



Applying Computer-Aided Production Engineering (CAPE)

PPI Annual Symposium

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Two Projects



Greenfield Project

CAPE during Construction

Focus on Pipelines



Brownfield Project

CAPE during Early Engineering

Focus on Cutovers



We will share this with you today

Why CAPE – Our drivers to innovate / look for better ways

What we mean by CAPE – What it is and what it is not

Our journey applying CAPE – Construction and Engineering

What we have learned to date



Why CAPE at TCO?

Drive Excellence in Project Performance

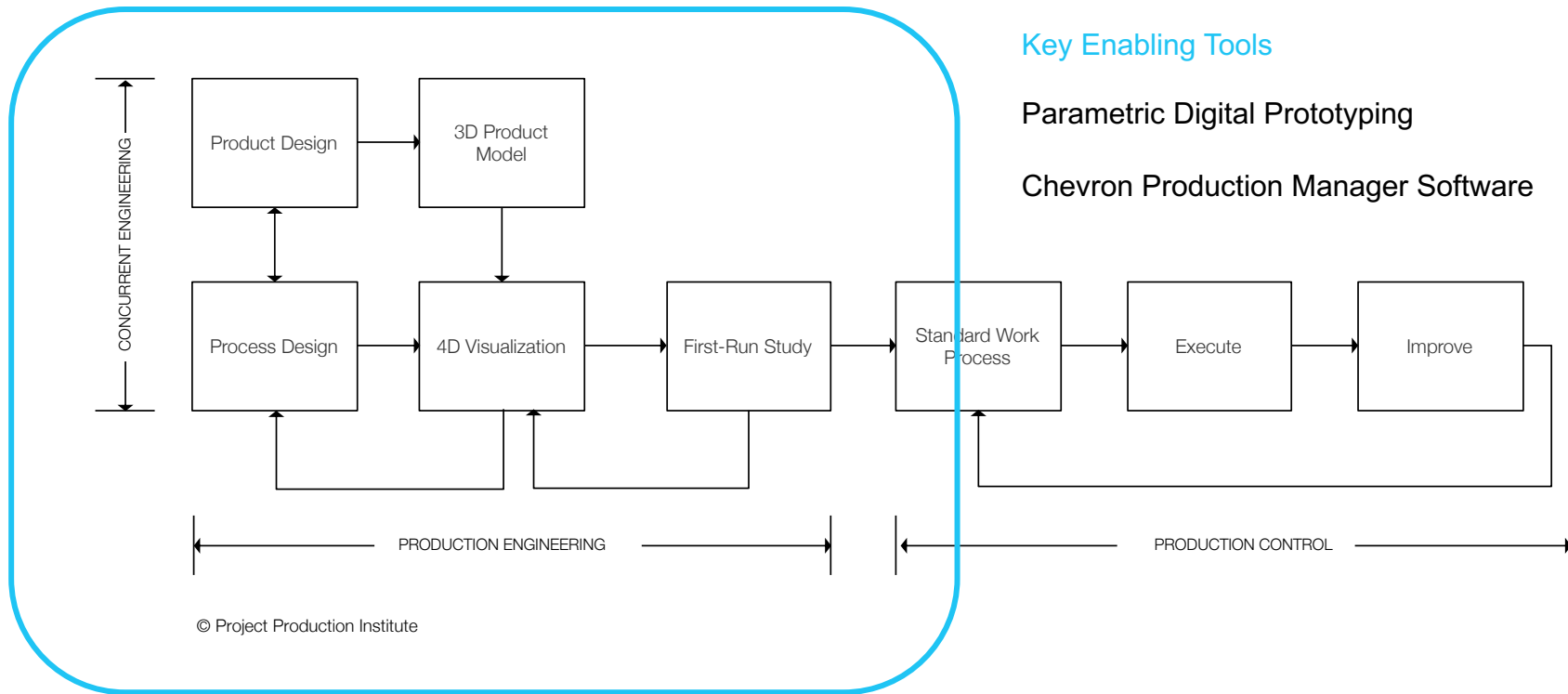
Be more effective at handling inherent **complexity and risks** at the execution level

Better define and design **how** we do field operations before we do them

How best to **simultaneously** design the asset and the process to build it and capture lessons learned for future applications



What are we implementing?



