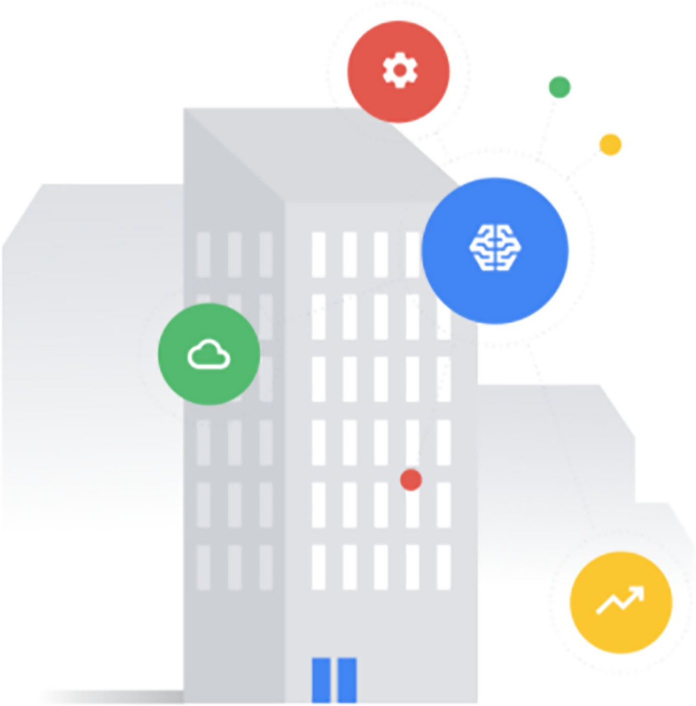
Module 2 | **Lesson 2**

Data modeling with the DBO



Before you get started

This learning module has interactive features and activities that enable a self-guided learning experience.
To help you get started, here are two tips for viewing and navigating through the content.

1 View this content outside of GitHub.

- For the best learning experience, you're encouraged to download a copy so links and other interactive features will be enabled.
- To download a copy of this lesson, click **Download** in the top-right corner of this content block.
- After downloading, open the file in your preferred PDF reader application.

2 Navigate by clicking the buttons and links.

- For the best learning experience, using your keyboard or mouse wheel to navigate is discouraged. However, this is your only option if you're viewing from GitHub.
- If you're viewing this content outside of GitHub:
  - Click the **Back** or **Next** buttons to go backward or forward in the deck. Moving forward, you'll find them in the bottom corners of every slide.
  - Click blue text to go to another slide in this deck or open a new page in your browser.

Ready to get started? Let's go!

Google

Workflow revisited

Here’s the recommended workflow for data modeling from Lesson 1.

In this lesson, you’ll walk through the first step of data modeling with the DBO.

1
2 Determine which data points are required
3 Name each data point using the DBO
4 Propose an ontology extension
5 Construct and finalize the building configuration file
6 Validate the instance and telemetry
7 Complete!

Determine which devices need to be modeled

Throughout the process, you’ll receive or request project documents containing your scope of work and important information about the equipment and systems installed in the building. From these, you’ll identify the reporting devices from each namespace that need to be modeled and integrated into Google Cloud IoT Core.

Back

Next

Lesson 2

Determine which devices need to be modeled

What you'll learn about:

- Project documents for data modeling
- Logical devices and namespaces
- "Drawing the box" around an entity

By the end of this lesson, you'll be able to:

- Recognize the different documents you'll use to gather information for a rough-in model.
- Identify the different devices within a namespace.
- Determine whether devices should be modeled independently or as a single entity.

Back

Next

Google

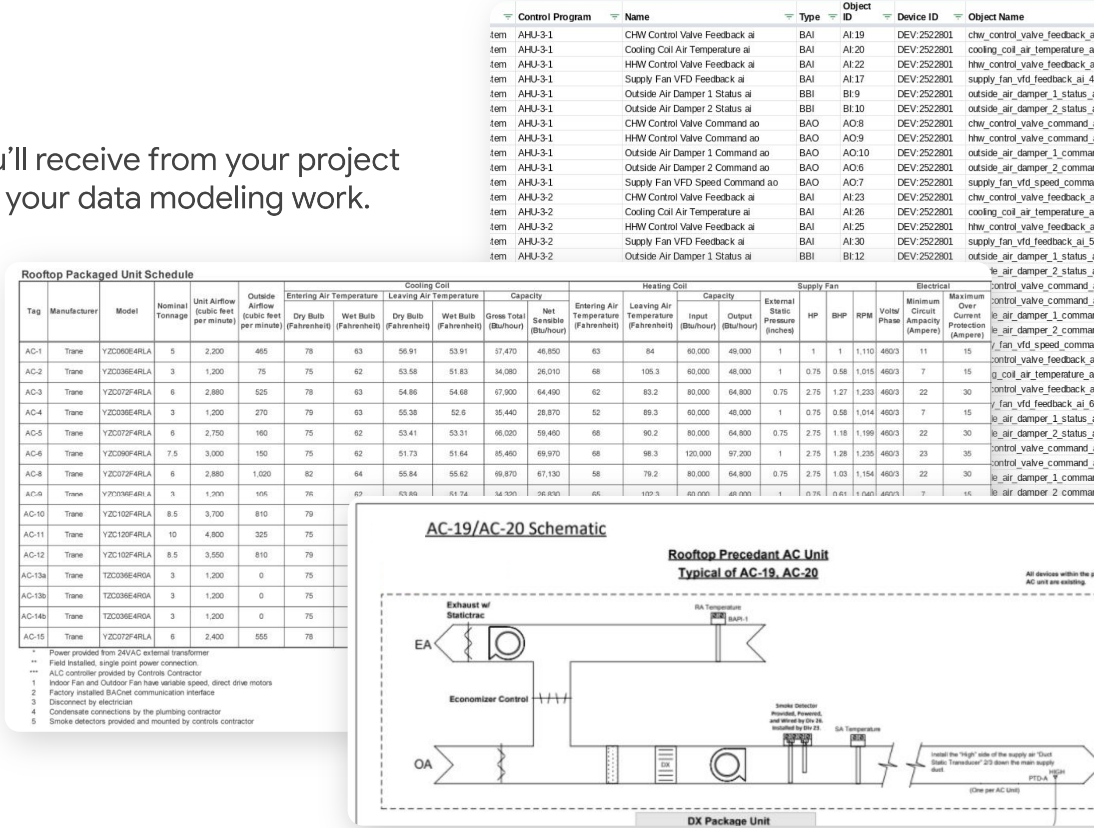
Project documents

You'll need to refer to a variety of documents that you'll receive from your project contributors about the building and its equipment for your data modeling work.

Documents will vary from project to project

While this isn't an exhaustive list of every document you may receive, these and others like them will contain detailed information about each of the devices and systems that will be installed in a building. Project docs can include:

- A BMS points list (if the site is Brownfield)
  - Points list from BMS instance (see an example)
- Drawing set from a mechanical engineer (see an example)
- Sequence of operations from a controls contractor
  - Controls drawings (contractor) (see an example)
- BIM file and information (if the site is Greenfield)
- Any other relevant design and submittal documentation



	Control Program	Name	Type	Object ID	Device ID	Object Name
tem	AHU-3-1	CHW Control Valve Feedback ai	BAI	AI:19	DEV:2522801	chw_control_valve_feedback_a
tem	AHU-3-1	Cooling Coil Air Temperature ai	BAI	AI:20	DEV:2522801	cooling_coil_air_temperature_a
tem	AHU-3-1	HHW Control Valve Feedback ai	BAI	AI:22	DEV:2522801	hhw_control_valve_feedback_a
tem	AHU-3-1	Supply Fan VFD Feedback ai	BAI	AI:17	DEV:2522801	supply_fan_vfd_feedback_ai_4
tem	AHU-3-1	Outside Air Damper 1 Status ai	BBI	BI:9	DEV:2522801	outside_air_damper_1_status_a
tem	AHU-3-1	Outside Air Damper 2 Status ai	BBI	BI:10	DEV:2522801	outside_air_damper_2_status_a
tem	AHU-3-1	CHW Control Valve Command ao	BAO	AO:8	DEV:2522801	chw_control_valve_command_
tem	AHU-3-1	HHW Control Valve Command ao	BAO	AO:9	DEV:2522801	hhw_control_valve_command_
tem	AHU-3-1	Outside Air Damper 1 Command ao	BAO	AO:10	DEV:2522801	outside_air_damper_1_comma
tem	AHU-3-1	Outside Air Damper 2 Command ao	BAO	AO:6	DEV:2522801	outside_air_damper_2_comma
tem	AHU-3-1	Supply Fan VFD Speed Command ao	BAO	AO:7	DEV:2522801	supply_fan_vfd_speed_comma
tem	AHU-3-2	CHW Control Valve Feedback ai	BAI	AI:23	DEV:2522801	chw_control_valve_feedback_a
tem	AHU-3-2	Cooling Coil Air Temperature ai	BAI	AI:26	DEV:2522801	cooling_coil_air_temperature_a
tem	AHU-3-2	HHW Control Valve Feedback ai	BAI	AI:25	DEV:2522801	hhw_control_valve_feedback_a
tem	AHU-3-2	Supply Fan VFD Feedback ai	BAI	AI:30	DEV:2522801	supply_fan_vfd_feedback_ai_5
tem	AHU-3-2	Outside Air Damper 1 Status ai	BBI	BI:12	DEV:2522801	outside_air_damper_1_status_a
						le_air_damper_2_status_a
						control_valve_command_
						control_valve_command_
						le_air_damper_1_comma
						le_air_damper_2_comma
						y_fan_vfd_speed_comma
						control_valve_feedback_a
						g_coil_air_temperature_a
						control_valve_feedback_a
						y_fan_vfd_feedback_ai_6
						le_air_damper_1_status_a
						le_air_damper_2_status_a
						control_valve_command_
						control_valve_command_
						le_air_damper_1_comma
						le_air_damper_2_comma

