

A Framework for Data Standard Readiness

Brandon Sapp - Boeing

GLOBAL PRODUCT DATA
INTEROPERABILITY
S U M M I T
2019



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3 years @ PLM Consultant

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PDES Cax-IF User Group Co-Leader

ASME MBE

Presentation Overview

Problem Statement for Implementing Data Standards
Solution – Industry Framework for Assessing Readiness
Implementation for AP242

Problem Statement

Many organizations fail to realize the full and complete benefits of using industry data standards because they have not or inappropriately implemented them.

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Cause 1: Knowledge of data standard's intended use

Cause 2: Poorly implemented in business processes

Cause 3: Inadequate tools to create/consume the data in a standard

Cause 4: Supply chain ability to consume

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Cause 2: Inadequate tools to create/consume the data in a standard

Cause 3: Supply chain ability to consume

Effect: Wasted Resources [Rework, Common tools, etc.]

ISO TC 184/SC5

ISO/DIS 22549-1 : Assessment on convergence of informatization and industrialization for industrial enterprises - **Part 1: Framework and reference model**

ISO/CD 22549-2 : Assessment on convergence of informatization and industrialization for industrial enterprises - **Part 2: Maturity model and evaluation methodology**

These standards serve as a framework and normalization guide for enterprises to promote the ***convergence of information technology into the processes of production and operations management.***

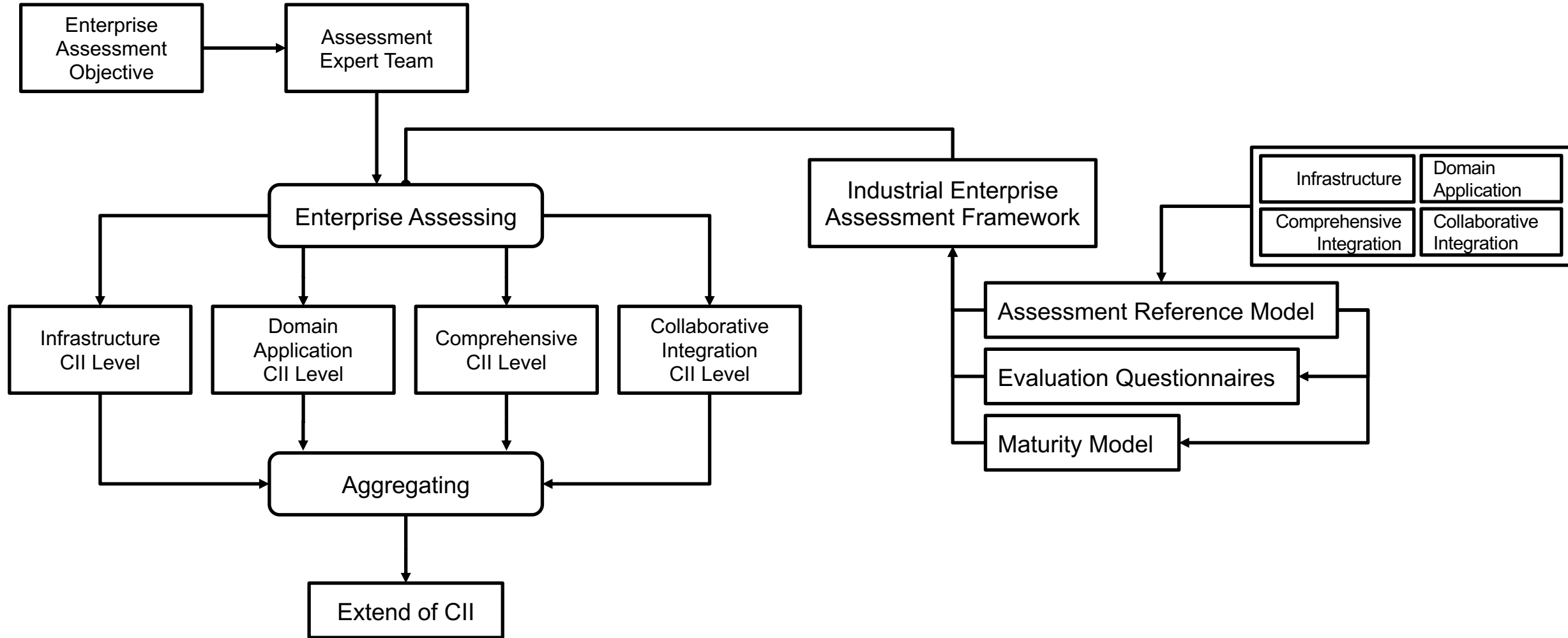
Provides industrial enterprises guidance for:

- assessing the current situation of CII

- finding weakness within the CII

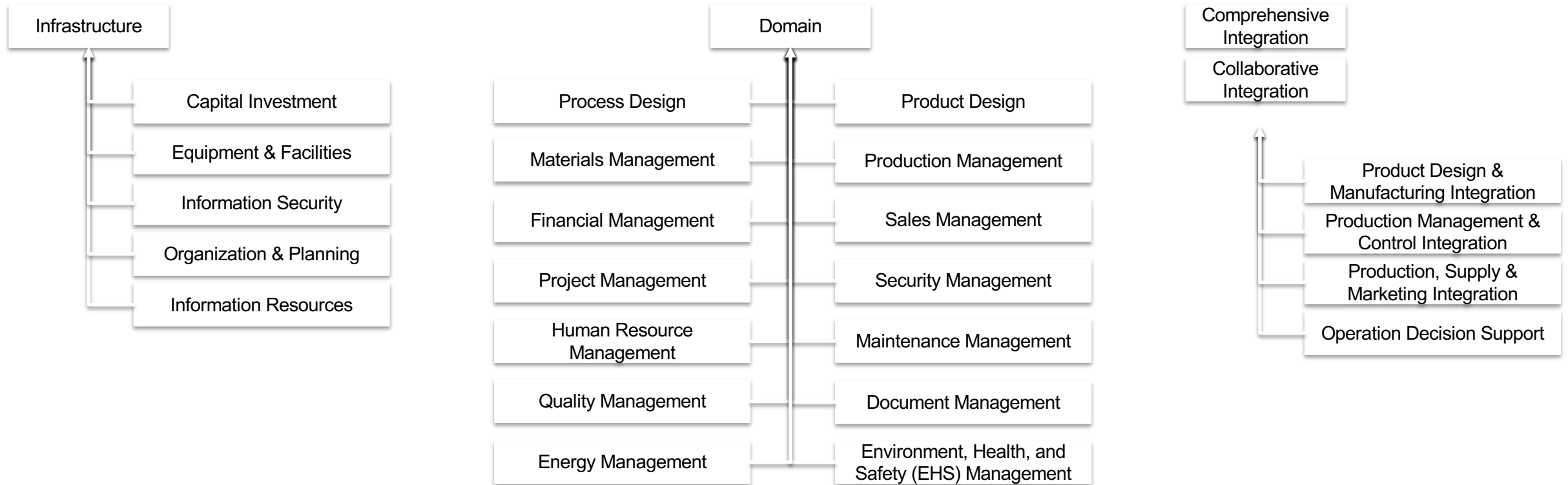
- identifying ways to improve CII

Overview of Assessment System



Breakdown of the Assessment Reference Model

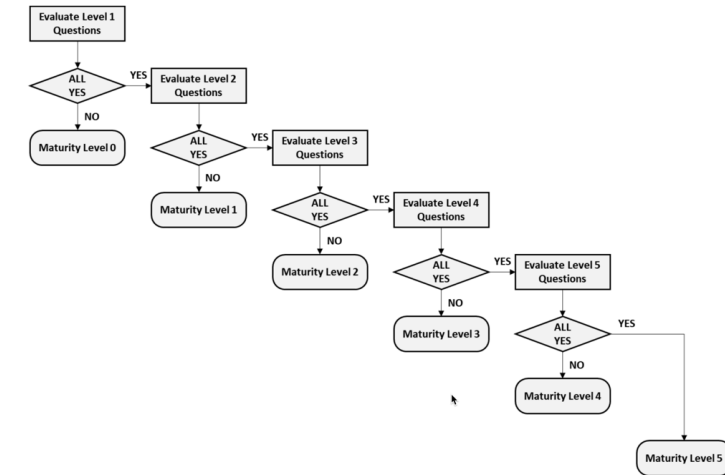
Example Breakdown



Maturity Model Definitions

Definition of Level and Method for Assessment

| Maturity level indicator | Descriptive name | Characteristics |
|--------------------------|------------------|---|
| Level 0 | Unidentified | <ul style="list-style-type: none">– Little or no systematic documentation available |
| Level 1 | Identified | <ul style="list-style-type: none">– Tracking and traceability of materials, data and etc.– Registration and management of data using information collection devices and systems |
| Level 2 | Measured | <ul style="list-style-type: none">– Real time data acquisition of materials, machinery, process and human roles, and data integration– Measurement, aggregation, classification and management of data using information collection devices and systems– Synchronous history of data for the same time, same lot and same product |
| Level 3 | Analysed | <ul style="list-style-type: none">– Data analysis and optimized decision making using aggregated data |
| Level 4 | Optimized | <ul style="list-style-type: none">– Automation of processes according to optimized decision making throughout the intra-enterprise and/or the inter-enterprises |
| Level 5 | Customized | <ul style="list-style-type: none">– Self-diagnosis and self-healing through cyber-physical system (CPS), Internet of Things (IoT), artificial intelligence (AI), etc.– Flexible production of customized products through autonomous control |

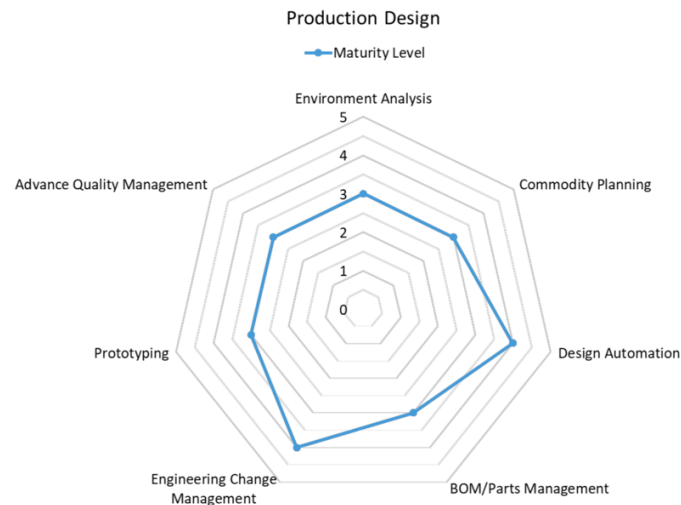


| Activity | Question | Maturity level indicator |
|---------------|---------------------------------|--------------------------|
| Activity name | Questions for maturity level 1. | 1 |
| | Questions for maturity level 2. | 2 |
| | Questions for maturity level 3. | 3 |
| | Questions for maturity level 4. | 4 |
| | Questions for maturity level 5. | 5 |

