AutoCodes Project: Phase 1, Proof-of-Concept Final Report

March 2012
AutoCodes Project: Phase 1, Proof-of-Concept

Final Report

Fiatech Regulatory Streamlining Committee
March 2012
Table of Contents
Acknowledgements ........................................................................................................................................... 3
Introduction: Project Origin and Objective ................................................................................................. 4
Project Framework, Methodology and Process ............................................................................................. 6
Phase 1A: 2D Plan Review ........................................................................................................................... 8
Point of Deviation ......................................................................................................................................... 12
Phase 1B: 3D Model Review ......................................................................................................................... 13
The Analysis of 2D and BIM ......................................................................................................................... 15
Marketing, Education and Information .......................................................................................................... 16
Findings & Suggestions ................................................................................................................................. 17
Phase 2: Widen Vertical Industry and AHJ Participation, Expand Code Classes ........................................ 19

Figures
Figure 1: POC Project Management Web Site ................................................................................................. 7
Figure 2: POC Accessibility and Egress Review Data Collection Form (page 1-2 of 10)............................. 8
Figure 3: 2D Code Review by Jurisdiction Summary Table ......................................................................... 9
Figure 4: Inconsistency – A clear code violation identified by only one AHJ............................................. 10
Figure 5: Automated Code-Check Result of Wheelchair Turning Radius in Model .................................. 13
Figure 6: Store Model Image Showing Produce Cooler Space ................................................................ 15
Figure 8: Items that were not identified at all during the manual (2D) review process ............................ 15
Figure 7: Items contained in the drawings, but not in the model .............................................................. 15
Figure 8: Phase 2 Organization Framework ................................................................................................. 19
Acknowledgements

The members of the Fiatech Regulatory Streamlining Committee wish to thank the Fiatech Board of Advisors and the following participating Authorities Having Jurisdiction for their support and participation in Phase 1 of this multi-year effort:

Amarillo, TX; Bend, OR; Carrollton, TX; Houston, TX; Irvine, CA; Livermore, CA; Mecklenburg County, NC; Philadelphia, PA; Redwood City, CA; Salt Lake City, UT; San Jose, CA; State of New Jersey Department of Community Affairs; State of New York Department of State; and the International Code Council, Chicago, IL.

Fiatech Regulatory Streamlining Committee

Steve Makredes, Director of Construction, Target Corporation, Board Liaison

Kevin Hart, Director - Construction, Kaiser Permanente, Board Liaison

Ronald Loback, CEO, Avolve Software, Co-Chair

Thomas Phillips, Code Compliance Manager, Target Corporation, Co-Chair

Jonathan Widney, CEO, Solibri LLC, SME-Model Checking

Bill Gould, Marketing Director, Avolve Software, SME Communications

Steven Wolf, Lead Project Architect, Target Corporation, SME Design

Robert Wible, Senior Project Manager, Fiatech
Introduction: Project Origin and Objective

Owners, architects, contractors and building regulatory personnel recognize that regulatory code compliance is one of the more challenging and time consuming requirements in the design and construction process. Advances within the architecture, engineering and construction (AEC) industry—specifically the introduction and adoption of building information modeling (BIM)—have accelerated the ability, and the possibility to transform the building regulatory process in order to keep pace with industry demands. In short, the current plan review process has become an alarmingly persistent bottleneck. This is significantly impacting the entire economic development ecosystem for both the private and public sectors.

The Fiatech Regulatory Streamlining Committee (RSC) is responding to this challenge. In 2010, this group launched a multi-phase project with the objective of developing both the optimal methodology and the consistent guidelines necessary to transform the regulatory process. This would be accomplished by applying technology to enable automated code checking of BIMs. The Fiatech Board of Advisors approved Phase I of the Project, and in early 2011 the initial Proof-of-Concept (POC) phase of the AutoCodes Project was launched. The stated goal of Phase 1 was to demonstrate that it is possible—today—to use technology to automatically check a BIM for code compliance. Phase 1 focused on the Accessibility and Egress (A&E) provisions of the International Code Council (ICC) International Building Code (2009). The Project Team collaborated with the ICC, as well as select Fiatech members and Authorities Having Jurisdiction (AHJs).

