First Ideas for a Digital Twin Index for Quality Management

Wednesday February 23rd, 2022

Martin Hardwick

Convenor WG15

Functionalities

Requirement

- Digital Twins for very large complex assemblies
- Context dependent details for same component
- Same detail for different components
- Quality control across entire assembly

Solution

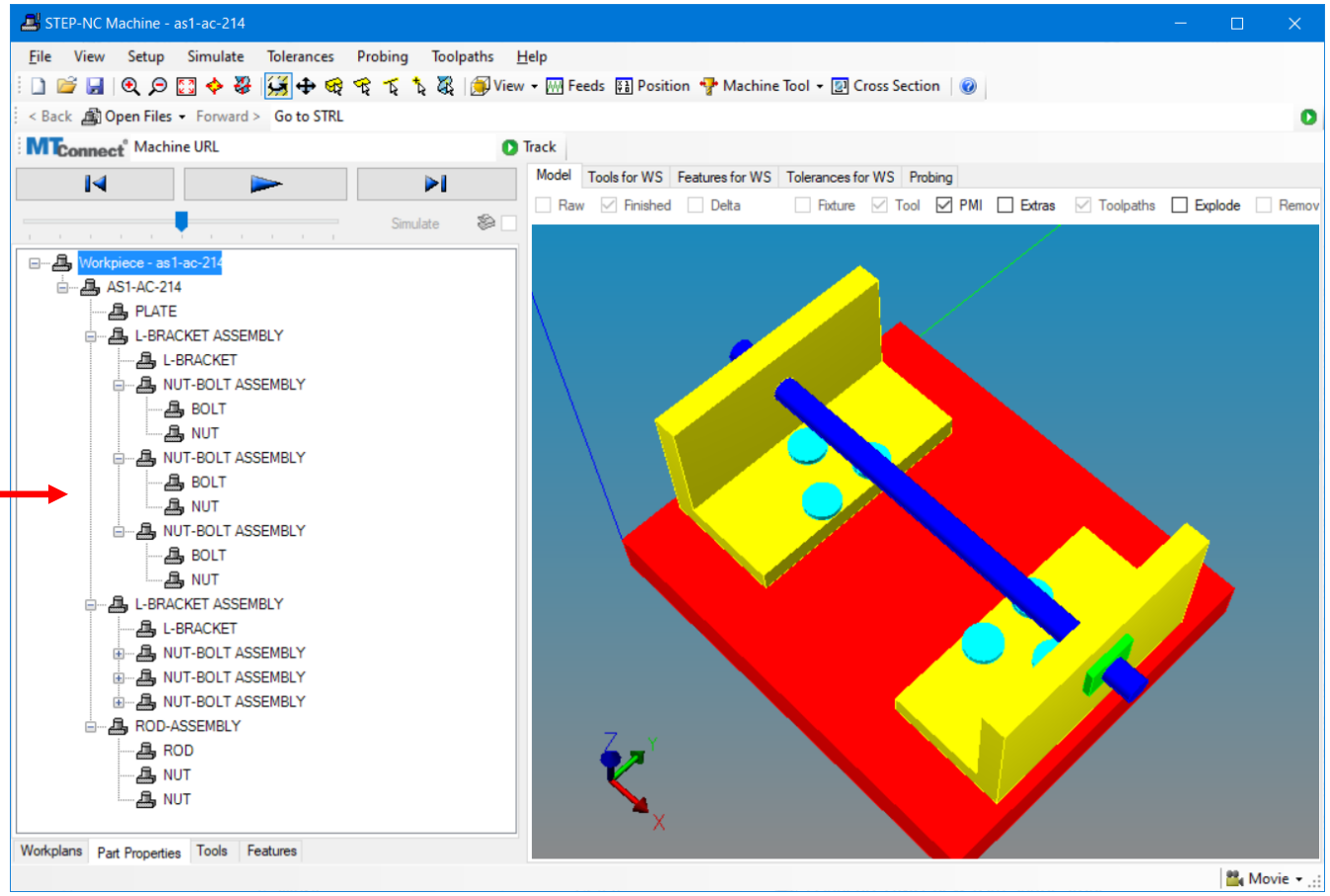
- Hierarchical decomposition (assembly->detail->assembly)
- L-Bracket left detail.stp, L-Bracket right detail.stp
- Three types of sunbed models on cruise ship use the same detail
- Each component has its own details, results and machining file

