Best Practices in Information Technology among A/E/C Firms

Northwest Construction Consumer Council:

Outlook 2000: Construction and Information Technology Forecasts

Kristine K. Fallon, FAIA
Portland, January 26, 2000

Research Findings Drawn From:

- *The AEC Technology Survival Guide,* 1997
  - John Wiley & Sons
- Benchmarking I.T. Best Practices Among Design Firms, 1998
  - Anonymous client
- CAD Technology Evaluation: Spallation Neutron Source, Oak Ridge National Laboratory, 1999
  - Knight/ Sverdrup Joint Venture
- CAD for Principals Council, 2000
  - Revit Technology Corporation

How Can We Identify Best Practices?

Best Practices result in Superior Performance

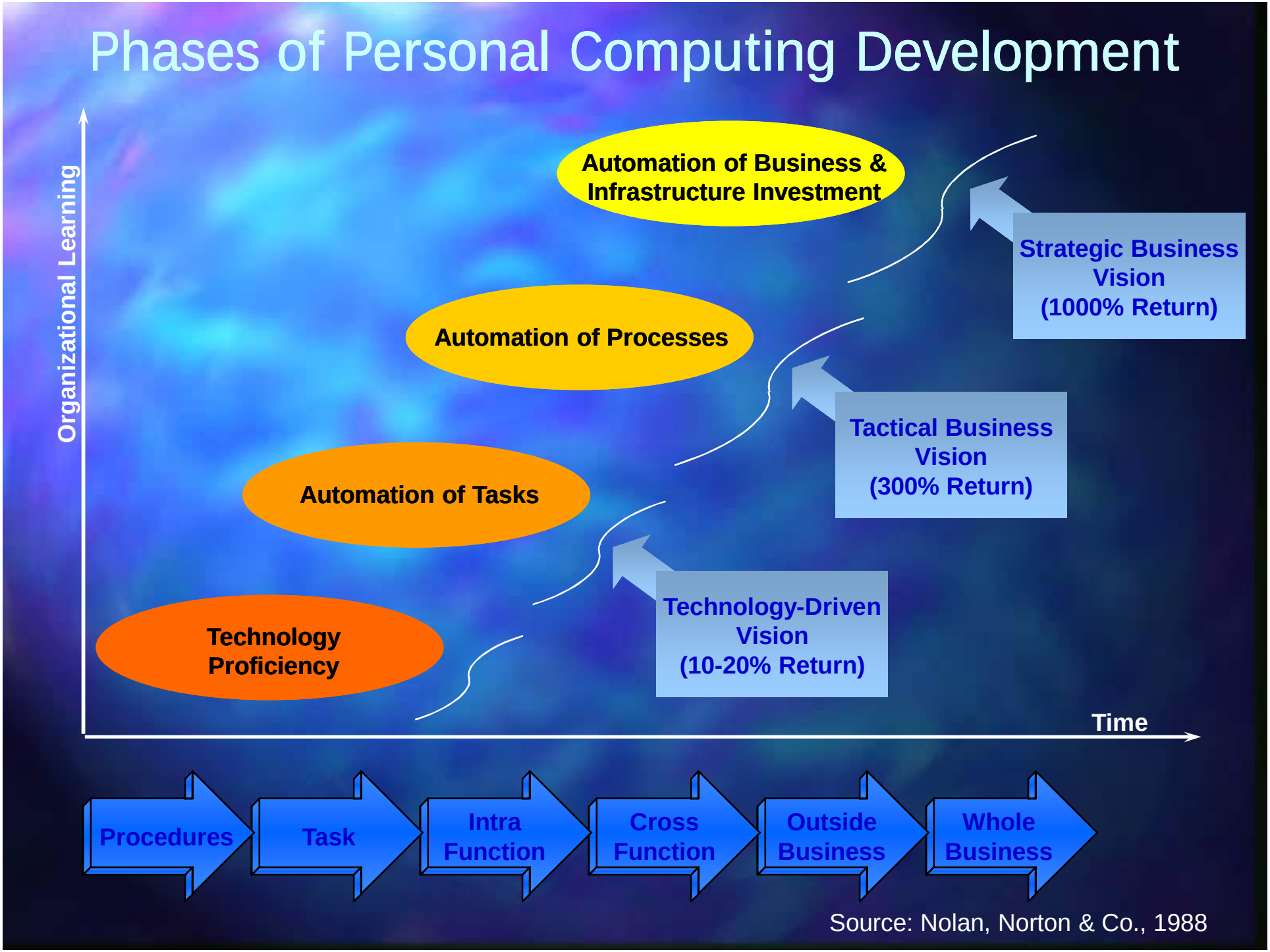
Performance Measurements

- Reduced cost
- Improved speed
- Conformance to budget
- Conformance to schedule
- Reduced rework
- Reduced errors and omissions
- Improved client satisfaction
- Higher profits

What Impacts Performance?

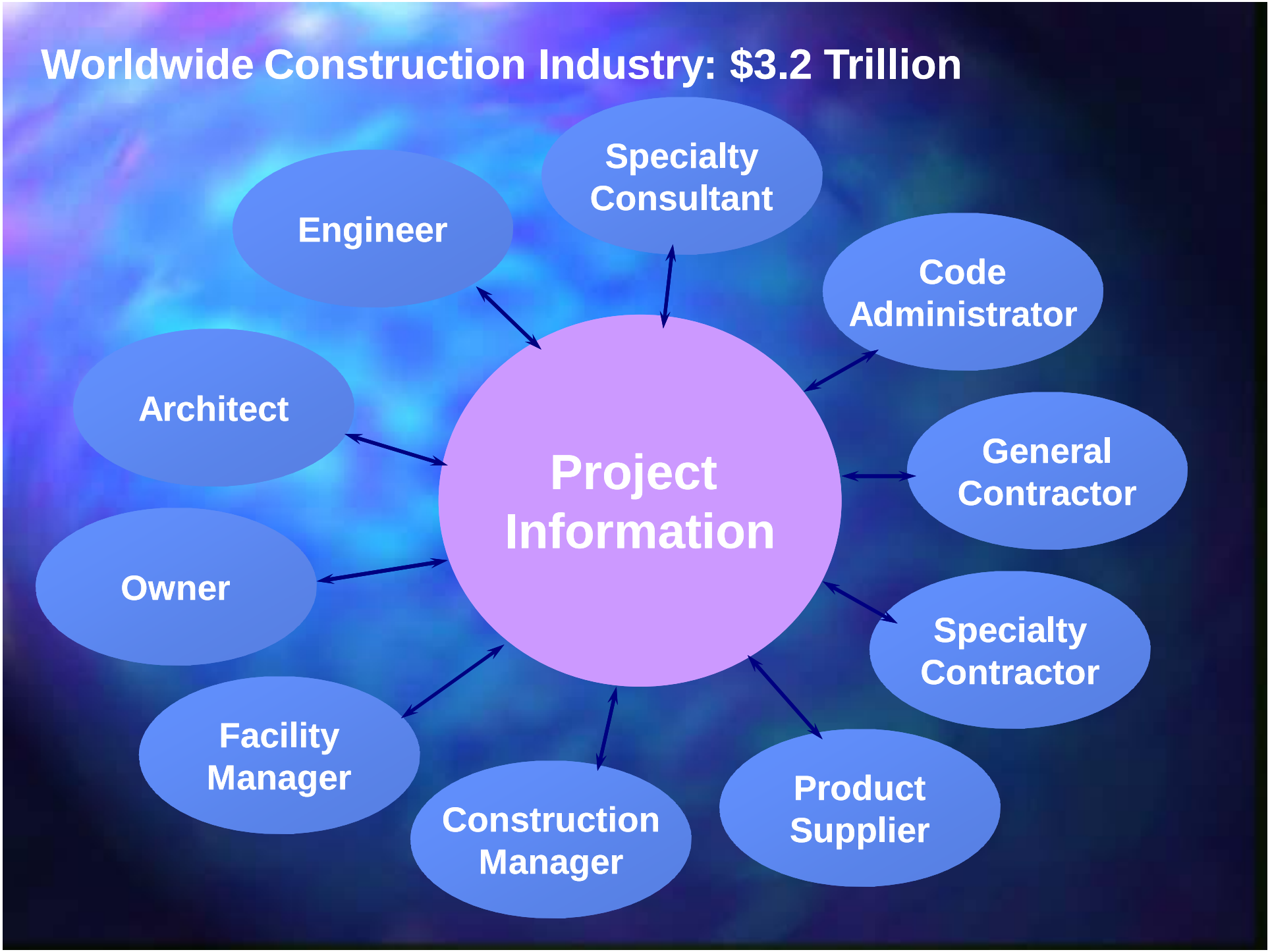
- Organizational structure
- Work processes
- Human factors
- IT approach

Phases of Personal Computing Development



Source: Nolan, Norton & Co., 1988

What does this have to do with the Design and Construction Industry?


Worldwide Construction Industry: $3.2 Trillion
Specialty Consultant
Engineer
Code Administrator
Architect
Project Information
General Contractor
Owner
Specialty Contractor
Facility Manager
Construction Manager
Product Supplier

What We Do Know

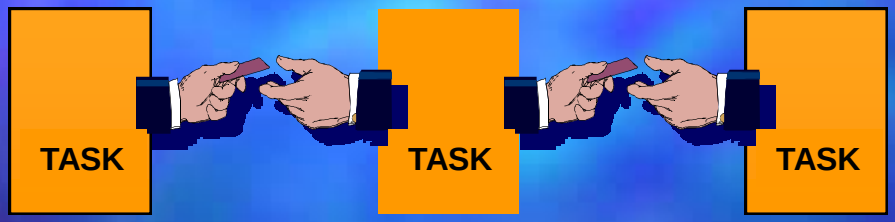
Information Technology yields return on investment that is an *ORDER OF MAGNITUDE GREATER* when applied to total work processes rather than discrete tasks.

Reengineering

- We have traditionally organized work as a sequence of separate tasks and employed complex mechanisms to track its progress.
- Conventional process structures are fragmented and piecemeal, and they lack the integration necessary to maintain quality and service.
- The goal of Reengineering is to break loose from outmoded business processes and create new ones.
- Information Technology is the enabler.

Reengineering

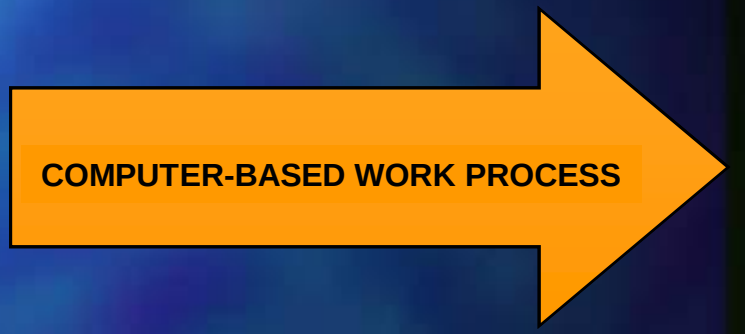
Industrial Age



Segmentation

vs.

Information Age



Integration

Reengineering Principles

- Base job descriptions on objectives.
- Let one person perform a work process from beginning to end.
- Link parallel activities instead of integrating their results (concurrent engineering).
- Build control into the process.
- Capture information once; avoid redundant data entry.
- Treat geographically dispersed resources as if they were centralized.

Case Study: Bechtel Group

- Global EPC organization
- 1997 revenues: $9.4 billion
- 20,000 employees worldwide

Bechtel Revisited

- What they did.
- How they did it.
- How they supported their EPC activities with information technology.

