

# SMARTcodes and e-Government



**SMART**codes ™  
International Code Council

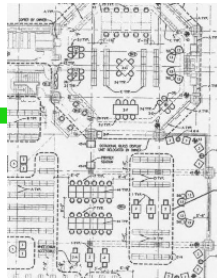


 **INTERNATIONAL  
CODE COUNCIL®**

# A Vision

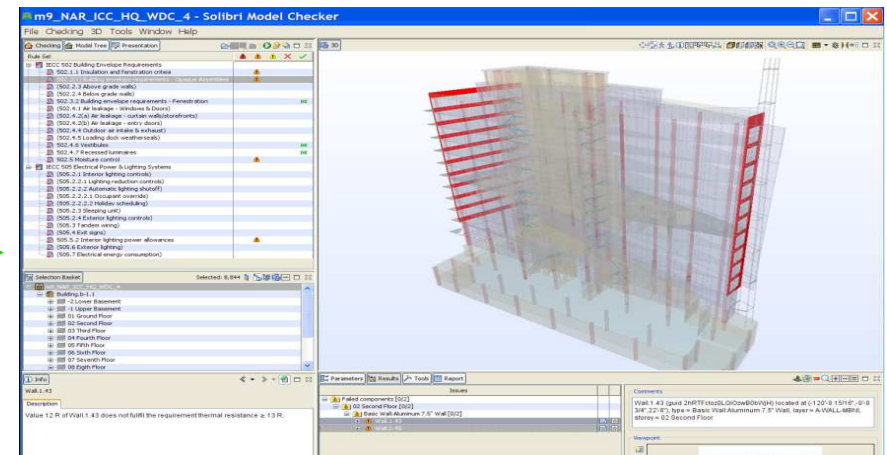
- Designers, specifiers and others collaborate on a building information model (BIM) and submit to regulatory authorities for review
- Regulatory agencies provide coordinated and automated plan review and issue a determination of compliance and permit
- BIM is a basis for collecting information during construction and can be delivered to the owner as an “as-built”

**Building  
Information  
Model  
(BIM)**



**e-Government**

**SMART**codes ™





# An Opportunity

- The building industry annual construction expenditures are on the order of \$5 trillion worldwide, of which the U.S. comprises 30%
- The productivity of the U.S. construction sector has declined over the past 40 years
- Application and use of IT, particularly BIM and smartCODEs, has the potential to reduce construction costs by over 30%
- Resource, safety, economic, demographic, environmental and technical forces are driving the need to change how we deliver and maintain buildings
- Technology can help lead and drive change

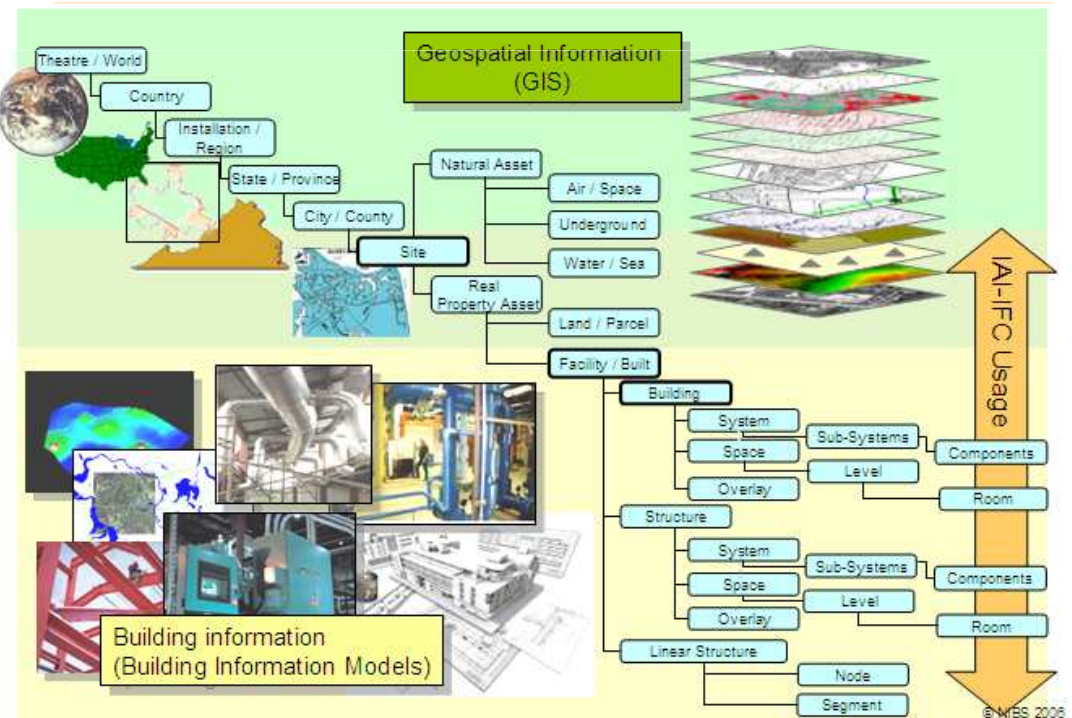


# The Big Picture

....the dynamic and seamless exchange, updating and maintenance of accurate, useful information on the built environment among all members of the building community throughout the lifecycle of a facility

....a smarter process for managing the lifecycle of a project to enhance public safety

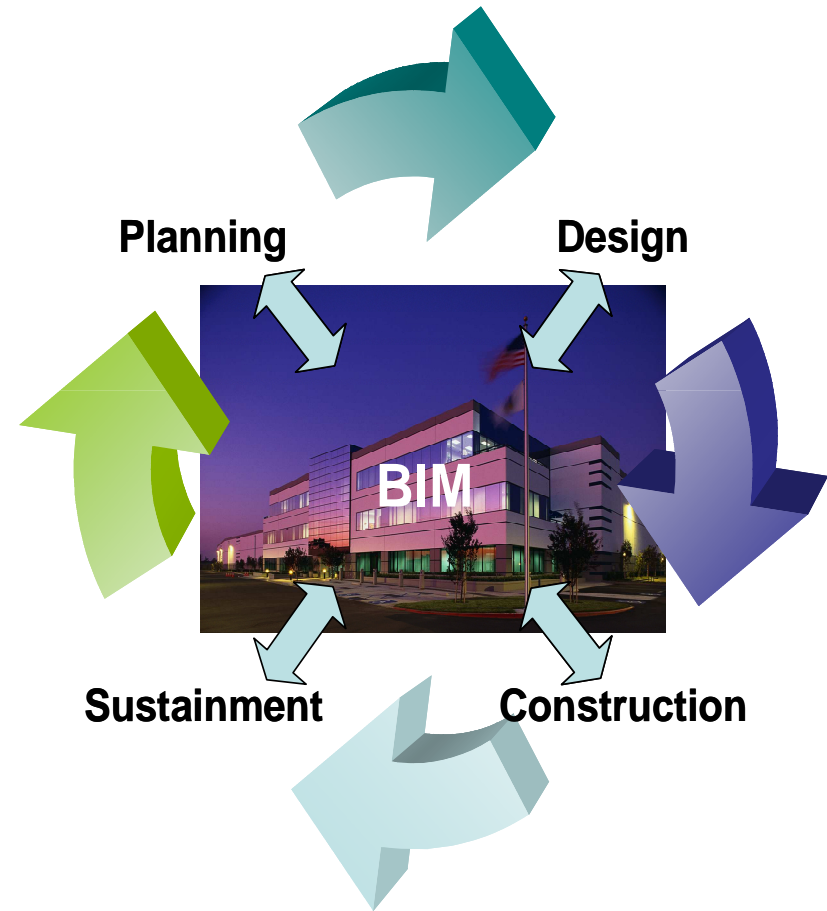
....continual access to and sharing of information about a building



