TRUCTIONARIUM
CONCEPT DEVELOPMENT

APRIL 2012

think up

OVERVIEW

The aim of the Constructionarium is to inspire undergraduate students to take up a career in construction, and to help them develop their practical skills by giving them the opportunity to carry out real construction activity in an exciting and challenging hands-on learning construction event. While students from a large number of university courses take part in Constructionarium, one barrier to participation has historically been access to the original site in Bircham Newton, in Norfolk.

Think Up has therefore been commissioned to explore the idea of operating a more mobile version of the Constructionarium, dubbed the 'Tructionarium'. This document sets out our initial thoughts on how the Tructionarium could work in practice.

DEPLOYING A REALISTIC AND EXCITING LEARNING ENVIRONMENT

If increased access is the original driver for the Tructionarium, it is important that the event be easy to deploy. As a working requirement, we suggest that it should be possible to deploy the event at a new site each week. It follows that the host sites for the event should require little preparation. It also makes sense that the event should make the most of local sources for consumable construction materials and plant for hire.

At the same time, in order for the Tructionarium to maintain the same impact as its ancestor, we believe it is important to be able to create an exciting learning environment in which realistic construction activities can take place. The requirement for easy deployment effectively means the construction activities must take place at or above ground level. While the scale of construction activity is necessarily limited by the need for easy deployment, it should still be possible to create an exciting learning space in much the same way that a traveling circus does: arriving at a site; establishing a boundary; and filling it with exciting hands-on activities to keep learners engaged.

Our proposal is to use shipping containers both as the mode of transport for the Tructionarium, and also to provide a base from which students will build their structures. Shipping containers offer a number of advantages:

- They are an economic way to transport materials around the country
- They are cheap to hire or purchase and easy to modify
- They come in many shapes and sizes and there are a wide range of other add-ons available
- They are robust and offer substantial structural strength
- They provide a secure place for storing equipment

THE WORKING CONCEPT

Universities will book Tructionarium to come to a nearby site to deliver a set of student-led construction projects. Universities can choose from a suite of 4-day projects that cover a range of structural forms: bridges, a tower, an offshore structure, a building; and that use a range of construction materials, including concrete, steel, masonry, timber and a host of renewable construction materials. Universities will choose the projects that they want for their Tructionarium event from a menu of options. For some projects there may be a choice of different construction materials to suit the university's desired learning outcomes. Universities will partner with a local contractor to deliver Tructionarium. The site can be either university land, or another local site to which the university has secured permission to run Tructionarium.

Each Tructionarium event is tailored according to the needs of the site and of the host university. The basic components are: a HQ container required for all events; project containers; collapsable portacabins for classroom space; locally hired construction plant and tools; and locally sourced construction materials.

A Tructoinarium site supervisor will oversee the deployment and decant, and to supervise the activity on site while Tructionarium is deployed. The site supervisor is assisted by at least one site operative. Constructionarium will train a team of site supervisors based around the country that can be contracted to supervise Tructionarium events in their area. This training will take place at the Constructionarium site at Bircham Newton. Additional supervision will be provided by the university's partner contractor.

When not in use, the HQ and project containers are stored at site such as NCC West Midlands, which is close to the motorway network and within easy reach of haulage companies. The Tructionarium will arrive at the site on Monday, when the Tructionarium operatives will deploy the various components ready for students to start on the Tuesday. The event will conclude on Friday early afternoon. The event will be packed down and transported to the new site over the weekend. Tructionarium will require a general manager to oversee university bookings, to book haulage of the containers from the storage location to the host site, to book local plant, to manage maintenance of the equipment, and to book local supervisors.

THE SITE

The host site for the Tructionarium should be an area of hard standing suitable for the delivery of shipping containers by lorry. The containers will be positioned using a hiab. The amount of space required depends on the number of projects programmed in. For a basic Tructionarium event involving three projects, an area of approximately 100m x 100m is required. Other requirements are as follows:

- Services: the Tructionarium will require three-phase power for lighting and some tools. If this is not available, then the event can powered using generators. The event will also require access to mains water.
- Classroom space - students need to access to space that they can use as their site office. If there is no classroom space available at the host site, collapsable portacabins can be ordered as part of the event.
- Catering - it is expected that participants can be fed in the vicinity of the event; however there will be a drinks station at the Tructionarium.
- Toilets - if there are no toilets in the vicinity of the site, then portaloos will must be hired in locally.

THE HQ

The HQ is deployed for every Tructionarium event. It contains the equipment that is used to help set up the site (signage, fencing, first aid equipment, basic tools, PPE, catering tent etc). Once on site it becomes the tool shed and the site manager's office. As well as being a hub for the Tructionarium, it is also one of the bases for the Millau Viaduct project (see below).

The HQ is a 20ft x 8ft shipping container that is modified as follows: to include a small site office at one end; to attach hand rails to the top and a staircase at one end; and to attach the bearing pads for one half of the Millau Viaduct project on the roof.

PROJECT CONTAINERS - GENERAL

All Tructionarium projects use a container-based component as a starting point for construction. In the very simplest cases, a container base is used as a solid foundation onto which other structural elements are attached, enabling us to create projects that do not require any foundations below ground level. In more complex cases, the containers are used to form the sides of a dock, or the base of a river bed. When being transported, the containers are used to carry all of the reusable components of each project. In each case, it should be possible to vary the level of complexity of the project. For example: students can either be asked to set out components, or be told where the components should be positioned; some structural components can be built from concrete or steel.

