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Information Technology

Charleston Operations

AP219: Dimensional inspection

And
STEP Manufacturing Suite

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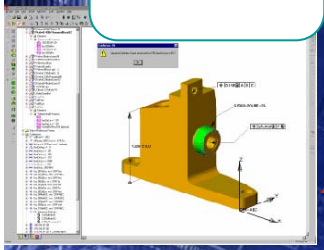
Dimensional Metrology System:

Component diagram with candidate open & non-proprietary interface standards

Design | **Planning** | **Execution** | **Analysis**



CAD + GD&T

Part geometry and design tolerances

STEP AP203e2, AP219, DML

Inspection process planning

Inspection process plans

DMIS

Inspection execution

CMM control commands and responses

I++ DME

Coordinate measuring machines (CMMs)

Measurement results

DML, STEP AP219

Reporting & analysis

Quality measurement information

AIAG Quality Data

Quality device integration

manufacturing interoperability

innovation & productivity

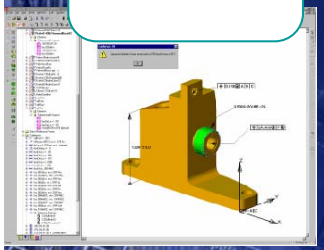
Dimensional Metrology System:

Component diagram with candidate open & non-proprietary interface standards

using STEP Manufacturing Suite Architecture

Design **Planning** **Execution** **Analysis**

CAD + GD&T



Part geometry and design tolerances

STEP AP224 DML

Inspection process planning

Inspection process plans

STEP AP240, AP223, AP229 DMIS

Inspection execution

Measurement results

DML, STEP AP219

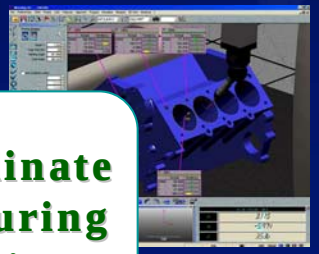
Reporting & analysis

Quality measurement information

AIAG Quality Data STEP AP223, AP229

CMM control commands and responses

STEP AP238 I++ DME



Coordinate measuring machines (CMMs)

Quality device integration

manufacturing interoperability

innovation & productivity

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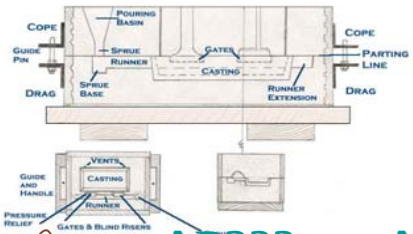
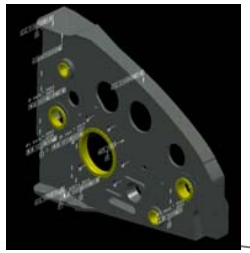
Integrated Manufacturing Architecture using Core Manufacturing Data

Exchange of Design and Manufacturing Product Information for Cast Parts



CMM

CAD



AP223 **AP219**

AP224

Machining Features And Tolerances

Dimensional Inspection Information Exchange

Mechanical product definition for process planning using machining features

AP238

CNC

CORE DATA

AP240

Process plans for machined parts

Application interpreted model for computerized numerical controllers

What is a Machining Feature ?

- Definition of an aspect of shape on a part.
- Terminology in terms of Manufacturing users
- Defines explicit definition of shape:
  - Geometry
- Defines implicit definition of shape:
  - Parametric attributes

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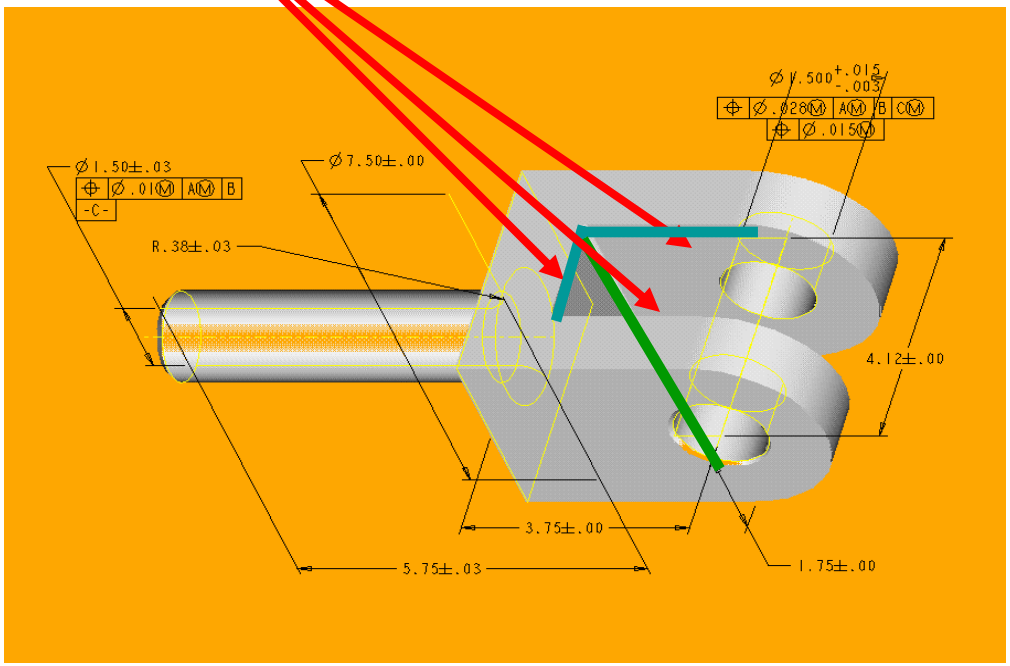
Explicit and Implicit feature information

- Example: Slot
  - Boundary Representation Geometry defines Slot Feature
  - Face Topology defines Slot floor and side walls

Faces



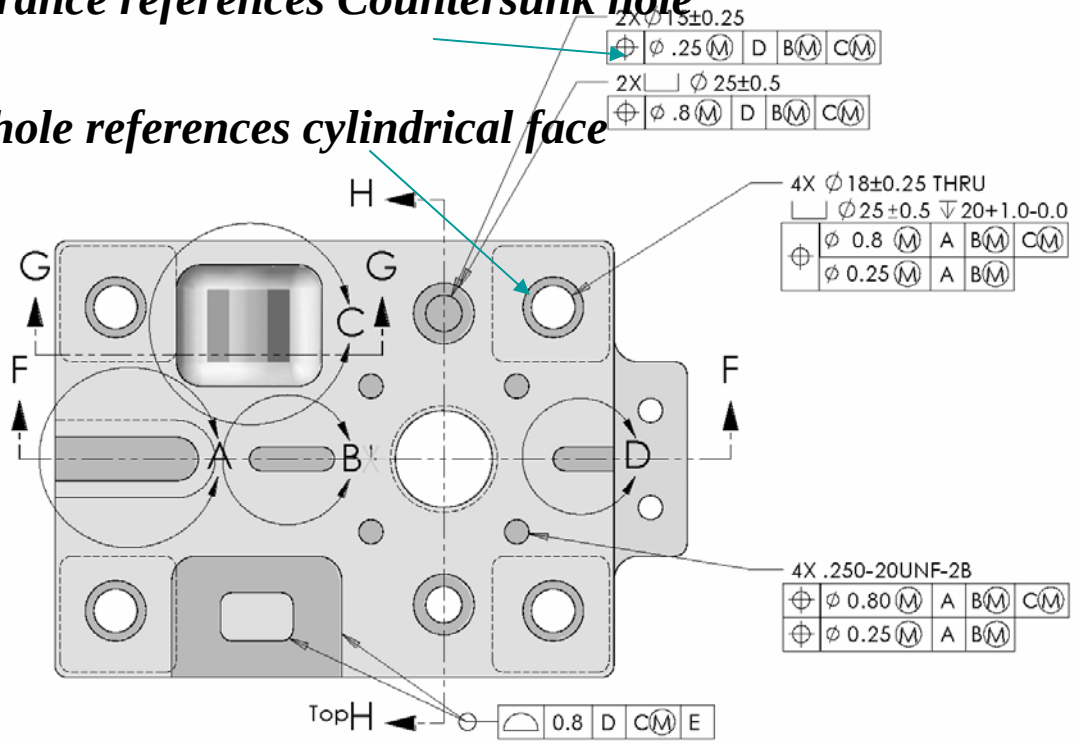
- Example: Slot
  - Parameters defines Slot
    - Slot depth
    - Slot width
    - Slot height
    - Corner radius

