3D Visualization

Requirements Document

LOTAR International, Visualization Working Group

ABSTRACT

The purpose of this document is to provide the list of requirements and their associated priorities related to LOTAR 3D visualization activities. The scope of this document is requirements and use cases related to the long term archiving and retrieval of 3D visualization information. The objective is to define common recommendations for LT Archiving and Retrieval of 3D Visualization information.

REVISION HISTORY

Revision	Date	Reason For Changes	Approvals
1.0	8 August 2014	Initial Release	P. Duchier T. Hedberg

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EXECUTIVE SUMMARY

The purpose of this document is to provide the list of requirements and their associated priorities that the LOTAR Visualization Working Group has addressed to assist the end user in achieving the business objectives of the long term archiving and retrieval of 3D visualization information.

The scope of this document is requirements and use cases related to the long term archiving and retrieval of 3D visualization information. The objective is to define common recommendations for LT Archiving and Retrieval of 3D Visualization information. These recommendations will be, consistent with LT Archiving and Retrieval of information concerning CAD models and related information, throughout the full product life cycle.

Historically, 2D drawings are the main exchange mechanism for communicating design information. The shift to 3D models and model-based definitions is replacing 2D drawings as the commanding design information. 3D visualization blurs the separation of product models and documents because semantic representation information may be stored within various 3D visualization formats that overlap with more traditional document based extensions (e.g. PDF). For the purposes of this document, 3D visualization is treated as a document based format and it is recommended that 3D visualization must be archived using document-based approaches.

A comprehensive list of requirements for the long term archiving and retrieval of 3D visualization data was developed by the LOTAR Visualization Working Group for the purposes of creating, ingesting, and retrieving 3D visualization artifacts to and from an archive. The requirements are organized into five sections, as follows:

1. General requirements
2. Business requirements
3. Interface requirements
4. System requirements
5. Technical requirements

Three LOTAR use cases, developed by the LOTAR Visualization Working Group, will assist the understanding and implementation of LOTAR best practices related to the archival activities for 3D visualization artifacts. The use cases cover the following topics:

1. Internal Use
2. External Support
3. Product Certification

Introduction

Purpose

The purpose of this document is to provide the list of requirements and their associated priorities that the LOTAR Visualization Working Group has addressed to assist the end user in achieving the business objectives of the long term archiving and retrieval of 3D visualization information.

Any end user changes to the scope of this document may have an impact on the schedule, cost, or quality of a project. The Project Manager and the customer, at a minimum should review all change request(s) affecting the scope, schedule, or cost of the project for approval. Approved changes must necessitate an update to this document, or its derivative, so that a complete description of deliverables is available to the end user.

Scope

The scope of this document is requirements and use cases related to the long term archiving and retrieval of 3D visualization information. The objective is to define common recommendations for LT Archiving and Retrieval of 3D Visualization information. These recommendations will be, consistent with LT Archiving and Retrieval of information concerning CAD models and related information, throughout the full product life cycle.

3D Visualization is any technique for efficiently communicating information and data (i.e. 3D models, 3D predefined views, diagrams, animations, etc) for the display of definition data, derived data, and other archived data artifacts.

The goal of the 3D Visualization Working Group is:

- To define the characteristics of the Visualization information to be archived.
- To prepare recommended practices for implementing available 3D Visualization standards by the LOTAR community.
- To describe the recommended processes to ensure the consistency between the archived CAD 3D (authoring) data and the archived 3D Visualization (derived) data

The data can be any 3D representation (3D geometry, 3D PMI & annotation, Assembly structure, user defined attributes) from the mechanical, electrical, and composite domains.

Product Models versus Documents

Historically, 2D drawings are the main exchange mechanism for communicating design information. While developed in a CAD system typically, 2D drawings are translated and exchanged in document-based formats such as TIFF, CGM, and PDF. The shift to 3D models and model-based definitions is replacing 2D drawings as the commanding design information. 3D visualization blurs the separation of product models and documents because semantic representation information may be stored within various 3D visualization formats that overlap with more traditional document based extensions (e.g. PDF). For the purposes of this document, 3D visualization is treated as a document based format and it is recommended that 3D visualization must be ar-

chived using document-based approaches. For more guidance and information, refer to EN/NAS 9300-003

Thought Process

The basic process tools below were utilized to develop the requirements listed in this document. The sources of requirements include:

- **Interviews and discussions with users.** The most obvious way to find out what potential users need is to ask them. Interviews are a fact-finding approach whereby the systems analyst collects information from individuals face to face. Though it is the most popular approach, it is the most time consuming. Interviewing encourages the interviewee to respond freely and openly. Its success relies heavily on the interviewer's skills. If the project is small with few stakeholders, interviewing is probably best.
- **Current Documentation** that describes the current product, describe corporate or industry standards, or regulations and laws with which the product must comply will be reviewed. Descriptions of both present and future business processes are also helpful.
- Either **observation** is a fact-finding technique where the analyst participates in or watches a person perform activities to learn about the system or business environment. Watching the users at work provides a more accurate and complete understanding than simply asking them to write down the steps they go through.
- **Prototyping** is the act of building a small-scale representation or working model of the customers' requirements. It is a good way to document the knowledge you have gained and receive stakeholders' feedback.
- **Interactive Workshop** is a facilitated workshop used to develop deliverables. When several people are involved and consensus is important, interactive workshops are better than separate interviews for most information gathering needs. It is an efficient use of time and provides the best results.

Overview

This document contains a comprehensive list of requirements for the long term archiving and retrieval of 3D visualization data. The requirements are organized into five sections, as follows:

6. General requirements
7. Business requirements
8. Interface requirements
9. System requirements
10. Technical requirements

Diagrams are used to show the hierarchy of the requirements. In addition to requirements, three use cases are described in detail Section 1.5.7 Use Cases.

1 Visualization LOTAR Requirements

#	A-ID	Name	Text
1	1	Visualization LOTAR Requirements	
2	1.1	General	
3	1.1.1	In Scope	The scope of the visualization LOTAR requirements is the long-term archival and retrieval of visualization artifacts generated using international standard visualization formats. The following is out of scope for the visualization LOTAR requirements: • Master definition data • Non-visualization artifacts • The definition of how to implement the requirements with the various formats, but linkage must remain between the LOTAR VU WG and the appropriate implementor forum(s) • Any requirements that are not addressed by the LOTAR standards parts
4	1.1.2	Out of Scope	
5	1.1.3	Verbal Forms	
6	1.1.3.1	Must	Indicates requirements strictly to be followed in order to conform to this document and from which no deviation is permitted. Must is equivalent to shall.
7	1.1.3.2	Should	Indicates that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required. Other possibilities may be applied subject to agreement.
8	1.1.3.3	May	Verbal form used to indicate a course of action permissible within the limits of the document.
9	1.2	Business	The LOTAR system must be based on the process of LOTAR and not technology.
10	1.3	Interface	Some commercial viewers reflected the BREP data in real time when tessellation data does not exist. When a user measures or does other types of interrogation on the visualization, he/she may not actually be using the BREP data. The interrogation may be upon the tessellated / graphical data without the user's knowledge.
11	1.3.1	Boundary Representation Usage	The should not include BREP data in PDF/A2 and 3? to ensure there is no misconception / confusion. At the very least, tessellation data must be available to ensure the visualization consistently displays in all viewers correctly.
12	1.4	System	
13	1.4.1	Reliability	The purpose of long-term data archival and retrieval (LOTAR) is to ensure the availability of product data for a period of time with the minimum length being the life of the product. An archival system must have the capability to archive and retrieve data based on business processes and regulatory requirements, both of which may include automated and/or on demand needs.
14	1.4.2	Performance	
15	1.4.2.1	File Size	The visualization data should use the minimum amount of file space required to comply with all requirements.
16	1.4.2.2	Data Access	The visualization data should open for display within a viewing tool in under 60 seconds.
17	1.4.3	Data Security	The visualization data security must be in accordance with EN/NAS 9300-001.
18	1.4.4	Configuration	The data format must be generated in full compliance with the international standard that defines the format and in accordance with EN/NAS 9300-003 section 4.1.5.6.
19	1.4.5	Usability	
20	1.4.5.1	Data Formats	The corresponding tool used to interact with the visualization data must read and/or display the data in accordance with the international standard that defines the format.
21	1.4.5.2	Annotation Highlighting	The corresponding tool used to interact with the visualization data must support annotation highlighting for annotations in accordance wit ASME Y14.41 and/or ISO 16792.
22	1.4.5.2.1	Cross-Probing	The annotation highlighting capability should support the selection of annotations in the 3D graphics window and the model tree.
23	1.4.5.3	Sectioning	The corresponding tool used to interact with the visualization data must support the creating and/or display of section planes and section views.
24	1.4.5.4	Measuring	The corresponding tool used to interact with the visualization data may support measurement of the geometry contained within the visualization data.
25	1.4.5.4.1	Measurement Capabilities	The basic measurement capabilities should support distances, diameters, and lengths.
26	1.4.5.5	Navigation	The corresponding tool used to interact with the visualization data must support the ability to pan, rotate, and zoom on the 3D model.
27	1.4.5.5.1	Zoom	The corresponding tools used to interact with the visualization data should support zoom area, zoom in, zoom out, and magnifier sub-functions.
28	1.4.5.6	Metadata	The corresponding tool used to interact with the visualization data must support the ability to read and display the metadata associated with entities in the visualization.
29	1.4.5.7	Validation	The corresponding tool used to interact with the visualization data should be able to perform a validation property check to prove the validity of the data in accordance with the validation properties.
30	1.4.5.7.1	Runtime	The validation check should give the user the opportunity to run the check automatically and on demand.
31	1.4.6	Operational	The data format must support the LOTAR visualization use cases that are applicable to the user and the use of the visualization data.
32	1.5	Technical	
33	1.5.1	Verification	The master source data (i.e. Native CAD) must be verified prior to creation of the visualization data. The verification requirements should be determined independent of the product data and based upon a set of commonly accepted use cases.
34	1.5.2	Elements and Validation	All elements and validation information included in visualization data must be in accordance with the appropriate EN/NAS 9300 standard part. Further detail is supplied in the following sub-requirements.
35	1.5.2.1	Validation Level Method and Risk	The level of risk acceptable to the archive must be established. The following validations level methods may assist the archive with establishing the acceptable level of risk.
36	1.5.2.1.1	Level 0	Method: No validation properties applied Risk: Highest risk
37	1.5.2.1.2	Level 1	Method: Mandatory validation properties Risk: Calculated risk
38	1.5.2.1.3	Level 2	Method: Mandatory plus optional properties Risk: Minimized risk
39	1.5.2.2	3D Exact Geometry	Validation properties must be included for 3D exact geometry when present in the visualization data. The following requirements, in accordance with EN/NAS 9300-110 must be utilized for the inclusion of validation properties for 3D exact geometry. For level 1 validation, the validation properties for the following must be present: • Mass properties (i.e. volume, mass, area, centroid, 3D moments of inertia, center of gravity, etc.) • May store the validation criteria, algorithm, results, and additional checking metadata For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties: • Direct comparison (e.g. cloud of point) • Validation criteria and results • May store the validation algorithm and additional checking metadata In addition to the validation properties above, the solid information must be included in the visualization data in accordance with EN/NAS 9300-110. For level 1 validation, the validation properties for the following must be present: • Mass properties (i.e. area, centroid, 2D moments of inertia, etc.) • Surface normal vector (also called the direction vector) • Topological data • May store the validation criteria, algorithm, results, and additional checking metadata
40	1.5.2.2.1	Solid	
41	1.5.2.2.2	Surface / Shell	For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties: • Direct comparison (e.g. cloud of point) • Validation criteria and results • May store the validation algorithm and additional checking metadata In addition to the validation properties above, the surface / shell information must be included in the visualization data in accordance with EN/NAS 9300-110 Edition 2. For level 1 validation, the validation properties for the following must be present: • Length • Centroid • Position • May store the validation criteria, algorithm, results, and additional checking metadata
42	1.5.2.2.3	Curve	For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties: • Direct comparison (e.g. cloud of point) • Validation criteria and results • May store the validation algorithm and additional checking metadata In addition to the validation properties above, the curve information must be included in the visualization data in accordance with EN/NAS 9300-110 Edition 2. For level 1 validation, the validation properties for the following must be present: • Position • May store the validation criteria, algorithm, results, and additional checking metadata
43	1.5.2.2.4	Point	For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties: • Validation criteria and results • May store the validation algorithm and additional checking metadata In addition to the validation properties above, the point information must be included in the visualization data in accordance with EN/NAS 9300-110 Edition 2.
44	1.5.2.3	Product and Manufacturing Information (PMI)	PMI included in visualization data must be, at a minimum, graphical polyline presentation information. Validation properties must be included for PMI when present in the visualization data. The following requirements, in accordance with EN/NAS 9300-120, EN/NAS 9300-121, and EN/NAS 9300-123, must be utilized for the inclusion of validation properties for 3D exact geometry.
45	1.5.2.3.1	Presentation	
46	1.5.2.3.1.1	Character-based presentation	At this time, character-based presentation is out of scope for the visualization LOTAR requirements.
47	1.5.2.3.1.2	Graphic presentation	
48	1.5.2.3.1.2.1	Polyline Presentation	Polyline presentation information included in visualization data must be in accordance with EN/NAS 9300-120.
49	1.5.2.3.1.2.2	Tessellated Presentation	Tessellated presentation information included in visualization data must be in accordance with EN/NAS 9300-120.
50	1.5.2.3.2.3	Validation	Graphic presentation of PMI must be included in accordance with EN/NAS 9300-120.
51	1.5.2.3.2	Representation (Semantic)	Semantic PMI may not be included in visualization data. If semantic PMI data exists, it must be included and validated in accordance with EN/NAS 9300-121. If linking / cross-highlighting is included in the master source data, then linking / cross-highlighting must be included in the visualization data. Validation properties for the linking / cross-highlighting must be included and capture, at a minimum, the following information:
52	1.5.2.3.3	Link / Cross Highlighting	• PMI reference • Geometry element / feature reference
53	1.5.2.4	Assembly / Product Structure	Assembly / Product Structure information may be included in the visualization data. If assembly / product structure information exists, it must be included and validated in accordance with the applicable EN / NAS 9300 parts.
54	1.5.2.5	3D Tessellated Geometry	3D tessellated geometry information included in visualization data must be in accordance with EN/NAS 9300-110.
55	1.5.2.6	Graphical Properties	Graphical information (i.e. color, texture, etc.) included in visualization data must be in accordance with EN/NAS 9300-110 and EN/NAS 9300-120.
56	1.5.2.7	View Point	For level 1 validation, the validation properties for the following must be present: • Camera position • Element filtering • Cutting plane • May store the validation criteria, algorithm, results, and additional checking metadata For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties: • Validation criteria and results • May store the validation algorithm and additional checking metadata In addition to the validation properties above, the view point information must be included in the visualization data in accordance with EN/NAS 9300-120.
57	1.5.2.8	Metadata	Metadata information included in visualization data must contain at least provenance information and facity information. The provenance information from multiple sources condensed in a single visualization artifact must be included in a clear and concise manner. If part information exists in the master source data, the part information must be included in the visualization data. If provenance information and facity information exists in the master source data, the provenance information and facity information in the master source data must not be included in the visualization data. The provenance information and facity information included in visualization data must be directly related to the visualization data.
58	1.5.3	Creation of Artifacts	The preparation of archive data must in in accordance with EN/NAS 9300-010.
59	1.5.3.1	General	The following are the minimum requirements for the creation of visualization artifacts for the purposes of LOTAR: • Visualization must have the ability to display graphical 3D CDRT and PMI information • Visualization must be able to display all information linked to authoritative controlling data in accordance with the validation requirements as defined by this document. • Validation properties must be available in the visualization in accordance with the validation requirements as defined by this document and EN/NAS 9300-003 section 7.3.5.2, EN/NAS 9300-100, and EN/NAS 9300-200 • Visualization must be secured to restrict exporting geometry, copying information, and/or editing the visualization • Visualization must be capable of displaying BREP and/or tessellated geometry • Visualization should be able to display all precise representations of geometry accurately, if available • Visualization should be capable of displaying the product structure of assemblies • Visualization must have the ability to display other annotations such as general notes, parts lists, etc. that are typically not considered CDRT and/or PMI • Visualization must have the ability to display standard and custom created model views (aka called combination states)
60	1.5.3.2	Geometry Display	Visualization must be capable of displaying BREP and/or tessellated geometry.
61	1.5.3.3	Validation Properties	Validation properties must be available in the visualization in accordance with the validation requirements as defined by the VZ WG and EN/NAS 9300-003 section 7.3.5.2, EN/NAS 9300-100, and EN/NAS 9300-200.
62	1.5.3.4	Product Structure	Visualization should be capable of displaying the product structure of assemblies.
63	1.5.3.5	PMI Display	Visualization must have the ability to display graphical 3D CDRT and PMI information.
64	1.5.3.6	Read Only	Visualization must be locked down to restrict exporting geometry, copying information, and/or editing the visualization.
65	1.5.3.7	Model Views	Visualization must have the ability to display standard and custom created model views (aka combination states)
66	1.5.3.8	Annotations	Visualization must have the ability to display other annotations such as general notes, parts lists, etc. that are typically not considered CDRT and/or PMI.
67	1.5.3.9	Validation	Visualization data must be validated against the master source data in accordance with commonly accepted validation requirements using commonly accepted validation methods.
68	1.5.3.10	Representation PMI	Visualization should have the ability to store representation (semantic) PMI data
69	1.5.3.11	Precise Representations	Visualization should be able to display all precise representations of geometry accurately, if available.
70	1.5.3.12	Filter	Visualization must give the user the ability to filter information from being included in the visualization.
71	1.5.4	Ingestion of Artifacts	The ingestion of artifacts must be in accordance with EN/NAS 9300-012.
72	1.5.4.1	Verification	The verification of product data quality must be performed upon submission of the SIP.
73	1.5.4.1.1	Verification Criteria	The verification criteria should be defined by in accordance with generally accepted requirements and independent of the product data for each type of use case of archived data.
74	1.5.4.1.2	File Format	File format representative unit syntax should be verified.
75	1.5.4.2	SIP Contents	The contents of the SIP may be: • Only the native model data • The native model and the visualization data • Only the visualization data
76	1.5.4.3	Duplications	The archive must check the SIP contents against existing AIPs to ensure consistency.
77	1.5.4.4	Metadata	The archive must create the new AIP from the SIP contents and must include the preparation of the metadata information in accordance with OAIS recommendations. • If the SIP contains only the visualization data, the archive must link the new AIP to an existing AIP that may contain the native model data • If the SIP contains only the native model data, the archive must create and include the visualization in the new AIP • If the SIP contains the native model data and the visualization , the archive must include both artifacts in the new AIP
78	1.5.5	Retrieval of Artifacts	The retrieval of artifacts must be in accordance with EN/NAS 9300-014.
79	1.5.5.1	Query	The archive must support the user's ability to query and download artifacts from AIPs.
80	1.5.5.2	Retrieval Process	The retrieval process is as follows: • The archive must verify that the retrieved data is complete and not corrupt • The archive must retrieve data in accordance with the appropriate user permissions • The archive must load the corresponding tool to display and read the visualization • End to end validation must be completed in accordance with EN/NAS 9300-002
81	1.5.6	Data Management / Preservation Planning of Artifacts	Utilized standards must facilitate backwards compatibility with all previous versions of the standard used for archival.
82	1.5.7.1	Internal Use	The following defines the workflow for the archival of visualization artifacts used in internal organizational processes.
83	1.5.7.2	External Support	The following defines the workflow for the archival of visualization artifacts used to support external organizational processes.
84	1.5.7.3	Certification	The following defines the workflow for the archival of visualization artifacts used in product regulatory certification processes.

