

Robotic fabrication of timber assemblies

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GRAMAZIO
KOHLER
RESEARCH
E EA



ETH zürich

05.10.2021 Swiss Re, Rüslikon | Tomorrow's Timber



The Sequential Roof



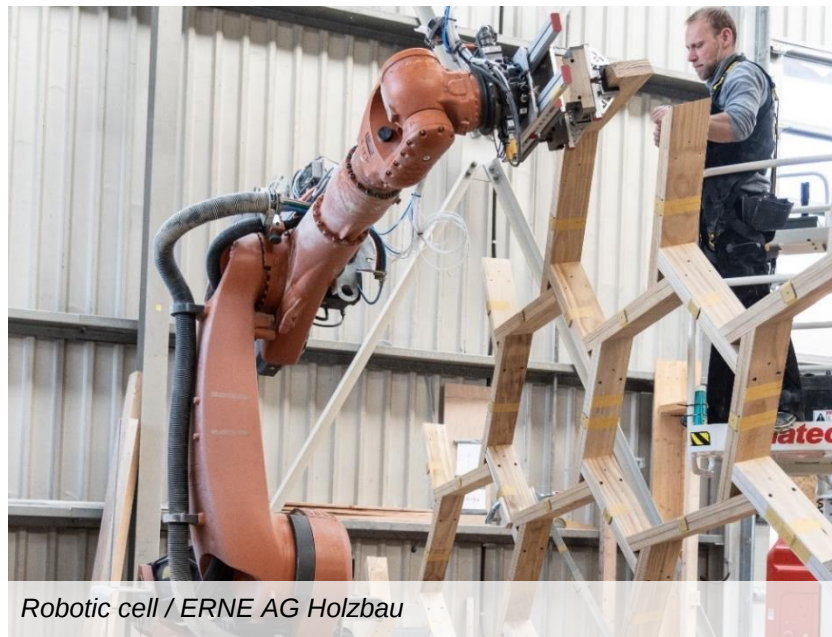
Future Tree



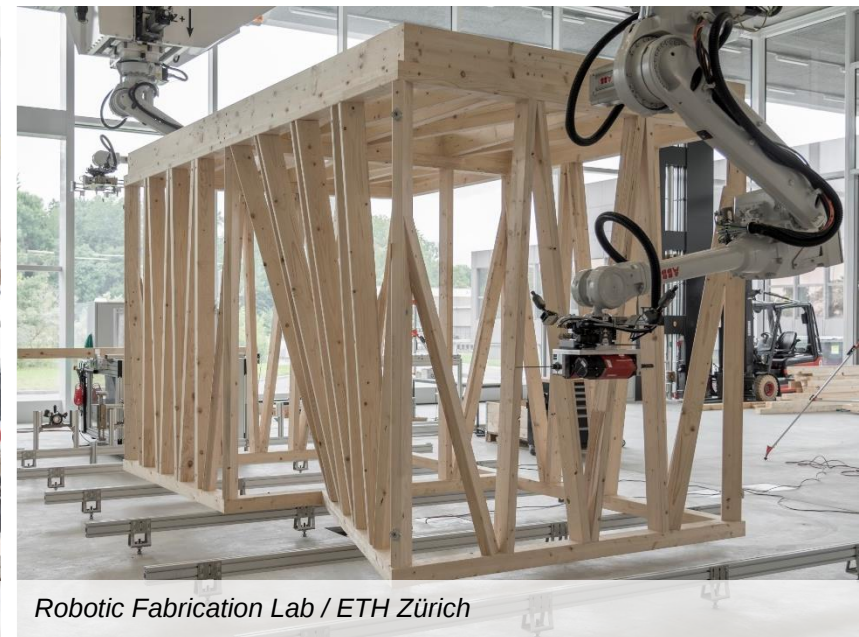
DFAB HOUSE Spatial Timber Assemblies



