developing open information exchange standards

E. William East, PE, PhD
buildingSMART Alliance Project Coordinator

Dana Smith, AIA
buildingSMART Alliance Executive Director

what is interoperability?

"a property referring to the ability of diverse systems and organizations to work together ."

ref: Wikipedia, http://en.wikipedia.org/wiki/Interoperability (cited 30-June-08)

what is interoperability?

"The ability of software and hardware on multiple machines from multiple vendors to communicate."

ref: *DLI Glossary*, Grainger Engineering Library, University of Illinois at Urbana-Champaign, http://dli.grainger.uiuc.edu/glossary.htm (cited 30-June-08)

what is interoperability?

"The ability of different types of computers, networks, operating systems, and applications to work together effectively, ***without prior communication***"

ref: *Information Services Metadata*, University of Melbourne, http://www.infodiv.unimelb.edu.au/metadata/glossary.html cited 30-June-2008

what is interoperability?

"to work with other systems or products ***without special effort on the part of the customer***. "

ref: *Digital Television Glossary,* University of Michigan, www.michigandtv.com/glossary cited 30-June-08

what is interoperability?

The ability to …

"implement and manage collaborative relationships among members of cross-disciplinary teams"

"manage and communicate electronic product and project data among collaborating firms"

ref: *Interoperability in the Construction Industry,* SmartMarket Report, McGraw-Hill, 2007

how is it defined?

Please, tell us what you want…

…can't you tell us what we want?

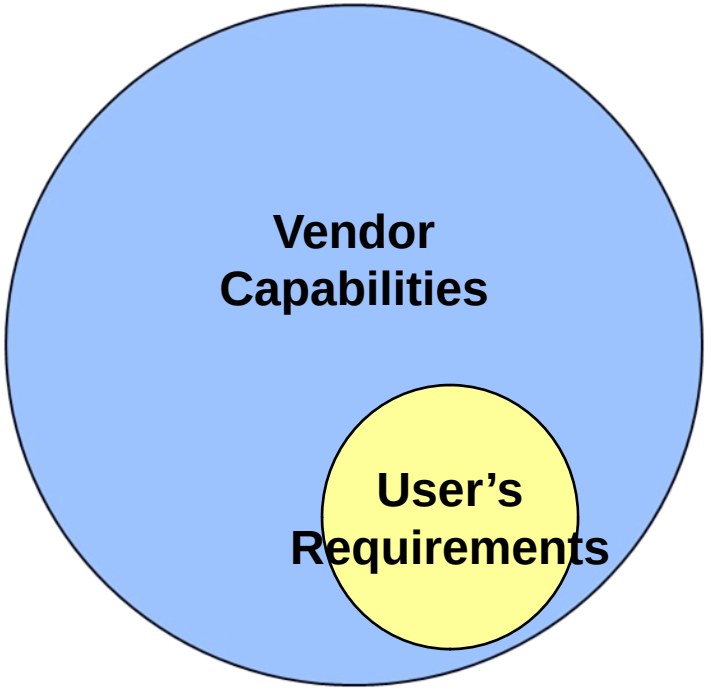
Unfortunately….

User's inability to clearly define detailed requirements requires software companies to make assumptions that may not work for a wider audience.

tightly coupled interoperability

Pro's

inexpensive to define limited requirements
rapid implementation in vendor software



Con's

resulting capability limited
directly linked to vendor-specific solutions
custom software development
expensive to maintain
may be "owned" by one or more participants

provides rapid, expensive, short-lived solutions

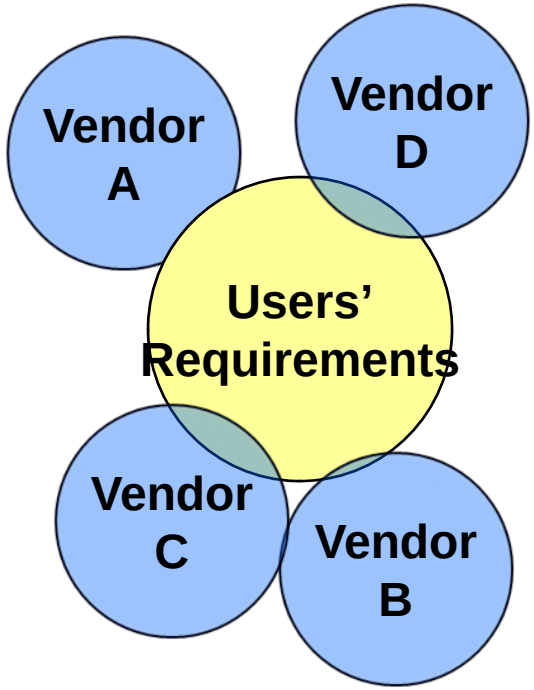
loosely coupled interoperability

Pro's

inexpensive evaluation of cursory requirements
rapid demonstrations

Con's

resulting capability does not solve the problem
resulting capability based on custom platforms
directly linked to vendor-specific solutions



provides rapid, state-of-practice descriptions

interoperability is overrated!

- vagueness in process allows sloppiness in result
  - “special” configuration settings
  - tech support not aware of “special” settings
  - not repeatable without specific software stack
  - not enforceable by contract

- vagueness of results in misplaced expectations
  - frustration
  - proprietary specifications

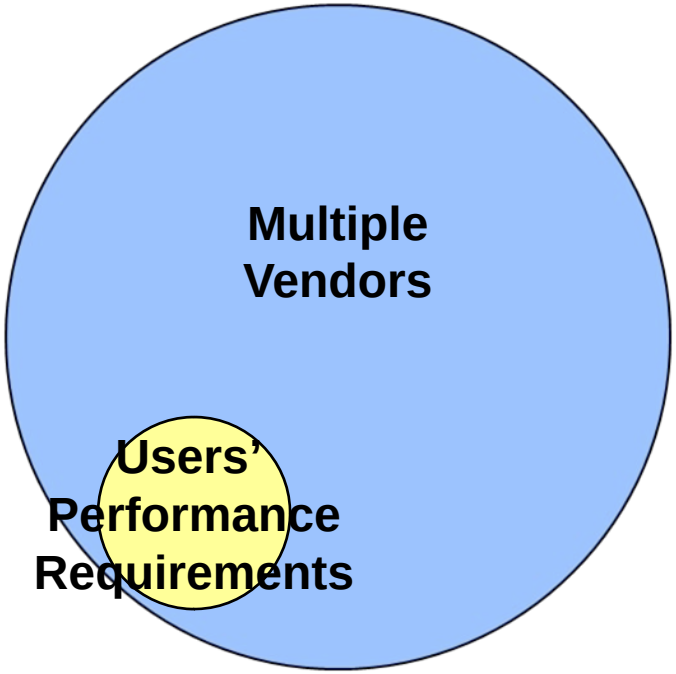
performance-driven interoperability

Pro's

requirements owned by stakeholders
provides open-solution to defined problem
path from current to future requirements
platform/version neutral solutions
empowers market innovation

Con's

buy-in from major stakeholder (reps.)
buy-in from major professional/trade assns.
meetings & coordination required
management of expectations
requires preparation of contract specifications



provides long-term solutions at least total cost

contracted information exchanges

- in contracts today
- in paper or e-paper formats
- examples in owner-based contracts include:
  - design deliverables
  - quality certifications
  - construction submittals
  - handover documents

contracted information exchanges

specifications define:

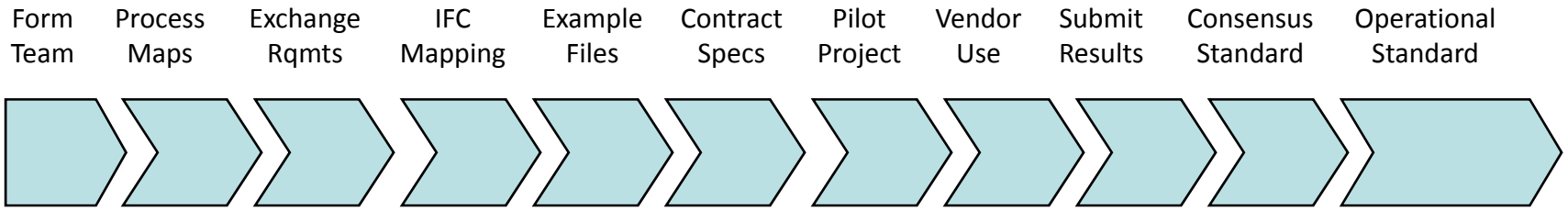
- information content
  - based on national consensus
  - Likely to be international variation
- deliverable timing
- format of data exchange
  - non-proprietary international standard
  - widely used by vast majority of stakeholders

contracted information exchanges

from e-paper to useful information

- an open process to update these specs
- software to import/export the data
- parties must use the specs
- outreach to community
  - demos with full disclosure of settings
  - repeatable at local end-user offices

information exchange roadmap



process designed to have questions answered up-front

subject matter experts, not consultants, drive the process

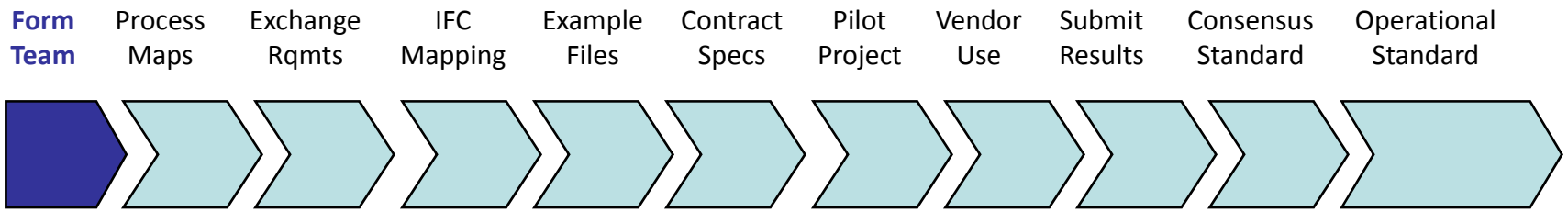
it is a “problem solving” not a “technology tinkering” process

technical work and pilots can be done in 12-24 months

goal is to meet 80% solution, don’t let perfection get in the way of progress

industry-wide adoption, well, we’ll all work on that one!

