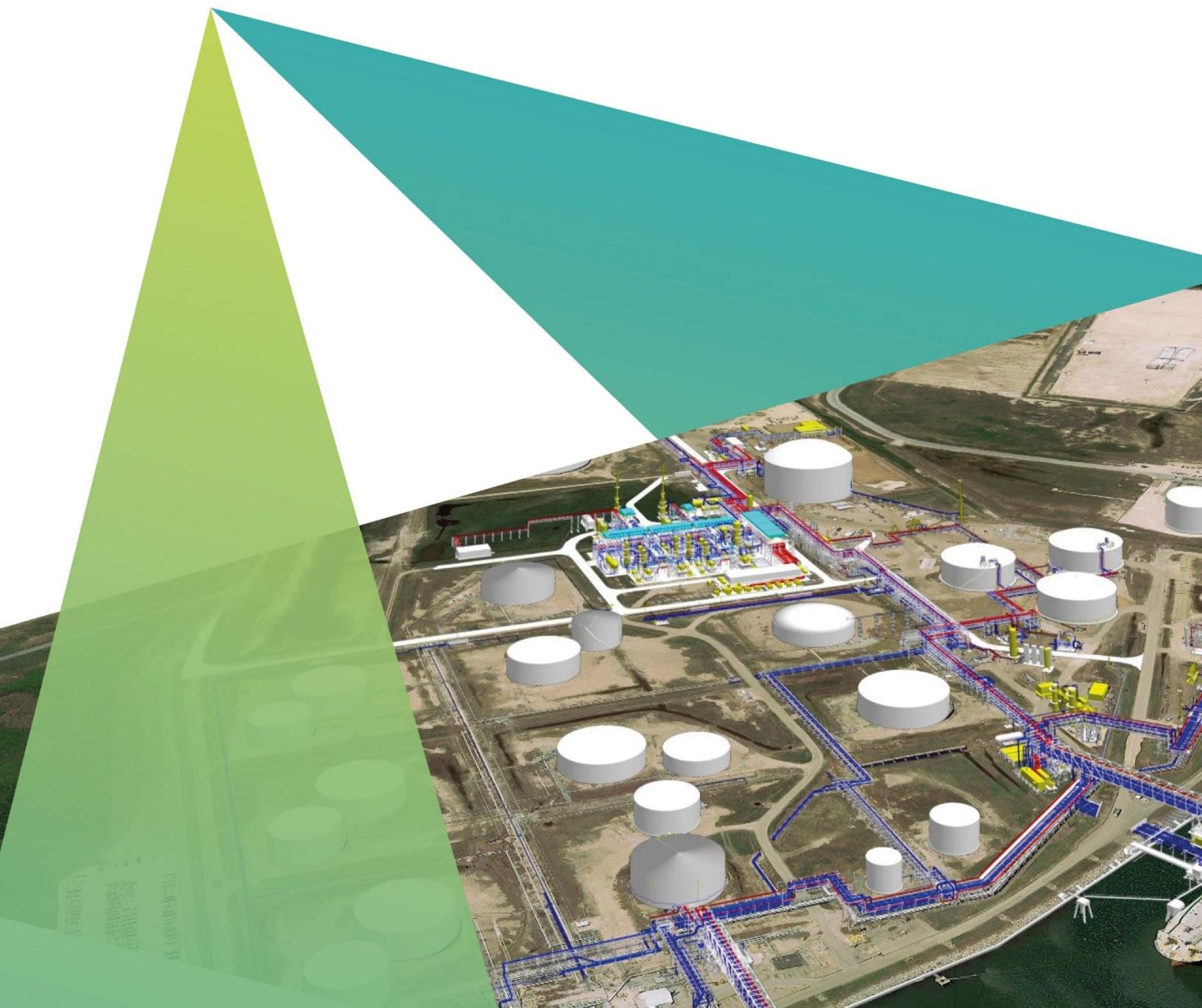


Interoperability Summary: Leveraging 3D Designs and Data

Referencing and Converting Existing External Data to and from Multiple Formats in Engineering and Construction Projects



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1. Executive Summary

1.1. Definition of the Problem

Large engineering capital projects require many partners, subcontractors, suppliers, EPCs, and other stakeholders who create project data. These companies have invested in software tools and training to support their own processes, workflows, and business objectives. Software solutions, and the designs and data they produce, become the pivotal point of collaboration, communication, and design integrity, and ultimately become deliverables for the project. Designs and data must move freely during the project, during handover, and for the lifecycle of the facility. However, project data is often locked into silos. It is governed by software format, readability, compatibility limitations, and restrictions. Converting very large project databases is a complex and expensive undertaking for owners and EPCs.

This white paper explores five scenarios (and relevant interoperability technology) to reuse 3D data throughout the design, construction, handover, and operations and maintenance (O&M) phases of the plant lifecycle. These include:

1. (Design Phase) Reuse data for Smart 3D design (3D Interop)
2. (Design Phase) Full conversion to Smart 3D (Importers)
3. (Construction and O&M) Provide 3D data from multiple formats during construction and O&M (3D Interop)
4. (O&M Design) Engineering in O&M (CAxparts)
5. (Handover) Conversion from Smart 3D to meet client handover requirements and specifications (Exporters)

1.2. Providing a Realistic Industry Solution

There is no automated “Black Box Migrator” that achieves 100 percent conversion between data created in different formats. Each software vendor’s products have fundamental differences in system architecture, data structure, functionality, end-user design, and modeling methodology and workflow. Hexagon PPM leverages and protects existing 3D model designs and data by combining 3D interoperability options of referencing and conversion.

Hexagon PPM’s extended 3D translation capabilities enable the use of a single design solution for engineering contractors who are required to deliver in Smart 3D or PDMS formats, including iterative updates. EPCs who take advantage of this feature will cut costs by only supporting one 3D solution. Through integration with Intergraph Smart® Interop Publisher (INTP), Smart 3D extends the number of supported 3D formats, providing a richer, centrally-managed 3D ecosystem.

Hexagon PPM’s Smart Interop Publisher, 3D Interop, and complementary Smart Enterprise software and automation tools enable faster, more efficient, and less costly utilization of 3D data from many formats (see Figure 1). Importers and exporters built-in to Smart 3D and other Hexagon PPM interoperability tools walk the user through the process of converting and referencing data from/to one format to another.

Interoperability Summary: Leveraging 3D Designs and Data

Interoperability enables users to:

- Reuse 3D data without having to convert and validate an entire model
- Incrementally deal with only the model sections needed
- Reference designs and data from previous non-Smart formats
- Attach reference files, filter objects, and extract drawings from the original design
- Speed transfer of designs and data using out-of-the-box (OOTB) utilities and automation routines
- Minimize the effort and cost of converting between Smart 3D, PDS®, and PDMS



Figure 1. Hexagon PPM's interoperability technology incorporates designs and data from many sources.

1.3. Purpose of this Paper

The purpose of this paper is to explain Hexagon PPM's:

- Interoperability capabilities
- Formats supported
- Interoperability tools

- Reference and conversion solutions
- PDS to Smart 3D
- Smart 3D to PDS
- PDMS to Smart 3D
- Smart 3D to PDMS
- CADWorx® to Smart 3D

2. Introduction

Process plant design and construction projects bring together data created by the:

- Owner operators
- Engineering teams
- Joint venture partners
- Procurement and construction contractor(s)
- Subcontractors
- Consultants

These stakeholders produce large volumes of 3D data using a variety of software solutions such as:

- PDS
- Smart 3D
- CADWorx
- CAESAR II®
- PDMS
- PlantSpace
- MicroStation
- AutoCAD®
- SAT
- IFC
- XMpLant
- i-model
- Other solutions

If software components change over time, data formats become incompatible and require conversion before data can be reused for similar designs and construction. It has traditionally been a time-consuming and costly process to map source model graphics and object property files into common formats that can be viewed and modeled against.

