



A traceability information model for CNC manufacturing

AP 238 Traceability Approach

**SC4 Technical Forum, June XX, 2005
Valencia**

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AP 238 Traceability Approach.

1. Traceability.

Traceability.

Traceability Principles & problems.

Traceability & e-Manufacturing. NC Systems.

- 2. Traceability Model.
 - Traceability Data Model & Step-NC
 - WorkingSteps : Operations.
 - Features & Tolerances: Characteristics.
 - 3. Work Done.
 -
 -
-



Traceability & Characteristics

What is traceability ⁽¹⁾ ?

"the ability to trace the history, application or location of what it is under consideration"

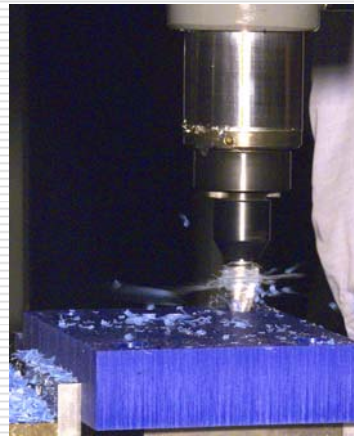
ISO 8402:1994
ISO 9000:2000

- Is a set of practices to make available all essential information about a product.
- Achieved within each product, by registering characteristics & product manufacturing information like:

with what
(raw materials)

who
(employees, personel)

when
(manufacturing timings)



how
machines & tools

where
(handling, store, transport)

How well
(characteristics)

other data
(additional data, resources)



Traceability & Characteristics

STEP, Traceability & Characteristics (1)

- ❑ SC4 Additional STEP requirements and traceability issues.

- Multiple Application support

- ❑ Conceptual Design & Product Planning
- ❑ Engineering Analysis
- ❑

- ❑ **Logistics**
- ❑ **Packaging**
- ❑ **Manufacturing**
- ❑ **Quality**
- ❑ **Support & Maintenance**

Traceability is about this,
but is more than this.

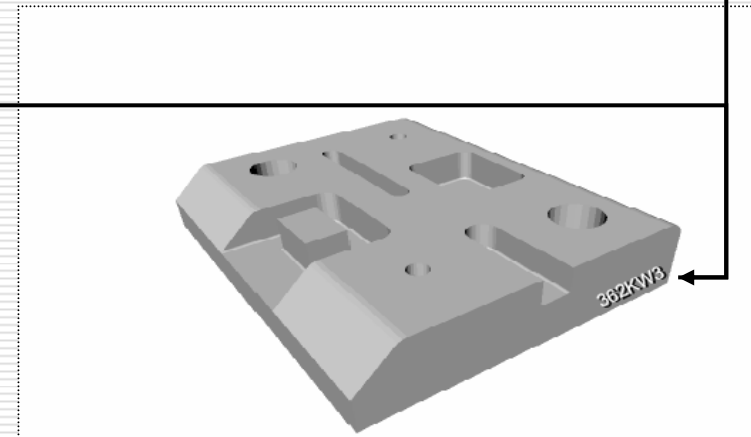


Traceability & Characteristics

What is traceability ⁽²⁾?

□ Traceability Principles:

- Identification
- Data Capture & Recording
- Communication
- Links Management.





Traceability & Characteristics

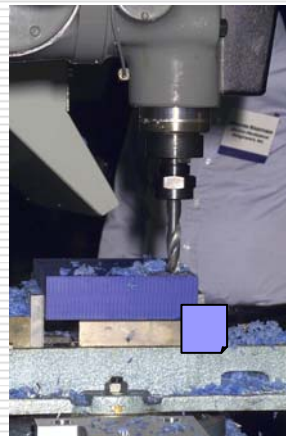
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(additional data, resources)

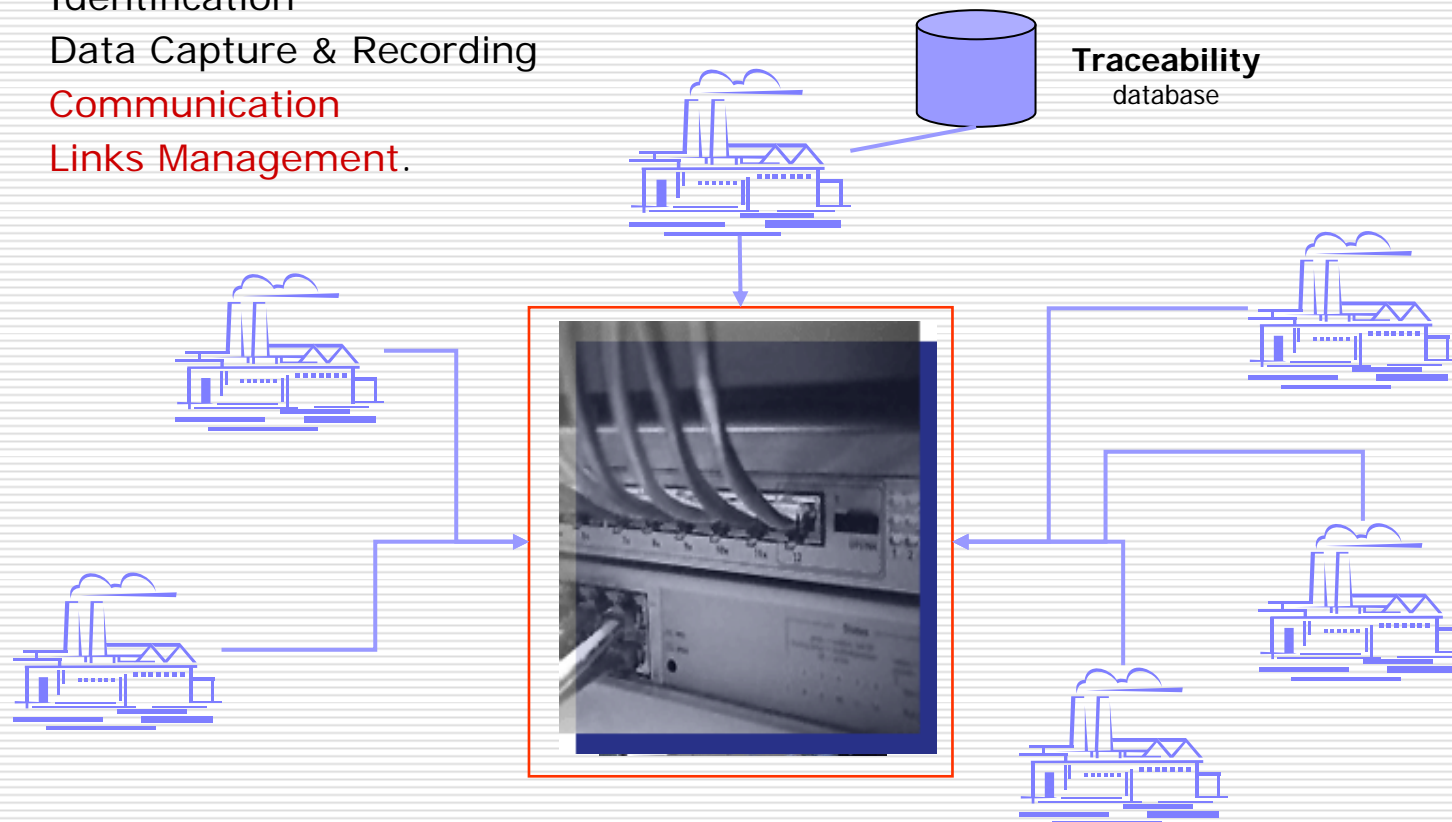


Traceability & Characteristics

What is traceability ⁽²⁾?

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- Identification
- Data Capture & Recording
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Traceability & Characteristics problems (1)

traceability is a complex process

traceability in complex & highly dynamic environments (**e-Manufacturing, CNC**) has complex problems:

1. the product or the manufacturing process is, itself complex :

→ **traceability data is difficult to “understand”.**



2. multiple, and “eventual” contractor-subcontractor relationships.

→ **traceability data is not always available for the main company.**



3. traceability databases are not interconnected (internal traceability systems).

→ **traceability data is disgregated, & full traceability is difficult to achieve.**



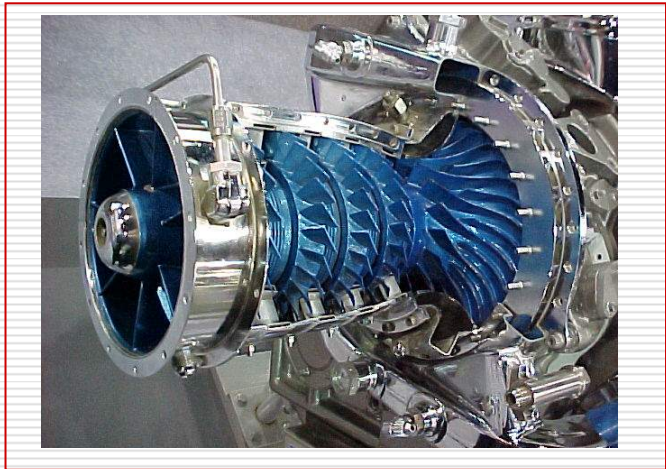
4. products can have 100s of different and heterogeneous characteristics defined.

→ **characteristics must be set, defined, recorded, communicated, audited ...**



Traceability & Characteristics problems (1)

- Traceability in Dynamic, Complex and Heterogeneous systems.