Figure 1. Requirements Table

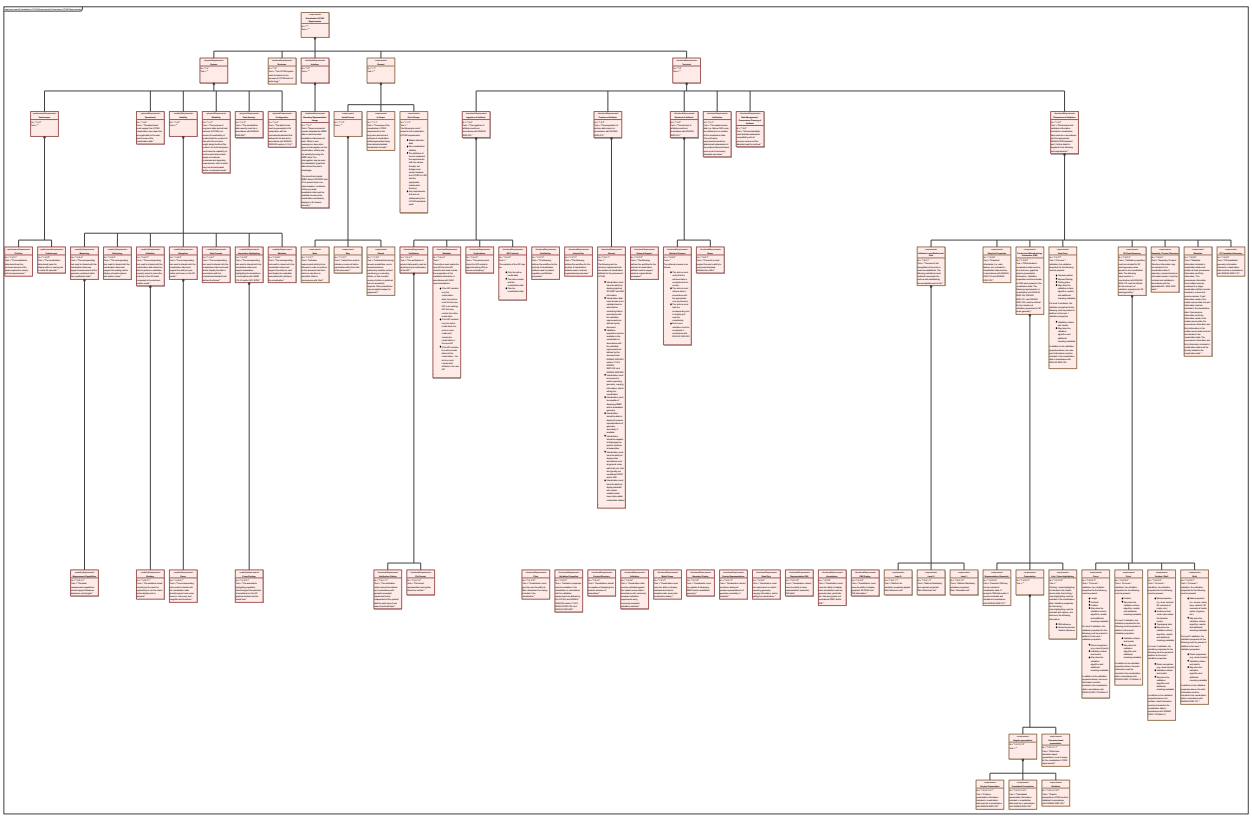


Figure 2. Visualization LOTAR Requirements (vector graphic, zoom for readability)

1.1 General

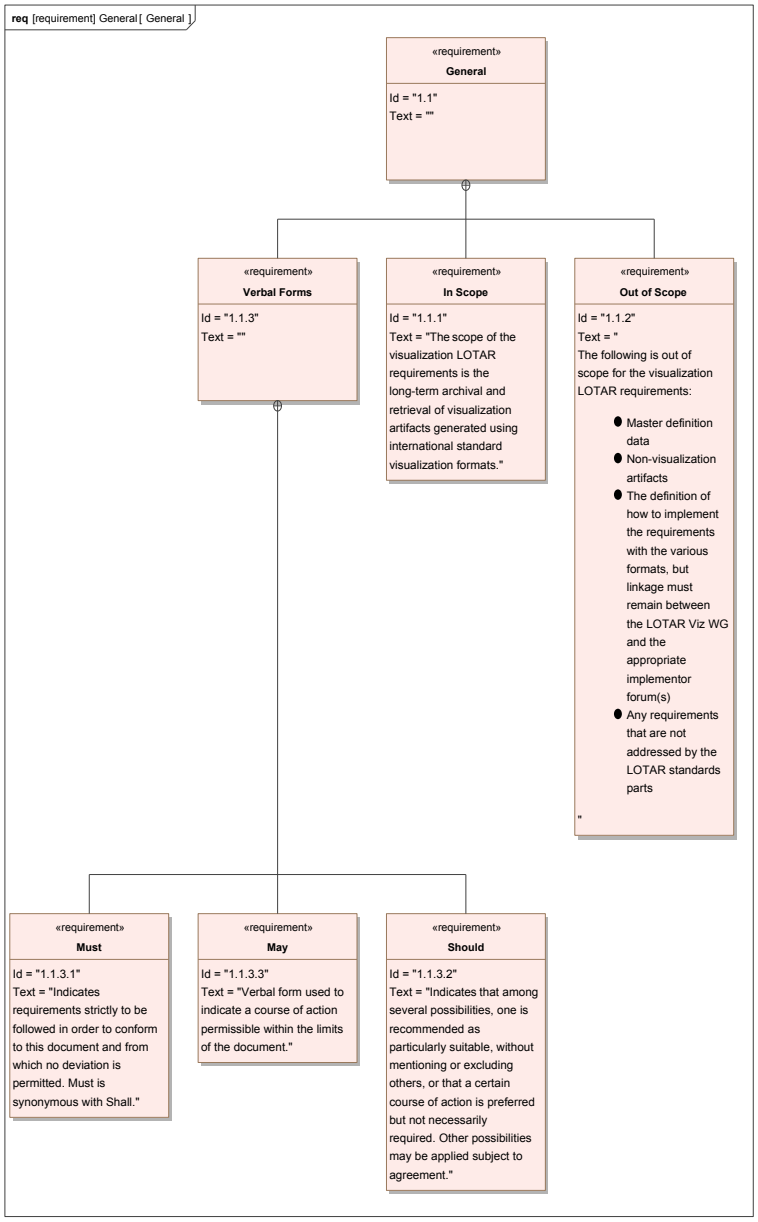


Figure 3. General (vector graphic, zoom for readability)

1.1.1 In Scope

The scope of the visualization LOTAR requirements is the long-term archival and retrieval of visualization artifacts generated using international standard visualization formats.

1.1.2 Out of Scope

The following is out of scope for the visualization LOTAR requirements:

- Master definition data

- Non-visualization artifacts
- The definition of how to implement the requirements with the various formats, but linkage must remain between the LOTAR Visualization Working Group and the appropriate implementer forum(s)
- Any requirements that are not addressed by the LOTAR standards parts

1.1.3 Verbal Forms

1.1.3.1 Must

Indicates requirements strictly to be followed in order to conform to this document and from which no deviation is permitted. Must is synonymous with Shall.

1.1.3.2 Should

Indicates that among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required. Other possibilities may be applied subject to agreement.

1.1.3.3 May

Verbal form used to indicate a course of action permissible within the limits of the document.

1.2 Business

The LOTAR system must be based on the process of LOTAR and not technology.

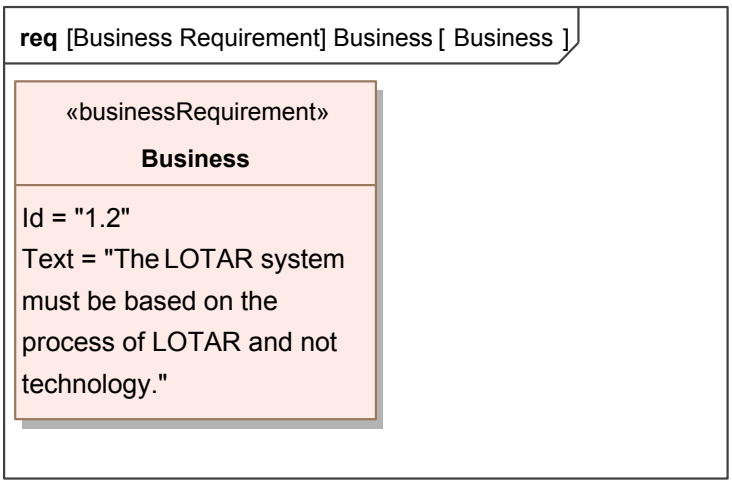


Figure 4. Business

1.3 Interface

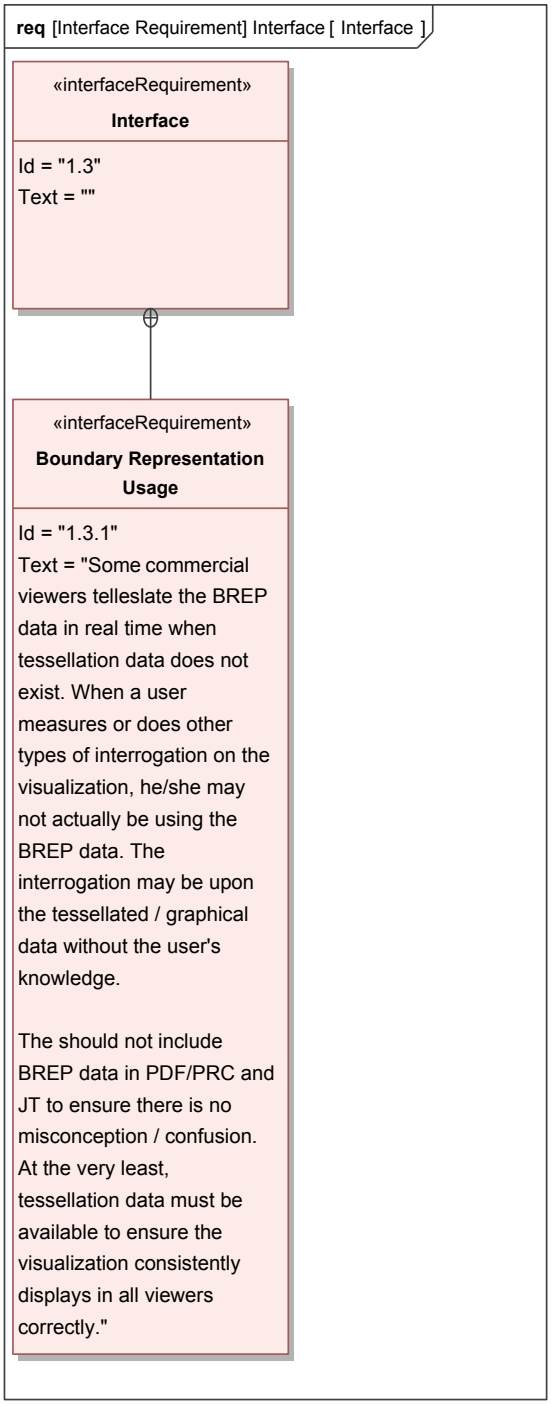


Figure 5. Interface

1.3.1 Boundary Representation Usage

Some commercial viewers tessellate the BREP data in real time when tessellation data does not exist. When a user measures or does other types of interrogation on the visualization, he/she may not actually be using the BREP data. The interrogation may be upon the tessellated / graphical data without the user's knowledge.

The visualization should not include BREP data in PDF/PRC and JT to ensure there is no misconception / confusion. At the very least, tessellation data must be available to ensure the visualization consistently displays in all viewers correctly.

1.4 System

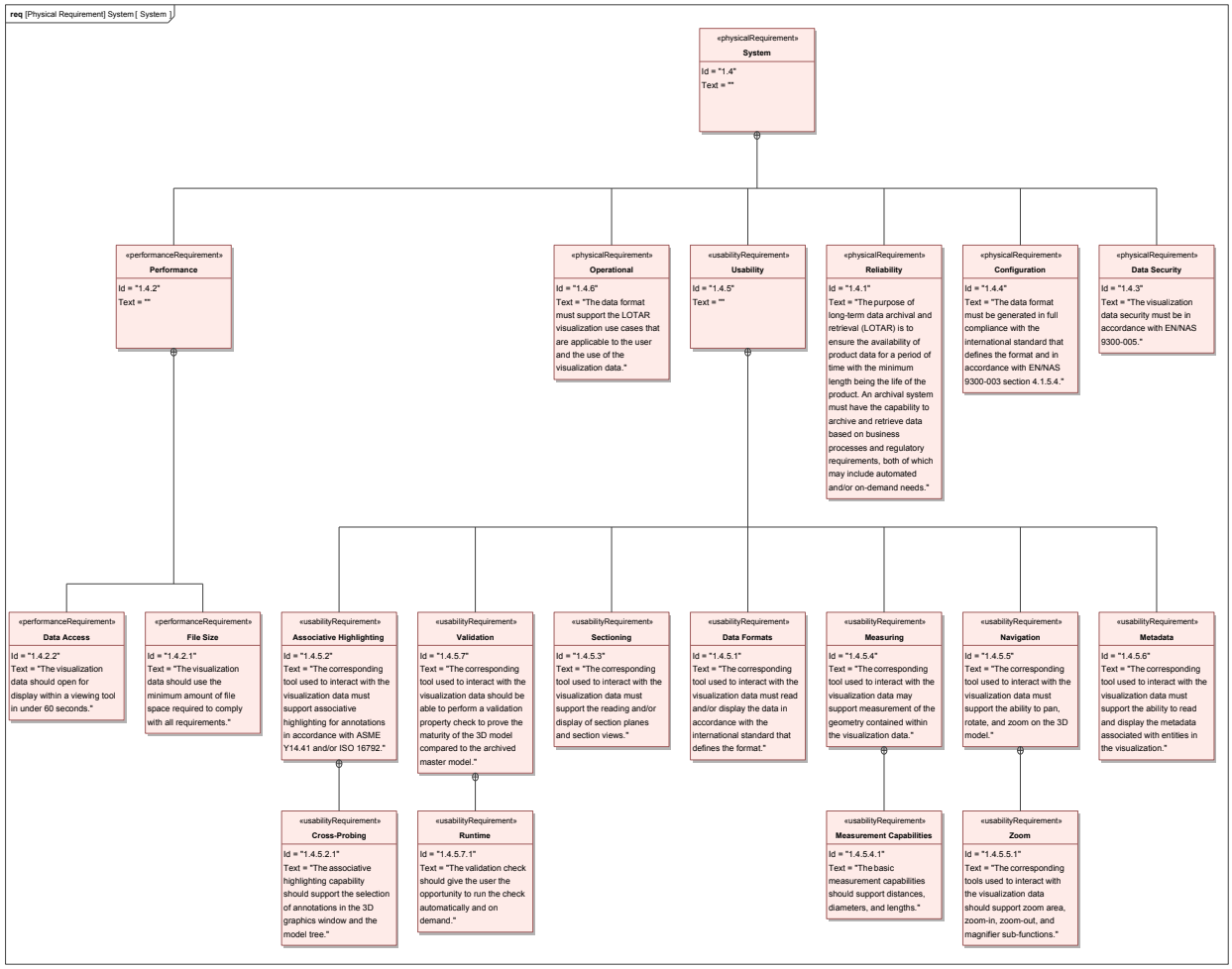


Figure 6. System (vector graphic, zoom for readability)

1.4.1 Reliability

The purpose of long-term data archival and retrieval (LOTAR) is to ensure the availability of product data for a period of time with the minimum length being the life of the product. An ar-

chival system must have the capability to archive and retrieve data based on business processes and regulatory requirements, both of which may include automated and/or on-demand needs.

1.4.2 Performance

1.4.2.1 File Size

The visualization data should use the minimum amount of file space required to comply with all requirements.

> *Recommended Practice: The storage of validation properties in visualization data increases the file size of the artifact. The recommended practice for the storage of validation properties is to determine the expected archival time and base validation risk upon the required length of time for the data to remain available within the archive.*

1.4.2.2 Data Access

The visualization data should open for display within a viewing tool in under 60 seconds.

1.4.3 Data Security

The visualization data security must be in accordance with EN/NAS 9300-005.

1.4.4 Configuration

The data format must be generated in full compliance with the international standard that defines the format and in accordance with EN/NAS 9300-003 section 4.1.5.4.

1.4.5 Usability

1.4.5.1 Data Formats

The corresponding tool used to interact with the visualization data must read and/or display the data in accordance with the international standard that defines the format.

1.4.5.2 Associative Highlighting

The corresponding tool used to interact with the visualization data must support associative highlighting for annotations in accordance with ASME Y14.41 and/or ISO 16792.

1.4.5.2.1 Cross-Probing

The associative highlighting capability should support the selection of annotations in the 3D graphics window and the model tree.

1.4.5.3 Sectioning

The corresponding tool used to interact with the visualization data must support the reading and/or display of section planes and section views.

1.4.5.4 Measuring

The corresponding tool used to interact with the visualization data may support measurement of the geometry contained within the visualization data.

1.4.5.4.1 Measurement Capabilities

The basic measurement capabilities should support distances, diameters, and lengths.

1.4.5.5 Navigation

The corresponding tool used to interact with the visualization data must support the ability to pan, rotate, and zoom on the 3D model.

1.4.5.5.1 Zoom

The corresponding tools used to interact with the visualization data should support zoom area, zoom-in, zoom-out, and magnifier sub-functions.

1.4.5.6 Metadata

The corresponding tool used to interact with the visualization data must support the ability to read and display the metadata associated with entities in the visualization.

1.4.5.7 Validation

The corresponding tool used to interact with the visualization data should be able to perform a validation property check to prove the maturity of the 3D model compared to the archived master model.

1.4.5.7.1 Runtime

The validation check should give the user the opportunity to run the check automatically and on demand.

1.4.6 Operational

The data format must support the LOTAR visualization use cases that are applicable to the user and the use of the visualization data.

