Build Anywhere using STEP-NC

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Who we are

- **Mission: Use STEP to make the development of production processes more time and cost efficient**
  - 35% reduction in process planning time
  - 50% reduction in system costs
  - 75% reduction in time to data preparation time
- **Forerunners in STEP technology since 1991**
  - Founders working on product data since 1978
  - First commercial software tool kit
  - First solid model data exchange using STEP
  - Software in >500,000 CAD stations
- **Contributors to STEP and STEP-NC**
  - Owner of Parts 14, 21, and 28 of STEP
  - Editor of AP 238 (STEP-NC)
  - Team leader of ISO TC184/SC4 Wg3/T24 STEP-Manufacturing

Build Anywhere Vision

“Enable the same price and quality competition for manufactured/custom parts as currently exists for off-the-shelf/purchased parts.”

<u>Using machine independent CNC control files</u>

- **3D manufacturing features**
- **Inspection quality tolerances**
- **Product and process data**

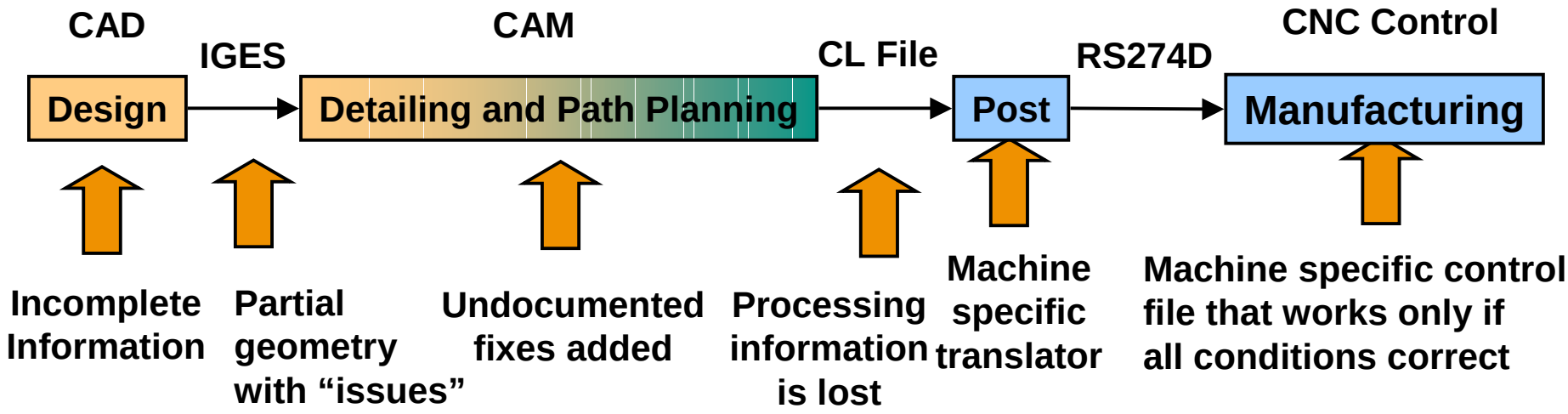
Contouring

Milling, Drilling,Turning

EDM

Problems in current method

- **Current process is inefficient**
  - Design sends incomplete data
  - Manufacturing makes fixes but does not document them
  - End result is a control file that can only run on one machine at one supplier
  - RS274D is more than 40 years old



Extensive CMM to check the geometry of as-built parts

Current NC programming using RS274D

The standard for 40 years!

machine-specific part program with axis data generated by a postprocessor

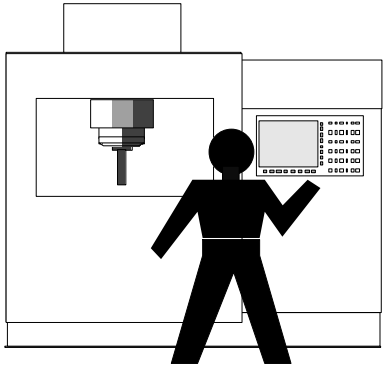
vendor-specific extensions of the original standard

only primitive motion and switch commands

no standardized data format for spline processing and sophisticated NC technology

```
%
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-0.500
...
```

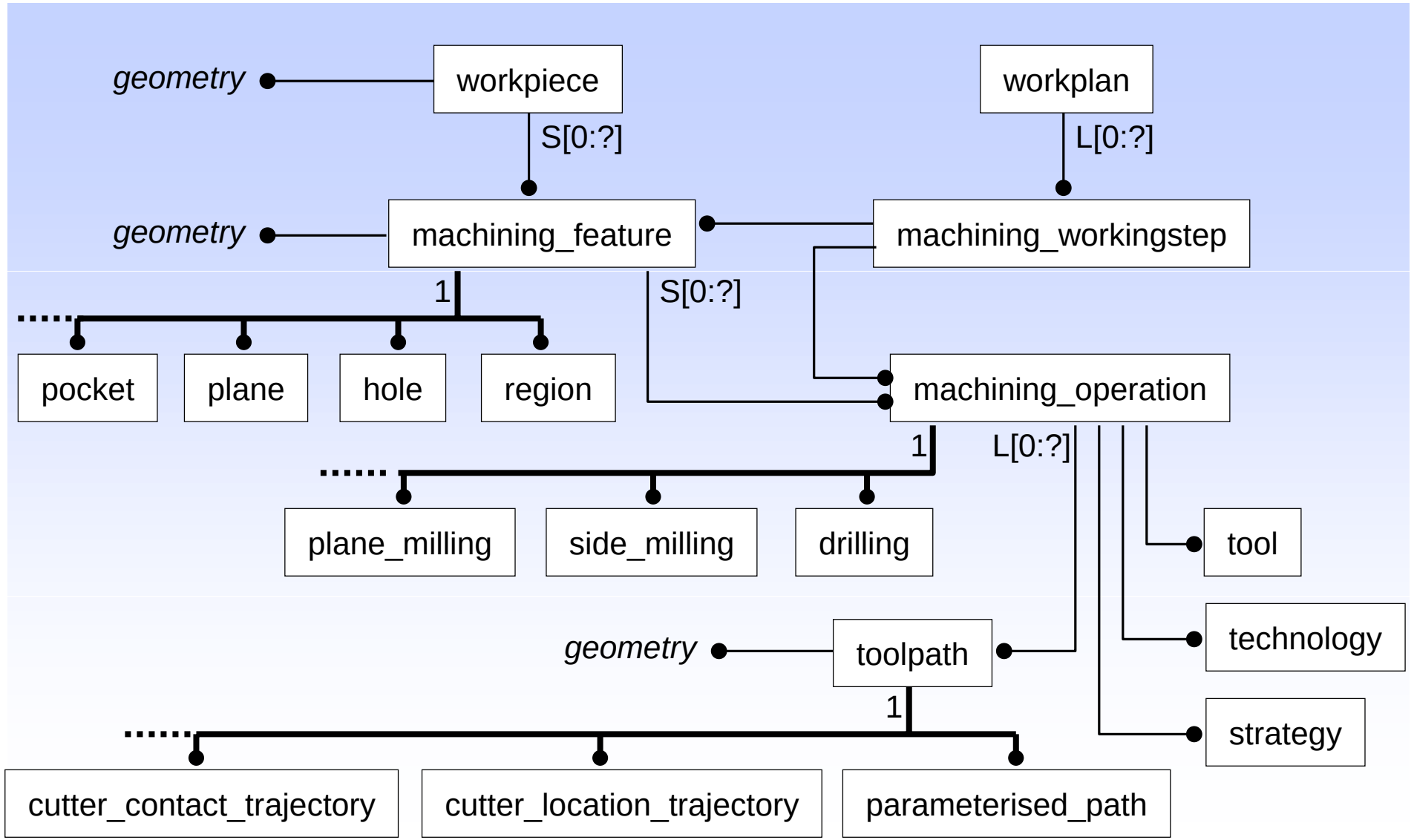
Ideal for Paper Tape!