Bill of Materials (list)

BILL OF MATERIAL

ITEM NO.	DESCRIP	QTY	UNIT	REMARKS
1	LAMP ELECTRIC, RED, 24V	1	EA	
2	PLUG ELECTRIFIC, 2 WIRE	1	EA	
3	PLATE BRASS, DIMPLE RESEP	1	EA	
4	SCREWS, DIMPLE, 2 WIRE	1	EA	
5	ROD, BRASS, 3/16" x 10 1/2"	1	EA	
6	WIRE, NO. 8 I/C STRANDED	1	EA	
7	SWITCH, SAFETY, 2P, 25 A	1	EA	
8	SLAB, BRASS 800	1	EA	
9	SWITCH, SAFETY, 250 AMP, 250V, 2P	1	EA	
10	FRIG. REVERSABLE, 1/2 HP	1	EA	
11	LINK, FUSE, 250 AMP	1	EA	
12	FRIG. FUSE, 250 AMP	1	EA	

Product Structure

In complex Products, traceability data could be difficult to understand



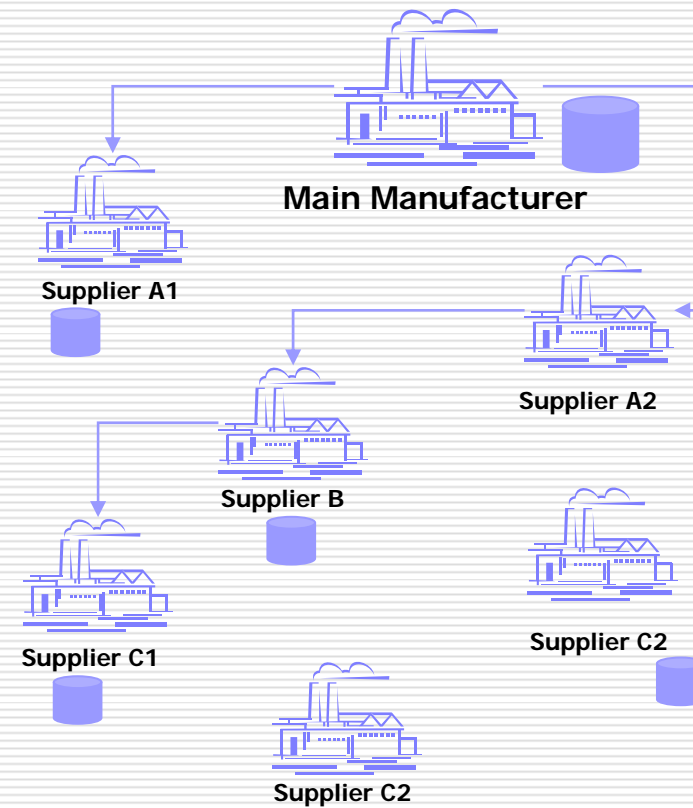
Traceability & Characteristics problems (1)

Traceability in Dynamic, Complex and Heterogeneous systems.

complex product
several different suppliers or providers



In complex Products, traceability data could be difficult to understand

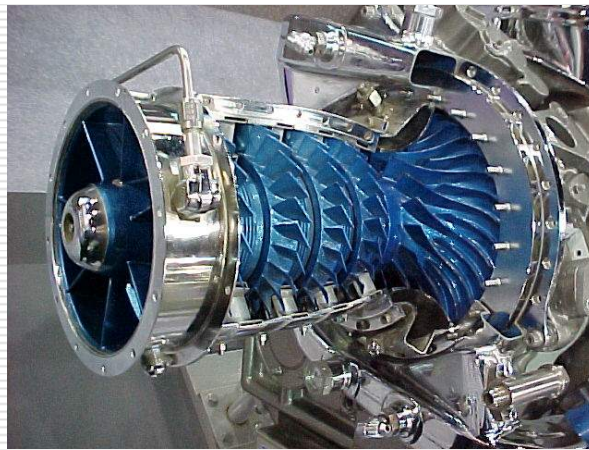


Traceability & Characteristics problems (1)

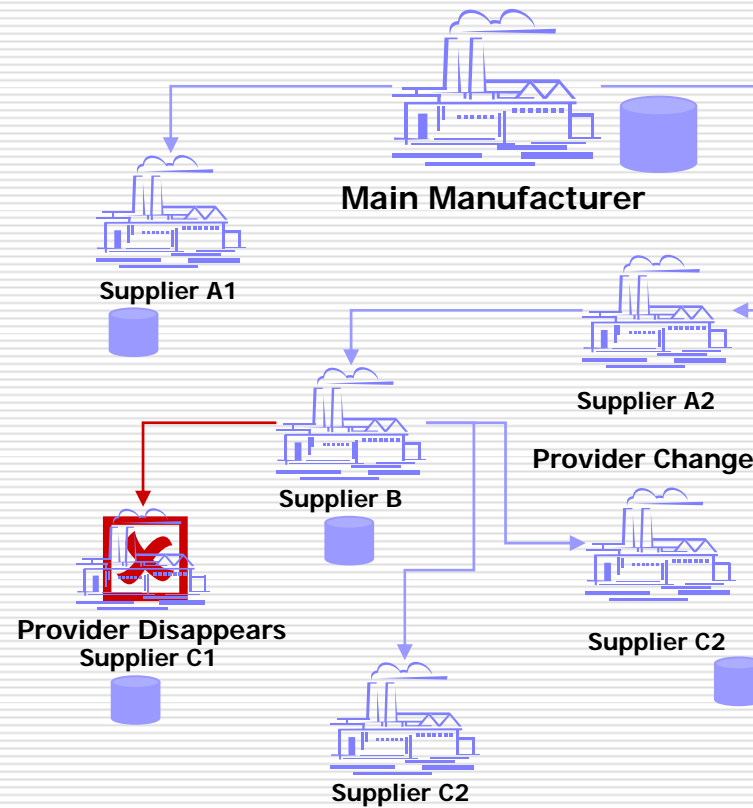
Traceability in Dynamic, Complexity and Heterogeneous systems.

complex product
several different suppliers or providers

dynamic relations
Supply chain is not static



In complex Products, traceability data could be difficult to understand





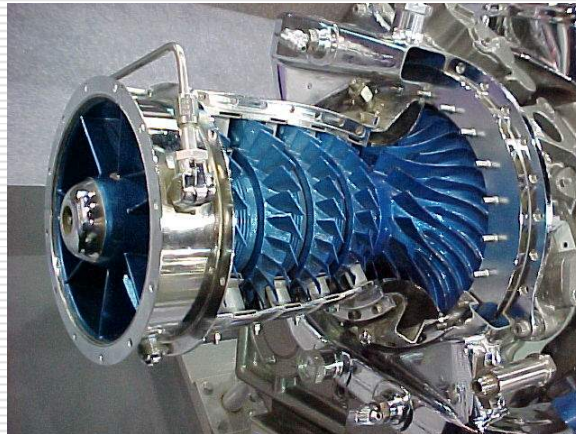
Traceability & Characteristics problems (1)

Traceability in Dynamic, Complex and Heterogeneous systems.

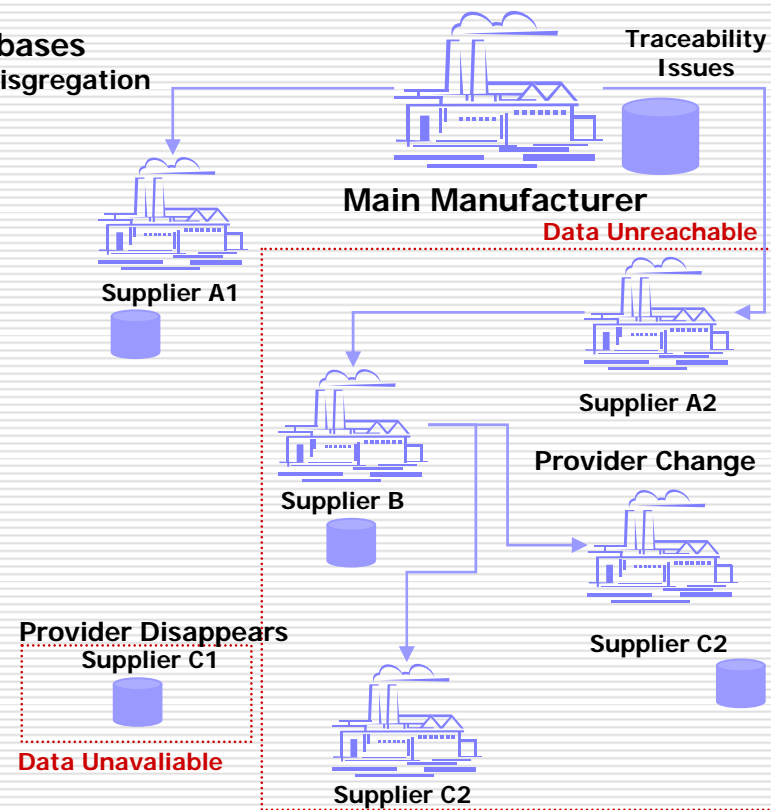
complex product
several different suppliers or providers

traceability databases
data availability & disgregation

dynamic relations
Supply chain is not static



In complex Products, traceability data could be difficult to understand





Traceability & Characteristics problems (1)

- **Characteristics (explanation)**
 - (¿ to fill by Martin ?)
 - ... slide from GE about product characteristics problems ...



AP 238 Traceability Approach.

- 1. Traceability.
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 - Traceability & e-Manufacturing. NC Systems.

2. Traceability Model.

Traceability Data Model & Step-NC

WorkingSteps : Operations.

Features & Tolerances: Characteristics.

- 3. Work Done.

-
 -
-



STEP NC & Traceability Model (1)

- ❑ **STEP – EXPRESS (ISO 10303) information data model for tracing manufacturing operations, features & characteristics (AP238) and assembled products (AP 203).**
 - ❑ **Ap238/AP203 compatible (linked).**
 - **assure traceability data will be understandable and available whenever required.**
 - ❑ no matter the product or the manufacturing process complexity.
 - ❑ even if the subcontractor that made the product no longer has a relationship with the contractor.
 - **the main feature of the model is the definition of an explicit link between the traceability data and the CAM product data.**
 - ❑ allows users to electronically browse the data and understand the relationships between the CAD/CAM data and the executed process.
 - **Input (configuration/requirements) and output (traceability data) are ISO 10303-21 files**
 - ❑ ISO 10303-21:1994/Cor.1:1995/DAM
 - ❑ **XML compatible Step ISO 10303-28.**
-

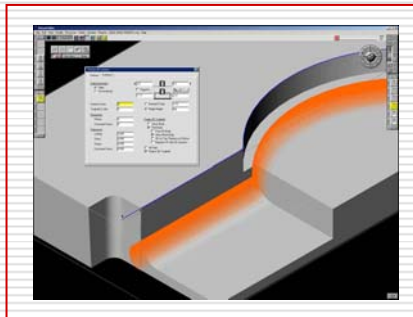


STEP NC & Traceability Model (1)

- Simple CNC machining Scenario.

