

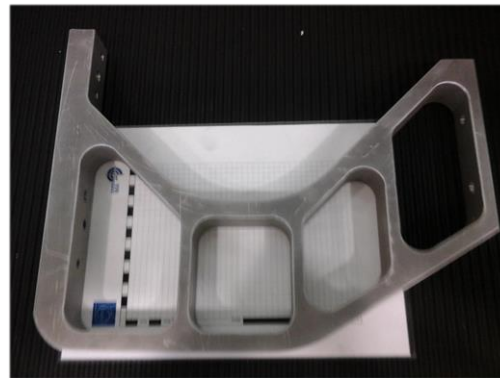
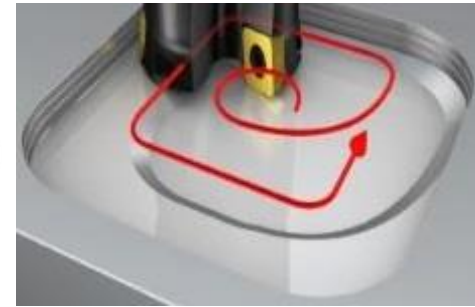


CATIA Design Requirements applied to Computer Aided Manufacturing at CERN

Pierre Naisson EN/MME/MA
Christophe Bault EP/DT/EO

Machining ?

- From raw material to real part



Outlines

- CNC workshop
- CAD/CAM
- Examples
- Outlook

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- CNC workshop
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Figures – EN/MME

- 8 CNC milling machines
 - +6 lathes
 - +9 non standard machines (no CAM)
- 3 computers for programming
 - Feature CAM
- 1500 jobs/year,
- ~250 programs created/year



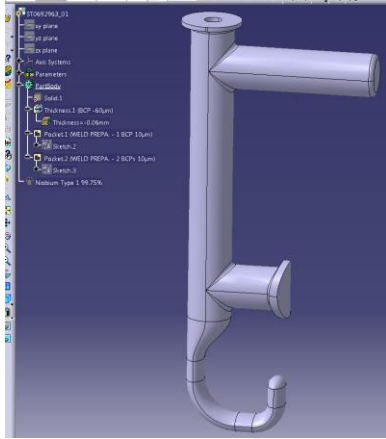
Figures – other workshops

- EP/DT
 - 3 CNC milling machines + 1 CNC lathe
 - Feature CAM + CATIA CAM
- BE/BI
 - CNC machines
 - ESPRIT CAM
- TE/MS
 - 3 CNC milling machines + 1 lathe
 - Go2CAM CAM
- EN/STI
 - Investigation

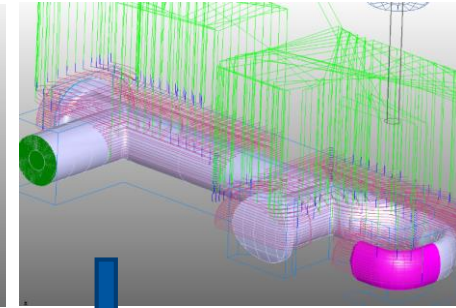
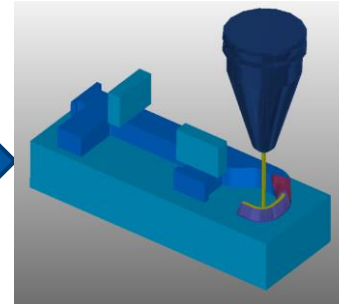


Standard Workflow

- 3D model based procedure



*CATPart or *stp (worst solution)



CAM software (Locally saved)

Post Processing

```
1 ;  
2 ;== cPost Standard PP for SINUMERIK 840 D ==  
3 ;  
4 N10 G0 G90 G40  
5 N20 G40 M8  
6 N30 ;  
7 N40 ; DESC :  
8 N50 ;  
9 N60 T7 M06  
10 N70 D7  
11 N80 G0 G90 G40 G17  
12 N90 F0 S0  
13 N100 G64 SOFT  
14 N110 G70 M3  
15 N120 G1 X381.025 Y231.017 Z90.1 F3000 G94  
16 N130 Z80.1  
17 N140 X382.086 Y230.763 Z79.808  
18 N150 X383.003 Y231.083 Z79.34  
19 N160 X383.241 Y232.074 Z78.872  
20 N170 X386.152 Y233.564 Z78.404  
21 N180 X386.378 Y235.295 Z77.936  
22 N190 X385.88 Y236.97 Z77.468  
23 N200 X384.745 Y238.296 Z77  
24 N210 X378.963 Y242.724 F1000  
25 N220 G3 X378.264 Y242.961 I=-0.699 J=0.513
```

