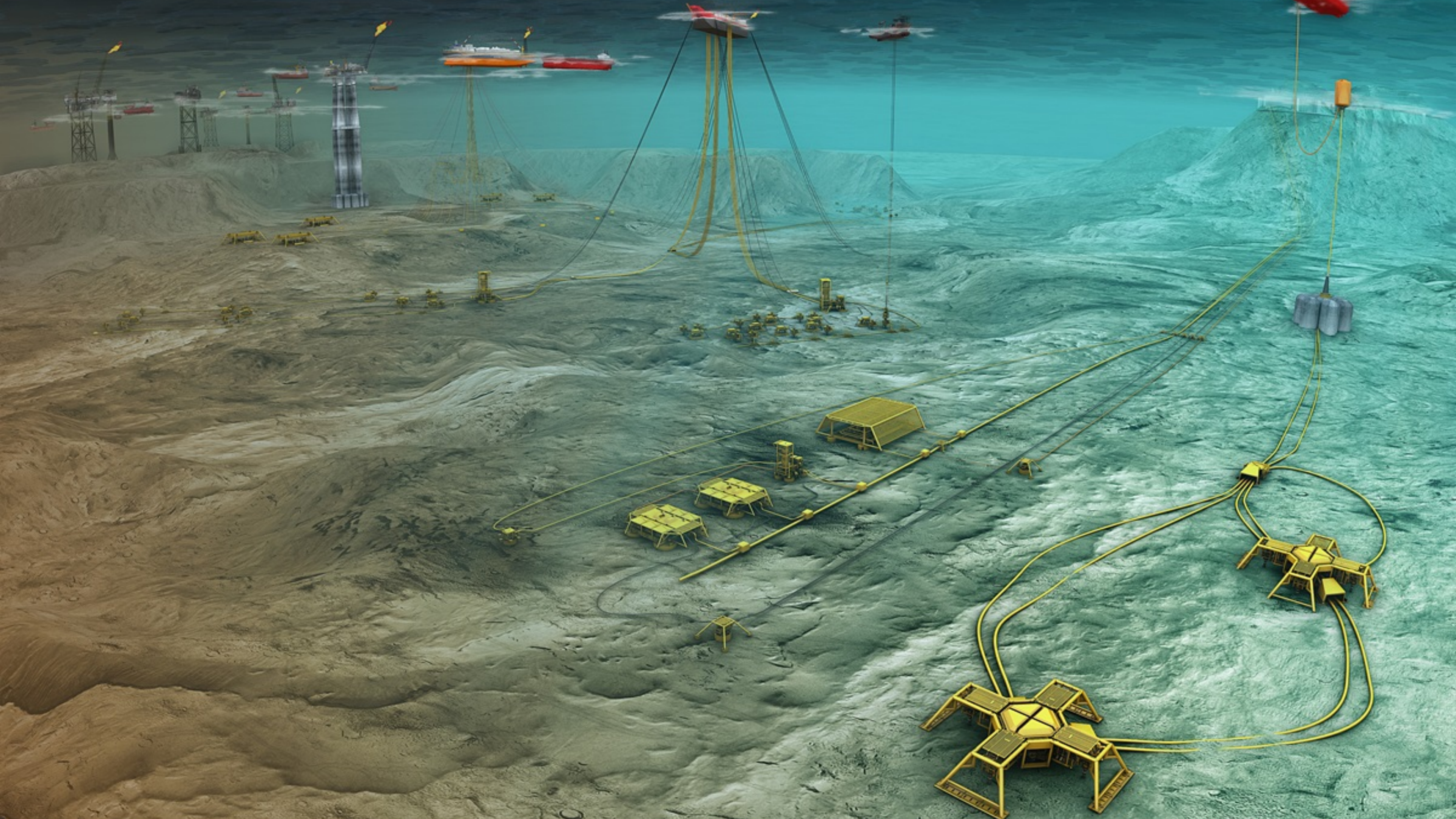
Industry Revolution Pulled by Lean Product and Process Development