STEP-NC replaces this with a rich, integrated data format

Courtesy WZL RWTH Aachen

STEP-NC is machine independent

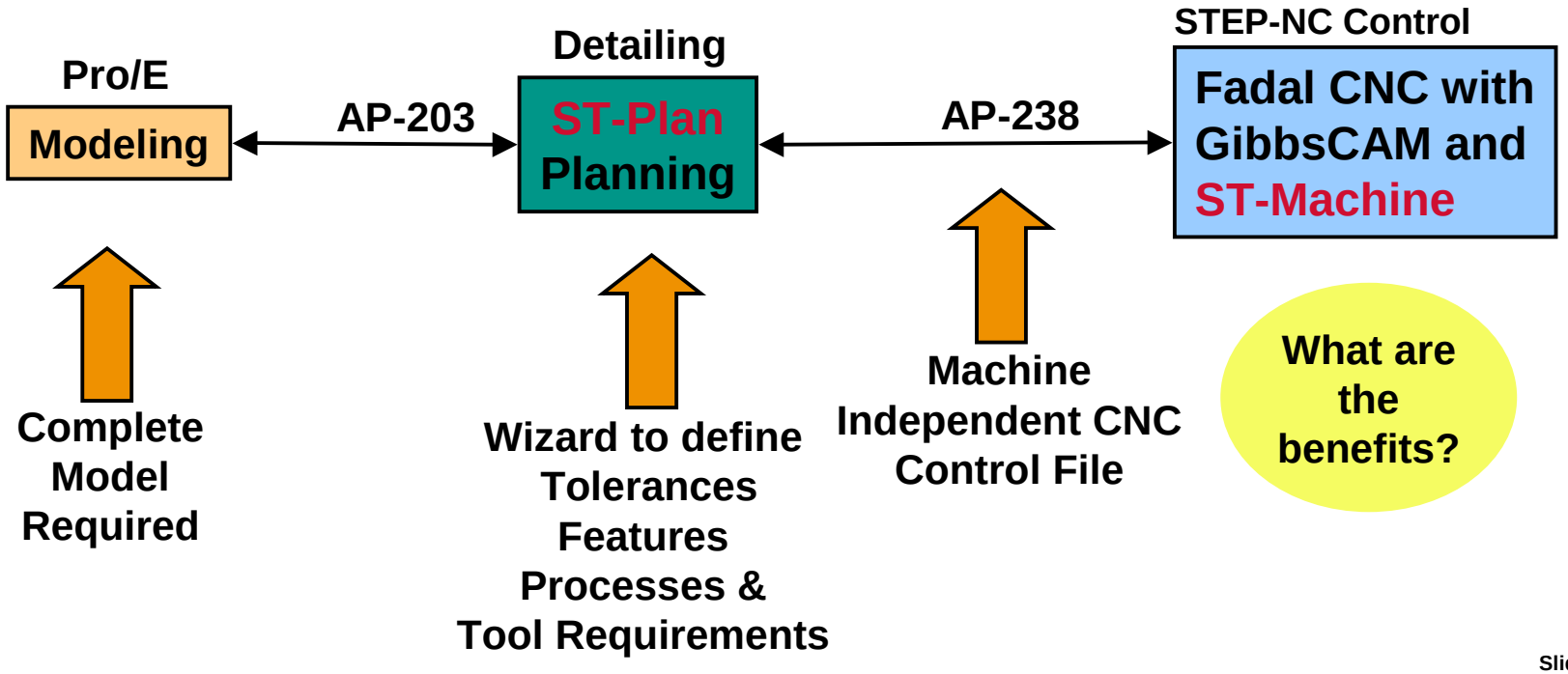


Key feature of STEP-NC

- **STEP-NC describes “what” not “how”**
  - Make this geometry from this stock
  - By removing these features
  - In this order
  - With these tolerances
  - And tools that meets these requirements
- **The old standard described “how”**
  - Move tool to this location
  - Move tool to this location
  - And so on for millions of commands

STEP-NC at NASA JPL

- **Rapidly manufacture AP-238 models**
  - Focus on making ordinary parts on multi-axis machines
  - Default tolerances and finishes set using Crib sheets
  - Allow ordinary machinists with little CAM training to be competitive with experienced machinists with extensive CAM training