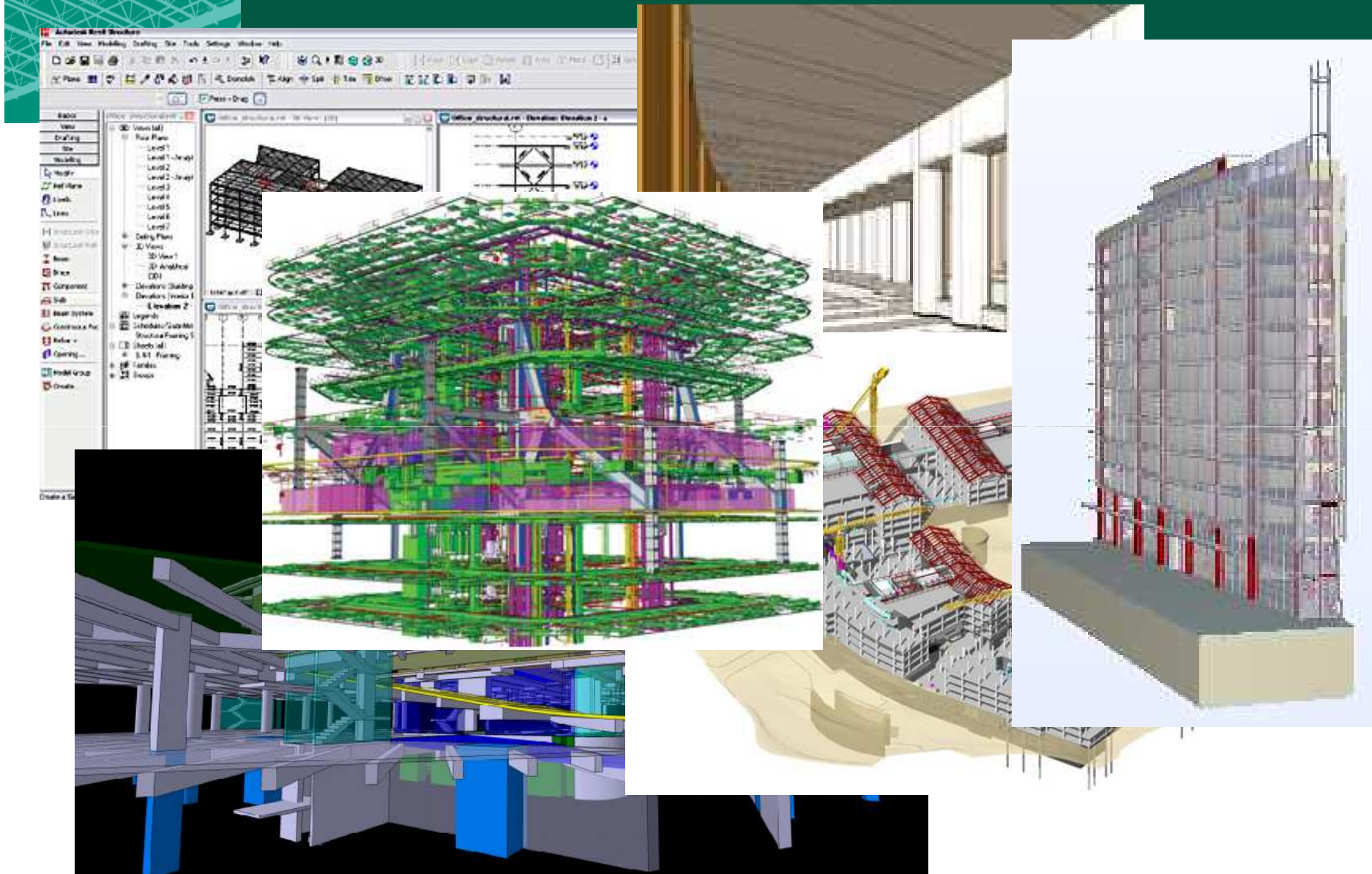
# Building Information Model

A digital representation of physical and functional characteristics of a building (data)

- ... a shared knowledge source or database for intelligent information about a facility that can be maintained over time that
- ... stays with the building forever
- ... can be seamlessly used by all
- ... must follow an established standard if BIMs are to contain needed information in a usable format