Rooftop Packaged Unit Schedule

Tag	Manufacturer	Model	Nominal Tonnage	Unit Airflow (cubic feet per minute)	Outside Airflow (cubic feet per minute)	Cooling Coil						Heating Coil				Supply Fan				Electrical		
						Entering Air Temperature		Leaving Air Temperature		Capacity				Capacity								
						Dry Bulb (Fahrenheit)	Wet Bulb (Fahrenheit)	Dry Bulb (Fahrenheit)	Wet Bulb (Fahrenheit)	Gross Total (Btu/hour)	Net Sensible (Btu/hour)	Entering Air Temperature (Fahrenheit)	Leaving Air Temperature (Fahrenheit)	Input (Btu/hour)	Output (Btu/hour)	External Static Pressure (inches)	HP	BHP	RPM	Volts/ Phase	Minimum Circuit Ampacity (Ampere)	Maximum Over Current Protection (Ampere)
AC-1	Trane	YZC060E4RLA	5	2,200	465	78	63	56.91	53.91	57,470	46,850	63	84	60,000	49,000	1	1	1	1,110	460/3	11	15
AC-2	Trane	YZC036E4RLA	3	1,200	75	75	62	53.58	51.83	34,080	26,010	68	105.3	60,000	48,000	1	0.75	0.58	1,015	460/3	7	15
AC-3	Trane	YZC072F4RLA	6	2,880	525	78	63	54.86	54.68	67,900	64,490	62	83.2	80,000	64,800	0.75	2.75	1.27	1,233	460/3	22	30
AC-4	Trane	YZC036E4RLA	3	1,200	270	79	63	55.38	52.6	35,440	28,870	52	89.3	60,000	48,000	1	0.75	0.58	1,014	460/3	7	15
AC-5	Trane	YZC072F4RLA	6	2,750	160	75	62	53.41	53.31	66,020	59,460	68	90.2	80,000	64,800	0.75	2.75	1.18	1,199	460/3	22	30
AC-6	Trane	YZC090F4RLA	7.5	3,000	150	75	62	51.73	51.64	85,460	69,970	68	98.3	120,000	97,200	1	2.75	1.28	1,235	460/3	23	35
AC-8	Trane	YZC072F4RLA	6	2,880	1,020	82	64	55.84	55.62	69,870	67,130	58	79.2	80,000	64,800	0.75	2.75	1.03	1,154	460/3	22	30
AC-9	Trane	YZC036E4RLA	3	1,200	105	76	62	53.89	51.74	34,320	26,830	65	102.3	60,000	48,000	1	0.75	0.61	1,040	460/3	7	15
AC-10	Trane	YZC102F4RLA	8.5	3,700	810	79																
AC-11	Trane	YZC120F4RLA	10	4,800	325	75																
AC-12	Trane	YZC102F4RLA	8.5	3,550	810	79																
AC-13a	Trane	TZC036E4R0A	3	1,200	0	75																
AC-13b	Trane	TZC036E4R0A	3	1,200	0	75																
AC-14b	Trane	TZC036E4R0A	3	1,200	0	75																
AC-15	Trane	YZC072F4RLA	6	2,400	555	78																

* Power provided from 24VAC external transformer
** Field Installed, single point power connection.
*** ALC controller provided by Controls Contractor
1 Indoor Fan and Outdoor Fan have variable speed, direct drive motors
2 Factory installed BACnet communication interface
3 Disconnect by electrician
4 Condensate connections by the plumbing contractor
5 Smoke detectors provided and mounted by controls contractor

AC-19/AC-20 Schematic

Rooftop Precedant AC Unit
Typical of AC-19, AC-20

Back

Note: A standard points list should include all of the mechanical equipment in the building. However, points lists from brownfield sites typically do not include explicit building, floor, and room/zone information or information about other systems (lighting, security, etc).

Next

Google

Which devices should be modeled?

In general, you'll model all systems along with their logical devices.

Remember, anything included in the building model will allow your project team to analyze its data.

At this point in the process, you'll begin making decisions about what you want to include in the building model. First, you'll need to identify the devices and systems installed in the building before establishing the logical entities.

How to identify devices to model

1. Review the project documents and any other relevant information to get a sense for what equipment is to be installed (or is already installed).
2. For all the devices being installed, partition them into their relevant namespaces.
   Example: Break out all HVAC equipment separately from lighting equipment.
3. List out all identified devices and their namespaces for future reference.
4. List out all systems that need to be defined.
   Example: The heating water system, the chilled water system

Back

Note: A **logical device** is any device or system that maps one-to-one with a canonical entity type in the DBO. Review Module 1, Lesson 7 for more info.

Next

Devices are modeled within their namespace

As you identify devices, be mindful of which namespace each one belongs to.

Click on each item to reveal more info about devices in each namespace.

- HVAC
- Lighting
- Metering
- Electrical
- Safety

Back

Next

Devices are modeled within their namespace

As you identify devices, be mindful of which namespace each one belongs to.

Click on each item to reveal more info about devices in each namespace.

HVAC

Lighting

Metering

Electrical

Safety

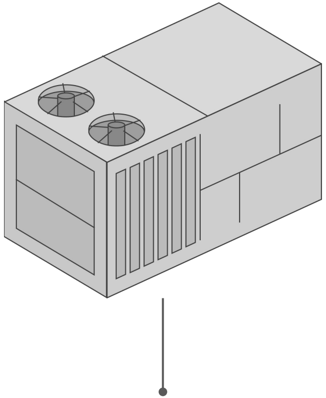
HVAC

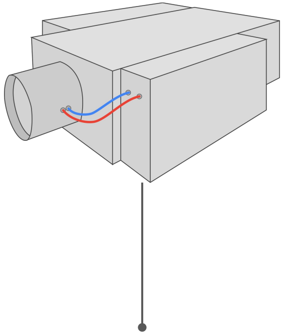
Devices in the HVAC namespace include:

- Air handling units (AHU)
- Boilers (BLR)
- Chillers (CH)

See HVAC general types for types of HVAC devices and systems commonly modeled.

In general, if it can communicate, it should be integrated.





Back

Next

Devices are modeled within their namespace

As you identify devices, be mindful of which namespace each one belongs to.

Click on each item to reveal more info about devices in each namespace.

HVAC

Lighting

Metering

Electrical

Safety

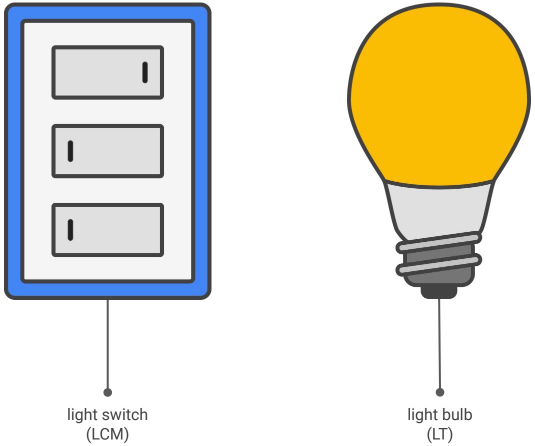
Lighting

Some devices in the Lighting namespace include:

- Light fixtures (LT)
- Lighting gateways (LTGW)
- Emergency lights (ELT)

See lighting general types for types of lighting devices and systems commonly modeled.

