



Internal Audit Report

Configuration Management Audit

Report Number: 2019-05 | Report Date: October 17, 2019

Executive Summary

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WE AUDITED the current configuration change management process to assess the controls in place over as-built drawings and whether they were complete and timely compiled, and configuration changes were identified, authorized and efficiently managed.

AUDIT OBJECTIVE was to determine whether the agency has effective controls to ensure:

- As-built drawings as input to subsequent change configuration management are complete and timely compiled following the completion of construction projects.
- All operational configuration changes are completely identified, properly authorized and efficiently managed in compliance with applicable agency policies.

We examined management controls in place as of April, 2019.

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WHAT DID WE FIND?

The agency has been constructing public transportation assets over the last two decades, and heavy construction activity from expansion projects of ST2 and ST3 will continue well into the future in all transportation systems.

One constant feature in the construction and operation of physical transportation assets is a need to make material modifications from time to time in order to better accommodate the ongoing and changing needs of the customer and the operator. Established practices designed to manage these modifications is often referred to as configuration management.

The agency's configuration management consists of two elements by two different groups:

- 1) Construction configuration changes by Design, Engineering & Construction Management (DECM)
- 2) Operational configuration changes by Operations

While all configuration changes result in a certain modification of physical assets, they do not always require an update in the as-built drawing. All required updates are incorporated into the final as-built drawings which is the agency's final record of all material changes made during and after construction.

Complete and accurate final as-built drawings are essential to future asset maintenance and modification efforts, as the project scope, timing and cost will be informed by the detail contained in the drawings. Incorrect or omitted information could cause future project delays and cost escalation.

We concluded that the agency has effective controls over operational configuration changes. However, controls over the complete and timely compilation of as-built drawings following construction as input to subsequent change configuration management are not adequate.

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Background

The agency has been constructing public transportation assets (e.g., rails and facilities) over the last two decades. Heavy construction activity from expansion projects of ST2 and ST3 will continue well into the future in all transportation systems: commuter rail (Sounder), light rail (Link), and regional express bus system (ST Express).

One constant feature in the construction and operation of physical transportation assets is a need to make material modifications from time to time in order to better accommodate the ongoing and changing needs of the customer and the operator. Established practices designed to manage these modifications is often referred to as configuration management which is roughly defined as a process of implementing, documenting, and preserving permanent changes to how an asset is “configured.”

The agency’s configuration management consists of two elements by two different groups: 1) construction configuration changes by Design, Engineering & Construction Management (DECM) and 2) operational configuration changes by Operations. In both cases, approved changes are incorporated into final as-built, a drawing reflecting all changes to working drawings based on a set of specifications.

During construction, either a change notice (e.g., Work Directive or Request for Proposal) or change order could trigger a configuration change. While all configuration changes result in a certain modification of physical assets, they do not always require an update in the as-built drawing. Currently, the agency’s Program Control Policies & Procedures (PCPP-14), as-built Records Management (revised, 06/18/13) requires the Resident Engineer (RE), in coordination with the agency’s computer aided design (CAD) team and Construction Manager (CM), review contractor as-built drawings periodically prior to final submittal for completeness and conformance to contract requirements. In the event DECM identifies a configuration change requiring an update in the as-built drawing, CM and RE must review and approve the necessary revision to update the final as-built drawing. For a three-year period ending December 2018, DECM processed over 11 thousand change orders, of which approximately 2,400 required a change in the as-built drawing.

All configuration changes following the placement of assets into service are subject to a review process by Operations Department’s Configuration Review Board (CRB). CRB evaluates requests for operational configuration changes by the project manager. Upon approval, the changes are implemented, and updates are made to the as-built drawing, as applicable. For a three-year period ending December 2018, there were approximately 150 operational configuration changes to various agency assets.

Audit Objectives

To determine whether the agency has the effective controls to ensure the following:

- As-built drawings as input to subsequent change configuration management are complete and timely compiled following the completion of construction projects.
- All configuration changes are completely identified, properly authorized and efficiently managed in compliance with applicable agency policies.

Scope and Methodology

We conducted this performance audit in accordance with Generally Accepted Government Auditing Standards and the International Standards for the Professional Practice of Internal Auditing. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

We gained an understanding of configuration management at the agency and department/division level through data analysis, documentation reviews, and personnel interviews. We identified risks in the processes and assessed management controls in place to mitigate those risks. Based on the assessment of management control effectiveness, we determined to focus on controls over the as-built drawing and operational configuration change management processes.

We examined configuration management process as of April 30, 2019

1. To determine whether the agency has effective controls to ensure the complete and timely compilation of as-built drawings as input to subsequent change configuration management, we performed the following procedures:
 - a. Selected nine change order samples requiring 76 as-built drawing updates from two construction projects.
 - i. Reviewed the final as-built drawing for each update to determine if the revision was incorporated into the drawing.
 - b. Selected 83 as-built drawings from the agency's as-built drawing library from 2016 to April 2019.
 - i. Compared the drawing date with the uploading date to the agency's library to determine if the drawings were timely compiled following the completion of construction projects.

