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Supplementary Materials for

Ultralight, strong, and self-reprogrammable mechanical metamaterials

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The PDF file includes:

Other Supplementary Material for this manuscript includes the following:

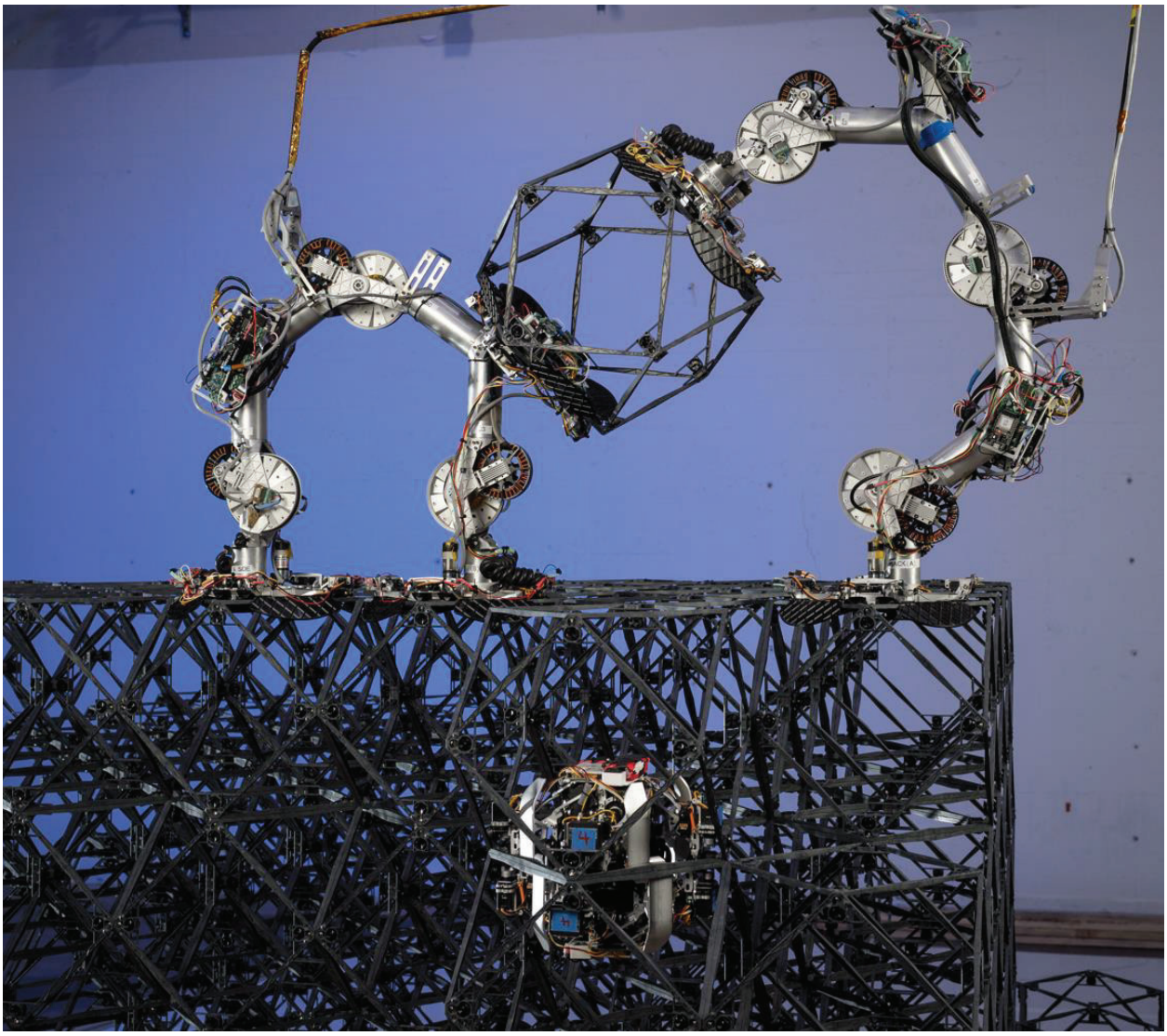

Fig. S1.
The system consists of structural building blocks and two types of robots that can traverse, assemble, and reconfigure the blocks into various structures.