Portal robot / ERNE AG Holzbau



Robotic cell / ERNE AG Holzbau



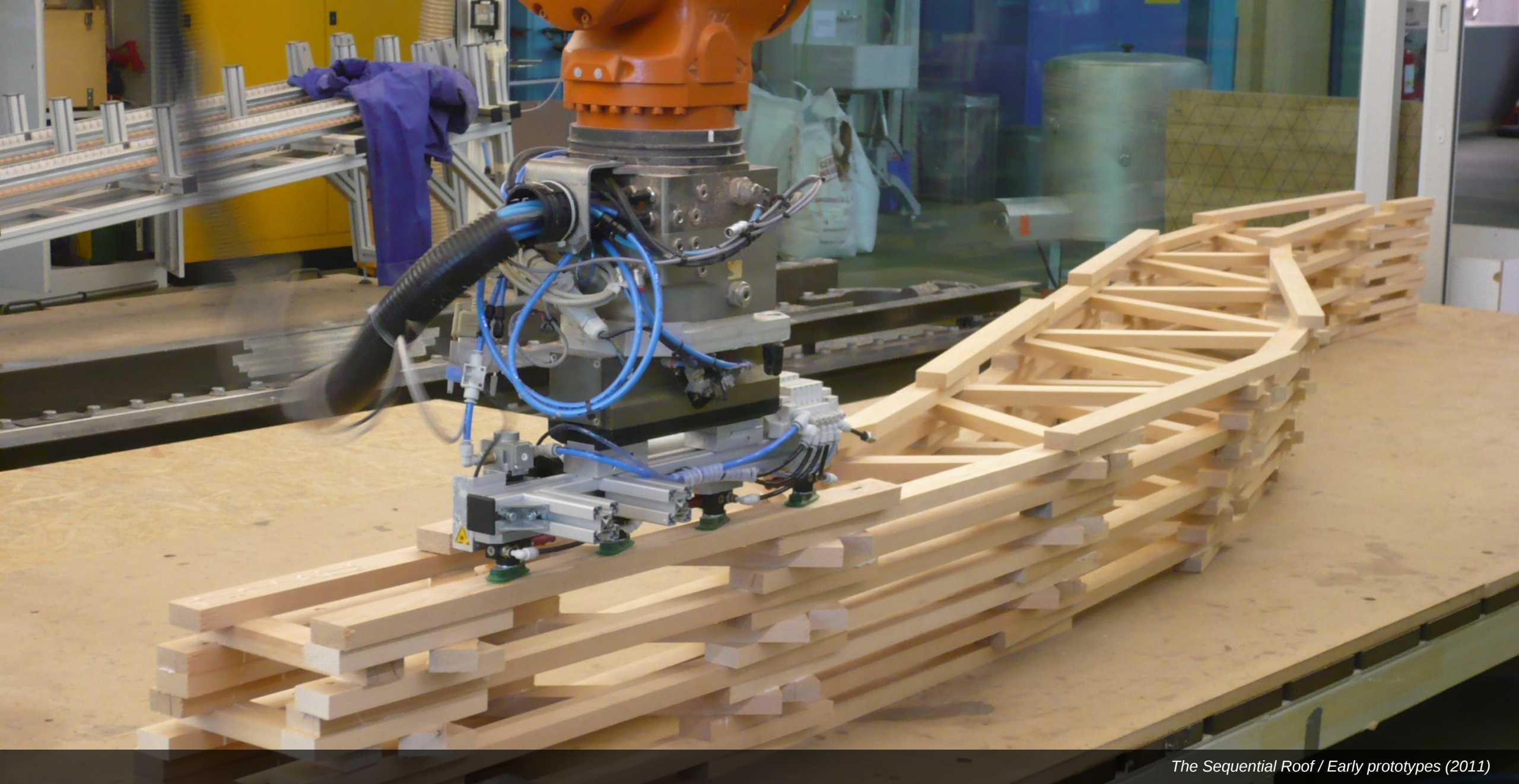
Robotic Fabrication Lab / ETH Zürich



Arch_Tec_Lab / ETH Zurich Campus Hönningerberg (Fot.: A.Diglas)



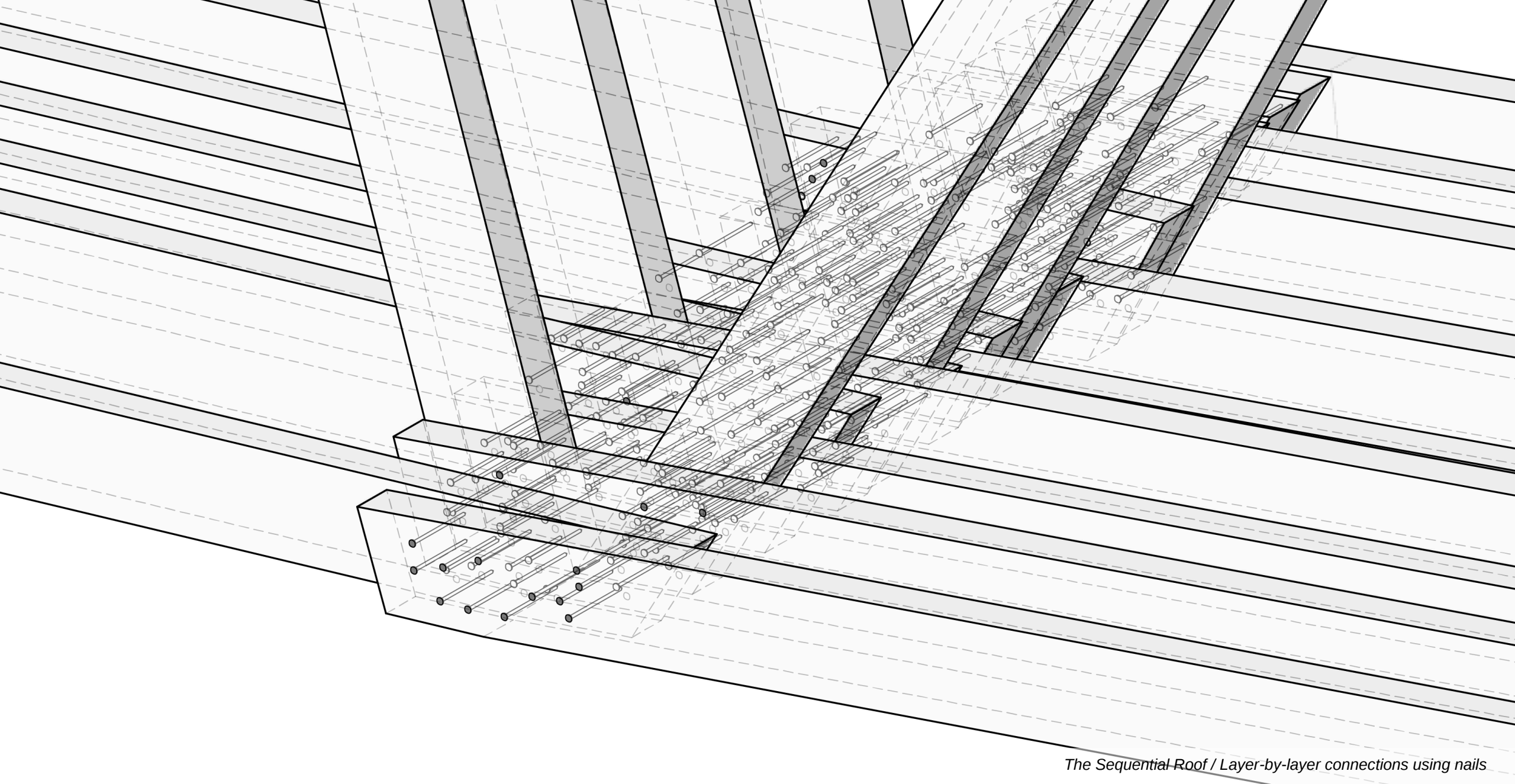
The Sequential Roof



The Sequential Roof / Early prototypes (2011)