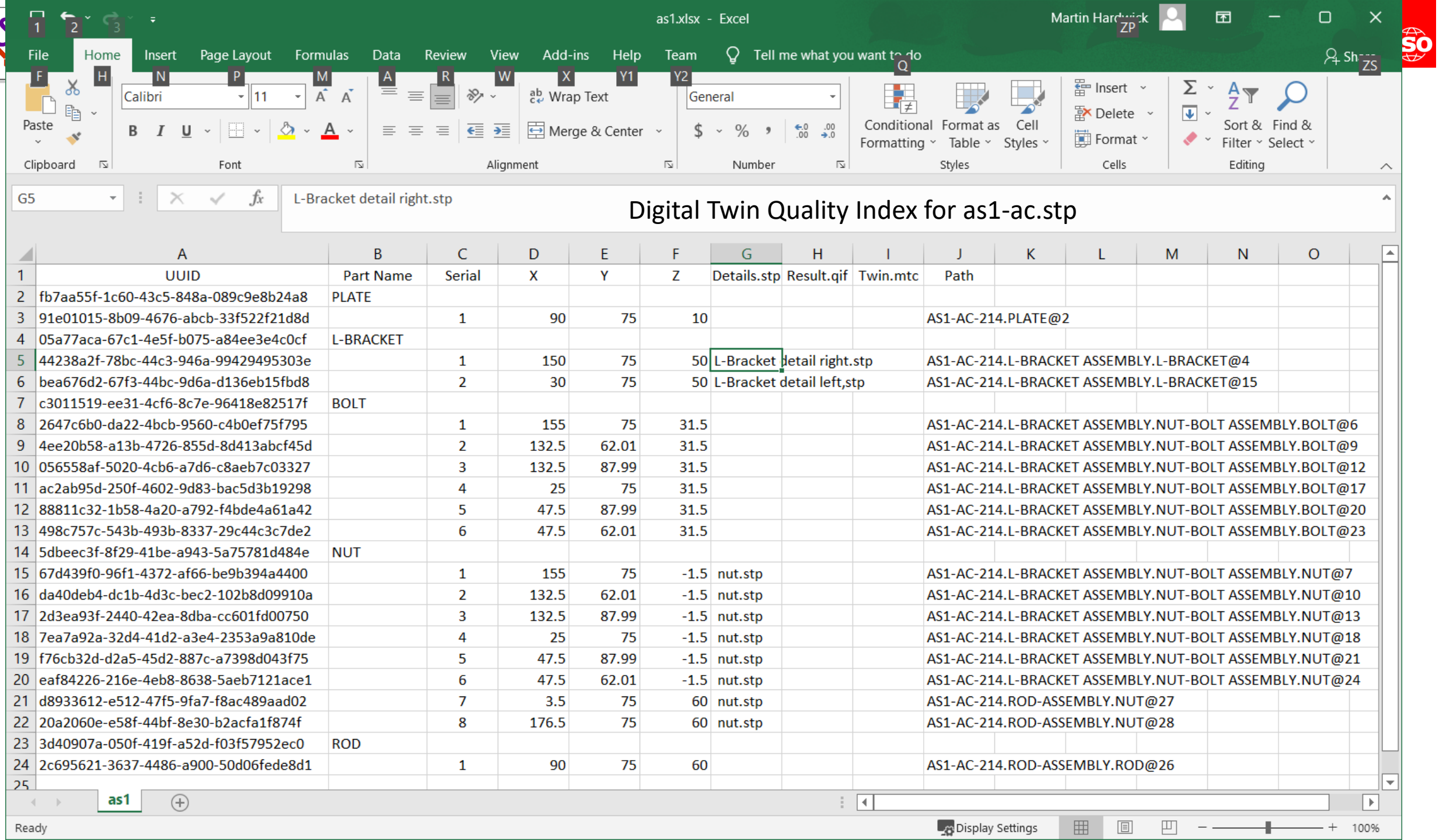
Test Case

5 designed items have engineering requirements (plate, L-Bracket, nut, bolt, rod)