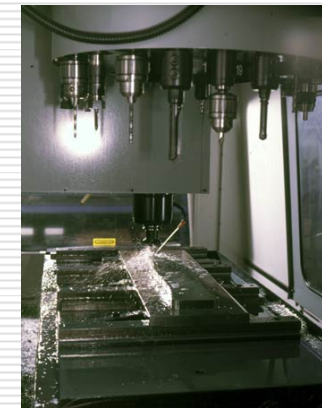
CNC Manufacturing
+ **traceability recording**

CAD/CAM Design
+ **traceability configuration**



Traceability Configuration File (Pat 21)
1 File Per design
AP-238 File

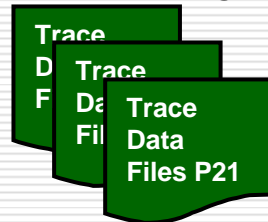
Manufacturing



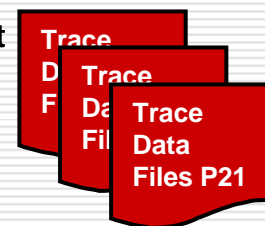
Inspection (Characteristics)



Data Audit & Storage



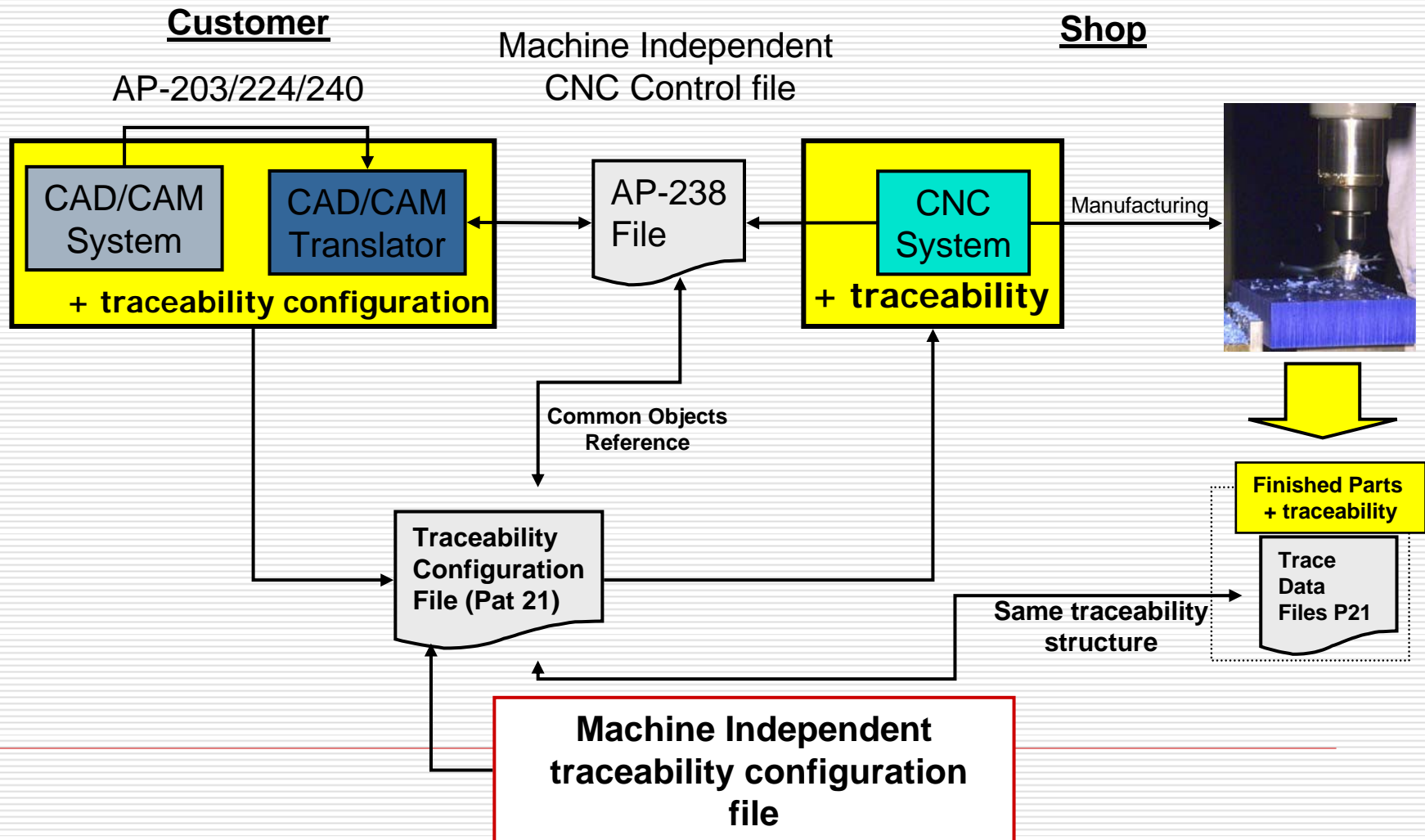
1 File Per Product Manufactured





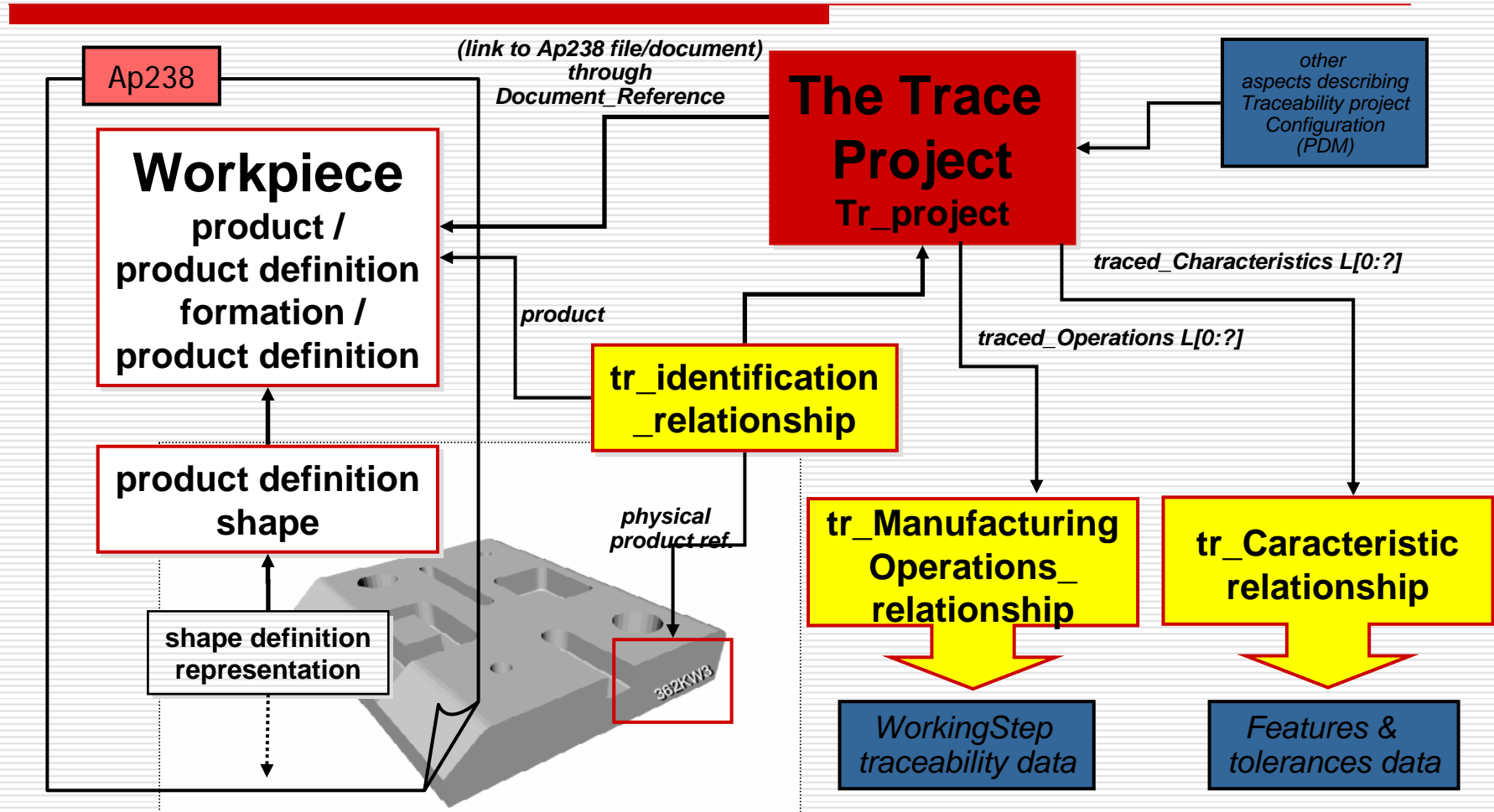
Traceability & Characteristics.