DER **ERNE** PORTALROBOTER

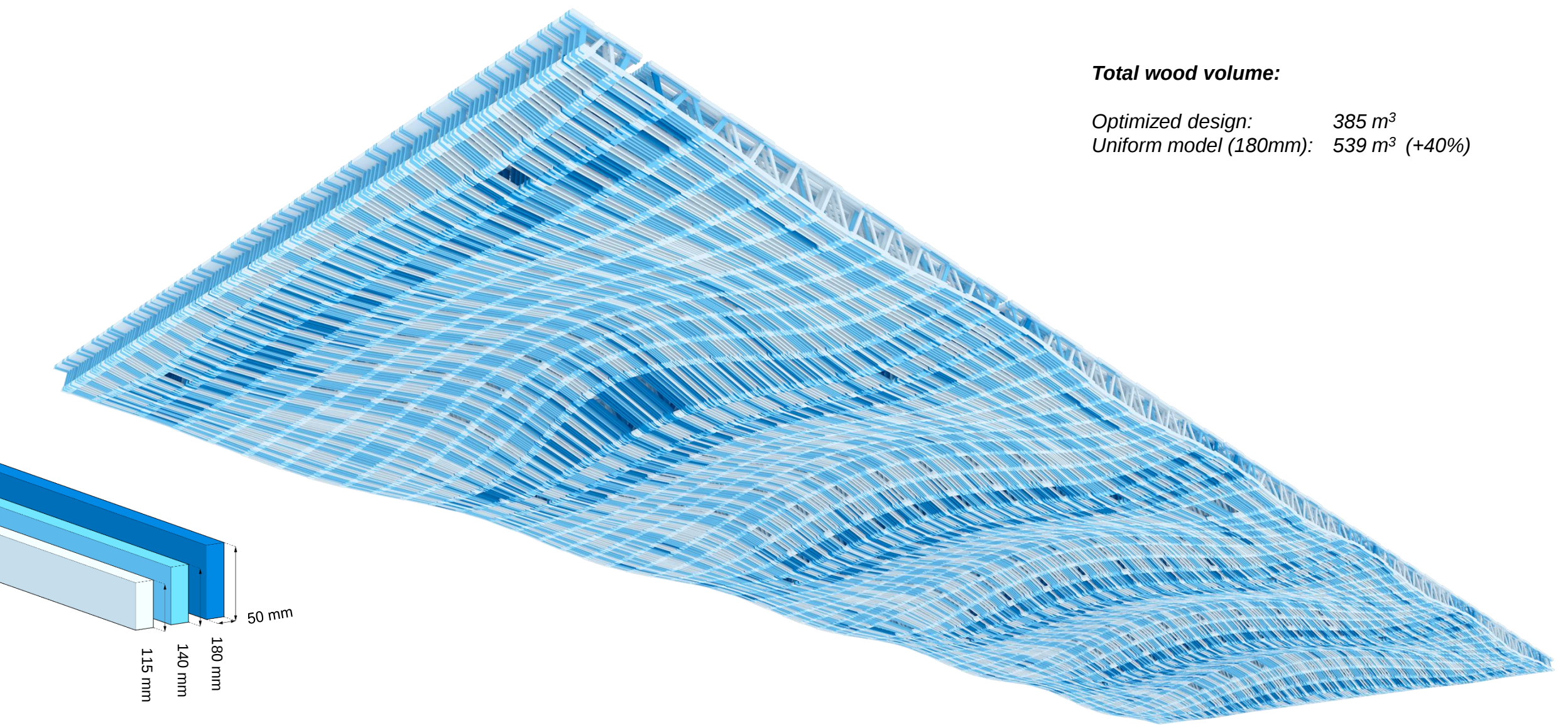
(c) ERNE AG Holzbau



The Sequential Roof / Layer-by-layer connections using nails



The Sequential Roof / Automated documentation of the nailed connections (ROB Technologies)

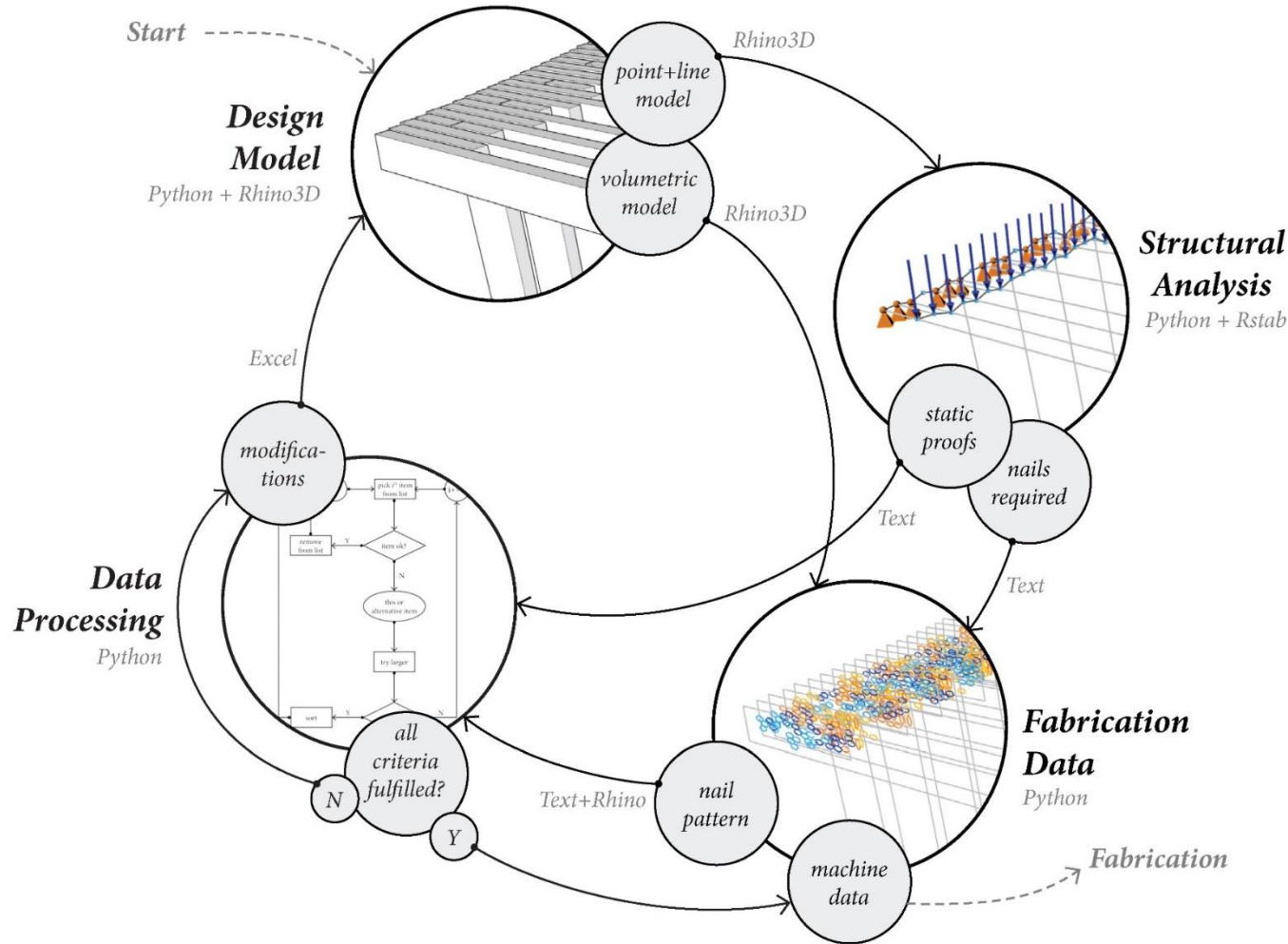


Total wood volume:

Optimized design: 385 m³

Uniform model (180mm): 539 m³ (+40%)

The Sequential Roof / Final model color-coded by slat cross-sections



```

523 slat_ok=False
524
525
526 if len(self.edgelines)>3:
527     self.verts_ec = self.slatvertices(self.edgelines)
528     self.verts = [gu.pt_raise(p,self.Layer.y) for p in self.verts_ec]
529
530 if len(self.verts)>3:
531     slat_ok=True
532     self.outline=self.outline_closed()
533     if self.outline:
534         self.n_cuts=self.outline.SegmentCount-2
535         self.axis_to_cuts(self.edgelines)
536
537 if slat_ok:
538     #===OUTPUT===
539     self.draw_extrusion()
540     if outline_type: self.draw_outline(outline_type)
541     if output_slataxis: self.draw_axis()
542
543 def slatvertices(self,L):
544     #INPUT: list of euclid lines
545     L.append(L[0])
546     pts=[]
547     for i in range(1,len(L)):
548         px=L[i-1].intersect(L[i])
549         if px is not None:
550             pts.append(px)
551     return pts #euclid Point2
552
553 def outline_closed(self):
554     pts=self.verts
555     pts.append(pts[0])
556     if len(pts)>2:
557         output= rg.Polyline(pts)
558         if output.IsValid: return output
559         else: return None
560
561 5/21-22/1a_Nails:2_Iter:7(141024)_Neighbours:2/16/22/1-3;2/16/21/1-1;
562 5/20-21/23b_Nails:2_Iter:7(141024)_Neighbours:2/16/20/21-23;2/16/21/23-23;
563 5/20-21/23a_Nails:3_Iter:7(141024)_Neighbours:2/16/20/21-23;2/16/20/21-23;2/16/
564 5/20-21/22b_Nails:6_Iter:7(141024)_Neighbours:2/16/21/20-22;2/16/20/22-22;
565 5/20-21/22a_Nails:7_Iter:7(141024)_Neighbours:2/16/21/20-22;2/16/21/20-22;2/16/
566 5/20-21/21b_Nails:4_Iter:7(141024)_Neighbours:2/16/21/19-21;2/16/20/21-23;2/16/
567 5/20-21/21a_Nails:5_Iter:7(141024)_Neighbours:2/16/21/19-21;2/16/21/19-21;2/16/
568 5/20-21/20b_Nails:2_Iter:7(141024)_Neighbours:2/16/20/18-20;2/16/21/20-22;2/16/
569 5/20-21/20a_Nails:1_Iter:7(141024)_Neighbours:2/16/20/18-20;2/16/20/18-20;2/16/
