An introduction to Building Management and Control Systems – Part 1

The benefits of control systems

It is unlikely that a modern building could operate safely and efficiently without controls. Some level of control is essential for all building systems but the benefits available will depend on the functionality of the control system. Control systems that are designed and operated correctly, with well defined functional requirements will generally:

- Create and maintain a functional and comfortable indoor environment, maintaining good thermal comfort and indoor air quality.
- Minimise human manual intervention in daily operations.
- Allow systems and buildings to operate with discrete functional zones.
- Ensure that systems only operate when required.
- Ensure that systems operate safely and efficiently.
- Ensure that systems are integrated with the building and with each other.
- Provide feedback data for monitoring performance, benchmarking energy efficiency, and planning or scheduling maintenance.

Control systems can be further enhanced to generate the following benefits:

- Integrate multiple building systems onto one operating platform for lower infrastructure and management costs.
- Integrate a portfolio of buildings under a single management and control system.
- Optimise system operation and reduce or minimise energy use.
- Enable integration with demand management requirements of the smart energy grid.
- Reduce water use.
- Reduce building operator time and costs, and enable remote monitoring and access.
- Ensure that all building systems are fully integrated.
- Improve indoor environment quality (IEQ), leading to potential productivity improvements.
- Ensure compliance with OH&S and essential services regulations.
- Ensure compliance with building energy efficiency regulations.
- Monitoring, trending, and analytical capabilities for building performance and data.
- Highlight maintenance issues and integrate computerised maintenance management.
- Extend equipment service life.
- Maintain asset logs and subsequently, asset values.

Controls can provide benefits to owners, operators, and occupiers.

Reduction in energy use also has wider environmental and community benefits. Appropriately designed and operated control systems can reduce energy use and improve performance, enhancing sustainability outcomes for buildings and their systems.

The risks of control systems

There are also potential risks associated with implementing and operating building control systems. If these risks can be identified early in the design/procurement process many can be mitigated.

Risk of improper scope – It is important to consider the consequences and impacts of early design decisions. For instance, specifying very tight tolerances for indoor environmental conditions may result in an unnecessarily complex or expensive control system that may not have been required for more realistic temperature tolerances.

Risks of no or improper control – Just having a control system does not automatically mean that the desired control is achieved. Controls must be functional and appropriate. The design and intent of control systems can fail to transfer successfully through the installation phase. Successfully implemented systems can fail due to improper operating or maintenance due to lack of training. Control systems need to be regularly assessed for functionality and performance.

Risk of inadequate commissioning – Commissioning is essential for control systems. The potential for installation and start up errors for complex control systems is high. Systems that are not fully and competently commissioned will not deliver the functionality that they were designed to deliver. Commissioning addresses many of the risks associated with implementing control systems, including design and installation defects which are detected early in the delivery process. Commissioning also facilitates training and good system documentation and knowledge transfer.

Controls systems and their components are also subject to drift over time. Systems need to be recommissioned periodically and a formal recommissioning plan should be in place.

Risk of scale and complexity – Controls can be as simple as a switch or as complex as a fully integrated building management and control system. It is important that systems are kept as simple as possible to achieve the required goal. The scale and complexity of the control system should be appropriate to the building and its operation. Given the enormous range of capabilities of control systems, there is a possibility that systems are designed to be more complex than their functionality requires. Complex systems are more susceptible to errors and those errors tend to be more difficult to diagnose. Complex controls may be difficult to operate and maintain and designers should aim to keep systems as simple as possible.

Complex goals may not necessarily require complex systems. The simplest control system available that meets the needs of the owner, operator, and occupant should generally be used. Simple systems can be reliable and low cost.

Risk of poor interoperability – Control systems are made up of many individual components and it is important when designing and building systems to ensure that each component is well matched to the system and its communication protocols. Interoperability needs to be carefully specified and assessed prior to final procurement. Addressing interoperability after procurement generally provides sub optimal and expensive control solutions. Existing systems also need to be considered in terms of interoperability requirements.