Machine specific
ISO G code

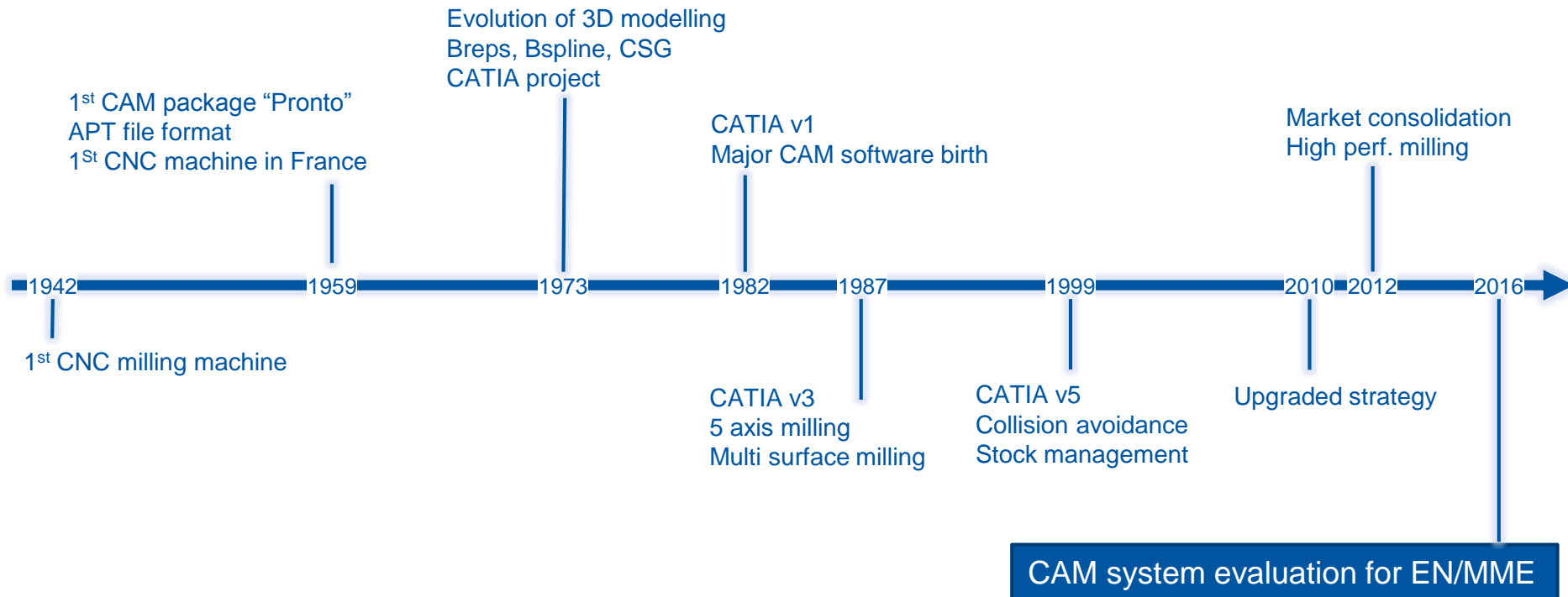


Outlines

- CNC workshop
- **CAD/CAM**
- Examples
- Outlook

What is CAD/CAM ?

- CAM = computer-assisted manufacturing
- Old but very dynamic field of R&D

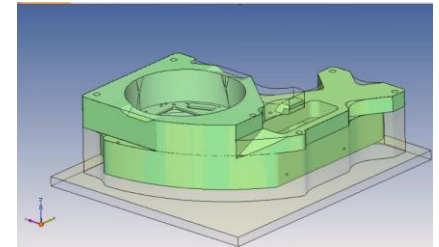
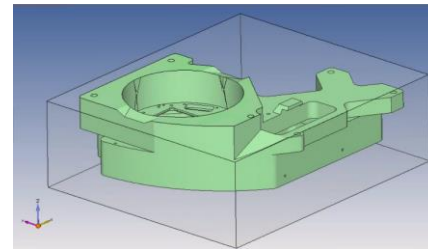
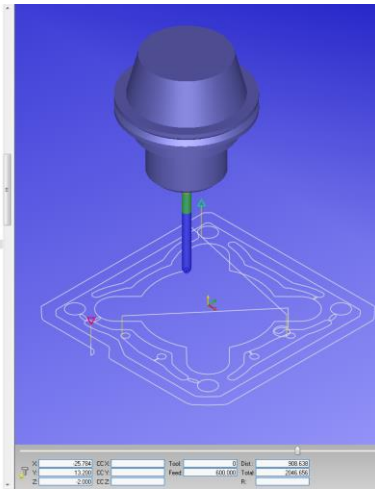


Adapted from <http://5axes.free.fr/chronologie.html>, <http://mbinfo.mbdesign.net/CAD-History.htm>

What is CAM ?

- Surface-based tool trajectory computation
 - Mathematics: tool axis positioning regarding the local normal vector of the surface
 - Influence of CAD, u/v's, format, precision,...

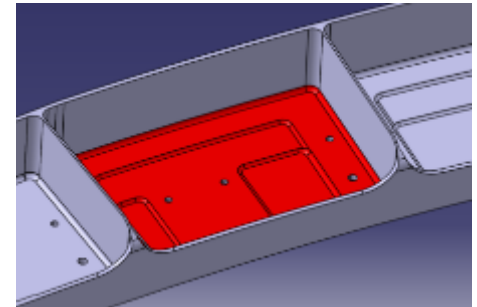
```
087 CR X-33.669 Y-29.545 R6.790 DR+ PQ3
088 CR X-34.535 Y-29.844 R1.303 DR+ PQ3
089 LR-24.0087-29.541
090 CR X-35.500 Y-41.691 R10.608 DR- PQ3
091 CR X-40.148 Y-43.100 R4.398 DR- PQ3
092 CR X-40.342 Y-35.000 R4.399 DR- PQ3
093 CR X-34.651 Y-40.052 R4.397 DR- PQ3
094 CR X-34.148 Y-40.642 R0.616 DR+ PQ3
095 CR X-33.275 Y-41.267 R3.214 DR+ PQ3
096 CR X-30.547 Y-41.889 R6.790 DR+ PQ3
097 CR X-29.681 Y-41.590 R1.303 DR+ PQ3
098 LR-29.6107-41.493
099 CR X-28.218 Y-40.374 R3.567 DR- PQ3
100 CR X-27.152 Y-29.943 R2.462 DR- PQ3
101 LR-27.0579-29.922
102 LR-26.9409-29.898
103 CR X-26.676 Y-29.563 R0.690 DR+ PQ3
104 CR X-26.360 Y-28.253 R3.556 DR+ PQ3
105 CR X-26.821 Y-26.425 R5.287 DR+ PQ3
106 CR X-26.825 Y-25.872 R1.266 DR+ PQ3
107 LR-26.9179-25.814
108 LR-27.0009-25.778
109 CR X-29.718 Y-25.300 R34.632 DR- PQ3
110 CR X-33.567 Y-21.000 R8.898 DR- PQ3
111 LR-25.7609-13.100
112 CR X-27.200 Y-7.600 R28.903 DR- PQ3
113 LR-26.782223-20.000
114 LR-31.000223-5.647
115 CR X-35.830 Y26.095 R10.367 DR- PQ3
116 CR X-37.850 Y26.889 R2.314 DR+ PQ3
117 CR X-36.774 Y19.345 R20.443 DR+ PQ3
118 LR-34.428213-3.669
119 LR-33.317212-1.044
120 LR-31.143210-0.991
121 LR-34.208209-5.996
122 CR X-34.148 Y-7.153 R70.925 DR+ PQ3
123 LR-33.12497-11.213
124 CR X-34.426 Y-13.166 R20.829 DR- PQ3
125 LR-36.8829-19.636
126 CR X-38.076 Y-26.194 R41.025 DR+ PQ3
127 CR X-41.796 Y-28.825 R1.937 DR- PQ3
128 CR X-40.582 Y-18.548 R24.849 DR- PQ3
129 LR-38.0082-11.885
130 LR-38.0469-6.933
131 CR X-38.008 Y-7.500 R74.679 DR- PQ3
132 LR31.888
133 LR-40.810118-1.882
134 LR-41.534222-8.853
135 LR-41.736925-8.833
136 CR X-38.046 Y26.191 R1.937 DR- PQ3
137 LR-37.912225-5.220
138 CR X-35.792 Y25.333 R2.313 DR+ PQ3
139 CR X-34.760 Y31.097 R9.948 DR- PQ3
140 LR-34.712-3.456
```