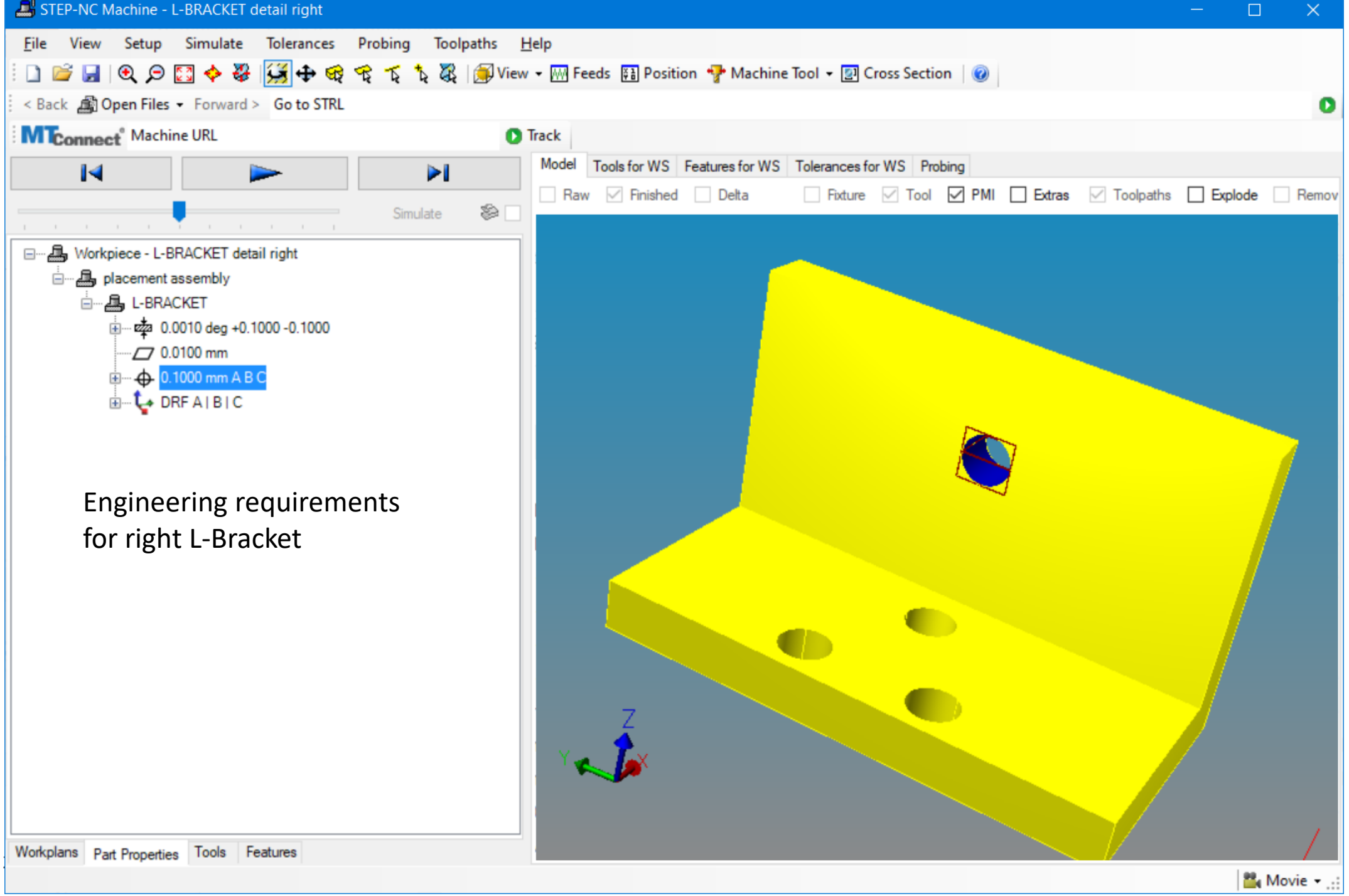
28 nodes in assembly tree

18 machined items (8 nuts, 6 bolt, 2 brackets, 1 plate, 1 rod)

