VRF and Building Integrations

Options and How to Choose Among Them

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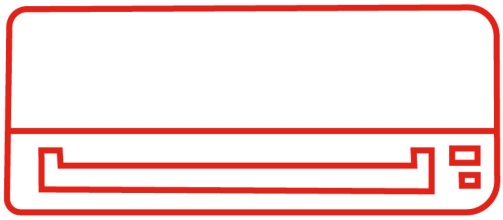
COOLING & HEATING

Buildings today are more sophisticated than ever — and the same is true for the mechanical equipment that supports building operations. This sophistication has made possible the world of advanced integration, or having a single point of control for multiple systems. For example, a building might have three systems (e.g., cooling and heating, a water feature and lighting) that can all be controlled from a single location. Or a campus might have 300 systems in separate buildings — all controlled from a single location. Integration is the act of bringing together multiple, often diverse systems into a single, centralized controls system.

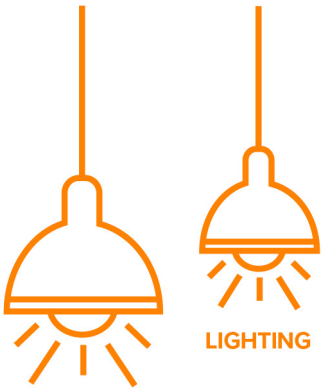
Now, integration is not just possible, it's desired. We're beyond the question of "Why should I integrate?" The answer has been proven time and time again, and is intuitive. One, integration makes facility management easier and more effective. It helps control utility costs; this is especially true for HVAC, which the U.S. Energy Information Administration states is responsible for about 40 percent of a building's energy costs[1]. So it makes sense to have HVAC systems run as well and wisely as possible, since this is where the most return on investment can be realized. Two, integration lets building managers and owners interact with just one controls system; people don't want service contractors and software updates for every little system. Plus, modern integration and open protocols let building managers and owners shop around. They're no longer tied to one manufacturer, introducing flexibility and cost savings.



COOLING AND HEATING

With the question of why behind us, the next question is "How do I integrate most effectively?" Integration is becoming much bigger than it used to be in terms of the number of integration options, as well as how complex the integrations can be.

This paper will discuss commercial integration, but it should be noted that smart homes are also on the rise. Once people have integration at home and use it daily, they'll demand it in their work lives; likewise once people see something at work each day, they'll want it at home. This positive feedback loop will result in the rate of integration continuing to grow. Now is a great time to learn more about integration and the options available.



LIGHTING

The "options available" cover a range of integration styles — from rudimentary to incredibly advanced. This paper will explain each style in detail, helping you identify what is the best fit for your team and application, and will detail the services to consider.

Regardless of the application, services will be key. Services make or break an integration. This includes design and scope coordination with an engineer, the creation of initial project documentation, commissioning assistance, training, post-installation follow-up visits and more.

WATER FEATURE

[1] U.S. Energy Information Administration

A Closer Look at Integration and the Ways People Integrate

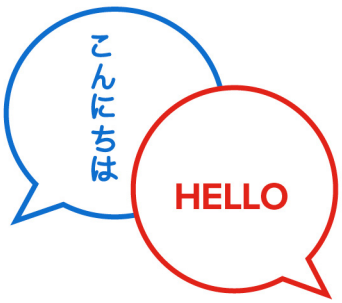
A Closer Look

As mentioned before, integration is a single point of control for multiple building systems. There are multiple styles, ranging from simple to advanced. Generally, advanced is the answer. An advanced controls system gets you more bang for your buck with mechanical systems by introducing efficiencies and making operation and maintenance easier. Advanced integration may not always be the answer, though.

This section will cover the various styles of integration, beginning with the simplest and working up to the most advanced. As you're reading, consider this: Most people focus on equipment and not controls when making a purchasing decision, but as much or more thought must be put into controls.

The Key to Integration Is Communication — An Overview

True integration would not be possible without the ability for systems to talk with each other. Like people talking, systems can only talk and understand each other if they share a language. Previously in the history of integration, there was no shared language. That made it complicated, at times impossible. It also necessitated using a third-party integrator who could employ their own proprietary language — somewhat like two people who speak a different language relying on a translator.



Building owners and managers who were unhappy with the proprietary nature of the building integration landscape drove a new concept: open protocols. Open protocols allow equipment to interoperate without any "translation," and are non-proprietary. The name you're most likely to hear at this point is BACnet®. BACnet is a standard protocol developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). BACnet-based devices talk with other BACnet-based devices no matter who developed them.

While BACnet is the most prominent protocol, LONWORKS® and Modbus® are comparable options. You can think of it like DVDs winning the market over Blu-rays; the two systems were essentially interchangeable — each offering the same features and benefits — but one gained slight popularity for whatever reason, and then continued gaining popularity because it was slightly more popular. This means that most integrations you encounter will be BACnet-based.

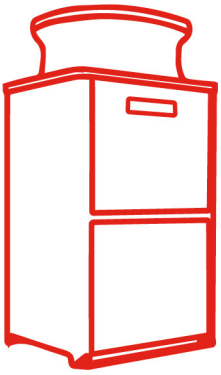
There are other options beyond BACnet, LONWORKS and Modbus, though these options are more obscure — for example Zigbee and OPC. Note that this obscurity can be a real problem, as integrators may not be familiar with them and that lack of familiarity may breed mistakes.

