays this information in the graph about your model rocket:

- Height
- Velocity (the speed of your model rocket)
- Acceleration
- Thrust (of the engine)
- Weight (of the model rocket – which reduces due to fuel consumption)

Several data bits are derived from these curves:

- Maximum acceleration (how fast did it accelerate?)
- Maxium velocity (how fast did it go?)
- Maximum height (how high did it go?) your model rocket reached plus the information at which point of time this happened. SpaceCAD uses this information to calculate
- “Best delay” for this motor configuration (which delay should you choose for your model rocket / how should I set my flight computer’s time).
- Minimum launch rod length for this rocket
- Best parachute diameter for your rocket

You will notice that small rockets have a very high acceleration. That explains why the model rocketry safety index does not allow you to transport small animals: these accelerations are lethal for them. The reason for this fast acceleration is that a model rocket requires to have a certain speed to fly stable – there must be enough airflow over the fins to stabilize the flight of your model rocket (typically 13.5 m/s) once it leaves the stabilized environments of the launch pad.

You can zoom into the flight prediction graph:

1. Zooming into the chart: Click the left mouse button in the chart, drag to the lower right and release the mouse button. The selected box is then zoomed.
2. Moving around in zoom mode: By clicking and dragging with the right mouse button, you can change your viewport.
3. Zooming back: Click on the left mouse button, drag to the upper left corner and release the mouse button. The whole chart becomes visible again.

3.1.5 Recovery simulation

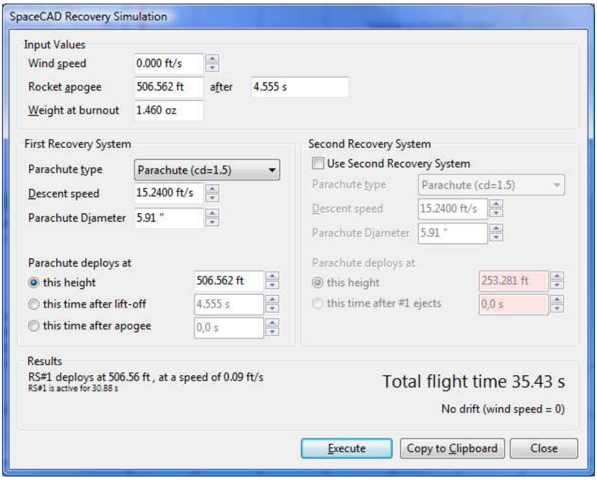
Location: Tools -> Recovery Simulation

The recovery designer allows you to analyze and fine-tune your rocket's landing.

This allows you to exactly see how long and how far away your rocket will float and how long it will take until it reaches the ground. This is especially helpful if you need to build your recovery system for an exact floating time, like in the TARC contest. Also, this feature allows your rocket to have two recovery systems that work in tandem. It can work on altitude ejection, time based ejection (after apogee or after launch), giving high-power rocketeers all the freedom they need to succesfully recover their rockets.

You can also prepare different recovery systems by running multiple simulations for different wind speeds. So you are prepared for all wind situations!

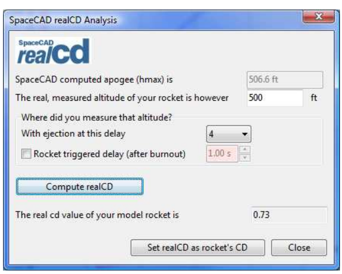
You can play around with the different values to find out how they affect your rocket's flight path.



3.1.6 Real CD Analysis

Location: Tools -> Find Real CD

SpaceCAD allows you to find out the real cd value by providing means to compare the measured altitude with the computed one.



Predicting the real cd value is difficult. Even complex algorithms that some software provides often does not reflect the "real" cd value of a model rocket. But, with today's means, it's easy to do it the other way round: equip your model rocket with an altimeter to measure the "real" altitude. Enter that data in SpaceCAD, and it will compute the real cd value from that. A very exact way to find out the real cd value!