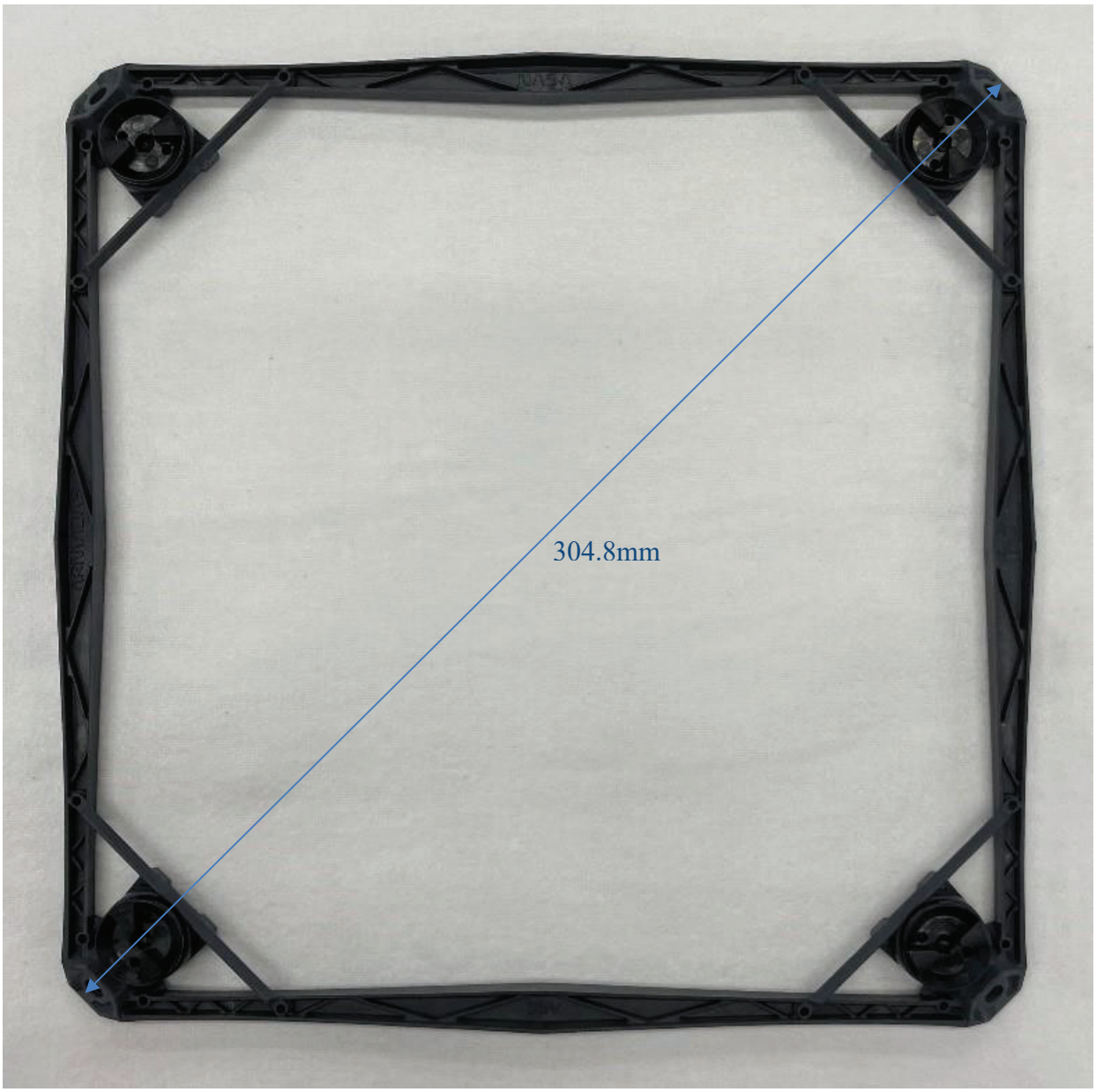

Fig. S2.
Photograph of an injection molded voxel face. Six square faces are joined at the corners to form a cuboctahedron.

