Setup Plant 3D to Meet Your BIM Requirement

Peggy Lin, David Manning

AUTODESK. UNIVERSITY

About the speaker

Peggy Lin

- Digital Engineering Technology Specialist in AECOM ANZ, BIM manager /Digital Engineering Lead in major projects
- 15 years of working experience on Civil Infrastructure Projects
- Revit, Plant 3D, Civil 3D, inventor, Navisworks, Infraworks, Recap and 12D user
- Capable of programming in C#. Python and Dynamo
- Particular interest in developing workflow and methodology that interact with data directly and increase efficiency and productivity

About the speaker

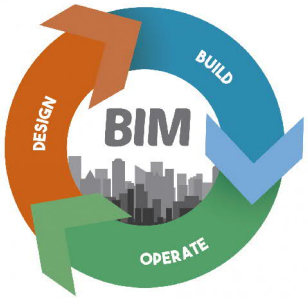
David Manning

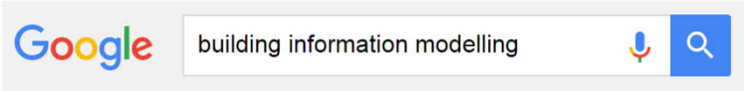
Designated Support Specialist

- Plant 3D and P&ID
- AutoCAD
- ReCap
- Recap Photo
- Navisworks
- Fusion 360
- Vault
- BIM 360 tools

- 6 years Steam Plant Design
- 12 Years Piping Design (Oil & Gas)
- 3 Years Autodesk Specialist

Introduction





WIKIPEDIA

Building information modelling (BIM) is a process supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of places.

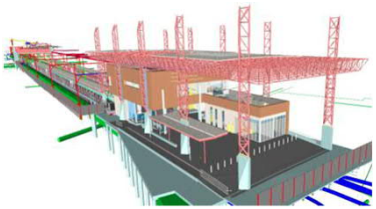
AUTODESK

Building Information Modelling is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure.

NBS

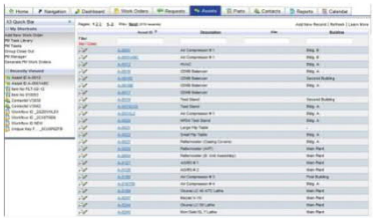
BIM is a process for creating and managing information on a construction project across the project lifecycle. One of the key outputs of this process is the Building Information Model, the digital description of every aspect of the built asset. This model draws on information assembled collaboratively and updated at key stages of a project. Creating a digital Building Information Model enables those who interact with the building to optimize their actions, resulting in a greater whole life value for the asset.

Digital Engineering

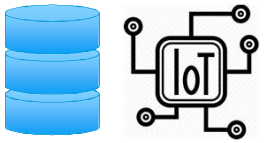


3D ‘BIM’ Model

6D BIM

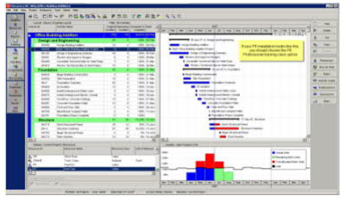


Asset Data



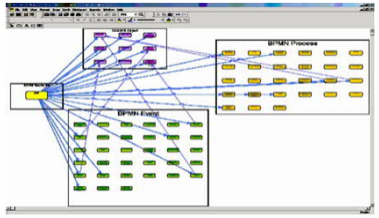
Other Data

4D BIM



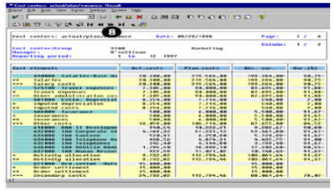
Time

2D/3D GIS

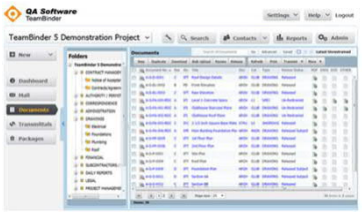


Requirements Mgmt

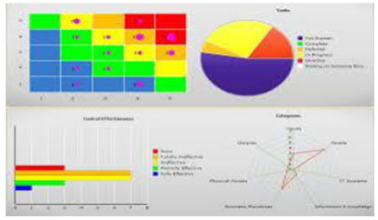
5D BIM



Cost



Document Mgmt



Risk Mgmt

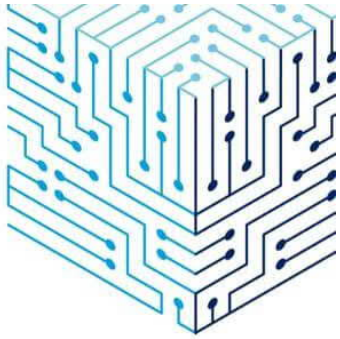
Source: TfNSW DE Framework

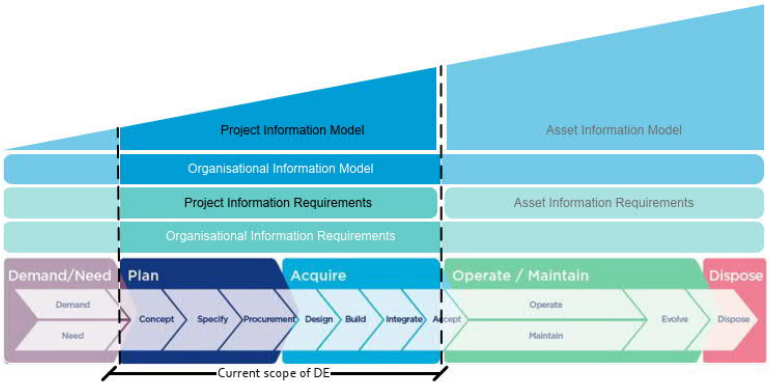
Digital Engineering

- Collaborative way of working
- Using digital processes
- Asset creation, construction and O&M

Transport for NSW

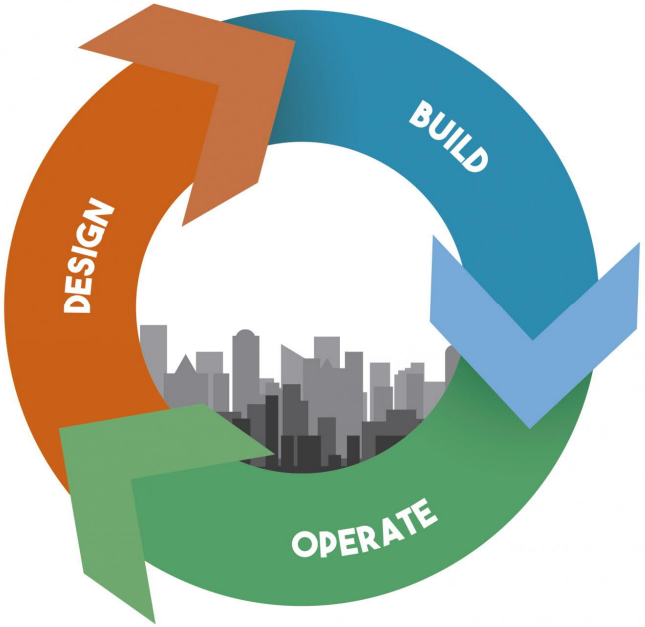
Digital Engineering Framework





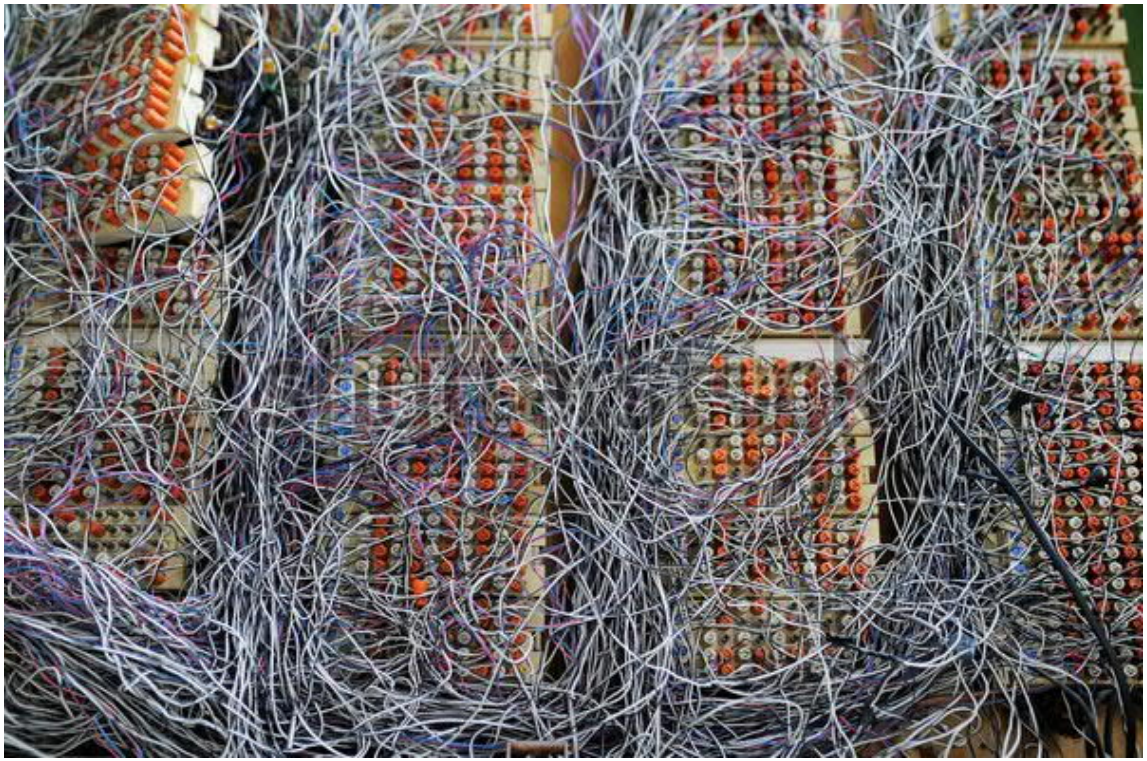
Benefits of BIM/DE

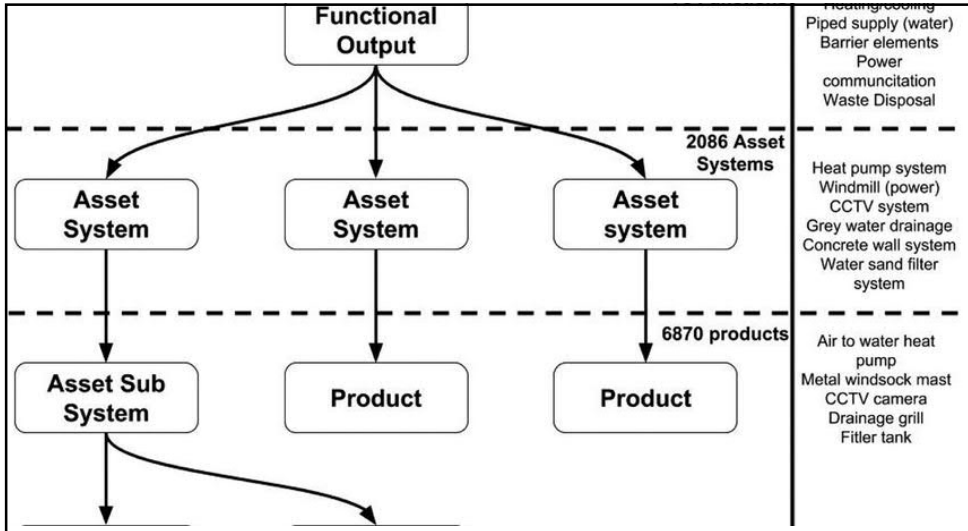
- Coordination
- Communication
- Data management
- Analysis and Simulation
- Improved working methods during design
- Improved Productivity during construction
- Better information for facility management

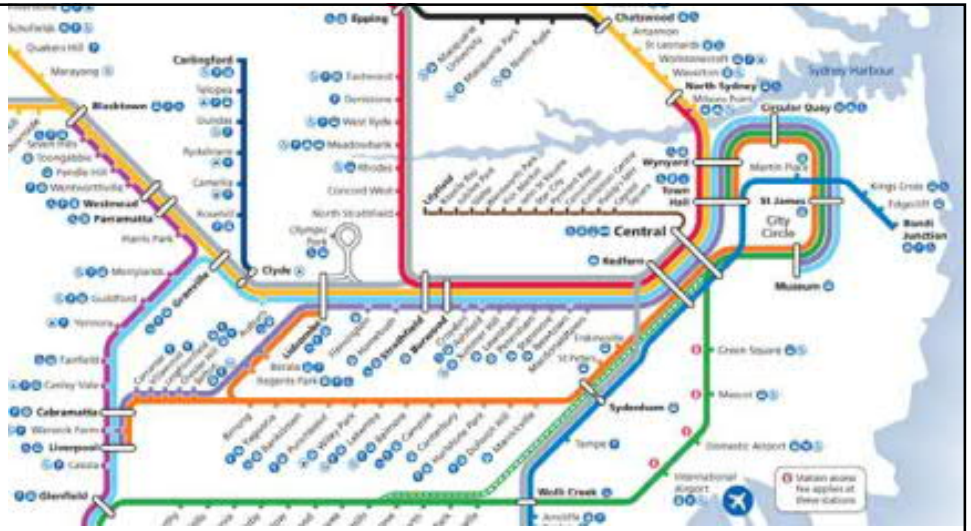


Information is the oil of the 21st century, and analytics is the combustion engine.