Remember that advanced integration is not possible without communication, and at this point, that communication happens primarily through BACnet.

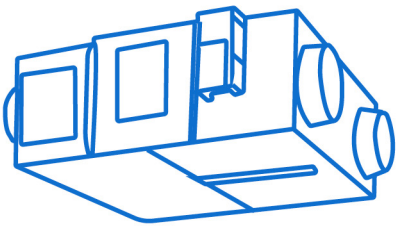
Non-integrated Standalone Building Controls System

AKA, Not integrating at all

1 **Snapshot.** You have multiple types and brands of equipment. One of them is Manufacturer A's Variable Refrigerant Flow (VRF) system and another is Manufacturer B's Energy Recovery Ventilator (ERV). You use the controls built into each system, including the VRF's built-in controls and the ERV's built-in controls. You do not attempt to connect them.



MANUFACTURER A (VRF)



MANUFACTURER B (ERV)

2 **Why people choose it.** Put simply, some projects don't require integration. Granted, not many of these projects exist at this point — and fewer and fewer will exist as time goes on. Most often, a project that does not require integration will be in standalone, non-institutional settings. You might picture a single gas station location or a convenience store, as opposed to a bank with 1,000 branches where headquarters wants to monitor each branch and dispatch local service technicians depending on what they're seeing.

3 **Benefits.** If you don't have a need to integrate, there's no need to pay for integration. That's really it. And that's just because almost all projects can benefit from integration.

4 **Pitfalls.** By not integrating, you're not taking advantage of your systems. They won't run as efficiently, so you won't benefit from the energy savings that efficient operation brings. When it comes to HVAC, this is especially important; as mentioned earlier, HVAC is responsible for about 40 percent of a building's energy costs.

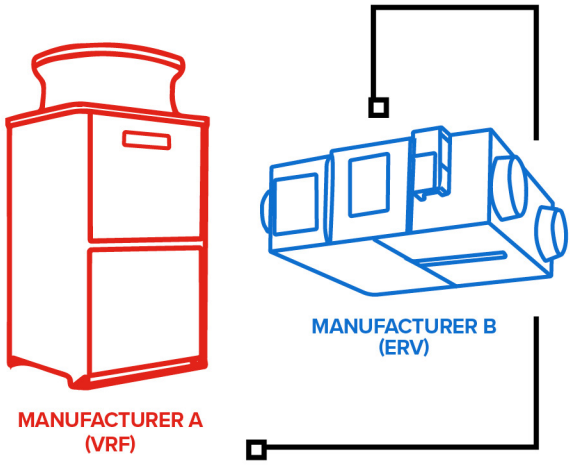
By not integrating, you also lose out on accumulating any data beyond each individual type (or even piece) of equipment on its own. That is a huge drawback by itself, but if you're pursuing green certification like LEED® or ENERGY STAR®, this can be a true deal breaker; every day there are more requirements to monitor energy usage.

Additional pitfalls of not integrating include added work for a building or facility manager. This person will need to be proficient on as many systems as they oversee. Take HVAC by itself; if the site has five brands of VRF, it will get cumbersome for the manager to know each brand's software and controls scheme. With integration, the manager would need to know just one system.

Discrete Logic

AKA: Physically hooking up two or more different systems via wired sensors and contact closures instead of talking via a communications protocol

1 **Snapshot.** You have multiple types and brands of equipment. One of them is Manufacturer A's VRF, and another is Manufacturer B's ERV. You physically connect the two systems' wires.

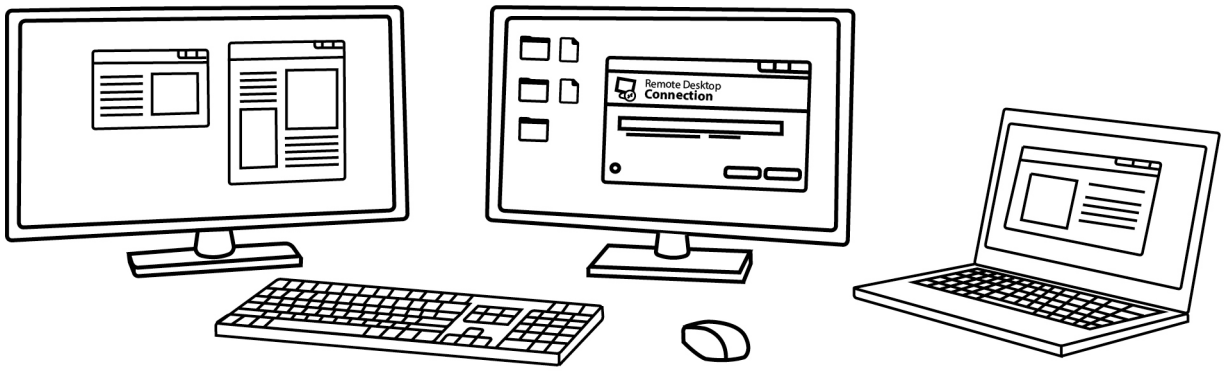


2 **Why people choose it.** In a setup that is very rudimentary — that doesn't need much control or data — this is a very basic form of integration. Note, though, that most people do not choose this style of integration; it's quite uncommon.

