

# Build Your Own Digital Railway

## Mode of Construction Recommendations

Listed below are several suggestions for how student teams can go about building the models for their digital railway. You may wish to have every group use the same mode of construction, depending on time and resources available, or you may wish to allow groups the freedom to choose their own.

Each mode of construction has a different learning curve, level of model complexity that can be produced, usage requirements, and expected cost range.

The table below gives a general overview on the different options:

Construction Choice Overview				
Mode of Construction	Learning Curve	Complexity	Cost Range	Requirements
<b>Engineering BIM Software</b>	HIGH	HIGHEST	Most software is free or discounted to educators and students	Computers that can handle running engineering software. See specifications on manufacturers' websites.
<b>Sandbox Video Games</b>	MEDIUM	MODERATE-HIGH	Free to upwards of £17.95 per students	Computers that can run games with low to moderate graphics requirements. Possible separate computer to run as world server.
<b>Building Kits</b>	LOW	LOW	£18.49 per student team to £569.99 per team	Building kit materials.
<b>Craft Construction</b>	VERY LOW	MODERATE	£0 if using recycled materials; otherwise, costs are relatively low	Craft tools (i.e. s scissors, hot glue, tape, rulers, etc.)



## Engineering BIM Software

### Overview:

BIM software is more than just CAD or 3D modelling. It allows the user to add building information such as: time, cost, manufacturer details, sustainability and maintenance information, etc. to the building model.

The table below shows several different types of software that can be used:

Engineering Software Comparison			
Software†	Cost	Comments	Computer Requirements†
<b>AutoDesk Revit</b>	Free*	BIM software that allows users to create 3D CAD models, annotate them with 2D drafts, and create a building information database	<a href="http://knowledge.autodesk.com/support/revit-products/troubleshooting/caas/sfdcarticles/sfdcarticles/System-requirements-for-Autodesk-Revit-products.html">http://knowledge.autodesk.com/support/revit-products/troubleshooting/caas/sfdcarticles/sfdcarticles/System-requirements-for-Autodesk-Revit-products.html</a>
<b>SketchUp Make</b>	Free*	SketchUp is a 3D modelling software. It has an assortment of useful plugins and libraries that help to model structures and incorporate BIM	<a href="http://help.sketchup.com/en/article/36208">http://help.sketchup.com/en/article/36208</a>
<b>Graphisoft ArchiCAD</b>	Free**	2D and 3D drafting software with documentation functions for users to create detailed technical documentation	<a href="http://www.graphisoft.com/support/system_requirements/AC18/index.html">http://www.graphisoft.com/support/system_requirements/AC18/index.html</a>
<b>Bentley MicroStation</b>	Free*	CAD software 2D and 3D design and drafting. Can also generate smart 3D BIM models based on input parameters	<a href="ftp://ftp.bentley.com/pub/help/microstation/081109292en/readme.htm">ftp://ftp.bentley.com/pub/help/microstation/081109292en/readme.htm</a>
<p>*Companies offer free software licenses to students and educators only  **Free to design and architecture students. Contact Graphisoft to see if you qualify  †Outdated software, computer requirements, and hyperlinks may no longer be relevant. Table is up to date as of April 2015.</p>			

**Pros:**

- Students will learn a marketable skill that they can put on their resume/CV
- Students will have a head start on understanding CAD and engineering software if they end up pursuing a related career or university degree
- Most software is free to students and educators
- Students can create models with the highest level of complexity and detail

**Cons:**

- High learning curve
- May require ambassador or volunteer help to teach the software
- Usually only one student will be able to work on the model at a time
- Requires computers that are able to run the software

**Recommendations:**

It is recommended to use AutoDesk Revit if choosing to use engineering software. Revit is one of the most commonly used types of BIM software. Other AutoDesk products, such as AutoCAD, are also used in universities and in engineering careers. Having knowledge in related programs is beneficial if students wish to pursue a degree or career in an engineering related field.

If instructor, ambassadors, or students are more familiar with one of the other programs above, then that software can easily be used instead. Bear in mind that time will have to be set aside for students to learn how to use the software properly. Formal instructional lessons can be delivered by teachers or ambassadors. Students can additionally be assigned to work on software tutorials and practice using it on their own time, if possible. There is a plethora of online resources available that students can take advantage of to learn how to use the software.

## Sandbox Video Games

### Overview:

Sandbox games allow players to freely roam and interact with a virtual environment. Many sandbox games let players build objects of variable complexity from static block structures to dynamic constructions controlled by intricate circuitry. Players can often work together on a project at the same time if they are connected to the same server which is usually hosted on a separate computer or through a paid hosting site.

Below is a brief overview of different sandbox games available:

Sandbox Games Overview				
Game <sup>†</sup>	Cost	Comments	Computer Requirements <sup>†</sup>	Server Requirements* <sup>†</sup>
<b>Minecraft</b>	<ul style="list-style-type: none"> <li>£17.95 per license</li> <li>£8 per month for hosted server</li> <li>Free self-hosted servers*</li> </ul>	Minecraft is one of the most popular sandbox games on the market. You collect and place blocks to build anything you can imagine.	<a href="https://help.mojang.com/customer/portal/articles/325948-minecraft-system-requirements">https://help.mojang.com/customer/portal/articles/325948-minecraft-system-requirements</a>	<a href="http://minecraft.gamemedia.com/Server/Requirements">http://minecraft.gamemedia.com/Server/Requirements</a>
<b>MinecraftEDU</b>	<ul style="list-style-type: none"> <li>£9.5 - £12 per license</li> <li>£14 per month for hosted server</li> <li>£28 for server software*</li> </ul>	Educational version of Minecraft. Includes access to commercial edition of Minecraft as well.	Same as above	Same as above
<b>Blockland</b>	£6.99 per license	Gameplay is similar to a virtual LEGO world	<a href="http://www.blockland.us/Help.html">http://www.blockland.us/Help.html</a>	<a href="http://www.blockland.us/portforward/index.html">http://www.blockland.us/portforward/index.html</a>
<b>Minetest</b>	Free	Open-source Minecraft clone. Similar gameplay with limitations and not as many features.	<a href="http://www.minetest.net/">http://www.minetest.net/</a>	<a href="http://wiki.minetest.net/Setting_up_a_server">http://wiki.minetest.net/Setting_up_a_server</a>
<b>Roblox</b>	Free	Multiplayer sandbox world in which users build things out of different sized blocks and share with friends.	<a href="https://en.help.roblox.com/hc/en-us/articles/203312800-Technical-Issues-Computer-Hardware-Operating-System-Requirements">https://en.help.roblox.com/hc/en-us/articles/203312800-Technical-Issues-Computer-Hardware-Operating-System-Requirements</a>	N/A