Feature relationships

Geometric Tolerance → Feature → Geometric Shape

Position tolerance references Countersunk hole

Countersunk hole references cylindrical face

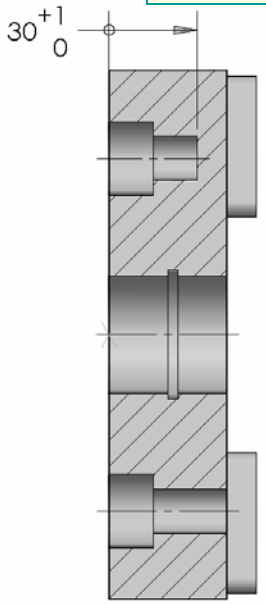


Explicit feature related

Feature relationships

Dimensional Tolerance → Plus minus tolerance

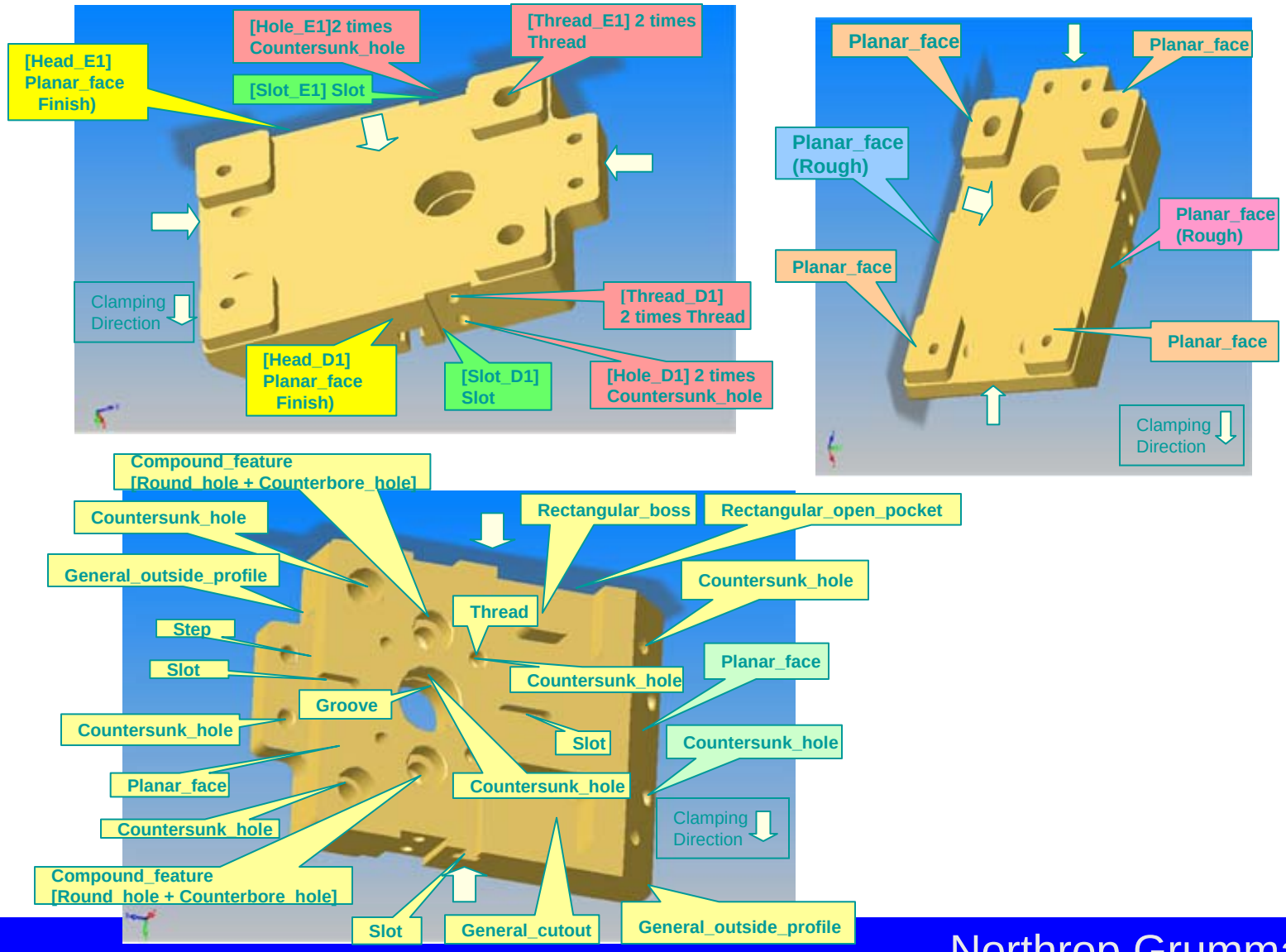
Feature → Feature Attribute For hole depth



SECTION H-H

Implicit feature related

Manufacturing Feature Example



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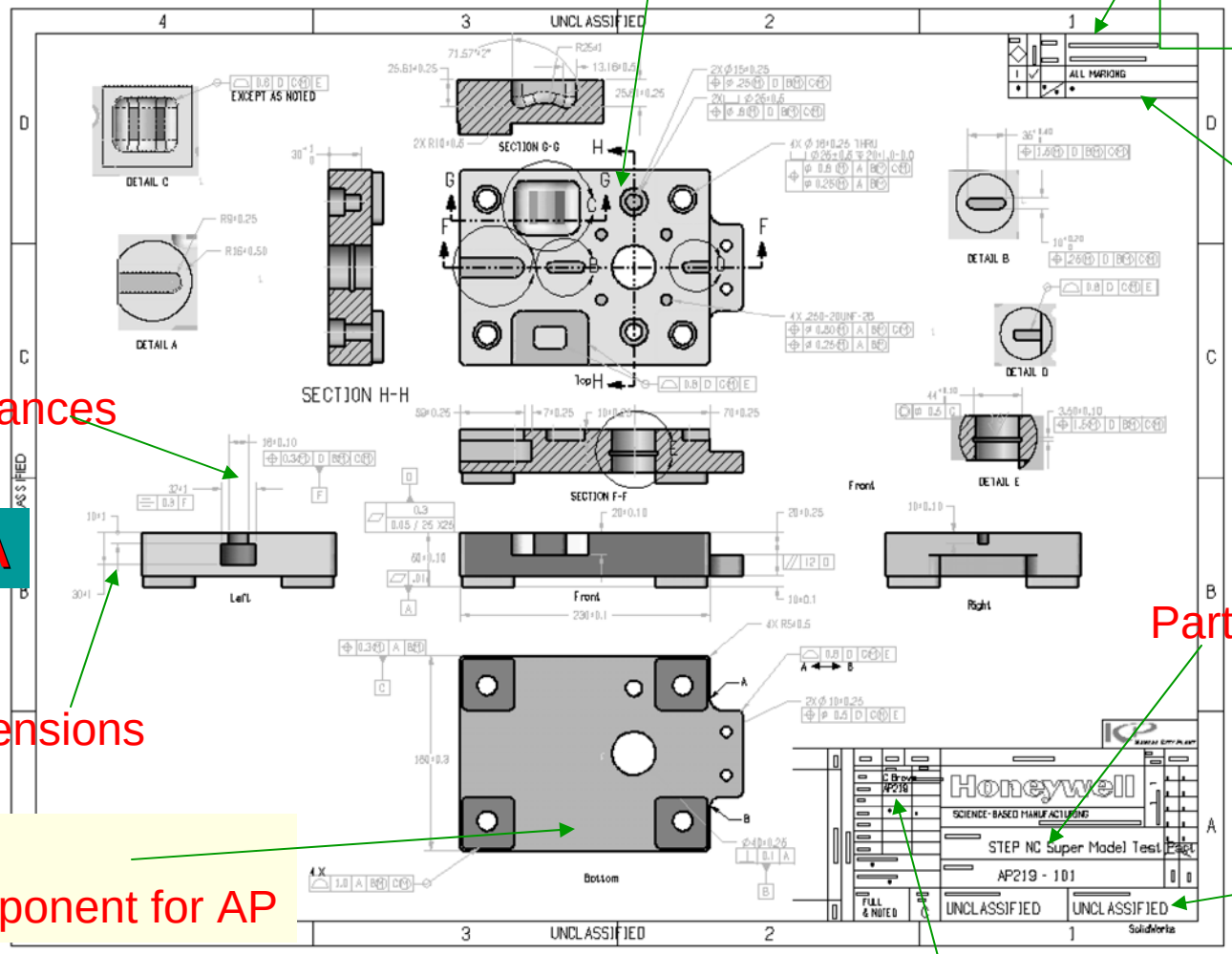
AP224