Extracted from <http://hu.topsolid.com/download/videos/topsolid-demo-library/complex-machining/stock-management.htm>

Powerful but tricky

- The same part could be machined with various strategies
- Example: pocket

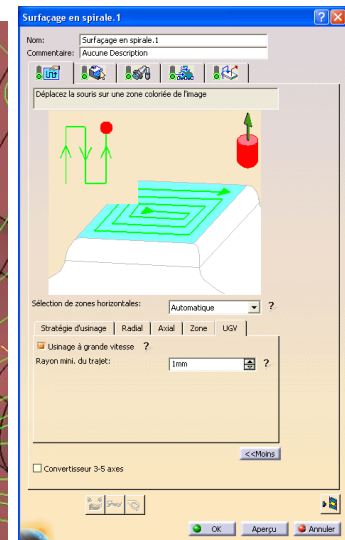
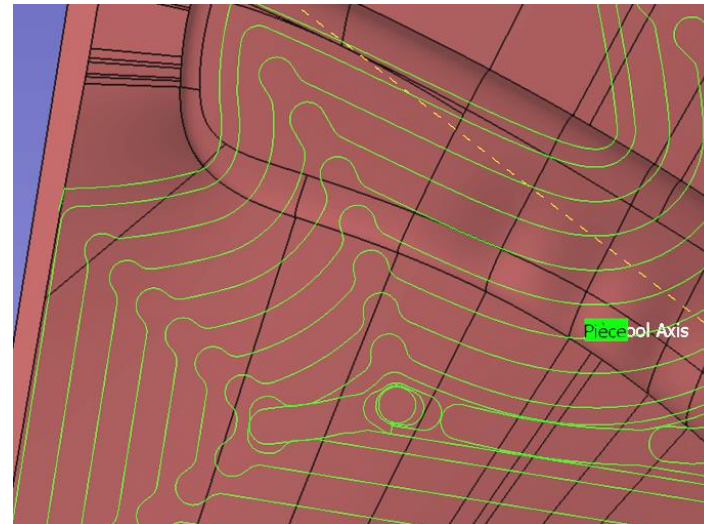
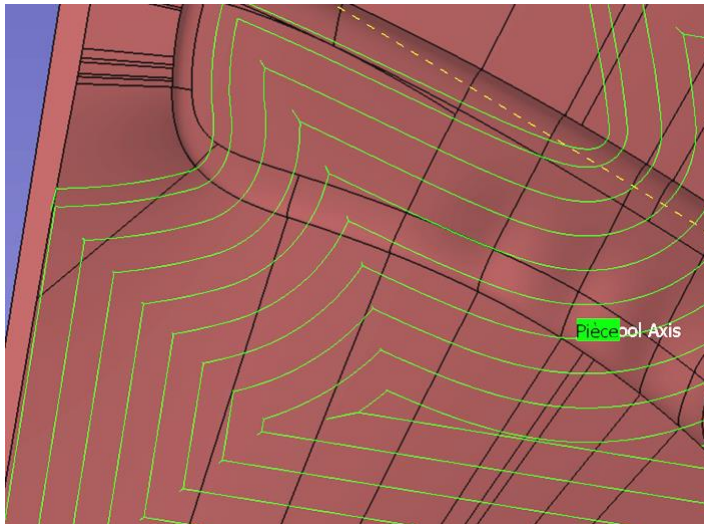


solution	tps (s)	volume (cm3)	débit (cm3/min)	Q outil	vc (m/min)	fz (mm/dt)	P (W)	Fc (N)	C (m.N)
surfacier dresser	165	320	116.4	127.3	250	0.25	4455	1069	27
fraise à surfacer	103	320	186.4	195.9	250	0.4	6856	1645	41
fraise à grande avance	51	320	376.5	399.9	250	1.1	13996	3359	76
plaquette ronde $\phi 12$	134	320	143.3	151.5	250	0.35	5303	1273	32

Safest
Easiest
Fastest
Hardest

Powerful but tricky

- The same part could be machined with various strategies
 - Example: toolpath
 - Continuity/vibration



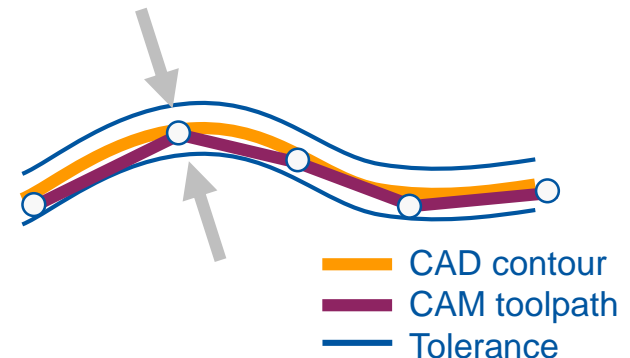
Powerful but tricky

- The same part could be machined with various strategies
 - Example: Parameters
 - Surface finish



