Outline

• BIM + IPD + Lean + SCI… = IDDS
• Examples of Deploying IDDS in the U.S.
  • Infrastructure, Process Plants, Government Facilities
• Observations
• IDDS + O&M + Optimization
• Delivery of IDDS Practices
Vision: to minimise all forms of waste, whilst delivering greater assured value for sustainable whole lifecycle outcomes.
INTELLIGENT CONSTRUCTION & SYSTEMS TECHNOLOGIES (ICST)

FHWA’s Current and Planned Research

Federal Highway Administration
Turner-Fairbank Highway Research Center

Richard B. Duval, P.E.
&
Lou Triandafilou, P.E.

October 4, 2013
How do the ICST research activity classifications and research activities themselves fit with the R&T strategic plan objectives?

• ICST research projects support these Strategic Plan Objectives:
  – **Project Delivery** - Improve the ability of transportation agencies to deliver projects that meet expectations for timeliness, quality and cost.
  – **Infrastructure Performance** - Improve highway condition and performance through increased use of design, materials, construction and maintenance innovations
Development of National Bridge Information Modeling (BrIM) Standards

Brian Kozy, PhD P.E.
Senior Bridge Engineer – Steel Specialist
Federal Highway Administration

Louis N. Triandafilou, P.E.
Office of Infrastructure Research & Development
Team Leader – Bridge & Foundation Engineering Team
Objective

This research is intended to develop, implement, standardize, and demonstrate an efficient and robust digital data exchange protocol (and file format) that could be used to digitally describe bridge engineering information.
Deployment of BrIM Standards

- This work is intended to be “seed” development, with handoff to industry for long-term
- Standards will be open source, with management by consortium
- Schema descriptions will utilize XML
Vision & Bridge Lifecycle (Enterprise) Process Map

Vision of Multi-Year Implementation Roadmap

- Practical Implementation

  Information Technology (IT) facilitated interoperability throughout the entire bridge lifecycle

- Model/Modular

  Either a (set of bridge industry-specific) model(s) or a integral part of the larger Civil Integrated Management (CIM) (or NIEM?, or IFC(5?), or next-gen transXML, or ...) umbrella
Vision & Bridge Lifecycle (Enterprise) Process Map

Process Map — Streamlined and Improved IT-enabled Managing Method

Portion of Bridge Enterprise Process Map (Chen et al. 2013)
Process Map Notation

Project Disciplines:
- Detailing
- Estimating
- Construction Management
- Fabrication
- Construction Engineering
- Inspection
- Load Rating
- Routing and Permitting
- Maintenance and Management

Project stages:
- Bidding and Letting
- Post-Award/Preconstruction Planning/Detailing
- Fabrication
- Construction
- Inspection and Evaluation
- Maintenance and Management
- Management
Geodesign Summit Europe
September 19–20, 2013 | Herwijnen, Netherlands
• Information Modeling:

IFC Bridge
INFRA – LOD

Concerned Networks
- Road
- River
- High Voltage

Motorway CH0-CH99
- TOLL PLAZA
- INTERCHANGE
- SERVICES AREA

DTM

Underground

FUNCTIONS

Project

Analysis
Simulations
Schedule
QTO
...
BIM Task group: a UK Government initiative

Government aim to derive significant improvements in cost, value and performance through the use of open source information.
• Observatory:

MAP OF ACTUAL INITIATIVES DEDICATED TO INFRASTRUCTURES

(France) Communie

(ANR) EGIS, SETEC, BOUYGUES, EIFFAGE, VINCI, CSTB, IREX, LCPC, CRG

(Comme l’Europe) INSPIRE

IGN, BRGM...

BuildingSMART Benelux

BRGM, Fraunhofer IGD

(IFC-Bridge) LandXML

CSTB, SETRA, TUM...

Norwegian government

UK BIM task group

Autodesk, Bentley, Trimble, ViaNova...

BuildingSMART Australasia

Open Geospatial Consortium

Finnish government

CSTB, TNO, RWS, TV

EGIS, BOUYGUES, CSTB...

