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A Study on Building Blocks of Digital Twin for Oil and Gas Industry

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***Abstract*— Oil & Gas Industry transform itself very rapidly and has witnessed and leveraged the technologies of Industry 3.0.This paper is an outcome of a study on projects executed in conventional methods using digital tools and how the data produced in FEED, Detail Engineering, Procurement, Construction and Commissioning has been controlled and distributed throughout the project and asset life cycle. This paper outline the significance of Industry 4.0 transformation in terms managing the data and deliverables from data centric solutions and how that data could aid to build Digital Twin in Oil & Gas Industry by integrating various technologies through agnostic approach where, in a computer-based environment, an agnostic approach is the one, which is interoperable across the systems, and there are no hard and fast rules towards using a set of technologies, model, methodology or data. Through various illustrations, this paper detail out the significance of appropriate handling of data produced during engineering, design, construction and commissioning of the assets, which would be crucial for implementing revolutionary technology such as Digital Twin for energy industry through efficient data and information management.**

Keywords—Oil & Gas, IoT, IIoT, Digital Twin, Predictive Analytics, Digital Transformation, Information Management, Digital Data Management.

I. INTRODUCTION

Oil and Gas Industry is a vast industry that drive global economy and geo political strategies. A multibillion-dollar industry commonly owned by governments across globe had been running their upstream, downstream facilities in a traditional ways influenced by Industry 3.0 which brought significant changes in industry through application of Computer/internet, Digital manufacturing,PLC/Robotics, IT and OT,digitization,automation,Electronic/digital networks, digital machines. The oil and gas (O&G) industry is the world's primary source of energy with a very complex process for production and distribution. It is noted for the economic transformation of the world, by supporting the demand for heat, electricity, mobility, and other essential petrochemical products of the world's population. The process of production and distribution involves state-of-the-art technology at different levels. These levels are the upstream, the midstream, and the downstream. The upstream segment involves exploration and production activities such as geological surveys, onshore and offshore drilling. The midstream segment involves operations such as transportation, storage, and the trading of crude oil, natural gas, and the products that are refined. The downstream segment covers refining and marketing. The upstream sector plays an important role in the O&G Maintaining the Integrity of the systems and specifications for complete value chain of field. Although Oil & Gas, and other industries have seen the benefits through Industry 3.0, there were unexplored areas left behind due to which Industry had been experiencing challenges in operating their assets safely, efficiently and sustainably. The digital solutions applied in design, build, operate and maintain the facilities were in silos and the power of digitalization was not fully capitalized, resulting in failure in core functioning of equipemnts, engineering systems that led to severe safety incidents that engulf billions of dollars and priceless human lives around the world in the oil & gas industry. Realizing the power of latest technologies industry has started embracing Digital transformation that can deliver increased operational efficiency and workplace safety, as well as minimize the carbon footprint of the industry. As a savior, Industry 4.0 technologies such as IoT, IIoT Digital Twin, Predictive Analytics, Robotics enabling energy industry to integrate Engineering, Design, Construction, Operation and Maintenance of their assets and operate the assets efficiently assessing the future -state of the core systems in advance to evaluate the risks and mitigate. Thus, the objective of this article is to detail about how the essential components of an oil & gas industry is integrated digitally for safe and efficient operation of the facilities and assets.

II. CURRENT STATE

Oil & Gas industry is one of its kind, which is distinguish other industries in several ways. In other words, it is the only industry that bring all the engineering disciplines together for its engineering, design, procurement, construction, commissioning, asset operations and maintenance. Digital act as an enabler throughout the project and plant lifecycle. In spite of the fact, that process and all engineering disciplines utilize digital technologies and tools for producing various outputs and deliverables which is an input for others to perform their work and analysis, there is a broken chain in terms of sharing the data and reuse of data in order to ensure the consistency in common data being handled by various disciplines, resulting in double handling of data, inaccurate information , that lead to quality issues, rework and resulting in collateral delays in the subsequent activities . Industry is facing these challenges for more than two decades. This state what is stated here is in particular to project execution where process licensors, EPC organizations design, build, start-up the plant facilities and when they handover the asset to O&O, they also handover all the design, engineering documents and drawings along with databases used for producing them. However, it is not effectively utilized by O&O throughout the asset life cycle. Even today, several O&O's in Oil & Gas Industry do not have their IT system capable of handling the design, simulation tools that were used to design and built the assets they are operating. This state is a challenge to the O&O to operate their plant facilities efficiently, ensuring utmost safety of men and machineries within the plant facilities. Fig.1.Process Flow Diagram of an EPC Execution, illustrate the association of multidiscipline in a typical EPC project where engineering design, procurement, and construction is carried out, and in some cases , EPC companies perform the commissioning of plants and handover to O&O after stipulated performance guarantee. As illustrated in the process flow diagram, in a typical Oil & gas project,