Alan Labes and Allison Weber

Designing the Future Summit 2019

lppd Lean Product & Process Development

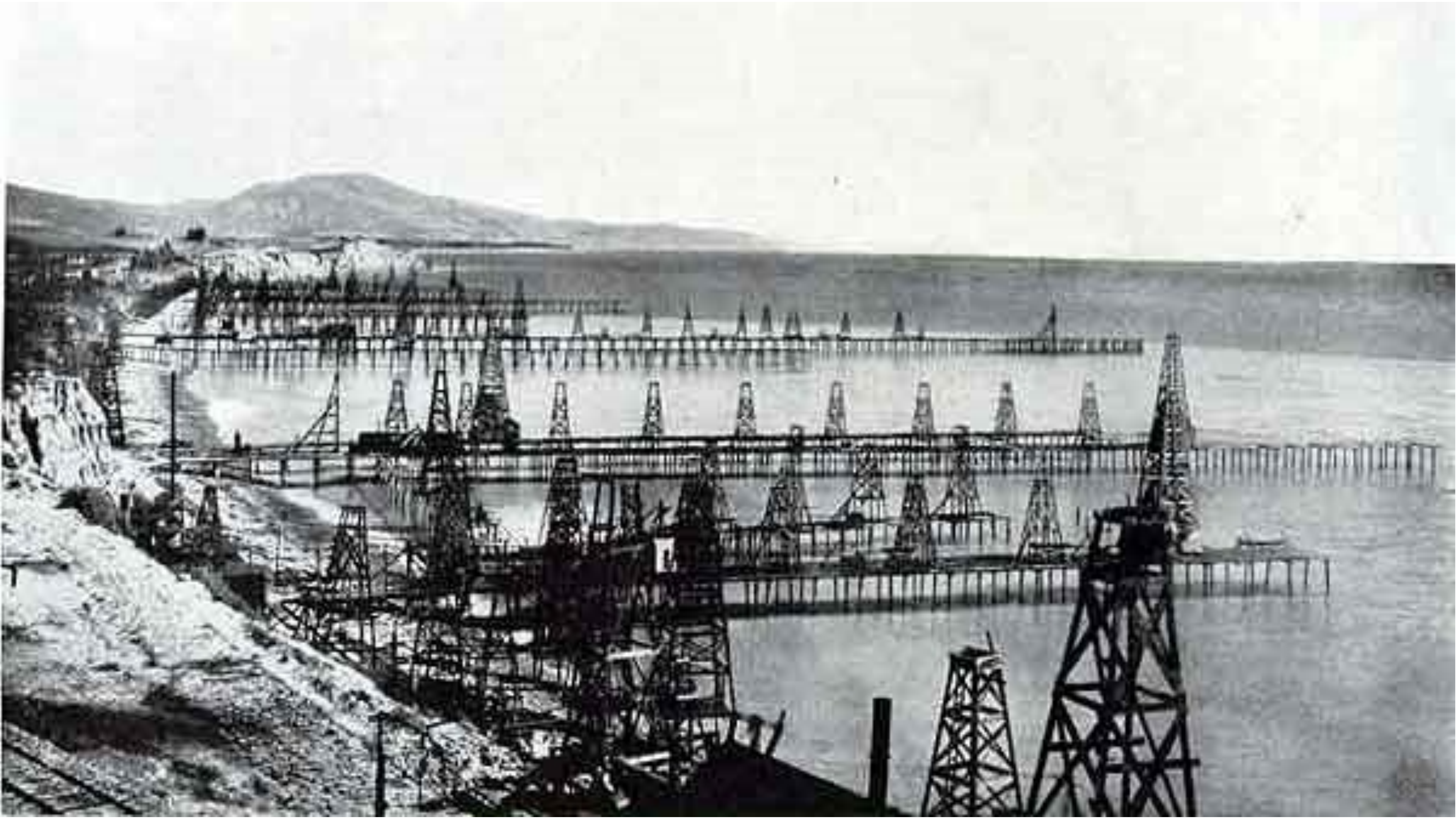


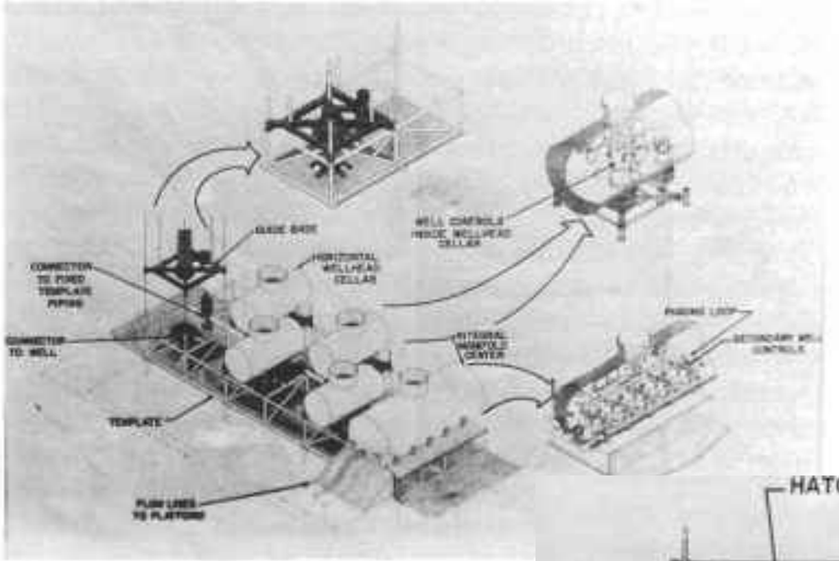

FL/U
CIT2
FULV

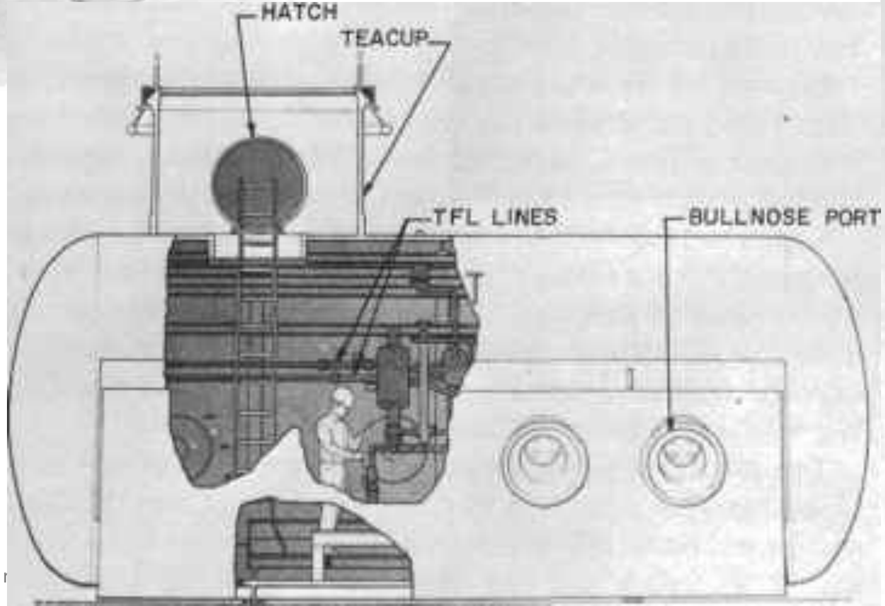

TechnipFMC
MGW:
24000 KG
8
8
5