> *Recommended Practice: A Visualization Implementers Forum is recommended for each data format to ensure that the format continues to comply with the respective international standards and the Visualization LOTAR requirements.*

1.5 Technical

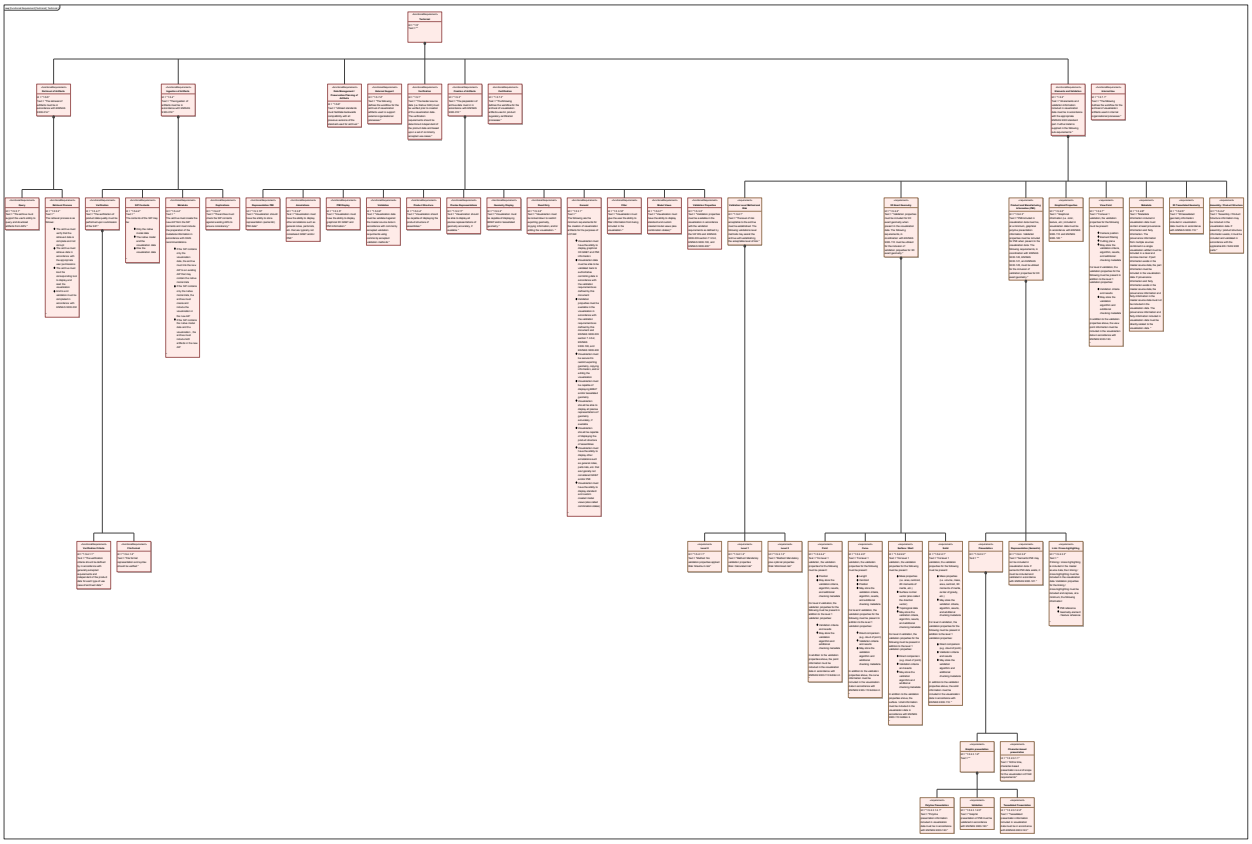


Figure 7. Technical (vector graphic, zoom for readability)

1.5.1 Verification

The master source data (i.e. Native CAD) must be verified prior to creation of the visualization data. The verification requirements should be determined independent of the product data and based upon a set of commonly accepted use cases.

1.5.2 Elements and Validation

All elements and validation information included in visualization data must be in accordance with the appropriate EN/NAS 9300 standard part. Further detail is supplied in the following sub-requirements.

1.5.2.1 Validation Level Method and Risk

The level of risk acceptable to the archive must be established. The following validations level methods may assist the archive with establishing the acceptable level of risk.

1.5.2.1.1 Level 0

Method: No validation properties applied
Risk: Maximum risk

1.5.2.1.2 Level 1

Method: Mandatory validation properties

Risk: Calculated risk

1.5.2.1.3 Level 2

Method: Mandatory plus optional properties

Risk: Minimized risk

1.5.2.2 3D Exact Geometry

Validation properties must be included for 3D exact geometry when present in the visualization data. The following requirements, in coordination with EN/NAS 9300-110 must be utilized for the inclusion of validation properties for 3D exact geometry.

1.5.2.2.1 Solid

For level 1 validation, the validation properties for the following must be present:

- Mass properties (i.e. volume, mass, area, centroid, 3D moments of inertia, center of gravity, etc.)
- May store the validation criteria, algorithm, results, and additional checking metadata

For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties:

- Direct comparison (e.g. cloud of point)
- Validation criteria and results
- May store the validation algorithm and additional checking metadata

In addition to the validation properties above, the solid information must be included in the visualization data in accordance with EN/NAS 9300-110.

1.5.2.2.2 Surface / Shell

For level 1 validation, the validation properties for the following must be present:

- Mass properties (i.e. area, centroid, 2D moments of inertia, etc.)
- Surface normal vector (also called the direction vector)
- Topological data
- May store the validation criteria, algorithm, results, and additional checking metadata

For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties:

- Direct comparison (e.g. cloud of point)
- Validation criteria and results

- May store the validation algorithm and additional checking metadata

In addition to the validation properties above, the surface / shell information must be included in the visualization data in accordance with EN/NAS 9300-110 Edition 2.

1.5.2.2.3 Curve

For level 1 validation, the validation properties for the following must be present:

- Length
- Centroid
- Position
- May store the validation criteria, algorithm, results, and additional checking metadata

For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties:

- Direct comparison (e.g. cloud of point)
- Validation criteria and results
- May store the validation algorithm and additional checking metadata

In addition to the validation properties above, the curve information must be included in the visualization data in accordance with EN/NAS 9300-110 Edition 2.

1.5.2.2.4 Point

For level 1 validation, the validation properties for the following must be present:

- Position
- May store the validation criteria, algorithm, results, and additional checking metadata

For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties:

- Validation criteria and results
- May store the validation algorithm and additional checking metadata

In addition to the validation properties above, the point information must be included in the visualization data in accordance with EN/NAS 9300-110 Edition 2.

1.5.2.3 Product and Manufacturing Information (PMI)

PMI included in visualization data must be, at a minimum, graphical polyline presentation information. Validation properties must be included for PMI when present in the visualization data. The following requirements, in coordination with EN/NAS 9300-120, EN/NAS 9300-121, and EN/NAS 9300-125, must be utilized for the inclusion of validation properties for 3D exact geometry.

1.5.2.3.1 Presentation

1.5.2.3.1.1 Character-based presentation

At this time, character-based presentation is out of scope for the visualization LOTAR requirements.

1.5.2.3.1.2 Graphic presentation

1.5.2.3.1.2.1 Polyline Presentation

Polyline presentation information included in visualization data must be in accordance with EN/NAS 9300-120.

1.5.2.3.1.2.2 Tessellated Presentation

Tessellated presentation information included in visualization data must be in accordance with EN/NAS 9300-120.

1.5.2.3.1.2.3 Validation

Graphic presentation of PMI must be validated in accordance with EN/NAS 9300-120.

1.5.2.3.2 Representation (Semantic)

Semantic PMI may not be included in visualization data. If semantic PMI data exists, it must be included and validated in accordance with EN/NAS 9300-121.

1.5.2.3.3 Link / Cross-highlighting

If linking / cross highlighting is included in the master source data, then linking / cross highlighting must be included in the visualization data. Validation properties for the linking / cross highlighting must be included and capture, at a minimum, the following information:

- PMI reference
- Geometry element / feature reference

1.5.2.4 Assembly / Product Structure

Assembly / Product Structure information may be included in the visualization data. If assembly / product structure information exists, it must be included and validated in accordance with the applicable EN / NAS 9300 parts.

1.5.2.5 3D Tessellated Geometry

3D tessellated geometry information included in visualization data must be in accordance with EN/NAS 9300-110.

1.5.2.6 Graphical Properties

Graphical information (i.e. color, texture, etc.) included in visualization data must be in accordance with EN/NAS 9300-110 and EN/NAS 9300-120.

1.5.2.7 View Point

For level 1 validation, the validation properties for the following must be present:

- Camera position
- Element filtering
- Cutting plane
- May store the validation criteria, algorithm, results, and additional checking metadata

For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties:

- Validation criteria and results
- May store the validation algorithm and additional checking metadata

In addition to the validation properties above, the viewpoint information must be included in the visualization data in accordance with EN/NAS 9300-120.

1.5.2.8 Metadata

Metadata information included in visualization data must contain at least provenance information and fixity information. The provenance information from multiple sources combined in a single visualization artifact must be included in a clear and concise manner. If part information exists in the master source data, the part information must be included in the visualization data. If provenance information and fixity information exists in the master source data, the provenance information and fixity information in the master source data must not be included in the visualization data. The provenance information and fixity information included in visualization data must be directly related to the visualization data.

1.5.3 Creation of Artifacts

The preparation of archive data must in in accordance with EN/NAS 9300-010.

1.5.3.1 General

The following are the minimum requirements for the creation of visualization artifacts for the purposes of LOTAR:

- Visualization must have the ability to display graphical 3D GD&T and PMI information
- Visualization data must be able to be validated back to authoritative controlling data in accordance with the validation requirements as defined by this document
- Validation properties must be available in the visualization in accordance with the validation requirements as defined by this document and EN/NAS 9300-003 section 7.3.5.2, EN/NAS 9300-100, and EN/NAS 9300-200
- Visualization must be secured to restrict exporting geometry, copying information, and/or editing the visualization
- Visualization must be capable of displaying BREP and/or tessellated geometry

- Visualization should be able to display all precise representations of geometry accurately, if available
- Visualization should be capable of displaying the product structure of assemblies
- Visualization must have the ability to display other annotations such as general notes, parts lists, etc. that are typically not considered GD&T and/or PMI
- Visualization must have the ability to display standard and custom created model views (also called combination states)

1.5.3.2 Geometry Display

Visualization must be capable of displaying BREP and/or tessellated geometry.

1.5.3.3 Validation Properties

Validation properties must be available in the visualization in accordance with the validation requirements as defined by the VIZ WG and EN/NAS 9300-003 section 7.3.5.2, EN/NAS 9300-100, and EN/NAS 9300-200.

1.5.3.4 Product Structure

Visualization should be capable of displaying the product structure of assemblies.

1.5.3.5 PMI Display

Visualization must have the ability to display graphical 3D GD&T and PMI information.

1.5.3.6 Read Only

Visualization must be locked down to restrict exporting geometry, copying information, and/or editing the visualization.

1.5.3.7 Model Views

Visualization must have the ability to display standard and custom created model views (aka combination states).

1.5.3.8 Annotations

Visualization must have the ability to display other annotations such as general notes, parts lists, etc. that are typically not considered GD&T and/or PMI.

1.5.3.9 Validation

Visualization data must be validated against the master source data in accordance with commonly accepted validation requirements using commonly accepted validation methods.

1.5.3.10 Representation PMI

Visualization should have the ability to store representation (semantic) PMI data

1.5.3.11 Precise Representations

Visualization should be able to display all precise representations of geometry accurately, if available.

1.5.3.12 Filter

Visualization must give the user the ability to filter information from being included in the visualization.

1.5.4 Ingestion of Artifacts

The ingestion of artifacts must be in accordance with EN/NAS 9300-012.

1.5.4.1 Verification

The verification of product data quality must be performed upon submission of the SIP.

1.5.4.1.1 Verification Criteria

The verification criteria should be defined by in accordance with generally accepted requirements and independent of the product data for each type of use case of archived data.

1.5.4.1.2 File Format

File format representation and syntax should be verified.

1.5.4.2 SIP Contents

The contents of the SIP may be:

- Only the native model data
- The native model and the visualization data
- One the visualization data

1.5.4.3 Duplications

The archive must check the SIP contents against existing AIPs to ensure consistency.

1.5.4.4 Metadata

The archive must create the new AIP from the SIP contents and must include the preparation of the metadata information in accordance with OAIS recommendations.

- If the SIP contains only the visualization data, the archive must link the new AIP to an existing AIP that may contain the native model data
- If the SIP contains only the native model data, the archive must create and include the visualization in the new AIP
- If the SIP contains the native model data and the visualization, the archive must include both artifacts in the new AIP

1.5.5 Retrieval of Artifacts

The retrieval of artifacts must be in accordance with EN/NAS 9300-014.

1.5.5.1 Query

The archive must support the user's ability to query and download artifacts from AIPs.

1.5.5.2 Retrieval Process

The retrieval process is as follows:

- The archive must verify that the retrieved data is complete and not corrupt
- The archive must retrieve data in accordance with the appropriate user permissions
- The archive must load the corresponding tool to display and read the visualization
- End to end validation must be completed in accordance with EN/NAS 9300-002

1.5.6 Data Management / Preservation Planning of Artifacts

Utilized standards must facilitate backwards compatibility with all previous versions of the standard used for archival.

1.5.7 Use Cases

1.5.7.1 Internal Use

Scope of the CAD information to be preserved:

Any 3D visualization[1] representation

- 3D geometry (tessellated and/or exact)
- 3D PMI (GD&T, annotation, symbols, user defined attributes)
- Assembly structure,

Domains:

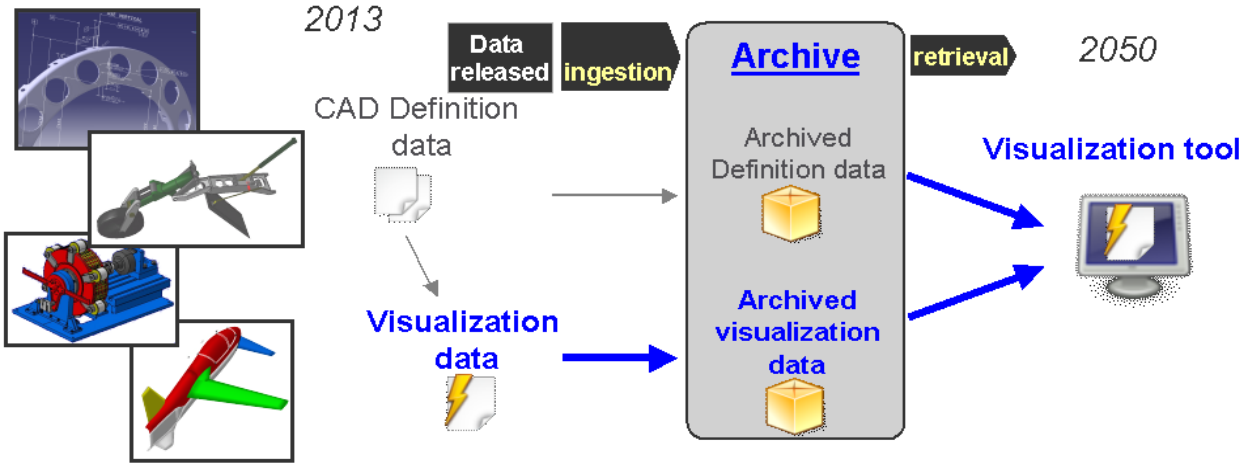
- Mechanical part
- Electrical harness
- Composite part

Out of scope:

- Description of archiving of definition data and retrieval of the data definition in the CAD system
- Out of scope of this version: animation

[1] a process by which displayable product information and presentation information are used to produce a picture (ISO 10303-

Illustration

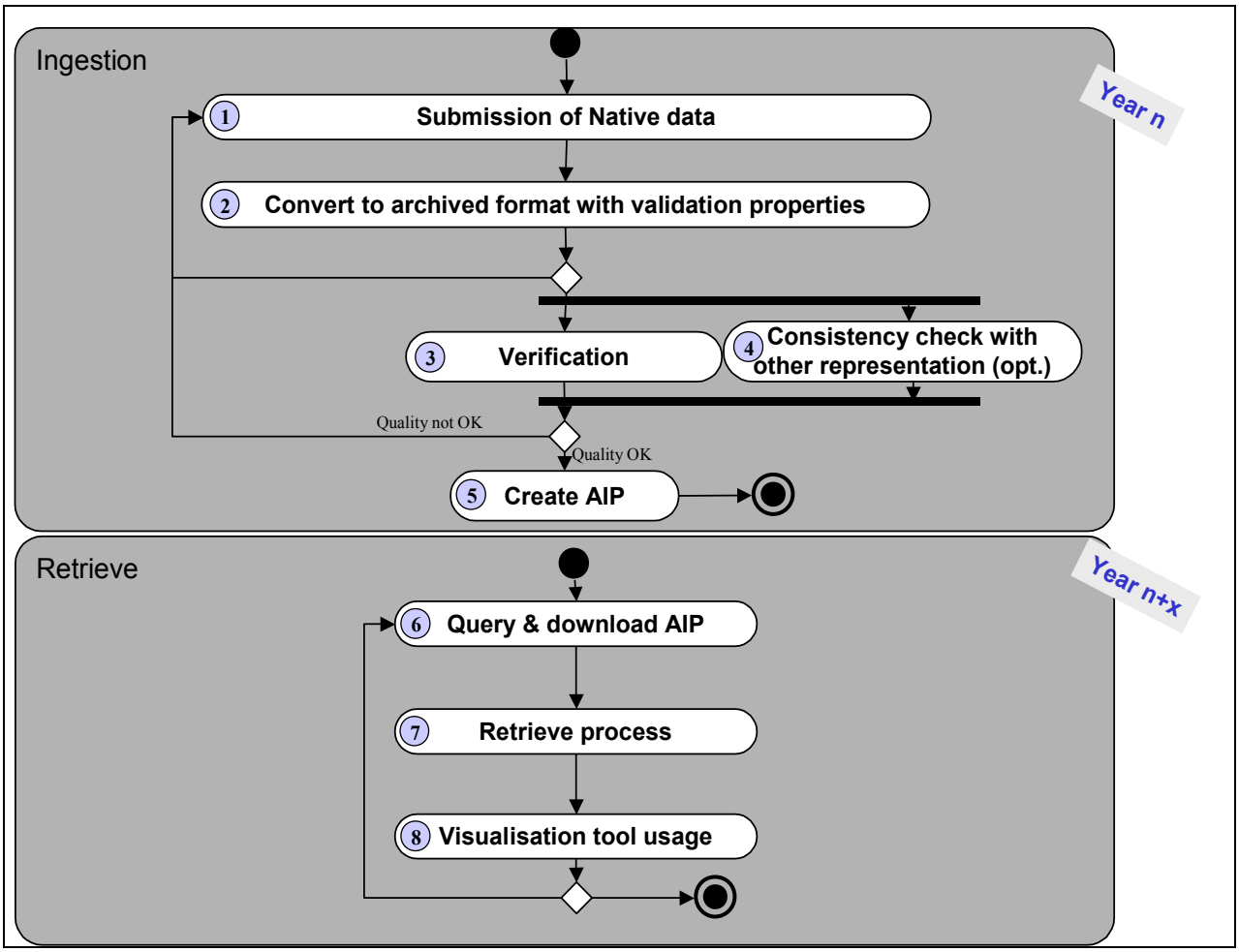


Business needs

Archive visualization data for downstream reuse:

- Manufacturing / assembly line / work instruction
- Design review
- Migration of visualization data
- Analysis

Process diagram



Scenario initiation

Visualization data is used during the released process

Sequence of events within activity:

Ingestion sequence

1. Submission of Native data

   The data are provided in the native format. The data can be a visualization data and/or definition data. See the scenarios describe in appendix

2. Conversion to the archived format with validation properties:
   - Conversion to an open standard format according to EN/NAS 9300-003[2]

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[2] EN/NAS 9300-003 section 4.1.5.4 Format

A standardized open format is a format of data in a syntax, which is defined by a broad community, such as by ISO, and which is independent of specific system or interface. …

EN/NAS 9300-003 section 7.3.3.3 Archive format

- Creation of Validation properties according to EN/NAS 9300-003[3]: The validation properties are generated from the native data. These validation properties will ensure that the archiving and the retrieval processes preserve the essential information:
  - Geometry (tessellated and/or exact)
  - Colors and textures
  - PMI graphical presentation (cross highlight)
  - Predefined views
  - Assembly structure

3. Verification
   Check that the archived data fulfill the quality required:
   - Criteria depending on the company and the types of archived data
   - Format syntax/ file …
4. Consistency check with other representation: The objective is to ensure that the different archived representations are equivalent (e.g. definition, other visualization representation).
   - If the ingestion scenario generates from one SIP two representations, this check must be performed by the ingestion system.
   - If the ingestion scenario generates from one SIP a new representation already archived, it is recommended to perform this check.
   - If only one representation is archived, it is not necessary to perform this check.