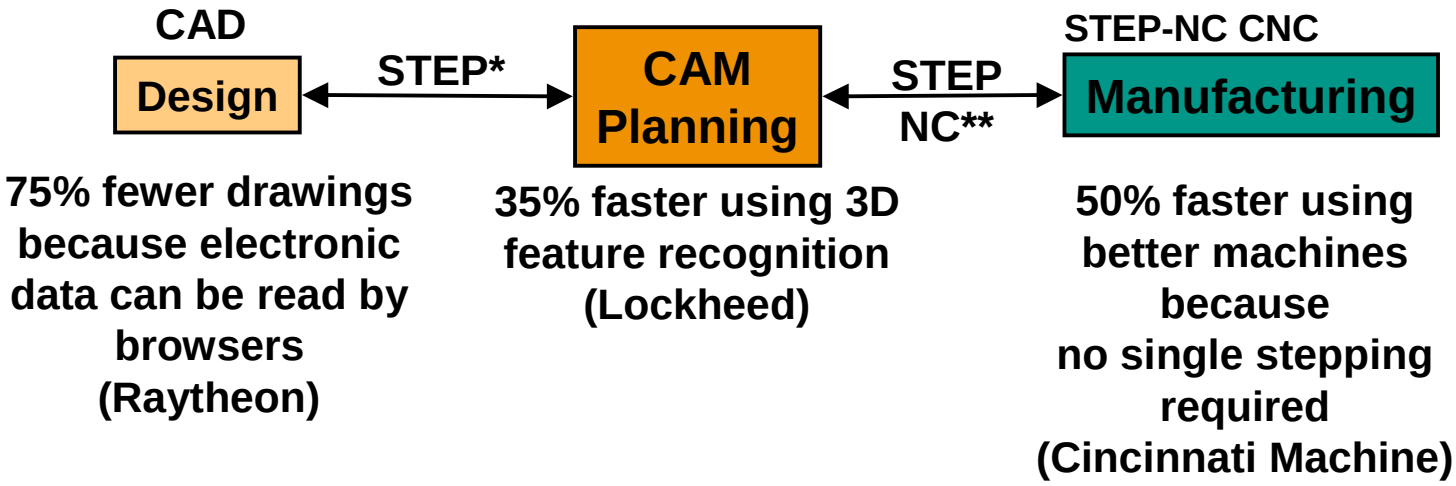


Benefits of STEP-NC

STEP NC

http://www.stepnc.com

- **Build Anywhere STEP-NC data**
  - Elimination of 4,500+ post processors
  - Safer, more adaptable machine tools
  - Out-source quality control
  - Process savings as follows

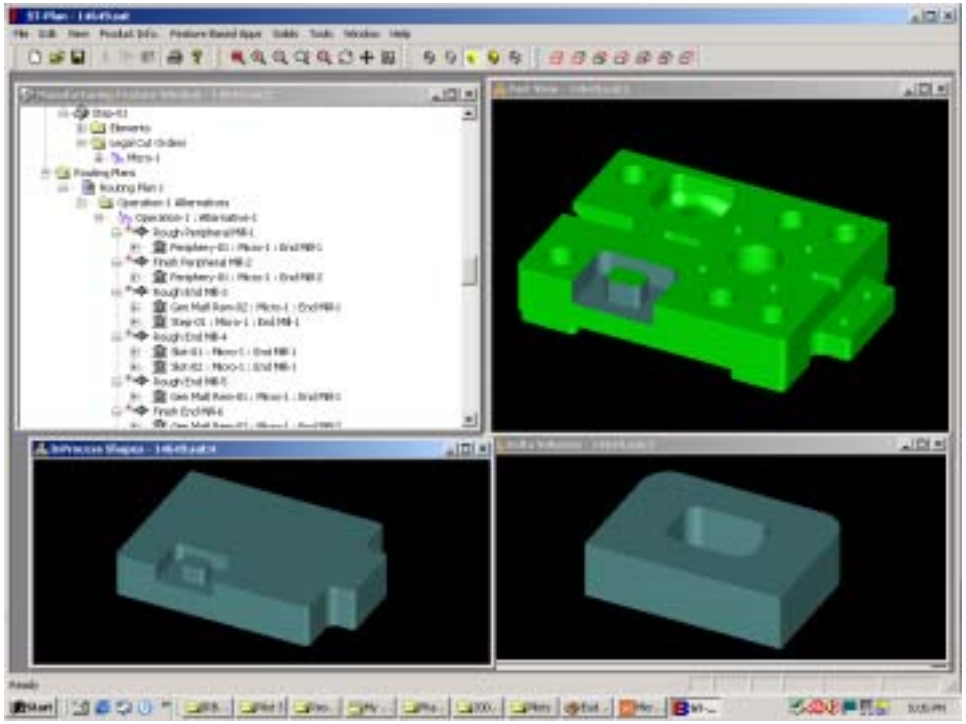


*AP-203 ed1, AP-203 ed2 or AP-224

** Must be AP-238

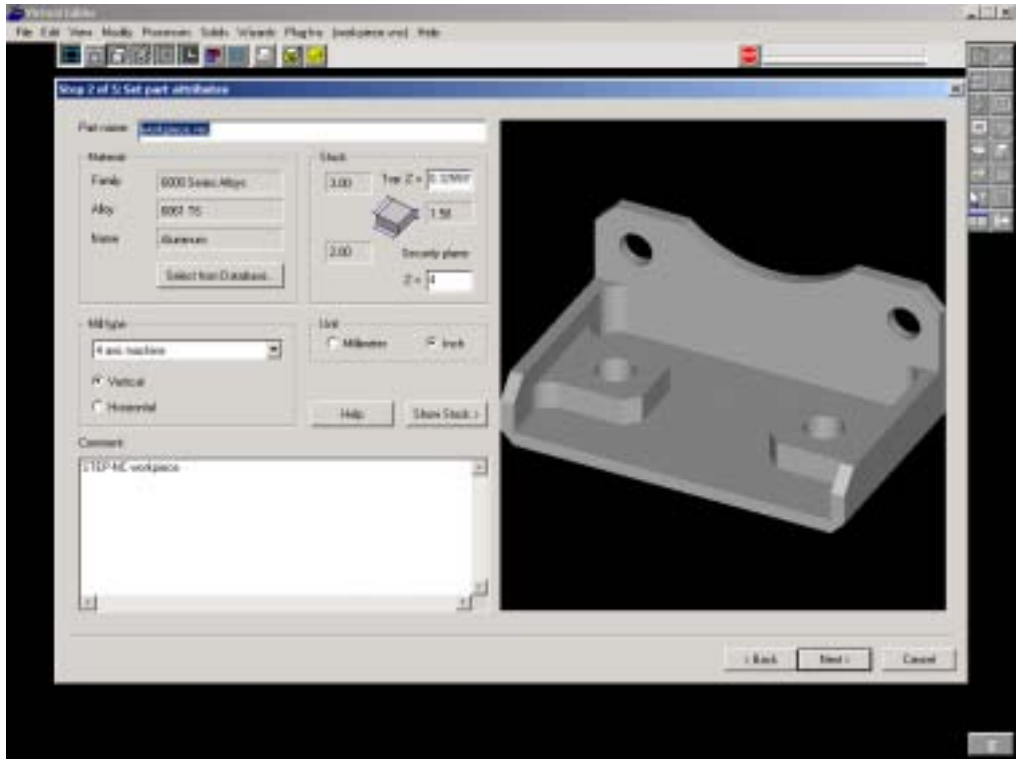
ST-Plan

- **ST-Plan creates machine independent CNC control files**
  - Tolerance definition
  - Feature recognition
  - Process sequence definition
  - Tool requirement definition