Breakdown of Activities and Sample Questions

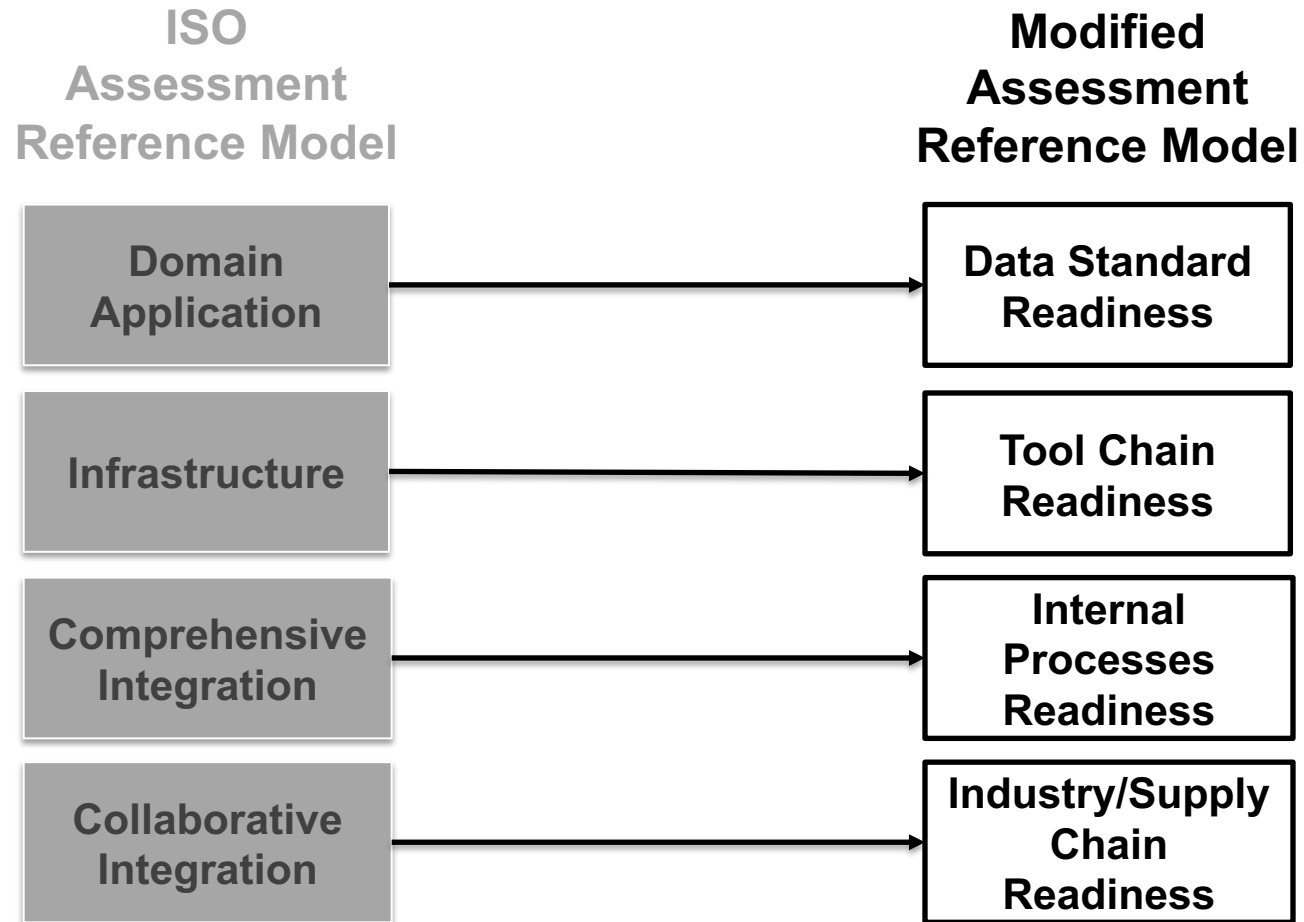
| Activity | Description |
|-------------------------------|---|
| Environment Analysis | Use of IT systems and applications for environment analysis |
| Commodity Planning | Use of IT systems and applications supporting commodity planning |
| Design Automation | Use of designing software systems and smart connected technology for design |
| BOM/Parts Management | Use of BOM/Part management system |
| Engineering Change Management | Use of engineering change management systems |
| Prototyping | Use of IT systems and applications for prototyping and its validation |
| Advance Quality Management | Use of IT systems and applications for advance quality management |

| Activity | Description | Level |
|-------------------|--|-------|
| Design Automation | Do you design with 2D CAD? | 1 |
| | Do you design with 3D CAD? | 2 |
| | Do you analyze and validate with CAE? | 3 |
| | Do you design automatically with optimization solutions as one of the following? <ul style="list-style-type: none"> Model-Based Parametric Design Engineering-based Parametric design Integrated parametrical design | 4 |
| | Do you design a product by using smart connected technology such as IoT, AR/VR | 5 |

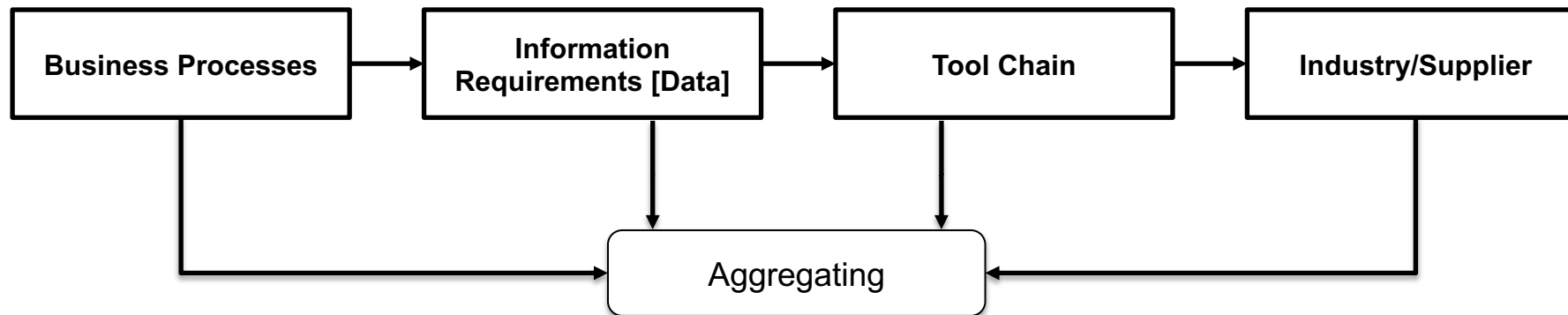
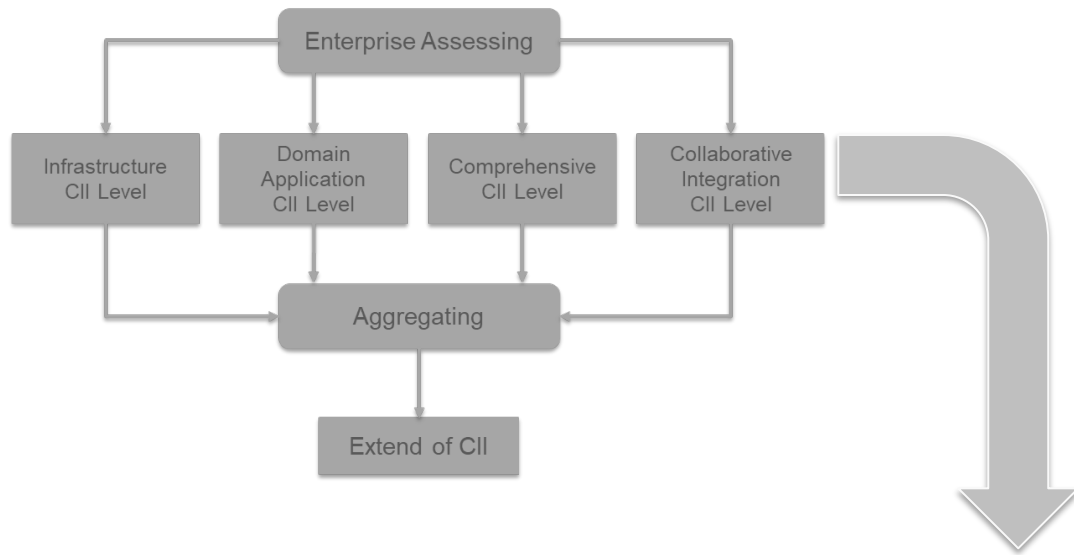


| Activity | Description | Level |
|----------------------|---|-------|
| BOM/Parts Management | Do you upload the engineering BOM [E-BOM] to the system | 1 |
| | Do you integrate the E-BOM with 3D CAD? Do you generate the E-BOM automatically | 2 |
| | Do you generate the manufacturing BOM [M-BOM] automatically in PLM? Do you manage the software configuration in PLM? | 3 |
| | Do you configure the BOM according to the purpose of use such as procurement, process cost, production, and customer service for warranty, etc? | 4 |
| | Do you improve business through preliminary simulation using the BOM data according to the purpose of use? | 5 |