\*Not required if using server hosting services

<sup>†</sup>Outdated games, computer requirements, server requirements, and hyperlinks may no longer be relevant. Table is up to date as of April 2015.

**Pros:**

- Effective way to engage students
- Students may already be familiar with the game or own it
- Multiple students can work at once if connected to a server
- Can create a moderately high level of complexity depending on game used

**Cons:**

- Computers with appropriate system requirements are required to run the games
- If using a server to allow students to collaborate simultaneously, an additional computer and internet connection may be required. Alternatively, a paid subscription to a hosting service will have to be used.
- Slight initial learning curve, but overall easier than CAD software

**Recommendations:**

If choosing to use a sandbox game, it is highly recommended to use Minecraft or MinecraftEDU because of the abundance of tutorials, wiki articles, and other instructional information readily available for both games. Other games are free, but some are open source and do not have the same capabilities as Minecraft and MinecraftEDU.

Purchasing MinecraftEDU also allows access to the commercial edition of Minecraft. However, students can only log on to a MinecraftEDU server through MinecraftEDU. A server is not entirely essential, but is recommended as it does allow students to work together at the same time in the same virtual world rather than one person working at a time. Servers can either be hosted by the instructor on a computer or through a hosting service for a small monthly fee. For more information on hosting servers see [https://help.mojang.com/customer/portal/articles/429052-how-do-i-play-on-a-multiplayer-server-?b\\_id=5408](https://help.mojang.com/customer/portal/articles/429052-how-do-i-play-on-a-multiplayer-server-?b_id=5408)<sup>1</sup> for information on Minecraft and <http://minecraftedu.com/hosting><sup>1</sup> for information on MinecraftEDU.

Since some students may already have knowledge of Minecraft and own the game, deciding to use the commercial Minecraft or the EDU version is dependent on convenience for educators, student knowledge, and computer availability. If students are particularly interested in using a sandbox game for their project, instructors can encourage teams to test out some of the free games and do their own research before instructors purchase licenses for the paid games.

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<sup>1</sup> Outdated links may be irrelevant. Last updated/checked April 2015



## Building Kits

### Overview:

Building kits contain an assortment of interlocking or connectable pieces that can be combined to create different structures.

Below is a table of a few brands of kits along with price ranges for each:

Kit Comparison		
Building Kit	Cost Range*	Comments
<b>LEGO</b>	£34.99 - £335.99	Kits can range from basic brick sets to LEGO Mindstorms kits.
<b>K'NEX</b>	£18.49 - £90.10	Many kits include a wide assortment of K'NEX pieces. Amount of total pieces is generally linearly proportional to pricing
<b>VEX</b>	£299 - £569.99	VEX is geared more towards creating and programming robots. Kits are very expensive and somewhat limited in what can be built.
*All costs shown are regular prices (no educational discounts applied) including VAT. Contact respective companies for educational pricing and bulk order discounts. Prices are recent as of April 2015		

**Pros:**

- Kits can easily be reused for multiple years
- Offers a more structured mode of construction for students
- Easier and quicker option if there are time constraints

**Cons:**

- Model can only have a low to moderate level of complexity since kits are limited by type and amount of pieces
- Kits can be very expensive
- Can limit the creativity of students by being too structured

**Recommendations:**

It is not highly recommended to use building kits for this project. Despite their ease of use, kits are generally expensive and limit what the students can build. For this reason, kits should really only be used if there are significant time constraints.

The instructor can, however, work these drawbacks into the lesson plan if they give teams a budget and have them buy the kits and pieces they need to complete their project. These tie in with concepts such as cost planning and resource acquisition.



## Craft Construction

### Overview:

Craft Construction can include anything from cardboard and duct tape to wood and screws to create a physical model.

### Pros:

- Allows the most creativity and flexibility.
- Costs can be close to zero if using recycled materials
- Low learning curve, students do not need to know much to begin construction

### Cons:

- Requires relevant tools to work with whatever materials are being used.
- Potentially most dangerous if using sharp hand tools, scissors, etc.

### Recommendations:

Craft construction is highly recommended if the use of computers is difficult or limited. It offers the most flexibility and can be one of the cheaper options. Instructors can give students a budget and have them research and source their own materials or alternatively provide an assortment of materials in bulk.

If the use of dangerous tools is required, be sure to go over safety rules beforehand. Stressing a “Target Zero” attitude is important to make sure that any accidents are prevented. Health and Safety are critical concepts in construction and engineering and can be tied in to the overall project.

## Other

These are only a handful of possible construction modes for this project. Students are encouraged to research other ways to construct their digital railway. Instructors can also have students combine different modes to make both a virtual and physical model of their project. If access to a 3D printer or laser cutter is possible, having students take CAD models they create and then 3D print or laser cut them is a great way to combine virtual and physical elements of design.