SmartPlant Enterprise and offshore engineering projects

Understanding interdisciplinary integration in complex engineering projects, and the impact of SmartPlant in Agility Group

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By

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To my mother

Abstract

Agility Group is an offshore engineering company that is implementing an integrated environment for the design and construction of their offshore projects despite their inherent differences. The aim of this research paper is to determine whether SmartPlant is a suitable tool for use in Agility Group for future complex offshore projects where the time frame of the project is short and project integration is complex. SmartPlant (and its 3D component “S3D”) is a state-of-the-art plant design system developed by Intergraph. It supports all disciplines that are involved in plant, offshore and marine installations. Because offshore projects generally involve most or not all disciplines, and the need for integration is the most important, it was selected as the basis for this analysis.

All offshore projects come with a contractual deadline and any delay invokes a penalty clause. More than that any time overruns lead to cost overruns because of inflation and also because of the additional resources required to make up the time losses. Project Management has a number of tools to keep control of time in a project and prevent any time overruns. The purpose of doing a project is to complete the project within the budgeted cost and make a profit. As such, if no control is kept on cost the project cost will increase and eat away into the profits. In this thesis we are about describing various activities that involved in offshore project and most importantly the deliverables required by clients. Deliverables and the time frame are key factors in deciding the suitability of an engineering tool. We are going to have a clear look at tool that was likely to be implemented here. The tool was detailed study with respect to bench mark and case study like mark project (where the sample project or successfully executed project or a part of it) reconstructed and analyzed before it was suggested to client.

Acknowledgements

I would like to express my sincere thanks and appreciation to my supervisor, Marius Stian Tannum who has provided direction, assistance and encouragement during my thesis. I also appreciate the opportunities he has provided for me to continue learning in Norway.
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Chapter1 Introduction

1.1 Introduction

The role and expectations of 3D systems in the design and production process are expanding day by day. In the traditional design environment, the most important requirement of the CAD system is to provide drawings for production.

In the offshore engineering environment the CAD system should not only provide drawings but also procurement data, detailed production information, and factory automation data [1, 2, and 3]. Many offshore companies are deploying a 3D product model based design system [4, 5] to support this variety of requirements.

Agility Group is one of the companies in Norway doing offshore engineering design work with a full 3D product model based environment. The engineers who are involved in a specific project have to share information in real time. The 3D CAD system has to support this requirement.

1.2 Background

Today's global, fast-track projects require engineering, procurement, and construction (EPC) contractors to successfully manage and perform projects involving the concurrent participation of multiple design centers worldwide, while still keeping a handle on project schedules and costs. They must also preserve their "best practice" design information for re-use on future projects, to increase productivity and preserve their corporate knowledge. Likewise, plant owner/operators (O/O's) must employ concurrent in-house and off-site contract design resources for Greenfield, major revamp, and maintenance projects. They also need the ability to re-use the as-built models of their plants to shorten project design cycles, while continuing to preserve the as-built plant model to support operations and maintenance activities. [6]

To understand the usability and efficiency of SmartPlant in Agility Group and offshore project integration it is important to understand its strengths and weaknesses in relation to the company's workflows and project management execution processes.

1.3 Computer based tools in the design process

Computer based design tools have offered a new dimension in the design process. Due to their introduction to the design process, designers now have a wide variety of media at their disposal, such as digital images, hypertext and multimedia as well as traditional pen and paper based media. In addition, computer based tools are used in many phases of the design process in supporting design activities. 2D graphics and CAD tools are used in the early phases of the design process, where designers want to focus on visualizing design concepts. A set of graphic design software originally developed to computerize the 'design for print' process became popular with product designers. These tools include illustration, desktop publishing and image manipulation applications and are used at various stages in the design process, for such tasks as rendering, image editing and designing and specifying product graphics. Designers also use multi-media authoring tools to simulate and test the interfaces of electronic products. Design database and information browsing systems are used throughout the design process, for instance where designers are required to investigate production processes, materials, or even the marketing of a product. [7].

There is no doubt that 3D CAD systems play an important role in design activities, because many design solutions are realized in the form of a 3D artifact. In product design, 3D CAD systems help designers by computerizing the process from early concept generation to detail development and manufacturing. These tools allow experimentation with such features as angle of view, color, surface finish, lighting, product graphics and various structural properties without fear of losing the original concept. 3D design concepts can be represented by wireframe, surface and solid 3D models. Tangible prototypes can be produced automatically using rapid prototyping tools, such as 3D printing and stereo lithographic systems. Effectively implemented 3D design tools are not only for product designers but also for other professionals participating in general product development. In this respect, 3D CAD tools are one of the most important computer based tools for product designers.

One of the problems with existing computer based design tools, particularly more complex tools such as 3D CAD systems, is that designers have difficulties using these tools efficiently. The difficulties may be caused by the complicated and unnatural user interfaces of existing 3D design tools. Developers of design tools sometimes build the tools without having a full understanding of how designers work. As a result, designers have to change their work patterns in order to match the interface that the tools may require, although this may not be the most efficient and natural way to accomplish a given design task. Therefore users' perspective on the development of design tools is essential.

1.4 Computer Supported Cooperative Work and Design

Most of the computer based tools mentioned above have been developed largely to support single user environments. The rapid development in network and computer technologies provides new opportunities to transform these single user oriented design tools to multi-user equivalents. This new generation of computer based design tools can be developed by applying the techniques and theories of Computer-Supported Cooperative Work (CSCW) into the design domain.

CSCW is defined as computer assisted coordinated activities carried out by a group of collaborating individuals [8]. The information technology of CSCW used to help People work together more effectively is called Groupware [9].

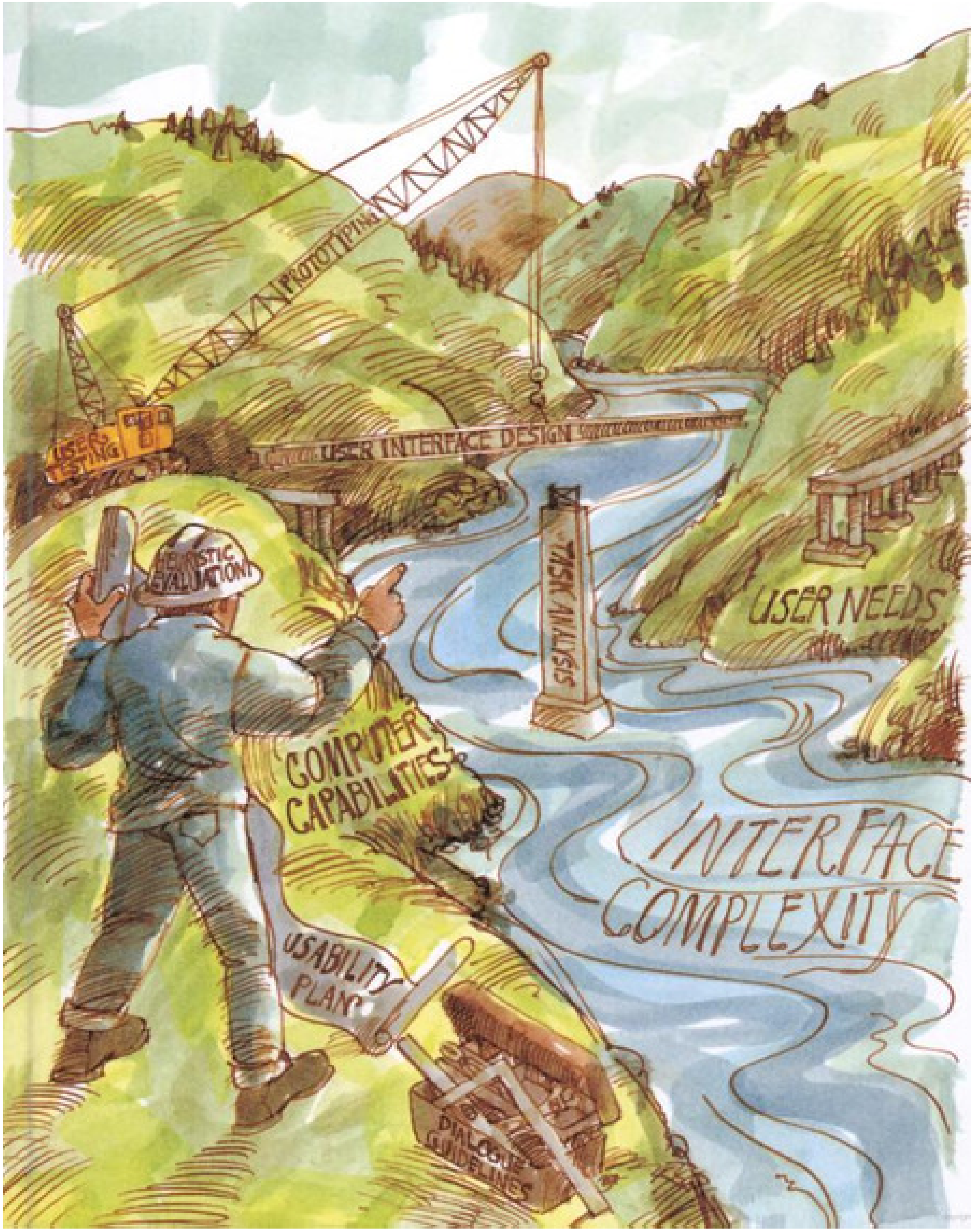


Fig. 1.1 CSCW (source: Usability engineering, Jakob Nielsen)

1.5 Definition of the problem

The main research problem in this thesis is "Understanding interdisciplinary integration in complex engineering projects, and the impact of SmartPlant in Agility Group". Offshore projects involve many disciplines and a thorough understanding must be established regarding how SmartPlant integration tools can support the project management execution process.

The SmartPlant tool how far integrated in Agility Group, it must be investigated whether all disciplines in Agility Group are fully utilizing the systems' capabilities. Knowing this is essential before measuring SmartPlant's suitability and efficiency in practice.

1.6 Purpose / AIM for this project

The background and problem discussion above leads us to the purpose of our thesis: to map out the advantages and disadvantages of using SmartPlant tools for integration in offshore projects at Agility Group. What is the advantage of using SmartPlant tools for integration?

The impact of SmartPlant tools efficiency, what advantages they give to Agility Group in interdisciplinary integration. It is hoped that a better understanding of the capabilities of SmartPlant integration tools and their use in Agility Group will benefit the company with improved implementation.

1.7 Perspective

Within this thesis project, is a case study which is strongly tied to the work processes of Agility Group. The primary data of this thesis has been collected mainly from Agility Group's previous projects.

The main focus of this thesis, how Agility Group executes their interdisciplinary integration in offshore projects and how the project execution benefits from the help of SmartPlant tools and what are the advantages using this tool in their organization.

1.8 Research objectives and methodology

The thesis' main objective is to investigate the integrated design environment for offshore projects and to identify the advantages of the SmartPlant system. The thesis paper will also explain the various types of disciplinary integration required in offshore projects and how SmartPlant tools help to fulfill the basic requirements.

1.9 Introduction to organization

1.9.1 About Agility group

Agility Group is an oil service company, headquartered in Norway serving its clients in the Norwegian continental shelf and in the international market [10]. Agility Group is organized in four main business areas:

- Solutions – EPCIC projects for oil and gas topsides, FPSOs, FSOs, drilling rigs and units
- Fabrication – World-leading fabrication of sub-sea products and systems
- Maintenance & Modifications – Maintenance and modification projects and services for the offshore and onshore industry
- Concepts and Technology – Front-runner in implementing new innovative technologies, products, solutions, tools and working methods to meet future challenges.

Agility Group (AG) is the owner company of the following companies; Agility Projects AS, Agility Operations AS. Agility Subsea Fabrications AS, Agility Services AS, Agility ConTec AS, Minox Technology AS, Athene AS, Agility China. Agility Group has a high level of competence, and solid references, in several areas. [11] The main capacities are:

1.9.2 Solutions

- EPCIC projects for FPSO/FSO, semi subs, drill ships, and other offshore and marine floater new builds
- Concepts, studies and FEED
- Design of semi-submersible drilling rigs, drill ships, FPSO/FSO
- Drilling systems on semi subs, drill ships and fixed platforms
- Topsides for fixed and floating installations; process modules, equipment packages, waste heat recovery, drilling modules, etc.
- Minox – complete units for de-oxygenation of seawater

1.9.3 Maintenance & Modifications

- EPCIC modification projects
- Modifications and services on operational offshore facilities; platform HSE upgrades, IOR, platform lifetime extension, tie-ins (topside), gas compression, water & gas injection
- Modification of drilling systems/units
- Upgrading of telecom systems offshore
- Modification and services on onshore process facilities
- Compressor and generator package assembling
- 270+ well qualified operators

1.9.4 Fabrication

- Sub-sea manifolds and integrated templates
- Sub-sea separation modules
- Platform topside modules including process and drilling units
- Fabrication required for offshore modification projects

1.10 Classification of projects

The literal meaning of the word “project” is

1. A course of action
2. A plan
3. An organized and rather extensive undertaking.

A project is a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates a definite beginning and end [12]. Every project creates a unique product, service or result [12] in general offshore projects are EPC (Engineering, Procurement & construction) or EPCC (Engineering procurement construction and commissioning)

1.10.1 Types of project executed

Everyday activities can be projects, but we should consider regular, repetitive activities as tasks or work. A specific activity which is to be carried out within a specific time-frame, at a certain cost and which serves a special purpose can be termed as a project.

In an organization when we mean a project it denotes an activity to be carried out at a pre-determined cost, within a fixed time frame and to serve the purpose as requested by the client. The common types of project handled are as follows:

1.10.2 RC (Reimbursable Contract)

Reimbursable Contract projects or Cost reimbursable contracts projects are based on payments to the service provider for actual costs incurred in addition to a fee. [13]

1.10.3 LSTK (Lump Sum Turn Key Projects)

Called Lump sum, Turnkey projects it is the most common of type of project handled by Agility Group. In this Agility Group undertakes all responsibilities such as:

1. Engineering
2. Procurement
3. Construction
4. Installation & Commissioning

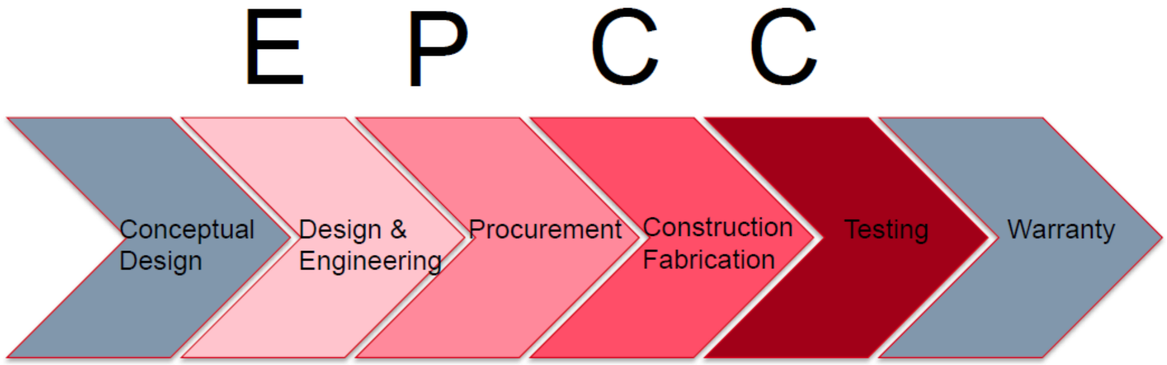


Fig. 1.2 EPCC business various phases

In other words the entire project, from start to finish, is executed by Agility Group. Agility Group is to be the leading EPCIC Company for medium sized projects [10]. During the proposal stage itself costs are worked out based on the tender requirements. During execution of the project as LSTK the entire project has to be completed within the quoted cost. Nothing extra will be paid in case the project cost goes beyond the quoted cost.

Because of this risk, LSTK project activities have to be rigidly monitored from the beginning to end to ensure project costs are kept under control.

1.10.4 LSS (Lump Sum Services)

Lump Sum Services contracts are projects wherein the entire project is not done by the contractor. Only the services of the contractor is utilized to carry out engineering, provide procurement services, provide construction supervision services, provide commissioning services and other services as required by client. All payments for supplies and construction contractors will be done directly by client. As such the financial risk involved in such type of projects is less and contractors get paid lump sum fees.

1.10.5 Guaranteed Maximum Price (GMP)

This type of contract is, though rare at present, is fast becoming more common. The contractor and the client, cooperate in preparing the project cost estimate. During this process the contractor, based on his experience, advises the client on all the options of executing the project along with its cost. The client, based on his requirement, chooses the best options on which the project cost is arrived at. During actual execution it is more or less similar to a LSS project wherein client takes the responsibility of all finances and the role of contractor is limited to advising the client.

The only difference being that the contractor will take the responsibility of completing the project within the estimated cost. If the project is completed below the estimated cost contractor is given an additional bonus along with his fees, whereas if the project cost escalates the contractor will be levied a penalty. This type of contract is possible when the client has sufficient knowledge of the project and also has enough manpower, of his own, to execute the project. Additionally, the client should have full confidence in the contractor as there will be no competition and client has to depend on one single contractor.

The following are the major parameters of any project and, if controlled efficiently, they will ensure the success of the project:

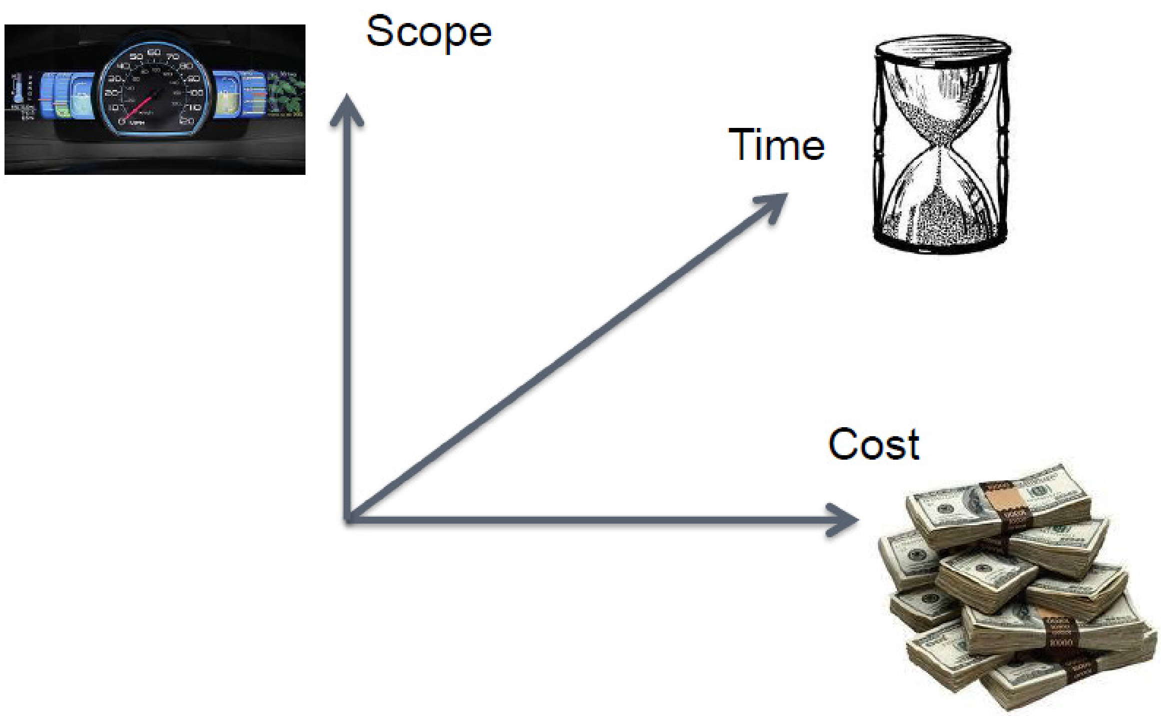


Fig. 1.3 EPCC business various factors

1.11 Project Time

Time is at the core of any project. All projects come with a contractual deadline and any delay invokes a penalty clause. More than that, time over-runs lead to cost over-runs because of inflation and also because of additional resources required either to make up the time losses or during the extra time. Project Management has a number of tools to keep control of time in a project and prevent any time over-runs. Below are a few critical tools for controlling time factor.

Project Planning: As soon as any project is received the Project Manager along with his project team studies the entire requirements of the project. Based on these studies a plan is finalized on the mode of execution of the project based on the optimal method of executing the project within the project time frame and within the project cost.

Project Schedules: Based on the above studies, the amount of work for each department is calculated and the time requirement of each activity is arrived at. This is discussed with the project manager to ensure that this time requirement suits the time requirements of the project. After detailed discussions, the time required and sequence of activities is frozen, based on which an overall schedule is prepared. This schedule gives the various activities to be performed, along with the time required and its period during execution of the project. This is a valuable tool in the hand of the project manager who uses it to monitor the project. Any slippage of time is noticed at an early stage giving enough time for the project manager to organize an alternate plans to prevent any further slippage and also to make up for the time lost. A sample of a schedule is enclosed for a better understanding.

Project Evaluation and Review Technique (PERT) & Critical Path Method (CPM) are the latest techniques available to keep track of time in a project. These are coupled with software and are very efficient in controlling projects having a very large number of activities.

Reports: Reports serve as an important tool in keeping the project manager informed of happenings in the project. These are reviewed by the project manager to ensure that the activities are progressing as per schedule and keeps him informed of any slippages. The various reports are generated monthly, fortnightly and weekly. They generally cover the following details:

• Project highlights
• Status of milestones
• Areas of concern
• List of delayed activities with corrective action
• Activities completed
• Activities in progress
• Procurement status
• Physical progress with progress curves
• Any other major factors affecting progress of project.

These reports are also circulated to the client as well as to management and serve to keep all concerned informed on the status of the project.

1.12 Project Cost

The purpose of doing a project is to complete the project within the budgeted cost and earn a profit. As such, if no control is kept on cost the project cost may well increase and eat away into the profits. The various tools for controlling cost are:

• Project review. Similar to the preparation of a schedule, the entire project is reviewed and broken down into components and the cost for each component is analyzed. At this stage, a study is made for the various options to reduce cost as well as to reduce time.

• Control Budget: This is the most important tool in the hands of the project manager to keep the cost of the project within limits. Based on the above review, the various costs of each item are frozen. After allowing for future contingencies and profit margin the budget available for each item is finalized and circulated to the relevant departments. It is the responsibility of each department to carry out each activity within the set limits.

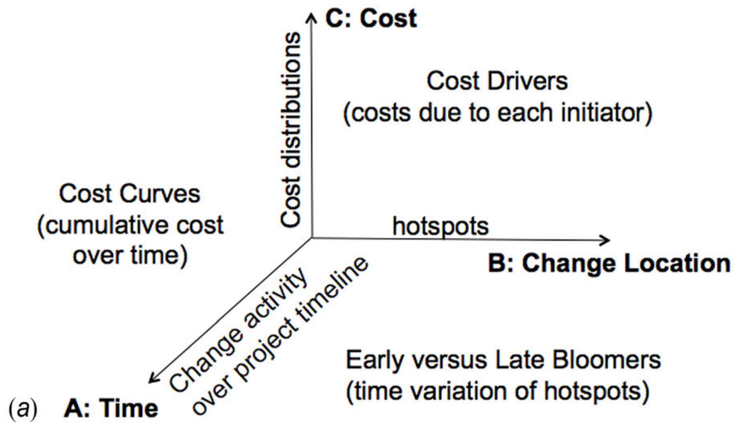
• Cost Control reports. These reports serve to inform the project manager of the actual amount spent for each activity, and keep him informed wherever the expenditures are exceeding the budgeted values and enables him to take advance action.

• F.C. Notes: These serve as a control for each item and ensures the activity is being done within the budgeted cost. It describes the resources required to complete the project within the schedule and within the budgeted cost. The major resources for any project are: 1) Manpower and 2) Material.

• Manpower. This is a major resource for any project and its success or failure depends on the type and proficiency of manpower deployed. A successful project should have a dynamic project manager assisted by a good team of dedicated personnel. They should work as a team with the common goal of fulfilling the requirements of the project. The control of cost and time should concern all individuals and not only with the project manager. Certain major projects operate with the Task Force method wherein the entire team selected for the project is housed in a separate area and will carry out the specific requirements of that project and will, normally, not do other work. For normal projects, the matrix type of organization is used and the project manager is assisted by lead engineers, in each department, who get the work done by their engineers. In this system, each engineer may be simultaneously working on more than one project.

• Material. For a normal project, the material cost comprises about 70% of the total cost. Hence it is essential to keep control on the quality and cost of the materials the project uses. Priorities for ordering of raw materials and equipment should be made based on schedules and ensure their availability, on site, at the correct time. Having material in advance only leads to unwanted inventory on site, blocked funds and higher cash outflow, whereas any delay leads to schedule slippages.

To summarize the above; the purpose of the project management team should be to complete a given project within the schedule, within the budgeted cost and to meet the project quality requirements thereby achieving client satisfaction.



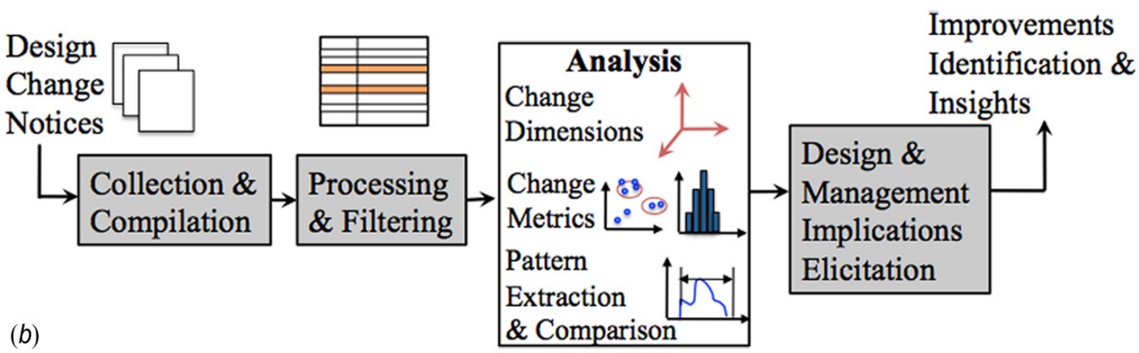


Fig. 1.4 (a) Dimensions of engineering change and (b) engineering design change analysis process

1.13 Offshore projects

The upstream petroleum sector encompasses: (1) exploration and appraisal, (2) development and construction, (3) production, and (4) major modification, and (5) de-commissioning. For natural gas (including liquefied natural gas), the definition of upstream includes processing and delivery to export terminals or domestic gas transmission pipeline in-takes. [14]

Fig. 1.5 Oil & Gas field – value chain / Phases

The piping systems that are constructed to work on the seashore or sub-sea are said to be offshore. [15] Drilling and floating platforms come under offshore piping. Offshore piping is classified as critical due to the climatic conditions where it operates and that space is extremely limited. Fixed platforms are used when the operating depth is below 600m and where climatic conditions would prevent operation from being economical. The figure below shows the types of fixed structures.

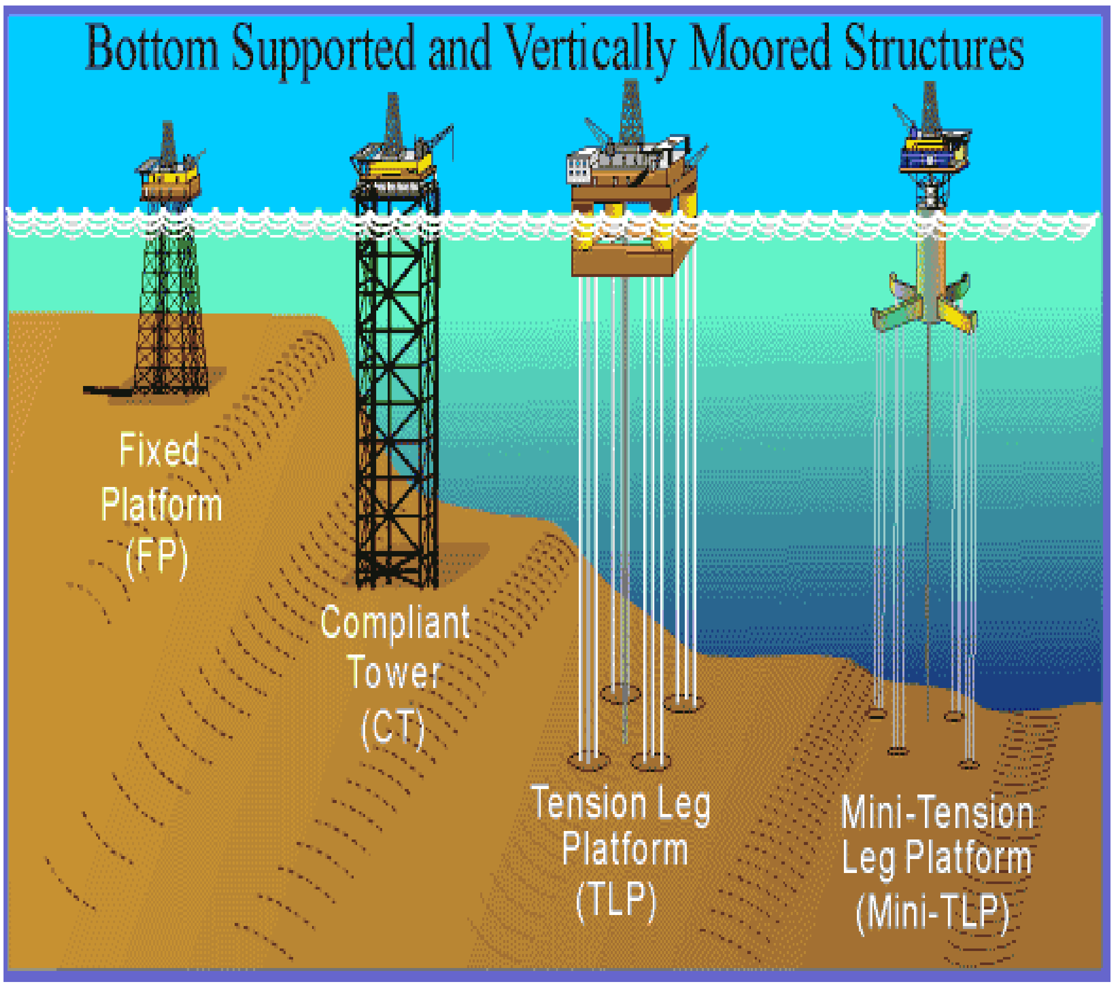


Fig. 1.6 Fixed Platforms

Floating platforms are used when the depth of exploration exceeds 600m.