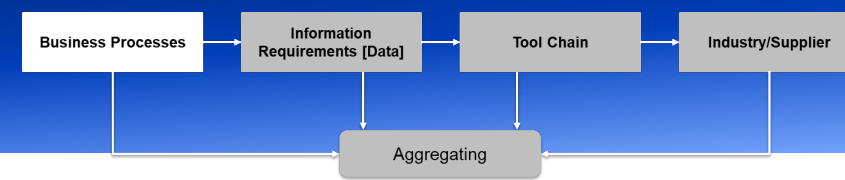
Modified Assessment Model



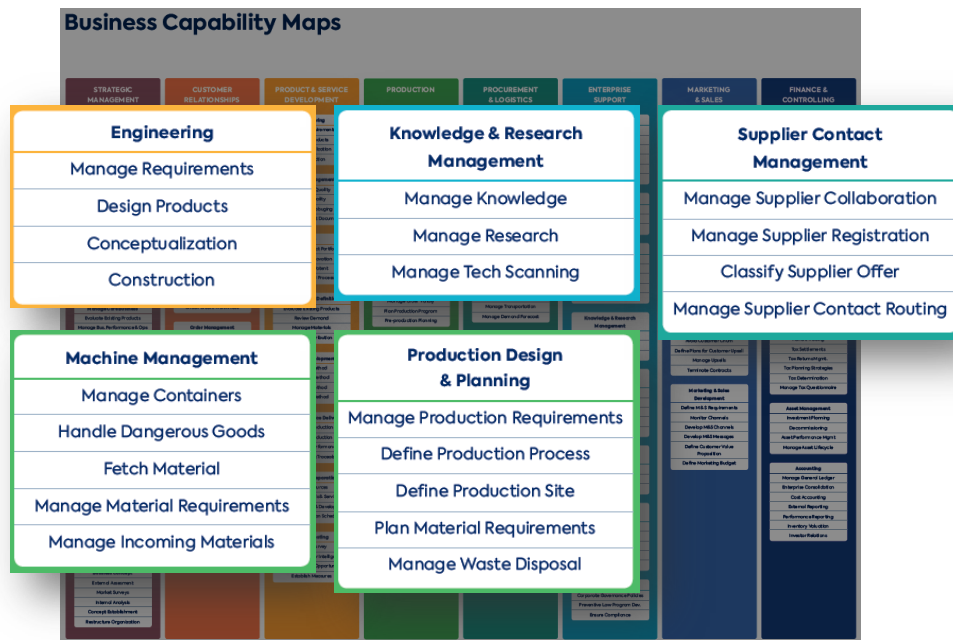
Modified Assessment System



Identify Business Processes

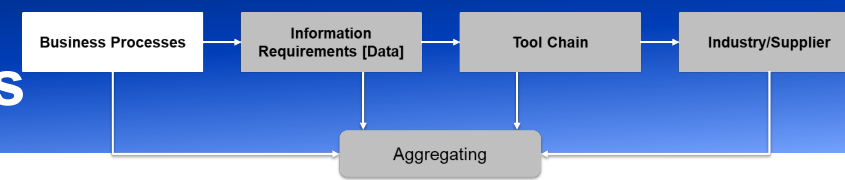


Start with Business Capabilities Breakdown to the Business Processes



| 2.0 Develop and Manage Products and Services (10003) | |
|--|--|
| 2.1 Govern and manage product/service development program (19696) | |
| 2.1.1 Manage product and service portfolio (100051) | 2.1.4.1 Manage materials master lists (11741) |
| 2.1.1.1 Evaluate performance of existing products/ services against market opportunities (10063) | 2.1.4.2 Manage bills of material (11742) |
| 2.1.1.2 Confirm alignment of product/service concepts with business strategy (10066) | 2.1.4.3 Manage routings (11743) |
| 2.1.1.3 Prioritize and select new product/service concepts (10074) | 2.1.4.4 Manage specifications (11744) |
| 2.1.1.4 Plan and develop cost and quality targets (10073) | 2.1.4.5 Manage drawings (11745) |
| 2.1.1.5 Specify development timing targets (10075) | 2.1.4.6 Manage product/material classification (11746) |
| 2.1.1.6 Plan for product/service offering modifications (10076) | 2.1.4.7 Develop and maintain quality/inspection documents (11747) |
| 2.1.2 Manage product and service life cycle (10057) | 2.1.4.8 Maintain process specification data (11748) |
| 2.1.2.1 Develop plan for new product/service development and introduction/launch (16824) | 2.1.4.9 Manage traceability data (11749) |
| 2.1.2.2 Introduce new products/services (10077) | 2.1.4.10 Review and approve data access requests (11750) |
| 2.1.2.3 Retire outdated products/services (10078) | |
| 2.1.2.4 Identify and refine performance indicators (10079) | 2.2 Generate and define new product/service ideas (19698) |
| 2.1.2.5 Conduct post launch review (11423) | 2.2.1 Perform discovery research (10065) |
| 2.1.2.5.1 Carry out post launch analytics to test the acceptability in the market (13845) | 2.2.1.1 Identify new technologies (10070) |
| 2.1.2.5.2 Review market performance (11424) | 2.2.1.2 Develop new technologies (10071) |
| 2.1.2.5.3 Review effectiveness of supply chain and distribution network (11425) | 2.2.1.3 Assess feasibility of integrating new leading technologies into product/service concepts (10072) |
| 2.1.2.5.4 Apply data and analytics to review supply chain methodologies (13847) | 2.2.2 Generate new product/service concepts (19699) |
| 2.1.2.5.5 Review quality and performance of the product/service (11426) | 2.2.2.1 Gather new product/service ideas and requirements (19996) |
| 2.1.2.5.6 Conduct financial review (11427) | 2.2.2.2 Analyze new product/service ideas and requirements (19997) |
| 2.1.2.5.7 Conduct new product development process assessment (11428) | 2.2.2.3 Evaluate new product/service inputs and requirements (19998) |
| 2.1.3 Manage patents, copyrights, and regulatory requirements (19698) | 2.2.2.4 Formulate new product/service concepts (19999) |
| 2.1.3.1 Conduct mandatory and elective reviews (19941) | 2.2.2.5 Identify potential improvements to existing products and services (10008) |
| 2.1.3.2 Review infringement of patents and copyrights (16826) | 2.2.3 Define product/service development requirements (19990) |
| 2.1.3.3 Determine patent and copyright needs (16827) | 2.2.3.1 Define product/service requirements (11331) |
| 2.1.3.4 Define product technical documentation management requirements (19697) | 2.2.3.1.1 Define basic functional requirements (19991) |
| 2.1.3.5 Manage regulatory requirements (12771) | 2.2.3.1.2 Derive interoperability requirements for products and services (16808) |
| 2.1.3.5.1 Train employees on appropriate regulatory requirements (12772) | 2.2.3.1.3 Derive safety requirements for products and services (16809) |
| 2.1.3.5.2 Maintain records for regulatory agencies (12773) | 2.2.3.1.4 Derive security requirements for products and services (16810) |
| 2.1.3.5.3 Manage regulatory submission life cycle (12776) | 2.2.3.1.5 Derive regulatory compliance requirements (16811) |
| 2.1.4 Manage product and service master data (11740) | 2.2.3.1.6 Derive requirements from industry standards (16812) |
| | 2.2.3.1.7 Develop user experience requirements (19992) |
| | 2.2.3.1.8 Derive 'services-as-a-product' offerings (16814) |
| | 2.2.3.2 Define post launch support model (16815) |
| | 2.2.3.3 Identify product/service bundling opportunities (17389) |