Key Enabling Tools

Parametric Digital Prototyping

Chevron Production Manager Software

CAPE IS:

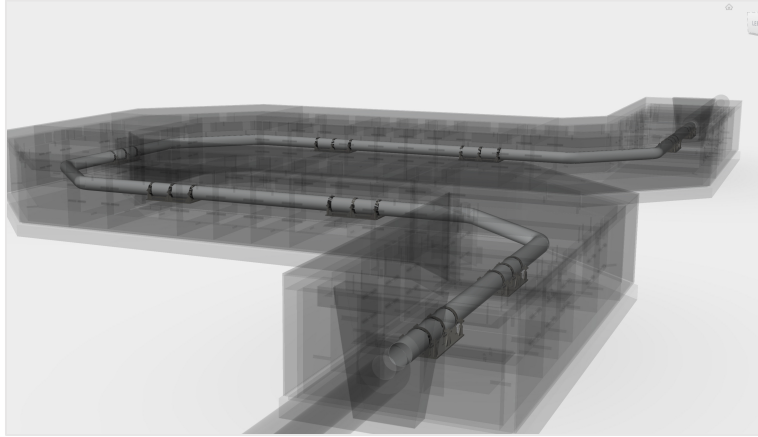
About the design and optimization of field operations that are either repetitive or one-offs (you have only once chance to get it right) during engineering or construction or both

CAPE IS NOT:

A constructability review that looks to identify interferences between systems



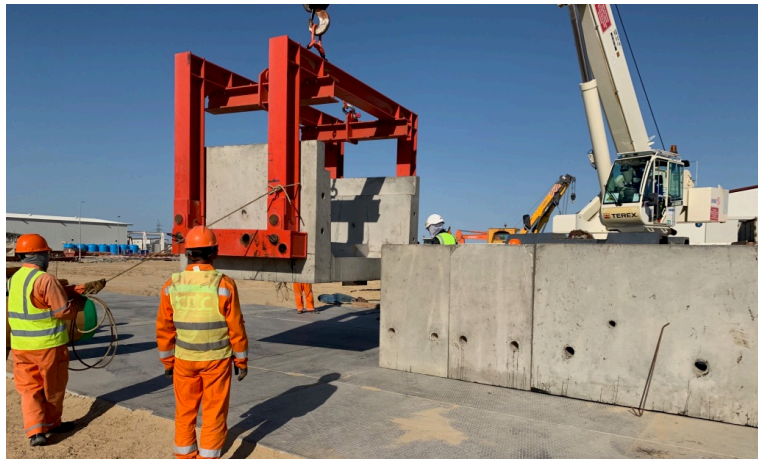
Our First CAPE Application – 93 Expansion Loops



Reduced cycle time by 30%

Reduced \$5 M on labor

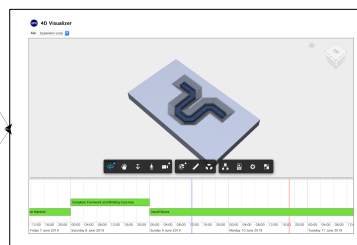
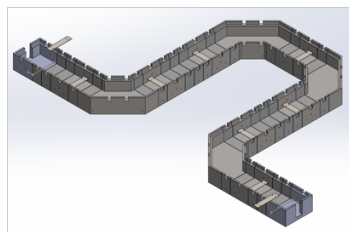
Identified 9 design issues using the construction digital prototype



Identified 27 Fabrication / Construction improvement opportunities during First Run Studies