In general, anything relevant to the function of the lighting system should be integrated.



Back

Next

Devices are modeled within their namespace

As you identify devices, be mindful of which namespace each one belongs to.

Click on each item to reveal more info about devices in each namespace.

HVAC

Lighting

Metering

Electrical

Safety

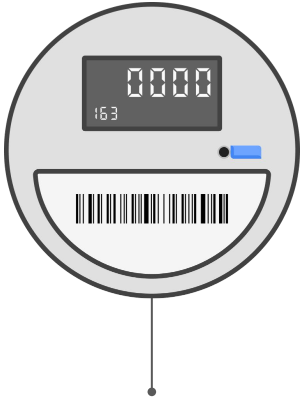
Metering

Some devices in the Metering namespace include:

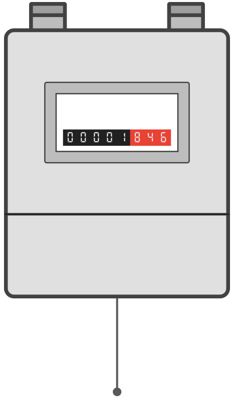
- Electrical meters (EM)
- Gas meters (GM)
- Water meters (WM)

See meter general types for types of meters commonly modeled.

In general, all meters should be integrated.



electrical meter
(EM)



gas meter
(GM)

Back

Next

Google

Devices are modeled within their namespace

As you identify devices, be mindful of which namespace each one belongs to.

Click on each item to reveal more info about devices in each namespace.

HVAC

Lighting

Metering

Electrical

Safety

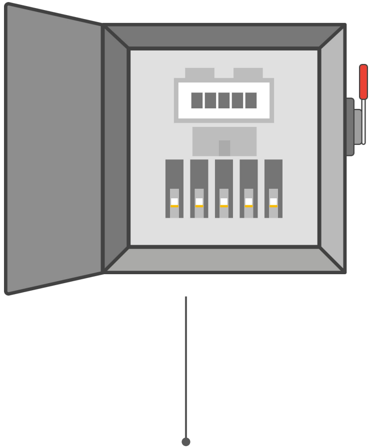
Electrical

Some devices in the Electrical namespace include:

- Batteries (BATT)
- Uninterruptible power supplies (UPS)
- Panels (PANEL)

See electrical general types for types of electrical devices and systems commonly modeled.

There is no general rule for electrical integration (beyond metering, which is considered separate). It’s up to the modeler and other project contributors to use their best judgment in determining what must be integrated.



Back

Next

Google

Devices are modeled within their namespace

As you identify devices, be mindful of which namespace each one belongs to.

Click on each item to reveal more info about devices in each namespace.

HVAC

Lighting

Metering

Electrical

Safety

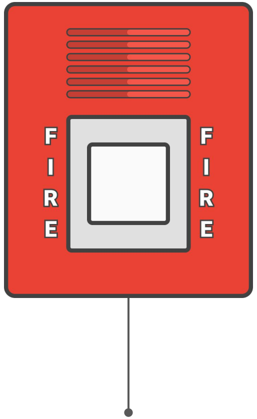
Safety

Some devices in the Safety namespace include:

- Smoke detectors (SD)
- Fire dampers (FD)
- Fire alarm systems (FAS)

See safety general types for types of safety devices and systems commonly modeled.

There is no general rule for safety (fire/life safety in particular) systems. It’s up to the modeler and other project contributors to use their best judgment to determine what must be integrated.



fire alarm system (FAS)

Back

Next

Google

Should a device be modeled independently or as part of an entity?

Device modeling can be somewhat arbitrary. Do we model the zone thermostat and FCU separately or together? Are circulation pumps onboard a boiler integral to that boiler or independent? In determining what should be modeled as an atomic component of a system, it will be necessary to use both precedent and reasonable judgment.

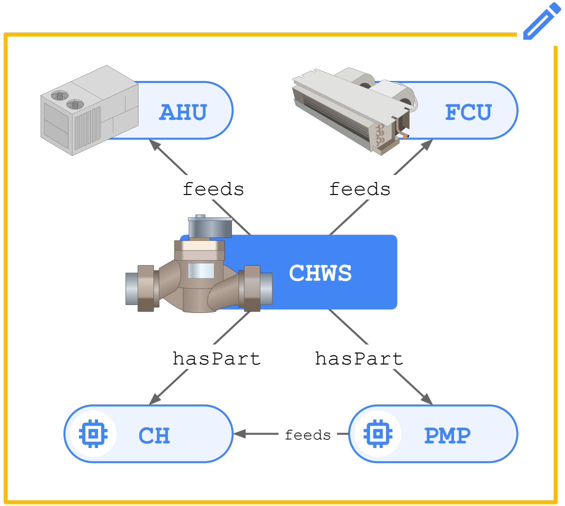
You'll need to "draw the box" around the logical device.

When considering a device to be modeled, try to imagine that you are drawing a box around it in some way – cutting out everything outside the box and focusing on just what is inside it. The box should contain the integral functionality of the device while omitting things that are best modeled elsewhere.

These boundaries are usually easy to define. In general, smaller components like valves, dampers, and controllers are not modeled independently when they are integral to a device. These are typically modeled as part of a single logical device.

Example

A chilled water system (CHWS) that serves downstream air handling units (AHU) and fan coil units (FCU) also has components like pumps (PMP) and chillers (CH). Even though these devices all connect to the system, they're all independent devices and would be modeled as independent entities. Therefore, we'd "draw the box" around each device in the system, including the system itself.



Back

Next

Should a device be modeled independently or as part of an entity? (continued)

How to “draw the box” around a logical entity

1. Review the devices that were identified in the project documents.
2. Determine whether each device is an integral component of a larger device.
3. Draw the box around the logical entity, containing all the integral components.
4. Keep a list of logical entities for future reference.

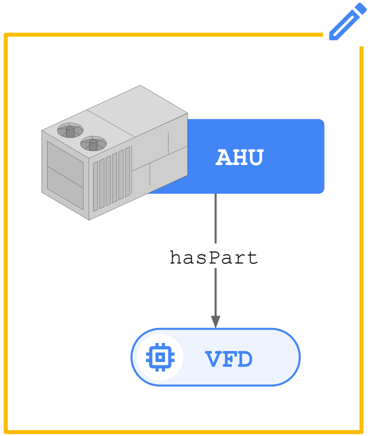
Example

Imagine that, during the review of a drawing set, you identify an air handling unit (AHU) that has variable speed fan control which it accomplishes using a variable frequency drive (VFD).

There are two options for how to model this:

- First, model the AHU and the VFD as separate logical entities.
- Second, model the AHU as the only logical entity and treat the VFD as part of the AHU.

Since the VFD is a smaller, functional component of the AHU (and usually is integral to it) the box should be drawn around the AHU and the VFD, and they should be treated as one device to model. You will see this is consistent with devices defined in the HVAC/AHU.yaml file (and that there is no HVAC/VFD.yaml file).



Back

Next

Google

“Drawing the box” around logical entities

Let’s explore a few scenarios that will require us to “draw the box” around devices that need to be modeled.

Scenario 1 - **Using a BMS points list**

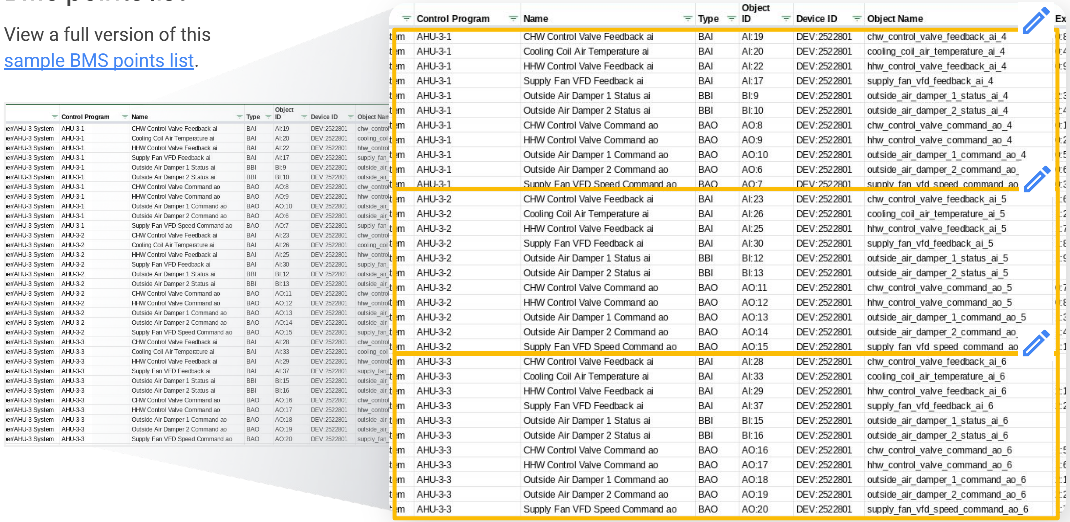
In a **brownfield scenario** where the building has already been integrated into the BMS, a points list is a spreadsheet/tabular representation of all of the available points in the building.

