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Automated Point-to-Point Checkouts in BMS

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Abstract: ***Point-to-point checkout in Building Management Systems (BMS) involves verifying thousands of sensors, actuators, and controllers to ensure they are correctly wired and functioning. This traditionally manual process is time-consuming and prone to human error, especially on large projects. The paper "Automated Point-to-Point Checkouts in BMS" presents a streamlined automation approach to tackle this complexity. By leveraging open communication protocols (like BACnet), scripting frameworks, and commissioning software, each I/O point can be systematically tested and validated against expected behavior. The automation simplifies the identification and resolution of complex issues by logging results and flagging discrepancies in real time. This approach not only reduces errors and oversight but also accelerates commissioning, provides comprehensive data collection, and delivers thorough documentation, demonstrating how complex BMS checkouts can be handled in a simple, repeatable manner through automation.***

Keywords: Automation, Point-to-Point Checkout, Building Management System (BMS), Building Automation System (BAS), BACnet Protocol, Commissioning, HVAC Systems, IoT Integration, System Verification, Error Reduction, Workflow Efficiency, Automated Testing, Digital Commissioning, Smart Buildings, and Cloud-Based Platforms

1.Introduction

Point-to-point checkout in a Building Management System (BMS) is the process of verifying each input and output device – sensors, actuators, controllers, etc. – to ensure they are wired correctly, communicating with the BMS, and functioning as intended. Traditionally, this involves manually testing thousands of points one by one, which is extremely detail-intensive [1]
On large projects with tens of thousands of points, manual checks can be time-consuming and prone to human error. Automating the point-to-point checkout process offers a way to **reduce errors**, **improve efficiency**, and ensure **thorough testing** of all devices. Modern tools and workflows can systematically exercise each point, record results, and generate documentation automatically, helping teams meet the stringent commissioning requirements often mandated by industry guidelines.

The implementation methods for automated point-to-point checkouts in BMS, including best practices, enabling technologies, integration strategies, and key considerations such as error reduction, efficiency gains, and compliance with standards.

2.Technologies and tools for automation

Implementing automated checkouts relies on a combination of software tools, connectivity technologies, and sometimes specialized hardware. Key technologies and tools include:

1. **Open Protocols (e. g. BACnet)** – Standard protocols like BACnet enable interoperability between testing software and various BMS devices. Automation tools can connect as a BACnet client to read sensor values and command outputs programmatically. This openness allows integration with existing systems regardless of vendor, by uploading or discovering the BMS point database and using it for testing. Other interfaces (Modbus, OPC UA, or vendor APIs) can similarly be used to access points in an automated fashion.
2. **Commissioning Management Platforms** – Cloud-based or on-premise software platforms are used to manage the checkout process and capture data. These platforms provide real-time collaboration for project teams to track point verification, flag issues, and update statuses [1] Instead of using spreadsheets, which can become disorganized and error-prone on large projects dedicated software ensures every detail is recorded and progress is visible to all stakeholders in real time.
3. **Automated Testing Frameworks** – Newer tools can **script** and automate the actual testing of points and sequences. For instance, frameworks like *PingCx* allow users to create or reuse test scripts that systematically exercise BMS points and control logic. These scripts can send commands to field devices (e. g. override an output or simulate a sensor reading) and verify the response via the BMS, with the results logged automatically. Such script-based testing is highly repeatable and can be applied across many devices or projects, improving consistency. The ability to import point names from the BMS database means the tool can adapt to any naming conventions and work with multiple BMS brands. Some advanced BMS controllers even incorporate logic to run **self-check sequences** based on the specified sequence of operations and then auto-generate a report [6] as evidenced by recent industry patents.
4. **Mobile Apps and Field Tools** – Portable applications are available to assist technicians in performing point checks more independently. For example, Honeywell's **Wire & Check (BMS Startup)** mobile app uses Bluetooth Low Energy (BLE) connectivity to interface directly with controllers in the field [2] Technicians can load I/O configuration data onto an empty controller via a tablet or phone and then locally validate each point's wiring and operation without needing a central BMS engineer online. These apps often provide live sensor readings and allow pushing test commands on-site, replacing paper diagrams with digital readouts. They also support multi-user scenarios, enabling multiple techs to commission different areas in parallel [2]. All results are synced to a database, and **automatic reports** are generated – eliminating manual paperwork and ensuring that project managers can remotely monitor checkout progress in real time [2]