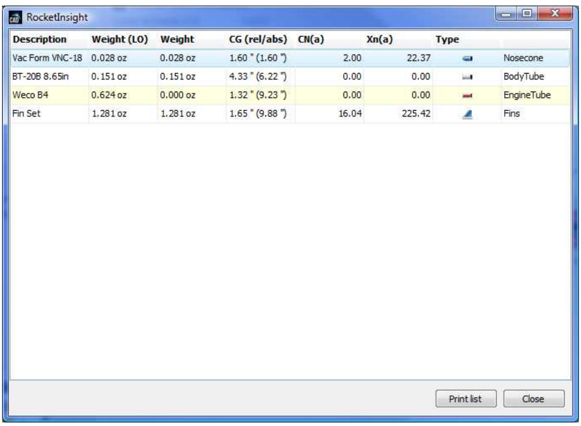
To use it,

- load (or design) a rocket
- go to the calculations menu
- click on "cd value derivation"
- enter the real (measured) altitude
- click on "next"

SpaceCAD now derives the real cd value from the height you have entered. It is important that you have loaded your rocket before, and that is has the same configuration as the model that you measured the height with.

3.1.7 Rocket Insight

Rocket insight allows you to view all your rocket's details in one dialog. You can open it through the Elements -> Rocket Insight menu.



4 SpaceCAD rocket elements

Some general notes on SpaceCAD's rocket elements dialogs. Most dialogs give you the option to enter a material, to select the element from the database and to add it to the database. All of them require a description that is displayed in the tree view.

When you see numbers behind the input fields, they correspond to the image to help you better understand which value is meant.

The color button allows you to select the color in which the element is drawn on the 2D-Screen.

Clicking "Apply" will immediately update the 2D-screen and all rocket-related data. This allows you to check how the CG and CP will react on your input.

Material selection

The material dialog allows you to select the material of the rocket part you are editing - either by selecting an item from the material database or entering the information directly ("direct input").

Typically, you have the "real" weight of the rocket's element – but the material is not included in SpaceCAD's material database. That's where you can use SpaceCAD's feature "convert to material". All you have to do is to enter the correct weight of rocket element, and SpaceCAD converts this automatically to a density (this is done by computing the volume of the rocket element you are editing) by clicking on the "convert to material" button. You can give it a name and save it to the database for future reuse!

If you click on "Set as default material" SpaceCAD will automatically choose this material everytime you open this dialog new.

Database interaction

Since you can buy model rocket elements in the shop, SpaceCAD comes with a large library of model rocket elements to help you design your model rockets faster. Simply click on the "select from database" button and select the element from the database. If it is not included in the database, you can easily add it – simply enter the data, and add it to the database. (Note - The databases are text files that are stored in SpaceCAD's data directory).

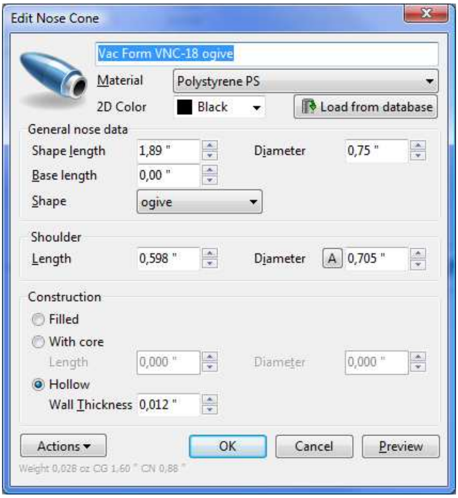
If the database dialog button is disabled, this means that no fitting element was found in the database – for example, you have a nose cone with a diameter of 2 inches and you want to add a body tube. If there's no body tube with a 2 inch diameter, the button is disabled.

Data input

To enter data in SpaceCAD, you provide the number and the unit. If you don't enter the unit, SpaceCAD uses the default unit settings from the Options dialog (see next chapter). You can enter data in mm, g, cm, kg, oz, in., and ft. .As soon as you leave the input box, SpaceCAD checks your input.

4.1 Nose cone

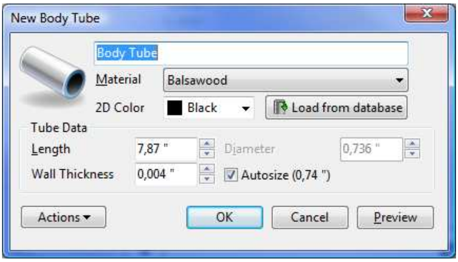
The only button that is enabled is the "nose cone" button. A model rocket can only have one nose cone, and it is always on the top… well, I guess you knew that before.



