UNIVERSITY OF CAMBRIDGE

NATURAL MATERIAL INNOVATION

@CamNatMat

#TimberTowers

WHO WE ARE

Centre for Natural Material Innovation

Department of Architecture, University of Cambridge

Director: Dr Michael H. Ramage

- Department of Chemistry
- Department of Biochemistry
- Department of Applied Maths and Theoretical Physics
- Department of Engineering

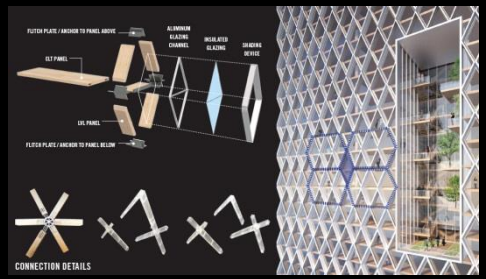
Donors

The Leverhulme Trust
Engineering and Physical Sciences Research Council
Interreg France (Channel) England – ERDF
Centre for Digital Built Britain

Industry Partners + Collaborators

PLP Architecture • Smith and Wallwork Engineers
Perkins + Will • Thornton Tomasetti
Rogers Stirk Harbour + Partners • Atelier One
Waugh Thistleton Architects • Eckersley O'Callaghan Engineers
Stora Enso
Pollmeier BauBuche
Margent Farm
Moso International BV

TIMBER TOWERS OF TOMORROW



River Beech Tower, Chicago
Architects: Perkins and Will
Structural Engineer: Thornton Tomasetti
Height: 243 m

Oakwood Timber Tower, London
Architects: PLP Architecture, London
Structural Engineers: Smith and Wallwork
Height: 300 m

The Lodge, The Hague
Architects: PLP Architecture, London
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Height: 130 m


TIMBER
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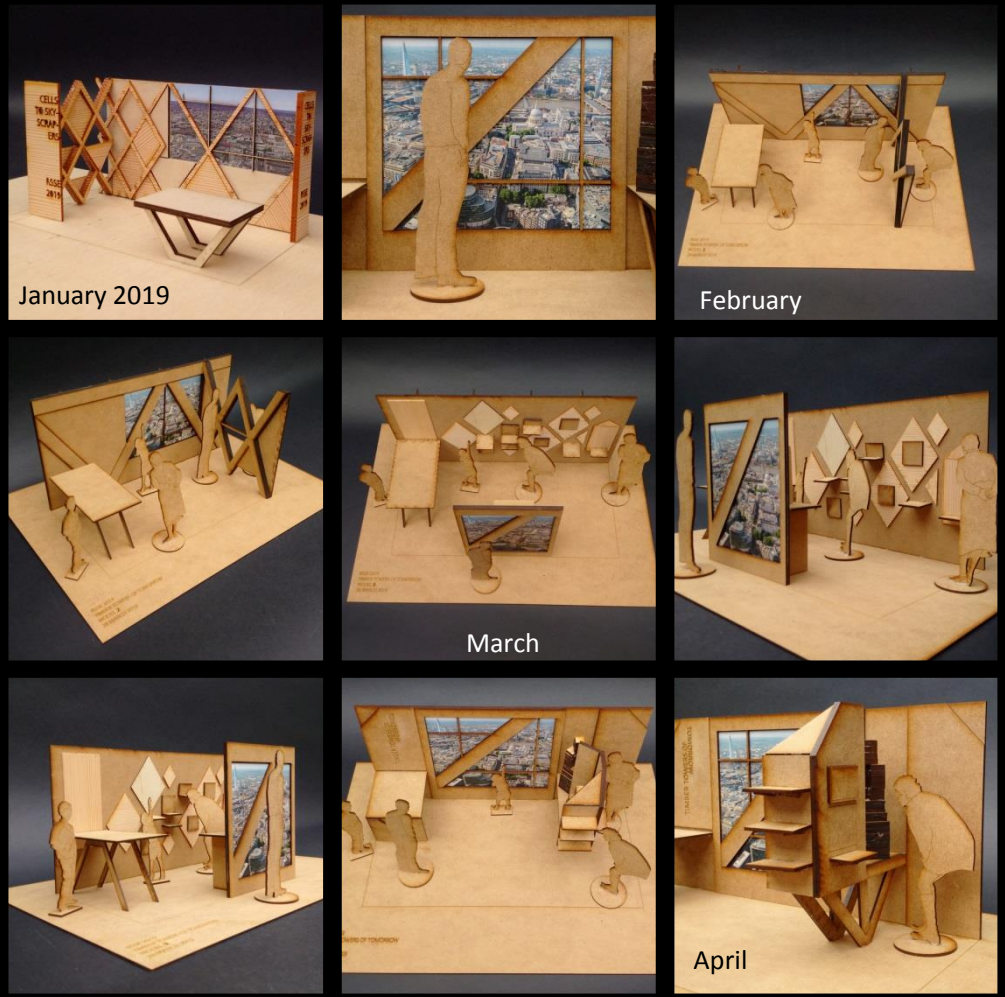