EXAMPLE PROJECTS

Millau Viaduct + Barcelona Tower + Masonry Arch

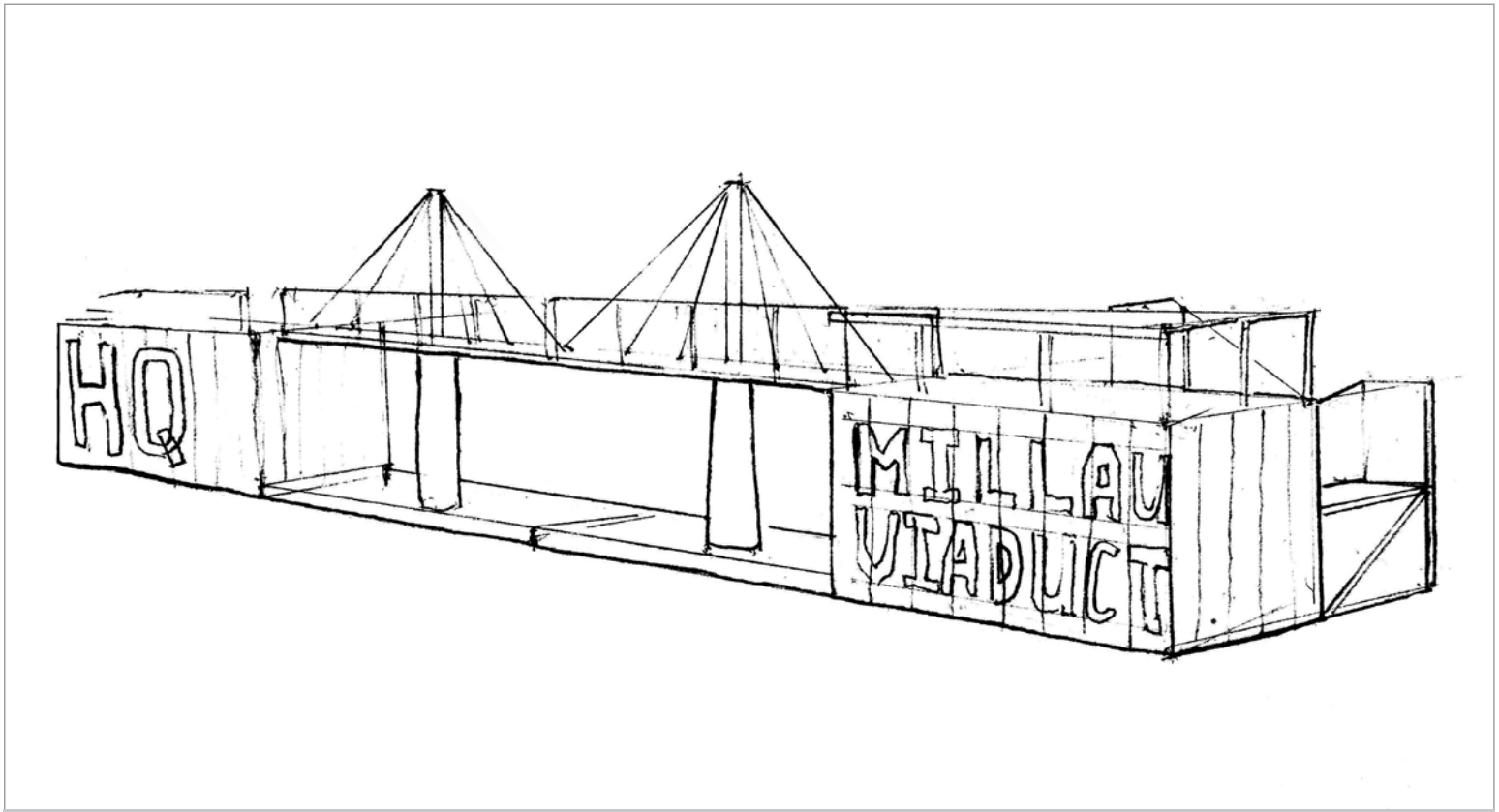
This three-in-one project set is designed as the basic project set to be delivered as part of the Tructionarium. The set requires one 20ft x 8ft container, and five 20ft x 8ft bases, which means that this set of projects can be transported in two 20ft x 8ft haulage berths. The container is used to transport all the reusable components, and forms one half of the base for the Millau Viaduct project.

Millau Viaduct

Based on the existing Millau Viaduct Constructionarium project, students bridge the gap formed between two shipping containers (one of which is the Tructionarium HQ) using an analogous construction method to that used on the original project. Students must build two bridge piers in the gorge, while the two halves of the superstructure are built on top of the two shipping containers, ready to be slid into place on the last day.

Two container bases are placed in the gap between the two containers that form the valley sides. The bridge piers are constructed on base plates attached to the container bases, thus providing a foundation for the structure. Universities choose whether they want students to build the bridge piers from concrete or steel. The students pre-fabricate the superstructure elements at ground level and then attach the launching blocks, covered with a neoprene pads onto the roof of the containers. The superstructure elements are lifted onto the roofs using a telehandler. In the final stage, the students push the two bridge elements together to complete the structure.

