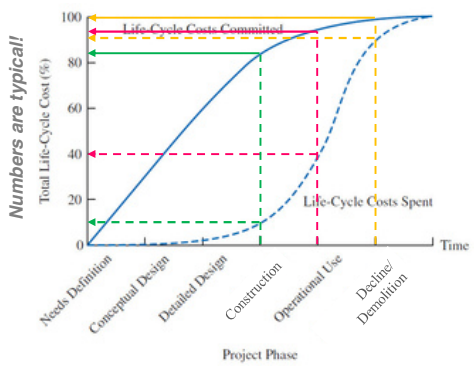
Module 9
BIM for Operation & Lifecycle

Learning objectives of this lecture

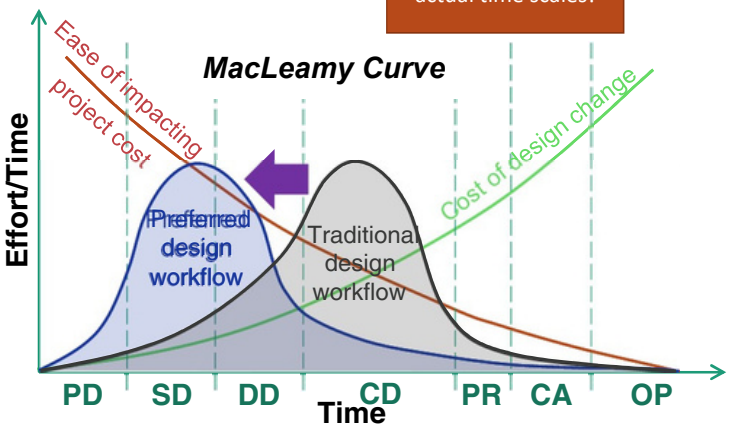
- BIM for Lifecycle Data
  - What is a 6D Model?
  - How can 6D BIM help with Building Design?
  - How can 6D BIM help with Building Operation?
- BIM for project handover
  - How to create ‘as-built’ models?
  - Using AIM (Asset Information Model) for facility management

Recall –Lifecycle Costs

& Let's not forget the actual time scales!



Cumulative life-cycle costs committed and dollars spent

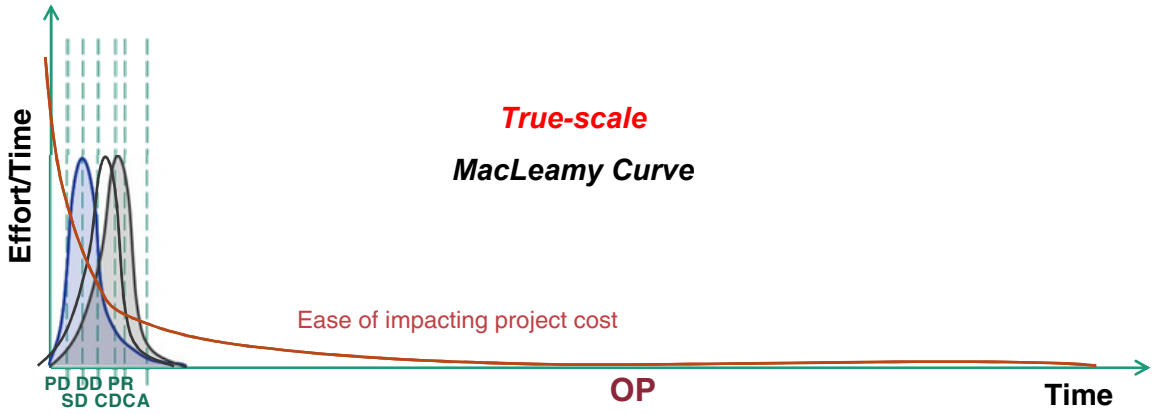


Life-cycle design change costs and ease of change

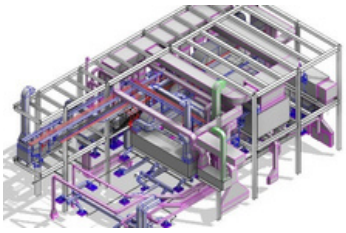
Source: Newnan, et al. Engineering Economics Analysis

Source: Patrick MacLeamyAIA/HOK

MacLeamyCurve -the real image!



What is 6D BIM?



3D Model

Lifespan Information

- Manufacturer details
- Installation data
- Maintenance requirements
- Optimal operation req.'s.
- Expected lifespan
- ….

Use of the 6D BIM

1) During Design

- Design impact over the building lifecycle –simulating anticipated
  - Lifecycle Costs
  - Lifecycle Impacts
- Switching the perspective from capital cost to the whole lifecycle cost of the asset

2) During Operation

- Handover of the complete as-built dataset, known as: Asset Information Model (AIM)
- Digital model provides a source which is:
  - Accessible
  - Navigable
  - Controllable

to be used in FM

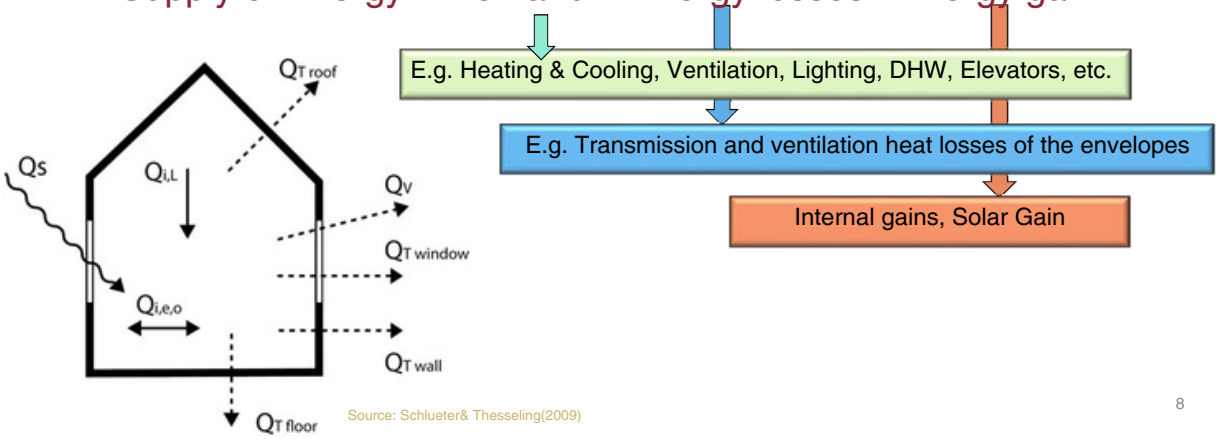
6D BIM for Design

- Shifting the focusfromcapitalcost (5D BIM) to the value of the building over lifetime span