Exhibit design evolution

Timber Towers of Tomorrow

Explore the science and engineering of supertall timber from cells to skyscrapers

Trees, and their derivative products, have been used by societies around the world for thousands of years. Contemporary construction of tall buildings from timber, in whole or in part, suggests a growing interest in the potential for building with wood at a scale not previously attainable.

At the smallest scale our research group is exploring how the molecular structure of wood contributes to its macro-scale attributes.

At the mega scale, we are developing our understanding of the engineering innovations required to realise super tall timber construction.

By bridging the two scales, we are taking a holistic approach to increasing the already significant potential for using plant material at a large scale in the built environment.

SELECTED FOR THE ROYAL SOCIETY SUMMER SCIENCE EXHIBITION 2019

Based at the Centre for Natural Material Innovation, University of Cambridge, our highly interdisciplinary research group comprises experts from architecture, engineering, biochemistry, materials science, polymer chemistry and fluid dynamics.

Bibliography and further reading

Ramage, M., et al., The wood from the trees - The use of timber in construction. Renewable and Sustainable Energy Reviews, 2017. 68(1): 333-359.

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Simmons, T.J., et al., Folding of xylan onto cellulose fibrils in plant cell walls revealed by solid-state NMR. Nature Communications, 2016. 7: 13902.

Thomas Peter A. Trees: their natural history. London: Cambridge University Press; 2014.

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TEACHER RESOURCE 1

Timber Towers of Tomorrow:
Explore the science and engineering of super tall timber from cells to skyscrapers

Humankind has built with timber for centuries.

Why then have we not yet constructed a timber building taller than the tallest tree in the world?

Cells to Skyscrapers

In order to understand this we must first look at what makes a tree so strong. Our research therefore starts at its molecular structure.

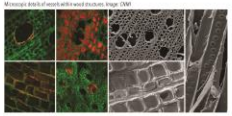
Trees (and plants) are made up of polysaccharides. We study their complex structures across various scales.

Property changes and counter measures

Timber is biological products and respond to different environmental conditions. Moisture content above 20% makes wood susceptible to attack by fungi and bacteria.

Degradation leads to unacceptable loss of mechanical properties.

Our group studies chemical and thermal properties of wood and its response to water flow and polymer impregnation.

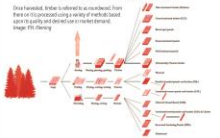


But is the promotion of timber in times of climate change a wise idea?

Unlike conventional building materials such as steel, concrete and brick, the supply chain for timber is quite distinct.

Forests outlive human timescales and if recommended rotations (ranging from 35 to 70 years) are followed, they can serve as excellent renewable resources.

So how does timber from the forest come to a construction site?



Wood treatment is a process that is used to improve the material properties of wood but produces a material that can be disposed off at the end of a product life cycle without environmental hazards.

Structural use of timber

20% of new houses in the UK and up to 70% in Scotland are timber frame.

Besides being a renewable resource, timber has a strength parallel to that of reinforced concrete.

Timber has low density and therefore superb structural efficiency for long-span and tall structures that typically need to carry their own weight. While timber has traditionally been successfully employed for the former, our group's research advances contemporary understanding for building super tall with timber.

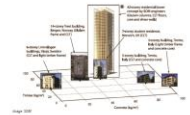
TEACHER RESOURCE 2

Timber Towers of Tomorrow:
Explore the science and engineering of super tall timber from cells to skyscrapers

Complex Engineering

In an earthquake, the force imposed on the structure by shaking depends strongly on its mass. A tall timber skyscraper will be much lighter than an equally tall one made out of reinforced concrete or steel. Similarly, it is possible to strengthen a lighter timber building through tectonic configurations not required in steel or reinforced concrete.