   The consistency check shall also take into account the appropriate version/iteration of the model.

5. Create AIP:
   The creation of the Archived information package includes the preparation of the metadata Information. According to the OAIS, the metadata must contain:
   - Reference information: (version / iteration of the part)
   - Context information
   - Fixity information: Authentication information: Hash Functions / Electronic Signature / Time signature/timestamps (see EN-9300-005)
   - Provenance information: For the case of the visualization data, the provenance information must includes if the Archived information Package is generated from the definition data or If the AIP is generated from the visualization data in the native format

Retrieval sequence

6. Query & download AIP
   Query Search according to the descriptive information

For the core models data, representations and formats used shall be open and standardized. "Open" means completely and precisely documented in syntax and semantics and shall be applicable for free.

[3] EN/NAS 9300-003 section 7.3.5.2 Definition of validation properties
The use of validation properties is mandatory, ensuring the data integrity and process security. Recommended subsets of STEP validation properties are described within EN 9300-100 series and EN 9300-200 series.

Download AIPs from the long-term storage

(Assembly case: a set of AIP can be retrieved)

7. Retrieve process:
    - If the retrieve purpose is to visualize data in order to identify data before retrieve of definition data, the retrieve process will consist in:
        1. Checking the information authentication information (ensure that the file was not corrupted)
        2. The loading in the tool *(or Conversion to the visualization format + loading)*
    - If the retrieve purpose is to get the visualization data for certification, the retrieve process will consist in
        1. Check information authentication information (ensure that the file was not corrupted)
        2. Loading in the tool (or Conversion to the visualization format + loading)
        3. Verification / End to End Validation according to EN/NAS 9300-002:[4]
           It ensures that the displayed information is equivalent to the native
            - The end to end validation is a comparison between:
                - Validation properties generated during ingestion with the properties
                - The properties computed in the retrieved data
8. Visualization tool usage

1.5.7.2 External Support

Scope of the CAD information to be preserved:

Any 3D visualization[5] representation

- 3D geometry (tessellated and/or exact)
- 3D PMI (GD&T, annotation, symbols, user defined attributes)
- Assembly structure

Domains:

- Mechanical part
- Electrical harness

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[4] EN/NAS 9300-002 section 7.3.7 Access
7.Validation properties: in case of translation of the archive representation into a native representation, or in case of processing by a viewer based on the archived open formats, the access process shall check the validation properties, and shall inform the Consumer of the result of the comparisons (refer to EN 9300-007 for detailed definition).

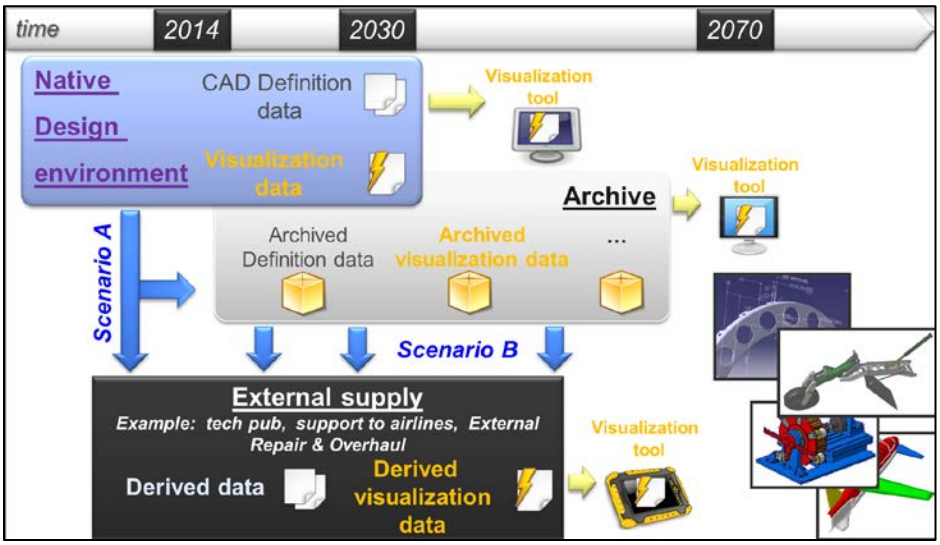
[5] a process by which displayable product information and presentation information are used to produce a picture (ISO 10303-46:1994, 3.2.11). In the context of Long Term Archiving and Retrieval, a visualization format is one where the focus is on the speed and efficiency of the display process for definition data, derived data, and other archived data artifacts.

- Composite part

Out of scope:

- Description of archiving of definition data and retrieval of the data definition in the CAD system
- Out of scope of this version: animation

Illustration

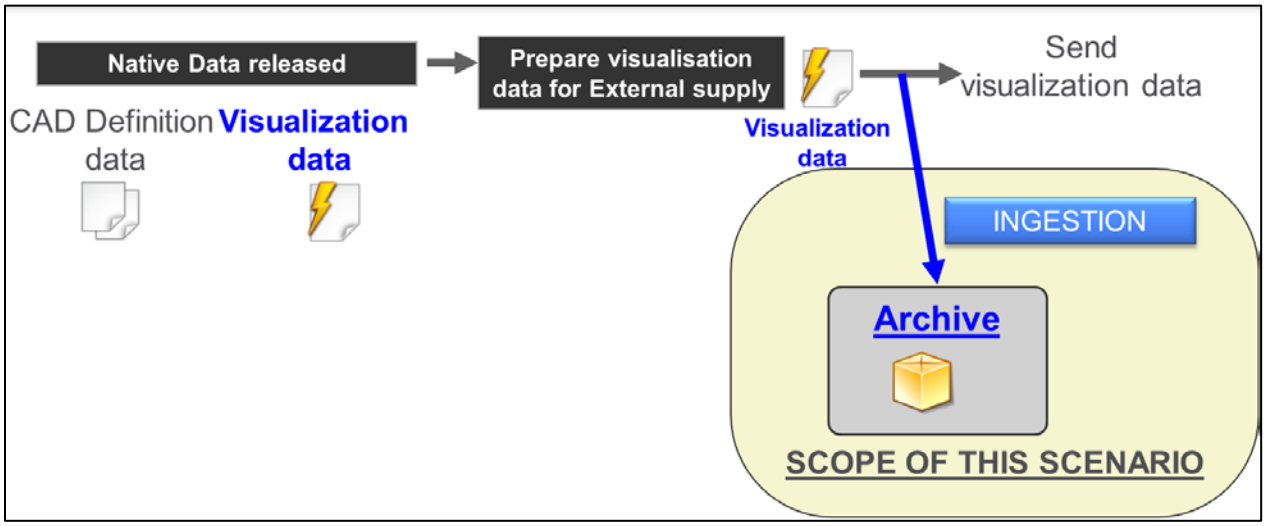


Business needs

- Scenario A: Archived visualization data used for external supply
- Scenario B: retrieve data for external supply

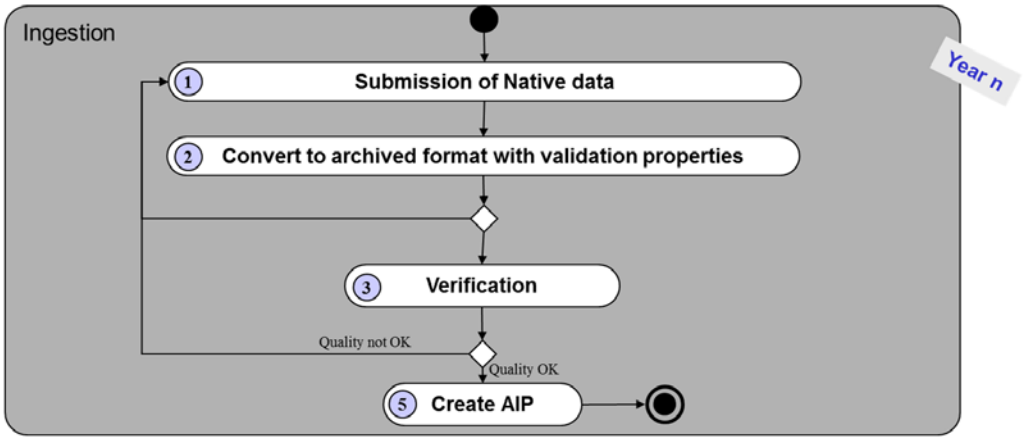
Scenario A: Archived visualization data used for external supply

3D visualization data derived from the definition data can be used for external supply. The purpose of this scenario is the archiving of these visualization data.



The scenarios of ingestion are similar to the scenarios described in the use case "Long term Archiving and Retrieval of derived visualization data for **certification**". As consequence, you can refer to this document for the complete definition of the ingestion scenario.

Process diagram



Scenario initiation

Visualization data is used for an external supply.

Sequence of events within activity:

Ingestion sequence

1. Submission of Native data
   The data are provided in the native format. The data can be a visualization data and/or definition data. See the scenarios describe in appendix
2. Conversion to the archived format with validation properties:
   - Conversion to an open standard format according to EN/NAS 9300-003[6]
   - Creation of Validation properties according to EN/NAS 9300-003[7]: The validation properties are generated from the native data. These validation properties will ensure that the archiving and the retrieval processes preserve the essential information:
     - Geometry (tessellated and/or exact)
     - Colors and textures
     - PMI graphical presentation (cross highlight)
     - Predefined views
     - Assembly structure
3. Verification
   Check that the archived data fulfill the quality required:
   - Criteria depending on the company and the types of archived data
   - format syntaxe/ file …
4. Create AIP:
   The creation of the Archived information package includes the preparation of the metadata Information. According to the OAIS, the metadata must contain:
   - Reference information: (version / iteration of the part)
   - Context information
   - Fixity information: Authentication information: Hash Functions / Electronic Signature / Time signature/timestamps (see EN-9300-005)
   - Provenance information: For the case of the visualization data, the provenance information must includes if the Archived information Package is generated from the definition data or If the AIP is generated from the visualization data in the native format

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[6] EN/NAS 9300-003 section 4.1.5.4 Format
A standardized open format is a format of data in a syntax, which is defined by a broad community, such as by ISO, and which is independent of specific system or interface. …
EN/NAS 9300-003 section 7.3.3.3 Archive format
For the core models data, representations and formats used shall be open and standardized. "Open" means completely and precisely documented in syntax and semantics and shall be applicable for free.

[7] EN/NAS 9300-003 section 7.3.5.2 Definition of validation properties
The use of validation properties is mandatory, ensuring the data integrity and process security. Recommended subsets of STEP validation properties are described within EN 9300-100 series and EN 9300-200 series.

Scenario B: retrieve data for external supply

The purpose of this scenario is the retrieval of data from the archive in a visualization format. The retrieval process includes the capability of filtering/blocking some type of information (for example IP protection). The purpose is to be able to define what are the information retrieved.

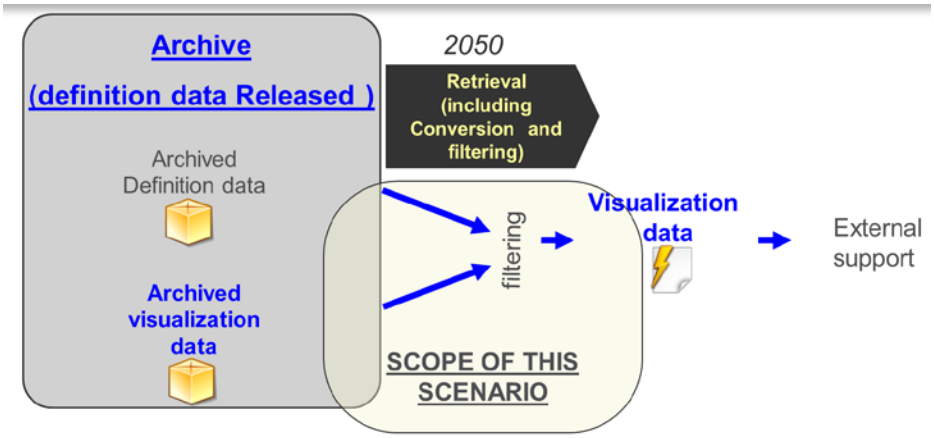
The archived file can be definition or visualization data.

The retrieve is done in a visualization tool or in a visualization format.

For example:

- The archive data contains PMI that should not be provided
- The archive data contains exact data and only the tessellated one should be provided.

Example of scenario: Support to for External Repair & Overhaul



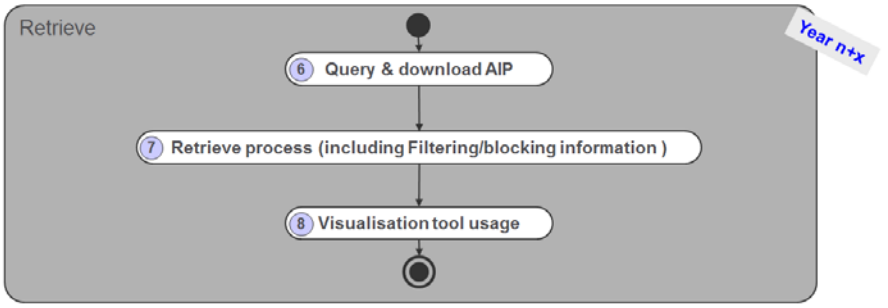
List of information that can be suppressed during the retrieval:

- Exact representation
- PMI
- Metadata
- Font

A retrieval report shall track which information has been filtered.

The remaining information shall be validating with the associated validation properties.

Process diagram



Scenario initiation

Retrieval sequence

6. Query & download AIP
   Query Search according to the descriptive information

   Download AIPs from the long-term storage

   (Assembly case: a set of AIP can be retrieved)

7. Retrieve process:
   - Filtering/blocking information according to the user needs
   - Validation of the remaining data

8. Visualization tool usage

1.5.7.3 Certification

Scope of the CAD information to be preserved

Any 3D visualization[8] representation

- 3D geometry (tessellated and/or exact)
- 3D PMI (GD&T, annotation, symbols, user defined attributes)
- Assembly structure,

Domains:

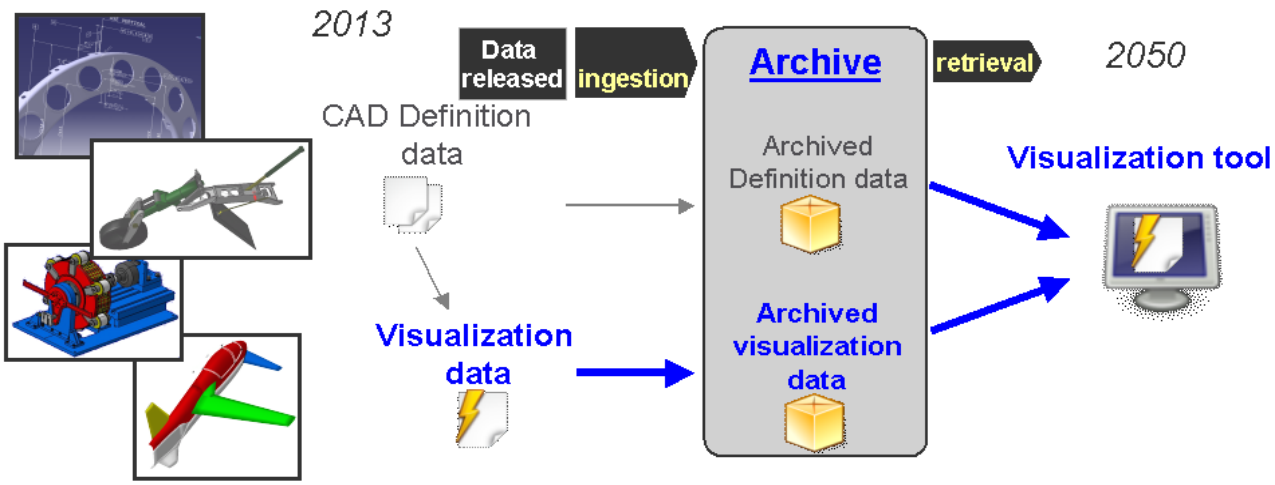
- Mechanical part
- Electrical harness
- Composite part

[8] a process by which displayable product information and presentation information are used to produce a picture (ISO 10303-46:1994, 3.2.11). In the context of Long Term Archiving and Retrieval, a visualization format is one where the focus is on the speed and efficiency of the display process for definition data, derived data, and other archived data artifacts.

Out of scope:

- Description of archiving of definition data and retrieval of the data definition in the CAD system
- Out of scope of this version: animation

Illustration



Business needs

Currently, the other LOTAR parts are focused on the description of archiving and retrieval of definition data.

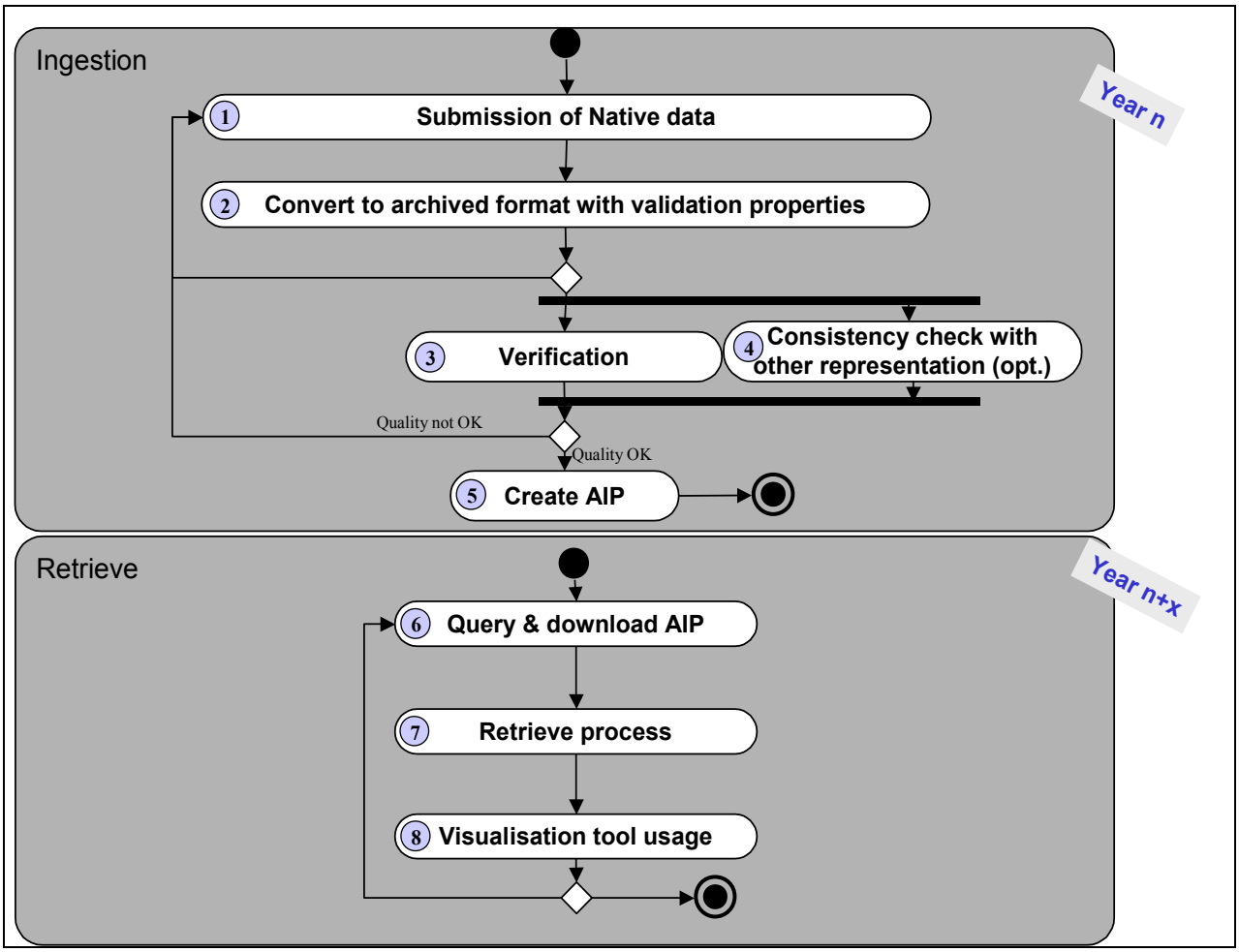
The visualization data is beginning to be used in the certification process of the product.