To the right is a sample BMS points list. Each row represents a single point on a piece of equipment (e.g., the zone temperature sensor for a specific single-zone AHU).

In this scenario, it’s rather obvious the “boxes” should be drawn around AHU-3-1, AHU-3-2, and AHU-3-3. They represent logical entities. Knowing that AHUs are an atomic entity type in DBO, this makes intuitive sense.

BMS points list

View a full version of this sample BMS points list.



Control Program	Name	Type	Object ID	Device ID	Object Name
AHU-3-1	CHW Control Valve Feedback ai	BAI	AI:19	DEV:2522801	chw_control_valve_feedback_ai_4
AHU-3-1	Cooling Coil Air Temperature ai	BAI	AI:20	DEV:2522801	cooling_coil_air_temperature_ai_4
AHU-3-1	HHW Control Valve Feedback ai	BAI	AI:22	DEV:2522801	hhw_control_valve_feedback_ai_4
AHU-3-1	Supply Fan VFD Feedback ai	BAI	AI:17	DEV:2522801	supply_fan_vfd_feedback_ai_4
AHU-3-1	Outside Air Damper 1 Status ai	BBI	BI:9	DEV:2522801	outside_air_damper_1_status_ai_4
AHU-3-1	Outside Air Damper 2 Status ai	BBI	BI:10	DEV:2522801	outside_air_damper_2_status_ai_4
AHU-3-1	CHW Control Valve Command ao	BAO	AO:8	DEV:2522801	chw_control_valve_command_ao_4
AHU-3-1	HHW Control Valve Command ao	BAO	AO:9	DEV:2522801	hhw_control_valve_command_ao_4
AHU-3-1	Outside Air Damper 1 Command ao	BAO	AO:10	DEV:2522801	outside_air_damper_1_command_ao_4
AHU-3-1	Outside Air Damper 2 Command ao	BAO	AO:6	DEV:2522801	outside_air_damper_2_command_ao_
AHU-3-1	Supply Fan VFD Speed Command ao	BAO	AO:7	DEV:2522801	supply_fan_vfd_speed_command_ao
AHU-3-2	CHW Control Valve Feedback ai	BAI	AI:23	DEV:2522801	chw_control_valve_feedback_ai_5
AHU-3-2	Cooling Coil Air Temperature ai	BAI	AI:26	DEV:2522801	cooling_coil_air_temperature_ai_5
AHU-3-2	HHW Control Valve Feedback ai	BAI	AI:25	DEV:2522801	hhw_control_valve_feedback_ai_5
AHU-3-2	Supply Fan VFD Feedback ai	BAI	AI:30	DEV:2522801	supply_fan_vfd_feedback_ai_5
AHU-3-2	Outside Air Damper 1 Status ai	BBI	BI:12	DEV:2522801	outside_air_damper_1_status_ai_5
AHU-3-2	Outside Air Damper 2 Status ai	BBI	BI:13	DEV:2522801	outside_air_damper_2_status_ai_5
AHU-3-2	CHW Control Valve Command ao	BAO	AO:11	DEV:2522801	chw_control_valve_command_ao_5
AHU-3-2	HHW Control Valve Command ao	BAO	AO:12	DEV:2522801	hhw_control_valve_command_ao_5
AHU-3-2	Outside Air Damper 1 Command ao	BAO	AO:13	DEV:2522801	outside_air_damper_1_command_ao_5
AHU-3-2	Outside Air Damper 2 Command ao	BAO	AO:14	DEV:2522801	outside_air_damper_2_command_ao_
AHU-3-2	Supply Fan VFD Speed Command ao	BAO	AO:15	DEV:2522801	supply_fan_vfd_speed_command_ao
AHU-3-3	CHW Control Valve Feedback ai	BAI	AI:28	DEV:2522801	chw_control_valve_feedback_ai_6
AHU-3-3	Cooling Coil Air Temperature ai	BAI	AI:33	DEV:2522801	cooling_coil_air_temperature_ai_6
AHU-3-3	HHW Control Valve Feedback ai	BAI	AI:29	DEV:2522801	hhw_control_valve_feedback_ai_6
AHU-3-3	Supply Fan VFD Feedback ai	BAI	AI:37	DEV:2522801	supply_fan_vfd_feedback_ai_6
AHU-3-3	Outside Air Damper 1 Status ai	BBI	BI:15	DEV:2522801	outside_air_damper_1_status_ai_6
AHU-3-3	Outside Air Damper 2 Status ai	BBI	BI:16	DEV:2522801	outside_air_damper_2_status_ai_6
AHU-3-3	CHW Control Valve Command ao	BAO	AO:16	DEV:2522801	chw_control_valve_command_ao_6
AHU-3-3	HHW Control Valve Command ao	BAO	AO:17	DEV:2522801	hhw_control_valve_command_ao_6
AHU-3-3	Outside Air Damper 1 Command ao	BAO	AO:18	DEV:2522801	outside_air_damper_1_command_ao_6
AHU-3-3	Outside Air Damper 2 Command ao	BAO	AO:19	DEV:2522801	outside_air_damper_2_command_ao_6
AHU-3-3	Supply Fan VFD Speed Command ao	BAO	AO:20	DEV:2522801	supply_fan_vfd_speed_command_ao_6

Back

*Click **Next** to see another scenario.*

Next

“Drawing the box” around logical entities

Let’s explore a few scenarios that will require us to “draw the box” around devices that need to be modeled.

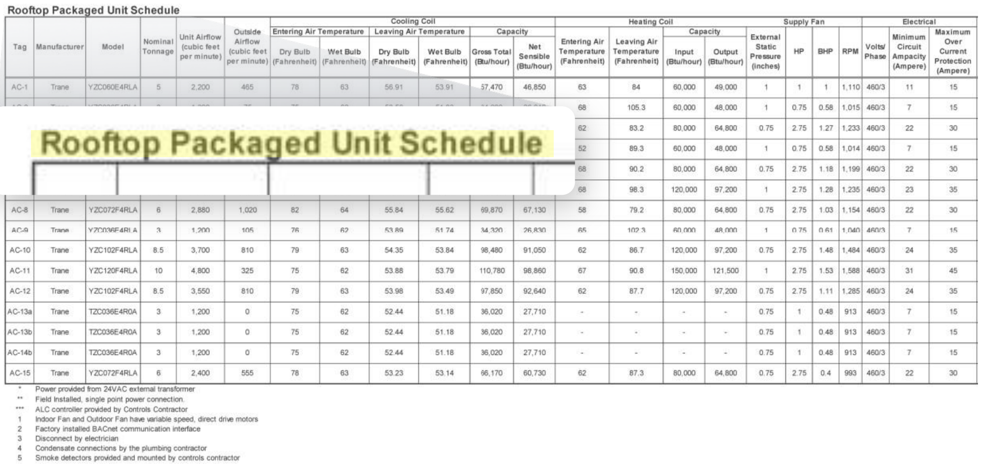
Scenario 2 - **Using mechanical drawings**

In a case where you have a mechanical drawing set, there will typically be a “Mechanical Schedule” section that outlines and specifies the pieces of mechanical equipment to be installed in the building.

While mechanical schedules don’t describe the telemetry that equipment is installed with, you know that there are (or will be) those pieces of equipment. The scheduled equipment in this case represents the list of logical entities that will ultimately need to be modeled.

Mechanical drawing

View a full version of this sample mechanical drawing.