The container elements used in this project require minimal adaptation: the main container needs to be modified to attach hand rails, a stair case, attachment points for the launch blocks on the roof and connections to attach the base that forms the valley floor; the base element needs to be modified so that the pier base plates can be securely fastened.

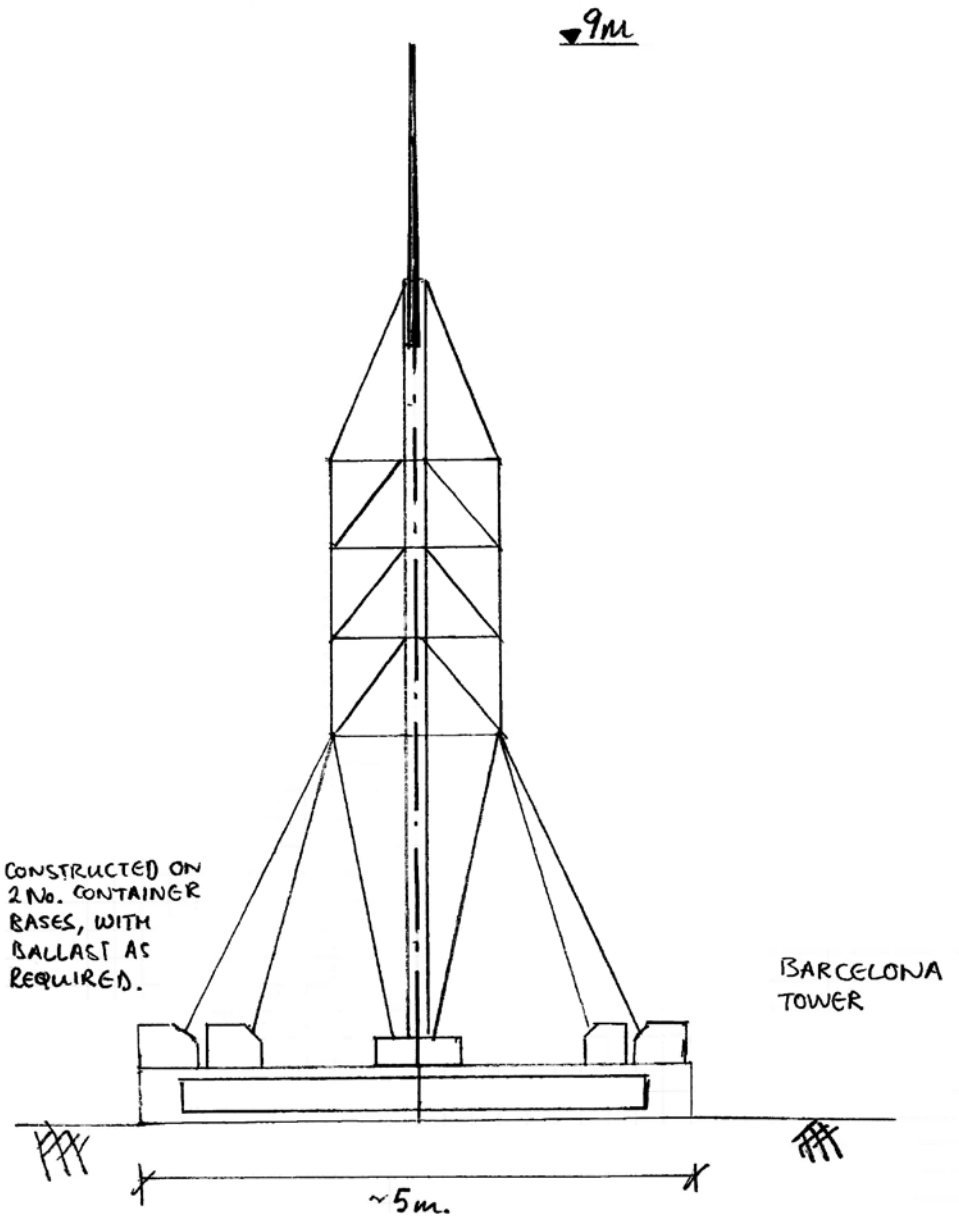


Sketch showing how the Millau Viaduct project could be deployed between two shipping containers, with shipping container bases providing a foundation for the bridge piers

Barcelona Tower

This is another project based on an existing one at the Constructionarium. In this project, students will recreate the Barcelona communications tower using the same construction sequence principles: first building a central core, constructing the superstructure at ground level and then jacking the superstructure up the core. The base for the project consists of two container bases attached to one-another side-by-side. As for the Millau Viaduct project, the core is attached to a base plate which is in turn attached to the two container bases. The core is constructed either using slip-formed concrete (in which case the concrete core is case onto the base plate) or using steel sections (in which case the sections are bolted to the base plate. Once the core is formed, students build the superstructure at ground level. The structure is them jacked into position and the cable supports or anchored to the edge of the container bases.

The re-useable elements for this project are transported in the Millau viaduct container. The two container bases for this project need to be modified in order to: provide a moment-resisting connection between the two; receive the base plate for the core; and to attach the cable anchors for the tower.