Visualizing & Testing the Design of the Process



Install T1 box



Install first T2 box with dowel



Place dowel



Install second T2 box



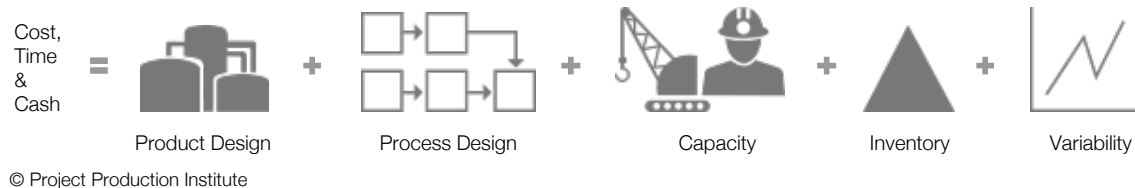
Install T3 box



Continue with Box Installation

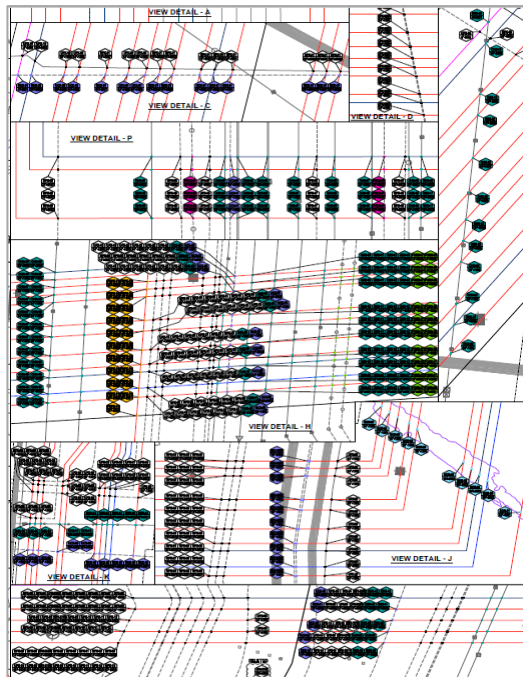
Digitally in the Computer

Physically before doing it
in the Field





Pipeline Crossings – More than 4000

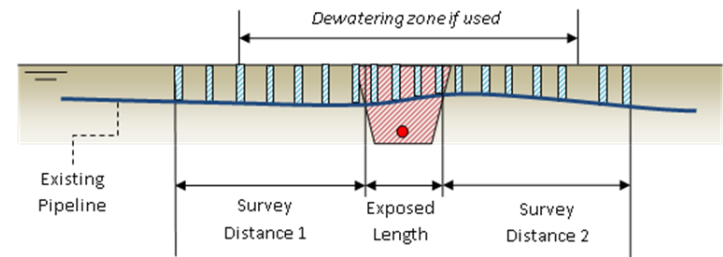


Stringent Specifications and Safety Requirements

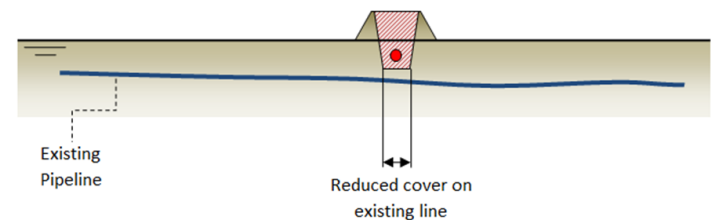
Dynamic SIMOPS linked to Operations

Complex high concentration of multiple crossing types co-located in one area

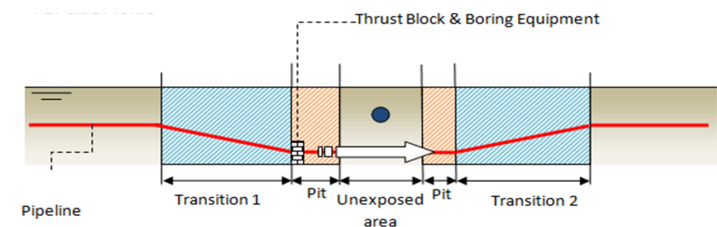
Execution Strategy critical to align with operational shutdown schedule