Bechtel's Goal:

Reduce Power Plant Installed Cost by 30%

- Changed engineering approach
  - Engineering = 10 – 15% of total costs
  - Developed and optimized standard plant designs
  - Reduced engineering costs by 40%
- Changed procurement approach
  - Procurement = 50% of total costs
  - Centralized procurement
  - Established strategic alliances with suppliers
  - Supported alliances with electronic integration
  - One result: reduced steel procurement time from 2 months to 2 weeks

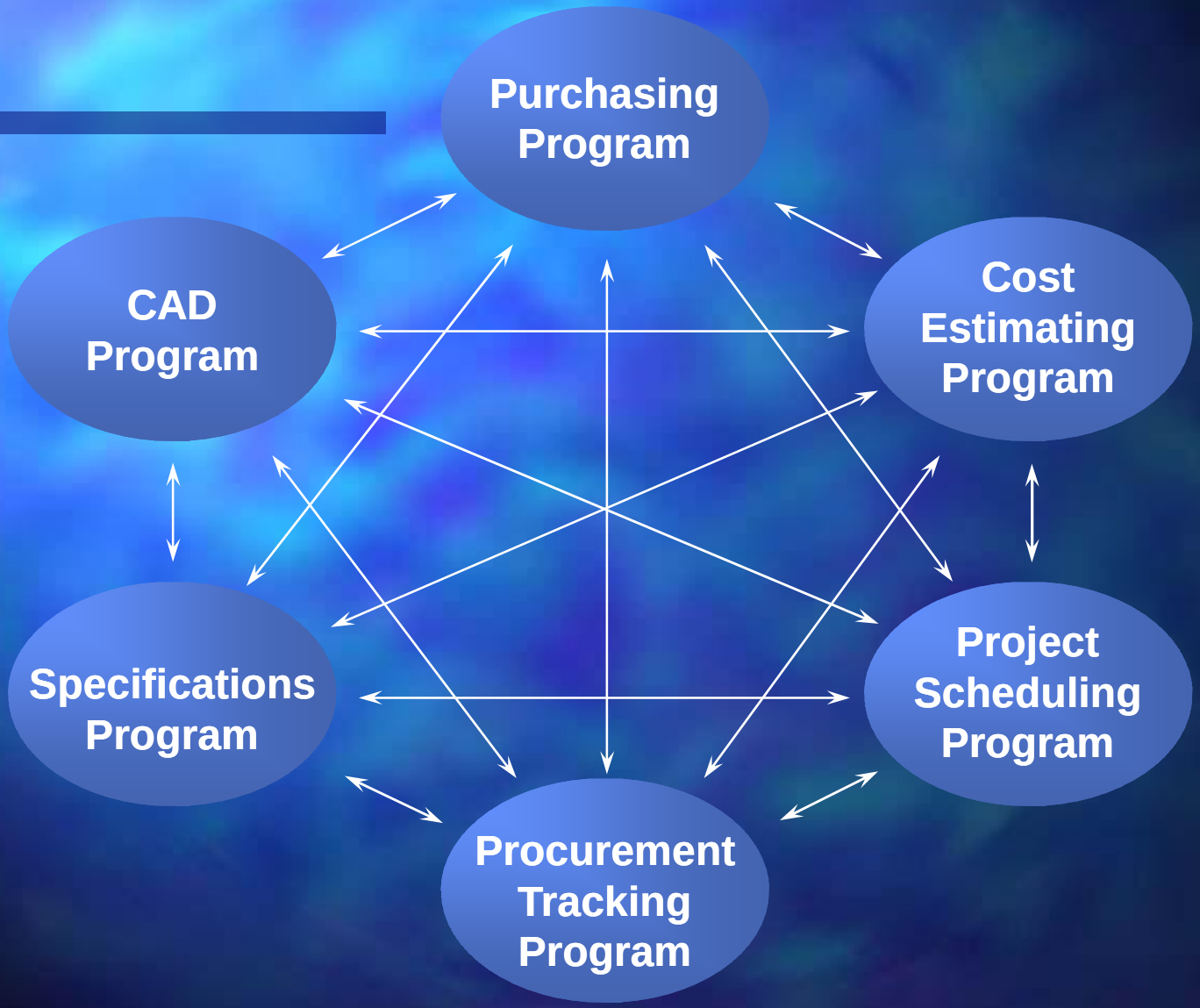
Bechtel's I.T. Support for EPC

- Integrated suite of applications for:
  - Engineering
  - Procurement
  - Construction
- Client/server with middleware integration platform
- Integrates applications from multiple sources
  - Bechtel-proprietary
  - Off-the-shelf
  - Client- and vendor-proprietary
- Uses Internet technologies to distribute information globally

Previous Integration Efforts

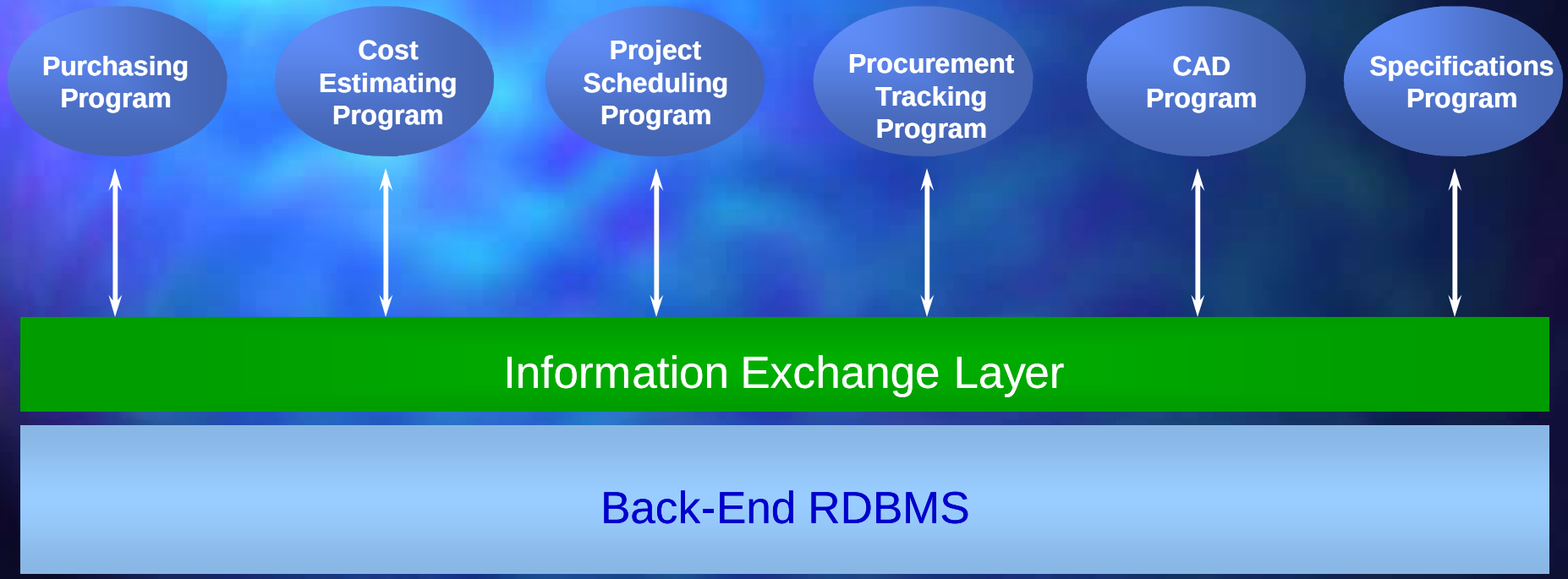
- Project-specific
- Point-to-point interfaces
- Not architected
- Not standard
- Not reusable