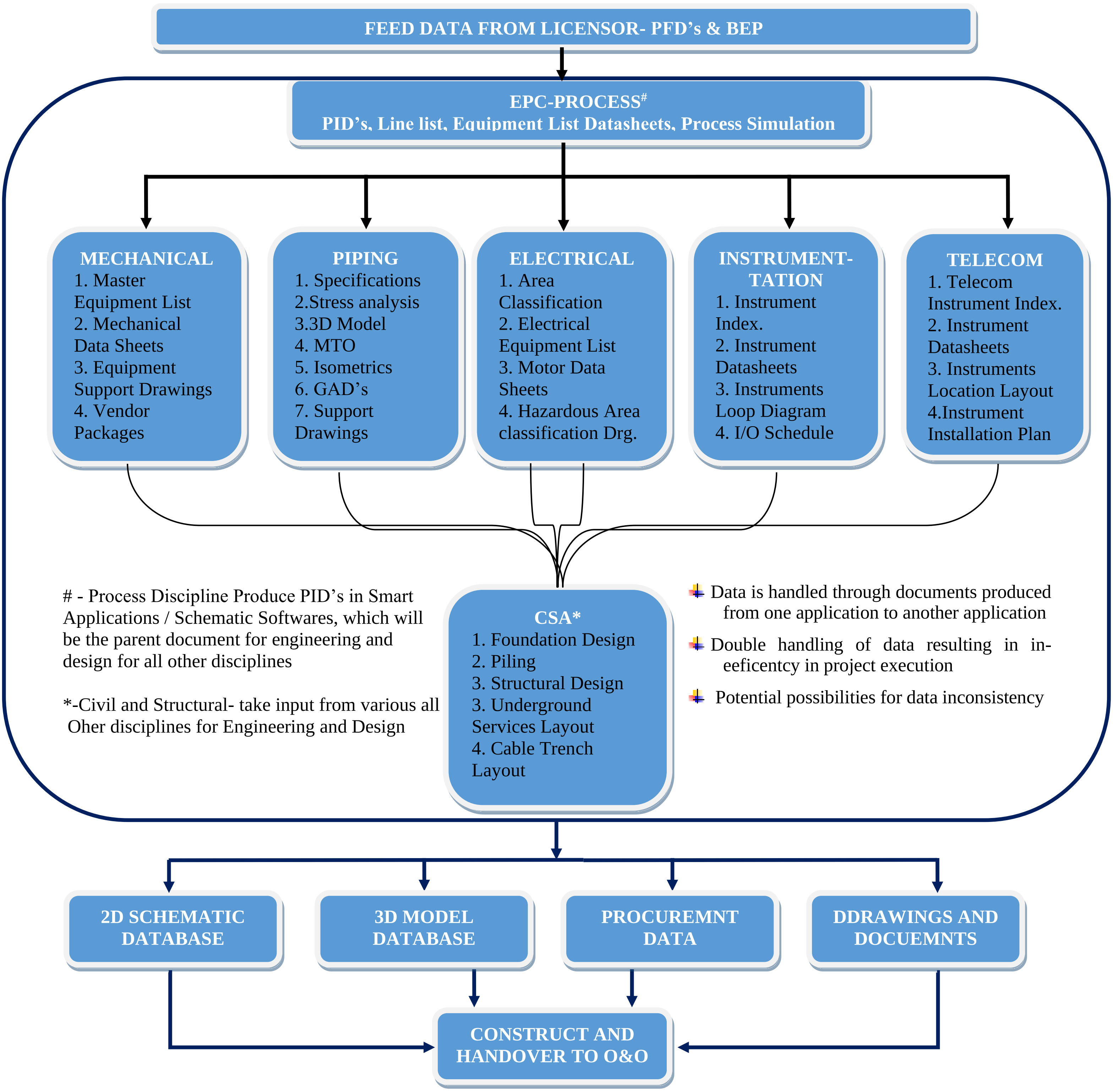

Fig. 1. Process Flow Diagram of an EPC Execution

multiple disciplines involve in engineering and design. Process documents such as PID and line list, equipment list, process data sheets will be the key parent document using which the design and engineering performed. In this case, very often the Licensors, chosen by the O&O, provide the license package, which includes PFD, Equipment List and BEP to the EPC contractor who is awarded with contract for executing the project. The BEP might only be a document and data in a drawing format. However, some licensors use the data centric digital applications to develop preliminary basic engineering. When such information is available with licensors it could be utilized for development of detail design.

From BEP, PFD the EPC Contractor develop the detail PID's for design with the data require for each service and equipment and perform the simulations. This will be the blue print of the complete design to prepare and check for process simulations, HMBs, and PIDs, sizing calculations for vessels, pumps, lines, etc. PID and process data also used for safety valve relief load calculation (as per API standard), Prepare design basis, and philosophy and control narrative, coordinate with other engineering disciplines, vendors and client. The most critical part of the process design is HAZOP. Hazard and Operability (HAZOP) is a systematic approach to determining potential problems that may be uncovered by reviewing the safety of designs and revisiting existing processes and operations in chemical, oil and gas, industries.