Energy Analysis

Abuilding needs a certainamount of energy to maintain functionality and occupants' comfort

- Supply of Energy = Demand + Energy losses –Energy gain



Source: Schlueter& Thesseling(2009)

Building Performance Analysis (BPA)

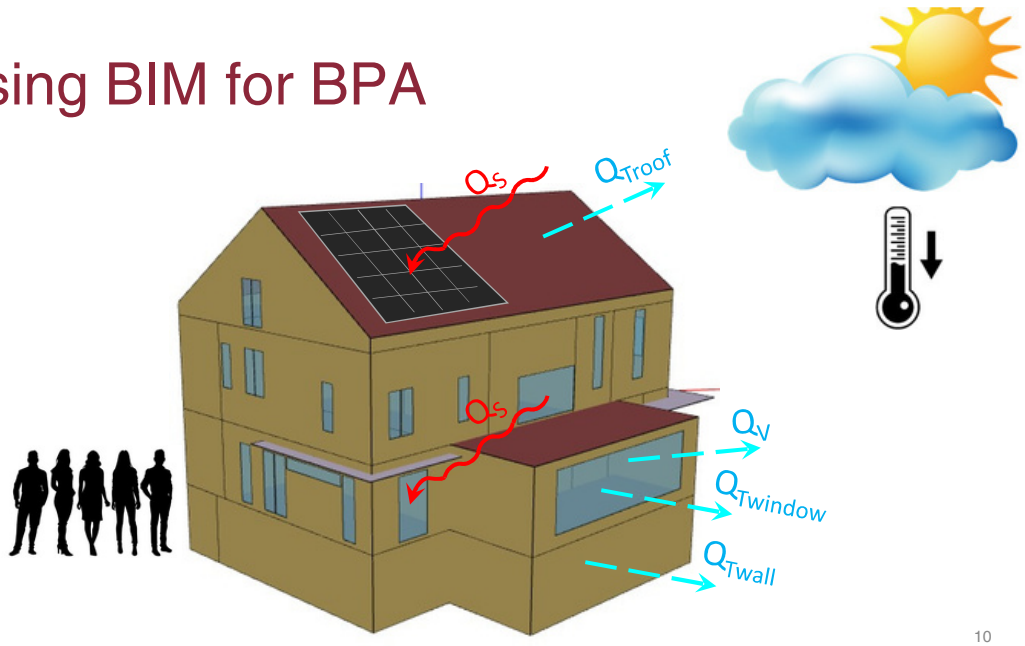
Thereare twocategoriesoftools:

- Statistic calculation models
  - Empirical,abstractandsimplified
- Physical calculation models

Precise calculation of detailed tasks and overall energy consumption possible

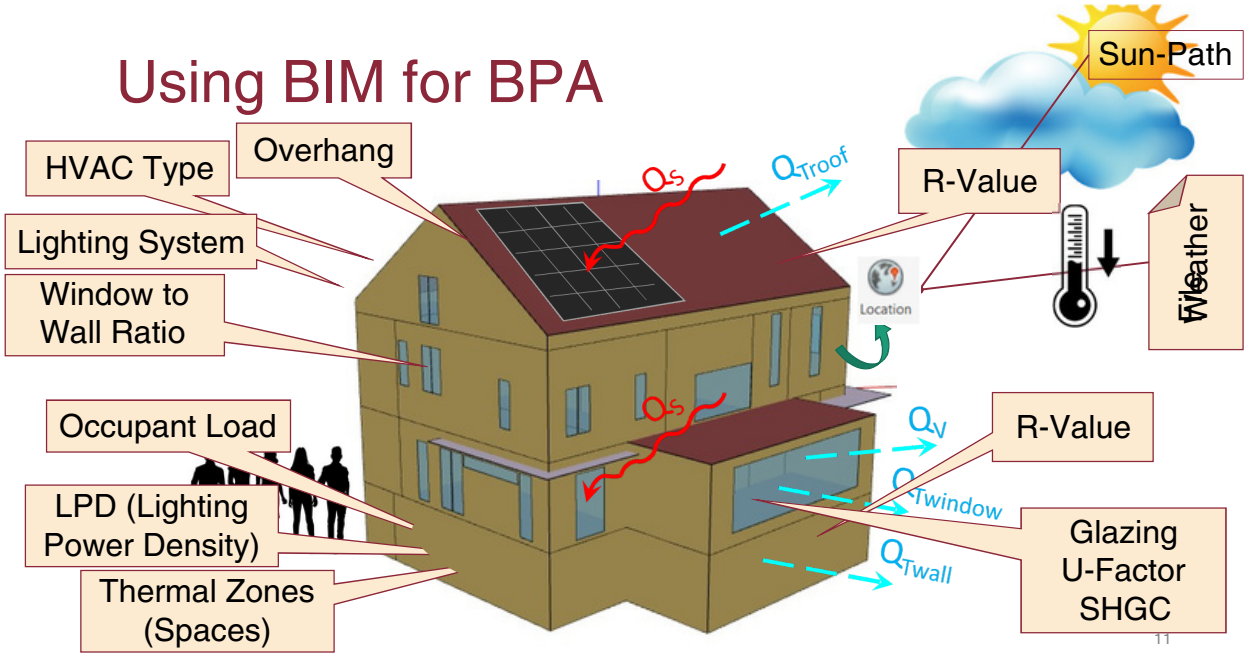
  - TRNSYS,EnergyPlus, Virtual Environment,etc.