5. **Built-in Controller Features** – Many modern BMS controllers come with features to facilitate commissioning. This can include on-board override switches or software "test modes" that can drive outputs (e. g., opening a valve or starting a fan) in a controlled sequence. Some systems have auto-discovery for attached sensors and actuators, or diagnostics that report mis wired or non-responding points. Taking advantage of these features via automation scripts or vendor-provided tools can speed up the point-to-point verification. For example, installing and networking controllers early in the construction phase allows the automation system itself to assist with checkout by cycling devices and verifying responses before the building is occupied.

By leveraging these technologies, teams can move from a manual, paper-based process to a more connected, software-driven process where much of the repetitive work is handled by tools. Next, we discuss how these tools are applied in practice through effective workflows and integration strategies.

3.Workflow strategies for automated checkouts

Automating point-to-point checkout requires a well-defined workflow so that all points are systematically tested and issues are captured. A typical automated checkout workflow might involve the following steps:

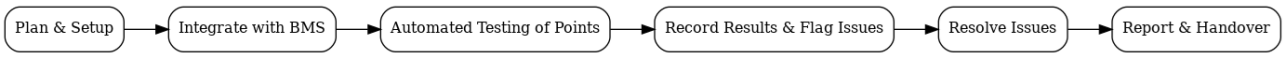

Figure 1: High-Level Conceptual Workflow Source: Author's Own Data

1. **Planning and Setup** – Early in the project, ensure the BMS network and controllers are accessible to the automation tools. Integration with the existing BMS is critical: the commissioning team might connect a laptop or server to the BMS network (or cloud gateway) and use BACnet or the BMS's API to retrieve the list of all points. This point database forms the foundation of the automated tests. It's a best practice to get the control system online as early as possible (even before final tuning) so that tests can be run in a safe, controlled manner. Also, define the test cases for each type of device (e. g. thermostats, valves, dampers) – many tools provide libraries of standard test sequences or templates that can be customized for the project.
2. **Integration with Existing Systems** – Connect the automation software to the live BMS. If the BMS is new, this might mean connecting to the programming environment or supervisory controller. For an existing system (e. g. during a retrofit or re-commissioning), use non-invasive methods: for example, a BACnet testing tool can be added as a temporary client on the network to poll values and command outputs without altering the BMS programming. Care must be taken to respect the existing system's operation – for instance, testing should be done during off-hours or in coordination with facility operators to avoid disrupting occupants. Compatibility is usually managed through open protocols; as noted, a well-designed platform can work across different vendor systems by interpreting their point data uniformly (). Ensure network security policies allow the connection, and isolate the testing environment if needed (some sites create a test mode or use an isolated copy of the BMS database for dry-run testing).
3. **Executing Automated Point Checks** – With integration in place, begin the automated point-to-point tests. This often involves systematically overriding or stimulating each point and observing the result via software:

   - **Inputs (Sensors):** For each sensor or input point, the workflow might prompt a field technician to simulate a condition (e. g. use a handheld simulator to send a 4-20 mA signal, or manually trip a smoke detector) while the software verifies that the correct value or alarm is registered in the BMS. In some cases, the BMS can be temporarily fed preset values via an automated script if the hardware supports simulation mode. Each reading is checked against expected ranges or states.
   - **Outputs (Actuators):** For each actuator or output point (valves, dampers, motors, etc.), the tool sends a command through the BMS to activate it (e. g. open a valve to 100% or turn a fan on). The automation system then checks feedback from the device if available (for example, position feedback from an actuator or status from a motor starter) to confirm the action occurred. If no electronic feedback exists, a technician may visually confirm operation and mark it in the software. Modern approaches can perform many of these output tests in parallel or in rapid sequence – for instance, commanding multiple VAV boxes one after another and logging their airflow or temperature responses. Automation greatly increases the number of devices that can be tested; whereas traditionally only a sample of devices might be spot-checked due to time constraints, automated routines make it feasible to verify **every device** even on large projects ().