Identify Business Processes and related Deliverables



People : Training, Certification, Skills Management, etc.

EX: 2 Classes [1 needing updates]

Process : Business Instructions, Modeling Requirements, etc.

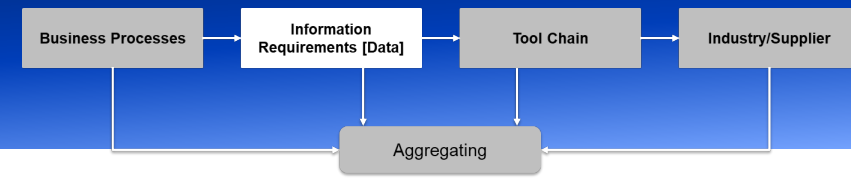
EX: 9 Internal Process Docs [4 needing updates]

Data : Modeling Requirements that define the structure of the information in the applications [STEP 2].

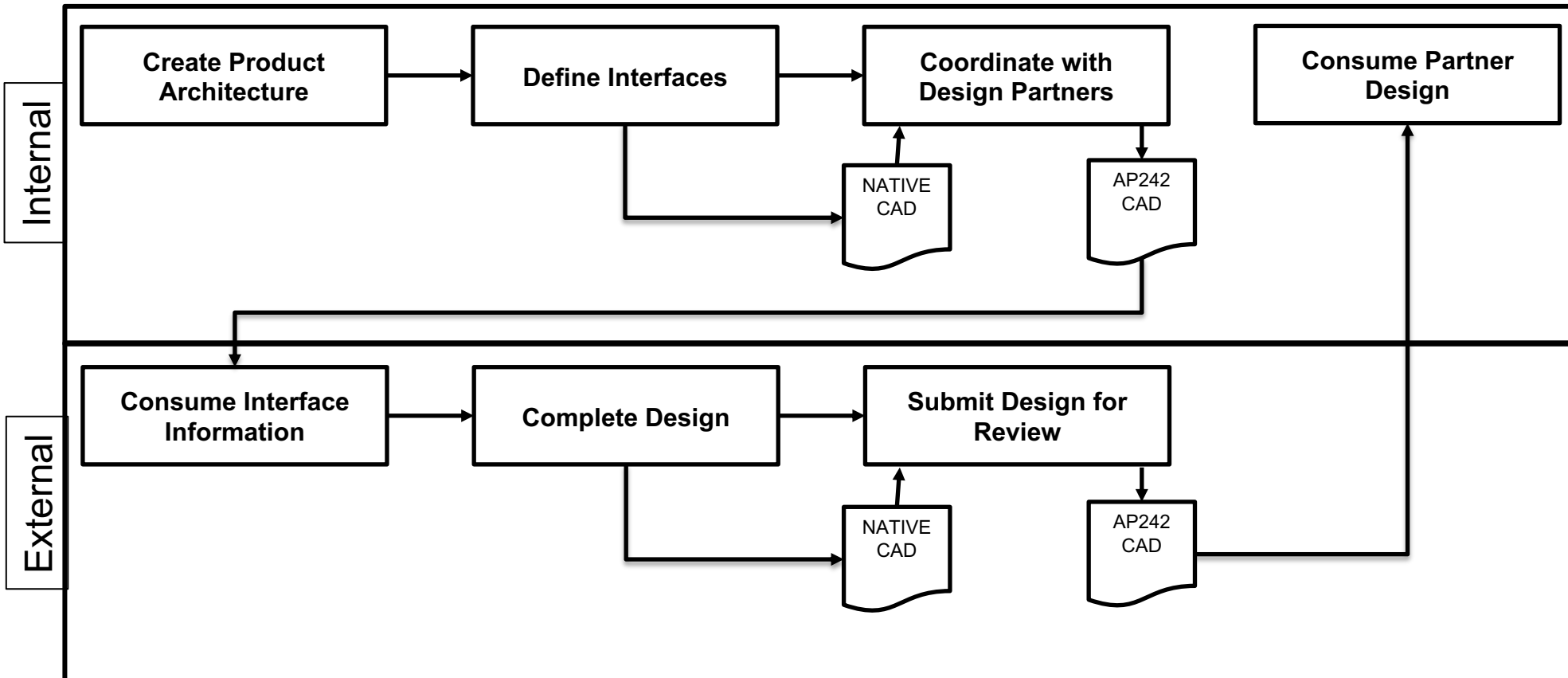
Tools : Software Applications used to create, manage or consume the information [STEP 3].