Peter Sondergaard, Gartner Research







Classification System

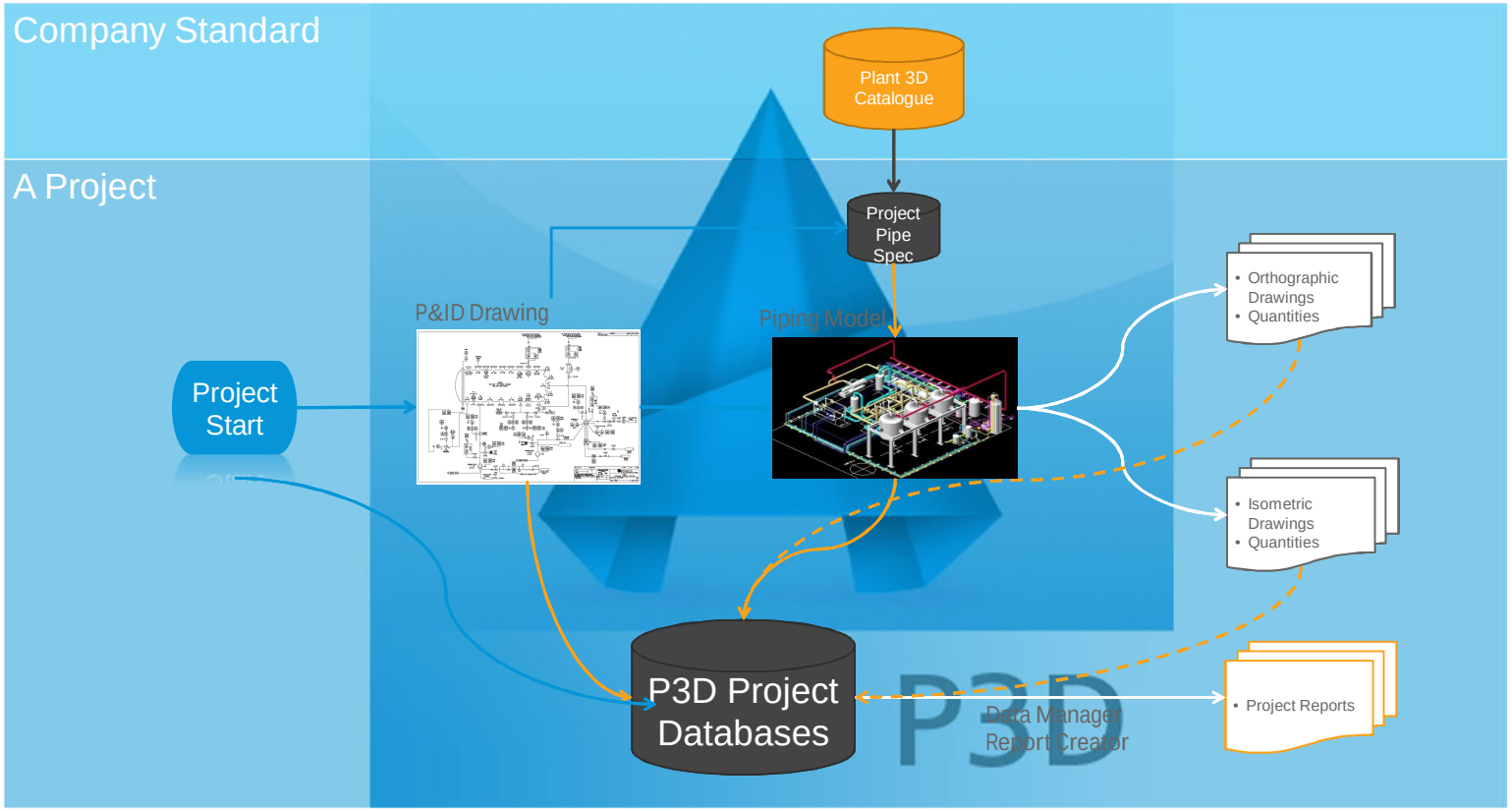
- Uniclass 2015 (UK, www.thenbs.com)
- OmniClass (North America)
- CCS (Cuneco Classification System, Denmark)
- CoClass (Sweden)
- ISO 81346-12

Location Referencing

- Address
- A unique code or label

Plant 3D Overview

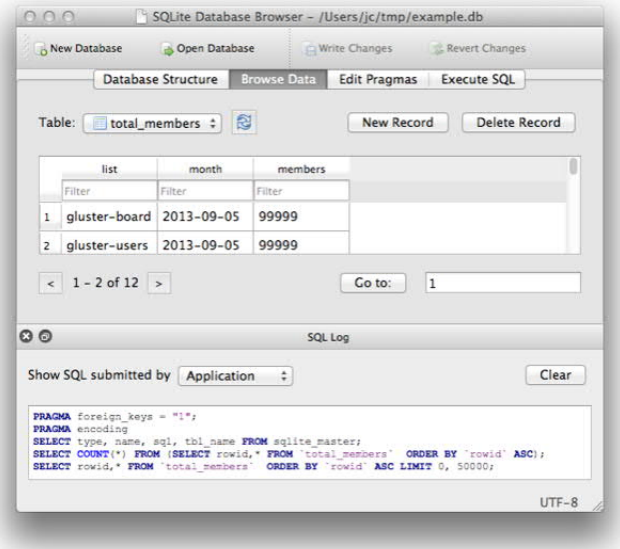
Plant 3D Overview



Plant 3D Database

https://sqlitebrowser.org/

DB Browser for SQLite



- Fast indexing
- Support 1-2 users to read/write in the same time

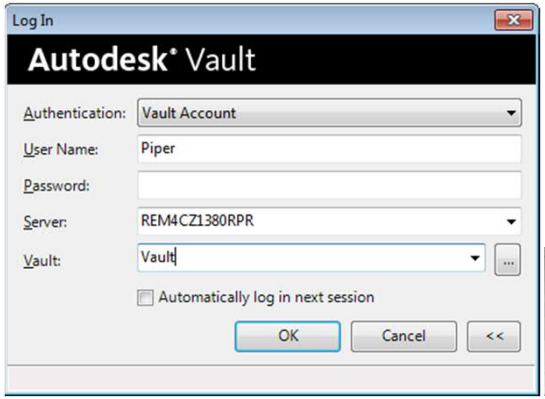
Microsoft® SQL Server®

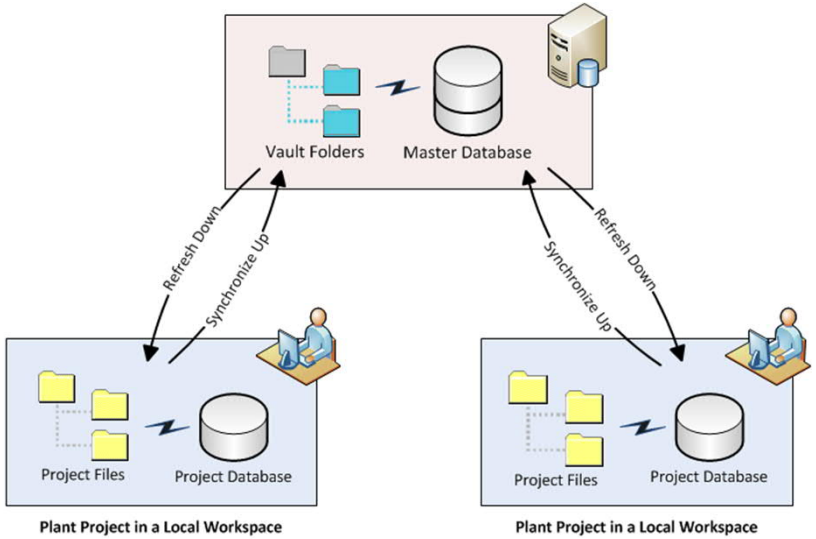
- Relational database
- Run on sever, user control
- Support many users to read/write at the same time

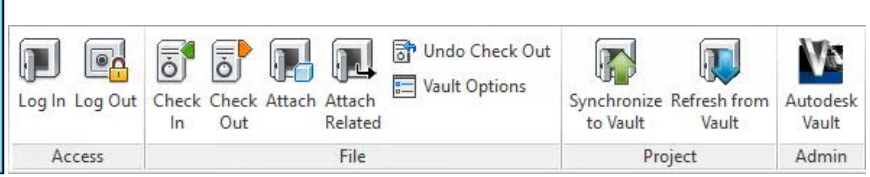
Reference: SQLite: The database at the edge of the network

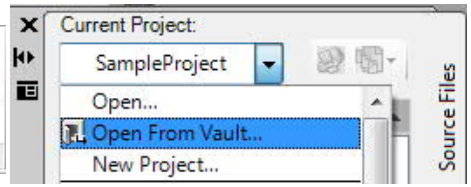
Plant 3D Collaboration - Autodesk Vault

- Local workspace
- check-in and check-out document management
- Automatic file version
- Master project database
- User authentication and access control





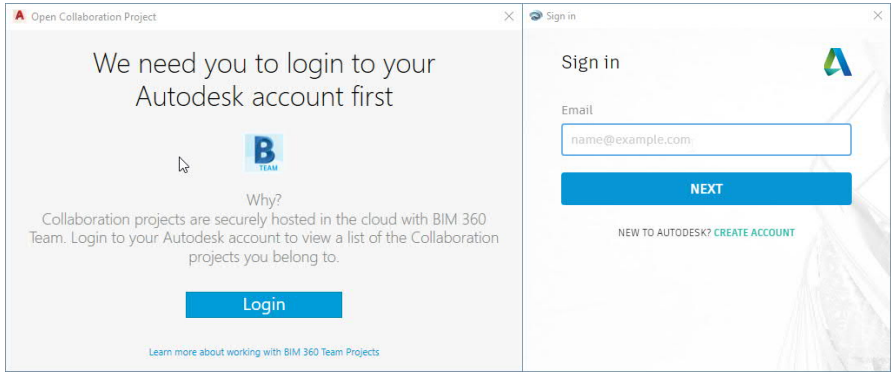


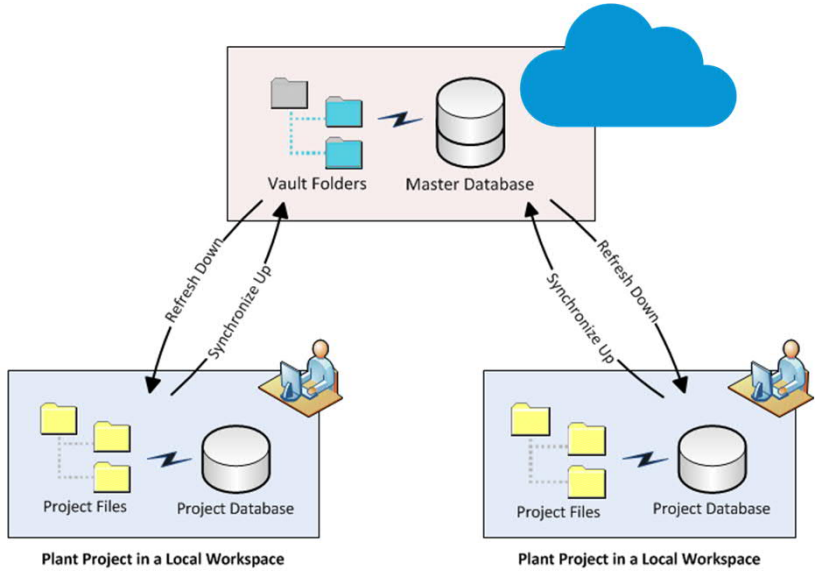


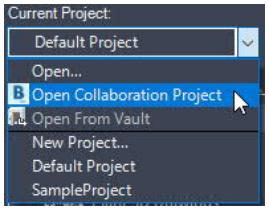
Reference: [About Autodesk Vault]

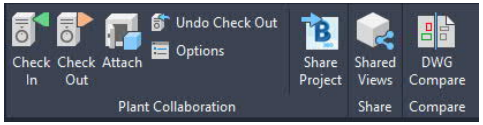
Plant 3D Collaboration – BIM360 TEAM

- Local workspace
- check-in and check-out document management
- Automatic file version
- Master project database
- User authentication and access control









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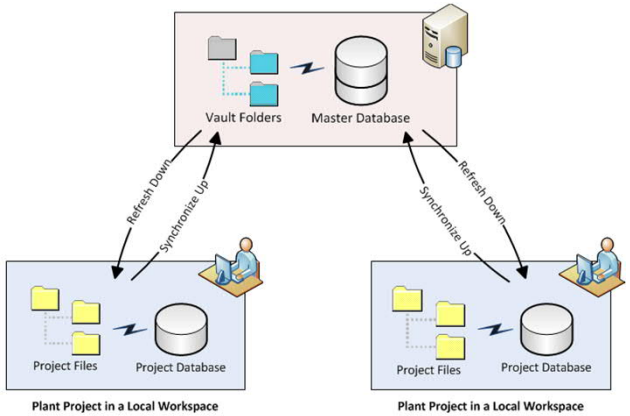
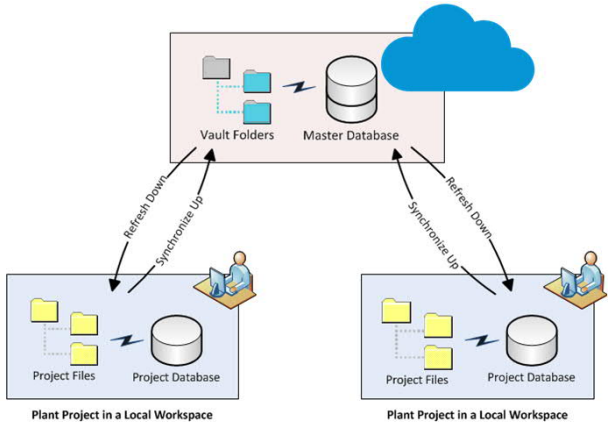


Autodesk Vault

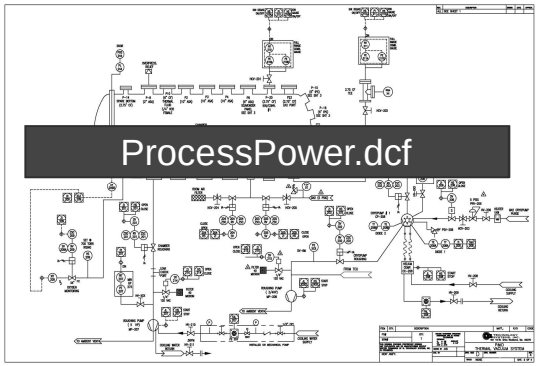
- Data sovereignty
- Cost and time on set up servers