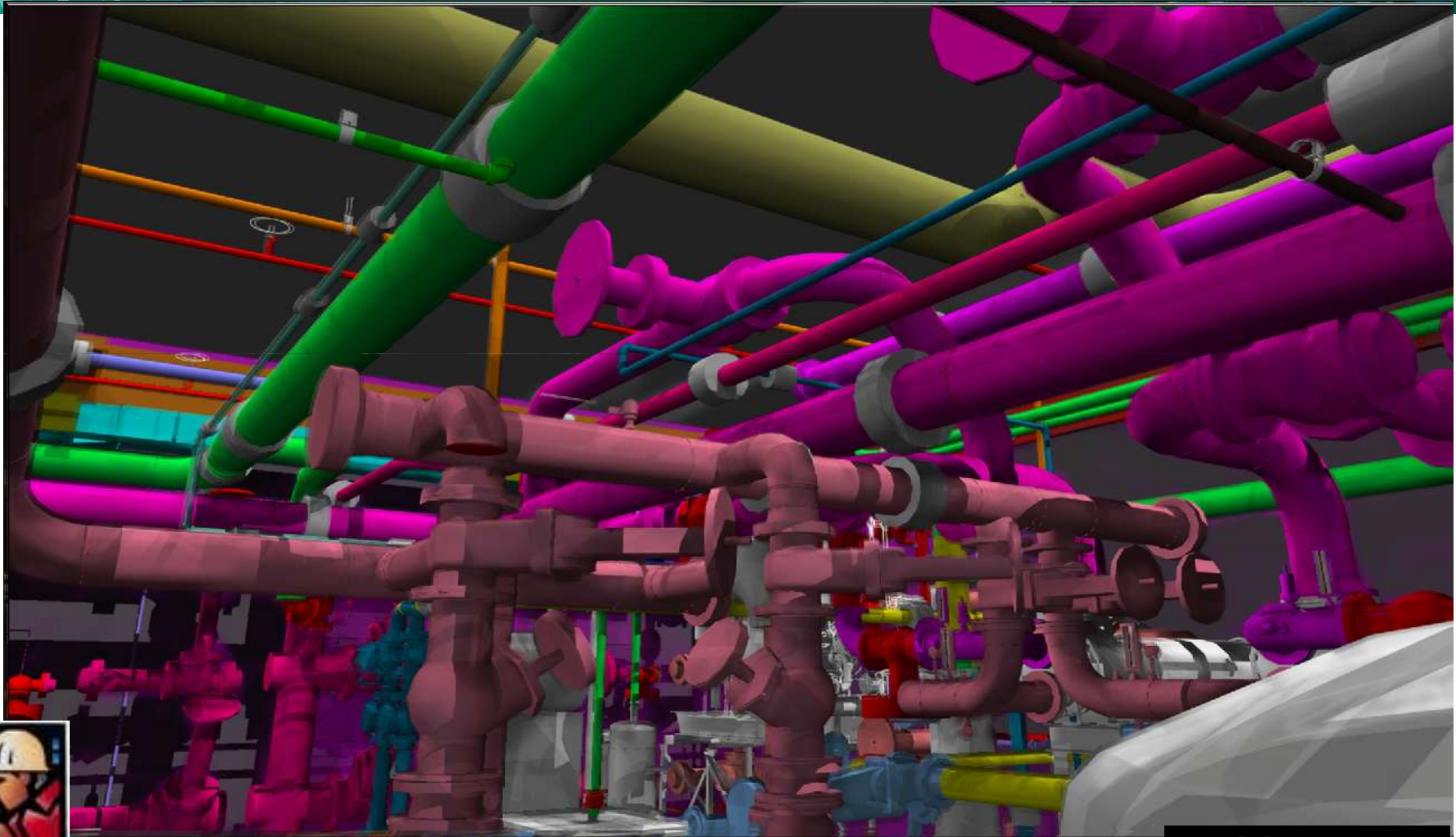
# Building Information Model





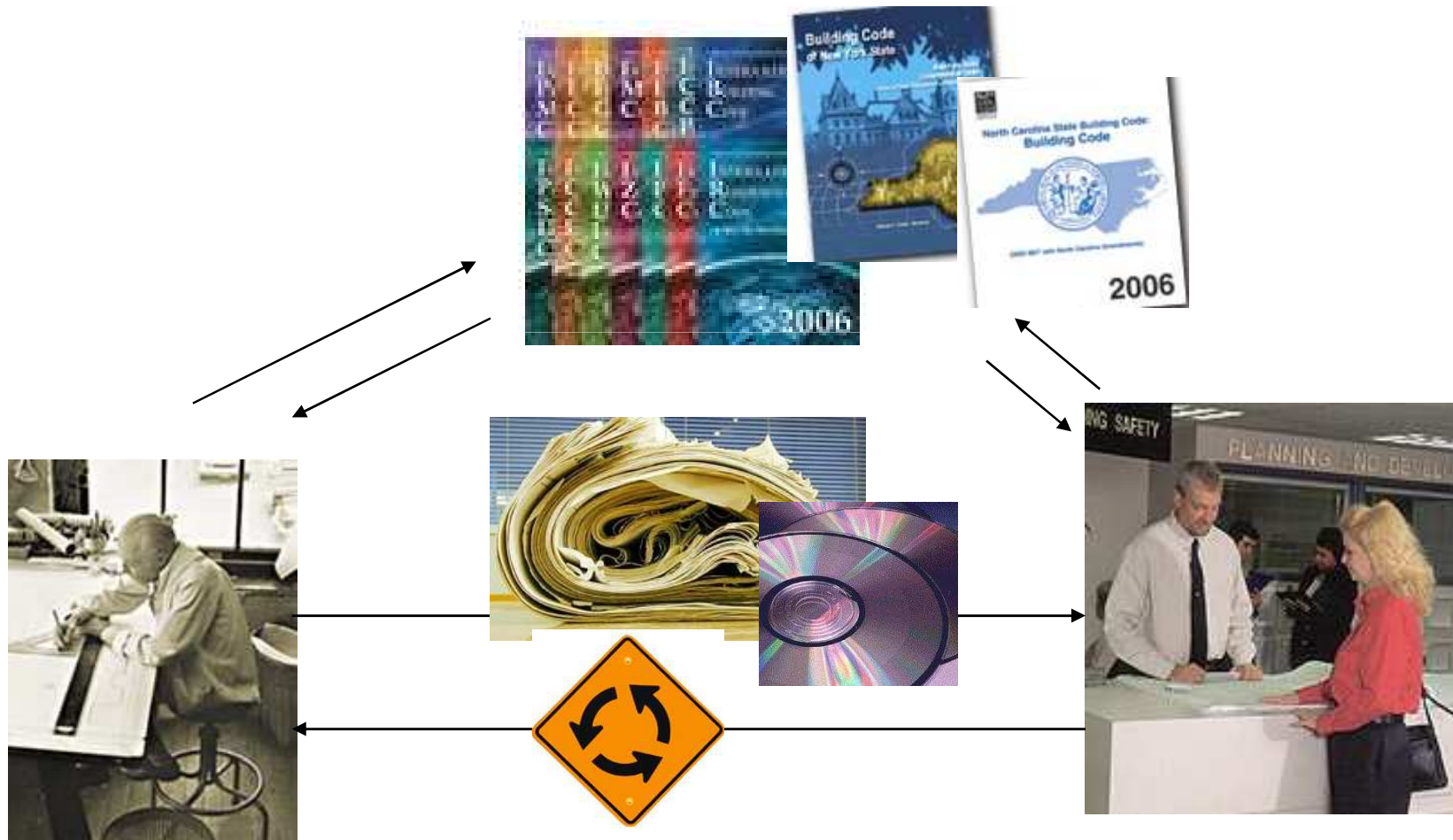
# Major Medical Facility in California

## How close is BIM to reality?



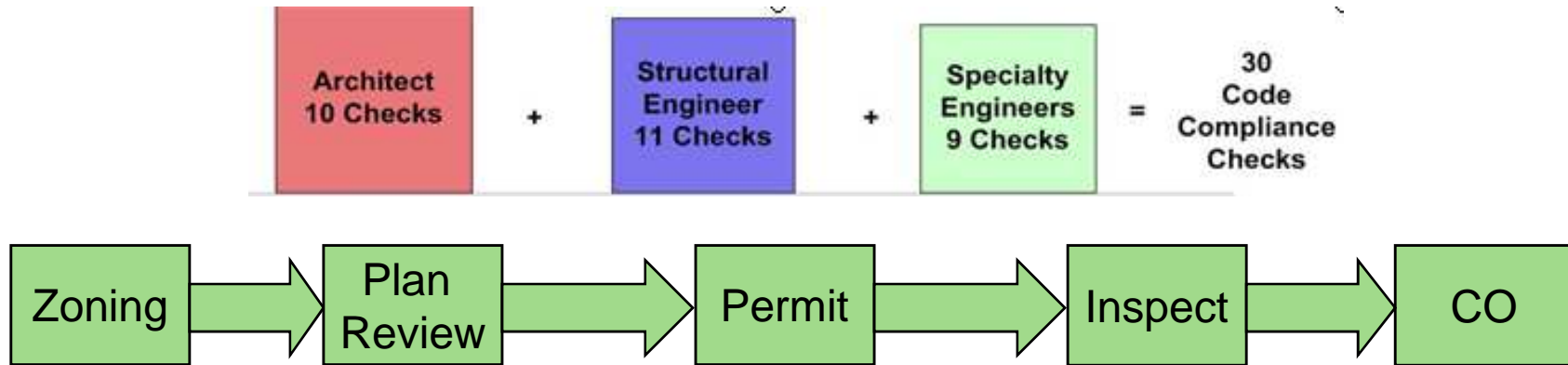
**MCARTHY**

# Code Compliance Today





# Code Compliance Today

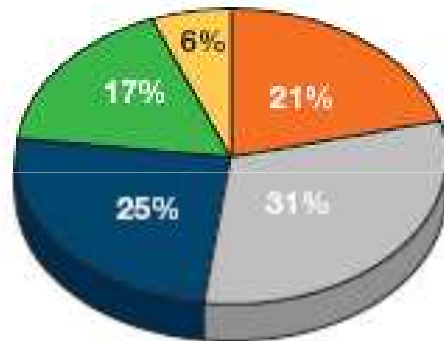


- Linear not circular
- Can be performed independently for each code
- Multiple agencies involved
- Difficulty sharing and collaborating on data
- Does not encourage collaboration with those regulated
- Increased probability of errors
- Less efficient use of time and manpower resources
- Limited application of what IT has to offer

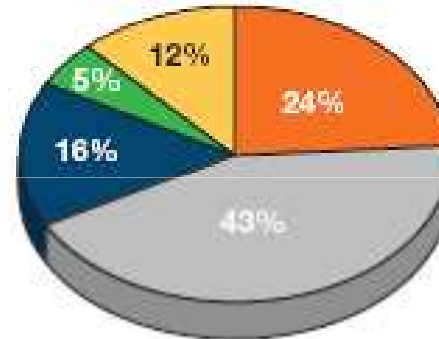
# Code Checking<sup>1</sup>

- Architects on average spend almost 50 hours per project on code checking with 11% spending over 100 hours