As such, the deliverables produced often does not come as a data straight to other disciplines in order to enable them to perform their design, very often, the process discipline , issue the PID's drafted using industry standard drafting tools such as AutoCAD which is not a data centric software. When this information flow to other disciplines, it goes as a drawing instead of data require for design and analysis. Hence, it prompting the consumer this input to re-enter the data in their design, which is eventually, lead to double handling of data. In a mid-size to large scale Oil & Gas projects would have approximately 150-300 PID's which will have numerous Tags of various elements of plant facilities such as Equipment's, Pipelines , Instruments, Specialties, bulk valves and Hard and Soft Signals Tag. All these tags in turn will carry critical data such as, Design, Testing and Operating parameters, which will be used by various disciplines.

III. CHALLENGES

The consistency of data is key for successful project execution in Oil & Gas Industry, O&G project execution in general is very complex in nature since it involves multiple discipline and sought for Inter-dependability for data and information, when the right data and information management is not in place, it would lead to chaos in the project execution and it would have a huge impact in the downstream activities especially the procurement. Conventionally the revision controls and versioning of parent document such as PID's, line list are followed in engineering Industry, and in spite of that, key elements are missed out in the design due to the fact that the information not passed to the concern discipline and that lead to collateral delays in design resulting is derailment of project schedule in terms of long lead time for procurement, rescheduling the priority activities and adjusting the construction schedules. Given an example, if there are any additions or deletion of service in the process design should be effectively communicated to downstream engineering discipline to evaluate the impact in MTO and adjust the quantities. Failing which would lead to drop or excess in quantities that would in turn both way will cost the project in terms of delay or additional cost for procurement. In a Typical EPC project, 90% cost involve in procurement of materials and construction, while 10% cost incurred in engineering design. But the mistakes in 10% engineering will have a huge impact in 90% cost. Maintaining data consistency is a continuous process and the key element for executing the project effectively and delivering it for safe and sustainable operation of assets. Technologies available for Oil & Gas industry does not yield the maximum benefits as long as they are not connected with each other for effective information and data management. Even though Industry is using various software technologies for engineering design, simulation, construction, it is not integrated and it work in silos. Integrating these tools and technologies has its own challenges such as lack in combined skill sets with process and software knowledge. Alignment of work process to suit better use of the tools and technologies or in other word, customizing the tools to align with business processes. To detail out the challenges, let us take a case where Process and instrument discipline require inter-disciplinary data exchange and coordination for delivering key output to the project. Process design has to provide the Process Data Sheets, which would provide all the simulation case data for inline instruments such as PSV's s and PRV's. Process discipline determine the requirement of a PSV and PRV to prevent failure of pressurized systems when it reaches the threshold parameters. Such information is crucial for Instrument team to prepare the specification for such items and issue for TBE for procurement processes. Process discipline simulates the design and operating cases for various fluid phases in the simulation software's and it generate the results and reports. Such results and reports have essential data for design and procurement. Providing such data in the conventional way using excel templates to instrument discipline will lead to double handling of data where instrument discipline has to feed this data in their datasheets and specification manually and that would lead to human errors and inconsistency in data.

In another case, where piping discipline solely rely on process data for various of their design and analysis, the data handling while performed manually will attract significant manual efforts. Piping discipline shares the 70% design in an EPC project and responsible for bulk materials such as pipes, fittings, valves, specialties. Selection of right material for a process system and service, they require rely upon data based on process simulation. The data includes, design, testing, operating pressure and temperatures which will be the basis for selection of materials. When process provide this data, it is applied to huge number of pipelines for design and production of deliverables such as isometrics, which is one of the key deliverables that normally count in thousands. When there is no rely upon data or the data handled manually, it has potential chance of inconsistency and rework in design. The critical part of an engineering design in oil & gas project is stress analysis, which require key parameters from process. Such parameters would be applied to various systems in a process and subject to stress analysis to ascertain the failures in operation before installing the critical piping system that carries the various process fluids that involve in several process. All the challenges explained clearly exhibit the signification of effective information and data management.

IV. FUTURE STATE

A. *Integrated Engineering Environment*

The stepping-stone for building the Digital Twin is Integrated Engineering Environment in which the project is executed. Industry is using various digital tools for design and project execution, it is not integrated, and data is not reused in the manner it has to be. In Integrated Engineering Environment, the project is hosted in a data centric sphere enabling all the engineering, procurement team work in collaborative manner and the right data is flowing across tools consistently. Based on outcome of a project where the IEE hosted using industrial data centric software solution from Hexagaon shall have an architecture as depicted in Fig 2. As the picture illustrate, a Typical IEE architecture using Smartplant Suite from Hexagaon is established integrating all the engineering, procurement and construction functions. The SEED data must be defined by Owner Operator that must have all require configuration in view of plug in to the Digital Twin environment that will be hosted by O&O. Otherwise, each EPC contractor will produce data in various formats and ways which will not help in building the homogenous environment after taking over of project and data from contractor. In the illustration various tools such as SPPID, SPI, SPEL, SP3D and SPF is defined. Each tool fulfill the design needs in an intelligent way and produce Smart data that can be exchanged between applications. Lets' start with SPPID, an application, which produce process data, which will flow to SPF from where the process data is retrieved to other engineering functions such as Instrumentation, Piping , Electrical and also data from other 2D tools flow into 3D design where all engineering function develop their model. Oil and Gas project is very complex in nature with several interface where developing the 3D design is paramount priority that help visualize the potential issues that would arise during construction and mitigate in advance. In this case, the 3D model is not just model where as it is full of data that would produce various deliverables right from reports to drawings for each disciplines. These reports and drawings are used for actual construction. Hence, the model should be consistent with data that is the sourced from process function. Unless, you have an intelligent system, handling of design and execution will be challenging and directionless. SP3D is one of such intelligent system available for developing complex, data centric model for oil & gas projects in Onshore and Offshore segments. Thus, the data produced from parent function shall be published to consuming function in and intelligent way through data centric applications and in an integrating engineering environment. Finally, all the data is collated in an EDW, which is a hub for all authoring applications. In this case, SPF is an application act as EDW for various authoring tools that would be used by various engineering and process disciplines, the data produced from such applications are published and retrieved through EDW and at the end of the project, this EDW will act as Single Source of Truth (SSOT). This consolidated, consistent, intelligent data along with model can be further leveraged for vast application throughout project and asset lifecycle.