Project Team Composition

The AutoCodes Project Phase I team consisted of three Fiatech member organizations and one Fiatech Project Manager. The member organizations included one owner (Target Corporation) and two software developers (Avolve Software and Solibri LLC). These companies are all considered experts in their respective market sector and each of these parties brought unique and valuable experience and capabilities to the project, with a singular commitment to successfully address the challenges that are presented within the current permitting environment. One key consideration that all parties identified from the initial meetings was that this undertaking is strategic and represents a paradigm shift in the way business is currently being conducted. This in turn would require launching an aggressive and wide sweeping information and education campaign that will take several (if not many) years to complete. The entire Project Team accepted this as ‘reality,’ and this requirement remained constant, as well as at the forefront throughout all subsequent discussions and key decision points.

This report summarizes Phase 1 of the AutoCodes Project, including any assumptions made, methodologies followed and the Project Team’s findings and suggestions.
**Why Accessibility and Egress?**

There were several reasons for selecting A&E code provisions as a starting point, including:

- A&E was identified very early as one of the top three (3) regulatory disciplines and industry pain points (the other two being Fire & Life Safety (F&LS) and Mechanical, Electrical and Plumbing (MEP)).
- A&E is a logical area to serve as the foundation for future code checking development (F&LS and MEP).
- Existing model-checking technology was already commercially available and in use, utilizing open-standard programming.
- For a Proof-of-Concept project, A&E was considered a logical starting point by the project validation participants (the AHJs).
Project Framework, Methodology and Process

The AutoCodes Phase 1: Proof of Concept methodology consisted of the following:

Multi-Jurisdictional Participation

From the outset, the Committee established that the POC and its operations should be conducted as a cooperative effort that would include multiple jurisdictions representing a diverse cross-section of U.S. demographics. This inclusive approach provided the Committee with the best prospect for meaningful data collection and analysis. It was believed that the participation of multiple jurisdictions, including the International Code Council (ICC), would also demonstrate the validity of project results and findings.

International Code Council Participation

Prior to the commencement of Phase 1 of the POC Project, the Committee held discussions with the ICC. This was important to the Committee for the following reasons:

- The ICC publishes the International Building Code (IBC); the required baseline documents (IBC 2009, Chapters 10 & 11),
- The ICC was considered to be a valued resource to provide insight into code intention and interpretation, should clarification be needed,
- The majority of jurisdictions in the U.S. use the IBC code as their model for code compliance,
- The ICC and the Fiatech RSC have successfully collaborated on previous projects,
- The ICC granted the Committee a license for the use of their published codes for the duration of the POC.

Real-World, Comparative Data Analysis (desired to avoid assumptions)

In conducting the POC, it was felt that, looking ahead to the future, the best way to achieve regulatory and market acceptance of AutoCodes methodology (for Accessibility and Egress only) was to utilize real-world plan review departments (the AHJs) and their personnel.

Acquiring POC Project Participants

The Committee used its collective relationships in the U.S. regulatory community to solicit participants for the POC. The participating jurisdictions were divided into four regions: East, South, West and Central. Primary representatives within the jurisdictions were contacted via email and telephone and invited to attend region-based conference calls explaining the nature of the project, methodology and procedures, and expectations. Fourteen AHJs agreed to participate in the POC.

The final list of participants by region consisted of:

- **East:** State of New York; State of New Jersey; Mecklenburg County, NC; City of Philadelphia, PA
- **South:** Houston, TX; Amarillo, TX; Carrollton, TX
- **West:** Bend, OR; Irvine, CA; Livermore, CA; Redwood City, CA; San Jose, CA; Salt Lake City, UT
- **Central:** ICC Review Staff
POC Phase 1A and 1B

The POC project was divided into two sub-phases (1A and 1B). Phase 1A activities consisted of performing a manual 2D A&E review, collecting the results, analyzing them and conducting follow-up telephone interviews with the participating AHJs, in any cases requiring clarification. Phase 1B consisted of conducting an automated A&E code-check on the BIM from which the 2D plans were derived.