For this reason the archival process has to ensure verification and validation in order to ensure that the data provided after retrieval is visually equivalent to the original data

The benefit will be to have a consistent approach of archiving and retrieval of exact and the associated visualization data.

Some company can also have the need to retrieve the definition data into a visualization tool instead of the CAD tool.

Process diagram



Scenario initiation

Visualization data is used during the released process

Sequence of events within activity

Ingestion sequence

1. Submission of Native data

The data are provided in the native format. The data can be a visualization data and/or definition data. See the scenarios describe in appendix

2. Conversion to the archived format with validation properties:

    - Conversion to an open standard format according to EN/NAS 9300-003[9]

[9] EN/NAS 9300-003 section 4.1.5.4 Format

- Creation of Validation properties according to EN/NAS 9300-003[10]: The validation properties are generated from the native data. These validation properties will ensure that the archiving and the retrieval processes preserve the essential information:
    - Geometry (tessellated and/or exact)
    - Colors and textures
    - PMI graphical presentation (cross highlight)
    - Predefined views
    - Assembly structure

3. Verification

Check that the archived data fulfill the quality required:

- Criteria depending on the company and the types of archived data
- format syntaxe/ file …

4. Consistency check with other representation: The objective is to ensure that the different archived representations are equivalent (e.g. definition , other visualization representation).
    - If the ingestion scenario generates from one SIP two representations, this check must be performed by the ingestion system.
    - If the ingestion scenario generates from one SIP a new representation already archived, it is recommended to perform this check.
    - If only one representation is archived, it is not necessary to perform this check.

The consistency check shall also take into account the appropriate version/iteration of the model.

5. Create AIP:

The creation of the Archived information package includes the preparation of the metadata Information. According to the OAIS, the metadata must contain:

- Reference information: (version / iteration of the part)
- Context information

A standardized open format is a format of data in a syntax, which is defined by a broad community, such as by ISO, and which is independent of specific system or interface. …

EN/NAS 9300-003 section 7.3.3.3 Archive format

For the core models data, representations and formats used shall be open and standardized. "Open" means completely and precisely documented in syntax and semantics and shall be applicable for free.

[10] EN/NAS 9300-003 section 7.3.5.2 Definition of validation properties

The use of validation properties is mandatory, ensuring the data integrity and process security. Recommended subsets of STEP validation properties are described within EN 9300-100 series and EN 9300-200 series.

- Fixity information: Authentication information: Hash Functions / Electronic Signature / Time signature/timestamps (see EN-9300-005)
- Provenance information: For the case of the visualization data, the provenance information must includes if the Archived information Package is generated from the definition data or If the AIP is generated from the visualization data in the native format

Retrieval sequence

6. Query & download AIP
   - Query Search according to the descriptive information
   - Download AIPs from the long-term storage (Assembly case: a set of AIP can be retrieved)
7. Retrieve process:
   - If the retrieve purpose is to visualize data in order to identify data before retrieve of definition data, the retrieve process will consist in:
     1. Checking the information authentication information (ensure that the file was not corrupted)
     2. The loading in the tool *(or Conversion to the visualization format + loading)*
   - If the retrieve purpose is to get the visualization data for certification, the retrieve process will consist in
     1. Check information authentication information (ensure that the file was not corrupted)
     2. Loading in the tool (or Conversion to the visualization format + loading)
     3. Verification / End to End Validation according to EN/NAS 9300-002:[11] It ensures that the displayed information is equivalent to the native
        - The end to end validation is a comparison between:
          - Validation properties generated during ingestion with the properties
          - The properties computed in the retrieved data
8. Visualization tool usage

Actors for both sub processes

- Actor or batch process

[11] EN/NAS 9300-002 section 7.3.7 Access
7.Validation properties: in case of translation of the archive representation into a native representation, or in case of processing by a viewer based on the archived open formats, the access process shall check the validation properties, and shall inform the Consumer of the result of the comparisons (refer to EN 9300-007 for detailed definition).

- Specific team for error handling and healing

Controls

"Ingestion" sub process:

- Quality control of the generated neutral models to be archived (year n), Check the conversion with the verification rules and the validation properties. Resulting information: the reports of - conversion, - validation, - and verification (to be archived).

"Retrieval" sub process:

- Quality control of the retrieved CAD 3D native models in the target CAD system (year $n + x$)
  Check the conversion with the verification rules and the validation properties. Resulting information: the reports of "conversion", "validation", and "verification".

Internal decision points

- Error handling/healing sub processes (e.g., the original CAD 3D native models to be archived are incorrect due to bugs, etc., and have to be fixed)

Scenario results (Conditions)

- The "Ingestion" sub process:
  - Successful: the neutral models are archived in one or a set of AIPs in Year (n)
  - Fail: conversion errors and/or quality control check failures.
- The "Retrieval" sub process
  - Successful: the resulting visualization models in the "target" system in operation in Year ($n + x$) can be used (Certification, support in operation)
  - Fail: conversion errors and/or quality control check failures.

Exception handling

Not described for this generic use case.

Performance requirements/Service level agreements

Not described for this generic use case.

Appendix A: Diagram

Business

NA

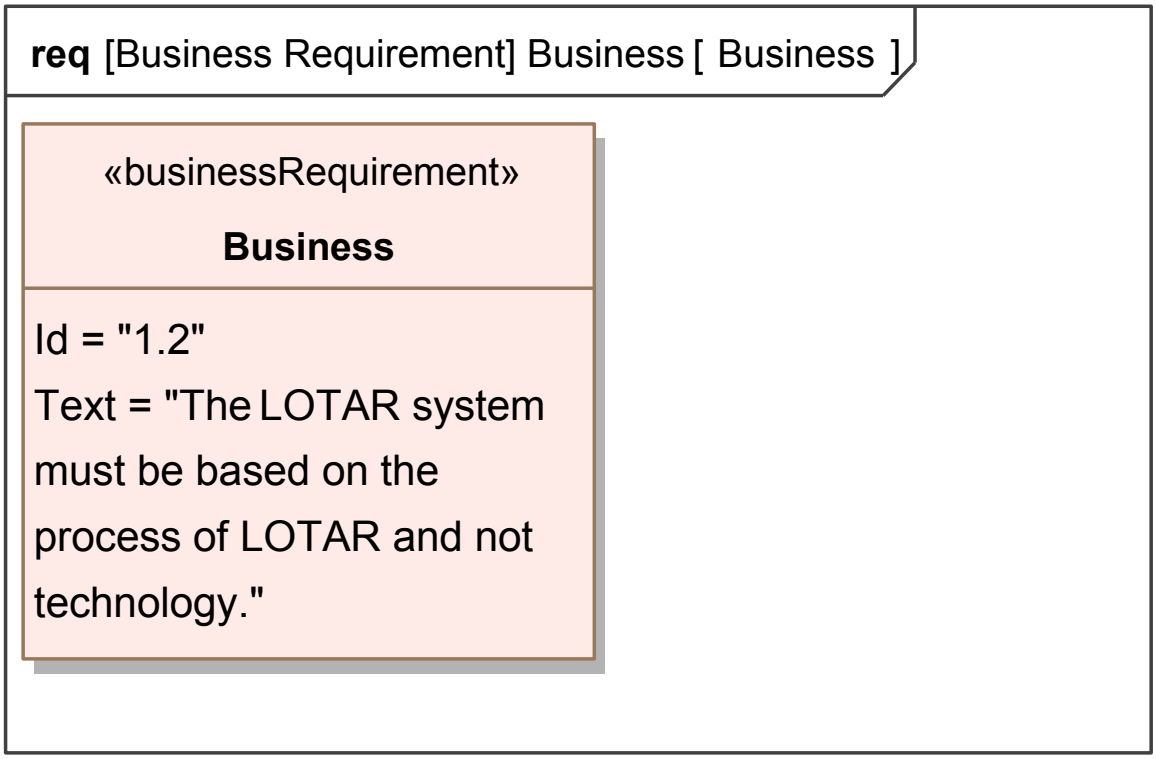


Figure 8. Business

General

NA

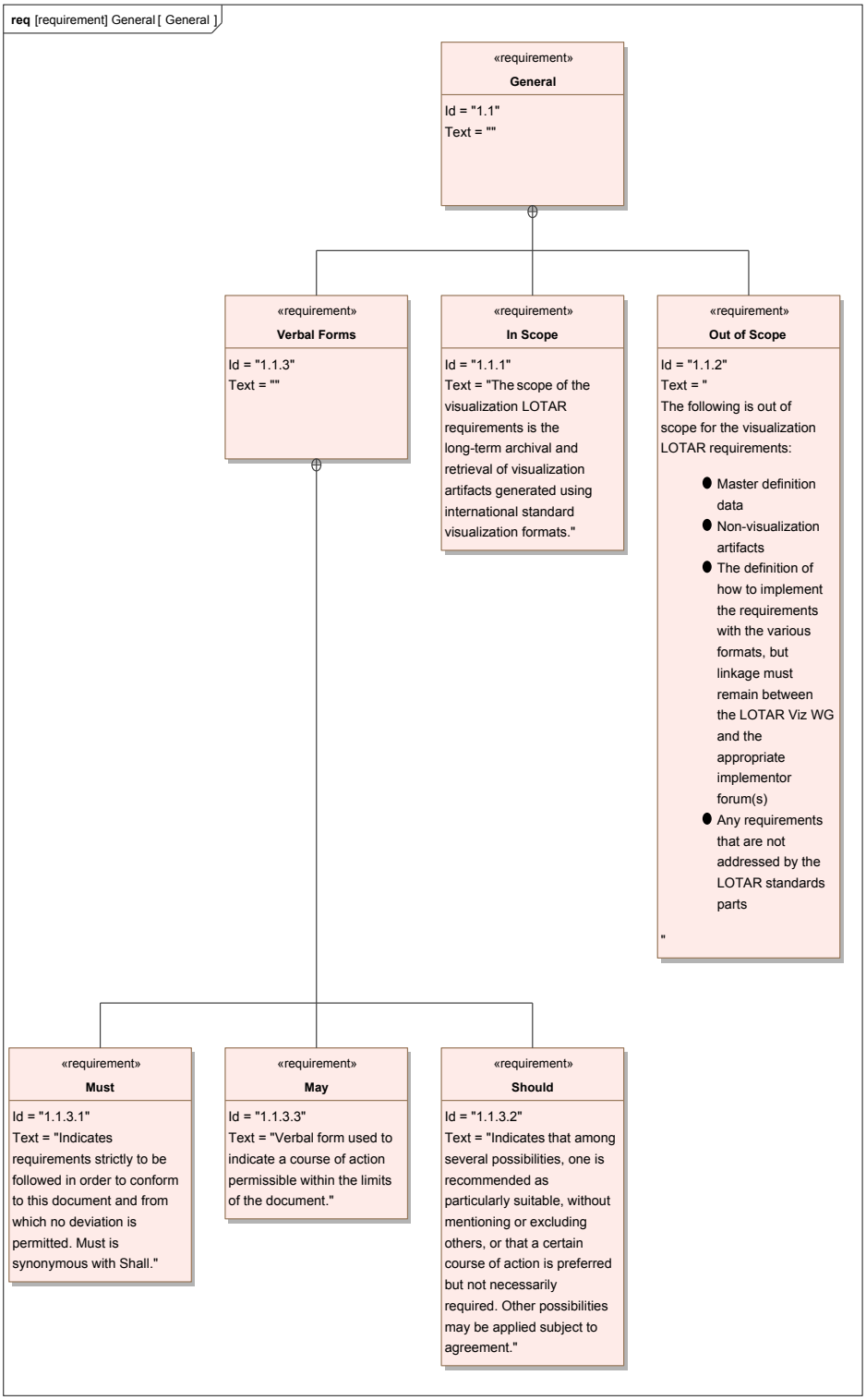


Figure 9. General (vector graphic, zoom for readability)

Interface

NA

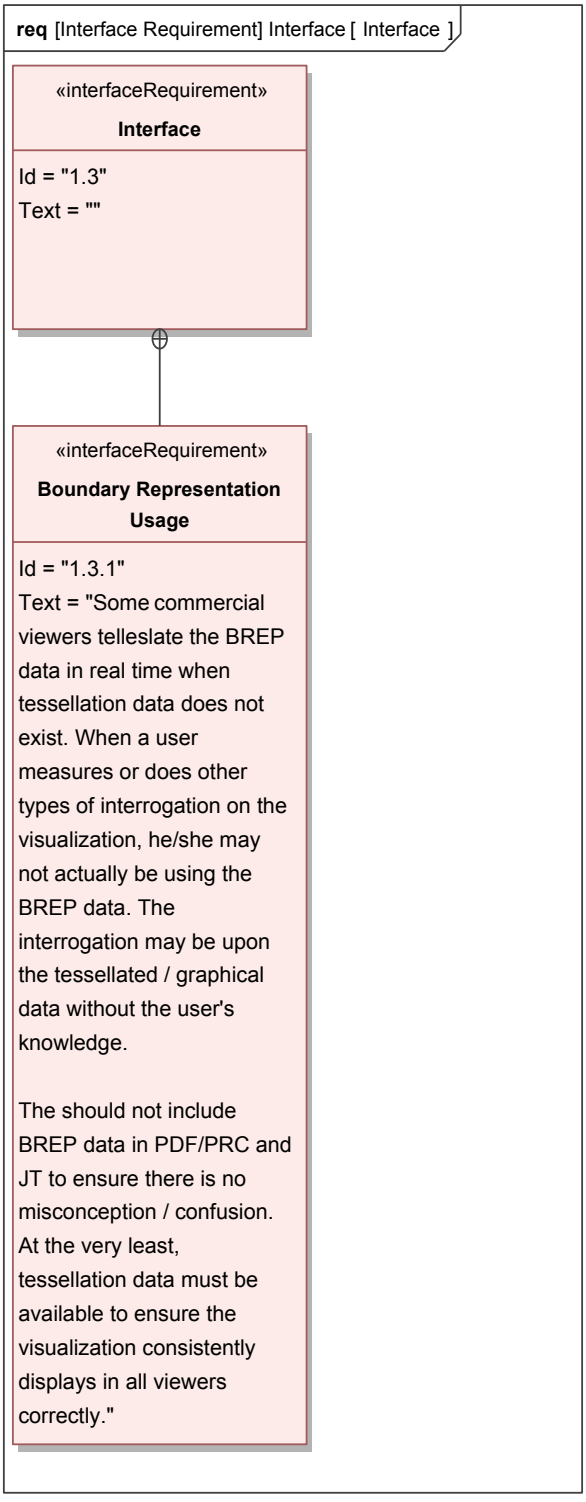
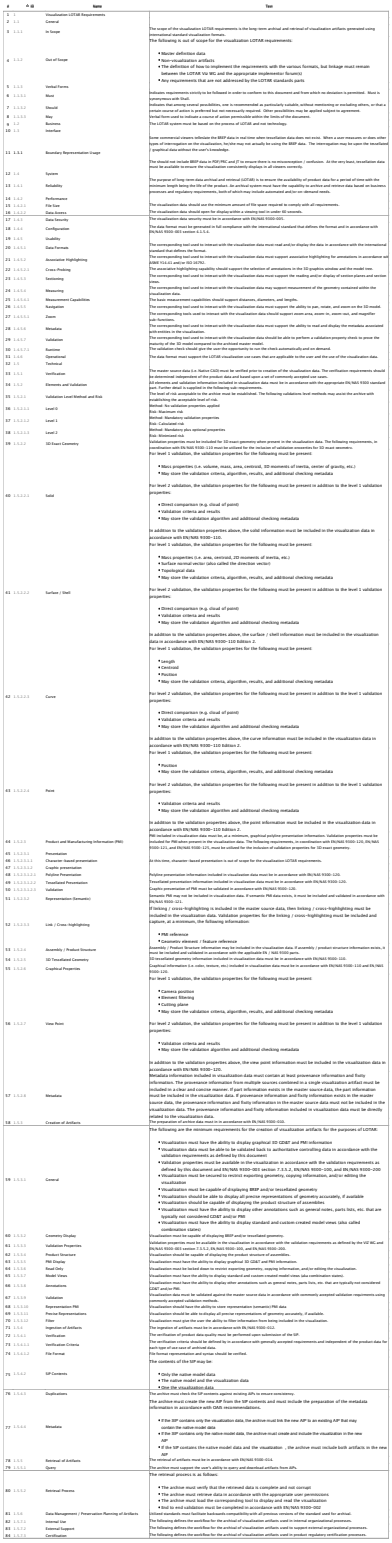