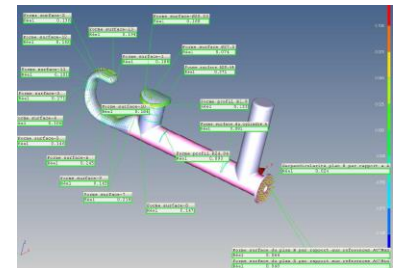
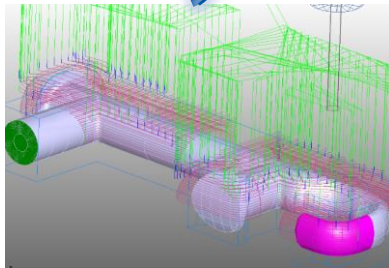
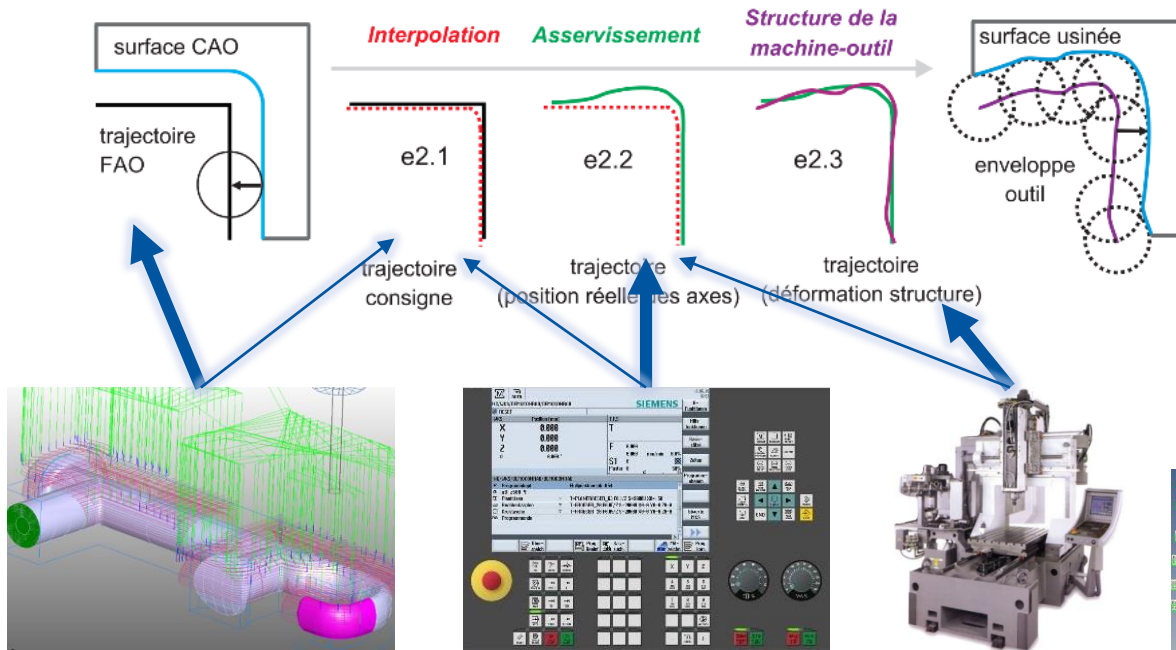
Distance between passes ↑