Step-NC Approach + Traceability



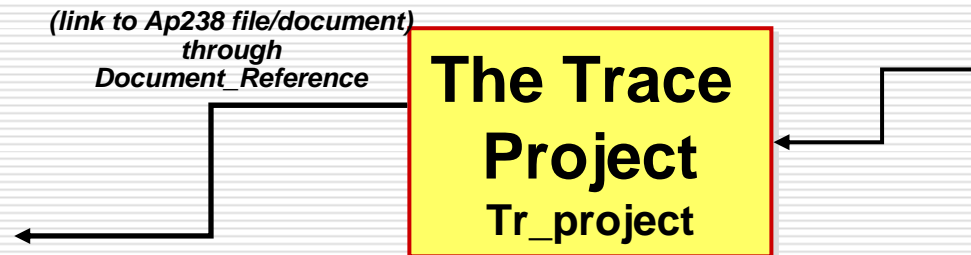


What is traced? (1). Traceability Model Header





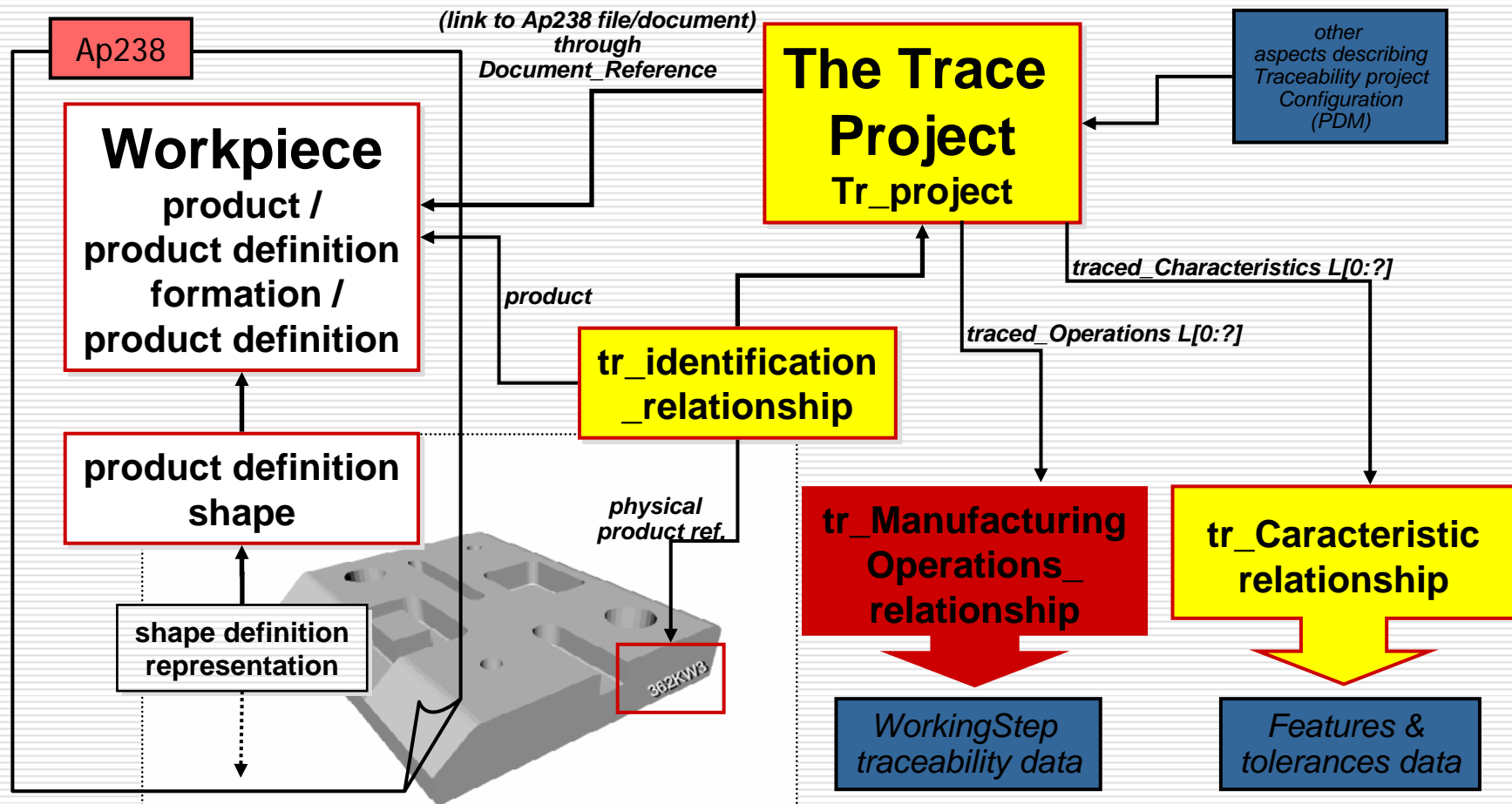
Traceability Project File header (1)



- ❑ Traceability Project Identification:
 - link between Step File & its traceability File.
 - Link between Product Design Data (WorkPiece) & Product Physical Reference.
- ❑ Traceability Project Structure:
 - **Additional WorkPiece PDM (product Data Management) , to be define & harmonized.**
 - ❑ Authorization, approval data, ... (10303-1015 & 1012)
 - ❑ Traceability Data Definitions.
 - **Traced Operations List (through traced_operations)**
 - **Traced Characteristics List (through traced_operations)**



What is traced? (1). WorkingSteps. Operations

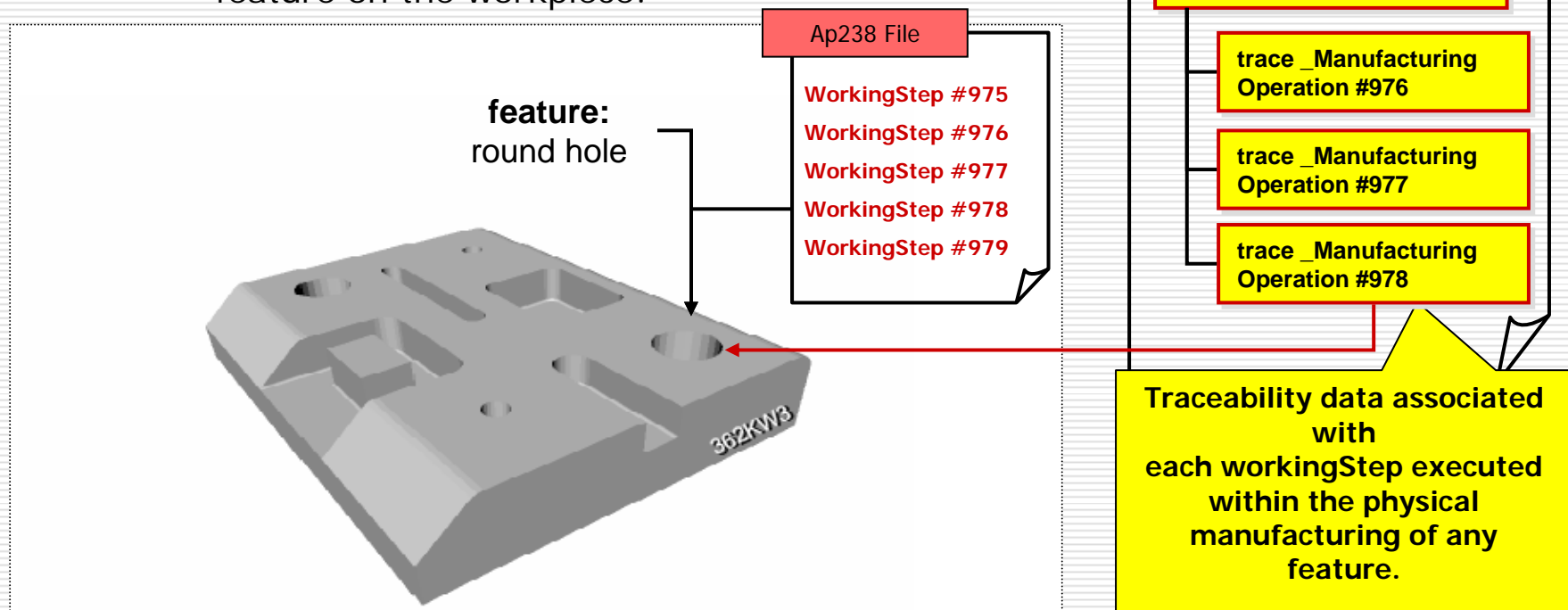




What is traced? ⁽²⁾. WorkingSteps. Operations

□ At the heart of the STEP-NC model

- Workplans containing a sequence of workingsteps.
- Each workingstep associates an operation with a feature on the workpiece.