Drawing notes
- Material property
- Surface finish
- Process property
- Hardness

Geometry with Topology



Materials

Tolerances

CORE DATA

Dimensions

Features
- Major component for AP

Part information

Security

Approvals

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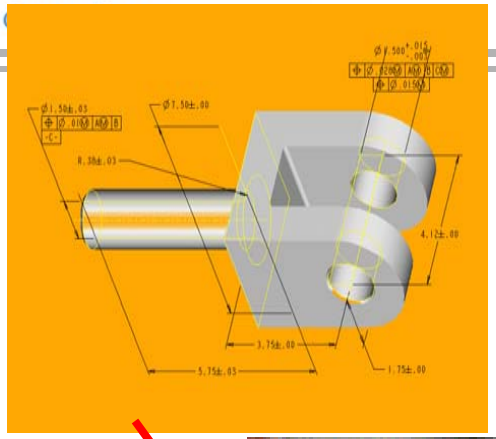
AP240-Process plans for machined parts



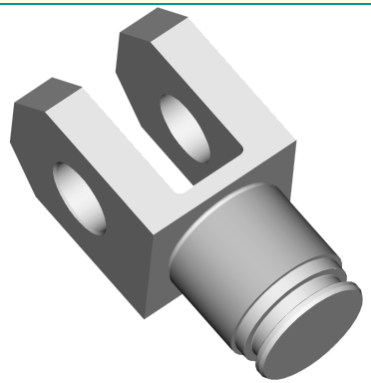
work instructions for the tasks required to manufacture a part, which include:

- references to the resources required to perform the work
- the sequences of the work instructions
- relationships of the work to the part geometry

CORE DATA

information contained in the process plans for machined parts which includes:

- numerical controlled machines
- manual operations



technical data for and/or out of the process planning for machined pats which includes:

- machining features for defining shapes necessary for manufacturing
- machining feature classification structure
- geometric and dimensional tolerances of the parts being manufactured
- materials, and properties of the parts being manufactured

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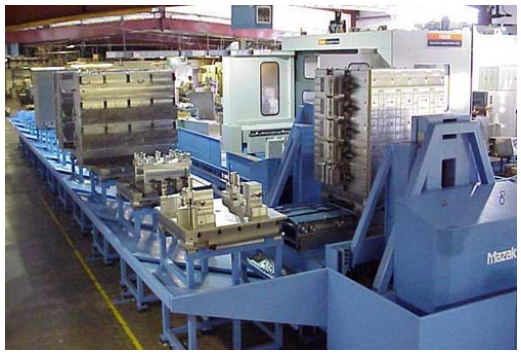
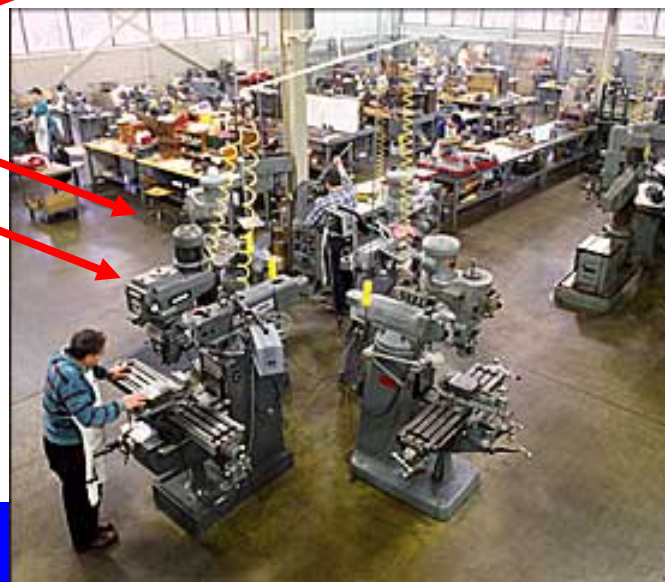
Process plan defines resources



- Defines:
  - **Machines**
  - **Tools**
  - **Fixtures**
  - **Workstation**
  - **Work cell**
  - **Controller**



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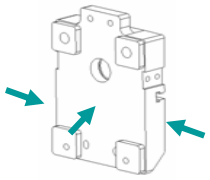
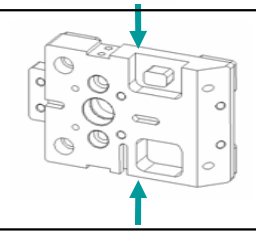
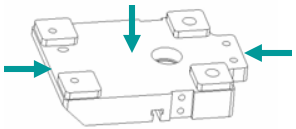
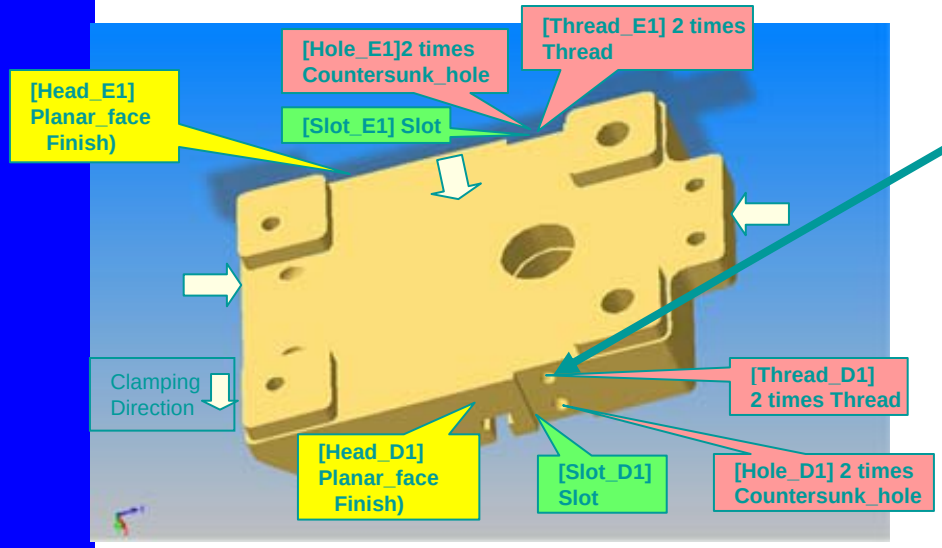
Develop Manufacturing Process (Macro Process Planning)

- **Manufacturing process defines:**
  - **sequential manufacturing operations**
  - **machine,**
  - **type of setup,**
  - **Machining processes**
    - **Assign process to features**

No	Machine	Setup activity	Machining process (Strategy for Feature Assignment)
1	Horizontal Machining Center		Planar_face of Plane-B, Planar_face of Plane-D(Roughing) a nd Planar_face of Plane-E(Roughing)
2	Horizontal Machining Center		All Features of Plane-A and Plane-C
3	Horizontal Machining Center		All Features of Plane-D and Plane-E

AP240 Machining operations

- **Machining operations defines:**
  - **Sequence of features for Manufacturing activity**



Process	Machining Feature		
	Id	No	Type
3	Head_D1	1	Planar_face (Finish)
	Slot_D1	1	Slot
	Hole_D101	2	Compound_feature
	Hole_D1	2	Countersunk_hole
	Thread_D1	2	Thread
	Head_E1	1	Planar_face (Finish)
	Slot_E1	1	Slot
	Hole_E101	2	Compound_feature
	Hole_E1	2	Countersunk_hole
	Thread_E1	2	Thread

AP240 Manufacturing activity

- Manufacturing activity are defined to process the feature
- Operations are defined for the manufacturing activity