Point-to-Point Interfaces



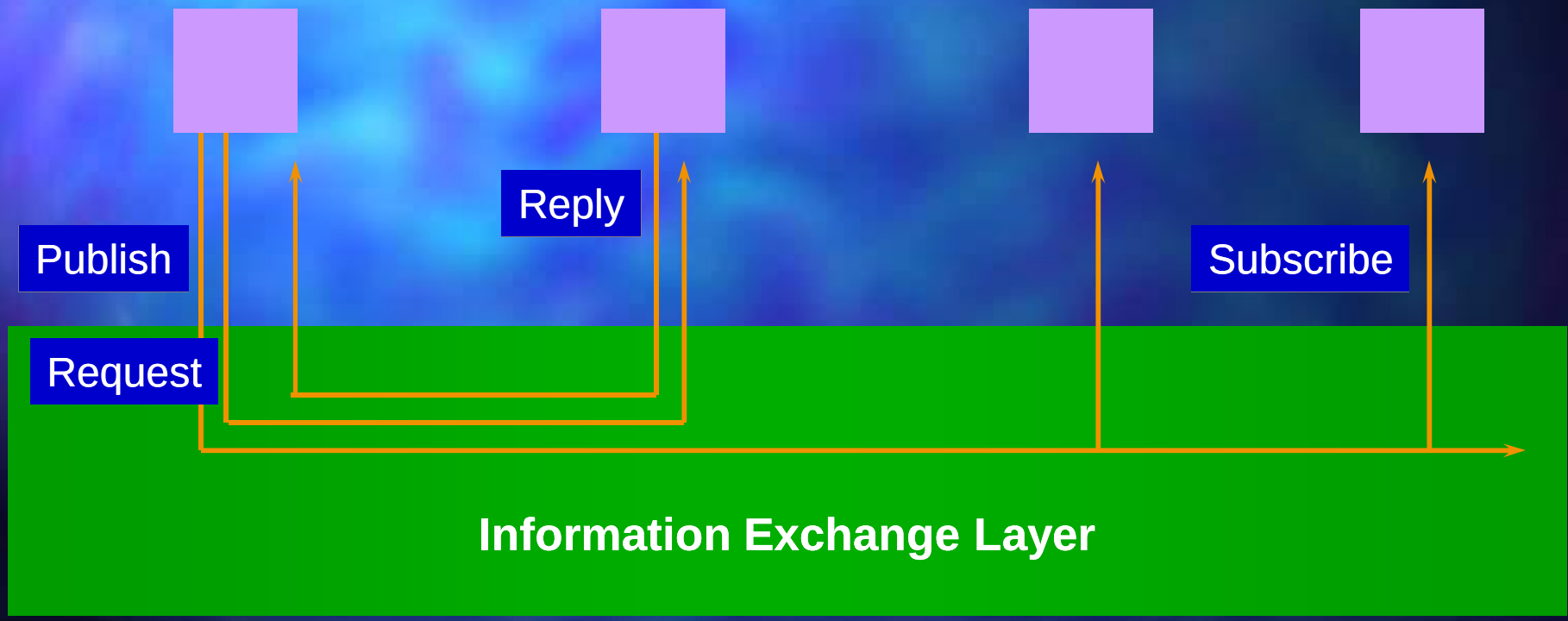
Middleware (Information Exchange) Layer

Creates Reusable, Standard Interfaces



Object Messaging

Automated Data Transport Based on Business Rules



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Bechtel Tackled

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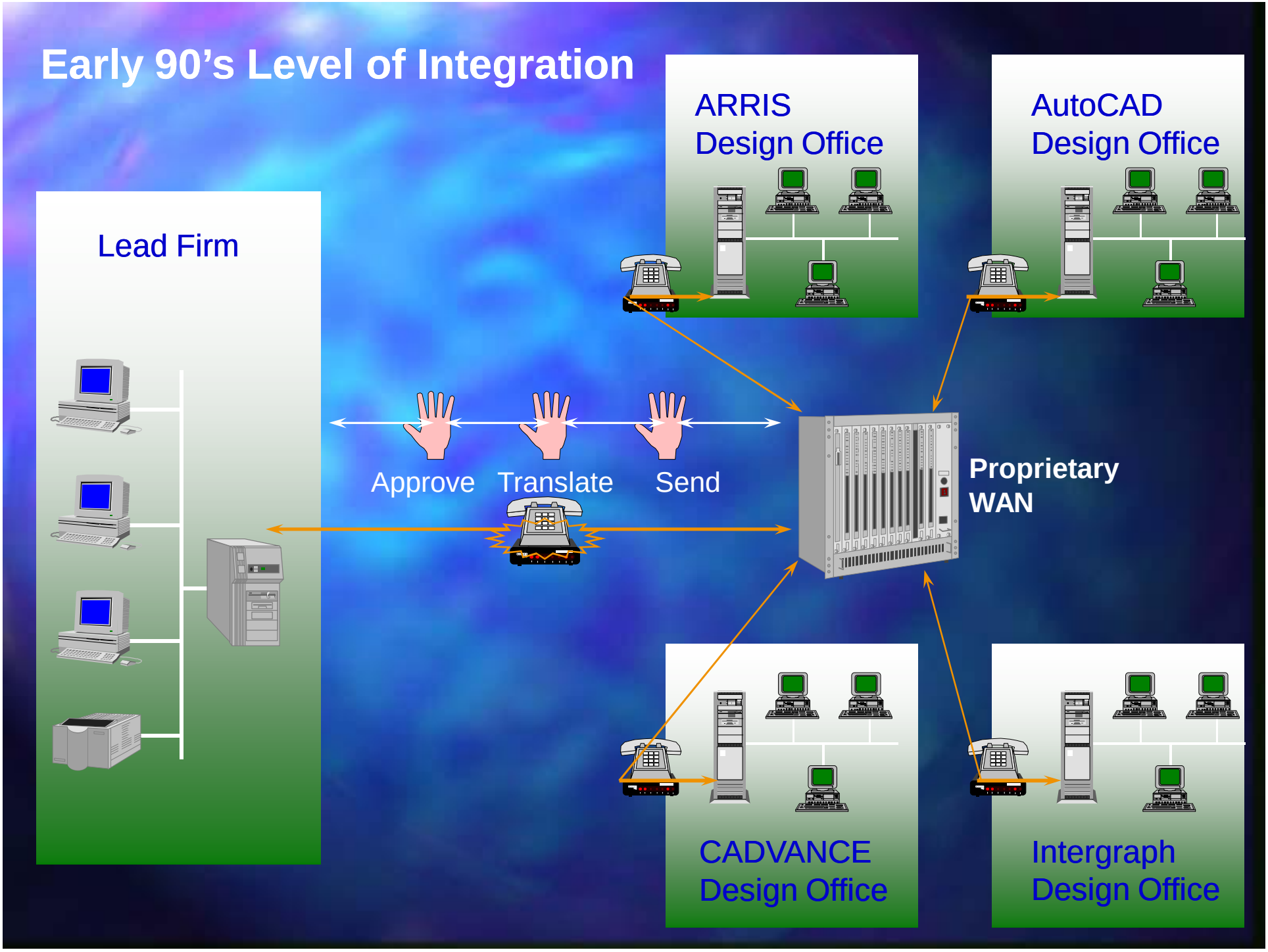
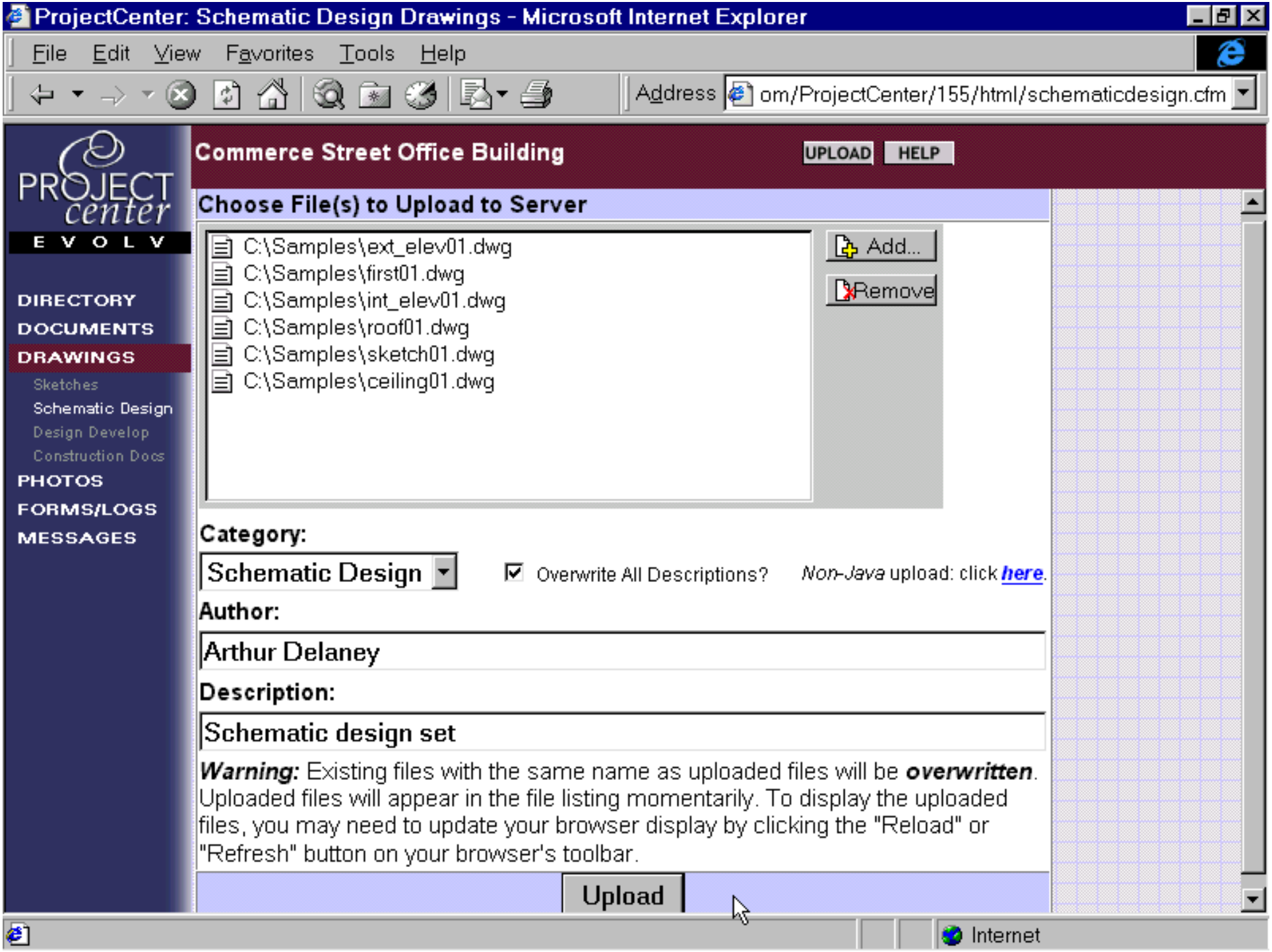
Early 90's Level of Integration



Internet Has Great Impact

- Global
- Standard
- Virtually free
- Easy to connect
- Browser technology is easy to use
- Extranet (Project Web Site)products are providing increasingly sophisticated project controls
  - Workflow management
  - Audit trails


ProjectCenter: Schematic Design Drawings - Microsoft Internet Explorer
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PROJECT center
EVOLV
DIRECTORY
DOCUMENTS
DRAWINGS
Sketches
Schematic Design
Design Develop
Construction Docs
PHOTOS
FORMS/LOGS
MESSAGES
Commerce Street Office Building
UPLOAD
HELP
Choose File(s) to Upload to Server
C:\Samples\ext_elev01.dwg
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Arthur Delaney
Description:
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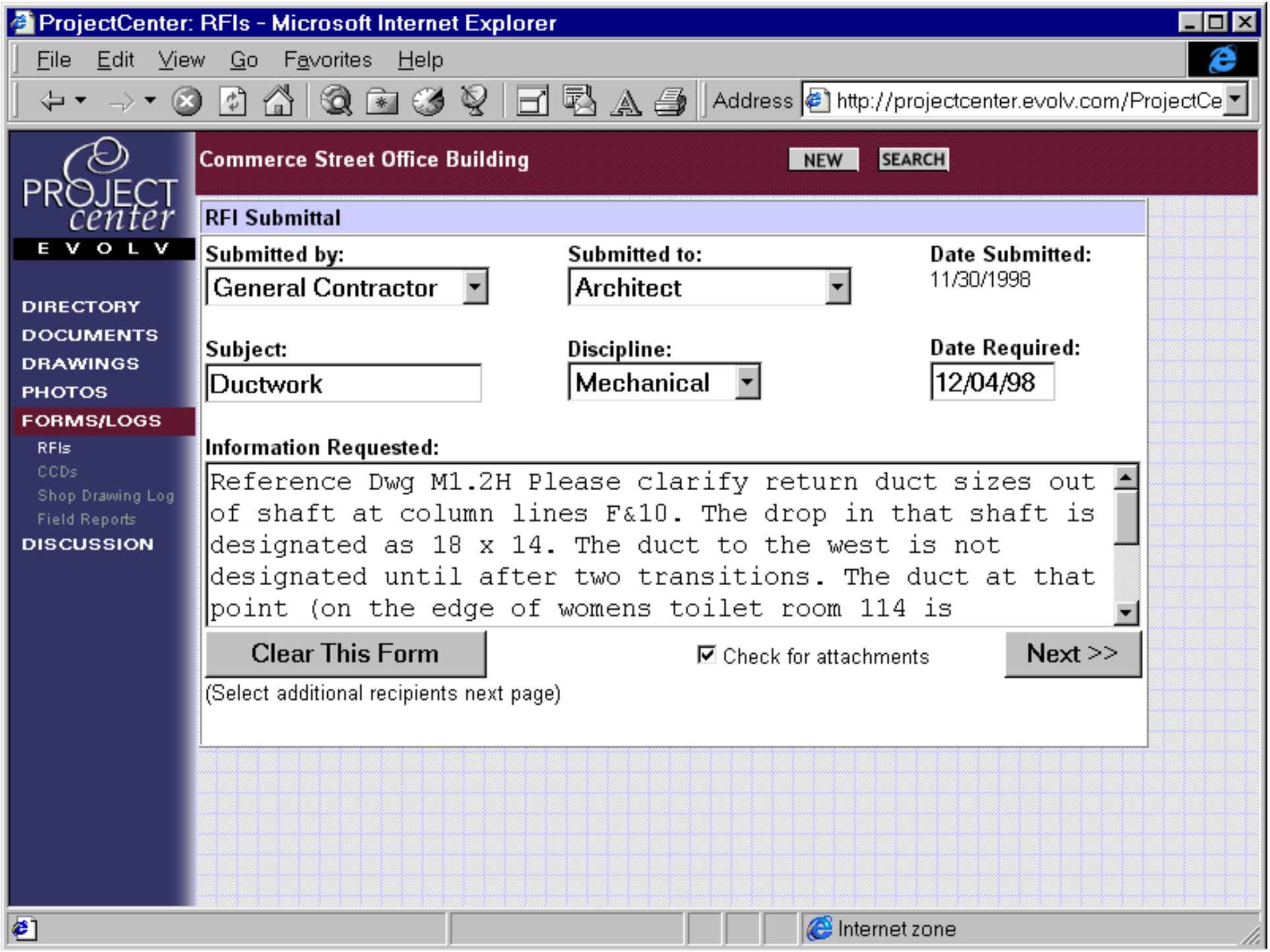
Upload
Internet