Rooftop Packaged Unit Schedule

Tag	Manufacturer	Model	Nominal Tonnage	Unit Airflow (cubic feet per minute)	Outside Airflow (cubic feet per minute)	Cooling Coil						Heating Coil				Supply Fan				Electrical		
						Entering Air Temperature		Leaving Air Temperature		Capacity		Entering Air Temperature (Fahrenheit)	Leaving Air Temperature (Fahrenheit)	Capacity		External Static Pressure (inches)	HP	BHP	RPM	Volts/ Phase	Minimum Circuit Ampacity (Ampere)	Maximum Over Current Protection (Ampere)
						Dry Bulb (Fahrenheit)	Wet Bulb (Fahrenheit)	Dry Bulb (Fahrenheit)	Wet Bulb (Fahrenheit)	Gross Total (Btu/hour)	Net Sensible (Btu/hour)			Input (Btu/hour)	Output (Btu/hour)							
AC-1	Trane	YZC060E4RLA	5	2,200	465	78	63	56.91	53.91	57,470	46,850	63	84	60,000	49,000	1	1	1	1,110	460/3	11	15
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	68	105.3	60,000	48,000	1	0.75	0.58	1,015	460/3	7	15
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	62	83.2	80,000	64,800	0.75	2.75	1.27	1,233	460/3	22	30
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52	89.3	60,000	48,000	1	0.75	0.58	1,014	460/3	7	15
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	68	90.2	80,000	64,800	0.75	2.75	1.18	1,199	460/3	22	30
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	68	98.3	120,000	97,200	1	2.75	1.28	1,235	460/3	23	35
AC-8	Trane	YZC072F4RLA	6	2,880	1,020	82	64	55.84	55.62	69,870	67,130	58	79.2	80,000	64,800	0.75	2.75	1.03	1,154	460/3	22	30
AC-9	Trane	YZC036E4RLA	3	1,200	105	76	62	53.89	51.74	34,320	26,830	65	102.3	60,000	48,000	1	0.75	0.61	1,040	460/3	7	15
AC-10	Trane	YZC102F4RLA	8.5	3,700	810	79	63	54.35	53.84	98,480	91,050	62	86.7	120,000	97,200	0.75	2.75	1.48	1,484	460/3	24	35
AC-11	Trane	YZC120F4RLA	10	4,800	325	75	62	53.88	53.79	110,780	98,860	67	90.8	150,000	121,500	1	2.75	1.53	1,588	460/3	31	45
AC-12	Trane	YZC102F4RLA	8.5	3,550	810	79	63	53.98	53.49	97,850	92,640	62	87.7	120,000	97,200	0.75	2.75	1.11	1,285	460/3	24	35
AC-13a	Trane	TZC036E4R0A	3	1,200	0	75	62	52.44	51.18	36,020	27,710	-	-	-	-	0.75	1	0.48	913	460/3	7	15
AC-13b	Trane	TZC036E4R0A	3	1,200	0	75	62	52.44	51.18	36,020	27,710	-	-	-	-	0.75	1	0.48	913	460/3	7	15
AC-14b	Trane	TZC036E4R0A	3	1,200	0	75	62	52.44	51.18	36,020	27,710	-	-	-	-	0.75	1	0.48	913	460/3	7	15
AC-15	Trane	YZC072F4RLA	6	2,400	555	78	63	53.23	53.14	66,170	60,730	62	87.3	80,000	64,800	0.75	2.75	0.4	993	460/3	22	30

* Power provided from 24VAC external transformer
** Field Installed, single point power connection.
*** ALC controller provided by Controls Contractor
1 Indoor Fan and Outdoor Fan have variable speed, direct drive motors
2 Factory installed BACnet communication interface
3 Disconnect by electrician
4 Condensate connections by the plumbing contractor
5 Smoke detectors provided and mounted by controls contractor

Back

*Click **Next** to see another scenario.*

Next

Google

“Drawing the box” around logical entities

Let’s explore a few scenarios that will require us to “draw the box” around devices that need to be modeled.

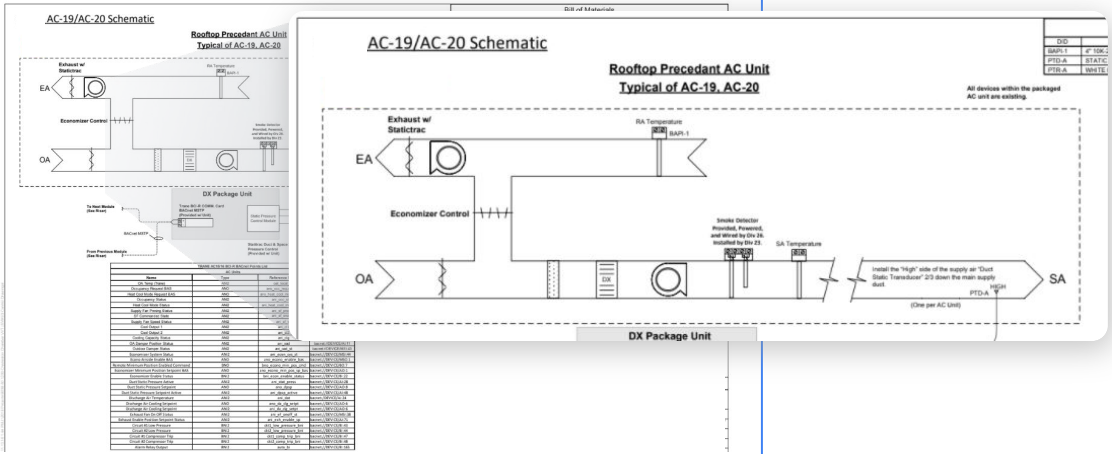
Scenario 3 - **Using controls drawings**

From this example it’s quite obvious where to draw the box since it has already been done by the controls contractor.

The AHUs have a box drawn around it. From the drawing, it’s clear that two logical entities will exist that follow this template: AC-19 and AC-20, both of which will be AHUs (as they handle outside air directly).

Controls drawing

Click here to view a full version of this sample controls drawing.



Back

Next

Google

Lesson 2

Practice

Let’s take a moment to apply what you’ve learned so far.

- The next slides will present three brief scenarios with questions related to information in this lesson.
- Answer each question on your own and check your answer on the following slide.
- After this practice activity, you’ll wrap up Lesson 2.

Back

Tip: Create a new doc in your Google Drive before starting this practice activity. You can use this doc to write down your answers.

Next

Google

Practice 1

You received a drawing set from a project contributor. You begin reviewing the document and end up on this page.

Which devices should be modeled?

Review the sample drawing set on your own to find all of the devices. If it helps, use a separate document to write down your answers.

Steps

1. Review the project documents and any other relevant information to get a sense for what equipment is to be installed (or is already installed).
2. For all the devices being installed, partition them into their relevant namespaces.
3. List out all identified devices and their namespaces for future reference.
4. List out all systems that need to be defined.

Mechanical drawing

View a full version of this sample mechanical drawing.

ROOFTOP PACKAGE VARIABLE AIR VOLUME UNIT SCHEDULE

					ENTERING CONDITIONS		LEAVING CONDITIONS		COOLING (MBH)			SUPPLY FAN					EXHAUST FAN					FILTER BANK								
TAG	MFR	MODEL	DESIGN CFM	OSA	DB	WB	DB	WB	SENSIBLE	TOTAL	UNIT EER	RPM	ESP (IN)	TP (IN)	BHP	HP	CFM	RPM	TP (IN)	BHP	HP	SIZE	TYPE	V/PH	MCA	MOCP	HT W/O LEVELING	WEIGHT (LBS)	AREAS SERVED	NOTES
AC-1	TRANE	SXHLF60E	20,000	4,365	78	63	52	51	527	640	10.50	1,752	1.25	4.700	24.00	30	17,000	604.00	1.00	5.90	7.5	2"	MERV 13	208/3	356	400	87"	10,923	FIRST FLOOR	1,2,3,4,5,6,7,8,9,10,11,12,13,14

Unit Options

1. HORIZONTAL DISCHARGE, SEE FACTORY SUBMITTALS ON HORIZONTAL OPENING LOCATIONS
2. INTERNALLY ISOLATED WITH 2" SPRING ISOLATERS BY FACTORY, WITH FRAME FOR WELDING POINTS ONTO STEEL
3. FACTORY INSTALLED ECONOMIZER WITH DRY BULB SWITCH SWICHOVER
4. FACTORY INSTALLED 100% POWERED EXHAUST WITH BUILDING PRESSUE CONTROL
5. SMOKE DETECTORS IN SUPPLY AIR PLENUM INSTALLED AND UNIT SHUTDOWN BY SVM (FURNISHED AND MONITORED BY OTHERS)
6. UNIT WEIGHT AND HEIGHTS EXCLUDES STRUCTURAL STEEL HEIGHT AND WEIGHT
7. ULTRA LOW LEAKAGE OUTSIDE AND RELIEF AIR DAMPERS
8. FACTORY INSTALLED OUTSIDE AIR MONITORING AND CONTROL
9. BACNET MS/TP CONTROL INTERFACE
10. VARIABLE SPEED COMPRESSORS
11. VFD ON SUPPLY AND EXHAUST FANS WITHOUT BYPASS, FACTORY INSTALLED
12. FACTORY PROVIDE SERVICE OUTLET TO BE SEPARATELY POWER BY ELECTRICIAN
13. CONDENSATE CONNECTIONS INCLUDING TRAP BY PLUMBING CONTRACTOR, REFERENCE UNIT SUBMITTAL FOR CONNECTION LOCATIONS
14. DISCONNECT BY ELECTRICIAN

