

## IMPLEMENTATION OF AN INTEGRATED 3-D INFORMATION SYSTEM FOR EPC PROJECTS

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**Abstract:** The process of engineering, procurement, and construction (EPC) project execution uses a great amount of diversified information. A means to integrate the various sources of data and concisely display this information is needed. An advanced object-oriented system developed by Jacobus Technology, Inc. and customized by Fluor Daniel, Inc., allows data integration between 3D-design model information and engineering, material management and construction databases. By focusing on construction as the end-user of the EPC process, this system streamlines the integration of data, and provides a user-friendly and flexible interface to the construction field staff.

**Keywords:** Construction Visualization, Integrated Project Information, InVision<sup>SM</sup>

### 1 INTRODUCTION

The engineering and construction of an EPC (Engineering, Procurement, and Construction) project creates and consumes large quantities of information [3]. The potential of information overload in attempting to understand and correlate data is high. A means to integrate diverse collections of engineering and construction related information into a centralized project information system would assist engineering and field construction to understand the complex problems and priorities of the project.

Fluor Daniel, Inc. began to investigate and develop a system that improves integration of project information sources based on the 3D-design model in 1996. The key user of such a system would be the construction field leadership. Issues to consider in selecting and developing a design model viewer suitable for construction field sites were: training requirements, user interface, and flexibility of the system to configure to unique project requirements. After surveying the market for available plant design viewer software, the PlantSpace<sup>TM</sup> Enterprise Navigator<sup>TM</sup> application by Jacobus Technology, Inc.

(Jacobus) was selected as the core technology of the Fluor Daniel system, which would come to be known as the InVision<sup>SM</sup> system.

### 2. SYSTEM FEATURES

The PlantSpace Enterprise Navigator provides an excellent user interface for field staff to navigate the model. The PlantSpace core provides the basic viewing functions of annotating, dimensioning, and other common model review features. The InVision system is composed of pull-down menu-based queries and connections to specific construction and engineering databases used throughout the Company or specific function databases created on individual projects.

Fluor Daniel has been using the InVision system on construction field sites since March, 1998. Training requirements for field users are minimal. Field foremen and first level leadership are proficient in navigating and querying the model for information in under an hour of instruction. Standard interfaces have been developed to link the InVision system to the Fluor Daniel field progress system, material

management and warehousing system, and welding quality system. Customized field database integration has also been implemented on several projects for their locally created turnover systems and supplier shipping databases. This flexibility of the InVision system to adapt to local project requirements is an additional strength to the implementation strategy.

As of mid-1999, there are twelve projects using the InVision system. Fluor Daniel's execution strategy for projects has embraced the InVision system as a viable tool for use in the preliminary engineering phase, through detailed engineering, into construction, and concluding with turnover of the project to the plant owner.