CAM tolerance ↑



Numerical workflow

- Error sources
 - CAM is one of many possible flaws



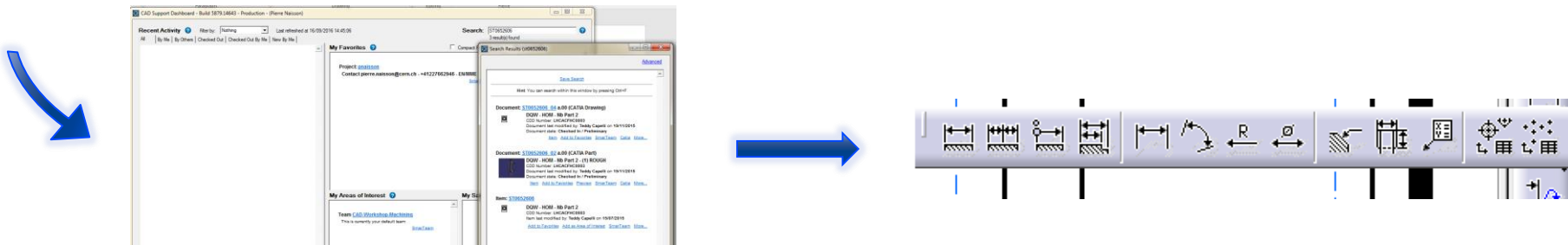
Outlines

- CNC workshop
- CAD/CAM
- **Examples**
- Outlook

3D model quality

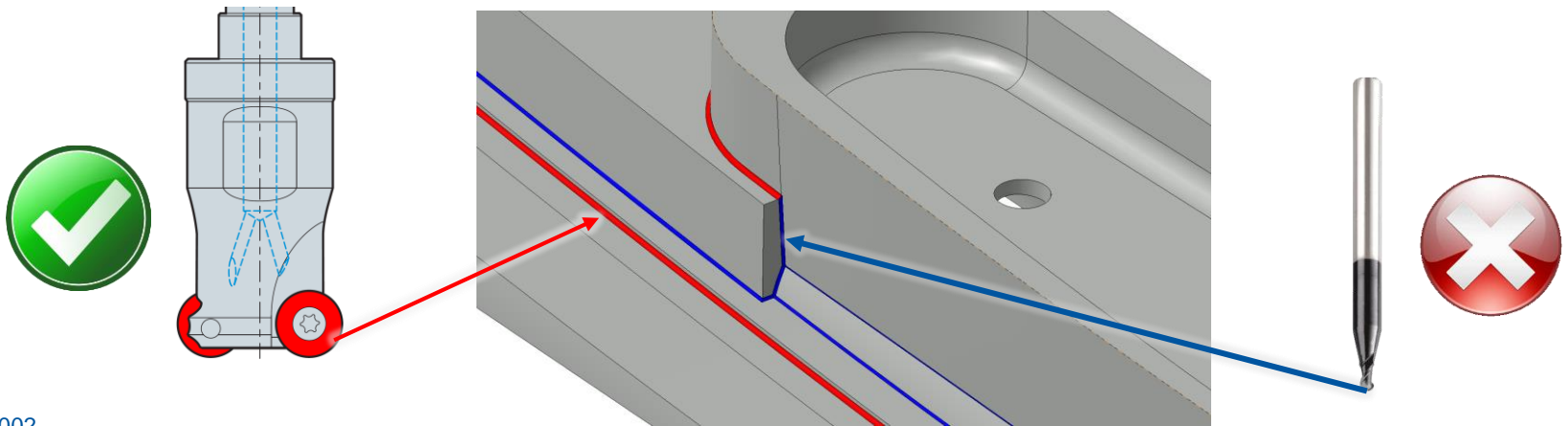
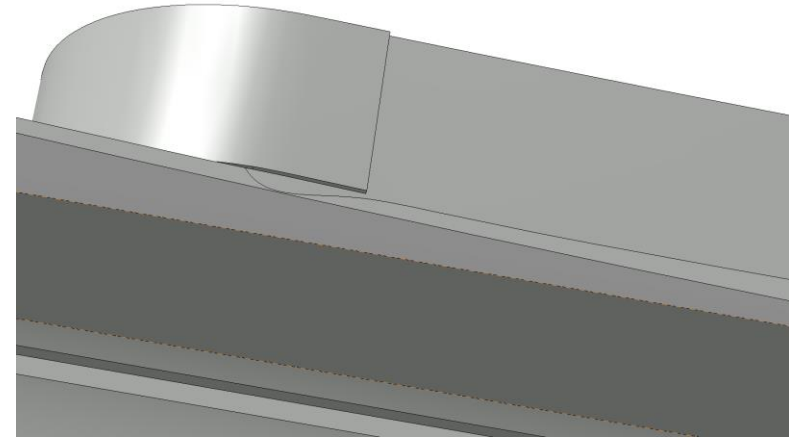
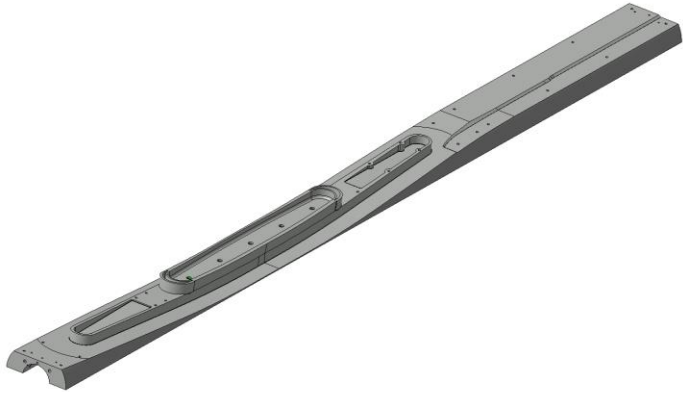
- The contract is on 2D drafting...
- Consistency of 2D \leftrightarrow 3D
 - Need for synchronization / conform 3D model