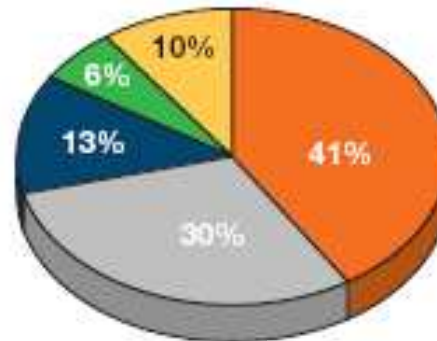
Architects - Average 49.1 hours



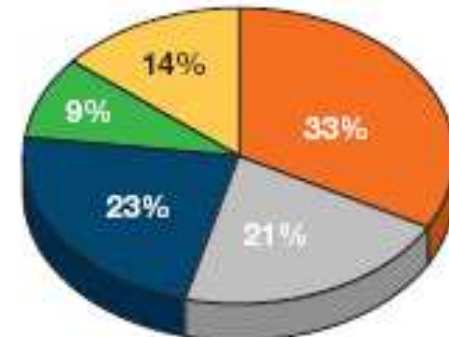
Engineers - Average 51.5 hours



Contractors - Average 56.7 hours



Owners - Average 59.1 hours



1. Interoperability in the Construction Industry  
McGraw Hill Construction, October 2007



# Connecting Codes and BIM

- *85% of architects see great potential in and expressed interest in auto code checking*
- *Owners will increasingly take a leadership role in requiring BIMs due to ability to increase ROI through expediting plan approval and shorter time to occupancy*
- *Code officials are establishing strategic plans for review and acceptance of BIM submittals*
- *The fire service is seeing the potential to use BIM as a resource to protect the public*



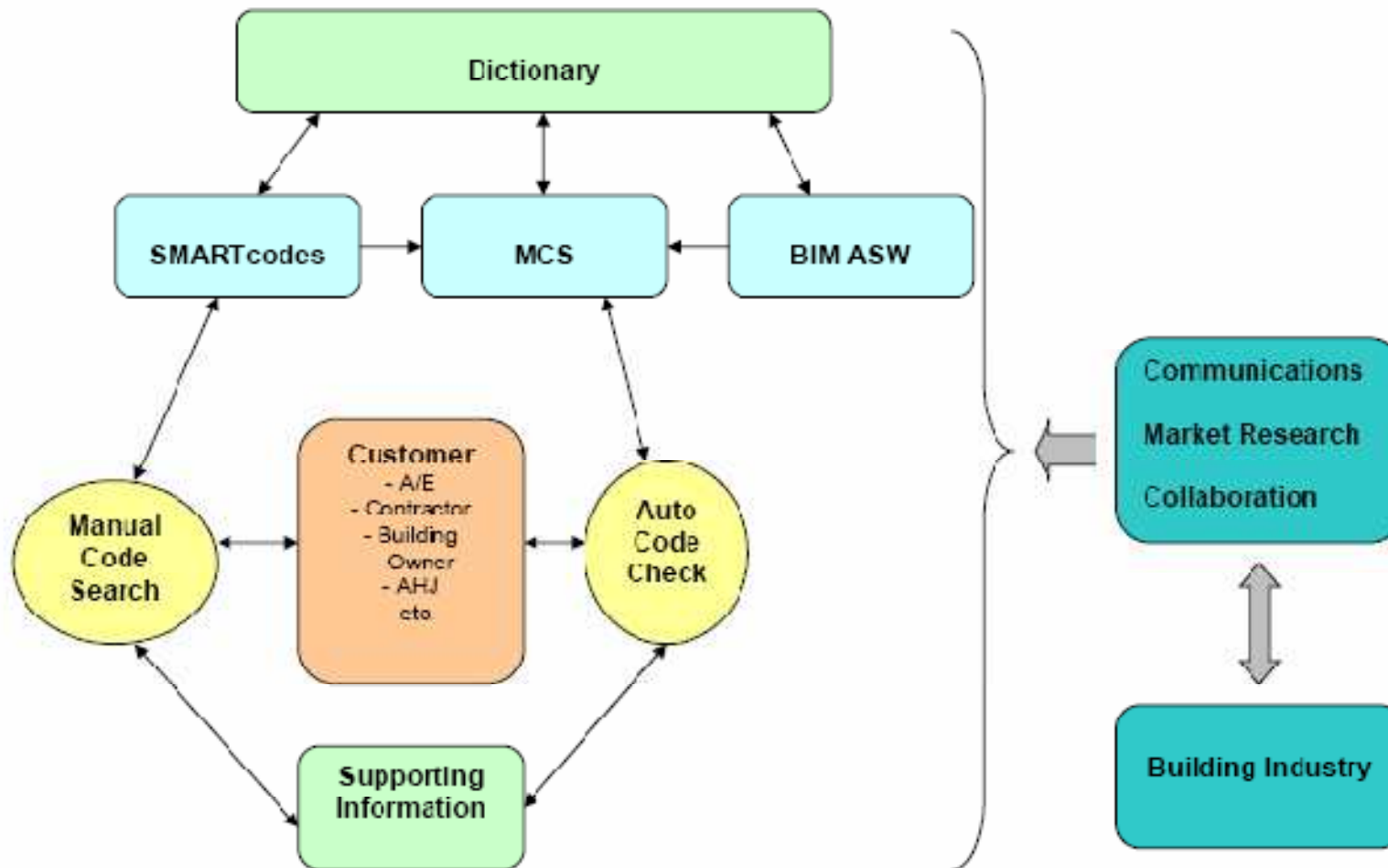
# Building Regulatory Compliance Tomorrow



ICC

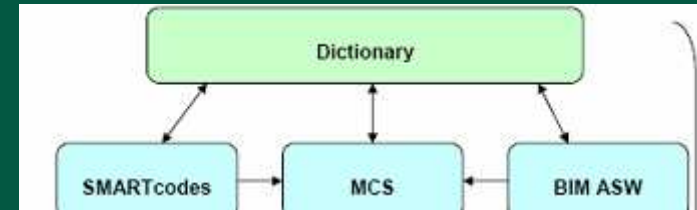
SMARTcodes 

# Project Overview



SMARTcodes 

# Dictionary



- ***Terms***

## ***Insulation***

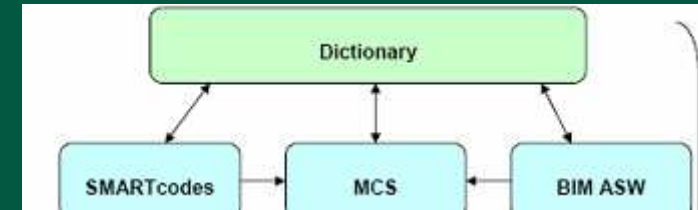
- ***Properties associated with each term***
- ***Enumerations of properties***
- ***Data type***
- ***Units associated with each property***

- ***Type***
- ***Material***
- ***Density***
- ***STC***
- ***FS***
- ***SDR***
- ***Thickness***
- ***R-value***
- ***continuity***

**Model View  
Definition  
(MVD)**



# Dictionary



- ✓ *Energy, egress and access dictionary*
- ✓ *Coordinated with CSI OmniClass and global IFD efforts*