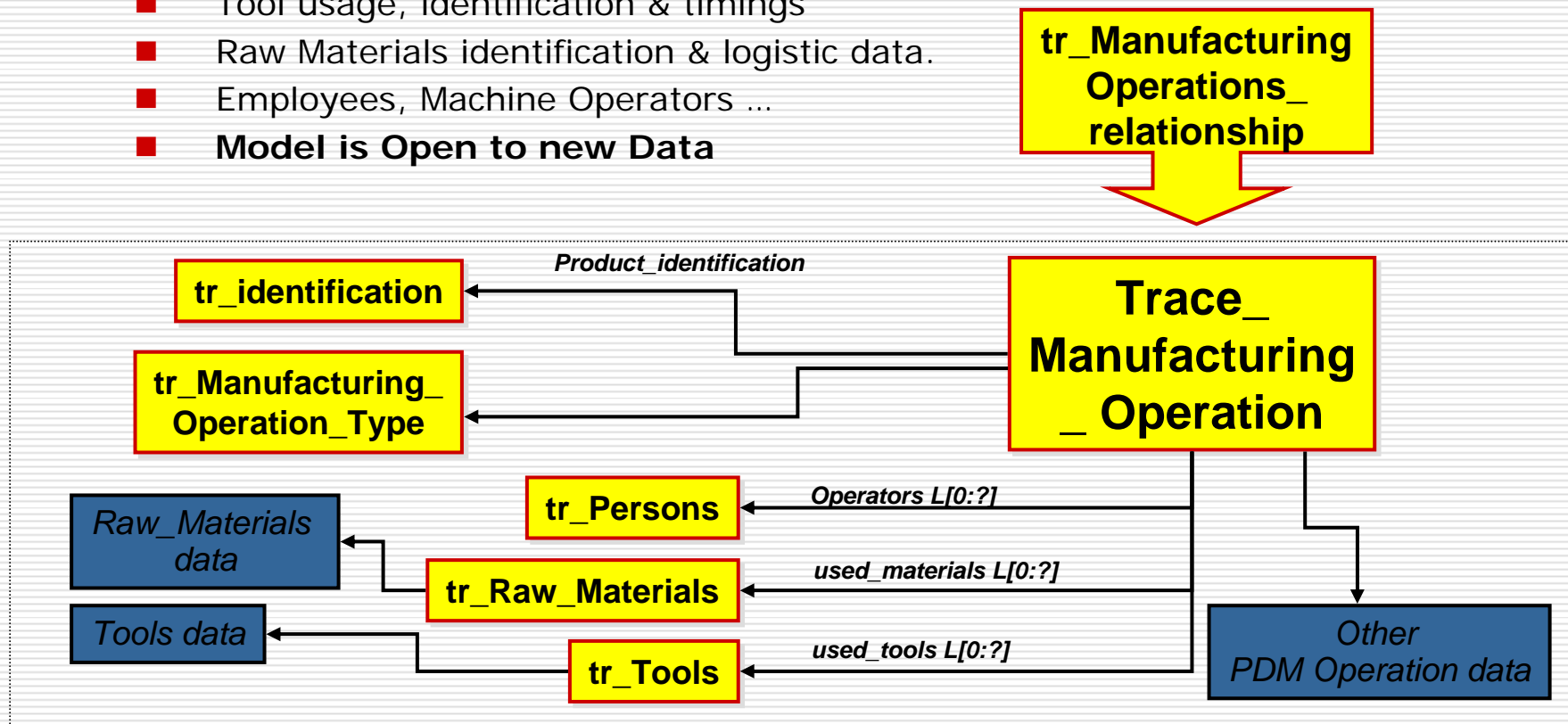




What is traced? (3). WorkingSteps. Operations

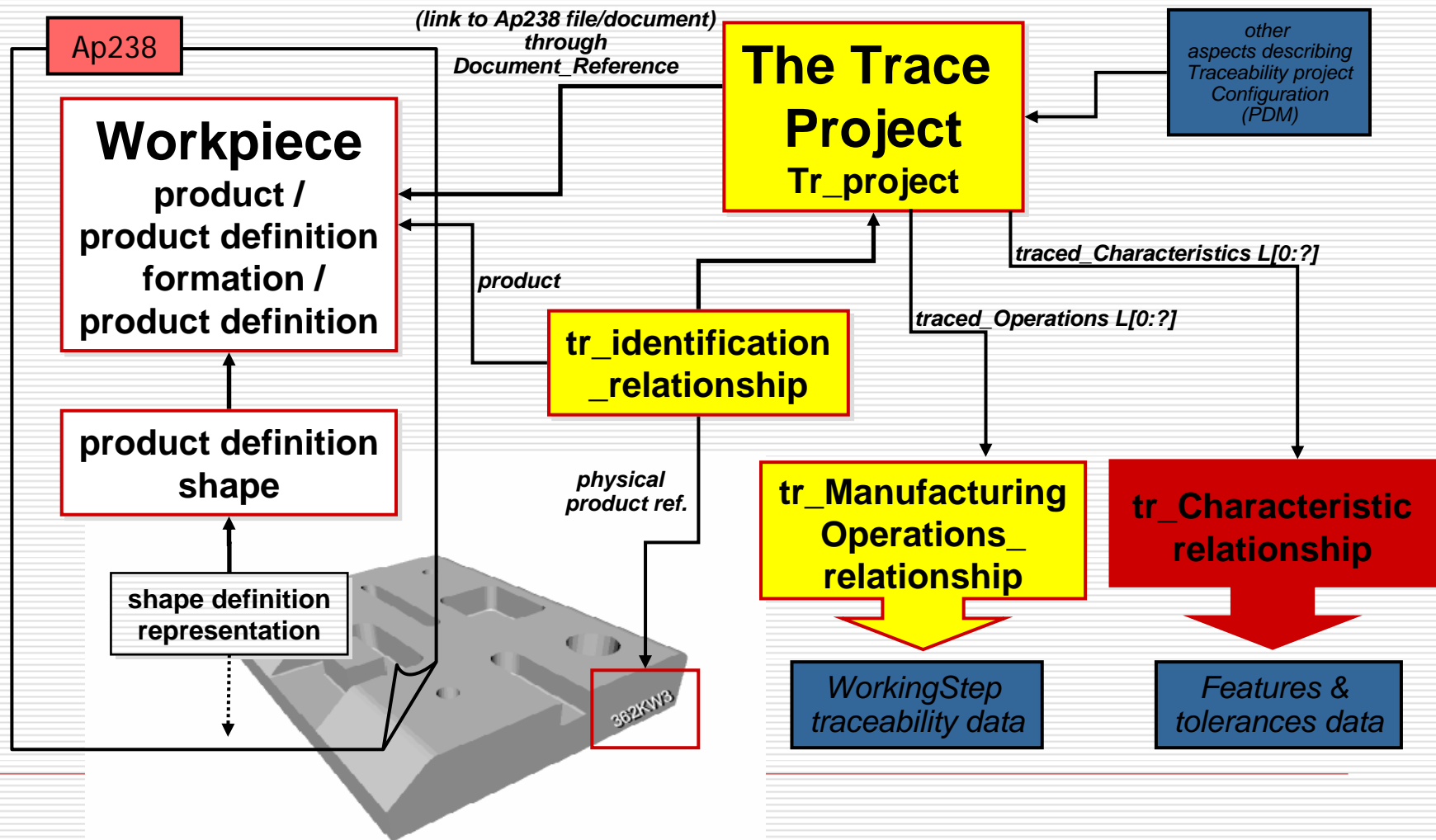
□ Operation traceability data. STEP-NC model

- Tool usage, identification & timings
- Raw Materials identification & logistic data.
- Employees, Machine Operators ...
- Model is Open to new Data





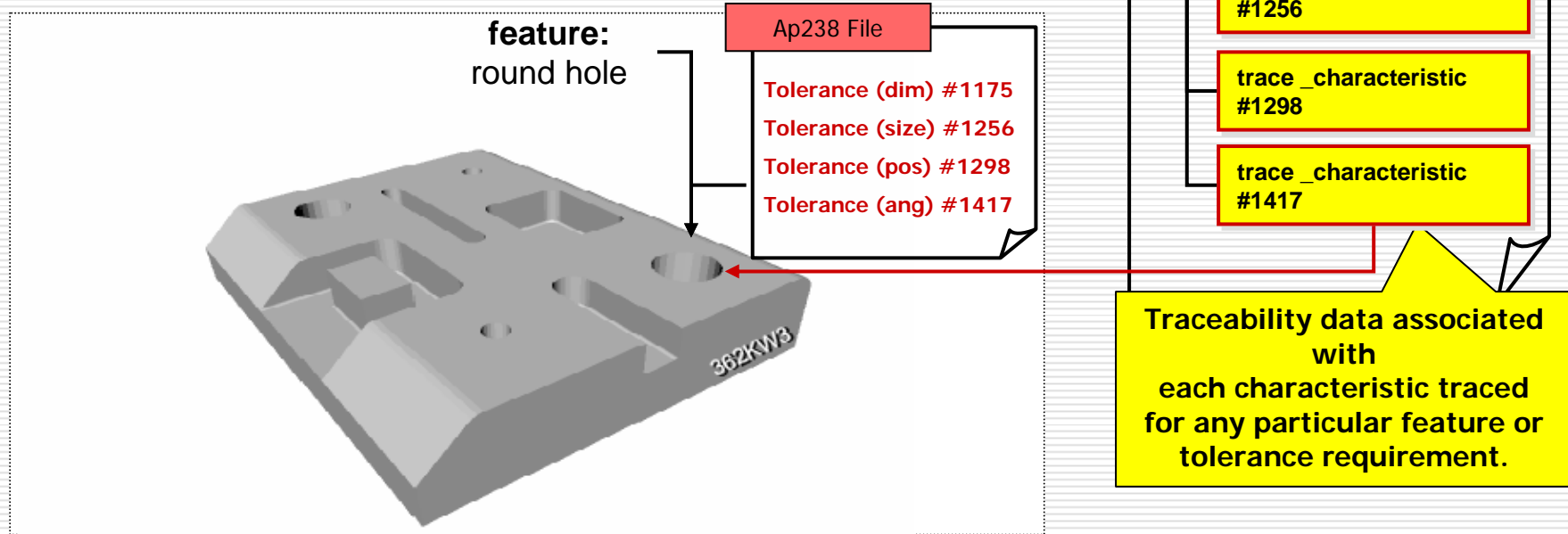
What is traced? (4). GD&T. Characteristics.





What is traced? ⁽⁵⁾. GD&T. Characteristics.

- **STEP-NC model supports GD&T. Tolerances**
 - Characteristics could be a wider concept.
 - Each Entity/object, can support, have, requirements specified by hundreds of different characteristics.
 - Characteristics should be defined, registered, stored, audited, validated ...

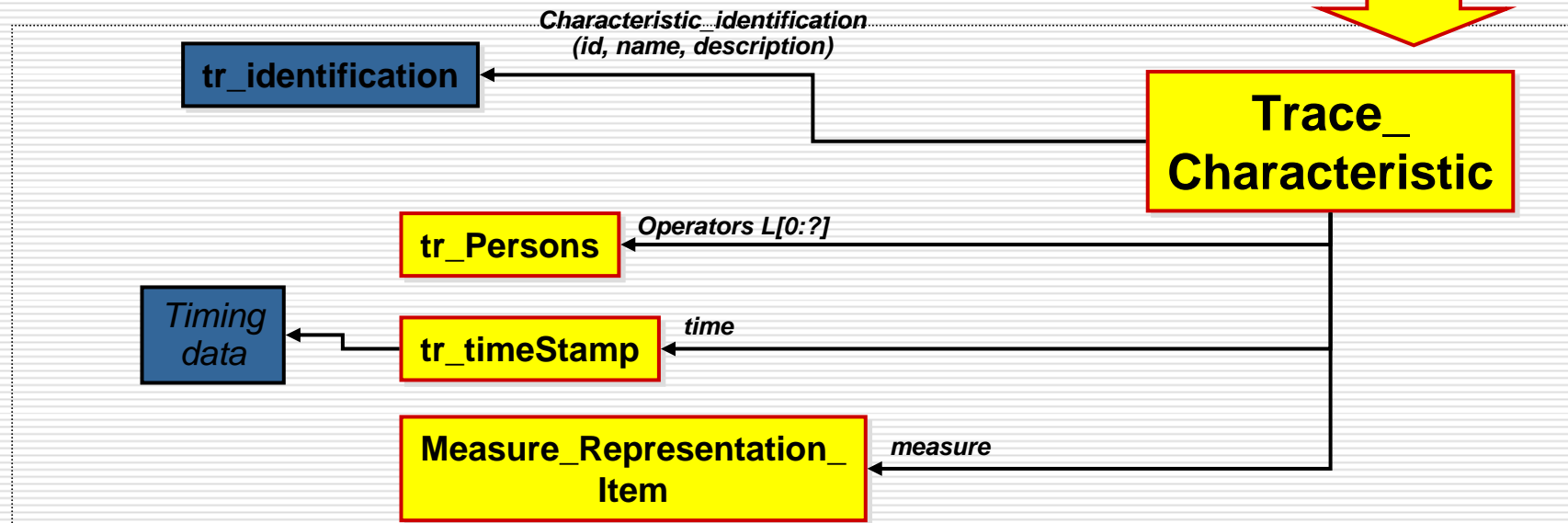




What is traced? (6). GD&T. Characteristics.