1. form team



teams are formed by subject matter experts to solve specific problems

teams need to have appropriate stakeholder representation

the Alliance supports teams with websites, listserve

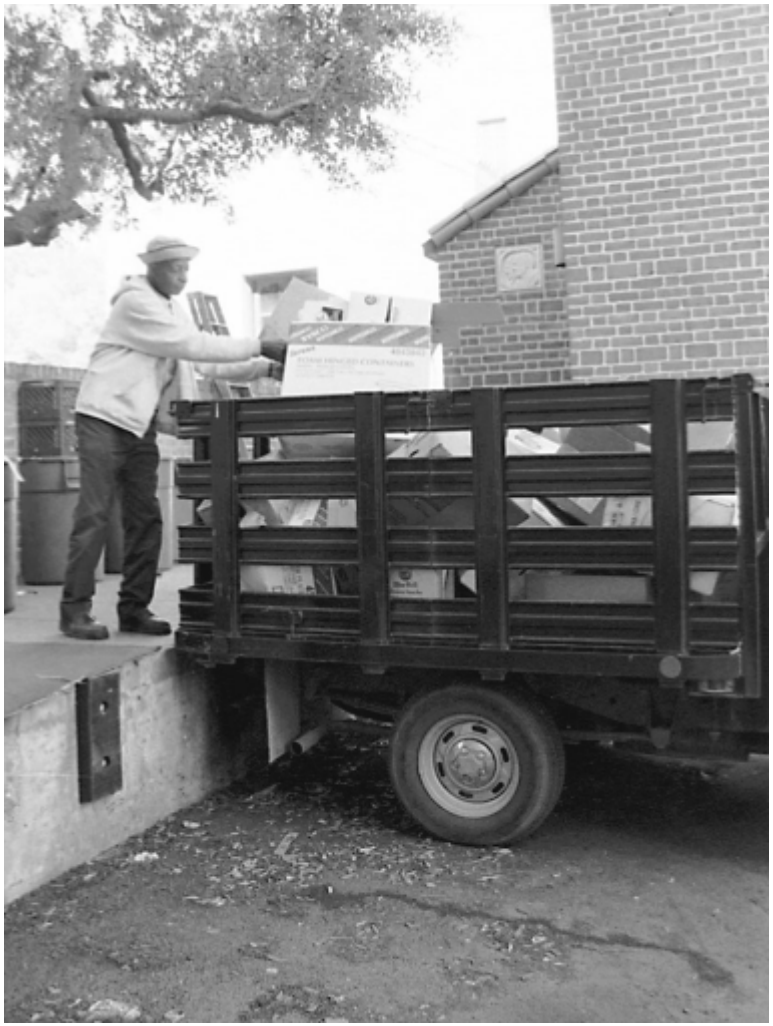
if team are Bronze or better, Alliance will hire ‘guide’ through process

a concise statement about specific exchanges causing problem

lessons learned – don’t start with IFC, start with clear problem statement

1. form team (cobie)

- today, handover information is created and lost ***several*** times
- designer creates space and equipment layouts
- construction contractor post-construction survey
- surveys “stored” in boiler rooms
- (*maintenance contractor paid to survey building*)
- hand load data into maintenance system

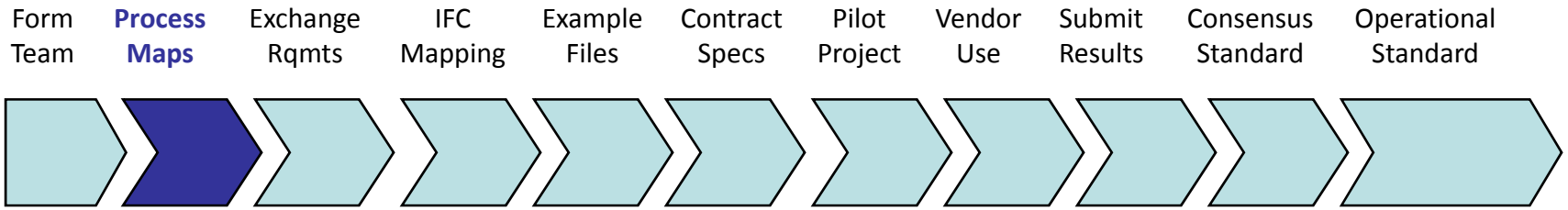


1. form team (cobie)

owners, designers, builders, operators, 3rd party providers

i.e. all parties who contribute/produce/use handover data

2. process maps



who needs what information when

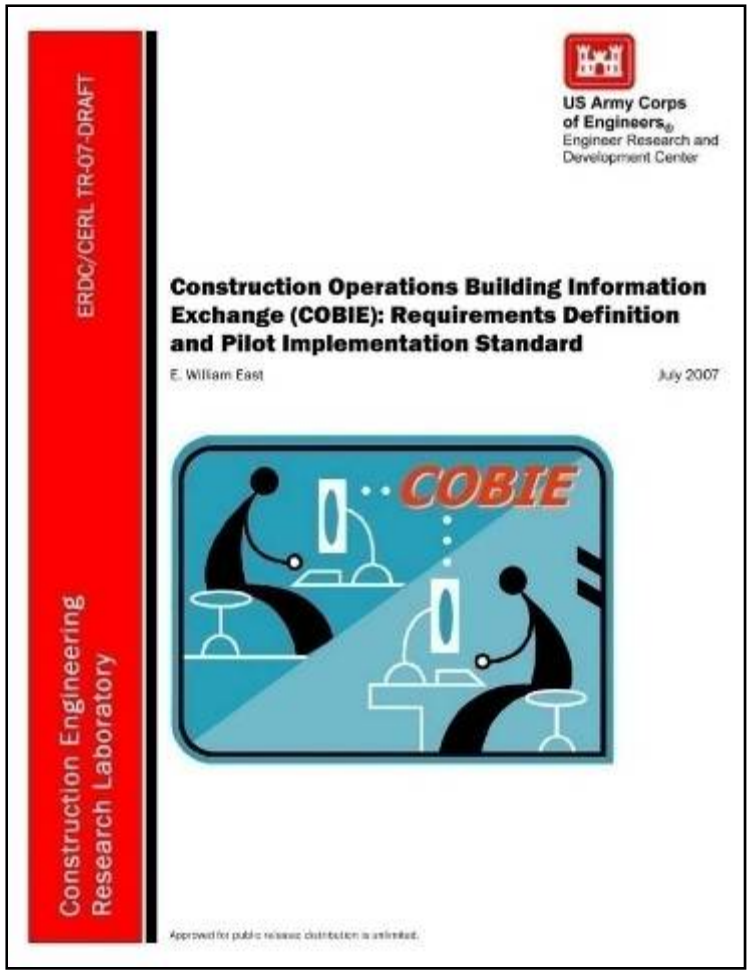
uses Business Process Modeling Notation (www.bpmn.org)