Figure 10. Interface

Requirements Table

NA



#	^ ID	Name	Text
1	1	Visualisation LOTAR Requirements	
2	1.1	General	
3	1.1.1	In Scope	The scope of the visualization LOTAR requirements is the long-term archival and retrieval of visualization artifacts generated using international standard visualization formats. The following is out of scope for the visualization LOTAR requirements:
4	1.1.2	Out of Scope	• Master definition data • Non-visualization artifacts • The definition of how to implement the requirements with the various formats, but linkage must remain between the LOTAR We WG and the appropriate implementor forum(s) • Any requirements that are not addressed by the LOTAR standards parts
5	1.1.3	Verbal Forms	
6	1.1.3.1	Must	Indicates requirements strictly to be followed in order to conform to this document and from which no deviation is permitted. Must is synonymous with Shall.
7	1.1.3.2	Should	Indicates that among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required. Other possibilities may be applied subject to agreement.
8	1.1.3.3	May	Verbal form used to indicate a course of action permissible within the limits of the document.
9	1.2	Business	The LOTAR system must be based on the process of LOTAR and not technology.
10	1.3	Interface	
11	1.3.1	Boundary Representation Usage	Some commercial viewers reflection the BREP data in real time when visualization data does not exist. When a user measures or does other types of interrogation on the visualization, he/she may not actually be using the BREP data. The interrogation may be upon the tessellated / graphical data without the user's knowledge. The should not include BREP data in PDF/PRC and JT to ensure there is no misconception / confusion. At the very least, tessellation data must be available to ensure the visualization consistently displays in all viewers correctly.
12	1.4	System	
13	1.4.1	Reliability	The purpose of long-term data archival and retrieval (LOTAR) is to ensure the availability of product data for a period of time with the minimum length being the life of the product. An archival system must have the capability to archive and retrieve data based on business, processes and regulatory requirements, both of which may include automated and/or on-demand needs.
14	1.4.2	Performance	
15	1.4.2.1	File Size	The visualization data should use the minimum amount of file space required to comply with all requirements.
16	1.4.2.2	Data Access	The visualization data should open for display within a viewing tool in under 60 seconds.
17	1.4.3	Data Security	The visualization data security must be in accordance with EN/NAS 9300-001.
18	1.4.4	Configuration	The data format must be generated in full compliance with the international standard that defines the format and in accordance with EN/NAS 9300-001 section 4.1.3.4.
19	1.4.5	Usability	
20	1.4.5.1	Data Formats	The corresponding tool used to interact with the visualization data must read and/or display the data in accordance with the international standard that defines the format.
21	1.4.5.2	Associative Highlighting	The corresponding tool used to interact with the visualization data must support associative highlighting for annotations in accordance with ASME Y14.41 and/or ISO 16792.
22	1.4.5.2.1	Cross Probing	The associative highlighting capability should support the selection of annotations in the 3D graphics window and the model tree.
23	1.4.5.3	Sectioning	The corresponding tool used to interact with the visualization data must support the creating and/or display of section planes and section views.
24	1.4.5.4	Measuring	The corresponding tool used to interact with the visualization data may support measurement of the geometry contained within the visualization data.
25	1.4.5.4.1	Measurement Capabilities	The basic measurement capabilities should support distances, diameters, and lengths.
26	1.4.5.5	Navigation	The corresponding tool used to interact with the visualization data must support the ability to pan, rotate, and zoom on the 3D model.
27	1.4.5.5.1	Zoom	The corresponding tools used to interact with the visualization data should support zoom area, zoom in, zoom out, and magnifier sub-functions.
28	1.4.5.6	Metadata	The corresponding tool used to interact with the visualization data must support the ability to read and display the metadata associated with entities in the visualization.
29	1.4.5.7	Validation	The corresponding tool used to interact with the visualization data should be able to perform a validation property check to prove the validity of the visualization data in accordance with this standard.
30	1.4.5.7.1	Runtime	The validation check should give the user the opportunity to run the check automatically and on demand.
31	1.4.6	Operational	The data format must support the LOTAR visualization use cases that are applicable to the user and the use of the visualization data.
32	1.5	Technical	
33	1.5.1	Verification	The master source data (i.e. Native CAD) must be verified prior to creation of the visualization data. The verification requirements should be determined independent of the product data and based upon a set of commonly accepted use cases.
34	1.5.2	Elements and Validation	All elements and validation information included in visualization data must be in accordance with the appropriate EN/NAS 9300 standard part. Further detail is supplied in the following sub-requirements.
35	1.5.2.1	Validation Level Method and Risk	The level of risk acceptable to the archive must be established. The following validations level methods may assist the archive with determining the appropriate level.
36	1.5.2.1.1	Level 0	Method: No validation properties applied Risk: Maximum risk
37	1.5.2.1.2	Level 1	Method: Mandatory validation properties Risk: Calculated risk
38	1.5.2.1.3	Level 2	Method: Mandatory plus optional properties Risk: Minimized risk
39	1.5.2.2	3D Exact Geometry	Validation properties must be included for 3D exact geometry when present in the visualization data. The following requirements, in coordination with EN/NAS 9300-110 must be utilized for the inclusion of validation properties for 3D exact elements. For level 1 validation, the validation properties for the following must be present:
40	1.5.2.2.1	Solid	• Mass properties (i.e. volume, mass, area, centroid, 3D moments of inertia, center of gravity, etc.) • May store the validation criteria, algorithm, results, and additional checking metadata For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties: • Direct comparison (e.g. cloud of point) • Validation criteria and results • May store the validation algorithm and additional checking metadata In addition to the validation properties above, the solid information must be included in the visualization data in accordance with EN/NAS 9300-110.
41	1.5.2.2.2	Surface / Shell	For level 1 validation, the validation properties for the following must be present: • Mass properties (i.e. area, centroid, 2D moments of inertia, etc.) • Surface normal vector (also called the direction vector) • Topological data • May store the validation criteria, algorithm, results, and additional checking metadata For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties: • Direct comparison (e.g. cloud of point) • Validation criteria and results • May store the validation algorithm and additional checking metadata In addition to the validation properties above, the surface / shell information must be included in the visualization data in accordance with EN/NAS 9300-110 Edition 2.
42	1.5.2.2.3	Curve	For level 1 validation, the validation properties for the following must be present: • Length • Centroid • Position • May store the validation criteria, algorithm, results, and additional checking metadata For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties: • Direct comparison (e.g. cloud of point) • Validation criteria and results • May store the validation algorithm and additional checking metadata In addition to the validation properties above, the curve information must be included in the visualization data in accordance with EN/NAS 9300-110 Edition 2.
43	1.5.2.2.4	Point	For level 1 validation, the validation properties for the following must be present: • Position • May store the validation criteria, algorithm, results, and additional checking metadata For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties: • Validation criteria and results • May store the validation algorithm and additional checking metadata In addition to the validation properties above, the point information must be included in the visualization data in accordance with EN/NAS 9300-110 Edition 2.
44	1.5.2.3	Product and Manufacturing Information (PMI)	PMI included in visualization data must be, at a minimum, graphical polyline presentation information. Validation properties must be included for PMI when present in the visualization data. The following requirements, in coordination with EN/NAS 9300-120, EN/NAS 9300-121, and EN/NAS 9300-125, must be utilized for the inclusion of validation properties for 3D exact geometry.
45	1.5.2.3.1	Presentation	
46	1.5.2.3.1.1	Character-based presentation	At this time, character-based presentation is out of scope for the visualization LOTAR requirements.
47	1.5.2.3.1.2	Graphic presentation	
48	1.5.2.3.1.2.1	Polyline Presentation	Polyline presentation information included in visualization data must be in accordance with EN/NAS 9300-120.
49	1.5.2.3.1.2.2	Tessellated Presentation	Tessellated presentation information included in visualization data must be in accordance with EN/NAS 9300-120.
50	1.5.2.3.1.2.3	Validation	Graphic presentation of PMI must be validated in accordance with EN/NAS 9300-120.
51	1.5.2.3.2	Representation (Semantic)	Semantic PMI may not be included in visualization data. If semantic PMI data exists, it must be included and validated in accordance with EN/NAS 9300-121.
52	1.5.2.3.3	Link / Cross-highlighting	If linking / cross-highlighting is included in the master source data, then linking / cross-highlighting must be included in the visualization data. Validation properties for the linking / cross-highlighting must be included and captured, at a minimum, the following information: • PMI reference • Geometry element / feature reference
53	1.5.2.4	Assembly / Product Structure	Assembly / Product Structure information must be included in the visualization data. If assembly / product structure information exists, it must be included and validated in accordance with the applicable EN / NAS 9300 parts.
54	1.5.2.5	3D Tessellated Geometry	3D tessellated geometry information included in visualization data must be in accordance with EN/NAS 9300-110.
55	1.5.2.6	Graphical Properties	Graphical information (i.e. color, texture, etc.) included in visualization data must be in accordance with EN/NAS 9300-110 and EN/NAS 9300-120. For level 1 validation, the validation properties for the following must be present: • Camera position • Element filtering • Cutting plane • May store the validation criteria, algorithm, results, and additional checking metadata
56	1.5.2.7	View Point	For level 2 validation, the validation properties for the following must be present in addition to the level 1 validation properties: • Validation criteria and results • May store the validation algorithm and additional checking metadata In addition to the validation properties above, the view point information must be included in the visualization data in accordance with EN/NAS 9300-120.
57	1.5.2.8	Metadata	Metadata information included in visualization data must contain at least provenance information and fixity information. The provenance information from multiple sources combined in a single visualization artifact must be included in a clear and concise manner. If part information exists in the master source data, the part information must be included in the visualization data. If provenance information and fixity information exists in the master source data, the provenance information and fixity information in the master source data must not be included in the visualization data. The provenance information and fixity information included in visualization data must be directly related to the visualization data.
58	1.5.3	Creation of Artifacts	The preparation of archive data must in in accordance with EN/NAS 9300-020.
59	1.5.3.1	General	The following are the minimum requirements for the creation of visualization artifacts for the purposes of LOTAR: • Visualization must have the ability to display graphical 3D GD&T and PMI information • Visualization data must be able to be validated back to authoritative controlling data in accordance with the validation requirements as defined by this document • Validation properties must be available in the visualization in accordance with the validation requirements as defined by this document and EN/NAS 9300-003 section 7.5.5.2, EN/NAS 9300-100, and EN/NAS 9300-200. • Visualization must be secured to restrict exporting geometry, copying information, and/or editing the visualization • Visualization must be capable of displaying BREP and/or tessellated geometry • Visualization should be able to display all precise representations of geometry accurately, if available • Visualization should be capable of displaying the product structure of assemblies • Visualization must have the ability to display other annotations such as general notes, parts lists, etc. that are typically not considered GD&T and/or PMI • Visualization must have the ability to display standard and custom created model views (aka combination states)
60	1.5.3.2	Geometry Display	Visualization must be capable of displaying BREP and/or tessellated geometry.
61	1.5.3.3	Validation Properties	Validation properties must be available in the visualization in accordance with the validation requirements as defined by the VIZ WG and EN/NAS 9300-003 section 7.5.5.2, EN/NAS 9300-100, and EN/NAS 9300-200.
62	1.5.3.4	Product Structure	Visualization should be capable of displaying the product structure of assemblies.
63	1.5.3.5	PMI Display	Visualization must have the ability to display graphical 3D GD&T and PMI information.
64	1.5.3.6	Read Only	Visualization must be locked down to restrict exporting geometry, copying information, and/or editing the visualization.
65	1.5.3.7	Model Views	Visualization must have the ability to display standard and custom created model views (aka combination states).
66	1.5.3.8	Annotations	Visualization must have the ability to display other annotations such as general notes, parts lists, etc. that are typically not considered GD&T and/or PMI.
67	1.5.3.9	Validation	Visualization data must be validated against the master source data in accordance with commonly accepted validation requirements using commonly accepted validation methods.
68	1.5.3.10	Representation PMI	Visualization should have the ability to store representation (semantic) PMI data.
69	1.5.3.11	Precise Representations	Visualization should be able to display all precise representations of geometry accurately, if available.
70	1.5.3.12	Filter	Visualization must give the user the ability to filter information from being included in the visualization.
71	1.5.4	Ingestion of Artifacts	The ingestion of artifacts must be in accordance with EN/NAS 9300-014.
72	1.5.4.1	Verification	The verification of product data quality must be performed upon submission of the SIP.
73	1.5.4.1.1	Verification Criteria	The verification criteria should be defined by in accordance with generally accepted requirements and independent of the product data for each type of use case of archived data.
74	1.5.4.1.2	File Format	The format representation and syntax should be verified.
75	1.5.4.2	SIP Contents	The contents of the SIP may be: • Only the native model data • The native model and the visualization data • Only the visualization data
76	1.5.4.3	Duplicates	The archive must check the SIP contents against existing AIPs to ensure consistency.
77	1.5.4.4	Metadata	The archive must create the new AIP from the SIP contents and must include the preparation of the metadata information in accordance with OAIS recommendations. • If the SIP contains only the visualization data, the archive must link the new AIP to an existing AIP that may contain the native model data • If the SIP contains only the native model data, the archive must create and include the visualization in the new AIP • If the SIP contains the native model data and the visualization , the archive must include both artifacts in the new AIP
78	1.5.5	Retrieval of Artifacts	The retrieval of artifacts must be in accordance with EN/NAS 9300-014.
79	1.5.5.1	Query	The archive must support the user's ability to query and download artifacts from AIPs.
80	1.5.5.2	Retrieval Process	The retrieval process is as follows: • The archive must verify that the retrieved data is complete and not corrupt • The archive must retrieve data in accordance with the appropriate user permissions • The archive must load the corresponding tool to display and read the visualization • End to end validation must be completed in accordance with EN/NAS 9300-002
81	1.5.6	Data Management / Preservation Planning of Artifacts	Utilized standards must facilitate backwards compatibility with all previous versions of the standard used for archival.
82	1.5.7.1	Internal Use	The following defines the workflow for the archival of visualization artifacts used in internal organizational processes.
83	1.5.7.2	External Support	The following defines the workflow for the archival of visualization artifacts used to support external organizational processes.
84	1.5.7.3	Certification	The following defines the workflow for the archival of visualization artifacts used in product regulatory certification processes.

Figure 11. Requirements Table (vector graphic, zoom for readability)

System

NA

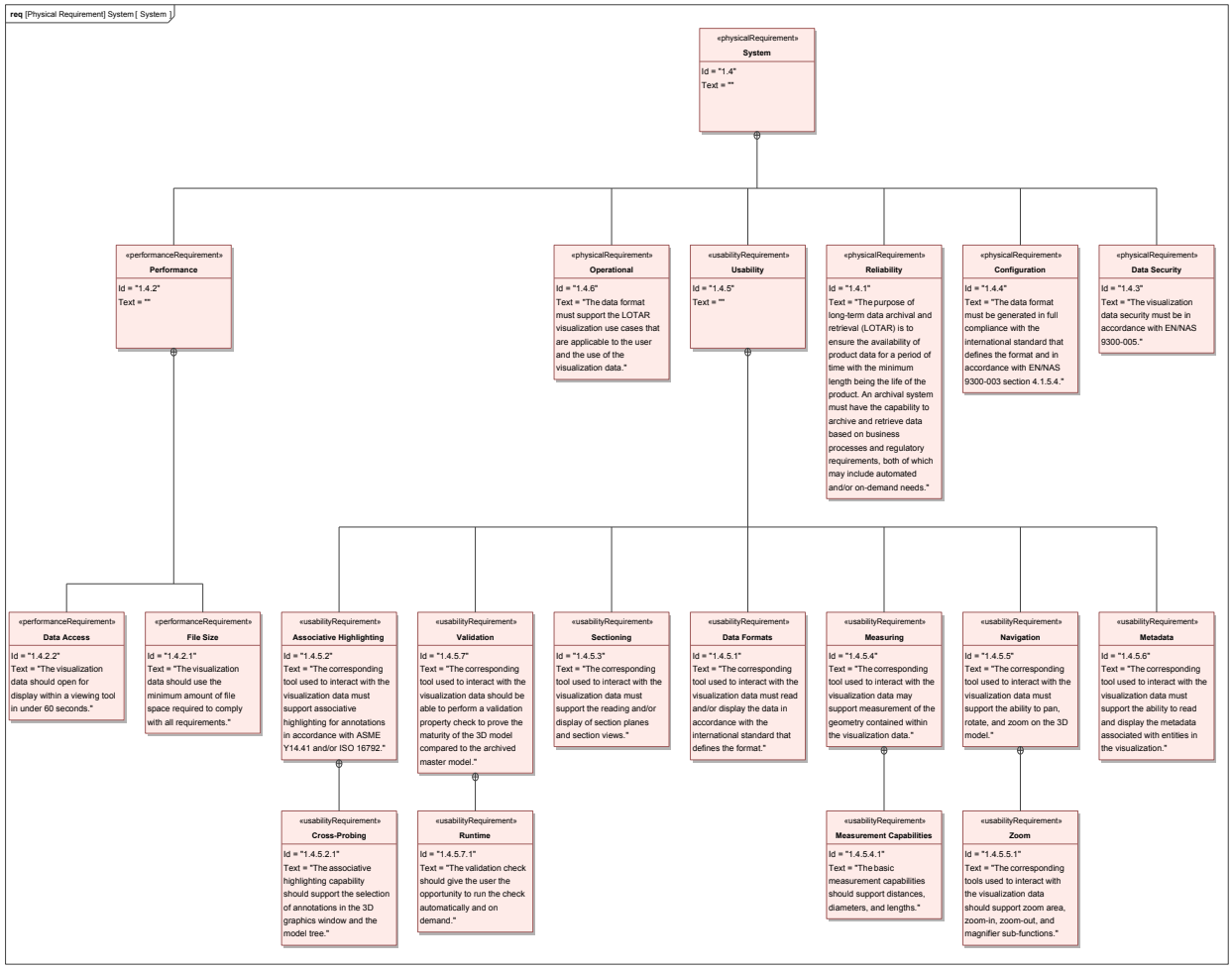


Figure 12. System (vector graphic, zoom for readability)

Technical

NA

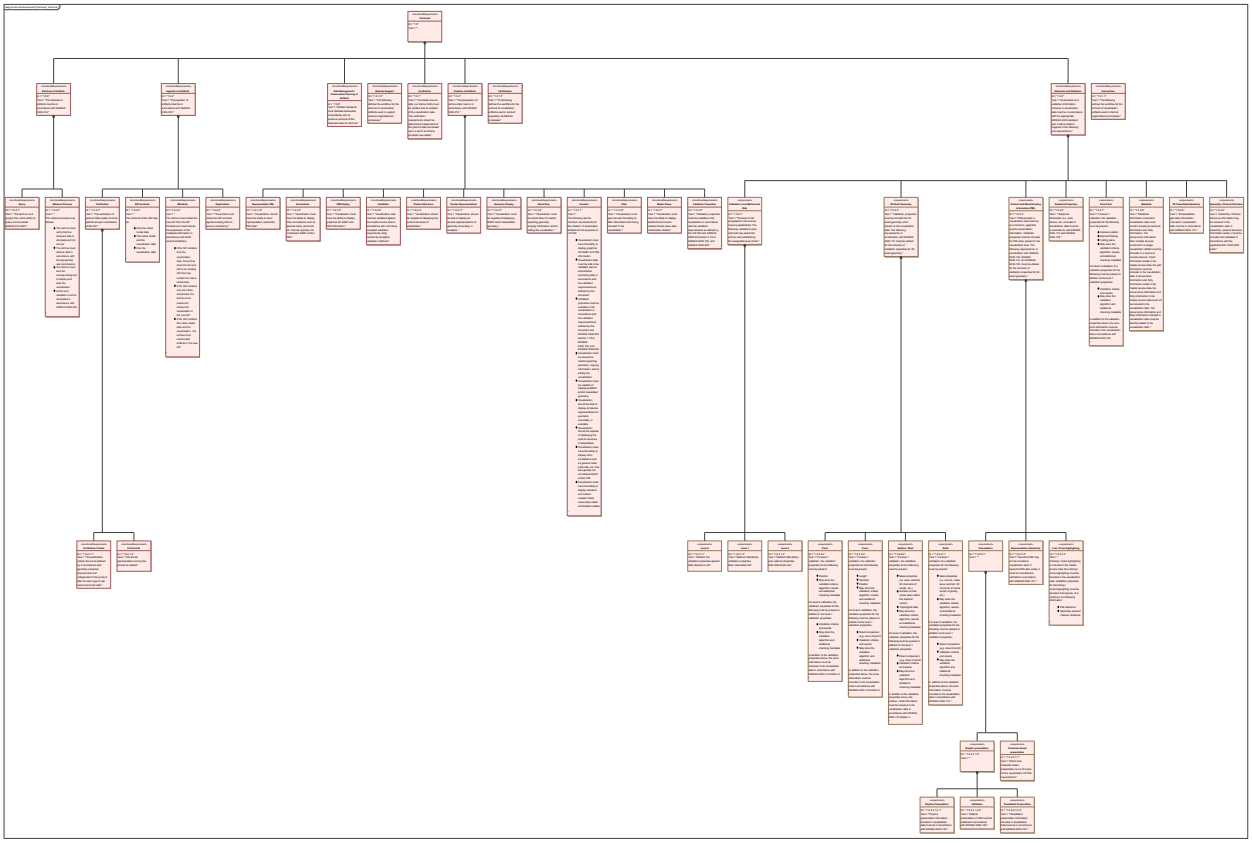


Figure 13. Technical (vector graphic, zoom for readability)