| Cross Industry Process Framework v721 | | | | |
|--|----|----|----|----|
| | Pe | Pr | Da | To |
| Total Requirements | | | | |
| Develop and Manage Products and Services | | | | |
| Generate and define new product/service ideas | | | | |
| Generate new product/service concepts | | | | |
| <i>Formulate new product/service concepts</i> | | | | |
| Develop products and services | | | | |
| Design and prototype products and services | | | | |
| <i>Conduct mandatory and elective external reviews</i> | | | | |
| Design products/services | | | | |
| <i>Design and manage product data, design, and bill of materials</i> | | | | |

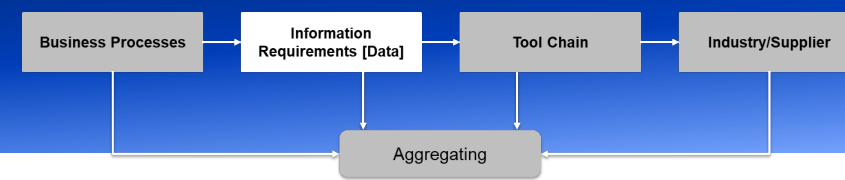
Identify Information Requirements



Identify the data used by the processes



Identify Information Requirements

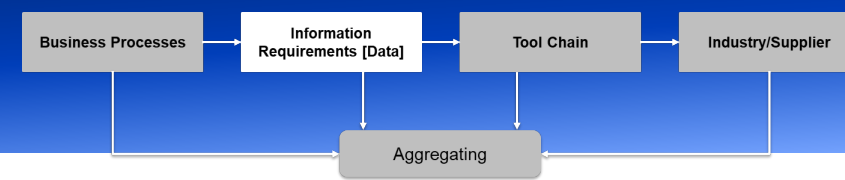


Aggregate all the Information Requirements from Business Processes
Use ASME/ISO Authoring Standards or A&D Minimum Digital Thread Position
Papers to provide additional perspectives.

| Information Requirement | Det | Mach | C/F | SM | Comp | MS | Elec | A&I |
|---|-----|------|-----|----|------|----|------|-----|
| Part Number & Revision | X | X | X | X | X | X | X | X |
| Engineering Definition | X | X | X | X | X | X | X | X |
| Construction Geometry | X | X | X | X | X | X | X | X |
| Information Requirement | Det | Mach | C/F | SM | Comp | MS | Elec | A&I |
| External References | | | | | | | | |
| Reference Geometry | | | | | X | | | |
| Marking Requirements - ECCN | | | | | X | | | |
| Marking Requirements - Approval | | | | | | | | |
| Axis System | | | | | | | | |
| Part Notes | | | | | | | | |
| Standard Notes | | | | | | | | |
| Dimensions | | | | | | | | |
| Tolerances | | | | | | | | |
| Annotations | | | | | | | | |
| 3DViews | | | | | | | | |
| Key Characteristics | | | | | | | | |
| Limited Area Application Indicator | | | | | | | | |
| Solid Definition | | | | | | | | |
| Material Description | | | | | | | | |
| Grain Direction - Complex Detail Forging | | | | | | | | |
| Grain Direction - Forged Block | | | | | | | | |
| Parting Surface | | | | | | | | |
| Prolongation Area | | | | | | | | |
| Test Specimen | | | | | | | | |
| Calculated Weight | | | | | | | | |
| Draft Angle | | | | | | | | |
| Intersecting Surfaces [mold lines or point] | | | | | | | | |
| Forging Plane [principle die face] | | | | | | | | |
| Nondestructive and mechanical properties | | | | | | | | |
| Mechanical properties of the casting | | | | | | | | |
| Surface Condition control Casting | | | | | | | | |
| Inspection method and acceptance criteria | | | | | | | | |
| Forging stock [billet] orientation | | | | | | | | |
| Forging Notes | | | | | | | | |
| Information Requirement | Det | Mach | C/F | SM | Comp | MS | Elec | A&I |
| Tube Line | | | | | | X | | |
| Run | | | | | | X | | |
| Tube Spool | | | | | | X | | |
| Bendable | | | | | | X | | |
| Connectors | | | | | | X | | |
| Park Marks | | | | | | X | | |
| Sleeving | | | | | | | X | |
| Internal Splice | | | | | | | X | |
| Dimensions and Annotations Collector | | | | | | | X | |
| BackShell | | | | | | | X | |
| Lugs | | | | | | | X | |
| External Splice | | | | | | | X | |
| Mounting Equipment | | | | | | | X | |
| Equipment | | | | | | | X | |
| Single Insert Connectors | | | | | | | X | |
| Backshell Clotting | | | | | | | X | |
| Flag Markers | | | | | | | X | |
| Connector Shell | | | | | | | X | |
| Shop Aid / Parts List | | | | | | | X | |
| Joint Definitions | | | | | | | | X |
| Hole Location[s] | | | | | | | | X |
| Hole Drill Requirements | | | | | | | | X |
| Hole Drill Direction | | | | | | | | X |
| Fastener Location | | | | | | | | X |
| Fastener Drill Direction | | | | | | | | X |
| Fastener Installation requirements | | | | | | | | X |
| Fastener physical representation | | | | | | | | X |
| Sealant Definitions | | | | | | | | X |
| Sealant Requirements | | | | | | | | X |
| Sealant Area | | | | | | | | X |
| Shim Definitions | | | | | | | | X |
| Shim Requirements | | | | | | | | X |
| Shim shape/location | | | | | | | | X |

| Total Requirements | 398 |
|-------------------------|-----|
| Detail MBD | 19 |
| Assembly&Instl MBD | 93 |
| PMI | 189 |
| Additive Manufacturing | 43 |
| Casting/Forging | 5 |
| Machined | 2 |
| Sheetmetal | 5 |
| Composites | 23 |
| Mechanical Systems | 6 |
| Electrical Wire Harness | 13 |