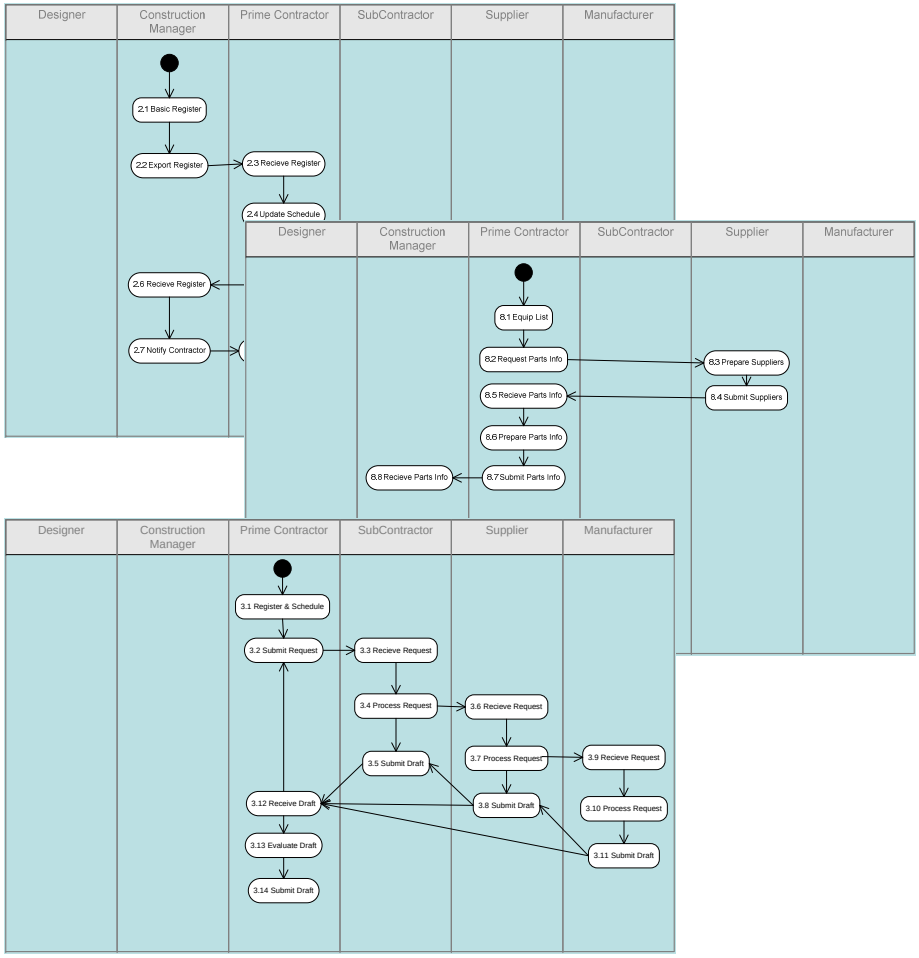
creates “swim lane” diagrams

identifies what information is given to whom, when

clearly defines the exchanges that, if resolved, would solve the problem

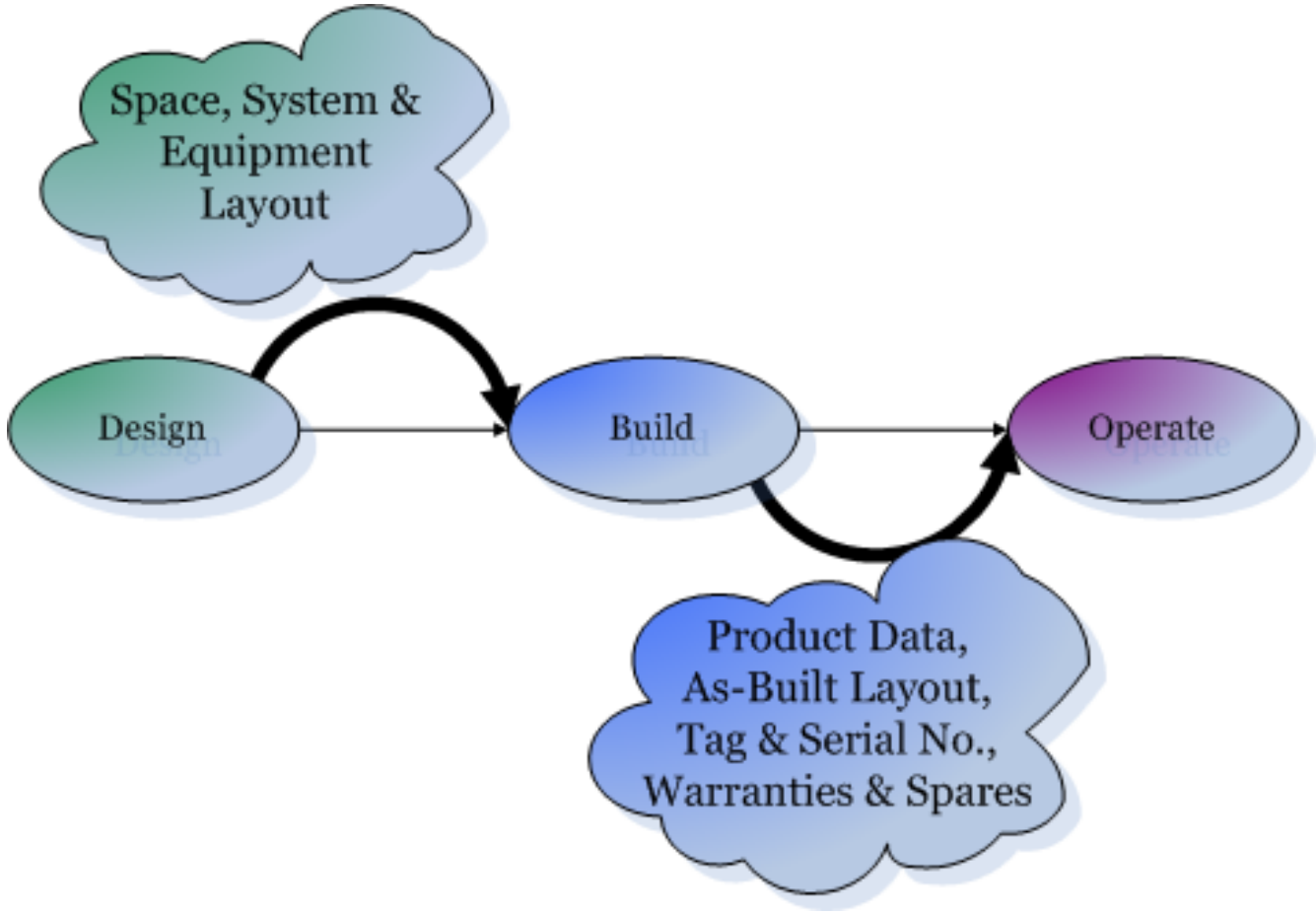
2. process maps (cobie)





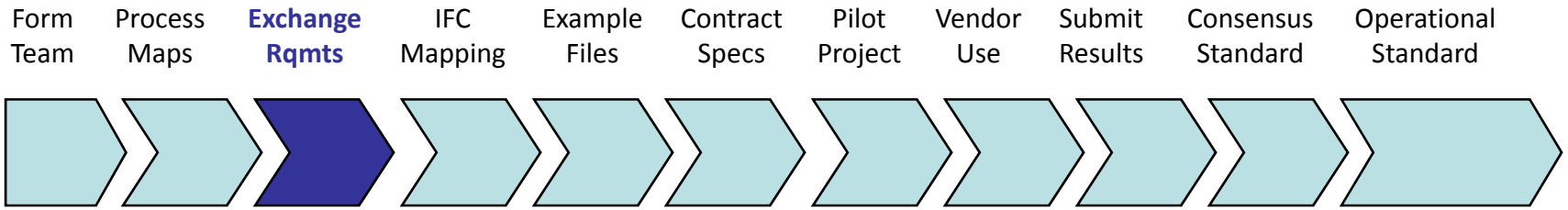
ref: http://www.wbdg.org/pdfs/erdc_cerl_tr0730.pdf

2. process maps (cobie)



ref: http://www.wbdg.org/resources/cobie.php

3. exchange requirements



based on “swim lane” diagram

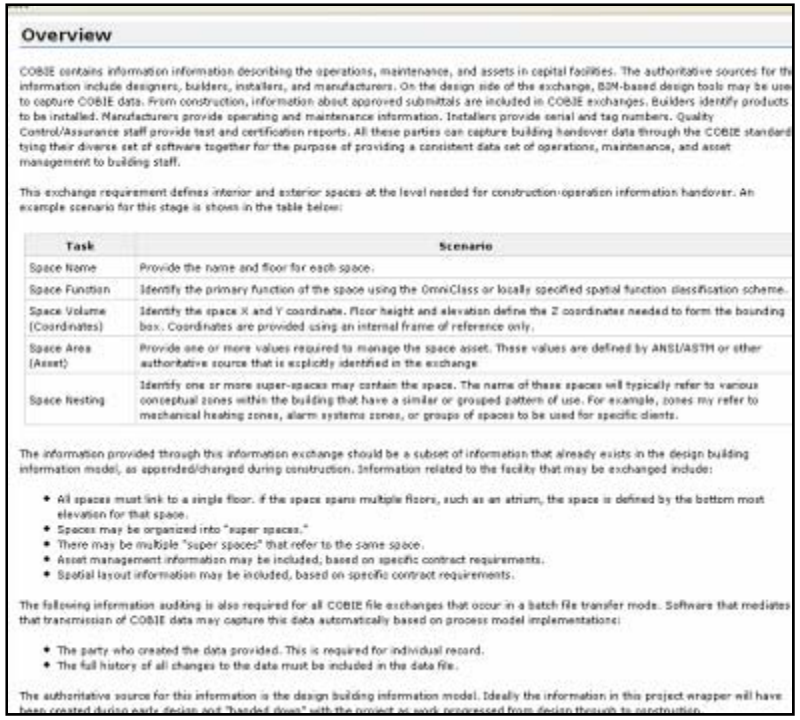
define what information is exchanged, during context of process

compare to existing sources of data for this exchange

find out where the gaps are between today and what’s needed

a concise statement about specific data on “swim lane” arrows

3. exchange requirements (cobie)



Overview

COBIE contains information information describing the operations, maintenance, and assets in capital facilities. The authoritative sources for th information include designers, builders, installers, and manufacturers. On the design side of the exchange, BIM-based design tools may be use to capture COBIE data. From construction, information about approved submittals are included in COBIE exchanges. Builders identify products to be installed. Manufacturers provide operating and maintenance information. Installers provide serial and tag numbers. Quality Control/Assurance staff provide test and certification reports. All these parties can capture building handover data through the COBIE standard tying their diverse set of software together for the purpose of providing a consistent data set of operations, maintenance, and asset management to building staff.