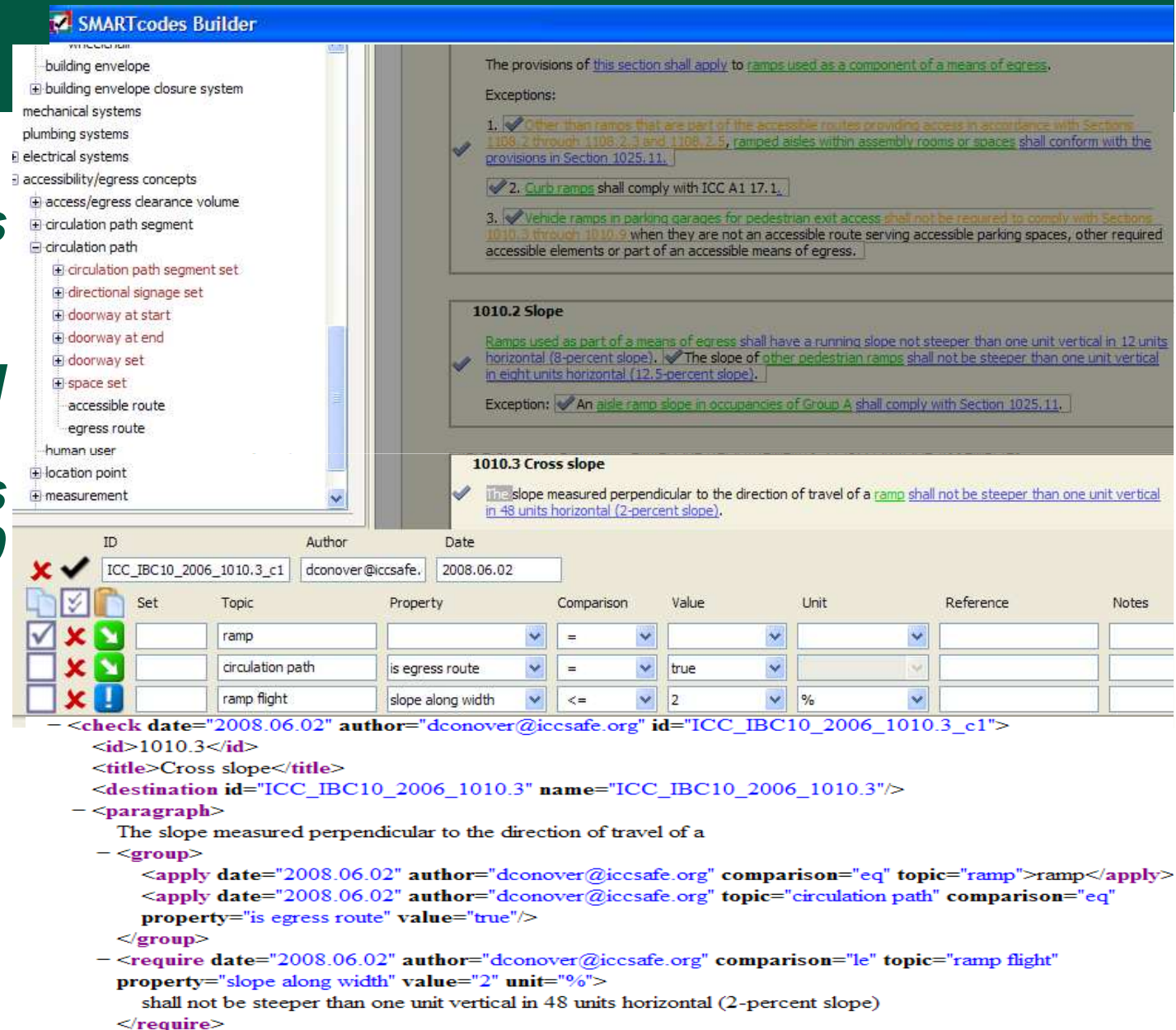
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
	Type	1	2	3	4	5	6	7	8	Definition	Code Sections	Synonyms	Data Type	Units	OmniClass Classification	IFC Object/Property	Code Atom Diffs
1	term	building envelope								The basement walls, exterior walls, floor, roof, and any other building element that enclose conditioned space. This boundary also includes the boundary between conditioned space and any exempt or unconditioned space.	IECC 502						
39	term	wall										above grade wall, below grade wall				IfcWall -- attached Pset_Wall_IECC_2006 with the following properties (except is_external)	
40	property			is external									boolean	n/a		Pset_WallCommon	
41	property			location relative to grade									integer index into enumeration wall_location_relative_to_grade	n/a		simple property in pset	
42	property			primary material						The primary material giving shape/structure to the wall. Note: this property applies to all walls -- even non structural walls. See enumeration of possible values.			integer index into enumeration wall_primary_material	n/a		simple property in pset	
43	term			[a] thermal envelope insulation								thermal block, secondary insulation				Pset_InsulationLayer_IECC_2006 -- attached to IfcMaterialLayer	
44	property			type						physical configuration of the insulation			integer index into enumeration thermal_envelope_insulation_type	n/a		simple property in pset	
45	property			material						material from which the insulation is made			integer index into enumeration thermal_envelope_insulation_material	n/a		simple property in pset	
46	property			density									real number				
47	property																

MVD

# SMARTcodes Protocol and Software

✓ **SMARTcodes protocol - completed and validated**

✓ **SMARTcodes builder – v1.0 completed and tested**



The screenshot displays the SMARTcodes Builder software interface. On the left, a tree view lists building systems: building envelope, building envelope closure system, mechanical systems, plumbing systems, electrical systems, accessibility/egress concepts, access/egress clearance volume, circulation path segment, circulation path, circulation path segment set, directional signage set, doorway at start, doorway at end, doorway set, space set, accessible route, egress route, human user, location point, and measurement. The main area shows a list of exceptions and a table of rules.

**Exceptions:**

- Other than ramps that are part of the accessible routes providing access in accordance with Sections 1008.2 through 1008.2.3 and 1008.2.5, ramped aisles within assembly rooms or spaces shall conform with the provisions in Section 1025.11.
- Curb ramps shall comply with ICC A117.1.
- Vehicle ramps in parking garages for pedestrian exit access shall not be required to comply with Sections 1010.3 through 1010.9 when they are not an accessible route serving accessible parking spaces, other required accessible elements or part of an accessible means of egress.

**1010.2 Slope**

Ramps used as part of a means of egress shall have a running slope not steeper than one unit vertical in 12 units horizontal (8-percent slope). The slope of other pedestrian ramps shall not be steeper than one unit vertical in eight units horizontal (12.5-percent slope).

Exception: An aide ramp slope in occupancies of Group A shall comply with Section 1025.11.

**1010.3 Cross slope**

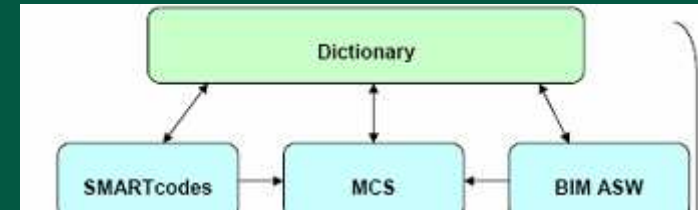
The slope measured perpendicular to the direction of travel of a ramp shall not be steeper than one unit vertical in 48 units horizontal (2-percent slope).