Using BIM for BPA



Supply of Energy = Demand+ Energy losses –Energy gain

Using BIM for BPA



Supply of Energy = Demand+ Energy losses –Energy gain

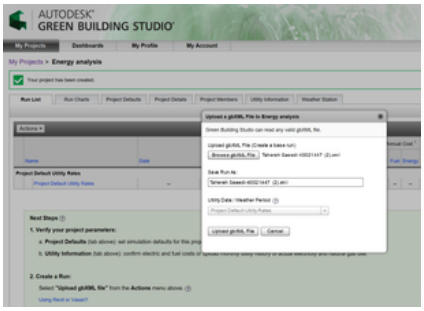
Some software tools for 6D BIM

- InsightandGreenBuilding Studio (by Autodesk)
- Sefaria(by Trimble)
- AECOsim(by Bentley)

All use EnergyPlus as their simulation **engine!**

Example–Green Building Studio

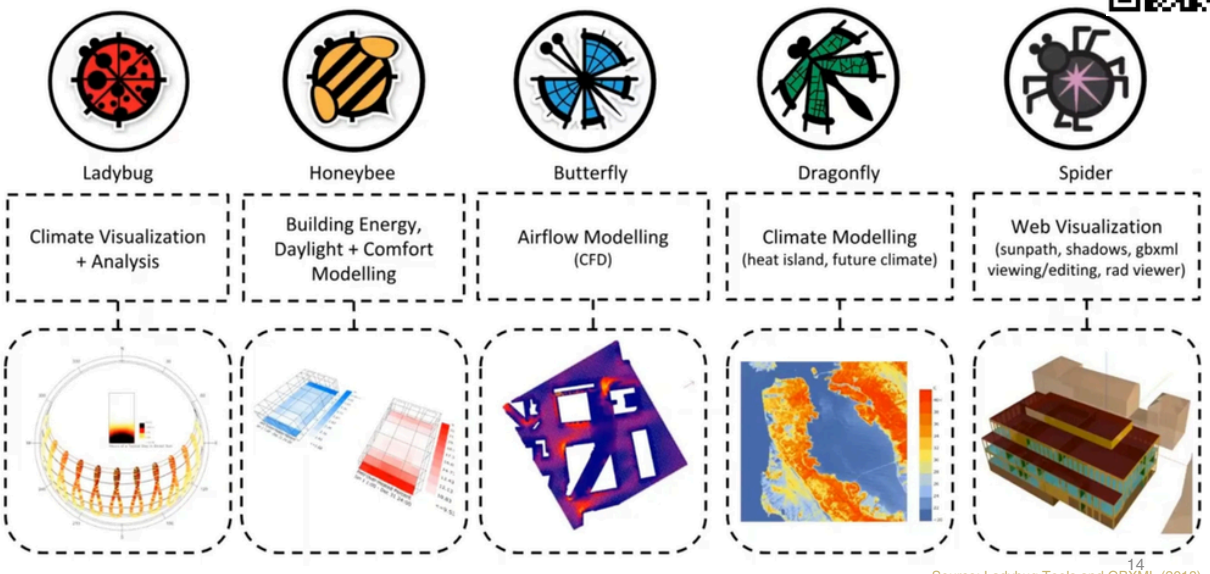
- Comparison of design alternatives in terms of:
  - Lifecycle Cost
  - Lifecycle Energy



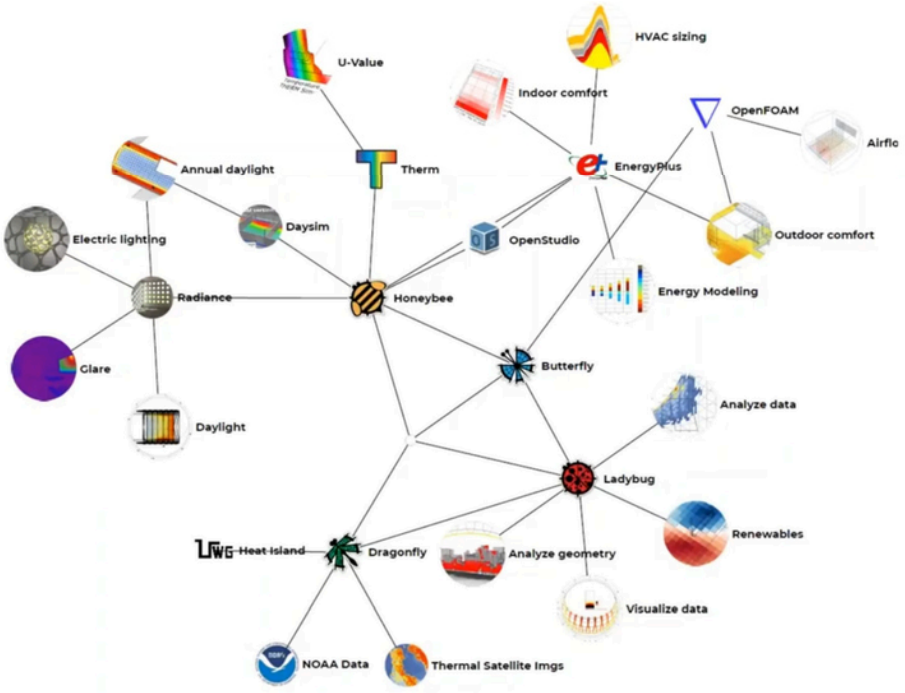
1 Base Run	
Energy, Carbon and Cost Summary	
Annual Energy Cost	$31,438
Lifecycle Cost	$428,186
Annual CO_2 Emissions	
Electric	0.0 Mg
Onsite Fuel	114.8 Mg
Large SUV Equivalent	11.5 SUVs / Year
Annual Energy	
Energy Use Intensity (EUI)	362 MJ / m² / year
Electric	161,947 kWh
Fuel	2,302,622 MJ
Annual Peak Demand	94.2 kW
Lifecycle Energy	
Electric	4,858,407 kW
Fuel	69,078,660 MJ
Assumptions	

2 Design Alternative	
Estimated Energy & Cost Summary	
Annual Energy Cost	$19,509
Lifecycle Cost	$265,712
Annual CO_2 Emissions	
Electric	0.0 Mg
Onsite Fuel	52.4 Mg
Large SUV Equivalent	5.3 SUVs / Year
Annual Energy	
Energy Use Intensity (EUI)	362 MJ / m² / year
Electric	124,615 kWh
Fuel	1,051,559 MJ
Annual Peak Demand	68.6 kW
Lifecycle Energy	
Electric	3,738,453 kW
Fuel	31,546,770 MJ
Assumptions	

Open Source Options–The lady bug Tools



Source: Ladybug Tools and GBXML (2018)