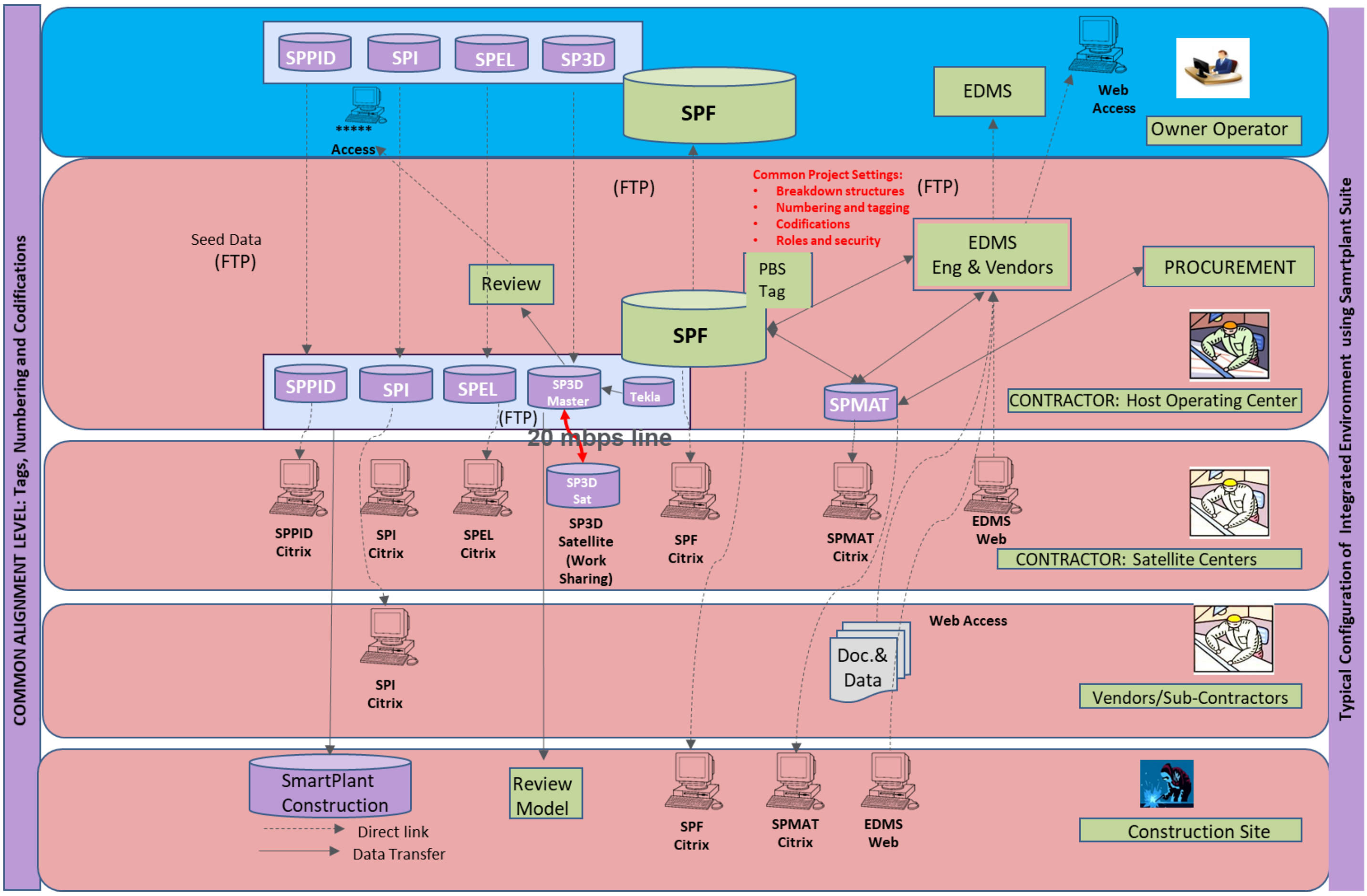

Fig 2. Typical IEE Architecture

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B. Data Driven Construction

When the Engineering design is performed, all the data is collated and exchanged through EDW, you have all data in one place. Oil and Gas onshore, offshore facilities and FPSO construction is unimaginably complex with interface to various engineering disciplines, the seamless construction is fully depending on consistent data. It is not only for construction, but also for testing various systems and commissioning the facilities to start up for production involves almost all-engineering function work together to achieve successful completion to commissioning. Let us consider Smart Construction a digital platform that is driven by data for construction, the data driven from various sources is collated in EDW, from there the construction is planned and executed.