Interoperability Summary: Leveraging 3D Designs and Data

Converting 3D models from one format to another before reuse dramatically increases the O/Os cost during the plant's lifetime – when 3D data availability is most critical for maintenance, modification, and eventually decommissioning.

This paper highlights Hexagon PPM's interoperability capabilities that eliminate the “big bite” of converting legacy 3D models. Hexagon PPM offers interoperability technology that incorporates valuable model data from many sources. These technologies are designed for five scenarios to reuse 3D data throughout the design, construction, handover, and operations and maintenance phases of the plant lifecycle.

This white paper is structured to cover each of these five scenarios, including:

1. (Design Phase) Reuse data for Smart 3D design (3D Interop)
2. (Design Phase) Full conversion to Smart 3D (Importers)
3. (Construction and O&M) Provide 3D data from multiple formats during construction and O&M (3D Interop)
4. (O&M Design) Engineering in O&M (CAXperts)
5. (Handover) Conversion from Smart 3D to meet client handover requirements and specifications (Exporters)

The following sections are intended to be an introduction to Hexagon PPM's:

- Interoperability capabilities
- Formats supported
- Interoperability tools
- Reference and conversion solutions
- PDS to Smart 3D
- Smart 3D to PDS
- PDMS to Smart 3D
- Smart 3D to PDMS
- CADWorx® to Smart 3D

Approaches will focus on referencing designs and data between formats and converting full or partial 3D models as appropriate for each scenario.

3. Design Data Reuse

During the design phase, data can be referenced as needed – rather than performing a full or partial conversion of the entire model at once. Hexagon PPM's interoperability solutions bridge the incompatibility gap to help joint venture teams accomplish this goal. Project stakeholders can easily share and collaborate through unified interfaces. Teams can create and connect efficient workflows that consolidate efforts and ensure security, and that protect intellectual property by sharing only data needed by partners.

3.1. Smart Interoperability Environment

Hexagon PPM's suite of solutions work together to create a new interoperability environment (see Figure 2) including:

- Intergraph Smart® Interop Publisher (INTP)
- Intergraph Smart® 3D (Smart 3D)
- PDS
- 3D Interop
- CADWorx (CW)
- Intergraph Smart® Review (SR)
- Intergraph Smart® Reference Data (SRD)
- Intergraph FreeView®
- SmartPlant® Foundation (SPF)
- Intergraph Smart® Construction (SPC)

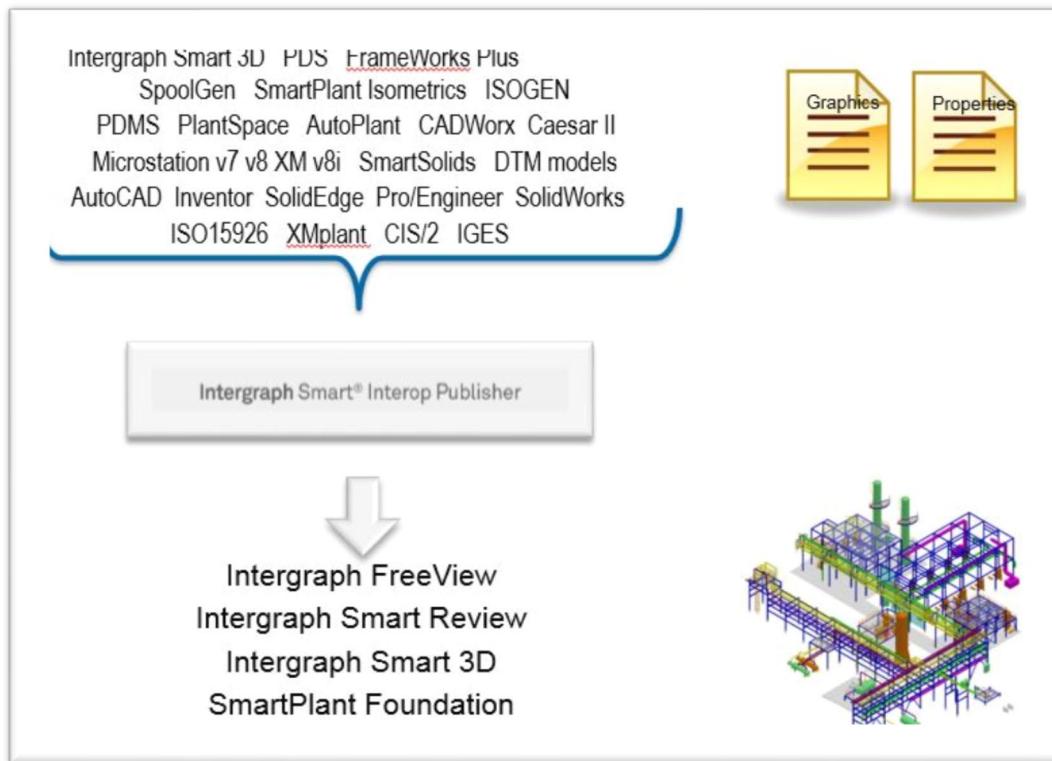


Figure 2: INTP brings most data formats into the Smart environment.

Smart Interop Publisher, the heart of Hexagon PPM's interoperability solution, offers a significantly more efficient path to reuse data rather than having to convert and validate an entire model. Avoiding the “big bite”

Interoperability Summary: Leveraging 3D Designs and Data

conversion enables incremental conversion of sections of the model as needed for design reuse. Portions of the model can be referenced from a new Smart 3D model (see Figure 3). INTP receives input from non-Smart 3D models in the form of sets of matching graphics and data files.

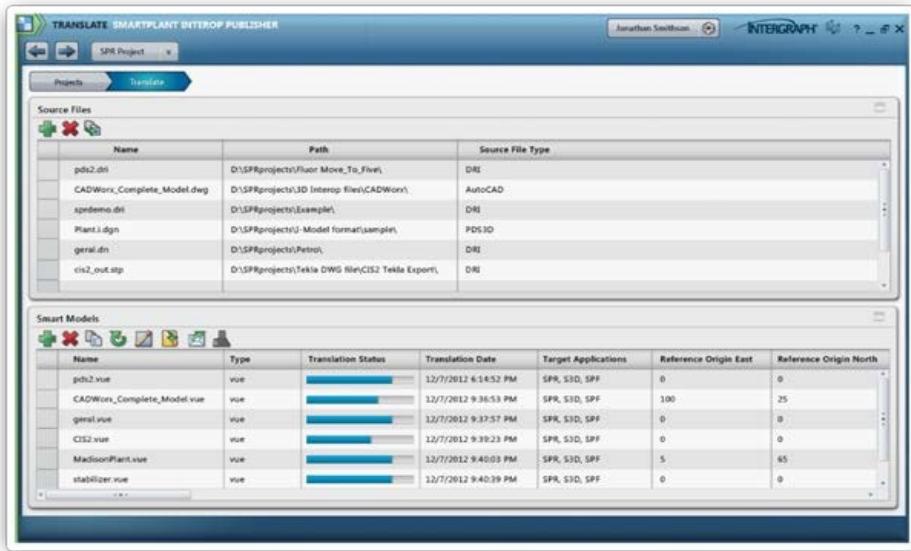


Figure 3: INTP references data from multiple formats.

Key technology features and benefits of Hexagon PPM's interoperability software include:

- **Unified View** – Data from a range of sources may all present similar objects but with different appearances. The system creates filters to apply styles and colors to present objects with a unified appearance. This makes it much easier for users to view the resulting models. Filters are also used to generate object reports which are exported as Microsoft® Excel® spreadsheets.
- **Import Once/Use Many Times** – Interoperability capabilities allow a model to be imported once and then used repeatedly in the Smart environment, to save work time and extra conversion cost across the project lifecycle.
- **Interference Checking** – Smart 3D and Smart Review provide clash detection (interference checking) features to ensure there is enough space around components for installation and removal, maintenance, and operations. Smart 3D is the main clash detection tool used for design, while Smart Review can be used for dynamic collision control when moving objects in the plant, such as simulating construction sequences.
- **Model Data Reuse** – Creating an independent data storage system with SPF protects plant information and addresses all design, build, and operation life cycle requirements. This encourages data reuse, manages risk, and reduces spending through sharing of consistently high-quality engineering data from within a single system. Users do not have to purchase multiple add-on converter programs for each new software package contributing data.