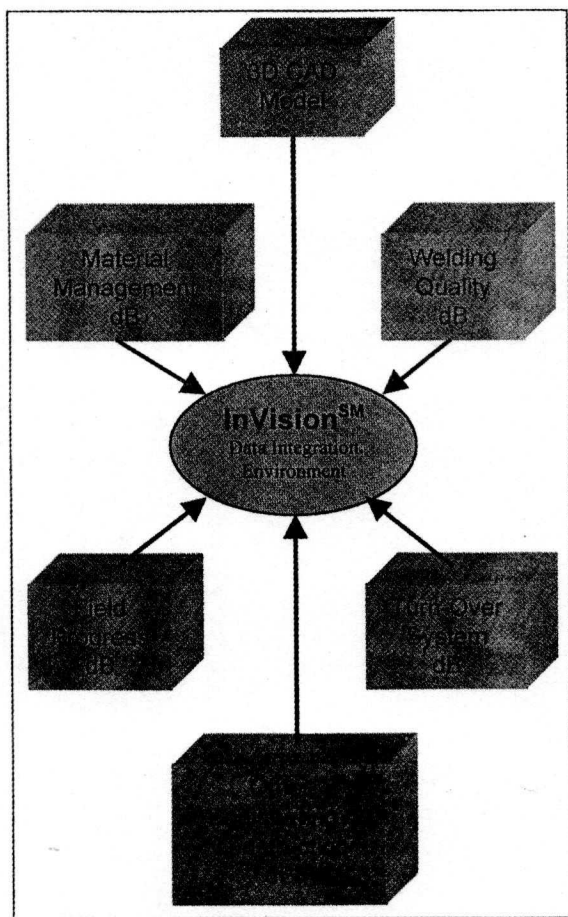


Figure 1. InVision System Data Model

Use of the InVision system model by the client for design review and operator training has occurred on at least three projects. A current project owner is using the InVision system for plant start-up training of operations personnel during the field construction execution phase, well in advance of the scheduled operator training.

### 3. WORK PROCESS CHANGE

The implementation of the InVision system on Fluor Daniel projects has provoked positive work process change. Introduction of an integrated system has encouraged traditional design and construction groups to collaborate and plan the format of project information as a deliverable product. In past projects using 3D CAD, construction received paper copies of isometric and plan view drawings, and did not receive the benefit of the encoded intelligent information in the design model. Introduction of a construction model viewer enables this valuable design information to be accessed and integrated with non-graphical databases. Field database programs are using the design information formatting to maintain consistent queries of data. For the InVision system to function, the coding structures of isometrics, work packages, uniquely tagged equipment, etc. must follow design conventions. This process is not difficult to implement, but requires effective communication among project parties in the planning phases of the 3D design and construction databases. Potential for automatic downloading of design information into the construction databases is available, but has only recently been utilized as required for the use of the InVision system.

Projects using the InVision system have greater accuracy in their construction databases due to their requirement to use design based information structures and early involvement in the information planning process.

Constructability is also enhanced through the use of the InVision system in the detailed engineering phase. The project teams mobilize construction planners early in the design process to achieve savings from design suggestions regarding the ability to construct the in-progress design efficiently. The Construction Industry Institute (CII) has published reports attesting to the high impact and low cost of design changes early in the project [1] [4] [5]. Fluor Daniel is capitalizing on the knowledge and experience of construction planners and managers to assist the design team produce a cost efficient design. This constructability effort is enhanced through the use of the 3D model in the InVision system. The ability to see the in-progress model assists these planners and managers in analyzing vessel placement and space-constraints, construction vehicle placement and space-constraints, pre-assembly studies of structures, lay-down and staging yard planning, rigging and heavy lifting operations, and simulation of the erection schedule.

Implementation of the InVision system has enacted a change in the traditional engineering – construction work process. With the consideration that

construction is the end-user of all EPC information, project teams are now designing for construction in an inter-disciplinary environment. Effective constructability is possible through the integrated visualization of diverse design and construction information. Projects using the InVision system are able to interject greater value in the delivery process of client facilities.

#### 4. PROJECT IMPLEMENTATION

In the period of March 1998 to April 1999, twelve projects have implemented the InVision system. The first project to use the InVision system has completed and won numerous Fluor Daniel, client, and industry awards for successful execution. The client named the InVision system as a significant contributor to the project success. Currently, six projects are active in the field, and five are in the detailed engineering phase.

An active InVision system field project will be referred to as *Gulf Coast Client* at project request. This project began to use the InVision system in the detailed engineering phase for model review and constructability in the Spring of 1998. The project is using two InVision system stations in the field with database connections to:

- Isometric approval database (engineering database)
- Pipe Spool Mark Piece received status (construction warehouse database)
- Pipe Spool Mark Piece shipping status (pipe supplier web-based report database)
- Progress database (construction database)
- Welding Quality database (construction database)
- Future integration to the project specific Turn-Over System database is planned.

The Gulf Coast project has foremen with prior experience using the InVision system from an earlier completed project, and is maximizing the system for purposes of field planning of pipe and equipment placement and erection.