Communications Protocol – The Fiatech AutoCodes Project Site

One of the critical requirements for managing multiple AHJs throughout the Phase 1 POC was a secure communication and collaboration environment. Avolve Software, a Project Steering Committee member, provided this capability through its ProjectDox® Electronic Plan Review technology. Following the Regional conference calls, all POC participants were provided access to a project website and given instructions on how to use it. This gave all AHJ participants and project contributors centralized, controlled access to 2D plans, review forms, and the prototype 3D model files (in Phase 1B). A secure account was created for each AHJ, accessible by their designated primary and alternate representatives.

![Figure 1: POC Project Management Web Site](image)

The Original Plan - Iterative Development

The original plan called for the development of AutoCodes POC Accessibility and Egress rulesets, to be conducted in iterative cycles, using the review data and commentary collected from jurisdictions, input from Building Information Model (BIM) subject matter experts (SMEs) and the ICC. This plan called for one cycle of initial data collection from the AHJs (based solely on the 2D manual review), followed by three cycles of development and testing in the 3D model environment and validation by the AHJs, also in the 3D model environment. The process would start by identifying the gap between the 2D and 3D results, then closing the gap over the course of the respective review cycles. These cycles would initially be specific to accessibility, then to egress. Regular, scheduled monitoring of the process was established on a weekly basis throughout the term of the POC.
Phase 1A: 2D Plan Review

The participating jurisdictions were asked to conduct the 2D A&E review on a single prototype design (a single floor, large retail facility developed by Target Corporation) per normative (manual) procedures. Target uploaded a prototype store design 2D PDF plan set (137 total files), which was derived directly from their prototype BIM, to the project site. The Project Committee then designed a standard electronic data collection form (in PDF) for recording all review-related comments. This approach provided a consistent baseline for all AHJs and provided the AHJs with a document they would find familiar.

![Data Collection Form](image)

AHJ participants downloaded the Phase 1A 2D plan resources from the project site and performed their standard-procedure A&E reviews, recording their comments using the Data Collection Form. The Form was then submitted back to the Committee, again via the project site. Some forms were submitted to the Committee via the form’s data submission function, and some were returned in the native PDF format. One was submitted per the jurisdiction’s own report form, but provided data in an acceptable, usable format.

Phase 1A – Review, Collection of Commentary and Analysis

During Phase 1A, the Project Team expected to see some deviation amongst the reviews, number of comments and even some unique findings. This was anticipated since most of the AHJs used locally modified, or amended, codes. What the team found, however, was that while there was some agreement, there was much more disparity. In fact, there was so much disparity and inconsistency that the gap analysis process that was originally planned (between 2D and 3D) had to be deferred. The immediate project requirement was to analyze all the 2D data. The table below presents the feedback that was received, as well as the range of deviation.
Among those findings were:

- Significant disparity between the number of comments from a single AHJ (low of 1, high of 40).
- Some found no non-compliant items, while another jurisdiction found 16 (from the same drawings).
The following color scheme is represented:

- **Red** = Non-compliant
- **Yellow** = Not enough
- **Green** = Guideline

Figure 4 above is an example of the matrix created to reflect the comments of each responding AHJ. In this example, the visible note reflects a non-compliant item, which although a clear issue, was only captured and commented on by one (of 14) review participant. The alpha-numeric items reference the 2D drawing sheet, while the strictly numeric items refer to comment numbers from the individual reviewers.

The next step was to communicate directly with each of the respondents to make sure the Project Team was not making any assumptions with regard to what was being measured, and why and how comments were generated.
The Project Team had to determine what to do with the information that was collected. It was determined that the right thing to do was to share it with the participants and see if there were any logical explanations for what was received.

Finally, the Project Team asked all participants a hypothetical question: If all the (A&E) items that were commented on were fixed, would the drawings be approved? Even here, there was inconsistency. Twelve of the 14 entities answered, “Yes, they would approve the drawings.” Two said, “No, they would not...they would require additional information before they could do so.” This response, by itself, was quite revealing.