ST-Machine

- **ST-Machine generates tool path data**
  - Optimizing compiler for STEP-NC
  - Machine independent data converted to machine specific tool paths
  - CAM system plug-in
  - Use On or Off the CNC



Non-optimizing version is on web site at www.stepnc.com

Optimizing version in process

Verification

	Old Method	New Method
Programming	105 minutes	15 minutes
Set up	90 minutes	90 minutes
Machining	16.5 minutes	23 minutes

As measured at 6th IRB meeting at NASA JPL on January 30, 2003

STEP-NC Implementation Program

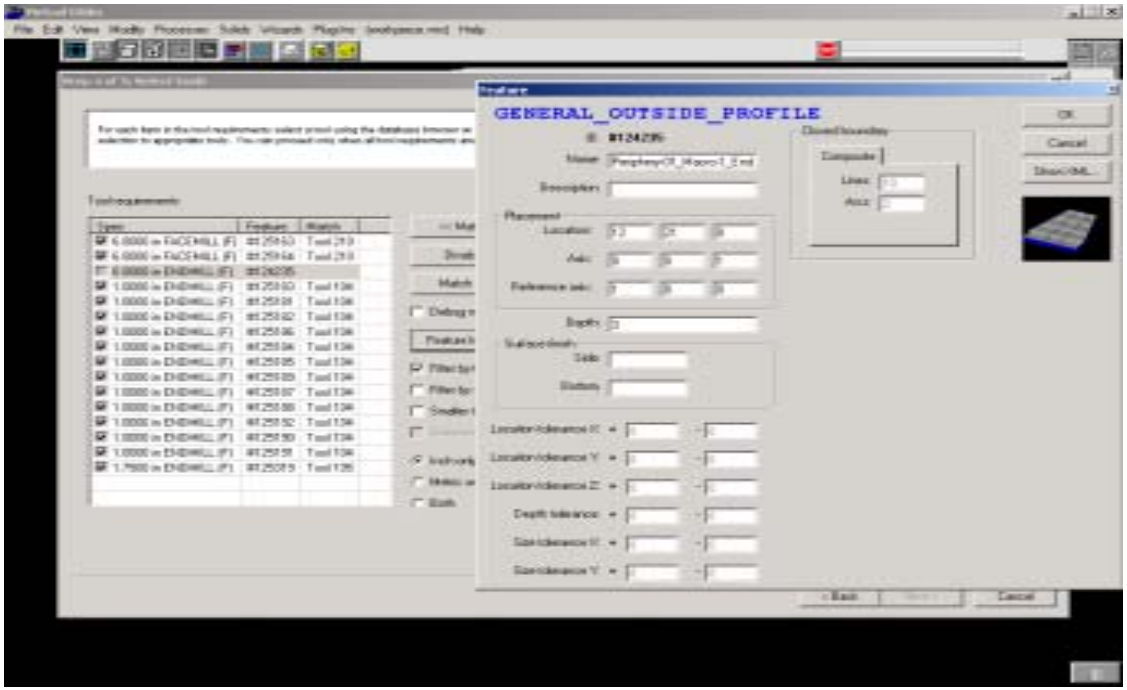
- **Implementation program participants show STEP-NC can be used to make production parts**
  - Round 1 2.5D feature milling 6/1/02 to 11/30/02
  - Round 2 Surface milling 12/1/02 to 5/31/03
  - Round 3 Turning 6/1/03 to 11/30/03
  - Round 4 Probing (EDM?) 12/1/03 to 5/31/04
- **Round 2 goals**
- **Minimize air milling**
  - Exploit direct geometry access provided by STIX
  - Suggest changes to standard as necessary
- **Continue optimization**
  - New heuristics
  - Exhaustive search
  - Integrate tolerances and surface descriptions into algorithms
- **Start processing surfaces**
  - Definition as foreign regions
  - Processing on the control
- **Make more robust**
  - Test using more models
  - Improve user interfaces
  - Interoperability

Current status

- **Processing Rectilinear parts**
  - If solid model geometry has no issues
- **Tools will soon be working on the desktop**
  - No longer have to use web site to get STEP-NC data
  - Extensive suite of viewing and checking tools
  - Implementing the STIX access and interface library
- **Learning about Optimization**
  - Design Tolerances exported from FB Tol to AP-238
  - Manufacturing Tolerances from JPL crib sheet
  - Prototyped Integration with JPL Cribmaster
  - Beginning to understand how to compile STEP-NC data