Interoperability Summary: Leveraging 3D Designs and Data

- **Replicate Only Relevant Data** – Working in the Smart environment, users can attach reference files, filter objects, and extract drawings from the original design and data sets without having to replicate entire databases.
- **Simplify Projects with Parallel Design** – This novel approach minimizes the time, effort, and cost of conversion and improves delivery of the design for the new project. If a project has several similar units to be designed and constructed, only one unit must be modeled and translated. The translated unit can be attached multiple times with required positioning and minimal customization, increasing productivity.
- **Survey Data** – Converted 3D models can be viewed when displaying laser data to ensure the model reflects the “as-built” plant, not just the digital plant. Smart 3D capabilities (together with Leica CloudWorx) efficiently model intelligent objects on top of point clouds. Smart 3D uses advanced geometry recognition tools for accurate determination and measurement of objects such as pipe diameters and allows semi-automatic modeling of pipelines.
- **Mechanical CAD** – Users can convert equipment files that were designed in mechanical CAD (MCAD) packages into Smart Enterprise. INTP reads MCAD formats (NX, SolidEdge, SolidWorks, Pro/E, CATIA, and Inventor). INTP adds value by:
 - Reducing equipment file size and memory
 - Allowing object selection from assembly hierarchies
 - Maintaining accurate 3D connect point information
 - Offering selective de-featuring of graphics or unwanted detail
 - Providing clash-checking
 - Storing intelligence for automated routing
 - Preserving equipment integrity in Smart 3D
 - Allowing batch file updates

INTP also protects intellectual property of equipment designers by not exposing the fabrication model. It includes unique equipment, subsystems, or modules, and supports design and reuse of mechanical equipment in the plant.

- **Lowering Barriers to Joint Venture (JV) Projects** – Joint venture projects typically involve several contractors. Projects primarily executed in Smart 3D will receive models – process units, design packages, skid units, etc. – produced by smaller contractors designed in other systems having different model formats. The project team can work in multiple 3D formats and eventually consolidate into a single environment and format. Live connections to original data sources are not required. INTP does not require live connections to data sources, minimizing concerns about security and IP protection risk. Only data that is required by partners is authorized to be shared. Periodic updates enable disconnected workshare while promoting ad hoc collaboration. INTP unifies multiple formats to allow joint venture partners to collaborate more easily, share design work, consolidate efforts, and enjoy more efficient work processes – even when using different software.
- **Smart Model References** – Users can attach multiple Smart Model references to the Smart 3D project to allow users to view the referenced model objects. The Smart Model filters objects from referenced models based on their type and properties. It also extracts drawings using graphic/label rules and shows object positioning from referenced models with limited annotation.

Interoperability Summary: Leveraging 3D Designs and Data

- **Design Reviews** – With INTP and Smart Review, users can review models during design and construction, open and combine reference files for design reviews and “walk-throughs” to see design or construction status, perform clash detection, and create queries across multiple sources. This leverages the entire project’s data as a single source.
- **Publish 3D Model Graphics and Object Property Data** – INTP provides OOTB mapping and data formats to publish 3D model graphic and object properties within the plant data repository. The SPF Schema Editor facilitates customizing properties in the translated model when the requirement is to transfer property data to SmartPlant Foundation and subsequently Smart Construction. Users can query the 3D model and links to plant data. Smart Construction retrieves components from reference files to create work packages and construction sequencing.

3.2. Formats Supported Out-of-the-Box

Source model graphics and object property files are mapped into a common graphic and data format, eliminating the need for a separate adapter for each format supported. Using INTP technology, 3D Interop accepts most industry-recognized formats in a single adaptor product (see Table 1). Full out-of-the-box conversion capabilities make it easier to consolidate and map the multiple models and properties into a single format across a multi-source project environment.

Table 1: Hexagon PPM supports a number of graphic and data formats out-of-the-box.

Company & Application Formats Supported	Graphic/Data File
Hexagon PPM	
Smart 3D v2009.1 & above (integrated environment)	ZVF/XML
Smart 3D Pre v2009.1, Smart 3D v2009.1 & above (non-integrated environment)	VUE/XML
Smart 3D using SP Review Direct	VUE/ MDB2
PDS, FrameWorks® Plus	DRI/ DRV, DGN/ TAG
Isogen®	IDF, PCF, POD
CADWorx (Equipment, Plant Professional)	AutoCAD (.dwg)
Aveva PDMS	RVM/ATT, DRV
Autodesk AutoCAD v2011 & earlier (supports proxy-enabled objects)	DXF, .dwg/DRV
Bentley MicroStation (J, VI, V8i, XM), AutoPLANT, PlantSpace, i-model	DGN, PRP, DTM/DRV
Industry-Standard Formats Supported	Graphic/Data File
Open Standards	
Industry Foundation Classes (IFC)	IFC/DRV
XMpLant	XML/DRV

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CIS/2 (design data from Smart 3D, SDS/2, StruCAD, Tekla, ProSteel, etc)	STP/DRV
Mechanical Applications	
Exports ACIS graphics from SolidEdge, SolidWorks, Pro/Engineer	SAT/ not available
Exports IGES graphics from Smart 3D using SP Review Direct	IGES, IGS/ not available
Generic Formats Supported	Graphic/Data File
BOCAD (SDNF exports converted into CIS/2 FrameWorks Plus)	CIS/2
SACS (SDNF to CIS/2 Conversion via FrameWorks Plus, export SAT from SACS) AutoPLANT, PlantSpace	CIS/2 or ACIS (SAT) AutoCAD (.dwg), PCF
ANSYS Workbench, SolidEdge, SolidWorks, AutoCAD Inventor, CREO Parametric, Siemens, Catia SmartPlant Spoolgen®, SmartPlant Isometrics	ACIS (SAT) IDF, PCF, POD
JT Open (JT Open to SAT conversion by Theorem)	SAT
Speedikon, Tribon M2 / M3	MicroStation
ShipConstructor (graphics only)	AutoCAD

3.3. Intelligent Referencing Scenarios

3D Interop has been successfully deployed in the following business situations for intelligent referencing:

- **JV Projects** – Intellectual property of individual firms participating in joint venture projects is protected, because the quality of information published can be controlled by the publisher. In addition, sensitive data such as reference data, piping specifications, and rules are not published.
- **Disconnected Workshare** – Hexagon PPM's intelligent referencing in a disconnected workshare enhances security because permanent network connectivity is not required. Published files may be transferred using any appropriate mechanism. Since the data is file-based at the source site and attached as a reference at the target site, live connection between the databases is not required. Periodic publish and update of the referenced models enables multiple partners to work on a joint venture project in a disconnected manner while still being able to effectively manage the interfaces.
- **Datasets from Different Smart 3D Versions or Underlying Relational Databases** – Smart 3D model data is created in a format that enables mapping to it and mapping from it. Therefore, data from different versions of Smart 3D can be mixed and matched. Since the data is published to a set of files, the underlying database platform (Microsoft SQL Server or Oracle) or Smart 3D version is no longer a concern.

- **Datasets from External Tools such as PDMS and XMpLant** – Data from other tools such as PDMS and XMpLant can be translated to the format recognized by 3D Interop and referenced in. This allows for heterogeneous tools with diverse reference data to be used on a single project.
- **Parallel Design for Increased Productivity** – If a project has many similar units, only one unit may be modeled and published. This published unit can then be attached multiple times with the required positioning. Additional modeling, such as civil work, can be performed simultaneously on all of the units by working with the references. In addition, if the original unit is changed, using referenced models can be more productive because the referenced model is more flexible for updates. When the original unit is completed, Model Data Reuse functionality can be used to replicate the unit to obtain real Smart 3D objects.