3 **Benefits.** Physically hooking up two or more systems is a low-cost way to connect systems and pick up run statuses or any kind of analog values. No additional controls are needed, and the installing contractor can take care of it, eliminating the need for an integrator.

4 **Pitfalls.** Lack of data is a huge one. Communications protocols give you much more data, and return that information in an easy-to-consume fashion (e.g., custom programs, custom graphics). With discrete logic, there is no interface providing those graphics. Likewise, because the setup is so rudimentary, remote support is tricky. With advanced integration, technicians can log in remotely to diagnose and address problems. With discrete logic, most problems will call for in-person, on-site assistance.

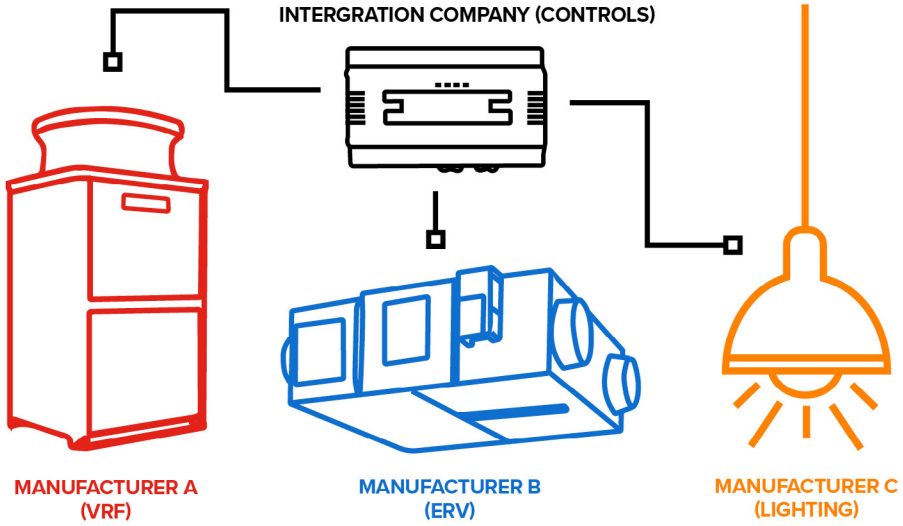
Finally, discrete logic is a step up from no integration, but not a significant one. When it comes to long-term savings, advanced integration that enables peak system efficiency has a big leg up.



Third-party Integration

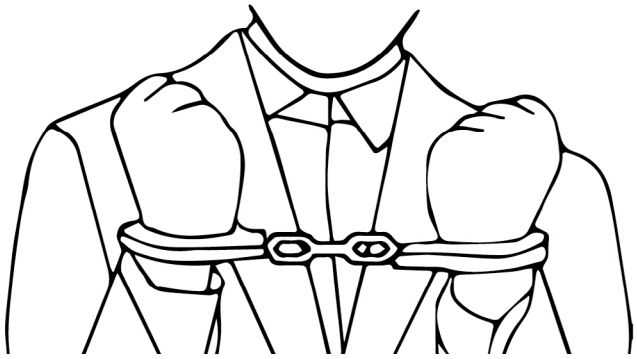
AKA: A third-party company integrates the products of multiple manufacturers

1 **Snapshot.** You have multiple types and brands of equipment. One of them is Manufacturer A's VRF, another is Manufacturer B's ERV and another Manufacturer C's lighting, etc. An integration company integrates the VRF, ERV and lighting systems into their proprietary controls system.



2 **Why people choose it.** This style — what people might think of as the "traditional" modern style of integration — is true integration. Beyond just a physical connection, third-party integration enables actual communication between systems. People have turned to third-party integrators for this style, like Johnson Controls, Siemens and other smaller companies with less name recognition.

This style of integration is still around, but is increasingly less popular due to people feeling "locked in." This locked-in concept will be discussed in the Pitfalls section, and you'll see it come up a lot in the world of integration.



3 **Benefits.** Because this is true integration, systems operate more efficiently — and can be managed more efficiently — than without integration or with discrete logic. Further, owners and managers have just one central interface to learn and use.

With third-party integration, you'll build a relationship with an integration company and use them again and again as you add systems. A benefit of this scenario is a long-term relationship. Once they know you, third-party integrators can customize your service.

Finally, the larger third-party integrators tend to have strong support networks across the country. So if a system goes down in the middle of the night or over the weekend, a technician can be quickly dispatched and soon thereafter on-site to address the issue.

4 **Pitfalls.** Using the same third-party integration company "again and again" also has its downsides, namely feeling locked in. The importance of this pitfall cannot be overstated. Simply put, once you have enough hardware and programming with one company, it can be prohibitively expensive and work-intensive to invest in a new company's system. So imagine that you've worked with Integration Company A for a decade but decide, for whatever reason, to switch to Integration Company B. While you technically can make the switch, you may feel locked in with Company A because the cost and complexity of transferring everything over to Company B is excessive, as opposed to remaining with Company A.