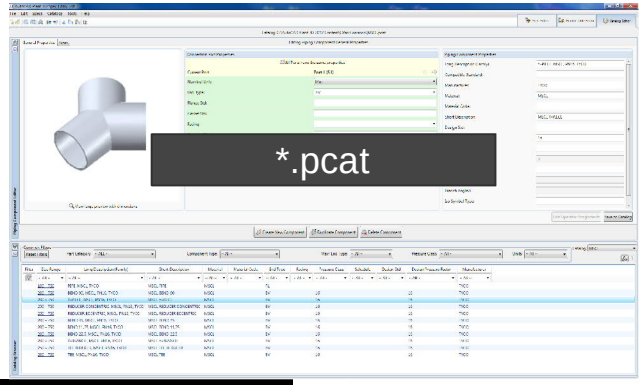


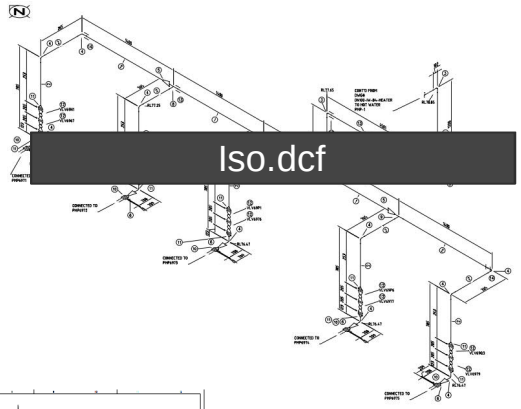
BIM360 TEAM

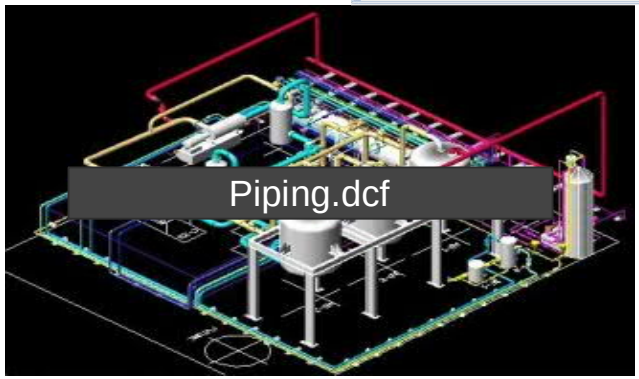
- Low cost
- Easy to setup
- Use (Amazon Web Services) AWS, main server in US

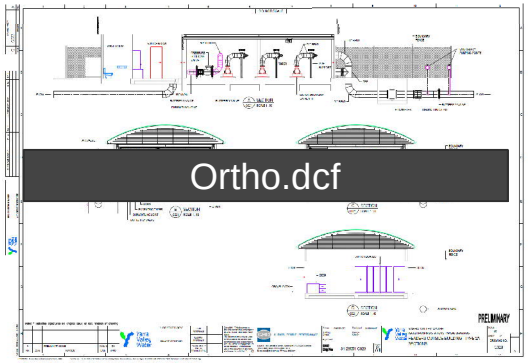
Plant 3D modules







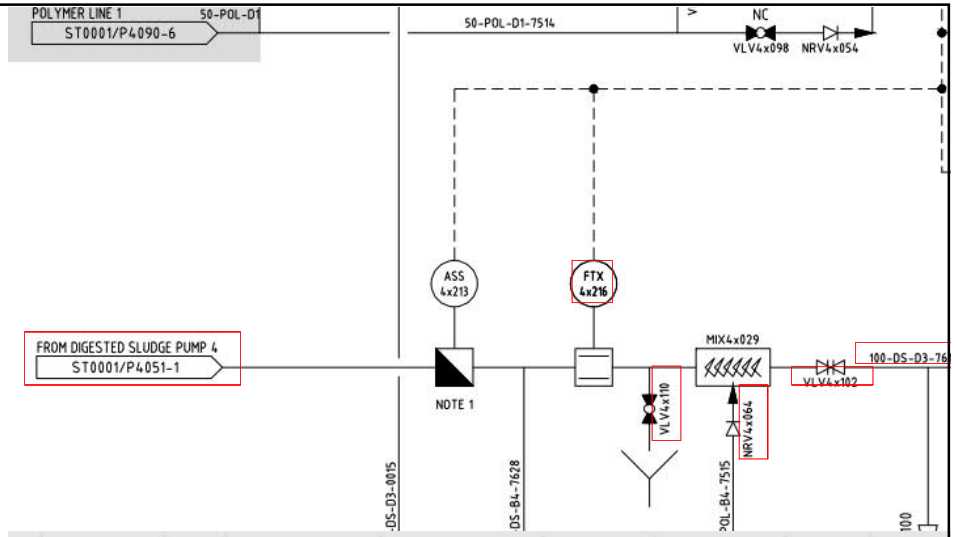




Misc.dcf

Smart P&ID

- Data saved in database as P&ID drawings created;
- Each graphic element presents a object class, and has set of properties
- All annotation come from class properties and useful not only present the data but also provide a way to visually check data
- Easy schedule and data update
- Validation with Plant 3D model



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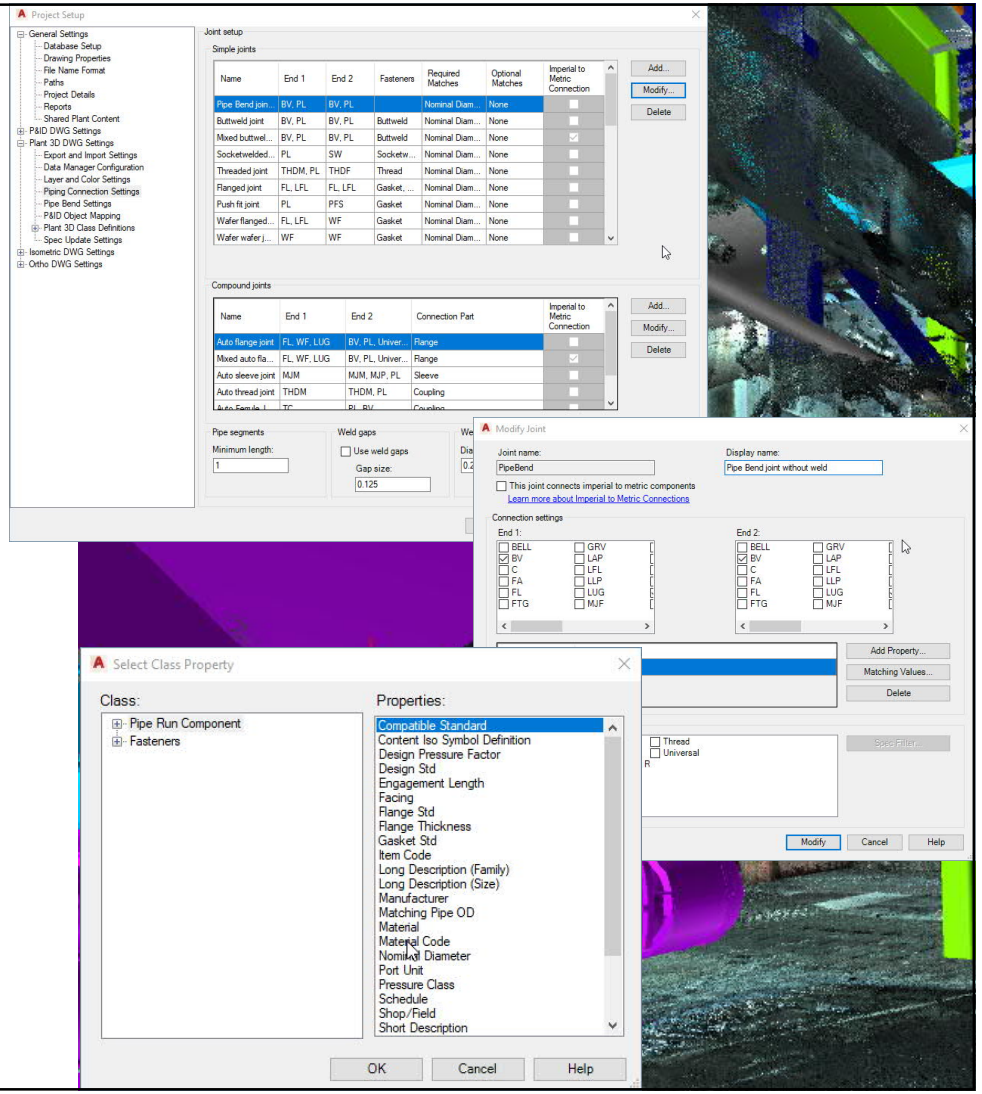
3		1045	ST0001	P4051-2	DMP	4x	200	DMP4x2
4		1084	ST0001	P4051-2	DMP	4x	201	DMP4x2
5		1147	ST0001	P4051-2	NRV	4x	055	NRV4x05
6		1151	ST0001	P4051-2	VLV	4x	102	VLV4x10
7		1744	ST0001	P4051-2	VLV	4x	103	VLV4x10
8		1861	ST0001	P4090-3	VLV	4x	421	VLV4x42
9		1881	ST0001	P4090-3	VLV	4x	420	VLV4x42
10		2288	ST0001	P4090-5	VLV	4x	001	VLV4x00
11		2294	ST0001	P4090-5	NRV	4x	056	NRV4x05
12		2299	ST0001	P4090-5	VLV	4x	002	VLV4x00
13		2335	ST0001	P4090-5	VLV	4x	003	VLV4x00
14		2340	ST0001	P4090-5	VLV	4x	004	VLV4x00
15		2387	ST0001	P4090-5	PRV	4x	115	PRV4x11

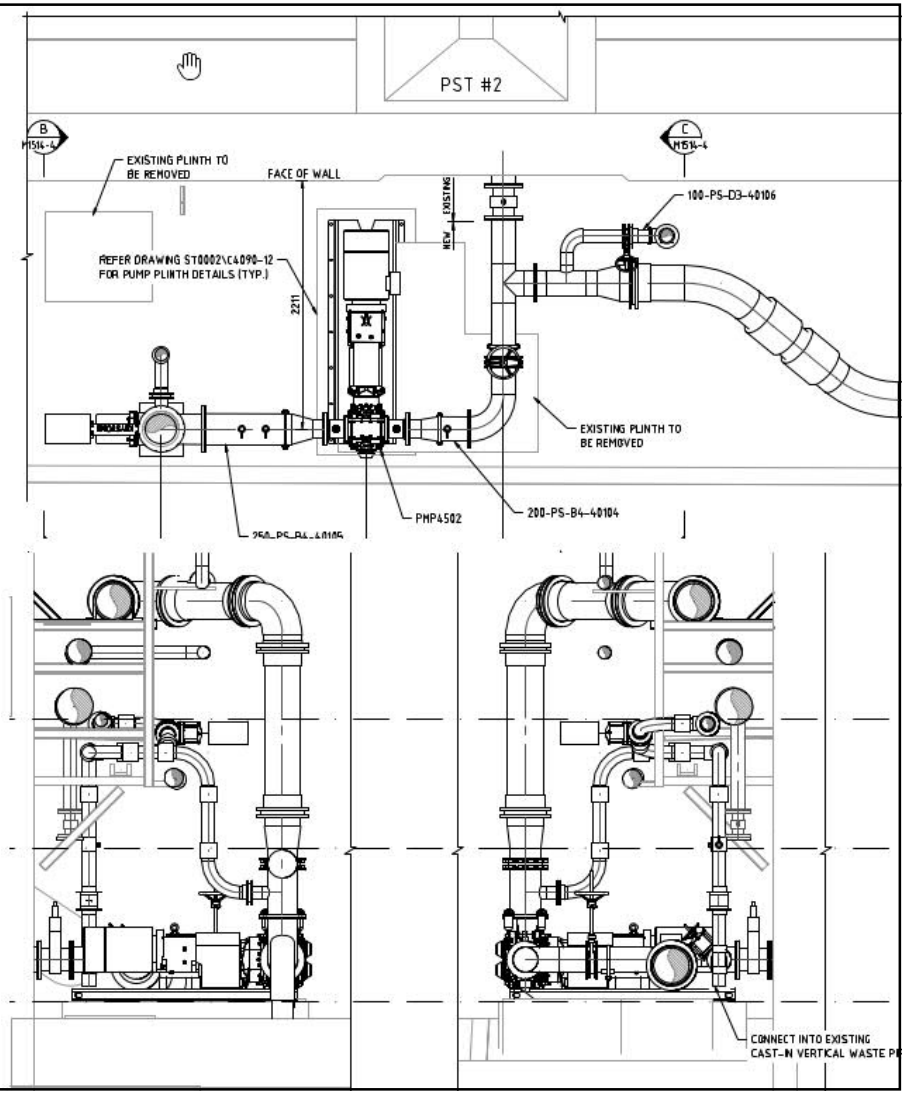
3D Modelling

- Spec driven, auto-routing
- Configurable branch table
- Customize to any level of rule enhancement as required
- Easily add, delete parameters
- Support sloping modelling