The entire POC exercise clearly established that the largest single issue within the plan review process continues to be the lack of consistency, regardless of the AHJ.

Addressing the lack of consistency in plan review became the key objective of the POC Project Team, from this point forward.
Point of Deviation

The BIM Approach
As mentioned earlier, Target Corporation provided 2D design drawings of a prototype retail store that were used for the AHJ manual review process, derived directly from the 3D model of the same facility to ensure the 2D and 3D review process could be accurately compared. This was a critical consideration since the original objective was to compare the manual process and all of its elements (consistency of comments, amount of time to complete, cost and completeness) with the model-based checking process. No modifications to either the 2D plans or the model from which they were derived were made during the duration of the POC.

Upon receipt of the model, Project Steering Committee member Solibri loaded the model into the Solibri Model Checker to perform a preliminary check. This technology is a commercially available, open-standard, rules-based application that is used to measure the quality of models for a range of purposes. In this instance, the model was checked for compliance with existing A&E rules. This initial check would allow the project committee to establish a baseline for the model, as it had with the 2D drawings.

The Initial BIM Check
With the initial review of the 3D model it was quickly determined that just creating a 3D model may not be sufficient. While the model was reflective of the store layout, many spaces were not ‘classified’, which meant that space types that differed in planned usage would be treated the same (e.g. if mechanical space was not designated, it would be treated like retail space, with regard to applying the aforementioned rules). Although there was discussion with Target about model creation, it was determined that the Project would work with the model in an ‘as-authored’ condition, and the Project Team would create some space classification designations, which would be consistent with the 2D review process. The additional implications that accompanied this check are identified in the Findings section (later in this report). There was no immediate impact to the POC related to the model check, as the Project Team had not yet gathered any of the 2D review results, at the time the model was being examined.
Phase 1B: 3D Model Review

Phase 1B is where the focus of the project, the team and the AHJs shifted to the 3D model. It should be reiterated that the project 3D model is the same planned retail store that was represented in the 2D drawings provided by Target Corporation.

To undertake Phase 1B, the team invited the following six AHJs to participate in the 3D model-based validation:

- Bend, OR
- Livermore, CA
- Irvine, CA
- Salt Lake City, UT
- Mecklenburg, NC
- Philadelphia, PA
- State of New York

Solibri established an account for each AHJ and provided secure access for each to download the Solibri Model Checker application, as well as to receive a license key to activate the software. The AHJ was then provided with the model of the Target prototype store.

Each AHJ was contacted and a web session was arranged between the Project Team and the interested parties within the AHJ. Each AHJ that participated was guided through the following steps:

1. A brief familiarization session, allowing them to gain comfort with the technology interface.
2. During the familiarization session they were afforded the opportunity to observe basic functions, understand the navigation capabilities and gain familiarity with the menu structure.
3. They were then shown how to load a model.
4. Next, they were shown how to load the relevant ruleset(s) and how to execute an actual model check against those selected rules.
5. They were shown how results are generated and displayed, and were able to review each result, make and save comments that were applicable and decide whether to approve or reject any results.
6. They were shown how to generate a report of their commentary

The goal for the Project Team was to better understand the approach to checking the codes, to ensure that no assumptions are made that differ from the traditional human concerns.

The Project Team was able to actively observe any hurdles to adoption, whether environmental, technical or social. This was extremely valuable, as it better prepares the Project Team for the challenges that will be encountered when the technology is introduced with a broader offering and on a national scale.

The Experience
One desired measurement was to observe the initial reaction by the AHJs to the 3D Model-based review, with rulesets providing the checking. As is the case with the adoption of BIM, technology is a relatively small consideration when compared to the sociological impact and the possible reaction to what would be considered a disruptive practice (as a totally new approach to the review process). The initial reaction from all participants was that the technology was extremely impressive, easy to comprehend and very compelling. The one aspect that the individual AHJ could not see but that the Project Team could was that every jurisdiction generated exactly the same results when they ran the model through the software application. This is the anticipated result since the check is automated and the results are produced by computational algorithms (existing situation vs. established parameters).