Visualization LOTAR Requirements

NA

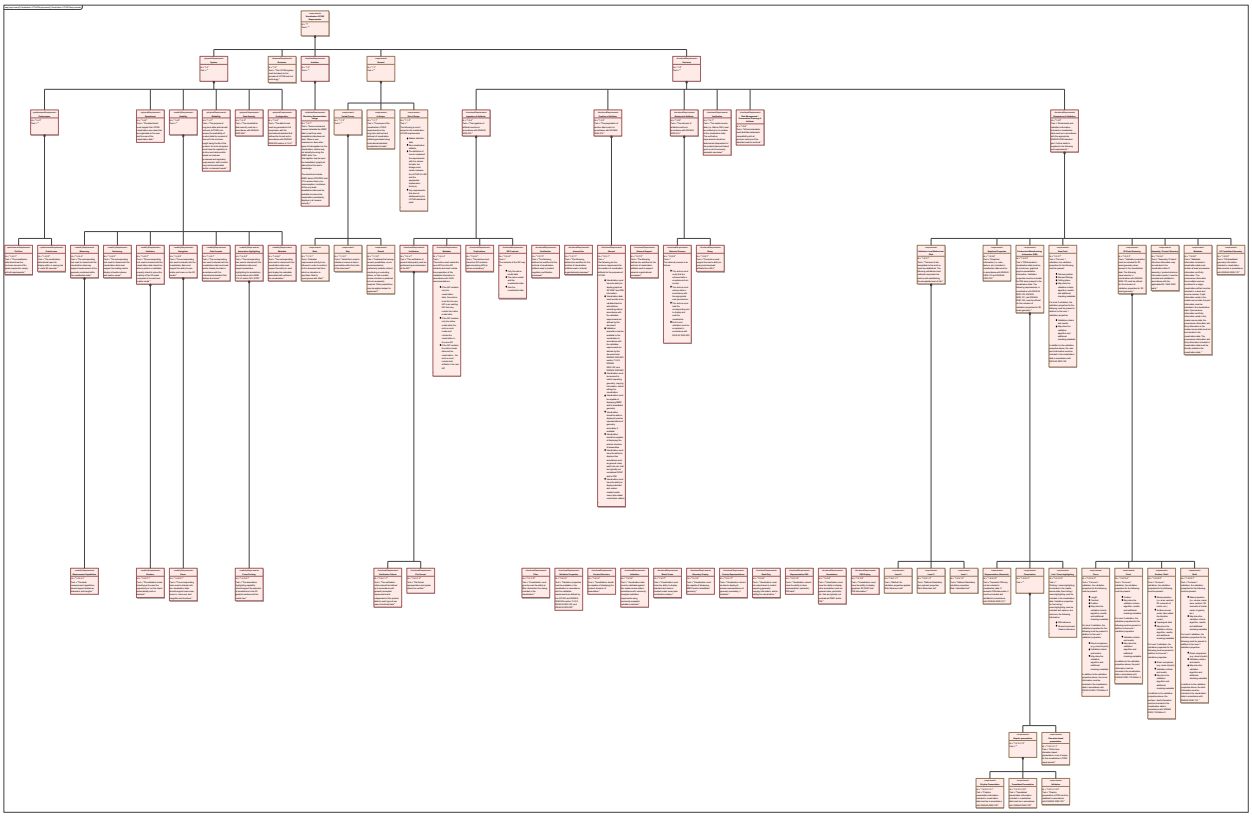


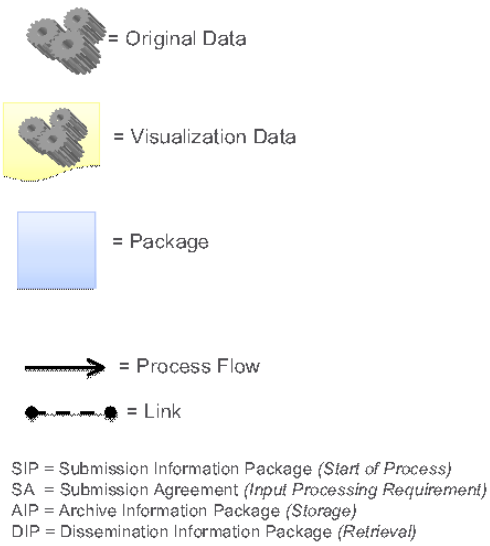
Figure 14. Visualization LOTAR Requirements (vector graphic, zoom for readability)

Appendix B: Certification Use Case Scenarios

Introduction:

The following section describes the possible scenario of visualization identified by the workgroup. Some scenario are identified in the following section but are not recommended

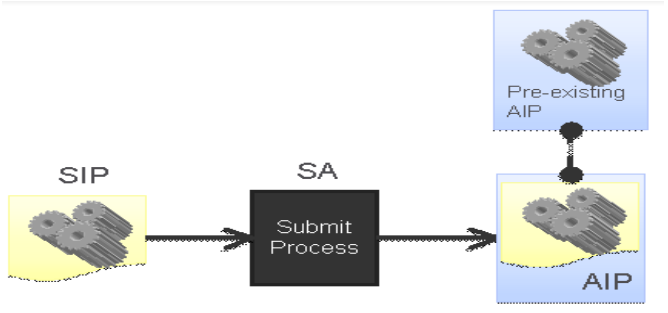
Legend of the illustrations:



Ingestion scenario of part

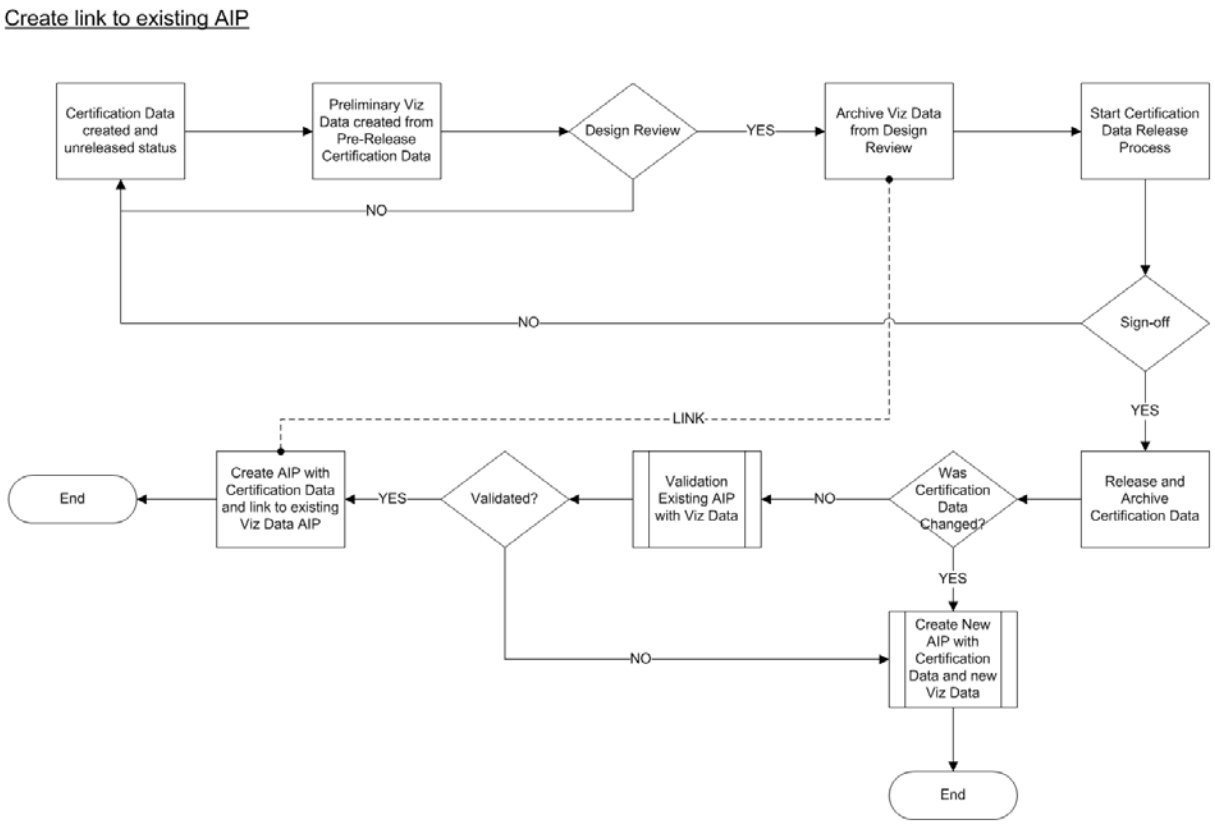
(Visualization representation in consistency with the definition representation)

Scenario 3: From the visualization data, the archival of AIP containing visualization data



This scenario consists, from native visualization data, in the ingestion of visualization data in archived format.

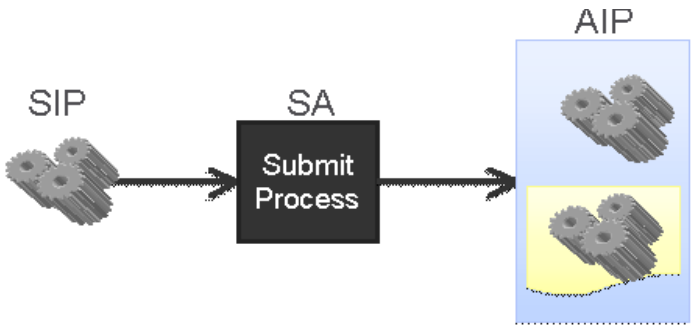
Example of process:



According to the ingestion sequence:

- The validation properties must be generated
- A consistency check with the pre-existing archived data can be performed

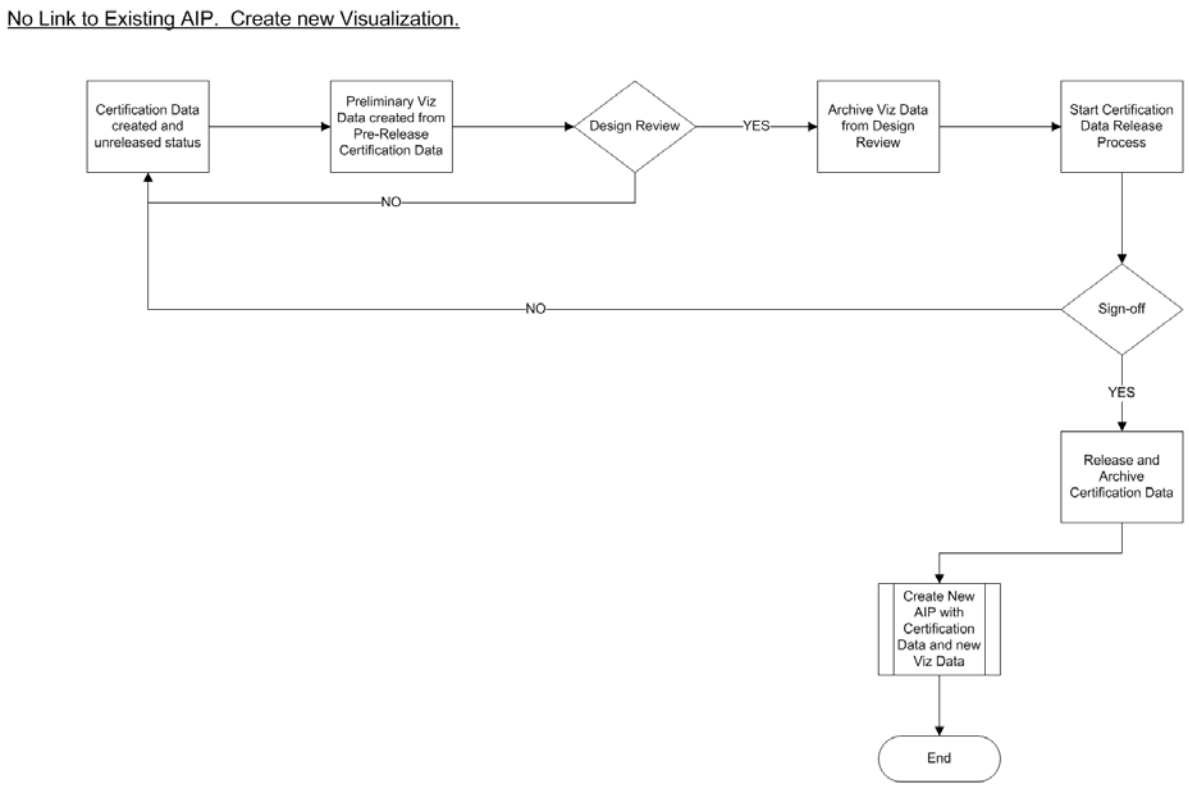
Scenario 1: From the definition data, the archival of AIP containing definition and visualization data



This scenario consists, from the native exact representation, in the archival of a package containing two representations of the part:

- a 'visualization' representation
- and the definition representation.

Example of process:



According to the ingestion sequence:

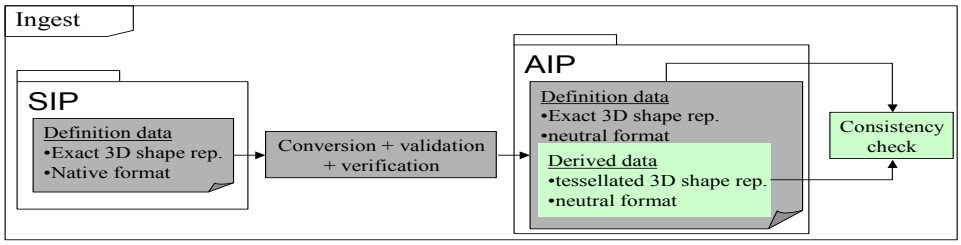
- The validation properties must be generated for the both representations
  - For the data domain specific part (CAD exact geometry, assembly, PMI,…) see the related LOTAR validation rules (LOTAR P110, P115, P120, …)
- A consistency check between the both representations shall be ensured.

As the visualization data is generated during the ingestion, the level of precision of the tessellation shall be agreed with the consumer of the Archived data.

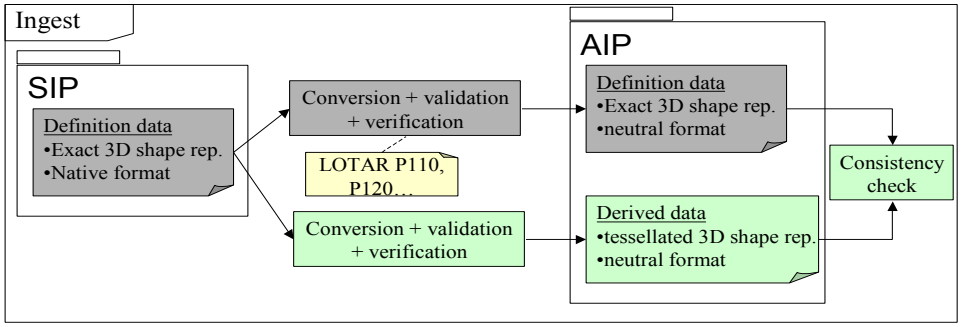
Theses two representations can be stored in:

- The same file (see option 1.a)
- 2 files (see option 1.b)

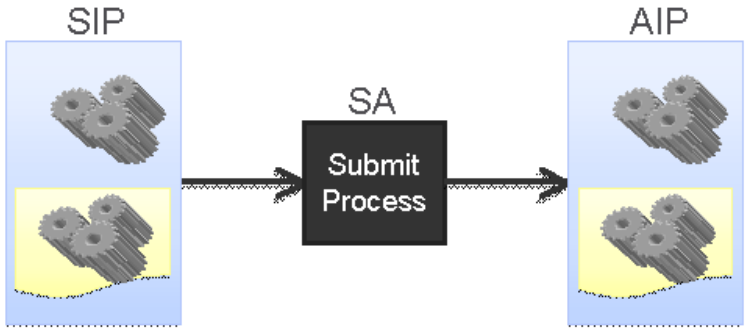
Option 1.a: 1 file in the AIP



Option 1.b: 2 files in the same AIP



Scenario 2: From the definition & visualization data, the archival of AIP containing definition and visualization data



This scenario consists, from the native representations (exact+visualization), in the archival of a package containing two representations of the part:

- a 'visualization' representation
- and the definition representation.

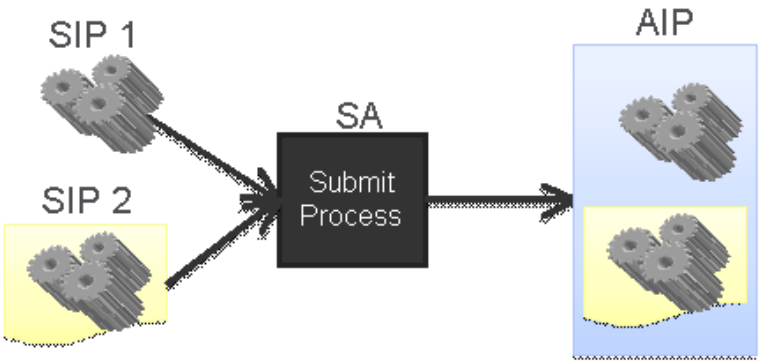
The visualization characteristics, required by the consumer of the archived data, must be the same as the native data characteristics. For example the archived visualization representation will have the SAG of the native CAD data.

According to the ingestion sequence:

- The archived definition representation (CAD exact geometry, assembly, PMI, …) must be generated according to the LOTAR data domain specific part rules (LOTAR P110, P115, P120, …)
- The archived visualization representation must be generated with the appropriated validation properties

An evaluation of the consistency between the both archived representations data can be performed. The consistency check of the native representations in the SIP isn't under the responsibility of the archiving system and shall be ensured by the provider of the data.

Scenario 4: From the definition & visualization data, the archival of AIP containing definition and visualization data



This scenario consists, from the native representations in 2 separate packages, in the archival of a single package containing two representations of the part:

- a 'visualization' representation
- and the definition representation.

The SIP 2 is derived from SIP 1 by another process (out side of the archiving process)

For some engineering process, the visualization data are generated in other format than the definition data. These visualization data can be manage in a separate system. This scenario is to capture the different representation during the same ingestion process.

Note: If the consistency between the 2 SIPs aren't ensured by the data producer, The Submit process may not be able to ensure a consistency of data inside the AIP so THIS SCENRAIO IS NOT RECOMMENDED by LOTAR

Scenario 5:

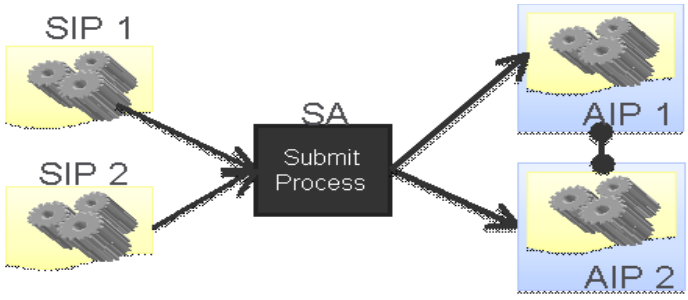
This scenario consists, from the native representations in 2 separate packages, in the archival of separate packages containing each representations of the part:

- a 'visualization' representation
- and the definition representation.