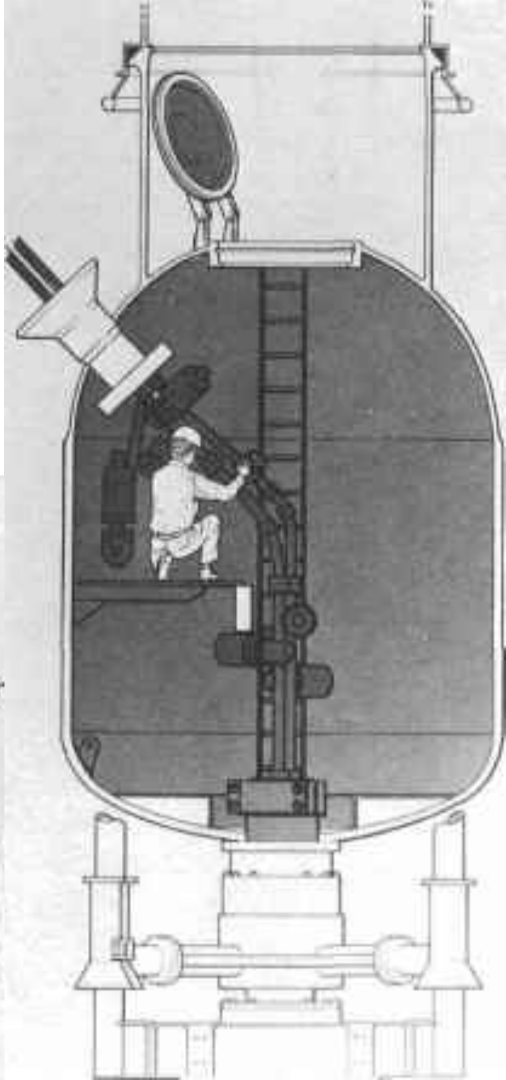

86

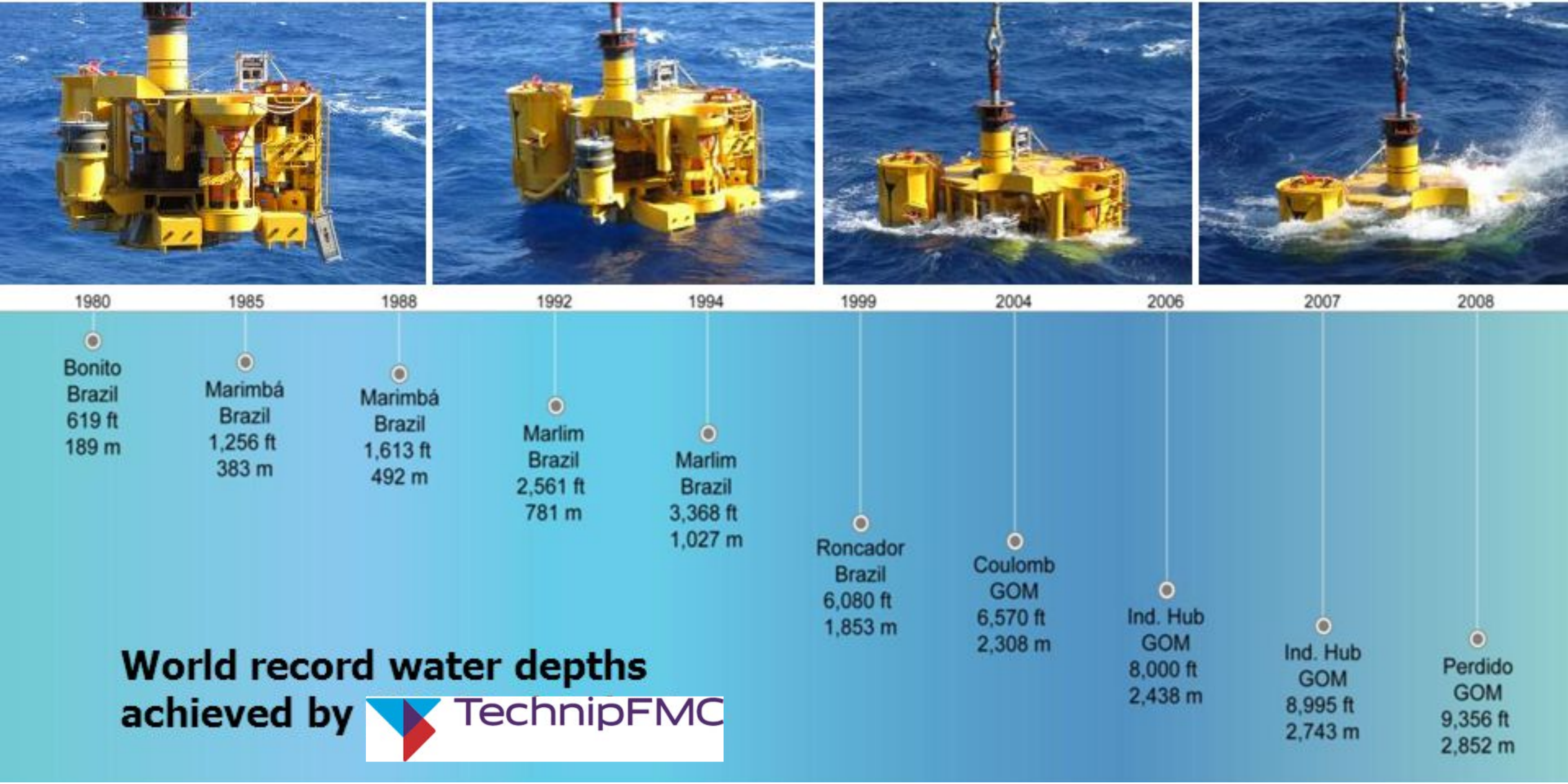

TechnipFMC




GUIDE BASE
WELL CONTROLS INSIDE WELLHEAD CELLAR
CONNECTOR TO FIXED TEMPLATE PIPING
HORIZONTAL WELLHEAD CELLAR
CONNECTOR TO WELL
INTEGRAL MANIFOLD CENTER
TEMPLATE
FLOW LINES TO PLATFORM