Open Cut



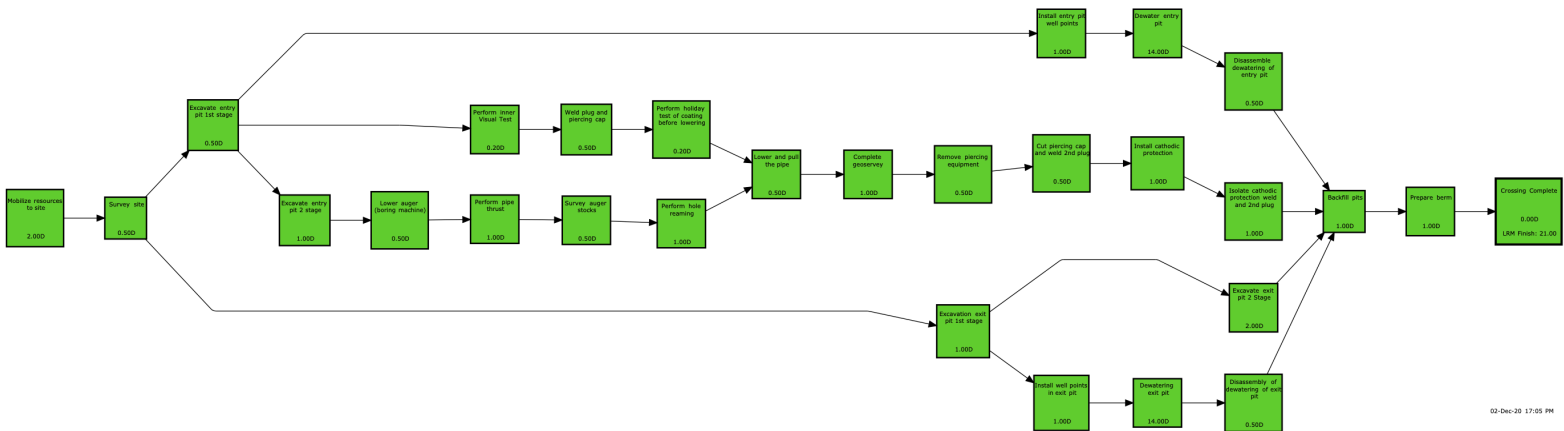
Above Ground



Trenchless



Analysis of Process Design



02-Dec-20 17:05 PM

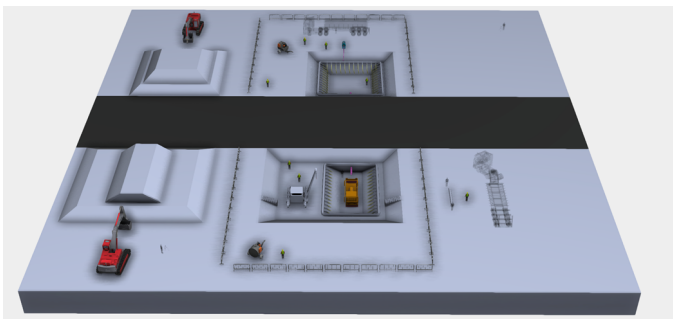
Cycle Time highly variable due to site constraints and execution method

Productivity challenged by dewatering activities and ineffective coordination and planning of shared resources