**NOTA 1 : NOMINAL DIMENSIONS ACCORDING TO 3D MODEL
(SEE ST0652606_02)**



3D model quality

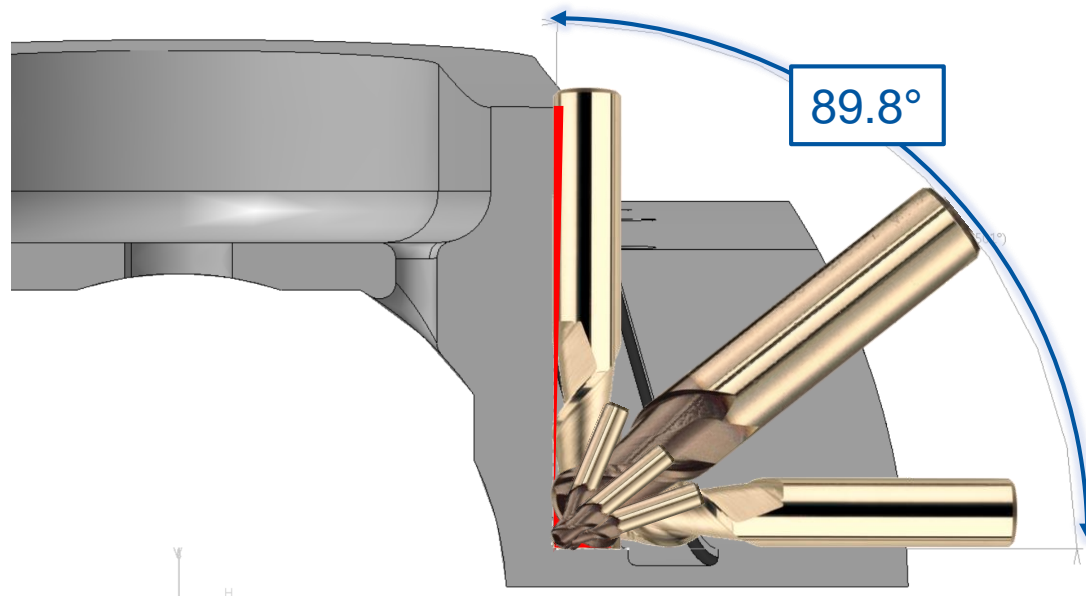
- The GSD issue



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3D model quality

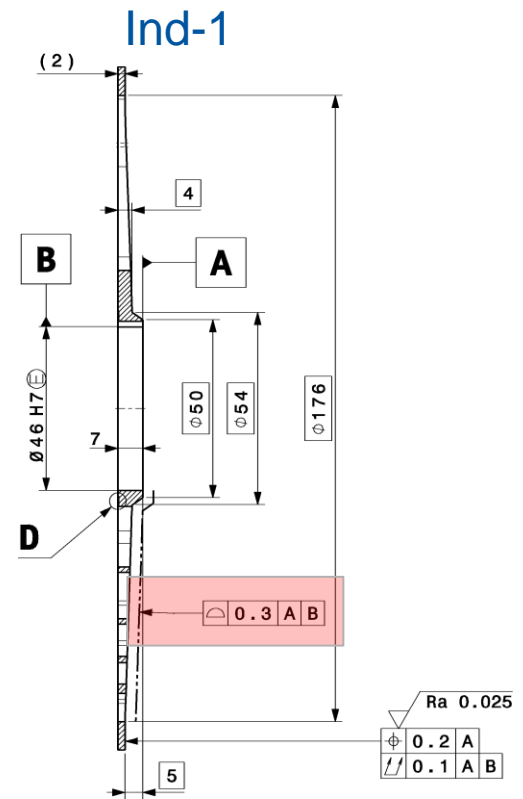
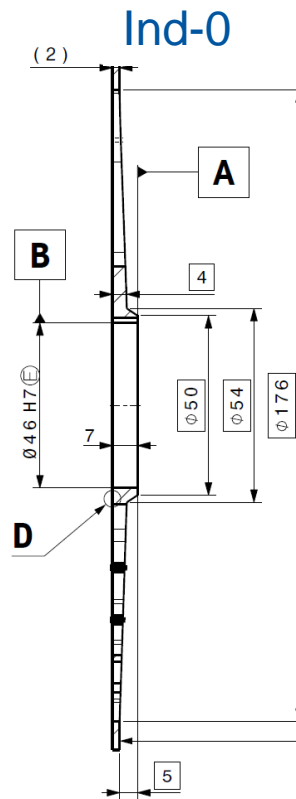
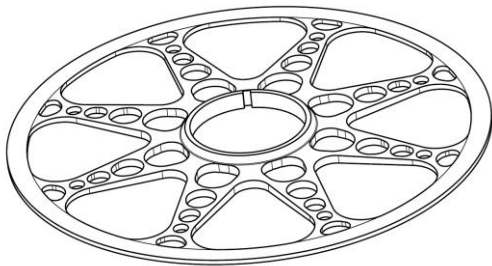
- The GSD issue
 - Low accessibility zone
 - Cost + poor quality



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GPS side effects

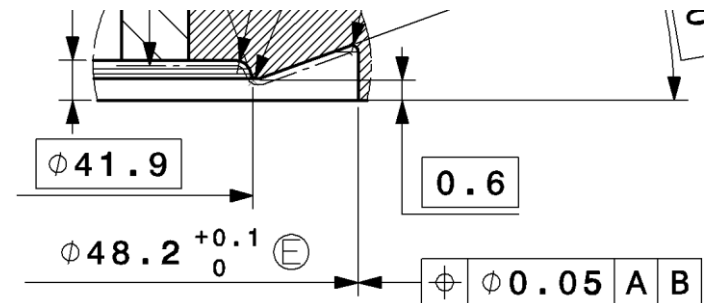
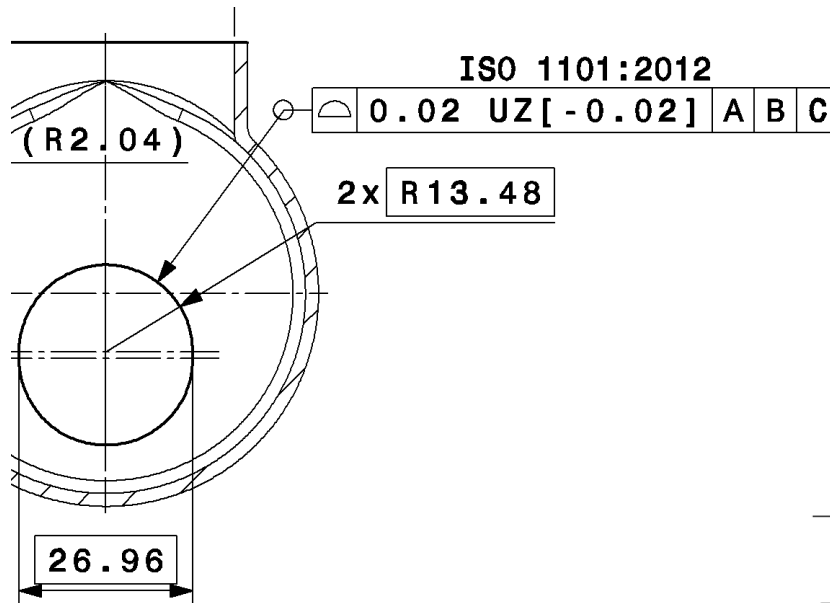
- Manufacturing scheme
 - Chocks, scratches