3.4. Referencing CADWorx Designs

An excellent example of the powerful referencing capabilities is shown when Hexagon PPM's CADWorx intelligent data and designs are incorporated into Smart 3D through referencing. A CADWorx model, like the one shown in Figure 4, is typically made up of several discipline .dwg files referenced together (in AutoCAD) to create a single view of the plant.

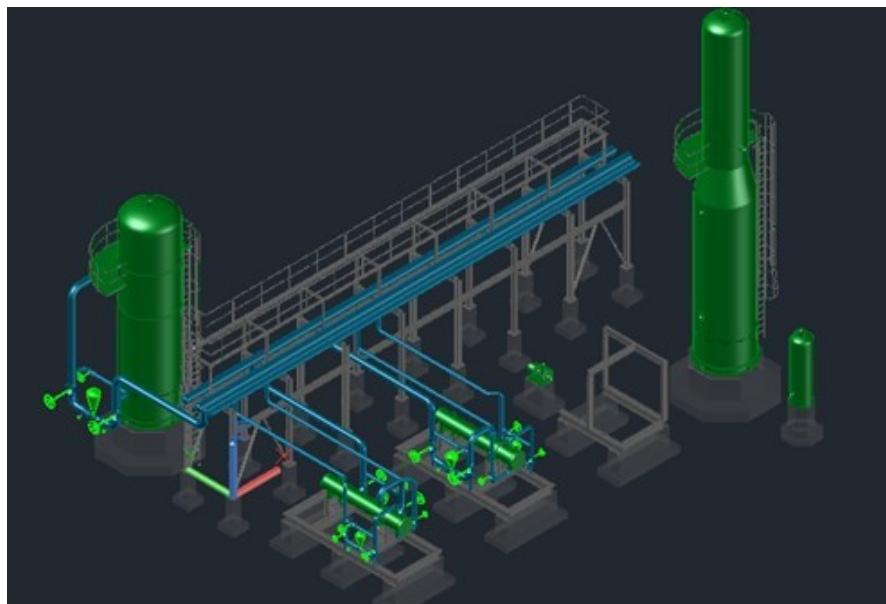


Figure 4: This CADWorx model shows .dwg files referenced in AutoCAD to create a single view of the plant.

Being an application built on top of AutoCAD, CADWorx models are saved in AutoCAD .dwg format. In addition to the information AutoCAD defines, dwgs created and saved by CADWorx include Extended Data

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(Xdata) for piping, equipment, structure, etc. INTP can automatically detect whether it is translating a native AutoCAD file, or an AutoCAD file containing CADWorx objects.

CADWorx .dwgs are processed through INTP to produce input for Smart Review (VUE), or Smart 3D (ZVF). Using INTP, CADWorx models can also be published to SPF. In CADWorx 2015 and later, CADWorx provides a more direct translation using CADWorx Design Review Professional to create the VUE file to reference into Smart 3D OOTB. In INTP, the main window is split into two main sections containing source files, CADWorx .dwgs in this case, and Smart Models (SR, Smart 3D, or SPF outputs) (see Figure 5).

A template mapping file installed by INTP is used to map CADWorx properties to corresponding Smart 3D classes and properties. INTP provides options for the user to fill in Smart Model output locations, mapping options, target applications, etc. VUE and ZVF files produced by INTP are used to visualize and reference the CADWorx model in the Smart environment.

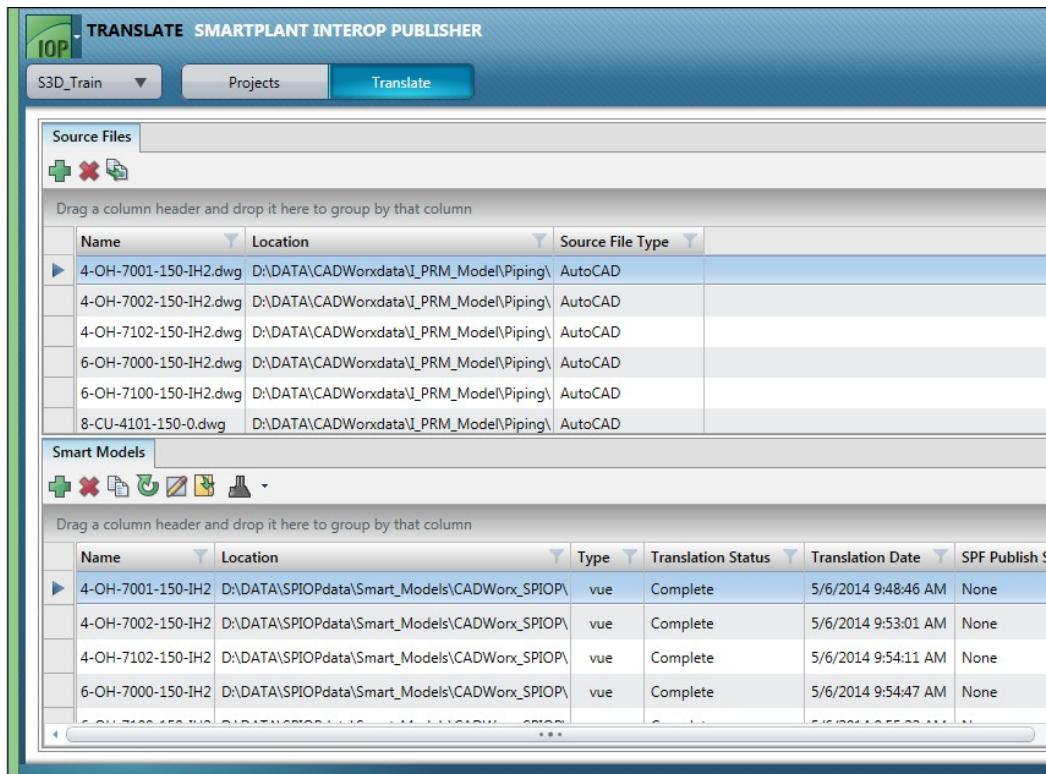


Figure 5: The INTP window shows CADWorx source files and corresponding translated Smart Model outputs.

For example, the CADWorx model in VUE format can be opened in Smart Review, enabling the model to be navigated and its properties and attributes to be queried. The same CADWorx model, this time in ZVF format, can be referenced in Smart 3D via the Smart 3D Project Management application. Once the CADWorx model is attached in Smart 3D, users can view and model and clash check against it.

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The Smart environment for CADWorx-referenced models includes several complementary functions, such as:

In Smart 3D

- Attach multiple Smart Models (reference files) to the Smart 3D model
- Inspect/provide property views for referenced model objects
- Filter objects from referenced models based on their type and properties
- Use Surface Style Rules to change the referenced model to look the same as the native Smart 3D model objects
- Use graphic/label rules to extract drawings showing position of objects from referenced models
- Connect Smart 3D pipe routes intelligently to nozzles on referenced models
- Complete pipe routings and tie-in connections between Smart 3D models and referenced models, enabling final isometrics and bills of materials to be generated
- Check for potential interferences and clashes between referenced models and Smart 3D model objects

In Smart Review

- Open and combine Smart Models for design reviews
- Walk through 3D Smart Models to understand the design or construction status
- Perform clash detection against objects in the Smart Models
- Perform motion collision detection by moving Smart Model objects along a path

In SmartPlant Foundation

- Register the Smart Models with the corresponding plant
- Publish 3D model graphic/object properties using mapping/data formats, delivered OOTB in SPF
- Map custom properties for the translated model using the Schema Editor in SPF
- Query/view the 3D model with associated links to other non-graphic data stored for the plant

In Smart Construction

- Retrieve components from the Smart Model to create construction work packages.

Note: Add-on module is required to publish to SmartPlant Foundation and Smart Construction.

4. Design Data Conversion

In addition to referencing existing designs and data during the design phase, Hexagon PPM offers tools, capabilities, and processes to migrate between data formats. There is no automated “Black Box Migrator” that converts 100 percent between data created in different formats, since there are several fundamental differences between underlying system architectures and data structures, functionality, end-user design, and modeling methodologies and workflows. Designs and data migrated into Smart 3D will be equivalent to those that are created in Smart 3D. The conversion modules are tuned to transfer the designs of one format to another through a series of steps. Conversion formats do not transfer the deliverables of Smart 3D to other tools (i.e., drawings and ISOs that need to be extracted on the converted designs).