Open Source

Under a GNU GPL license

Validated

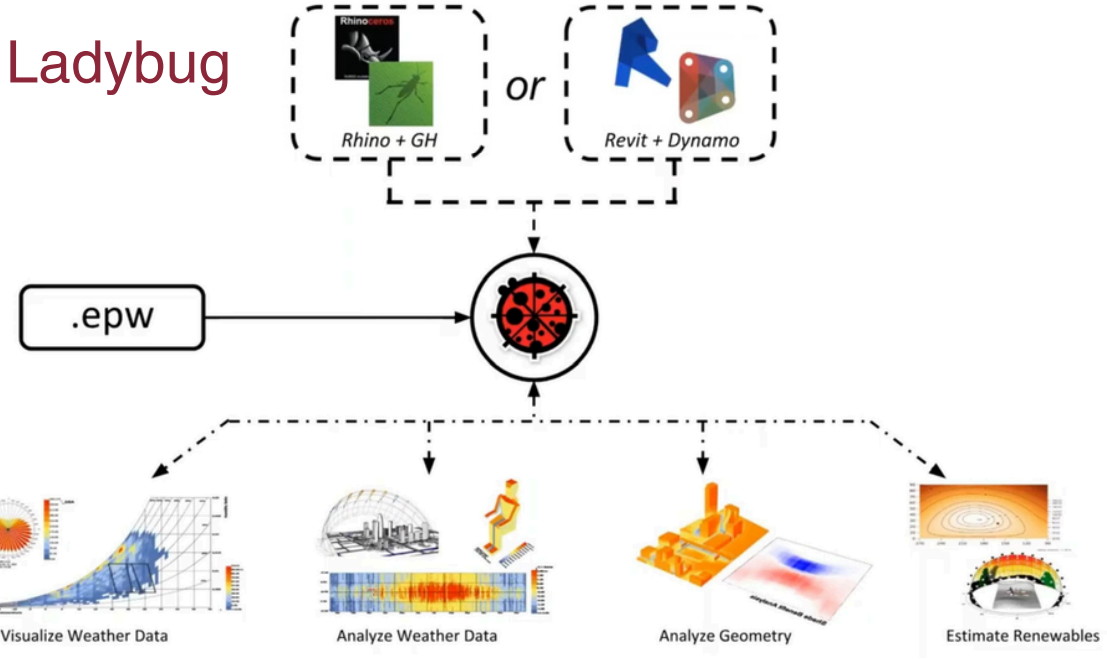
Using consensus-built, open-source engines

Community-Driven

Responsive to needs of our industry rather than the need to sell a software product

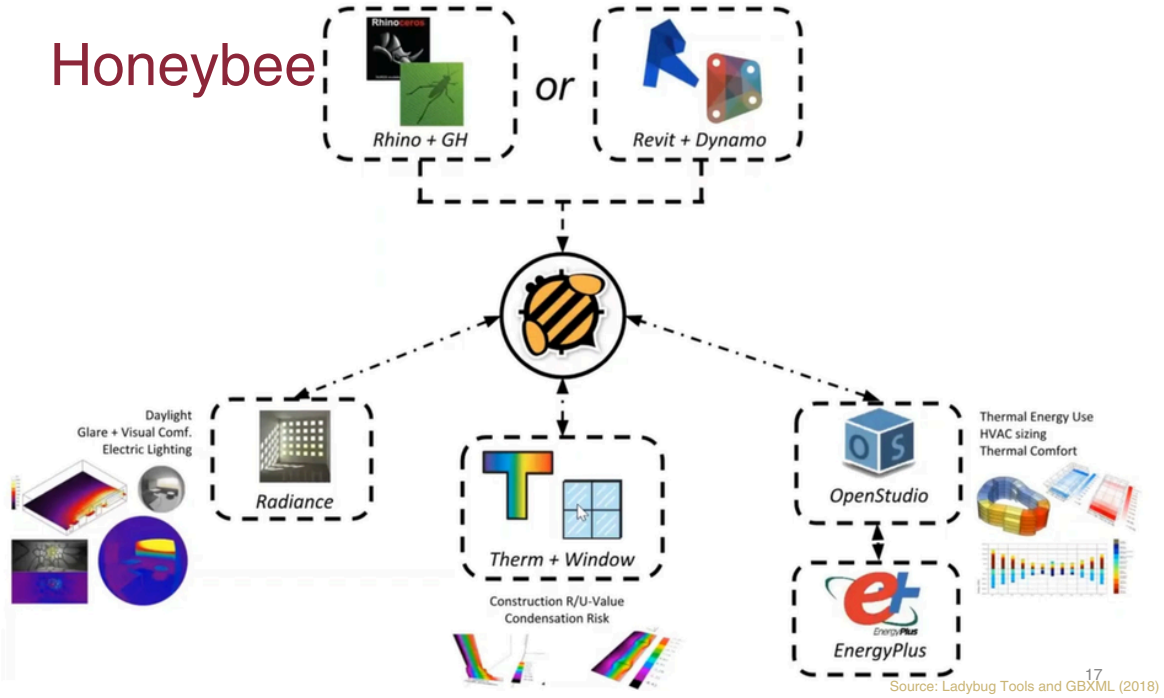
Source: Ladybug Tools and GBXML (2018)

Ladybug



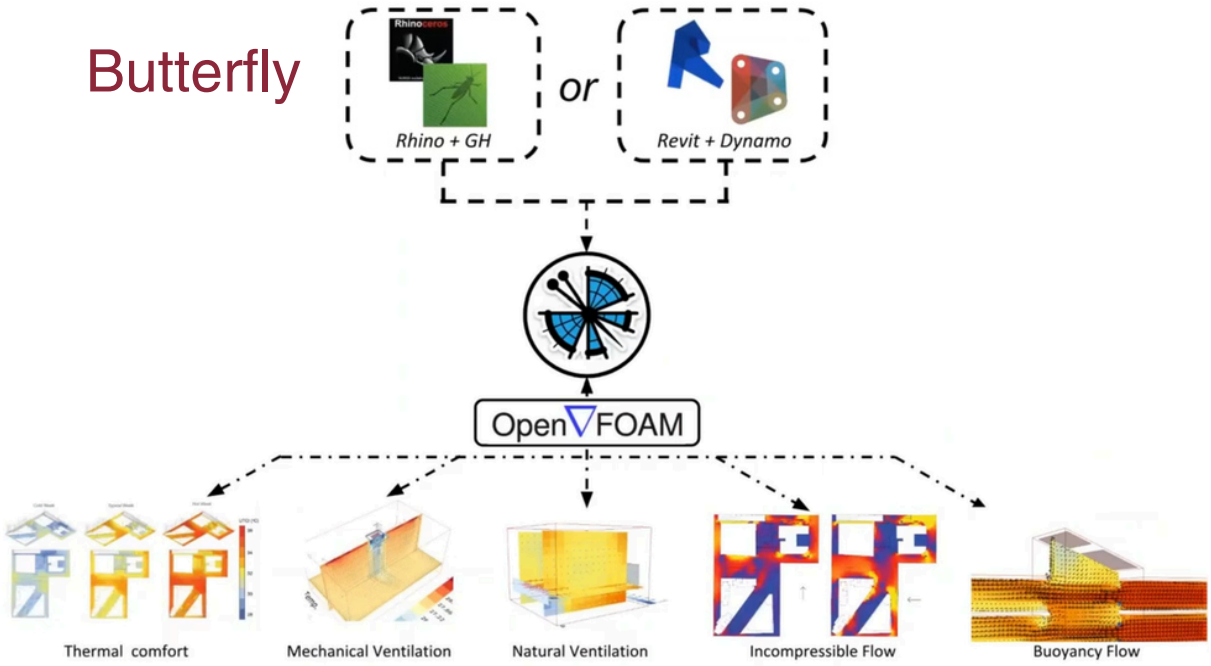
Source: Ladybug Tools and GBXML (2018)