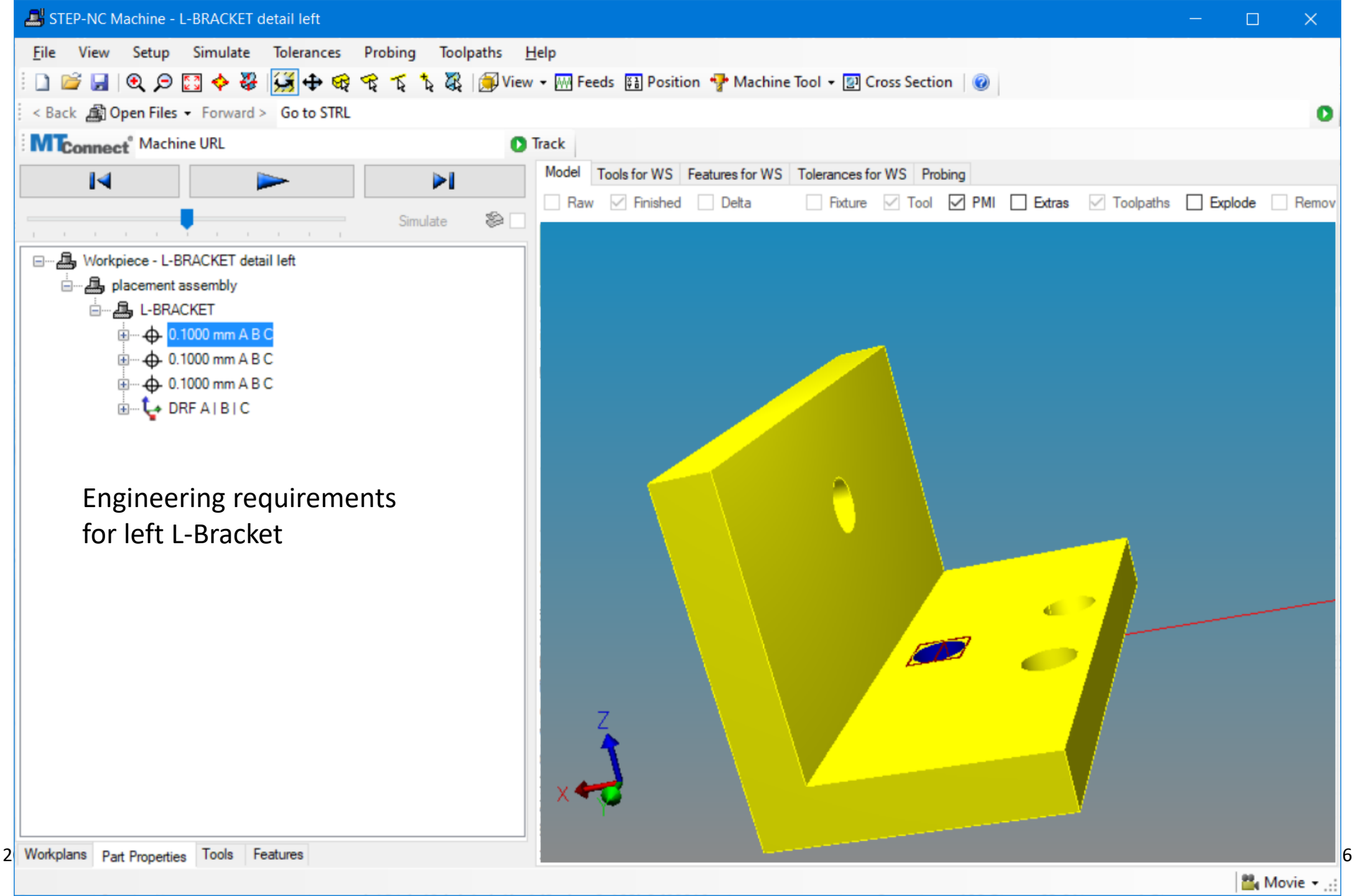




	A	B	C	D	E	F	G	H	I	J
1	UUID	Part Name	Serial	X	Y	Z	Details.stp	Result.qif	Twin.mtc	Path
2	fb7aa55f-1c60-43c5-848a-089c9e8b24a8	PLATE								
3	91e01015-8b09-4676-abcb-33f522f21d8d		1	90	75	10				AS1-AC-214.PLATE@2
4	05a77aca-67c1-4e5f-b075-a84ee3e4c0cf	L-BRACKET								
5	44238a2f-78bc-44c3-946a-99429495303e		1	150	75	50	L-Bracket	detail right.stp		AS1-AC-214.L-BRACKET ASSEMBLY.L-BRACKET@4
6	bea676d2-67f3-44bc-9d6a-d136eb15fbd8		2	30	75	50	L-Bracket detail left,stp			AS1-AC-214.L-BRACKET ASSEMBLY.L-BRACKET@15
7	c3011519-ee31-4cf6-8c7e-96418e82517f	BOLT								
8	2647c6b0-da22-4bcb-9560-c4b0ef75f795		1	155	75	31.5				AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.BOLT@6
9	4ee20b58-a13b-4726-855d-8d413abcf45d		2	132.5	62.01	31.5				AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.BOLT@9
10	056558af-5020-4cb6-a7d6-c8aeb7c03327		3	132.5	87.99	31.5				AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.BOLT@12
11	ac2ab95d-250f-4602-9d83-bac5d3b19298		4	25	75	31.5				AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.BOLT@17
12	88811c32-1b58-4a20-a792-f4bde4a61a42		5	47.5	87.99	31.5				AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.BOLT@20
13	498c757c-543b-493b-8337-29c44c3c7de2		6	47.5	62.01	31.5				AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.BOLT@23
