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Achieving Reliability in Highly Integrated Control Systems

Some of the most challenging aspects of a high technology facility are the procurement and implementation of the integrated monitoring and control systems that will be the life blood of the operations. There are many aspects that need to be considered in the design and implementation of these systems, but there are some major areas that one should immediately focus on to set the process on a successful track. The systems and levels of integration required, the reliability required, the implementation plan and the operations of the facility are key factors. As these factors are important, there are other considerations that should be taken into account to avoid common pitfalls of the implementation process that could prove detrimental to a successful project.

In the early planning phase of a facility, many questions inevitably arise relating to the planning and implementation of low voltage monitoring and control systems. As a planning group we should be considering the following elements that will drive our final solution:

• How do we want this facility to function?
• Will it require a high degree of reliability because of the process it supports?
• What is our expected capital budget outlay?
• What are our operating budgets once the facility is on-line?
• Will we need to integrate some or all of the separate building subsystems to meet our construction and operational goals?
• What subsystems within the facility should we be considering for integration?
• What systems can act as hosts or backbones for information exchange?
• Can we stay with "off of the shelf" software integration solutions, or do our needs warrant custom software applications?
• How will we achieve the various integrations?
• Will a single contractor or multiple contractors be required to achieve the integration required?

Defining the roadmap

One of the first questions we should be considering is should we integrate any of the various subsystems within the facility? This subject matter can take you in many directions, so it is key to develop a clear and concise roadmap for the design and implementation process. This roadmap is called a Basis of Design " this is simply a series of written statements of what is required of the facility and how it is intended to operate. Once completed, everything you do from this point forward should be consistent with, and following, the Basis of Design. The Basis of Design document is best created in a workshop format including the Owner, design team members, commissioning team and the operations team. This group then discusses and develops clear direction on the key aspects of the facility. In developing the Basis of Design, the following areas are covered:

• What the "intent" of each subsystem should be defined:
- What monitoring features are required?
- What alarming features are required?
- Who needs to receive alarms?
- Who needs control of which systems?
- Is any system redundancy required?

• Why would we want to integrate any of the subsystems? Reasons include:
- To potentially reduce building operating costs.

- To potentially reduce initial system installation costs.
- To allow for automatic operations between building systems.
- To share information with other building/facility functions.

If during this evaluation process, you do not answer to the affirmative to any of these conditions, then integration is most likely not a viable solution for that subsystem. What systems should be considered for integration? Every electronic system within the facility should be considered for integration. Many common candidate systems include those in Figure 1:

Candidate Systems for Integration
Building automation system
Fire alarm system
Security access control system
Security intrusion alarm system
Elevator control system
Information Technology
Lighting control system
Primary electrical power monitoring system
Standby/emergency power systems (generators, UPS, PDU)
Major HVAC components (chillers, CRAC, etc.)
Electrical performance monitoring systems (waveform capture)
Thermal energy metering
CCTV surveillance
Audio Visual Systems
Parking control systems
Point of sale
Time and attendance

Figure 1: Candidate Systems for Integration

Defining interoperability

After we have identified all of the candidate systems, prepare a interoperability matrix. This matrix identifies all of the subsystem in the facility (both x and y axis) and then identify which subsystems should share information with other subsystems as show on Figure 1. We follow that evaluation process for each subsystem in the facility.

The result is a matrix that defines which systems will be required to interact with other systems within the building.

We have just completed a major milestone in the development process; we have defined which systems are required to be integrated or have some degree of interoperability. The process of defining additional requirements continues. We must now define specifically what information is needed between the systems and that requirement will most likely drive the next decision of how achieve the interoperability between the subsystems. Options include: hardwired interfaces for simple discrete event driven information; sharing of subsystem information from standard software information exchanges such as “look up tables” or standard data base sharing; sharing of information using custom programming to obtain unusual or non-standard information from a subsystem, or integrating multiple subsystems with a third party common operator interface “overlay” system.

As we identify interfaces requiring exchange of data via software interfaces, we need to define the protocol AND the architecture to be used. Are industry or vendor specific standard protocols, as shown in Figure 2, viable solutions? In the majority of cases, this is the most desirable approach.

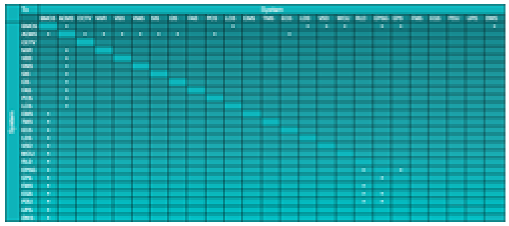

Figure 2: Systems interaction matrix

Defining reliability and redundancy
Now we know which systems need operability and what they need to exchange and how they are going to do it. The next step is to review the reliability requirements of our subsystems and the information that will be exchange in vane of how the facility will be monitored and operated. Again, another level of evaluation occurs:

• Is there a high degree of reliability required?
• Will redundant controllers be required?
• Should some of the facility subsystems be configured with redundant or backup components?
• Is a fully redundant communication backbone required? If so, does the redundant communication path need to be physically separated?
• Can our subsystems within the facility support redundancy at the required levels?