ProjectCenter: RFIs - Microsoft Internet Explorer
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PROJECT center EVOLV
DIRECTORY
DOCUMENTS
DRAWINGS
PHOTOS
FORMS/LOGS
RFIs
CCDs
Shop Drawing Log
Field Reports
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SEARCH
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General Contractor
Submitted to:
Architect
Date Submitted:
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Ductwork
Discipline:
Mechanical
Date Required:
12/04/98
Information Requested:
Reference Dwg M1.2H Please clarify return duct sizes out of shaft at column lines F&10. The drop in that shaft is designated as 18 x 14. The duct to the west is not designated until after two transitions. The duct at that point (on the edge of womens toilet room 114 is
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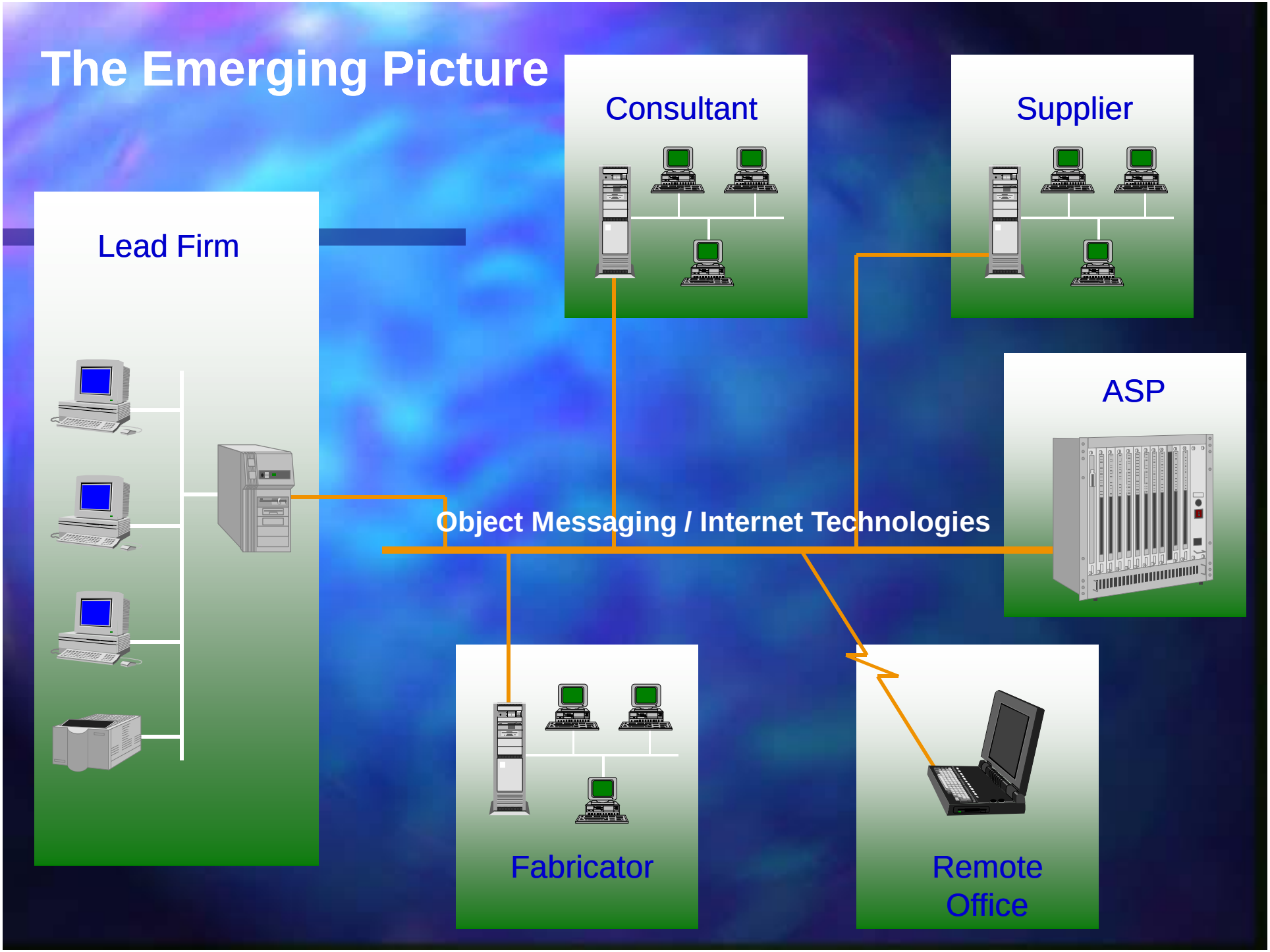
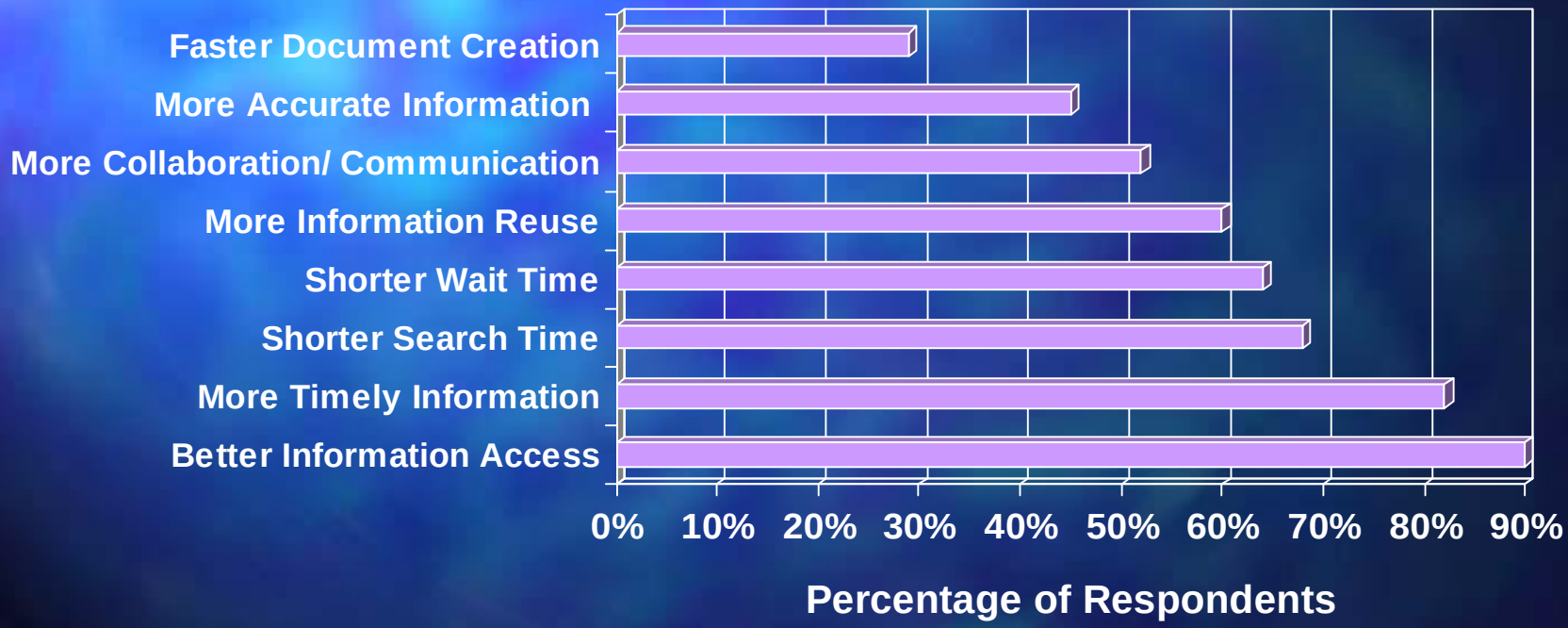
The Emerging Picture



Impact of Web Technologies on Electronic Document Management

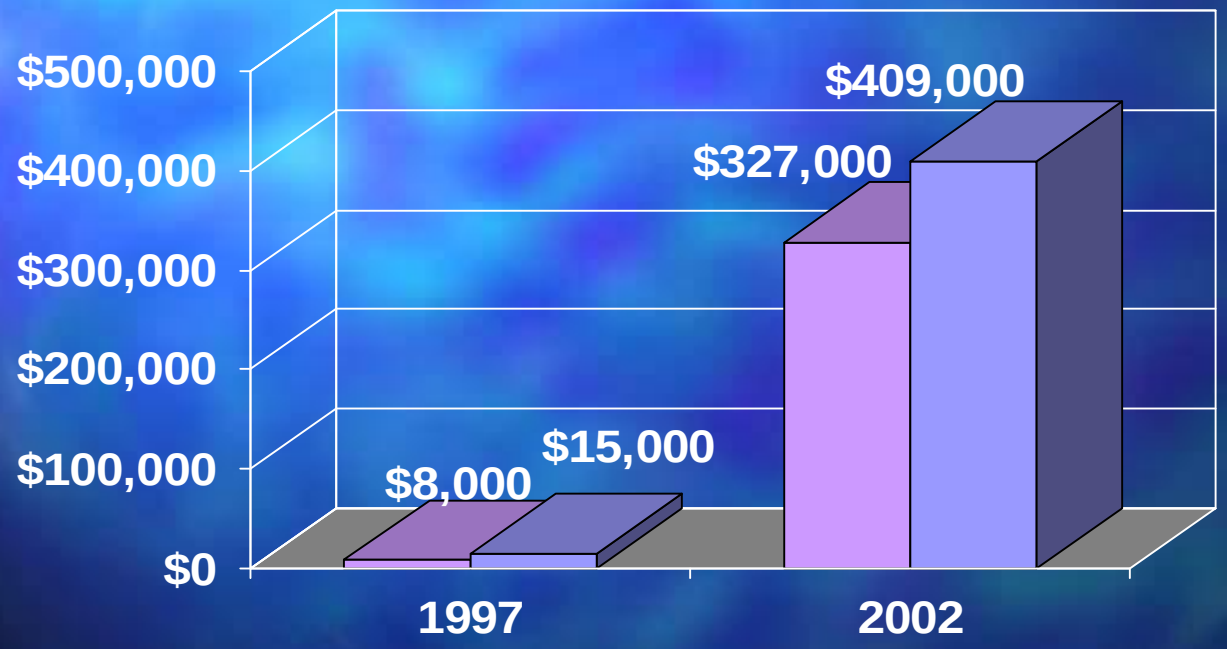
Survey of 456 Users



SOURCE: MYERS-TIERNEY AND ASSOCIATES, 1997

Business-to-Business Internet Commerce

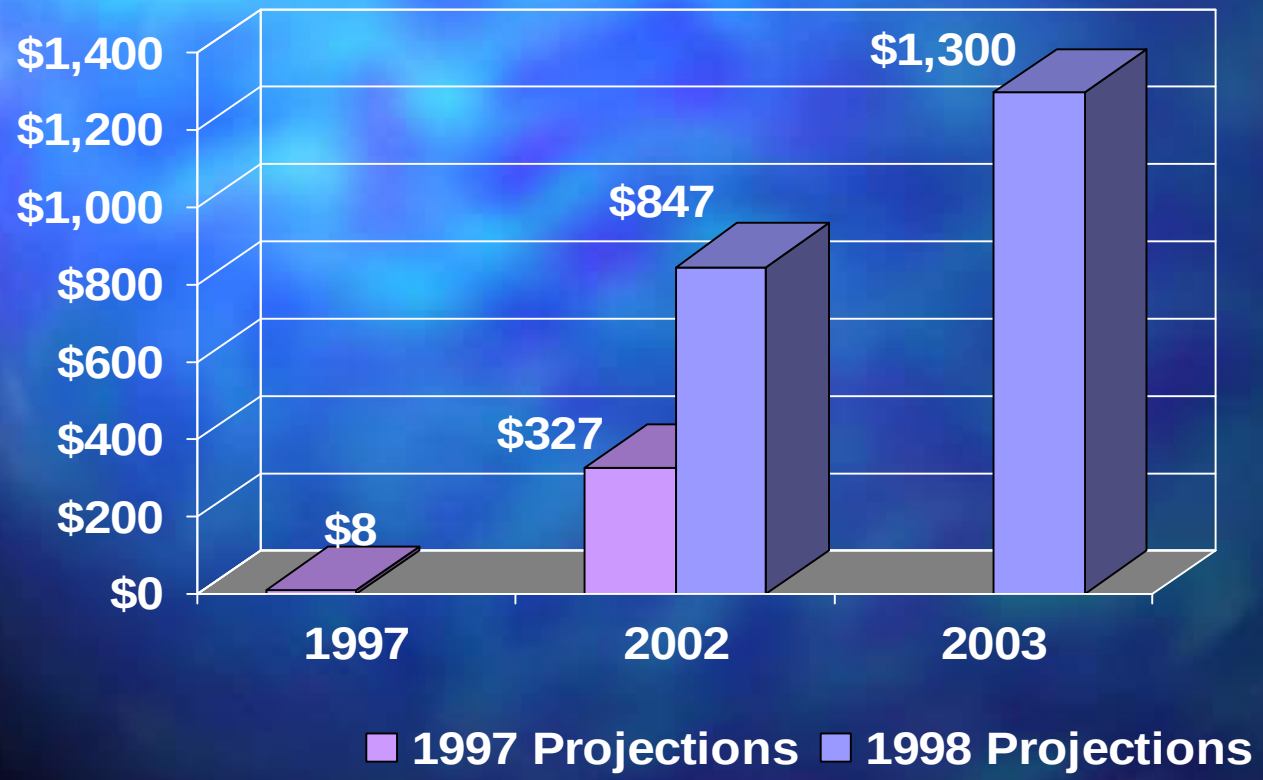
In Millions :