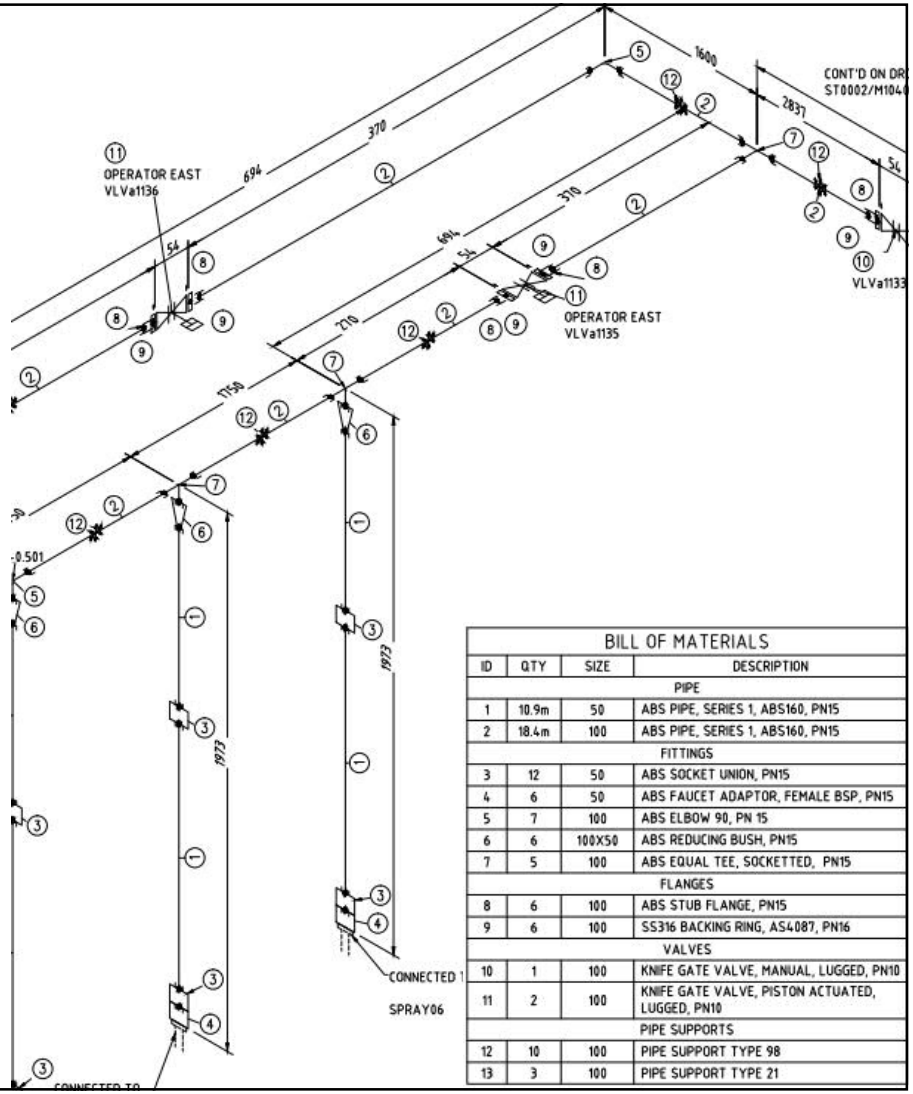
Orthographic Drawings

- Layer control
- Annotation from model properties
- Cut and slide anywhere
- BOM



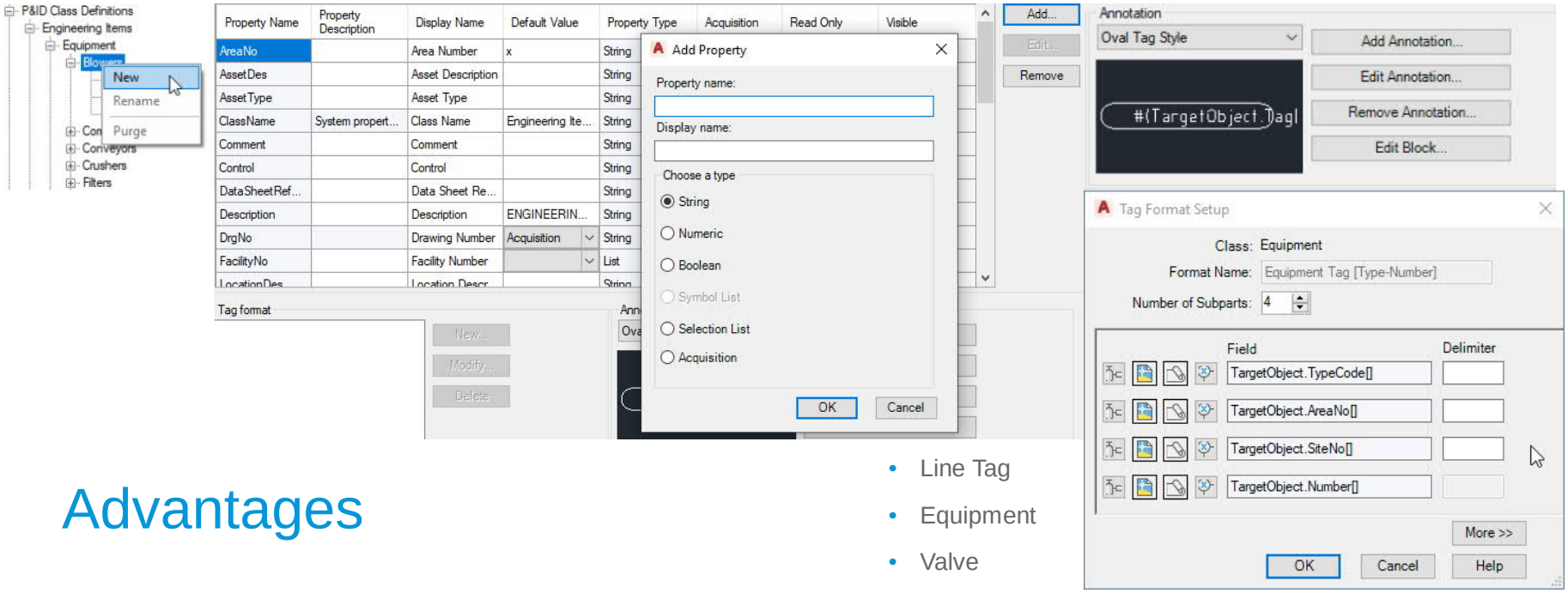
Isometric

- Generated from model without manual editing
- BOM auto generation per line
- Enable off site construction
- Configuration customisable



BILL OF MATERIALS

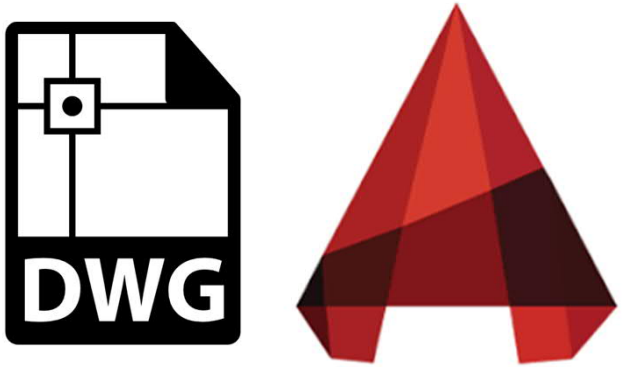
ID	QTY	SIZE	DESCRIPTION
			PIPE
1	10.9m	50	ABS PIPE, SERIES 1, ABS160, PN15
2	18.4m	100	ABS PIPE, SERIES 1, ABS160, PN15
			FITTINGS
3	12	50	ABS SOCKET UNION, PN15
4	6	50	ABS FAUCET ADAPTOR, FEMALE BSP, PN15
5	7	100	ABS ELBOW 90, PN 15
6	6	100X50	ABS REDUCING BUSH, PN15
7	5	100	ABS EQUAL TEE, SOCKETTED, PN15
			FLANGES
8	6	100	ABS STUB FLANGE, PN15
9	6	100	SS316 BACKING RING, AS4087, PN16
			VALVES
10	1	100	KNIFE GATE VALVE, MANUAL, LUGGED, PN10
11	2	100	KNIFE GATE VALVE, PISTON ACTUATED, LUGGED, PN10
			PIPE SUPPORTS
12	10	100	PIPE SUPPORT TYPE 98
13	3	100	PIPE SUPPORT TYPE 21



Advantages

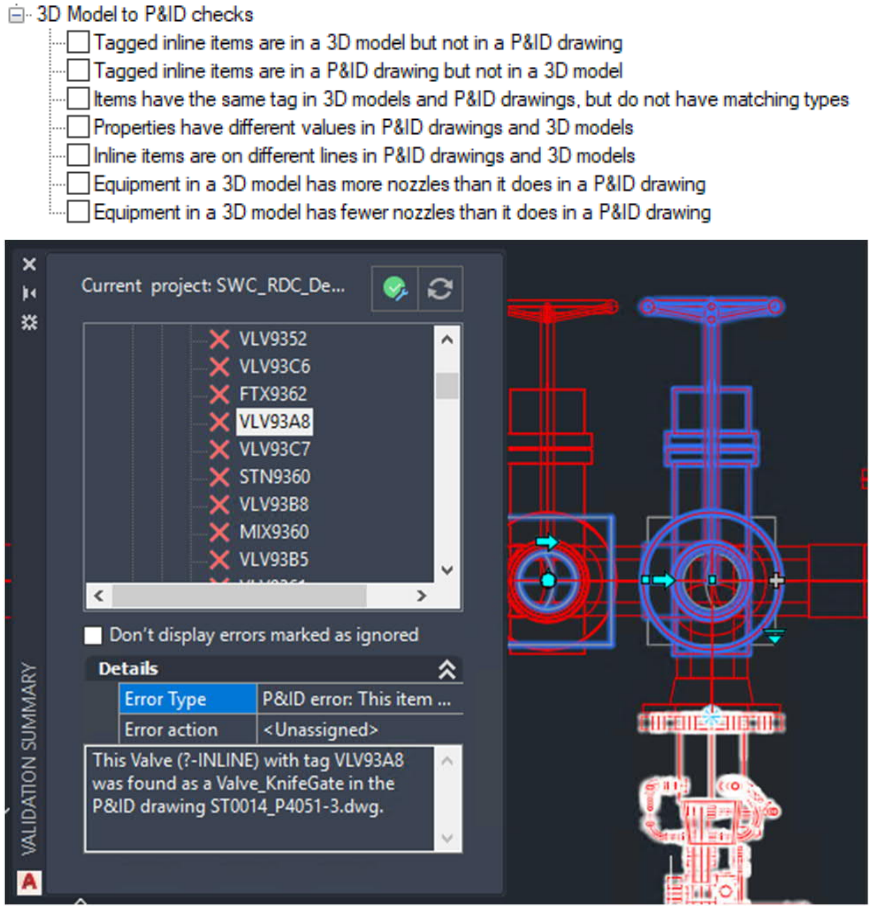
- Line Tag
- Equipment
- Valve
- Instruments

- Data Structure and object classification
- Smart annotation
- Standardize the look and feel across all drawings using project level tagging/annotation customization
- Tag concatenation



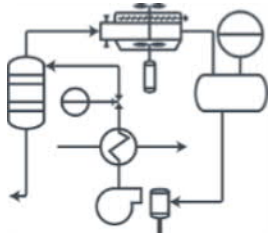
Limitations

- DWG /AutoCAD based
- Data verification is not in its best
- Navisworks out model only contain limited data



Plant 3D Customization

P&ID Module



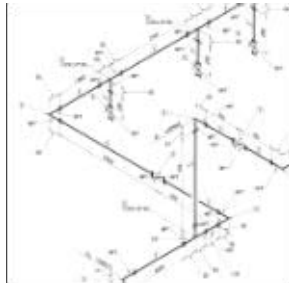
- SubstitutionPalettes.xml

PIDTo3dClassMapping.xml

3D Modelling Module

- DefaultConnectorsConfig.xml
- ProjectSetupSpecUpdateSettings.xml

Isometric Module



- BoltSizeMappings.xml
- IsoSkeyAcadBlockMap.xml
- IsoSymbolStyles.dwg
- Plant3dIsoSymbols.dwg
- IsoConfig.xml
- Iso.dwt