(World) COBie

NBI

InfraBIM

V-Con for roads
The FIATECH Capital Project Technology Roadmap Vision of the Future

DELIVERY

Client/ Customer Needs/ Wants
- Technical Approach
- Requirements and Conceptual Design
- Scenario-based Project Planning

Real-time Project and Facility Management, Coordination and Control
- Technical Plan, Target Cost and Schedule
- Resources, Schedules, Cost
- Plan Updates

Detailed Work Pkgs Command/ Control Instructions
- Real-Time Status
- Technical Schedule
- Cost Issues

Real-Time Operational Status
- Technical
- Systems
- Processes
- Infrastructure

Integrated Automated Procurement and Supply Network
- Electronic As-Builts
- Facility Sim Model w/ Processes, Materials, etc.

Intelligent and Automated Construction Job Site
- Intelligent, Self-maintaining and Repairing Operational Facilities
- Decision/Design Support
- Capacity Mgmt.
- Upgrades, Renovations
- Conversions
- D&D, Recycle, etc.

New Materials, Methods, Products and Equipment
- Supplier Designs/Capabilities/Products and Services

Technology- and Knowledge-enabled Workforce
- Feedback of O&M Knowledge and Experience

Lifecycle Data Management and Information Integration
- Fully integrated and highly automated project processes coupled with radically advanced technologies across all phases and functions of the project/facility lifecycle.
Work Processes must assure that:

- Elements conform all the time
- All changes are authorized
- Conformance can be verified
Business Challenge

Infrastructure and Process Plant Configuration Management

Knowledge Workers

Challenge

Paper-based Quality Assurance Process

Automation Systems

Challenge

Plant Documentation

Lots of Tribal Knowledge, Semi-Connected and Disconnected Systems, Manual Processes and yes...... Paper

R. Adams, Dominion
Observations

- Where there are:
  - compelling business drivers,
  - multiple stakeholders who recognize the need for improved processes,
  - commitment to defining increments of capabilities viable for broad deployment,

leaders are applying IDDS and transforming industry practices.

- To succeed, it is essential to understand:
  - larger business and supply chain context,
  - IT landscape and supporting services,
  - information needed for commissioning, operations, maintenance and optimization,
  - where there are inefficiencies and potential productivity gains that could benefit multiple stakeholders.

- Enterprises must assess their internal IDDS readiness level and the IDDS readiness capacity of their potential partners and target markets when planning an IDDS strategy.

- There are overlapping and duplicative efforts to build the semantic and services infrastructure for broad adoption of IDDS in the different sectors and regions of the capital facilities industry.
Discussion

• CIB could provide unique value by:
  developing mechanisms that enable communication and collaboration on cross-cutting challenges and advancements to build the IDDS semantic and services infrastructure.

• This could develop into IDDS recommended practices.

Note: The challenges of global coordination and convergence for achieving the aspirations of openINFRA is an excellent example for articulating the institutional and technical challenges.

• Should IDDS enable Operations and Optimization?
Back-up Slides
BIM + IDDS

- BIM is transforming engineering and construction.
  - Building Information Modeling / Integrated Design and Delivery Solutions
- Stakeholders are changing their sectors, e.g., structural steel.
- Bridge industry is changing to life cycle delivery.
- Process and power industries know they must transform delivery and operation of future plants.
- Integration of supplier processes, expertise, and systems for optimizing is still largely untapped.
- Synergy of combining manufacturing and construction innovation
  - Common challenges in advancing systems integration, intelligent sensing, control and automation
  - Distributed configuration management of federated information and controls