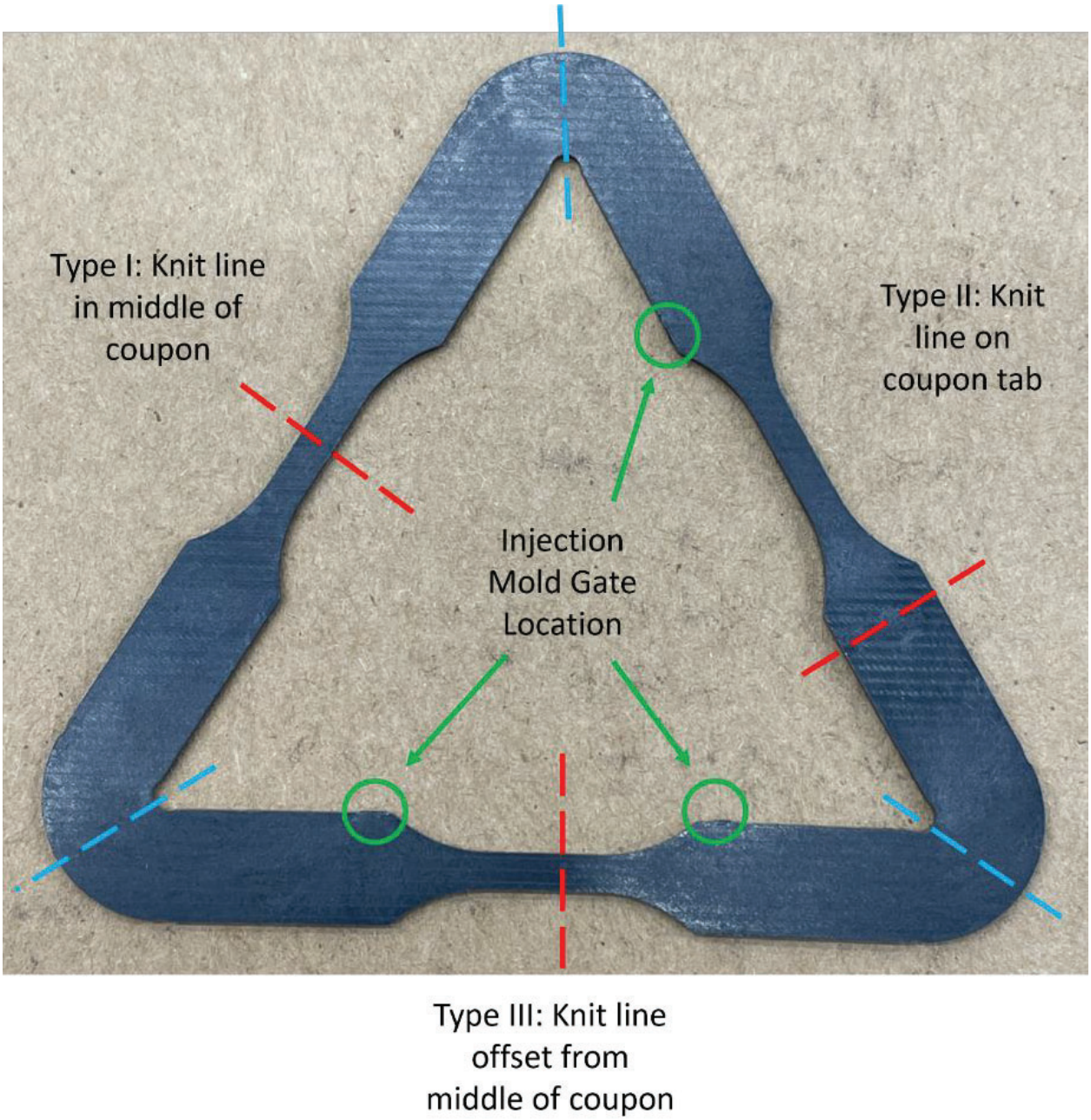

Fig. S3.
Injection molded test coupons were used to test the constituent material. This injection molding part geometry yielded coupons with and without knit lines in the test region.