ID	Author	Date	Set	Topic	Property	Comparison	Value	Unit	Reference	Notes
ICC_IBC10_2006_1010.3_c1	dconover@iccsafe.org	2008.06.02		ramp		=				
				circulation path	is egress route	=	true			
				ramp flight	slope along width	<=	2	%		

```

- <check date="2008.06.02" author="dconover@iccsafe.org" id="ICC_IBC10_2006_1010.3_c1">
  <id>1010.3</id>
  <title>Cross slope</title>
  <destination id="ICC_IBC10_2006_1010.3" name="ICC_IBC10_2006_1010.3"/>
  - <paragraph>
    The slope measured perpendicular to the direction of travel of a
    - <group>
      <apply date="2008.06.02" author="dconover@iccsafe.org" comparison="eq" topic="ramp">ramp</apply>
      <apply date="2008.06.02" author="dconover@iccsafe.org" topic="circulation path" comparison="eq"
        property="is egress route" value="true"/>
      </group>
    - <require date="2008.06.02" author="dconover@iccsafe.org" comparison="le" topic="ramp flight"
      property="slope along width" value="2" unit="%">
      shall not be steeper than one unit vertical in 48 units horizontal (2-percent slope)
      </require>
  
```

# SMARTcodes



- ✓ **IECC SMARTcodes – envelope and lighting drafted and “plug and play” with different MCS validated**
- ✓ **Egress and accessibility drafted**
- ✓ **Successful collaboration with two MCS for their application and use of SMARTcodes**
- ✓ **Successful collaboration with four BIM software vendors**

## 502.4 Air leakage. (Mandatory)

### 502.4.1 Window and door assemblies.

✓ The air leakage of [window](#) and [sliding](#) or [swinging door assemblies](#) that are part of the building envelope shall be determined in accordance with AAMA/WDMA/CSA 101/I.S.2/A440, or NFRC 400 by an accredited, independent laboratory, and labeled and certified by the manufacturer and shall not exceed the values in Section 402.4.2.

#### Exception:

[Site-constructed windows](#) and [doors that are weatherstripped or sealed](#) in accordance with Section 502.4.3.

### 502.4.2 Curtain wall, storefront glazing and commercial entrance doors.

✓ [Curtain wall](#), [storefront glazing](#) and [commercial-glazed swinging entrance doors](#) and [revolving doors](#) shall be tested for air leakage at 1.57 pounds per square foot (psf) (75 Pa) in accordance with ASTM E 283. For [curtain walls](#) and [storefront glazing](#), the maximum air leakage rate shall be 0.3 cubic foot per minute per square foot (cfm/ft<sup>2</sup>) (5.5 m<sup>3</sup>/h f#151; m<sup>2</sup>) of fenestration area. For [commercial glazed swinging entrance doors](#) and [revolving doors](#), the maximum air leakage rate shall be 1.00 cfm/ft<sup>2</sup> (18.3 m<sup>3</sup>/h f#151; m<sup>2</sup>) of door area when tested in accordance with ASTM E 283.

### 502.4.3 Sealing of the building envelope.

✓ [Openings](#) and [penetrations](#) in the building envelope shall be [sealed with caulking materials](#) or [closed with gasketing systems compatible with the construction materials and location](#). [Joints](#) and [seams](#) shall be sealed in the same manner or [taped](#) or covered with a moisture vapor-permeable wrapping material. [Sealing materials spanning joints between construction materials](#) shall allow for expansion and contraction of the construction materials.

### 502.4.4 Outdoor air intakes and exhaust openings.

✓ [Stair](#) and [elevator shaft vents](#) and other [outdoor air intakes](#) and [exhaust](#) openings integral to the building envelope shall be equipped with not less than a Class I motorized, leakage-rated damper with a maximum leakage rate of 4 cfm per square foot (6.8 L/s · C m<sup>2</sup>) at 1.0 inch water gauge (w.g.) (1250 Pa) when tested in accordance with AMCA 500D.

#### Exception:

[Gravity \(nonmotorized\) dampers](#) are permitted to be used in buildings less than three stories in height above grade.



# Demonstration

- ✓ *Availability of multiple BIMs for application and use in demonstrations and testing*
- ✓ *Launch of enhanced on-line demonstration of auto code check and manual code search*

INTERNATIONAL CODE COUNCIL®  
People Helping People Build a Safer World™

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Search

Search

SMART

Please make

AEC3 XABIO  
Automatic code compliance checking

Building Correction Notice: Upon inspection, a violation of Code Section ICC\_IECC2006\_502\_5 was in evidence:

Submission:	NAR_ICC_HQ	SLAB:	Basic Roof:Insulation on Concrete slab:322511
PROJECT:	K:\My Documents\DCStrategies\ICC Building\final test\ICC-IFCreadywithLightFixtures.Ifc	Description:	Basic Roof:Insulation on Concrete slab:322511 Slab#48
Description:	K:\My Documents\DCStrategies\ICC Building\final test\ICC-IFCreadywithLightFixtures.Ifc Submission#1	Climate Zone:	4 moist
Site:	Building#1	Geospatial:	(37.553609999999999 deg, -77.460560000000001 deg, 190 ft approx)
Jurisdiction:	Richmond	Position:	(-90.5, 7.1, 141.3 FOOT) (-27.600, 2.178, 43.078 m)
State:	Virginia	Identifier:	3pYgJPQb2Fh8IOJC2Er3O
Identifier:	1cNqCMNcr9ivQHGsZWMQyp	Back:	<a href="#">Return to summary</a>
Feedback:	<a href="#">Thank You</a>	Citation:	<a href="#">ICC IECC2006_502_5 Moisture Control</a>
Inspector:	<a href="#">John Smith</a>	Comment:	Moisture Control may be passed by altering existence of vapor retarder of Basic Roof:Insulation on Concrete slab:322511 Slab#48 to be true
Copyright:	(c) 2006-2007 ICC and AEC3		

ICC

# Automated Code Checking

The screenshot displays the Solibri Model Checker interface, which is used for automated code checking of building information modeling (BIM) data. The interface is divided into several panes:

- Top Pane:** Displays a 3D model of a building. The building has a yellow facade and a blue roof. A red rectangular area on the ground floor indicates a specific location of interest.
- Left Pane:** Contains a "Rule Set" list on the left and a "Selection Basket" on the right. The "Rule Set" list includes various building codes and standards, such as "Building Envelope Requirements", "Insulation and fenestration criteria", "Opaque envelope", "Above-grade walls", "Below-grade walls", "Floors over outdoor air or unconditioned space", "Slabs on grade", "Doors", "FENESTRATION", "Window and door assemblies", "Curtain wall, storefront glazing", "Commercial entrance doors", "Outdoor air intakes and exhaust openings", "Loading dock weatherseals", "Vestibules", "Recessed luminaires", "Moisture control", "ICC\_IECC2006\_S05.xml", and "ELECTRICAL POWER AND LIGHTING SYSTEMS". The "Selection Basket" shows "No Selection".
- Bottom Left Pane:** Contains a "Description" tab for the selected element, "Wall.0.31". The description states: "Value 0 R of Wall.0.31 does not fulfill the requirement thermal resistance  $\geq 13$  R."
- Bottom Right Pane:** Contains a "Results" tab showing a list of issues. The issues are categorized as "Failed components [0/14]", "Missing Information [2/2]", and "Undefined Concepts [0/1]". The "Failed components" list includes: "Basement/Foundation [0/13]", "Floor 1 [0/1]", "Brick Face, 2x6 Stud, Gyp [0/1]", "Wall.0.31", and "Wall.0.31". The "Missing Information" list includes "Wall.0.31". The "Undefined Concepts" list includes "Wall.0.31".