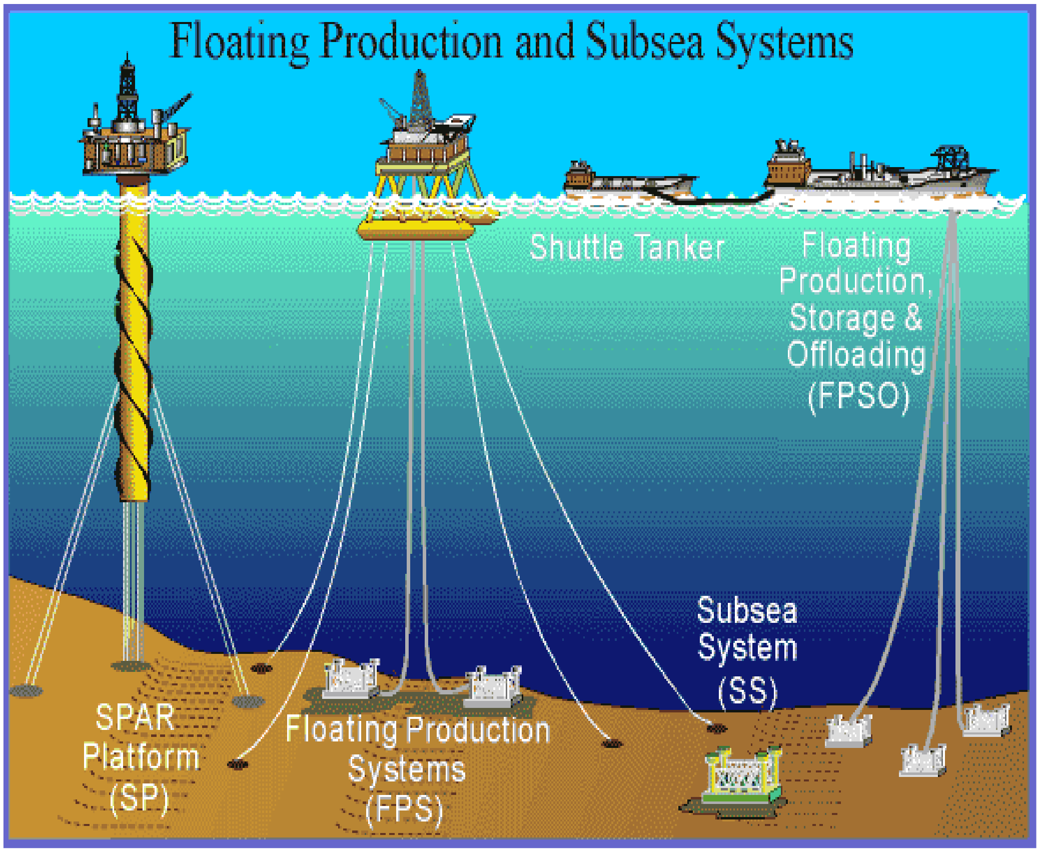


Fig. 1.7 Floating Platforms

1.13.1 FPSO (Floating Production Storage and Offloading)

An FPSO (Floating, Production, Storage and Offloading) unit is a floating vessel used by the offshore industries for the processing of hydrocarbons and for storage of oil. FPSOs are designed to receive hydrocarbons produced from nearby platforms or sub-sea templates, process them, and store it until it can be offloaded onto tankers or transported through a pipeline. FPSOs are preferred in frontier offshore regions as they are easy to install. They can be economical in smaller fields that can be expected to exhaust in a few years. Once a field is depleted, the FPSO can be moved to a new location.

Fig. 1.8 FPSO operating Platforms

Important considerations with FPSOs: Space constraints due to the combination of processing operation. Ship weight increases during loading operations. Construction and fabrication costs are high due to compact physical design requirements.

1.14 About Intergraph

Intergraph is the leading global provider of engineering and geospatial software that enables customers to visualize complex data. Businesses and governments in more than 60 countries rely on Intergraph's industry-specific software to organize vast amounts of data to make processes and infrastructure better, safer and smarter. The company's software and services empower customers to build and operate more efficient plants and ships, create intelligent maps, and protect critical infrastructure and millions of people around the world. [16]

Intergraph operates through two divisions: Process, Power & Marine (PP&M) and Security, Government & Infrastructure (SG&I). Intergraph PP&M provides enterprise engineering software for the design, construction, operation and data management of plants, ships and offshore facilities. Intergraph SG&I provides geospatially powered solutions, including ERDAS technologies, to the public safety and security, defense and intelligence, government, transportation, photogrammetry, utilities and communications industries. Intergraph Government Solutions (IGS) is a wholly owned subsidiary of Intergraph Corporation responsible for the SG&I U.S. federal business.

1.14.1 About SmartPlant

SmartPlant, the most advanced plant design software offered in two decades, is Intergraph Process, Power & Marine's next-generation, data-centric, rule-driven solution for streamlining engineering design processes while preserving existing data and making it more usable/re-usable. A member of Intergraph's SmartPlant family of plant modeling software, SmartPlant 3D is a full suite of complementary software that provides all the capabilities needed to design a plant, and then keep it as-built throughout its life cycle.

SmartPlant 3D is the world’s first and only next-generation 3D plant design solution, employing a breakthrough engineering approach that is focused on rules, relationships and automation. It is the most advanced and productive 3D plant design solution that effective enables optimized design to increase safety, quality and productivity, while shortening project schedules. Companies using SmartPlant 3D typically report a 30 percent improvement in overall engineering design productivity. [17]

SmartPlant is a forward-looking product that is changing the way plants are engineered and designed. It breaks through the constraints imposed by traditional plant modeling software and design technology. Rather than focusing on simply achieving design, SmartPlant 3D effectively enables optimized design, increasing productivity and shortening project schedules. [18]

SmartPlant gives out-of-the-box solutions that can be quickly adjusted to meet specific customer needs for fast, low risk implementation. It provides owner operators and project management contractors with best practice work processes for the management of project change, interface management, non-conformity management, and technical/site query management, enabling them to achieve lower CAPEX costs and shorter project schedules.

SmartPlant 3D is the world's first and only next-generation 3D plant design solution, employing a breakthrough engineering approach that is focused on rules, relationships and automation. It is the most advanced and productive 3D plant design solution that effective enables optimized design to increase safety, quality and productivity, while shortening project schedules. Companies using SmartPlant 3D typically report a 30 percent improvement in overall engineering design productivity.

Gerhard Sallinger, Intergraph Process, Power & Marine president, said, "Intergraph is recognized as the top provider of engineering design solutions in the global power industry, with SmartPlant 3D offering powerful rules and relationships that automate repetitive tasks, enforce design standards, ensure design integrity and protect design consistency. The comprehensive SmartPlant Enterprise suite will provide a business process integration platform to support regulatory compliance for enhanced plant reliability. Our ongoing partnership with one of the world's biggest engineering companies is validation of our global leadership position and SmartPlant Enterprise's ability to meet the needs of even the most large-scale and complex projects."

Chapter 2 Review of current work methodology in Agility Group

2.1 Introduction

In this chapter, review the work earlier working tools and environments for collaborating designers. Begin by reviewing studies with a broad perspective on collaborative design activities and environments. Researcher then focus on works related to the focus of this thesis, real-time collaborative design tools to support shared design workspace activities. The review is classified into four sub areas: research into team design activities, shared 2D workspace, shared 3D workspace and interaction techniques for 3D workspaces.

2.2 Project execution methodology at Agility Group

Project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements. This application of knowledge requires the effective management of appropriate processes [19]. Project management is accomplished through the appropriate application and integration of the 42 logically grouped project management processes comprising the five Process Groups: initiating, planning, executing, monitoring and controlling and closing [20].

Agility Group Corporate Processes, CREEM (Contract, Risk, Engineering and Execution Management)

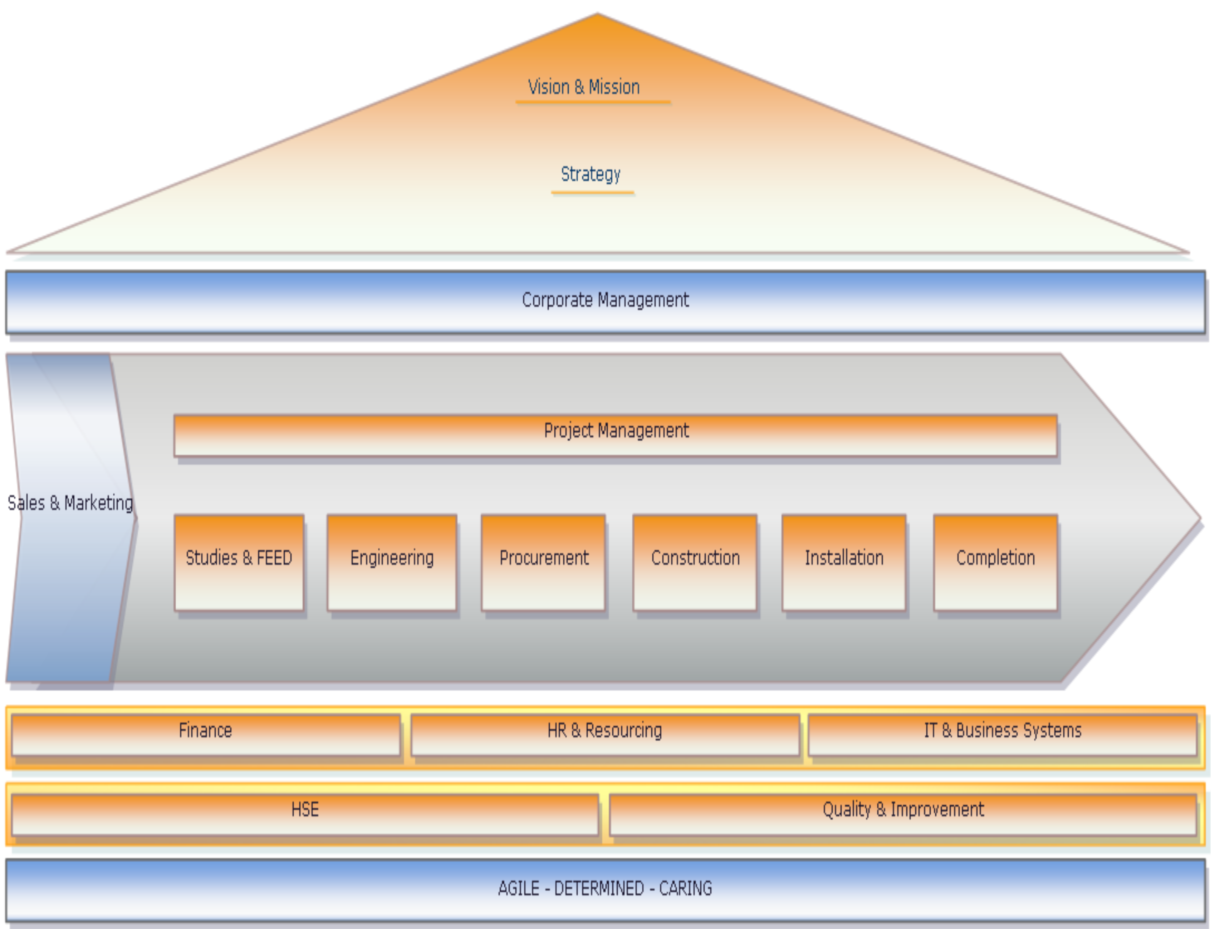


Fig. 2.1 Overall Agility Group corporate process [39]

2.3 Agility Group Management process

A project management process is the process of planning and controlling the performance or execution of a project [21]. “A project is a problem scheduled for solution” - a definition by Dr. J.M. Juran. As in any organization, every department is set up and designated with specific functions in order to perform its business or purpose for that organization. The Project management is the application of knowledge, skills tools and techniques to project activities to meet all the project requirements.

Project management involves planning, scheduling and controlling all of the project activities to achieve its objectives. In other words, project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements. Agility Group executes their projects with initiation, planning, execution and project closing.

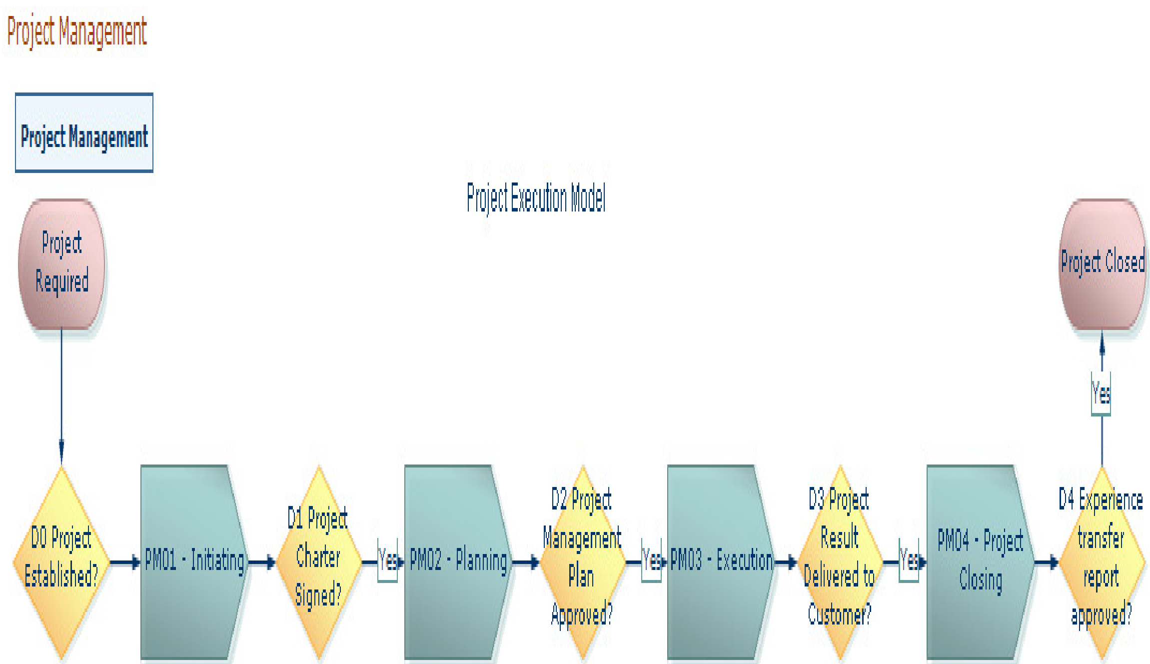


Fig. 2.2 Project execution model in Agility group [39]

2.4 Agility Group Project Initiating Model

The first stage of any project is the initiating process. As it is a formal part of the project an analysis of the project must be conducted and documented before the project starts. The analysis will include a description of the scope of the project, its longevity, an estimation of the resources required etc. Upon completion of this, the project may be formally authorized. The Agility Group, the ultimate purpose of the initiation is to make sure all documents and relevant information is transferred from sales and marketing/tender team to project execution team.

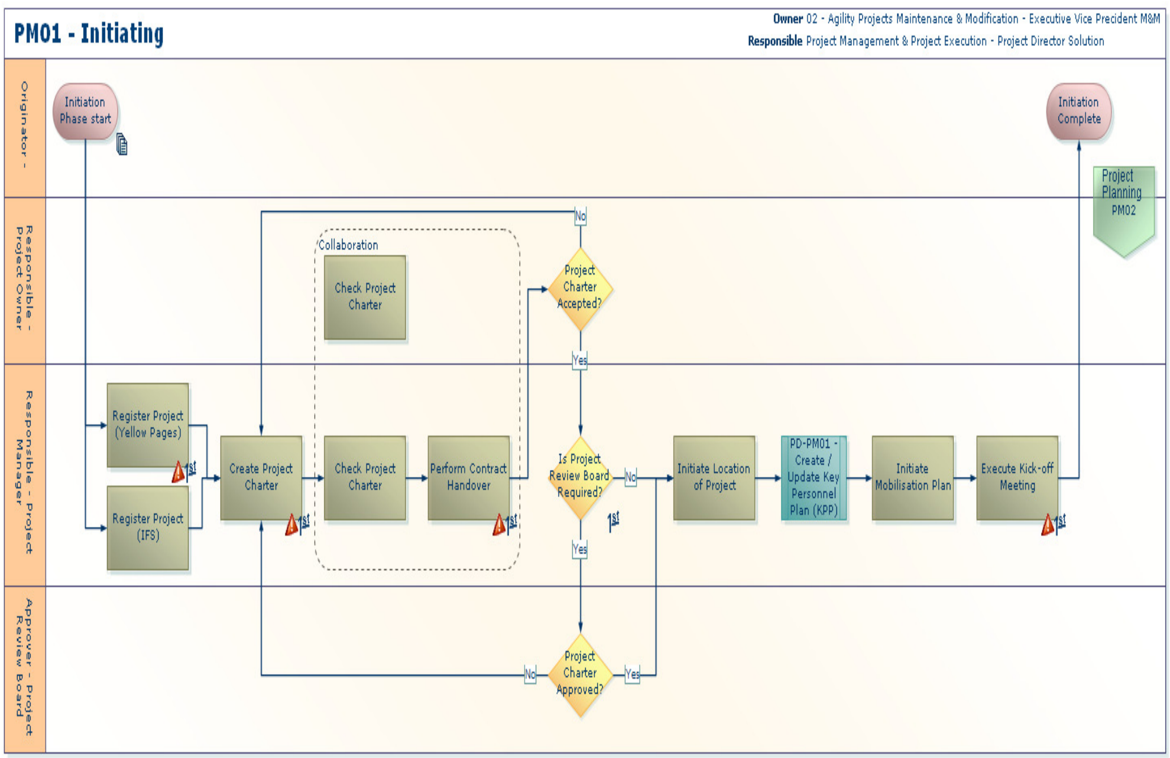


Fig. 2.3 Project initiating model in Agility group [39]

In Agility Group the other purpose of Project Initiation is to discover the project's scope, to which the project manager has been assigned, this person. The project manager works with all the involved parties, including and the client, and agree to perform on the project scope. The project scope will include project goals, budget, timelines and any other variables that can be used for success measurement once the final phase, closing, is reached.

2.5 Agility Group Project Planning Model

All projects shall be planned and estimated in terms of time, costs, need of resources, competence and infrastructure. All projects shall have a project manual according to customer requirements. Including, but not limited to: The list of AG project management plant activities listed below.

Establish engineering management, Establish Procurement management, Establish construction management, Installation Management, Completion management, Establish HSE Management, Project Quality Management, Establish Risk Management, Budget and cost Management, Establish WBS & Schedule Management. Establish Resource Management. The need for risk analysis and project audits shall be evaluated in all projects.

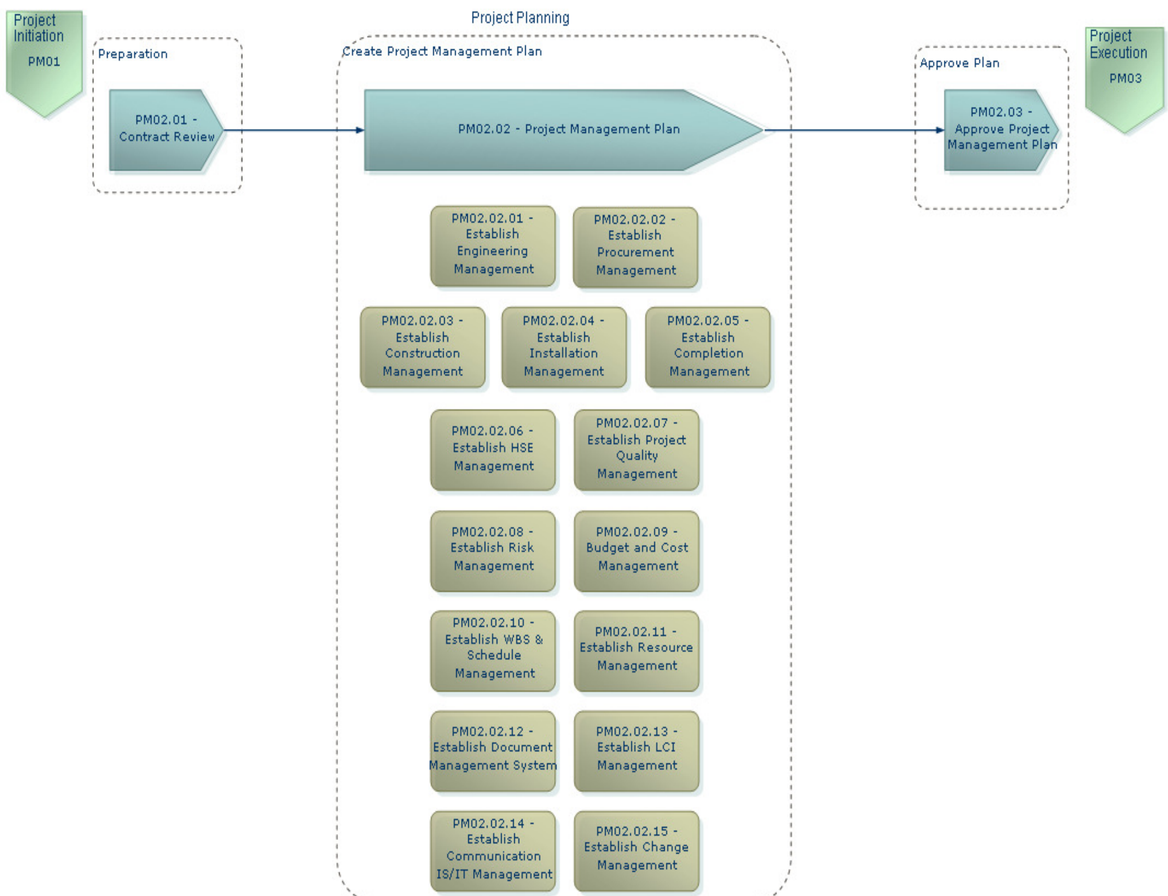


Fig. 2.4 Project planning model in Agility group [39]

In Agility Group, the Project Manager shall provide a short written summary of the overall project strategy, including construction, installation and completion management. Project Management is the application of knowledge, skills, tools and techniques to project activities to meet all the project requirements. *Create a Project Management Plan* is the process of documenting the actions necessary to define, prepare, integrate and coordinate all subsidiary plans and define how the project will be executed, monitored and controlled, and closed. It also includes activities, strategies, requirements and goals from the contract and the project review board.

When finished, the Project Management Plan describes how the Project Manager and his team will execute the project within the limitations and requirements described in the project charter and the contract. The project management plan becomes the primary source of information for how the project will be planned, executed, monitored and controlled, and closed.

2.6 Agility Group Project Execution Model

Business units shall have procedures for project management in line with relevant corporate procedures and Agility Group's authorization matrix, including, but not limited to: Engineering management, Procurement & Material administration, Construction management, Installation management, Completion management, Project HSE, Project Quality assurance, Project Risk Monitoring and control, Project cost control & invoicing, Project scheduling, Project resource management, Project document management, Project LCI control, Project IT coordination, Project change control.

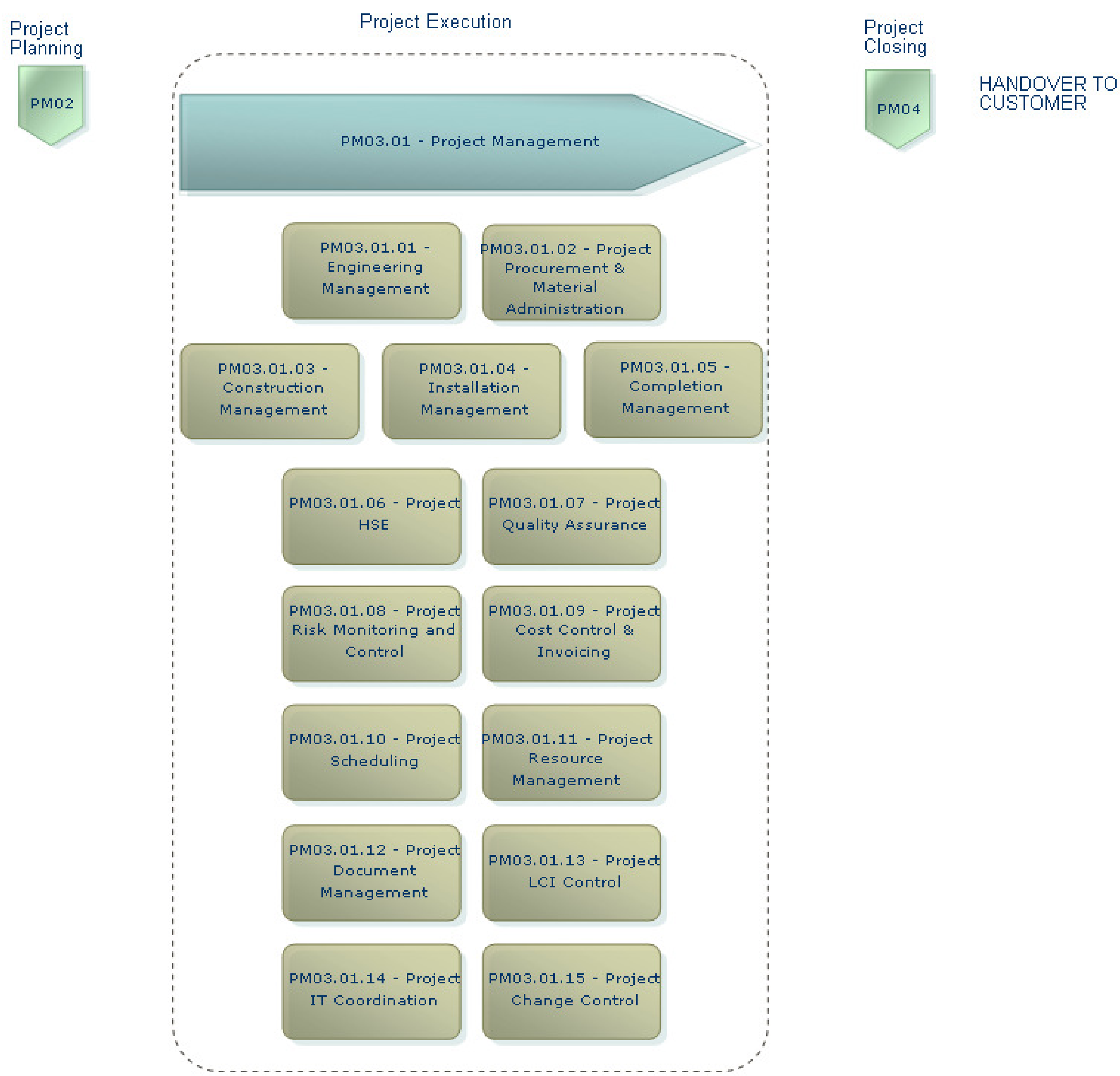


Fig. 2.5 Project execution model in Agility group [39]

2.7 Agility Group Project Closing Model

All projects shall be officially closed by a closing meeting when relevant experience reports are presented and relevant project documents are filed.

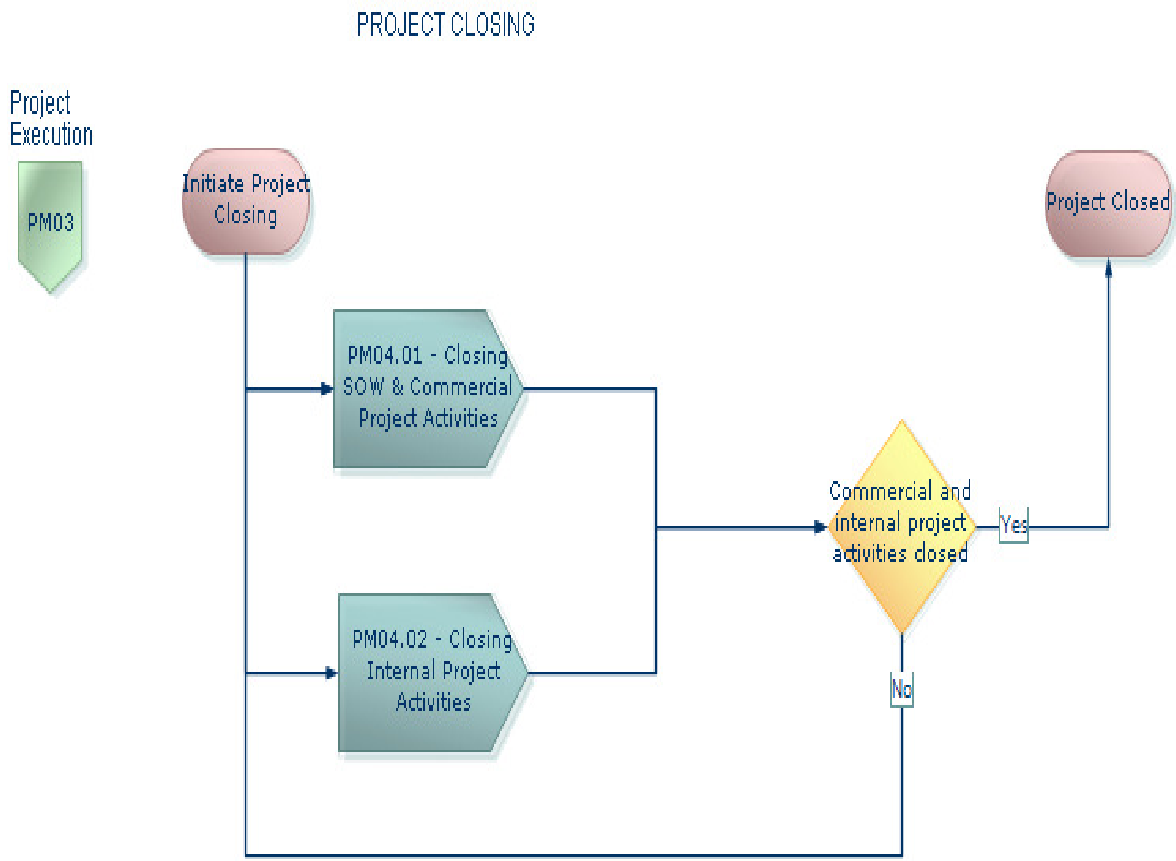


Fig. 2.6 Project closing model in Agility Group [39]

The Closing Process group verifies and delivers the completed product or service and terminates the project or project phases. The Closing Process group includes the following processes:

1. Closing project: finalize all activities to close the project or project phases.

2. Contract closure: completes and settles all contracts with suppliers and buyers.

Agility Group closing external project the client shall issue the completion certificate on its own initiative when the work with the exceptions of guarantee work has been completed in accordance with the contract. The completion certificate shall be issued at the date of conclusion of the delivery protocol, if the condition of issuing completion certificate toe each has been fulfilled.