AIR CONDITIONING UNIT SCHEDULE

				DESIGN	SUPPLY FAN				EA	EA	COOLING (MBH)		FILTERS		ELECTRICAL			EFF.	ECONMZR	HT W/O	WT	AREA	
TAG	MFR	MODEL	TONS	CFM	RPM	ESP (IN)	BHP	HP	DB	WB	SENSIBLE	TOTAL	SIZE	TYPE	V/PH	MCA	MOCP	SEER	Y/N	LEVELING	(LBS)	SERVED	NOTES
AC-2	TRANE	THC037E4R0A	3.0	1,150	906	0.75	0.41	--	78	63.0	26.4	32.6	2"	THROWAWAY	208/3	24.0	30.0	13.0 SEER	Y	36.25"	701		1,2,3,4,5
AC-3	TRANE	THC067E3R0A	5.0	1,900	1,017	0.75	0.84	1	78	63.0	45.8	54.3	2"	THROWAWAY	208/3	33.0	45.0	17.5 SEER	Y	41"	953		1,2,3,4,5

1. HORIZONTAL DISCHARGE, CURB-MOUNTED ROOF TOP PACKAGE UNIT
2. PROVIDE AND INSTALL MERV 13 THROW-AWAY FILTERS
3. PROVIDE W/ 100% ECONOMIZER
4. FAN CONTROL W/VFD WITHOUT BYPASS
5. BACNET MS/TP CONTROL INTERFACE

VAV Box Schedule

Type	Tag	Size		Design Cooling CFM	Deadband /Min CFM	DCV?	DCV CFM/Alternate "Deadband" (DCV zones only)	Design Heating CFM	EAT	LAT	MBH	GPM	EWT	LWT	Rows	TCV	Cv	SERVING	NOTES
		Unit / Inlet	Outlet			Y/N													
RH	VAV 1-01	14	20x17.5	2175	285	N	--	655	55	90	25	1.7	140	110	2	3-WAY	0.83		1,2
RH	VAV 1-02	16	24x18	2505	300	N	--	750	55	90	28	1.9	140	110	2	2-WAY	0.95		1,2
RH	VAV 1-03	16	24x18	2505	300	N	--	750	55	90	28	1.9	140	110	2	2-WAY	0.95		1,2
CO	VAV 1-04	16	24x18	2600	330	N	--	--	--	--	--	--	--	--	--	--	--		1,2
CO	VAV 1-05	14	20x17.5	2200	285	N	--	--	--	--	--	--	--	--	--	--	--		1,2
RH	VAV 1-06	8	12x10	250	75	N	--	75	55	90	3	0.2	140	110	2	2-WAY	0.09		1,2
RH	VAV 1-07	12	16x15	1020	140	N	--	305	55	90	12	0.8	140	110	2	3-WAY	0.38		1,2
RH	VAV 1-08	8	12x10	330	180	N	--	180	55	90	7	0.5	140	110	2	2-WAY	0.23		1,2
RH	VAV 1-09	8	12x10	220	120	N	--	120	55	90	5	0.3	140	110	2	2-WAY	0.15		1,2
CO	VAV 1-10	8	12x10	200	65	N	--	--	--	--	--	--	--	--	--	--	--		1,2
CO	VAV 1-11	12	16x15	1200	140	N	--	--	--	--	--	--	--	--	--	--	--		1,2
RH	VAV 1-12	8	12x10	330	180	N	--	180	55	90	7	0.5	140	110	2	2-WAY	0.23		1,2
RH	VAV 1-13	8	12x10	110	65	N	--	65	55	90	2	0.2	140	110	2	2-WAY	0.08		1,2
RH	VAV 1-14	8	12x10	480	120	N	--	145	55	90	5	0.4	140	110	2	3-WAY	0.18		1,2
RH	VAV 1-15	12	16x15	1220	140	N	--	365	55	90	14	0.9	140	110	2	2-WAY	0.46		1,2
RH	VAV 1-16	10	14x12.5	610	100	N	--	185	55	90	7	0.5	140	110	2	2-WAY	0.23		1,2
RH	VAV 1-17	8	12x10	350	65	Y	105	105	55	90	4	0.3	140	110	2	2-WAY	0.13		1,2,3
RH	VAV 1-18	8	12x10	350	65	Y	105	105	55	90	4	0.3	140	110	2	2-WAY	0.13		1,2,3
RH	VAV 1-19	8	12x10	310	65	N	--	95	55	90	4	0.2	140	110	2	2-WAY	0.12		1,2
RH	VAV 1-20	8	12x10	370	65	Y	75	110	55	90	4	0.3	140	110	2	2-WAY	0.14		1,2,3
RH	VAV 1-21	8	12x10	480	65	Y	120	145	55	90	5	0.4	140	110	2	3-WAY	0.18		1,2,3
RH	VAV 1-22	8	12x10	550	80	Y	345	165	55	90	6	0.4	140	110	2	2-WAY	0.21		1,2,3
RH	VAV 1-23	8	12x10	360	65	Y	180	110	55	90	4	0.3	140	110	2	2-WAY	0.14		1,2,3
RH	VAV 1-24	8	12x10	490	135	N	--	145	55	90	5	0.4	140	110	2	2-WAY	0.18		1,2
RH	VAV 1-25	8	12x10	220	65	N	--	65	55	90	2	0.2	140	110	2	2-WAY	0.08		1,2
RH	VAV 1-26	8	12x10	400	90	N	--	120	55	90	5	0.3	140	110	2	2-WAY	0.15		1,2
RH	VAV 1-27	8	12x10	200	65	N	--	65	55	90	2	0.2	140	110	2	2-WAY	0.08		1,2
RH	VAV 1-28	8	12x10	380	65	N	--	115	55	90	4	0.3	140	110	2	2-WAY	0.14		1,2
RH	VAV 1-29	14	20x17.5	1920	190	Y	150	575	55	90	22	1.4	140	110	2	2-WAY	0.72		1,2,3
RH	VAV 1-30	12	16x15	1200	150	N	--	360	55	90	14	0.9	140	110	2	3-WAY	0.45		1,2
RH	VAV 1-31	8	12x10	250	65	N	--	75	55	90	3	0.2	140	110	2	3-WAY	0.09		1,2

1 24V CONTROL POWER
2 DDC CONTROL
3 FURNISHED WITH CO_2 SENSOR FOR DEMAND CONTROL VENTILATION

HOT WATER BOILER SCHEDULE

TAG	MFR	MODEL	INPUT MBH	OUTPUT MBH	DESIGN GPM*	GAS PRESSURE (in. W.C.)	WPD (FT)	EWT	LWT	AFUE %	HEIGHT (IN)	OPER WT (LBS)	IN H20 CONN.	NOTES
B-1	RAYPAK	506L	500	489	33	5" TO 13"	3.4	110	140	97.8%	59"	231	2"	1,2,3,4,5,6,7,8,9
B-2	RAYPAK	506L	500	489	33	5" TO 13"	3.4	110	140	97.8%	59"	231	2"	1,2,3,4,5,6,7,8,9

1. MOTORIZED ISOLATION VALVE ON INLET
2. 10 TO 1 TURNDOWN RATIO, WITH DDC INTERFACE, LOW NOx
3. 60 PSI PRESSURE RELIEF VALVE, FURNISHED BY MANUFACTURER
4. GAS PIPING & SIZING BY PLUMBER, SEE GAS PRESSURE DROP AND BTU FOR SIZING FROM SUBMITTAL
5. STARTER & DISCONNECT, BY ELECTRICIAN
6. CONDENSATE NEUTRALIZER KIT, BY MANUFACTURER
7. B-85 CONTROLLER AND BACNET MS/TP INTERFACE MODULE, FACTORY MOUNTED
8. MOUNTED ON SKID, FURNISHED AND SUPPLIED BY MECHANICAL CONTRACTOR
9. N+1 CONFIGURATION, SIZED FOR 100% OF LOAD