In general, the application and use of rules for automated code checking were received extremely well with little or no negative feedback or trepidation from the AHJs. The comments and feedback were overwhelmingly positive, with particular excitement about the ease of use of the interface and the simplicity of the workflow. Other than a few who expressed concerns about training time required, the AHJ contacts did not convey any concerns about technology and automated code checking negatively impacting their processes or turnaround times, and in fact acknowledged the great potential for just the opposite: improvements in time requirements, processes and procedures.
The Analysis of 2D and BIM

The following represents a sampling of discrepancies relating to the 2D review and the as-authored BIM.

1. Instances where there were discrepancies between the two environments (i.e., objects were not found to be in the same location).
2. Items present in the 2D environment that were not modeled in 3D.
3. Issues identified in the 3D model that were not found in the manual process.

Discrepancies with Model and 2D Documents

**Issue**
This group of spaces is different than the PDFs.
The Produce Cooler is on the exterior wall in PDFs (A021).

**Figure 6: Store Model Image Showing Produce Cooler Space**

**Issue**
Model does not match PDF. Model corrects the layout problem, however the doors are missing in the model.

**Figure 7: Items contained in the drawings, but not in the model**

**Issue**
Not enough space at the end of ramp. The required dimension is 6’ x 5’. Object intersects the required free area. This is an example of an issue that was not identified by any of the reviewing AHJs.

**Figure 8: Items that were not identified at all during the manual (2D)**
Marketing, Education and Information

As mentioned earlier, the Project Steering Committee recognized that communication would be a key strategic component for successful adoption of a streamlined process. This communication would have to address multiple audiences, from the Fiatech Board and general membership to the project participants and their organizations, as well as the industry as a whole. Necessarily, the type of communication would differ, depending on the intended audience.

Between the Spring of 2011 and early 2012, members of the Project Steering Committee participated in more than 35 presentations across the U.S., sharing the AutoCodes story and discussing the needs for process transformation to achieve a Digital Review Process. These presentations included slide shows, speeches, panel discussions and technology demonstrations. Additionally, Project Committee members worked in conjunction with Target Corporation to produce a 10-minute video of the AutoCodes project that describes the nature of the problem facing regulatory bodies and the AEC industry, as well as how the technology today and that which will be developed as a result of the project will be instrumental in streamlining and expediting the permitting process. The response to the video has been excellent as it clearly articulates that there are answers—today—for this long-term problem of inconsistency. More than 250 DVDs have been distributed to a broad audience of interested parties, including owners, federal agencies, foreign officials and members of the North American AEC industry. The video has also been available for viewing on the Fiatech, Avolve Software and Solibri Inc. websites. The most recent estimate is that web viewings have exceeded 5,000 to date.

Now that the project has gained traction and momentum, it will be an ongoing requirement to continue to promote, inform and educate any and all who are members of the regulatory ecosystem. This is a long-term requirement to ensure that all impacted parties clearly understand what is involved to move from a paper-based, inefficient and extremely inconsistent process to a hybrid (2D and BIM), consistent and efficient workflow.
Findings & Suggestions

Phase 1 of the Proof of Concept was an excellent source of lessons learned and items for careful consideration. The Project Team consistently identified new steps, new processes, and a wide range of actions and behavior that truly warrant consideration as part of the overall Digital Review Process, as well as this more focused project environment. It should be noted that the Project Team did not underestimate the magnitude of the ultimate task at hand—a process transformation that will impact thousands of cities, companies and individuals.

The following represents a small sampling of some lessons learned as a result of the Project Team’s experience in this initial phase, along with some recommended by-products for development and some suggestions to seriously consider for the future:

1. **Not all models are equal** - Essentially, a model must be authored with consideration given to the type of facility and what analysis is planned for the model, once created (e.g. energy analysis, circulation, safety or access). Many times this is unknown, which results in models coming in all shapes and sizes. Some are extremely detailed, well defined and well-coordinated federated models, while others may be conceptual, with no defined spaces and little consistency in model content. This creates a requirement for a clear and concise model specification, which requires careful planning and vision. By-product: The creation of a Modeling Protocol Guideline that addresses different building types and the level of model development desired/required while being flexible enough to be applied (or adapted) across industry lines (e.g. retail, education, healthcare).