2.8 Legacy CAD tools used in Agility Group

In Agility Group, prior to 2007, there various software solutions were in use. It presented a complicated, challenging and manpower intensive process for the execution of the varied types of projects the company had. Like estimating project hours, skill requirements, man power planning etc. Several different systems could be in use in any single department or process, including, for example, piping and mechanical design.

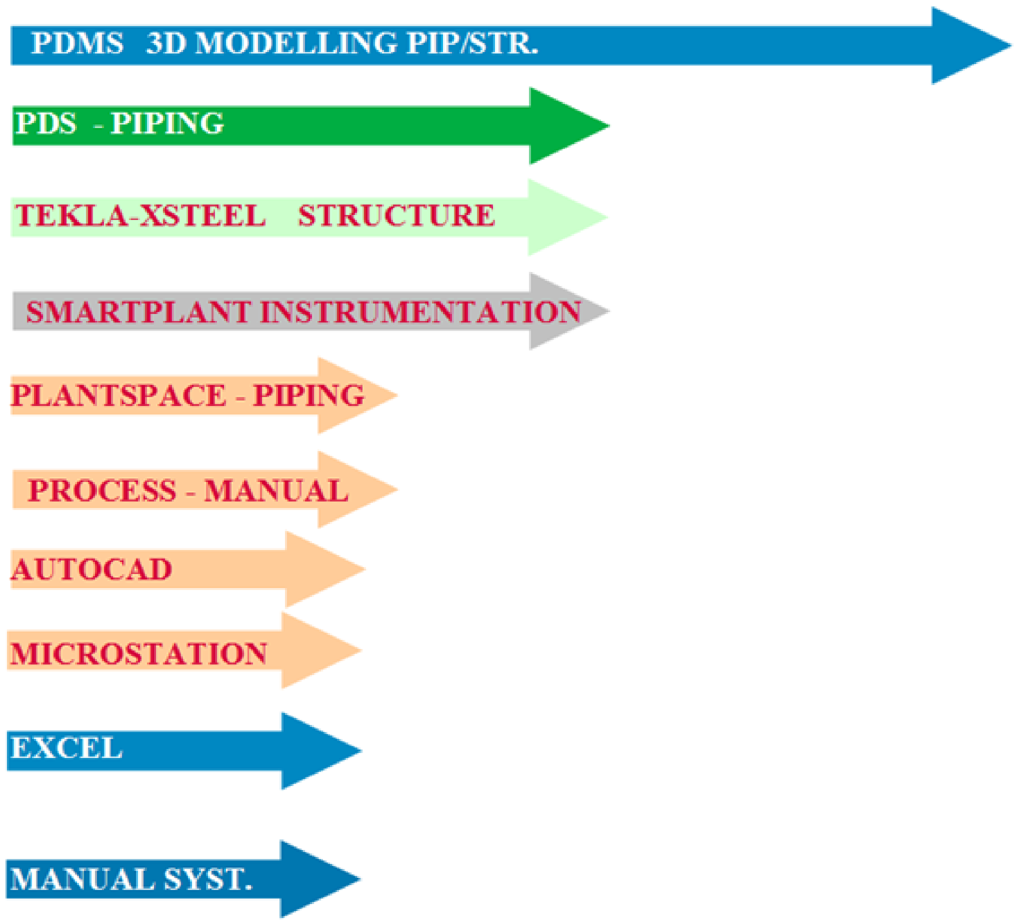


Fig. 2.7 Agility Group used various traditional CAD systems

2.9 Multidiscipline Tools in Agility Group

The tools used various software is used in various discipline in different projects. Please find below some examples different tools used in different disciplines in AG before 2007.

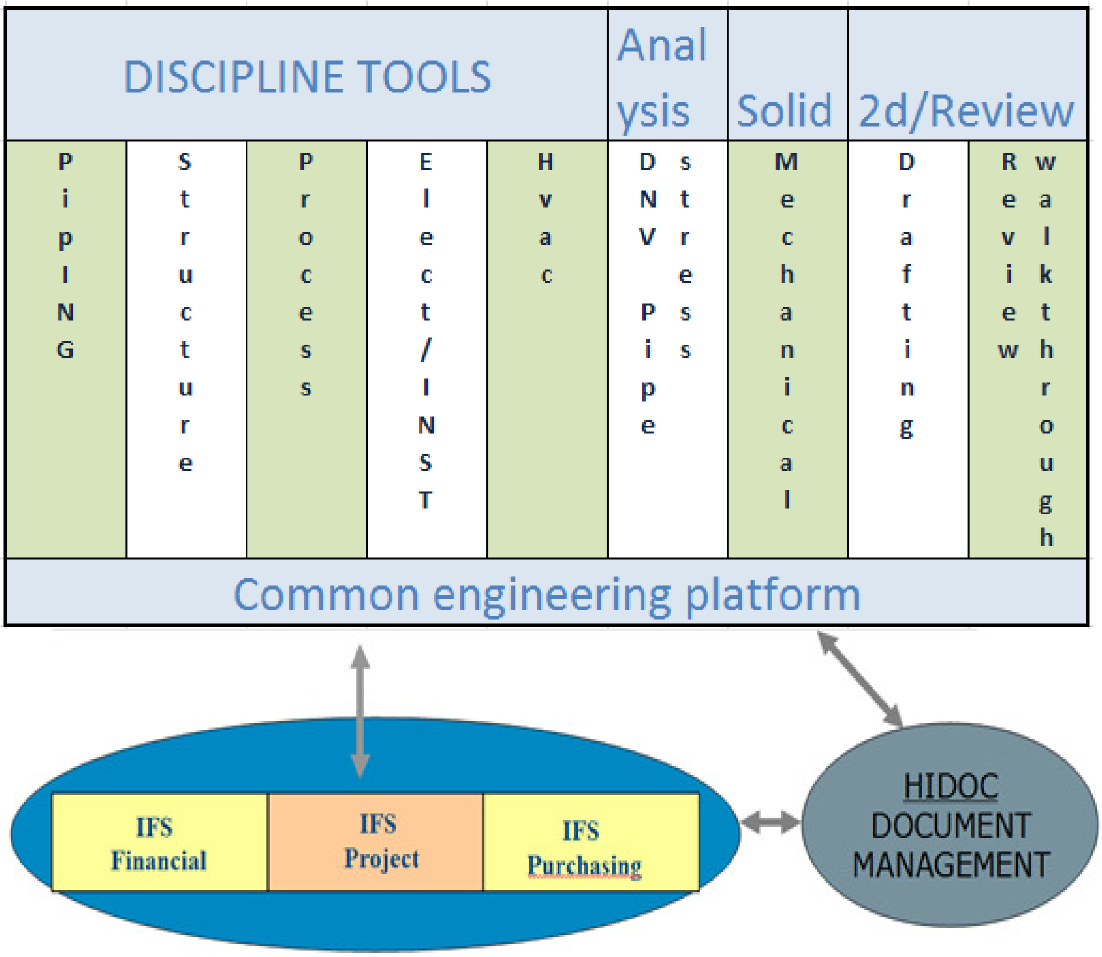


Fig. 2.8 Agility Group various discipline tools

2.9.1 Common tool in Agility Group

Agility Group used different tools for the various disciplines and projects; this made the CAD design and documentation picture too complicated. It made manpower planning very difficult too, because a wide range of skills were required. Other drawbacks included inefficient data sharing and difficulties in supporting all projects and clients.

Due to various complications Agility Group made the decision to identify a single system which could improve this picture dramatically. It was found that Intergraph's “SmartPlant” would provide a unified design and documentation capability and overcome the problems with traditional tools.

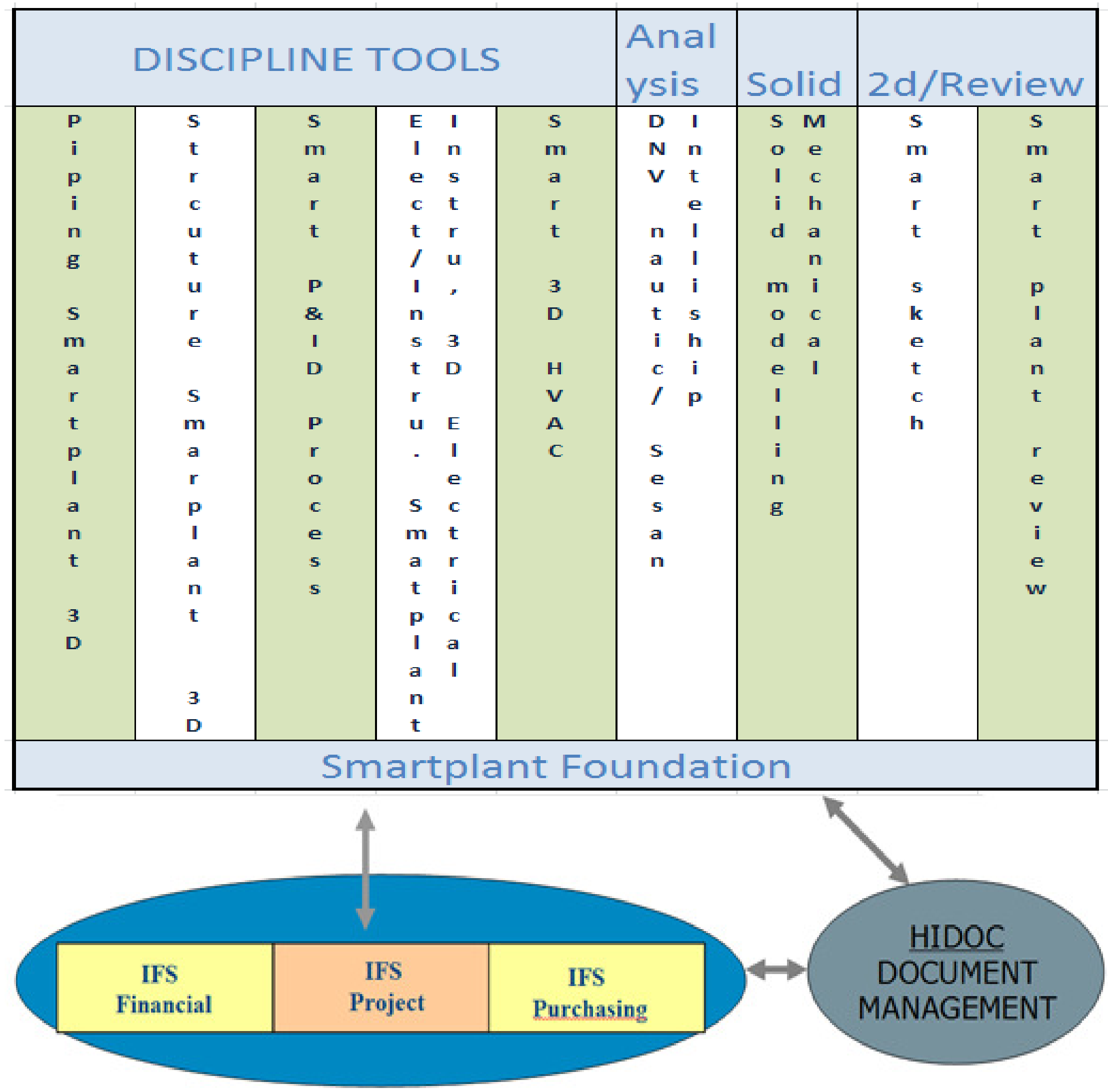


Fig. 2.9 Agility Group various discipline SmartPlant tools

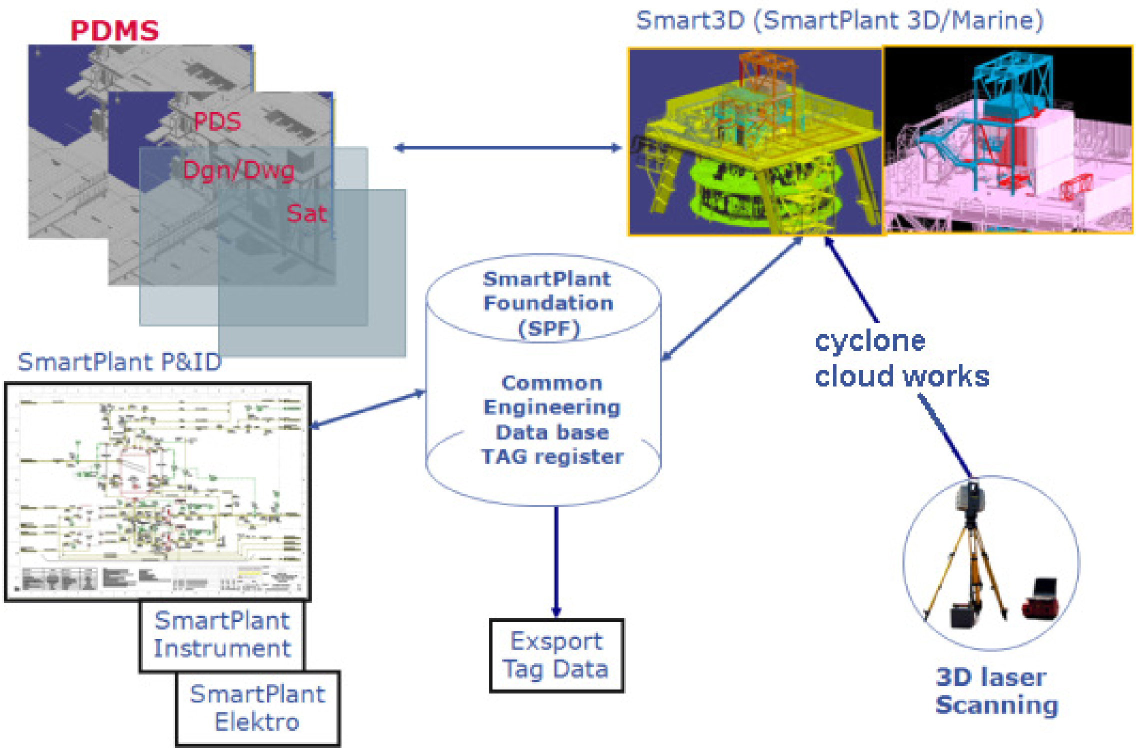


Fig. 2.10 SmartPlant in different disciplines in Agility Group

2.10 Agility Group's vision

Agility Group's vision is to be the leading EPCIC Company for medium-sized projects and the preferred partner for oil companies internationally. They are flexible and adaptable, as reflected in their name, and competitive on price. [11]

Early in 2007, Agility Group started the implementation of SmartPlant Enterprise from Intergraph. A state-of-the-art, multidiscipline engineering and design tool, SmartPlant Enterprise is a system for today but built for the future. It allows the company to focus on engineering in a predictable way without compromising engineering quality and price.

Agility Group has trained the engineering organization to use these tools very efficiently. A training program has been established to introduce new employees and consultants to the common-tool system.

2.11 Introduction of SmartPlant 3D in Agility Group

The decision to go for SmartPlant Enterprise applications was taken at the end of December 2006, followed by the signing of an agreement between Agility Group and Intergraph Corporation. The agreement was based on provision to use the complete Intergraph ”Plant Design” related software portfolio in all, then “Agility Group” companies world-wide.

The agreement allowed Agility Group ’unlimited’ license access (with some exceptions with respect to numbers of licenses) This type of agreement is good for Agility Group and for Intergraph. It is a relatively expensive arrangement but, over time, it is easy to administrate since the problem with lack of licenses doesn’t exist.

2.12 Associated Deliverables

Every project has a definite start and a definite end the specific deliverable and activities that take place in between will vary widely with the project [22]. Many projects may have similar phase names with similar deliverables, few are identical. Some will have only one phase [23]. The main transfer is Model transfer, drawing, Materials, execution methodology / Philosophy etc.

SmartPlant 3D is CAD neutral and can deliver the drawing information in CAD file of type dwg, dxf (AutoCAD) or dgn (MicroStation), PDF or native Intergraph format. In Agility group SmartPlant / SmartMarine 3D may deliver the 3D model in different formats. MicroStation (dgn) and AutoCAD 3D (dwg) is available. Also PDMS format is available.

SmartPlant Enterprise is in many ways data neutral. With document saving in pdf, dwg/ dxf (AutoCAD) or dgn (MicroStation) Agility Group can deliver CAD formats that let their customers implement the drawings into their own CAD and documentation systems. The 3D model is delivered, through the Smart3D PDMS export interface, as a native PDMS Global model. Agility Group operates the Statoil PDMS Global model and make sure the data export fulfills the Statoil requirements for the PDMS 3D model.

2.12.1 Agility Group SmartPlant enterprise deliverables

There are various discipline involved in the projects there are different kind of deliverables released from various departments/disciplines in the Agility group.

2.12.2 3D model

Multidiscipline 3D model containing Piping, Structural, Access platforms/Stairs, Process Equipment, Cable Tray, Electrical/Instrument Equipment, HVAC, Pipe Support. PDMS Global 3D model updated "side-by-side" with the SmartPlant 3D model.

Model progress report for piping disciplines reported automatically from the SmartPlant 3D model. MTO extract, summary and detailed reports. Weight and Center of Gravity data

2.12.3 Electrical

2D plans/sections drawing for cable way routing, Isometric views of cable way routing,

Weight report including cables (xls format), Center of gravity including cables (xls format)

2D plans/sections for lighting fixtures ((MicroStation or AutoCAD format).

Lighting summary and MTO produced in conjunction with Opti Win software (xls format).

2.12.4 Hvac

2D plans/sections for Hvac routing, Isometric views of HVAC routing, Weight report (xls format). Center of gravity report (xls format), MTO report (xls format)

2.12.5 Instrumentation

2D plans/sections for instrumentation location

2.12.6 Mechanical

Weight report (xls format), Center of gravity report (xls format), 2D plans/sections for layout location, 2D plans/sections for mechanical handling routes.

2.12.7 Piping

Design and Fabrication isometrics including full MTO, stock numbering, Weights, center of gravity & line conditions, 2D plans/sections for layout location, Bulk MTO report (xls format), Bulk weight report (xls format), Area center of gravity report (xls format), Tie-in report (xls format)

2.12.8 Pipe Supports

Fabrication drawings including full MTO, stock numbering & weights. Summary schedule (xls format)

2.12.9 Safety

2D plans/sections for escape routes.

2.12.10 Structural

Structural Arrangement and fabrication drawings, structural detail drawings, bulk MTO (xls format), Area center of gravity report (xls format)

2.12.11 Telecommunication

2D plans/sections for layout locations (Micro Station or AutoCAD format).

2.12.12 Process

Intelligent P&ID’s (Agility Group scope of work only),

Existing P&ID's to be updated finally in native SH format. Line list, Valve list, Equipment list

2.12.13 Engineering database

TAG register for process, instrumentation and electrical TAG’s on all related TAG documentation. Sub-supplier TAG and document information stored with cross-references to the main project TAG. Common central database for reviewing of 3D model and model extracted drawings.

Revision control on model related information and documents. Those are the deliverables from various disciplines in Agility Group. The below table shows each discipline shall be responsible in Agility Group SmartPlant 3D model input as 3D modeling.

Table 2.1 Summary of the SmartPlant, 3D Model content, responsible discipline & Modeling discipline in Agility Group.

3D Model Content	Responsible Discipline	Modelling Discipline
Piping Items		
Piping	Piping	Piping
Fittings	Piping	Piping
Valves	Piping	Piping
Special items	Piping	Piping
Actuators/gears/levers/hand wheels	Piping	Piping
Access volumes	Piping	Piping
Insulation	Piping	Piping
Mechanical		
Vessels & tanks	Mechanical	Mechanical
Pumps	Mechanical	Mechanical
Lifting beams & lugs	Mechanical	Structural
Access for maintenance	Mechanical	Mechanical
Crane operating radius	Mechanical	Mechanical
In deck tanks	Mechanical	Structural
Structural		
Primary structural steel	Structural	Structural
Secondary structural steel	Structural	Structural
Access platforms	Piping	Structural
Stairs & ladders	Structural	Structural
Equipment supports	Mechanical/Structural	Structural
Pipe racks	Structural	Structural
Blast walls	Structural	Structural
Hatches for access	All disciplines	Structural
Sleeves & penetrations	All disciplines	Structural
Drain boxes	Piping	Structural
In deck nozzle	Structural	Mechanical
Electrical		
Panels & cabinets	Electrical	Electrical
Cable trays	Electrical	Electrical
Lighting fixtures	Electrical	Electrical
Access volumes	Electrical	Mechanical
Telecom equipment	Electrical	Electrical

Instrumentation		
Panels & cabinets	Instrument	Instrument
Inline components	Instrument	Piping
Valves	Instrument	Piping
Level gauges	Instrument	Piping
Level transmitters	Instrument	Piping
Junction boxes	Instrument	Instrument
Tubing	Instrument	Piping
Access volumes	Instrument	Mechanical
Safety		
ESD valves	Safety	Piping
Equipment	Safety/Mechanical	Mechanical
Fire water piping	Safety	Piping
Escape routes	Safety/Mechanical	Mechanical
Detectors	Safety	Mechanical
Architecture		
Walls	Structural	Structural
Doors	Structural	Structural
Windows	Structural	Structural
Ceilings	Structural	Structural
Raised floors	Structural	Structural
Floating floors	Structural	Structural
Explosion relief panels	Structural	Structural
Pipe Supports		
All items	Piping	Piping

Chapter 3 Understanding SmartPlant integration in offshore projects

3.1 Introduction

This chapter discusses SmartPlant Integration and how to attain close and seamless coordination between several disciplines, groups, organizations and systems, etc. It will also, briefly, deal with CAD tool integration in the offshore EPC business today; why integration is needed in offshore engineering, what it is used for and its advantages.

All design and development processes involve engineering changes which can be an important factor in the success of the system as a whole. This work seeks to create a multidimensional understanding of change activity in large systems that can help in improving future design and development efforts. This is achieved by a posteriori analysis of design changes. It is proposed that by constructing a temporal, spatial, and financial view of change activity within and across these dimensions, it becomes possible to gain useful insights regarding the system of study. Engineering change data from the design and development of a multiyear, multibillion dollar development project of an offshore oil and gas production system is used as a case study in this work.

3.2 What is Integrated Engineering?

What is integrated engineering it is a good to know before to understand the offshore integration. In engineering, system integration is the bringing together of the component subsystems into one system and ensuring that the subsystems function together as a system. In information technology, systems integration is the process of linking together different computing systems and software applications physically or functionally, to act as a coordinated whole [25].

The system of systems integration is a method to pursue better development, integration, interoperability, and optimization of systems to enhance performance in future combat zone scenarios that related to area of information intensive integration.

The integration provides integrated engineering services to plan, design and manage the delivery of solutions for complex offshore projects [26]. The Integrated Engineering is a program created to meet the demand for engineers who are able to deal with a wide range of problems, often involving knowledge from several disciplines. The demand arose from the current state of industry, where both the products manufactured and the plants which make them are progressing towards greater diversity and sophistication

System integration ensures that all interfaces fit together and component interactions are compatible with functional requirements. The important for this integration, any projects the management of subcontractors is of special importance for systems integration involving large, complex engineered systems. It is highly likely that multiple subcontractors will be employee by the prime contractor. Prudent management of these subcontracts is critical to the success of the systems integration program [27].

3.3 Offshore integration

SmartMarine 3D’s planning environment reduces the overall project schedule by allowing users to define physical boundaries and construction packages for the different modules / blocks at early stages of the project. These dynamic, multi-discipline definitions define the objects belonging to each block and the total volume, weight and center of gravity for the module. [28].

The modules are further broken down into assemblies and sub-assemblies, containing detailed assembly orientations, installation sequences and work center assignments. The definitions are made across a database and are not constrained by files or the plant breakdown structure, which enables them to be modified at any time to reflect fabrication / installation methodology changes [29].

SmartPlant Foundation is the ISO15926 [30]. compliant information management solution within SmartMarine Enterprise, an integrated solutions suite that provides full design, construction, materials and engineering data management capabilities needed for the creation, safe operation and maintenance, and as such supports the Capital Project Life cycle Management (CPLM) of large-scale process, power, marine and offshore projects.

SmartPlant Foundation’s life cycle data management also enables a smoother handover for EPCs to owner operators and for owner operators to more easily maintain, refurbish or modify their plants, ships, or offshore vessels. The solution permits electronic management of all project, plant and marine engineering information, integrating data on the physical asset, work processes, and regulatory and safety imperatives to facilitate enhanced global decision support capabilities [31].

The enterprise has been designed to help owner operators (O/O) address the issue of interoperability by providing pre-packaged solutions that can be rapidly deployed, incorporating customer-specific requirements at low risk. SPO is built on the Intergraph SmartPlant Enterprise suite.

Advantages of Intergraph’s SmartPlant Enterprise for owner operators' software include the following: [31].

- Enjoy higher quality data, leading to less reworks during design and in the field
- Reduce the risk of loss of critical asset intelligence due to a retiring workforce
- Keep your maintenance data updated for auditability and ensure correct procurement of replacement parts
- Realize significant savings on design time and costs
- Improve facility safety with better configuration management and ensured data consistency
- Intergraph PP&M provides the future of engineering, today.

3.4 Understanding Integration Workflow

The following is a simple and typical example of how the applications share data in an integrated environment [32].

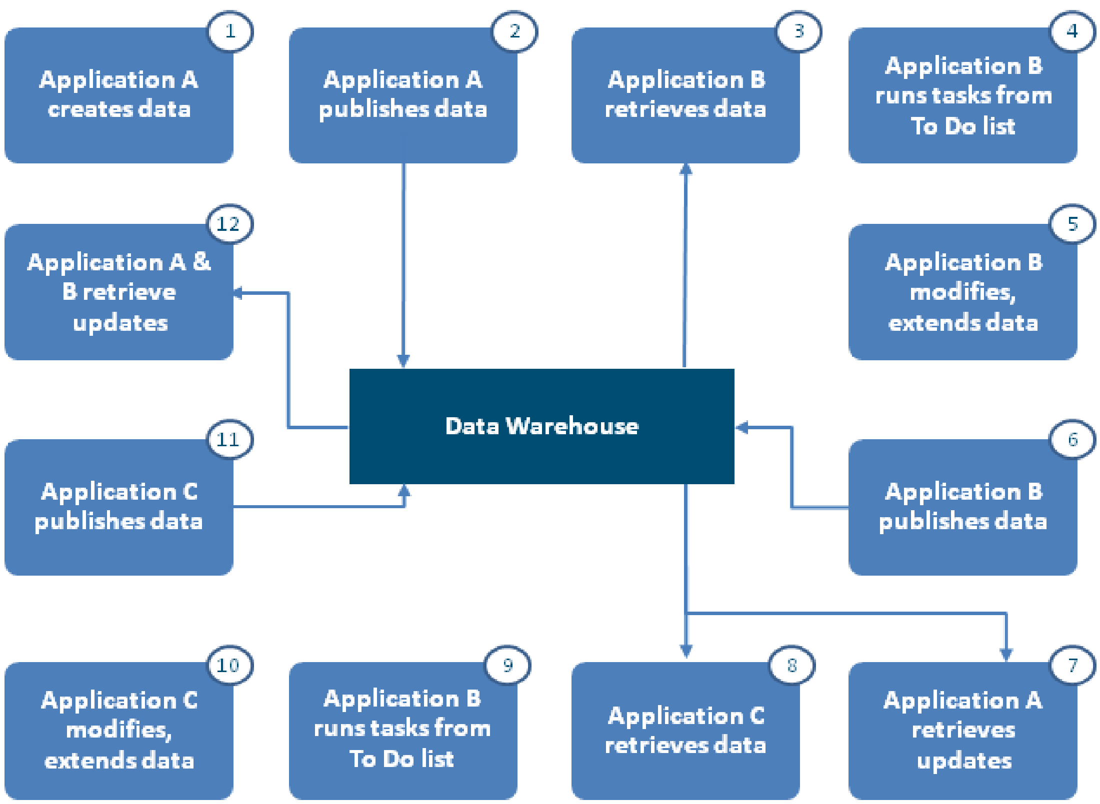


Fig. 3.1 Integration Workflow

3.5 Understanding Common Integration Tasks

In an integrated environment, data is published to, and retrieved from, a central repository by applications. During a publish operation, drawings, documents, reports and data is sent to the repository. During a retrieve operation, drawings, documents, data or the design basis is brought into the software and then related to an application's objects. “Design basis” is the term used for piping, instrumentation, electrical, and equipment data from other applications.

3.6 SmartPlant Integration

A primary goal of the SmartPlant Enterprise is to establish a framework and methodology for “Life-cycle Information Management” and “Information Integration.” What exactly is meant by “Integration” – especially when all systems or business processes are not homogenous? Intergraph identifies five different forms of integration – referred to as tiers – to indicate increasing levels or steps of capability – evolving as best suits the business. While the following solutions are situation-dependent, the product platform, tools and architecture deployed support a wide range and mix of these options. This is a requirement if they are to address more than one problem in a given business [32].