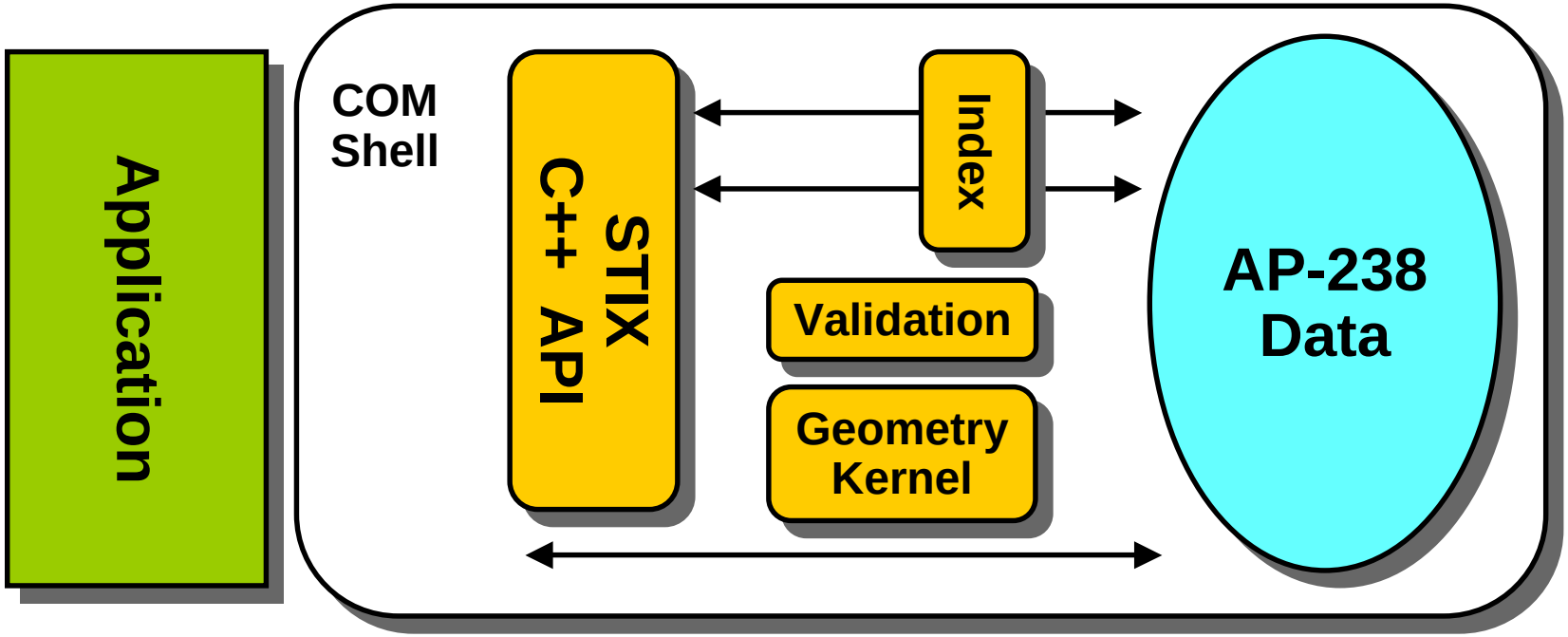
STEP-NC Compilation

- **Optimization Heuristics**
  - Eliminate unnecessary operations
  - Remove material in shallowest first order
  - Avoid regions
    - Use one face regions only
  - Fold operations that use the same tool together
  - Fold operations that use the same axis together
  - Machine steps from shallowest side



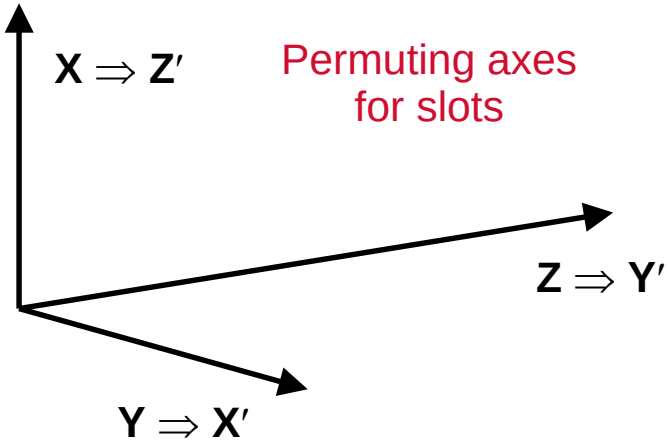
STIX — STEP Index

- **Provide a direct interface to the AP-238 data.**
  - **Read and build in-memory indices and backpointers on the AP-238 data for speed of processing.**
  - **Simplify use of AP-238 data by providing API to common access paths and calculations.**
  - **Wrap with COM interface for lightweight applications.**

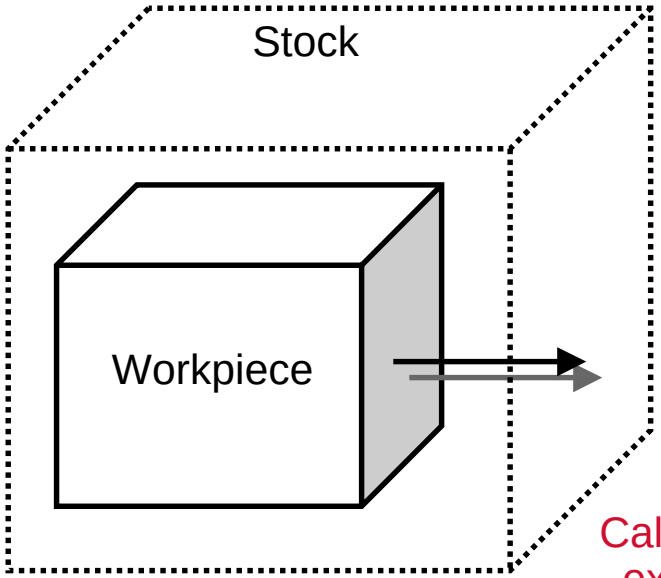


STIX Calculations

- **Library of NC geometric calculations.**
  - Switch axes and applying transforms,
  - Calculate geometric bounding boxes and volume extents
  - Parameters in preferred units