BIM + IPD + Lean + SCI…= IDDS
<table>
<thead>
<tr>
<th>Near-term Research Priority</th>
<th>Long-term Research Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IDDS should enable a more coherent approach to sustainability modelling and achievement, whether at the building or area scale</strong></td>
<td></td>
</tr>
<tr>
<td>Target One</td>
<td></td>
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<tr>
<td><strong>Develop improved sustainability models &amp; measures</strong></td>
<td></td>
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<tr>
<td>Expand human behaviour modelling</td>
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<td>Develop Human Building Interfaces</td>
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<td>Develop performance &amp; consumption models</td>
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<tr>
<td>Develop knowledge-based architectural programme</td>
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<tr>
<td>Coherent information flow and reusable knowledge development</td>
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<tr>
<td><strong>An information fabric should be developed which extends to campus/city scale models to solve emerging infrastructure network problems and facilitate integration of traditionally disparate domains</strong></td>
<td></td>
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<tr>
<td>Target Two</td>
<td></td>
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<tr>
<td><strong>Define the Built Environment Information Fabric</strong></td>
<td></td>
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<tr>
<td>Support building operations &amp; assets</td>
<td></td>
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<tr>
<td>Modelling on installation scale but integration on geographic scale</td>
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<tr>
<td>Information systems lifecycle &amp; interoperability</td>
<td></td>
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<tr>
<td>Context-based individualised interaction</td>
<td></td>
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<tr>
<td>Collaborative project development process &amp; legal framework</td>
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<tr>
<td>Presentation of information on construction and use</td>
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<tr>
<td><strong>IDDS must provide the cohesive element to overcome the obstacles of trying to tackle fundamental change to current practices, particularly by developing improved knowledge management</strong></td>
<td></td>
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<tr>
<td>Target Three</td>
<td></td>
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<tr>
<td><strong>Improve current practices</strong></td>
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<tr>
<td>Further adapt industrial design processes for the product and its manufacture</td>
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<tr>
<td>Design, construction &amp; supply chain improvement</td>
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<tr>
<td>Technological development</td>
<td></td>
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<tr>
<td>Electronic submission &amp; approval systems</td>
<td></td>
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<tr>
<td>Facilities &amp; operations management advances</td>
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<tr>
<td><strong>It is essential that we capture knowledge and re-use it both in practice and education, so that we can foster improvement at the pace of the fastest, rather than at the pace of the slower majority</strong></td>
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<tr>
<td>Target Four</td>
<td></td>
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<tr>
<td><strong>Cultural change &amp; knowledge management and dissemination</strong></td>
<td></td>
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<tr>
<td>Industry/enterprise business process re-modelling</td>
<td></td>
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<tr>
<td>Develop new and expanded collaborative roles/technologies</td>
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<tr>
<td>Develop new pedagogy for integrated design &amp; construction curriculum</td>
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<tr>
<td>Types of Knowledge Management needed for technology transfer vs. steady state</td>
<td></td>
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<tr>
<td>Dissemination &amp; diffusion model</td>
<td></td>
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<tr>
<td>Performance management &amp; measurement</td>
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</tbody>
</table>
The Evolution of IDS
A Historical Perspective
(CIB IDS Workshop June 2009)
Norway. Statsbygg has collaborated with the University of Trondheim in the development of its own guidelines.

Singapore. Automated code checking for many years; now encouraging the use of BIM, including teaching at Universities.

China & Hong Kong. Considerable BIM experience but implementation low. Housing Authority BIM guidelines. 2012: "BIM the future IT solution in the Chinese Government." Strongly supporting BIM.

South Korea. On-going programme on the mandate of BIM use on Government projects and considerable standard development.

Australia. BuildingSMART leading adoption of BIM adoption patchy. History of using Alliancing, although with mixed reviews. Lean and Integrated Design also gaining ground.


Germany. Some adoption of BIM (e.g. Bavaria) but varies across agencies and States.

Denmark. Several state agencies require BIM, especially for larger projects; BIM use high and IFC required for interoperability. Guidelines being developed.

Sweden. Late 2012 five Swedish State agencies and companies collaborating in promoting BIM.

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Current FHWA Research

Addressing Challenges in Intelligent Construction Systems and Technologies (ICST)

Scope:

The contractor shall address gaps identified for ICST from project development through construction and develop guidance for State highway agencies to assist them in determining how best to use ICST to improve accelerated delivery. The scope of the study covers various types, sizes and scopes of transportation projects using ICST delivered by State highway agencies. The study involves collecting, organizing and analyzing data from various State highway agencies and other facility owners using ICST. Addressing the known gaps in how electronic information/data is shared and used by other parties.
Current FHWA Research, cont’d

Objectives: Working with States, documenting barriers, and developing guidance.