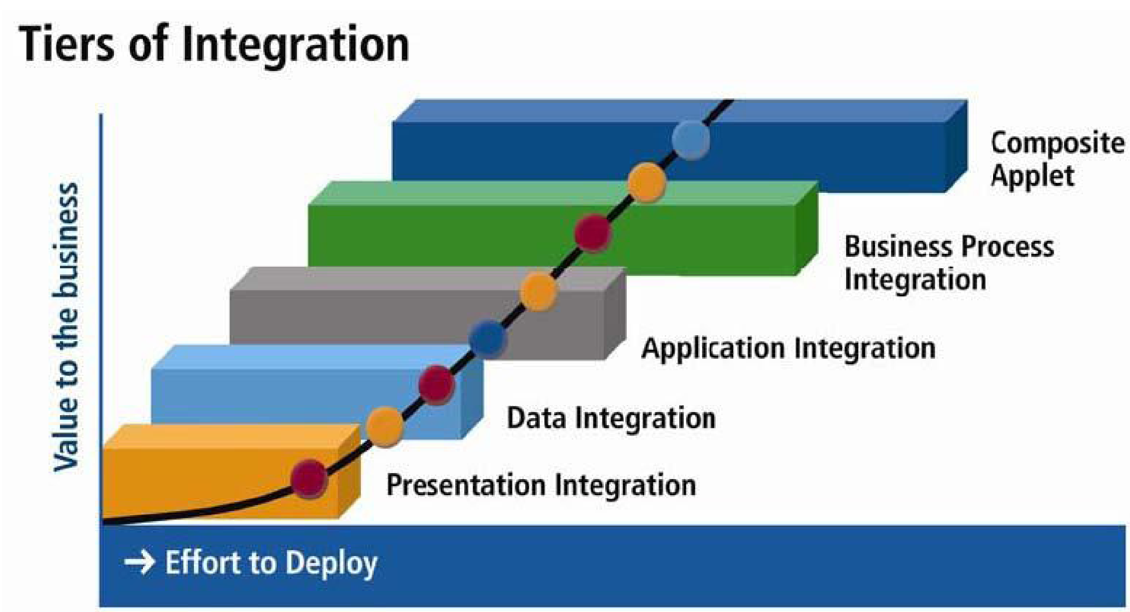


Fig. 3.2 Various tiers of Integration

3.7 Presentation Integration

The simplest tier of integration is presentation integration. Data from multiple sources are accessible and provided side-by-side within a single interface, such as that of a Web portal, e.g. Microsoft SharePoint Portal or SAP Net Weaver, though this is not the only technology to provide this capability. SmartPlant Explorer is one such example of presentation integration, presenting information from the SmartPlant Enterprise engineering tools. SmartPlant Foundation can also be used in this context. For example, a user could navigate from data within SmartPlant Foundation, such as a plant tag, to corresponding data in other systems – e.g. to a maintenance procedure in SAP, to associated records in Document, or to real-time data in OSI-PI – and have it all presented in the same client interface to promote the decision support process.

Data from two source applications are presented side-by-side within the same interface. An action or selection of data in one system view may trigger a pre-determined response from the other system view. To the end-user, it appears that the data may in fact be integrated (supplied by one integrated system), when in reality it is not [32].

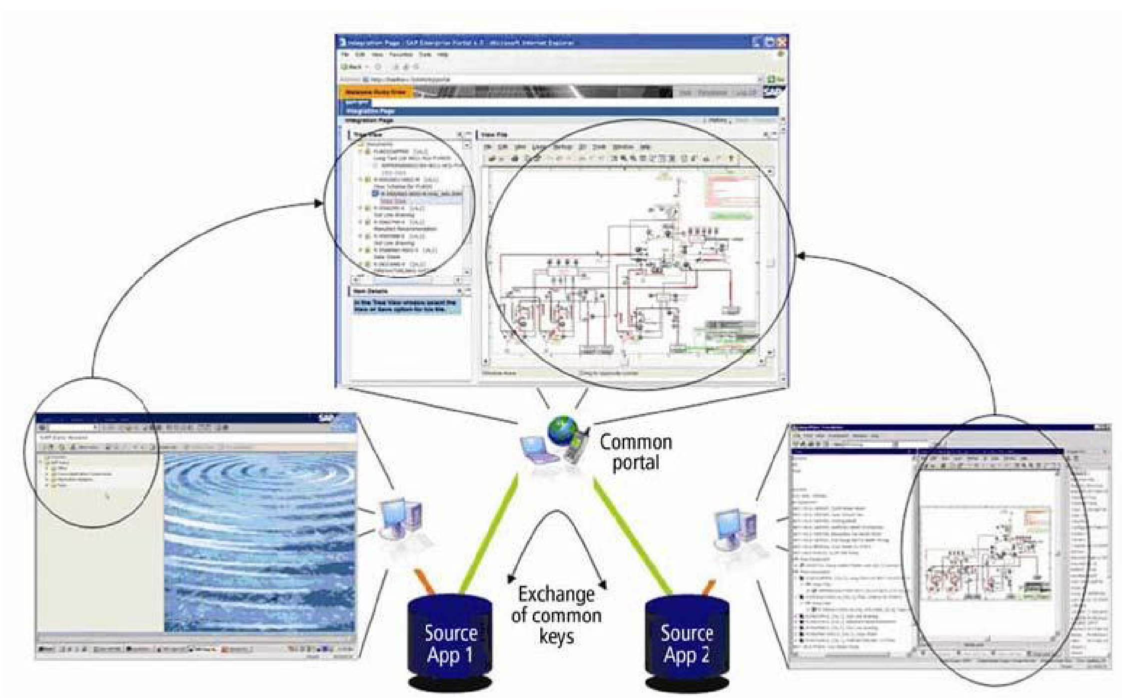


Fig. 3.3 Presentation Integration

This type of integration is most beneficial to users for whom information creation is not their primary role, such as the managerial, clerical and manual workforce. In this illustration, SAP Net Weaver provides the portal technology. The next version of SmartPlant Foundation will offer generalized portal capabilities and will supply “Web parts” for inclusion in a project portal. As we will see, this portal technology also provides vital underpinnings for deploying composite applets [32].

3.8 Data Integration

The second tier, data integration, is primarily about aggregating and consolidating information from different sources together into a single common storage mechanism. Applications provide the data as exports, either with the content already mapped to the receiving system’s data model during export, or via an external transformation mechanism to then be loaded into the target system, a process of Export/Transform/Load (ETL). In this environment, the applications providing the data do not care, nor do they need to know, that the data integration (receiving) system exists.

A classic example of a data integration environment is document management. Documents, drawings, models, files and “containers” of many varieties are brought together and loaded into a common classification indexing or librarian system for storage and retrieval. Intergraph’s solution for document management is SmartPlant Foundation.

Another more granular form of data integration is that of the engineering data warehouse (EDW), also supported by SmartPlant Foundation. “Content” from multiple disparate applications is brought together and harmonized to form a single uniform view of the “truth.” This more granular data integration also forms the foundation of the other tiers of integration. It supports the uni-directional movement of data between systems and requires the data to be mapped to the data model of the target system.

In point-to-point integrations, this is invariably a direct translation. But when multiple systems are required to share the same common data, pressures, temperatures, units of measure, etc., it is more advantageous to translate/map this data to a common intermediate application, agnostic and neutral in form, such as Intergraph’s SmartPlant Schema, thereby reducing the number of transformations required to support “enterprise integration.”

SmartPlant Foundation manages these two different levels of data granularity containers and contents simultaneously: documents (containers) define the boundary condition/scope for exchanges and provide the deliverable record, while the data (content) is extracted and aggregated together with that from other exchanges [32].

Clearly, if data are being brought together from multiple sources, it is possible that some duplication exists. If they don't have information management capabilities, most tools importing data simply overwrite the existing data. Some may have revision management capabilities for this new data, but it is not common.

Therefore, as well as providing a common language for the exchange, the information management capability associated with data integration must also deal with this duplication – consider it a process of enforcing consistency on a project – correlation, aggregation, consolidation, etc.

Additionally, data integration should also deal with the provenance, status and security of the data. It is for these reasons that such capabilities are considered essential for the project data handover application of a data warehouse.

3.9 Application Integration

Application integration extends the data integration capabilities by adding transportation of the data to the correct location for the receiving application, and then importing it via an application-specific protocol. This is different from data integration, because the data integration mechanism does not assume that anything more than a "file parser/loader" capability exists for the receiving system – which results in reduced time and cost of deployment, but requires that the tool supports some form of validation (correctness) of the data. Many tools today provide sophisticated Application Programmatic Interfaces (APIs) or other methodologies for data acquisition which ensure quality and integrity of the resulting data. But they do require more effort to deploy. Typically, this route is chosen if the applications are going to exchange data bi-directionally, on a frequent basis, and the user is engaged in the export and import process. Such examples include high-value, high frequency point-to-point exchanges – for example, between a 3D design tool and a stress analysis program. Another key difference is in the scope of the content being exchanged as represented by the data overlaps. The circles represent the content of data within three different applications. The primary goal for data integration is to remove the overlaps so that the receiving system has the total sum of the data – or, in other words, to "enforce consistency". [32].

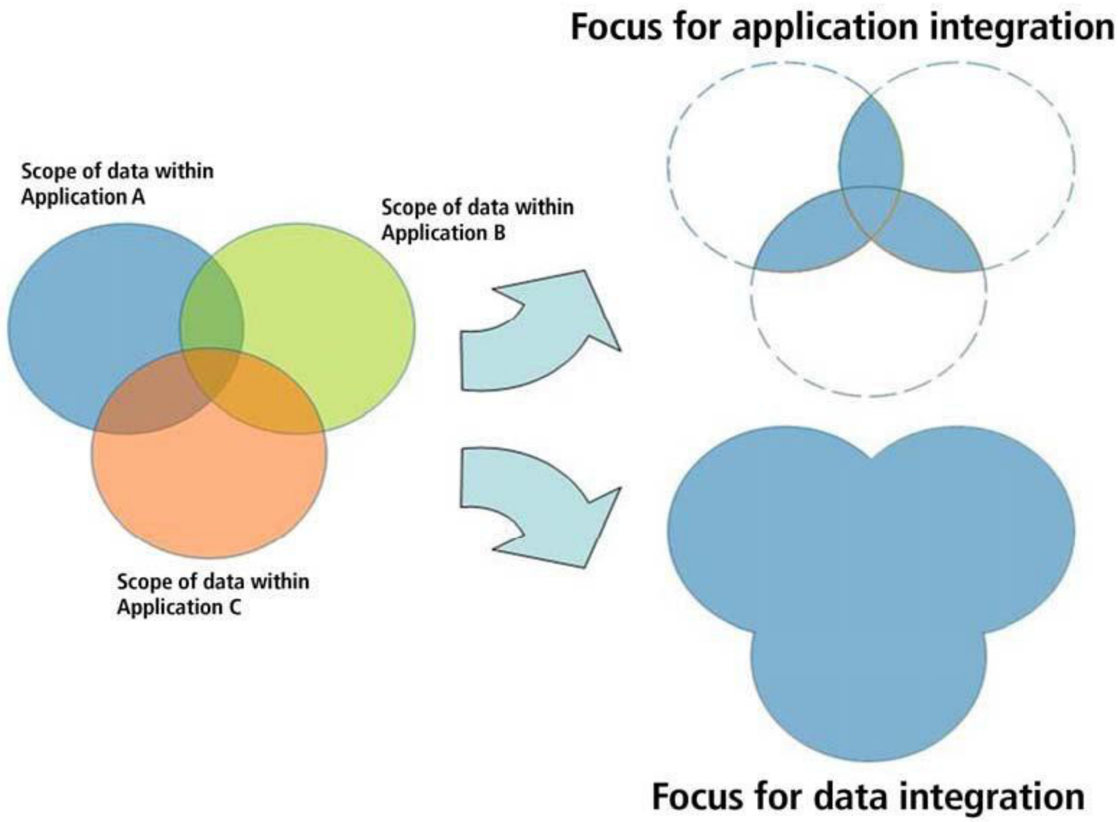


Fig. 3.4 Sample of application integration

Conversely, the primary goal for application integration is to exchange only the common/shared data between the applications. So the goal is to manage the data overlaps – or, in other words, to “manage inconsistency.” This latter aspect of application integration is provided in the SmartPlant Enterprise via SmartPlant Foundation and SmartPlant Adaptors to the tools.

Why are these two methodologies different or required? To answer that question, one needs to look at the business process being executed. Consider two examples:

1. The engineering data about an instrument have been checked and approved. The data are pushed to the procurement system for purchasing.

A dialog is going on between a process engineer and an instrument engineer during the definition of an instrument. In the first example, there is no dialog – it is non-negotiable. In the second, there is a back-and-forth exchange of evolving data. It is this negotiation, the iterative refinement process, which is the substance of engineering – the essence of SmartPlant Enterprise [32].

3.10 Business Process Integration

Application integration alone takes no account of the business process involved – application integration can be set up, the user can push the “integration” button and data flows from application A to application B. It can be executed in a point-to-point fashion. This works fine if one of the following applies: There are only two applications involved.
Integration occurs in a small workgroup where interpersonal communication is good.
Milestones between disciplines can be aligned for the exchange to occur.

But business process integration is normally required when one of the following occurs:
The user has to interact with the data externally to their working application to decide what to accept or reject. This would be a negotiated transaction – engineers want to be notified of change, but may decide not to accept for many reasons. The projects extend beyond a workgroup (enterprise or extended-enterprise). Milestones between disciplines or partners do not neatly align. For example, engineering is not a real-time activity. There has to be some control, distribution, notification and management of the integration.

This requires an electronic workflow execution, involving the actions to notify, store, deliver, consume and move on. Therefore, need to establish business process integration when that cannot determine or predict the synchronicity of processes, exchanges and tasks between business functions. Need to control the flow of the data between these functions and understand progress. Need to notify and warn of change, but allow the process to continue unabated

For this to be successful, not only are data integration and application integration required, but also require: Modeling and execution of the workflow processes between disparate business functions Identifying the timing and scope of the handover/exchange tasks. Interjecting into the application itself or providing a notification mechanism to warn the user of potential change storing the change until the user is ready to receive and absorb the change (an information messaging bus for real-time data exchange is a distinct liability here) Delivering the change (after applying data and application integration, of course).

Optionally, you could enable the user to choose what to retrieve now, what to retrieve at a later date, and what to reject. This may sound like a lot of effort, but it is necessary to provide true concurrency of project execution tasks without the anarchy of data changing “under the feet” of the end-user (a recipe for disaster) [32].

3.11 Composite Applet Implementation

The final tier of integration offers the ability to create entirely new applications (or applets) that may or may not have a data store of their own, and that utilize the high-quality, high-integrity data stores that have been integrated together in the previous tiers. For example, a SAP Net Weaver portal can host “Web parts” (iView’s) from Intergraph, Meridium and SAP simultaneously – all communicating with each other as part of a “role-based” application. In this example, a reliability engineer is browsing engineering data, maintenance data and failure data simultaneously, querying each application as if they were one, and then executing a new task which is not part of the three integrated systems, but of the new “composite applet.”

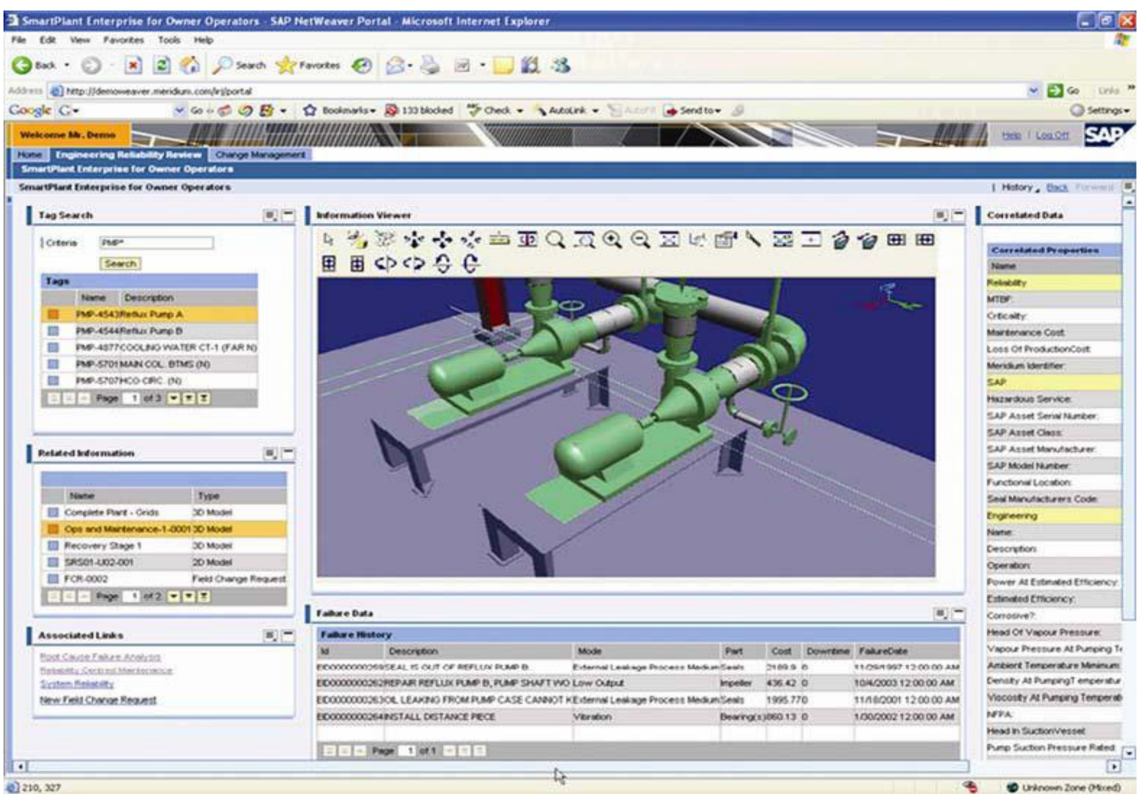


Fig. 3.5 Composite Applet Implementation

A recently released product “SmartPlant Offshore” is intended for the engineering, design and construction of marine oil and gas facilities. The software provides 3D modeling with concurrent engineering, fabrication, and the construction or making of a restoration and construction capabilities as well as integration with analysis software and 2D design tools for outfitting. Concurrent, global engineering features are supported by workflow, integration and life-cycle data management architecture. In addition to topside design, capabilities include molded forms, nesting, penetration management, weight and center-of-gravity management, reinforced plate and connection design, structural manufacturing and fabrication as well as construction planning and automated drawing production. SmartPlant Offshore supports commissioning and operation as well as maintenance and modification through digital handover. The act of relinquishing property or authority etc. to another; as, the handover of occupied territory to the original possessor’s; the handover of the facility engineering information asset[33].

The data-centric, rule-based, integrated environment aims to shorten time to first oil by fundamentally improving work processes, significantly lowering manpower requirements Human resources needed to accomplish specified work loads of organizations and material costs. SmartPlant Offshore provides vessel design functions and addresses conceptual and detailed design of hulls and topsides structures and outfitting, plan approval, production planning . The function of a manufacturing enterprise responsible for the efficient planning, scheduling, and coordination of all production activities, materials control, manufacturing and construction engineering including piping, electrical, process equipment, instrumentation and controls and related systems.

The initial release supports floating production, storage and offloading (FPSO Floating Production Storage and Off-loading vessels. Future releases will support all major types of offshore designs including fixed, tension leg, floating and spar provides Concurrent Engineering, SmartPlant Offshore is developed specifically for multi-discipline, concurrent global execution and enables organizations to flexibly apply expertise to solving engineering problems, optimizing time use and producing high-quality designs on a consistent, worldwide basis. Regardless of location, all authorized personnel access a single, logical 3D model which eliminates traditional work sharing barriers and the heavy administrative overhead posed by current systems. Unlike current modular systems that tend to isolate disciplines and require serial work processes, SmartPlant Offshore helps users focus on productive tasks and provides an environment enabling multi-discipline, parallel design cooperation.

The data-centric, integrated architecture of SmartPlant Offshore provides a number of productivity benefits unavailable in traditional engineering and design software. Productivity advances are enabled by design rules, real-time interference detection, and automation of routine detailing tasks and automated drawing production. The software applies rules which promote consistency and engineering integrity and contribute to a high level of automation for design and fabrication. For example, specialized rules drive detailing of structural plates and profiles including management of stiffener end-cuts and penetrations as well as weld definitions, based on connection geometries.

The software also includes advanced component and detailing catalogues, which pre-configure manufacturing equipment characteristics relative to the particular detail, enabling optimal selection of shop fabrication lines for hull and outfitting without the delay of design reiterations. Continuous, real-time clash detection flags interferences early in the process as they are created and helps avoid costly design changes. Automated drawing generation eliminates bottlenecks, simplifying and speeding production for fabrication and construction. Drawings are generated as graphical reports from current project data and users can generate numerous drawing types on demand [33].

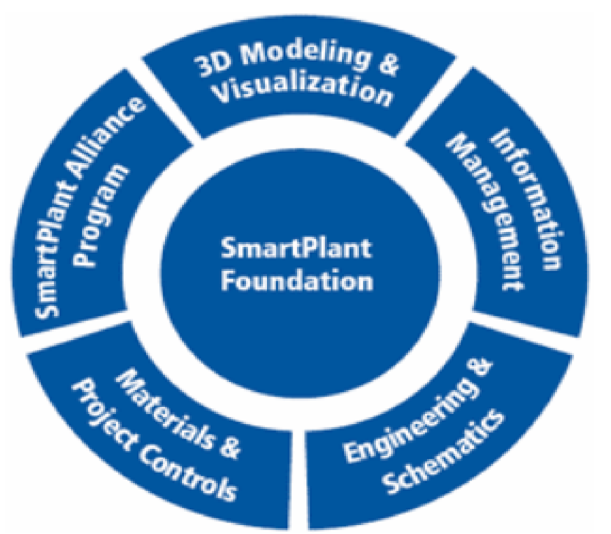


Fig. 3.6 SmartPlant Foundation / SmartPlant application integration [36]

SmartPlant 3D has been designed for productivity in both modeling and interdisciplinary integration. It provides a consistent, integrated family of multi-disciplinary applications based on the familiar Microsoft Windows user interface. This boosts productivity and substantially reduces software learning curves by offering a familiar, easy-to-use 3D design and modeling environment. SmartPlant 3D enables designers to more effectively capture and manage design intent via design rules and relationships between SmartPlant items. This helps to retain, and in many cases, increase engineering and corporate knowledge, increasing overall data quality and integrity. It offers intelligent integration, providing a money-saving step toward a truly integrated engineering enterprise. With new technology, Intergraph has developed SmartPlant 3D to address the constraints imposed by existing technical, software, data management, functional, and integration deficiencies by enabling an optimized, integrated design environment used to define and manage the 3D plant model. Intergraph's SmartPlant environment strives to maximize return on investment, while protecting existing investments around infrastructure, training, and organizational processes. This helps support changes in the way the global plant design industry manages plant assets through the complete life-cycle. SmartPlant 3D helps drive and shape this change and, as a result, helps increase the competitive advantage of the organization [33].

3.12 SmartPlant 3D in an Integrated Environment

SmartPlant Materials is the Intergraph integrated life-cycle material and supply chain and subcontracting management solution. It provides a common collaboration platform and project workbench for all partners in any engineering, procurement, and construction (EPC) project supply [34].

3.13 Interdisciplinary Integration

Using SmartPlant 3D in an integrated environment allows you to re-use data in SmartPlant 3D that has already been entered into authoring tools such as SmartPlant P&ID and SmartPlant Instrumentation. In this integrated environment, data is published to and retrieved from a central repository. During a publish operation, drawings, reports, or 3D model data is sent to the repository. During a retrieve operation, the design basis is brought into the software and then related to 3D objects. Design basis is the term used for piping, instrumentation, electrical, and equipment data from other applications outside SmartPlant 3D. The role of SmartPlant Foundation (SPF) is crucial in an integrated environment, not only from the standpoint of managing the transfer of the data but also setting up the project structure.

Before any project work is created, the project structure must be created in SmartPlant Foundation and then published. The published structure is then retrieved into the authoring tools. The retrieval of this PBS (Plant Breakdown Structure) automatically creates the same structure in the tools. Then, when data is created in the authoring tools, the publish functionality automatically groups items in SmartPlant Foundation to that structure and builds relationships among the data within that PBS. If a new area or project is created in an authoring tool, but not in SPF, a publish operation places that data at the top level of the plant in SmartPlant Foundation. The following graphic shows how to publish and retrieve operations along with the central repository (SmartPlant Foundation) in a conceptual manner.

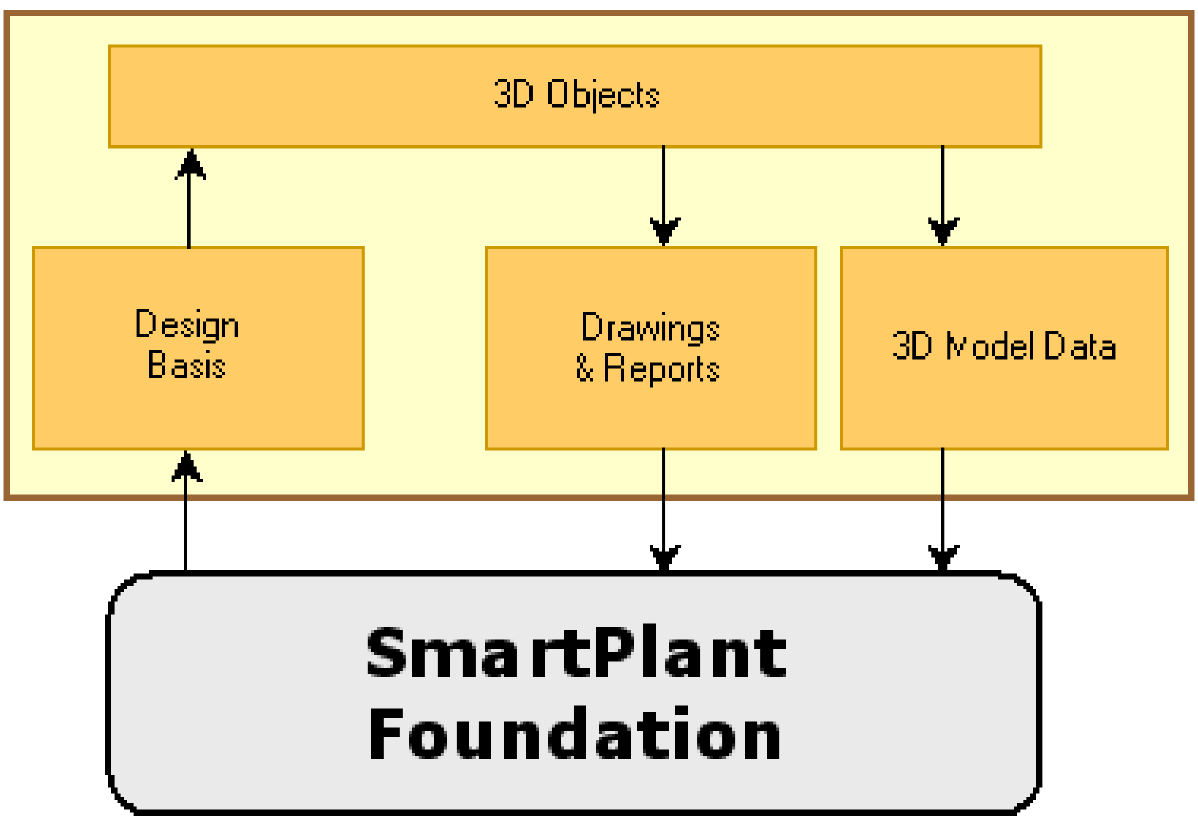


Fig. 3.7 SmartPlant Foundation integration

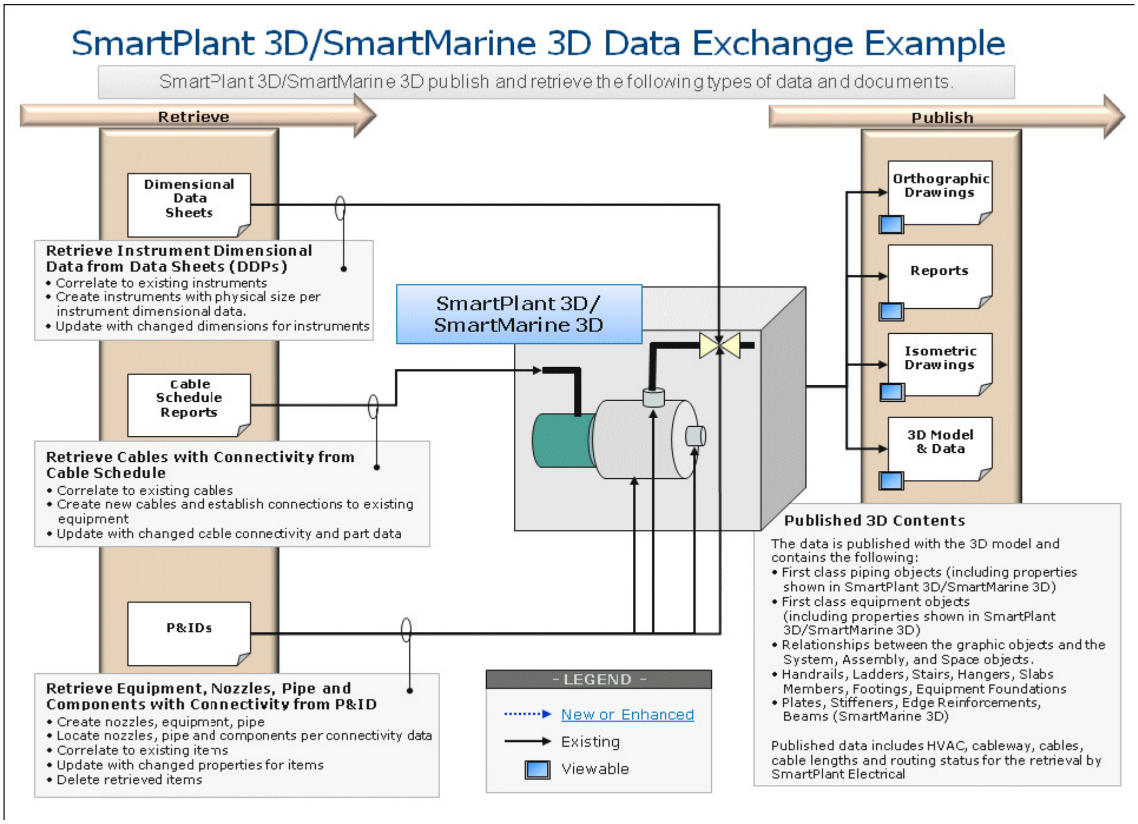


Fig. 3.8 SmartPlant 3D/SmartMarine 3D Data exchange example [35]

SmartPlant 3D can retrieve P&IDs, SmartPlant Electrical cable schedules, SmartPlant Instrumentation DDP files, Plant Breakdown Structure (PBS). The retrieved information assists in creating and modifying objects in the model. For example, after retrieving a P&ID, the P&ID Viewer in SmartPlant 3D can be used for guidance when routing pipe, inserting components and instruments, and placing equipment in the 3D model. In the SmartPlant 3D Drawings and Reports task, you can publish orthographic drawings, isometric drawings, and reports as view files. The view files include relationships to the 3D model data. You can publish 3D model data for use with SmartPlant Foundation and SmartPlant Review. The 3D model data can include data related to the orthographic, isometric, and report documents [35].