Process	Machining Feature		
	Id	No	Type
3	Head_D1	1	Planar_face (Finish)
	Slot_D1	1	Slot
	Hole_D101	2	Compound_feature
	Hole_D1	2	Countersunk_hole
	Thread_D1	2	Thread
	Head_E1	1	Planar_face (Finish)
	Slot_E1	1	Slot
	Hole_E101	2	Compound_feature
	Hole_E1	2	Countersunk_hole
	Thread_E1	2	Thread

	Manufacturing activity	Operation Data		
		Id	Activity type	Tool type
1	Head_D1 Finish	PF_01	Plane_finish_milling	Facemill
1	Slot_D1 Rough	BSR_01	Bottom_and_side_rough_milling	Endmill
2	Slot_D1 Finish	BSF_01	Bottom_and_side_finish_milling	Endmill
1	Hole_D101 Drilling	DR_01	Drilling	Twist_drill
2	Hole_D101 Chamfering	CS_01	Counter_sinking	Countersink
3	Hole_D101 Tapping	TA_01	Tapping	Tap
1	Head_E1 Finish	PF_01	Plane_finish_milling	Facemill
1	Slot_E1 Rough	BSR_01	Bottom_and_side_rough_milling	Endmill
2	Slot_E1 Finish	BSF_01	Bottom_and_side_finish_milling	Endmill
1	Hole_E101 Drilling	DR_01	Drilling	Twist_drill
2	Hole_E101 Chamfering	CS_01	Counter_sinking	Countersink
3	Hole_E101 Tapping	TA_01	Tapping	Tap

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AP238 *Application interpreted model for computerized numerical controllers*

Manufacturing Features
- ***Slot***
- ***Hole***
- ***Planar face***
- ***Thread***
- ***Outer Round***
- ***Chamfer***

Executable
- ***Working step***
- ***Working plan***
- ***Setup***
- ***Cutting tool***
- ***If and While statement***
- ***Program structure***

Operation
- **Machine functions**
- **Machining operation**
- **Tool direction**
- **Tool path list**

Process data for milling
- **Boring**
- **Drilling**
- **Reaming**
- **Tapping**

Cutting tools
- **Drill**
- **Tap**
- **Reamer**
- **Boring tool**

CORE DATA

Workpiece
- **Workpiece**
- **Material**
- **Parameters**
  1. **Property**
  2. **Numeric**
  3. **Descriptive**

Measure
- **Limits and fits**
- **Plus minus value**
- **Tolerance length measure**

Tool path
- **Tool path**
- **Feed stop**
- **Parameterized path**
- **Cutter contact and location trajectory**

Project
- **Project**
- **Person and address**

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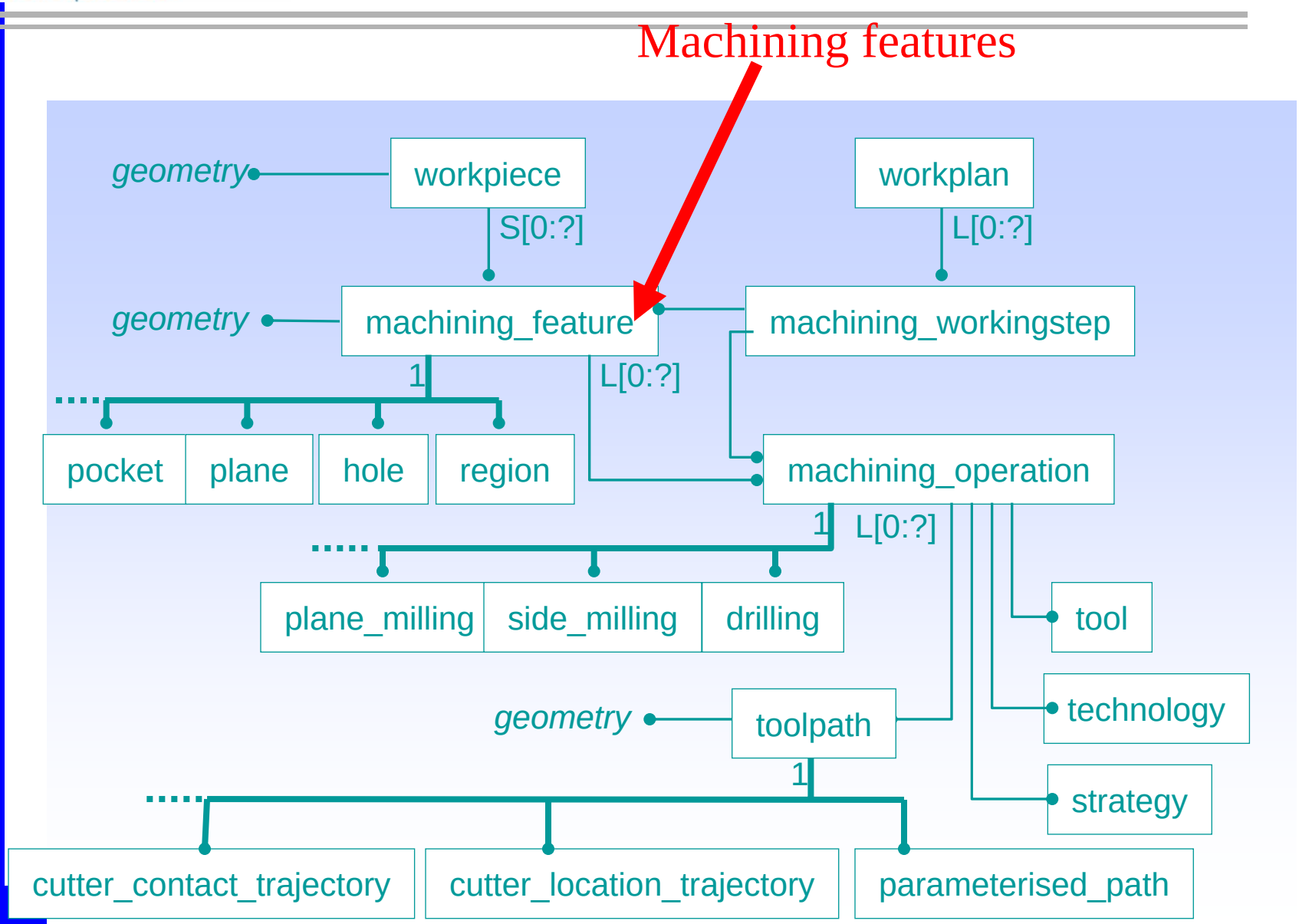
AP238 – Machining operation



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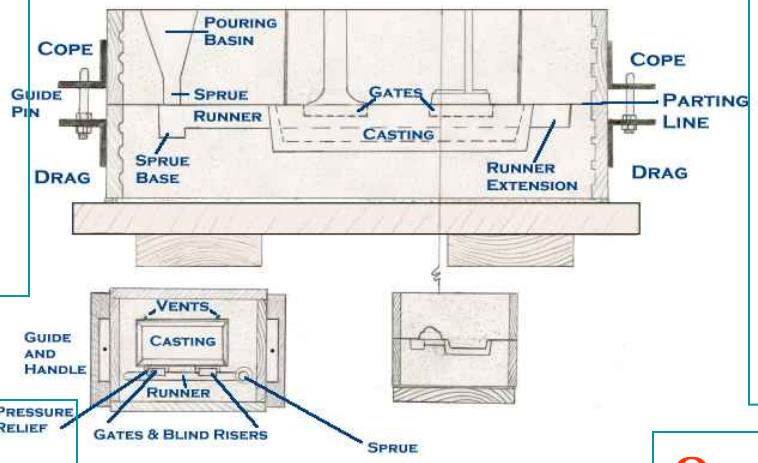
AP223 - Exchange of Design and Manufacturing Product Information for Cast Parts

CORE DATA

Data Supported

- Shapes of cast parts
- Materials of cast parts
- Tolerances and surface finish
- Physical and mechanical properties
- Harmonized with **AP224 features**, tolerances, properties

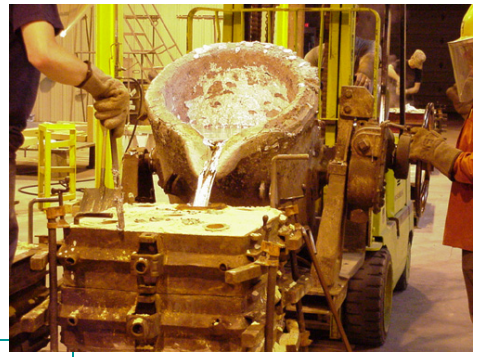


Process Plan

- Process_plan harmonized with AP240
- Melting, pouring, cooling, shakeout, extracting, and gate removal of a casting
- Process used to produce a casting
- Metal alloys used to produce a casting.
- Equipment used to produce a casting.