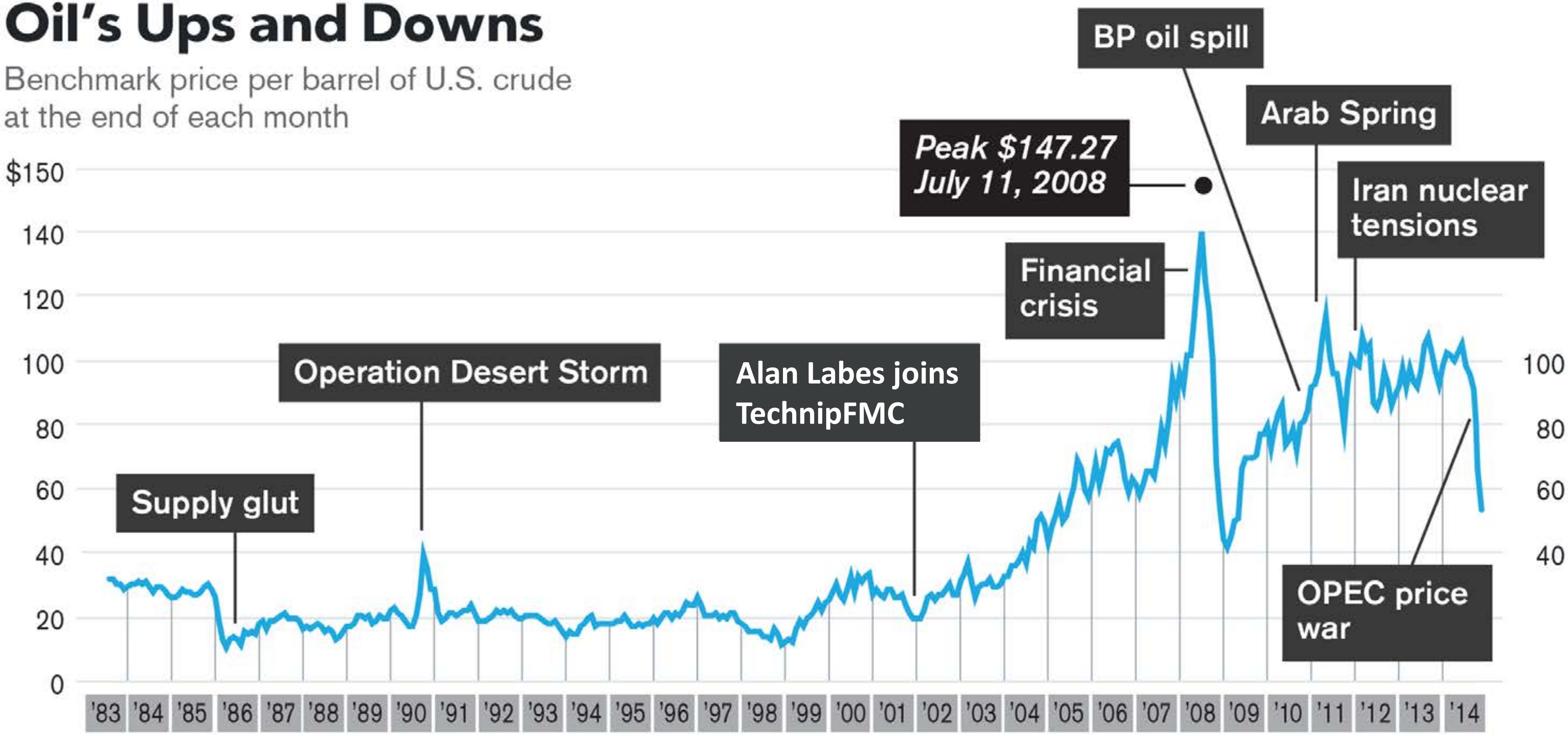

HATCH
TEACUP
TFL LINES
BULLNOSE PORT




1980
Bonito Brazil 619 ft 189 m
1985
Marimbá Brazil 1,256 ft 383 m
1988
Marimbá Brazil 1,613 ft 492 m
1992
Marlim Brazil 2,561 ft 781 m
1994
Marlim Brazil 3,368 ft 1,027 m
1999
Roncador Brazil 6,080 ft 1,853 m
2004
Coulomb GOM 6,570 ft 2,308 m
2006
Ind. Hub GOM 8,000 ft 2,438 m
2007
Ind. Hub GOM 8,995 ft 2,743 m
2008
Perdido GOM 9,356 ft 2,852 m
World record water depths achieved by
TechnipFMC

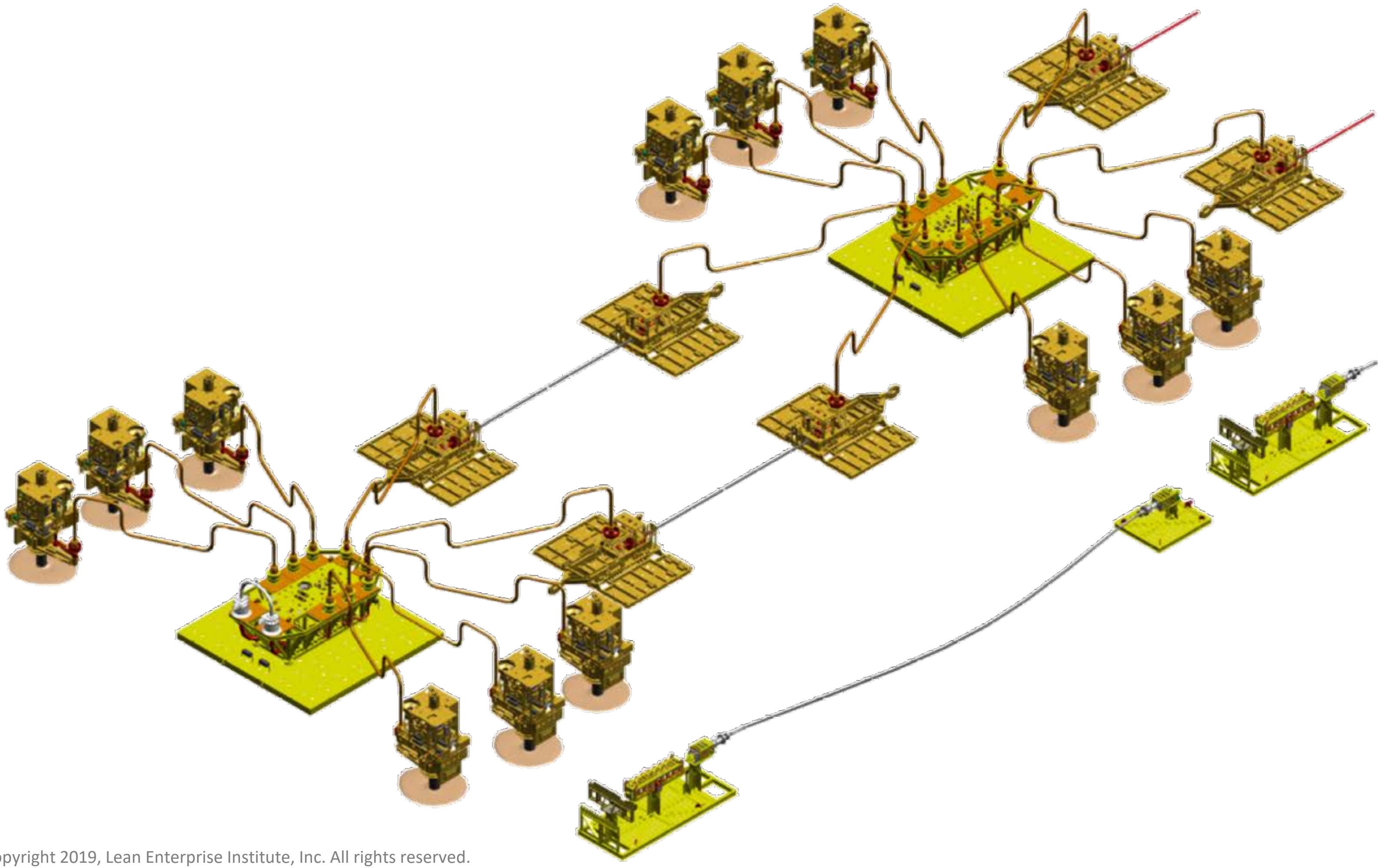
Oil's Ups and Downs

Benchmark price per barrel of U.S. crude at the end of each month



The vision for Subsea 2.0 project is to **enable an enterprise wide transformation through radically different product development**, designed fully integrated with manufacturing, assembling and supply chain development. The FMC post-Subsea 2.0 has the potential to be a company that can **manufacture its products with no product engineering after purchase order, requiring no project management for execution and manufacturing its products consistently, on stable assembly lines**, with very predictable delivery schedule and manufacturing cost. The simplicity of the products and perfect fit to manufacturing process and assembling lines would allow FMC to dramatically simplify its worldwide organization reducing headcount requirements and assets, while increasing profitability and market share.