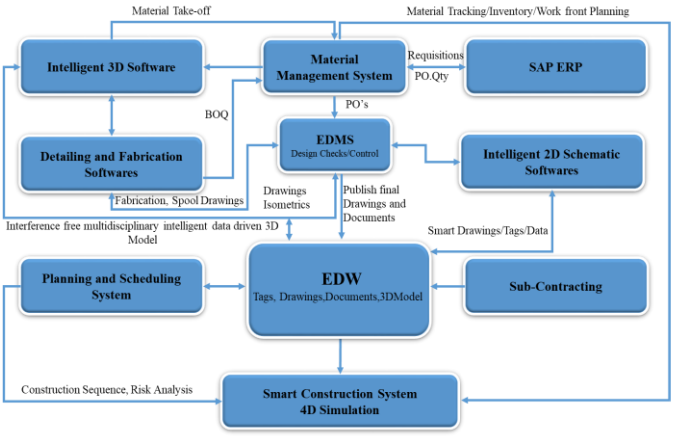

Fig 3. Schematic of Data Driven Construction

In a data-driven project, the digital data streams are consistent, reliable and reusable across project disciplines and project phases. Data drives and connects the entire process, while manual handling is minimized or eliminated to safeguard data integrity and to optimize the process. The Digital Twin combines the information stored in different systems, represents the single source of truth, and prevents silos of disconnected information. It will also enable handover of all released technical information to be used as a source for an operational Digital Twin for the Owner/Operator. Ensuring constructability is a core element in the successful implementation of projects. It allows EPC contractor to analyze all project processes with the aim of optimizing construction sequences and practices. Interferences and possible schedule impacts are identified before starting construction, thereby preventing errors, delays or cost overruns. The effective integration of construction knowledge with planning activities, design and field operations allow seamless construction in compliance with time, accuracy and HSE requirements which is paramount priority. Deployment of digital platforms with single source of truth of data has been transforming oil & gas industry construction. Data driven construction provide insights that help identifying the safety risks for construction workers thus help in achieving zero LTI, which is always a topmost objective of a project in a complex environment

C. Digital project Delivery

For an EPC contractor, the project life cycle end with successful construction, commissioning of facilities. However, the asset lifecycle starts from the day one since the project is handed over to Owner/Operators. To operate the facilities/assets efficiently data and information plays a pivotal role. In Digital Twin era, even a bolt and gasket information should be available in a click of a button, which would reflect a company's maturity in terms of governing the assets through data and information. It is imperative that owner operator take over the project in the form of data from EPC contractors for building a meaningful Digital Twin that will yield benefit throughout the asset life cycle, which is approximately 25-30 years. In order to enable the owner operators to take over the asset with information and data essential to run and maintain a standardized specification is very much require which should define the details of data and information to take over from EPC Contractor. CFIHOS is one such standard evolving in oil & gas industrial sphere, which help consolidating information, enabling easier handover so plants can open and start working sooner, easier document/data retrieval saves significant time while operating the plant facilities. CFIHOS standard defines the data models that require for safe, efficient, and sustainable operations of asset through various specifications that encompass operation, maintenance, safety, supply chain. Most important part of CFIHOS is interoperability.

When you think of Digital Twin, be prepared for handling data from various sources such as engineering, procurement, construction, contracts, commissioning, and automation vendors. The data coming from one source should be readable by other source and consolidation of data possibility is called interoperability. Digital Twin is an agnostic approach, hence the software's tools, data involve in building the Digital Twin must support interoperability, another global standard ISO15926 that enable sharing, exchange, handover of data between software systems , in particular integration of life-cycle data for process plants including oil and gas production facilities. As depicted in Fig.4. an oil& gas plant will deal with data from various sources and consolidating this data and integrating it for efficient operation and maintenance lies in interoperability of data.