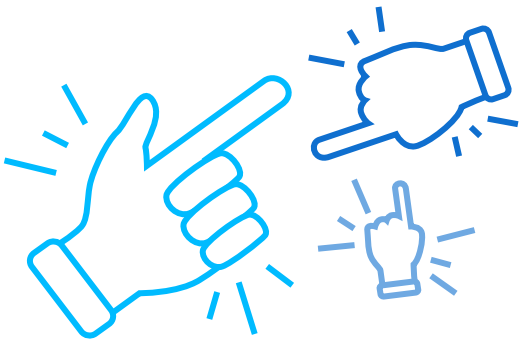
In the case where someone wants to switch third-party integrators but feels locked in, one option is to stick with Company A for the old systems and use Company B for the new systems. However, there is a significant downside: You then have to learn two systems, run them both simultaneously, monitor both, etc. Further, if you switch integrators, consider that project documentation won't be standardized, which can create confusion down the line.

This is all unappealing enough that while you can switch or add integrators, for all intents and purposes, you'll be locked in.

Unfortunately, some third-party integrators have earned a reputation for playing a tricky game — the installation is very cheap, which lures a new client in, but then the service and future projects will be quite expensive. And by then you're locked in, or are what gets called a "captured customer."

If being locked in is not a concern, there are still other pitfalls of third-party integration that should be kept in mind. One is the education hurdle in understanding the cost. The cost of third-party integration is not terrible, and having an advanced controls system can decrease lifecycle costs. However, a lot of people experience sticker shock the first time — not because integration is overpriced, but because most people just don't know what integration costs (or how it will pay back over time!).

An additional concern is finger-pointing. In the case of third-party integration, if there's a problem, who do you turn to? An integrator will point to the manufacturer, while the manufacturer will point to the integrator. Getting an answer may take more time, effort and even money.



Finally, third-party integrators may have limited knowledge. They tend to have their own brand of controls, and while they may be well-versed enough in other systems to integrate different manufacturers' products, this is generally not true when it comes to VRF. Third-party integrators are generally not educated on how a VRF system works, or are not interested in learning about VRF because of its advanced, electronics-based nature. This means integrators need to hardwire into the inputs or outputs from electronics or controls — something third-party integrators avoid doing due to their lack of familiarity with these systems. As a result of not truly understanding VRF, third-party integrators tend to over-control it. Since HVAC is such a large component of a building's energy usage, this is a key point.

As an example, VRF uses a concept called "Last Command Wins." In short, a unit will respond to the last command it was given — whether 5 seconds ago, 5 minutes or 5 days. Third-party

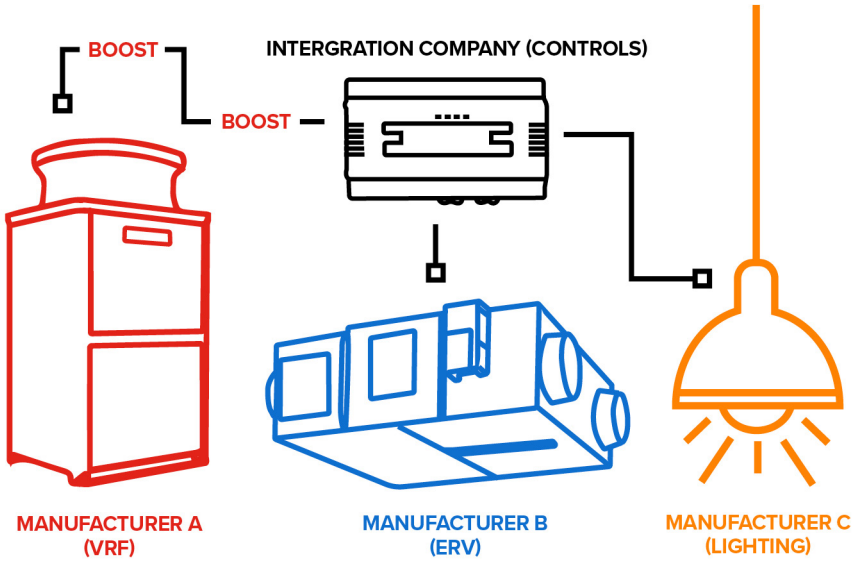
integrators use Pulse Commands, which send a new command every five minutes, for example. Pulse commands work with traditional HVAC systems, but not with VRF. This results in over-controlling the VRF system, and can result in non-optimal commands being executed.