PSBBWSRA0041

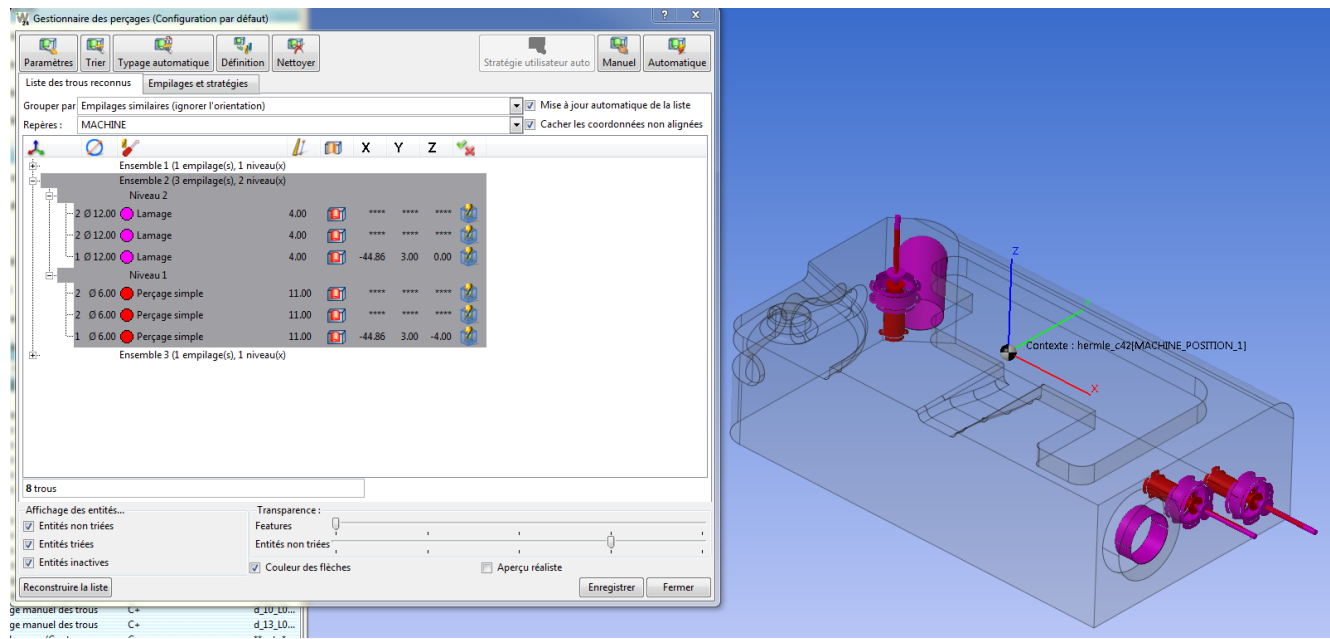
GPS side effects

- Decentered tolerances
 - Programmed as centered value IRL



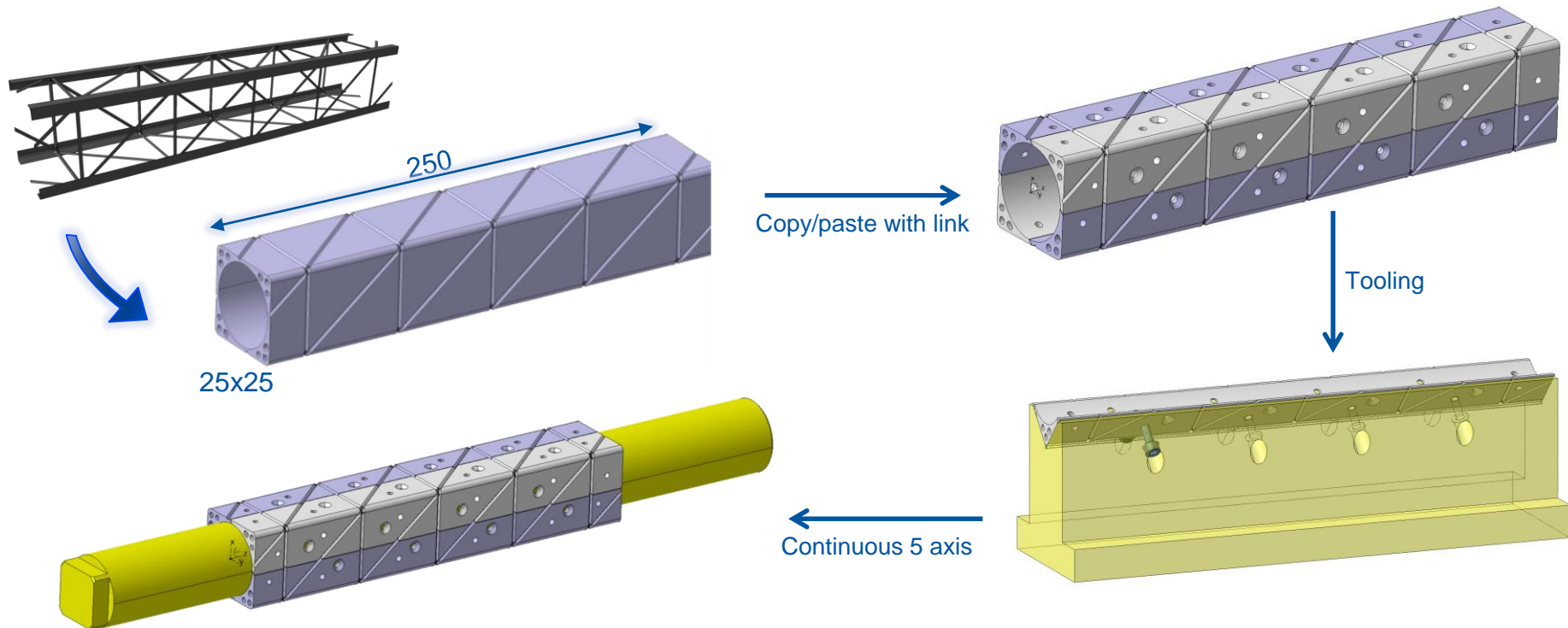
Design to manufacturing

- Hole, thread and counterboring
 - Automatic recognition through colored feature
 - Ex: blue = threads, red = counterbore, ... ?