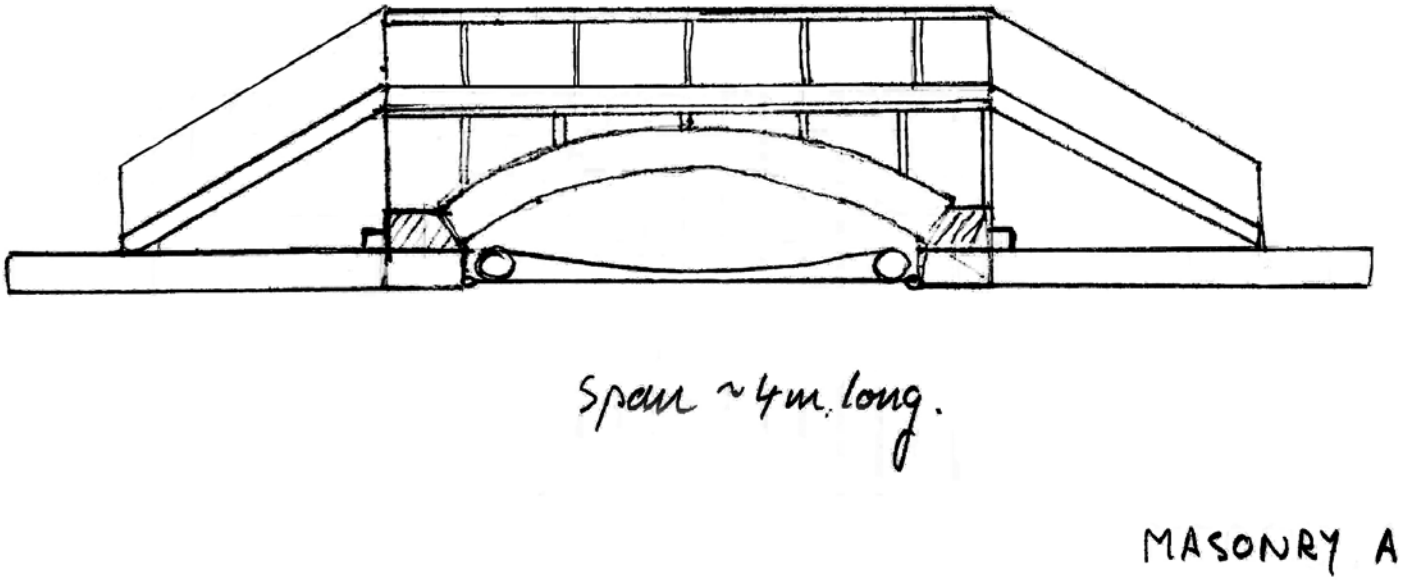
The Barcelona Tower could be constructed on base fabricated from shipping container bases, weighted down to resist over turning.

Masonry Arch

This project would be a new project designed for Tructionarium to give students the opportunity to work with masonry. In this project students construct two concrete bridge abutments, build a timber formwork, build a masonry arch, and then a deck to pass over the top (deck material tbc). Students should also form approach steps or ramps on either side.

The abutments for the bridge are built on two container bases set apart from each other; the gap between the two is the river that the bridge must cross. The river is formed from a tarpaulin slung between two inflatable tubes. The tarpaulin will be on a slight incline, so that water will flow one end to the other from where it will be pumped back to the top. The thrust from the masonry arch is resisted by two cables that will link the two container bases together and that will be hidden under the river.

The re-uaseable elements for this project are transported in the Millau viaduct container. The two container bases for this project need minimal modification - the creation of a shoe into which the bridge abutments can be built, and points to attach cables for resting the lateral thrust for the bridge



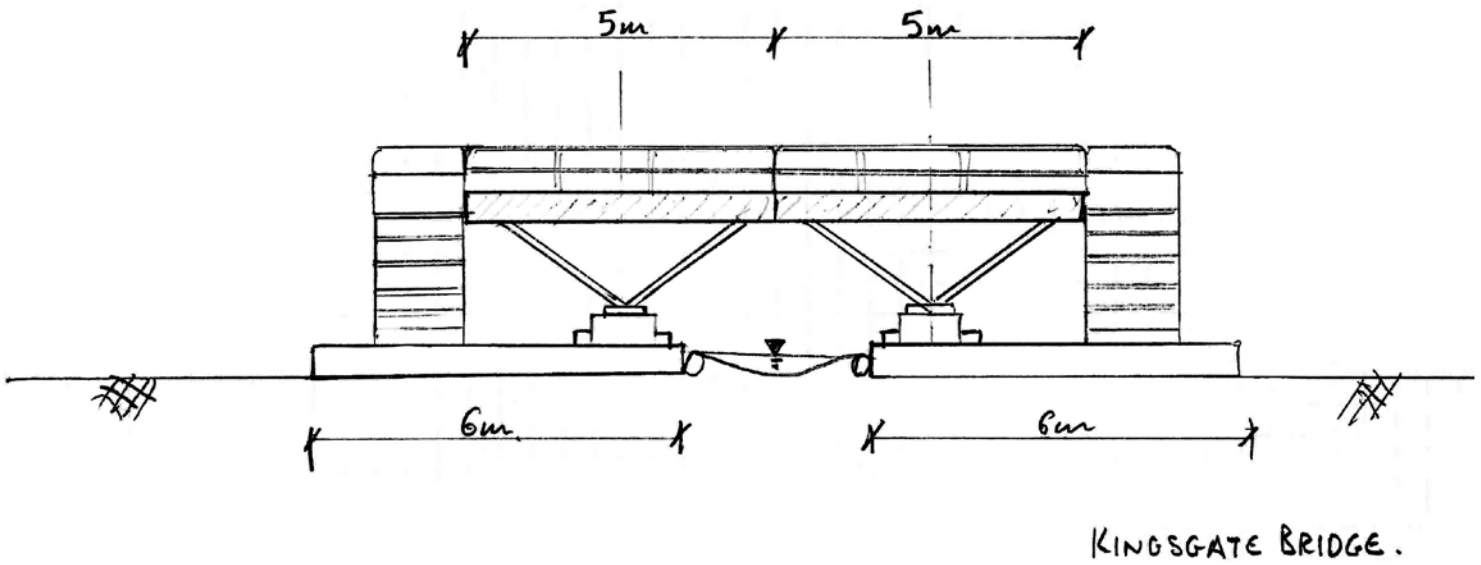
Sketch showing how a masonry arch could be built between two shipping container bases, connected by a pair of steel cables that would resist the horizontal thrust of the arch