##### 4.1 Visualize Complex Field Erection

Foremen who assist their craftsmen with field construction planning frequently use InVision system generated screen prints. These printouts allow journeymen and helpers to understand the complexities of the design in a 3D modeled perspective.

A difficult field construction situation involves the use of rolling off-sets. When a section of pipe travels down a vessel or large piece of equipment, it may

need to roll in two directions to make a connection to another section of pipe. This rolling off-set is displayed on an isometric drawing as a rectangular framed box containing the pipe off-set. The image contains dimension lines along with the pipe line segments, and can often be misleading or require lengthy analysis by the construction personnel erecting this section of pipe.

The InVision system has been used in the construction of piping off-sets to show foremen exactly how the finished section of pipe should look. This is especially useful on international projects where craft workers may not read or understand English drawings. The old cliché, 'A picture is worth a thousand words' truly applies in this situation.

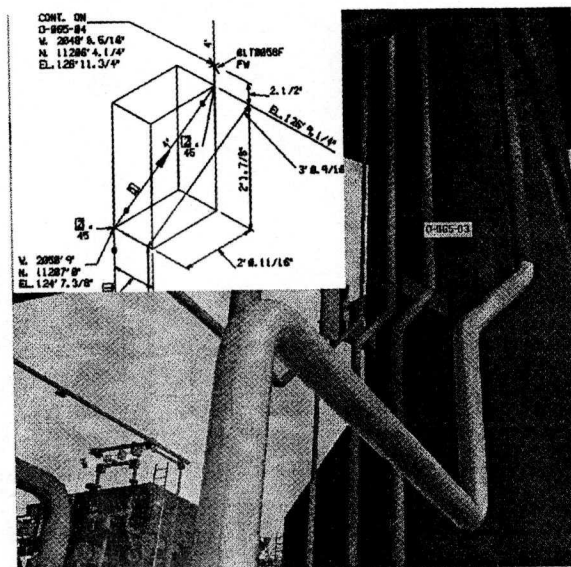


Figure 2. Rolling off-set Isometric and InVision system model view

##### 4.2 Pipe Material Status

Piping material status is available to the field user through a pull-down menu of query options. Field leadership is able to quickly display relevant information regarding pipe spool mark pieces received in the field warehouse, and inquire on the status of pieces not yet received. Planning and expediting for other material availability and labor resources is enhanced by this visual access to critical information.

The *Piping Material Status* pull-down menu consists of three queries: ISO Issued, Spool Received, and Spool ETA.

The ISO Issued query displays sections of pipe that have been released to the pipe manufacturer for shop fabrication. This status is known by examining the design software database for approval status, and

then displaying corresponding isometrics in the InVision system model.

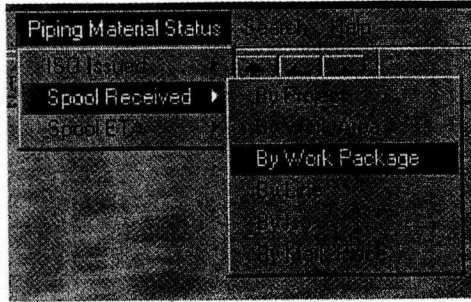


Figure 3. Piping Material Status Pull-Down Menu

Choosing the Spool Received query option displays all pipe spool mark pieces that have been received in the warehouse database system. Pipe spool mark pieces are sub-assembly units of a complete isometric of pipe. This function is useful to foremen and construction planners when they examine the model to identify areas ready for pipe installation.

The pipe fabrication contractor on the Gulf Coast project maintains a spreadsheet of estimated time of arrival (ETA) shipping information on an internet web site. Fluor Daniel downloads this shipping information, and accesses the ETA data through the InVision system interface. When planners and foremen are examining the model and discover pipe spools that have not been received, the shipping status and ETA can be quickly and easily referenced.