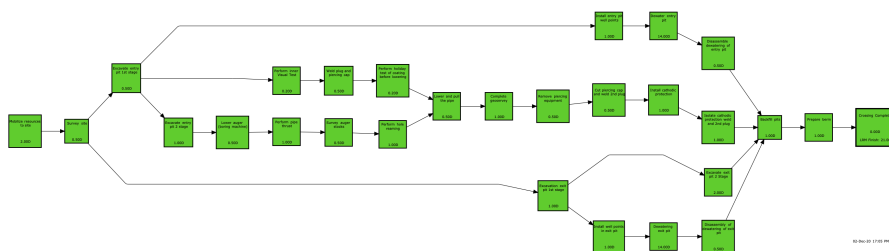
Critical Path scope to complete Pipeline scope



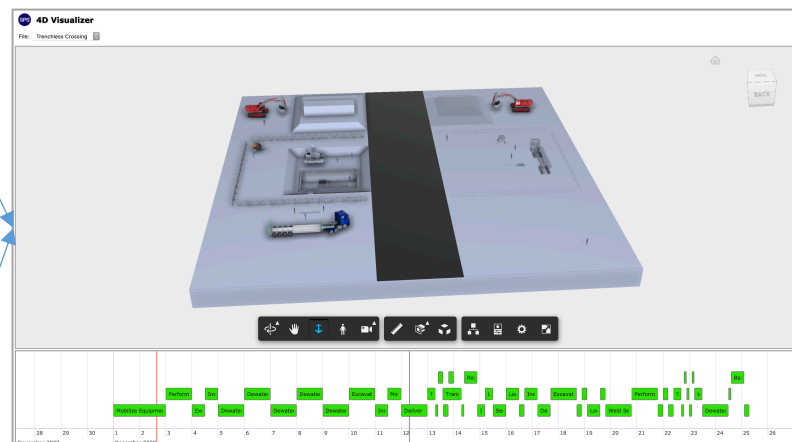
4D Visualization - Is the Process Design Robust / Optimal?



Digital Prototype
(Permanent & Temporary Components)



Process Design
(Sequence, Handoffs, SIMOPS, etc.)



4D Visualization



Executing 690V Cutovers – Applying CAPE During Engineering



~ 2044 690V hot cutovers

30 years old facility / brownfield

Site congestion / live equipment / H2S

Limited personnel onsite - schedule impacts

Compatibility between old and new equipment

Weather limitations





Process Design – How to do the work?

#	Sub. #	SWBD#, Circuit #	Cable #	Cable Size	Cable disconnect (min)	Cable pulling out of RP (min)	Cable cut, megger test (min)	Splice kit installation (min)	Final megger test (min)
1	RP-1	SWBD#1, A7-7	03-P-139	3x2.5mm2+1x2.5mm2	30	10	30	30	15
2	RP-1	SWBD#1, A10-3	08-P-106	3x2.5mm2+1x2.5mm2	30	10	30	70	15
3	RP-1	SWBD#2, A4-10	002-P-213	3x150mm2+1x150mm2	30	20	30	180	15
4	RP-1	SWBD#2, B9-4	08-P-211	3x4mm2+1x4mm2	30	10	30	50	15
5	RP-1	SWBD#3, A6-4	07-P-128	3x35mm2+1x35mm2	30	15	30	115	15
6	RP-1	SWBD#3, A4-4	07-P-144	3x70mm2+1x50mm2	30	15	30	130	15
7	RP-1	SWBD#4, B6-5	10-P-102	3x8mm2+1x8mm2	30	10	30	60	15
8	RP-1	SWBD#4, B7-3	02-P-183	3x8mm2+1x8mm2	30	10	30	60	15
9	RP-2	SWBD#1, B4-7	02-P-157	3x2.5mm2+1x2.5mm2	30	15	30	105	15
10	RP-2	SWBD#1, A8-9	04-C-103	7x2.5mm2	30	15	30	100	15
11	RP-2	SWBD#2, A8-10	05-P-228	3x2.5mm2+1x2.5mm2	30	15	30	145	15
12	RP-2	SWBD#2, B7-8	04-P-202	3x70mm2+1x50mm2	30	20	30	140	15
13	RP-2	SWBD#3, A6-2	07-P-221	3x8mm2+1x8mm2	30	20	30	110	15
14	RP-2	SWBD#3, B3-3	07-P-209	3x8mm2+1x8mm2	30	15	30	120	15
15	RP-2	SWBD#3, B6-1	07-P-150	3x2.5mm2+1x2.5mm2	30	25	30	130	15
16	RP-2	SWBD#3, A4-4	07-C-144	5x2.5mm2	30	20	30	125	15
17	RP-2	SWBD#1, B4-7	02-C-157	4x2.5mm2	30	20	30	120	15