□ Characteristic traceability Data. STEP-NC model

- Characteristic Identification: Implicit or Explicit (Repository)
- Measure Rep. Item for Open Characteristics Data.
- Validation, Verification, Auditing, Comprobaton, Control.
- Characterisitics are heterogeneous
- **Model is Open to new Data or Redefinition**





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 - WorkingSteps : Operations.
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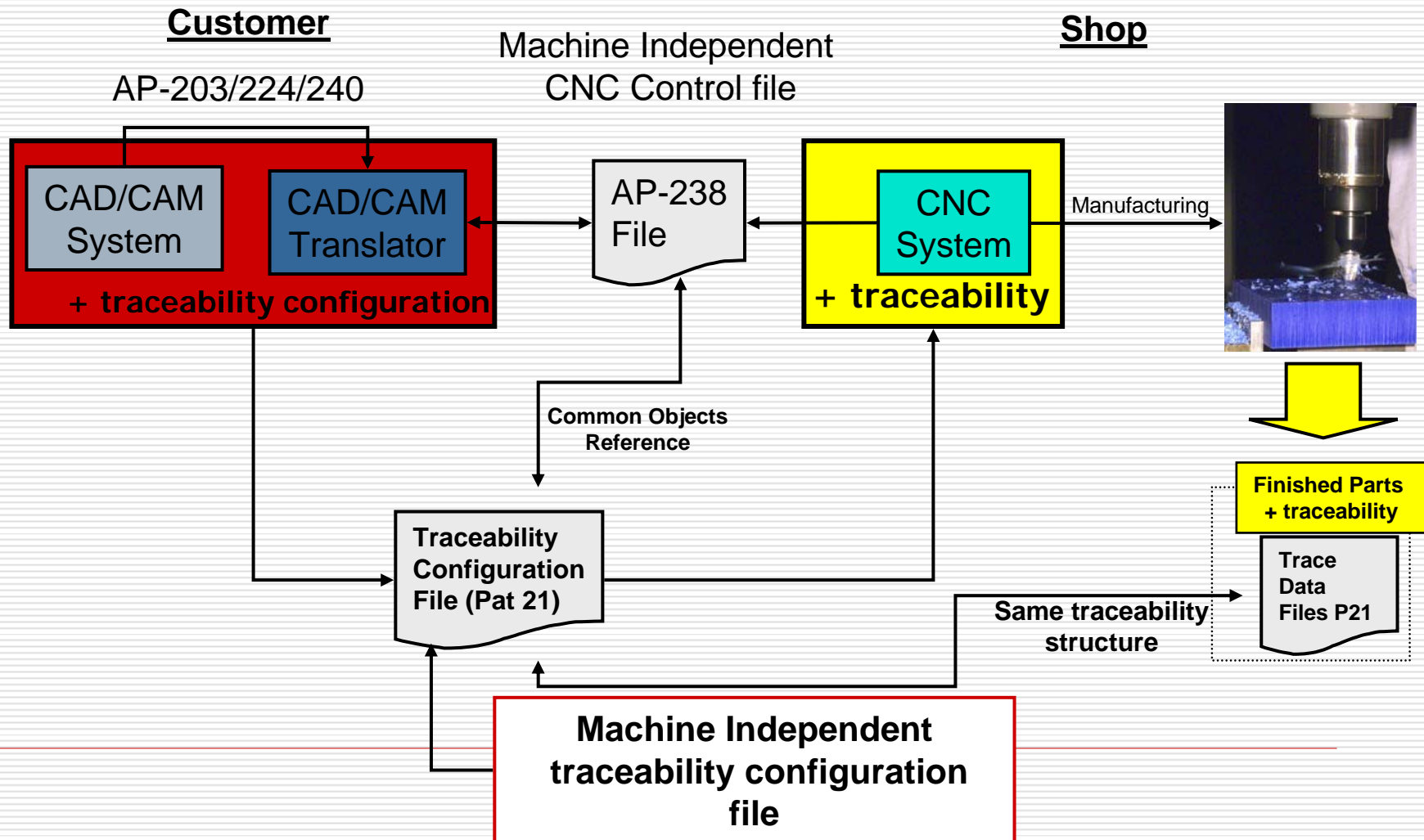
Bla 1

Bla 2.



Traceability & Characteristics.

Step-NC Approach + Traceability





Traceability & Characteristics. Step-NC Explorer (1)

- Setting Traceability Requirements on a WorkingStep. (Tracing Operations)

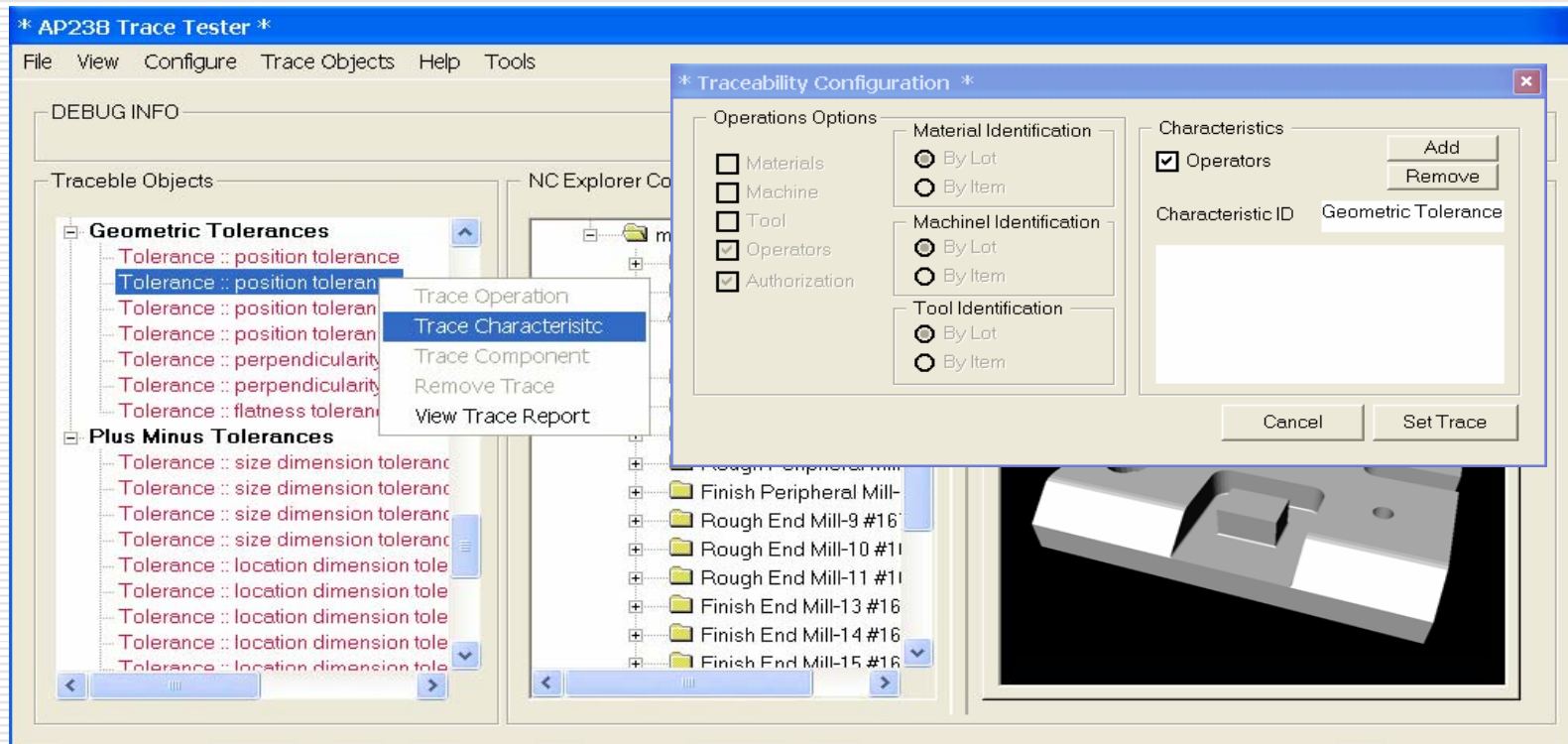
The screenshot displays the AP238 Trace Tester software interface. The main window is titled '* AP238 Trace Tester *' and contains a menu bar (File, View, Configure, Trace Objects, Help, Tools) and a 'DEBUG INFO' section. The 'Traceable Objects' pane on the left lists various workplan steps, including 'WorkingStep :: drilling'. A context menu is open over the 'WorkingStep :: drilling' item, showing options: 'Trace Operation', 'Trace Characteristic', 'Trace Component', 'Remove Trace', and 'View Trace Report'. The 'NC Explorer' pane on the right shows a hierarchical tree of manufacturing features, such as 'Finish End Mill-15 #1681', 'Center Drill-17 #1682', 'Drill-18 #1683', and 'Rough End Mill-20 #1685'. A 'Features List' pane at the bottom left shows 'Feature :: Hole-01'. A 'Traceability Configuration' dialog box is overlaid on the right side of the main window. This dialog has three sections: 'Operations Options' with checkboxes for 'Materials', 'Machine', 'Tool', 'Operators', and 'Authorization'; 'Material Identification' with radio buttons for 'By Lot' and 'By Item'; 'Machine Identification' with radio buttons for 'By Lot' and 'By Item'; 'Tool Identification' with radio buttons for 'By Lot' and 'By Item'; and 'Characteristics' with a checked 'Operators' checkbox, an 'Add' button, a 'Remove' button, and a 'Characteristic ID' input field. 'Cancel' and 'Set Trace' buttons are at the bottom of the dialog. A 3D CAD model of a mechanical part is visible in the bottom right corner of the main window.



Traceability & Characteristics.

Step-NC Explorer (2)

- Setting Traceability requirements on a tolerance. (tracing Characteristics).