Throughout execution, the system will record each test result (pass/fail, values observed, timestamp, tester, etc.). Any point that does not respond correctly (e. g. a sensor reading doesn't change as expected, or an actuator fails to move) is flagged for troubleshooting. Issues can be logged in detail within the platform, allowing the team to assign them for correction [1]

4. **Data Collection and Reporting** – One of the benefits of automation is automatic **documentation**. As tests run, the software compiles results into a database. Upon completion, detailed reports can be generated, showing each point tested, the method of test, and the outcome. This fulfills the common requirement to maintain accurate test records for handover. In real time, project managers can view dashboards of commissioning progress – for example, how many points have passed, how many are pending fixes – enabling better project tracking. If a cloud platform is used, all stakeholders (contractors, commissioning agents, owners) can access up-to-date reports remotely. This digital recordkeeping replaces the need for manually filled check sheets and reduces the chance of missing or illegible data.

5. **Issue Resolution and Retesting** – When a point fails its test (for instance, a temperature sensor reads incorrectly due to a calibration issue or a valve doesn't respond due to wiring error), the issue is documented and assigned to the responsible party (controls contractor, electrician, etc.). After the fix, that point can be retested. Automated workflows make retesting efficient – you can rerun the specific failed test or a batch of tests with one command, and the system will update the status. All historical data is kept for audit trail purposes, providing accountability and a clear picture of what was done to get the system fully functional.
6. **Handover and Final Integration** – After all points are confirmed operational, ensure the BMS is returned to **normal operating mode**. A best practice is to verify that no points remain in forced or "operator override" status at the end of commissioning. Automated tools should release any overrides they applied, or at least highlight any still-active overrides. The final step is integrating the results with the project closeout: delivering the test reports to the owner and meeting any third-party commissioning agent's requirements. Often, automated test reports can be formatted to align with industry templates or the owner's specifications, smoothing the handover process.

Throughout this workflow, **communication and training** are important. Field technicians should be trained on using mobile apps or test software, and the sequence of testing should be coordinated so that, for example, a fire alarm test doesn't inadvertently shut down HVAC systems while other tests are running (unless that is intentional). Teams that adopt these **repeatable processes** and leverage training see smoother execution and higher quality results, as noted in industry practice [1]