14	5dbeec3f-8f29-41be-a943-5a75781d484e	NUT								
15	67d439f0-96f1-4372-af66-be9b394a4400		1	155	75	-1.5	nut.stp			AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.NUT@7
16	da40deb4-dc1b-4d3c-bec2-102b8d09910a		2	132.5	62.01	-1.5	nut.stp			AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.NUT@10
17	2d3ea93f-2440-42ea-8dba-cc601fd00750		3	132.5	87.99	-1.5	nut.stp			AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.NUT@13
18	7ea7a92a-32d4-41d2-a3e4-2353a9a810de		4	25	75	-1.5	nut.stp			AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.NUT@18
19	f76cb32d-d2a5-45d2-887c-a7398d043f75		5	47.5	87.99	-1.5	nut.stp			AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.NUT@21
20	eaf84226-216e-4eb8-8638-5aeb7121ace1		6	47.5	62.01	-1.5	nut.stp			AS1-AC-214.L-BRACKET ASSEMBLY.NUT-BOLT ASSEMBLY.NUT@24
21	d8933612-e512-47f5-9fa7-f8ac489aad02		7	3.5	75	60	nut.stp			AS1-AC-214.ROD-ASSEMBLY.NUT@27
22	20a2060e-e58f-44bf-8e30-b2acfa1f874f		8	176.5	75	60	nut.stp			AS1-AC-214.ROD-ASSEMBLY.NUT@28
23	3d40907a-050f-419f-a52d-f03f57952ec0	ROD								
24	2c695621-3637-4486-a900-50d06fede8d1		1	90	75	60				AS1-AC-214.ROD-ASSEMBLY.ROD@26
25										

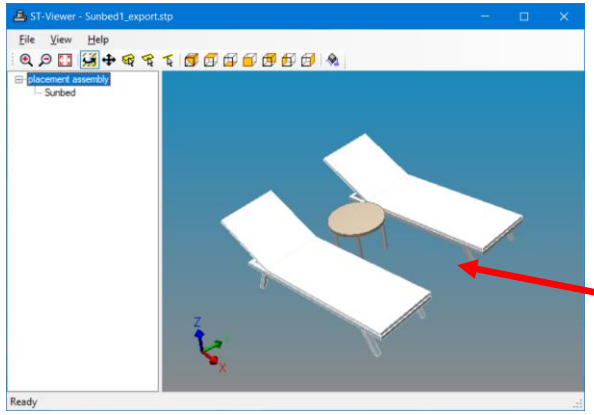


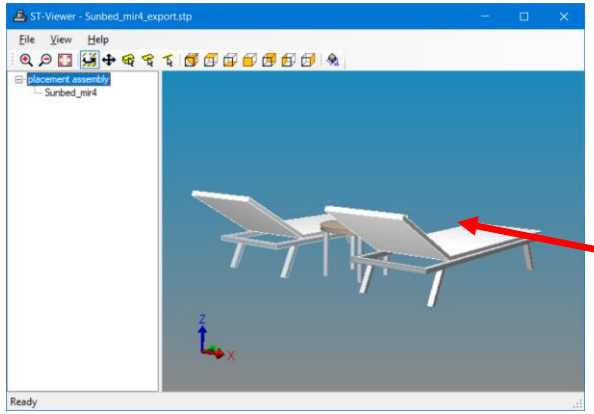
Engineering requirements
for right L-Bracket