Full or partial conversion of databases generally applies to:

- Converting Hexagon PPM PDS data to Intergraph Smart 3D
- Converting Intergraph Smart 3D data to PDS
- Converting Intergraph Smart 3D data to Aveva PDMS
- Converting Aveva PDMS data to Intergraph Smart 3D

When converting full or partial databases between any of these formats, two important components must be addressed to accommodate the intelligence rules for Smart 3D. Reference data must be created or reused from the Standard Database (SDB). Model data must be migrated via automated tools and/or referencing graphic/property data via INTP. Each of these components is discussed in the following sections from the perspective of the three migration scenarios involving PDS, Intergraph Smart 3D, and Aveva PDMS software. Import and export tools are highlighted in these sections.

4.1 Converting PDS to Smart 3D

When PDS clients decide to begin using Smart 3D, they may need to translate, migrate, or reference existing PDS legacy model data for use on future projects. Several migration technology options are available to EPCs and owners, based on the ultimate scope and purpose of the conversion. Two primary technology approaches include CAXperts® PlantReModeller and PDS Migration Translator. Both are discussed in this section. Once the technology approach is determined, the two components to be considered for the migration of data from PDS to Smart 3D are reference data and model data. Both can be achieved using either the CAXperts or Hexagon PPM migration solutions.

4.1.1. Migration Technology

In traditional migration projects for a fully intelligent model with full conversion of piping specs, PDS users can undertake their own model translation using the Smart 3D PDS Project Translator software and training. This is a separately licensed Hexagon PPM software product, enabling PDS customers to export piping, HVAC, electrical, equipment, and structure model data (geometry and attributes) from PDS into Smart 3D. The intent of this translator software is to protect and leverage the equity in existing reference data and plant models to establish a comparable Smart 3D production-level design environment to replace PDS. Current

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software tools and utilities are not designed to undertake a “big bang” migration into Smart 3D at the end of a PDS project to meet data handover obligations specified by an owner.

4.1.2. Reference Data

Reference data is extremely important to modeling in an intelligent rules-based system such as Smart 3D. If rules are missing or incorrect, the 3D design may be compromised. Examples of reference data include:

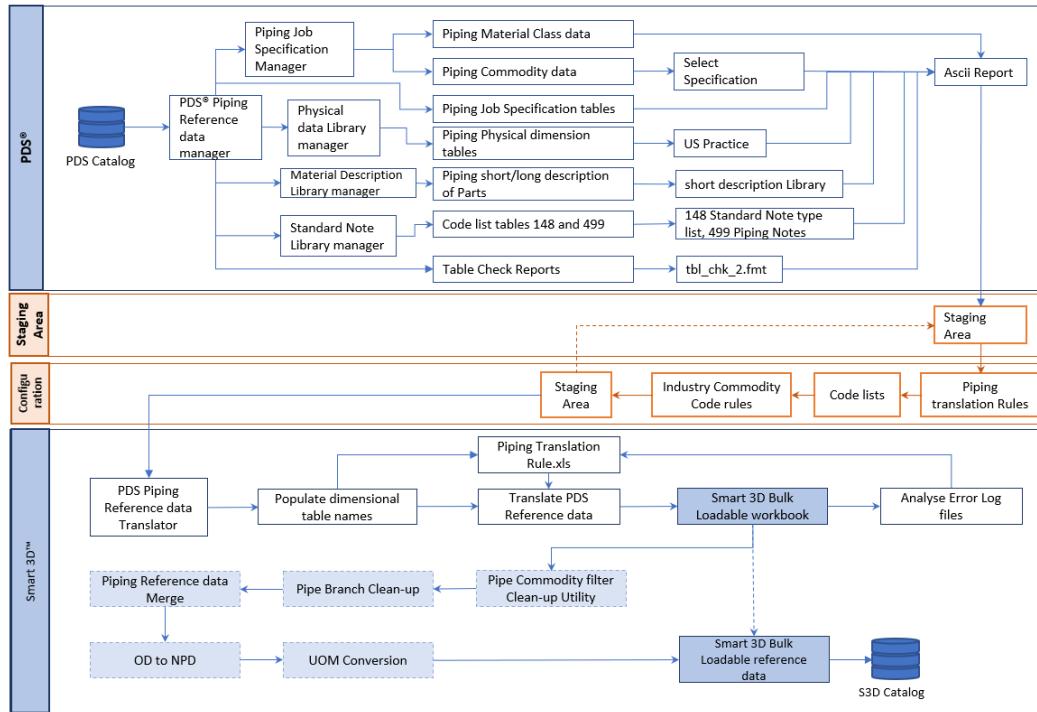
- Components: dimensions, descriptions, and connectivity for all disciplines; naming rules, symbols
- Piping, electrical, and HVAC specifications and rules
- Other rules, such as structural connection rules

To manage these components in Smart 3D, Hexagon PPM recommends the transfer of PDS reference data to Smart 3D and to Smart Reference Data (SRD) to create and manage the graphical, dimensional, and rule basis for all reference data.

The major portion of the PDS® reference data (Piping reference data) can be transferred to Smart 3D with very good quality using the tool (PDS Piping Reference data Translator) delivered in Smart 3D. The generated Piping reference data can directly be bulk loaded into Smart 3D Catalog database for on-going projects. Process also allows the same to be loaded into Smart Reference Data for the further lifecycle management of Piping reference data.

Hexagon PPM also provides services to assist with reference data creation. In addition to the “start from scratch” approach, users can also take a “data reuse” approach with existing reference data already in the Intergraph Standard Database (SDB). This would become the graphical, dimensional, and rule basis, with only commodity codes and descriptions changing.

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4.1.3. Model Data

Smart 3D requires additional information such as rules and relationships that do not exist in PDS. PDS data can be exported to Smart 3D using Smart Interop Publisher's options of migration and/or referencing. Using the PDS Model Data Exporter (with PDS version 8.0 or higher), users can generate discipline-specific XML files and import them directly into Smart 3D in multiple disciplines (see Table 2):

- **Equipment** – Catalog equipment, designed equipment, shapes, nozzles
- **Piping** – Pipelines, runs, stock parts, components, connection items, insulation, flow directions
- **Structure** – Linear/curved members, plates, slabs, stairs and ladders, handrails, slab and plate openings, assembly connections, fire proofing, foundations, footings
- **Hangers and supports** – Piping, HVAC, electrical supports, hanger assemblies/components

4.2. Converting Smart 3D to PDS

4.2.1. Advanced Mapping Concepts

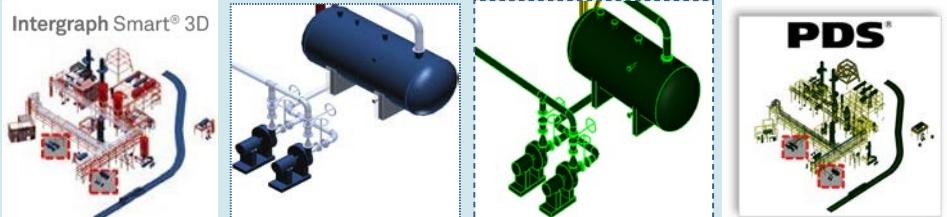
Advanced mapping concepts support heterogeneous schema between the tools. OOTB discipline-based mapping transfers data between Smart 3D and PDS object property definitions. Additional features include:

- Design intent used in Smart 3D is captured and transforms same system hierarchy to PDS
- Different levels of intelligence are transferred for specific disciplines
- Equipment nozzles can be revised/edited in PDS, making them intelligent
- 100 percent intelligent transfer of piping to PDS
- A PDS project can be automatically configured and populated without opening the PDS project
- Users can export only data needed instead of the whole plant
- OOTB mapping with properties; users select system hierarchy to export
- Export wizard simplifies user experience in moving project data from Smart 3D to PDS