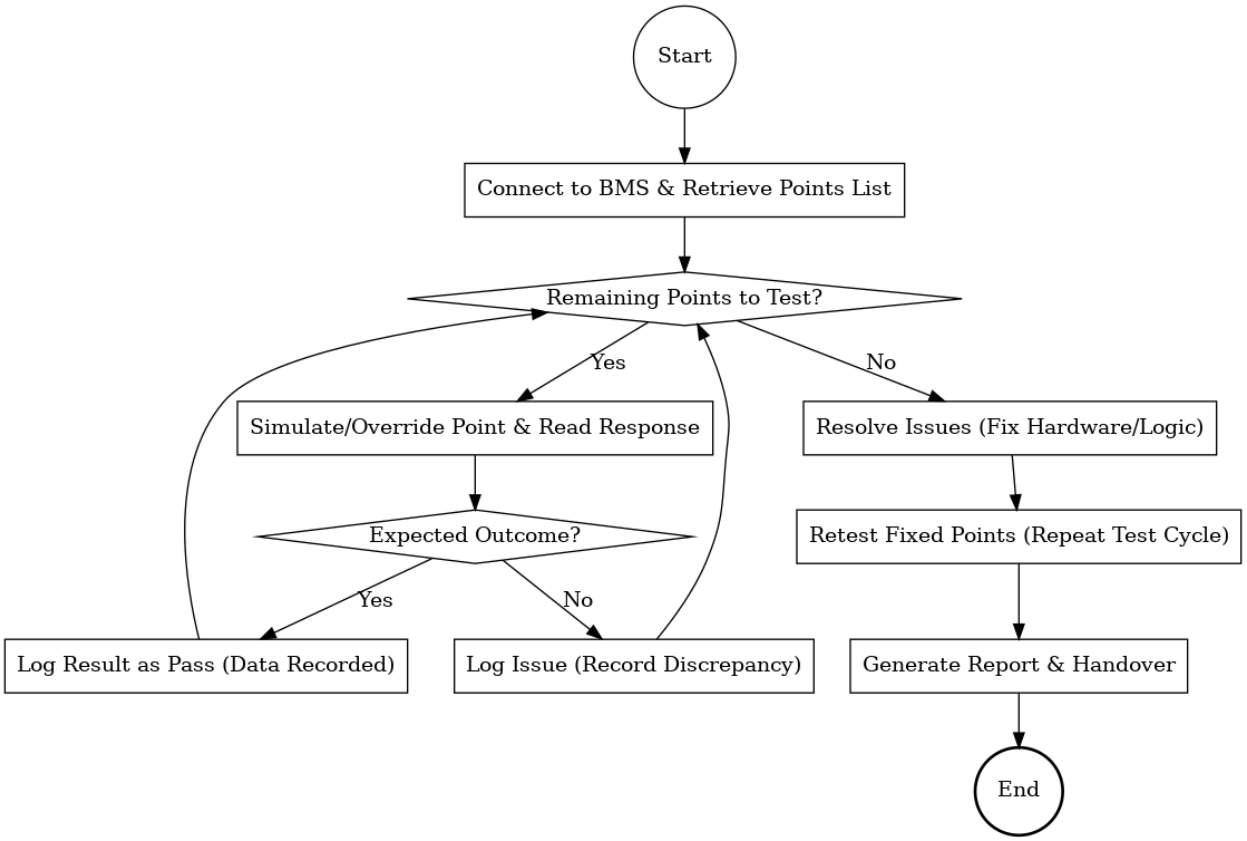

Figure 2: Detailed Technical Flowchart Source: Author's Own Data

4.Reducing errors through automation

Automated point-to-point checkout methods greatly reduce the likelihood of errors compared to manual processes. Some key ways errors are minimized include:

1. **Elimination of Manual Data Entry**: By using digital tools, technicians no longer have to transcribe readings into paper forms or spreadsheets. This prevents transcription mistakes. All point values and statuses are pulled directly from the BMS into the software, ensuring accuracy in what is recorded [2] Moreover, automatic report generation means the final documentation is compiled by the system, which avoids the risk of omitting a point or copying a value incorrectly.
2. **Comprehensive Coverage**: Human fatigue or oversight can lead to some points not being tested or documented. Automation systematically iterates through the entire point list, so nothing is skipped unless explicitly deferred. The software can track coverage and show if any point was missed, providing a completeness check which is hard to achieve with ad-hoc manual methods. As an industry specification might put it, *"Every input/output point shall be tested for proper performance through the entire system"* – automation helps ensure this mandate is actually met by covering all points.
3. **Standardized Test Procedures**: Automation enforces a consistent test method for each type of point. This standardization reduces variability in how tests are performed. For example, each analog temperature sensor can be tested with the same two-point calibration check,

each valve command can wait the same duration for feedback, etc., removing the inconsistency that can occur if different individuals use slightly different methods. Scripted sequences and templates essentially encode best practices for testing, so the quality of testing is not solely dependent on an individual technician's experience or diligence.

4. **Real-Time Validation and Alerts**: When a point is tested manually, a person might misread a value or fail to notice a slight deviation. Automated systems can be programmed with expected outcomes and tolerance bands. If a reading falls outside of expected range or an output doesn't change state, the system can immediately flag it. This real-time validation means issues are caught on the spot. It also reduces errors of omission – for example, if a tester forgets to check a particular status lamp or alarm, the automated sequence will not forget and can even prompt the user for confirmation if a manual action is needed.
5. **Tracking of Overrides and Resets**: In manual testing, it's easy to leave a point forced in a certain state (e. g. a valve manually opened) and forget to restore it, which can cause errors in system operation later. Automated checkout tools keep track of any overrides they apply and can automatically release them at the end of the test, or remind the user to do so. This reduces the chance of human error in returning the system to normal. Additionally, the software's audit log provides a history of every command sent and change made, so any anomalies can be traced back to their source, which is crucial for debugging complex issues.