CONFIDENTIAL



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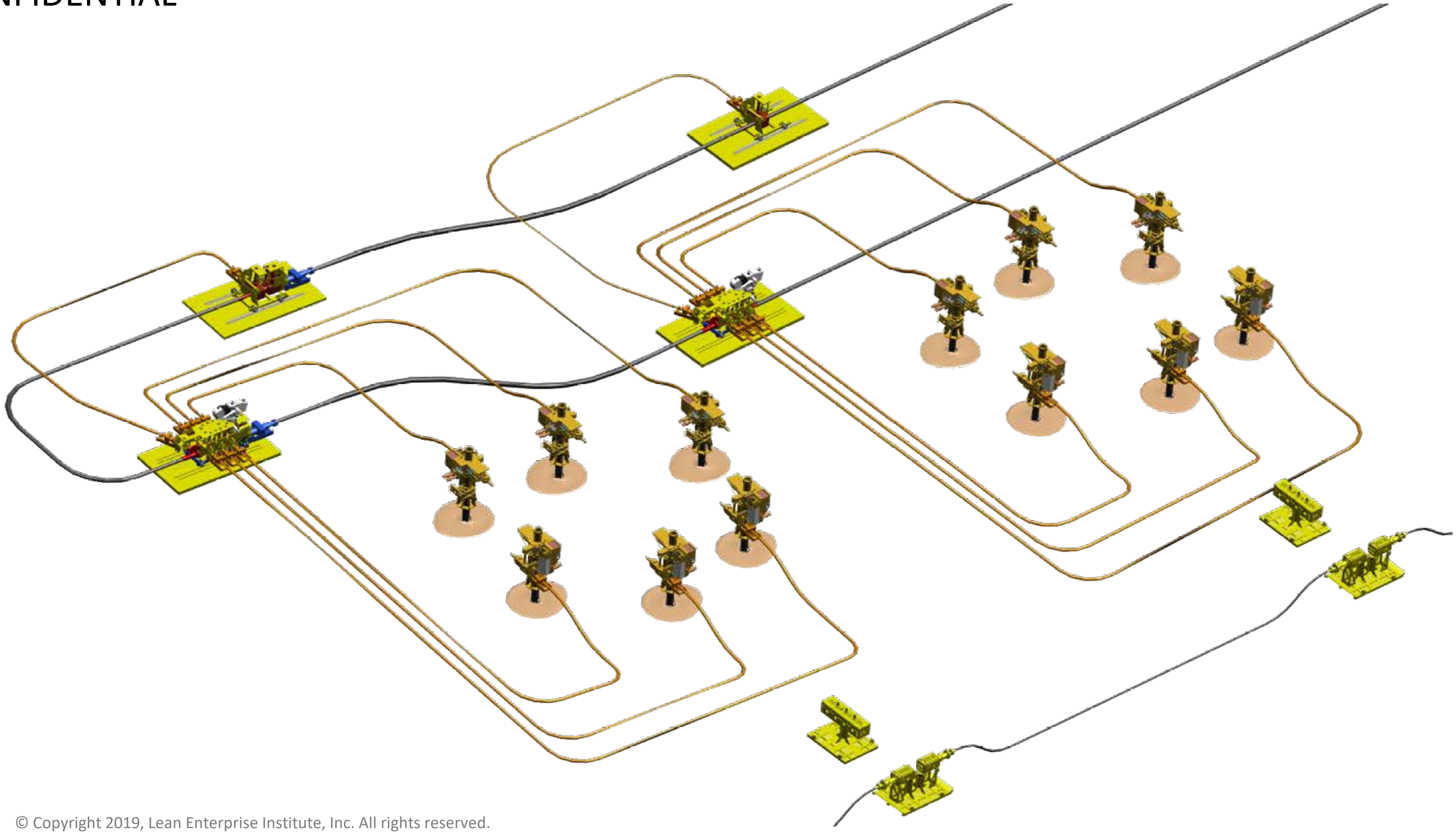
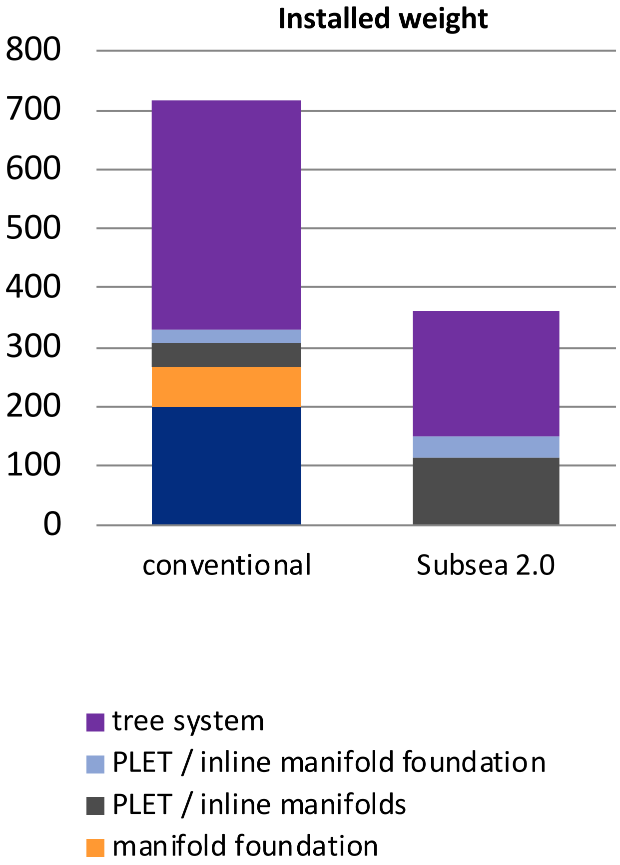
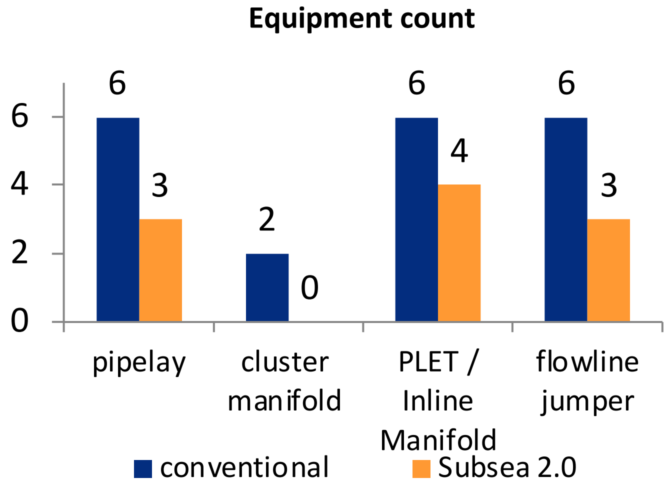
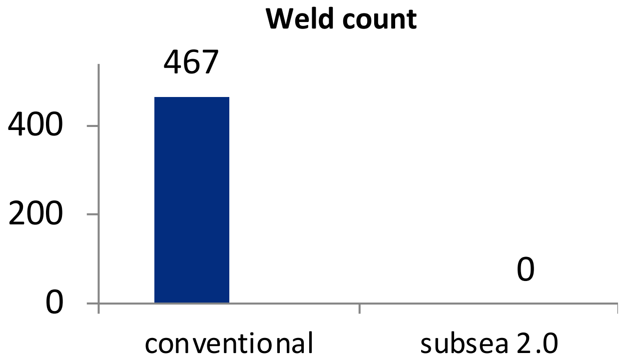