XML

- XML stands for Extensible Markup Language
- Is a markup language much like HTML
- Was designed to store and transport data
- Was designed to be self-descriptive
- Open standard
- Text file
- Data storage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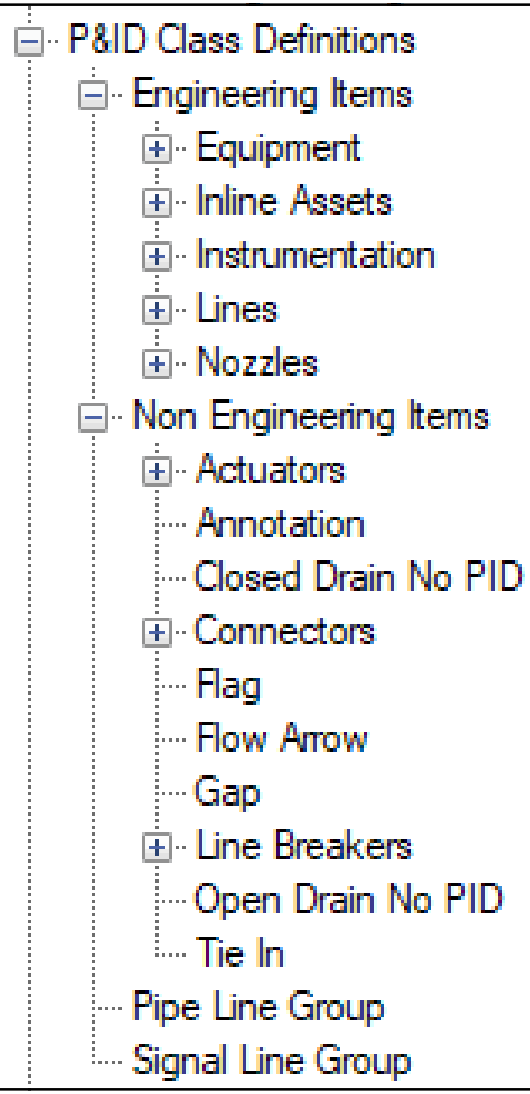
  </ProjectParts>
  <ProjectPartDirectories>
    <ProjectPartDirectory name="SpecSheets" directoryName="C:\Users\LinP3\Documents\Project1\Spec Sheets" relativeDirectoryName="Spec Sheets" uncDirectoryName="" />
    <ProjectPartDirectory name="Ortho" directoryName="C:\Users\LinP3\Documents\Project1\Orthos\DWGs" relativeDirectoryName="Orthos\DWGs" uncDirectoryName="" />
    <ProjectPartDirectory name="Related Files" directoryName="C:\Users\LinP3\Documents\Project1\Related Files" relativeDirectoryName="Related Files" uncDirectoryName="" />
  </ProjectPartDirectories>
</Project>
```

P&ID Customization

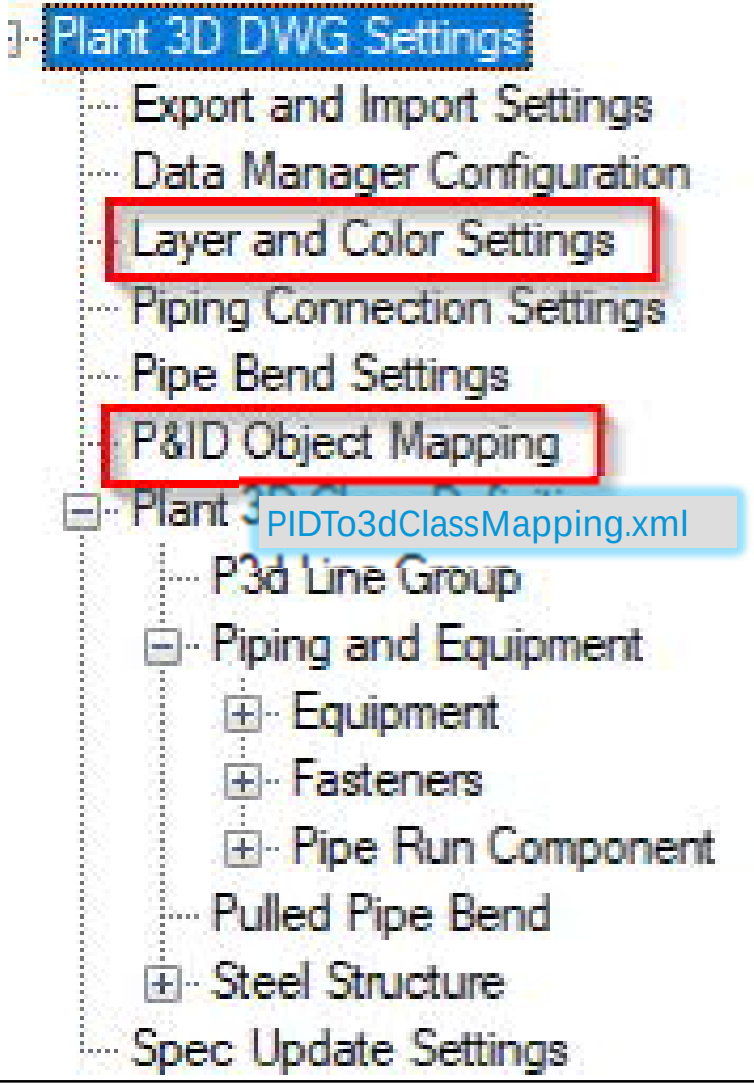
- **Inheritance**
- Should setup tags for all annotation need in drawings
- Understand the output required before modify class definitions
- Not all class is schedulable



- P&ID drawings
- Equipment
- Instrument
- Line
- Nozzle
- Specialty Items
- Valve
- Control Valve

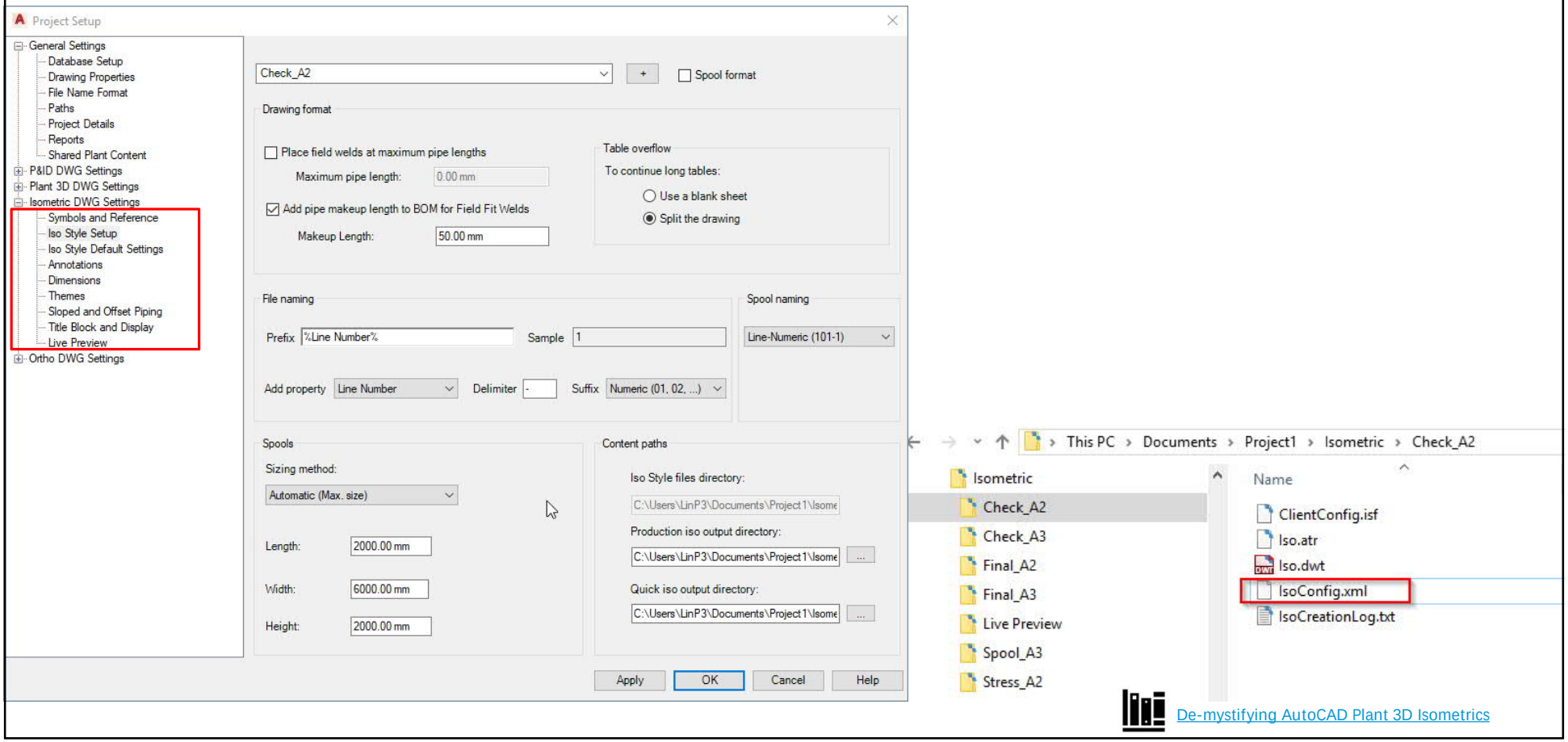
Plant 3D Modelling Customization

- Layer and color settings
- P&ID Object Mapping
- Pipe Number Setting



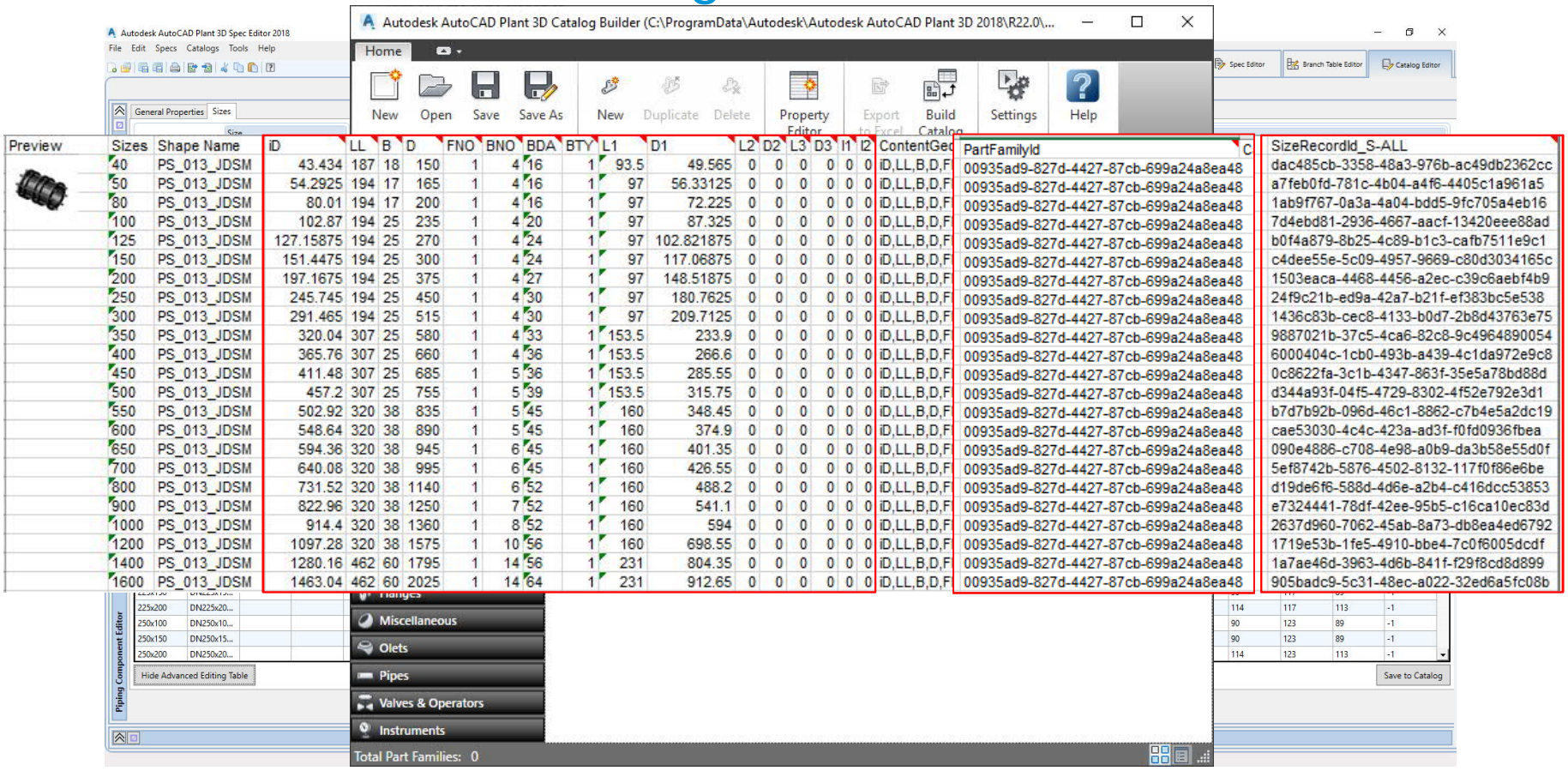
Tailoring AutoCAD P&ID and AutoCAD Plant 3D

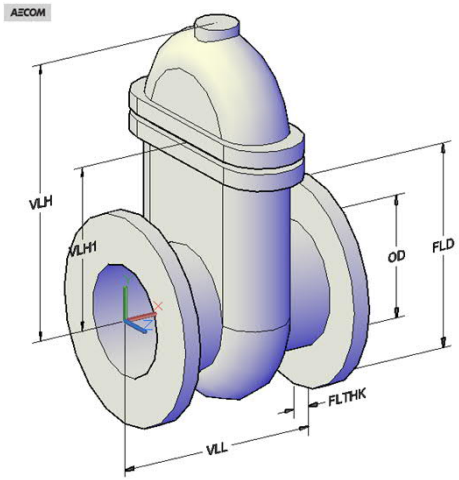
Isometric Customization

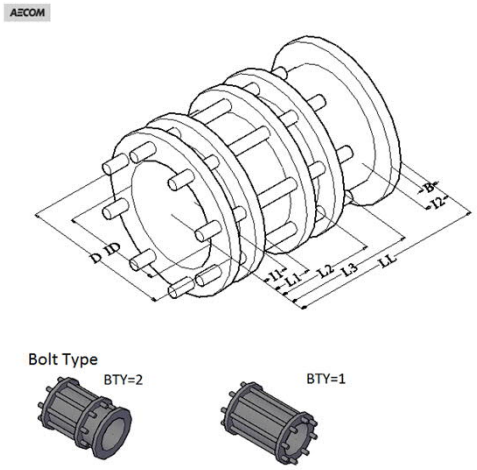


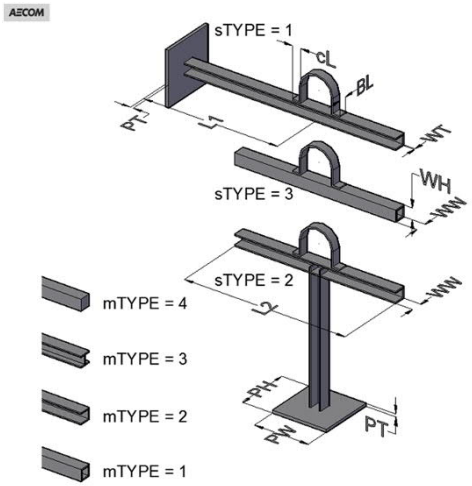
De-mystifying AutoCAD Plant 3D Isometrics

Catalogue Creation









Python Scripted parts

Advantage over block

- Good look and feel
- Simple and productive

Custom Python Scripts for AutoCAD Plant 3D – Part 1
Custom Python Scripts for AutoCAD Plant 3D – Part 2
Custom Python Scripts for AutoCAD Plant 3D – Part 3

	Actuator Create Type			
Valve Body	Catalogue Standard	Catalogue Block	Catalogue Python	3D Block
Catalogue Standard	Yes	Yes		Yes
Catalogue block		Yes		Yes
Catalogue Python		Yes		
Custom Standard	Yes			Yes
Custom block				

matplotlib

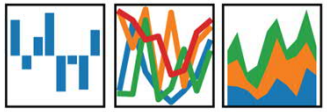
NumPy

TensorFlow

pandas

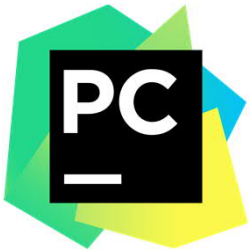
$y_i t = \beta' x_{it} + \mu_i + \epsilon_{it}$

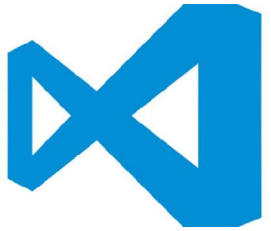
SciPy



Python

- Popular object-oriented language
- Easy to read
- Run as it is being compiled





```
## create by Peggy Lin (Peggy.lin@aecom.com/Peggy.lin.syd@gmail.com) @24.01.2016
## tested in Plant 3D 2018

from aqa.math import *
from varmain.primitiv import *
from varmain.var_basic import *
from varmain.custom import *