This exchange requirement defines interior and exterior spaces at the level needed for construction-operation information handover. An example scenario for this stage is shown in the table below:

Task	Scenario
Space Name	Provide the name and floor for each space.
Space Function	Identify the primary function of the space using the OmniClass or locally specified spatial function classification scheme.
Space Volume (Coordinates)	Identify the space X and Y coordinate. Floor height and elevation define the Z coordinates needed to form the bounding box. Coordinates are provided using an internal frame of reference only.
Space Area (Asset)	Provide one or more values required to manage the space asset. These values are defined by ANSI/ASTM or other authoritative source that is explicitly identified in the exchange
Space Nesting	Identify one or more super-spaces may contain the space. The name of these spaces will typically refer to various conceptual zones within the building that have a similar or grouped pattern of use. For example, zones my refer to mechanical heating zones, alarm systems zones, or groups of spaces to be used for specific clients.

The information provided through this information exchange should be a subset of information that already exists in the design building information model, as appended/changed during construction. Information related to the facility that may be exchanged include:

- All spaces must link to a single floor. If the space spans multiple floors, such as an atrium, the space is defined by the bottom most elevation for that space.
- Spaces may be organized into "super spaces."
- There may be multiple "super spaces" that refer to the same space.
- Asset management information may be included, based on specific contract requirements.
- Spatial layout information may be included, based on specific contract requirements.

The following information auditing is also required for all COBIE file exchanges that occur in a batch file transfer mode. Software that mediates that transmission of COBIE data may capture this data automatically based on process model implementations:

- The party who created the data provided. This is required for individual record.
- The full history of all changes to the data must be included in the data file.

The authoritative source for this information is the design building information model. Ideally the information in this project wrapper will have been created during early design and "handed down" with the project as work progressed from design through to construction.

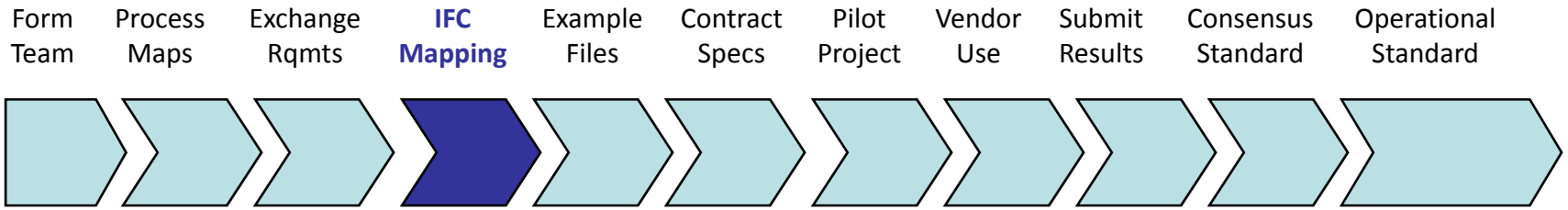
Subject matter experts document what data is needed when…

Project Stage

Stage	Name	Valid
0	Portfolio requirements	
1	Conception of need	
2	Outline feasibility	
3	Substantive feasibility	
4	Outline conceptual design	
5	Full conceptual design	
6	Coordinated design and procurement	
7	Production information	
8	Construction	✓
9	Operation and maintenance	✓
10	Disposal	

ref: http://idm.buildingsmart.no/confluence/display/IDM/COBIE+Project

4. ifc mapping



first step to consider actual ifc model

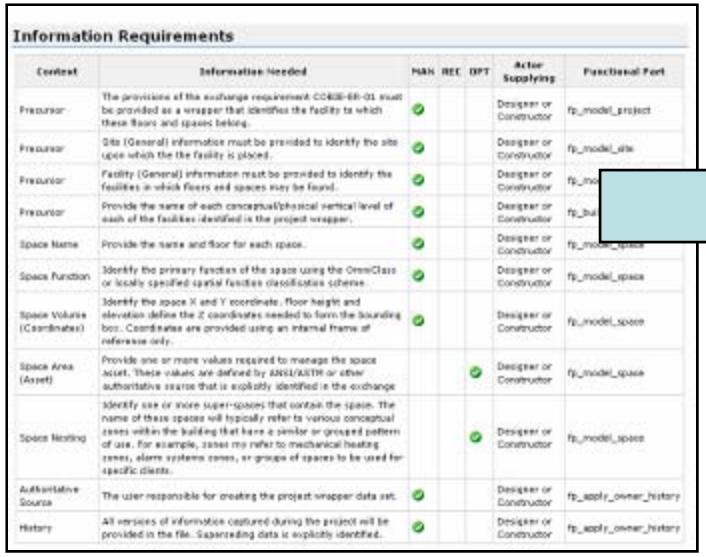
ifc modeler support recommended for this step

“model view definition” is coordinated with international IAI

identify if existing IAI activities have/are working on this

implementation formats developed in “human usable” format also

4. ifc mapping (cobie)



Information Requirements

Context	Information Needed	MAN	REC	OPT	Actor Supplying	Functional Part
Precursor	The provisions of the exchange requirement COBIE-EX-01 must be provided as a wrapper that identifies the facility to which these floors and spaces belong.	✓			Designer or Constructor	fp_model_project
Precursor	Site (General) information must be provided to identify the site upon which the the facility is placed.	✓			Designer or Constructor	fp_model_site
Precursor	Facility (General) information must be provided to identify the facilities in which floors and spaces may be found.	✓			Designer or Constructor	fp_mo
Precursor	Provide the name of each conceptual/physical vertical level of each of the facilities identified in the project wrapper.	✓			Designer or Constructor	fp_bu
Space Name	Provide the name and floor for each space.	✓			Designer or Constructor	fp_model_space
Space Function	Identify the primary function of the space using the OmniClass or locally specified spatial function classification scheme.	✓			Designer or Constructor	fp_model_space
Space Volume (Coordinates)	Identify the space X and Y coordinate. Floor height and elevation define the Z coordinates needed to form the bounding box. Coordinates are provided using an internal frame of reference only.	✓			Designer or Constructor	fp_model_space
Space Area (Asset)	Provide one or more values required to manage the space asset. These values are defined by ANSI/ASTM or other authoritative source that is explicitly identified in the exchange			✓	Designer or Constructor	fp_model_space
Space Nesting	Identify one or more super-spaces that contain the space. The name of these spaces will typically refer to various conceptual zones within the building that have a similar or grouped pattern of use. For example, zones may refer to mechanical heating zones, alarm systems zones, or groups of spaces to be used for specific clients.			✓	Designer or Constructor	fp_model_space
Authoritative Source	The user responsible for creating the project wrapper data set.	✓			Designer or Constructor	fp_apply_owner_history
History	All versions of information captured during the project will be provided in the file. Superseding data is explicitly identified.	✓			Designer or Constructor	fp_apply_owner_history

ref: http://idm.buildingsmart.no/confluence/display/IDM/COBIE+Project

IFC Entities Required

- IfcElement
- IfcObject
- IfcProduct
- IfcRoot
- IfcSpace
- IfcSpatialStructureElement

IFC Datatypes Req

- IfcElementCompositionEnu
- IfcGloballyUniqueId
- IfcInternalOrExternalEnum
- IfcLabel
- IfcLengthMeasure
- IfcText

IFC Functions Req

- .

IFC Property Sets

- Pset_SpaceCommon

IDM Functional Pa

- fp_address
- fp_aggregates
- fp_apply_owner_history
- fp_apply_quantity
- fp_contains_in_spatial_str
- fp_define_by_properties
- fp_place_object

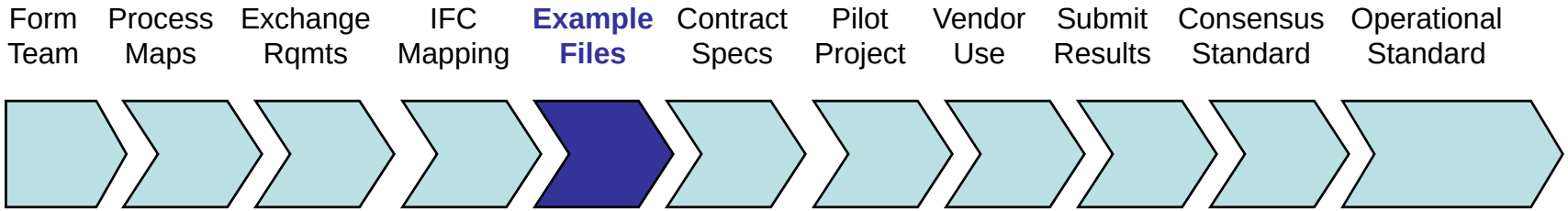
EXPRESS Schema

```
SCHEMA FP_MODEL_SPACE;

  TYPE IfcGloballyUniqueId = STRING (22) FIXED;
  END_TYPE;

  TYPE IfcLabel = STRING;
  END_TYPE;

  TYPE IfcLengthMeasure = REAL;
  END_TYPE;

  TYPE IfcText = STRING;
  END_TYPE;

  TYPE IfcElementCompositionEnum = ENUMERATION OF
    (COMPLEX,
     ELEMENT,
     PARTIAL);
  END_TYPE;

  TYPE IfcInternalOrExternalEnum = ENUMERATION OF
    (INTERNAL,
     EXTERNAL,
     NOTDEFINED);
  END_TYPE;

  ENTITY IfcProduct
    ABSTRACT SUPERTYPE
    SUBTYPE OF(IfcObject);
      ObjectPlacement : OPTIONAL fp_place_object;
      Representation  : OPTIONAL fp_represent_product;
    WHERE
      WR1 : (EXISTS(Representation) AND EXISTS(ObjectPlacement))
            OR (EXISTS(Representation) AND
            (NOT('IFC2X2_FINAL.IFCPRODUCTDEFINITIONSHAPE' IN TYP
            OR (NOT(EXISTS(Representation)));
```