- You can choose the **shape** of the nose cone – the small image will be updated so that you can see how the nose cone will look like.
- The **shoulder** is the coupler that connects the nose cone to the body tube. The input is optional.
- You can **print** a nose cone pattern, which is a 1:1 representation of the nose cone you have entered.

4.2 Body tube

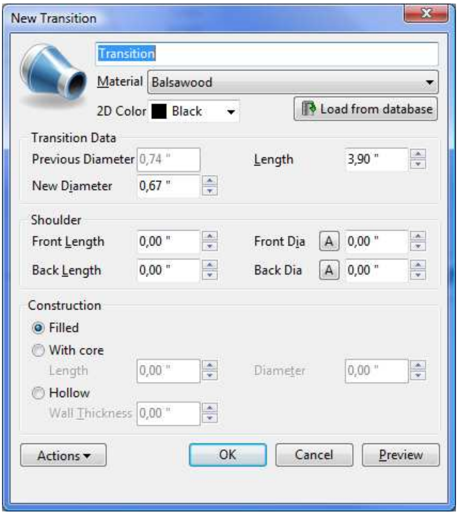
You can append body tubes to the end of the model rocket. They automatically adjust their diameter to the previous element – for example a nose cone, or a transition. If you move them around in the treeview, they change their diameter. This also applies to tubes from the database.



- When you select a body tube from the database, it automatically has the length it is sold in.
- The first page also displays you if your body tube has engines or fins – helpful, if you edit a model rocket element.
- When you click on “Preview Height”, SpaceCAD calculates your rocket with these values. You can “preview”, how high your rocket will fly with this motor configuration.

4.3 Transition

Transitions connect two body tubes of different diameter. They can have a shoulder (optional) just like the nose cone – one in front (sticking in the upper tube) and one back shoulder.

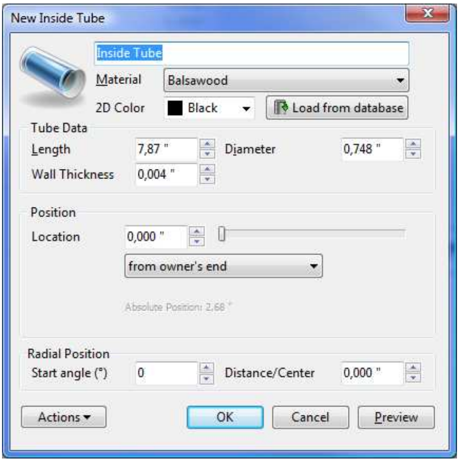


You can print a transition guide, allowing you to easily build a cutout transition.

4.4 Inside Tubes

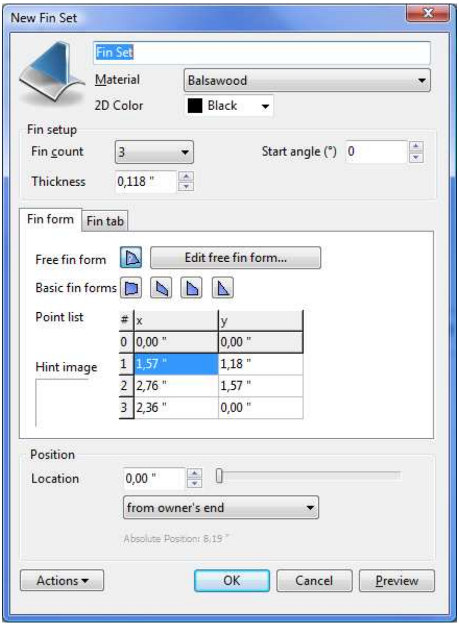
These tubes are inside of other tubes and are attached to the outer tube with centering rings.

Inside tubes can be used to channel your engine's ejection charge to the parachute bay. They are independent of the surrounding tube, and can be positioned with centering rings (that automatically adjust to the outer diameter of the containing body tube).



4.5 Fins

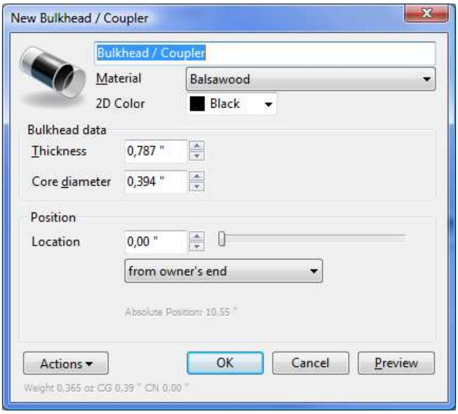
Your body tube can have an attached fin set. You can either enter the data for a predefined fin type, or you can use the free form editor. Simply click and drag the points around. You can print a fin and fin alignment guide – directly from the dialog.