Mold Design

- Shapes of sand mold, die assembly, and investment pattern assembly
- Materials used in the casting processes
- Building a sand mold, a die assembly, and an investment pattern assembly



Quality Control Records

- Processes of building a sand mold, of building a die assembly, and of building an investment pattern assembly.
- Processes of melting, pouring, cooling, shaking out, extracting, and knocking out a casting
- Melting processing and resulting metal composition
- Inspection and testing results of the cast part.

Casting process simulation

- Shape representation
- Process design parameters
- Simulation results

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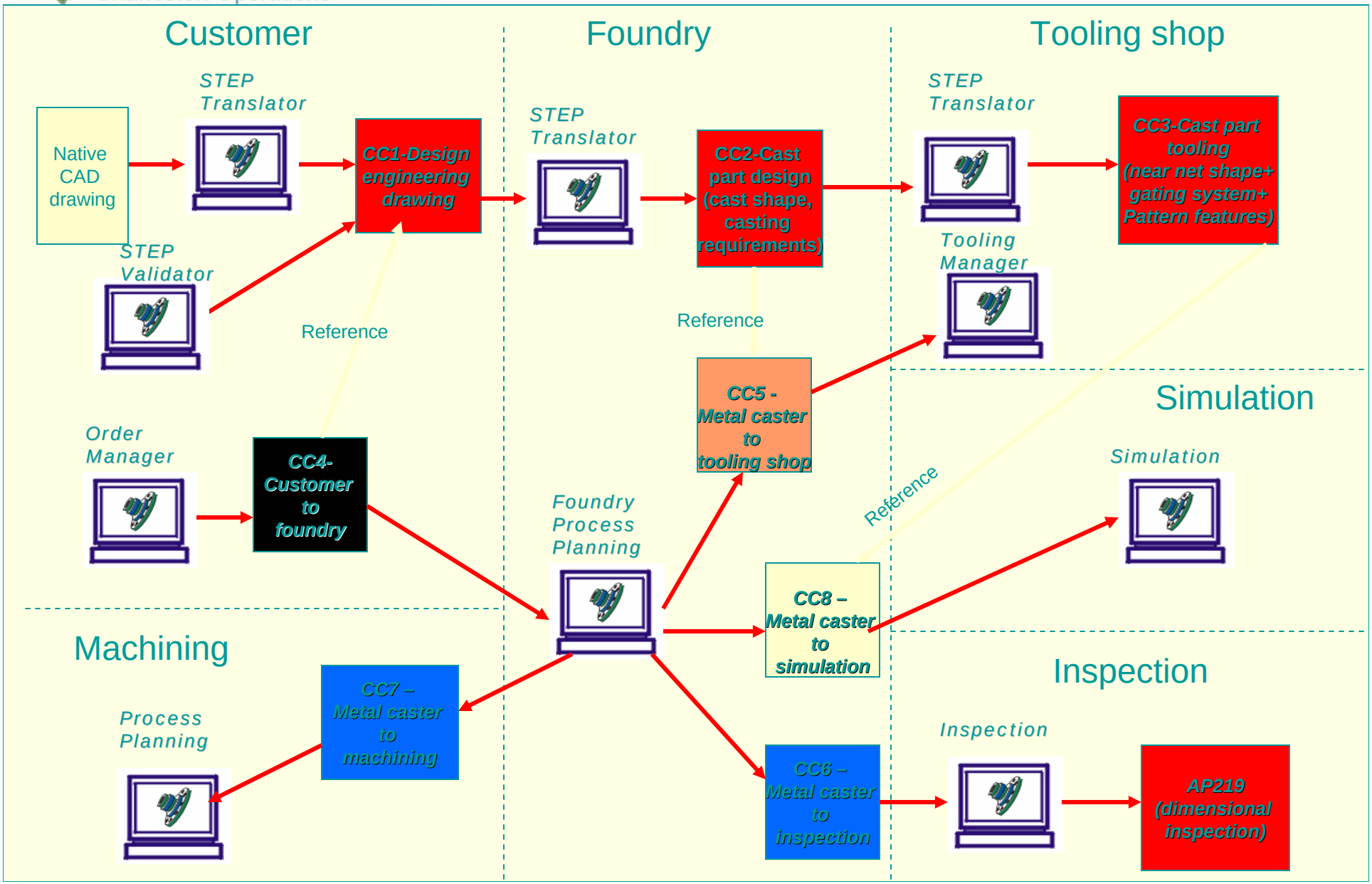
AP223- Cast parts Architecture



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AP219 - Dimensional Inspection Information Exchange

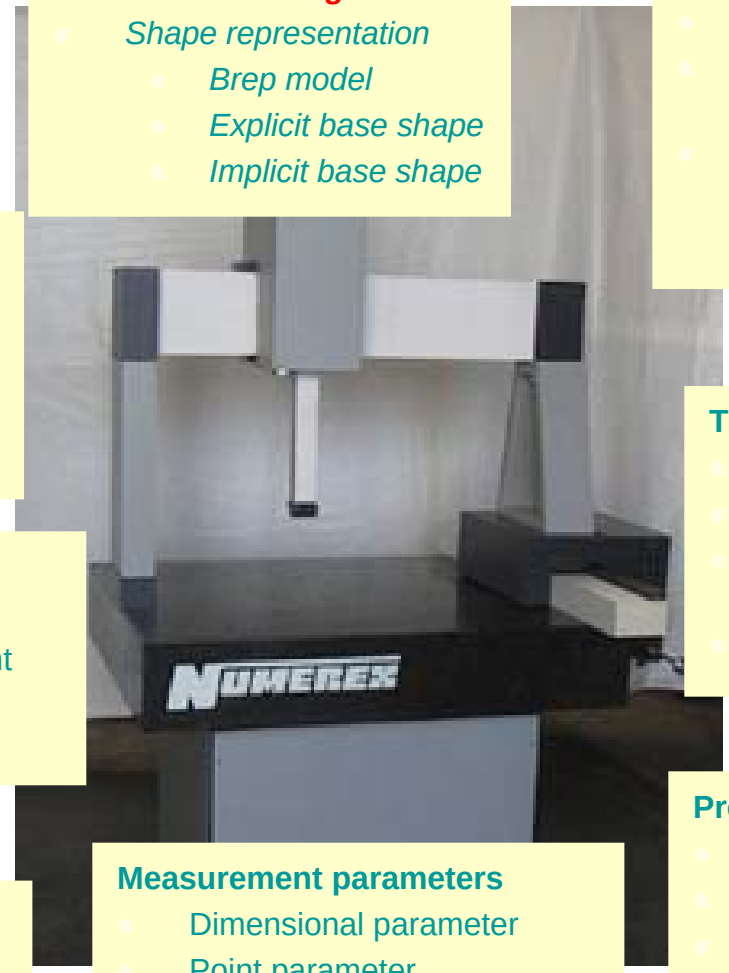
CORE DATA

Part
- *Part*
- ***Manufacturing features***
- *Shape representation*
  - *Brep model*
  - *Explicit base shape*
  - *Implicit base shape*

Analysis
- *Feature analysis mode*
- *Feature tolerance mode*
- *Parameter analysis mode*

Part Properties
- Calculated value
- Parametric calculated value
- Parameters
  1. Property
  2. Numeric
  3. Descriptive

Dimensional Measurement features
- Circle, arc, sphere
- Geometric surface
- Lines, planes
- Pattern



Tolerances
- Geometric tolerances
- Dimension tolerances
- Material condition modifier
- Tolerance range

Measurement execution
- Execution result
- Execution result measurement
- Data acquisition software
- Result parameter

Program run
- Program identification
- Run administrator
- Measurement location
- Program Run