Here's how that might look. A VRF system's indoor unit in a classroom that has an advanced integration system can receive commands from three places: the wallmounted controller in the classroom, the VRF system's centralized controller or the integrator's interface. (e.g., BACnet interface). Imagine the interface is set to keep the classroom at 70 degrees Fahrenheit; to do so, it sends a pulse command every 5 minutes that sets the VRF indoor unit to 75 degrees — 2:00pm, 2:05pm, 2:10pm, 2:15pm, etc. At 2:16pm, a teacher is very hot and walks up to the wall-mounted controller, decreasing the temperature to 68 degrees. The VRF indoor unit, which operates under last command wins, follows this most recent command, and adjusts its setpoint to 65 degrees. Within seconds she feels a cool breeze of air flowing, and is comforted knowing the room will cool down. But then 4 minutes later, at 2:20pm, the interface sends a pulse command, adjusting the setpoint back to 70 degrees. The cool air stops flowing. The teacher, realizing that the room is getting no cooler, will go back up to the wallmounted unit and attempt to adjust it again, only to have the interface undo her change a few minutes later. This can cause frustration for occupants or users because even when they change the thermostat, 5 minutes later, it reverts back. Further, commands that are nonoptimal for the performance of the system can be executed even when an occupant or user is trying to break away from the pulse commands because they see something the interface does not. This is not an issue inherent to building integrations, but to third-party integrators who are not aware of VRF's nuances.

Third-party Integration... With a Boost From the VRF Manufacturer's Controls Engineers

AKA: A VRF manufacturer sets up the back end of the controls for the VRF system, which gets integrated into a pre-existing third-party system

1 Snapshot.
You have multiple types and brands of equipment. One of them is Manufacturer A's VRF, another Manufacturer B's ERV and another Manufacturer C's lighting, etc. Manufacturer A's controls engineers work to integrate their VRF systems into the integration company's controls system that runs the VRF, ERV and lighting systems.



2 **Why people choose it.** This is a great option for those already locked in with a third-party integration company but who want the benefit of working directly with the VRF manufacturer.

3 **Benefits.** Third-party integration with a boost from the VRF manufacturer's controls engineers addresses some of the issues of third-party integration. Manufacturers can control their equipment better than anyone else; in the case of VRF, third-party integrators prefer not to integrate VRF because of its complexity. VRF manufacturers may also keep some information private. Combined, the effect is that you get the best integration of VRF if your integrator is your VRF manufacturer. That issue of Last Command Wins vs. Pulse Commands? With a VRF manufacturer setting up the back end of the controls, that's no longer an issue. The correct commands and amount of programming will happen, ensuring peak performance of the VRF system, and in turn occupant and user satisfaction.

Top-quality control also means better, more efficient operation, as well as a higher level of information available to the end user (e.g., trending). A VRF manufacturer will also be able to control a much greater number of points within the VRF system than a third-party integrator. The VRF manufacturer can integrate points such as, but not limited to, the following:

- Air Direction Setup
- Air Direction State
- Air to Water Mode Setup
- Air to Water Mode State
- Alarm Signal
- Communication State
- Controller Alarm Signal
- Controller Electric Energy
- Error Code
- Fan Speed Setup
- Fan Speed State
- Filter Sign [Circulating Water Exchange Sign]
- Filter Sign Reset [Circulating Water Exchange Sign Reset]
- Group Appointment Parameter
- Group Apportioned Electric Energy
- Interlocked Units Appointment Parameter
- Interlocked Units Apportioned Electric Energy
- Night Purge State
- On Off Setup
- On Off State, Number of ON/OFF, Cumulative Operation Time
- Operational Mode Setup
- Operational Mode State
- Prohibition Filter Sign Reset [Prohibition Circulating Water Exchange Sign Reset]
- Prohibition Mode
- Prohibition On Off
- Prohibition Set Temperature
- Pulse Input Electric Energy
- Room Temperature [Water Temperature]
- Set High Limit Setback Temperature
- Set Low Limit Setback Temperature
- Set Temperature [Set Water Temperature]
- Set Temperature Auto
- Set Temperature Cool
- Set Temperature Heat
- System Alarm Signal
- System Forced Off
- Thermo On Off State
- Trend Log Controller Electric Energy
- Trend Log Group Appointment Parameter
- Trend Log Group Apportioned Electric Energy
- Trend Log Interlocked Units Appointment Parameter
- Trend Log Interlocked Units Apportioned Electric Energy
- Trend Log Pulse Input Electric Energy
- Trend Log Room Temperature
- Ventilation Mode Setup
- Ventilation Mode State

These points will also be pulled over more quickly by a VRF manufacturer, since they'll be pulled automatically. A third-party integrator will have to map each point one at a time. So if there are 1,000 points, that's a big difference in labor. Selecting the VRF manufacturer as the integrator for the VRF system can save significantly on labor.

Third-party integration with a boost from the VRF manufacturer's controls engineers is also a helpful option when you already have a sophisticated building management system (BMS), for example a school campus, and are just adding a new building and its new VRF equipment.