- Fins can have "through-the-wall" tabs. This is especially helpful for high-power rockets that need specially attached fins.

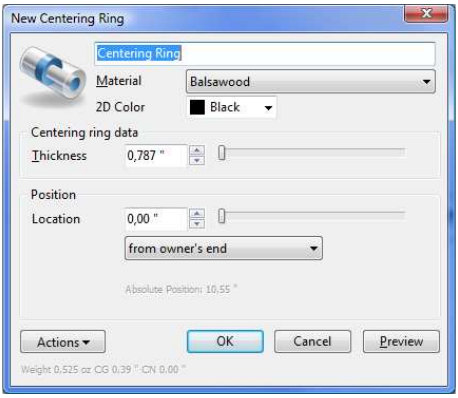
4.6 Bulkhead

Bulkheads are cylinders typically made of balsa wood that can either connect two body tubes as an internal coupler, or be used to partition off your body tube. SpaceCAD's bulkheads automatically adjust to the diameter of the surrounding body tube. Bulkheads can have a "core diameter" – a hole in the middle.



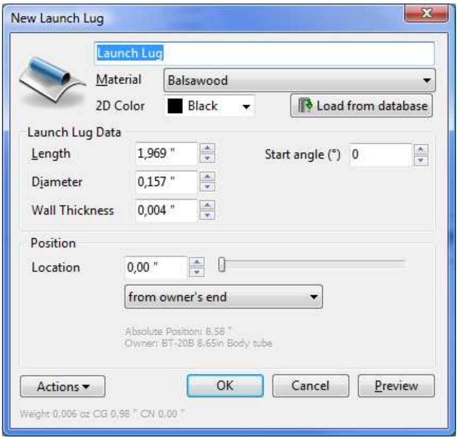
4.7 Centering Ring

Weights (a general object that allows you to enter any type of weight at any position of your model rocket)



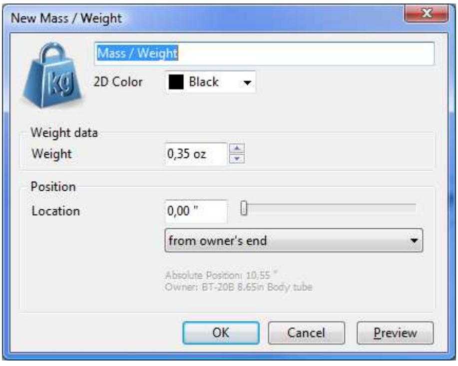
4.8 Launch lug

Your model rocket can also have a launch lug that will connect your rocket’s fuselage to the launch rail.



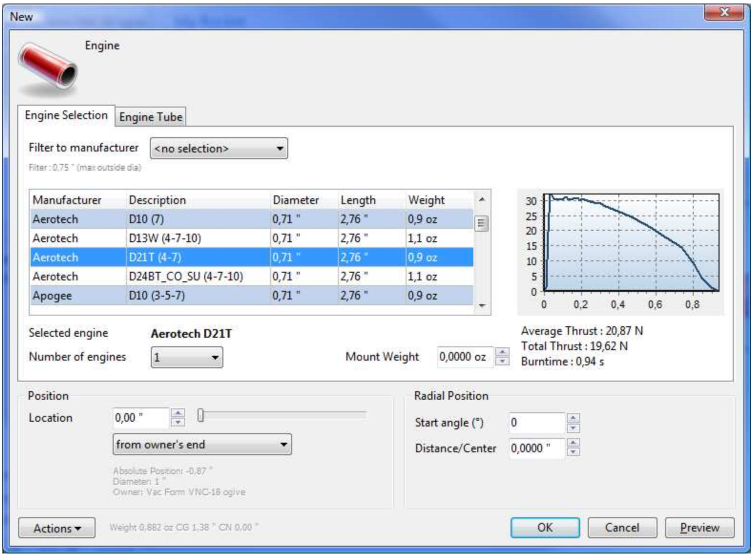
4.9 Weight

Weights are generic items that can be used for any object that has no representation in SpaceCAD, for example a recovery device (parachute, streamer) or altimeters. Of course, weights can also be used for trimming. Adding weight to the nose cone pulls the center of gravity to the top of the model rocket, while putting the weight into the tail section pulls the CG back. Usually, you need a trim weight in the nose cone.