570 5/20-21/19b_Nails:3_Iter:7(141024)_Neighbours:2/16/20/17-19;2/16/21/19-21;2/16/
571 5/20-21/19a_Nails:2_Iter:7(141024)_Neighbours:2/16/20/17-19;2/16/20/17-19;2/16/
572 5/20-21/18b_Nails:5_Iter:7(141024)_Neighbours:2/16/20/18-20;2/16/20/18-20;2/16/
573 5/20-21/18a_Nails:6_Iter:7(141024)_Neighbours:2/16/20/18-20;2/16/21/16-18;2/16/
574 5/20-21/17b_Nails:6_Iter:7(141024)_Neighbours:2/16/21/15-17;2/16/20/17-19;2/16/
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576 5/20-21/16b_Nails:4_Iter:7(141024)_Neighbours:2/16/20/14-16;2/16/21/16-18;2/16/
577 5/20-21/16a_Nails:4_Iter:7(141024)_Neighbours:2/16/20/14-16;2/16/20/14-16;2/16/
578 5/20-21/15b_Nails:4_Iter:7(141024)_Neighbours:2/16/20/13-15;2/16/21/15-17;2/16/
579 5/20-21/15a_Nails:4_Iter:7(141024)_Neighbours:2/16/20/13-15;2/16/20/13-15;2/16/
580 5/20-21/14b_Nails:6_Iter:7(141024)_Neighbours:2/16/20/14-16;2/16/20/14-16;2/16/
581 5/20-21/14a_Nails:6_Iter:7(141024)_Neighbours:2/16/20/14-16;2/16/21/12-14;2/16/