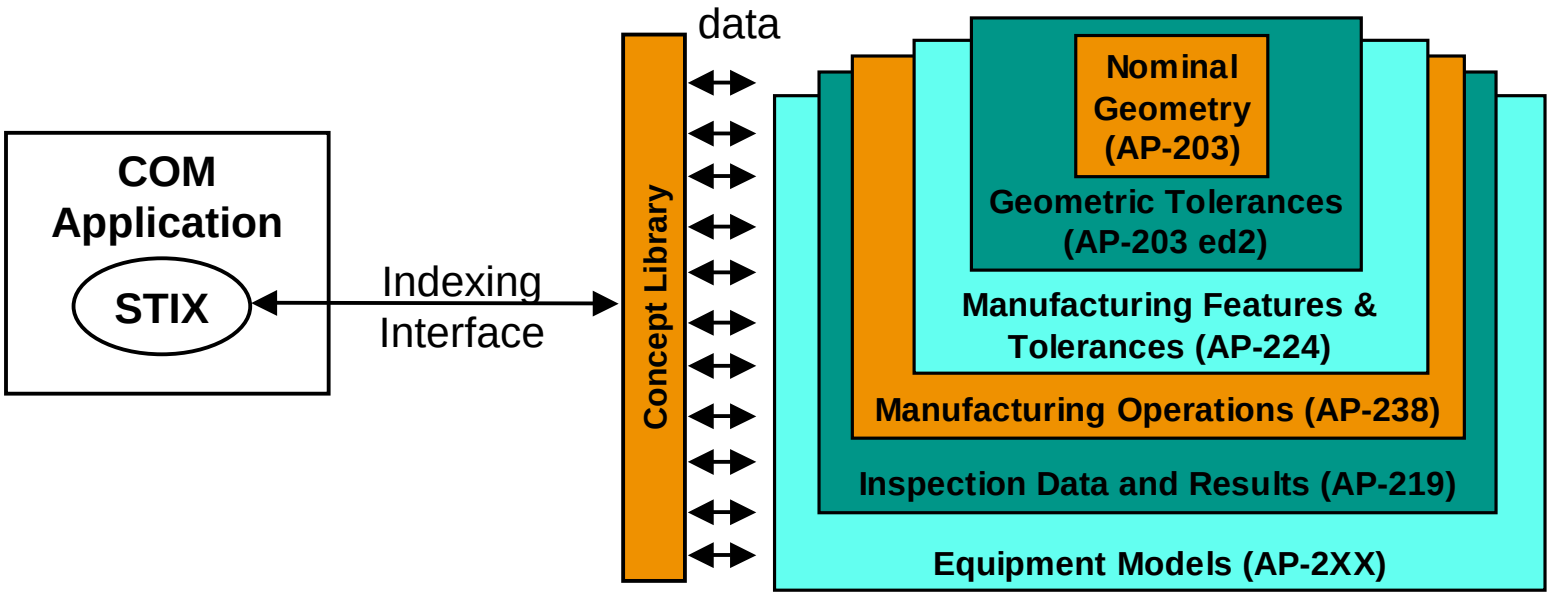
Permuting axes for slots



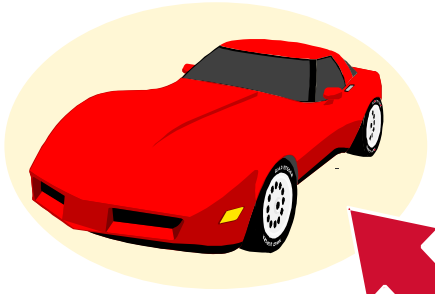
Calculating extent of material

Moving Forward

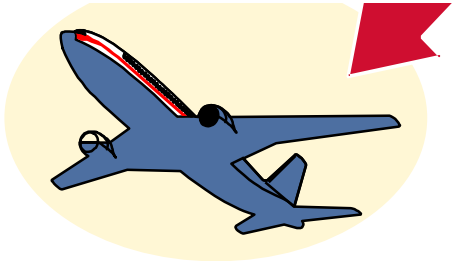
- **API functions for the breadth of Manufacturing**
  - Next level of optimization using information compilation
  - Machine independent CNC control data
    - » Milling, Turning
    - » Inspection, Robotics



Conclusion – the ongoing achievement

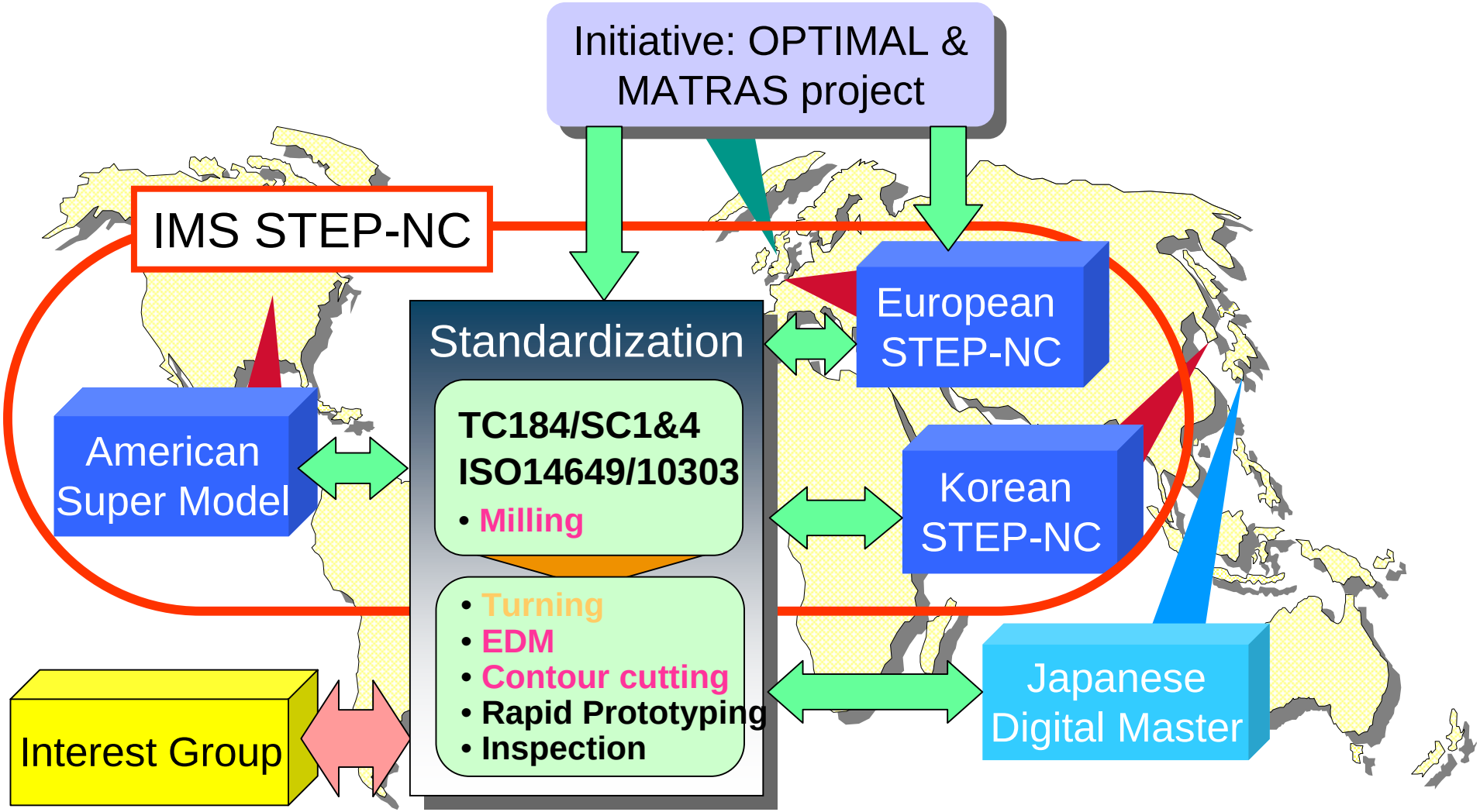


There are more than one million STEP enabled CAD stations in the world



The next step is CAM and CNC systems and SIGNIFICANT process savings

Backup


Initiative: OPTIMAL & MATRAS project
IMS STEP-NC
Standardization
TC184/SC1&4
ISO14649/10303
• Milling
• Turning
• EDM
• Contour cutting
• Rapid Prototyping
• Inspection
American Super Model
European STEP-NC
Korean STEP-NC
Japanese Digital Master
Interest Group

Some Customers

Enterprises

Aerospatial
Boeing
British Aerospace
DaimlerChrysler
EDF
ESA
Ford
General Dynamics
General Electric
General Motors
Hitachi Zosen
IBM
Lockheed Martin
NASA
Newport News
Peugot
Raytheon
Samsung
Toyota

CAD Vendors

SGI Alias, Bentley, Unigraphics, CADKEY, Cimatron, HZS, Entity Systems (Alibre), Intergraph, Spatial