SOURCE: INFOWORLD, 1997

Business-to-Business Internet Commerce

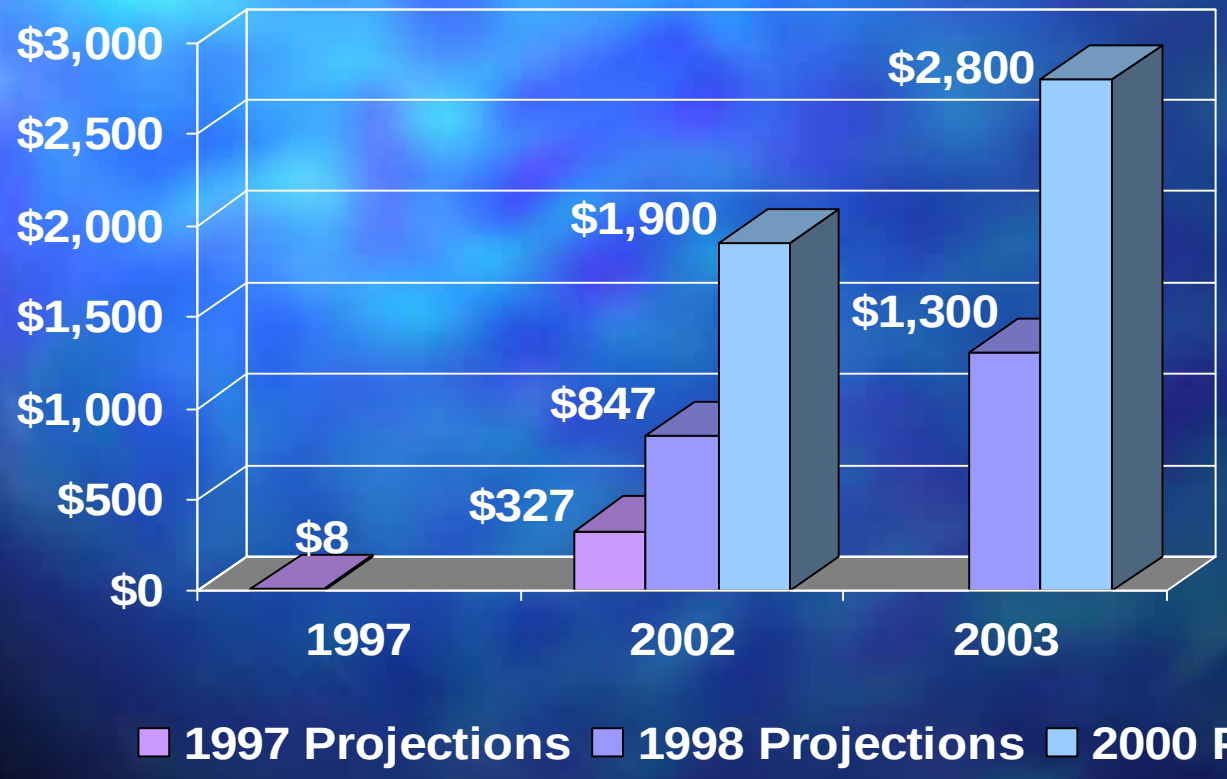
In Billions :



SOURCES: INFOWORLD, 1997
Forrester Research, 1998

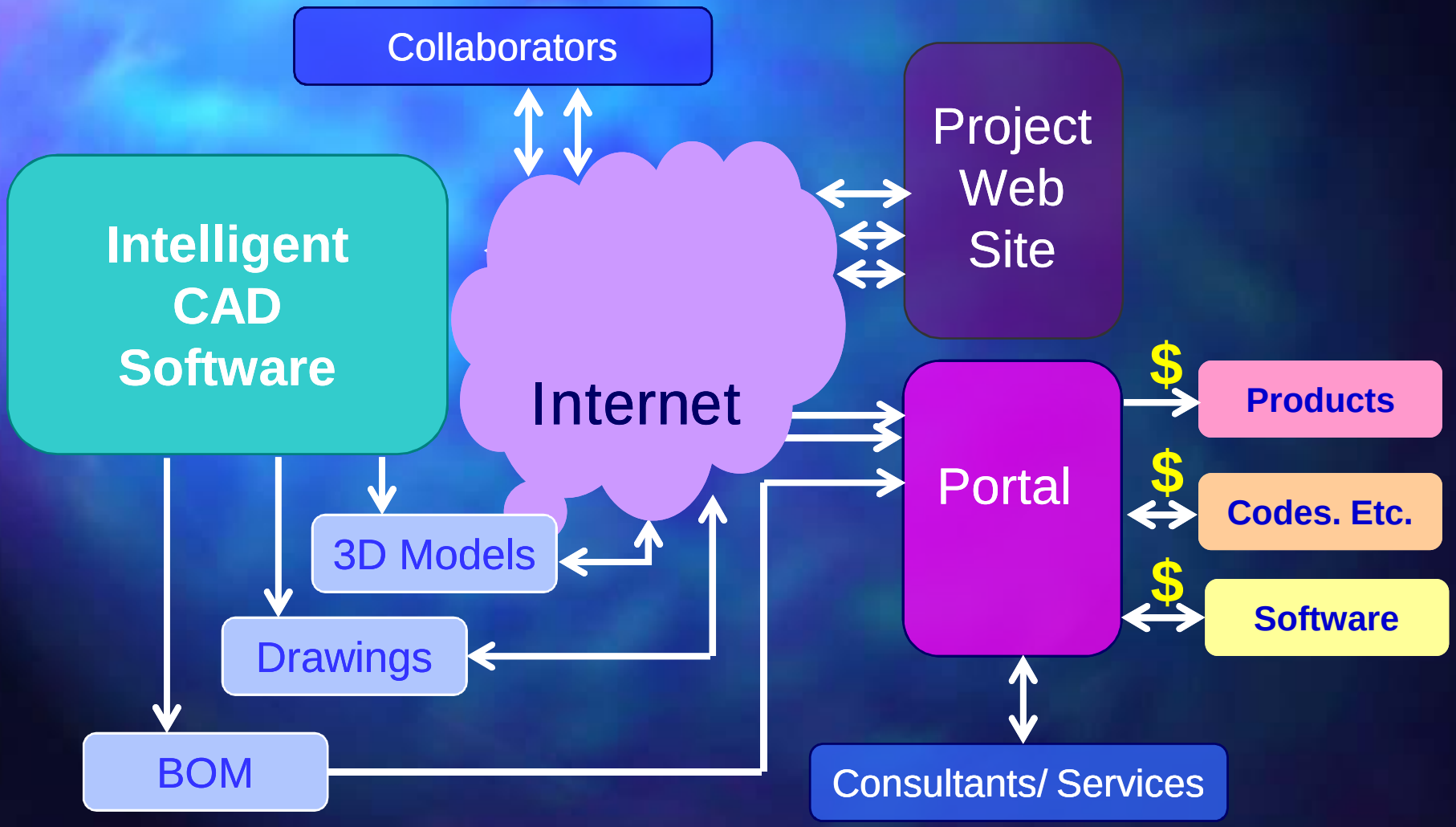
Business-to-Business Internet Commerce Projections

In Billions :



SOURCES: INFOWORLD, 1997
Forrester Research, 1998
Boston Consulting Group, 2000

The Latest: Industry-Specific Web Portals



Technology Components

- Internet communications
- Browser interfaces
- ASPs for Project Web Sites/ Extranets & ...
- Electronic brokers
  - Collect data from multiple sources
    - Product data
    - Codes
  - Provide domain-specific search capabilities
  - Provide transaction infrastructure (e-commerce)
- CAD systems that can operate in this environment!

What About CAD?

Assessment of the Current State of CAD Technology

Benchmarking I.T. Best Practices among Design Firms

- 1997 - 1998
- Small sample
- Firms from 22 to 700 staff
- Focus
  - Chicago office
  - Architectural practice
  - General building types

Methodology

- Surveys
  - Technology Components
  - Business Effects
- Interviews with project teams

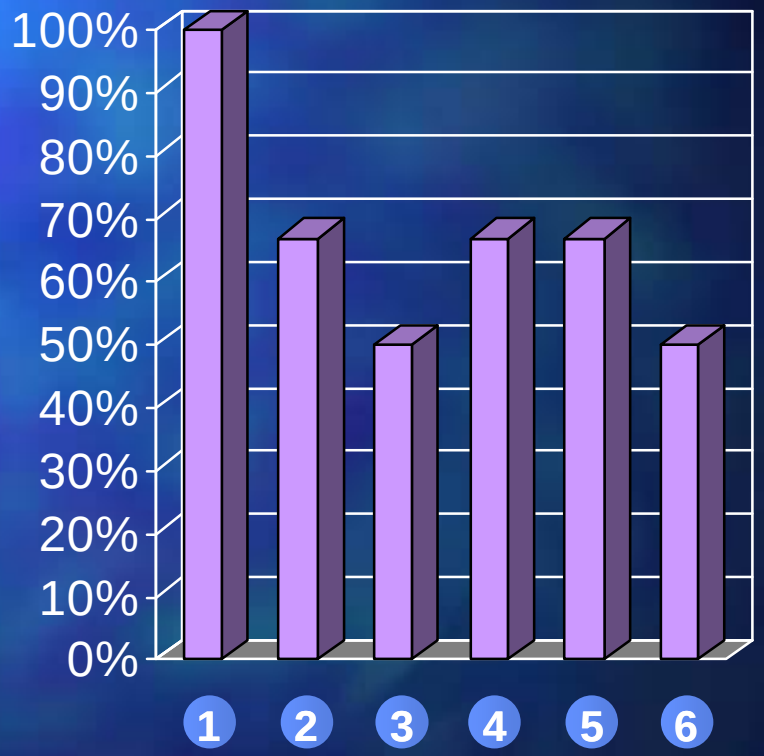
All Firms Agreed

- Money spent on computer technology had yielded benefits.
- Computer technology had changed the firm's work processes.
- These changes were positive.

Architectural Groups:

Benefits in Design Phases

1. 2D CAD is indispensable.
2. Computer use reduces the number of people needed on a project.
3. Computer use reduces the total number of hours per project.
4. Computer use shortens the calendar time it takes to complete a project.
5. Computer use increases revenue per person.
6. Computer use increases firm profitability.



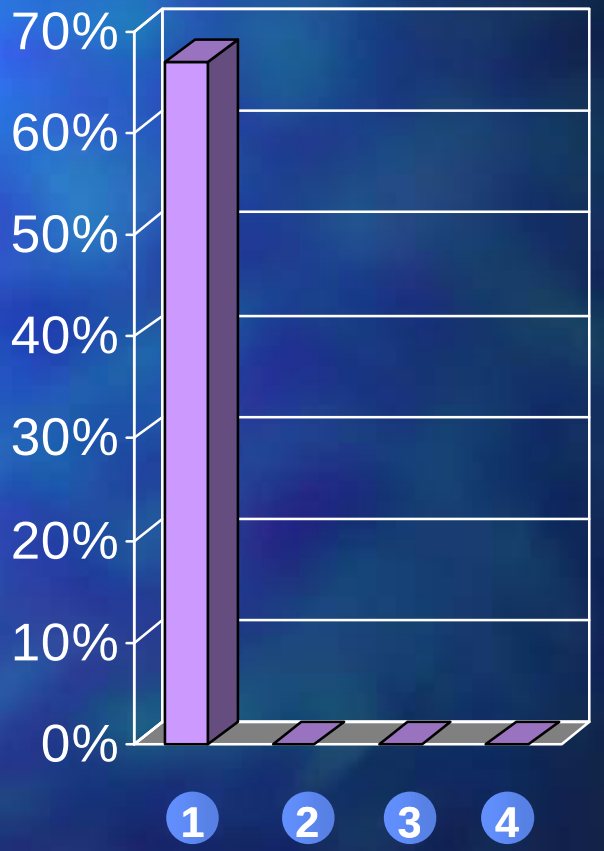
Failures to Reap Benefits

- Missed higher level benefits
- Missed 3D modeling benefits
- Little emphasis on applications other than CAD

Architectural Groups:

“Big Picture” Benefits

1. Computer use improves client satisfaction.
2. Computer use reduces the number of field change orders.
3. Computer use reduces the cost of field change orders.
4. Computer use reduces errors and omissions.