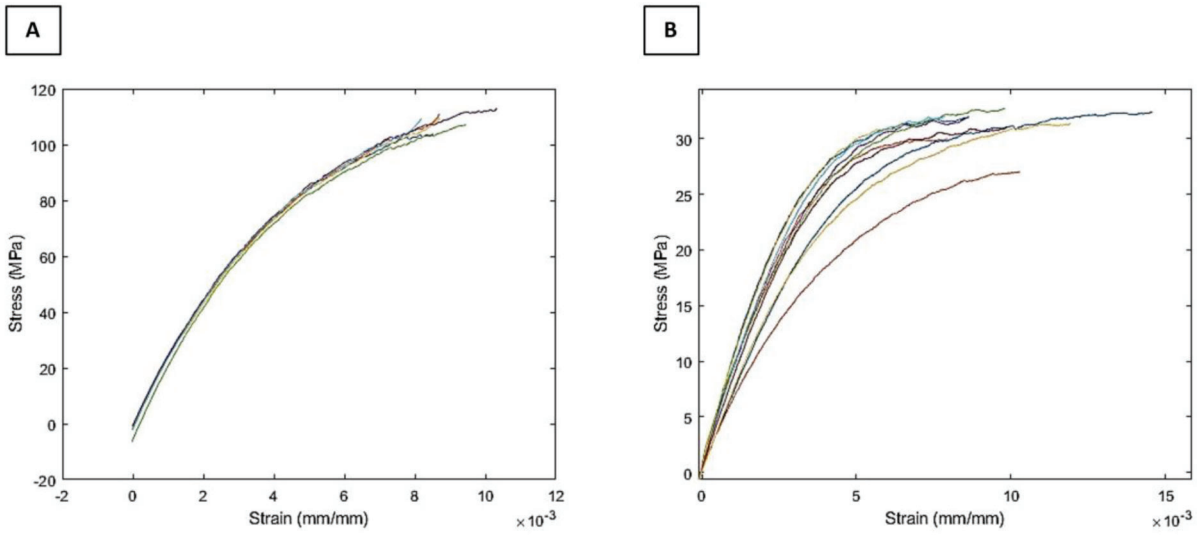

Fig. S4.

(**A**) Stress-strain curves for non-knit line StattechNN-40CF tension coupons. (**B**) Stress-strain curves for knit line StattechNN-40CF tension coupons.

Fig. S5.
Fastener tensile testing fixture and set-up.