SmartPlant P&ID interfaces with SmartPlant 3D Catalog data through the Remote Piping Specification data. This connection allows the P&ID user to validate components against the catalog data before you retrieve it in SmartPlant 3D. To use this functionality, the SmartPlant 3D value is specified for the Use Piping Specification property in SmartPlant P&ID Options Manager.

3.14 Understanding Integration Terminology

In the context of integration, certain terms carry a specific connotation for their usage with SmartPlant 3D. The following terms are used frequently:

Work Breakdown Structure (WBS) - The composition of the model based on the construction work to be completed. The model occupies the top level of the hierarchy (area), followed by projects, contracts, and documents.

Area - A group of work organized primarily by geographic position relative to a named volume or area to which you can assign a relationship.

Project - The scope of work approved for capital expenditure; a financed set of work (that is, a job). Normally, a project begins in the design world and then progresses to the physical world when the actual construction is approved. Use the Project > Claim command to associate an object with a project.

Contract - A specific contract to the fabricator or erector. You can associate published documents to a contract and then reassign the document from one contract to another. You can also assign documents to multiple contracts.

As-built - Describes the computer model intended to accurately represent the physical model as it was built (constructed). Objects in the as-built model contain property values (for example, contractor or industry commodity codes) that associate the model objects to physical objects in the model. The accuracy of this model depends on the incorporation of changes based on changes made in the actual model during construction. If no such changes are made, the model is "as-designed." As-designed - Describes the computer model that depicts the design of the physical model. This model does not use property values (that is, serial numbers) but identifies objects by a tag number or actual location. Currently, the authoring tools update the as-designed model, not the as- built model.

As-is - Describes the set of physical objects that actually exist in the model. The as-is model is not a computer model but a physical entity. Claim - To identify objects as part of a project. Design Basis - A collection of objects that represent the pieces of data from other authoring tools outside of SmartPlant 3D.

Design object - Any object that you can select with a property page. An object can be related to one or more contracts of different types. Or, you can limit this relationship to only one contract of a given type, by setting the Exclusive property.

Part - An object managed for production by a unique identity.

Assembly - A set of parts, using a unique identity, grouped together for production purposes.

Pipe spool - A set of piping parts assembled in a workshop and installed as a unit in the field. Typically, a pipe spool represents the lowest level assembly of piping parts. The Piping task includes commands to automatically define the spool groupings based on rules.

Pipe run - A piping path with the same nominal pipe diameter (NPD). The contents of a pipe run use the same specification and have the same service.

3.15 Other tools integration methods

There are plenty of software tools and integration methods to help combine and run the system consistently. A legacy Intergraph product PDS (Plant Design software) provides several methods to integrate operations and ensure data accuracy. Those methods are maintained for SmartPlant integration.

3.15.1 Piping clash check

Piping clash is a routine that checks a pipeline or user-defined groups of objects for interferences immediately after completing the line. It automatically creates interference envelopes in memory for easy retrieval and viewing.

It checks any attached reference models for which interference envelope files have been created previously. It also reports any reference models for which interference envelopes have not been created previously.

3.15.2 Design check review

This command graphically reviews design check errors and generates a report. It helps engineers to review the system and solve modeling and design issues.

3.15.3 P&ID comparison review

This command graphically reviews any discrepancies in piping segment data between the P&ID Database and the piping model. It displays information from the Segment Data report generated using the P&ID Comparison Report Manager in the Piping Design Data Management module.

3.15.4 Review RDB report

The review rdb report reviews any component in the model requiring reconstruction, replacement, or update as a result of changes to the Reference Database. This helps to maintain model consistency. Inconsistencies can result in errors in the generation of piping isometric drawings.

3.15.5 Review isometric drawing

This command graphically reviews an isometric drawing in the Piping Designer modeling environment. The isometric drawing defaults option must reference the line id of the piping segment. The command determines the network address and path name for the isometric drawing on the basis of the isometric revision management data in the Project Control Database.

PDS integrates with Intergraph's SmartPlant P&ID, a data-centric, rule-based engineering solution that creates intelligent P&IDs while building a comprehensive data model. It also integrates with SmartPlant Instrumentation - the industry standard PDS for instrumentation - which drives deliverables for different phases of the life cycle, enforcing data consistency and eliminating duplicate data entry. PDS can also be used in conjunction with SmartPlant Electrical, an electrical schematics and wiring diagram application that interfaces with the instrument application to generate wiring diagrams.

Chapter 4 A Real-time integration with SmartPlant projects / Theoretical framework

4.1 Introduction

This chapter looks at how SmartPlant Integration works in Agility Group; how it was organized and what the pros and cons are in using this system. For the production and use of all engineering data, in offshore projects, it is important for reasons of reusability, security and automated processes and data integration and so on, that all organizations have a common platform and methodology. It is important for the common engineering system portfolio which interfaces and works together with the company's' and customers' standards and requirements.

In Agility Group, preparing a common Engineering System provided a solution portfolio which interfaces and works together with company and customer standards and requirements. Having defined a multi-discipline engineering system concept positioned Agility Group in as an advanced, cost effective and quality supplier in the marine/offshore business.

4.2 Plant Life Cycle Software Solutions

Agility Group has multiple disciplines involved in offshore projects requiring significant integration in order to function efficiently. Intergraph's SmartPlant product suite offers a powerful portfolio of best-in-class applications, which may be deployed individually. For optimum performance and execution benefit, however, they may be combined into a flexible, integrated enterprise solution -- the SmartPlant Enterprise, allowing an organization to successfully unleash the untapped value that is often restricted by silo-centric communication and execution [37].

Fig. 4.1 SmartPlant Enterprise solution [35]

A key success factor of SmartPlant Enterprise is its ability to standardize and share information among all applications. As with product implementation, product integration is, of course, scalable and customizable. SmartPlant Enterprise, therefore, provides three progressive levels of application integration: Direct integration for direct data transfer among design tools, Basic integration using SmartPlant Basic Integrator, which provides publish and retrieve functionality and system administration features. Full integration of design tools and SmartPlant Foundation, Intergraph's comprehensive data and document management system

4.3 Agility Group Integration activities

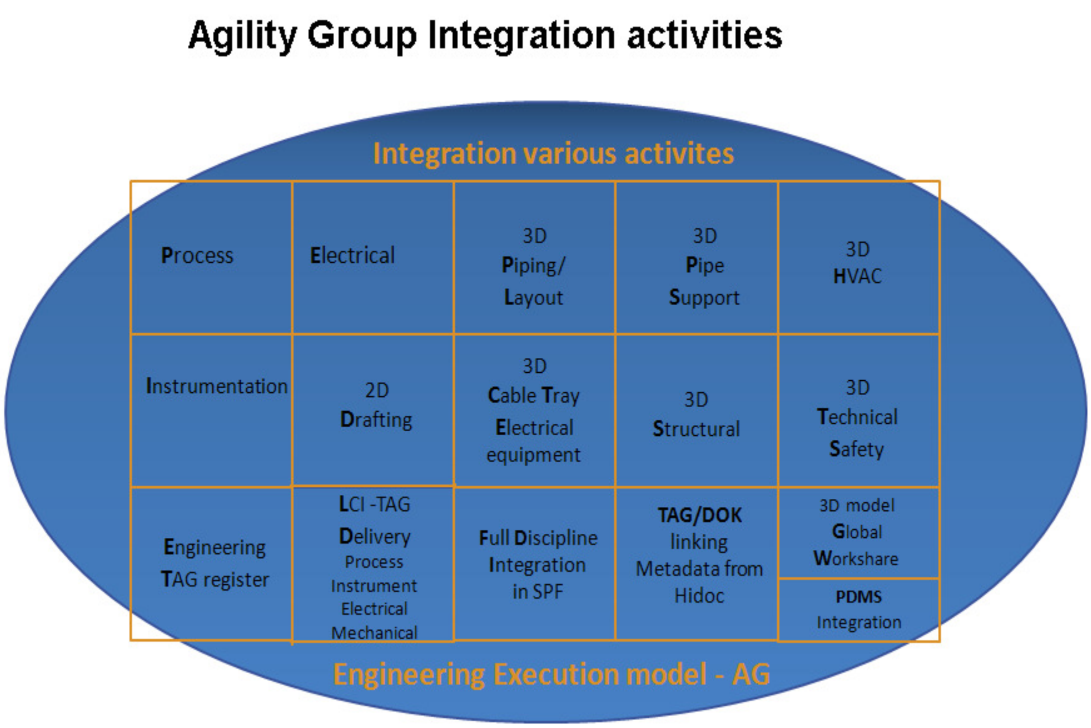


Fig. 4.2 Agility Group SmartPlant Integration Activities

The objective to describe the integration between 3D Piping and Process P&ID's in an integrated project, where P&ID's are made in SmartPlant P&ID and published to the Common Engineering Register (SPF), the piping discipline can take data from the P&ID which is populated directly onto the 3D pipeline.

A previously modeled pipeline can also be checked against the published P&ID to verify that important pipeline data match with the process P&ID. That way the traditional, 'yellow line check' now can be executed by the system and semi-automated.

The below diagram explains when start the pipe what are the integration checking for the process.

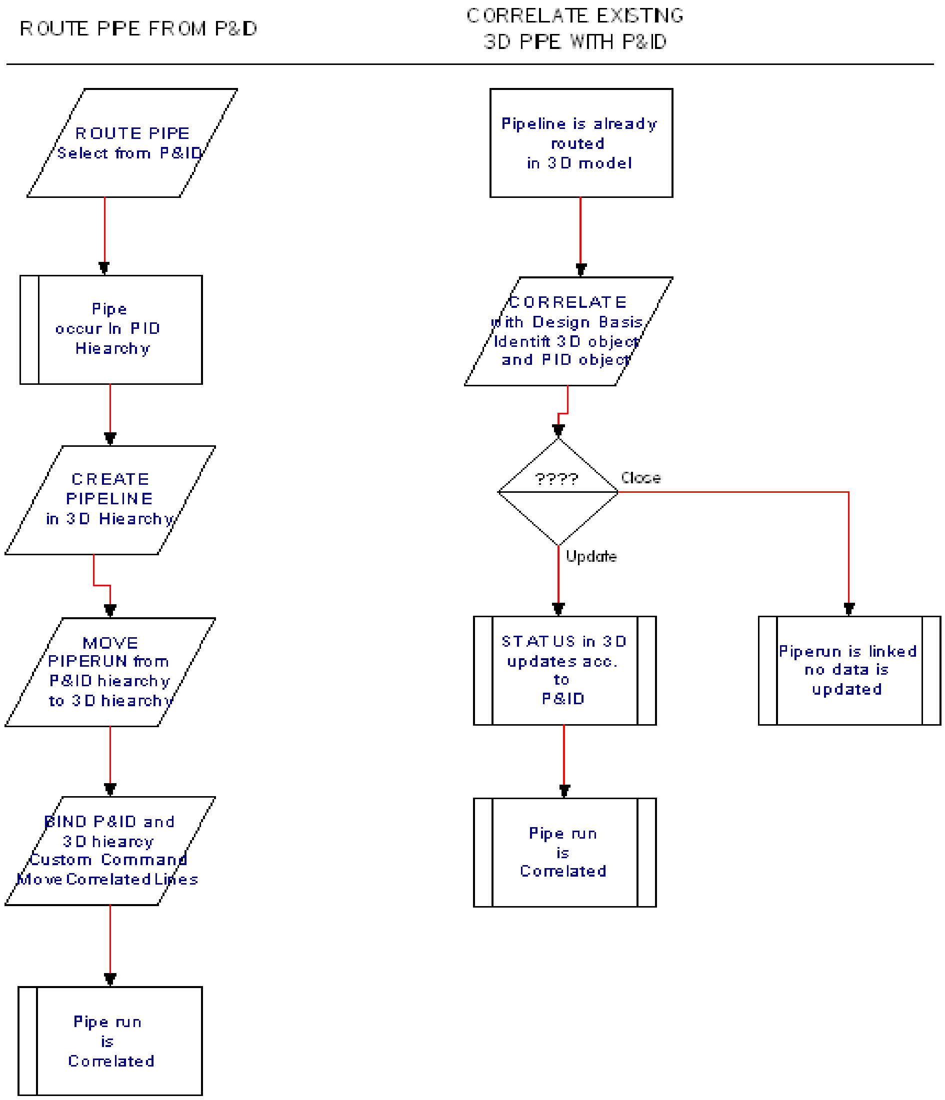


Fig. 4.3 Example of Integration checking for the Process P&ID

4.4 SmartPlant Integration

In selecting other solutions from the comprehensive SmartPlant Enterprise suite, including SmartPlant Foundation, Instrumentation, P&ID, Electrical, Reference Data, and Review, the shipyards will also use these solutions in an integrated environment for the design, construction, production, and planning of offshore facilities for improved efficiency and quality [35].

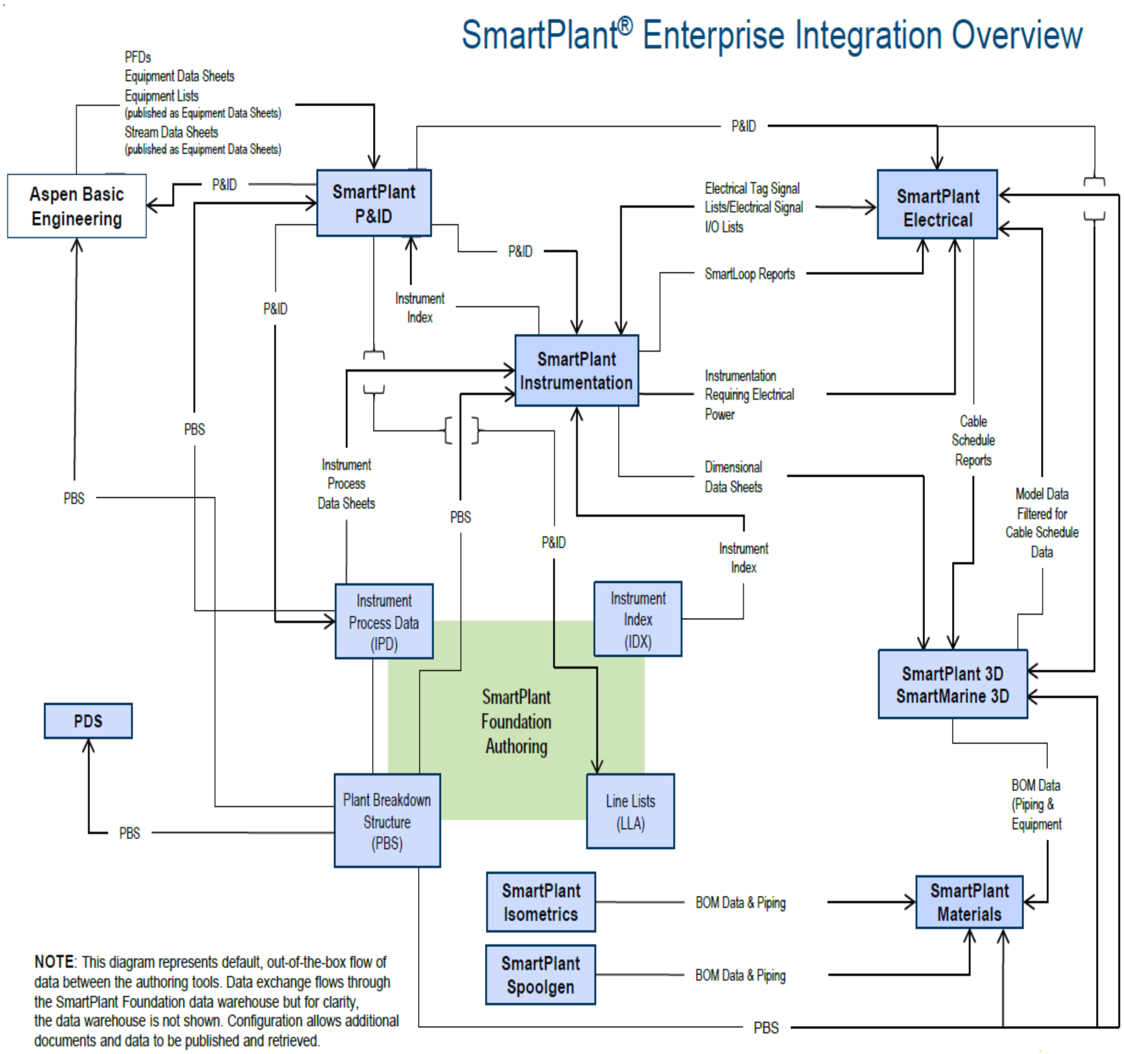


Fig. 4.4 SmartPlant Enterprise integration overview [35]

Agility Group selected SmartPlant Enterprise for its extensive projects since it offers a complete solution from start to finish. The company undertook a phased approach to software, starting with SmartPlant Foundation and SmartPlant P&ID and is now taking advantage of the assets created during engineering. In a structured manner, the company receives accurate and complete plant information in terms of data and documents from the suppliers. This is accomplished by means of an integrated information management system. In addition, the company is now using SmartPlant 3D to design the new facilities and assets.

SmartMarine 3D can handle the dense and complex structural and outfitting designs required in offshore projects, from the schematic design of an asset through to physical modeling, materials management, construction management, and fabrication automation and information management. Data and design parameters are entered only once into the authoring disciplines and re-used downstream. The out-of-the-box integration is a change management environment that facilitates publishing, retrieving, reviewing and comparing data and documents electronically between disciplines. With an integrated information management system with full interoperability, secure access to engineering information of our offshore assets is ensured whenever and wherever it is needed. This provides enhanced safety, improved quality of data, and increased productivity and efficiency. An integrated information management system offers easy and secure access to accurate and intelligent engineering data better decision-making for significant cost and time savings and effective change management for improved safety, quality, and productivity.

The SmartPlant solution is a multidiscipline solution taking care of the project data in a standard common database powered by SmartPlant foundation. SPF is the central Hub and database storage for Agility group SmartPlant projects.

4.5 SmartPlant exchange overview

In Agility Group, the following data exchange is dealt with by SPF. The system offers central tag data storage, central storage of documents and models, versioning control and is a central Hub for the discipline tools. It manages automated tag/document relationships and the delivery of Engineering tag data (LCI delivery) to customers' systems.

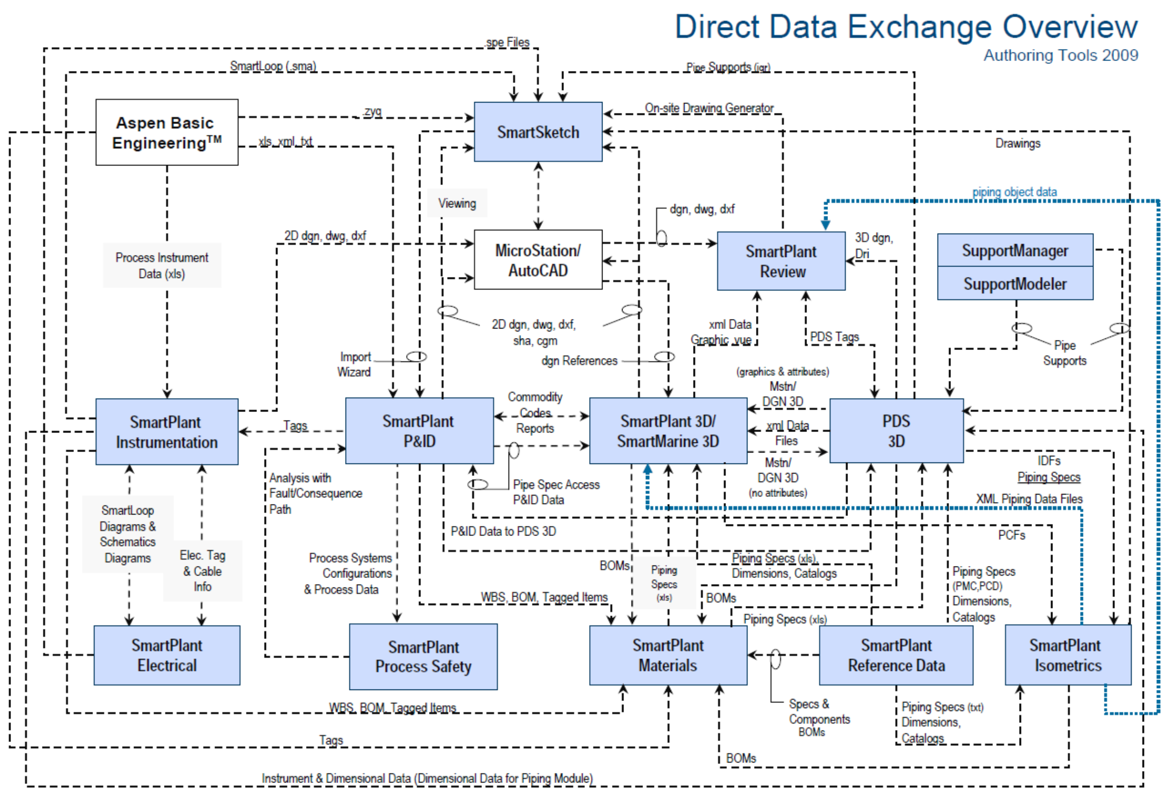


Fig. 4.5 SmartPlant Direct Data Exchange overview [35]

4.6 SmartPlant Foundation

SmartPlant Foundation has two different functions in the workflow: The main use is as a database of the information related to the various tags in a project. (The terms data repository and data warehouse are also often used for this database.) To get information into the database each tool publishes their data, i.e. the relevant data is exported from the tool and imported into the database. Each tool has "its own part" of the database and the data will not be overwritten by information from the other tools. However, during the import process the tags in the different parts are linked to each other. In this way information regarding a tag in one tool can be compared to the information regarding the same tag in the other tools.

When information has been placed in the data warehouse it is available to be "retrieved" into other tools – the tool imports data from the SPF database.

The other main use of SPF is as a separate tool to enter / modify tag data - the "SPF authoring" mode. While the data in the data warehouse cannot be changed directly from any SPF tool (they must be changed in the original toll and republished), the data in the "authoring" part of SPF may be changed from the SmartPlant Desktop Client. One main use of this will be to handle process data.

The publish and retrieve processes described above require "mapping" to work. This "mapping" tells which property in one tool that corresponds to the matching property in the other tool.

SPF (SmartPlant Foundation) is the heart of the system. It keeps all the common information in a standard open database (Oracle). This makes it possible to share or exchange information with other database or customer systems.

SPF: Project Portal

SPF is also the project "portal" for technical information. By having the capability of storing all the process, instrument/electrical and 3D model information and drawings, it gives the project users a complete picture of the project.

SPF: Revision Control

SPF also manages revision control of drawings from SmartPlant. By keeping track of all the revisions and issues, the history of the documentation is kept and can be reviewed at any time.

SPF: Tag Index System

SPF acts as the project TAG Index system. With the TAG number in focus, all the information related to the Tag may be viewed and referenced.

With Tag reference to schematic, layout and piping isometric drawings, the 3D model and suppliers' documentation, SPF is the heart of the project workflow.

SPF: Extended Document Management Facilities

SPF may be extended to also act as the technical document managing system for the project. In general, “HiDoc” is Agility Group's document management system. It contains an archive of documents and manages the transmittal and delivery of documents to and from the project.

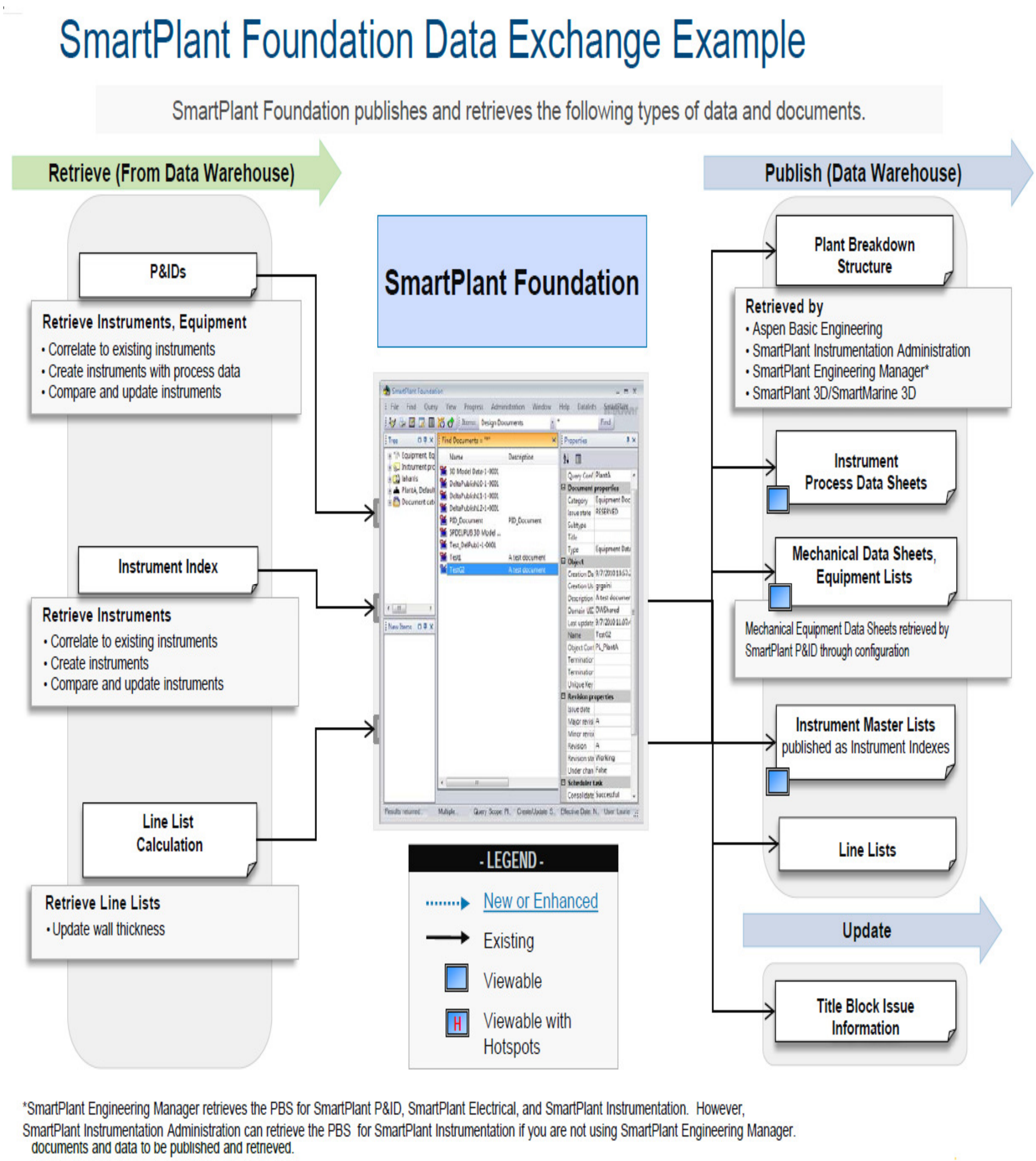


Fig. 4.6 SmartPlant Foundation Direct Data [35]

4.7 Agility SPF Basic work flow

The picture below shows how Agility Group integrates with their customers with the SmartPlant Foundation (SPF) system.

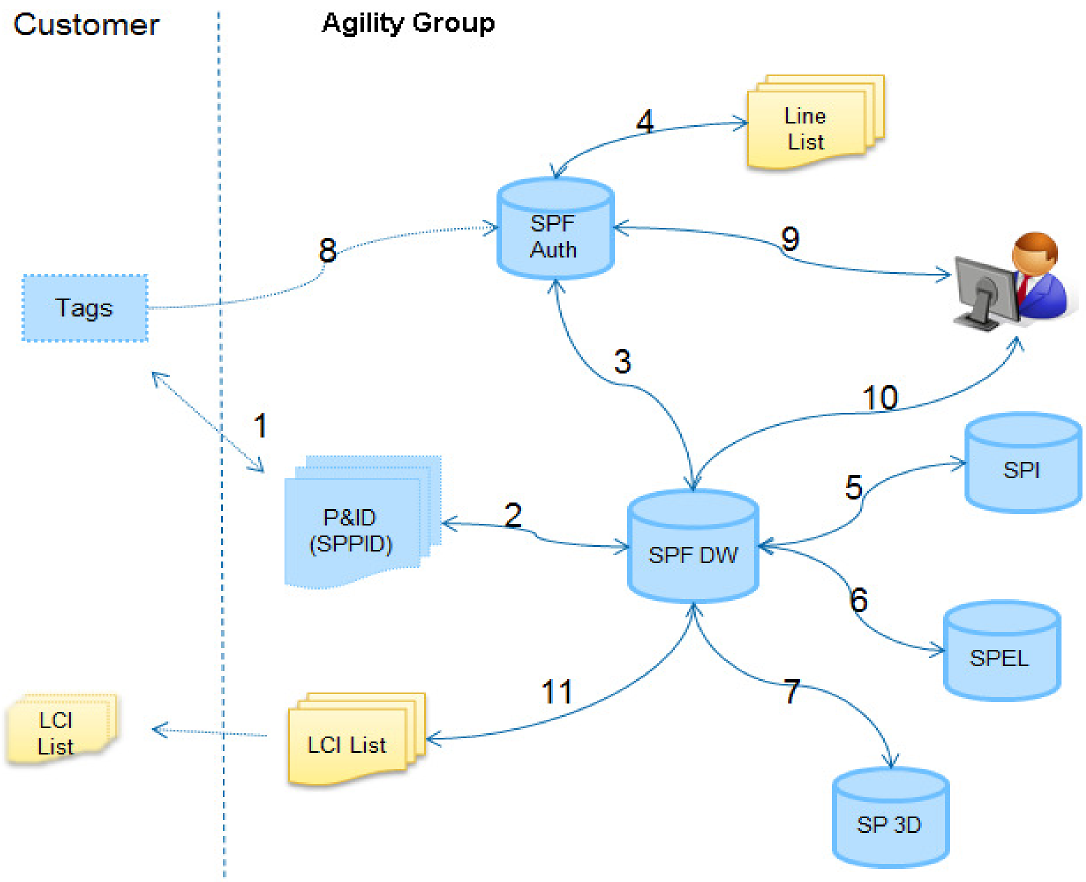


Fig. 4.7 Agility Group & Customer integration setup model

1	Tags numbers (in maintenance projects) are created in the customer system.and used on the PI&Ds.
2, 3, 5, 6, 7	Information is published and retrieved between the varoius tools as specified in TR3111_Team.xls.
4, 9	Process information is maintained directly in SPF Authoring or in an Excel Line List.
10	Comparison and validation between the data in the diffent tools.
11	Various reports and files for import in customer systems delivered.