Kingsgate Bridge

This uses the same principles as the Constructionarium project of the same name. It is a standalone project that requires one half-height shipping container, and two container bases, which means it can be delivered to site in a single 20ft x 8ft haulage berth. Like the masonry arch bridge proposed above, the landscape for this project is built using two container bases, between which a river flows, constructed from a tarpaulin slung between two inflatable tubes.

Students build the bridge piers within a shoe on each of the two container bases. Precast deck elements are built on the ground adjacent to the two sides. A telehandler is used to lift the steel superstructures onto the bearings mounted on the bridge piers, after which the deck units are lifted onto the steel superstructures.

The re-uaseable elements for this project are transported in a half-height shipping container. The two container bases for this project need minimal modification - the creation of a shoe into which the bridge abutments can be built, and points to attach cables for resting the lateral thrust for the bridge.



Like the masonry arch, the Kingsgate bridge could be built to bridge the gap between two shipping container bases.

Multi-building

This is a new project The idea is to create a flexible building structure into which a range different construction materials and techniques can be included. The basic structure is in steel, built on two container bases attached side-by-side. The column elements are attached to the container base using bolted connections. Lateral stabilit is either provided by cross-bracing or infill elements.

This basic framework provides a structure within which students can construct using a range of other materials: masonry, timber, concrete, hempcrete, straw bales, rammed earth… to name a few. This project is deliberately flexible so that universities can choose which construction methods they want to demonstrate. A flexible project such as this also provides opportunities for widening the potential audiences for Tructionarium, to people involved with building design, construction and operation in general.

The two shipping container bases used as the basis for this project need to be modified in order to accommodate the steel columns. The reusable components for this project can be transported in a half-height container, which means that in total the project can be transported in a single 20ft x 8ft haulage berth.

