Digital Twin Machining and Cyber Security

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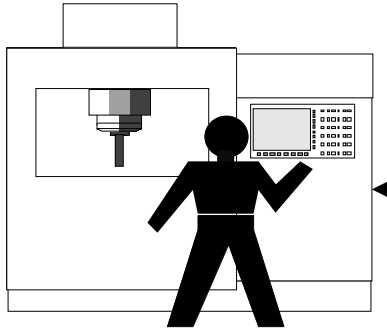
Code machining



- Gcode machining is not secure
  - Data format is simple
  - Has to be in clear text for the operator
  - Has to be regenerated from CAM using a post-processor for every change

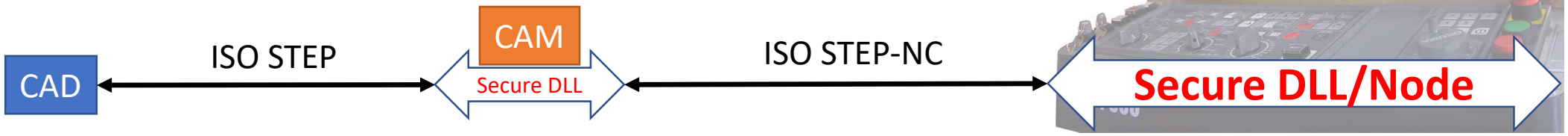
The standard for 40 years!

```
N05   G54
N10   G00 Z10.000
N15   G91 G0 Z200
N20   T5 D1 WW
N30   G90 M5
N35   G00 X0.000  Y  150.000
N40   G00 Z5.000
N45   M08
N50   S3183.000
N55   M03
N60   F1477.000
N65   G00 X60.000  Y  150.000
N70   G00 Z5.000
N75   G00 X60.000  Y  150.000
N80   G01 Z
...
```

Ideal for paper tape!!
Easy to copy

Digital Twin machining

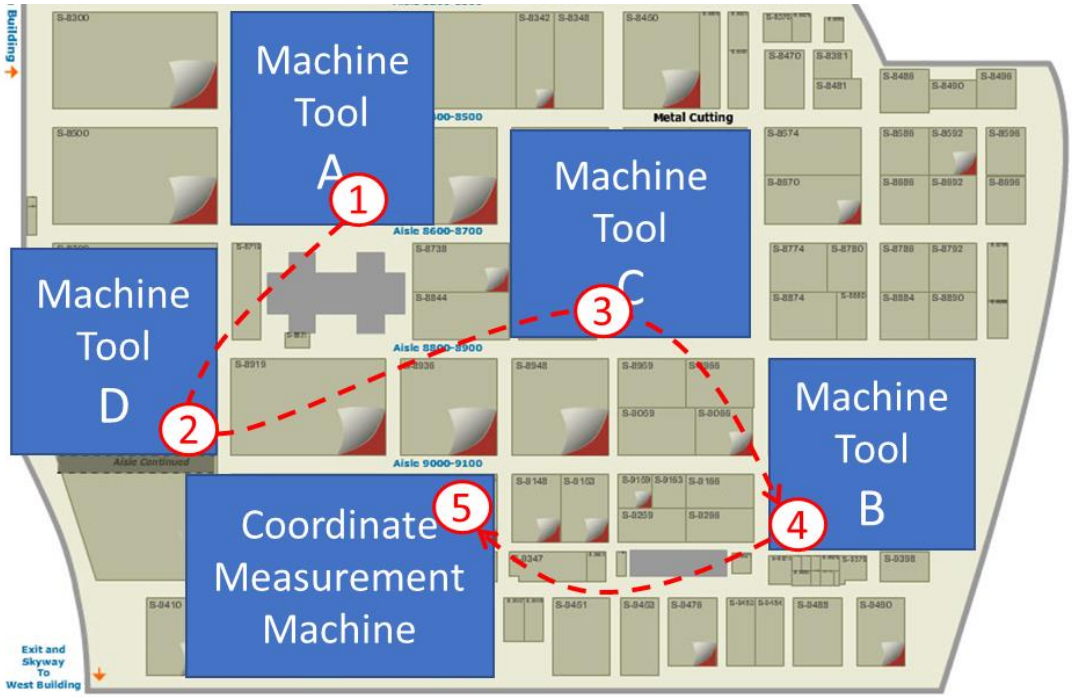
- Requires software that is expensive to duplicate for illegal cheating
- Requires a signature that governs usage*
  - Model must be encrypted
  - Model requires security clearances
  - Model requires usage to be logged in a block chain



*Options enabled by ISO 10303-21 Edition 3

Applications for digital twin machining

- In-process measurement
  - Measure on the machine
- “Self driving” tools
  - Optimize feeds after tool changes
- Error free manufacturing
  - Prevent collisions on restarts
- Faster life cycle
  - Communicate issues and opportunities



Demonstration at IMTS 2018

Call to action

- Time is ripe for action
- Digital Twin Implementors Forum being initiated
- Security should be included at the beginning
- Opportunity to enforce licenses, patents and copyrights
- Opportunity to detect copying, espionage and security threats

Photocopiers will not copy dollar bills
The movie industry has been challenged but survives
The music industry has been decimated by illegal copying
Must protect manufacturing and defense while increasing performance