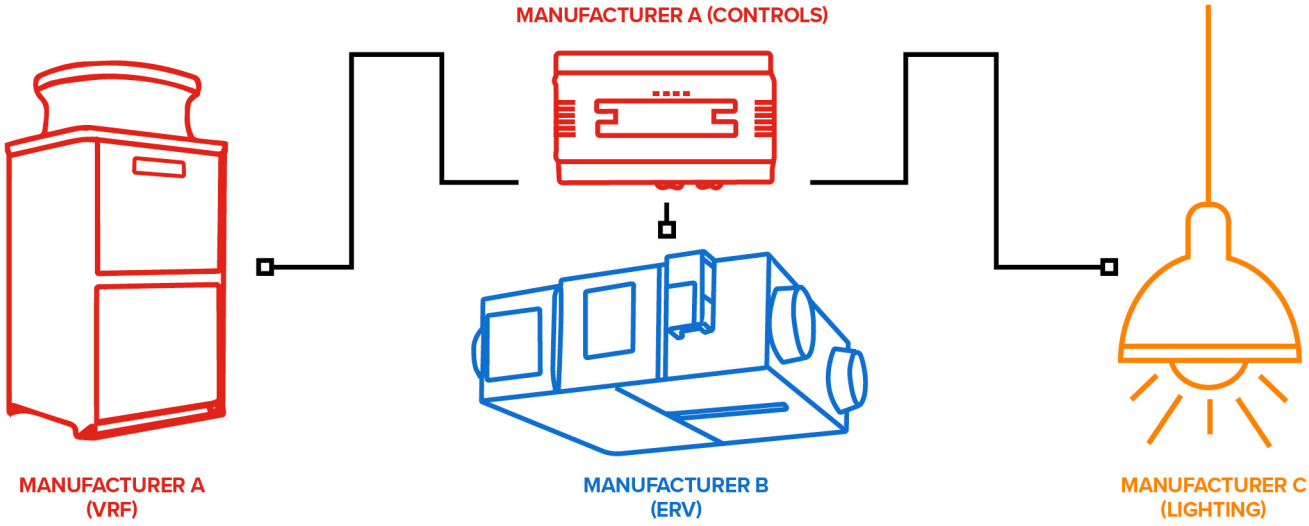
With this style you reap the benefits of a VRF manufacturer's knowledge without needing to replace your entire system — whether you want to replace it but can't afford to do so, or whether you don't want to replace it. The VRF manufacturer will use a BACnet license on the third-party integrator's controllers and give full read/write capabilities to that company. This communication on the back end ensures that the VRF system can be integrated into the third-party's controls' front end.

4 **Pitfalls.** The finger-pointing issue mentioned in the previous style remains. If something goes wrong, which integrator or manufacturer is responsible? Additionally, cost begins to add up. In this style, you're paying two integrators — the third-party integrator and the VRF manufacturer.

Manufacturer-specific Controls That Can Handle Other Manufacturers' Products

AKA: The integrator is not a third-party company but one of the manufacturers of a system you're integrating

1 **Snapshot.** You have multiple types and brands of equipment. One of them is Manufacturer A's VRF, another is Manufacturer B's ERV, another Manufacturer C's lighting, etc. Manufacturer A's controls engineers work to integrate the VRF, ERV and lighting systems into Manufacturer A's controls system via a common integration protocol.



2 **Why people choose it.** People who choose to integrate with a manufacturer are on the forefront as it's the newest style of integration, and at this point only some manufacturers are offering this service. Also, it's a means of controlling their building(s) more efficiently from an energy standpoint, as well as the general advantage of having a full, advanced integration. And because you have a single provider of both the BMS and VRF equipment, you have a single point of contact for the most important, and complex, type of equipment that gets integrated. Finger-pointing eliminated!

3 **Benefits.** No finger-pointing. That's huge. If you have a problem, you know who to turn to. Whether the problem rests with the controls or equipment, the integrating manufacturer is responsible.

The other issue with feeling locked in — feeling like you are financially tied to one company — is also negated by this style of integration. Most manufacturers currently offering integration use open protocols — primarily BACnet — so service providers can be switched down the line.

Another benefit: peak performance. As with turning to a third-party integrator but getting a boost from the VRF manufacturer's controls engineers, turning to the VRF manufacturer for the integration, as well, means you'll have full control over your VRF equipment. That issue of Last Command Wins vs. Pulse Commands? That's no longer a problem when you have a VRF manufacturer performing the integration. And top-quality control means better, more efficient operation, as well as a higher level of information available to the end user (e.g., trending). Additionally, that can be pulled over is pulled over fastest by the VRF manufacturer. That means money saved on labor.

Additional cost benefits relate to the streamlined nature of this integration style. There is a cost to this extremely advanced method, but there is also a cost in learning and simultaneously maintaining several different pieces of software or working with multiple integrators. As with other true integration styles, there's a little hurdle when it comes to that initial sticker shock the first time you do an advanced integration. But then you see benefit after benefit.

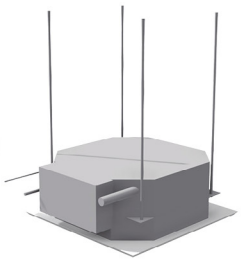
Cost also comes in when discussing labor during integration, as mentioned in the previous style. A manufacturer has access to the largest number of VRF system points, and these points will also be pulled over fastest by the VRF manufacturer, since they'll be pulled automatically. A

third-party integrator will have to map each point over one at a time. So if there are 1,000 points, that's a big difference in labor. Selecting the VRF manufacturer as the integrator can save significantly on labor.

Another benefit: reliability. Since your VRF manufacturer can be a large, trusted brand with a long history, you don't have to worry about your integrator going out of business in the middle of the job like you might with some smaller third-party integrators.