Challenges Identified

- Interdisciplinary coordination issues
- Barriers to information reuse
- Lack of automated controls

Interdisciplinary Coordination

"Interferences between building systems is where all the reworks occurs."

CAD for Principals Council, 1999

Case Study: LS3P Architects

- Initiated a TQM project directed toward building quality control into the design and documentation process
- Tackled the interdisciplinary drawing coordination problem, using 2D CAD techniques
- Replaced a final coordination checking procedure with use of master project CAD model during production

LS3P's Goals

- Eliminate cost of producing redundant information
- Improve management of design information
- Improve project team communication
- Improve accuracy and graphic quality
- Reduce review and rework effort
- Improve ability to respond to client-driven revisions

What the Effort Involved

- Setting up the CAD system so all plan drawings referenced the primary model.
- CAD standards that:
  - Segmented data to serve all disciplines
  - Plotted data in correct line weights for different drawing types
- CAD customization to handle rotated and irregular geometry
- Establishing procedures for data exchange with outside consultants
- Refining the approach over time

TQM: Anticipated Benefits

- Higher Profit Margins
- Better On-Time Performance
- Less Re-Work
- Fewer Under-Performing Jobs
- Work Process Improvements

What Benefits Did LS3P Reap?

- Reduced design cycle time by nearly 50%
- Reduced review and rework time by 35%
- Reduced construction change orders by 80% (client estimate)

One Project Team in Benchmark Tackled the Same Problem

- Developed CAD Standards that worked for all disciplines.
- Made adherence to these standards “idiot-proof.”
- Automated creation of drawing backgrounds.
- Automated drawing background updates.
- Trained project team in tools and procedures.
- Provided project-dedicated IT support.

Results

- Only team in benchmarking study to rate computer use “Highly Effective” for all project phases
- Only team to rate computer training and support “Highly Effective”
- Errors and omissions: less than 1% of construction cost

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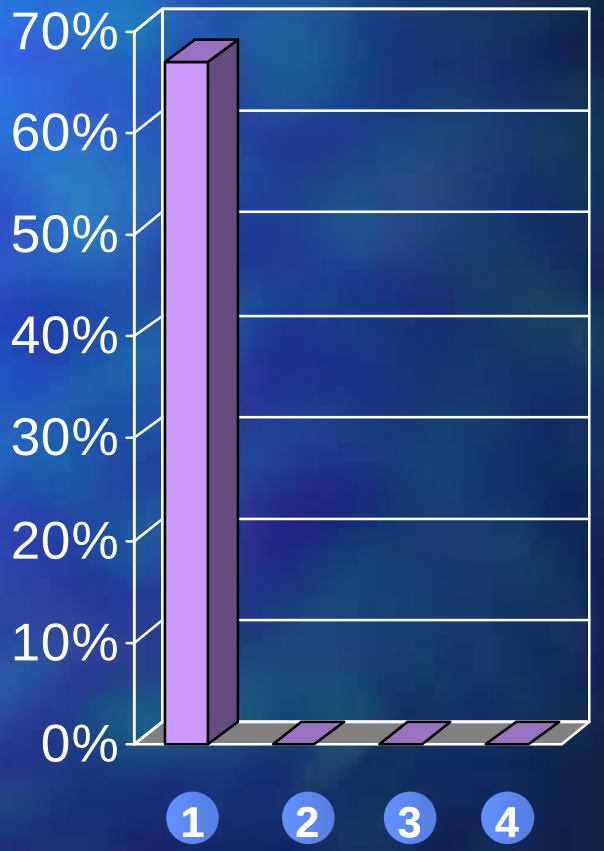
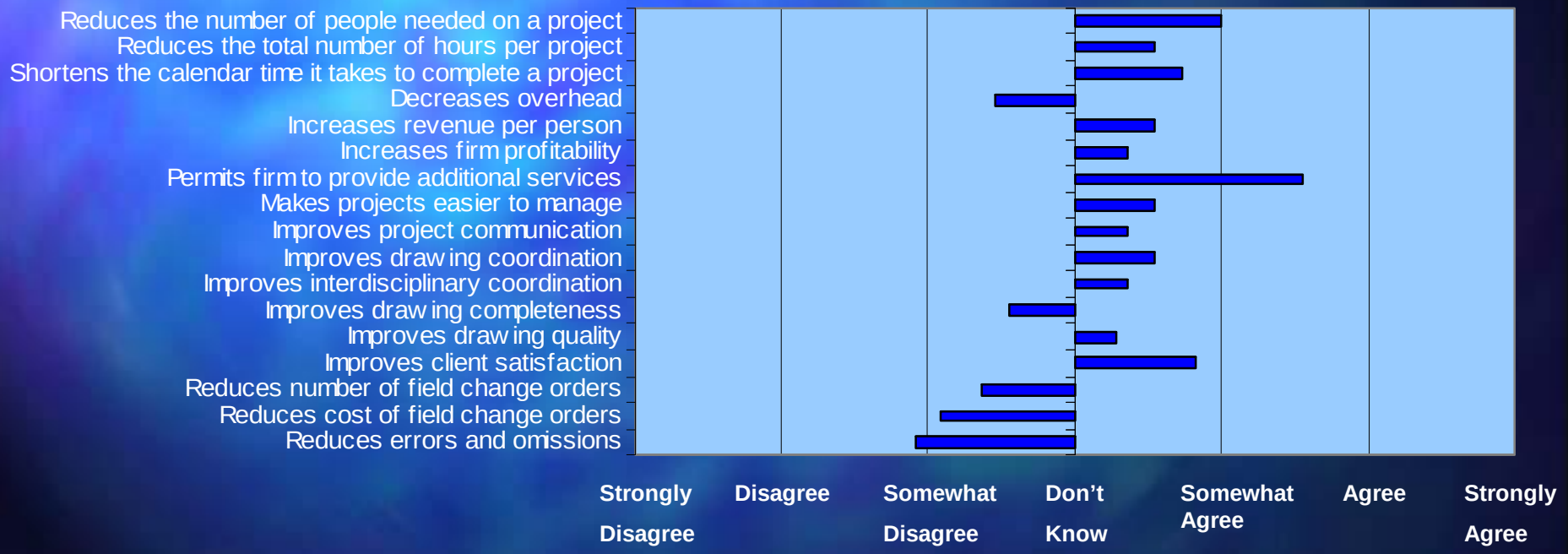


Obvious Questions:

- Why aren't all AEC organizations using CAD in this way?
- Why don't design firm believe they realize high-level benefits?
- Is the problem with the firms?
- Or is the problem with the CAD products?

CAD Impact Evaluation:
CAD for Principals Council, 1999

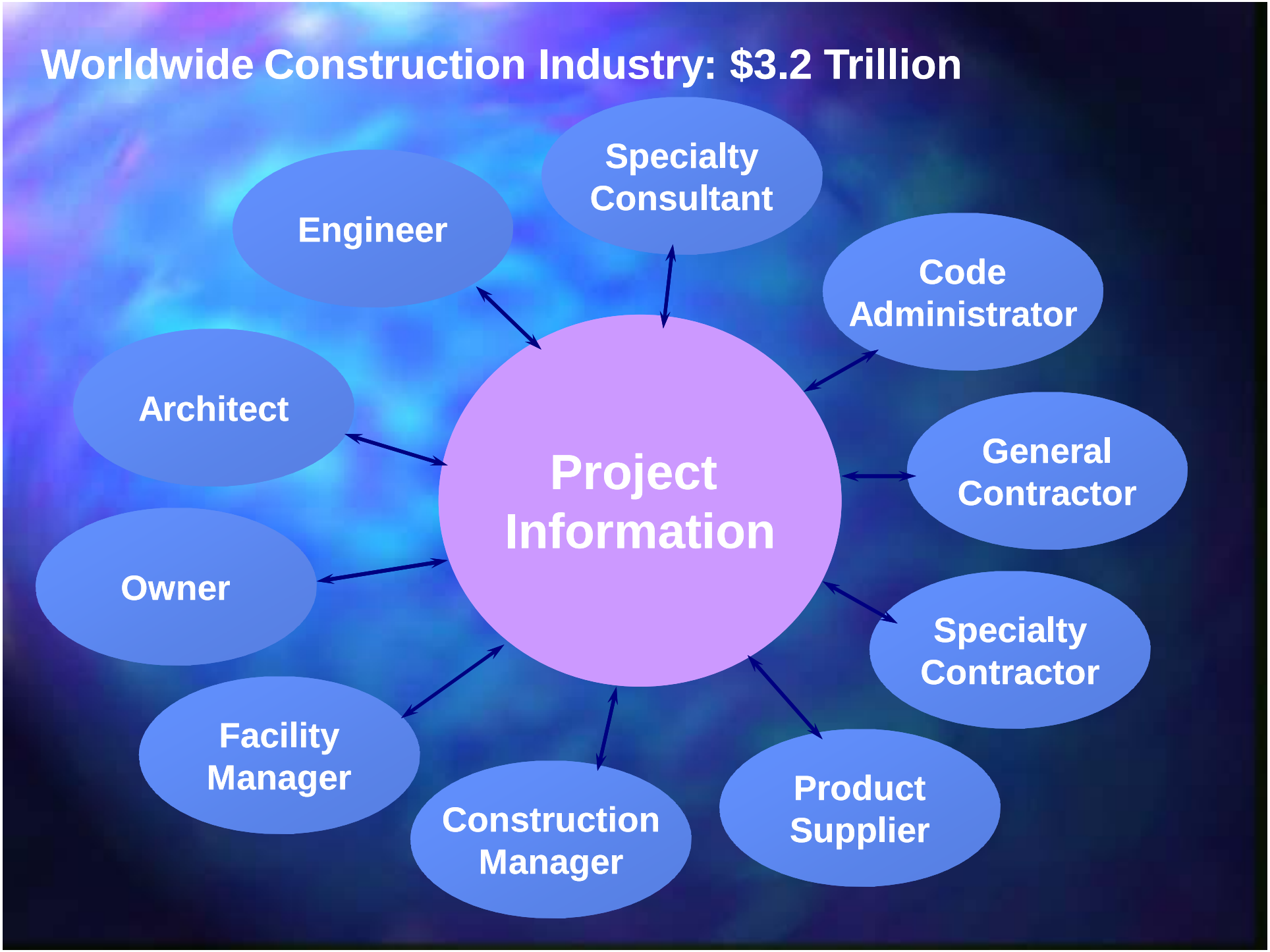


What Are the Problems with Existing CAD Technology?

- Initial training hurdle
- Constant relearning/ obsolescence of skills
- Isolation of experienced personnel from the process
- Staff develop either computer skills or professional expertise, not both
- Difficulties in monitoring project progress and catching mistakes early
- Difficulty of coordinating and enforcing complicated CAD standards and procedures
- Problems getting output

"To date computers have eased the cumbersome task of preparing complex documents that require enormous amounts of data. Computers have improved our ability to envision a three-dimensional object and present it to the user. The next step is to seamlessly link the architect's efforts to the industry that procures, assembles, constructs, delivers, and operates and occupies the buildings."

W. STEPHEN SAUNDERS AIA
Eckenhoff Saunders Architects, Inc.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The Paradigm Shift: CAD Concept is Changing

- From Creation of Drawings
  - 2D
  - Symbolic Representations
- To building electronic simulations
  - Complete (to some level of detail)
  - Unambiguous(non-symbolic)

Beyond 3D Visualization

- 3D *Geometry*
- Focuses on the appearance of surfaces
- Provides tools for:
  - Assigning materials to surfaces
  - Setting light sources and intensities
  - Moving through the designed environment
  - Generating “photo-real” images
  - Generating and recording animations

“Next Generation” CAD Products

- Autodesk:
  - Architectural Desktop
- Bentley
  - TriForma
  - PlantSpace
- iez
  - speedikon
- Nemetschek
  - AllPlan
- Revit – coming soon

The New CAD Generation Must Provide Tools For:

- Selecting/ substituting construction products/ assemblies
- Managing the relationships among building components
- Creating and modifying the model based on design and analysis applications
- Maintaining associated data, especially cost
- Generating and working in multiple views of the model
  - 3D views
  - 2D drawings
    - Plans
    - Sections
    - Elevations
  - Schedules
  - Bills of materials
- Identifying interference conditions

The Holy Grail of CAD

"Starting in 1959 we outlined a system that would, in effect, join man and machine in an intimate cooperative complex... the designer seated at the console drawing a sketch of his proposed device on the screen of an oscilloscope tube with a light pen, modifying his sketch at will, and commanding a computer slave to refine the sketch into a perfect drawing, to perform various numerical analyses having to do with structural strength, clearances of adjacent parts, and other analyses as well."