# Automated Code Checking

National Association of Realtors – National Headquarters  
IECC 505 Electrical Power & Lighting Systems  
505.5.2 Interior lighting power allowances  
Results

Page 5 of 5

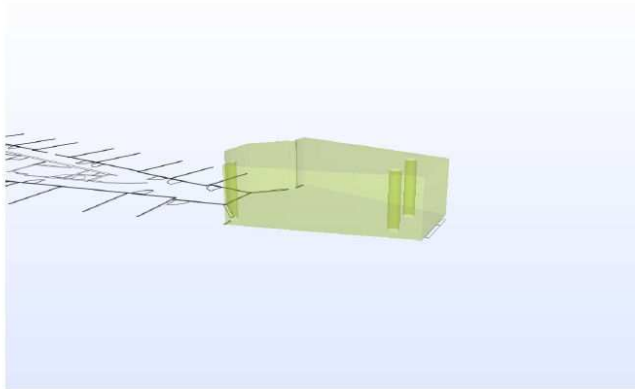
## Failed components

06 Sixth Floor

Office

Space.5.10 : CONFERENCE ROOM[14]

Value 2,436 W/sqft of Space.5.10 : CONFERENCE ROOM[14] does not fulfill the requirement lighting power density  $\leq 1$  W/sqft. Total lighting power is 1,800 W. Space area is 738.83 sq ft



Space.5.10 : CONFERENCE ROOM[14] (GUID 3HCOM\_uILAXRyRUG0xW\_zo) located at (0',0',55'-8"),  
type = CONFERENCE ROOM, layer = A-AREA-IDEN, storey = 06 Sixth Floor

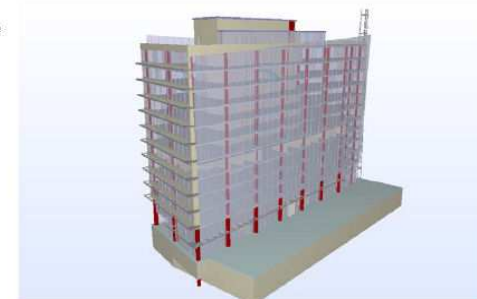
----- Digital Alchemy Automated Code Compliance Checking for SMARTcodes -----  
Powered by Solibri Model Checker

Digital Alchemy Building Code Checking:

## SMARTcodes Code Checking Report for BIMstorm LAX

Building Model: National Association of Realtors - National Headquarters  
Jurisdiction: Los Angeles, CA

Organization: International Code  
Council  
Date: 31-Jan-08



Rule	Result
IECC 502 Building Envelope Requirements	
502.1.1 Insulation and fenestration criteria	Issues
502.2(1) Building envelope requirements - Opaque Assemblies	Issues
(502.2.3 Above grade walls)	Not checked
(502.2.4 Below grade walls)	Not checked
502.3.2 Building envelope requirements - Fenestration	Passed
(502.4.1 Air leakage - Windows & Doors)	Not checked
(502.4.2(a) Air leakage - curtain walls/storefronts)	Not checked
(502.4.2(b) Air leakage - entry doors)	Not checked
(502.4.4 Outdoor air intake & exhaust)	Not checked
(502.4.5 Loading dock weather seals)	Not checked
502.4.6 Vestibules	Passed
502.4.7 Recessed luminaires	Passed
502.5 Moisture control	Passed
IECC 505 Electrical Power & Lighting Systems	
(505.2.1 Interior lighting controls)	Not checked
(505.2.2.1 Lighting reduction controls)	Not checked
(505.2.2.2 Automatic lighting shutoff)	Not checked
(505.2.2.2.1 Occupant override)	Not checked
(505.2.2.2.2 Holiday scheduling)	Not checked
(505.2.3 Sleeping unit)	Not checked
(505.2.4 Exterior lighting controls)	Not checked
(505.3 Tandem wiring)	Not checked
(505.4 Exit signs)	Not checked
505.5.2 Interior lighting power allowances	Issues
(505.6 Exterior lighting)	Not checked
(505.7 Electrical energy consumption)	Not checked

----- Digital Alchemy Automated Code Compliance Checking for SMARTcodes -----  
Powered by Solibri Model Checker



# Why SMARTcodes ?

- *Improved services*
- *High quality code searching*
- *Guided shortlists*
- *Automatic checking of proposals*



# The Basics

- *Each building code is a tree of tests*
- *Each building project is made up of elements and spaces*
- *For the project to pass the code, every element must pass the test*
- *Question: how does a wall pass the plumbing requirements?*
- *Answer: by showing it doesn't apply.*

# What 's a check?

- *A check is any section or sub-section that can be passed or failed. Hence the symbol and box.*
- *Question: what is in a code that is not checks ?*
- *Answer: titles, definitions...*



# What do you mean by highlighting ?

- *Highlighting underlines phrases in four different colors. Behind the highlighting we store the exact meaning, using terms from a dictionary.*
- *Question: what does a check have to contain?*
- *Answer: a requirement*



# What are the four colors for?



Highlight any phrase that means ...

- more scope as a **'select'**
- less scope as an **'applies'**
- 'shall'/'must' as a **'requirement'**
  - NB alternative Requirements
- 'unless' as an **'exception'**
  - NB composite Exceptions

# Alternate requirements and composite exceptions

These cases are quite common and will be discussed later:

- Two or more alternative Requirements
- ... **MUST DO THIS OR DO THAT.**
- Two or more composite Exceptions
- ... **UNLESS THIS AND THAT**

# Example: ICC IECC 2006 502.5

## 502.5 Moisture control. (Mandatory).



All framed walls, floors and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a permeance rating of 1 perm (5.7 f#151; 10<sup>-128;?11</sup> kg/Pa · s · m<sup>2</sup>) or less, when tested in accordance with the dessicant method using Procedure A of ASTM E 96. The vapor retarder shall be installed on the warm-in-winter side of the insulation.

### Exceptions:



1. Buildings located in Climate Zones 1 through 3 as indicated in Figure 301.1 and Table 301.1.
2. In construction where moisture or its freezing will not damage the materials.
3. Where other approved means to avoid condensation in unventilated framed wall, floor, roof and ceiling cavities are provided.



# Commentary

- *Question: why has someone bubbled the ASTM reference ?*
- *Answer: because this is not a part of the requirement – it's a definition of a 'perm' and its measurement.*
- *Question: why is the 'approval' bubbled ?*
- *Answer: because this can not be checked except by an officer.*



# What goes behind an atom ?

- *Specific Topic of Interest*
  - *Property to be tested*
  - *Comparison*
  - *Target Value*
  - *Unit of measure.*
- *building element .*
  - *vapor barrier*
  - *permeance*
  - *less than*
  - *1.0*
  - *perm*

# What information must be in the BIM ?

- *buildingSMART IFC (ISO 16759) – IFC for short*
- *Coordination View MVD – project, site, building, storeys, spaces, walls and slabs, beams, columns, footings, windows, doors and openings, mechanical, electrical and plumbing parts, and their relationships... as commonly produced already,*
- *Plus ...*



# Building Information Models Plus

- *Zone and System group definitions*
- *Ceiling elements and Plenum spaces*
- *Extra sets of information on ...*
  - *Element and Opening*
  - *Project, Site, Building, Storey, Space*
  - *Zone and System*
  - *Type, Material Layer Set, Material Layer, Material*
  - *.....*

# Beyond Plan Review

**Availability of a contemporary and current BIM as a data resource for emergency responders and others during the life of the building**

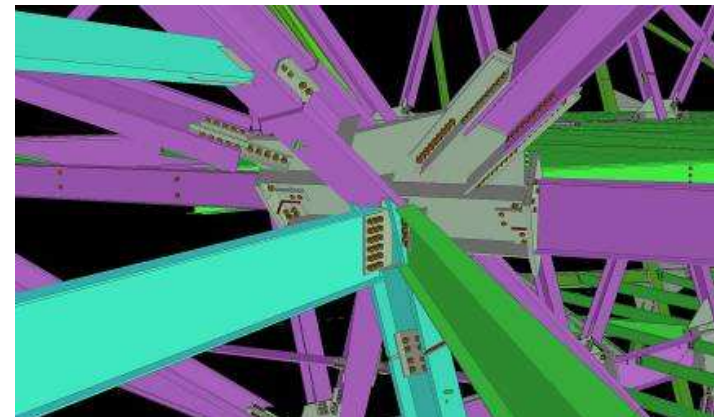
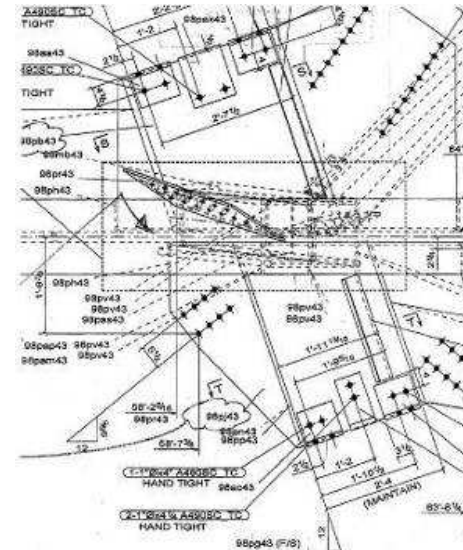
- **Use the BIM as an information resource to capture change orders, construction information and commissioning data to yield an as-built BIM**
- **Maintain and enhance the BIM representing the building as operated and make it available when issues arise that demand timely and accurate information on a building**