@activate(Group="Valvebody", TooltipShort="GATE Valve", TooltipLong="GATE Valve", LengthUnit="mm", FirstPortEndtypes="FL", Ports=2)
@group("MainDimensions")
@param(VLL=LENGTH, TooltipShort="Length of Valve", TooltipLong="Length of Valve")
@param(FLTHK=LENGTH, TooltipShort="Thickness of the valve flange", TooltipLong="Thickness of the valve flange")
@param(FLD=LENGTH, TooltipShort="OD of Valve Flange", TooltipLong="OD of Valve Flange")
@param(OD=LENGTH, TooltipShort="OD of pipe", TooltipLong="OD of Pipe")
@param(VLH=LENGTH, TooltipShort="H
@param(VLH1=LENGTH, TooltipShort="I

def PS_004_VGAT(s, VLL=100, FLTHK=
    adH=20.0
    FLgap=3.0

    ob1=CYLINDER(s, R=OD/2.0, H=VL

    ob2=CYLINDER(s, R=FLD/2.0, H=F
    ob1.uniteWith(ob2)
    ob2.erase()

    ob2=CYLINDER(s, R=FLD/2.0, H=F
    ob1.uniteWith(ob2)
    ob2.erase()

    ob2=TORUS(s, R1=OD/2.0, R2=VLL,
    ob1.uniteWith(ob2)
    ob2.erase()

    ob2=CYLINDER(s, R=OD/2.0, H=VL
    ob1.uniteWith(ob2)
    ob2.erase()
    ob4=BOX(s, L=OD*1.2, W=FLTHK, H=VLL/3.0*1.2).translate((0,0,VLH1+FLTHK/2.0+FLgap))
    ob1.uniteWith(ob4)
    ob4.erase()
    ob4=CYLINDER(s, R=VLL/6.0*1.2, H=FLTHK, O=0.0).translate((0,OD*1.2/2.0,VLH1+FLgap))
    ob1.uniteWith(ob4)
    ob4.erase()
    ob4=CYLINDER(s, R=VLL/6.0*1.2, H=FLTHK, O=0.0).translate((0,-OD*1.2/2.0,VLH1+FLgap))
    ob1.uniteWith(ob4)
    ob4.erase()

    if OD > VLL:
        ob4=CYLINDER(s, R=VLL/6.0, H=VLH, O=0.0)
    else:
        ob4=CYLINDER(s, R=OD/6.0, H=VLH, O=0.0)
    ob1.uniteWith(ob4)
    ob4.erase()

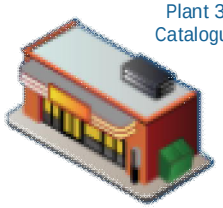
    ob5=CYLINDER(s, R=OD*0.45, H=VLL, O=0.0).rotateZ(-90).rotateY(90).translate((-VLL/2.0,0,0))
    ob1.subtractFrom(ob5)
    ob5.erase()

    s.setPoint((-VLL/2.0,0,0),(-1,0,0))
    s.setPoint((VLL/2.0,0,0),(1,0,0))
```

Valve Alignment
Valve Body Type

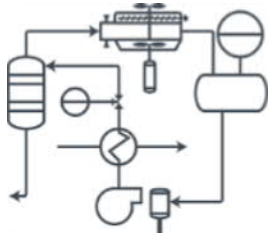
Plant 3D
Catalogues

Iso Symbol Type
Iso Symbo SKEY

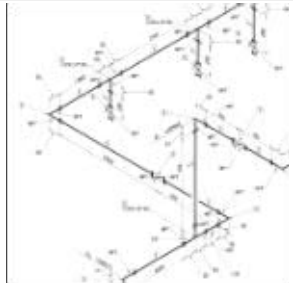


Spec