- Steven Coons, 1963

What Information Constitutes this *Parametric* Building Model

- Form: the traditional CAD domain
- Attributes
- Relationship/Assembly
- Behavior

Form

- Shape
- Size
- Location

Attributes

- Materials
- Finishes
- Physical properties
  - Color
  - Stiffness
  - R-value

Relationship/Assembly

- How parts are related
  - Moving a wall changes the room area
- What moves with what
  - Windows are part of the wall
- What may not move
  - Shear walls
  - Building core

Behavior

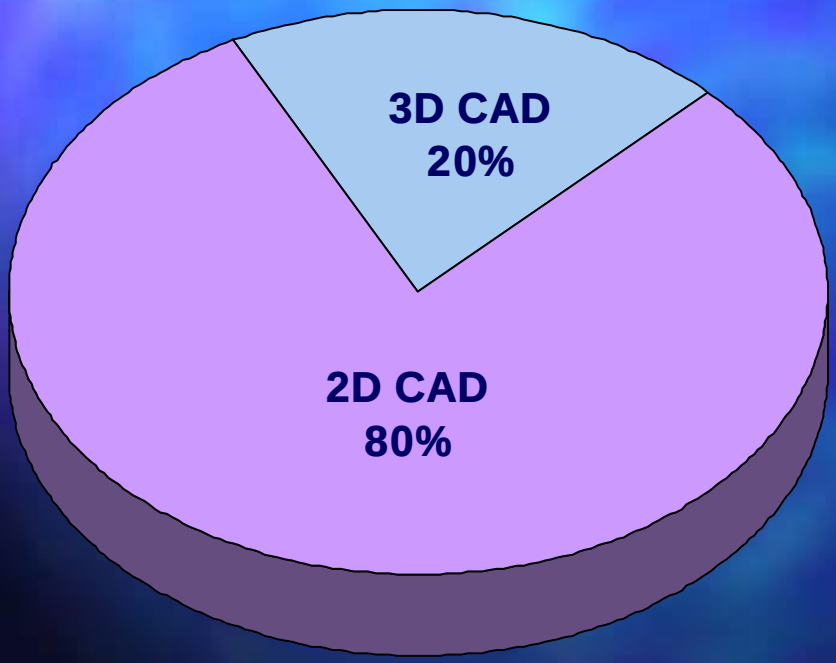
- Structural members must be sized for the load.
- More glazing allows more solar heat gain which must be offset by cooling capacity.
- Certain activities require acoustical separation.
- Building materials and systems require specific construction techniques and equipment.

What are the Benefits of this Approach?

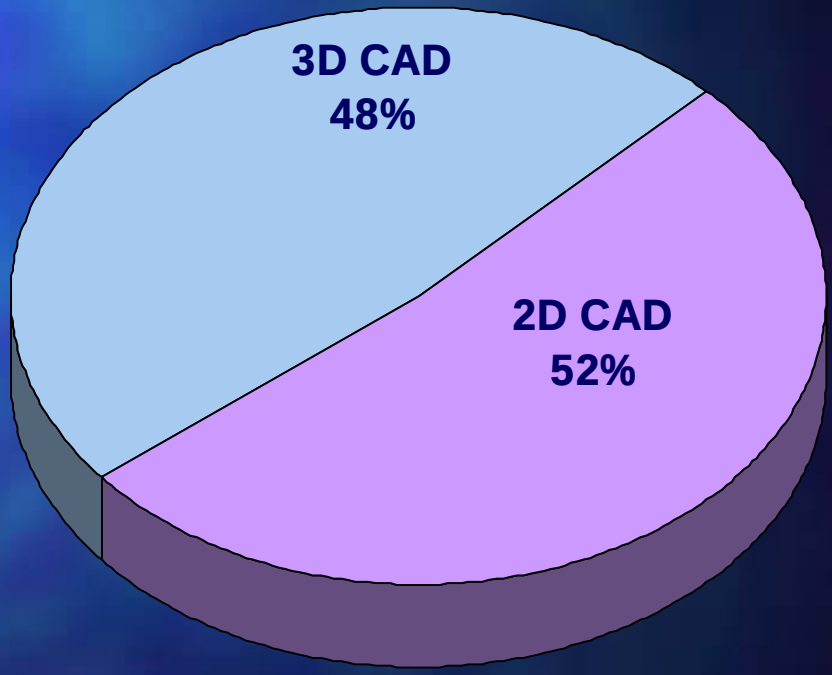
1995 CII Study - '3D CAD Link'

Plant Projects

Project Value
$5M - $50M



Project Value
$50M - $500M



CII Study: 3D vs 2D Benefits

Where Computer Use was “Average” to “Very Good”

- 5% Reduction in construction cost growth
- 4% Reduction in construction schedule slip
- 65% Reduction in construction costs due to rework

However…

- Poor use of 3D modeling increased:
  - Costs
  - Schedule slip
  - Rework
- Proper use required:
  - 3D modeling in design phase
  - Automatic interference checks
  - Integrated database
- Major use of 3D model by most advanced groups was to access the data associated with the model, not the spatial information.

Real Issues in Adopting Next Generation CAD

- Ease of use/ learning curve
- Additional design time/ costs
- Ability to handle complex geometries and unique components
- Performance
- Determining the appropriate level of detail for the model
- Ability to partition the model among multiple users while maintaining coordination
- Ability to integrate models form multiple sources
  - With sufficient detail for accurate interference checks
  - Without bogging down performance
  - Interoperability of objects from different systems
- Tools for model review and Web publishing
- Speed and ease of drawing extraction
- Maintenance of annotation when model triggers drawing update
- Techniques for batching global changes and updates
- Ability to expand the non-graphic database incrementally

CAD for Principals Council:

Requirements for the Next Generation of CAD Products

- Ease of use
- Software that works like a design professional thinks
- Design and quality feedback
- Budget, schedule, performance controls
- Output and deliverables
- Industry-wide interoperability / electronic process

Ease of Use

- Consistent user interface from release to release
- User interface objects should stay put
- Short or non-existent learning curve
- Training on the desktop on demand
- Ability to create new parametric building components without programming

Software that Works Like a Design Professional Thinks

- Support the casual user
- Plain English prompts
- Ability to see and edit the model in multiple views
- Flexible conceptual design tools with seamless progression to greater detail
- Integrated rendering and animation

Design and Quality Feedback

- Live interface between the architectural program and the graphic representation
- Ability to begin with generic components, then refine and substitute
- Ability to evaluate alternative products for fit, performance, cost, etc.
- Two-way interfaces with engineering design and analysis programs
- Automate the creation of drawings
- Automate interference detection

Budget, Schedule, Performance Controls

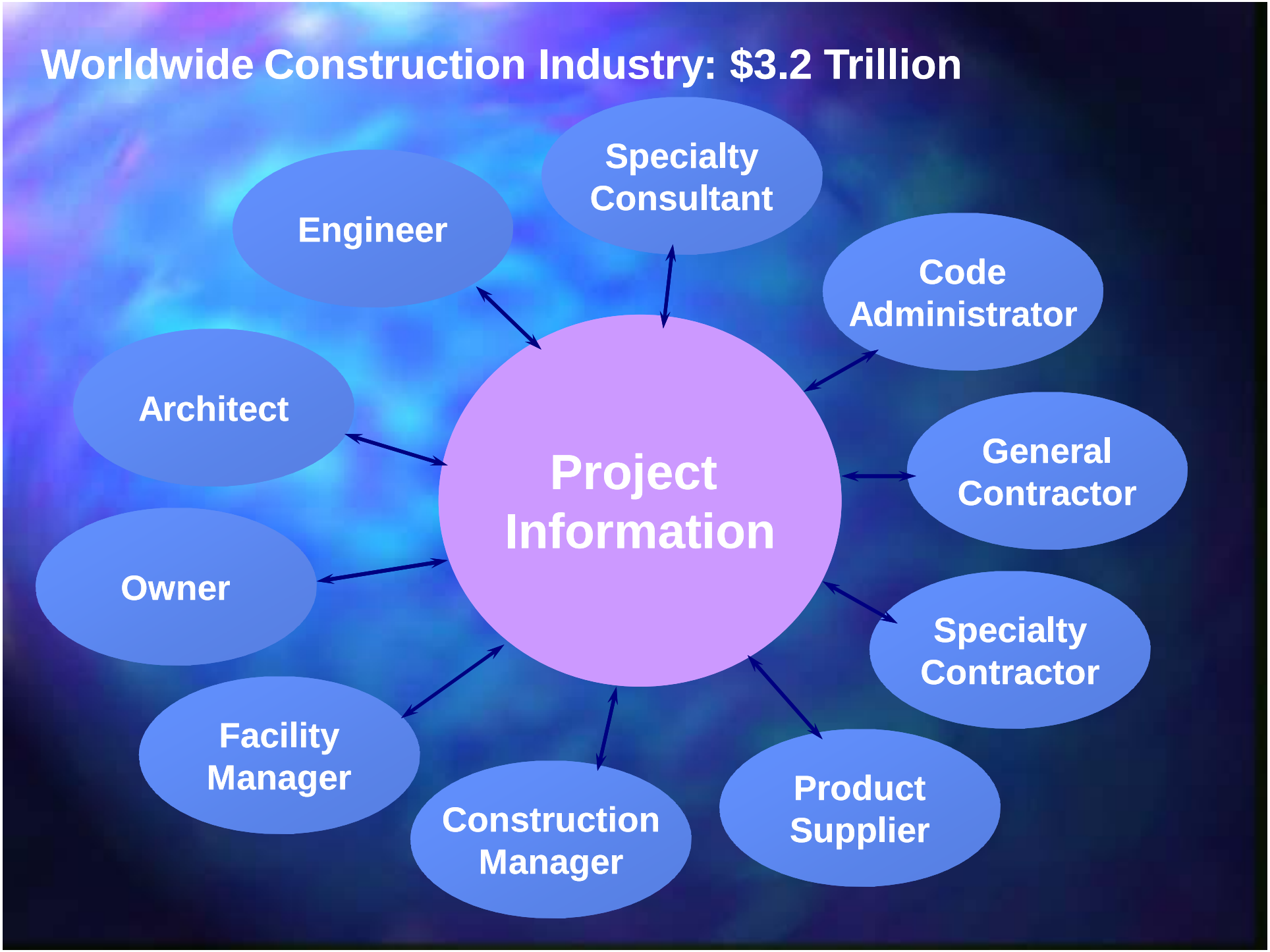
- Two-way quantification
- Support “live” QTOs
- Support a full range of cost estimating approaches (ASTM E 1557)
- Interface with RS Means Cost Works and other sources of cost data
- Ability to substitute products and immediately see cost impact

Output and Deliverables

- Output
  - WYSIWYG preview for both color and monochrome output
  - Quickly and easily output different views and scales
  - Cut and paste to other applications, such as Desktop Publishing
- Deliverables
  - Maintain compatibility with 2D CAD systems
  - Ability to conform to client CAD standards
  - Ability to bring legacy data forward into the next generation