Design to manufacturing

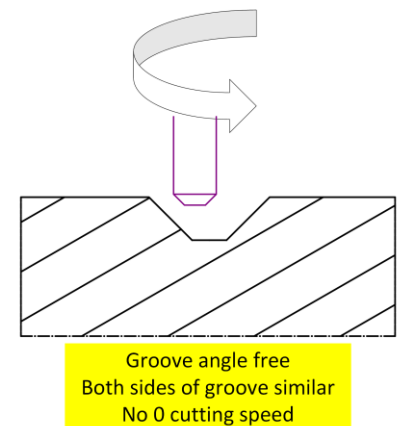
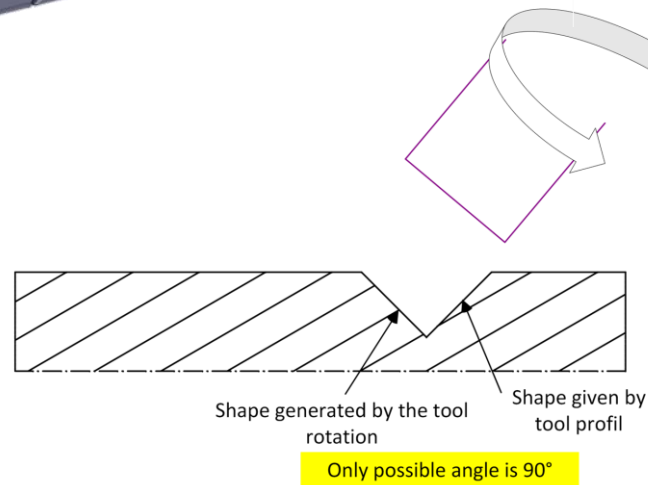
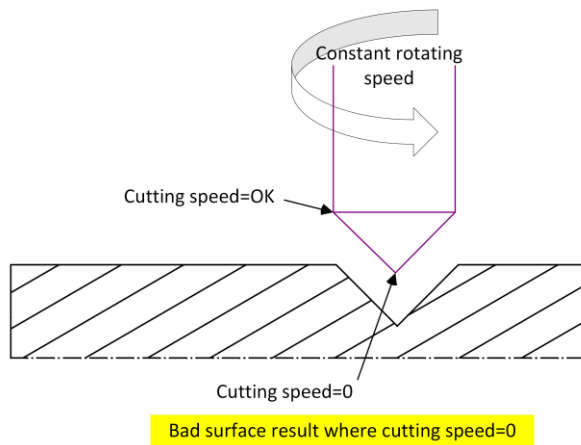
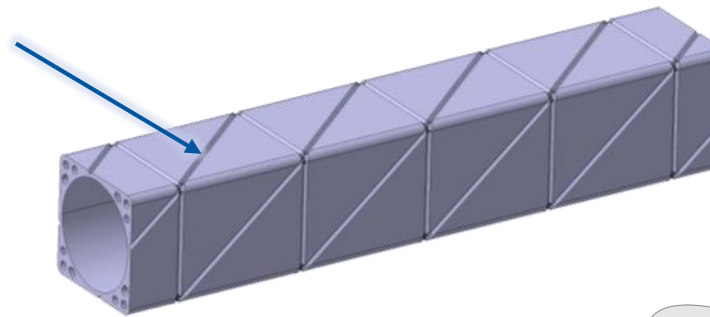
- Shape adaptation to improve machinability
 - Accuracy + precision



EP-DT: Carbon fibre stave

Design to manufacturing

- Shape adaptation to improve quality
 - Unmolding, surface finish

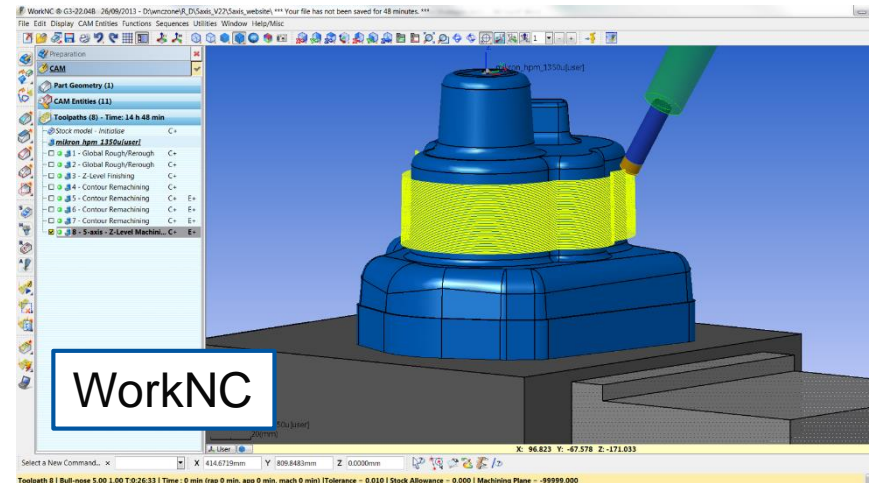
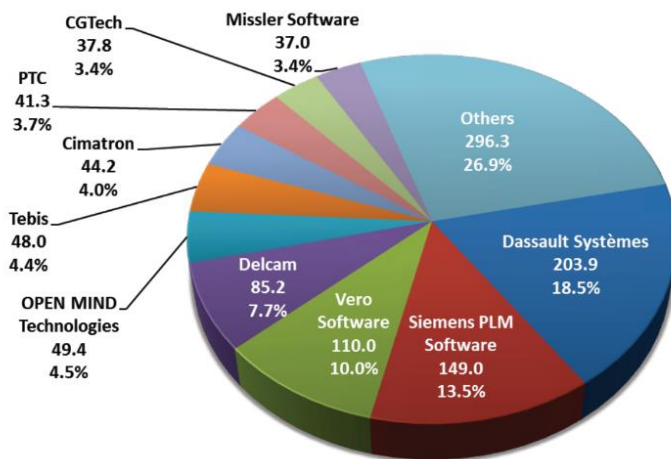


Outlines

- CNC workshop
- CAD/CAM
- Examples
- **Outlook**

EN/MME CAM solution

- CAM evaluation
 - Efficiency in milling (5 axis)
 - Easy to use (aside milling machine)
 - Turning → TBD (future investments)



<http://www.verosoft.com/news/articles/Vero-Number-1-CAM-Business>

Think manufacturing !

- Don't hesitate to ask workshops
 - Reduce cost, time
 - Increase efficiency
- Valid 3D model
 - Smarteam ?
 - Strict control of consistency 2D/3D
- CAD @ CERN
 - EP/DT using CATIA CAM → 2020 ?
 - Compatibility tests to be carried out



www.cern.ch