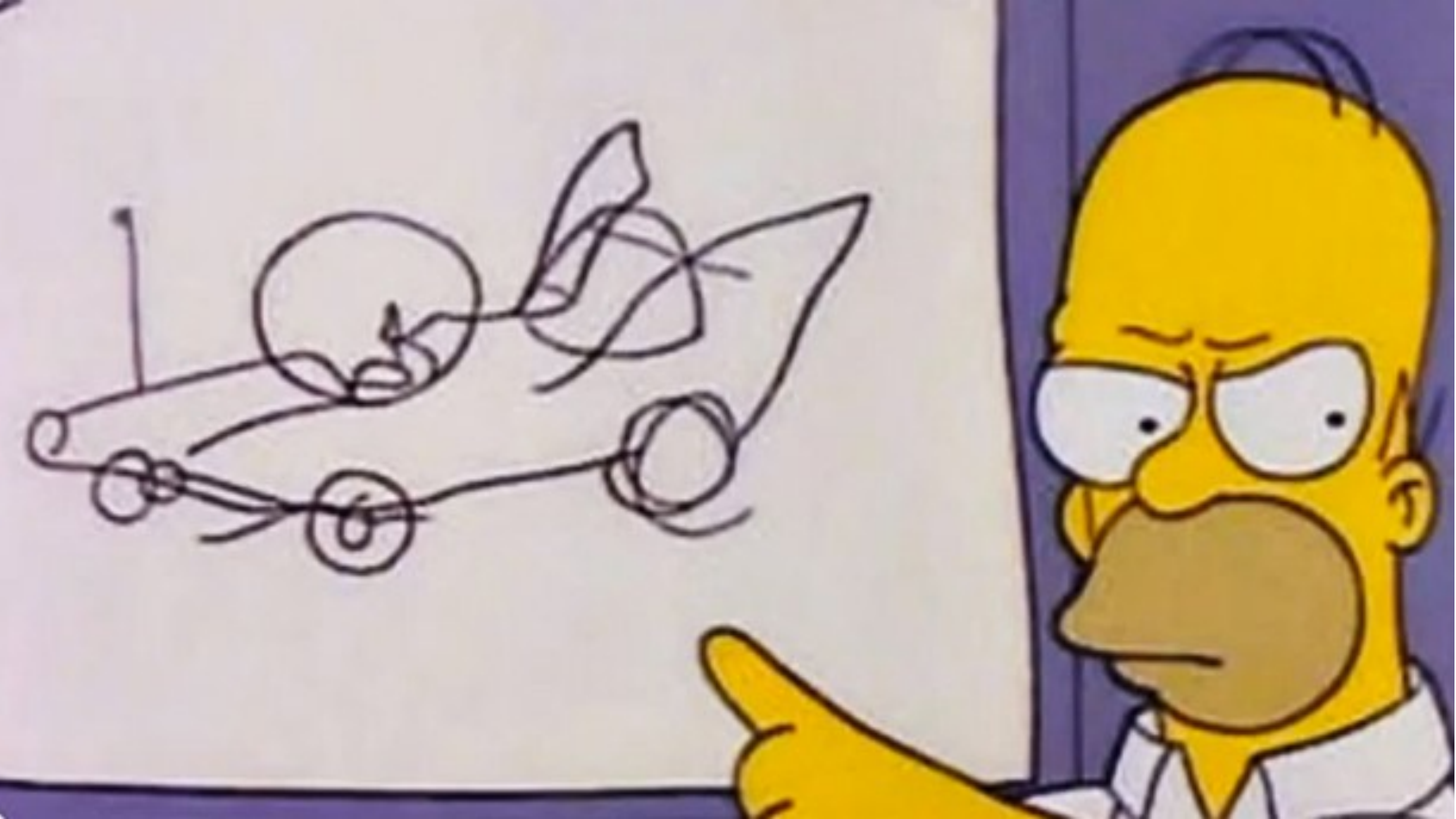






* 6 XTs scenario


FC474ME
FMC
FC474ME
FMC
FMC
ME
FC 474



SS2.0E – KENGAI EXTENSION

Author:	John Calder – Chief Product Developer, Valve & Choke
Revision Date:	March 22, 2018

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Chief Product Developer

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Chief Architect & Platform Integration

Huei Lai
Chief Product Developer

Rick Murphy
Chief Product Developer

Carlos Trevisani
Chief Product Developer

Tom Hergarden
Chief System Engineer

Vision

The vision of the **Kengai** project is to design a range of subsea gate valves, either hydraulic actuated or manual operated, that, by challenging current requirements and judicious introduction of new technology a 50% reduction in cost, size, weight and part count, will be achieved when compared to the current baseline product offering (M3000).

Background

Over the past 25+ years FMC has designed several actuator families for subsea applications. These have ranged from the original shallow water and deep water actuators through the M2500 and M3000 product families to the latest generation, which is the E3 actuator.

Through out this time design features have come and gone, knowledge either not being captured or being ignored, recycling performance issues and adding additional complexity on each iteration. This has caused the product cost, size and weight to spiral out of control, leaving us in a position where our valve/actuator products are no longer commercially viable.

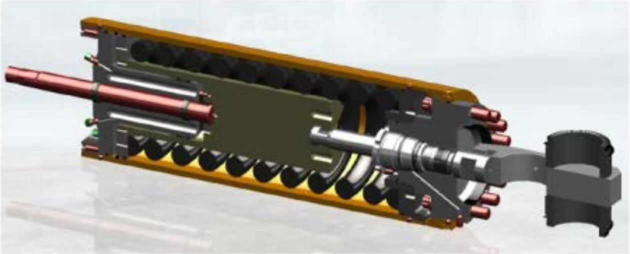


Figure 3: **Kengai** 5" 10K Actuated Valve Kit

The 2" and 5" 15KSI actuators will be developed in conjunction with an ongoing project supported by a client. **Kengai2** will leverage this hyper-deep water project.

The 7" 10KSI actuator will be a deepwater version of the actuator that was developed last year for shallow water applications. The deepwater version was designed at the same time as the shallow water, with the specific requirement to only change (3) components to facilitate the depth increase.

Scope

Product

The **Kengai2** project scope will encompass the following key deliverables:

- 7" 10KSI (10,000ft) actuated valve kit
- 7" 10KSI manual valve kit
- 2" and 5" 15KSI actuated valve kits
- 2" and 5" 15KSI manual valve kits

Must Have
Complete alignment with **Bonsai** tree and Compact Robotic Manifold projects
Actuated valves – product family extension sharing common features with Kengai: • T-slot connection between gate and stem • SBMS bonnet gasket • 12pt ferry head cap screws • Coil spring • 2 chamber design
Manual valves – product family extension with the following features: • DO NOT TOUCH DRIVE TRAIN! • SBMS bonnet gasket • 12pt ferry head cap screws • ROV extension interface integral to bonnet cap
Manual and actuated valves must share common interface to valve body or tree block

Changes are shown in RED font

A3

15K EVDT and EHXT Tree Designs - 3Mar2019

Thursday, August 16, 2018 5:27 PM

Owner: Allison Weber
Title: Subsea 2.0 Vertical and Horizontal Tree Design

Problem/Importance:

The SS2.0 Vertical and Horizontal Tree assemblies have set out to accomplish the following goals:

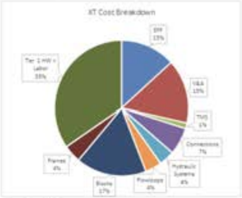
- 50% less cost than a SS1.0 tree,
- 70% less parts than a SS1.0 tree, and
- 30% less weight than a SS1.0 tree
- 8 month product delivery time

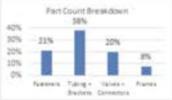
Both tree systems shall use a UCON-H KC4.2-10 flowline connection, TFMC choke, TFMC meter, TFMC gate valves, and TFMC controls. Tree team to determine if PSDV + G2i will provide value. 3" oil, 5" oil, and 5" gas meters should be considered.