As we tackle the task of developing the redundancy requirements it becomes inevitable that Programmable Logic Controllers (PLC) based systems can easily achieve high degrees of reliability and common building automation systems are more challenged by theses requirements. PLC based systems are very suitable to simple switching schemes and the like, but building automation systems are well suited for complex sequences of operation that may vary on external conditions. So as a planner of these systems you will need to take all of these considerations into account in your evaluation of the approach you intend to implement.

Industry Standard Protocols/Architecture	Vendor Standard Protocols/Architecture
BACnet / TCP/IP BACnet / MSTP Lonworks PRofibus Modbus RTU / RS 485 OPC XML	JCI N2 Siemens FLN

Figure 3: Standard Protocols

Implementation sourcing
Sourcing of the subsystems and there interoperability are a major decision. One approach is to have one of the systems contractor be responsible for the integration. This approach assumes that the systems contractor can provide many or most of the integrated subsystems and already has integrated solutions to each of the subsystems. The second approach is to use a third party integrator. In this case all systems exchange information VIA a SEVER in one of several open protocols Such as BACnet, LON TALK , MODBUS, OPC, OR XML, etc, Typically, the third party integrator does not have any subsystems within the building and is merely an information clearinghouse for the operator interface. The last approach is to allow multiple subsystem contractors to interface directly to the systems requiring integration. Figure 4 outlines some of the pros and cons of each of the methods of implementation:

Method	Pros	Cons
Single Source Contractor	Only one direction to point a finger Coordination and delivery responsibility lies with one party Many of the integration solutions should not be new Coordinated and seamless operator interface An operator may have access to more features of the individual subsystems	May have inherent limitations on integration capability of "their" system offering May have limitations on their subsystem offerings
Third Party Integrator "Overlaid"	May get the best that each subsystem has to offer Seamless operator interface to multiple systems	Will require subsystem interfaces for high level programming
Direct Integration Between Systems	Each interface only involves two parties for discrete information exchange	May be limitation of protocol exchange capabilities Operator interface will most likely be different Will require subsystem interfaces for high level programming

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Figure 4: Integrator Sourcing

Lessons learned

There are some key points that must be included in your planning and implementation process for it to be successful. These include:

- **Defined protocol exchange capability between the systems. Not only define the protocol, but also the architecture and the physical connection types.**
- **Which subcontractor is going to provide the physical cabling between the systems?**
- **Which subcontractor is going to make the final connection between the systems?**
- **Get each subcontractor involved in an integrated solution to share all available point data and the associated registers.**
- **Define how the information will be displayed. Will the information be displayed in a custom graphical display, or simple look tables? Will any alarming be done from the information? How much of the available information will be displayed for the operators?**
- **Bench test integrated designs prior to the installation in the field. The requirement for bench testing will provide numerous benefits including; getting the vendors/subcontractors concentrating on the integration away from the construction environment and it forces the vendors and subcontractors to plan ahead. As planning is scheduled for the bench testing, plan for failure, meaning have time in the schedule to fail and provide corrective actions then perform retests.**
- **Field test after installation, simply repeat the previous testing on the live systems installed in the field.**

As there are important tasks that must be done for a successful project, there are equally important items to avoid, these include:

- **Don't assume a catalogue listing the interface is a guarantee that the interface will work right out of the box. Vendors tend to continuously update their software and some of these updates could potentially affect their "standard" interfaces.**
- **Do not wait until the systems are installed on site to test the integration for the first time. You will loose the attention of the subcontractors as they are typically trying to finish many other aspects of a project and the time frames are compressed with no room for error and you may have to settle for less that had specified.**
- **If at all possible, you should strive to solve your systems integration needs with standard architectures using open protocols. This will minimize any development time, minimize extensive bench testing of the developed interfaces and reduce problems between the communications of the two subsystems. If your solution cannot be solved with standard architectures using open protocols, choose a standard protocol for that respective industry.**

Following the above methodology of developing the Basis of Design, defining the exact interoperability required between subsystems, designing the proper reliability into the systems, selecting the proper sourcing method for the specific applications and testing the systems prior to and post installation will ensure a successful deployment of an integrated system.

About the author

John Hatcher is President and one of the founding principals of HMA Consulting, a worldwide professional engineering consultancy with offices in the UK, US, Canada, UAE and India. John earned a Bachelor of Science in Mechanical Engineering from Texas A & M University and a Master of Business Administration from Dallas Baptist University and is currently on the Board of Governors for the University of Houston Masters Program in Security Management. John is a member of the American Society of Heating, Refrigerating & Air-Conditioning Engineers (ASHRAE), 7 x 24 High Reliability Exchange, Building Commissioning Association, US Green Building Council, the International Association of Professional Security Consultants, the Energy Security Council and the ASIS International in which he has held the offices of Chapter Chairman and National Vice President. John is a Certified Protection Professional (CPP), LEED professional and a professional registered engineer in over 20 states and districts.