The SIP 2 is derived from SIP 1 by another process (out side of the archiving process)

Ingestion scenario of part multiple visualization representation

Scenario 6



This scenario consists of the native visualization representations in 2 separate packages, in the archival of separate packages containing each representations of the part.

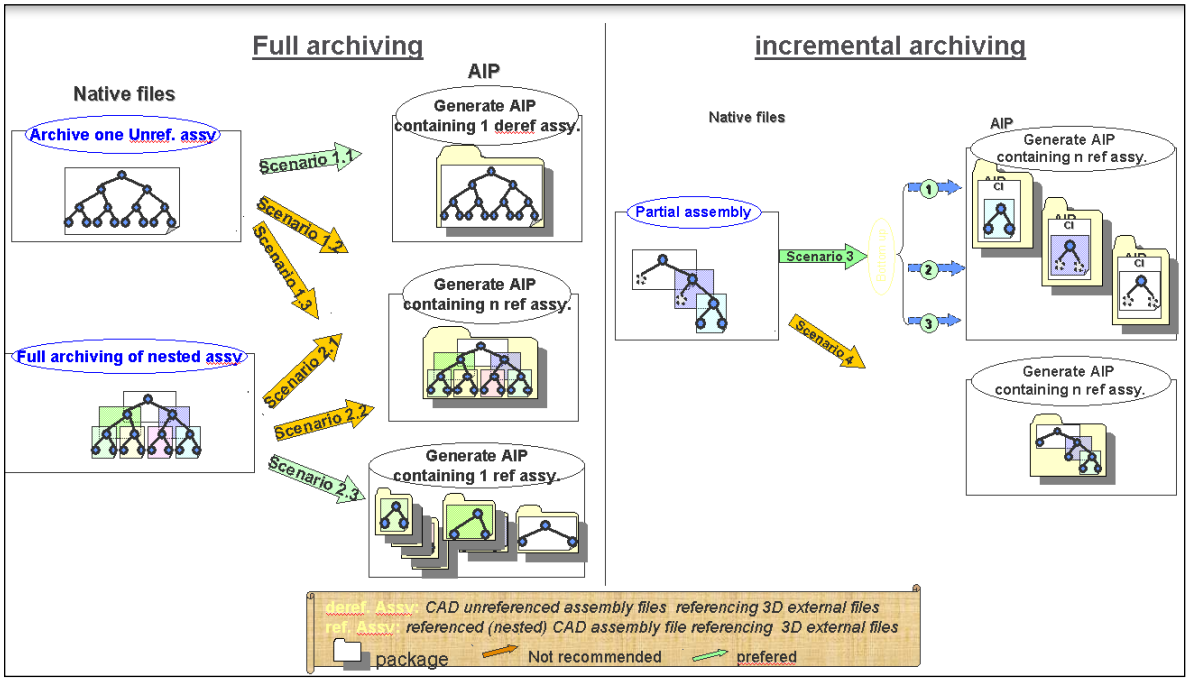
According to the ingestion sequence:

- The validation properties must be generated
- A consistency check between the archived data can be performed

Ingestion scenario of Assembly

LOTAR P115 Reminder

The following figure summarize the scenarios recommended by the LOTAR P115



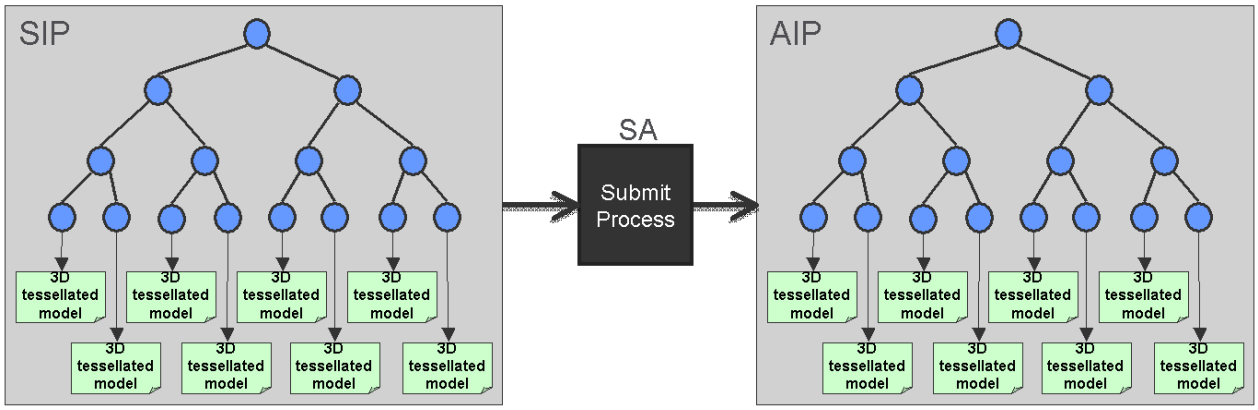
Scenario 7 Assembly of visualization data

These scenarios consist in the archival of the native assembly visualization representations

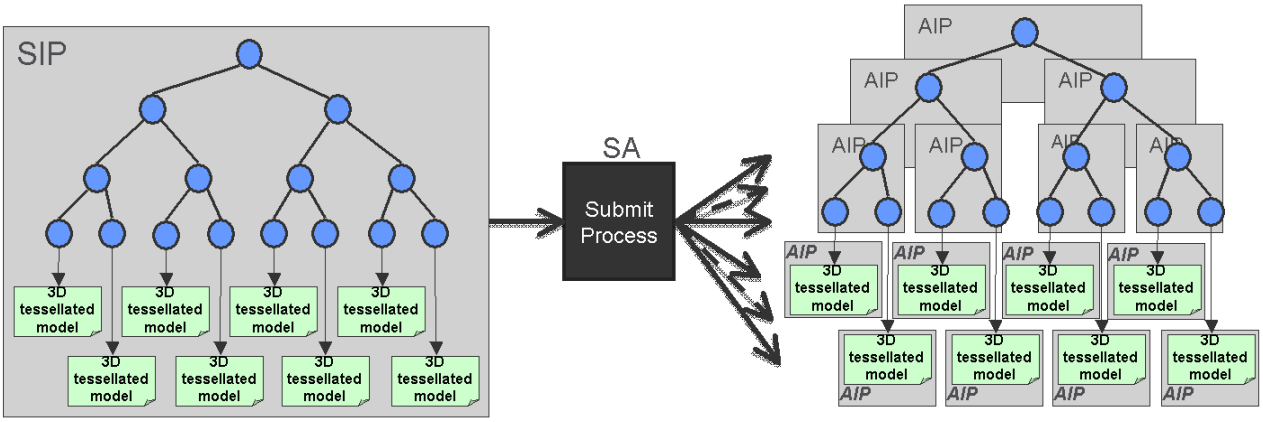
The assembly structure must be archived according to the LOTAR P115 rules, in particular for the validation rule

The visualization data for the 3D model have to be archived according to the scenario 1 to 5 (see above)

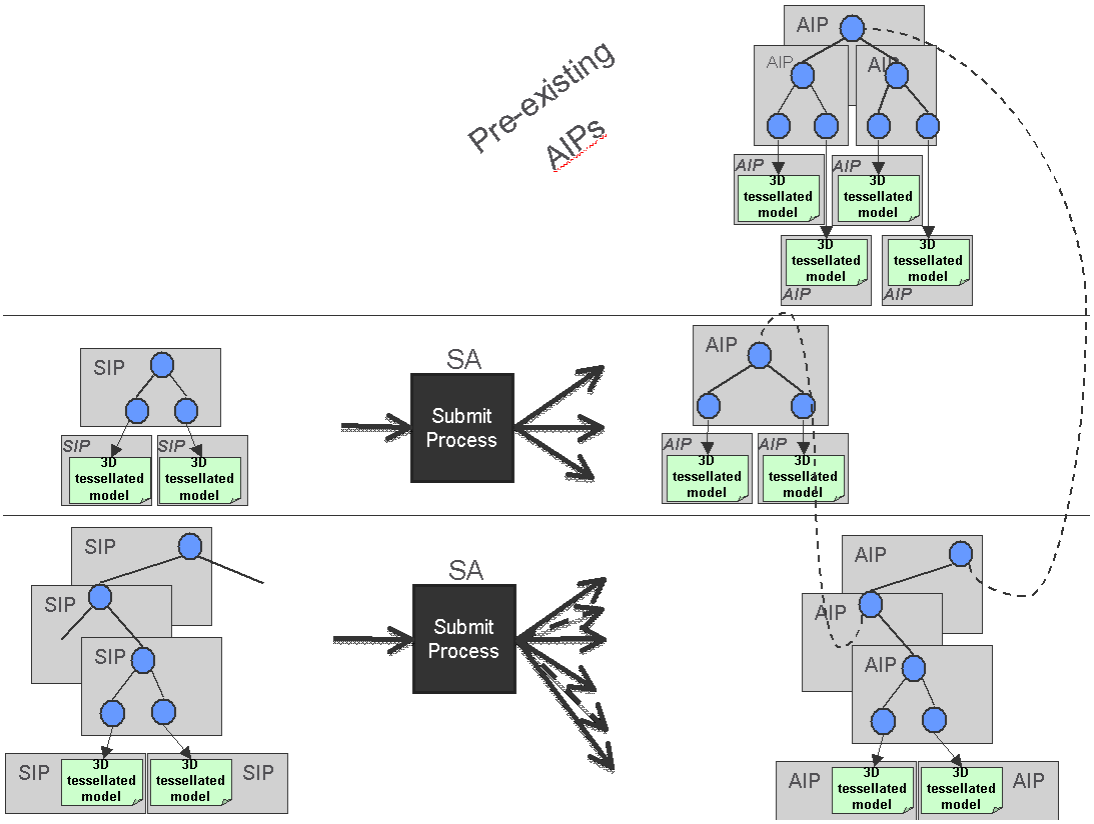
7.a archiving of visualization assembly in one time



7.b archiving of visualization assembly in one time (several AIPs)



7.c incremental archiving of visualization assembly



Summary of ingestion scenario

Table 1: Overview of the ingestion scenario

			Assembly/product structure	3D exact geometry	3D tessel-lated ge-ometry	PMI	texture	view point
Scenario 1	SIP	Definition data		X		X		
	AIP	Definition data		X		X		
		Visualization data		X	X	X		
Scenario 2	SIP	Definition data		X		X		
		Visualization data		X	X	X	X	X
	AIP	Definition data		X		X		
		Visualization data		X	X	X	X	X
Scenario 3	SIP							
		Visualization data		X	X	X	X	X
	AIP							
		Visualization data		X	X	X	X	X
Scenario 4	SIP 1	Definition data		X		X		
	SIP 2	Visualization data		X	X	X	X	X
	AIP	Definition data		X		X		
		Visualization data		X	X	X	X	X
Scenario 5	SIP 1	Definition data		X		X		
	SIP 2	Visualization data		X	X	X	X	X
	AIP 1	Definition data		X		X		
	AIP 2	Visualization data		X	X	X	X	X
Scenario 6	SIP 1	Visualization data		X	X	X	X	X
	SIP 2	Visualization data		X	X	X	X	X
	AIP 1	Visualization data		X	X	X	X	X
	AIP 2	Visualization data		X	X	X	X	X
Scenario 7	SIPs	Visualization data	X		X	X	X	X
	AIPs	Visualization data	X		X	X	X	X

Validation properties

Table 2 summarizes the existing validation properties for definition (i.e. geometric validation properties, assembly validation properties).

The validation properties for visualization data will be defined in the requirements documentation.

Table 2: Summary of the current LOTAR p110, p115, p120 Validation Properties per information

		Visualization data	LOTAR Part	Validation properties
3D exact geometry	exact solid	(X)	P110 ed1	Volume
				Area
				Centroid
				Cloud of Point
	exact surface / shell	(X)	planned in P110 ed2	
	exact curve			
	exact point			
PMI	graphical	X	P120 ed1	Total number of PMI annotations in the file
				Number of views in the file
				Number of annotations per view
				Total number of UDA associated to a point or vertex ,a curve and/or an edge ,a face and/or a surface, a solid and/or a shell , a part
				PMI Polyline curve length
				PMI Centroid
				Equivalent Unicode string
	Link / cross highlight			
	semantic	X*		
Assembly/product structure	full assy archiving	X	P115 ed 1	volume
				center of gravity
	increment archiving			number of children
				notional solids centroid

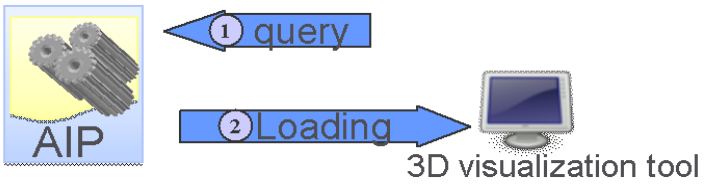
		Visualization data	LOTAR Part	Validation properties
3D tessellated geometry	tessellated solid	X	planned in P110 ed2	
	tessellated surface/shell			
	tessellated curve			

Retrieval scenario

The following section describes the retrieval of visualization data. Several scenarios are identified according to the type of geometry.

Scenario

Scenario 1: Visualization of tessellated geometry for consumption



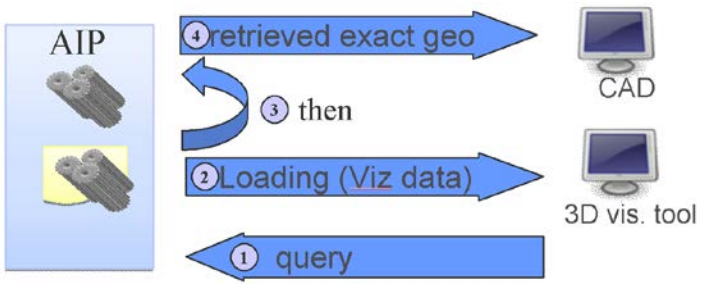
The archived package contains tessellated data only

Description:

1. The archive is queried in order to retrieve package(s) containing visualization data
2. The retrieved package(s) by the archiving system is loaded into the 3D visualization tool.
   - According to the validation level, the 3D visualization tool shall perform a validation. The validation is performed according to properties defined for the visualization purpose and may differ from the validation properties of the definition data.

Scenario 2: Visualization for definition retrieval

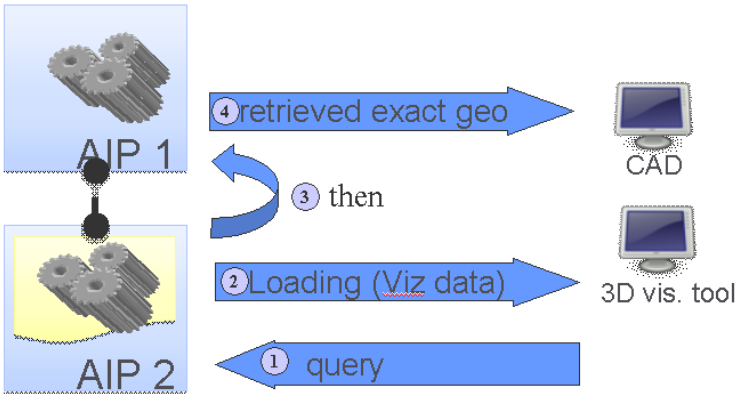
2.a:



Description:

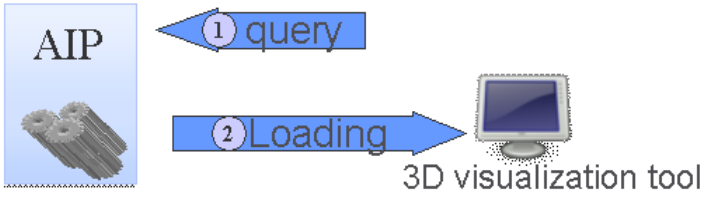
1. The archive is queried in order to retrieve package(s) containing visualization data
2. The retrieved package(s) by the archiving system is loaded into the 3D visualization tool.
3. If the user is satisfied by the visualized data, he can launch the retrieval of exact data. If not , he can launch additional query
4. The definition data is retrieved in the CAD system according to the corresponding LOTAR Part (P110, P115, P120, P121 …)

2.b



Same scenario as the previous, except that the visualization and definition data are stored in separate packages

Scenario 3: Direct Viewing of definition data



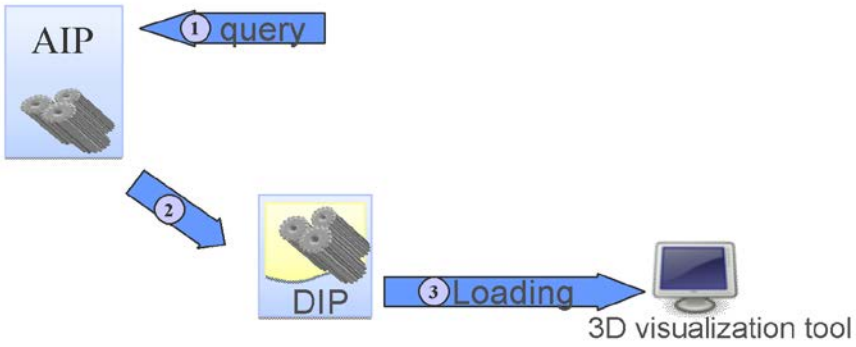
Archived package contains exact data

Description:

1. The archive is queried in order to retrieve package(s) containing definition data
2. The retrieved package(s) by the archiving system is loaded into the 3D visualization tool.

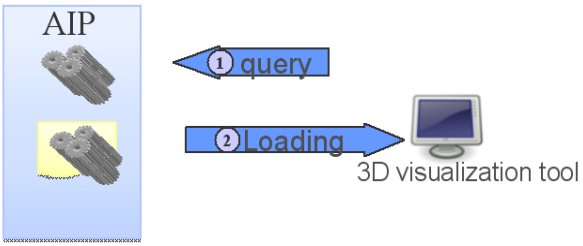
The 3D visualization tool shall be able to perform the validation according to **definition** validation properties defined by LOTAR Part (P110, P115, P120, P121 …).

Scenario 4: Retrieve for the Viewing of definition data



Archiving system generated the package with the visualization representation from the AIP (def. Data)

Scenario 5 Visualization of tessellated/exact geometry for consumption



The archived package contains on file mixing the tessellated + exact geometry

Description:

1. The archive is queried in order to retrieve package(s) containing visualization data
2. The retrieved package(s) by the archiving system is loaded into the 3D visualization tool.

The retrieval of validation of the tessellated geometry is performed according to properties defined for the visualization purpose.

The exact geometry data is retrieved according to the corresponding LOTAR Part (P110, P115, P120, P121)

Example of retrieval query:

During the creation of AIP the adequate metadata shall be defined. During retrieval process, these metadata will be used to identify which data have to be retrieved

Hereafter some example of retrieval:

- Search part by part number (last issue/version)
- Search assembly by part number (last issue/version)
- Search part by part number + issue/version
- Retrieve an assembly defined by a bounding box
- Retrieve an assembly with a configuration (effectivity, date, …)