CAE Vendors

Tecnomatix, Deneb

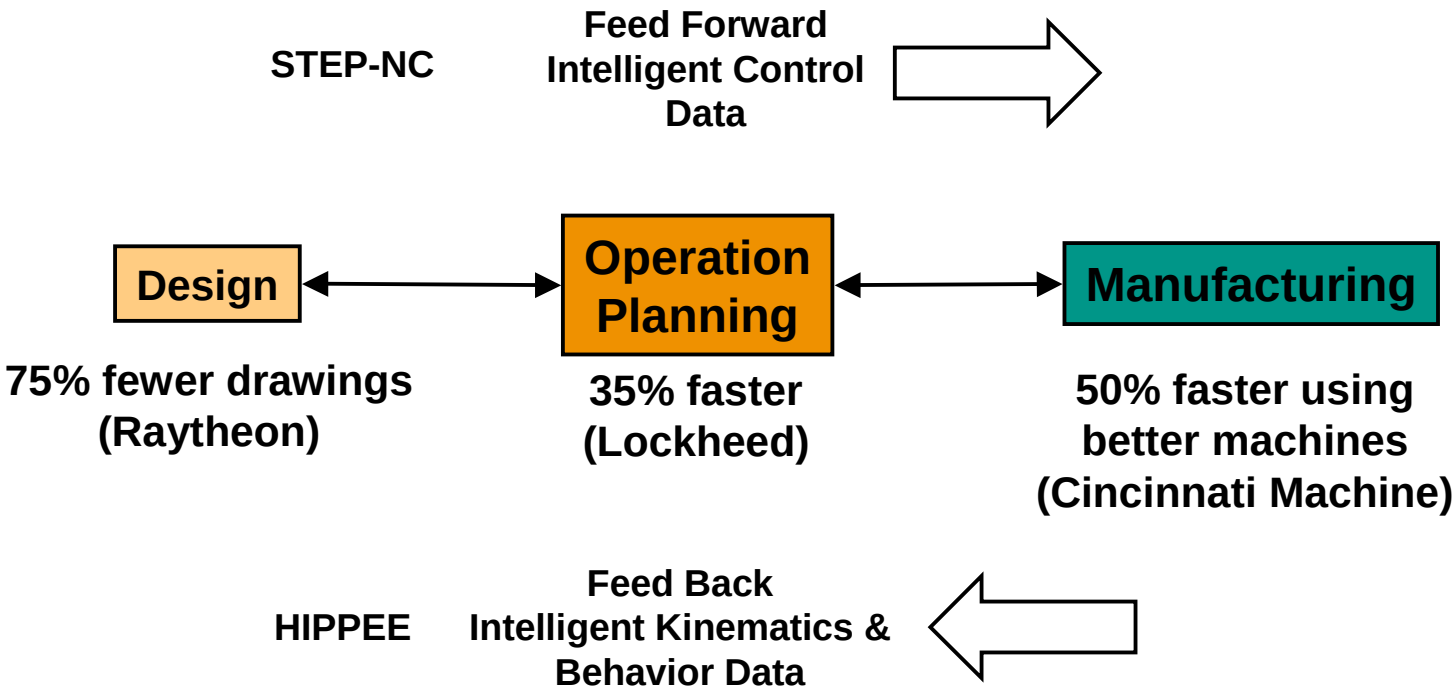
PDM Vendors

IMAN, Boeing DCAC/MRM (Metaphase)

CAM Vendors

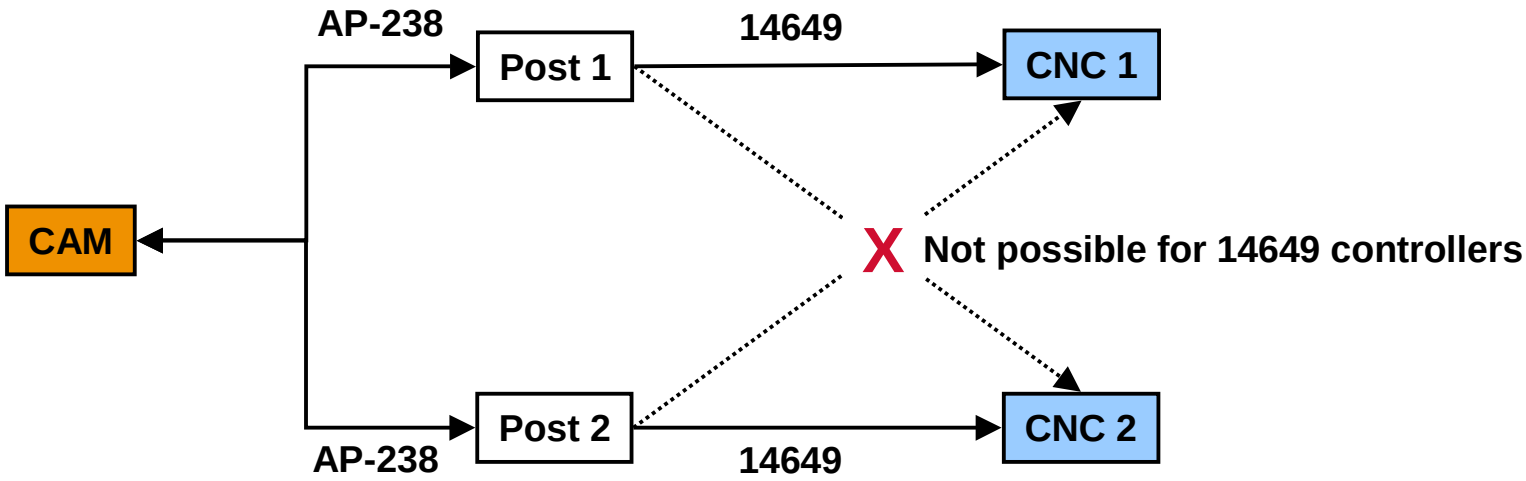
Bridgeport Controls, DelCAM, Licom, Fanuc Robotics, Mastercam, GibbsCAM, Esprit

Role of STEP-NC



AP-238 or ISO 14649?