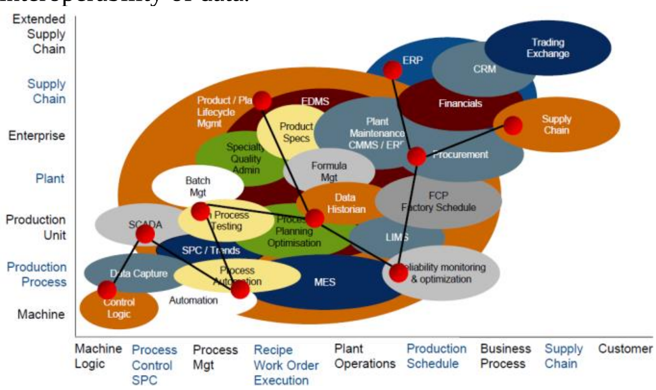

Fig 4. Engineering Data Spread in Asset Operation

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D. Digital Twin

Digital Twin in simple words, is a system where digital data and physical asset should speak to each other. An asset in a complex facility must be traceable, operable with ease and monitor and predict its state any time live, to prevent fatigue and catastrophic failures that would have cascading effects in the core system failures and incidents which would be a costly affair for Owner and Operators. Conventionally, the oil and gas facilities have had the partial Digital Twin which is now getting reshaped with modern communication and analytical systems available in the industry. Given an example, the PLC/DCS systems have been functioning in process industry since several years for control and monitoring process and assets, which itself a form of Digital Twin. However, with cutting edge the technologies such as IIoT, AI, ML, not only the control and monitoring of asset is performed, but also you can analyse, act in advance in decision-making with the easy access of data and insights from analysis.

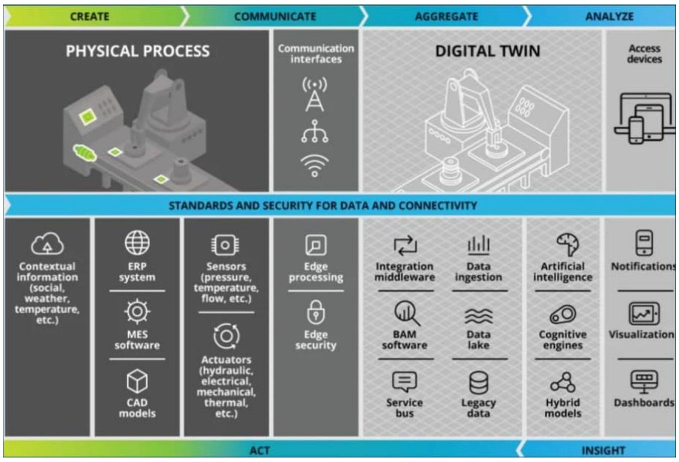

Fig 5. Digital Twin Concept Architecture

To build a successful Digital Twin, early engagement with all stake holders is a crucial part of the project. All key stack holders right from the process licensors, EPC contractors, and process automation contractors must be aligned for the purpose. In principle the owner operators must have clarify on what to look for from building Digital Twin. With the complexity involve in integrating the system from various domains, it can be clearly understood that Digital Twin is not a regular IT automation. It is about driving the data to bring value to the life cycle of the facilities and asset. Therefore to what degree you want to leverage the data you have and investing that data in right direction is all about Digital Twin. Hence, from the beginning of the project, we should define the data requirements, systems to be used for engineering, procurement, construction and commissioning of facilities and assets through specification for alignments and compliance. To achieve this IEE is imperative and the data model is crucial. Upon completion of project and commissioning, another important aspect that to consider is As-Built information of your facility and assets. As-Built data is your final data you should take over from the EPC contractor with due diligence and that is your final data you can reply upon for the life cycle of the facility and assets. This is one of the challenging areas where the integrity of data an information might be broken where and when the appropriate system is not in place to capture all the changes that is made in design documents during construction and commissioning. The rely upon data take over from various stake holders would assure the successful implementation of Digital Twin.

Data and information taken over from project phase, must be plugged in to various components for analytics, visualization and decision making. The instrumentation data generated during engineering phase is used for process automation and one step ahead for analytical purpose in Digital Twin environment. Mechanical data from various equipment's could be used for Predictive Analytics and Maintenance using AI and ML techniques and the 3D Model developed during project phase would have digital replica of all physical plant facilities , that could be used for developing Operator Training Systems using Virtual Reality and Augmented Reality. The EDW which has all the data and documents collated during engineering, construction and commissioning , will act as a central source of information that can be deployed anywhere on mobile accessibility devices that will be the key element for accessing data and information about any asset at ease.

The most important and critical aspect of Digital Twin is establishing reliable communication system that enable the digital asset effectively communicating with physical asset and vice versa. An O&G facility as mentioned elsewhere is a complex setup with numerous equipment's, pipelines and instruments that are located remotely. Traditionally, the control systems fetch the data from Instruments that are connected to key equipments through sensors and such systems are TAS/ DCS/SCADA/ PLC/ OPC.However, typically the O&G facilities are spread across upstream, midstream, downstream with multiple critical equipment running from remote locations and connecting to the analytical system for data retrieval and continuous monitoring has always been challenging or it is expensive to bring such assets for continuous monitoring. That's where technologies such as IoT and IIoT plays a pivotal role in leveraging the telecom technologies such as 4G/5G. The difference between the traditional control systems based monitoring of performance of assets and IIoT based monitoring is that the prior one has the network established between assets and control system within the facility through intranet, while the second one is using internet to collect the data from various assets through the sensors attached to it and send to a cloud location for data processing, analysis and decision making in advance.IIoT is complex in nature which interconnecting multiple assets through sensors and it is highly essential that the network is up and running to fetch the live data from critical equipments which are backbone of process to determine its future state and prevent any unexpected failures. Hence, IIoT implementation should consider the key elements such as strong wireless network , non-intrusive sensors along with readymade COTS software apps which would enable easy and rapid deployment of these solutions at low cost.