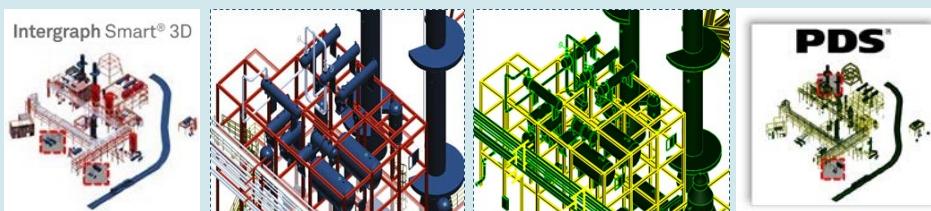
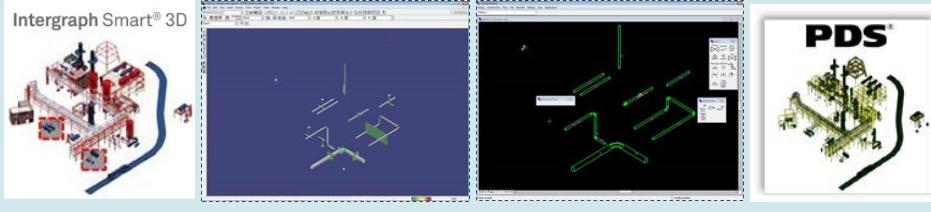
4.2.2. Discipline Conversion Scope

Smart 3D and PDS tools enable model intelligence conversion among disciplines (see Table 2).

Table 2: Smart 3D conversion to PDS covers a variety of disciplines.

Discipline	Discipline Scope Detail
Piping	<p>Pipelines/stock parts/components/connections exported by mapping between Smart 3D and PDS</p> <p>Intermediate format used is APL; piping specs must exist in Smart 3D and PDS Imported designs can be revised in PDS</p> 

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Structure	<p>Exports linear/curved members/slabs/openings/stairs/ladders/handrails/foundations/footings/walls Imported member slabs can be revised in PDS Materials/member cross sections need to exist in both tool catalogs Cross section utility.exe extracts structural catalog data and loads into PDS as CIS/2 format</p> 
Hangers & Supports	<p>Smart 3D supports exported as logical hangers and supports written in APL file Supports are processed with piping; no special provisions required</p> 
HVAC	<p>Smart 3D HVAC exported to PDS as geometry (reviewable only) and properties written in DRV files</p>

4.3. Converting PDMS to Smart 3D

In another migration scenario, PDMS data can be converted to create intelligent Smart 3D model data.

Two alternatives are available for using PDMS data in Smart 3D, including:

- Option 1: Smart 3D references PDMS Model using INTP
- Option 2: PDMS Data is migrated into Smart 3D
- Option 2.1: PDMS Reference Data is created
- Option 2.2: PDMS Model Data is converted

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Two important variables must be considered when converting PDMS data to Smart 3D: creating reference data and migrating model data. Both situations are described in the following sections.

4.3.1. Reference Data

PDMS reference data does not have the additional rules and intelligence of reference data, codes, and descriptions built into Smart 3D. For conversion, PDMS reference data and rule data will need to be created in either Smart 3D or Smart Reference Data and other information added, such as:

- Drawing rules (graphical, dimensional, and label rules)
- Custom commands
- Automations
- Drawing/report templates
- Publish and retrieve schema definitions

Hexagon PPM recommends that Smart Reference Data manage component dimensions, descriptions, and connectivity in Smart 3D catalogs and specifications. Data within SRD can be exported directly to Smart 3D to support future additions and modifications.

4.3.2. Model Data

As with reference data, model data from PDMS lacks full rules and relationships in Smart 3D, and these will have to be added as part of the migration from PDMS to Smart 3D. This is done through two options:

- **Intelligent migration of data** – Involves extracting data from PDMS, translating it, and then creating it as Smart 3D objects that can be added, modified, or deleted from the Smart 3D model.
- **Referencing of data** – Involves referencing data in PDMS using INTP. When PDMS data is referenced, it cannot be modified, but view styles and other features can be applied to the graphic data and viewed by the user.

4.3.2.1. Intelligent Conversion of Data

Automated tools exist in Smart 3D versions 2011 R1 onward for converting the PDMS DATAL to create Objects in Smart 3D. Reference data need to be created manually or referenced in Smart 3D. Such automation tools are used by Hexagon PPM services teams working with the customer. Automated migration tools that can be used to read piping, HVAC, electrical, equipment, and structure model data from PDMS include:

- **Structure** – Hexagon PPM's model translator software will convert PDMS Structural DATAL files into Smart 3D as intelligent structural objects. A structural system such as StruCAD also imports PDMS SDNF files (additional PDMS license required) and can export to CIS/2 format and Smart 3D.
- **Equipment** – Hexagon PPM's model translator software converts PDMS DATAL files to Smart 3D as intelligent equipment objects. Obstructions defined in PDMS can be brought as different

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aspects for Smart 3D Equipment. If the PDMS model uses any third-party formats like 3D MicroStation, AutoCAD, or SAT file as an equipment object, these can be imported by native Smart 3D as well.

- **Piping** – Hexagon PPM's model translator software converts PDMS DATAL and ATT files extracted from PDMS into Smart 3D as intelligent piping objects. Conversion has capability to bring in designed instruments / specialties, along with complete flow directions defined in the source PDMS. If an equipment connection exists in PDMS when imported, the relationship is automatically generated in Smart 3D.
- **Electrical** – Hexagon PPM's model translator software will convert the PDMS DATAL files into Smart 3D as intelligent cable tray objects in Smart 3D. This functionality will be available in Smart 3D version 2016.
- **Supports** – Hexagon PPM Model transfer software will convert PDMS DATAL Support files into Smart 3D as intelligent Support objects in Smart 3D. All the Attachments declared in PDMS piping can also come as Support in Smart 3D. Intelligence level can be controlled with full intelligence or with object and properties.
- **HVAC** – Hexagon PPM's model translator software will convert the PDMS DATAL files into Smart 3D as intelligent duct objects in Smart 3D.

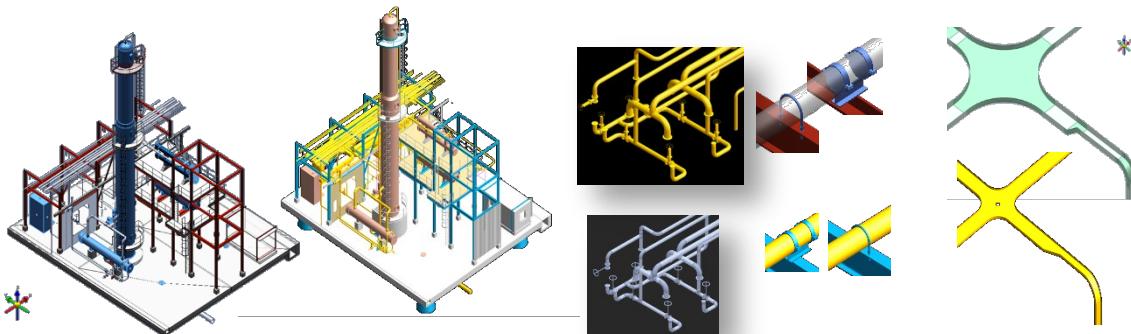


Figure 6: Smart 3D's model translator converts PDMS designs into intelligent Smart 3D data

4.3.2.2. Smart 3D Referencing PDMS Data

Smart 3D offers OOTB capabilities to reference a PDMS model. PDMS data is exported into PDMS RVM and ATT files that are converted into a streamed Smart 3D format (zvf) using a standard Smart 3D ConvertToZvf utility that utilizes the INTP technology. Streamed data is referenced from Smart 3D because sample mapping files for PDMS data are supplied with Smart 3D. PDMS attributes can be added to the mapping file to be available in Smart 3D. A user can reference any number of reference models (in formats supported by INTP) at the same time. Individual models can be moved, rotated, and scaled. Model display is controlled by the workspace definition filter in operation in the Smart 3D session.