0	37558	Pull New cable from Splicing Point to New RP	
1	37567	Identify position of feeder on switchboard at substation	Best Case Scenario - 15 min Worst Case Scenario - 30 min
1	37568	Lockout/Tagout Equipment @ sub-station	Best Case Scenario - 15 min Worst Case Scenario - 30 min
1	37571	Test cable to ensure no voltage with Multimeter	
1	37562	Disconnect or Cut cable from Switchboard (MCC)& Dress	Best Case Scenario - 10 min for small cable (per one cable) Worst Case Scenario - 60 min...
1	37569	Ground Cable	
1	37566	Identify Equipment in the field and make sure that cable is de-energized at Load	
1	37565	Lockout/Tagout Equipment @ Plant HOA station	Best Case Scenario - 15 min Worst Case Scenario - 30 min
1	37559	Test cable for voltage with Multimeter	
1	37564	Disconnect cable from consumer/load	Best Case Scenario - 15 min Worst Case Scenario - 60 min
1	37572	Megger test for cable integrity IR and PI	
1	37561	Dress and insulate cable ends	Best Case Scenario - 5 min Worst Case Scenario - 30 min
1	37570	Remove ground and insulate cable end	
1	37560	Splice cable to make sure cable is not live (de-energized)	WORST CASE
1	37573	Pull existing cable to splice point	Duration depends on cable size and length
1	37556	Perform Insulation Resistance (IR) test on New Cable	
1	37574	Splice old and new cable using splice kit instructions	
1	37659	Check and verify protection settings at new RP	
1	37547	Inspect and Test the Cable	
1	37546	Perform Final Megger Test	
1	37545	Remove insulation and terminate at Load	
1	37542	Assemble and Crimp Lug at switchgear	
1	37541	Tape and heat seal lug	
1	37540	Connect Cable to Switchboard	
1	37657	Perform Continuity Test by Multi meter or Megger Test	
1	37658	Complete Bump Test on Motor (Check motor rotation (for motor only))	
1	37557	Seal, label and abandon old cable from splicing point to old RP switchboard	
1	37539	Complete Documentation and Release to Operations	

Initial Field Data

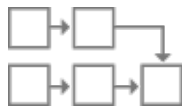
Designing the cutover field operation (NOT a schedule)