1. Further identify gaps in design procedures, design manuals, applications, etc. for highway agencies to properly generate accurate 3/4/5 D models and electronic data for downstream uses in construction.


3. Document the types of costs and resources required by industry and agencies for implementation of these technologies, and their associated return on investment.

4. Document the ICST challenges in the areas of surveying, utilities, real time verification, and data management.

5. Provide a technology development plan to address the challenges and opportunities encountered in the project.

– Awarded Contract September 2013 to Transtec Group Inc.
Purpose and Need

- Many stakeholders in evolution of project have need of same engineering information
- Most information lends itself to digital format
- 3 Levels, with increasing stakeholder interest
Expected Outcomes

- Widespread interoperability between engineering software platforms is achieved
- Move practice towards digital delivery and receipt of project information
- Supports advanced modeling and analysis and visualization
- Accounting aspects of design are streamlined
- Move away from paper
- More efficient and less errors
Bridge Data Protocols for Interoperability
and Life Cycle Management

Work-in-Progress

Stuart S. Chen, Ph.D., P.E.
UB Bridge Information Modeling Research Group
Hanjin Hu, P.E., Ph.D. Candidate, LEED Green Assoc.
Najaf Ali, Ph.D. Candidate
Rohit Srikonda, P.E., MSCE, M.S. Candidate in CSE

Department of Civil, Structural and Environmental Engineering
University at Buffalo

June 2013
Selected Developments in Related Fields

resources/liaisons; mutual interests to varying degrees...

- Infrastructure (e.g., IFC-Infra, buildingSMART) ∩ Geospatial (e.g., OGS)
- Steel structures (e.g., AISC, FIATECH & ISO 15926)
- Concrete structures (e.g., ACI for cast-in-place, PCI for precast/prestressed, PTI for post-tensioned, nuclear for their audit trail requirements)
- Geotech (e.g., gINT, DIGGS)
- AASHTO (e.g., TCEED, transXML/NCHRP 20-94, NCHRP 20-83(03), etc)
- Manufacturing (e.g., NIST initiatives, etc) & Construction (e.g., BIMForums)
- Electric Power Plants (e.g., EPRI, etc)
- Emerging Technology Law (e.g., AIA and ConsensusDocs BIM Addenda)
- Application software consortia (existing or perhaps yet to be constituted)
- Markup languages & models (e.g., ISM) for structural/FEM data exchange
- other existing and emerging exchange standards (e.g., COBie, SPie, BIMSie, BPie, ELie, LCie, QTie, WALLie, etc)
Implementation Roadmap

Overview

A range of recent and emerging state-of-art technologies have the potential to transform the efficiency, effectiveness, reliability, cost-effective life cycle management of bridge network in coming decades.

Approach Recommended:
Roberts Leadership and Management Model
### Implementation Roadmap

#### Examples of Roberts Model Elements

<table>
<thead>
<tr>
<th>Roberts Model Element</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vision</strong></td>
<td>As a result of BrIM-standards based interoperability being implemented, owners dealing with construction claims could quickly access the searchable electronic “audit trail” that is a byproduct of BrIM – enabled processes to quickly assess the merits of claims just as easily as a contractor with suitable access to model data can interrogate it instead of issuing RFI's.</td>
</tr>
<tr>
<td><strong>Authorizing Environment</strong></td>
<td>Increasing interconnectedness of pieces of the workflow is increasingly realized by software translators, and the integrative Vision embraced by various stakeholders (owners, designers, contractors, etc.) in the bridge lifecycle in a given owner’s jurisdiction</td>
</tr>
<tr>
<td><strong>Organizational Capacity</strong></td>
<td>In an owning agency organization and the consulting firms serving them, long standing animosities between previously separated highway design and bridge design squads reduce over time; re-tooling of CAD technicians and bridge engineers to productively use 3D modeling tools, possibly partially subsidized using MAP-21 funds incentivizing deployment of ABC technologies.</td>
</tr>
<tr>
<td><strong>Working Space</strong></td>
<td>Progressive CEO’s and managers clearly understand and champion the vision throughout the organization in an energetic and sustained manner to facilitate the migration from initially non-interoperating software operated by a not-fully-IT-savvy workforce to collaboratively influence that agency’s next-gen CAD standards and associated workflows to implement Task 12 – generated data exchange standards (or suitable derivative(s) thereof)</td>
</tr>
</tbody>
</table>
COBie