STEP File Browser - trace-char1.stp [page 1/1]

File View Navigate Help

```
ISO-10303-21;
HEADER;
.....
.....

FILE_SCHEMA (('TRACEABILITY_SCHEMA','INTEGRATED_CNC_SCHEMA'));
ENDSEC;

DATA;
#10=TR_TIMESTAMP(#56,#57);
#11=TR_TIMESTAMP(#58,#59);
#12=TR_TIMESTAMP(#60,#61);
#13=TR_TIMESTAMP(#62,#63);
.....
.....

#65=DOCUMENT_TYPE("");
#66=DOCUMENT("",D:\data\tolerance_part.stp',
'AP238 Base Document - Configured for Traceability',#65);
#67=DOCUMENT_REFERENCE(#66,D:\data\tolerance_part.stp');
#68=TR_PROJECT(#67,#69,$,(#75,#76,#77,#78),#64);
#69=TR_IDENTIFICATION_RELATIONSHIP(3716,#70);
#70=TR_IDENTIFICATION("","",",LOT.);
#71=TR_CHARACTERISTIC(0,'location #45',
'Characterstic Applied to (Plus Minus Tolerance)--> location dimension
tolerance',#30,#10,());
#72=TR_CHARACTERISTIC(0,'Feature - Hole #56',
'Characterstic Applied to (Feature)--> ',#31,#11,());
#73=TR_CHARACTERISTIC(0,'Position #93',
'Characterstic Applied to (Geometric Tolerance)--> position',#32,#12,());
#74=TR_CHARACTERISTIC(0,'Dimension #45',
'Characterstic Applied to (Plus Minus Tolerance)--> size dimension tol
erance',#33,#13,());
#75=TR_CHARACTERISTIC_RELATIONSHIP(219,#71);
#76=TR_CHARACTERISTIC_RELATIONSHIP(3368,#72);
#77=TR_CHARACTERISTIC_RELATIONSHIP(31,#73);
#78=TR_CHARACTERISTIC_RELATIONSHIP(205,#74);
ENDSEC;
END-ISO-10303-21;
```

AP-238 File

Entity ID #31

Characteristic Requeriments Data Fields

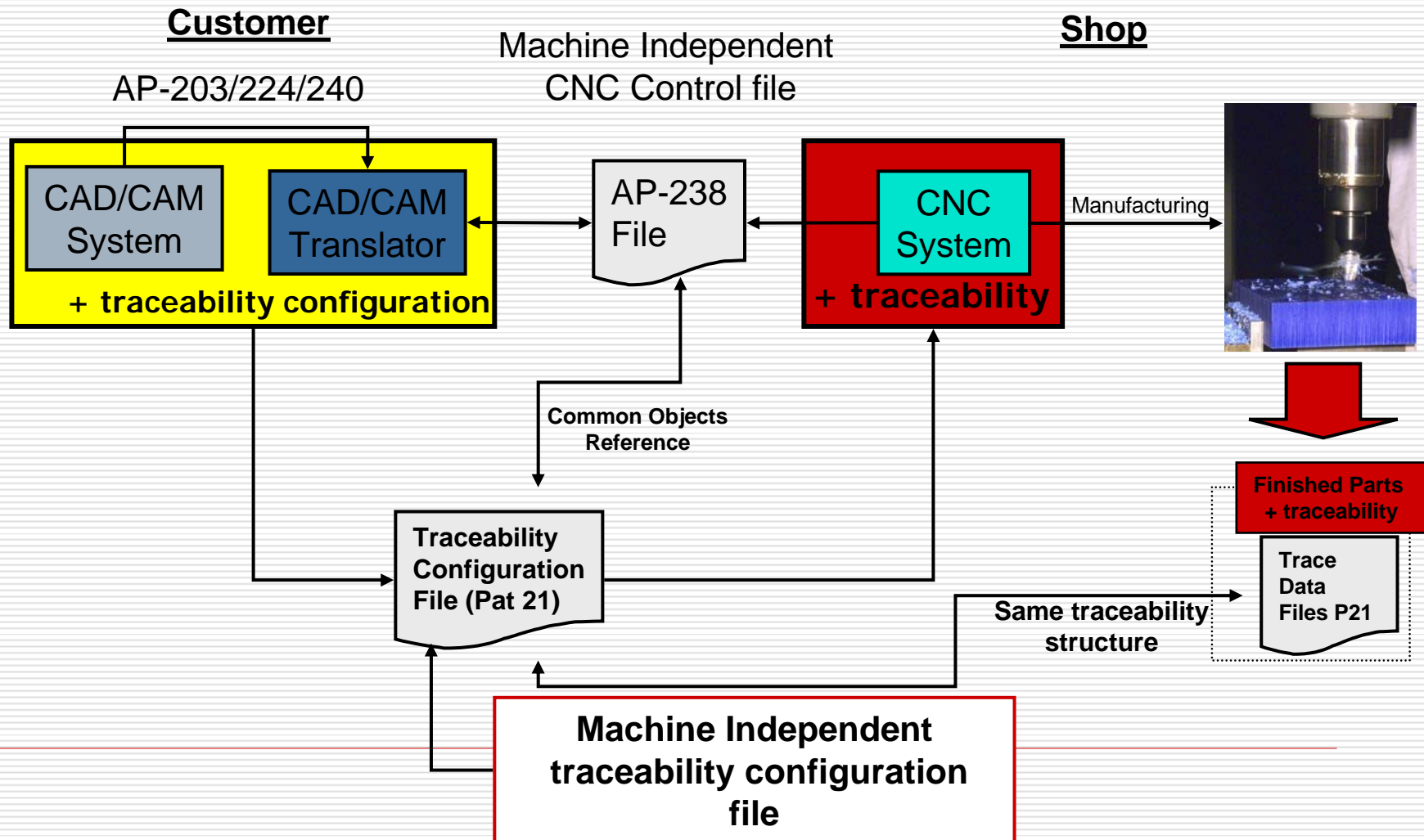
Ap238 file & traceability File Link

CONFIGURATION
Traceability File
Entity Links/Relations



Traceability & Characteristics.

Step-NC Approach + Traceability





Traceability & Characteristics.

Step-NC Explorer (3)

- Inspecting Traceability data on a Feature. (NC-Explorer Update) (traced Characteristics & timings resume).

The screenshot displays the AP238 Trace Tester application window. The main interface includes a menu bar (File, View, Configure, Trace Objects, Help, Tools), a DEBUG INFO panel, and a Traceable Objects list. The Traceable Objects list contains various features such as Hole-03_Micro-1_C'Drill, Hole-04_Micro-1_C'Drill, Periphery-01, and Planar Face-01. A tree view on the right shows a hierarchy of features, including Center Drill, Drill-18 #18, Drill-19 #18, and Rough End.

Two dialog boxes are overlaid on the main window, both titled "* Trace Report for the Selected Item *".

The first dialog box shows the following data for the selected feature "Hole-03_Micro-1_C'Bore-1_NC Hole-9":

* Trace Report for the Selected Item *	
FEATURE	:: Hole-03_Micro-1_C'Bore-1_NC Hole-9
- Feature Traced	
- Traced Characteristic	
Characteristic Code ::	0
Name ::	Feature - Hole #56
Description ::	Characteristic Applied to (Feature)-->
Measured Value ::	
Associated TimeStamp ::	Start :: Sat De
Operators List ::	

The second dialog box shows the following data for the selected item:

* Trace Report for the Selected Item *	
CHILD WorkingPlan ::	00:21:00
CHILD WorkingPlan ::	01:28:21
CHILD WorkingPlan ::	00:35:40
WorkingStep ::[#974]::	Working Time:: 00:09:23
WorkingStep ::[#975]::	Working Time:: 00:14:41
CHILD WorkingPlan ::	00:54:47
WorkingStep ::[#976]::	Working Time:: 00:35:17
WorkingStep ::[#977]::	Working Time:: 00:19:30
CHILD WorkingPlan ::	00:09:06
WorkingStep ::[#978]::	Working Time:: 00:04:04
WorkingStep ::[#979]::	Working Time:: 00:05:02
CHILD WorkingPlan ::	00:18:34



STEP File Browser - Trace_data1.stp [page 1/1]

File View Navigate Help

```

#26=TR_TOOL(#197,#32);
#31=TR_TIMESTAMP(#153,#154);
#32=TR_TIMESTAMP(#155,#156);
#42=TR_RAWMATERIAL(#193,#29);
#43=TR_RAWMATERIAL(#196,#31);
#48=TR_RAWMATERIAL(#202,#39);
#71=DATE(18330);
#85=DATE(12000);
#120=LOCAL_TIME(10,10,39.,$);
#155=DATE_AND_TIME(#85,#120);
#156=DATE_AND_TIME(#86,#121);
#179=TR_PERSON(#67,#152);
#183=DOCUMENT_TYPE("");
#184=DOCUMENT("D:\data\tolerance_part
'AP238 Base Document - Configured for Trace
#185=DOCUMENT_REFERENCE(#184,D:\da
#186=TR_PROJECT(#185,#187,(#207,#208
#187=TR_IDENTIFICATION_RELATIONSHIP
#195=TR_IDENTIFICATION(
'#ID#bP1oF3P443200sR6mZ1kR4K8I8X7U9A
'Category String','Supplier String',.LOT.);
#205=TR_MANUFACTURING_OPERATION('drilling','Description String',.CNC.,
(#42,#45,#46,#47),#192,#25,'remarks String',(),#178);
#206=TR_MANUFACTURING_OPERATION('drilling','Description String',.CNC.,
(#43,#48,#49),#195,#26,'remarks String',(#181,#182),#179);
#209=TR_MANUFACTURING_OPERATION_RELATIONSHIP(975,#206);

```

AP-238 File

WorkingStep ID #975

* Trace Report for the Selected Item *

CHILD WorkingPlan ::	00:21:00
CHILD WorkingPlan ::	01:28:21
CHILD WorkingPlan ::	00:35:40
WorkingStep ::[#974]::	Working Time:: 00:09:23
WorkingStep ::[#975]::	Working Time:: 00:14:41
CHILD WorkingPlan ::	00:54:47
WorkingStep ::[#976]::	Working Time:: 00:35:17
WorkingStep ::[#977]::	Working Time:: 00:19:30
CHILD WorkingPlan ::	00:09:06
WorkingStep ::[#978]::	Working Time:: 00:04:04
WorkingStep ::[#979]::	Working Time:: 00:05:02
CHILD WorkingPlan ::	00:18:34

OK

DATA
Traceability File
Entity Links/Relations

Ap238 file & traceability File Link



Traceability & Characteristics. Step-NC Explorer (2) .Auditing

- ❑ Fast Auditing Traceability data for defined characteristics.

Hundreds of characteristic and traceability requirements per product, operation, feature or file.

Characteristic data is recorded on traceability data files.