DIFFUSER SCHEDULE

TAG	MFR	MODEL	SIZE	FACE	BORDER	FINISH	BACK PAN COLOR	T-BAR WIDTH	NOTES
SA-1	PRICE	SPD	24x24	FLUSH	31	WHITE	WHITE	15/16" FINELINE	1
SA-2	PRICE	520D	VARIES	FLUSH	F	WHITE	--	--	--
SA-3	PRICE	SDGE	VARIES	FLUSH	--	ALUMINUM	--	--	--
RA-1	PRICE	SPD	24x24	FLUSH	31	WHITE	WHITE	15/16" FINELINE	1
RA-2	PRICE	520D	VARIES	FLUSH	F	WHITE	--	--	--
EA-1	PRICE	SPD	24x24	FLUSH	31	WHITE	WHITE	15/16" FINELINE	1

1. ATTACH FIVE FEET OF FLEX DUCTING

PUMP SCHEDULE

TAG	MFR	MODEL	SIZE	DESIGN GPM	TDH (FEET)	RPM	BHP	HP	VOLTS/ PHASE	VFD?	IMPELLER SIZE (MAX)	SUCTION SIZE	DISCHARGE SIZE	OP.WT. (LBS)	SERVICE	LOCATION	NOTES
HWP-1	ARMSTRONG	4380	2X2X6	33	30	1760	0.55	1	208/3	Y	5.42"	2"	2"	171	B-1, B-2	ROOF	1,2,3,4,5
HWP-2	ARMSTRONG	4380	2X2X6	33	30	1760	0.55	1	208/3	Y	5.42"	2"	2"	171	B-1, B-2	ROOF	1,2,3,4,5

1. IN-LINE PUMP
2. PUMP SIZED FOR 100% OF CAPACITY.
3. FURNISH WITH REMOTE MOUNTING VFD IN NEMA 3R ENCLOSURE
4. STANDARD SEAL PUMP W/FURNISHED TEFC STANDARD EFFICIENCY MOTOR
5. PUMPS MOUNTED ON SKID, FURNISHED AND SUPPLIED BY MECHANICAL CONTRACTOR
6. DISCONNECT BY ELECTRICIAN

EXHAUST FAN SCHEDULE

TAG	MFR	MODEL	CFM	ESP (IN)	RPM	BHP	HP	V/PH	SONES	HT W/O * LEVELING	WEIGHT (LBS)	AREAS SERVED	NOTES
EF-1	GREENHECK	G-163-VG	2,305	0.75	1266	0.77	2.00	208/1	15.2	36"	68		1,2,3,4,5
EF-2	GREENHECK	SQ-80-VG	200	0.30	1562	0.06	0.10	120/1	7.4	15"	54		2,3,4,5
TF-1-1	GREENHECK	SQ-120-VG	1,100	0.500	1326	0.22	0.50	115/1	7.8	19"	68		2,3,4,5

1. FACTORY SUPPLIED ROOF CURB, FURNISHED BY MANUFACTURER
2. FIELD INSTALLED BACKDRAFT DAMPER, FURNISHED BY MANUFACTURER
3. DISCONNECT BY ELECTRICAL CONTRACTOR
4. FACTORY MOUNTED EC MOTORS
5. FAN CONTROLLED AND MONITORED BY BMS

POT FEEDER

TAG	MFR	UNIT MODEL	TANK VOLUME (GALLONS)	NOTES
PF-1	GRISWOLD	FB-2-SB-CS	2	1

1. SEE BOILER P&ID AND BOILER SKID SCHEMATICS AND LOCATION. SUPPORTED BY SKID

VFD SCHEDULE

TAG	MFR	MOTOR HP	V/PH	UNIT SERVED	NOTES
VFD-1	ABB	1.0	208/3	HWP-1	1,2,3,4,5
VFD-2	ABB	1.0	208/3	HWP-2	1,2,3,4,5

1. FACTORY SUPPLIED BYPASS AND DISCONNECT
2. NEMA 3R ENCLOSURE
3. VFD RATED FOR 4.6 AMPS
4. FACTORY SUPPLIED JOHNSON CONTROLS INTERFACE CARD
5. DISCONNECT W/CONTACTS BY ELECTRICIAN

Title: MECHANICAL SCHEDULES
Sheet: M-1

Back

Next

Practice 1

Check your answer! 👨‍🏫

Here are all the devices that should be modeled. **Are these the same ones you identified?**

- Rooftop package variable air volume (AHU) unit
- Air conditioning unit (another type of AHU)
- VAV box
- Hot water boiler
- Pump
- Exhaust fan

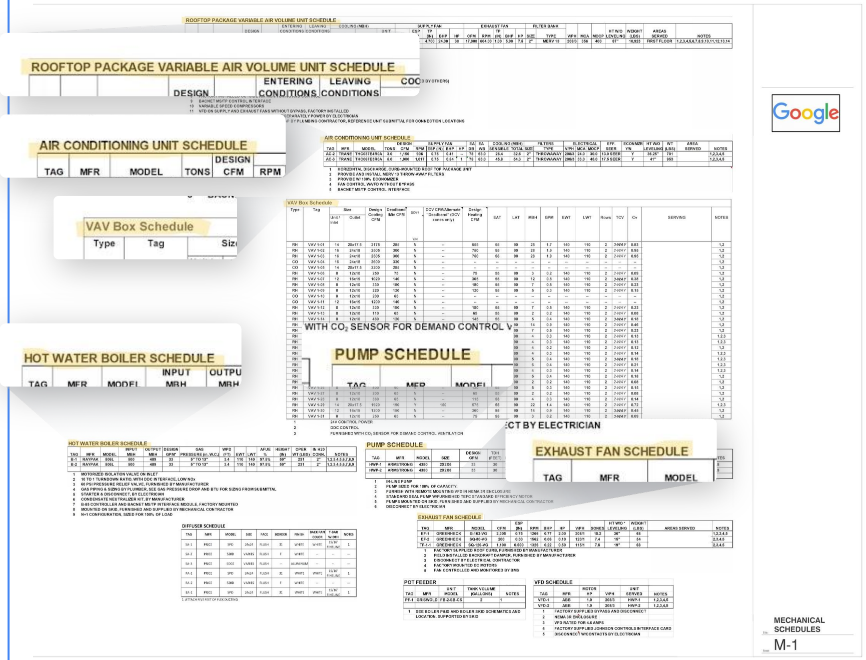
We determined it will be important to model the information in the highlighted schedule sections. These were identified as important pieces of equipment because they are common GENERAL TYPES in the HVAC namespace.

We chose not to model the equipment listed in the Diffuser, Pot Feeder, and VFD sections. Diffusers and pot feeders aren't common GENERAL TYPES in the HVAC namespace, and generally do not send telemetry. While it may seem important to include the VFDs in our model, because they are noted as serving the heating water pumps, their functionality will be captured in the translations for the pumps. You can check this by reviewing the models previously defined in HVAC/PMP.yaml and seeing that they include fields related to speed.

And don't forget to identify the HW system as an entity itself, because they tend to have data independent of the equipment attached to them (header temperatures and pressures that apply to the system).

Mechanical drawing

View a full version of this sample mechanical drawing.



Back

*When you're ready, click **Next** to move on to the next practice activity.*

Next

Practice 2

You listed all of the devices from a drawing set you received from a project contributor. Here's a list of all the devices that were identified.

Which namespace does each device belong to?

Review the list on your own to determine the appropriate namespace of each device. If it helps, use a separate document to write down your answers.

Namespaces

For your reference, here are the possible namespaces these devices may belong to:

- HVAC
- Lighting
- Metering
- Electrical
- Safety
- IoT

Device name	Namespace
AC-1	???
AC-2	???
AC-3	???
B-1	???
B-2	???
HWP-1	???
HWP-2	???
HWS	???
EF-1	???
EF-2	???
TF-1-1	???
All VAVs	???

Back

Note: The HWS is also included because things like header temperatures and pressures will need a place to reside. Since they are not associated directly with the pumps or boilers (they are system-level sensors), it makes sense to also have a system-level entity to house that data.

Next

Google

Practice 2

Check your answer! 👨‍🏫

Here’s each device within its appropriate namespace.

Does this match what you came up with?