an open-standard for managed assets
AS-BUILT RECORD OF EQUIPMENT AND MATERIALS

SPARE PARTS DATA

Furnish [one copy] [_____] copies of preliminary record of equipment and materials used on the project [_____] days prior to final inspection. This preliminary submittal will be reviewed and returned [_____] days after final inspection with Government comments. Submit [_____] copies of final record of equipment and materials [_____] days after final inspection. Key the designations to the related area depicted on the contract drawings. List the following data:

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification Section</th>
<th>Manufacturer and Catalog, Model, Serial Number</th>
<th>Composition and Size</th>
<th>Where Used</th>
</tr>
</thead>
</table>

HARDWARE SCHEDULE

Prepare and submit hardware schedule in the following form:

<table>
<thead>
<tr>
<th>Hardware Item</th>
<th>Quantity</th>
<th>Size Reference Publication Type No.</th>
<th>Finish Name and Catalog No.</th>
<th>Key Control Symbols</th>
<th>UL Mark (if fire rated and listed)</th>
<th>SMDA Finish Specification</th>
</tr>
</thead>
</table>

SIGNAGE, INSTALLATION

<table>
<thead>
<tr>
<th>Door/Room Number</th>
<th>Sign Type</th>
<th>Text</th>
<th>Insert(s)</th>
<th>Symbol/Remarks</th>
</tr>
</thead>
</table>

PREVENTATIVE MAINTENANCE

Submit Preventative Maintenance, Condition Monitoring (Predictive Testing) and inspection schedule with instructions that state when systems should be retested.

- a. Indicate manufacturer's name, part number, nomenclature, and stock level required for maintenance and repair. List those items that may be standard to the normal maintenance of the system.

- b. Repair requirements must inform operators how to check out, troubleshoot, repair, and replace components of the system. Include electrical and mechanical schematics and diagrams and diagnostic techniques necessary to enable operation and troubleshooting of the system after acceptance.

WARRANTY MANAGEMENT PLAN

3. A list for each warranted equipment, item, feature of construction or system indicating:

   - (1) Name of item.
   - (2) Model and serial numbers.
   - (3) Location where installed.
   - (4) Name and phone numbers of manufacturers or suppliers.
   - (5) Names, addresses and telephone numbers of sources of spare parts.
   - (6) Warranties and terms of warranty. Include one-year overall warranty of construction, including the starting date of warranty of construction. Items which have extended warranties must be indicated with separate warranty expiration dates.
   - (7) Cross-reference to warranty certificates as applicable.
   - (8) Starting point and duration of warranty period.
   - (9) Summary of maintenance procedures required to continue the warranty in force.
   - (10) Cross-reference to specific pertinent operation and maintenance manuals.
   - (11) Organization, names and phone numbers of persons to call for warranty service.
   - (12) Typical response time and repair time expected for various warranted equipment.
**Section Table of Contents**

**Division 01 - General Requirements**

**Section 01 79 00**

Construction-Operations Building information exchange (COBie)

08/2013

**1. General**

<table>
<thead>
<tr>
<th>1.1 References</th>
<th>1.2 Submittals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2.1 COBie Information Delivery Plan</td>
<td>1.2.2 COBie-Specific Submittals</td>
</tr>
<tr>
<td>1.2.3 COBie-Formatted Submittals</td>
<td>1.2.4 Installed Equipment Photographs</td>
</tr>
<tr>
<td>1.3 Government Furnished Information</td>
<td></td>
</tr>
<tr>
<td>1.3.1 COBie Tool Kit</td>
<td>1.3.2 COBie Design File</td>
</tr>
<tr>
<td>1.4 Quality Assurance</td>
<td></td>
</tr>
<tr>
<td>1.4.1 COBie-Specific Submittals</td>
<td>1.4.2 COBie-Formatted Submittals</td>
</tr>
<tr>
<td>1.4.3 COBie Data File and Photographs</td>
<td>1.5 Information Delivery, Storage, and Handling</td>
</tr>
<tr>
<td>1.5.1 Delivery Method - COBie-Specific Submittals</td>
<td>1.5.2 Electronic Media</td>
</tr>
<tr>
<td>1.5.3 Transmission of Physical Media</td>
<td>1.5.4 Encryption</td>
</tr>
<tr>
<td>1.6 Retainage</td>
<td></td>
</tr>
<tr>
<td>1.6.1 Architectural Design Phase (30% Design)</td>
<td>1.6.2 Coordinated Design Phase (60% Design)</td>
</tr>
<tr>
<td>1.6.3 Construction Documents Phase (100% Design)</td>
<td>1.6.4 Construction Mobilization Phase</td>
</tr>
</tbody>
</table>
| 1.6.5 Construction 60% Complete | }
PROJECT DELIVERY METHODS FOR