Owners and facility managers will also value the custom graphics that this style of integration offers. Representations of equipment, regardless of manufacturer, can be displayed in 3D.

Likewise, floor plans are displayed in 3D and graphics can be animated. These features effectively represent a facility and convey its current statuses, affording managers a deep understanding of their facilities and well-informed decision-making.



4 **Pitfalls.** One hurdle that manufacturer-integrators must overcome is skepticism. This is a new style of integration, and beyond that, we're used to avoiding all-in-one options because all-in-one tends to mean "I can do everything, but can do nothing well." That isn't the case here, but it's an issue of building trust and confidence; that takes time and some convincing of the personnel who will be using the controls system on a day-to-day basis.

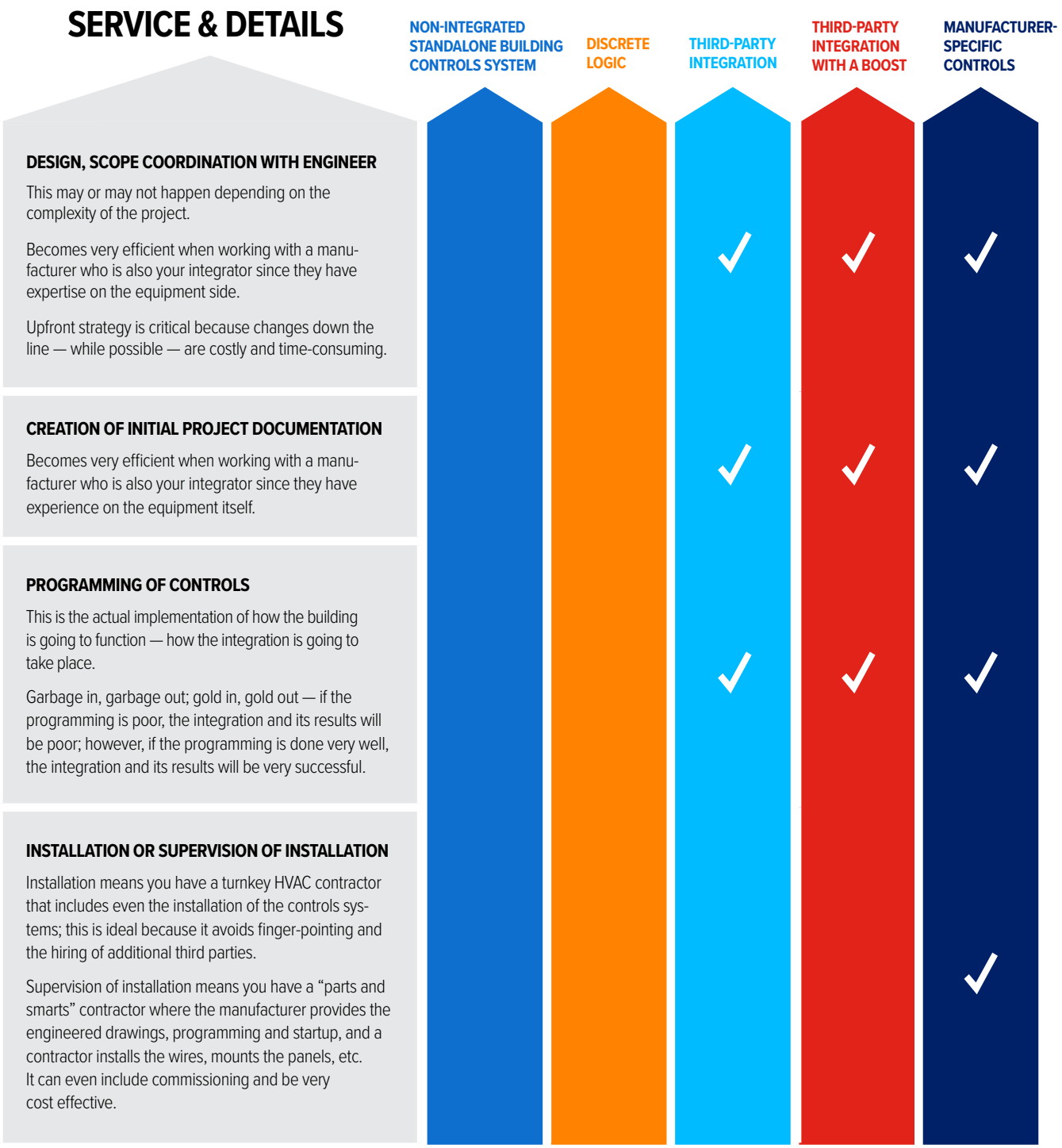
Another pitfall you might encounter is hesitance to walk away from the great relationship you already have with a third-party integrator. Or, you might feel like you're unable to walk away from a bad relationship because of feeling locked in.