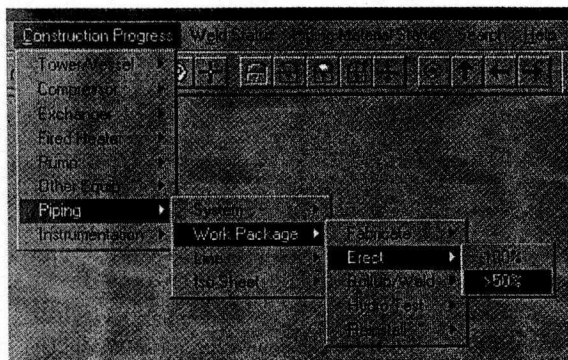


Figure 4. Progress Query Menu

#### 4.3 Construction Progress

Tracking field progress on Fluor Daniel construction projects is the responsibility of the project controls team. A database program and standard reference system used for field progress tracking is called MileMarker. The InVision system has an interface to the MileMarker system which allows field personnel to check progress of the project in the visual model environment. The queries in the Construction Progress menu allow field leaders to select by

discipline various levels of the work break-down system (WBS), and milestone percentages.

#### 4.4 Weld Status

Fluor Daniel utilizes a weld tracking and quality control database program as a standard reference system. The Non-Destructive Examination and Welding System (NEWS™) tracks all weld production, welder qualification, and administers selection and tracking of non-destructive examination (NDE) requirements. The InVision system is integrated to the NEWS program and can display a project's welding status at the isometric level of detail. Field uses of this interface have been to identify locations of randomly selected welds for NDE testing, and monitor the weld production of erected isometrics of pipe.

#### 4.5 Client Uses

The Gulf Coast client is currently using an InVision system station to conduct operator start-up training during the construction execution phase of this project. This advance training and planning will accelerate the duration of commissioning the new unit. Clients have consistently been impressed with the InVision system and its capabilities and support its use as a constructability tool.

Expanded future use of the InVision system model by owner-operator clients is possible. Suggested integration applications would be to the owner's maintenance and operations legacy database systems. Many Fluor Daniel clients are using the SAP™ R/3™ application by SAP Aktiengesellschaft, Systems, Applications and Products in Data Processing (SAP) for plant maintenance and production planning. Development between SAP and Jacobus is underway to offer an off-the-shelf linkage to the SAP brand Enterprise Resource Planning suite of products.

## 5. BENEFITS OF THE INVISION SYSTEM

Prior research in the field of quantifying the benefits of effective use of 3D CAD models in construction have been conducted by the CII [2]. This research produced benchmarks of effective construction use of the 3D model in the areas of:

- Reduction of rework
- Improved communication
- Visualization of related information

The following benefits were found to be the result of effective use of 3D CAD models:

- 5% reduction in cost growth
- 4% reduction in schedule slip
- 65% reduction in rework

Fluor Daniel is in the process of benchmarking its use of the InVision system's performance against these metrics. Project teams have already recognized the InVision system's benefits in the areas of:

- Reduction of direct labor hours in Piping, Structural Steel, and Electrical trades
- Field visualization of related database information
- Comprehension of difficult design structures
- Improved constructability planning
- Productive field material and execution planning

Three Fluor Daniel projects, which currently have the InVision software system in the field, were surveyed to document InVision savings. An InVision log sheet was used to track daily InVision system use.

- Description of work performed on InVision
- Discipline
- Estimated manhours saved using the InVision System
- Prints made (Y/N?)
- Date

From this data, several assumptions were made to quantify actual dollar values from the manhours saved.

- The manhours were averaged over a specific time period, depending on the survey dates, and projected over the duration of the project.
- As of April 1999, the German Project is 55% complete, the Gulf Coast Project is 50% complete, and the Canadian Project is 26% complete.
- Duration of InVision system use in the field: German Project 18 months, Gulf Coast Project 12 months, Canadian Project 24 months.