Security risks – Poorly managed system changes can cause a break down in the original programming and design intent. Systems design, operation, and maintenance protocols need to incorporate a formal change management system and define levels of access or authority for; viewing data and trends, changing settings and schedules, changing system programming.

Internet connectivity brings with it a series of security risks including risk of intrusion (hacker) or virus contamination of the software. Control systems incorporating wireless and wifi enabled components also present some security risks that need to be addressed in the design and installation.

Risks associated with operational systems – No matter how well designed and operated a system may be, they will fail and in some cases through no fault of the system, e.g. power loss, fuel loss, external tampering, etc. These risks can be reduced with hardware and software inclusions but prevention can never be totally guaranteed.

Risks associated with system failure – Failure to design, install or commission control systems properly can result in failure to comply with ventilation codes, breach of workplace standards, failure to comply with essential services requirements, and failure to meet energy standards all of which may have the consequence of exposing the stakeholder to financial loss and potential litigation.

The limitations of control systems

Controls, and particularly electronic or microprocessor based items, are highly functional and the technology is constantly being updated and improved. However, there are limiting factors to be considered when designing and installing control systems. Failure to consider these limitations may lead to severe functional deficiencies within the final control system. Limitations sometimes associated with control systems can include the following:

Poor design – Controls cannot make up for poor design. If a system is oversized or poorly designed no amount of complexity or number of control components will make up for that systems design inefficiencies. Controls can be applied to mask or mitigate inadequate system design, but can rarely fix the underlying design problems.

Poor installation – Controls are susceptible to poor installation. Systems are very sensitive to installation factors, location of sensors, environmental conditions, installation methods and practices can all have an effect on the overall functionality of the system.

Integration – Controls are not plug and play line items. Individual control components need to be integrated into the control system and interoperability and compatibility issues need to be addressed. In many cases components will not simply plug and play and intercommunication protocols and logic needs to be standardised across the system.

Sensors – Even the most complex and capable control system must depend on its sensors for information. The quality of the system depends on the quality of the information it receives, and hence the quality of its sensors including their manufacture, selection, and installation. The capability of the control system is built from the bottom up, not the top down.

Infrastructure – Controls need infrastructure. Building controls, like any other electronic based system, will have operating requirements such as cabling, power supply, power quality, communications network, wifi enabled environment etc. The building environment and infrastructure arrangements need to be compatible with the proposed controls software and hardware, or conversely the building controls need to be compatible with the building environment and infrastructure arrangements.

Operating environment – Many control components, particularly digital components, cannot operate at very high or very low temperatures, in very high humidity, or in corrosive environments. The environmental limitations of controls hardware need to be assessed, and in some circumstances non-digital control solutions will be required.

Building factors – Controls respond to real events in real time. Controlling a variable, such as temperature or relative humidity, to a very precise condition may be difficult due to building issues such as thermal inertia, the inertia of the controlling system, local heat gains and processes, and weather related factors such as air infiltration, building pressure or solar gains. Control system accuracy and responsiveness should be matched with the building type, configuration, and expected outcomes.

Recommissioning and fine tuning – Control systems are the brains of a building, however, the settings and sensitivities can slide over time. To maintain system accuracy and optimisation, systems and buildings should be periodically tuned and recommissioned to ensure the correct performance.

Operation and maintenance – In order to provide optimised outcomes, controls need to be operated and maintained correctly and systems that are not will not perform satisfactorily. Controls are items which integrate with mechanical components such as valves and dampers in the field. Therefore the confirmation of correct mechanical operation is required as part of control system maintenance.

Skills and knowledge – A lack of training and poor system documentation leads to poor system knowledge. Operators and maintainers cannot optimise systems that they do not understand. Training, information sharing between companies, dialogue between designers and contractors, and interoperability challenges are all areas that industry needs to address. Controls tend to be poorly understood within the building industry, often because they are generally considered to be highly mathematical and dependant on expert programming knowledge.