The final pitfall is the potential loss of a good thing. If this is your project's first and only BMS but you move away from the manufacturer down the line, for example to a third-party integrator or a different manufacturer, you won't get the advantage of full knowledge on any new equipment. And as has been driven home here, that full knowledge is so important when it comes to HVAC, since HVAC is such a big component of your building's energy usage. So while manufacturers who are also integrators use open protocols such as BACnet as part of integration, each integrated system (e.g., VRF, ERV, lighting) runs based on proprietary information of which only the manufacturer of that system is aware. If your VRF system's manufacturer is also your integrator, you have access to that proprietary information that makes the VRF system run as efficiently as possible. If you move away from the manufacturer as the integrator down the line, you won't have access to that proprietary information for any newly installed equipment.

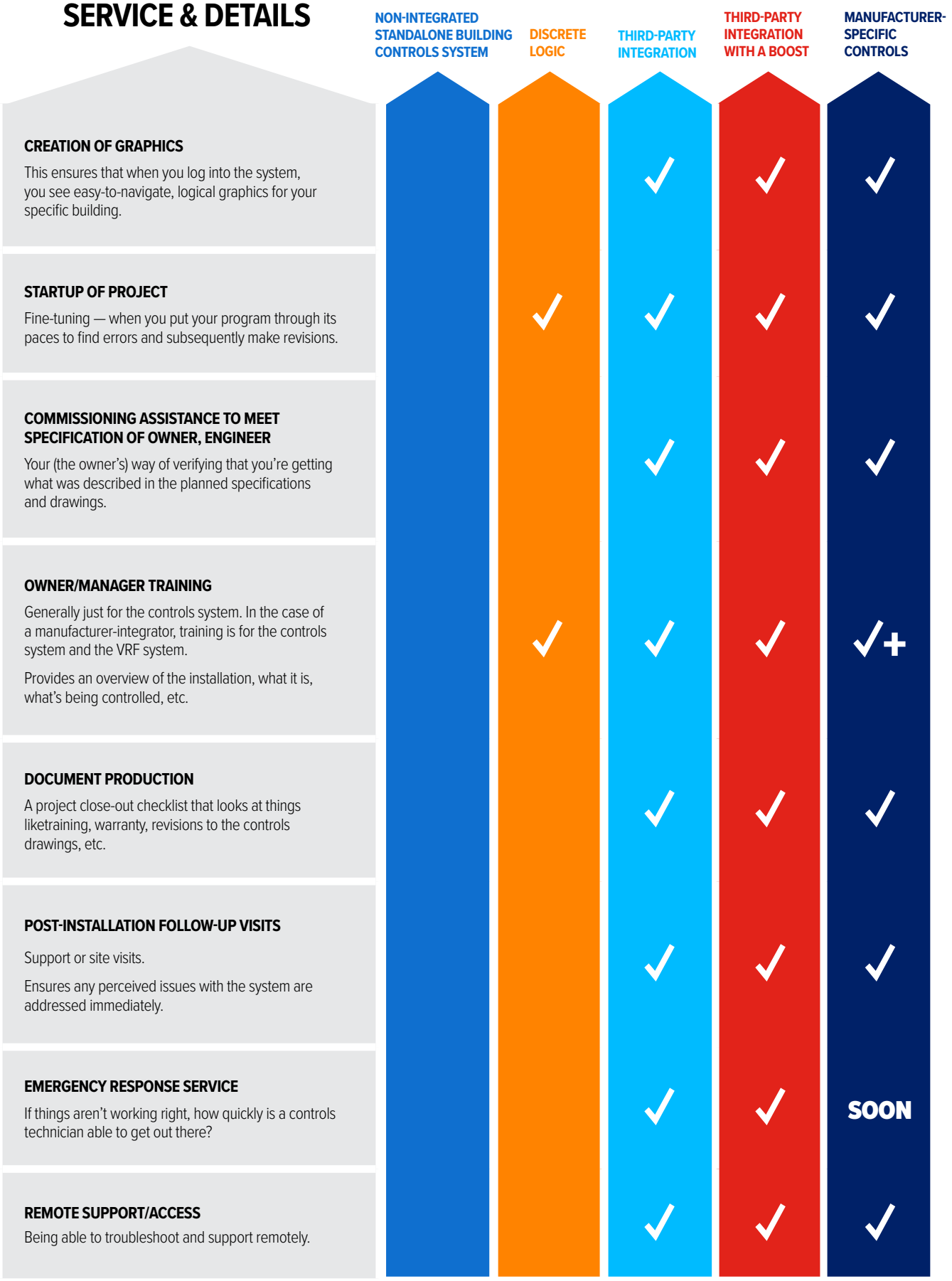
Services

No integration could happen without services, though some integrations employ just a few services while others get the full A–Z treatment.

The chart below lists services associated with building integrations, gives relevant details of each and identifies which of the five integration styles mentioned in this paper tend to offer that service.



SERVICE & DETAILS



Conclusion

Now that you've read more about integration, as you move through your day, think about it. What systems in your building(s) would you want to integrate? What data would be of use in keeping costs down, keeping occupants safe and comfortable? Because, at this point, remember that the question isn't "Why integrate" but "How do I best integrate?" With at least five styles of integration available to you, there are more options than ever.

If you're tempted to consider a more advanced form of integration — especially ones that let you work directly with a VRF manufacturer — you're right to feel tempted. Integration is only going to become more necessary and beneficial as time goes on. These styles best set you up to take full advantage of your VRF system.