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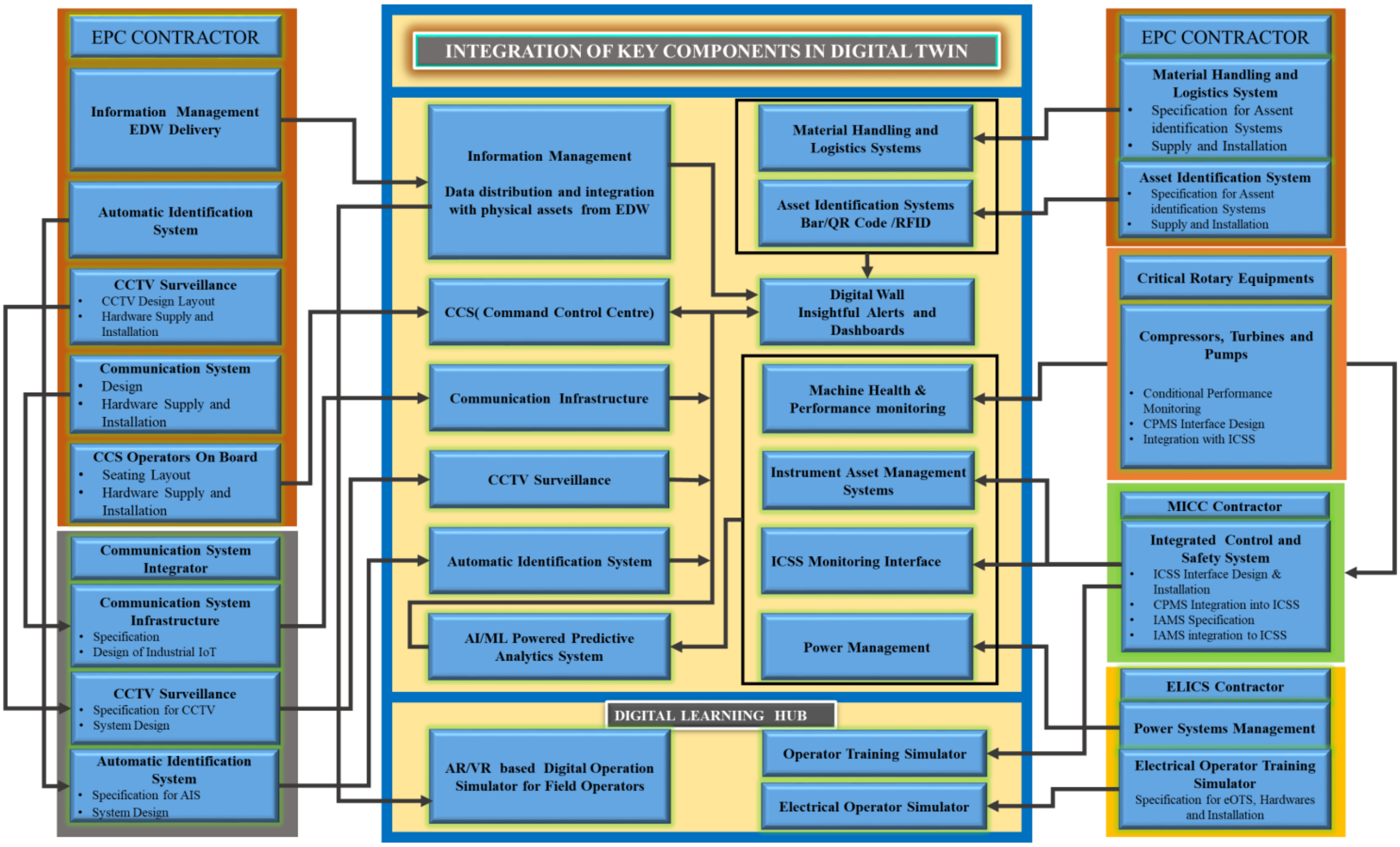

Fig 6. Typical Architecture of Digital Twin for O&G Industry

Digital Twin has its obverse attached which is the vulnerability to data security. Typically, you bring almost everything about your production facilities, supply chain together in a central location in Digital Twin. It is imperative to protect that data which in turn protecting the assets. Multiple layers of data security must be applied to prevent any unforeseen security related incident. VAPT is the best known process to identify the risk to your systems and continuous evaluations is a must. Selection of product and component which has embedded system security into its product design, system development and services. The integrated components which enable the communications between assets should not only focus on communication but also the security aspects such as firewall and VPN. Various industrial IIoT implementation partners has the solutions which has data security techniques and components as an integral part of their product and process that could be an idle solution to plug in to your Digital Twin to protect your assets which will be connected to numerous communication systems. An O&G facility has normal life span of 25 to 30 years, throughout its lifecycle ,protecting the assets would be a serious business in order to keep up the core business continuity, hence, investment in data and cyber security is a must. Contracts with key components covering the data security is advisable during the project phase itself. The EPC contracts could have specifications and clauses with the scope and clarity, so that EPC contractors choose the right partners for evaluating and implementing the appropriate security systems for your Digital Twin. The area where you have to focus to integrate the security aspects while implementation is process automation. The process automation companies has vast experience in developing, implementing the systems that have the security components as an integral part of their systems and they can be a right partner to choose an appropriate solution to mitigate your data and security related risks. As depicted in Fig.7, three layers of security is essential while operating a facility, a plant level security that encompass the systems integrity and network security. Any solution that an O&O envisage for data security should be in compliance with IEC 62443 standards series on "IT security for industrial control systems – network and system protection". Each country has their Computer Emergency Response Team, such organizations must be effectively utilized for guidelines, advisories, information related to vulnerabilities, best security practices, procedures, prevention, response and reporting.