2. To determine whether the agency has effective controls to ensure all configuration changes are completely identified, properly authorized and efficiently managed in compliance with applicable agency policies, we performed the following procedures:
 - a. Reviewed all engineer project requests from January 2016 to April 2019.
 - i. Traced the requests to the CRB's list of configuration management projects to verify all configuration related requests were completely identified, and subjected to the CRB process and approval.
 - b. Reviewed all configuration management projects from January 2016 to April 2019.
 - i. Reviewed the project detail (i.e., the board approval date for proposal, planning, implementation, & close out) to determine whether CRB processes are effective and efficient.

Conclusion

We concluded that the agency has effective controls over operational configuration changes. However, controls over the complete and timely compilation of as-built drawings following construction as input to subsequent change configuration management are not adequate.

See Finding #1.

Findings and Recommendations

1. As-Built Drawings Management During Construction Should be Strengthened

The agency's Program Control Policies & Procedures (PCPP-14) requires the Construction Manager (CM), in coordination with the Resident Engineer (RE), review the contractor provided as-built drawings for completeness in accordance with contract requirements.

The agency has instituted a number of procedures to ensure continuous engagement with the contractor throughout construction to manage as-built changes completely, accurately and timely. Both¹ in-scope and out-of-scope configuration changes with respect to the original contract requirements are subject to the same set of management controls if a drawing change becomes necessary. These controls are designed to ensure that all physical modifications from the original drawing are accurately captured for posterity in the agency's final as-built drawing. The completeness and accuracy of the final as-built drawings is of high importance because all future asset maintenance and modification efforts will be informed by the detail contained in the drawings. Incorrect or omitted locations, for example, of plumbing, cabling or any other components could cause future project delays and cost escalation. The importance is further demonstrated by the fact that the information in the final as-built drawing could be integral to internal and external safety checks of agency assets.

Inconsistent with the criticality of the final as-built drawing to future asset management efforts, the current management controls do not adequately address the risk of incomplete and inaccurate final as-built drawings. We noted many exceptions. Specifically, we observed a high rate of exceptions on completeness and timeliness: (1) 35 (46% of the tested) required drawing updates were not incorporated in as-built drawings with Construction Mark Up (CMU)²; and (2) 37 (45% of the tested) took more than 12 months from the completion of construction to store updated as-built drawings in the agency's library.

Absent Configuration Changes From Change Orders In CMU

The final as-built drawings should be a complete transcription of all revisions to the original plans. It should include modifications, design changes, additional work, etc. that occurred during the construction process. On average, eight hundred configuration changes start with a construction change order annually. However, management practices to control these changes are not effective.

We tested 76 as-built drawing updates selected from nine change orders and noted that the majority of the updates were not present in CMUs stored in the SharePoint library. Each

¹ If the construction configuration change is within the scope of the construction, the change is made with change notice after the review of construction management. However, if the changes are beyond the scope of the construction, it must go through change order process, and have approval of the agency's Capital Program Control Board.

² CMU is the as-built drawing with markups of all configuration changes (i.e. redlines, change notice and change order numbers) from the original design drawings. The complete CMU is the basis for the final as-built drawing.

change order reviewed had at least one drawing update missing from the CMU. Overall, 35 (or 46%) required drawing updates were not incorporated in the CMU.

Contract	Delivery Method	Change Orders	No. of Absent Updates in the CMU
U240 – Capitol Hill Station	GCCM	CO NO. 361 – West Entry Escalator Pit Revisions	2
		CO NO. 361R – West Entry Escalator Pit Revisions	5
		CO NO. 414 – Emergency Illumination Requirements	2
		CO NO. 426 – Door/Landing Mods at Central Station Basement Wales	0
		CO NO. 435 – Added Gutter at Platform Level	7
		CO NO. 435R – Added Gutter at Platform Level	7
		CO NO. 462 – Door Hardware Revisions for Stair Pressurization	10
S300026 – Yard Expansion	Design Build	Delete Under Train Lighting	1
		Delete Pole Mounted Camera Brackets	1

Individual sets of change order documents for the samples clearly identified the update as a change to the as-built. In fact, the drawing updates were part of the document sets reviewed for approval by management, but the CMU does not reflect the updates. Because the final CMU, as approved by the RE and the CM, is a basis for the update in the final as-built, the missing drawing updates in the CMU logically indicates the absence of the update in the final as-built. As such, the current management controls do not provide assurance that the agency’s formal and final configuration document (i.e., the final as-built) is completely and accurately reflecting agency asset configurations.

The observed conditions are attributable to inadequate utilization of available configuration change information such as as-built log by the RE. The information as a whole provides a base against which CMUs can be reviewed for completeness, but the current process does not include such an element.