Cost,
Time
&
Cash



Product Design

+



Process Design

+



Capacity

+



Inventory

+

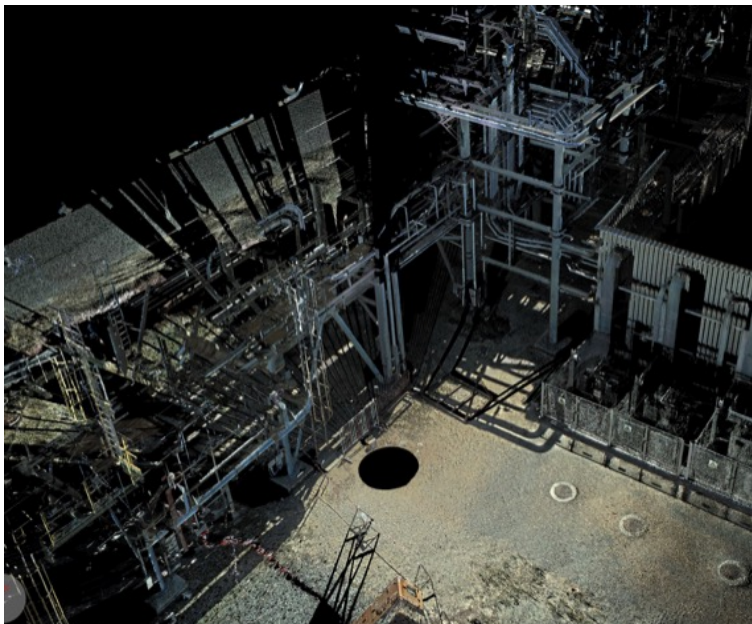


Variability

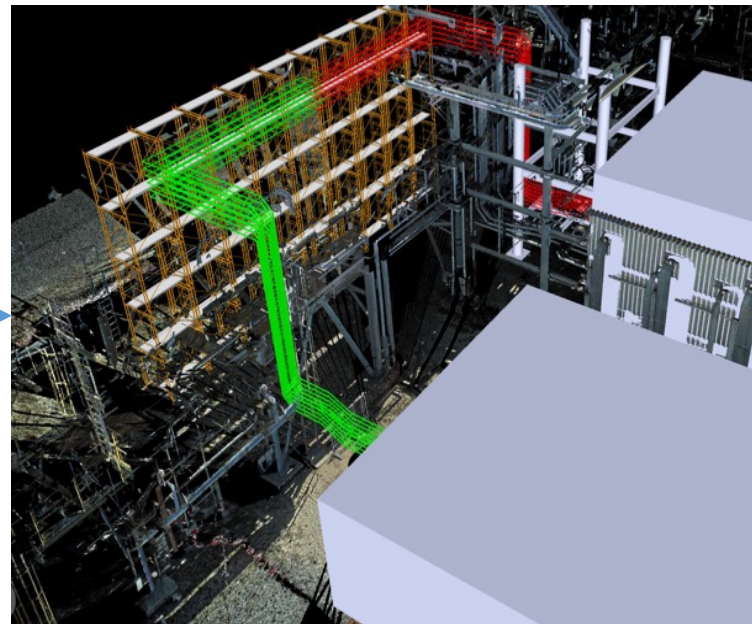
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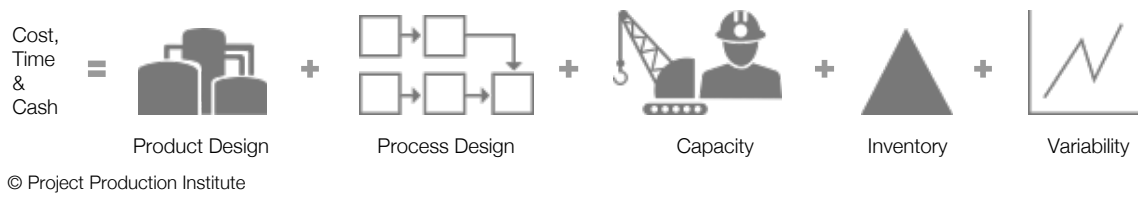
Product Design – Current Conditions & New Asset