4.8 SmartPlant 3D/ SmartMarine 3D

This is the 3D application in SmartPlant Enterprise. It's a complete, multidiscipline 3D design environment. Piping, Structural, Electro/Instrumentation, HVAC, Safety, Civil & HSE Smart3D is a common word for SmartPlant 3D and SmartMarine 3D. Smart3D delivers the optimal design environment by having all the disciplines connected in one database. Smart3D is connected to the Common Engineering Database (SPF) and shares its information with all the project participants with a very simple user interface. The 3D model and all the produced drawings from the model may be viewed "intelligently" in SPF. You may point to an object on a P&ID and have a direct lookup in the 3D model on that particular object. This also applies to layout or piping isometric drawings [35].

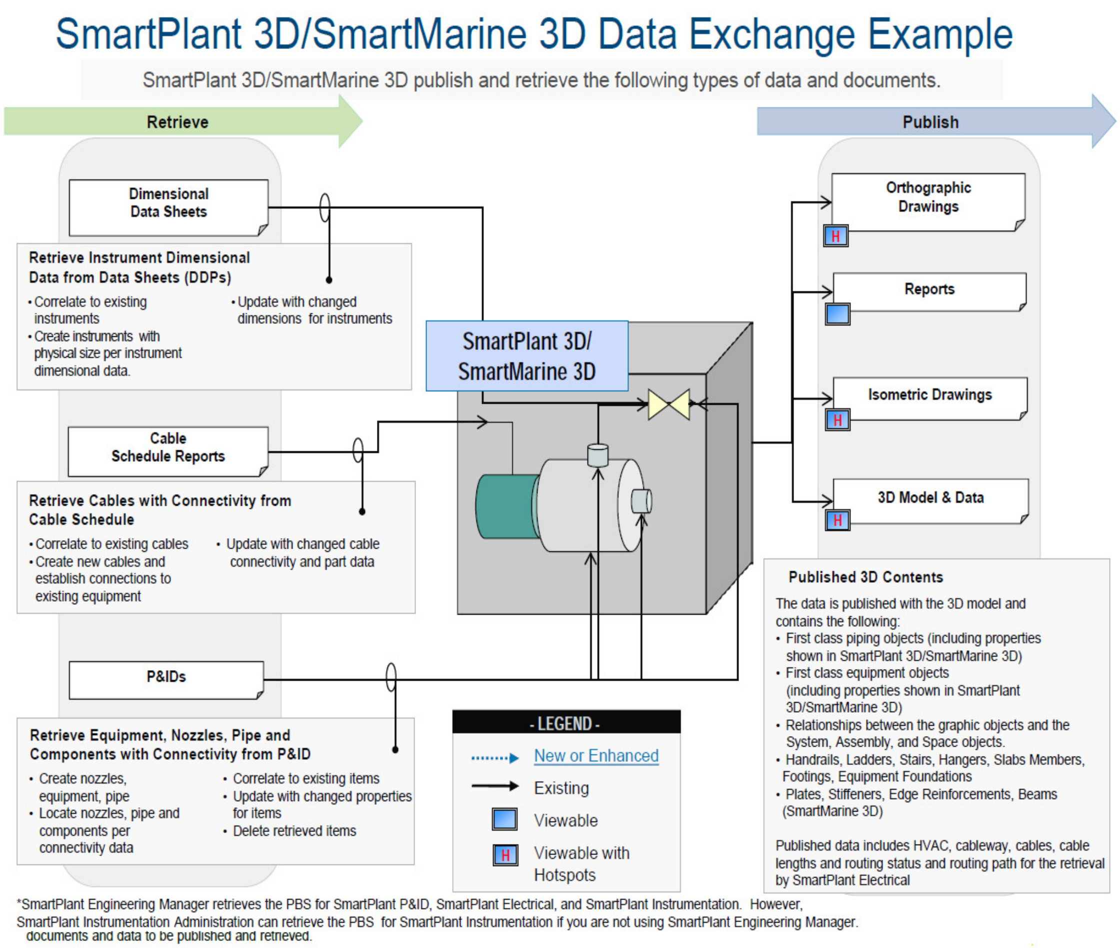


Fig. 4.8 SmartPlant 3D/SmartMarine 3D Data exchange [35]

4.9 SmartPlant Electrical integration

This is the discipline application for electrical cabling and cabling diagrams. The application keeps all the electrical information in the database. SmartPlant Electrical publishes the information to the Common Engineering Database (SPF). This information may be used in the 3D application while cable routing in 3D. SmartPlant Electrical is CAD neutral and can deliver the information in .dwg, .dxf (AutoCAD) or .dgn (MicroStation) formats or the native Intergraph format .sha [35].

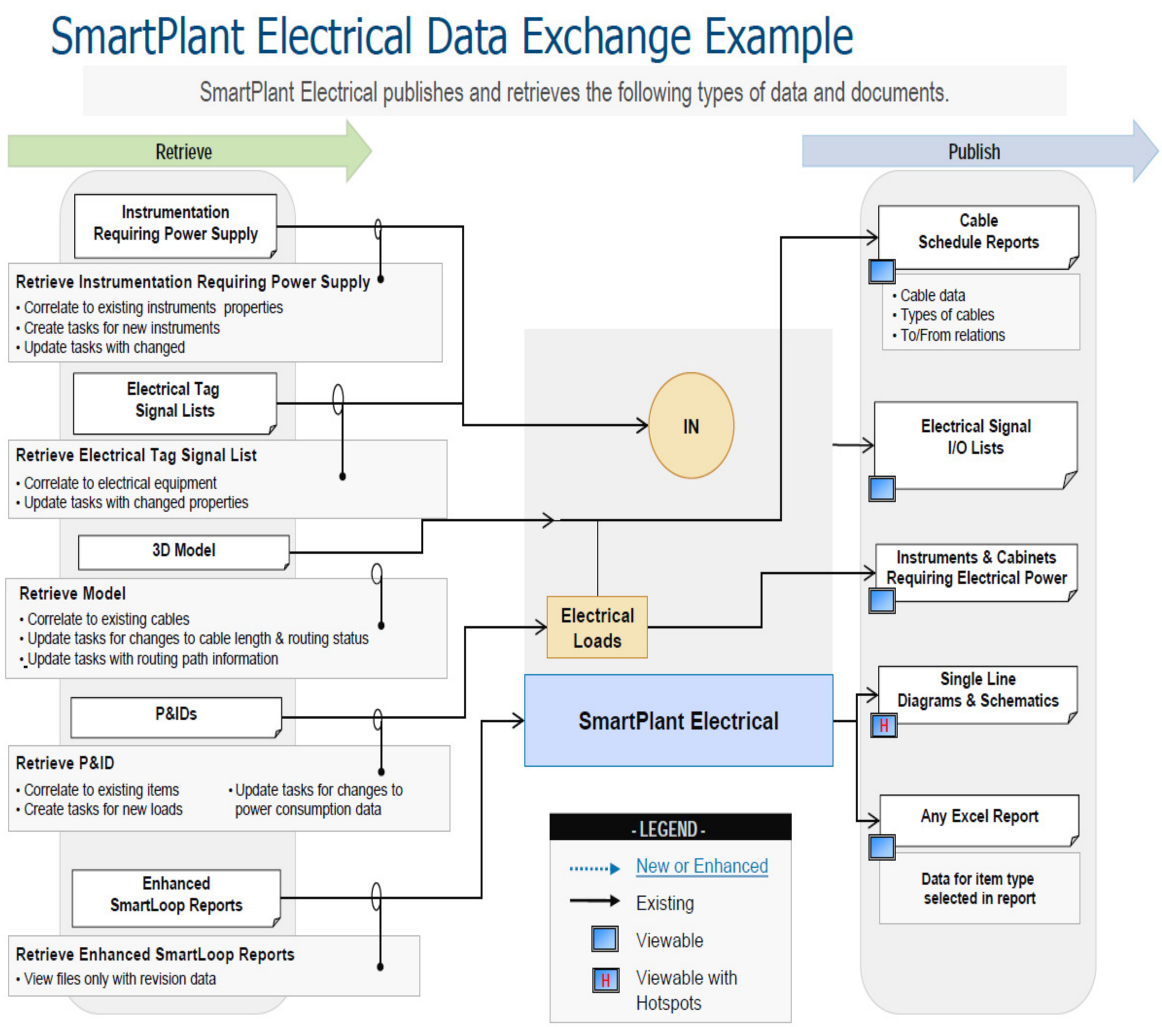


Fig. 4.9 SmartPlant Electrical Data exchange [35]

4.10 SmartPlant Instrument

SmartPlant Instrumentation is the tool for the instrument Engineer. It keeps all the instrumentation data in the database. The information produced is typical loop-diagrams, data lists and hook-up drawings. SmartPlant Instrumentation is connected to SmartPlant P&ID through the Common Engineering Database SmartPlant Foundation (SPF). The instrument information is available for all projects attendees from SmartPlant Foundation. SmartPlant Instrumentation is CAD neutral and can deliver the information in CAD file of type dwg, dxf (AutoCAD) or dgn (MicroStation) formats or the native Intergraph format .sha [35].

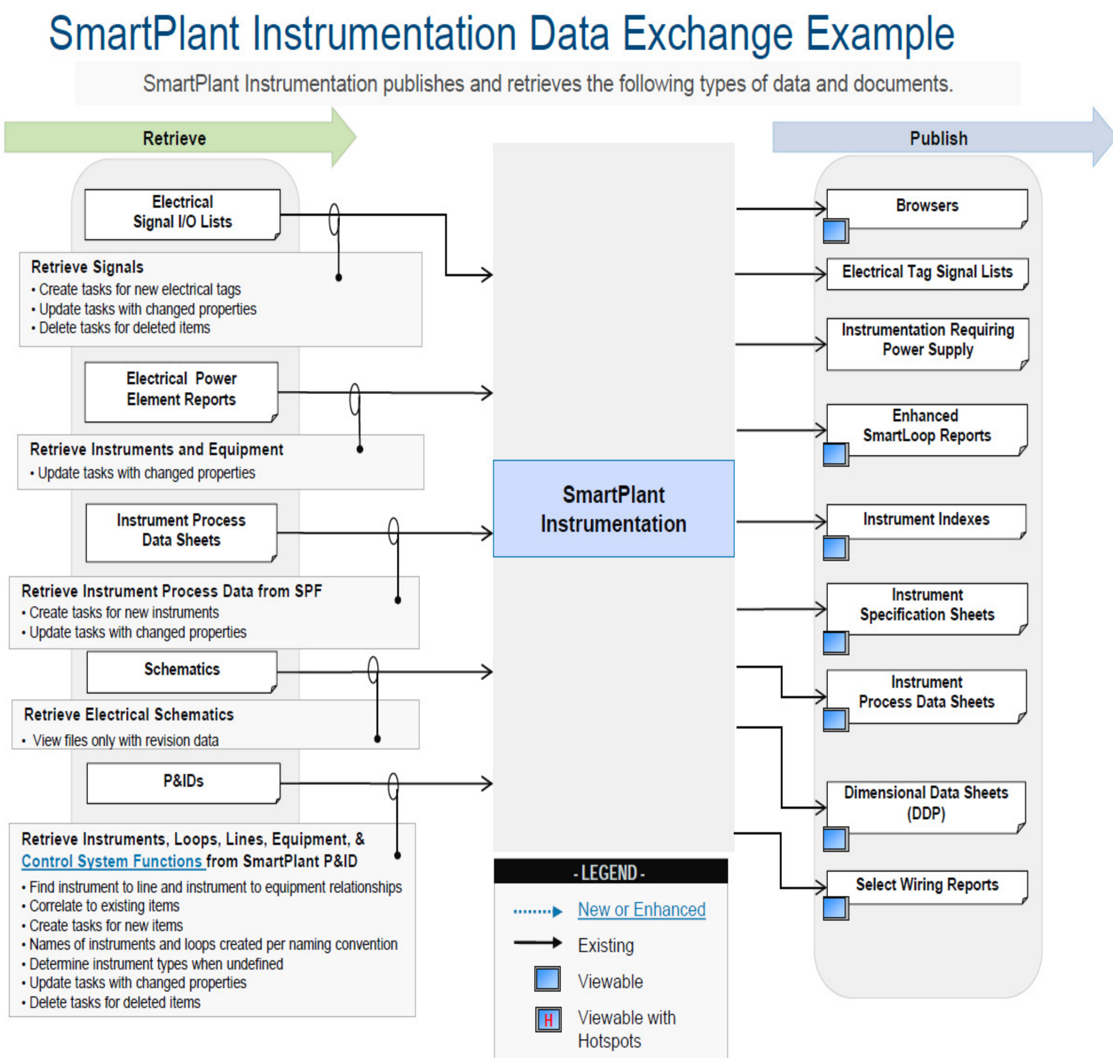


Fig. 4.10 SmartPlant Instrumentation Data exchange [35]

4.11 SmartPlant Process integration

SmartPlant P&ID is the tool for the process engineer. It collects all the process information in a database and produces reports either as drawings (P&ID's or PFD's), line, and equipment- and valve-lists. SmartPlant P&ID is connected to the Common Engineering Database system (SPF) though which it shares information with the other discipline tools. SmartPlant P&ID is CAD neutral and can deliver the information in .dwg, .dxf (AutoCAD) or .dgn (MicroStation) formats or the native Intergraph format .sha [35].

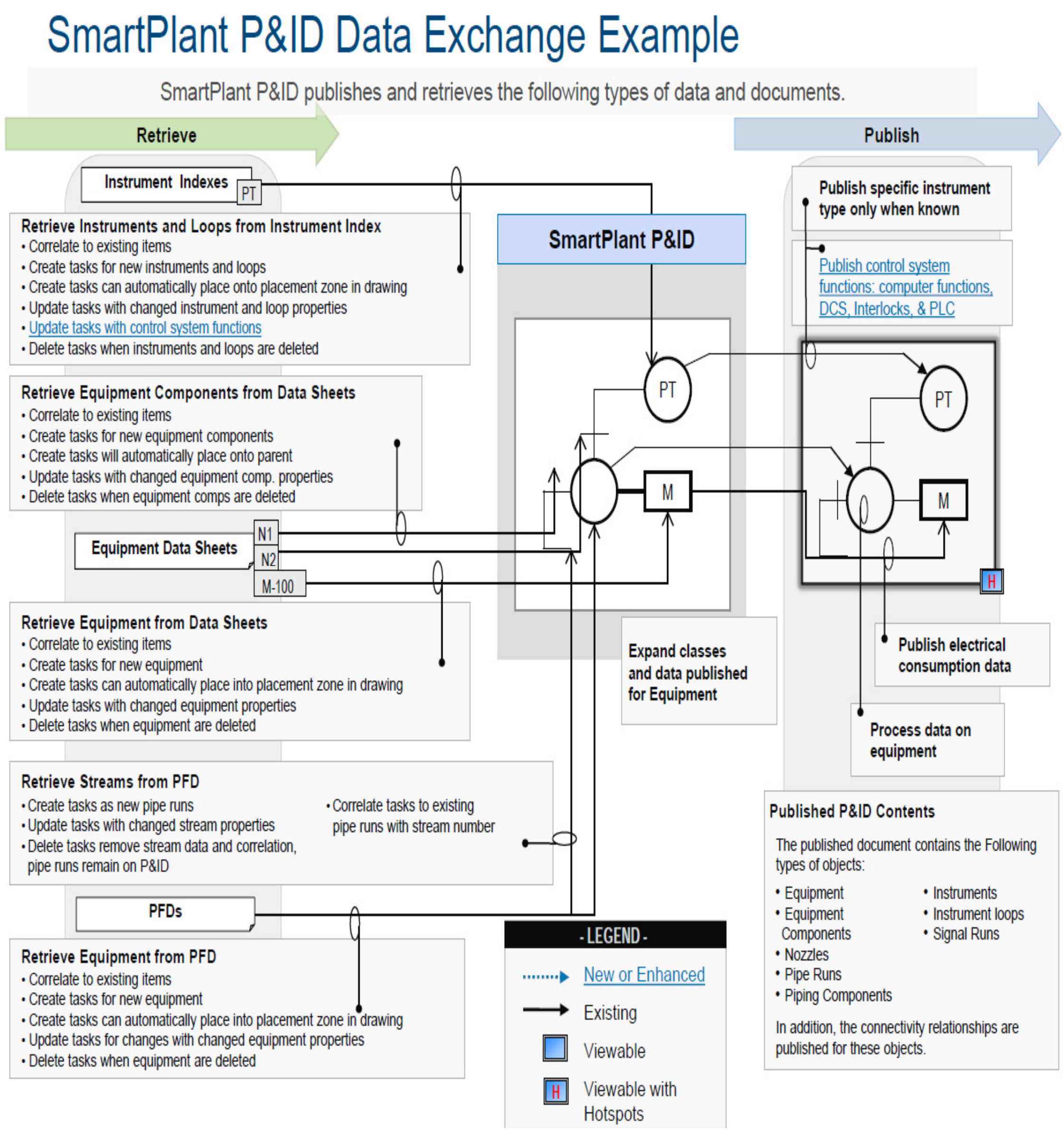


Fig. 4.11 SmartPlant Process &Instrument Diagram (P&ID) exchange [35]

Chapter 5 Usability Evaluation

5.1 Introduction

In previous chapters, the various SmartPlant functions and integration methodologies have been presented and discussed in detail. The main subjects of this chapter are research methodology and the usability evaluation. The usability evaluation examines the impact of the SmartPlant tool and its effect on productivity and integration between disciplines.

Fig. 5.1 Research Methodology

5.2 Research Methods

The process used to collect information and data for the purpose of making business decisions. The methodology may include publication research, interviews, surveys and other research techniques, and could include both present and historical information. [38].

Every researcher has their own style of research methods use to understand their design activity. While others researcher used observational and descriptive examination on the design activities [40]. In this thesis, researchers was produced and the observational interview and experimental was validated as a research technique for design to some extent.

5.3 Choice of research approach

The outcome of research will never be better than the original choice of research approach. This statement highlights an essential part of every study's methodology. Without an accurate research approach, the fundamental plan that points the direction for data acquisition and the analysis of the research object will be flawed.

The choice of which method to employ depends upon the nature of the research problem, Morgan and Smirch (1980) argue that the actual suitability of a research method, derives from the nature of the social phenomena to be explored [41]. There are two basic methodological traditions of research in social science, namely positivism and post positivism (phenomenology).

5.4 Data collection

Data is one of the important and valuable aspects of any research study. Very often, researchers have their own style and set of methods but, in general, all research is based on data which is analyzed and interpreted to achieve the results. There are two sources of data collection techniques; primary and secondary. A condition for any type of academic research is the collection, analysis and presentation of data. Christensen et al. states that data could be divided into qualitative or quantitative depending on its character in primary and secondary data and on how it was collected

Primary data is data that is collected for the first time in order to answer a previously unanswered problem or question. This type of data could be collected by methods such as interviews, or questionnaires. Primary data collection has its advantages as it results in up-to-date information but is often time consuming and expensive [42]. In this thesis, the primary data is collected from observation, experimentation and interviews with project managers, SmartPlant administrators, various discipline users and discipline leads. Their interviews and past project experience provides the primary data for this thesis [43].

5.5 Method and theory for collection of data

The thesis is conducted with exploratory, hermeneutic and adductive approaches. The primary data is collected from interviews with personnel and the secondary data is gathered from past project man-hour estimations and consolidation. The thesis has been conducted with a focus on the factors discussed within interdisciplinary integration of SmartPlant in offshore projects in Agility group.

A number of required questions were prepared where the answers would adequately provide an understanding of users' knowledge and relationships to SmartPlant in Agility Group. The researcher visited the selected respondents at their respective work places and offices, and requested them to fill out the questionnaires. Some respondents immediately filled out their questionnaire and returned them. Some few others agreed on a time and date to deliver theirs. Participation in this survey was completely voluntary; it took around 2 weeks to collect the data.

The primary data was collected from various SmartPlant discipline users; engineering tools administrators, project managers and discipline lead. A total of approximately 25 questionnaires were distributed of which 22 were completed and returned. The response rate is slightly less than 90%. The main reason for this high response rate is that the researcher knew the users very well, both through previous projects and. If questionnaires had been sent by different mode or by another person then the time to gather responses would have been higher and the response rate lower.

Secondary data is data collected by someone other than the user. Common sources of secondary data for social science include censuses, organizational records and data collected through qualitative methodologies or qualitative research. Primary data, by contrast, are collected by the investigator conducting the research. Secondary data analysis saves time that would otherwise be spent collecting data and, particularly in the case of quantitative data, provides larger and higher-quality databases that would be unfeasible for any individual researcher to collect on their own. In addition, analysts of social and economic change consider secondary data essential, since it is impossible to conduct a new survey that can adequately capture past change and/or developments [44].

In this research, the secondary data collections are past project man hours data. Agility Group's first SmartPlant project, Oseberg, is taken as a sample project for the secondary data method. Very useful data was available in being able to compare Agility Group's efficiency both in a period immediately after SmartPlant implementation and after a relatively long period of building expertise.

5.6 Methods of communication

When collecting primary data, the researcher has to decide which type of method to use. The characteristics of each communication method often vary in the effort put in and the substance returned [45]

As explained earlier in thesis, personal interviews were used when collecting primary data from the Agility Group employees. The respondents were all aware of the purpose of this thesis when being interviewed. The interviews each took approximately 30 minutes and the discussions were structured to avoid too much variation. The questions were focused on promoting answers that would provide data about the interviewees experience and knowledge. The questions were carefully formulated in order to minimize the probability of the respondents interpreting them differently.

5.7 Overview of the respondents

The user prospective of the outcome and the process were also measured in the questionnaire after each task. Questions involved five aspects of user perception to the SmartPlant tool. They were

i) Quality of the SmartPlant system.

ii) SmartPlant usability

iii) SmartPlant performance.

iv) Interdisciplinary integration

v) Efficient use of SmartPlant

The questions used a five point scale ranging between 1 to 5 where 5 is best.

Comments section: The respondent is guided through some header titles to provide feedback on the size of projects, integration problems, suitability of SmartPlant tool and general comments etc.

The total of respondents was followed during the process of this study in order to validate and promote the most honest answers as possible from the interviews. The table below shows selected respondents' name, position, and length of each interview.

Twenty-five respondents were randomly selected from various disciplines and responsibilities in Agility Group.

Table 5.1: Respondents Name, Position and Duration of interview time source: own research

Respondents	Position	Time of Interview
Darren Litherland	SmartPlant programmer	45 min
Valerio Bottari	Instrument administrator	30 min
Jon Stokstad	Structural administrator	15 min
Knut Åge Børufsen	SmartPlant Foundation administrator	15 min
Mette Henriksen	Piping super user	15 min
Rohan Nalawade	Process engineer	15 min
Adina Tutu	Piping engineer	15 min
Petter Høven	Project manager	30 min
Terje Ørbeck	Lead Engineering tools	30 min
Dag Narve Ludvigsen	Project manager	30 min
Adrian Chirita	Piping SmartPlant user	15 min
Angel Caipilan	Piping SmartPlant user	15 min
Lloyd Page	PDMS administrator	30 min
Jan Svendsen	Piping user	15 min
Terje Jacobsen	Piping administrator	30 min
André Johannessen	Structural user	15 min
Subhash Prasad Ram	Structural user	15 min
Gajanan R. Gaikwad	Stress engineer	15 min
Kjell Nilsen	SmartPlant Foundation administrator	15 min
Ken Lie-Haugen	Instrumentation engineer	15 min
Terje Sommerstad	IT-engineer	30 min
Pawan Kumar	Mechanical engineer	15 min
P. Deshai C. Botheju	HSE engineer	30 min
Harpal Singh Sidhu	Electrical user	15 min
Richard Moore	Piping user	15 min

5.8 Measurement of Variables

The questions are focused on understanding and assessing quality, usability values and performance of SmartPlant and the integration execution process.

The values given are a summary consolidated from the questions.

Table 5.2: Questionnaires consolidation report source: own research

Questions	Strongly agree	Agree	Neutral	Dis agree	strongly dis agree	Not answered
Quality of SmartPlant:						
Quality of SmartPlant output	4	10	8	0	0	0
Drawing quality, extraction time and output	0	15	4	2	0	1
Quality of clash check and integration	2	5	7	1	1	6
Quality of interdisciplinary integration	2	10	5	0	0	5
Usability of SmartPlant:						
Would you be Satisfy to use SmartPlant tool in the future?	9	10	2	0	0	1
Customization level (specs, custom commands etc.)	1	9	9	3	0	0
How much of the tools' functionality is being used in your discipline	1	6	10	3	0	2
Trouble shooting level	0	5	10	4	1	2
Performance and users satisfaction:						
SP3D Modelling tools of compared to modelling tools like PDS and PDMS.	0	10	6	2	0	4
Ease of modification functions in SP3D. Like rerouting, modifying line numbers etc.	4	5	7	4	0	2
Speed and efficiency of graphics in SP3D?	5	11	3	1	0	2
SmartPlant user friendliness rating	1	10	9	1	0	1

Interdisciplinary Integration:						
How do you rate the efficiency of clash detection in SP3D?	1	6	6	1	2	6
How do you rate SmartPlant Foundation usability? For example, Tag registering function.	0	9	4	1	0	8
How do you rate the P&ID graphical link with piping?	2	8	2	2	0	8
How do you rate SmartPlant MTO/weight calculation from your discipline	1	13	3	1	0	4
Awareness or efficient usage of SmartPlant:						
How familiar are you with SmartPlant tools?	3	8	9	2	0	0
Do you use any SmartPlant tools in projects? If yes, rate your knowledge	5	7	8	1	0	1
Are you aware of SmartPlant integration and interdisciplinary functions?	6	6	5	0	1	4
How does SmartPlant Review (SPR), the reviewing tool in SP3D, compare with the viewers in PDS, PDMS?	2	11	3	0	0	6

Comments:

Did you face any interdisciplinary or integration issues? If yes, please give details.

What level of project did you use SmartPlant in?

What size of project do you feel it works most efficiently?

If any other comments

If you wish can you please write your name and discipline below:

Name: Discipline:

5.9 Summary of the quantitative results

There are limitless ways to summarize the variety of results and outcomes from such a complicated initiative. It must be decided how to interpret and understand the collected data in order to access system efficiency and integration.

The choice of understanding this thesis is, integration and how efficiency the SmartPlant tools is used in the organization and how much user satisfied using this tool as part of Quality and awareness of the SmartPlant tool.

The summary concludes with the following results; twenty-seven respondents participated. The questionnaire was divided into five categories; each category contained four questions, with scale range 1 to 5. Strongly agree = 5, Disagree = 1, Neutral = 3. Some respondent didn't answer all the questions because they never used the specific function or felt the question was otherwise inappropriate.

After consolidating all the data and the following results were derived.

Table 5.3: Questionnaires category wise consolidation report source: own research

Quality of SmartPlant out put

Maximum number of unanswered Questions	:	6
The Average score	:	69.75
Average Mean	:	3.2

Function Usability of SmartPlant

Maximum number of unanswered Questions	:	2
The Average score	:	72.25
Average Mean	:	3.3

SmartPlant user satisfaction level

Maximum number of unanswered Questions	:	4
The Average score	:	71.25
Average Mean	:	3.2

SmartPlant Inter disciplinary integration at Agility Group

Maximum number of unanswered Questions	:	8
The Average score	:	52.25
Average Mean	:	2.5

Efficient usage of SmartPlant tool

Maximum number of unanswered Questions	:	6
The Average score	:	72.5
Average Mean	:	3.3

Chapter 6 Case study

6.1 Introduction

This chapter discusses two real case studies taken at Agility Group, drawing production and HSE technical safety drawing. The chapter starts with the drawing production, how Agility Group implemented Drawing Wizard and the advantages gained from it in integrating drawing production methods into one user-interface. Secondly, the HSE (Health, Safety and Environment) discipline and why they should implement SmartPlant tools into their discipline and what benefits would result from integration with the other engineering tools in Agility Group.

Case Study 1

6.2 Drawing production (Drawing Wizard)

6.2.1 An automatic drawing creation routine for SmartPlant composed drawings

SmartPlant 3D features excellent methods for the automatic creation of structure, hangers and supports and piping isometrics. Unfortunately, the drawings created cannot be modified with sections and scaled detail views which are a particular requirement in modification projects where existing and reference objects have to be taken into consideration and differentiated from new objects.

Another type of drawing has, until recently, been used in Agility Group, the so-called «composed drawing». These drawings are created manually. The engineer places primary views and secondary details and sections on the drawing. Which objects to be included in each view can be controlled relatively easily thus satisfying the demands of brown-field projects. The problem with this type and method of drawing production is that it is very labour-intensive.

Generally speaking, the performance of SmartPlant 3D in the first few projects it was used in was very good, the main criticism was in the time used in creating drawings. Something had to be done.

Attempts were made to adapt the existing automatic routines, but these failed due to the drawings' inherent inability to support details and sections. The next step was to take the matter to Intergraph.

Issues were brought up during a meeting at Intergraph's international user conference in Orlando in June 2011 [46]. An explanation was given that the drawings SmartPlant's automatic routines created were unfit for the needs of small- to medium-sized, modification projects. The question was asked if it would be possible for Intergraph to provide the same detail and section view features as existed in composed drawings. Intergraph replied that the opposite was being considered; creating composed drawings automatically. Intergraph were unable to say when this would happen but a piece of code could be provided by them. It would include neither a user-interface nor a means to gather input for it; that would have to be developed. At that point in time, Agility Group had attained a reasonably high level of capability in SmartPlant programming or «automation» and felt that it would be possible to make use of the code. Work began immediately upon the receipt of the code from Intergraph.

The code actually consisted of two programs. One creates a drawing from a template contain pre-defined views and the other associates drawing volumes – boxes that are modeled around 3D objects – to the views. All very straightforward, but in order to do the second step, a better understanding of the SmartPlant SQL database was needed. After a lot of experimenting and trial and error the internal database object identifier «OID» for each new drawing's views was found and, using a crude batch method with a text file, the first automatic composed drawing with fully associated views was created in November 2011. Five months after bringing up the problem with Intergraph. All that remained was a user-interface.