4.3.3. PDMS to Smart 3D Conversion Performance Metrics

Hexagon PPM recently compiled the following performance metrics to test the import of data from PDMS to Smart 3D (performed on a 64-bit computer with 8GB RAM Windows 7 Professional), as shown in Table 3.

Table 3: PDMS to Smart 3D conversion performance was measured by discipline.

Discipline	Number of First-class Objects	File Size	Import Time
Equipment	17 equipment items, 8 sub-equipment items, 52 nozzles, 690 primitives, 230 panels	1,447 KB	3,168 seconds
Piping	36 pipes, 71 branches, 438 piping components	114 KB	544 seconds
HVAC	42 duct components, 6 branches	60 KB	54 seconds
Structure	1,528 primitives, 200 sections/connections, 27 panels, 5 floors	437 KB	619 seconds

4.4. Converting Smart 3D to PDMS

A third conversion scenario is to export Smart 3D data to PDMS format. Smart 3D designs and data can be exported to PDMS with precision and intelligence, allowing downstream operations of the exported data within PDMS. This enables project teams and EPCs to use Smart 3D software for the intelligent design process and then deliver designs to the owners in PDMS format. Smart 3D's interoperability facilitates exporting the Smart 3D-modeled designs and catalog data in most disciplines to PDMS format (see Figure 7). This includes:

- **Equipment** – Smart 3D catalog equipment and components, designed equipment and equipment components, shapes and solids, etc.
- **Piping** – Piping stock parts, components, bends, elbows, connections, connection items (i.e., gaskets and welds), etc.
- **Plant and Marine Structures** – Linear/curved, members, assembly connections, cutbacks, stiffeners, slabs, openings, footings, foundations, stairs, handrails, built-ups, hole fittings, etc.
- **Hangers and Supports** – Piping, HVAC, cable tray supports, standard and designed support components, connectivity information (logical connection), etc.
- **HVAC** – HVAC runs, components and bends, baskets, etc.
- **Electrical** – Cable trays, runs, conduits, components, bends, etc.

Once the configuration/mapping is done, the export process can be set up to run automatically on a scheduled basis, exporting only objects that have been created or modified since the last export. This is a unique feature as opposed to the "typical" one-off exports that other systems perform and allows incremental

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update of the PDMS model during the project. This is important for projects where the PDMS model is participating in a "PDMS Global" configuration, and other parties might be interested in seeing the progress day by day.

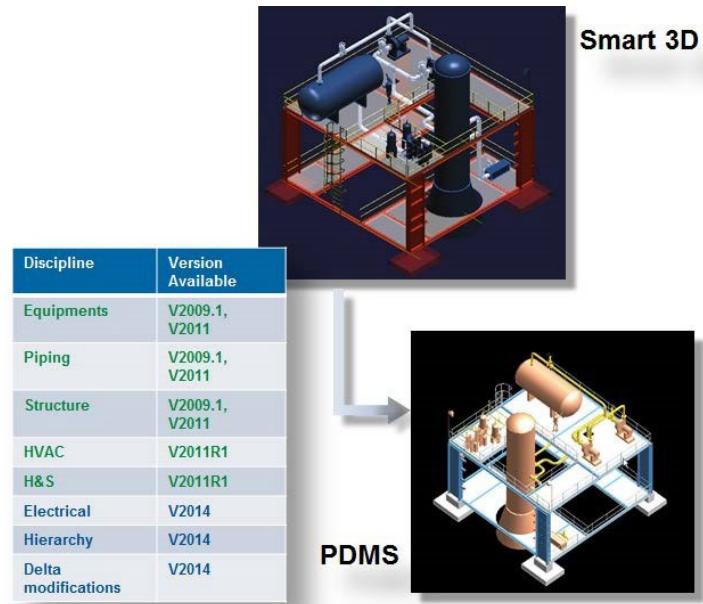


Figure 7: Smart 3D exports designs and catalog data for most disciplines used by PDMS.

5. Leveraging 3D Data for Construction and O&M

Process plant construction and subsequent O&M revamp projects bring together data created by the:

- Owner operator
- Engineering teams
- Joint venture partners
- Procurement and construction contractor(s)
- Subcontractors
- Consultants

In the initial construction and in follow-up projects during the lifecycle of the plant, these stakeholders produce large volumes of 3D data using a variety of software solutions. It has traditionally been a time-consuming and costly process to map source model graphics and object property files into common formats that can be viewed and modeled against for construction planning and execution.

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Later during O&M, software components may change over time. Data formats become incompatible and require conversion before data can be reused for similar designs and construction. Converting 3D models from one format to another before reuse dramatically increases the owner's cost during the plant's lifetime – when 3D data availability is most critical for maintenance, modification, and decommissioning.

Hexagon PPM's interoperability technology incorporates valuable model data from many sources and helps eliminate the "big bite" of converting legacy 3D models for construction and O&M projects.

As a capability built into Smart 3D, 3D Interop gives users the ability to intelligently reference external 3D model data in the Smart 3D environment. Such external data might have been created from other typical sources:

- Another Smart 3D model
- Other Hexagon PPM products such as PDS or CADWorx
- Third-party model such as PDMS or Tekla
- AutoCAD or MicroStation file

These files are converted for use with 3D Interop. The resulting converted files are then referenced, positioned, rotated, and scaled in the Smart 3D Project Management application. Generic files can have optionally generated schema and mapping files and, like other supported types, map their data to 3D Interop properties. Once referenced; the 3D Interop model data is available for use in the Smart 3D model for interactive design, including connectivity, clash checking, drawings, and more. An important aspect of the 3D Interop technology is the fact that the catalog and specification information from the third-party system is NOT required. The data from external models is expected as a set of matching graphic (.zvf) and data (.xml or .drv) files. This feature significantly augments the current global workshare solution, because it does not require replicated model or catalog databases.

3D Interop supports the following activities:

- Attach and orient (position, rotate, scale) the reference model relative to the active plant
- View the reference model data graphically and model against it
- Manage interfaces when undertaking joint venture projects
- Use multiple reference files from different sources
- Control (add) reference object, hierarchy, and properties with user-defined schema and mapping files to extend the delivered 3D Interop schema
- Inspect referenced model objects and properties (viewed in property dialogs, labels, and ToolTips)
- Use the Smart 3D filtering mechanism on referenced objects to filter objects from referenced models based on their type and properties – regardless of the authoring tool
- Extract General Arrangement drawings using graphic and label rules, showing relative positioning of objects from referenced models with limited annotation

6. O&M Engineering Design

Industry third-party technology, such as from CAXperts, helps easily import engineering designs to the Smart 3D environment for O&M projects. This is especially relevant in situations where owners do not need a fully intelligent model, but instead need to delete elements for modification using Smart 3D specs. CAXperts PlantReModeller capabilities offer an immediate and significant return on investment as compared to manual remodeling. The PlantReModeller technology is especially suitable for owners since there is less setup time and configuration needed, no one-for-one mapping of pipe specs is required, and the conversion uses existing data.

The following features and benefits in converting model data to Smart 3D show PlantReModeller capabilities result in extremely fast project completion with a very high success rate. The solution:

- Reads the 3D model data directly from the schema, so setup of source data is minimal and straightforward.
- Allows designer control of the import with minimal training. PlantReModeler presents a list of the data available; end users can select items for import – from individual objects to an entire project.
- Provides rapid conversion and delivery of results; this often reduces the migration time from months to just days or weeks.
- Achieves migration goals at a much lower cost and with less resources than manual migration methods. Typically, the PlantReModeler process cost is 60 percent to 70 percent of manual remodeling costs, based on low-cost center conversion services provided by CAXperts.
- Helps owners (and EPCs) achieve conversion time savings through PlantReModeller's capabilities for generic component placement that require specs containing pipes only with no components. Each component is placed separately as a generic component with the graphic definition. Attribute information is transferred.
- Helps align and validate specs from the source system and target system (Smart 3D).
- Uses Smart 3D command environment to edit data from the source and develop as needed.