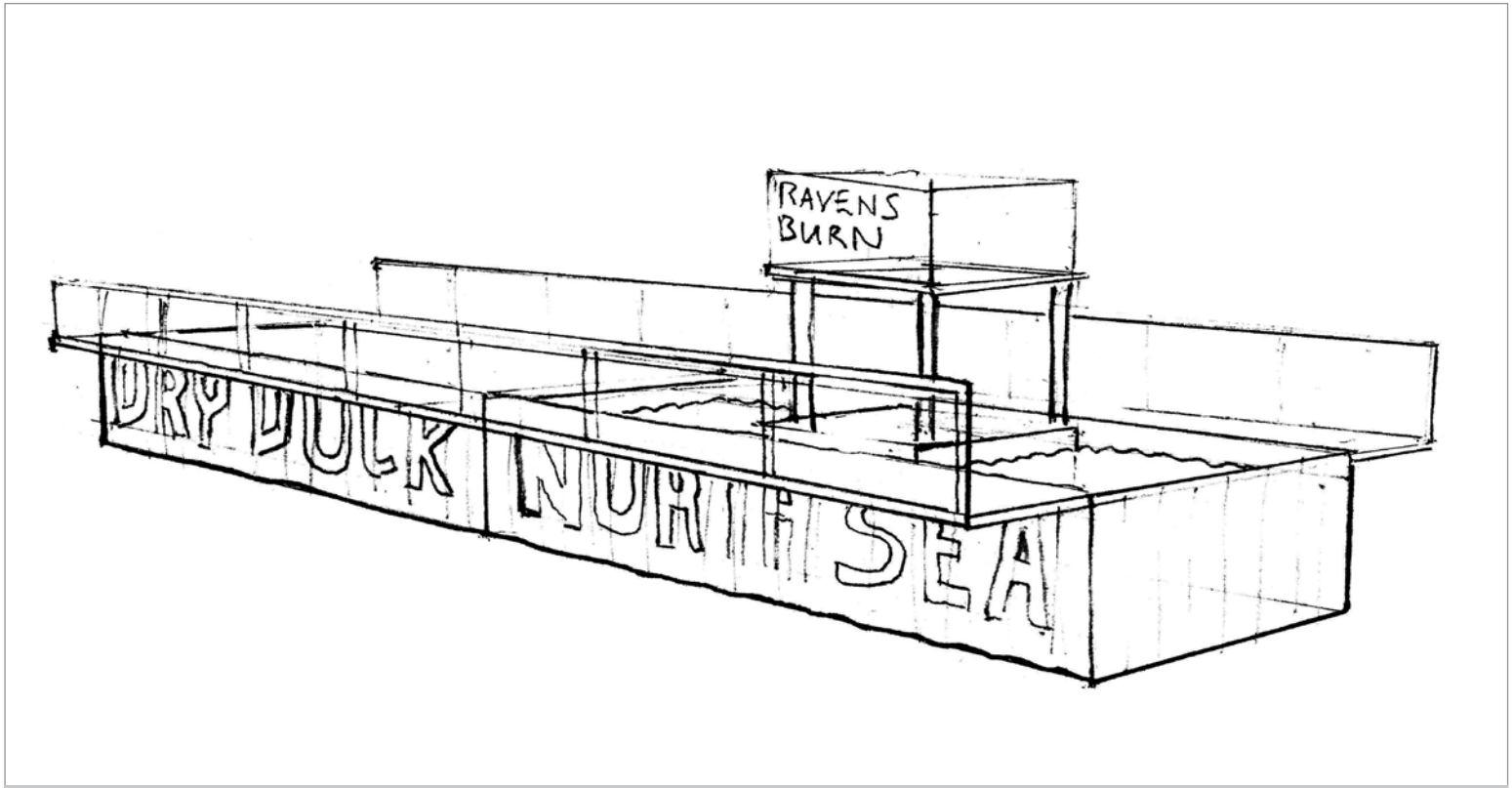
Ravensburn Oil Rig

This project is another one based on an existing Constructionarium project. It is another standalone project that requires two half height shipping containers, which could be stacked on top of one one another, which means it can be delivered to site in a single 20ft x 8ft haulage berth. The idea is for students to build a miniature oil platform in a dry dock and to float into position in deep water. The dry dock and deep water elements are created using two half-height open-top shipping containers with a water proof connection between the two. One half is flooded with water; the other is the dry dock; and there is a sluice between the two.

Students build the concrete sub-structure of the rig in the dry dock. First they lay formwork, place rebar and pour concrete for the base slab. Next they construct the walls and finally the top slab. The walls are built tight up against the edge of the container, with striking pieces to ensure that sub-structure can be separated from the walls. The students build the superstructure on the ground adjacent to the dry dock; the superstructure is then lifted using a tele handler onto the deck of the sub-structure. Finally, the dry dock is flooded with water from a bowser, and the structure is floated into position in the deep water channel.

The two half-height containers need to be modified to allow them to be connected end-on-end and water-tight. The sides of the containers need to be modified to accommodate a catwalk around the outside of the dry dock and water channel. In transport mode, the two open-top channels can be stacked on top of each other. The plant and reusable components can be stowed inside the containers for transport.

This project is likely to take additional set-up time given the time needed to fill and empty the water tanks, and so it will not necessarily be possible to run this project on a weekly basis.



Sketch showing how two open-top half-height shipping containers could be used to recreate the lake and dry dock for the Ravensburn Oil Rig Constructionarium project

Other project ideas

- Retractable bridge
- Concrete arch dam
- Earth-fill dam
- Tidal basin - barking reach
- River engineering

CREATING THE SITE

The site will be surrounded by fencing, not only for safety and security, but also for helping to develop a sense of place at the Tructionarium. Students will be able to gain access to the roof of some of the containers, giving the chance to get an overview of the activity. Tructionarium containers will be spray painted with eye-catching designs and large format print panels will be hung around the site to provide information about the projects. In addition to the project structures it should be possible to create a number of work and rest stations around the site located under temporary awnings.

SUPPORT MATERIALS

With the creation of the Tructionarium, there is the opportunity to update the way that briefing information is provided to students. As well as the traditional briefing packs, briefing and background information should be made available through a Tructionarium website. The website will also provide support material for lecturers, and suggested lesson activities to accompany the Tructionarium, as well as standardised health and safety information. On-site additional support will be provided by large-format information panels, providing suggestions for how different construction elements can be assembled.

DEPLOYMENT IN OTHER FORMATS

The ideas in this initial proposal have focused on how Tructionarium could be used to support universities, but there is scope to develop this concept for a wide range of other audiences.

Schools - local authorities or UTCs might be interested in booking Tructionarium in order to run a local event to encourage school children to consider careers in construction. The construction activities can be simplified to the learners' level, for example, by removing the need to survey the site before commencing. The multi-building project in particular offers the opportunity to introduce participants to a whole range of construction materials and techniques.

Apprentices - FE colleges and training providers could similarly run Tructionarium as a way of recruiting apprentices. Alternatively, the event could be used a boot camp for new recruits, and as a staging post before apprentices start on a real site.

CPD for construction professionals - site experience is an important aspect to developing professional skills. Tructionarium can be run as an opportunity for professionals to get that site experience.

Team Building - the Tructionarium could be used as a venue for outward bound and team building events, relying as it does on hands-on activity and team work.

Management Training - It also could be the basis of management training, especially for first line supervisors, giving them the opportunity to manage members of staff in a non-critical environment.