Ref: http://idm.buildingsmart.no/confluence/display/IDM/Model+Space+%28FP%29

cobie-specific ifc model: http://www.wbdg.org/zips/cobie_working_2008_html.zip

5. example files



"a picture is worth a thousand words"

examples from real, but "sanitized" projects for public release

examples should exercise several exchange parts

examples should demonstrate who provides what data

examples help exercise problem statement and prior steps

5. example files (cobie)

multiple mappings to formal ifc definitions may be required

ifcXML file of ifcSpace object

```
    </RelativePlacement>
  </IfcLocalPlacement>
  <!-- Representation of  COBIE worksheet 04-Space key 1  -->
- <IfcSpace id="_04_sp_HE000000000000_1">
    <GlobalId>_04_sp_HE000000000000_1</GlobalId>
  - <OwnerHistory>
      <IfcOwnerHistory xsi:nil="true" ref="_01_oh_HE000000000000_2" />
    </OwnerHistory>
    <Name>B1.001</Name>
    <Description>Baggage collation</Description>
    <ObjectType>13-15 21 11 27 Material Handling Area</ObjectType>
  - <ObjectPlacement>
      <IfcLocalPlacement xsi:nil="true" ref="lp_04_1" />
    </ObjectPlacement>
  - <Representation>
    - <IfcProductDefinitionShape>
      - <Representations>
        - <IfcShapeRepresentation>
          - <ContextOfItems>
              <IfcGeometricRepresentationContext xsi:nil="true" ref="grc1" />
            </ContextOfItems>
            <RepresentationIdentifier />
            <RepresentationType>BoundingBox</RepresentationType>
          - <Items>
            - <IfcBoundingBox>
              - <Corner>
                  <IfcCartesianPoint xsi:nil="true" ref="origin" />
                </Corner>
                <XDim>3000.</XDim>
                <YDim>3000.</YDim>
                <ZDim>3000.</ZDim>
              </IfcBoundingBox>
            </Items>
          </IfcShapeRepresentation>
        </Representations>
      </IfcProductDefinitionShape>
    </Representation>
    <LongName>Baggage collation</LongName>
    <CompositionType>element</CompositionType>
```

spreadsheet format (for us humans!) can also be used!

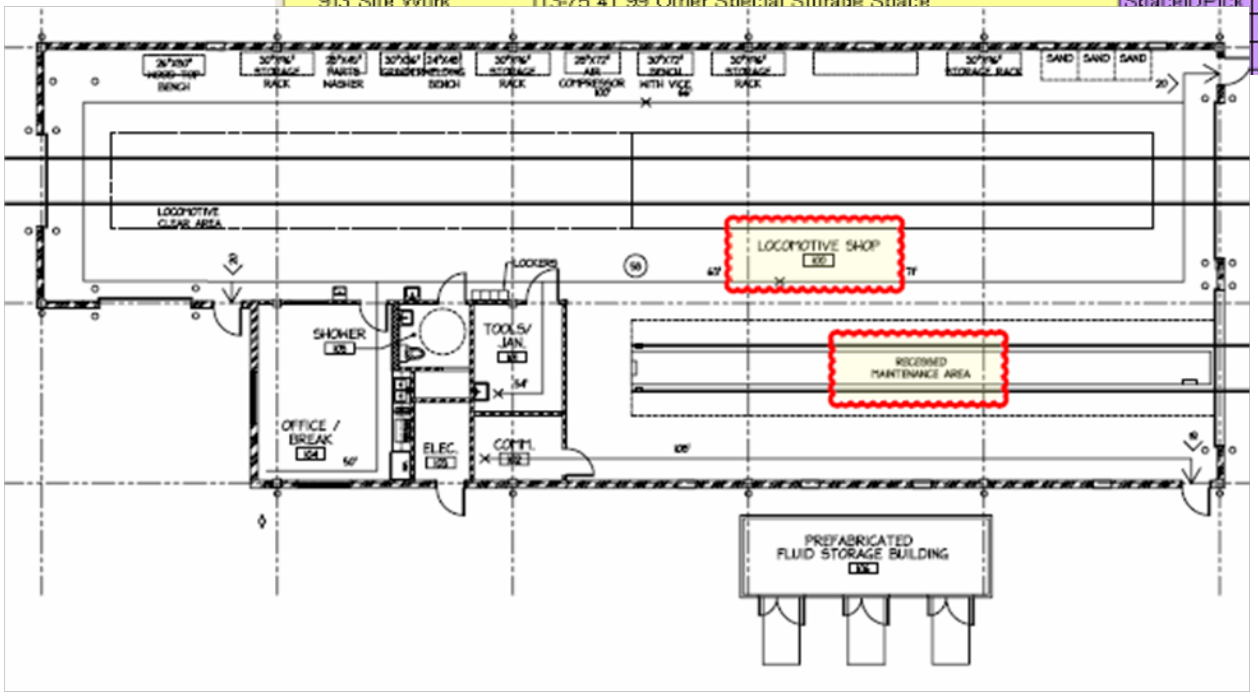
	A	B	C	D	E	F	G	H
1	SpaceID	FloorID	SpaceFunction	SpaceReferenceID	SpaceNumber	SpaceName	SpaceDescription	SpaceUsableHeight
2	1	1	15 36 10 Material Handling space	SpaceID	B1.001	Baggage collation	Baggage collation	
3	2	1	15 36 10 Material Handling space	SpaceID	B1.002	baggage dispatch	baggage dispatch	
4	3	2	15 36 10 Material Handling space	SpaceID	B2.002	baggage reception	baggage reception	
5	4	2	15 36 10 Material Handling space	SpaceID	B2.001	baggage holding	baggage holding	
6	5	4	10 10 00 Gathering	SpaceID	OE.C01	departure lounge	departure lounge	
7	6	4	10 00 00 Interacting	SpaceID	OE.C02	departure gate	departure gate	
8	7	3	10 10 00 Gathering	SpaceID	AR.C01	arival corridor	arival corridor	
9	8	3	10 00 00 Interacting	SpaceID	AR.C02	passport control	passport control	
10	9	5	15 11 10 Office space	SpaceID	OF.C01	administration	administration	
11	10	5	10 72 10 Conference Room	SpaceID	OF.C02	conferecne room	conferecne room	

cobie format translator available to vendors

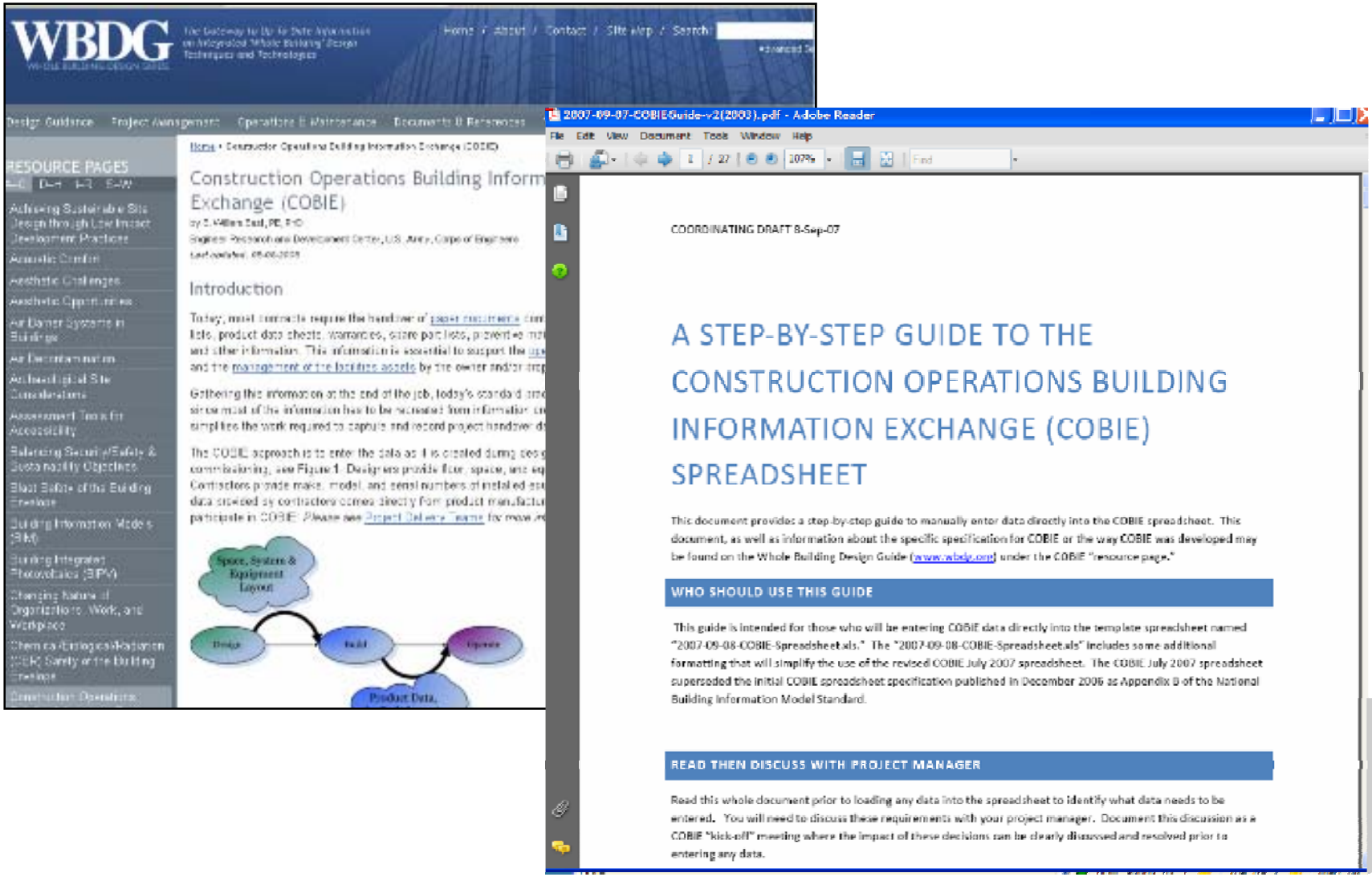
cobie spreadsheet examples available through WBDG