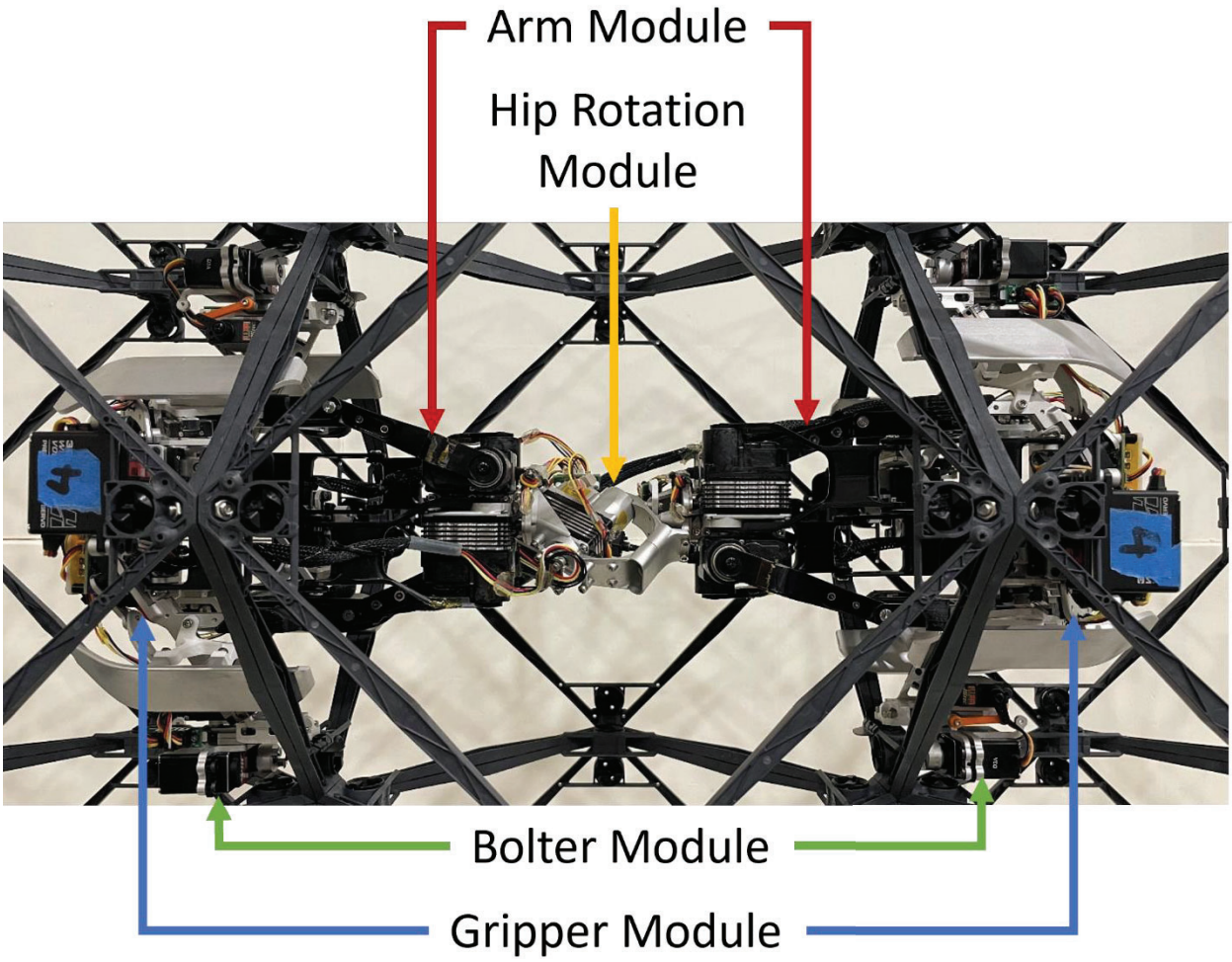

Fig. S6.
MMIC-I in extended position with labeled sub-component modules.

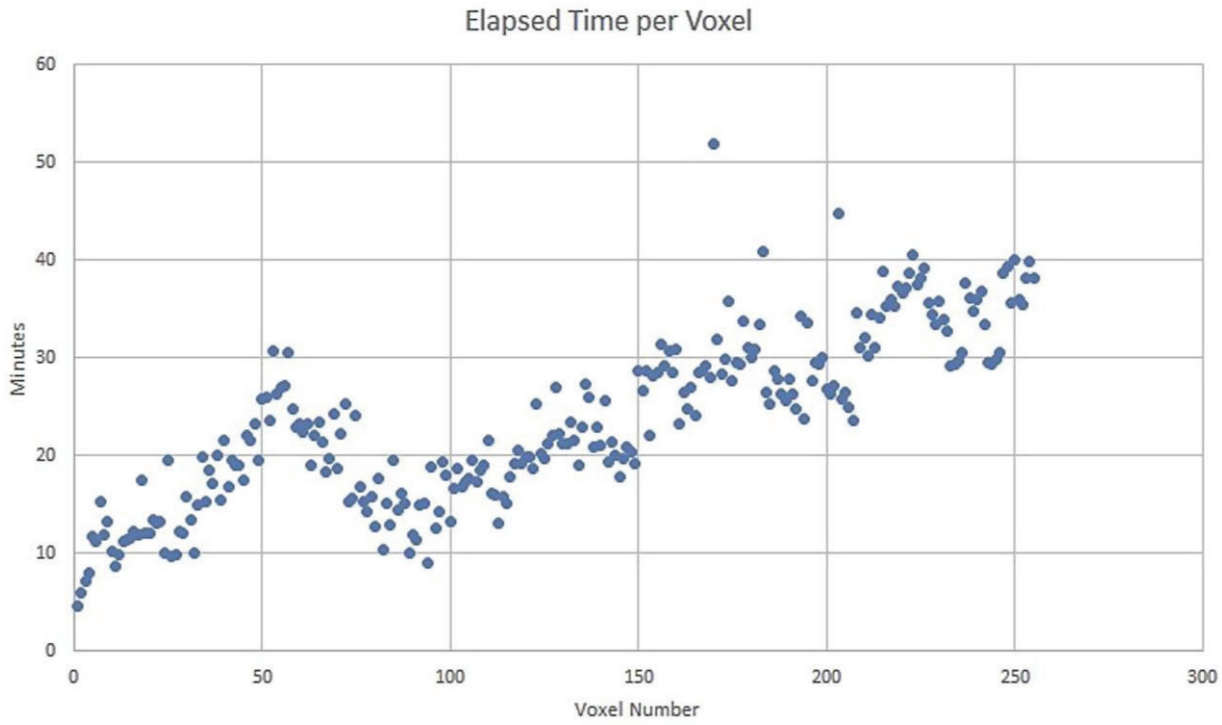

Fig. S7.