Honeybee



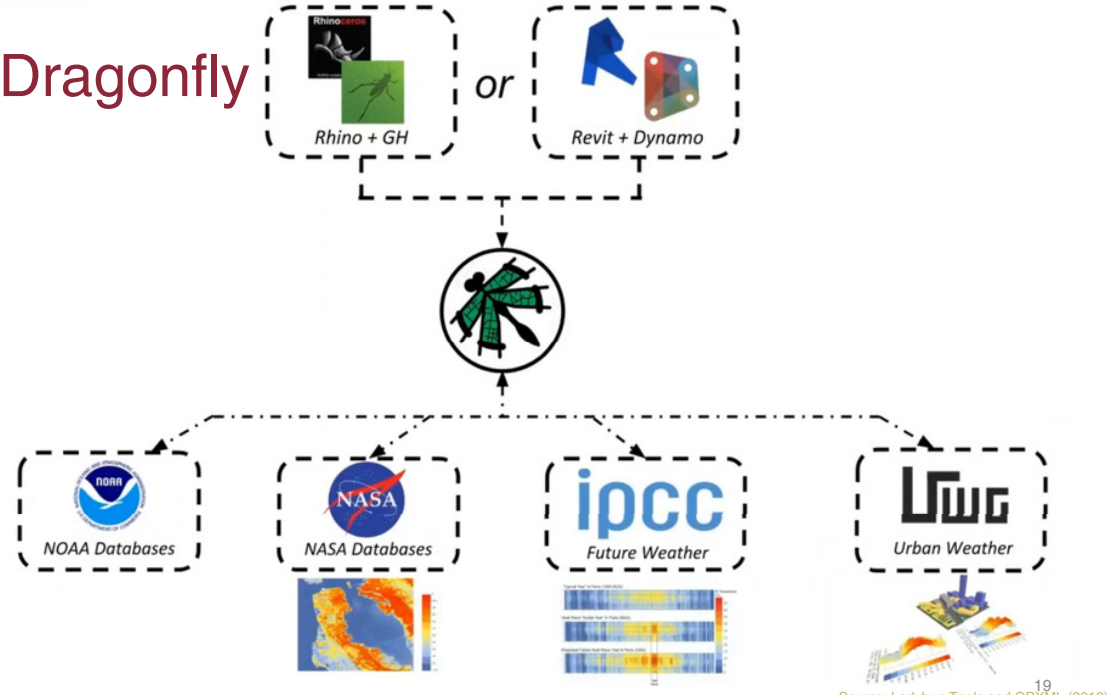
Source: Ladybug Tools and GBXML (2018)

Butterfly



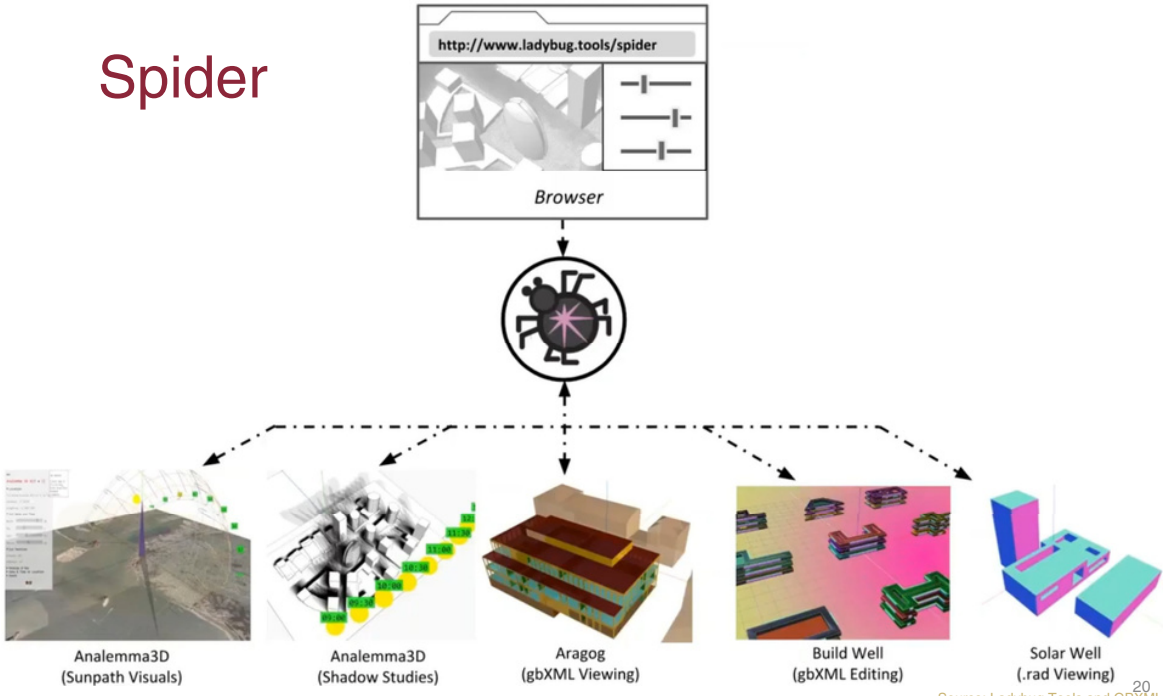
Source: Ladybug Tools and GBXML (2018)