5. example files (cobie)

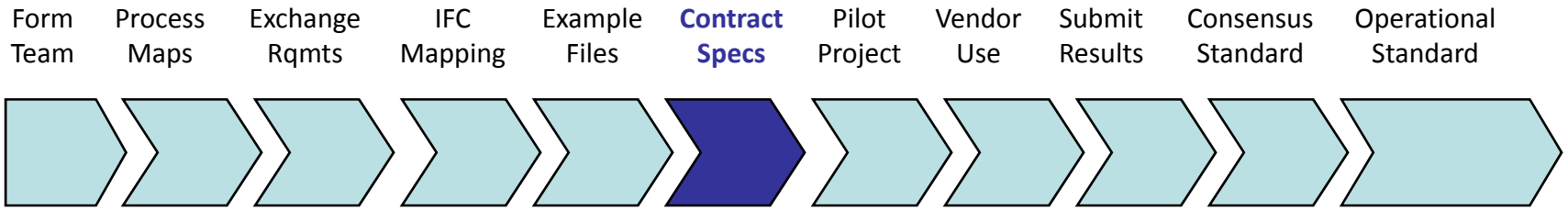
SpaceID	FloorID	SpaceFu	SpaceRef	External	External	SpaceNu	SpaceNar	SpaceDes
1	1,First Floor	13-15 21 17 Maintenance Spaces	SpaceIDPick			100	Maintenance Bay	
2	1,First Floor	13-15 21 17 Maintenance Spaces	1,100			100A	Locomotive Shop	
3	1,First Floor	13-15 21 17 Maintenance Spaces	1,100			100B	Recessed Maintenance Area	
4	1,First Floor	13-75 00 00 Storage Spaces	SpaceIDPick			101	Tools/Janitor	
5	1,First Floor	13-81 21 24 Telecommunications Room	SpaceIDPick			102	Communication room	
6	1,First Floor	13-81 21 21 Electrical Room	SpaceIDPick			103	Electrical Room	
7	1,First Floor	13-15 11 34 11 Office	SpaceIDPick			104	Office/ Break	
8	1,First Floor	13-41 11 14 14 Shower	SpaceIDPick			105	Shower	
9	3 Site Work	13-75 41 99 Other Special Storage Space	SpaceIDPick			106	Prefab Fluid Storage Bldg.	
						0	Roof	
						0	Exterior Pavement	



5. example files (cobie)



6. contract specs



if it is not in a contract, it won't be used

find current information exchanges on which project is based

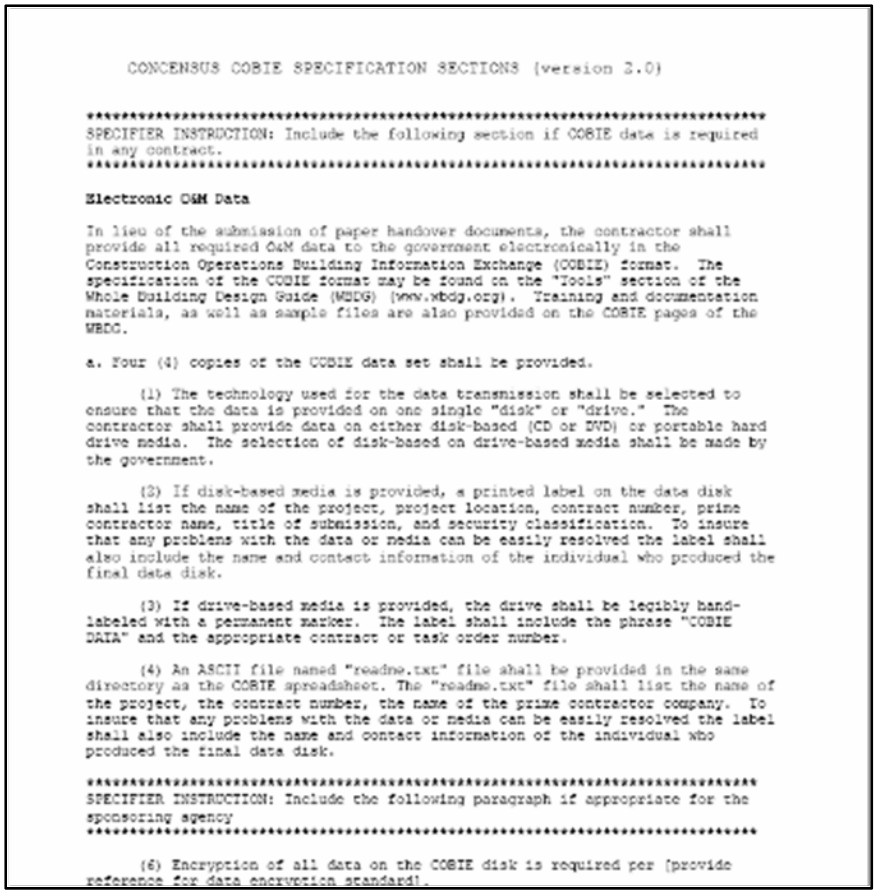
modify those examples to change "format" and "content" of deliverable

specification states who provides what data, when

specification must include true cost of information exchange failure

6. contract specs (cobie)

- replaces paper-based specifications
- designer submits space and equipment layouts with plans and specs
- construction contractor loads mfg, serial, and tag no's
- commissioning agent provides job plans
- final deliverable eliminates paper reproduction



CONCENSUS COBIE SPECIFICATION SECTIONS (version 2.0)

****
SPECIFIER INSTRUCTION: Include the following section if COBIE data is required in any contract.
****

Electronic O&M Data

In lieu of the submission of paper handover documents, the contractor shall provide all required O&M data to the government electronically in the Construction Operations Building Information Exchange (COBIE) format. The specification of the COBIE format may be found on the "Tools" section of the Whole Building Design Guide (WBDG) (www.wbdg.org). Training and documentation materials, as well as sample files are also provided on the COBIE pages of the WBDG.

a. Four (4) copies of the COBIE data set shall be provided.

(1) The technology used for the data transmission shall be selected to ensure that the data is provided on one single "disk" or "drive." The contractor shall provide data on either disk-based (CD or DVD) or portable hard drive media. The selection of disk-based or drive-based media shall be made by the government.

(2) If disk-based media is provided, a printed label on the data disk shall list the name of the project, project location, contract number, prime contractor name, title of submission, and security classification. To insure that any problems with the data or media can be easily resolved the label shall also include the name and contact information of the individual who produced the final data disk.

(3) If drive-based media is provided, the drive shall be legibly hand-labeled with a permanent marker. The label shall include the phrase "COBIE DATA" and the appropriate contract or task order number.

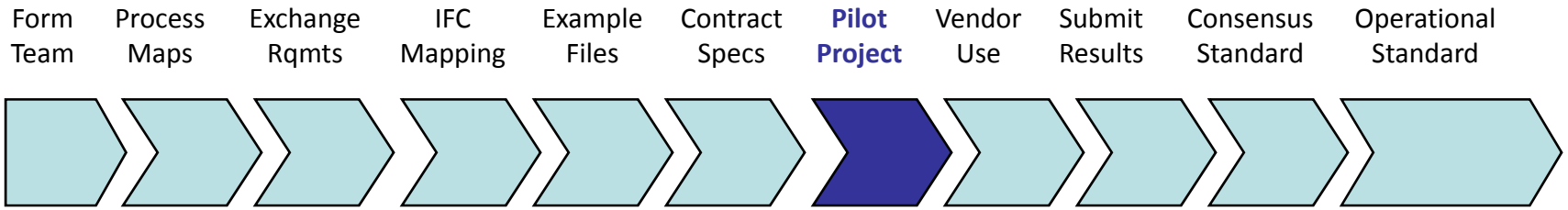
(4) An ASCII file named "readme.txt" file shall be provided in the same directory as the COBIE spreadsheet. The "readme.txt" file shall list the name of the project, the contract number, the name of the prime contractor company. To insure that any problems with the data or media can be easily resolved the label shall also include the name and contact information of the individual who produced the final data disk.