Industry-Wide Interoperability and Electronic Process

- Support for collaboration
  - Multi-person
  - Multi-discipline
  - Multi-organization
  - Multi-location
  - Web-based
  - With model management and control
- Ability to import intelligent product templates from Web sites to evaluate:
  - Fit
  - Performance
  - Code compliance
  - Cost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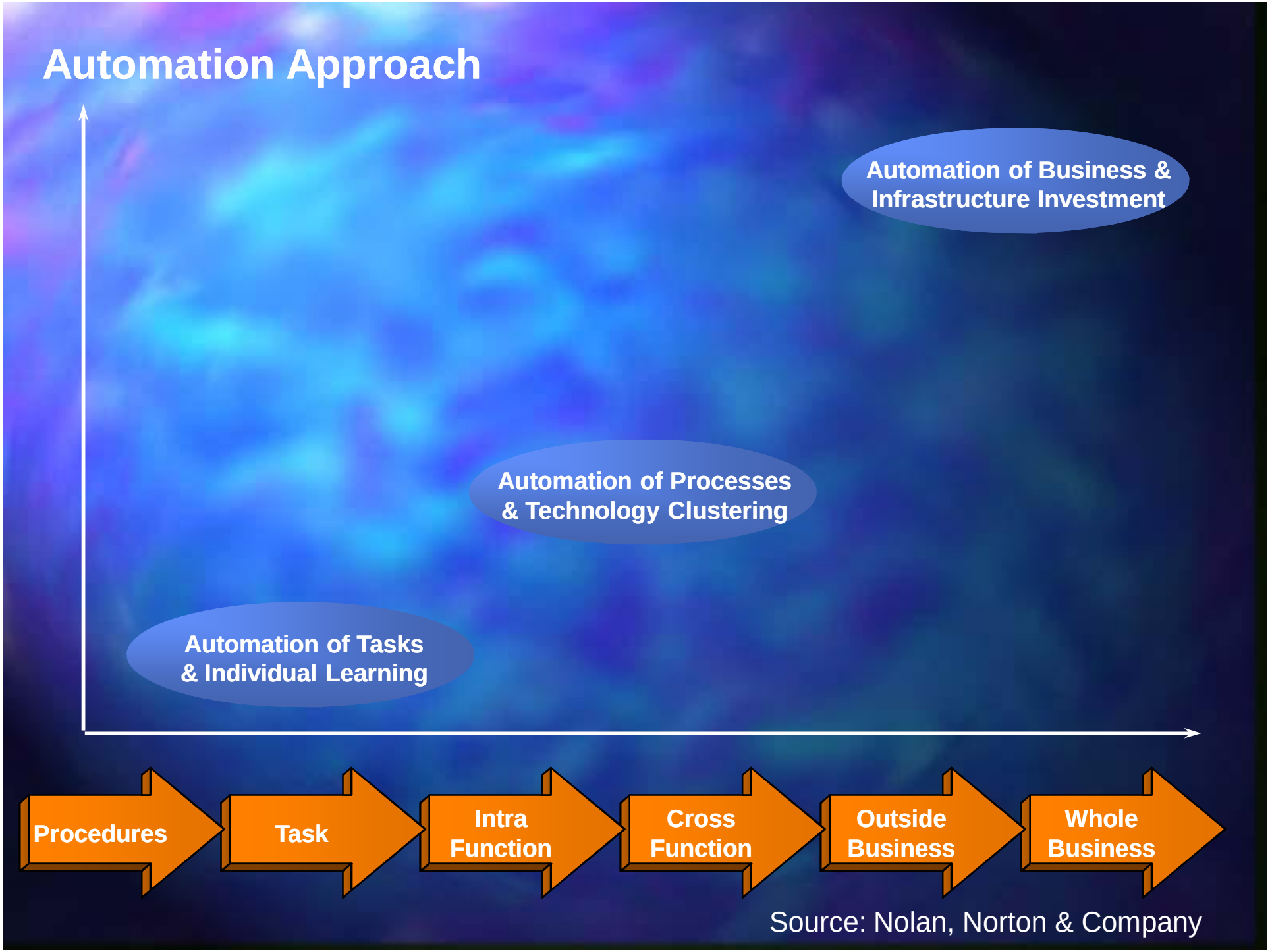
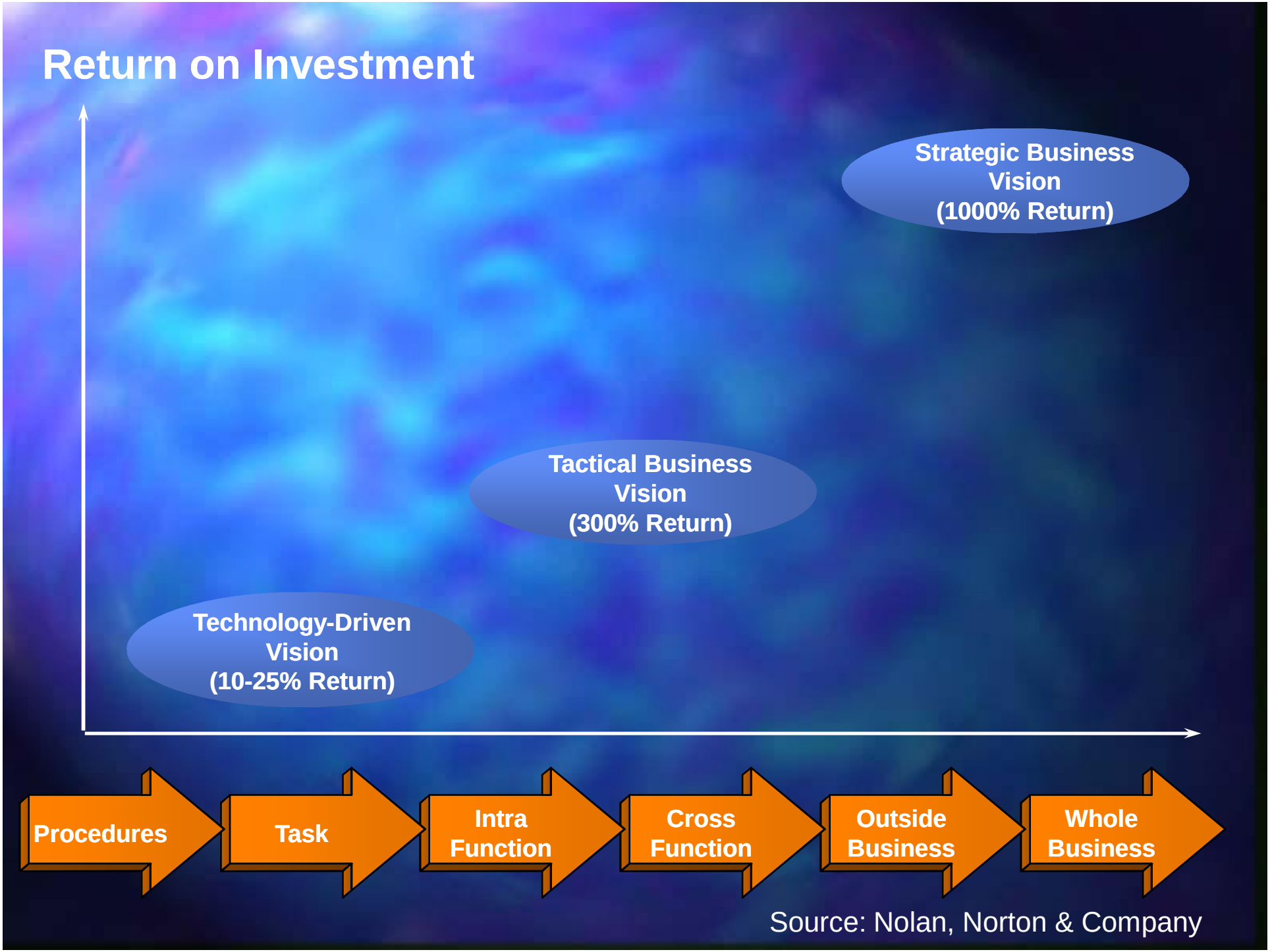
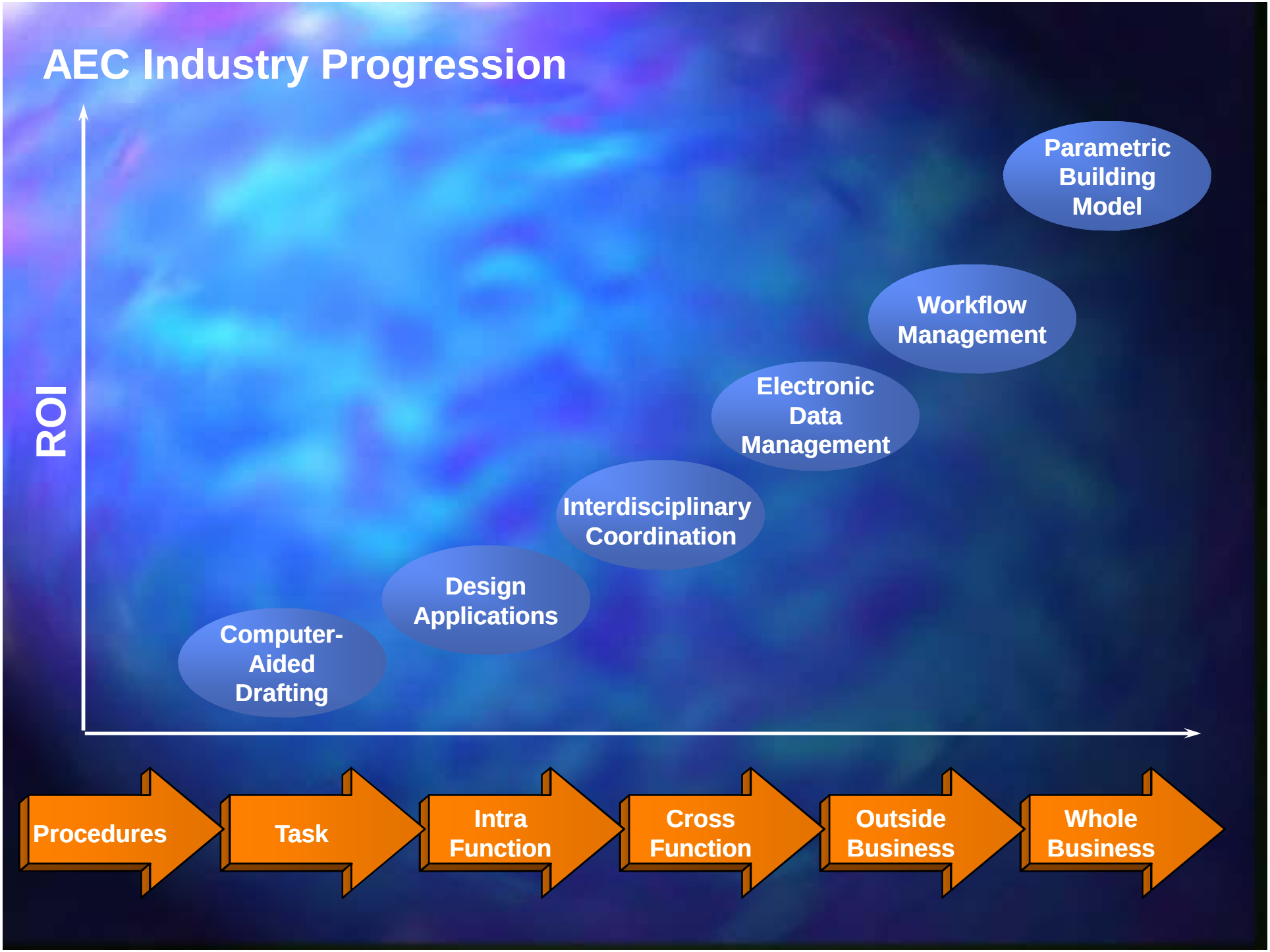
Product Supplier

Automation Approach



Source: Nolan, Norton & Company


Return on Investment
Strategic Business Vision (1000% Return)
Tactical Business Vision (300% Return)
Technology-Driven Vision (10-25% Return)
Procedures
Task
Intra Function
Cross Function
Outside Business
Whole Business
Source: Nolan, Norton & Company


AEC Industry Progression
ROI
Parametric Building Model
Workflow Management
Electronic Data Management
Interdisciplinary Coordination
Design Applications
Computer-Aided Drafting
Procedures
Task
Intra Function
Cross Function
Outside Business
Whole Business

Additional Information

- www.kfa-inc.com
- www.cadforprincipals.org
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Best Practices in Information Technology among A/E/C Firms

Kristine K. Fallon, FAIA
Kristine Fallon Associates, Inc.
30 E. Adams Street, Suite 600
Chicago, IL USA 60603
(312) 641 9339
kfallon@kfa-inc.com