Dragonfly



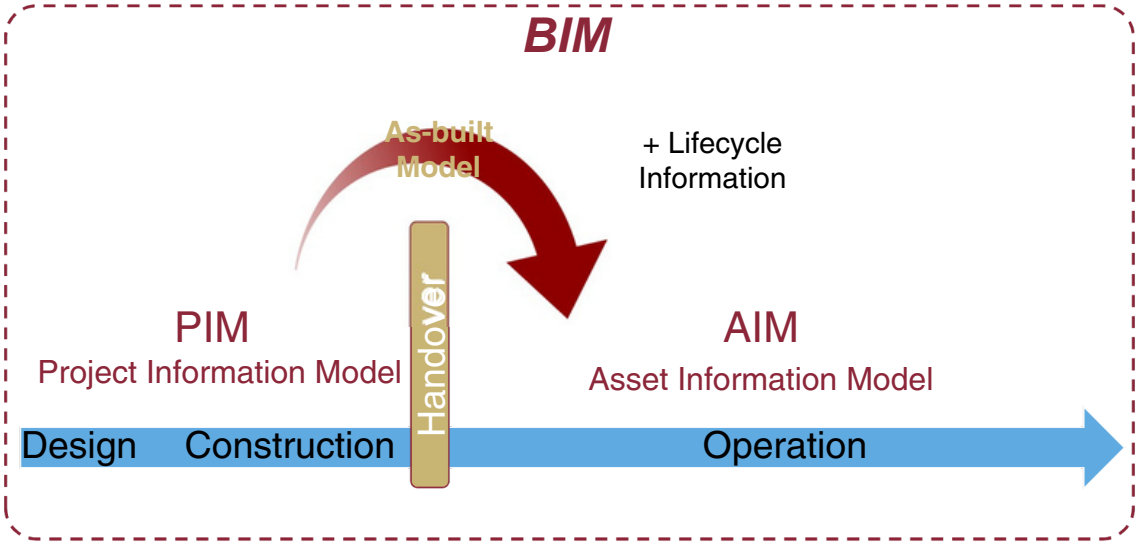
Source: Ladybug Tools and GBXML (2018)

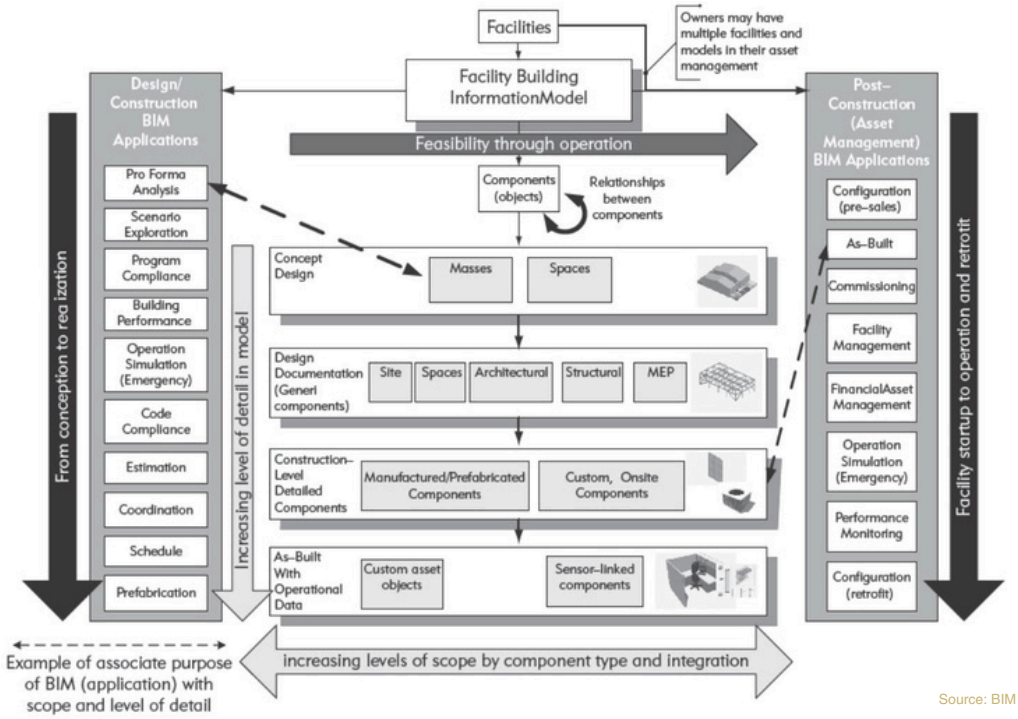
Spider



Source: Ladybug Tools and GBXML (2018)

6D BIM for Operation





Source: BIM Handbook

Asset Information Model (AIM)

- DefinitionofAIM
  - Dataand information (graphical, nongraphical, documentation, metadata) related to the assets to support an organization's asset managementsystem
- Purpose of AIM:
  - To be thesingle source of approved and validated information related to the assets and their lifecycle
    - Data andgeometrydescribing the assetsandspaces
    - Data about performance of the assets
    - Information about the assets, such as: specification –operation & maintenance m anuals
    - Health and safety information

Source: BSI –PAS 1192-3

AIM –What to store?

- **3Dobject-basedmodels** ofthe facility and location of the assets;
- **Ownership**information of (and rights associated with) the assets;
- Information regarding **original installation**of the asset and any subsequent changes;
- Information regarding **maintenance, inspection** or other works carried out on the asset during its lifespan;
- Information regarding **monitoring the operation** and condition of the asset.

Source: BSI –PAS 1192-3

Table 4–2 Owner's Building Information Model

Purpose	Type of Model Information
To support program compliance and facility management. In a typical design process, the spatial information is defined to meet program compliance and support code-checking analysis. These are critical for program compliance and use of the BIM for facility management.	Spaces and functions
To support commissioning activities such as performance specifications	Performance specifications for HVAC and other facility operation equipment
For postconstruction analysis and tracking as well as data for future forecasting	As-built schedule and cost information
To budget and schedule maintenance	Manufactured product information
For replacement costs and time periods and assessment information (See Coast Guard Facility Planning case study)	Financial asset management data
To plan and prepare for evacuation and other emergency crises	Emergency information
To monitor and track progress of design, construction, or maintenance activities	Activity status
To monitor building sensors and real-time control of building systems	Sensor data

Source: BIM Handbook

AIM –Where the data/info comes from?