4.10 Engine

You can add engines to your body tube. Simply select the rocket engine from the engine list. SpaceCAD displays the diameter of the model rocket and the list only contains engines that fit into that body tube. You can add a motor mount weight and you can define if the motor mount sticks out of the body tube.



5 Launch your rocket

Changes can happen when building – check for differences especially in weight and CG location. Don't forget to add stuff like wadding, parachute, shock cord, shock cord mount to the rocket tube.

When you have built your rocket, make sure

☑ Weights (Lift-off, empty) of actual rocket is same as simulated rocket

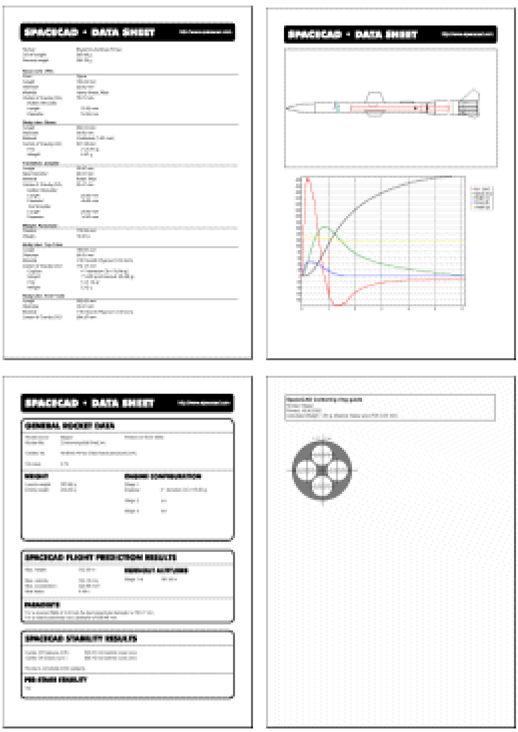
☑ Computed Center of Gravity (CG) is the same as the balancing point of your rocket when put on a string

☑ Print the rocket datasheet and take it with you to the range

☑ First launch: Follow NAR safety codex procedures

6 Print your design

When you are satisfied with your design, SpaceCAD includes a complete printout suite to help you to a ctually build your rocket. SpaceCAD allows you to print templates for fins, transitions, or parachutes. This feature will save you a lot of time, because you can skip ruler and compass.



6.1.1 Nose cone pattern

This prints a 1:1 profile of your nose cone. This is helpful if you want to build your own nose cones. You can use it as a pattern when you are working at the lathe.

6.1.2 Centering Ring pattern

Centering rings hold other tubes or engines. So you use them to hold these in place. SpaceCAD automatically checks which sizes you need to cut (and uses this also for its internal calculations). So you can use this to cut a centering ring from your desired material, plus you see where to drill the holes for your engine tube.

6.1.3 Print datasheet

Centering rings hold other tubes or engines. So you use them to hold these in place. SpaceCAD automatically checks which sizes you need to cut (and uses this also for its internal calculations). So you can use this to cut a centering ring from your desired material, plus you see where to drill the holes for your engine tube.

6.1.4 Print parts list (all elements & their data)

Centering rings hold other tubes or engines. So you use them to hold these in place. SpaceCAD automatically checks which sizes you need to cut (and uses this also for its internal calculations). So you can use this to cut a centering ring from your desired material, plus you see where to drill the holes for your engine tube.

6.1.5 Print parachute pattern / sewing help

Centering rings hold other tubes or engines. So you use them to hold these in place. SpaceCAD automatically checks which sizes you need to cut (and uses this also for its internal calculations). So you can use this to cut a centering ring from your desired material, plus you see where to drill the holes for your engine tube.

6.1.6 Print fin pattern & alignment guide

When you want to use the fins that you have designed you wonder how to turn that into a real fin. SpaceCAD makes it easy - with the fin pattern printer. This helps you to align the fins to the tube.