REVENUE AND COSTING

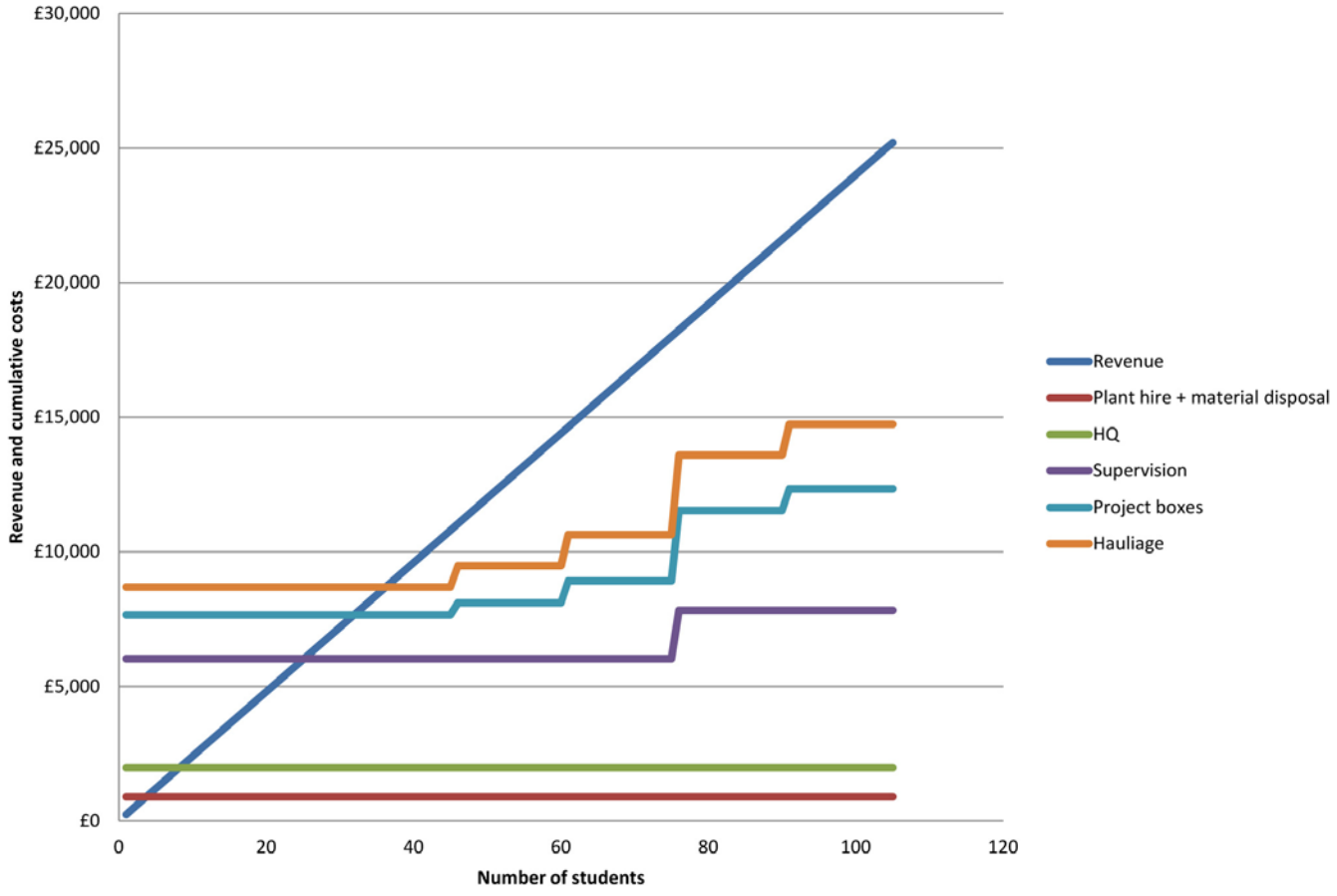
At this stage in the development of the Tructionarium concept, we are working with very rough operational costing in order to test its viability. If Constructionarium agrees that the approach is the right one, we can develop more detailed cost models.

Our key assumptions are as follows:

- A fee of £50/learner/day
- Haulage per event is just the cost of bringing the containers in from the previous location, and that the distance between consecutive events is limited to one haulage day
- Where possible, plant and consumable materials are sourced locally
- Tructionarium site supervisors and operatives are hired on a per event basis
- Storage of the materials when not in use is free

We have not yet costed the capital costs of the project, including purchase and modification of the containers and the overall design of the Tructionarium. A significant factor in the viability of the event is the time over which the capital costs need to be recouped.

The next stage in the costing process is to liaise with Constructionarium in order to look at the potential costs in more detail.