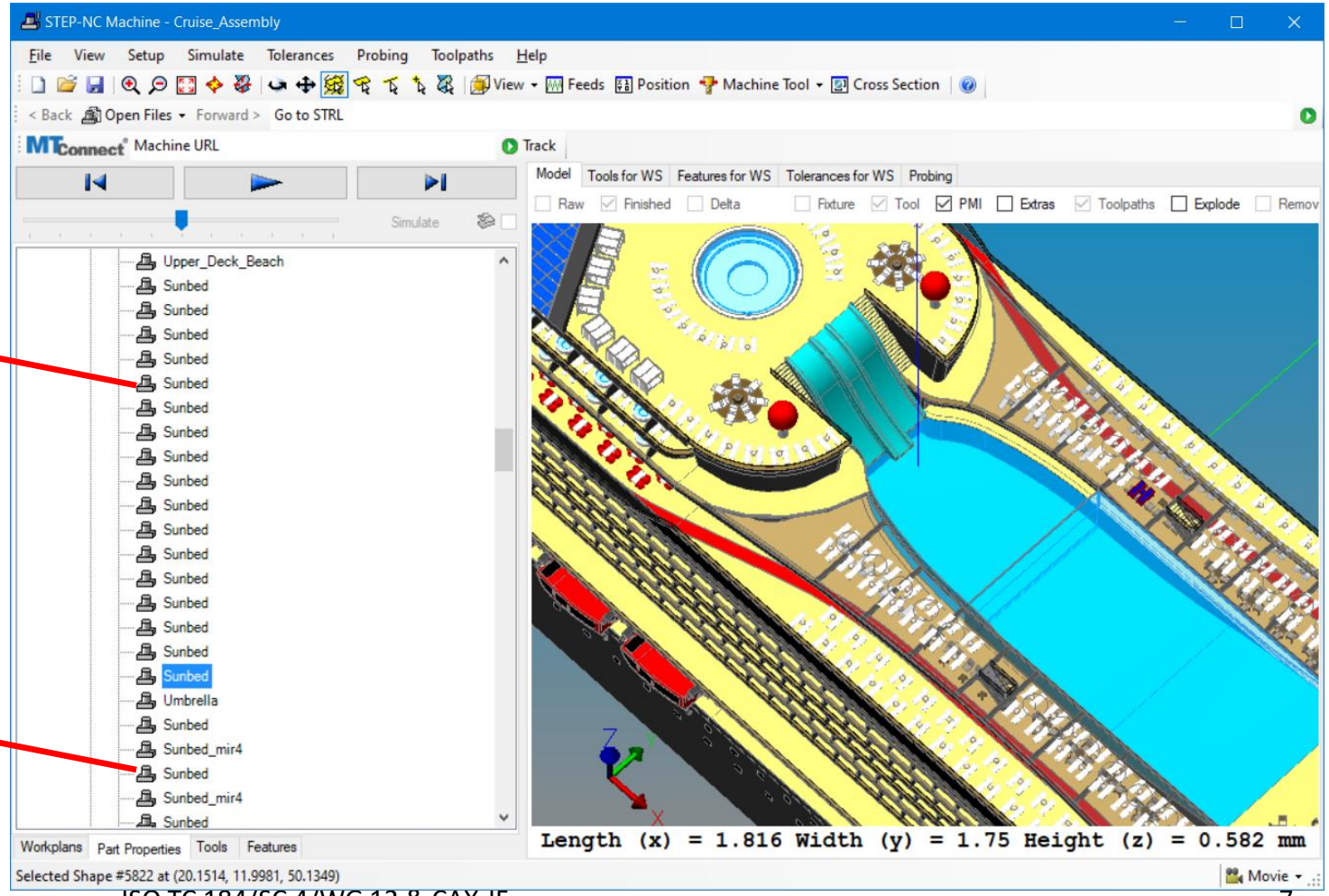


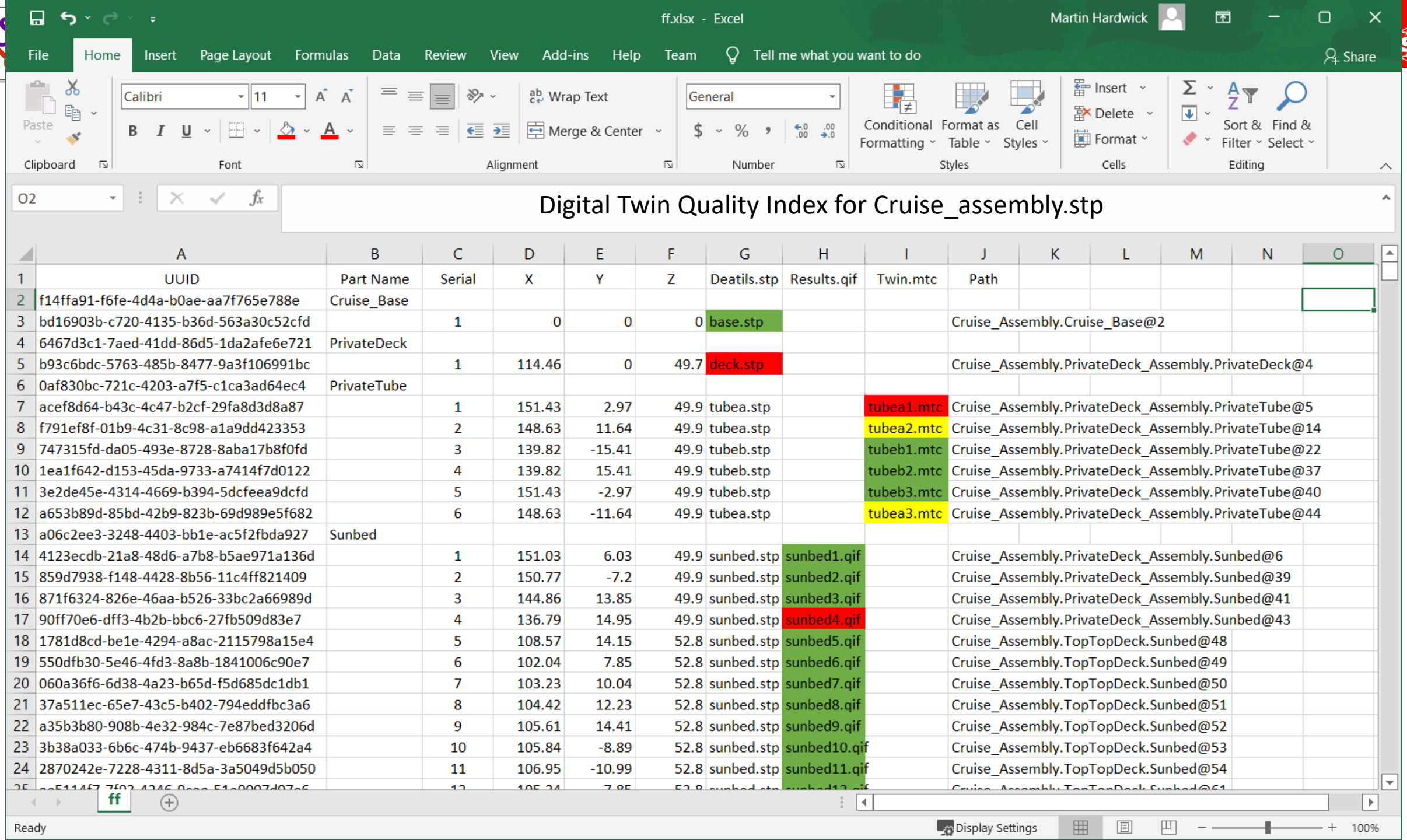
Engineering requirements
for left L-Bracket