```
<IsoSkeyMap xmlns:xsi="http://www.w3.org/2001/XMLSchem
  <!-- Begin: Fittings -->
  <SkeyMap SKEY="EL??" AcadBlock="Elbow"/>
  <SkeyMap SKEY="EB??" AcadBlock="Elbow"/>
  <SkeyMap SKEY="ER??" AcadBlock="ElbowReducing"/>
  <SkeyMap SKEY="PB??" AcadBlock="Bend"/>
  <SkeyMap SKEY="BE??" AcadBlock="Bend"/>
  <SkeyMap SKEY="PB" AcadBlock="Bend"/>
  <SkeyMap SKEY="BE" AcadBlock="Bend"/>
  <SkeyMap SKEY="MI??" AcadBlock="BendMitre"/>
```



PIDTo3dClassMapping.xml



- SubstitutionPalettes.xml

- DefaultConnectorsConfig.xml
- ProjectSetupSpecUpdateSettings.xml

- BoltSizeMappings.xml
- IsoSkeyAcadBlockMap.xml
- IsoSymbolStyles.dwg
- Plant3dIsoSymbols.dwg
- IsoConfig.xml
- Iso.dwt

Plant 3D Setup for BIM/DE

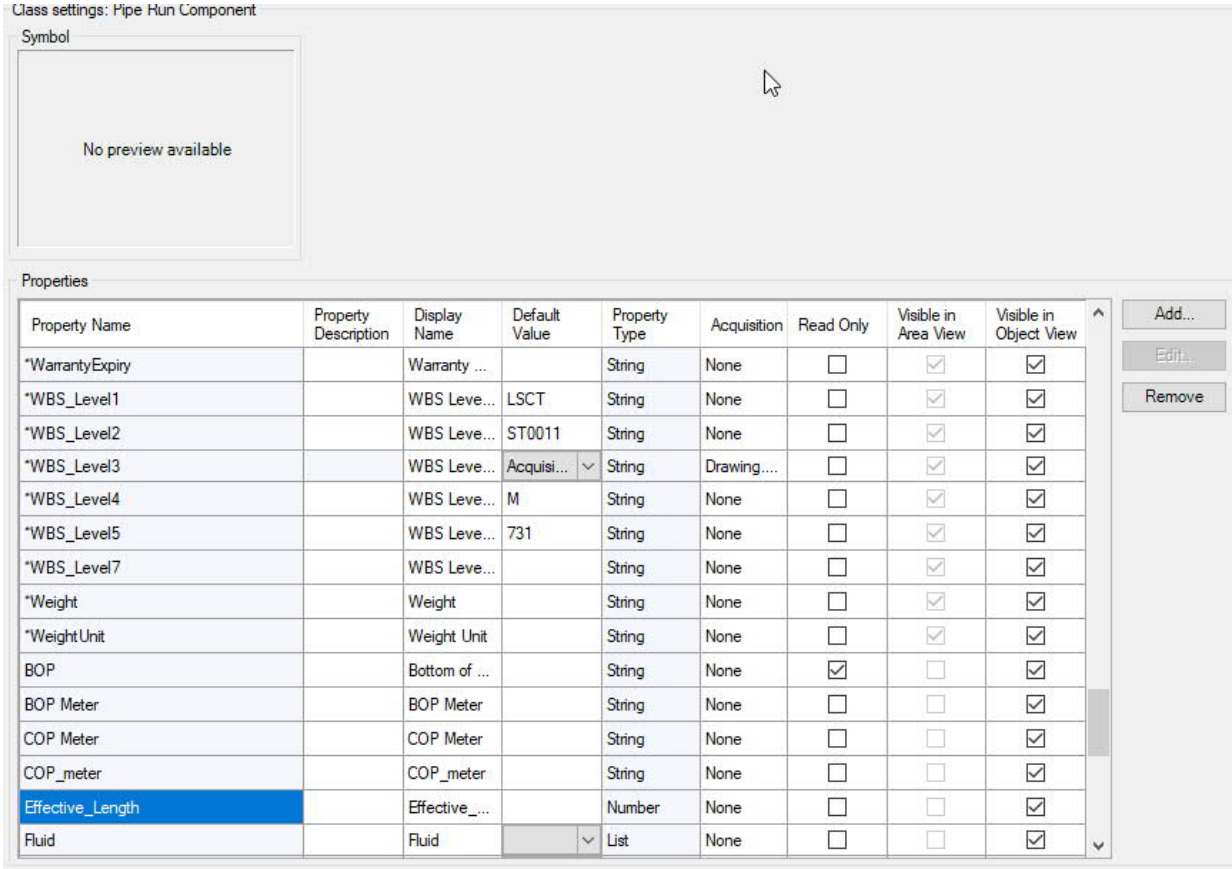
Employer Information Requirement

- Sets out the information required by the employer, enabling suppliers to produce a BIM execution plan or Digital Engineering execution plan;
- Defines what the employer wants to get out of the project information model at each stage.
  - Who is sharing the information? – outline responsibility matrix
  - What Information is needed – Detailed Information Requirements
  - When information is needed by? Project milestones
  - Why the information is needed? Defined information purpose

Custom Properties

Satisfy Asset Information Requirement

- Add custom properties to object class
- Have a coding system
- Add to catalogue
- Add to project



Property Name	Property Description	Display Name	Default Value	Property Type	Acquisition	Read Only	Visible in Area View	Visible in Object View
*WarrantyExpiry		Warranty ...		String	None	☐	☑	☑
*WBS_Level1		WBS Leve...	LSCT	String	None	☐	☑	☑
*WBS_Level2		WBS Leve...	ST0011	String	None	☐	☑	☑
*WBS_Level3		WBS Leve...	Acquisi...	String	Drawing....	☐	☑	☑
*WBS_Level4		WBS Leve...	M	String	None	☐	☑	☑
*WBS_Level5		WBS Leve...	731	String	None	☐	☑	☑
*WBS_Level7		WBS Leve...		String	None	☐	☑	☑
*Weight		Weight		String	None	☐	☑	☑
*Weight Unit		Weight Unit		String	None	☐	☑	☑
BOP		Bottom of ...		String	None	☑	☐	☑
BOP Meter		BOP Meter		String	None	☐	☐	☑
COP Meter		COP Meter		String	None	☐	☐	☑
COP_meter		COP_meter		String	None	☐	☐	☑
Effective_Length		Effective_...		Number	None	☐	☐	☑
Fluid		Fluid		List	None	☐	☐	☑

Properties

Item | AutoCad | Entity Handle | TimeLiner | Material

Property	Value
EntityTransparency	ByLayer
Material	ByLayer
Class	Pipe
PnPGuid	21087e5c-62df-450a-8d48-ef27e1f11921
Long Description	PIPE, SCH 10S, BE
Plant Material	SS
Schedule	10
Size	100
Status	New
End Type	PL
Spec	B4
Service	DS
Line Number	100-DS-B4-7747
Length	550

Nwc out data output

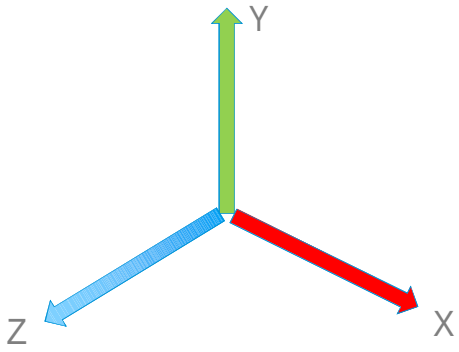
Item | DWF - Generic Properties | DWF - Pipe | TimeLiner | Material

Property	Value
BOP	25118.487
BOP Meter	25.118
COG X	247922.750
COG Y	-2135.774
COG Z	25202.625
COP Meter	25.202625
ContentIsoSymbo...	TYPE=PIPE,SKEY=PIPE
CutLength	6000.000
EndType	PL
EngagementLen...	0.000
ItemCode	A112015
Length	6000.000
LengthUnit	mm
LineNumberTag	150-SL-B4-216
LinearWeightUnit	KG/M
MatchingPipeOd	168.275
Material	SS
NominalDiameter	150.000
P&ID DrawingNu...	P4024-2
PartFamilyLongD...	PIPE, SCH 10S, BE