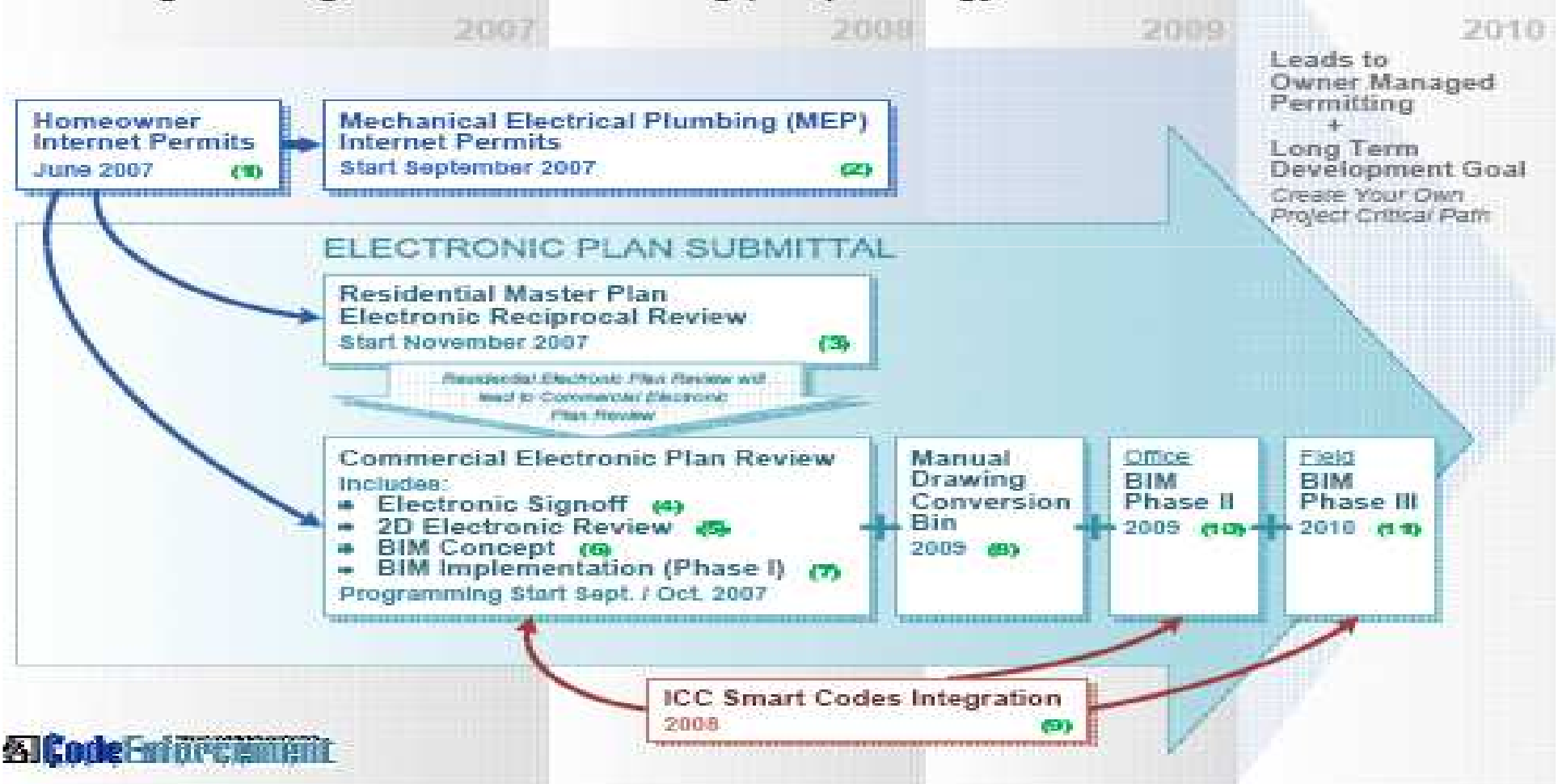
# E-government

- Facilitate current processes and develop new processes based on application of IT
- Plans will evolve from hard copy to e-submission of 2Ds to BIMs
- Conduct virtual reviews in 3D and 4D automatically



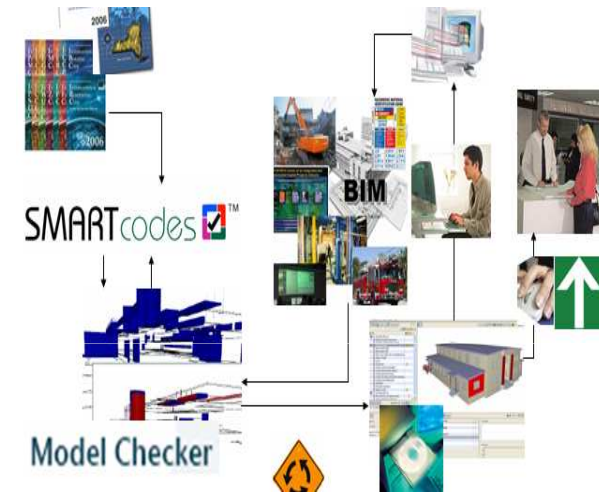
# ePermitting Strategy Mecklenburg County, NC

## Electronic Plan Submittal (EPS) Five Year Technology Strategy Including Building Information Modeling (BIM) Strategy



# Future Outlook for e-Government

- Standards for BIMs, communication and data interaction
- A new design and construction process founded on interoperability
- e-Government software and portals for BIM submittal and auto checking
- More timely and accurate review and approval of plans
- More timely and robust construction review and record availability
- Better buildings and increased public safety



# Summary

*Availability of BIMs creates an opportunity for auto code checking and related products and services*



*Availability of SMARTcodes and auto code checking can drive demand for and use of BIMs*



# Thank You!

## Any Questions?



**ICC**

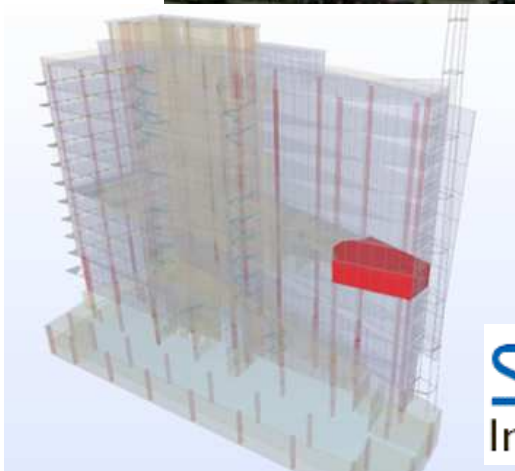
**500 New Jersey Avenue**

**6th Floor**

**Washington, DC 20001**

**Stephen Benedict**

**Design + Construction Strategies, LLC**



**SMART**codes ™  
International Code Council