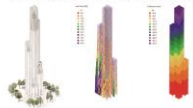
Working with timber in this unprecedented manner requires innovative solutions in structural engineering and architectural design.



Cross-laminated Timber

The recent development in timber processing has made the use of cross-laminated timber (CLT) a lot more feasible. CLT enables designers to not only revisit timber but also explore new structural configurations with it.

While building up to 6 storeys with CLT may not be cost-appropriate, the economics of building super tall buildings with CLT (and light frame timber) make for a very persuasive case.



Architectural rendering of the Oakwood Timber Tower, London with structural calculations for axial forces and deflection. Image: PLP

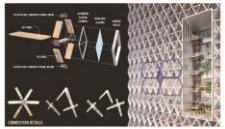
FIRE

While exploring building tall with timber, we are mindful of the fire hazard involved.

Our designs for timber buildings implement fire safety with the understanding that in the event of a fire, the building retains its structural integrity for fire extinguishing and evacuation.

As CLT is made up of laminated boards of timber, glued at 90 degrees to the preceding grain, it has superior strength to GluLam. Due to its laminated nature, it emerges as a strong choice for fire resistance too.

In the event of a fire, its outer layer chars and in turn protects the inner mass. The thickness of the outer layer is therefore factored in as sacrificial safety measure upon loss of which, the building's structural integrity is not compromised.



Special joints and structural assembly systems have been developed to optimise the deployment of timber in tall buildings.
Image: Perkins and Will / Michael Ramage

Synthesis

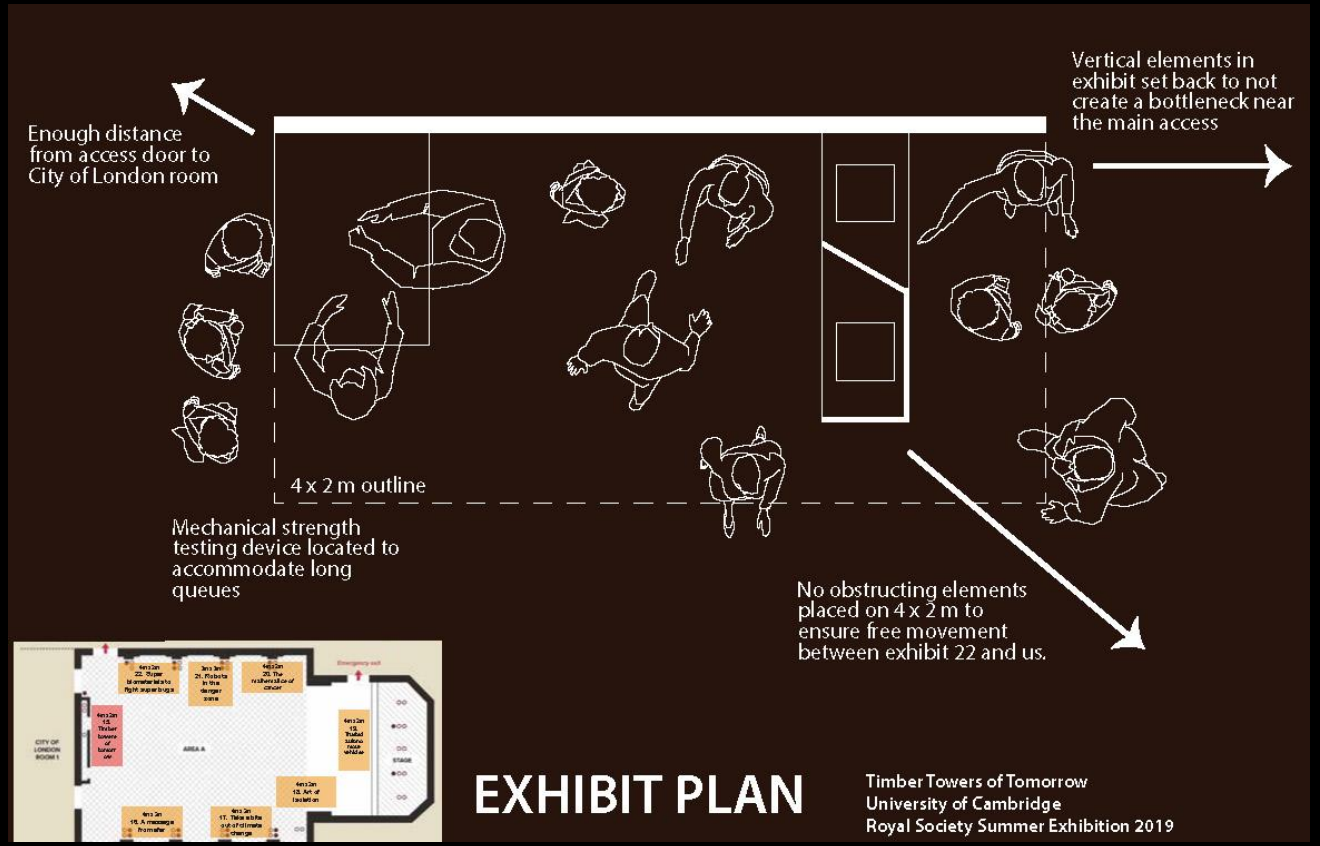
Synthesising the group's research from cells to skyscrapers, the Centre for Natural Material Innovation at the University of Cambridge is collaborating with partners on the following super tall timber buildings around the world