PartSizeLongDesc	DN150, PIPE, SCH 10S, BE
Position X	247666.828
Position Y	853.291
Position Z	25202.625
Schedule	10
Service	SL
Shop_Field	SHOP
ShortDescription	Pipe, Seamless
Site ID	ST0011
Size	150
Spec	B4
Status	New
TOP	25286.763
Top Meter	25.287
UseFixedLength	False
WBS Level 1	LSCT
WBS Level 2	ST0011
WBS Level 3	4024
WBS Level 4	M
WBS Level 5	731
WBS Level 6	A112015
WBS Level 7	0004295
Weight	0.000
WeightUnit	KG

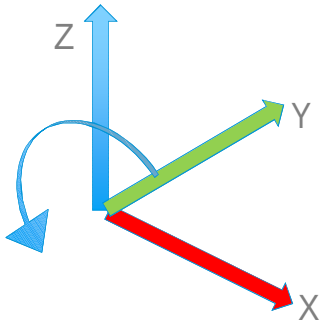
Dwf data output

Present model with custom data

Export model as 3D dwf

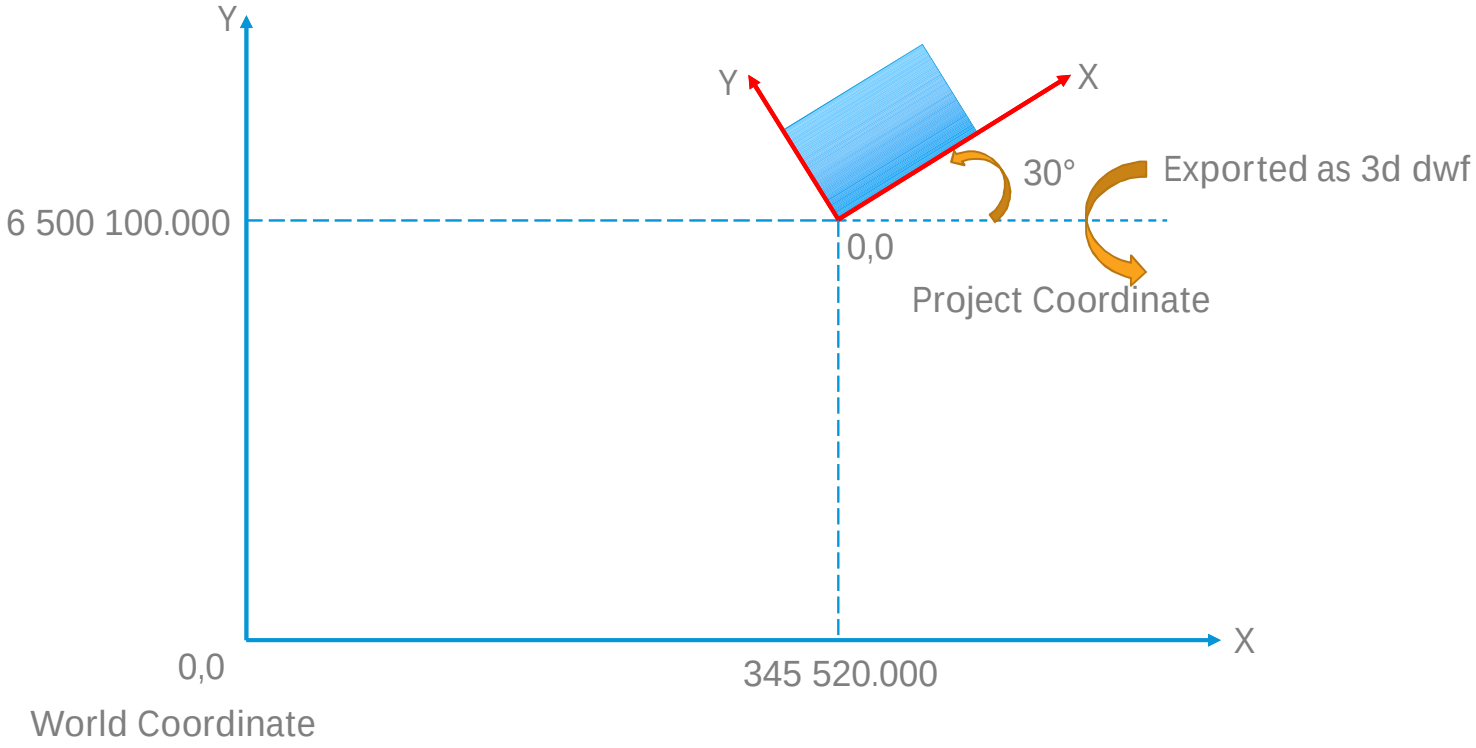


Inventor and Dwf file Axis

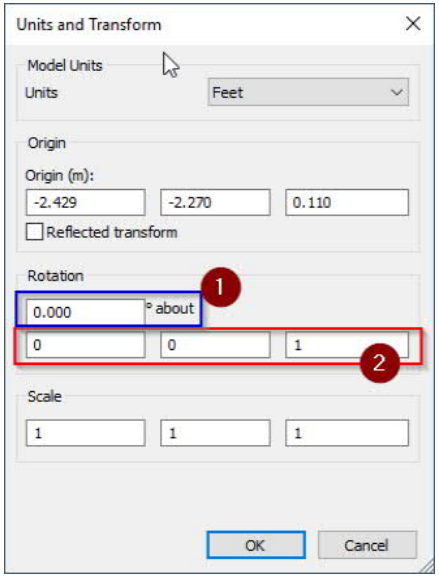


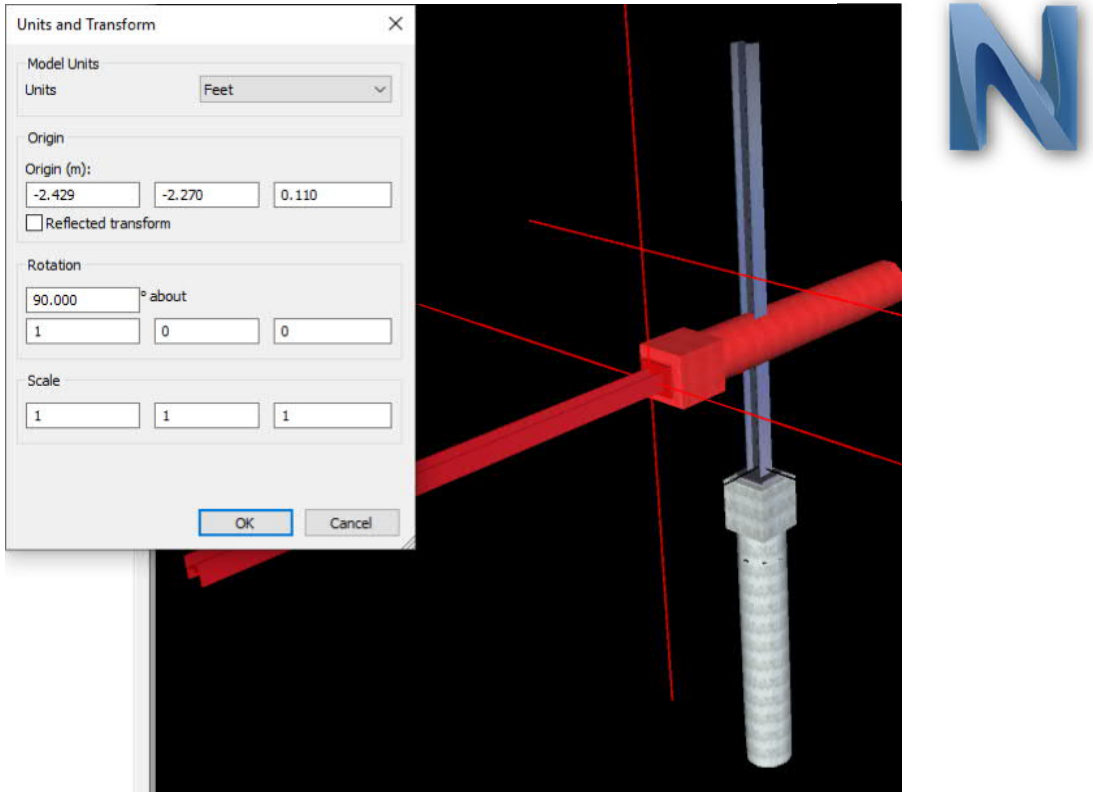
AutoCAD and Revit Axis

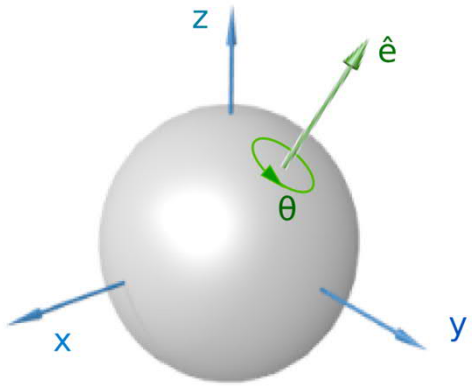
Present model with custom data (cont.)



3D Rotation Question



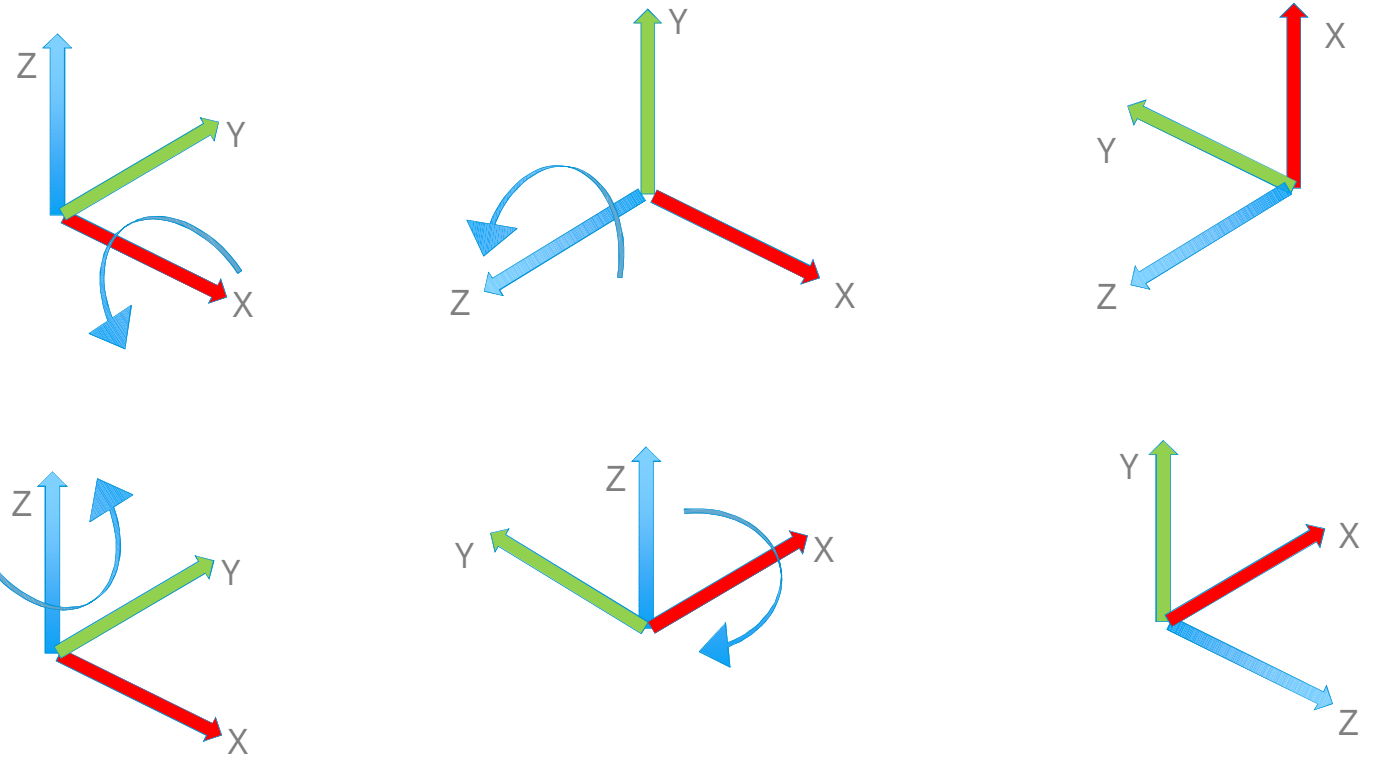




Euler's rotation theorem

- In three-dimensional space, any displacement of a rigid body such that a point on the rigid body remains fixed, is equivalent to a single rotation about some axis that runs through the fixed point.
- It also means that the composition of two rotations is also a rotation.

Rotation order matters



Formula

$$R_x(\theta) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix}$$

Rotation matrix on X axis

$$R_y(\theta) = \begin{bmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{bmatrix}$$

Rotation matrix on Y axis

$$R_z(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Rotation matrix on Z axis

Final Rotation Matrix

1. Rotate around X axis 90°;
2. Rotate around Z axis 82.163°

$$R_x(\theta) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix} \qquad R_z(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

1.0000	0.0000	0.0000
0.0000	0.0000	-1.0000
0.0000	1.0000	0.0000

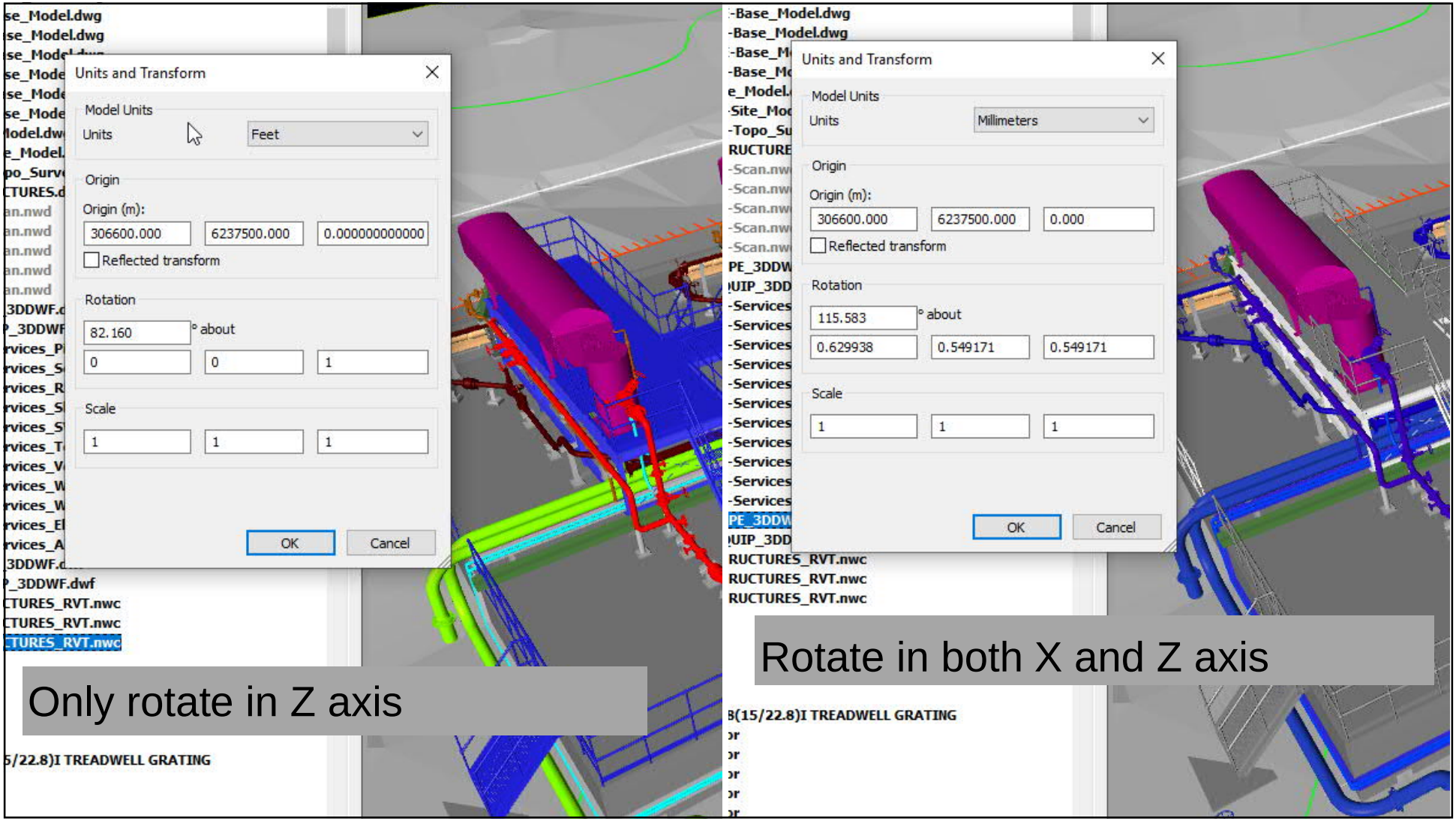
X

0.1364	-0.9907	0.0000
0.9907	0.1364	0.0000
0.0000	0.0000	1.0000

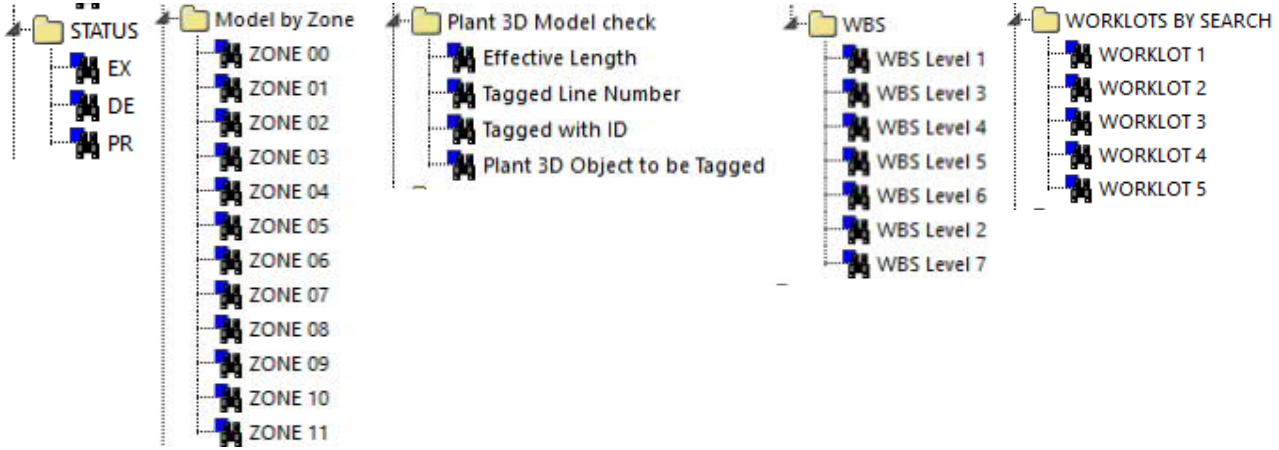
=

m00	**m01**	**m02**
m10	**m11**	**m12**
m20	**m21**	**m22**

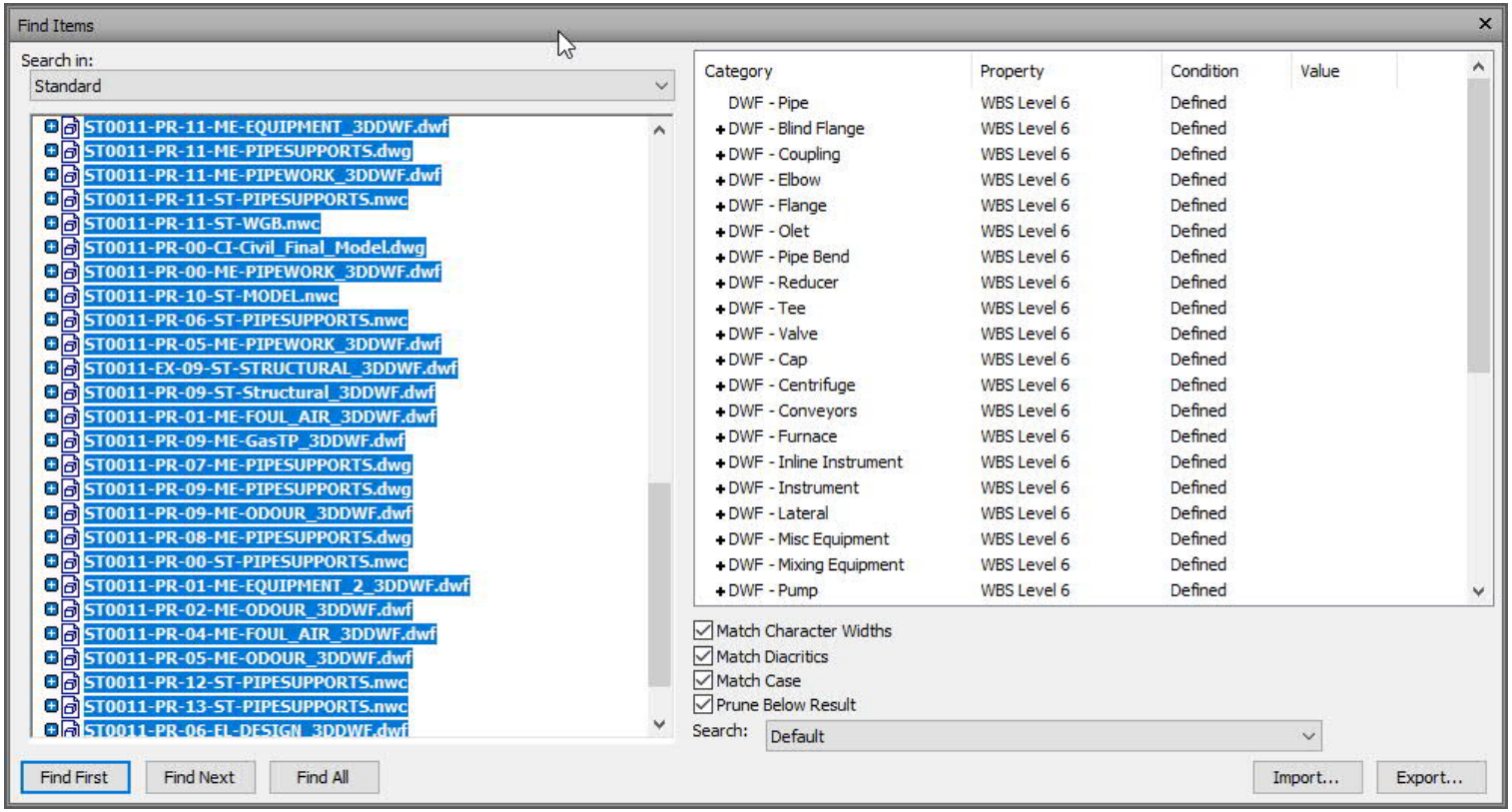
angle = acos((m00 + m11 + m22 - 1)/2) =115.58°
x = (m21 - m12)/√((m21 - m12)²+(m02 - m20)²+(m10 - m01)²)=0.629938
y = (m02 - m20)/√((m21 - m12)²+(m02 - m20)²+(m10 - m01)²)=-0.54917
z = (m10 - m01)/√((m21 - m12)²+(m02 - m20)²+(m10 - m01)²)=0.549171


Units and Transform
Model Units
Units
Feet
Origin
Origin (m):
306600.000
6237500.000
0.000000000000
Reflected transform
Rotation
82.160
° about
0
0
1
Scale
1
1
1
OK
Cancel
Only rotate in Z axis
Units and Transform
Model Units
Units
Millimeters
Origin
Origin (m):
306600.000
6237500.000
0.000
Reflected transform
Rotation
115.583
° about
0.629938
0.549171
0.549171
Scale
1
1
1
OK
Cancel
Rotate in both X and Z axis

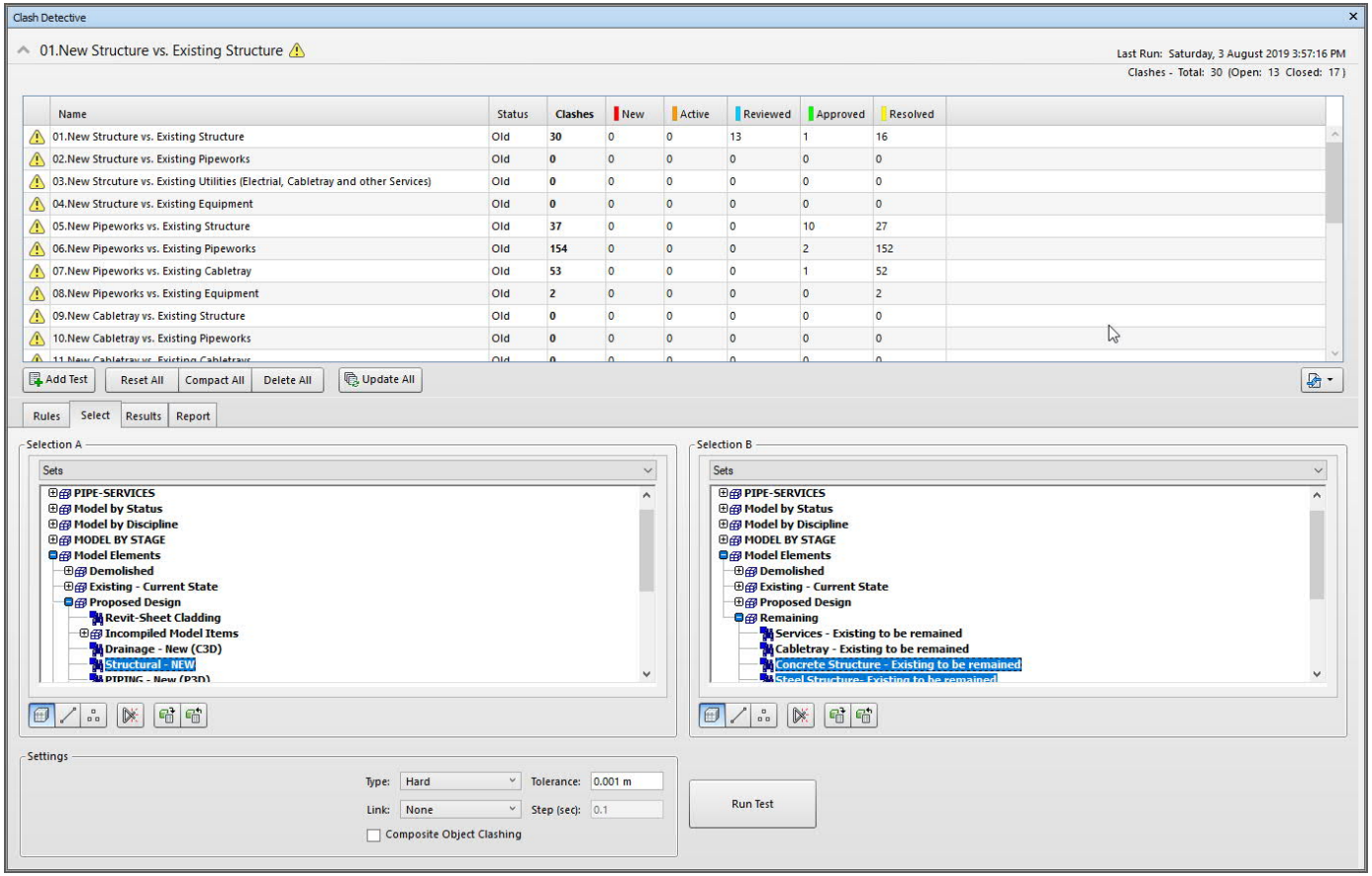
Search with properties



Search with properties

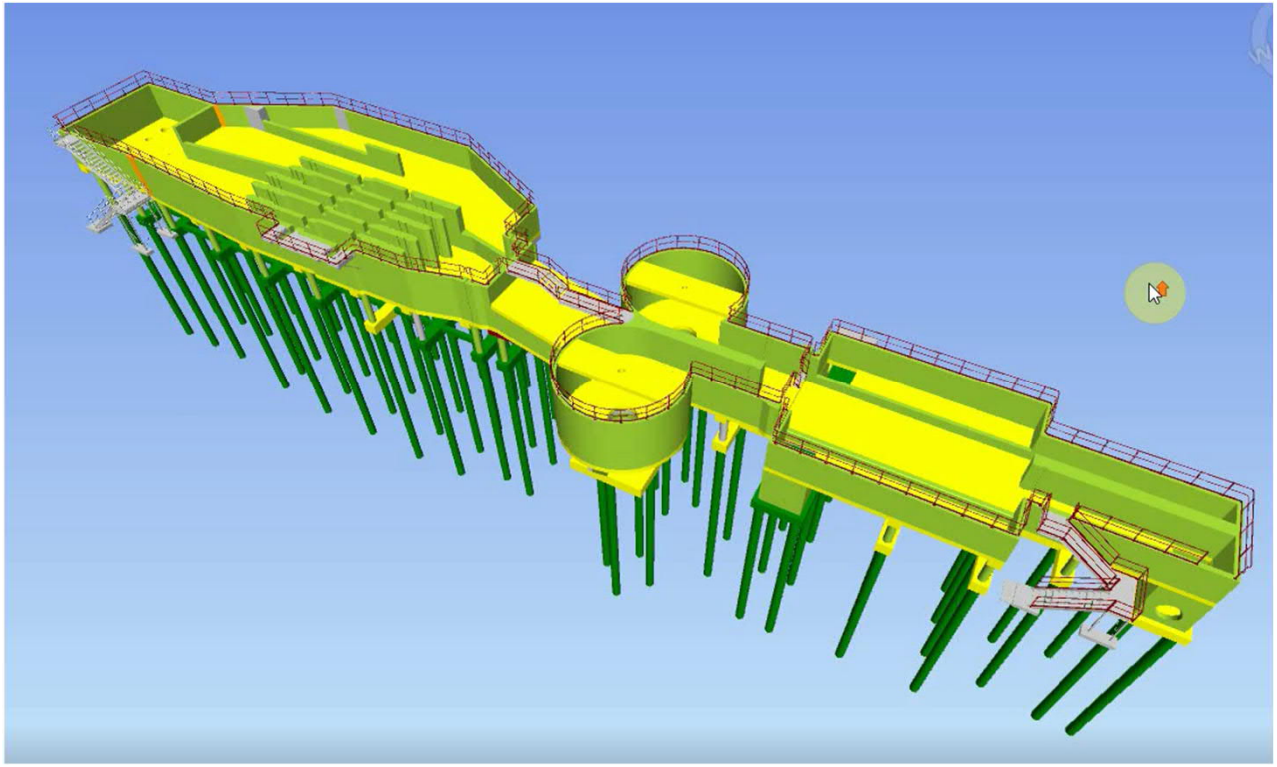


Clash Detection



Construction Simulation

Other use of Data



Model and Data quality

- Make sure spec is reviewed and approved before use
- Have rules about pipe group before start P&ID
- Make sure all pipe is connected and with correct pipe number
- Object tagging match with the project standard

Questions?

Make anything™