Some Data could be erroneous, out of range or even not unavaliable

*** Trace Report for the Selected Item ***

FEATURE :: Hole-03_Micro-1_C'Drill-1_NC Hole-3

- Feature Traced

+ - Traced Characteristic

- - Traced Characteristic

Characteristic Code ::	0
Name ::	Characterisitic Repository Code #454
Description ::	Characterisitic Applied to (Feature)-->
Measured Value ::	
Associated TimeStamp ::	Start:: Sat Dec 30 00:00:00 1899 End:: Sat Dec 30 00:00:00 1899
Operators List ::	

OK

```
#545=TR_CHARACTERISTIC(0,'Char...
#829,());
#546=TR_CHARACTERISTIC(0,'Char...
#832,());
#547=TR_CHARACTERISTIC(0,'Char...
#835,());
#548=TR_CHARACTERISTIC(0,'Ch...
#836,());
#549=TR_CHARACTERISTIC(0,'Ch...
#837,());
#550=TR_CHARACTERISTIC(0,"'C...
#838,());
#551=TR_CHARACTERISTIC(0,"'C...
#839,());
#552=TR_CHARACTERISTIC(0,"'C...
#840,());
#553=TR_CHARACTERISTIC(0,"'C...
#841,());
#554=TR_CHARACTERISTIC(0,"'C...
#842,());
```

```
#1818=DATE(12000);
#1819=DATE(17151);
#1820=DATE(1922);
#1821=DATE(8748);
#1822=LOCAL_TIME(5,41,2,.$);
#1823=LOCAL_TIME(4,9,43,.$);
#1824=LOCAL_TIME(2,44,30,.$);
#1825=LOCAL_TIME(2,52,36,.$);
#1826=LOCAL_TIME(1,57,59,.$);
#1827=LOCAL_TIME(1,59,59,.$);
#1828=LOCAL_TIME(11,3,6,.$);
#1829=LOCAL_TIME(11,18,14,.$);
```



Traceability & Characteristics

CONCLUSIONS ⁽¹⁾

traceability is a complex process

traceability in complex & highly dynamic environments (**e-Manufacturing, CNC**) has complex problems:

STEP – EXPRESS (ISO 10303) information model for tracing manufacturing operations.

1. the product or the manufacturing process is, itself complex :

→ traceability data is difficult to “understand”.



2. multiple, and “eventual” contractor-subcontractor relationships.

→ traceability data is not always available for the main company.



3. traceability databases are not interconnected (internal traceability systems).

→ traceability data is disgregated, and full traceability is difficult to achieve.



4. products can have 100s of different and heterogeneous characteristics defined.

→ characteristics must be set, defined, recorded, communicated, audited ...





Traceability & Characteristics

CONCLUSIONS ⁽¹⁾

Automation of traceability is an important task

traceability in complex & highly dynamic environments (**e-Manufacturing, CNC**)
solution & proposals :

STEP – EXPRESS (ISO 10303) information model for tracing manufacturing operations.

1. the product or the manufacturing process is, itself complex :

→ **traceability data linked to CAD/CAM data.**



2. multiple, and "eventual" contractor-subcontractor relationships.

→ **traceability data delivered with the product.**



3. traceability databases are not interconnected (internal traceability systems).

→ **traceability data as a standard part of PDE (product data exchange)**



4. products can have 100s of different and heterogeneous characteristics defined.

→ **generic definition of characteristics data fields.**

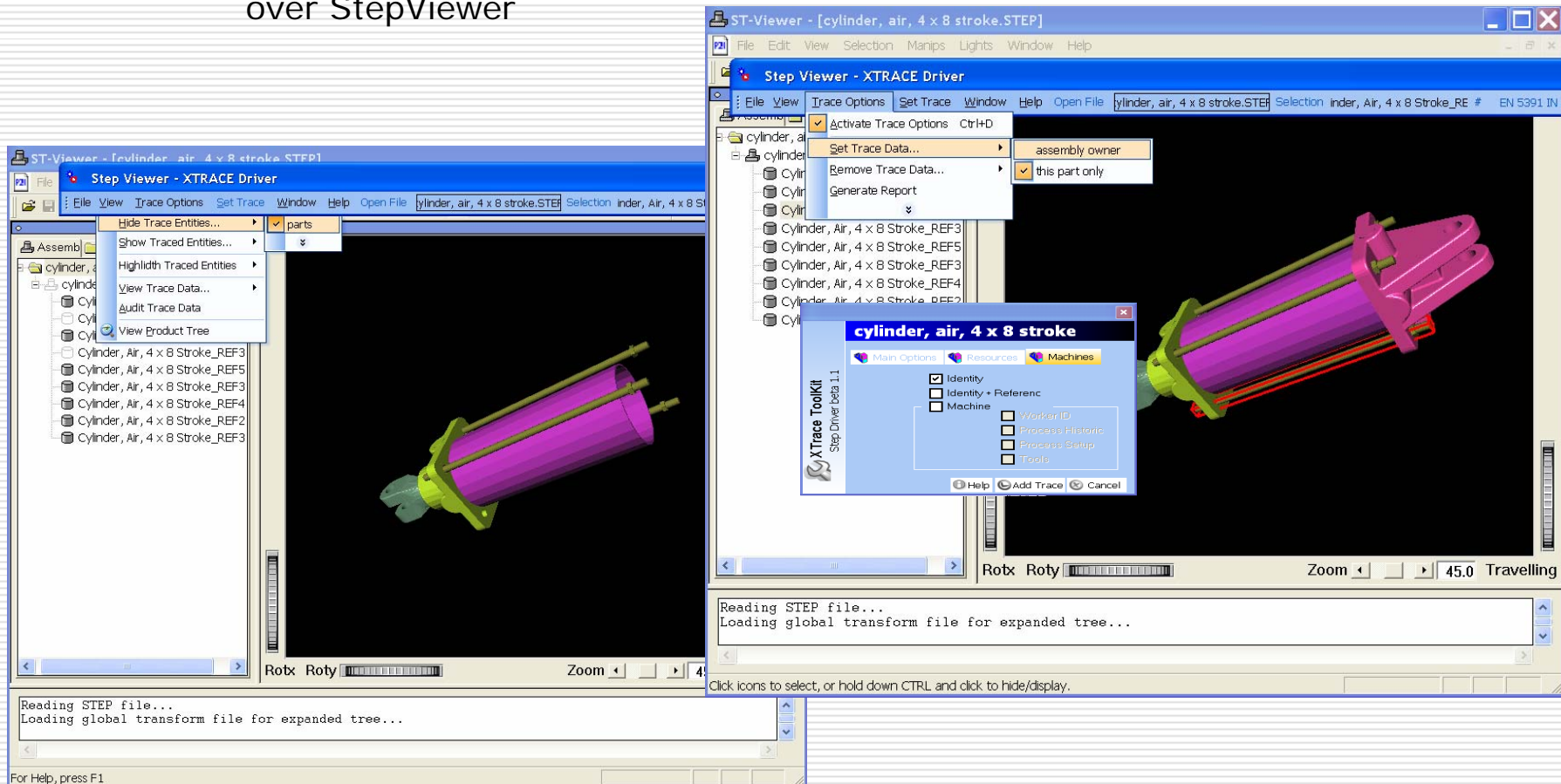




Related & Future Work.

Ap 203 (1)

- Traceability Model is also AP 203.
 - Samples of Configuration, Auditing & Visualization of trace requirements over StepViewer

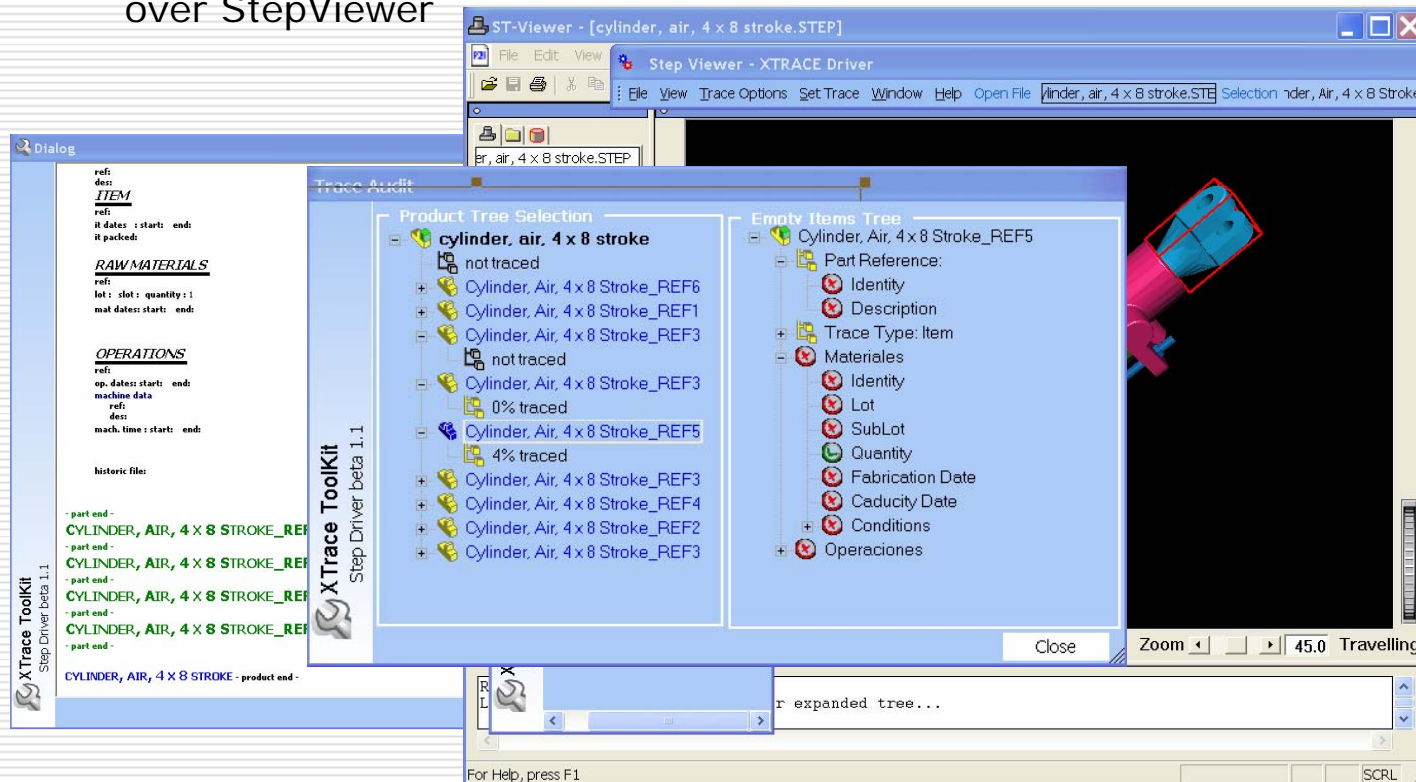




Related & Future Work.

Ap 203 (2)

- Traceability Model is also AP 203.
 - Samples of Configuration, Auditing & Visualization of trace requirements over StepViewer





Traceability & Characteristics.

The BIG QUESTION (1)

- A new STEP Standard Information model for traceability ?