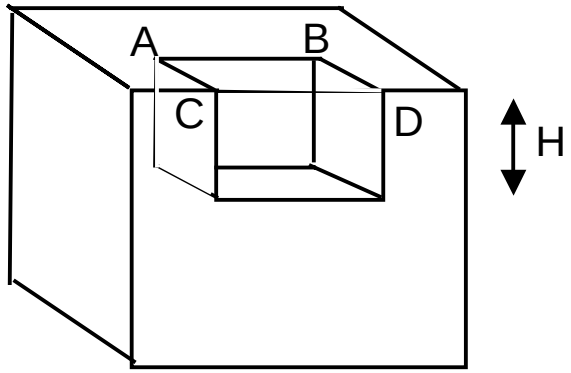
- **ISO 14649 is an object model for STEP-NC**
  - Many important associations between the features, geometry and tolerances are not in the 14649 model but are in AP-238.
  - Convert AP-238 to 14649 using a two stage post
    - » 1. Compute machine specific setup (axes, origin etc)
    - » 2. Summarize and delete feature and geometry relationships



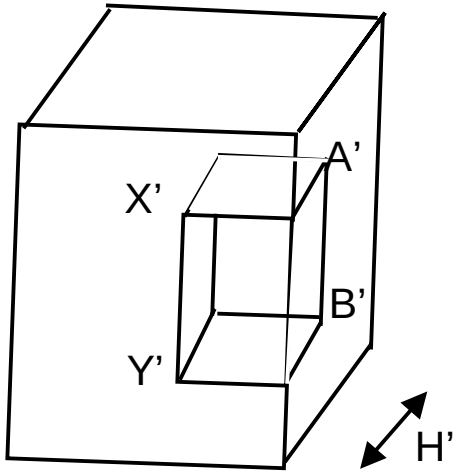
Reading AP-238 directly into the controller is a better solution

Simplified illustration

- **14649 does not contain the solid model geometry**
  - **careful calculation is required to flip the part**
- **AP-238 does contain the solid model geometry**
  - **Point, click and flip to rotate the part**



#20 = Pocket (H, D, B, A, C)



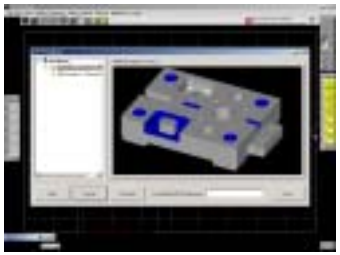
#20 = Pocket (H', D', X', Y', C')

Testing Site

Upload STEP or STEP-NC files

There are about 65,122 small manufacturing enterprises using about 500,000 CNC machines.

STEP-NC Compilation

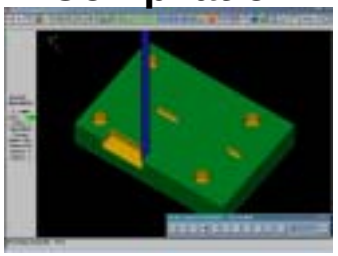


GibbsCAM
ST-Machine™

Convert AP-203 to AP-238

ST-Plan™
On-line

STEP-NC Compilation



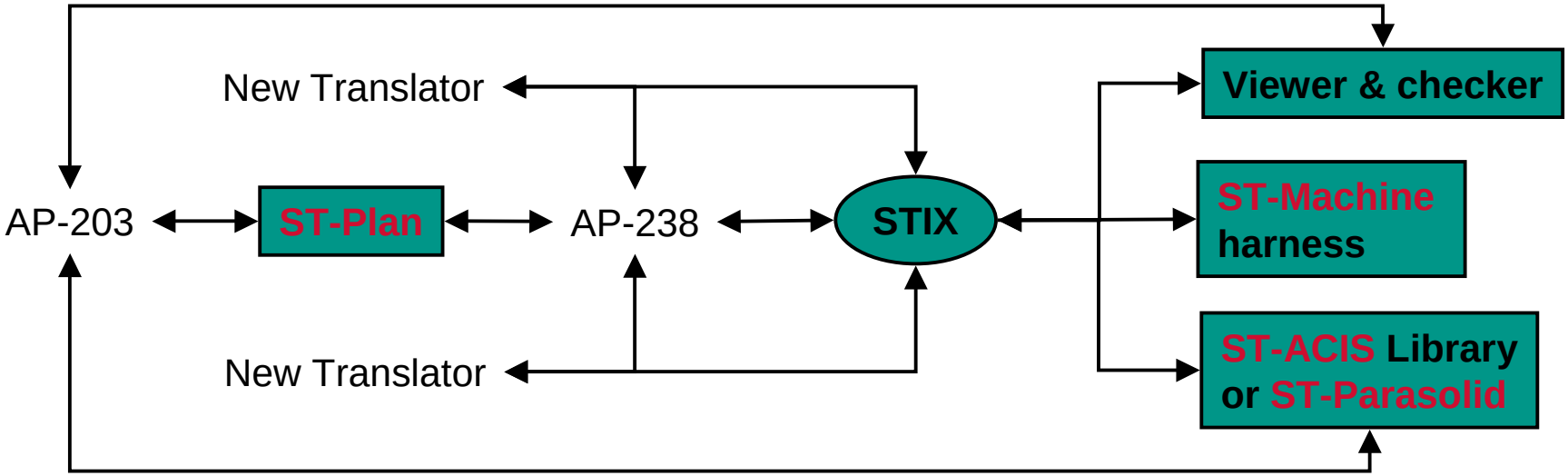
Mastercam
ST-Machine™

http://www.stepnc.com

Esprit Plug-in soon!
Optimizing compilers will not be free

ST-NC Developer

- **Write manufacturing applications and translators**
  - Make or use the Machine independent CNC control data
  - ST-Plan desktop translator with feature recognition to make data
  - STIX Programming API with links to ACIS and Parasolid
  - Viewers, checkers and ST-Machine harness

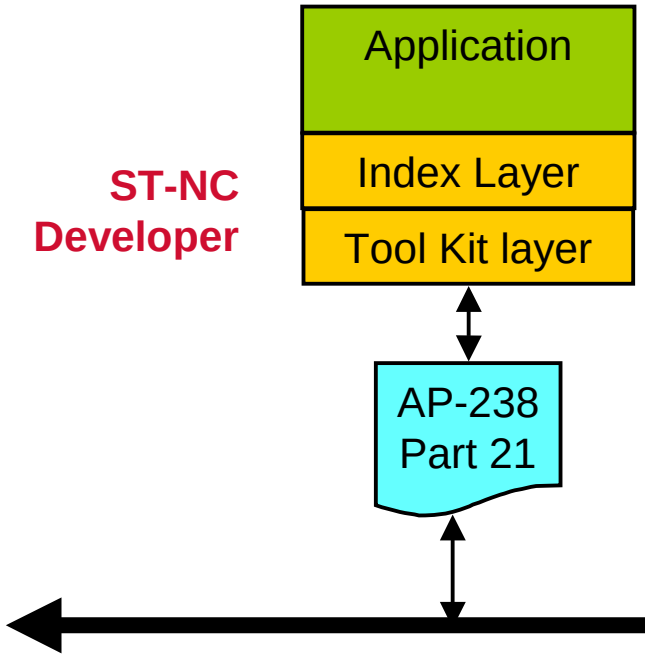


Included in package

AP-238 Direct Interface

NEW

- **New Method**
  - **Enables Updates**
  - **Smaller footprint**
  - **Easier to maintain**
  - **More sophisticated functions.**



ST-NC Developer

OLD