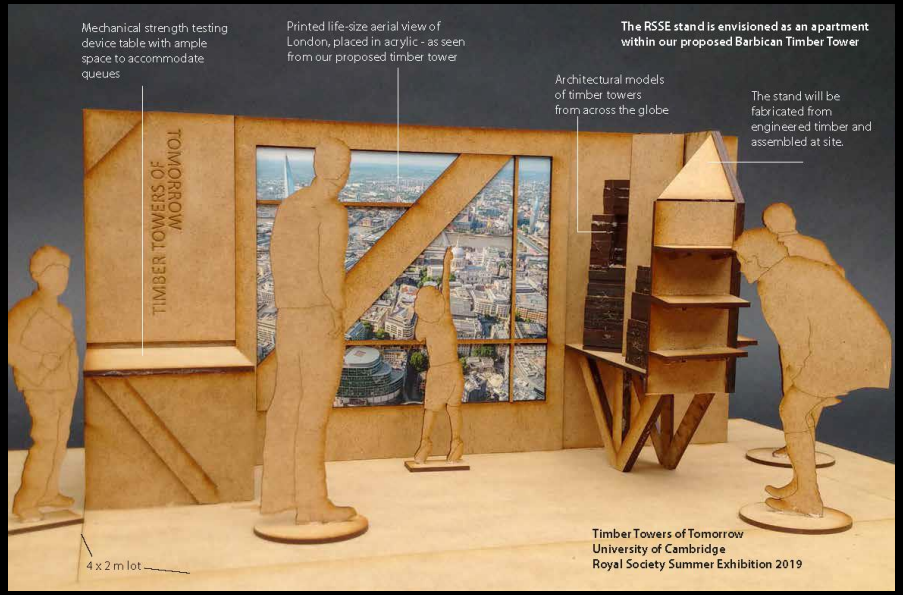
Project: **Oakwood Timber Tower, London**
Architects: PLP Architecture, London
Structural Engineers: Smith and Wallwork
Height: 300 m

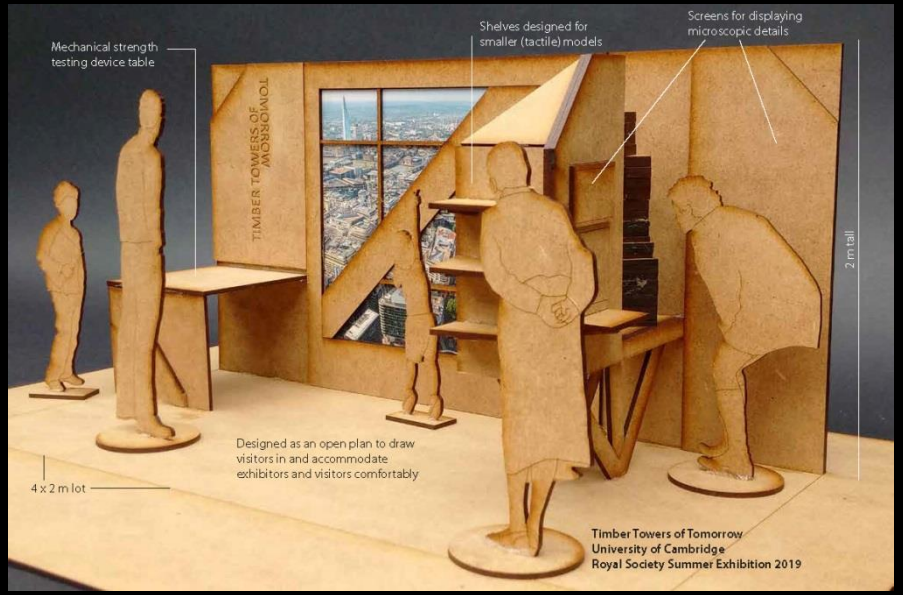
Project: **River Beech Tower, Chicago**
Architects: Perkins and Will
Structural Engineer: Thornton Tomasetti
Height: 243 m