The first, working UI was developed after a few days. For user-friendliness, the goal was to make it as intuitive and simple as possible.

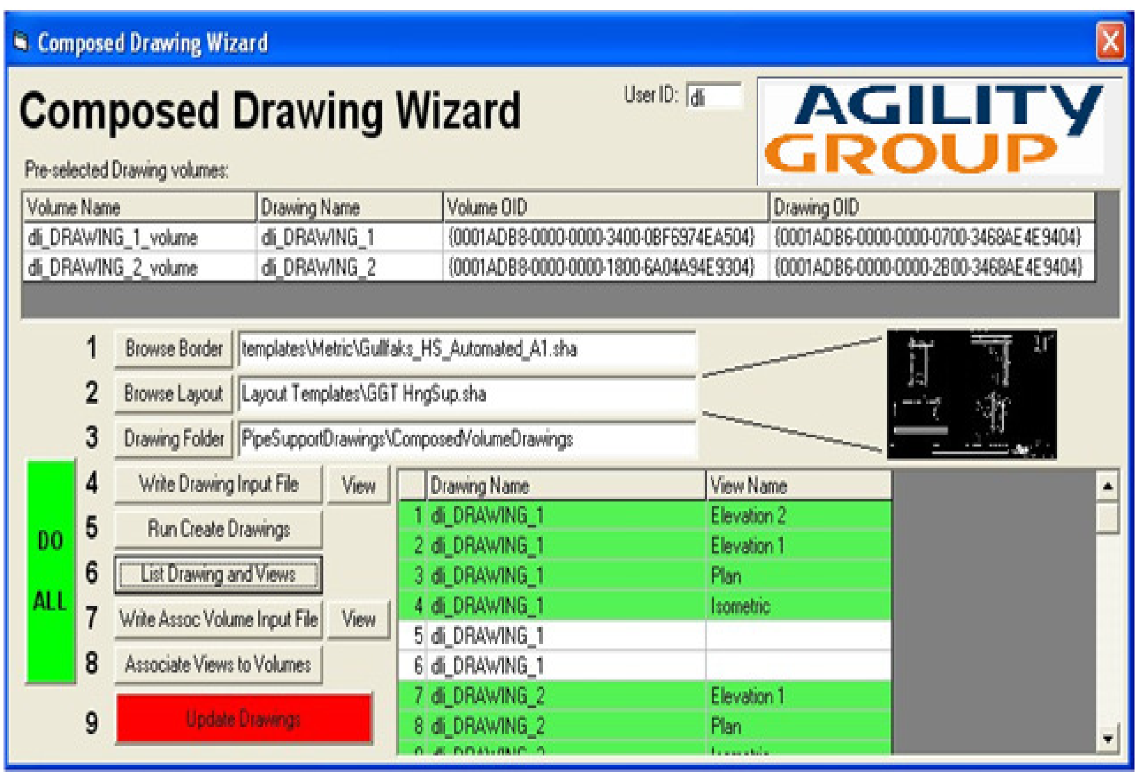


Fig. 6.1 Composed drawing wizard - Fig source draw wizard

Having control over drawing creation within a self-developed UI provided the opportunity to offer the user a little more help than was usual in the Intergraph environment – a «preview» of how the finished drawing might look was added. The preview is the black and white image on the right.

«Composed Drawing Wizard» went into production in February 2012 in a new FPSO project. Under the leadership of a manager with experience from a previous project where SmartPlant drawing issues became apparent, it was a great success. 3D modeling was performed with the usual efficiency and, above all, drawings were created in a very short time.

An analysis of the increased drawing production rate showed an improvement of approximately 60% compared to manual composed drawings.

At this point in time, further development of «Drawing Wizard» was integrated into Agility Group's company-wide improvement effort called «TEAM». This allowed for a dedicated effort to implement Drawing Wizard into all disciplines that create drawings. Layout templates, view styles, preview graphics and filters were standardized for structure, hangers and supports, HVAC, electrical (cableways) and layouts. It even acted as a catalyst to developing a new SmartPlant discipline – Safety. Drawing Wizard provided a framework in which safety symbols and drawing templates could be made to work together in such a systematic fashion that it could be considered a new SmartPlant «task».

New features were also added. The most significant being the ability to select reference object types with a single mouse-click. This was achieved by a sophisticated combination of object filters and view styles. This is a very useful feature because achieving this without the Drawing Wizard user-interface is very difficult and time-consuming.

In addition, the user is able to choose drawing scale with a simple mouse-click and, if needed, dimensioning and labeling. In the old way, the user would have to browse through a long text-list of layout templates in an attempt to find a suitable layout.

Eventually, the number of steps required to create a drawing was reduced while more drawing and view information (for example, scale) was provided.

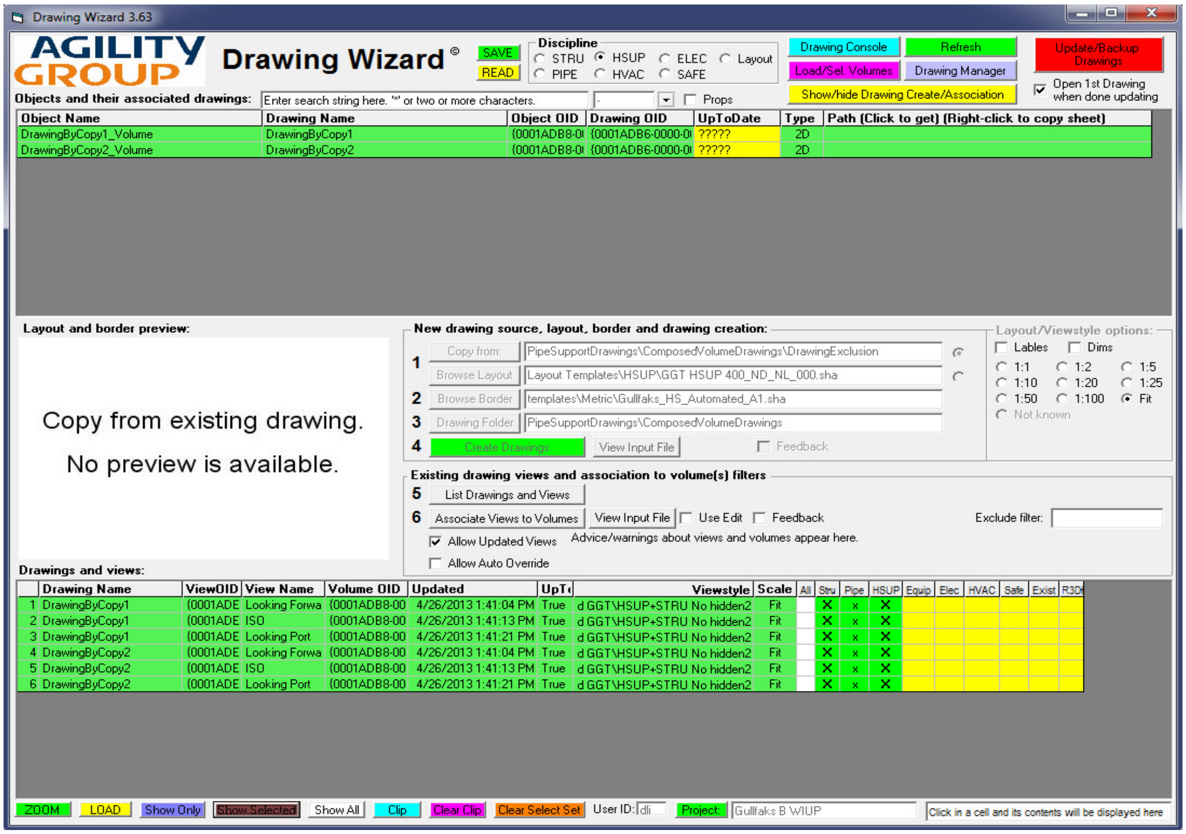


Fig. 6.2 Front screen of drawing wizard - Fig source draw wizard

The present Drawing Wizard user-interface:

The latest features to be added are:

- Drawing searching
- Drawing view object location
- Object found on which drawings
- Object exclusion and re-inclusion.
- Drawing backup prior to update
- View style quality check

6.3 Conclusion

Drawing Wizard has been a success; it has not only solved the original problem of automatic drawing production but also provides functionality not otherwise available in SmartPlant. Drawing production efficiency has improved to a very satisfactory level. Its framework is a stable foundation for standardization and promotes a greater level of unification of methods and drawing content over all SmartPlant disciplines. With greater standardization, administration is reduced.

Case Study 2

6.4 HSE & SAFETY sign production improvement

3D modeling within the piping, structural and mechanical disciplines has been carried out in many years by use of solid modeling technology in Agility Group. The HSE discipline produces technical safety and safety signs drawings as part of integrated work in the projects.

6.4.1 The implementation of technical safety into 3D design

Before, to measure the efficiency of SmartPlant integration before that it is important to understand fully utilize in that various discipline for their integration. In Agility Group, the HSE (Health Safety and Environment) discipline is also an integrated part of project; the discipline produces various 3D related documents in 2D. Other 3D disciplines need to visualize the HSE objects together with their own objects in order to avoid collisions. Achieving this without 3D integration is very time-consuming and unreliable.

The need to implement technical safety in 3D design was not only a matter of efficiency. There are requirements in customer projects to show safety objects like escape routes and Area zones, Safety Equipment, and safety signs in 3D. This gives a more accurate and reliable picture and better integration for the whole project.

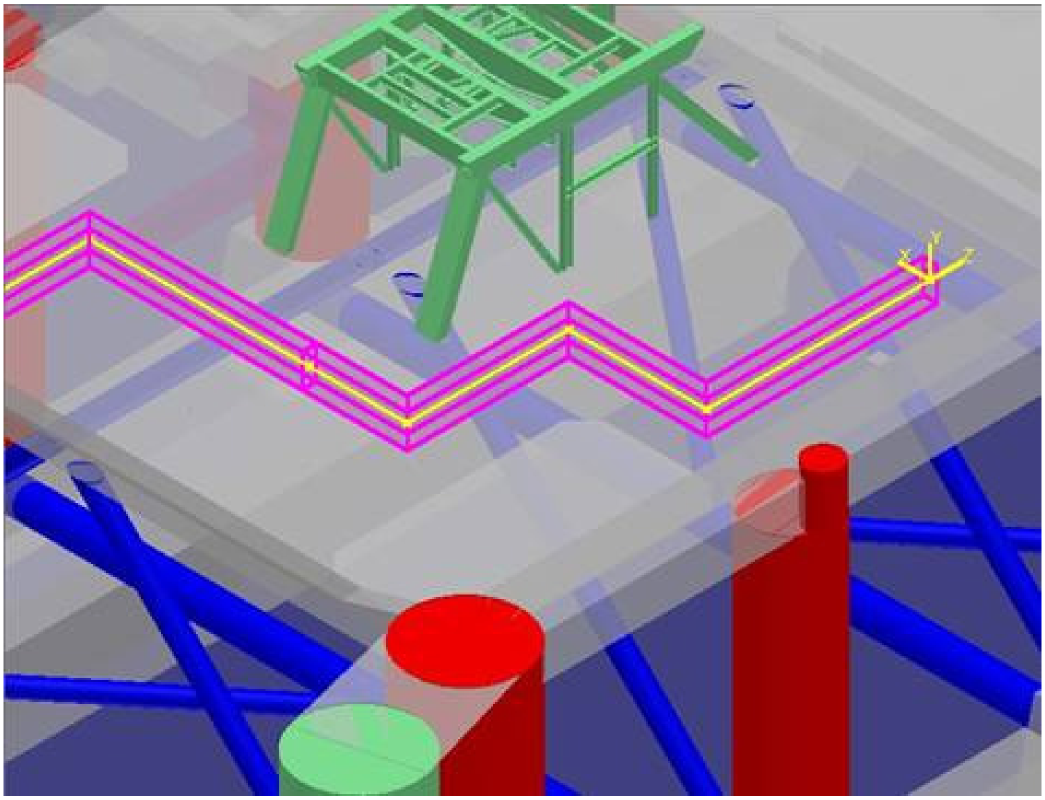


Fig 6.3 Sample of 3D Escape route model from SmartPlant

Technical safety, electrical and HVAC are a part of the total 3D multidiscipline environment in Agility Group, if the 3D disciplines connected together in a common 3D database, the information flow between the disciplines would be simplified and improved.

If technical safety design could be performed with SmartPlant, it would provide good design, faster modeling and improved quality of work. Entire projects could access the same model information in real time. Avoiding delays in information exchanges improves design quality, speeds up modeling, and ultimately saves money for the company.

6.4.2 Project Solution supports extraction of Technical Safety Drawings - 3D model

Traditionally, the HSE discipline's final deliverable was 2D drawing. If all HSE objects were modeled in 3D then drawings could be produced almost free of cost. Technical Safety 2D drawings could be produced directly from the 3D model with automatic labeling and symbolization.

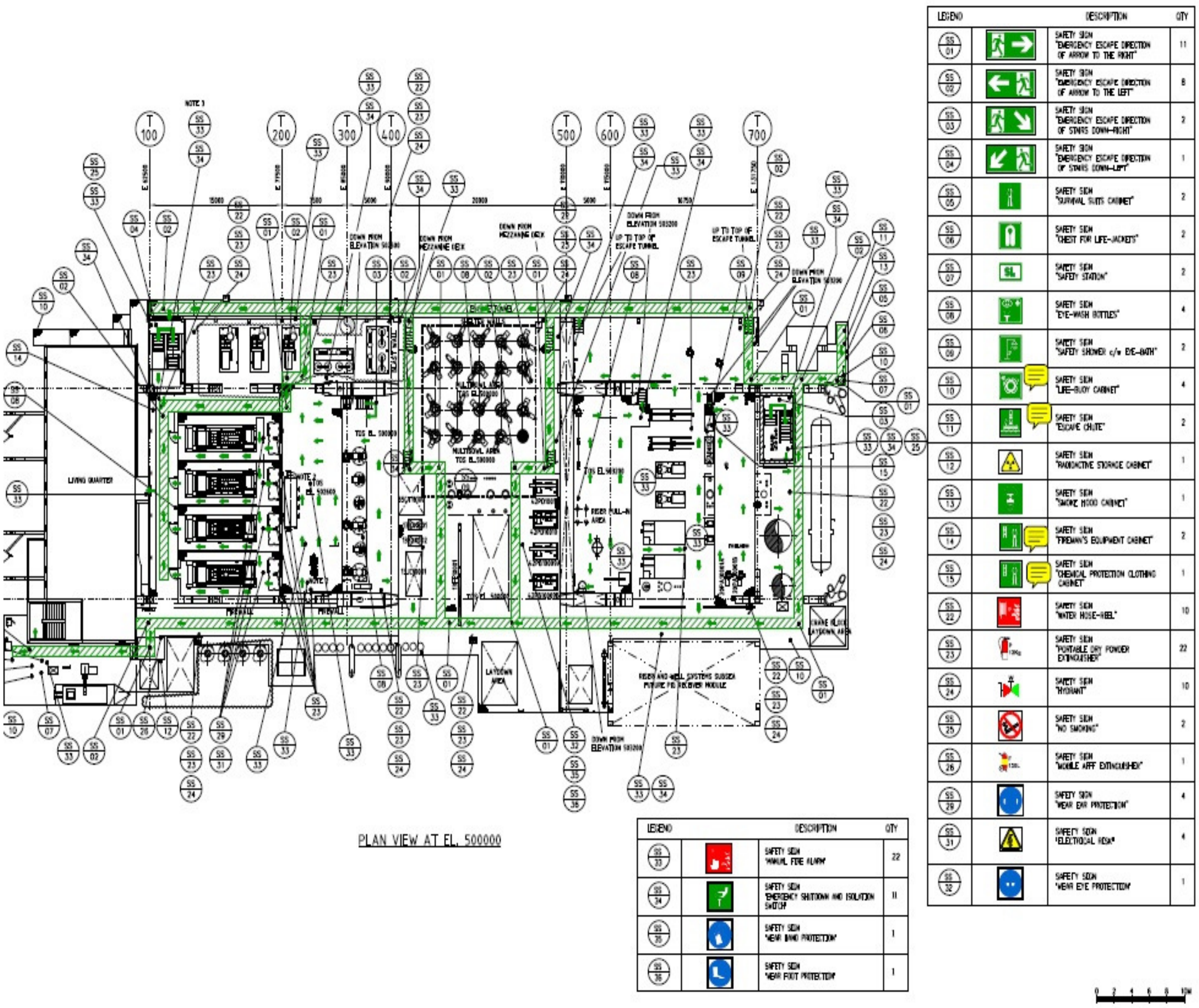


Fig 6.4 Sample of Safety sign and escape route 2D Drawing

In SmartPlant 3D model, need to model Escape Routes & Safety, Equipment Drawings, Area Classification and Fire Partitions Drawings, Safety Sign Layout Drawings, Reports of Technical Safety Objects & Equipment

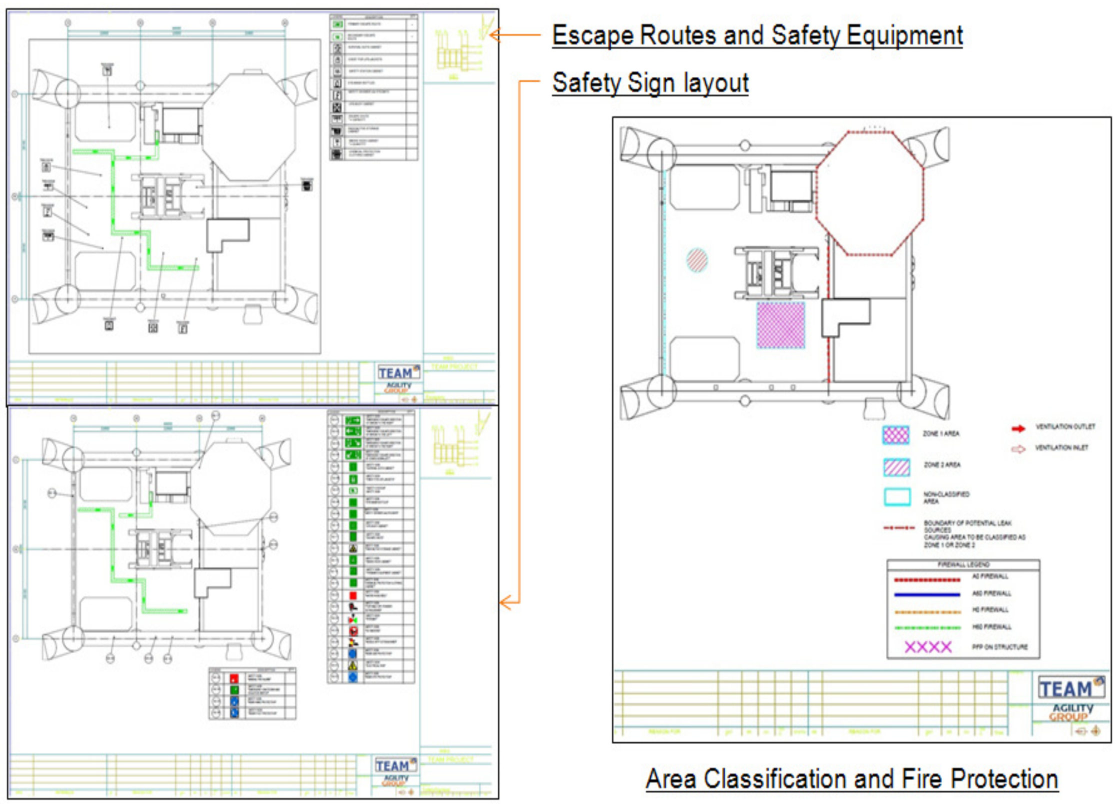


Fig 6.5 Sample of Safety sign layout, escape route and safety equipment & area classification 2D Drawing

The above shows various 2D drawing layouts deliverables from HSE discipline. If Agility Group implemented the 3D system in technical safety, the deliverable 2D drawings can easily be extracted from 3D. It would reduce modification time.

6.5 Conclusion & Recommendations

The implementation of technical safety in 3D would require only a small investment to create the database objects in the first project. This could then be reused in subsequent projects.

There would be many benefits with the implementation of technical safety in 3D:

- Technical Safety data kept in a standard database system integrated with the other disciplines. This reduces man-power requirements and allows for total project integration.
- Data is immediately available to other disciplines and easier to access.
- Having a HSE project data in 3D allows drawings to be created at a very late stage. This allows for modifications to be made at any point in time.

If Agility Group implements technical safety modeling in SmartPlant, there would be significant benefits to both the company itself and its customers.

Benefits	Customer advantage	Agility advantage
Improved project execution	√	√
Improved quality of deliveries	√	√
Improved efficiency (projects size and numbers)	√	√
Improved margins (better project economy)		√
Improved competitive ability		√
Secure Agility Group existence as a Multi Discipline actor in the Offshore and Marine market.	√	√

Fig. 6.6 implements Benefits of Agility Group and Customer

There is an improved project execution and integration in the organization as well as customers. It enables the optimal use of engineering and other resources and provided improved efficiency of the project. Improved quality of deliverables, accuracy is achieved by eliminating the possibility of 3D modeling. And also improved margins, competitive ability provides in the Agility. In this case HSE discipline in Agility Group recommend to implement that system, easily above said benefits can harvest.

Chapter 7 Results

7.1 Introduction

In the previous chapters, shows the consolidated results from the questionnaire and the two case studies one earlier implemented and discussed the advantages and the other one why Agility Group need to implement and what are benefits from that.

This chapter discusses the result of the questionnaire and various user interviews results. How SmartPlant integration and efficiency usage in Agility Group, also comparison with the other traditional tools used in Agility Group.

7.2 Questionnaire results and analysis

One primary objective of the questionnaire study was to examine the impact of the Agility Group improvements of projects integration method, and the effective usage of the SmartPlant tools in various disciplines. This impact study is further divided into five categories for better understanding purpose. 1) Quality of the SmartPlant system 2) SmartPlant usability 3) SmartPlant performance 4) Interdisciplinary integration 5) Efficient use of SmartPlant.

In Agility Group, *The quality of the SmartPlant* system can be investigated through answering the following questions:

i) Overall Quality of Smart Plant output satisfaction level
ii) Drawing quality, extraction time and output processing procedure
iii) Quality of clash checks level. Example inter disciplinary electrical trays vs. pipes
iv) Quality of interdisciplinary integration example instrument tags VS P&ID

Questions to examine the SmartPlant usability disciplinary in Agility Group may include:

i) Would you be preferred to use SmartPlant tool in the future? If yes
ii) Customization level (specs, custom commands etc.)
iii) How much of the tools' functionality is being used in your discipline
iv) Trouble shooting level

Questions to examine the *SmartPlant performance* level in Agility Group:

i) SP3D Modeling tools of compared to other 3d modeling tools like PDS and PDMS
ii) Ease of modification functions in SP3D. Like rerouting, modifying line numbers etc.

iii) Speed and efficiency of graphics in SP3D? compare to other tools

iv) Smart Plant user friendliness rating

Questions to examine the Interdisciplinary integration in Agility Group may include:

i) How do you rate the efficiency of clash detection in SP3D?

ii) How do you rate SmartPlant Foundation usability? For example, Tag registering function.

iii) How do you rate the P&ID graphical link with piping?

iv) How do you rate Smart Plant MTO/weight calculation from your discipline?

Questions to examine the efficient use of SmartPlant in Agility Group may include:

i) How familiar are you with SmartPlant tools?

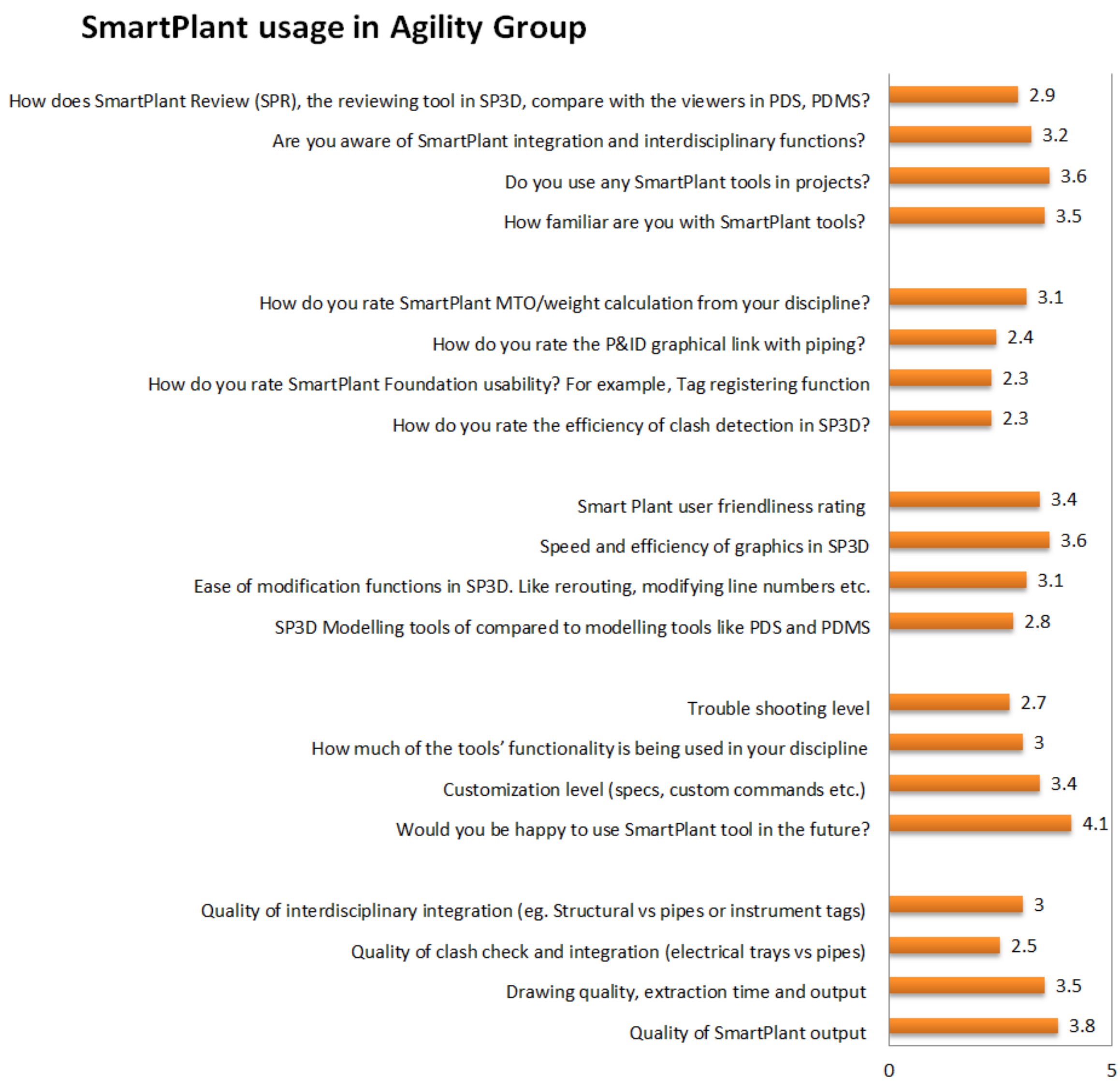
ii) Do you use any Smart Plant tools in projects? If yes, rate your knowledge

iii) Are you aware of SmartPlant integration and interdisciplinary functions? If yes

iv) How does SmartPlant Review (SPR), the reviewing tool in SP3D, compare with the viewers in PDS, PDMS?

The Table 7.1 summarizes the mean responses for each question shown in the graph bar chart shows the satisfaction level of the users in Agility Group.

Table 7.1 Overall results from the questionnaire about SmartPlant Usage in Agility Group



5: Most Positive 1: Most negative

7. 3 User response measure

The user perception of the outcome and the process were also measured in the questionnaire, after each task. Questions involved five aspects of user perception to the integration and effectiveness of the SmartPlant tools in Agility. The outcome of questionnaire can be compared by assessing the quality of the Agility Group user perception. The Table 7.1 summarizes the mean responses for each question, and Figure 7.2 shows the mean values in a bar chart.

Table 7.2 Summary of questionnaire response of SmartPlant output Quality

The table shows, scored scale percentage (5 – 1) N/A not answered or Not Applicable and Mean of the each questions.

Question no	*Quality of SmartPlant output*	5	4	3	2	1	N/A	Mean
Q1	Quality of SmartPlant output	18.2%	45.5%	36.4%	0.0%	0.0%	0.0%	3.8
Q2	Drawing quality, extraction time and output	0.0%	68.2%	18.2%	9.1%	0.0%	4.5%	3.5
Q3	Quality of clash check and integration (electrical trays vs pipes)	9.1%	22.7%	31.8%	4.5%	4.5%	27.3%	2.5
Q4	Quality of interdisciplinary integration (eg. Structural vs pipes or instrument tags)	9.1%	45.5%	22.7%	0.0%	0.0%	22.7%	3

5: Most Positive 1: Most negative

The quality of SmartPlant output took place at the starting phase of the questionnaire, it involved about the overall quality of SmartPlant output, extracted drawing quality from SmartPlant, Quality of Integration and clash and Quality of interdisciplinary integration. The main activities were to understand from this first category questionnaire, Overall SmartPlant quality and each quality of the SmartPlant functions.

While consolidating, the quality of SmartPlant Q1 to Q4 questions, the overall Quality of SmartPlant Output scored Mean value 3.8 this high score in this category and also no one not answered N/A in that question- The Q3 Quality of Clash check least scored 2.5 in this category. 27.3% not answer and said not aware of the integration function.

Table 7.3 Summary of questionnaire response of Usability of SmartPlant in Agility Group

Question no	SmartPlant Usability	5	4	3	2	1	N/A	Mean
Q5	Would you be happy to use SmartPlant tool in the future?	40.9%	45.5%	9.1%	0.0%	0.0%	4.5%	4.1
Q6	Customization level (specs, custom commands etc.)	4.5%	40.1%	40.1%	13.6%	0.0%	0.0%	3.4
Q7	How much of the tools' functionality is being used in your discipline	4.5%	27.3%	45.5%	13.6%	0.0%	9.1%	3
Q8	Trouble shooting level	0.0%	22.3%	45.5%	18.2%	4.6%	9.1%	2.7

5: Most Positive 1: Most negative

This 2nd category of questionaries' is SmartPlant usability, the question Q5 to Q8 what asked, overall satisfaction of usability, Customization level, Interdisciplinary functionality, & Participants trouble shooting level. The Q5 asked about the user overall satisfaction to use SmartPlant in future in your projects. Higher score 4.1 mean scored in that question in that category and least trouble shooting level 2.7mean scored. During the interview time, with user, administrator & programmers also pointed trouble shooting in SmartPlant enterprise is difficult to understand. They are learning and doing. That answer reflects in the questionnaire result here.