Overall, by offloading repetitive and precision-sensitive tasks to software, the process becomes much less error-prone. The result is a more reliable commissioning outcome – devices are correctly verified, and the BMS is less likely to suffer from calibration errors or misconfigurations that escaped detection.

5.Improving Efficiency and Project Delivery

In addition to accuracy, efficiency is a major driver for automating point checks. Projects can realize significant time and cost savings by using these methods:

1. **Faster Testing Cycles**: Automation speeds up the execution of tests. What might take a team days to do manually (checking hundreds of points and documenting them) can often be done in hours with automated tools running continuous sequences. Tests can sometimes be run in parallel – for instance, multiple controllers or floors of a building can be commissioned simultaneously by one software instance issuing commands to different network segments. A U. S. Department of Energy study noted that due to the high number of devices (like VAV boxes) in modern buildings, automating the process allows many components to be tested in parallel, whereas in manual practice typically only a small fraction might be tested due to labor limits [4]. This parallelism and speed directly translate to shorter commissioning durations.
2. **Labor Savings and Cost Reduction**: By automating routine tasks, the team can be more productive. Skilled engineers can oversee the automated tests instead of physically performing each one, allowing their time to be used for analyzing results and solving problems. Field technicians with a mobile app can independently verify points without needing a second person at the head-end to confirm readings [2]. Some vendors report that automating startup and checkout can save a substantial portion of labor – for example, one platform claims up to **25% reduction in total project labor costs** by automating point-to-point checkout and commissioning. These savings come from both reduced test time and less rework (since issues are caught early and systematically).
3. **Early Issue Detection**: Efficiency is not just speed, but doing the right work at the right time. Automated checkouts can be initiated as soon as components are installed and powered, even before final programming is complete. For instance, using a tool like the BLE-enabled mobile app, technicians can perform **early wiring checks** and ensure each sensor is reading plausibly at installation time [2]. This early checkout means wiring errors or device failures are caught and fixed while contractors are still on site, preventing delays later. It compresses the feedback loop – rather than discovering a wiring mistake during final commissioning (which might require revisiting completed work), it's caught immediately. Shortening these feedback loops improves overall project efficiency.
4. **Automated Documentation and Handover**: Preparing commissioning documentation manually can be a slow process. Automation produces ready-to-go reports of test results, often in real-time or at the push of a button [2]. This not only saves time in compiling reports at the end, but also means interim reports can be reviewed throughout the project. Owners and commissioning agents appreciate getting organized, timestamped verification records for every point, without waiting weeks for someone to type up notes. It streamlines project closeout and reduces back-and-forth, thereby improving the efficiency of the project delivery phase.
5. **Reuse of Test Scripts and Templates**: On projects with many similar systems (say a commercial building with dozens of identical air handling units or hotel floors with repeat layouts), automated test scripts can be written once and reused. This avoids duplicating effort. The commissioning team can develop a library of tested routines – for example, a functional test for a VAV box or a chiller plant – and apply it across all relevant points or even across projects. This scalability means larger portfolios of buildings can be commissioned with a consistent approach, more quickly than if each project were started from scratch. It also eases **ongoing commissioning** or future expansions, since the scripts remain available to test changes or new integrations at any time.

In summary, automating the checkout process not only ensures quality but also accelerates completion. The time saved can be allocated to more complex troubleshooting or to optimizing system performance once the basics are verified. Many building owners and contractors are finding that investing in these tools pays off through smoother project execution and an earlier move to normal building operation.