Measurement parameters
- Dimensional parameter
- Point parameter
- Vector parameter
- Parameter value limits

Administration data
- Person and Organization
- Date and time
- Time offset

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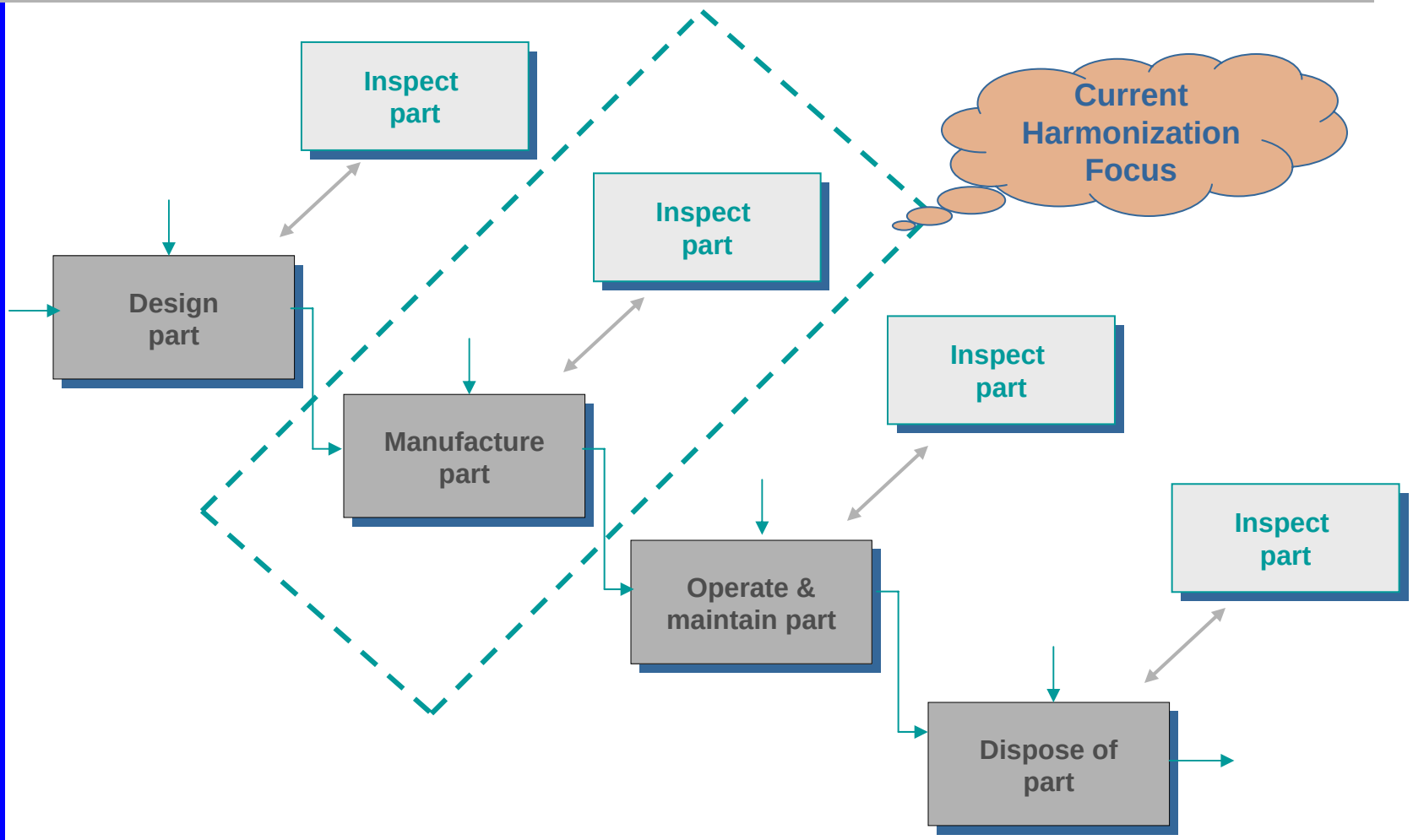
Part life cycle: *Example activity model*



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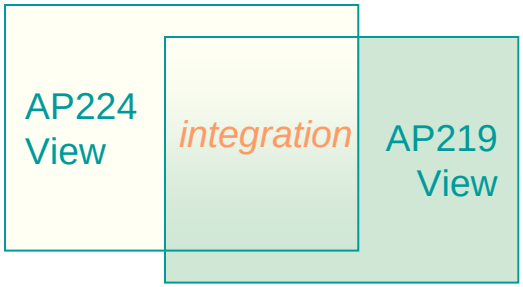
Harmonization: *Mapping and integration*

- **Harmonization through *mapping* between requirements specifications**

- **Harmonization through *integration* of requirements specifications**



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AP219 Harmonization activities

- Dimensional inspection
  - DMIS (Dimensional Measuring Inspection Standard)
  - ISO 22093 (DMIS equivalent)
  - Metrology Interoperability Project

    (Reporting Work Group of the Automobile Industry Action Group)

mapping

- STEP
  - AP224 (Process Planning using Machining Features)
  - AIC 522 (Machining Features)
  - AIC 519 (Geometric Tolerances)

integration

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AP219 feature sets

DMIS Feature actual

- Dimensional_inspection_features
  - Dmf_arc
  - Dmf_circle
  - Dmf_cone
  - Dmf_cylinder
  - Dmf_edge_point
  - Dmf_ellipse
  - Dmf_generic_feature
  - Dmf_geometric_curve
  - Dmf_geometric_surface
  - Dmf_line_bounded
  - Dmf_line_closed_parallel
  - Dmf_line_unbounded
  - Dmf_pattern
  - Dmf_plane
  - Dmf_plane_closed_parallel
  - Dmf_plane_symmetric
  - Dmf_point
  - Dmf_sphere
  - Dmf_surface_of_revolution_dml
  - Dmf_torus

DMIS Feature nominal

- **Machining_features**
  - **different categories of features**
  - **Many features have sub-categories**
    - **Boss**
    - **Pocket**
    - **Hole**
    - **Slot**
    - **Protrusion**
    - **Rounded_end**
    - **Outer_round**
    - **Step**
    - **Planar_face**
    - **Revolved_feature**
    - **Spherical_cap**
    - **General_outside_profile**
    - **Thread**
    - **Marking**
    - **Knurl**
    - **General_volume_removal**
- **Transition_features**
  - **different types of transitions**
    - **Chamfer**
    - **Fillet**
    - **Edge_round**
- **Replicate_feature**
  - **3 different ways to replicate features**
    - **Circular_pattern**
    - **Rectangular_pattern**
    - **General_pattern**
- **Compound_feature**
  - **Union of one of more features to create a more complex feature definition.**

AP219 tolerances

- Dimensional tolerances
  - Size tolerance
    - radial
    - diameter
    - curve dimension
    - angular size
  - Location tolerance
    - distance along curve
    - angular
    - Location
- Tolerance value
  - Plus minus value
  - tolerance limit
  - tolerance range
  - limits and fits

- Geometric tolerances
  - Angularity
  - Circularity
  - Circular runout
  - Concentricity
  - Cylindricity
  - Flatness
  - Linear profile
  - Parallelism
  - Perpendicularity
  - Position
  - Straightness
  - Surface profile
  - Symmetry
  - Total runout
- Geometric tolerance precedence
- Datum
- Compound datum
- Material condition modifier
- Tolerance zone
- Datum target