Table 7.4 Summary of questionnaire response of Performance and user satisfaction in Agility Group

Question no	SmartPlant Performance and Users satisfaction	5	4	3	2	1	N/A	Mean
Q9	SP3D Modelling tools of compared to modelling tools like PDS and PDMS	0.0%	45.5%	27.3%	9.1%	0.0%	18.0%	2.8
Q10	Ease of modification functions in SP3D. Like rerouting, modifying line numbers et	18.2%	22.7%	31.8%	18.2%	0.0%	9.1%	3.1
Q11	Speed and efficiency of graphics in SP3D	22.7%	50.0%	13.6%	4.6%	0.0%	9.1%	3.6
Q12	Smart Plant user friendliness rating	4.5%	45.5%	40.9%	4.6%	0.0%	4.5%	3.4

5: Most Positive 1: Most negative

The next category of questionaries' is SmartPlant Performance and user satisfaction, the question Q9 to Q12, the question contains about comparison between SmartPlant and other similar tools like PDS and PDMS, User flexibility, graphic and speed efficiency, and friendliness about the tool usage. The highest score scored efficiency 3.6 and least score comparison with similar tools 2.8 mean.

Table 7.5 Summary of questionnaire response of Interdisciplinary integration in Agility Group

Question no	Interdisciplinary Integration	5	4	3	2	1	N/A	Mean
Q13	How do you rate the efficiency of clash detection in SP3D?	4.5%	27.3%	27.3%	4.6%	9.1%	27.3%	2.3
Q14	How do you rate SmartPlant Foundation usability? For example, Tag registering fu	0.0%	40.9%	18.2%	4.6%	0.0%	36.4%	2.3
Q15	How do you rate the P&ID graphical link with piping?	9.1%	36.4%	9.1%	9.1%	0.0%	36.4%	2.4
Q16	How do you rate SmartPlant MTO/weight calculation from your discipline?	4.5%	59.1%	13.6%	4.6%	0.0%	18.2%	3.1

5: Most Positive 1: Most negative

This category of questionaries' about Interdisciplinary integration, the question from Q13 to Q16, the question contains about efficiency of clash detection, SmartPlant foundation efficiency, Process P&ID and piping integration, Other discipline integration. In this chapter almost all the mean are least 2.3, 2.3 and 2.4 mean scored respectively Q13, Q14 & Q15 the percentage ration for Not Applicable also more in this area, very few of groups can understand about the integration in Agility Group those also results proven from the interviews.

Table 7.6 Summary of questionnaire response of Awareness / Efficient usage of SmartPlant in Agility Group

Question no	Efficient usage of SmartPlant	5	4	3	2	1	N/A	Mean
Q17	How familiar are you with SmartPlant tools?	13.6%	36.4%	40.9%	9.1%	0.0%	0.0%	3.5
Q18	Do you use any SmartPlant tools in projects?	22.7%	31.8%	36.4%	4.6%	0.0%	0.0%	3.6
Q19	Are you aware of SmartPlant integration and interdisciplinary functions?	27.3%	27.3%	22.7%	0.0%	4.5%	4.5%	3.2
Q20	How does SmartPlant Review (SPR), the reviewing tool in SP3D, compare with the viewers in PDS, PDMS?	9.1%	50.0%	13.6%	0.0%	0.0%	0.0%	2.9

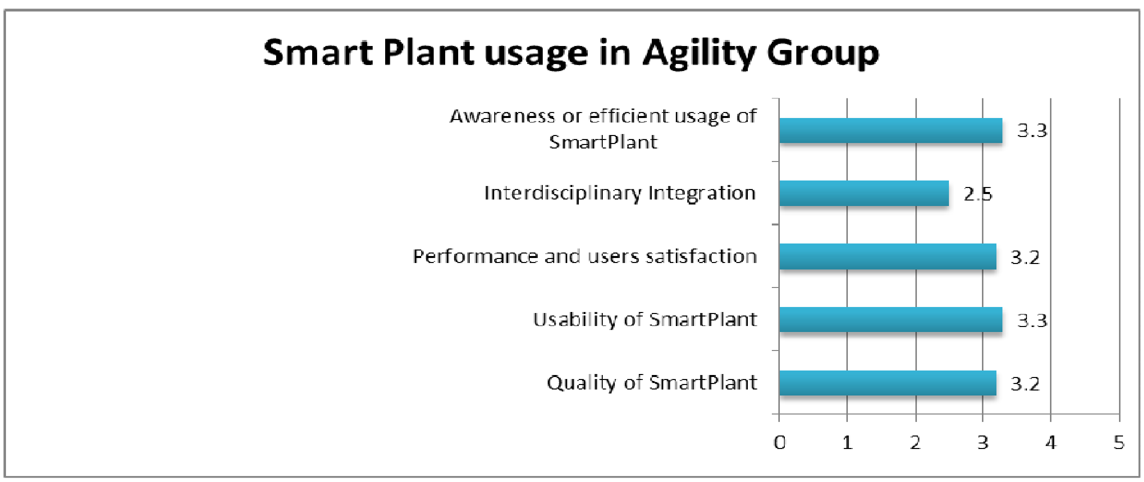
5: Most Positive 1: Most negative

This last category of questionaries' about efficient usage of SmartPlant, the question from Q17 to Q20 the question about, user familiarization about the tools in their discipline, integration usage in their discipline, compare to other tools usage in their discipline. 3.6 mean scored Q18, and least score on Q20.

7.4 Summary of questionnaire response

The questionnaire spilt into five categories, Quality of SmartPlant, Usability of SmartPlant, Performance and user satisfaction, Interdisciplinary integration and awareness of usage of the tool. The below diagram shows, each categories scored mean value.

Table 7.7 Questionnaire categorized mean wise



5: Most Positive 1: Most negative

The overall 3.3 mean values scored two categories, Usability of SmartPlant and Awareness/efficiency usage of SmartPlant inter disciplinary. And next also 3.2 mean values scored two categories, Quality of SmartPlant enterprise and Performance and user satisfaction. The least 2.5 mean value scored in the Interdisciplinary integration. Based on the quantitative and explorative analysis, the result clearly shows the following conclusion.

The interdisciplinary integration awareness is less in those users. Also high rate of N/A answer also in the same categories. It shows the picture of the interdisciplinary integration knowledge awareness is lacking. It is very beginning phase of integration using SmartPlant enterprise in Agility Group.

Satisfaction about the output and efficient, quite high score shows the users are satisfied to use the tools.

SmartPlant Integration is very beginning stage, many of users not fully aware of the full functionality.

7.5 Past Project study

7.5.1 Agility Group's First SmartPlant Project

The first project conducted in Agility Group with SmartPlant started in 2007. The project details are given below:

7.5.2 Project - Oseberg Low pressure project man-hour

OSEBERG LOW PRESSURE PROJECT

Upgrade of Oseberg A and B platforms to extend the oil production period.

Two smaller skid-units were engineered and manufactured for the Kristin and Heidrun platforms in the North Sea. The disciplines and documentation involved were: process (intelligent P&ID's), piping (3D modeling, arrangement layouts, isometric drawings and MTOs), Structure (3D modeling, MTOs, detail and shop drawings).

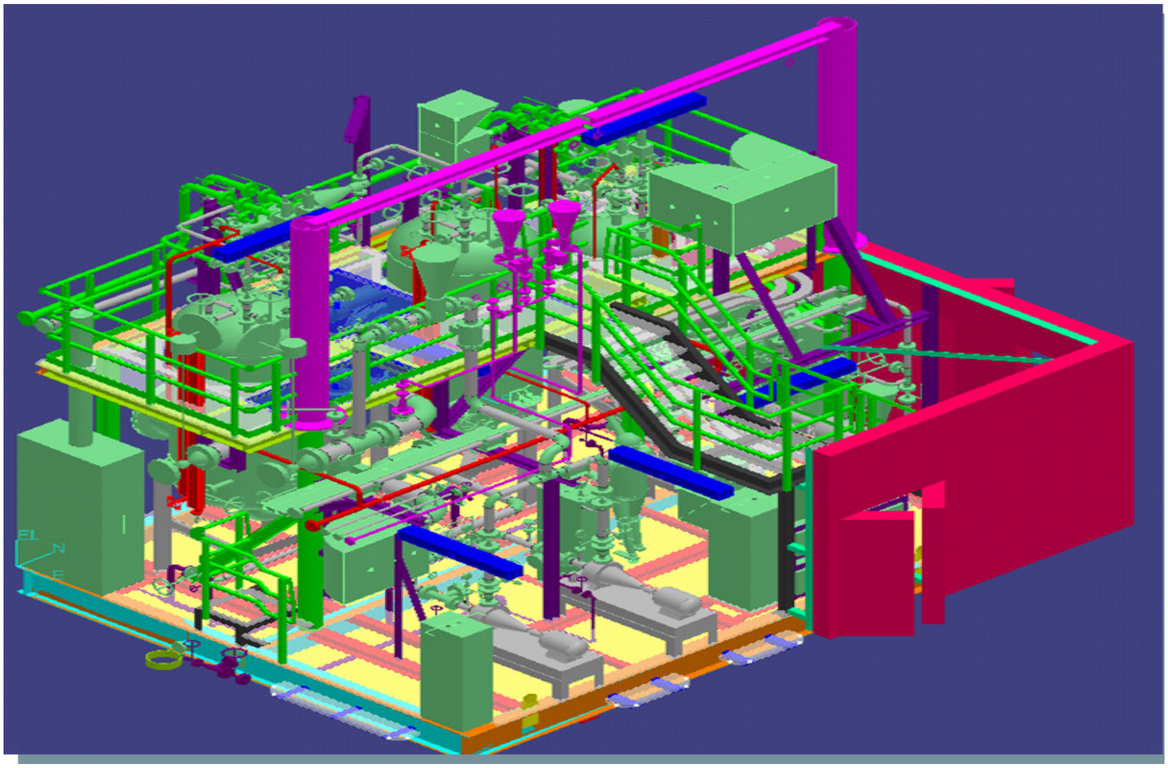


Fig 7.1 SmartPlant model example - Kristin skid. Client: Statoil Hydro

Table 7.8 Summary of Oseberg Project SmartPlant man-hours usage in Agility Group

Client: Statoil Hydro, Norway

Total Project	170,000	man-hours
Piping	45,000	man-hours
Structural	30,000	man-hours
Contract level	670	Mill NOK

Project Start-up

Design Start-up	1st September, 2007
Design finished	1st December, 2008
Project Completed	Summer 2010

Fig 7.2 Oseberg Low Pressure module - Kristin skid. Client: Statoil Hydro

Experience from the first project showed that:

SmartPlant does provide an efficient collaborative design environment. Drafting operations should be automated. Out-of-the-box, automatic drawing routines for structure and pipe supports didn't suit a modification project like Oseberg.

Administrative resource requirements are high compared to traditional systems. This can be reduced with standardized project initialization in projects with similar requirements. For example, a robust set of templates for drawings, isometrics, and reports is needed.

Standardized workflows are important and must be established in all disciplines. They must be documented and implemented in training programs.

7.6 Productivity Comparison with drafting tools

When using drafting systems like AutoCAD or MicroStation, it can take the average drafter from one to four hours per isometric sheet,(source: Intergraph) which means a typical pipeline consisting of eight spools and Material Take Off list with everything together take at least one man-day to produce all required drawings.

Engineering represents only a small percentage of overall project costs, but it has a significant impact on construction & procurement costs. Ensuring accuracy in the key first stage could produce significant cost savings during construction and procurement.

SmartPlant 3D provides 20 to 35 percent productivity gains in key plant design areas compared to traditional CAD technologies in Agility Group. SmartPlant 3D shatters the constraints imposed by traditional plant design systems by providing an advanced plant design environment based on intelligent integration. SmartPlant 3D's tangible productivity savings include:

Process:

The process discipline implemented SmartPlant P&ID design as soon as SmartPlant was introduced in Agility Group. More than 90 percentage reduction in required P&ID validation and consistency checking between 2D and 3D plant models.

3D model

SmartPlant 3D produces a good visual representation of designs. 3D modelling time has improved significantly compared with the previous project, Oseberg. Currently, the time taken for each line is approximately 40% shorter. Clash checking is used in a more efficient way with noticeable time reduction.

SmartPlant Electrical and HVAC

SmartPlant electrical and HVAC are in an early phase of their implementation in Agility Group, but improvements have already been made in 3D modelling. Generally, a 20 to 35 percentage overall productivity gains has been achieved through increased cross-discipline data integration.

SPF and Integration

SmartPlant Foundation has improved communication between disciplines. It has reduced manual data transfer and data duplication.

Offline instrument connection forms are automatically transferred directionally between P&ID and instrumentation. This is a big improvement for Agility Group and gives significant time savings.

The integration between P&ID and piping 3D models has given a noticeable reduction in design time. High quality is achieved in shorter time.

End of project consolidation and comparison has improved and reduced the amount of manual integration checking.

Automation

Automation has improved 2D drawing creation from the 3D disciplines. Its time savings in projects has been tested. The table below illustrates the savings Agility Group's "Drawing Wizard" provides in drawing generation.

Table 7.9 Summary of Drawing Wizard productivity measurement

Drawing Type	Traditional method with snaps shots	Drawing Wizard method	Average % productivity gains
Standard drawings	107 sec	52 sec	51%
Complicated drawings	150 sec	122 sec	29%
Total of 5 drawings	750 sec	260 sec	65%

The implementation of SmartPlant resulted in a general improvement of 30% in engineering performance.

Chapter 8 Discussion & Further Issues

8.1 Introduction

In the previous chapters, how integration was organized and executed in a real time project at Agility Group was discussed. The questionnaire results and past project comparison have also been discussed in the chapter 7. This chapter discusses the results of the investigation in relation to integration in Agility Group, how Integration plays a major role in the fields of deployment support, planning and allocation of resources. The first discussion is about the consolidation of various SmartPlant user interviews in Agility Group. Additionally, the background for Agility Group's selection of SmartPlant integration is discussed and finally, which challenges were faced during implementation particularly in relation to breaking into areas occupied by well-established traditional systems.

8.2 Consolidation of the results

There are totally collected three sets of data. The first set of data are man-hour records from a previous project, the second, consolidation results from the questionnaires and the third, results from user interviews and consolidation comments from the questionnaires. The past project consolidated data and questionnaires results were discussed and reviewed in a previous chapter (chapter 7). This part are discusses the consolidated opinions from specific levels of SmartPlant users, administrators and project managers etc.

Firstly, it is important to understand the project managers' opinions from their point of view. During the interview they shared a lot of vital information with the researcher. Many of them discussed their past project experience – both pros and cons.

One project manager explained about the problems that an earlier project experienced regarding integration – particularly between structure and piping. Various 3D tools were used for each discipline in that particular project and that led to serious geometrical errors. With structural and piping design models existing on different systems, many cases of physical collisions occurred without them being identified until late in the project. This led to a large amount of rework, extra cost and time. This is convincing evidence that integration is very important for Agility Group. Using SmartPlant eliminates this kind of issue.

Man-hour efficiency management is important in all projects. The method used to calculate man-hours will depend on the size of the project. Man-hour estimates can be based on the number of pipelines, total weight or number of drawings. For example, in a small project the number of pipelines is used to estimate the man-hours required to model the system. There are 20 pipelines and each takes 10 man-hours to model. That gives 20 pipelines x10 man-hours/pipeline = 200 man-hours. In addition to the variable man-hours there are fixed hours that are required for initial administration and setup. In the example project, 75 fixed man-hours are added to the 200 variable man-hours giving 275 man-hours. The fixed man-hours impact small projects much more than it does in medium and large projects. Its impact in medium sized projects is relatively small which makes the implementation of integration in Agility Group's projects economically justifiable.

The users' point of view, some felt that the graphics capability of SmartPlant became an issue when working with large and complex models.75% of respondents said they would be interested in using SmartPlant because of the advantage it gives over other systems in modeling intelligence.

During interviews with members of the administrator group, one topic was mentioned by all interviewees: the demands and challenges of customization. SmartPlant and in particular integration requires customization in order to for it to function. Presently, a large organization is needed to perform all the customization and there is great potential for Intergraph to improve and simplify operation.

Likewise, it was expressed that SmartPlant 3D's administrative functions are not "easy" to use - SmartPlant 3D's database structure is quite complicated – it takes time to understand. Some administrative routines required for the normal operation of SmartPlant have little or none aids to help in their use. For example, SmartPlant 3D piping "specs" is based on Microsoft Excel worksheets – and the administrator must manage the content of this data manually. Such an important task should be more interactive and user friendly.

It has been necessary to install software upgrades frequently during the project. Intergraph is correcting problems by use of SmartPlant 3D 'Hot Fixes' & Service Packs. Frequent software upgrades result in additional SmartPlant 3D administration.

8.3 Transition to new technology

The offshore industry market is highly competitive. It is very important to meet demands for higher quality, frequency and timeliness on delivery of data and documents throughout multidiscipline engineering processes.

The system should be able to work with global, large scale multidiscipline and multi-location projects in areas like process modules, ship & rig design and offshore/onshore modification activities.

The system should be able to support the whole engineering life-cycle process from study early-phase design, through detail engineering and into manufacturing. The system should be future-orientated and be able to support Agility Group business and project demands for at least 10 years.

It is important for all organizations to be able to replace old technology with new and advanced technology.

Having too many CAD systems in use within the company is quite expensive. It results in inefficient data integration between the applications and can be difficult to provide internal user/application support.

Agility Group introduced the new SmartPlant system with the aim of achieving a competitive edge and market visibility and also put themselves in the position as a recognized advanced EPCIC service provider.

SmartPlant improved performance in the project execution methodology. It reduced risk and improved engineering productivity, quality of output, timeliness, efficiency and profitability.

Still some of experienced, senior CAD users don’t want to leave their familiar tools and need to be motivated and given proper training. If this doesn't happen they will always present a bottle-neck in projects and the company.

8.4 Tool awareness in the disciplines

Tool capability awareness plays an important role in any organization. Before measuring the efficiency of tools it is necessary to investigate whether disciplines fully utilize the tools, otherwise the measurements cannot be accurate. Awareness of the tools’ capabilities helps people to establish a common ground, co-ordinate their activities, and avoid surprises in their projects.

While researching this thesis, it became clear that some of the disciplines were not aware of how SmartPlant tools could help them in their projects (chapter 6 case study: 2). It is vital to provide the discipline with the necessary knowledge about how the tools work. To remove the barrier of lack of understanding of the engineering tools, meetings and presentations can be held with each discipline. Frequent talks with users and learning to understand their work flow provides the administrator with the information to find the best way the tools can be automated and improved for their project.

In chapter 6 case studies 2, the HSE discipline and its deliverables is discussed. The deliverable are: safety signs, layout, escape routes, safety equipment layout and fire protection area classification drawings. If the SmartPlant automation tool is implement, the efficiency in this discipline would increase and better suit requirements; it would provide a better data flow, accurate and fast data, improved efficiency and also better quality at low cost. This solution would ensure that Agility Group's HSE discipline could execute their projects quickly, with higher quality, reduced risk of unplanned late changes and improved design.

Agility Group is going through a period of rapid development in the integration of projects. They have a focus on improving their interdisciplinary work processes, creating awareness of and utilizing the SmartPlant tools in better way.

8.5 Awareness of Integration in project

In order to manage the delivery of the agreed scope of offshore projects, there will always be the need for full integration between the design and construction teams, discipline to discipline (inter disciplinary), design and procurement, procurement and construction etc.. In Agility Group, offshore projects require a significant amount of guidance in order to achieve the level of integration within the offshore team to meet the project schedule in an efficient manner.

During the design phase, the various design tools create a lot of integration issues, those issues clearly discussed in this chapter above. There are many advantages in implementing an integration tool in the organization; faster work preparation, improved internal and external communication, elimination of duplicated data and improved quality of deliverables and improved ability to meet deadlines.

Once Agility Group starts to fully implement SmartPlant tools for integration in their projects, (case study chapter 6) they will probably experience a significant increase in accuracy and quality in their projects. Operating costs should be reduced in line with a shortening of project schedules. Manual operations required for integration will be minimized. Costs may increase in the setup and configuration of integration but this will probably be countered by the availability of better tools from Intergraph.

8.6 Agility Group Challenges

The following challenges were described by interviewees and questionnaire respondents.

Agility Group faces many challenges during SmartPlant interdisciplinary integration implementations, because they started with "Learning by doing". Although some challenges were expected, some were unexpected and were a problem during in the execution phase.

The plant design industry and particularly the offshore plant design industries are very conservative. They demand deliverables in traditional formats and from established systems. It is hard to break in with a new system. The North Sea sector is predominately a PDMS environment; therefore it is important that Intergraph make export and import of 3D data between PDMS and SmartPlant easy.

Another key issue is the fact that the offshore Industry makes extensive use of contractors and consultants. In spite of them being in demand, it is hard to find users with SmartPlant background.

Some of consultants use their own SmartPlant method or working style which doesn't necessarily fit-in in integrated projects, it has been necessary for Agility Group to establish an integration awareness program to make use of existing user knowledge in related tools like PDMS PDS, and train them in SmartPlant technology.

SmartPlant 3D administrative routines are very challenging. SmartPlant 3D's database structure is quite complicated – it takes time to become familiar with. SmartPlant 3D piping specs are bulk loaded from Micro Soft Excel worksheets. This important task should be more interactive and user friendly. However, experienced PDS spec writers are familiar with the Intergraph environment.

Any organization that starts to implement new ways of doing things will experience a mix of opinions – both welcoming and resistive during an initial period. The organization will "fight" back when implementing new tools.

Some people in the organization that will not want to use a new system. There will be people internally that are not interested in learning something new. They believe that they already have a satisfactory plant design system and can't understand why they should change. They may also believe any new system (like SmartPlant) has less functionality then they are using today. This kind of opinion and opposition occurs at all levels in every company. It is very important that Agility Group over comes these barriers by using motivation and providing interesting training to the users.

Lead of Engineering Tools said: “If you start such a project and want to succeed:

> “Be prepared to stick your head out.”
>
> “Be ready for a ’fight’!”
>
> “Never give up!!”

As said above, if members of an organization are willing to face these challenges then the implementation can be a success.

Chapter 9 Conclusion

Agility Group is a pioneer in the Scandinavian offshore and marine industry; they have taken a relatively large risk in adopting SmartPlant because the majority of their competitors use either traditional CAD tools or Aveva PDMS. The major oil and shipping companies use or require documentation – 3D models, databases, drawings etc. in non-SmartPlant formats. In spite of this, Agility Group saw the potential of integrated engineering and decided to standardize on Intergraph SmartPlant Enterprise.

Though many obstacles were found on the way, the company has been determined to succeed and can show significant benefits in many areas. Efficiency is satisfactory, quality is good and user acceptance is growing. There is more potential to be found in further improvements to the system and methodology.

This chapter concludes the thesis and has three parts. The objectives of the research set out in Chapter 1 are recalled and the findings are summarized by showing where and how these objectives were met in the thesis. Secondly, a summary of contributions that this research has made is presented. Finally, directions for future plans for Agility Group and Intergraph are given. Final concluding remarks follow.

9.1 Measuring on research objectives

The objectives of the research and the progress of each objective in the thesis are as follows. "Understanding interdisciplinary integration in complex engineering projects, and the impact of SmartPlant in Agility Group". This research objective was met by the preliminary questionaries' (Chapter 5). There are lot of observation from the SmartPlant users and administrator. It provides a platform of the thesis research platform, valid points from many of the users and pros and cons from Project Manager.

9.2 Summary of Contributions

After careful evaluation, it is clear that SmartPlant Enterprise is a very exciting and powerful set of tools with a high potential to handle the complexity of offshore, multi-discipline engineering projects. Other tools, commonly implemented for particular disciplines such as 3D modeling, 2D drafting, analysis, etc., satisfy the requirements of only one process without any integration. This situation is undesirable; there will always be compatibility problems that lead to inefficiency of the entire project execution process.

SmartPlant tools provide almost full integration in offshore projects without the conversion or duplication of data. But there remain a few gaps that must be considered. In the questionnaire clearly shows that Interdisciplinary Integration results score average 2.5 low in the other categories, since many respondents didn't answer or said the questions weren't applicable, it shows that the company needs to educate their staff regarding integration to make them aware of its potential.

9.3 Future Plan

After evaluating the questionnaires, user interviews and observation from the various groups, it is possible to establish some recommendations for Intergraph for SmartPlant enterprise improvement as well as Agility Group for better understanding the better integration and efficient usage of the SmartPlant enterprise tools in their organization.

9.3.1 Area of improvements-Intergraph

The North Sea sector is predominately a PDMS software World, Many of users using this tools, therefore it is important that Intergraph make exporting/ importing of 3D data between other plant design systems it is easy main players as easy as possible for their customers. AG knows that Intergraph wants the business, but it would be very useful to have access to ‘simple’ on-line training programs developed by Intergraph for individual training

At user Level: Improve accessibility to help and documentation.

At customization level: Efficient customization of catalogs and symbols etc. can only be achieved with expensive 3rd party software. Intergraph should either improve their built-in administrative routines or acquire similar solutions as those that otherwise must be purchased.

At administrative level:

1. SmartPlant software updates are too cumbersome; requiring hours to install.

2. SmartPlant suffers from a considerable number of errors (“bugs”) and the feedback given from the system is insufficient for swift problem solving. Intergraph should implement a better error messaging system together.

SmartPlant still needs some development in certain key areas such as:

Drawing generation (drawing detailing)

Graphical viewing enhancements

Structural modeling

SmartMarine 3D brings new modeling features into the product and make it more suitable for marine and offshore use.

SmartPlant 3D's administrative functions have potential for improvement and simplification for customers who do not possess a large information technology (IT) department.

9.3.2 Area of improvements -Agility Group

Agility Group will be empowered to execute projects more quickly and with improved data quality using the SmartPlant Enterprise suite. But some of departments and disciplines do not fully utilize all the functions available. Indeed, some departments are not even aware of what is available.

A few senior employees don't want to leave their familiar, traditional software. This applies particularly to those involved in drafting. If they can be motivated to use SmartPlant tools, especially Smart Sketch, for their drafting, it reduce other software license costs and promote a more efficient, standardized drawing environment with little or no conversion .

Integration in Agility Group is, at present, only at an elementary stage and many users aren't aware of its potential. If the SmartPlant Administrator group held frequent training sessions and update-seminars for users of various abilities (beginner, intermediate and super-user) then a greater level of appreciation and awareness would be achieved.

The table 9.1 below lists the improvements that Agility Group require in various areas

Table 9.1 Summary of Area of improvements in Agility Group

Area	Type of improvements/implementations in Agility Group	Implementation Benefits
3D modelling	HSE technical safety drawings and safety sign drawings need to be implemented in SmartPlant. Pipe supports 3D symbols library should be expanded to further match the company standard.	One common 3D standard database for all disciplines provides better quality of project execution and integration. Eliminates the need for 2D drafting detail drawing modifications for pipe supports. Provides clash free pipe support modelling
Integration	Awareness of interdisciplinary integration between P&ID, instrumentation and electrical, data sharing between discipline tools. Customers often require data in non-SmartPlant formats. Improve support interaction and delivery to other system formats for example Aveva PDMS, DGN and DWG format	Will improve the engineering process by keeping information constantly updated and immediately available to all project members. Satisfies contract requirements creating greater business opportunities.
SmartPlant Foundation	Delivery of tag data from central, common standard database (LCI delivery)	Higher quality of delivery, on time, cost efficiency and project time shortened etc.,
Reports	All line, valve, equipment, SI, instrument and I/O lists should all be extracted from the common central database source. More focus on weight monitoring, Material Take off	Improved, well documented workflows. Improved accuracy and efficiency.
Process	P&ID used as drawing production tool, Agility Group start to use as a improved an intelligent document with all process related tag data attached and stored in a standard common database, Further need to extend the integration areas.	it provides improving data quality and speeding up the performance
General	Increase motivation and eliminate the primary barrier to using SmartPlant: users are more comfortable with the traditional systems they have experience with.	Improved competence in the organization makes a powerful combination of project execution and delivery.

9.4 Conclusion

SmartPlant is a very efficient tool for integration and, if fully and properly utilized, would increase benefits even more. The tool is still in its development infancy and Intergraph must address several key issues (bugs) and further development is necessary in certain areas. Despite using SmartPlant for 6-7 years, Agility Group is still in a learning phase and needs to train those users who are lacking in knowledge of particular disciplines. They must also try to overcome the resistance to use the new tools of the few senior users with training. This will remove a serious bottleneck in existing workflows. Integration area need to more training to use from their real time projects.

SmartPlant integration tools are very extensive and powerful. Used as intended they can save a lot of cost and time in large, complex projects. In medium-sized projects, the initial setup cost and time is high but this can be compensated for if the setup can be reused. The potential for reuse of setup is higher for medium-sized than for large-scale projects.

In relation to small-sized projects, the cost and time of integration implementation is harder to justify. Functionally, it could be very beneficial but not economical. It is unlikely that a small project could afford the initial investment in resources. Agility Group is a leading EPCIC company in the market for medium size projects. Agility Group is going through a period of rapid growth and, in the near future, there is no doubt, can harvest time and cost from their projects with integration.

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List of Abbreviations

AG	Agility Group
CAD	Computer Aided Design
CAPEX	Capital expenditures
EDW	Engineering Data Warehouse
EPC	Engineering, Procurement and Construction
FIG.	Figure
HSE	Health Safety and Environment
HVAC	Heating Ventilation and Air Conditioning
LCI	Life Cycle Inventory
P&ID	Process and Instrumentation Diagram
PDB	Plant Break Down Structure
PDMS	Plant Design Management System
PDS	Plant Design System
PFD	Process Flow Diagram
PLCM	Plant Life Cycle Management
RDB	Reference Data Base
SAP	System Application and Products
SPF	Smart Plant Foundation
SPR	Smart Plant Review
2D	2 Dimensions
3D	3 Dimensions