2. **There is a huge requirement for change.** It was clear that AHJs operate independently, are clearly impacted by multiple events (attrition, downsizing, rapid advancement of technology, etc.) and require assistance to operate efficiently. By-product: The Project Team believes and strongly recommends the drafting of a Process Transformation Guideline for AHJs to assist in the transition to a hybrid (2D, 3D and web) environment in the near term.

3. **Reporting is an important consideration.** This is another area where consistency can be achieved and ambiguity eliminated. There is still a necessary capability for AHJ officials to address intent, as well as content, when applying code regulations. One suggestion would be to embed or integrate a report form that would be familiar and consistent, thereby establishing a “transitional” piece that would resonate well with the AHJs. This would also establish a sense that any new process would also consider all elements from the past.

4. **There is an opportunity, and perhaps a need, to establish confidence within the AHJ as the model becomes more central to the code checking process.** Perhaps a computer-generated audit trail could be developed of all items that have been checked so that issues could be identified and isolated. This would be an excellent element to consider in follow-on projects. This would assist in the adoption of a new workflow, as it would serve as a readily accessible resource to demonstrate the completeness and thereby the consistency of the BIM-based review process.
5. *The AHJs have been left out of the BIM discussion, as well as the workflow.* While there may be rudimentary acknowledgement of BIM, this entire segment of the design/build/operate community requires significant attention. In addition to the Guideline referenced in item 2 above, the suggestion herein is to design, develop and deliver a nationwide (or perhaps even broader) information and education program (or campaign) to deliver consistent and evolving messaging that will expedite the knowledge transfer to this audience. Without this type of commitment to educate, there will be sporadic (at best) adoption and limited implementation of new processes, which means a longer period of inconsistency.

**Phase 1 Closing Comment**

The AutoCodes Proof of Concept Project (Phase I) goal was to validate the use of automation technology for real-world code compliance assessment and the acceleration of the regulatory approval process. In addition to meeting the stated goals of the project, the methods and procedures yielded results that have provided key insight into the root causes of inefficiencies, costs and delays in the regulatory approval process. The outcome of Phase 1 validates the critical importance of AutoCodes to the regulatory and commercial industry. In conclusion, the AutoCodes Phase 1 Project has provided the necessary foundation for the Committee’s continuing effort to establish a more comprehensive Digital Review Process that streamlines regulatory review and delivers consistent, verifiable code-check results.
Phase 2: Widen Vertical Industry and AHJ Participation, Expand Code Classes

In March 2012, the Committee will commence Phase 2, which adds more industry-vertical and AHJ participants to the project, expands technology and/or guideline development to include more code classes (F&LS, MEP) and requires specifications for and deployment of a technology integration platform to validate streamlining applications and processes.

To successfully manage Phase 2 activities, the Committee enhanced its organizational structure to accommodate a series of industry-vertical-focused Workgroup Committees (Industry Teams), with a view to optimizing subject matter expertise as it relates to technology development and digital review workflow best practices.

As a global retailer, Target Corporation provides expertise regarding the retail merchandise market in its continuing role on the Steering Committee. Kaiser Permanente, a recognized leader in the healthcare services market, will contribute resources for the development of technology and processes relating to Accessibility, Egress and Fire & Life Safety codes applied to healthcare facilities. Each Workgroup Committee will be asked to work with selected AHJs providing regulatory process expertise for testing and validation of technology and practices in a hybrid environment (both 2D and BIM technologies).

At least four additional construction-specific verticals are envisioned for Industry Teams. Each Industry Team will operate with some latitude with regard to its function, but in order to maintain
consistency, a template defining specific requirements is currently under discussion by the Steering Committee.