Project: **The Lodge, The Hague**
Architects: PLP Architecture, London
Structural Engineers: Smith and Wallwork
Height: 130 m

Testing ideas
Cambridge Science Festival
March 2019

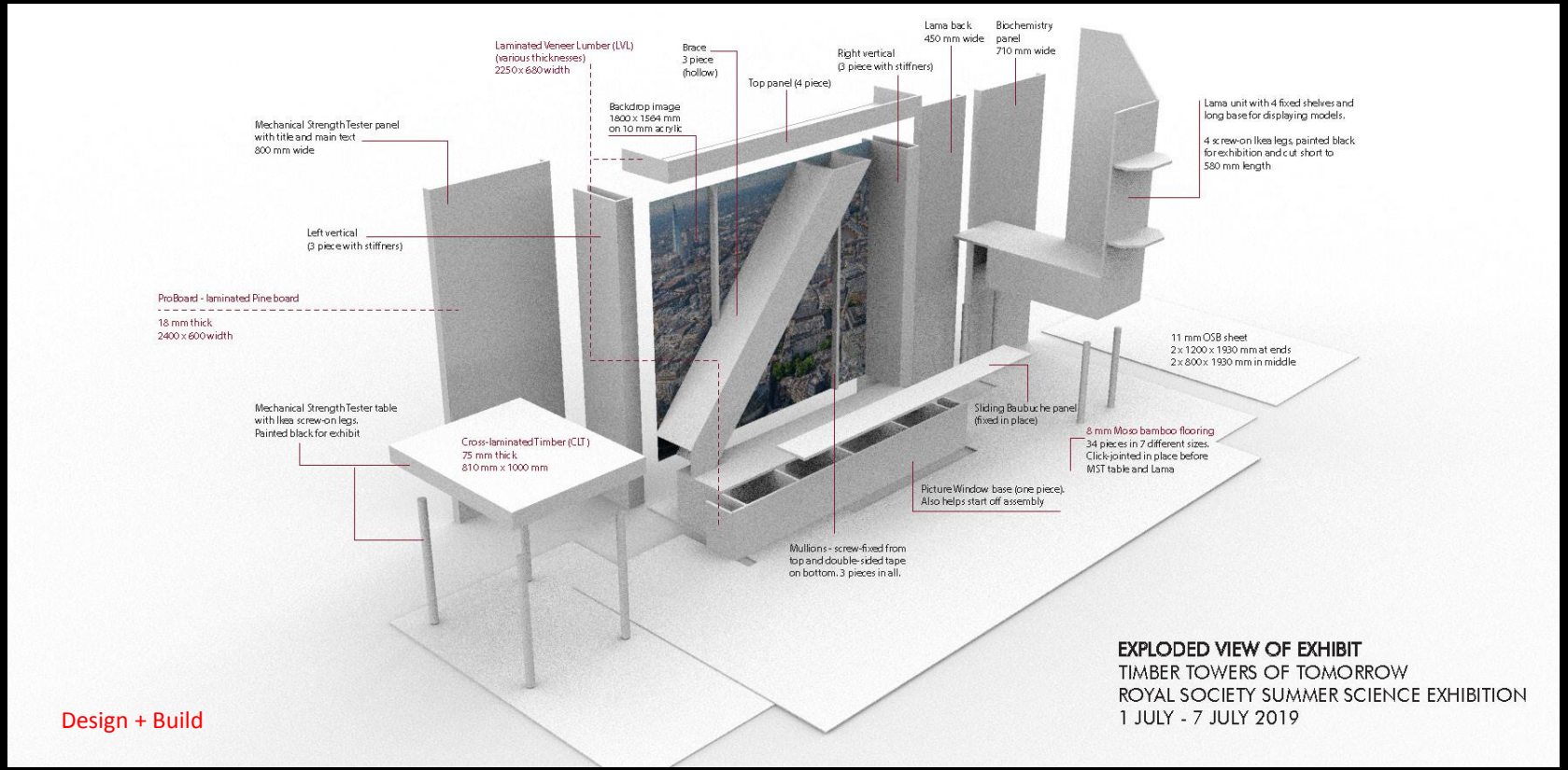

Enough distance from access door to City of London room
Vertical elements in exhibit set back to not create a bottleneck near the main access
4 x 2 m outline
Mechanical strength testing device located to accommodate long queues
No obstructing elements placed on 4 x 2 m to ensure free movement between exhibit 22 and us.
EXHIBIT PLAN
Timber Towers of Tomorrow
University of Cambridge
Royal Society Summer Exhibition 2019