Graph of elapsed time per voxel during the 256-voxel build. Voxels further from the source depot took longer to place.

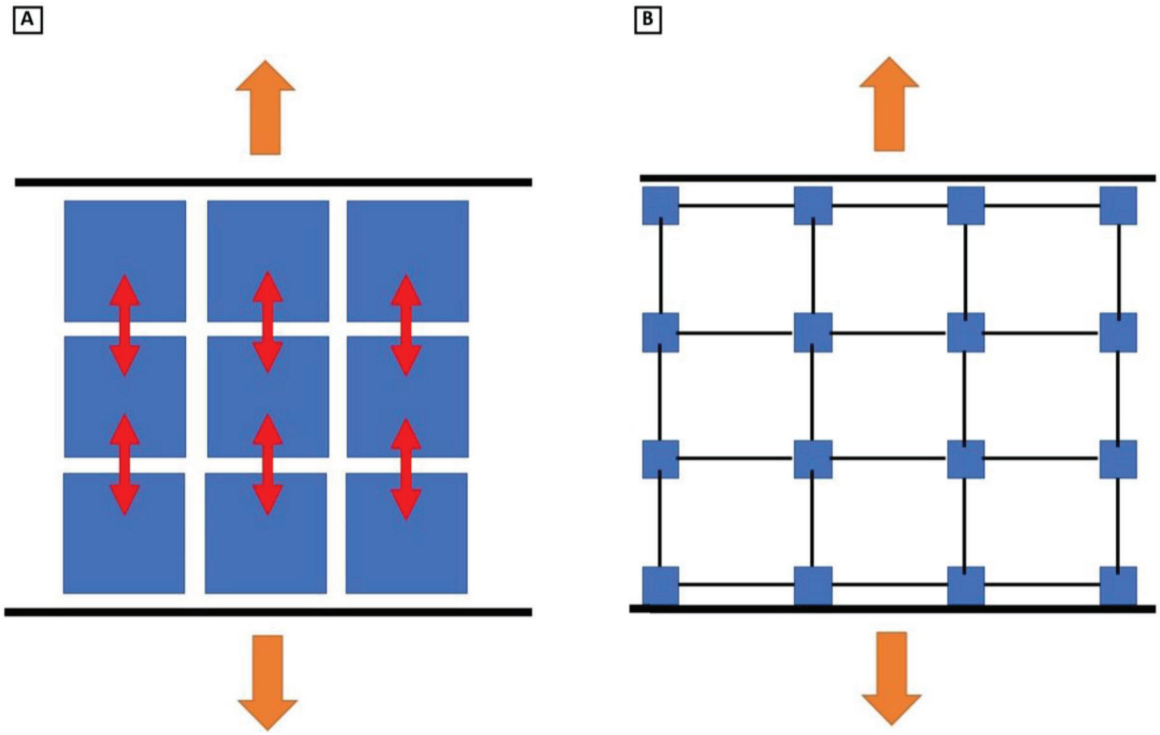

Fig. S8.
Diagrams of reconfigurable robot system strength estimation methods. (**A**) Rigid body tension method (**B**) Rigid body tension method modification for reconfigurable truss systems.

Specimen	Failure Load (N)
1	805.3
2	808.2
3	798.6
4	787.0
5	799.9
6	784.8
AVG	**797.3**
STD	**8.7**

Table S1.
Tensile failure loads for each fastener.

Robot Name	Total Distance Traveled	Robot Body Length (m)	Distance Traveled per Robot Body Length
Cargo SOLL-E	3,151.918 m (3.152 km)	0.681	4624.975
Crane SOLL-E	355.800 m (0.356 km)	0.681	522.085
MMIC-I	229.831 m (0.230 km)	0.305	754.077

Table S2.
Distance traveled for each robot.