Identify Information Requirements

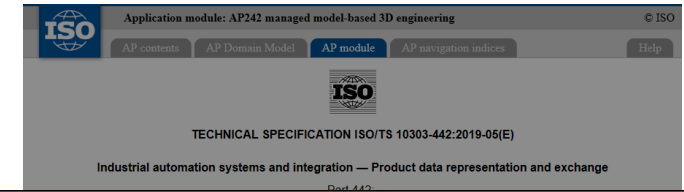


Map the Information Requirements to AP242 and Aggregate

EX: 520 unique information requirements, AP242 supports 450 = Score 86

| Business Object [Function] | | Part Types | | | | | | | |
|----------------------------|------------------------|------------|----|-----|----|----|----|---|---|
| CATIA VS Object BCA | | Gen | Me | C/F | SM | BC | MS | E | |
| Part Number & Revision | Part Number, Revision | X | X | X | X | X | X | X | X |
| Solid Definition | Part Body | X | X | X | X | X | X | X | X |
| Material Description | Parameters | X | X | X | X | X | X | X | X |
| Engineering Definition | Manufacturing Features | X | X | X | X | X | X | X | X |

| PMI Entity | | | |
|----------------------------|------------|--|----------------|
| Tolerances | PMI symbol | Name | Description |
| Geometric tolerance | | | |
| Form | — | Straightness | Form Tolerance |
| | ▭ | Flatness | Form Tolerance |
| | ○ | Roundness (ISO) Circularity (ASME) | Form Tolerance |
| | ⌀ | Cylindricity | Form Tolerance |
| | ⌒ | Profile any line (ISO 1101:2012) Line Profile (ISO 1101:2017) | Form Tolerance |
| | ⌒ | Profile any surface (ISO 1101:2012) Surface Profile (ISO 1101:2017) | Form Tolerance |



| Interop standard | | | | | | |
|------------------|----------------|-----------------|---|---------------------------|---------------------------|--------------------|
| STEP AP242 ed1 | STEP AP242 ed2 | Bugzilla number | Module | ARM entity | AIM entity | Rec Practice CAX-I |
| YES | YES | | ISO/TS 10303-1051:2013-01 Geometric tolerance | Straightness_tolerance | straightness_tolerance | YES |
| YES | YES | | ISO/TS 10303-1051:2013-01 Geometric tolerance | Flatness_tolerance | flatness_tolerance | YES |
| YES | YES | | ISO/TS 10303-1051:2013-01 Geometric tolerance | Roundness_tolerance | roundness_tolerance | YES |
| YES | YES | | ISO/TS 10303-1051:2013-01 Geometric tolerance | Cylindricity_tolerance | cylindricity_tolerance | YES |
| YES | YES | | ISO/TS 10303-1051:2013-01 Geometric tolerance | Line_profiles_tolerance | line_profile_tolerance | YES |
| YES | YES | | ISO/TS 10303-1051:2013-01 Geometric tolerance | Surface_profile_tolerance | surface_profile_tolerance | YES |