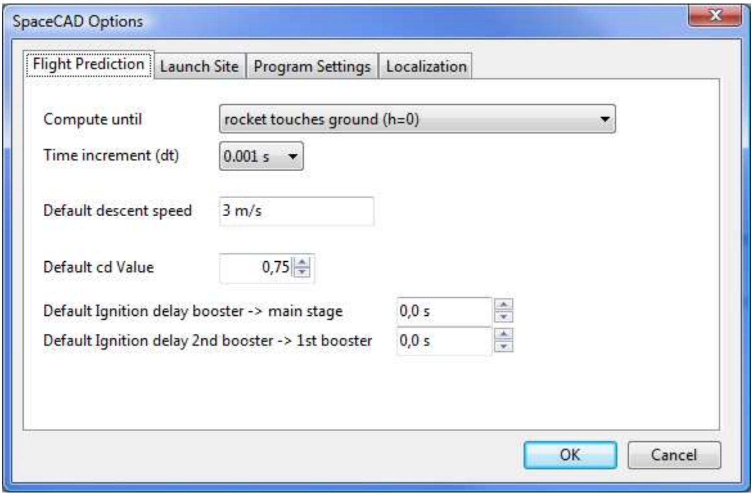
6.1.7 Parachute pattern print

SpaceCAD allows you to print patterns for hand-sewing them on your own parachute. That way you can easily make the big parachute yourself that heavy models require. It prints them on multiple pages and allows you to setup the number of panels (gores), the allowance to stitch them together and the sphere diameter. This is an invaluable tool for the expert rocketeer!

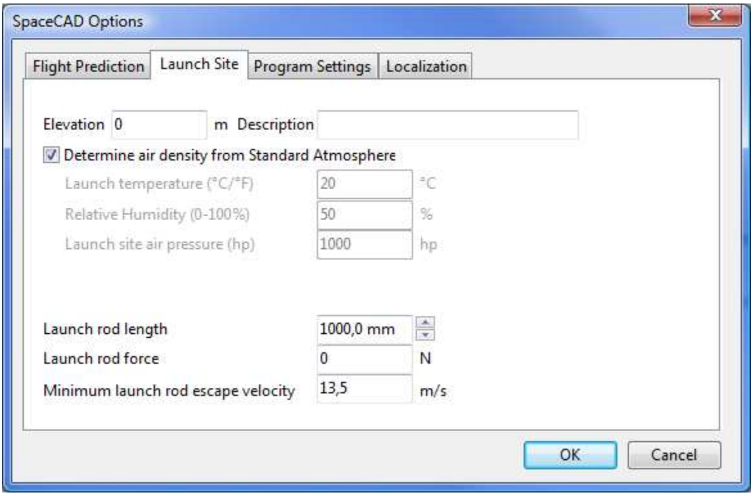
7 SpaceCAD settings

Location: Tools → Options

7.1.1 Flight prediction setup



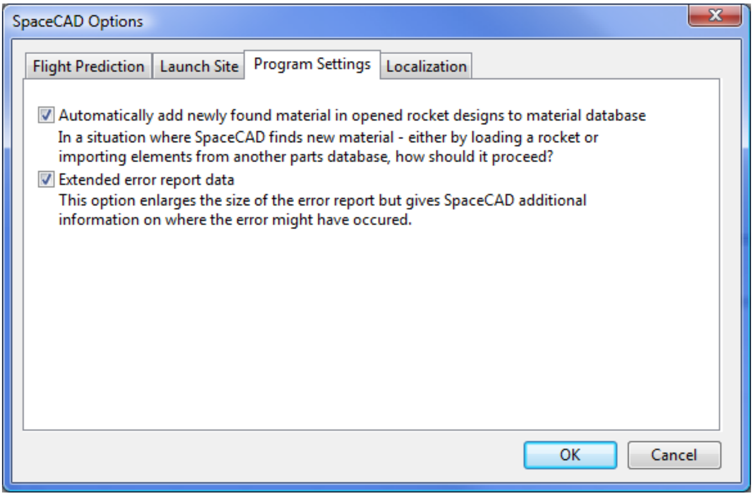
This dialog allows you to setup the flight prediction details that are used by default.



SpaceCAD allows you to enter launch site details like air pressure, height, humidity to realistically model the air density. Entering your **local launch data** results in a more accurate flight prediction, because the air density has an impact on your rocket's flight.