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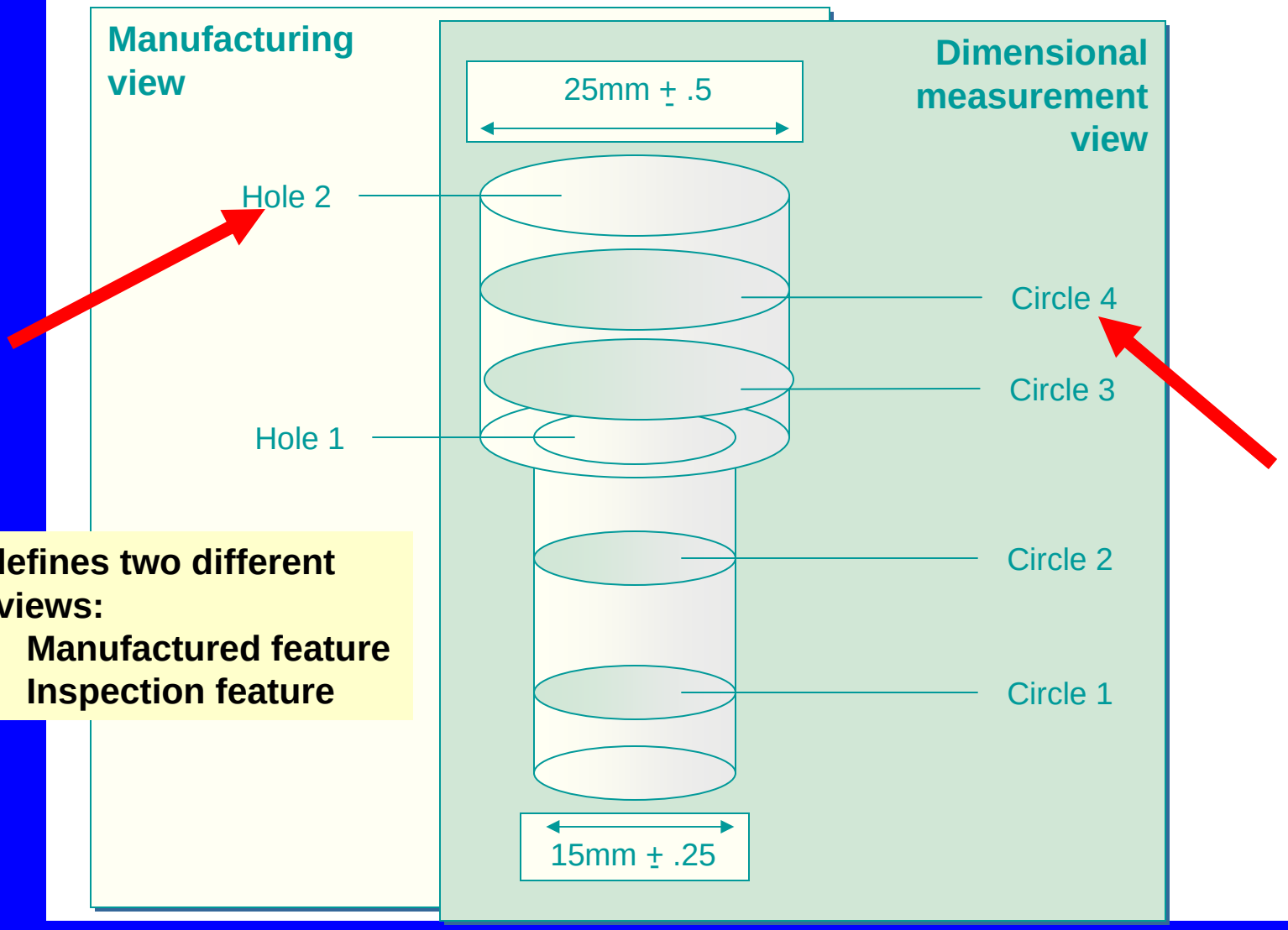
AP219 - Dimensional Inspection



AP219 defines two different feature views:

Manufactured feature
Inspection feature

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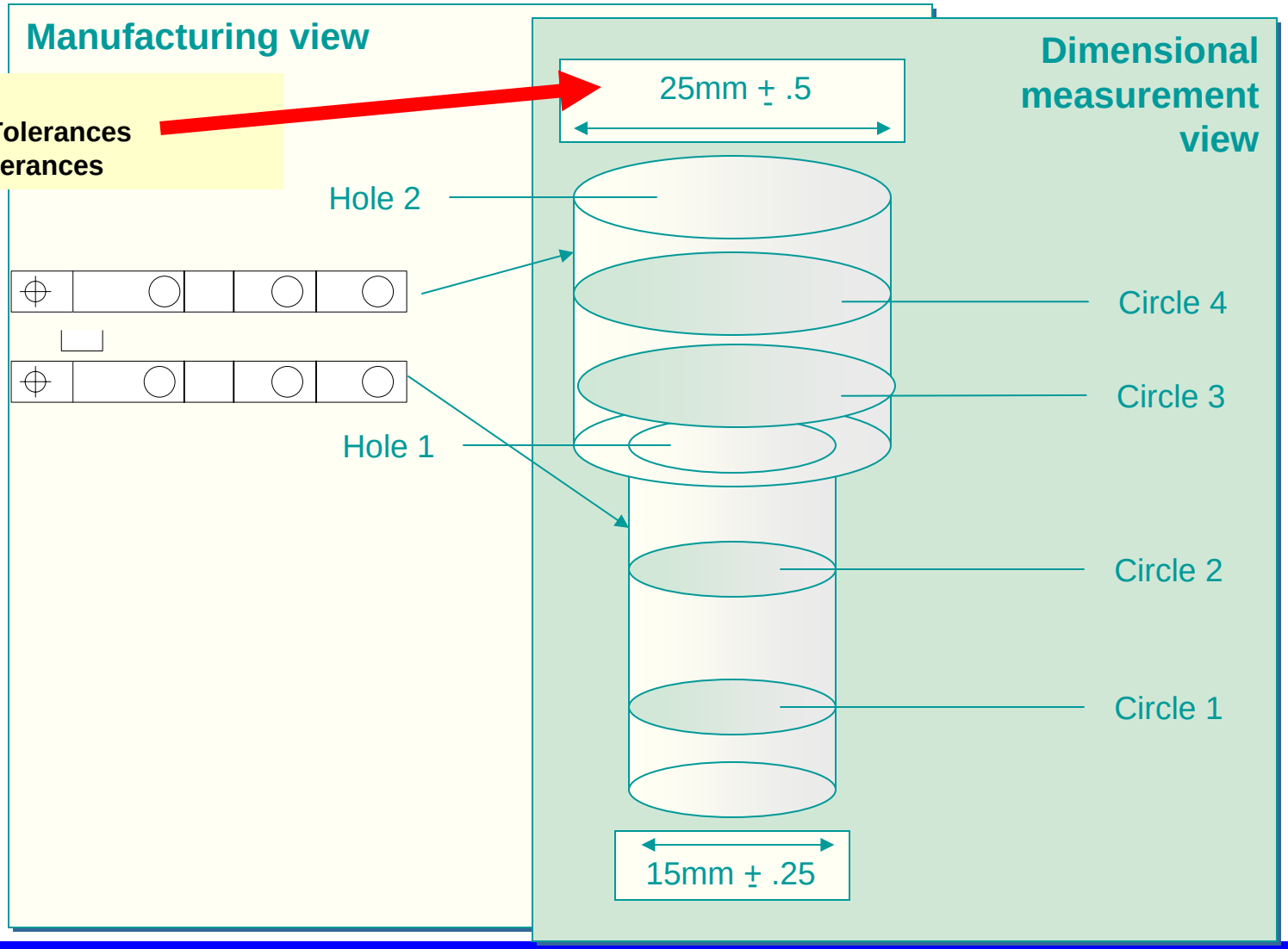
AP219 - Dimensional Inspection with tolerances