****
SPECIFIER INSTRUCTION: Include the following paragraph if appropriate for the sponsoring agency
****

(5) Encryption of all data on the COBIE disk is required per [provide reference for data encryption standard].

ref: http://www.wbdg.org/pdfs/cobie_specification_sections.pdf

7. pilot project



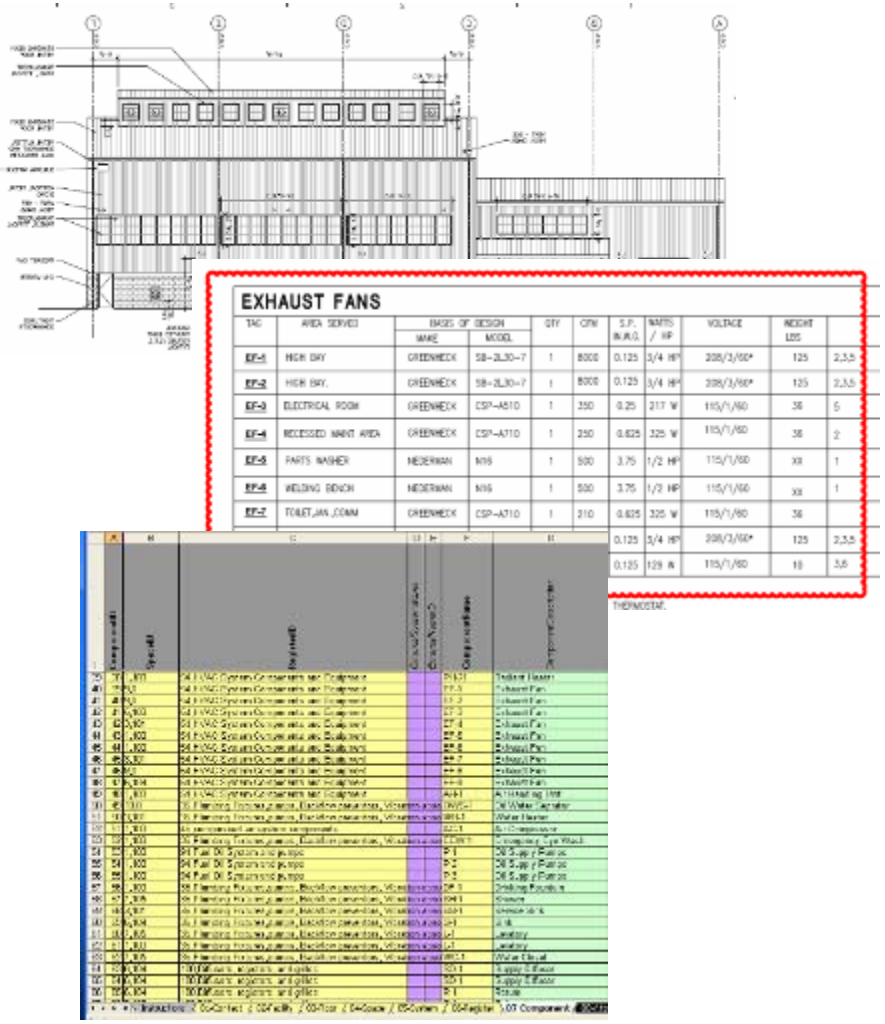
ensure release of “sanitized” data is possible

use real project and pay for the data by-hand if needed

results verify format and specifications

results validate scope of problem statement and value of information

7. pilot projects (cobie)



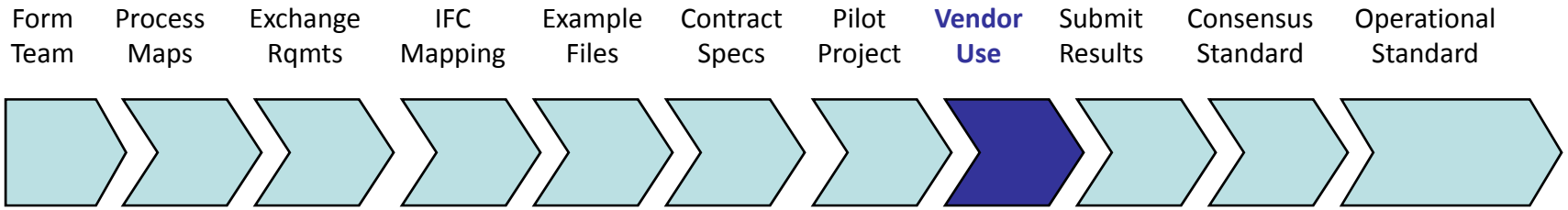
spreadsheet deliverables

- Overseas Buildings Operations (OBO), U.S. Dept of State
- NAVFAC
- Corps of Engineers

new electronic submittal process

- OBO
- NASA

8. vendor use



by-hand (or partially by-hand) has value now but has limited application

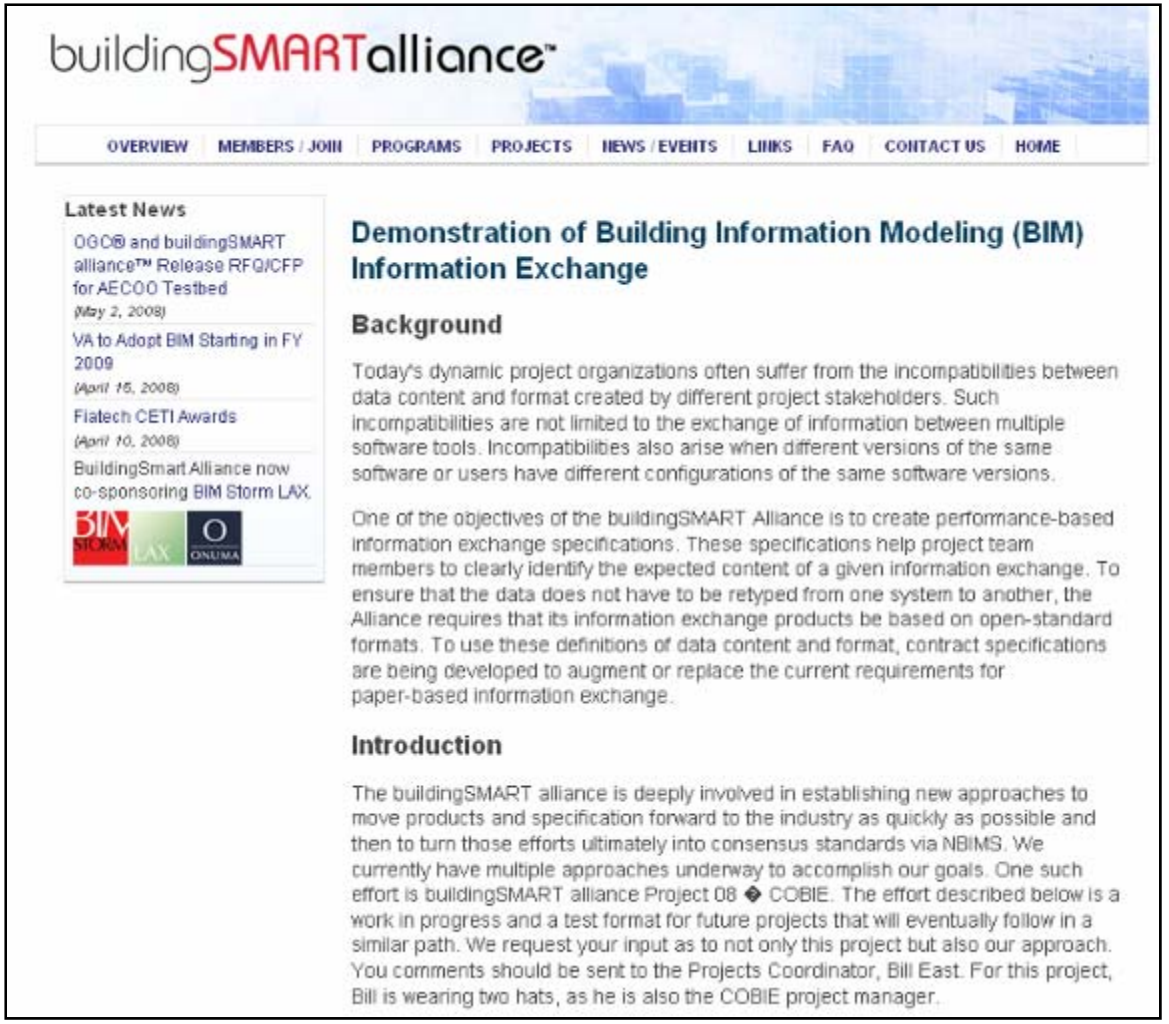
ultimately these exchanges should be transparent to users

consider the example of the ASCII format

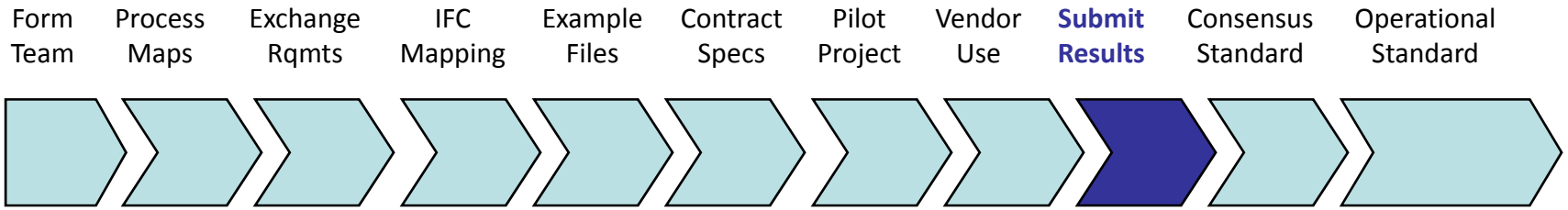
vendors demonstrate compliance with information exchange specification

results of demonstrations made public to allow replication of results

8. vendor use (cobie)