Alternatively, you can also let SpaceCAD use the "standard atmosphere" that uses a standardized way for the air density based on your launch site height. Basically, this allows you to simulate how the rocket flies at different launch sites - for example, if you're in Florida you can better prepare for the different conditions in Virginia.

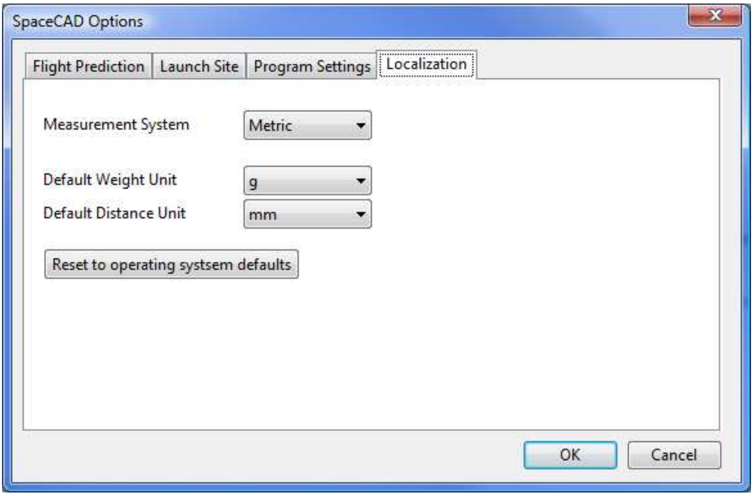
7.1.2 Program Settings



This dialog allows you to setup how SpaceCAD reacts when finding a new material.

Also, you can select extended error reporting.

7.1.3 Localization



You can select the measurement system SpaceCAD should use (metric or U.S.). By default, this is taken from the your system's regional settings

You can set the weight and distance unit SpaceCAD assumes if you don't enter a value.

8 NAR Safety Codex

1. Materials.
   I will use only lightweight, non-metal parts for the nose, body, and fins of my rocket.
2. Motors.
   I will use only certified, commercially made model rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer.
3. Ignition System.
   I will launch my rockets with an electrical launch system and electrical motor igniters. My launch system will have a safety interlock in series with the launch switch, and will use a launch switch that returns to the "off" position when released.
4. Misfires.
   If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher's safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.
5. Launch Safety.
   I will use a countdown before launch, and will ensure that everyone is paying attention and is a safe distance of at least 15 feet away when I launch rockets with D motors or smaller, and 30 feet when I launch larger rockets. If I am uncertain about the safety or stability of an untested rocket, I will check the stability before flight and will fly it only after warning spectators and clearing them away to a safe distance.
6. Launcher.
   I will launch my rocket from a launch rod, tower, or rail that is pointed to within 30 degrees of the vertical to ensure that the rocket flies nearly straight up, and I will use a blast deflector to prevent the motor's exhaust from hitting the ground. To prevent accidental eye injury, I will place launchers so that the end of the launch rod is above eye level or will cap the end of the rod when it is not in use.
7. Size.
   My model rocket will not weigh more than 1,500 grams (53 ounces) at liftoff and will not contain more than 125 grams (4.4

ounces) of propellant or 320 N-sec (71.9 pound-seconds) of total impulse. If my model rocket weighs more than one pound (453 grams) at liftoff or has more than four ounces (113 grams) of propellant, I will check and comply with Federal Aviation Administration regulations before flying.

8. Flight Safety.
   I will not launch my rocket at targets, into clouds, or near airplanes, and will not put any flammable or explosive payload in my rocket.

9. Launch Site.
   I will launch my rocket outdoors, in an open area at least as large as shown in the accompanying table and in safe weather conditions with wind speeds no greater than 20 miles per hour. I will ensure that there is no dry grass close to the launch pad, and that the launch site does not present risk of grass fires.

10. Recovery System.
    I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

11. Recovery Safety.
    I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places.

Launch Site Dimensions

Installed Total Impulse (N-sec)	**Equivalent Motor Type**	**Minimum Site Dimensions (ft.)**
0.00--1.25	1/4A, 1/2°	50
1.26--2.50	A	100
2.51--5.00	B	200
5.01--10.00	C	400
10.01--20.00	D	500
20.01--40.00	E	1,000
40.01--80.00	F	1,000
80.01--160.00	G	1,000
160.01--320.00	Two Gs	1,500

Revision of February 2001. Source: http://www.nar.org/NARmrsc.html