Water & Wastewater Infrastructure
Design-Build
– and –
Construction Management
At Risk

Produced by the Water Design-Build Council
October 2012
The Water Design-Build Council

Trade organization of national design-build companies that serve the water and wastewater industry
MARKET FOCUS: Water / Wastewater Capital Projects

- Facility expansions / refurbishments
- Treatment process upgrades
- Conveyance / collection
- Residuals management
- Energy efficiency
- Water resources development / maintenance
- Asset management tools & systems
WDBC Mission

- Advocate for the added value and applications of Design-Build and CMAR delivery, specifically in North America
- Defines and develops Design-Build and CMAR best practices for owner planning, procurement and project implementation
- Promotes collaborative relationships between Owners and industry practitioners that create innovation and quality solutions to save time and cost, with less risk for all parties
Water / Wastewater Project Drivers and Objectives

- Services demand – schedule/time priority
- Regulatory driven – schedule and performance priorities
- Treatment processes - innovative solutions
- Reliability and operational flexibility – best value
- Lower and predictable O&M cost – life cycle cost
- Budget constraints – acceptable firm cost
- Community and economic impacts – reduced risk
Project Delivery Defined

- A comprehensive process including planning, design, permitting, construction, testing & acceptance and other related services, necessary for executing a capital project

- Fundamental Owner decisions for Project Acquisition

What Project Delivery Method?  
What Procurement Method?  
What Contracting Approach?
Design-Build Market Perspective

- Major utilities consider design-build as a standard delivery process
- Active market with many players and team structures
- Major projects are being implemented throughout US and Canada

- Many forms of design-build being applied by owners
  - Progressive design-build
  - Lump sum design-build
  - Design-build-operate
  - Design/CMAR

- Project drivers remain
  - Cost
  - Schedule
  - Risk transfer
  - Performance
  - Single point of accountability
Market Changes

Source: Design Build Institute of America 2005

- Traditional Design-Bid-Build
- Design-Build
- Construction Management (At Risk)
Data to be updated in 2013
Owner/Operator Data Requirements

Corrective Action Program (CRs, Root Cause Analysis, etc.)

Operate Plant (Procedures, SSC Tag & Position, Location Centric)

Training (Lesson Plans, Simulator Fidelity, etc.)

Licensing (COLA, Commitment Tracking)

CM & Equip Reliability (SSC Design Requirements, Margins, Tag #, Plant Config Info Documents)

Materials & Services (Piece/Parts, Work Order Centric)

Work Control (Procedure, Work Order, Tag, Location, Test Data, Piece Parts Centric)

HP/Chemistry (Procedure, Measured Data Centric)

SHARED DATA

K.Barry, EPRI
Exciting Times

- Engineering and construction are changing.
- Some sectors are changing industry’s integration, automation, agility and profitability, e.g., U.S. steel fabricators.
- Bridge industry is transforming the delivery, operation and maintenance of the U.S. bridge portfolio.
- Process and power industries know they must transform delivery and operation of future plants.
- Integration of supplier processes, expertise and systems for optimizing design, delivery and operations is still largely untapped.
- Synergy of combining manufacturing and construction innovation
  - Common challenges in advancing systems integration, intelligent sensing, control and automation
  - Distributed configuration management of federated information and controls
- IDDS principles are being deployed.