Device name	Namespace
AC-1	HVAC
AC-2	HVAC
AC-3	HVAC
B-1	HVAC
B-2	HVAC
HWP-1	HVAC
HWP-2	HVAC
HWS	HVAC
EF-1	HVAC
EF-2	HVAC
TF-1-1	HVAC
All VAVs	HVAC

Back

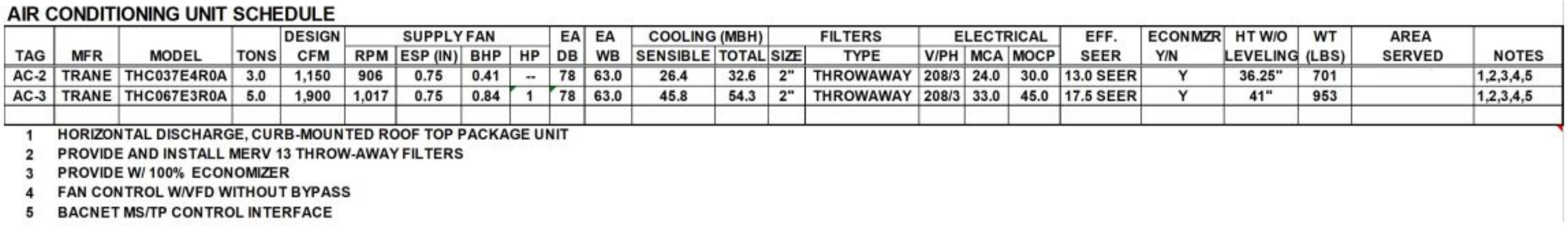
*When you’re ready, click **Next** to move on to the next practice activity.*

Next

Practice 3

Let’s “draw a box” around a logical entities.
Here are some of the individual devices from the drawing set you received.

Mechanical drawing



AIR CONDITIONING UNIT SCHEDULE

				DESIGN	SUPPLY FAN				EA	EA	COOLING (MBH)		FILTERS		ELECTRICAL			EFF.	ECONMZR	HT W/O	WT	AREA	
TAG	MFR	MODEL	TONS	CFM	RPM	ESP (IN)	BHP	HP	DB	WB	SENSIBLE	TOTAL	SIZE	TYPE	V/PH	MCA	MOCP	SEER	Y/N	LEVELING	(LBS)	SERVED	NOTES
AC-2	TRANE	THC037E4R0A	3.0	1,150	906	0.75	0.41	--	78	63.0	26.4	32.6	2"	THROWAWAY	208/3	24.0	30.0	13.0 SEER	Y	36.25"	701		1,2,3,4,5
AC-3	TRANE	THC067E3R0A	5.0	1,900	1,017	0.75	0.84	1	78	63.0	45.8	54.3	2"	THROWAWAY	208/3	33.0	45.0	17.5 SEER	Y	41"	953		1,2,3,4,5

1 HORIZONTAL DISCHARGE, CURB-MOUNTED ROOF TOP PACKAGE UNIT
2 PROVIDE AND INSTALL MERV 13 THROW-AWAY FILTERS
3 PROVIDE W/ 100% ECONOMIZER
4 FAN CONTROL W/VFD WITHOUT BYPASS
5 BACNET MS/TP CONTROL INTERFACE

What are the logical entities? What are their components?

Review the mechanical drawing on your own to determine what should be modeled together.
If it helps, use a separate document to write down your answers.

Back

Next

Practice 3

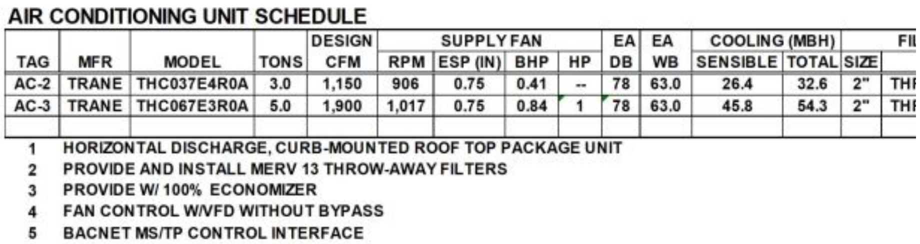
Check your answer! 👨‍🏫

Here's how we'd "draw the box."

Does this match what you came up with?

Device name	Component
AC-2	Supply fan
AC-2	Mechanical cooling (DX)
AC-2	Economizer
AC-2	Air filters
AC-2	Supply fan speed control (VFD)
AC-3	Supply fan
AC-3	Mechanical cooling (DX)
AC-3	Economizer
AC-3	Air filters
AC-3	Supply fan speed control (VFD)

Mechanical drawing



AIR CONDITIONING UNIT SCHEDULE

				DESIGN	SUPPLY FAN				EA	EA	COOLING (MBH)		FI	
TAG	MFR	MODEL	TONS	CFM	RPM	ESP (IN)	BHP	HP	DB	WB	SENSIBLE	TOTAL	SIZE	
AC-2	TRANE	THC037E4R0A	3.0	1,150	906	0.75	0.41	--	78	63.0	26.4	32.6	2"	TH
AC-3	TRANE	THC067E3R0A	5.0	1,900	1,017	0.75	0.84	1	78	63.0	45.8	54.3	2"	TH

1 HORIZONTAL DISCHARGE, CURB-MOUNTED ROOF TOP PACKAGE UNIT
2 PROVIDE AND INSTALL MERV 13 THROW-AWAY FILTERS
3 PROVIDE W/ 100% ECONOMIZER
4 FAN CONTROL W/VFD WITHOUT BYPASS
5 BACNET MS/TP CONTROL INTERFACE

You can infer quite a bit about what the device will have onboard just from the mechanical drawing:

- First, it has supply fans and variable speed control (see note 4 in the mechanical drawing).
- Second, it has economizing.
- Third, it has mechanical cooling but no heating.
- Fourth, it has filters but no callout for monitoring. This means it could implement filter pressure monitoring, but that remains unclear.

Back

*When you're ready, click **Next** to complete this activity and wrap up this lesson.*

Next

Repeat for each project document

To determine all of the devices that need to be modeled, you'll repeat these steps with each project document you receive from project contributors.

Click on each item to review the step-by-step instructions.

Identify devices to model

"Draw the box" around a logical device

Back

Next

Google

Repeat for each project document

To determine all of the devices that need to be modeled, you'll repeat these steps with each project document you receive from project contributors.

Click on each item to review the step-by-step instructions.

Identify devices to model

"Draw the box" around a logical device

Steps to identify devices to model

1. Review the project documents and any other relevant information to get a sense for what equipment is to be installed (or is already installed).
2. For all the devices being installed, partition them into their relevant namespaces.
   Example: Break out all HVAC equipment separately from lighting equipment.
3. List out all identified devices and their namespaces for future reference.
4. List out all systems that need to be defined.
   Example: The heating water system, the chilled water system

Back

Next

Repeat for each project document

To determine all of the devices that need to be modeled, you'll repeat these steps with each project document you receive from project contributors.

Click on each item to review the step-by-step instructions.

Identify devices to model

"Draw the box" around a logical device

Steps to "draw the box" around a logical device

1. Review the devices that were identified in the project documents.
2. Determine whether each device is an integral component of a larger device.
3. Draw the box around the logical entity, containing all the integral components.
4. Keep a list of logical entities for future reference.

Back

Next

Google

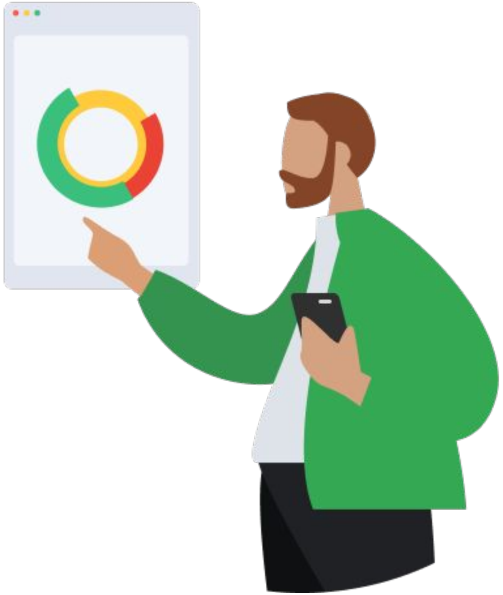
Lesson 2 summary

Let’s review what you learned about:

- Project documents for data modeling
- Logical devices and namespaces
- “Drawing the box” around an entity

Now you should be able to:

- Recognize the different documents you’ll use to gather information for a rough-in model.
- Identify the different devices within a namespace.
- Determine whether devices should be modeled independently or as a single entity.



Back

Next

You completed Lesson 2!

Now's a great time to take a quick break before starting Lesson 3.

Ready for Lesson 3?

Let's go!

Back

Google

Helpful resources

For future reference, keep these resources easily accessible for technical and procedural questions.

- Digital Buildings Project GitHub
  Contains source code, tooling, and documentation for the DBO.