Technology such as PlantReModeller can help deliver an intelligent model that can be edited and further developed within Smart 3D. Hexagon PPM highly recommends using the CAXperts technology when the conversion project meets the following criteria:

- An exact replica of the model is not required
- There is not sufficient time in the project schedule to allow for exact spec/component mapping between the source and Smart 3D
- The original model has outdated specs and/or components and requires rework
- Only part of the model is required for reuse on a new project
- Non-intelligent graphics must also be translated
- The designer needs to retain control of the data being brought into Smart 3D

7. Handover to Meet Client Requirements

Smart 3D catalog data can be converted to other catalogs using SRD features, including:

- Transfer piping specification data, materials data, and detailed text
- Extract mapping data for export to the other format's mapping tool

For example, in a situation where Smart 3D data is exported to Aveva's PDMS, PDMS 12.x supports the system hierarchy of plants. Its Lexicon module allows users to create user-defined types (UDETs) based on ZONE type and map them to the Smart 3D system. Incremental export can occur as data is needed from Smart 3D (see Figure 8).

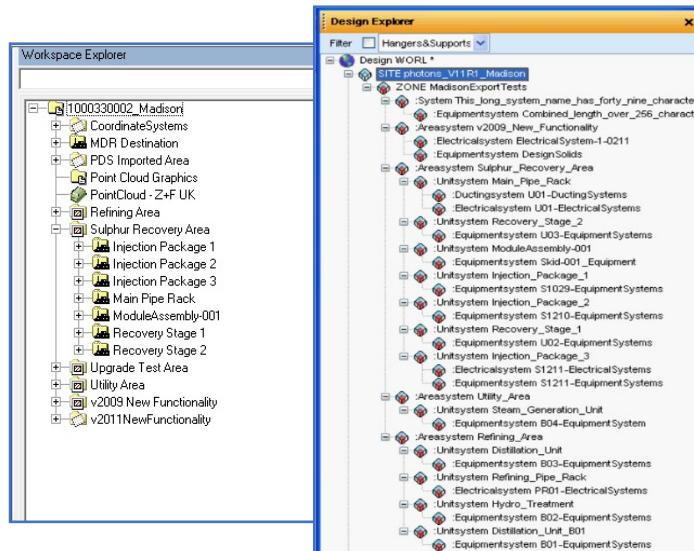


Figure 8: The plant hierarchy is incrementally mapped to PDMS schema types.

Smart 3D designs exported to PDMS can have different intelligence levels that can be controlled through:

- Mapping between Smart 3D and PDMS data
- Initialization and customization for specific project needs

Mapping features between Smart 3D and PDMS data include:

- Single initialization file based on the Windows .ini concept, supporting all disciplines
- XLS-based mapping between Smart 3D and PDMS objects
- Customizable attribute mapping (attribute, value, formula, etc.)
- OOTB default mapping between Smart 3D and PDMS
- Mapping data organized by discipline
- Built-in validation to show missing mapping

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Smart 3D provides several built-in productivity tools to assist with the conversion to PDMS and boost project team productivity. These include:

- Receive warning for missed and many-to-many mapping through discipline-based mapping
- Customize to fit project needs with Smart 3D filters
- Eliminate export order dependencies thanks to object connections
- Automate object naming/geometry grouping
- Support plant and marine world objects of Smart 3D
- Maintain intelligence of exported Smart 3D designs and data

Export-to-PDMS capability is an add-on tool to Smart 3D. Customers can manage their own configuration and use of the export solution, but even advanced Smart 3D users typically request Hexagon PPM assistance to get started and deal with the specifications, catalog data, dynamic checking of mapping, and Smart 3D reference data. The export to PDMS tool was designed with the following engineering characteristics:

- Scalable for large-scale projects
- Dual mode of export of graphics with properties or by mapping
- Integration with SRD and SDB drastically reduces catalog creation time

8. Conclusion

Hexagon PPM offers interoperability technology that helps protect and leverage valuable model data from many project sources and formats. This paper highlights Hexagon PPM's interoperability capabilities that eliminate the "big bite" of converting legacy 3D models for process, power, and marine projects.

This white paper explores five scenarios (and relevant interoperability technology) to reuse 3D data throughout the design, construction, handover, and operations and maintenance (O&M) phases of the plant life cycle. These scenarios include:

1. (Design Phase) Reuse data for Smart 3D design (3D Interop)
2. (Design Phase) Full conversion to Smart 3D (Importers)
3. (Construction and O&M) Provide 3D data from multiple formats during construction and O&M (3D Interop)
4. (O&M Design) Engineering in O&M (CAxPerts)
5. (Handover) Conversion from Smart 3D to meet client handover requirements and specifications (Exporters)

Each scenario was discussed in the context of leveraging data (through conversion and referencing) between Hexagon PPM's Smart 3D, PDS, and CADWorx formats and Aveva's PDMS environments.

This white paper is intended to be an introduction to Hexagon PPM's 3D interoperability options. For more information about Hexagon PPM's interoperability solutions, please visit www.hexagonppm.com.

9. Definitions

Table 4: This is a list of the definitions of the terms used in this white paper.

Term	Definition
Conversion	Changing one form of encoded software data to another form
Convert to ZVF utility	Translates PDS and/or PDMS data to read-only Smart 3D data
DATAL	Data exchange format of PDMS 3D designed data, for importing to PDMS software or exporting from PDMS
Export to PDMS	An export tool added-on to Smart 3D to convert data from Smart 3D to PDMS
Import from PDMS	An import tool added-on to Smart 3D to convert data from Smart 3D to PDMS
JV	Joint venture projects managed by multiple stakeholders
Mapping	Process of identifying the suitable match of objects, properties between the source (PDMS model) and destination (Smart 3D model) and their corresponding Reference Data (parts, materials, cross sections, specifications, etc.) between the source (PDMS catalog) and destination (Smart 3D catalog)
MCAD	Mechanical Computer-aided Design
Migrate	Transferring data between storage types, formats, or computer systems
Model Data	The three-dimensional representation of geometric images
OOTB	Out of the Box: refers to functionality, capabilities, configurations, utilities, and automation routines that are standard to a software product
PDMS	Plant Design Management System: 3D design solution for plant industries from AVEA
PDS	Plant Design System: 3D design solution for plant industries from Hexagon PPM
Reference Data	Data associated with the 3D model used to create intelligent “rules” for design
Referencing	Referring to designs and data in different formats from the current design file
Schema	A data model of a specific domain expressed in terms of a particular data management technology related to relational tables and columns, object-oriented classes, or XML tags
SDB	Intergraph Standard Database
Smart 3D	Intergraph Smart 3D, which combines the former SmartPlant 3D and SmartMarine 3D
Smart 3D Convert Database Mode Utility	Converts Smart 3D plant data mode to Marine or Material Handling mode
Smart 3D Database Conversion Wizard	Converts Smart 3D data between database platforms (MS SQL Server to Oracle or Oracle to MS SQL Server)
Smart 3D Translators Module	Exports/imports PDS and/or PDMS data from or to native (editable) Smart 3D data (which can be published to SPF)
SPC	Intergraph Smart Construction from Hexagon PPM
SPF	SmartPlant Foundation from Hexagon PPM

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INTP	Intergraph Smart Interop Publisher from Hexagon PPM: translates PDS and/or PDMS data to read-only Smart Review and Smart 3D data (which can be published to SPF)
SR	Intergraph Smart Review from Hexagon PPM
SRD	Intergraph Smart Reference Data from Hexagon PPM
Translation	Changing one form of encoded software data to another form
Upgrade	Transferring data between versions of data formats



About Hexagon

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications. Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous — ensuring a scalable, sustainable future.

Hexagon's PPM division empowers its clients to transform unstructured information into a smart digital asset to visualize, build and manage structures and facilities of all complexities, ensuring safe and efficient operation throughout the entire lifecycle.

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