9. submit results



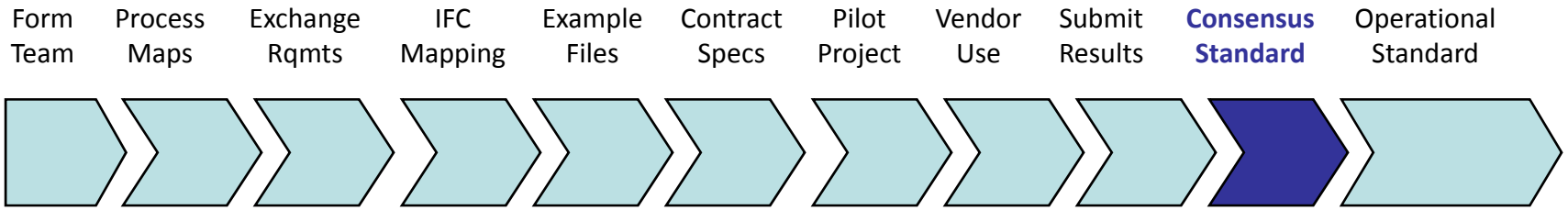
re-package information per NBIMS guidelines

key 1. demonstrate wide stakeholder participation

key 2. non-proprietary, performance-based specification

key 3. no follow-on “harmonization” with “competing standards”

10. consensus standard



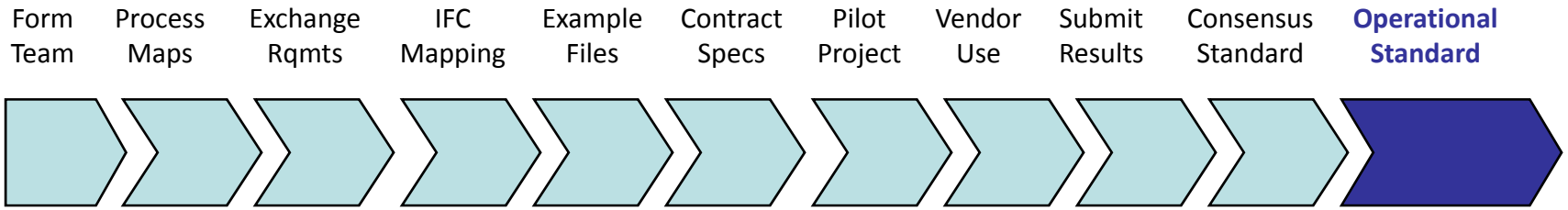
NBIMS voting process allows members to make suggestions

key 1. if you left out a group up-front, they may participate now

key 2. non-proprietary, performance-based specification

key 3. reduce follow-on “harmonization” with “competing standards”

11. operational standards



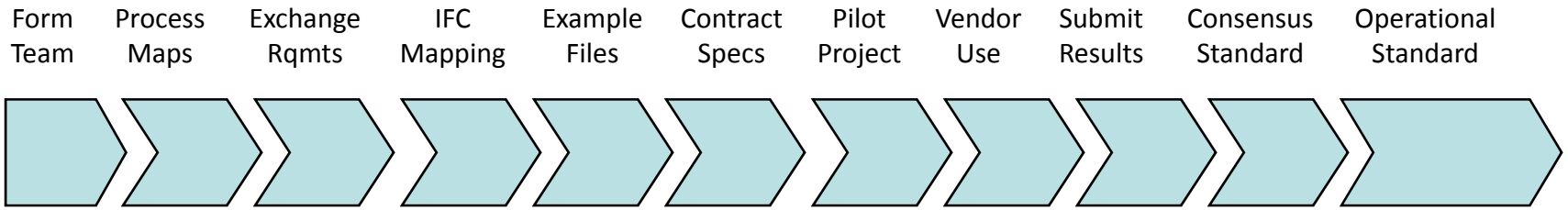
NBIMS will develop process for updating standards over time

key 1. requirements not technology driven

key 2. changes based on problem statement scope and definition

key 3. integration with wider international efforts following use

process summary



subject matter experts, not consultants, drive the process

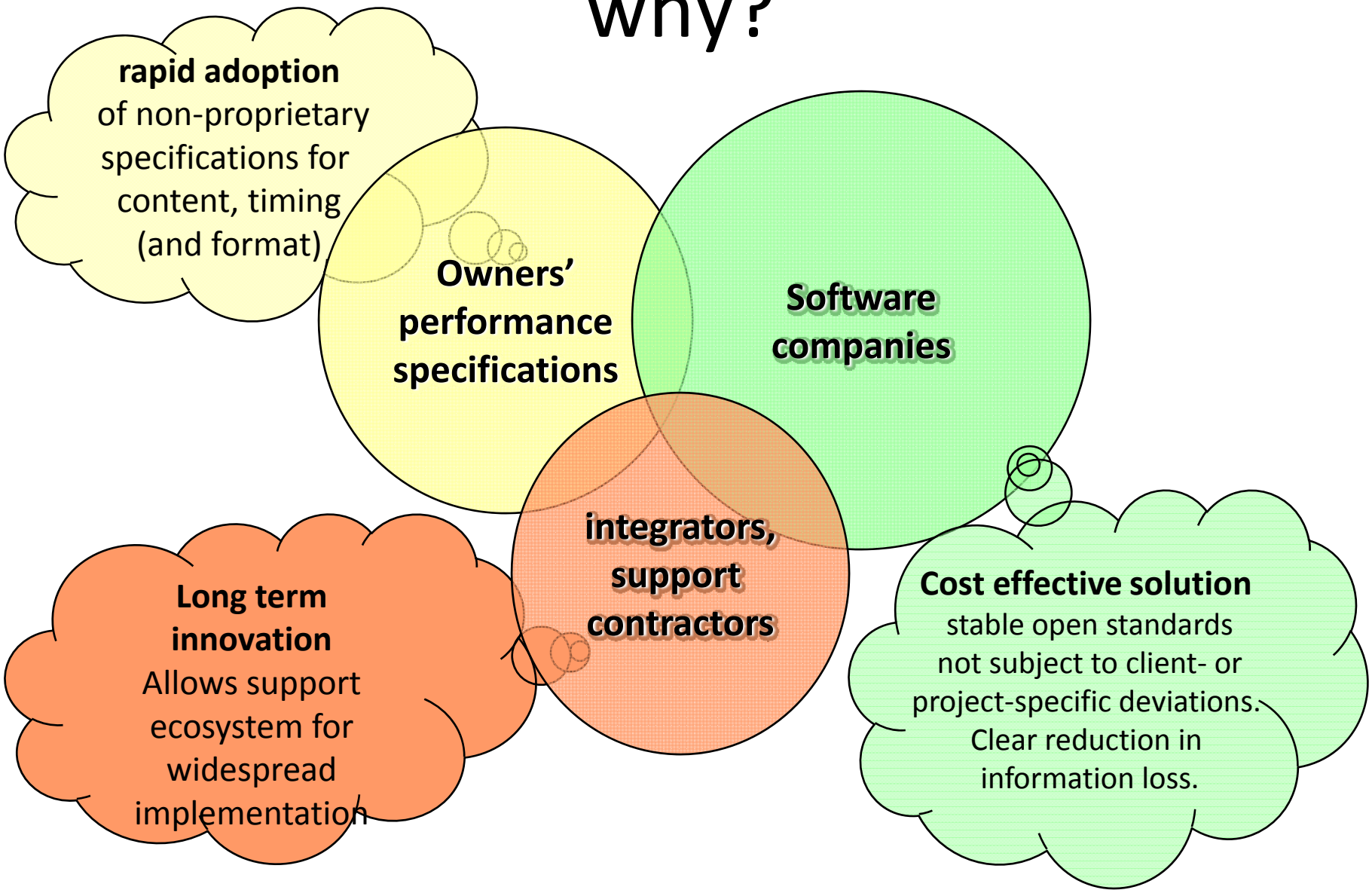
the problem drives the technology, not the other way around

technical work including contracts and pilots in as little as 12 months

phasing allows rapid, measured progress on complex topics

early adoption reduces client-driven requirements/customizations

why?


rapid adoption
of non-proprietary
specifications for
content, timing
(and format)
Owners'
performance
specifications
Software
companies
integrators,
support
contractors
Long term
innovation
Allows support
ecosystem for
widespread
implementation
Cost effective solution
stable open standards
not subject to client- or
project-specific deviations.
Clear reduction in
information loss.

developing open information exchange standards

E. William East, PE, PhD
buildingSMART Alliance Project Coordinator

Dana Smith, AIA
buildingSMART Alliance Executive Director