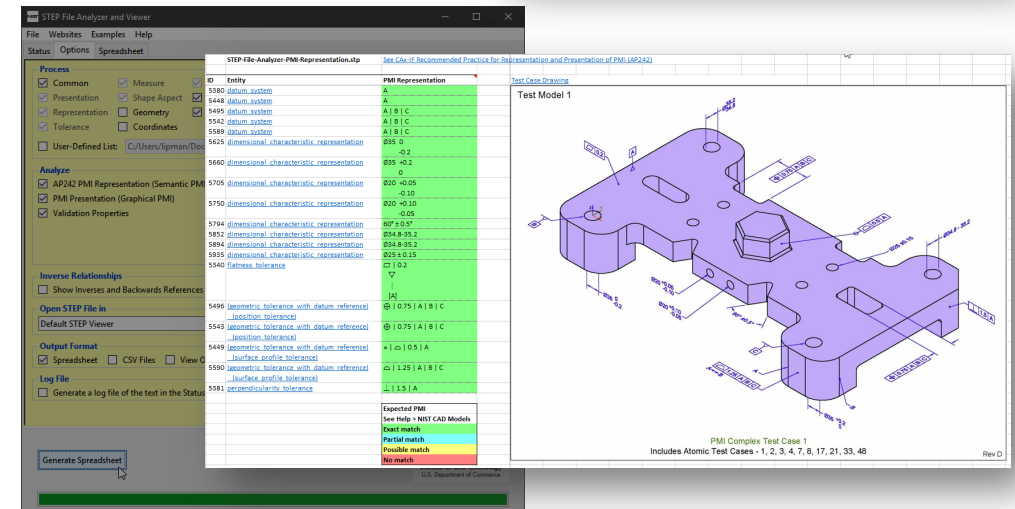
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graph LR; A[Business Processes] --> B[Information Requirements [Data]]; B --> C[Tool Chain]; C --> D[Industry/Supplier]; A --> E[Aggregating]; B --> E; C --> E; D --> E;
```

The diagram illustrates a process flow where four main components (Business Processes, Information Requirements [Data], Tool Chain, and Industry/Supplier) are interconnected sequentially and also feed into a central 'Aggregating' block. The flow is as follows: Business Processes leads to Information Requirements [Data], which leads to Tool Chain, which leads to Industry/Supplier. Additionally, each of these four components has a direct path to the Aggregating block at the bottom.

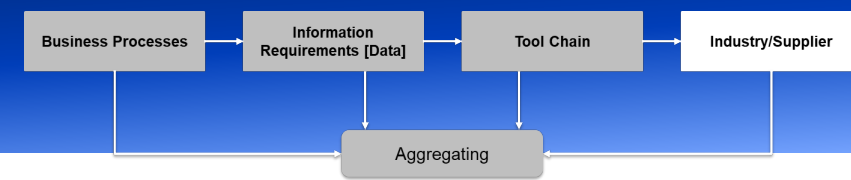
Manual Creation of AP242 focusing on all information requirements

Control exported content [control IP]

Consume/Import back into native authoring system

[illegible]

Industry/Supplier Requirements



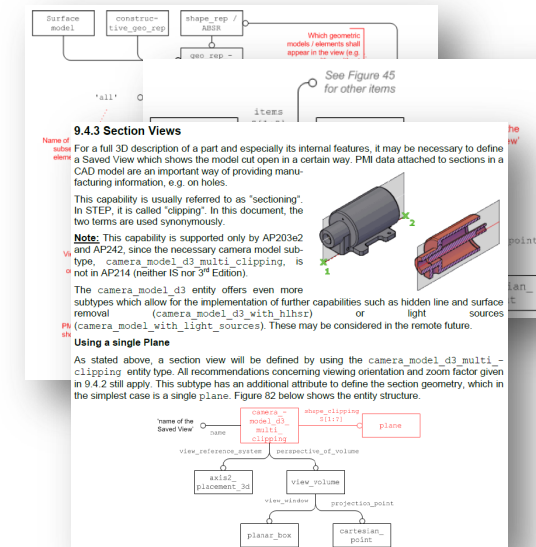
Analyze needs of the industry [primary or potential suppliers] to support business identified business processes such as design collaboration, build to print or regulatory certification.

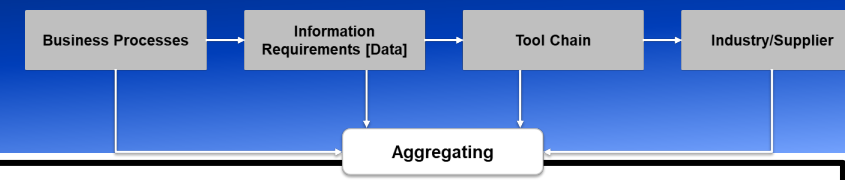
Industry Agreement on data representation of AP242 Generally Available tools to create/consume AP242

EX: 4 RP [2 needing update] and 3 Imp [2 needing updates] = Score 42



| A: Dassault Systèmes (CATIA V5-6R2020) | | B: Siemens PLM (NX 12) | | | | | | | | |
|--|--|----------------------------|-----------------|-----------------|------------------|------------------------|------------------------|------------------------|--------------|--------------|
| Last updated: Jun 12, 2019 | | Last updated: Jul 16, 2019 | | | | | | | | |
| Recommended Practices Functionality | | AP203 E2 Import | AP203 E2 Export | AP214 E3 Import | IS (2001) Import | AP214 E3 (2001) Export | AP214 E3 (2010) Import | AP214 E3 (2010) Export | AP242 Import | AP242 Export |
| Geometry | | | | | | | | | | |
| Wireframe | | A / B | A / B | A / B | A / B | A / B | A / B | A / B | A / B | A / B |
| Geom. Bounded Surface Mode | | | | | | | | | | |
| BREP Solid | | | | | | | | | | |
| 3D Tessellated | | | | | | | | | | |
| Assembly Structure | | | | | | | | | | |
| Assembly Structure | | | | | | | | | | |
| Mapped Item | | | | | | | | | | |
| Composite Material | | | | | | | | | | |
| Composite Material | | | | | | | | | | |
| Composite Validation Properties | | | | | | | | | | |
| Model Styling | | | | | | | | | | |
| Solid Color | | | | | | | | | | |
| Face Color | | | | | | | | | | |
| Overriding Face Color | | | | | | | | | | |
| Edge / Curve Color | | | | | | | | | | |
| Overriding Edge Color | | | | | | | | | | |
| Point Styling | | | | | | | | | | |
| Invisibility | | | | | | | | | | |
| Curve Style | | | | | | | | | | |
| Layer | | | | | | | | | | |
| Group | | | | | | | | | | |
| Assembly Instance Styling | | | | | | | | | | |
| NAUO approach (1 level) | | | | | | | | | | |
| Material Identification and Density | | | | | | | | | | |
| Material as Property | | | | | | | | | B | B |
| Density as General Property | | | | | | | | | B | B |
| External References | | | | | | | | | | |
| Simple External References | | A / B | A / B | A / B | A / B | A / B | A / B | A / B | A / B | A / B |
| Nested External References | | A / B | A / B | A / B | A / B | A / B | A / B | A / B | A / B | A / B |
| External Element References | | | | | | | | | | |
| Document Properties | | A | A | A | A | A | A | A | A | A |





Over All Readiness Summary

57

Ready: Manual creation of partially complete AP242e1, 1 Class and 5 Internal documents

Not Ready: 1 Class, 4 Internal documents and Automated Tool Chain to create complete Ap242

Major Next Steps to Close: Work with external organizations to close on industry capabilities

Data Standard

90

Ready: AP242e1

- Shape Representation, Some PMI/Composites

Almost Ready:

- AP242e2

Actions to Close:

- Incorporate needs [e.g. Mech Sys/Hyd] into AP242e3

Internal Processes

54

Ready:

- 1 Class, 5 Internal business documentation

Not Ready:

- 1 Class, 4 Internal business documentation

Actions to Close:

- Agreement with end users on methods
- Creation of content

Industry/Supplier

42

Ready:

- 2 Partial Commercial Implementations
- 4 Partial Free Implementations

Not Ready:

- 0 Fully Implemented solutions

Actions to Close:

- Provide requirements to implementers

Tool Chain

40

Ready:

- Manual CATIA V5 of partially complete AP242e1

Not Ready:

- STEP AP242e2 Translator and Validator

Actions to Close:

- Internal funding, prioritization, resourcing, purchase, development....



Aligns A&D Community to common Use Cases and established Position for use of Standards/Tool



Establishes Product Data Formats for exchange of product data



Established Practice/Authoring Standards for Model Based Engineering and content requirements



Provides Implementer Forums and Frameworks to validate exchange methods

Over All Readiness Summary

57

Ready: Manual creation of partially complete AP242e1, 1 Class and 5 Internal documents
Not Ready: 1 Class, 4 Internal documents and Automated Tool Chain to create complete Ap242
Major Next Steps to Close: Work with external organizations to close on industry capabilities

Data Standard

90

Ready: AP242e1
 • Shape Representation, Some PMI/Composites
Almost Ready:
 • AP242e2
Actions to Close:
 • Incorporate needs [e.g. Mech Sys/Hyd] into AP242e3

Internal Processes

54

Ready:
 • 1 Class, 5 Internal business documentation
Not Ready:
 • 1 Class, 4 Internal business documentation
Actions to Close:
 • Agreement with end users on methods
 • Creation of content

Industry/Supplier

42

Ready:
 • 2 Partial Commercial Implementations
 • 4 Partial Free Implementations
Not Ready:
 • 0 Fully Implemented solutions
Actions to Close:
 • Provide requirements to implementers

Tool Chain

40

Ready:
 • Manual CATIA V5 of partially complete AP242e1
Not Ready:
 • STEP AP242e2 Translator and Validator
Actions to Close:
 • Internal funding, prioritization, resourcing, purchase, development....

Implementing AP242 is EASY!



References

ISO/DIS 22549-1:2019, Automation Systems and Integration – Assessment on Convergence of Information and Industrialization for Industrial Enterprises Part 1: Framework and Reference Model

ISO/CD 22549-2:2019, Automation Systems and Integration – Assessment on Convergence of Information and Industrialization for Industrial Enterprises Part 2: Maturity Model and Evaluation Methodology

ISO 15704, Industrial Automation Systems – Requirements for Enterprise-Reference Architectures and Methodologies