Preliminary data shows the following percentage savings of Total Installed Cost (TIC).

Project	Projected Total Savings from InVision	Total Installed Cost	Percentage Saved* *April 1999
German Project	\$661,000	\$215,000,000	0.31%
Gulf Coast Project	\$1,011,000	\$111,000,000	0.91%
Canadian Project	\$278,000	\$640,000,000	0.04%

Figure 5. Percentage of TIC Saved by Using the InVision System

A consideration to be taken into account when reading the above percentages, is that the Gulf Coast Project and the Canadian Project are self-perform projects while the German Project is a construction management (CM) project. The Gulf Coast Project and the Canadian Project are therefore expected to have greater savings because of the craft's increased utilization and access to the InVision system. An additional factor to be taken into consideration is that the Canadian Project is only 26% complete. In the first quarter of the execution plan, the majority of piping and conduit routing has not begun. These are both areas where significant manhour reductions are expected.

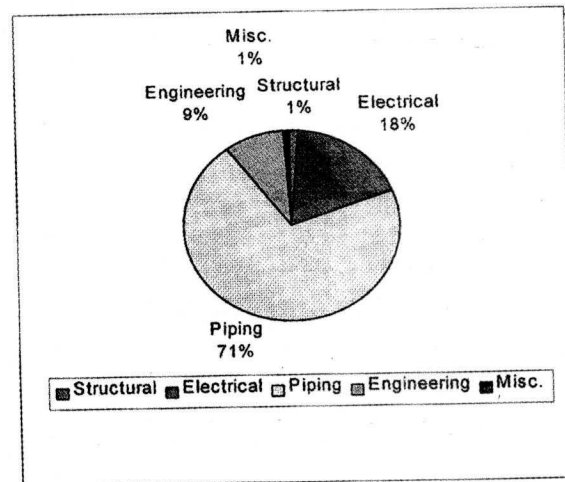


Figure 6. Percentage Manhours Saved Per Discipline

As seen in Figure 6, the majority (71%) of the manhours saved were in the Piping discipline. The use of the InVision system by the Electrical discipline (18%) is very interesting. Electrical conduit is typically not modeled in PDS, but the Electrical foremen and supervisors are second only to Piping in their use of InVision. It is significant that a trade whose design information is not contained in the model is a major user of the system.

Project	Benefit/Cost Ratio
German Project	8.26
Gulf Coast Project	12.63
Canadian Project	2.78

Figure 7. InVision Benefit/Cost Ratio

The benefit/cost ratio is a measure of the benefits, or savings, created by the InVision system divided by the total cost of the system. The total cost of the InVision system includes the software, hardware, training, licensing fees, and installation charges. To date in April 1999, use of the InVision system has produced a minimum benefit/cost ratio of 2.78 on the

Canadian Project and a maximum benefit/cost ratio of 12.63 on the Gulf Coast Project. The benefit/cost ratio for the Canadian Project is expected to increase as more substantial progress is made. The InVision system savings are expected to result in an average benefit/cost ratio of 8.0.

The InVision system's first year of use in the field has been an unqualified success. Actual project savings allow a prediction of an average reduction in TIC of 1.0% for a Fluor Daniel self-perform project and an average reduction in TIC of 0.5% for a Fluor Daniel construction management project. An average reduction of 0.5% of total field manhours is also an accepted benefit of using the InVision system.

The future of the InVision system at Fluor Daniel is solid. In the first year of use, twelve projects initiated the system. Many foremen have transferred from the completed InVision system project to the Gulf Coast client field site, and avidly requested use of the InVision system. As project teams dissolve and re-form on new task forces, experienced InVision system users will assist the propagation of the new work processes and use of the system.

Fluor Daniel expects to remain an industry leader through the use of effective automation to deliver the highest quality facilities to our clients for the best value. The InVision system supports the Fluor Daniel culture of Better, Faster, Cheaper, and Safer.

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