- Transfer ofdata fromthePIM (**as-built model**)
- Existing data and information supplied by the **manufacturer**
- New (or updated) data /information from **surveys**and **inspection**of physical assets
- Data/Information stored by **sensors**, building operation and control systems (such as BMS and BAS)

Source: BSI –PAS 1192-3

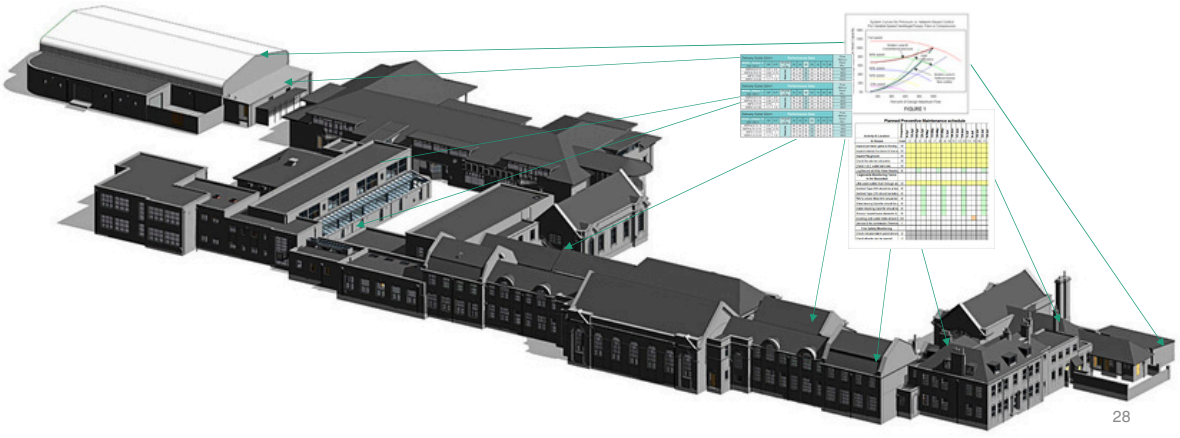
Traditional As-built documentation

- 2D andpaper-based

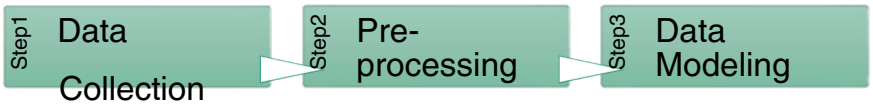
> The Contractor shall maintain at the site for the Owner one copy of the Drawings, Specifications, Addenda, Change Orders and other Modifications, in good order and marked currently to indicate field changes and selections made during construction, and one copy of approved Shop Drawings, Product Data, Samples and similar required submittals. These shall be available to the Architect and shall be delivered to the Architect for submittal to the Owner upon completion of the Work as a record of the Work as constructed.
>
> AIA A201 (2007)

3D As-Built

- Actualconditions of building/facility elements
- Non-geometrical information



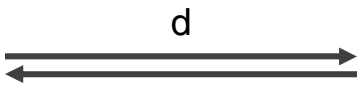
How to create 3D as-built



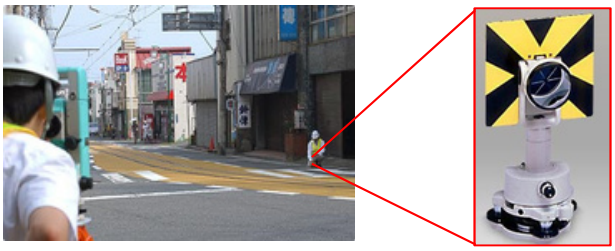
- Data Collection
  - Tapes/ surveying
  - Laser scanning > Point-clouds
  - Digital cameras > Digital photos
- Pre-processing
  - Removingunneeded data
  - Alignment
- Modeling
  - Objectrecognition & allocation

Laser scanning

- Lightbeamgoesoutandbounces back!



2d = v.t V = 300,000 km/s

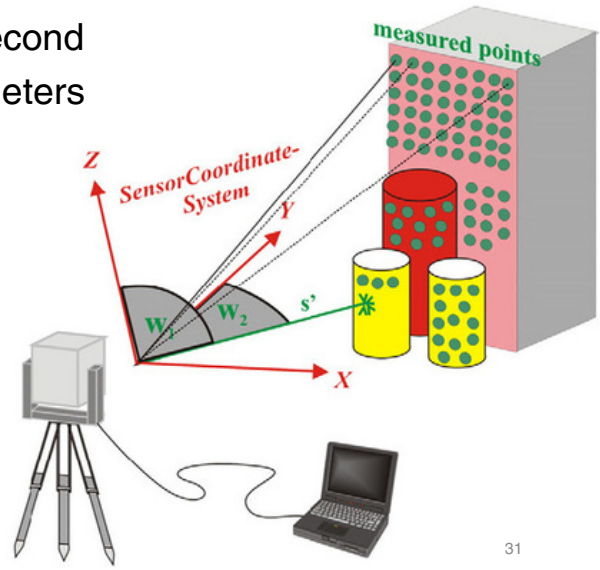


An accuracy of 2-3 millimeters per kilometer
Measuring distance up to 4,900 feet

Measure distance from 1.5 feet to 60 feet

Point cloud Laser scanning

- 10,000~100,000 points everysecond
- Accuracy on the order of millimeters



Point cloud Laser scanning

- Want to learn more about thelaser scanning?

You may watch these videos (among other available videos):

Laser Scanning: Chapter 1 - The Basics

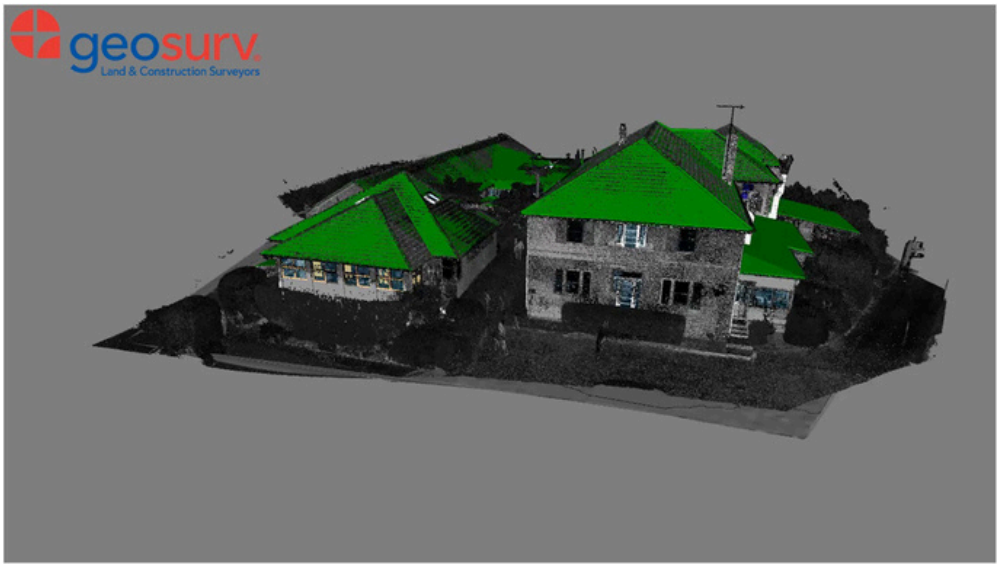
Laser scanning: Chapter 2 - How It All Works