Fig 7. Concept Architecture of Security layers

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V. CONCLUSIONS

Energy Industry capitalizing the Digital Transformation depending on integrating the work process and technology to the engineering systems. Despite having traditional control and monitoring system, even today there are safety incidents in the process industry, in particular in O&G industry where serious sabotage caused to human and assets. While industry think of leveraging technology, reduce human interface, automate the workflow, emphasize should be on health and safety of men and machines. Digital Twin is the Age of Aquarius for Energy Industry. There is no alternate for energy industry to run and maintain giant facilities, which host thousands of equipments and engineering systems other than adopting digital. While adopting to digital, it is not just one solution that industry can look at, they must look at agnostic approach for integrating various tools and technology. That is the key for successful implementation of Digital Twin, and Predictive Analytics is such kind of solutions that make Digital Twin a reality for grassroots projects. For brown field facilities, identifying the areas where you intend to implement the solution is the key. Among thousands of equipments and hundreds of processes, the mother of the process will play the pivotal role in identifying and deploying solution, bearing in view of lifecycle of the Assets. Complete digital revamp of a brown field facilities will attract more challenges such as integrating the innovative technology to outmoded existing facilities, which might not compatible, and it will deviate from the fit for purpose and economically not beneficial when you look at return on investment.

While developing a project, we generate abundant data, which would play a critical role in implementing and deploying the Digital Twin for O&G industry. There are three pillars that determine the successful deployment of solutions and capitalizing the benefits from Digital Twin. The three pillars include data, the models you build for analyzing the data, and the most important thing that the technology you integrate with the solutions. Your data available from various sources should enable you to build the models for analytics, which will be used as baseline models. For standard industrial equipments, there are data model available with various parameters such as the cavitation, Vibration of Pump, lubrication, bearing alignment, surge of compressors. These models are part of software packages, which can be used to build models based on your data. However, if you would like to monitor various other parameters, you should possess usable data to build new models and implement for analytics. The effective implementation of Digital Twin is fully depending on the technologies you adopt to strengthen the communication system and the advance data security layers. The amount of data require for constant analysis, visualization and validation is huge, where the data quality and structuring of data is essential, and securing it is even more crucial. The live data coming from various sources must be well recognized, refined and utilized for analytics. With the three pillars such as Data, Models, and Technology, Digital Twin will be an impeccable solution for O&G industry to solve future problems efficiently with greater insights of core elements of business process.

VI. ACRONYMS

FEED	Front End Engineering Design
BEP	Basic Engineering Package
EPC	Engineering , Procurement , Construction
O&O	Owner Operator
2D	2 Dimensional
3D	3 Dimensional
O&G	Oil & Gas
TAS	Terminal Automation System
DCS	Distributed Control System
SCADA	Supervisory Control And Data Acquisition
PLC	Programmable Logic Control
OPC	Open Platform Communication
IoT	Internet of Things
IIoT	Industrial internet of Things
IEE	Integrated Engineering Environment
PFD	Process Flow Diagram
PID	Piping and Instrument Diagram
HMB	Heat and Material Balance
HAZOP	Hazard and Operability Study
MTO	Material Take-off
PSV	Pressure Safety Valve
PRV	Pressure Relief Valve
EDW	Engineering Data Warehouse
SPF	SmartPlant Foundation
SPPID	SmartPlant PID
SPEL	SmartPlant Electrical
SPI	SmartPlant Instrumentation
SP3D	SmartPlant 3D
SPMAT	SmartPlant Materials
LTI	Lost Time Injury
CFIHOS	The Capital Facilities Information Handover Specification
HSE	Health, Safety and Environment
CPMS	Cathodic Protection Management System
COTS	Commercial-Off-the-Shelf
IAMS	Instrument Asset Management System
BOQ	Bill of Quantity
EDMS	Electronic Document Management System
AI	Artificial Intelligence
ML	Machine Learning
FTP	File Transfer Protocol
4D	4 Dimensional Spacetime
AR	Augmented Reality
VR	Virtual Reality
RFID	Radio Frequency Identification
CCTV	Closed Circuit Television
MICC	Main Instrument and Control Contractor
ELICS	Electrical Integrated Control System Contractor
ICSS	Integrated Control and Safety System
OT	Operational Technology
VPN	Virtual Private Network
VAPT	Vulnerability Assessment and Penetration Testing

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