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586 5/20-21/11b_Nails:5_Iter:7(141024)_Neighbours:2/16/20/9-11;2/16/21/11-13;2/16/2
587 5/20-21/11a_Nails:5_Iter:7(141024)_Neighbours:2/16/20/9-11;2/16/20/9-11;2/16/2
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589 5/20-21/10a_Nails:5_Iter:7(141024)_Neighbours:2/16/20/10-12;2/16/21/8-10;2/16/2
590 5/20-21/9b_Nails:5_Iter:7(141024)_Neighbours:2/16/21/7-9;2/16/20/9-11;2/16/20/
591 5/20-21/9a_Nails:5_Iter:7(141024)_Neighbours:2/16/21/7-9;2/16/21/7-9;2/16/20/9
592 5/20-21/8b_Nails:6_Iter:7(141024)_Neighbours:2/16/20/6-8;2/16/21/8-10;2/16/21/
593 5/20-21/8a_Nails:6_Iter:7(141024)_Neighbours:2/16/20/6-8;2/16/20/6-8;2/16/21/8
594 5/20-21/7b_Nails:6_Iter:7(141024)_Neighbours:2/16/20/5-7;2/16/21/7-9;2/16/21/7/
595 5/20-21/7a_Nails:6_Iter:7(141024)_Neighbours:2/16/20/5-7;2/16/20/5-7;2/16/21/7/
  
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Future Tree / Basler & Hofmann office courtyard in Esslingen, Switzerland

107 m²
ca. 10x10m