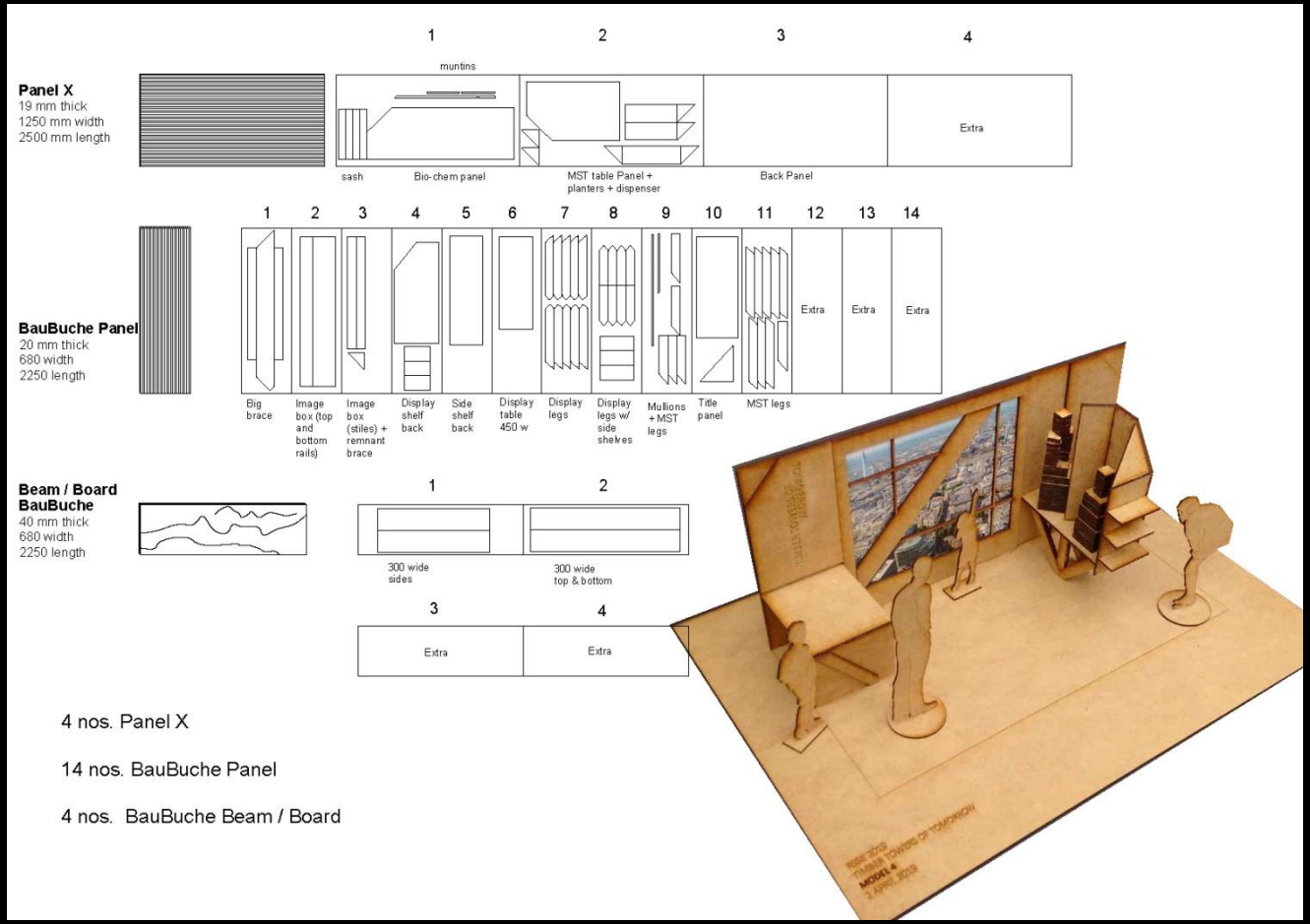
Final design model with notes

Mid- April 2019



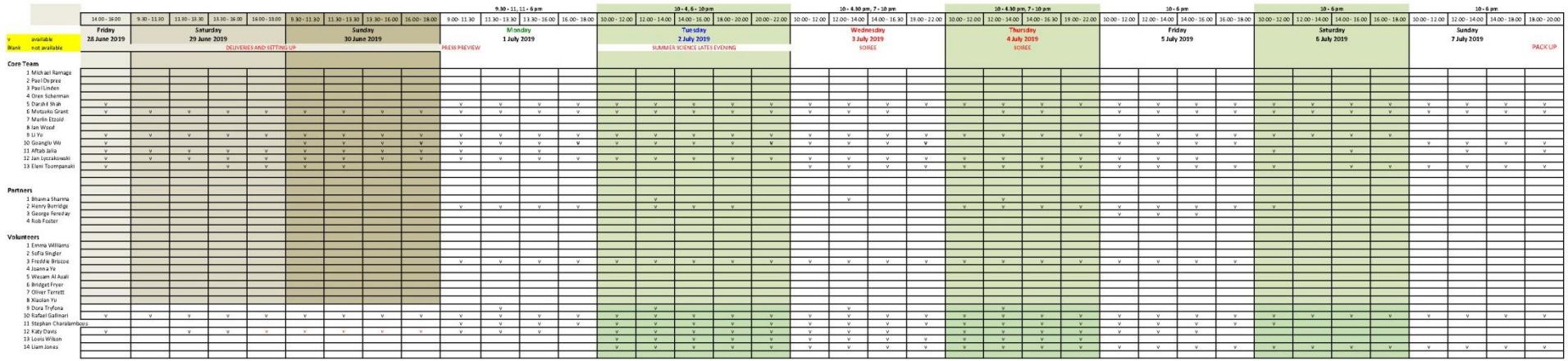
EXPLODED VIEW OF EXHIBIT
TIMBER TOWERS OF TOMORROW
ROYAL SOCIETY SUMMER SCIENCE EXHIBITION
1 JULY - 7 JULY 2019

Design + Build



Fabrication

Prototype +
full test assembly



Team assembly = 31+

Core Team 13
External Partners 4
Volunteers 14

Don't account just for exhibition week!

Packing, loading, unloading, unpacking before and after also count.

UNIVERSITY OF CAMBRIDGE

The Royal Society Summer Science Exhibition

Enjoying the experience and getting the most from it

Dr Lucinda Spokes, Public Engagement Team

Team briefing + Preparation

TIMBER TOWERS OF TOMORROW

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Volunteer Reference Document

Setting up at RS in 4 hrs

Exhibition week!

Exhibition week!

Exhibition week!


TIMBER
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TOMORROW
Explore the science and engineering of super tall timber
from cells to skyscrapers
o not
this door

Soiree

Final remarks

- Do it yourself
- Start early and persist: it takes time
- Talk to your neighbour *(at Uni and RS)*
- Oversubscribe: make large teams + backup
- Prepare for the unexpected:

press coverage, uncomfortable conversations, amazing connections beyond RSSE

- Enjoy yourself

TIMBER TOWERS OF TOMORROW

Explore the science and engineering of super tall timber from cells to skyscrapers

Did you know it takes just 4 hours to grow a 300 metre tall timber tower in the sustainable forests of Europe?

Royal Society Summer Science Exhibition
July 1st to 7th 2019

6-9 Carlton House Terrace
London
SW1Y 5AG

The Barbican Tower and St Paul's Cathedral, London
Image: PLP Architecture

UNIVERSITY OF CAMBRIDGE

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