- **AP219 defines**
  - **Dimensional Tolerances**
  - **Geometric Tolerances**



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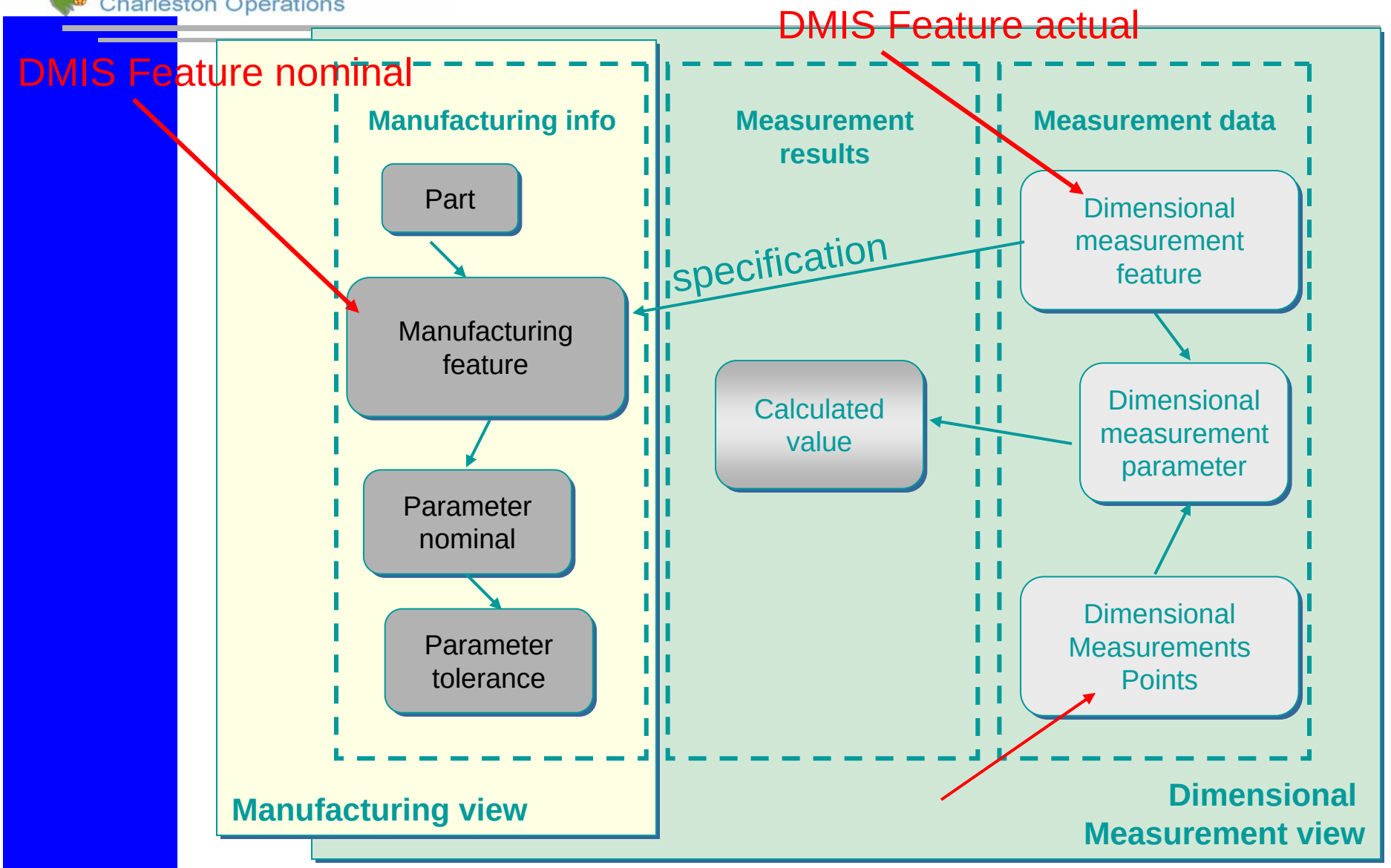
Manufacturing and dimensional measurement views



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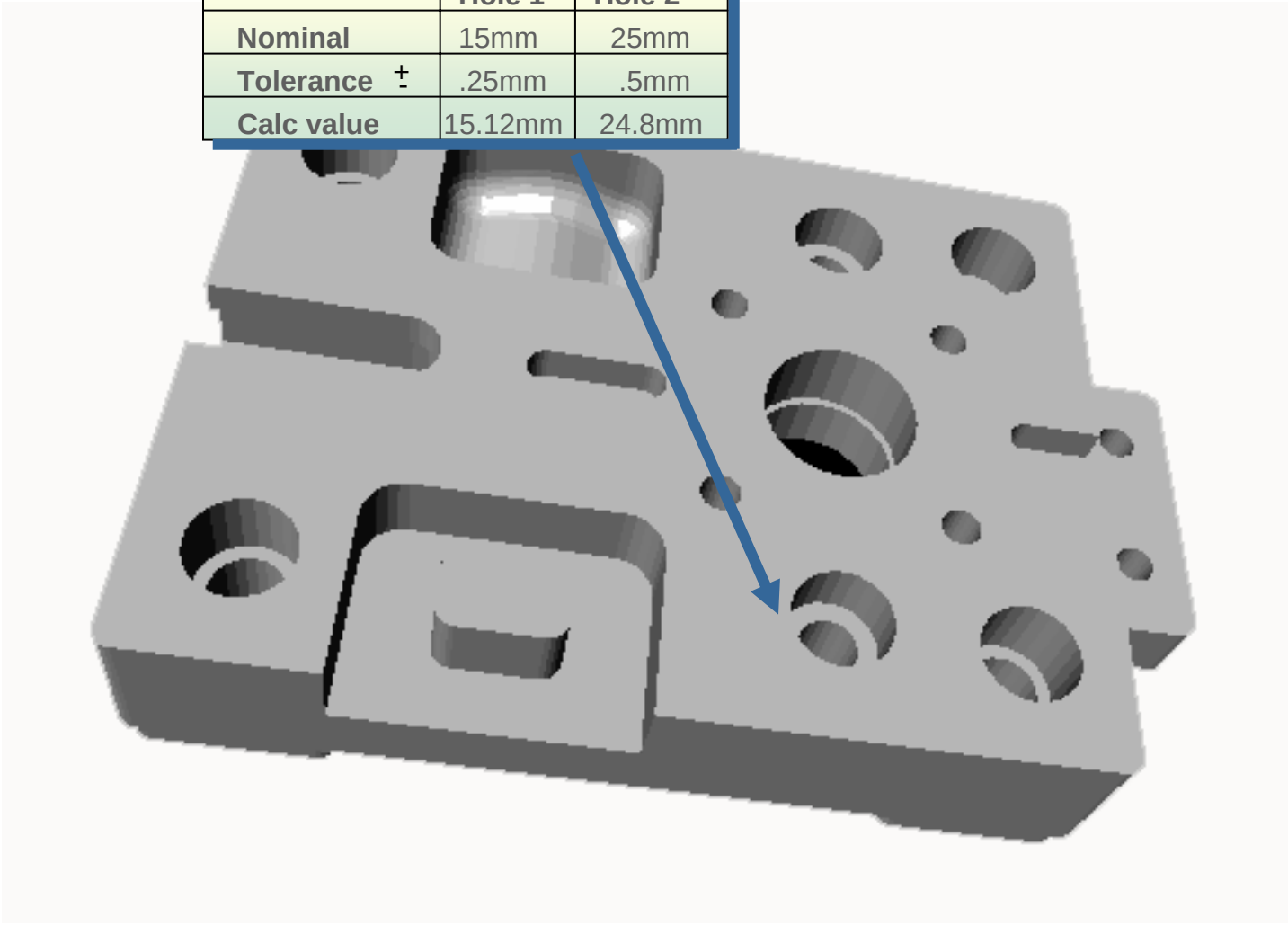
Example part: *Nominals, tolerances, and calc values*

Counterbore_hole

	Hole 1	Hole 2
Nominal	15mm	25mm
Tolerance ±	.25mm	.5mm
Calc value	15.12mm	24.8mm



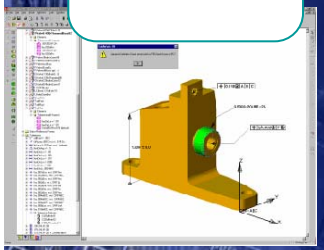
Dimensional Metrology System:

Component diagram with candidate open & non-proprietary interface standards

using STEP Manufacturing Suite Architecture

Design **Planning** **Execution** **Analysis**

CAD + GD&T



Part geometry and design tolerances

STEP AP224 DML

Inspection process planning

Inspection process plans

STEP AP240, AP223, AP229 DMIS

Inspection execution

Measurement results

DML, STEP AP219

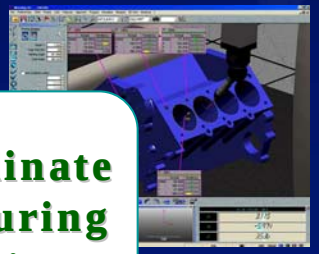
Reporting & analysis

Quality measurement information

AIAG Quality Data STEP AP223, AP229

CMM control commands and responses

STEP AP238 I++ DME



Coordinate measuring machines (CMMs)

Quality device integration

manufacturing interoperability

innovation & productivity