Laser scanning: Chapter 3 -Simple Projects and Complex Projects

Fast growth in resolution & accuracy

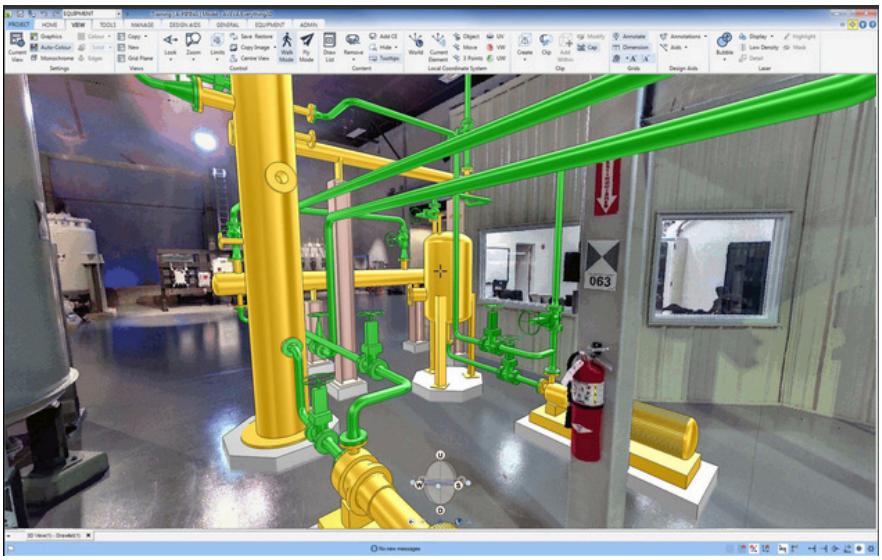
Combination with other new technologies

Reality Capturing

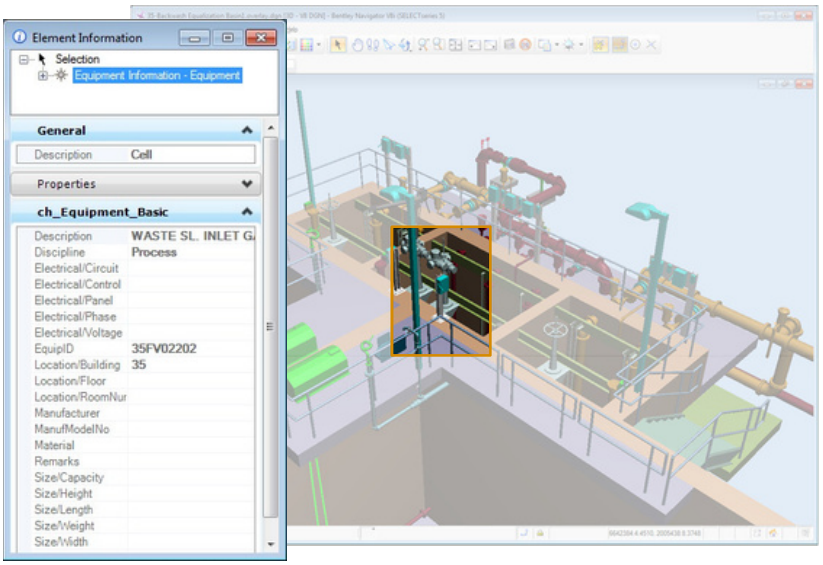


Turning point cloud to a BIM

Turning point cloud to a BIM



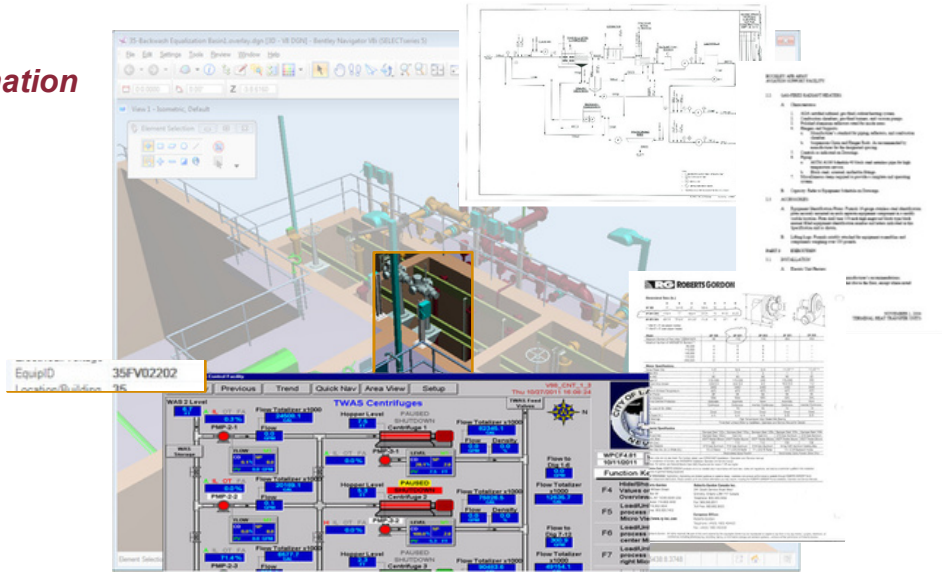
Fill it with Lifecycle Information



Fill it with Lifecycle Information

Asset

Information Model

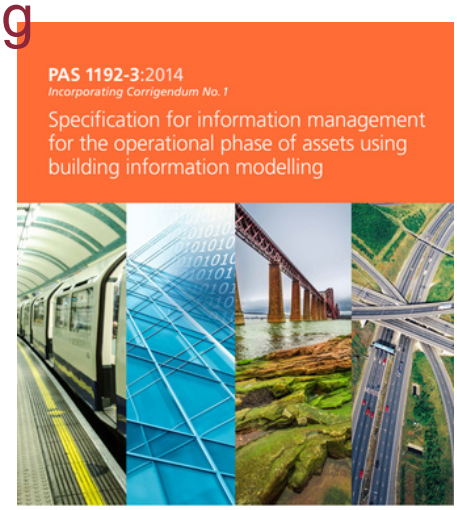


Asset Information Modeling

- Formore information,youcansee

BSI –PAS 1192-3

(Posted on Moodle)



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