Cruise ship example









	A	B	C	D	E	F	G	H	I	J
1	UUID	Part Name	Serial	X	Y	Z	Deatils.stp	Results.qif	Twin.mtc	Path
2	f14ffa91-f6fe-4d4a-b0ae-aa7f765e788e	Cruise_Base								
3	bd16903b-c720-4135-b36d-563a30c52cfd		1	0	0	0	base.stp			Cruise_Assembly.Cruise_Base@2
4	6467d3c1-7aed-41dd-86d5-1da2afe6e721	PrivateDeck								
5	b93c6bdc-5763-485b-8477-9a3f106991bc		1	114.46	0	49.7	deck.stp			Cruise_Assembly.PrivateDeck_Assembly.PrivateDeck@4
6	0af830bc-721c-4203-a7f5-c1ca3ad64ec4	PrivateTube								
7	acef8d64-b43c-4c47-b2cf-29fa8d3d8a87		1	151.43	2.97	49.9	tubea.stp		tubea1.mtc	Cruise_Assembly.PrivateDeck_Assembly.PrivateTube@5
8	f791ef8f-01b9-4c31-8c98-a1a9dd423353		2	148.63	11.64	49.9	tubea.stp		tubea2.mtc	Cruise_Assembly.PrivateDeck_Assembly.PrivateTube@14
9	747315fd-da05-493e-8728-8aba17b8f0fd		3	139.82	-15.41	49.9	tubeb.stp		tubeb1.mtc	Cruise_Assembly.PrivateDeck_Assembly.PrivateTube@22
10	1ea1f642-d153-45da-9733-a7414f7d0122		4	139.82	15.41	49.9	tubeb.stp		tubeb2.mtc	Cruise_Assembly.PrivateDeck_Assembly.PrivateTube@37
11	3e2de45e-4314-4669-b394-5dcfeea9dcfd		5	151.43	-2.97	49.9	tubeb.stp		tubeb3.mtc	Cruise_Assembly.PrivateDeck_Assembly.PrivateTube@40
12	a653b89d-85bd-42b9-823b-69d989e5f682		6	148.63	-11.64	49.9	tubea.stp		tubea3.mtc	Cruise_Assembly.PrivateDeck_Assembly.PrivateTube@44
13	a06c2ee3-3248-4403-bb1e-ac5f2fbda927	Sunbed								
14	4123ecdb-21a8-48d6-a7b8-b5ae971a136d		1	151.03	6.03	49.9	sunbed.stp	sunbed1.qif		Cruise_Assembly.PrivateDeck_Assembly.Sunbed@6
15	859d7938-f148-4428-8b56-11c4ff821409		2	150.77	-7.2	49.9	sunbed.stp	sunbed2.qif		Cruise_Assembly.PrivateDeck_Assembly.Sunbed@39
16	871f6324-826e-46aa-b526-33bc2a66989d		3	144.86	13.85	49.9	sunbed.stp	sunbed3.qif		Cruise_Assembly.PrivateDeck_Assembly.Sunbed@41
17	90ff70e6-dff3-4b2b-bbc6-27fb509d83e7		4	136.79	14.95	49.9	sunbed.stp	sunbed4.qif		Cruise_Assembly.PrivateDeck_Assembly.Sunbed@43
18	1781d8cd-be1e-4294-a8ac-2115798a15e4		5	108.57	14.15	52.8	sunbed.stp	sunbed5.qif		Cruise_Assembly.TopTopDeck.Sunbed@48
19	550dfb30-5e46-4fd3-8a8b-1841006c90e7		6	102.04	7.85	52.8	sunbed.stp	sunbed6.qif		Cruise_Assembly.TopTopDeck.Sunbed@49
20	060a36f6-6d38-4a23-b65d-f5d685dc1db1		7	103.23	10.04	52.8	sunbed.stp	sunbed7.qif		Cruise_Assembly.TopTopDeck.Sunbed@50
21	37a511ec-65e7-43c5-b402-794eddfbc3a6		8	104.42	12.23	52.8	sunbed.stp	sunbed8.qif		Cruise_Assembly.TopTopDeck.Sunbed@51
22	a35b3b80-908b-4e32-984c-7e87bed3206d		9	105.61	14.41	52.8	sunbed.stp	sunbed9.qif		Cruise_Assembly.TopTopDeck.Sunbed@52
23	3b38a033-6b6c-474b-9437-eb6683f642a4		10	105.84	-8.89	52.8	sunbed.stp	sunbed10.qif		Cruise_Assembly.TopTopDeck.Sunbed@53
24	2870242e-7228-4311-8d5a-3a5049d5b050		11	106.95	-10.99	52.8	sunbed.stp	sunbed11.qif		Cruise_Assembly.TopTopDeck.Sunbed@54

Content of the Index

- One spreadsheet row for each machined item
  - UUID of the item
  - Engineering part name
  - Serial number
  - Airframe coordinates of item placement
  - Details.stp/stpnc (further detail)
  - Results.qif (measurement results for measured items)
  - Twin.mtc (machining results for machined items)
  - Path to item in assembly (for visualization hot linking)

TBD

- Breakdown assemblies – so left L-Bracket plus nuts can have different constraints to right L-Bracket plus nuts.
- System details for HVAC, Electrical, Piping, etc.
- Allowed types for details, results and manufacturing files – for example a spreadsheet instead of an mtc, or a CAD file instead of a STEP file.
- Colors and rules for managing failure modes
- Make the index robust for various types of engineering changes – e.g. checksums, indicators
- Decide on formats allowed for the index - e.g. csv, SQL, EXPRESS?
- Others?