380 timber elements

cantilevering corner

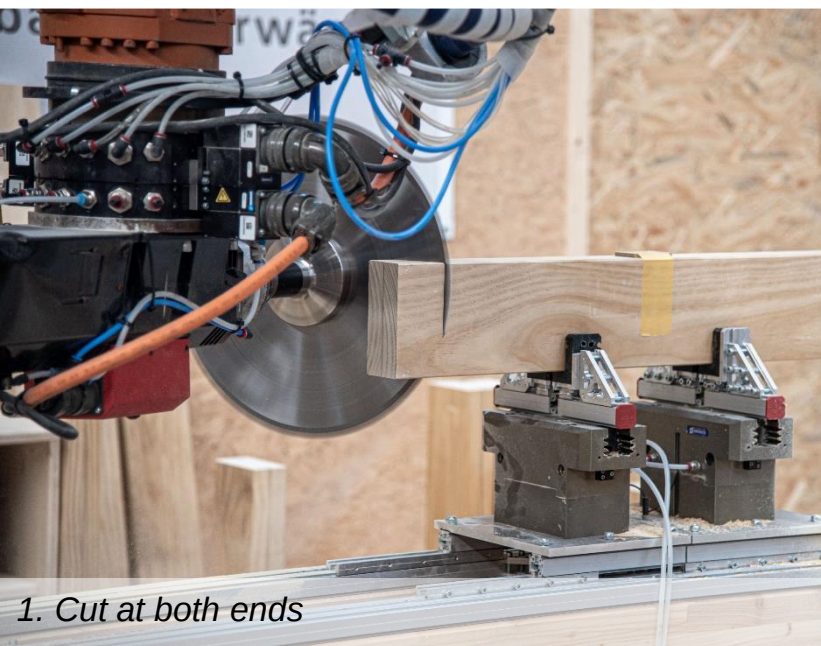
concrete column



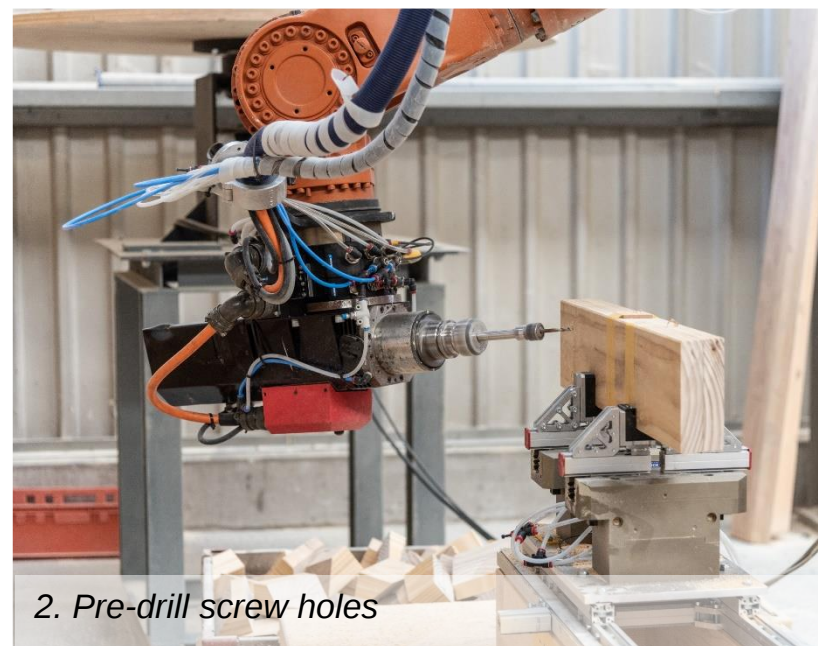
Future Tree



Fabrication setup / ERNE AG Holzbau



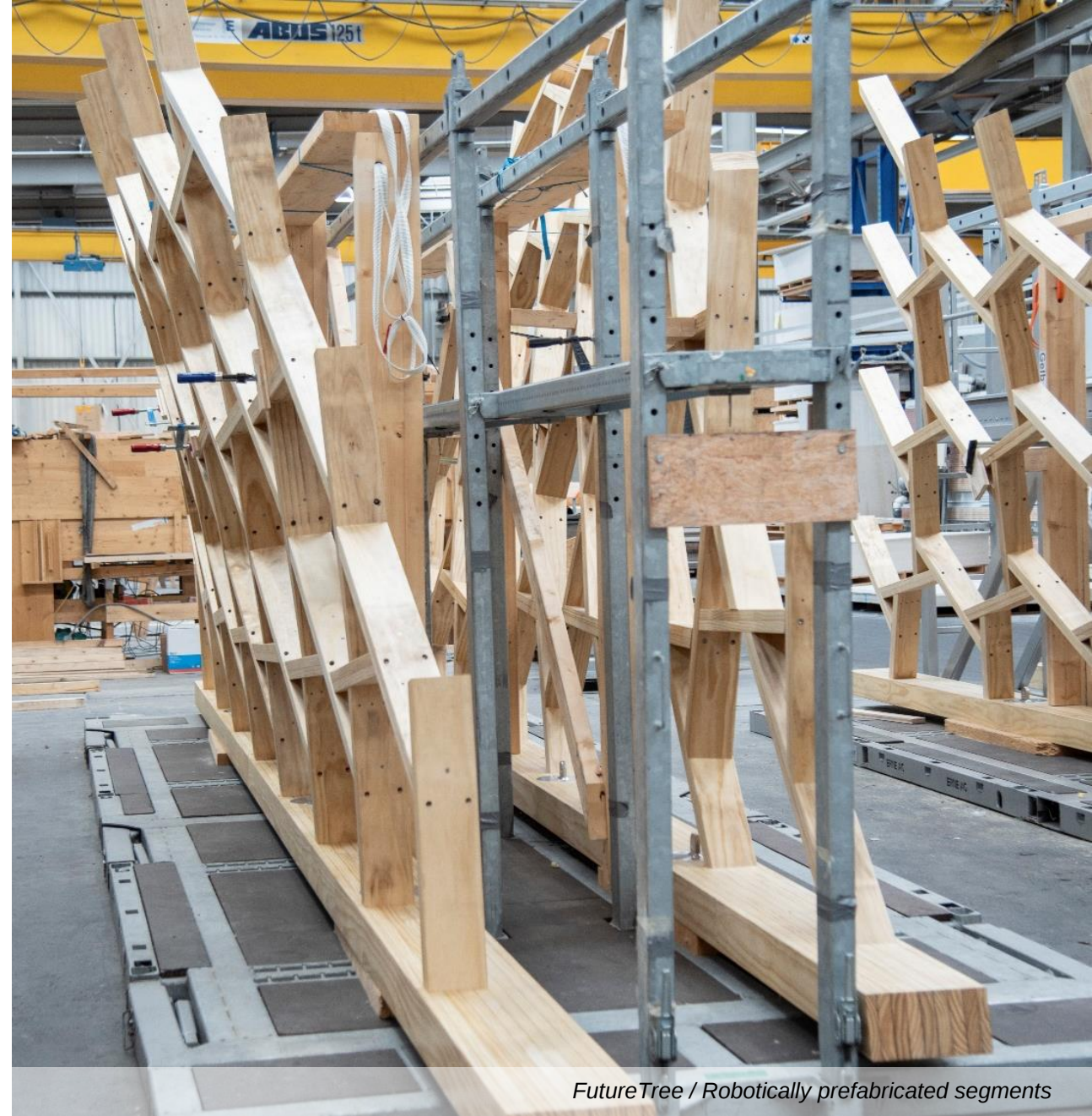
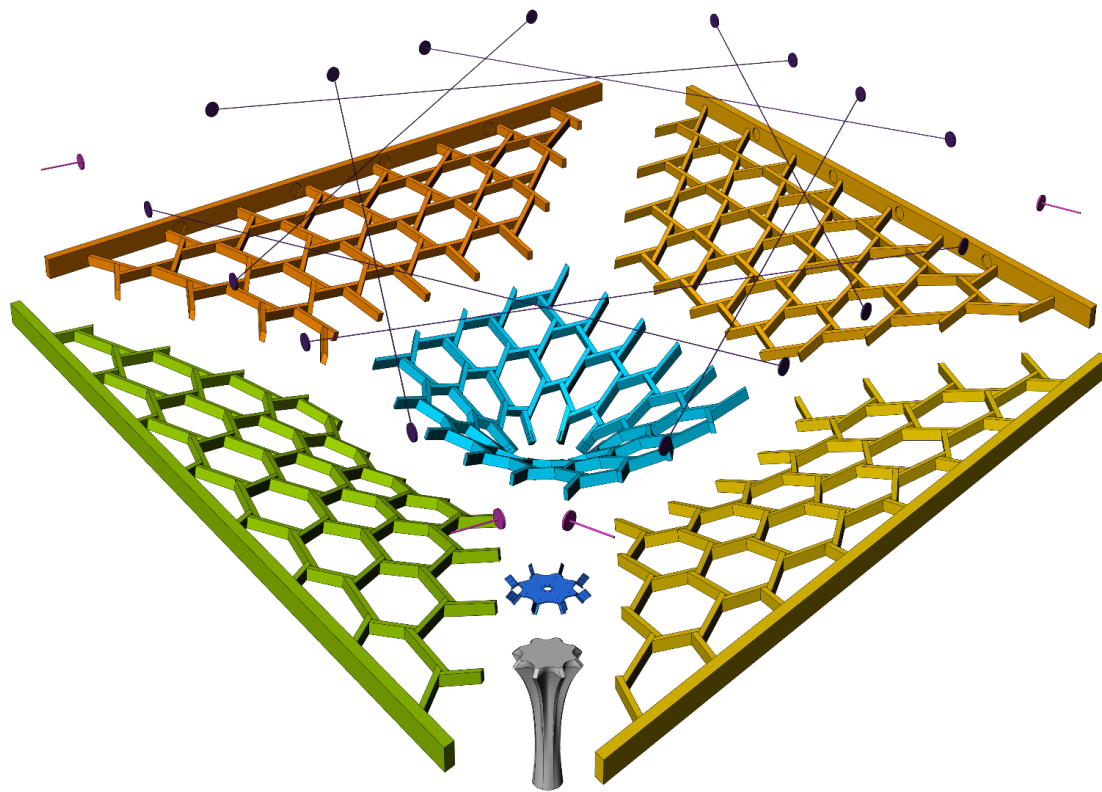
1. Cut at both ends



2. Pre-drill screw holes



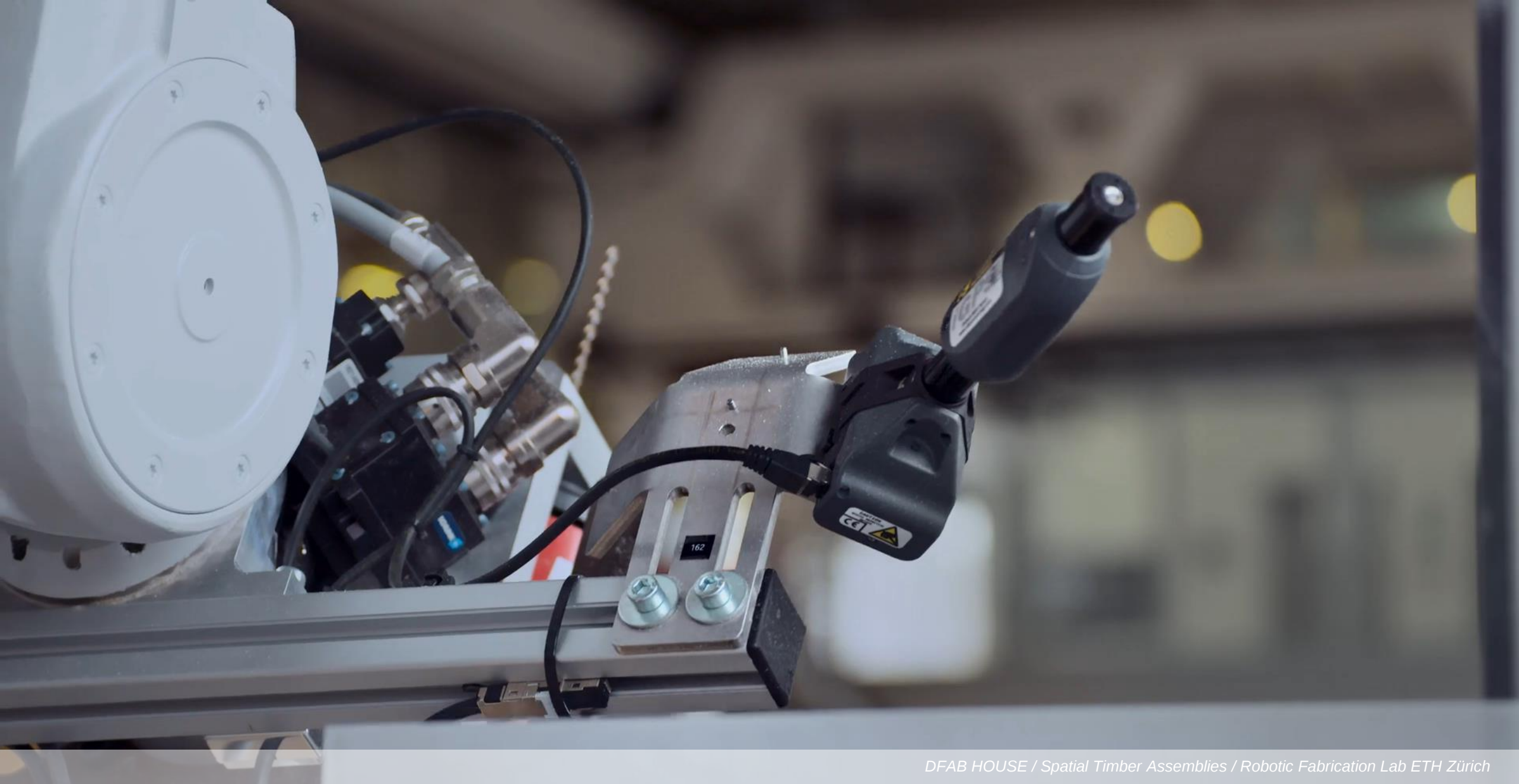
3. Hold at target position



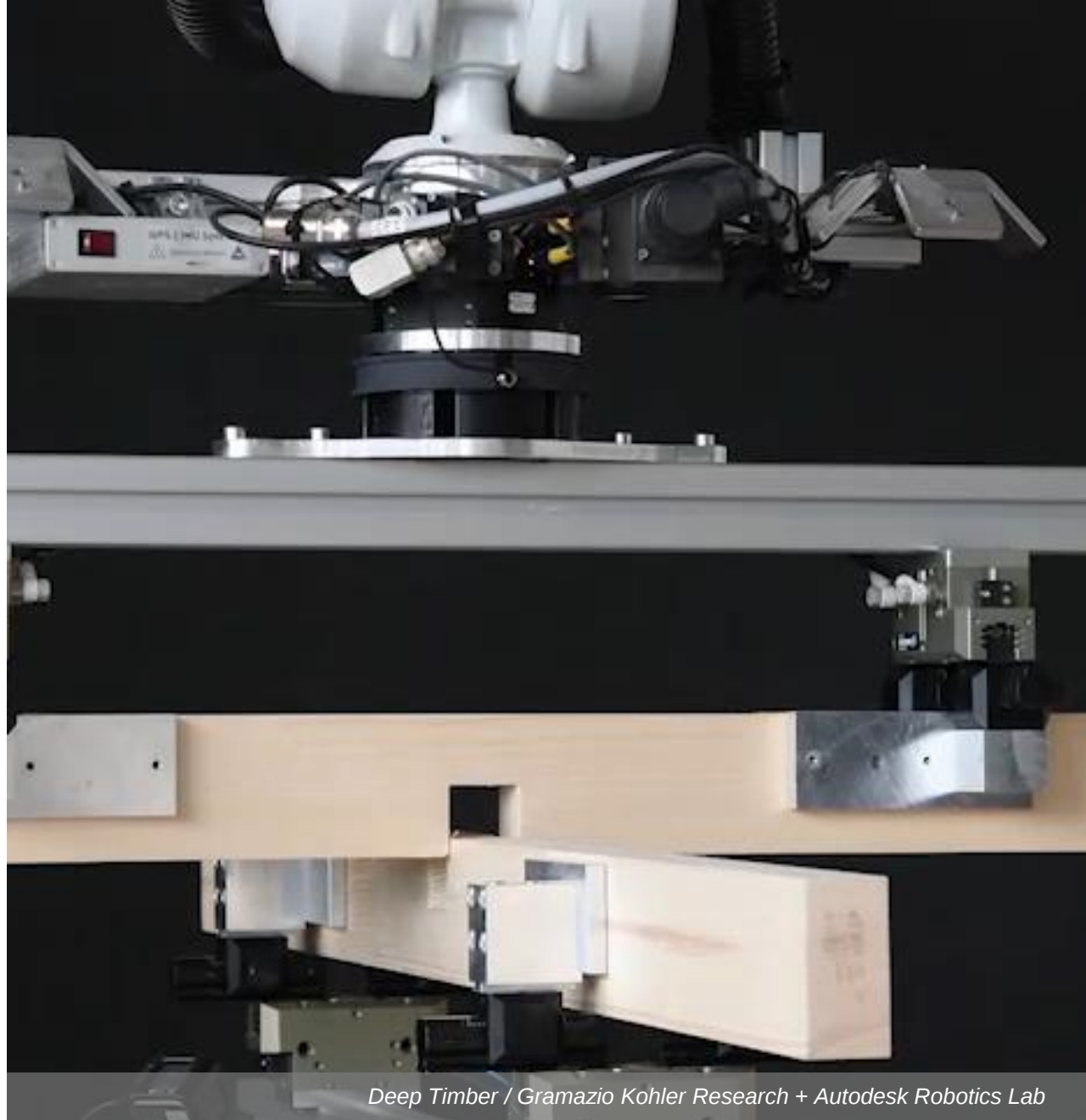
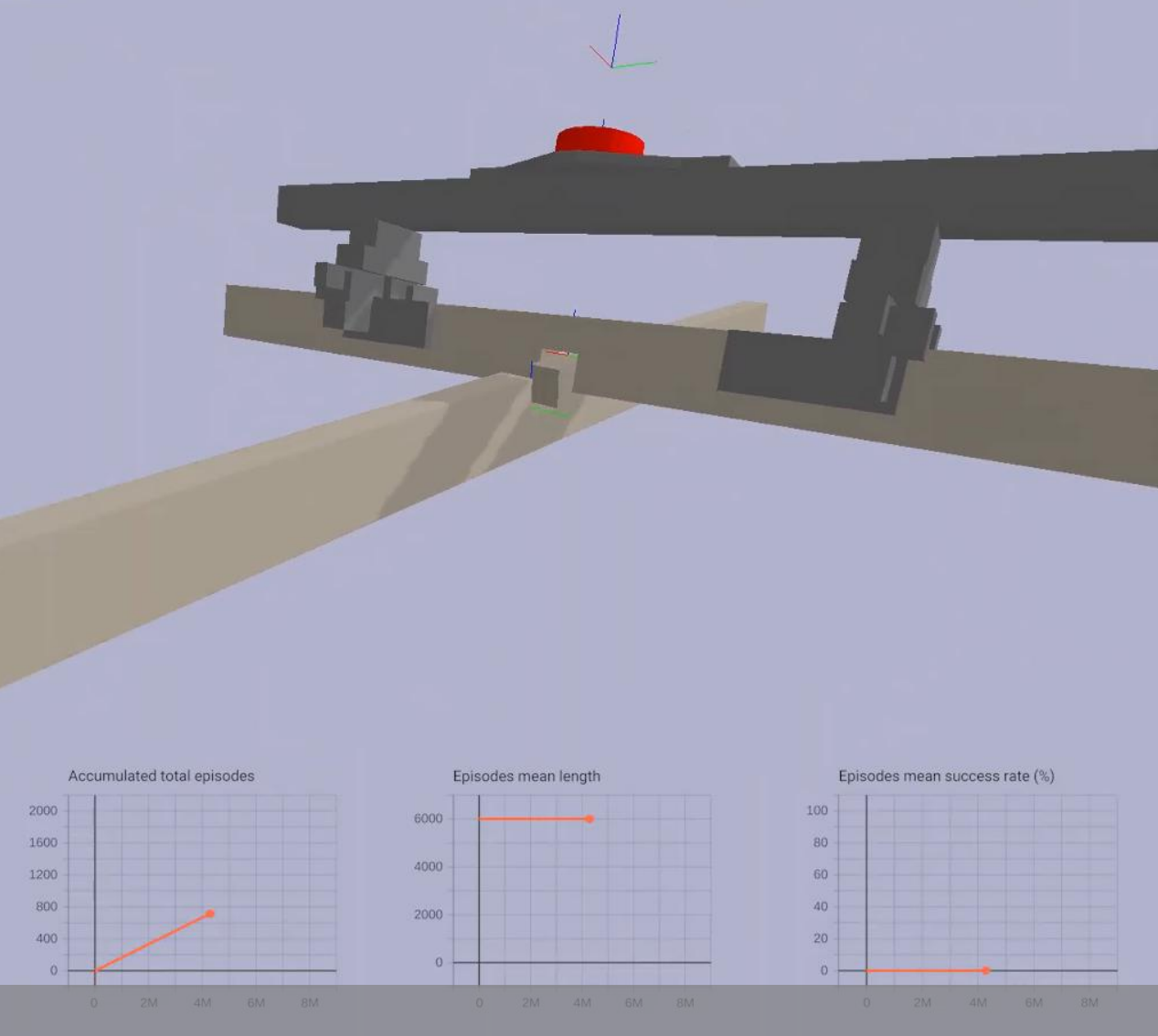
FutureTree / Robotically prefabricated segments



DFAB HOUSE / Dübendorf CH (Fot.: R. Keller)



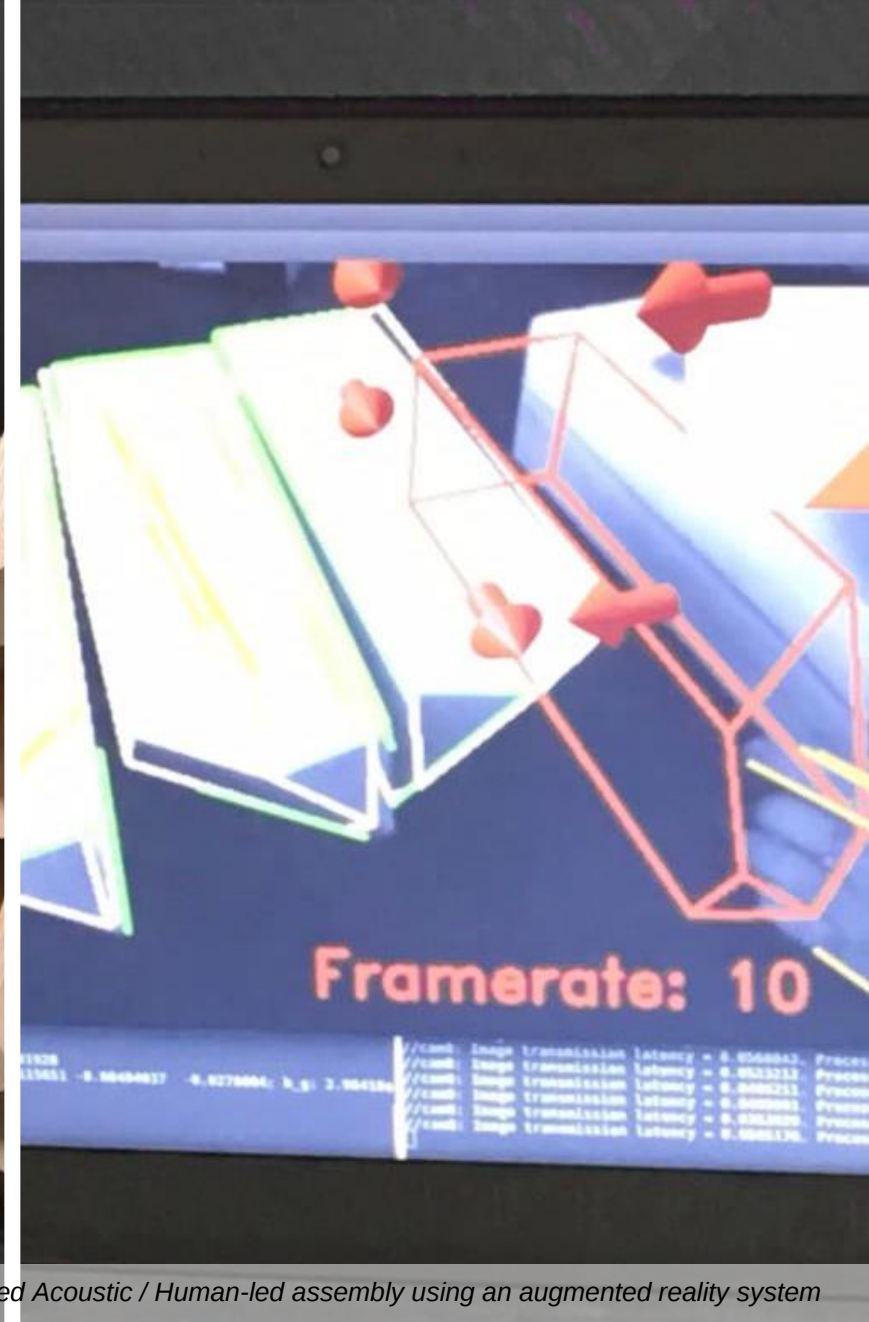
DFAB HOUSE / Spatial Timber Assemblies / Robotic Fabrication Lab ETH Zürich



Deep Timber / Gramazio Kohler Research + Autodesk Robotics Lab



Augmented Acoustics / with: T. Sandy (incon.ai), Basler&Hofmann, ERNE AG Holzbau



Augmented Acoustic / Human-led assembly using an augmented reality system

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