Point Cloud – Existing Infrastructure & Conditions

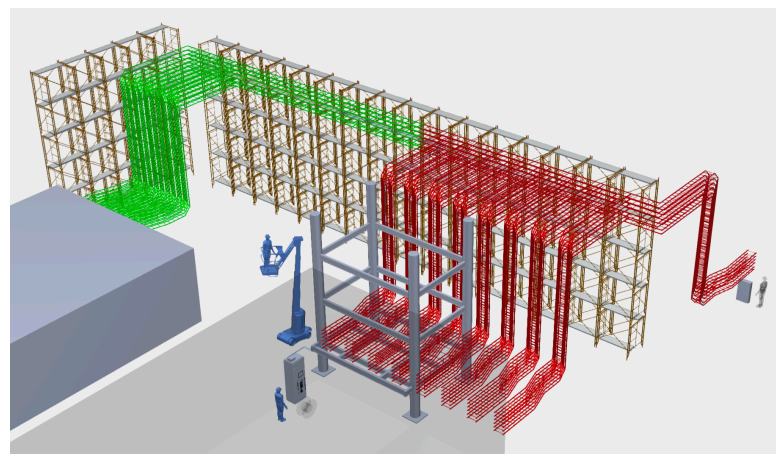
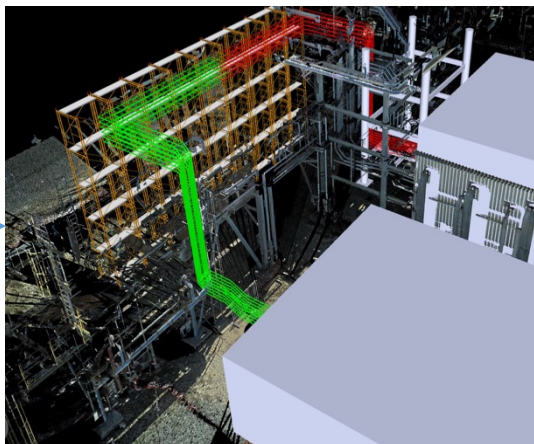


Product Design – Temporary & Permanent Elements





Simultaneous Process / Product Design



0	1	2	3	4
37559	Pull new cable from Splicing Point to New RP			
37567	Identify position of feeder on switchboard at substation Best Case Scenario - 15 min Worst Case Scenario - 30 min			
37568	Lockout/Tagout Equipment @ sub-station Best Case Scenario - 15 min Worst Case Scenario - 30 min			
37571	Test cable to ensure no voltage with Multimeter			
37562	Cut cable from Switchboard (NCC) Dress Best Case Scenario - 10 min for small cable (per one cable) Worst Case Scenario - 60 min			
37569	Ground Cable			
37566	Identify Equipment in the field and make sure that cable is de-energized at Load			
37565	Lockout/Tagout Equipment @ Plant HOA station Best Case Scenario - 15 min Worst Case Scenario - 30 min			
37559	Test cable for voltage with Multimeter			
37564	Disconnect cable from consumer/load Best Case Scenario - 15 min Worst Case Scenario - 60 min			
37572	Heater test for cable integrity (IR and PI)			
37561	Dress and insulate cable ends Best Case Scenario - 5 min Worst Case Scenario - 30 min			
37570	Remove ground and insulate cable end			
37560	Splice cable to make sure cable is not live (de-energized) WORST CASE			
37573	Pull existing cable to splice point Duration depends on cable size and length			
37566	Perform Insulation Resistance (IR) test on New Cable			
37574	Splice old and new cable using splice kit instructions			
37559	Check and verify protection settings at new RP			
37547	Inspect and Test the Cable			
37546	Perform Final Megger Test			
37545	Remove insulation and terminate at Load			
37542	Assemble and Crimp Lug at switchgear			
37541	Tape and heat seal lug			
37540	Connect Cable to Switchboard			
37557	Perform Continuity Test by Multi meter or Megger Test			
37558	Complete Bump Test on Motor (Check motor rotation (for motor only))			
37557	Seal, label and abandon old cable from splicing point to old RP switchboard			
37559	Complete Documentation and Release to Operations			



What We Are Learning

Enhanced understanding of constraints in the product and process design enables us to focus on the key areas and take the required actions/mitigations to improve execution cycle time, thus increasing throughput

Learnings and experience from current execution reality are now informing the digital model enabling the implementation of improvements and redesigning and testing of the future process before execution

Better understanding of the complexity of a process or workflow to inform early schedule development

Early engagement with engineering maximizes potential benefits to identify and address potential conflicts and omissions

The Implementation of CAPE forces alignment on the process from the start