People – Successful deployment of controls technology needs to align with the people and processes for which the control is provided. Designers and providers should never lose sight of the fundamental purposes of building controls.

Balancing need with complexity

There is increasing pressure on building owners and designers to provide or achieve high performance buildings. Common drivers include:

- Building owners' (PCA) office quality matrix.
- Commercial and government green leases.
- Green Star and NABERS rating requirements.
- Corporate sustainability goals and programs.
- Community expectations.
- Mandatory energy reporting.

As a result of this, buildings often include:

- Linked BMCS and facilities management systems.
- Daylight dimming and management systems.
- Lighting control systems.
- Renewable energy systems.
- Co – and tri-generation systems.
- Rainwater, greywater and blackwater collection, treatment and use.

The addition of these systems can add considerably to the complexity of the control systems. Increasing complexity can lead to an increasing likelihood of errors in design, installation, commissioning, operation, and maintenance. A significant limiting factor in the provision and effective operation of complex systems is the building management skills available to effectively and efficiently operate and monitor them once they are installed. The management of a complex system is generally assisted by management programming within the BMCS system. However, the outputs and capabilities of BMCS should also be matched to building management capabilities. Too much system information can be just as much a barrier to optimum system performance as too little. Even with a well functioning system there is the potential for the facility manager to be overwhelmed with building information.

Control systems can be relatively simple or highly complex. As the capability of the control system rises, the costs and complexity also tend to rise, leading to an increasing level of operating knowledge and maintenance expertise required. Buildings and their systems should be designed with the available level of building management input in mind. The available knowledge level, skills, resources and staffing numbers may limit the options for implementing technologically complex building systems.

Designers should consider the following guiding principles when matching complexity to building needs. In particular designers should:

- Understand where maintenance contractors and parts will be coming from.
- Estimate the complexity of the building systems.
- Estimate the level of skill, time, and cost to effectively operate and maintain systems.
- Design the level of complexity to match the likely building management input.

Identify strategies for either; reducing the complexity; reducing the level of building management input required; or increasing the effectiveness of building management.

Reducing the complexity – Methods to reduce system complexity include the use of packaged or standardised systems, moving design back down the scale of complexity, the use of passive or natural systems.

Reduce building management input – Systems such as fault detection and diagnosis systems, well designed plant and plantroom spaces, and well designed BMCS dashboard and KPI monitoring will all act to reduce the level of input or skill required by the facility manager.

Increase effectiveness of building management – Up skill facility management staff with training and education, increased emphasis on knowledge transfer in the project including building documentation, extended handover, additional system training, or outsourcing of building management role with appropriate contractual conditions (e.g. performance contract).

Occupant interfaces

Occupant interfaces relates to the provision of controls that can be manipulated by the occupants. Allowing occupants control over their environment has been shown to improve satisfaction and reduce complaints. However, for occupant controls to be effective they should be designed to the following criteria:

Clarity of purpose – Controls should be easy to understand, switching and purpose should be intuitively obvious. Labels and annotation should be clear.

Provide feedback – Tangible feedback such as a click to indicate to the user that the device has operated and a readout or indicator light to show that the intended effect had occurred.

Provide control – They should work effectively providing the required degree of fine control, not need to be used too often (fine control not total control), and not require too much intervention (automatic reset time).

Ease of use – They should be located as close to the point of need as possible and indicate the current status.

The operation and design intent of all occupant interfaces should be clearly explained in the building user guide and included in the occupant training program. The length of user override should be carefully selected, and ideally controls should indicate to people how long until the default state is restored.

The provision of occupant controls or interfaces needs to be considered in terms of integration and energy efficiency. Occupants tend to operate controls for their comfort needs rather than for energy efficiency. For example, switching systems and equipment off with automatic sensors is generally more energy efficient than relying on occupants to switch off when they leave a space. ■

The content in this month's Skills Workshop originates from the AIRAH Application Manual DA28 – Building Management and Control Systems (BMCS).