Assembly	Mass (g)
Motor Assembly	1311
Upper Strut Assembly	290
Lower Strut Assembly	96
Gripper	1528
Cargo Gripper (only for Cargo SOLL-E)	388
Board and Cabling	1100
Accessories	86
Total Estimated Robot Mass	**4799**

Table S3.
Mass distribution for the SOLL-E robot used in the distance traveled calculation.

Assembly	Mass (g)
Hip	227
Arm Servo Block	710
Arms	198
Grippers	1300
Bolters	1208
Total Estimated Robot Mass	**3642**

Table S4.
Mass distribution for the MMIC-I robot used in the distance traveled calculation.

Specimen	Modulus (MPa)	Strain Bound (lower)	Strain Bound (upper)	Regression R^2	Valid Break?	Ultimate Strength (MPa)
'3.1'	18271	1.39E-03	2.82E-03	0.99890	yes	103.76
'3.2'	23921	-1.00E-05	1.47E-03	0.99778	no	not valid
'3.3'	18129	1.43E-03	2.91E-03	0.99911	yes	109.44
'3.4'	16458	1.73E-03	3.40E-03	0.99631	yes	112.87
'3.5'	25056	-1.00E-05	1.49E-03	0.99781	yes	107.14
'3.6'	18659	1.41E-03	2.77E-03	0.99893	yes	109.37
AVG	**20083**				**AVG**	**108.52**
STD	**3207**				**STD**	**3.00**

Table S5.
Mechanical testing results from StattechNN-40CF tension coupon specimens without knit lines.

Specimen	Modulus (MPa)	Strain Bound (lower)	Strain Bound (upper)	Regression R^2	Valid Test?	Valid Break?	Ultimate Strength (MPa)
'1.1'	9121.7	0	0.00174	0.9968	yes	yes	31.996
'1.2'	-	-	-	-	no	no	-
'1.3'	8344.4	0	0.00157	0.9968	yes	yes	29.986
'1.4'	9093.3	0	0.00149	0.9973	yes	yes	31.491
'1.5'	-	-	-	-	no	no	-
'1.6'	8043.3	0	0.00171	0.9951	yes	yes	31.801
'2.1'	8043.4	-1.00E-05	0.00164	0.9949	yes	yes	32.723
'2.2'	8665.2	0	0.00159	0.9982	yes	no	-
'2.3'	7825.5	0	0.00171	0.9993	yes	yes	31.007
'2.4'	6329.6	0	0.00249	0.9982	yes	yes	32.436
'2.5'	5632.6	0	0.00178	0.9963	yes	yes	27.091
'2.6'	6844.6	0	0.00192	0.9985	yes	yes	31.379
AVG	**7794.4**						**31.101**
STD	**1111.6**						**1.608**

Table S6.
Mechanical testing results from StattechNN-40CF tension coupon specimens with knit lines.

	Break Load (N)	Ultimate Strength (kPa)	Chord Modulus (0.002-0.008) (MPa)
Specimen 1	10064.8	12.04	1.1120
Specimen 2	9442.7	11.29	1.1139
Specimen 3	9031.1	10.80	1.1128
AVG	**9512.9**	**11.38**	**1.1129**
STD	**424.9**	**0.51**	**0.00078**

Table S7.
Compression testing results for 3x3x3 voxel assemblies.

Component	Average Mass (g)	Number Per Voxel	Total Component Mass (g) / Voxel
Fastener w/ O-ring	2.1114	24	50.6736
Face	35.055	6	210.33
10-32 nut and bolt pair	2.52	12	30.24
Voxel Total Mass			**291.24**
Voxel Bounding Box Length (mm)	304.8		
Voxel Bounding Volume (mm^3)	28316847		
Voxel Bounding Volume (cc)	28316.85		
Voxel Density (g/cc)	0.010285		
Voxel Density (kg/m^3)	10.285		

Table S8.
Voxel mass breakdown and density calculations.

Number of Voxels	256
Volume / Voxel (mm^3)	28316846.59
Total Volume (mm^3)	7249112728
Build Time (hours)	100.3767
Build Time (seconds)	361356.12
Throughput (mm^3/s)	20060.855

Table S9.
Build throughput calculations.

Movie S1.
A simulation of multiple sets of ARMADAS robots working together to build a tower.