Graph of approximate revenue and operating costs for the Tructionarium. The basic set-up includes three projects for 45 students. The cost then steps up as extra projects are added

COSTING OVERVIEW

Item	Description		Unit Value	No.	Total
Revenue					
Fee/learner	Assume £60/day/student; 60 students at an event		£240	75	£1,800
Costs					
Supervision					
Site supervisor	Contract site supervisor at £250/day for 6 days		£2,250	1	£2,250
Site operatives	Contracts site operative £175/day for 6 days		£1,800	1	£1,800
HQ					
Marginal costs					£1,080
	Contribution to capital costs				tbc
	(Total 20ft x 8ft hauliage berths)	1			
Millau + Barceona + Masonry Arch					
	Marginal costs			1	£1,631
	Contribution to capital costs				tbc
	(Total 20ft x 8ft hauliage berths)	2			
Kingsgate Bridge					
	Marginal costs				£450
	Contribution to capital costs				tbc
	(Total 20ft x 8ft hauliage berths)	1			
Ravensburn					
	Marginal costs				£812
	Contribution to capital costs				tbc
	(Total 20ft x 8ft hauliage berths)	1			
Haulage					
	Assuming desitination is within one haulage day from depot				
	Assume haulage directly on to next event				
	Number of haulage berths =	5	£685	2.5	£1713
Plant hire	Cherry picker + telehandler + bowser		£760	1	£760
Disposal of materials	Waste disposal by skip		£140	1	£140
Total Cost					**£10,635**

BASE DATA

Item	Description	Unit Value	No.	Total
Supervision				
Site supervisor	Contract site supervisor at £250/day for 6 days	£1,500	1	£1,500
	Accommodation	£400	1	£400
	Expenses	£150	1	£150
	Mileage (500 miles @ 40p)	£200	1	£200
			Total	**£2,250**
Site operatives	Contracts site operative £175/day for 6 days	£1,050	1	£1,050
	Accommodation	£400	1	£400
	Expenses	£150	1	£150
	Mileage	£200	1	£200
			Total	**£1,800**
Haulage				
	Based on transport of 20ft x 8ft shipping containers			
	One haulage day is the time for a driver to leave the depot, pick up the cargo, deliver the cargo and drive back to the depot			
One haulage day option	1 container	£465	1	£465
	2 containers	£685	1	£685
Two haulage day options	1 container	£465	2	£930
	Overnight charge	£250	1	£250
			Total	**£1,180**
	2 containers	£685	1	£685
	Overnight charge	£250	**1**	£250
			Total	**£1,620**
Plant				
	Telehandler (includes delivery to and collection from site)	£310	1	£310
	Cherry picker - estimate for two days	£250	1	£250
	Water bowser - estimate for a week	£200	1	£200
			Total	**£760**
Waste disposal				
	Approx 3m3 of RC concrete + timber for shuttering, disposed in a 4 yrd skip	£140	1	£140

PROJECT ELEMENTS

Item	Description	Unit Value	No.	Total
HQ				
Capital costs				
	20ft x 8ft shipping container including windows and door	1		tbc
	Modifications - none	0	0	tbc
	Staircase and handrails			tbc
	Fit out to store equipment			tbc
	Safety hats, gloves, goggles, glasses + ear muffs	£10.30	100	£1,030
			Total	tbc
Marginal costs				
	Standard tool kits, including power tool hire	£20	30	£600
	Generator	£200	1	£200
	Fencing around site (70p/m)	£0.70	400	£280
			Total	**£1,080**
Millau + Barcelona + Masonry Arch				
Capital costs				
	20ft x 8ft shipping container		1	
	20ft x 8ft container base		5	
	Modificaitons to shipping container -connection points for launch pads on roof		1	
	Modifcaitons to bases: various connection points		5	
	Staircase and handrails for shipping container			
	Millau steelwork			
	Barcelona steelwork			
	Masonry Bridge - deck			
	Masonry bridge - cables to connect shipping bases			
	Tarpaulin, inflatable tubes and pumps for ‘river’			
			Total	tbc

Marginal costs				
Materials	Millau reinforced concrete in m3	£200	0.8	£156
	Millau timber for shuttering			
	Barcelona reinforced concrete	£200	4.5	£900
	Barcelona timber for shuttering			
	Masonry arch: masonry - volume tbc	£150	2	£300
	Masonry arch: timber for formwork under arch and for RC abutments			
Plant	Platofrm for working at height	£75	1	£75
	Bowser to supply water for 'river'	£200	1	£200
			Total	**£1,631**
Kingsgate Bridge				
Capital costs				
	20ft x 8ft half-height shipping container		1	
	20ft x 8ft container base		2	
	Modificaitons to shipping container - none	0	0	
	Modifcaitons to bases:creation of a 'shoe' into which concrete piers are constructed		2	
	Tarpaulin, inflatable tubes and pumps for 'river'			
	Steelwork for superstructure			
	Bridge bearings		2	
	Hand rails			
			Total	tbc
Marginal costs				
Materials	RC for bridge piers and bridge deck	£150	1	£150
	Timber for shuttering for bridge deck and piers			
Plant	Bowser to supply water for 'river'	£300	1	£300
			Total	**£450**

Ravensburn Oil Rig				
Capital costs				
	20ft x 8ft half-height shipping container		2	
	Modificaitons to shipping container -opening of two ends and creating a water tight connection detail. Creation of sluice gate. Modificaiton to accommodate catwalk around edge of containers		1	
	Catwalk for containers + handrails			
	Sluice gate			
	Steel superstructure for oil rig			
			Total	tbc
Marginal costs				
Materials	RC for substructure	£150	2.6	£384
	Timber for shuttering for substructure			
	Plastic sheeting onto which base is poured in dry dock container			
Plant	Bowser to supply water for dry dock	£300	1	£300
	'Safety boat'			
	Water for channel	£1.46	36	£53
	Water pump	£75	1	£75
			Total	**£812**

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