Untimely Close-Out Of The As-Built

All drawing updates must be marked and stored in the final as-built within a reasonable period following the completion of construction. The actual time for the update can vary as a function of project complexity, as well as available staffing resources. At the time of audit, there was a shared understanding that configuration changes should be updated within 12 months following construction. The understanding is not a policy expectation but a working benchmark among staff.

We reviewed 83 configuration changes and compared the approval date of the change to the date of the upload of the final as-built to the library to determine if the drawings were timely updated following construction. Testing results noted that 45% (37 out of 83 tested) took more

than 12 months from the completion of construction to store the updated as-built drawings in the agency's library.

Testing Results	
Elapsed Time from Construction Completion	No. of Drawing
< 5 months	11
6 months > <11 months	35
12 months > < 17 months	18
18 months > < 23 months	16
24 months > < 29 months	2
30 months > < 35 months	1

The source of the exceptions appears to be the inconsistent application of the shared 12-month benchmark and a lack of subsequent monitoring. Monitoring is absent because the current practice lacks the rigor of a clearly stated performance expectation with detail guidance in a policy and/or procedure.

The final as-built is the agency's final set of records describing how assets are configured. While there are other documents as support, the final as-built in the SharePoint library is designed and maintained as the document to be consulted and relied upon for all things related to asset configuration. In order to serve its purpose effectively, drawings must be updated completely within a reasonable period following the completion of construction. We, however, noted numerous exceptions. Unless reasonably mitigated, untimely and incomplete updates in the final as-built can negatively affect the scope, timing and cost of future asset management efforts.

Recommendations:

We recommend the agency:

1. Improve the as-built process to ensure timely and complete capture of all as-built drawing changes.

The following specific procedures are for management consideration:

- Compile a separate list of all required drawing updates or add an attribute to existing logs to indicate the updates.
- Establish a period following construction for completing all required drawing updates in the final as-built.

Management Response:

Sound Transit's Internal Audit conducted an audit of the agency configuration management processes and procedures, including configuration changes by DECM as well as operational configuration modifications by Operations.

The audit objective was to determine whether the agency has effective controls to ensure the following:

- As-built drawings, as input to subsequent change configuration management, are complete and timely compiled following the completion of construction projects
- All configuration changes are completely identified, properly authorized, and efficiently managed in compliance with applicable agency policies

The audit focused on configuration change projects for the period January 2016 to April 2019.

The audit also reviewed the following:

- Agency Policy 37 - Agency Configuration Control Policy & Agency Policy 38 - Configuration Review Board Policy
- Configuration Review Board Procedures
- PCPP 04 - Configuration Management
- PCPP 14 - As Built Records

The draft audit report identified one finding: As-Built drawings management during construction should be strengthened. The report noted exceptions on completeness of construction markup drawings and timeliness of conversion of construction markup drawings to final CAD as-builts being posted in the as-built library.

In our experience, projects may often experience additional work beyond substantial completion, which may in turn impact the completion of the Contractor as-builts and the final record drawing packages. Prior to the audit, we had recognized this as an opportunity for improvement.

Earlier this year, the Agency initiated a cross-departmental, cross-divisional Continuous Process Improvement (CPI) project focused on improving the as-built process. The CPI team identified six areas to concentrate its improvement efforts, including accuracy and timeliness. Below is a list of recommendations from the CPI Team:

1. Locate all drawings including shop drawings, associated segments and Operations & Maintenance manuals in one centralized location. This will meet the needs of both Operations & DECM.
2. Ensure drawing version history is easy to locate.
3. Consider developing a single set of operational "exhibit" drawings that reflect the most current configuration, including boundary lines.
4. Ensure that Final As-Built (Record) drawings are in CAD and uploaded to the as-built library within 90 days of final approval / contractor completion.
5. Improve accuracy of As-Built drawings.
6. Revise PCPP-14 to reflect future state processes.

The CPI team is currently developing a work plan. We expect this work plan to include timelines and points of accountability. The work plan will be completed by the end of this year, with the actual measures being incorporated into our processes and procedures as developed and implemented.

Meanwhile, the Design Technology and Construction Management groups in DECM are now using Bluebeam technology on construction projects to document changes on the contractor red-line as-builts. The Design Support During Construction consultant and Design Technology have continuous access to the Contractors' Bluebeam red-line as-builts throughout the duration of construction. This will enable changes to be captured in the Final As-builts without waiting until the end of construction, when the contractor officially submits the red-line as-builts to the Resident Engineer.

Also, the configuration management audit draft management letter contained a recommendation to improve the system storage and the naming convention for as-built drawings. This is also being addressed as part of the as-built CPI effort. In the interim, Operations and DECM are performing data cleanup for existing as-built records.

In conclusion, DECM and Operations appreciate the input on this topic and are committed to improving the configuration management controls.