6.Integration with Existing Systems

A critical consideration when introducing automated checkout is how it will **integrate with the existing BMS and**

project environment. Successful integration involves both technical compatibility and procedural alignment:

1. **Technical Integration**: Most modern BMS support some form of integration via open protocols or interfaces. BACnet is commonly used as it's vendor-agnostic – an automated testing tool can connect to the BMS network as if it were just another BACnet client or workstation, reading and writing points [4]. The commissioning software may require a copy of the BMS database or at least access to all point addresses; platforms like PingCx streamline this by letting users import the entire point list from the BMS automatically. In cases where the BMS has proprietary elements, the integration might use the vendor's own API or an OPC interface if provided. It's important to verify early on that the automation tool can communicate with the specific controllers or supervisory software in use (checking versions, communication settings, etc.). Network firewalls or IT policies should be addressed – for instance, enabling a test laptop to join the BAS VLAN or obtaining credentials for secure API access.
2. **Non-Disruptive Operation**: Integration should not adversely affect the existing controls. Automated tests are generally run during the commissioning phase of new systems or during scheduled re-commissioning for existing systems. In a live building, coordinate with facility management to avoid surprise activations. Integration strategies can include testing during off-hours or implementing safeguards in test scripts (e. g. ensuring that if a critical alarm is triggered during a test, the script stops and returns control to the BMS). Good integration means the automated tool can insert itself into the control loop for testing and then cleanly withdraw without leaving any trace (no stuck overrides, no residual test logic running). As noted in one standard procedure, by the end of testing, no point should remain in manual or "locked" mode [5]. This requires the tool to diligently undo any temporary changes it made, and it highlights the need for close integration – the tool must be aware of the system's state and not just blindly write values.
3. **Workflow Integration**: Beyond the technical connection, the automated checkout process should integrate with the project's overall workflow. This means aligning with the construction schedule (e. g. performing point-to-point checkout as soon as each system is installed and powered), and working alongside other commissioning activities (like mechanical startup, balancing, and functional testing of sequences). Many commissioning teams integrate the automated point checkout as a precursor to formal functional performance tests – ensuring all sensors and actuators work first, then moving on to sequence testing. Modern platforms often handle both aspects: they manage the **workflow for point-to-point testing and system startup, as well as automated sequence testing** in one solution. Integration with project management tools or issue tracking is also a plus – for example, if the BMS checkout platform can export a list of deficiencies to a project management system or send notifications to responsible parties, it creates a seamless loop between finding an issue and getting it resolved.
4. **Training and Adoption**: An often-overlooked factor in integration is human adoption. The existing team (contractors, technicians, commissioning agents) must integrate the new tool into their routines. Best practice is to provide training and make the use of the platform a standard part of the process, not an optional add-on [1]. When everyone uses the same integrated system to log progress and results, it becomes a single source of truth. This might require some change management if the team is used to paper forms, but strong leadership and demonstrating the benefits (fewer errors, less re-testing) can drive adoption [1]. Over time, using an automated checkout tool should become as ingrained as using the BMS interface itself during commissioning.

In essence, integrating automated checkouts with existing systems is about ensuring compatibility and harmony between the new methods and the established controls environment. When done correctly, the automation layer sits on top of the BMS without fighting it, leveraging the BMS's data and control capabilities to perform tests faster and more reliably than manual methods.

7.Compliance with industry standards and best practices

Any new method or tool in building commissioning must align with industry standards and best practices to be accepted. Fortunately, automated point-to-point checkouts are generally a means to fulfill existing requirements more effectively, rather than a radical change in what is done. Here's how they relate to standards and guidelines:

1. **Commissioning Standards**: Standards like ASHRAE Guideline 0-2019 (The Commissioning Process) [7] and ASHRAE Standard 202 [8] outline a commissioning process that includes verifying all control system components. More specifically, **ASHRAE Guideline 1.1 (for HVAC&R systems) [**9] provides technical requirements for commissioning control systems, which include testing and calibrating every sensor and actuator. These documents don't mandate *how* to perform point-to-point checks, but they require that it *be done* and documented. Automated checkouts serve this need by providing a rigorous and documented approach to verifying each point. For example, an owner's BMS standard may explicitly state that *"Every input/output point shall be tested for proper performance. . . Maintain accurate test records for submittal to the owner. "* [5]. An automated tool directly supports this by producing a complete log of each I/O test and its outcome, ready to hand over as part of the commissioning report.
2. **Quality and Documentation**: Commissioning guidelines emphasize documentation of tests and issues. Using automation, the documentation is generated as a by-product of the testing process, and often is more detailed than a typical manual report. This can help comply with **commissioning authority** or **owner's requirements** for evidence. Detailed timestamps, readings, and even trend logs of how a system responded can be provided. In many cases, third-party commissioning agents or authorities having jurisdiction are amenable to automated testing as long as they can review and approve the procedures beforehand and witness a sample of the process. The repeatability and audit trail provided (with a history of test scripts and results) meet the intent of most commissioning

standards, which is to verify performance and catch deficiencies.

3. **Best Practices from Industry Groups**: Organizations like the Building Commissioning Association (BCxA) and AABC Commissioning Group publish best practice guides which increasingly mention the use of technology to improve commissioning. The trend is toward **"data-driven commissioning"**, where instead of clipboards, commissioning providers use analytics and automated tests to validate systems. The use of **automated functional test scripts** has been explored in research settings for decades [4], and now it's entering practical use. Standards are evolving to incorporate these approaches – for instance, specifications might require that the BAS provide capabilities for automated testing or that the commissioning team utilize software tools to manage the process. Adopting automated point checks is in line with the industry's push for better quality control and efficiency through digital means.
4. **Interoperability and Data Standards**: When integrating with multiple systems, adherence to communication standards (like BACnet as mentioned, which is an ASHRAE/ANSI Standard 135) ensures that automated tests can cover **integrated systems** as well, not just HVAC. For example, if a BMS integrates fire alarms, generators, or lighting controls via standardized interfaces, those points can also be included in the checkout (verifying signals hand off correctly between systems). This holistic approach is advocated by smart building initiatives and guidelines for integrated systems testing. Using standardized data formats also means the results from one project could feed into benchmarking or continuous commissioning efforts (sometimes called ongoing commissioning). Some advanced platforms extend into the operational phase, using the same data gathered to monitor system health continuously [4]. While that goes beyond the initial point-to-point checkout, it shows that the industry is moving toward *lifecycle commissioning* where the line between construction-phase testing and operation-phase monitoring is blurred by constant data collection.

In summary, automated point-to-point checkout methods are a powerful way to satisfy and even exceed the requirements set by industry standards. They ensure that the intent of commissioning guidelines – delivering a fully functional and verified building system – is met with high fidelity. As the industry embraces these tools, we can expect future standards to explicitly encourage or reference digital and automated techniques as best practice for BMS commissioning.

8.Conclusion

Automating the point-to-point checkout process in Building Management Systems brings significant benefits in accuracy, efficiency, and clarity. By leveraging modern software tools, open protocols, and well-planned workflows, project teams can verify every sensor and actuator in a building more quickly and reliably than ever before. Integration with existing BMS infrastructure is made possible through standards like BACnet and the availability of APIs, ensuring that automation augments rather than disrupts the system. The result is a reduction in human errors and labor hours, as repetitive testing is handled by scripts and devices, while engineers focus on problem-solving and optimization. Importantly, automated checkouts produce detailed records and follow consistent procedures, aligning well with commissioning industry standards that demand thorough verification and documentation [5].

In practice, successful implementation of automated point-to-point testing requires upfront planning, team training, and the adoption of tools suited to the project's needs – whether it's a cloud-based commissioning platform, a field mobile app, or a script-driven test engine. When these elements are in place, the checkout process becomes more **integrated**, **efficient**, and **transparent**. Issues are caught early, progress is easier to track, and the building systems can be brought online faster and with greater confidence in their performance. As intelligent buildings and IoT technologies advance, we can expect automated commissioning techniques to become standard practice, continually improving the delivery and reliability of building management systems.

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