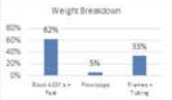
Current Conditions:

15K trees are predominantly in Gulf of Mexico with a smaller market in the North Sea and an emerging market in Brazil.
The forecasting and upside data shows that there is potential for approximately 80 15ksi tree contract awards from 2019 to 2021. 30% of these trees are horizontal opportunities and 70% are vertical opportunities. Shell and LLOG have communicated plans to standardize their tree portfolios with 15ksi EVDT's and EHXT's rather than buying 10ksi and 15ksi products in the future. If this holds true, this will add approximately 50 trees to the forecast data.

Project	Description	Cost (XT, FM, THD; 2018; USD)	Part Count (XT, THD)	Weight (XT, THD; lbs)
Anadarko K2	15K HXT w/out FM	$2,321,631	9,761	97,483
Shell Vito	15K VXT w/ FM	$4,405,803	14,648	115,730 56,405







Opportunities -

- Equinor Cacara - TRL4 June 2019
- LLOG - TRL4 June 2019; Award Q3 2019

Objective:

Realize the following product targets by Dec 2019. Product TRL4 by June 2019.

Tree System Targets		
Feature (in order of importance)	**Reduction**	**Target Value**
Cost	50% from SS1.0	EVDT - $2,402,901 [2018 data] EHXT - $1,160,815 [2018 data]
Lead Time	-	8 months
Part Count	70% from SS1.0	4395 - Vertical XT w/ retrievable meter and THD 2928 - Horizontal XT w/ out retrievable meter
Weight	30% from SS1.0 XT 50% from SS1.0 THD	Retrievable Meter XT - 70 kips Resident Meter XT - 65 kips No Meter XT - 65 kips Tubing Head - 27.5 kips

Analysis of Targets:

Parameter	Target	EHXT	EVDT
Product Cost	*50% Reduction from SS1.0*	⇩ 26% (on track per Glide Path)	⇩ 23% (on track per Glide Path)
Product Lead Time	*8 months*	8 months - with stocking plan	8 months - with stocking plan
Part Count	*70% Reduction from SS1.0*	⇩ 15% +2.5% (on track per Glide Path)	⇩ 21% + 4% (on track per Glide Path)
Weight	*30% Reduction from SS1.0*	65 kips	75 kips; 25 kips
Schedule	*TRL4 June 2019* *DR4 Dec 2019*	TRL4 - Aug '19 DR4 - Dec '19	TRL4 - Aug '19 DR4 - Dec '19

Breakdown of Part Count Realizations

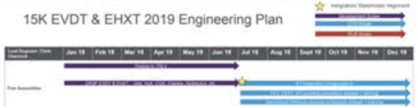
Scope	EHXT Part Count	EVDT Part Count
Blocks	⇩ 37%	⇩ 53%
Hydraulic & Electric System	0% - June '19	0% - June '19
connections	⇩ 93%	⇩ 80%
Frames	0% - June '19	0% - June '19
Flowloops	⇩ 100%	⇩ 100%
V&A	⇩ 51%	⇩ 58%
Total	⇩ 17.5%	⇩ 25%

Breakdown of Cost Realizations

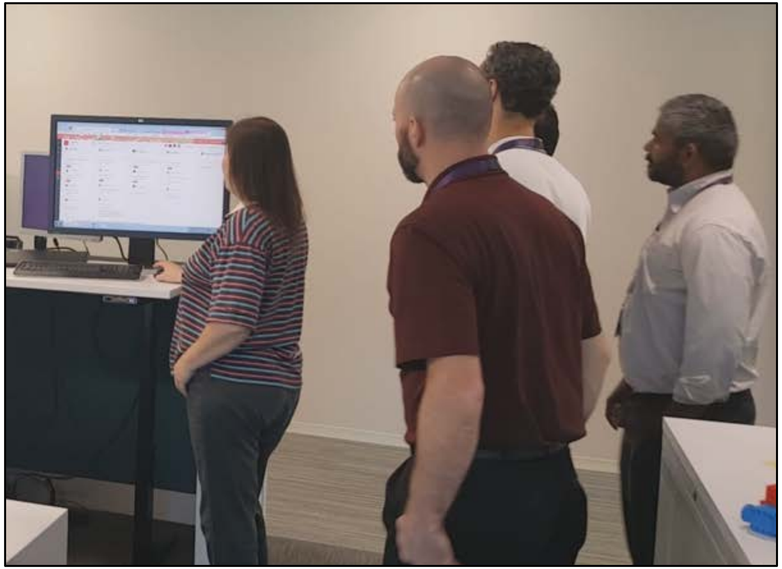
Scope	EHXT Cost	EVDT Cost
Blocks, Connections, Flowloops, V&A	⇩ 47%	⇩ 51%
Hydraulic & Electric System	0% - June '19	0% - June '19
Tier 1 HW & Labor	0% - Dec '19	0% - Dec '19
Total	⇩ 26%	⇩ 23%

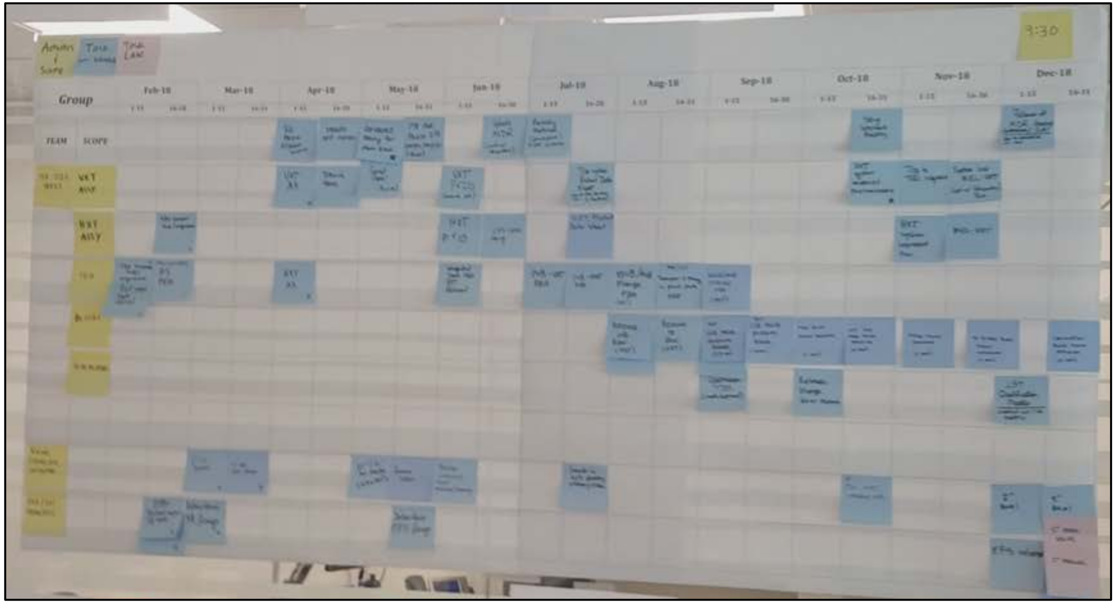
Countermeasures & Plan:

Action	POC	Start	End	Status	Remarks
TRL4 - Manage all activities that lead up to each test in scope. Ensure each test committed date is met on time.	Sabin Holland		Jun '19	IP	Email sent pulling Andon cord to the following Functional Mangers - Development, Technology PM, Planning & Buying.
Lead Time - Supply chain to develop vendor list and strategy for all components.	Michael Morrissey		Sep '19	IP	This is usually triggered and managed through a tender process.
Lead Time - Commercial to define market need and financially support a stocking program investment.	Jocelyn Waggoner & Milena LaCour		Sep '19	NS	
Lead Time - Tree Portfolio to see what can be done to maximize common parts and/or raw material in order to simplify stocking program and supply chain strategy.	Jonathan Morley & Michael Morrissey		May '19	IP	Jonathan - business/ strategy Michael - SC to use economy of scale into decision making criteria.
Lead time - Can we create a glide path for lead time analysis?	TBD		Jun '19	NS	
Cost & Lead Time - Take our tree through tender process to prepare for market acceptance and check that cost and lead time match team's projections.	TBD		Jun '19	NS	
Cost - Finalize test plan and labor required.	Chris Charnock		Dec '19	IP	Labor to be reduced by minimizing A&T time.
Part Count - Update Glide Path with Hydraulics and Framework	Chris Charnock		June '19	NS	
Cost - Update Glide Path with hydraulics and framework	Chris Charnock		June '19	NS	
Cost - Update Glide Path with Tier 1 HW & Labor	Chris Charnock		Dec '19	NS	



Obeya: First Attempt

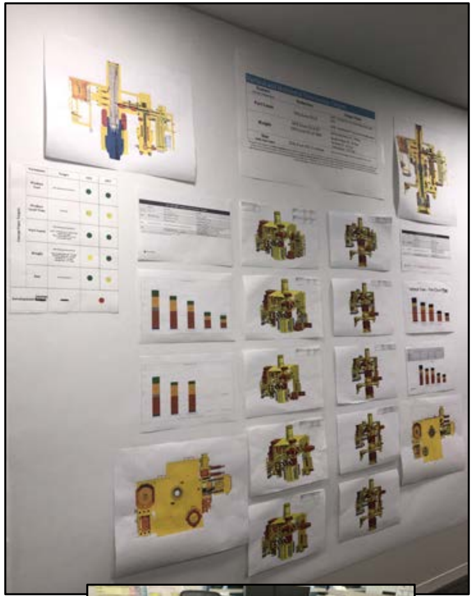




Obeya: 15 Months Later

Obeya: 15 Months Later

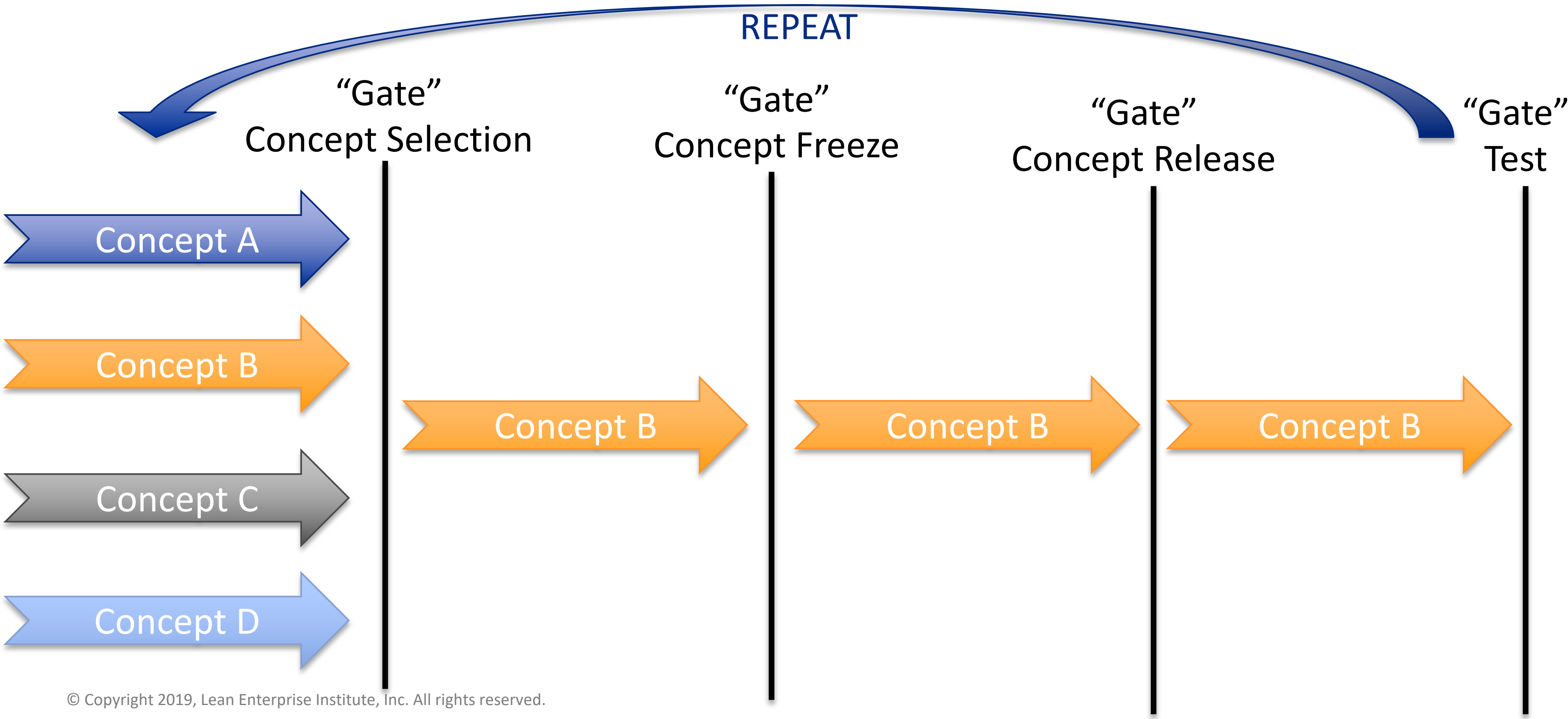
Product Targets and Concepts



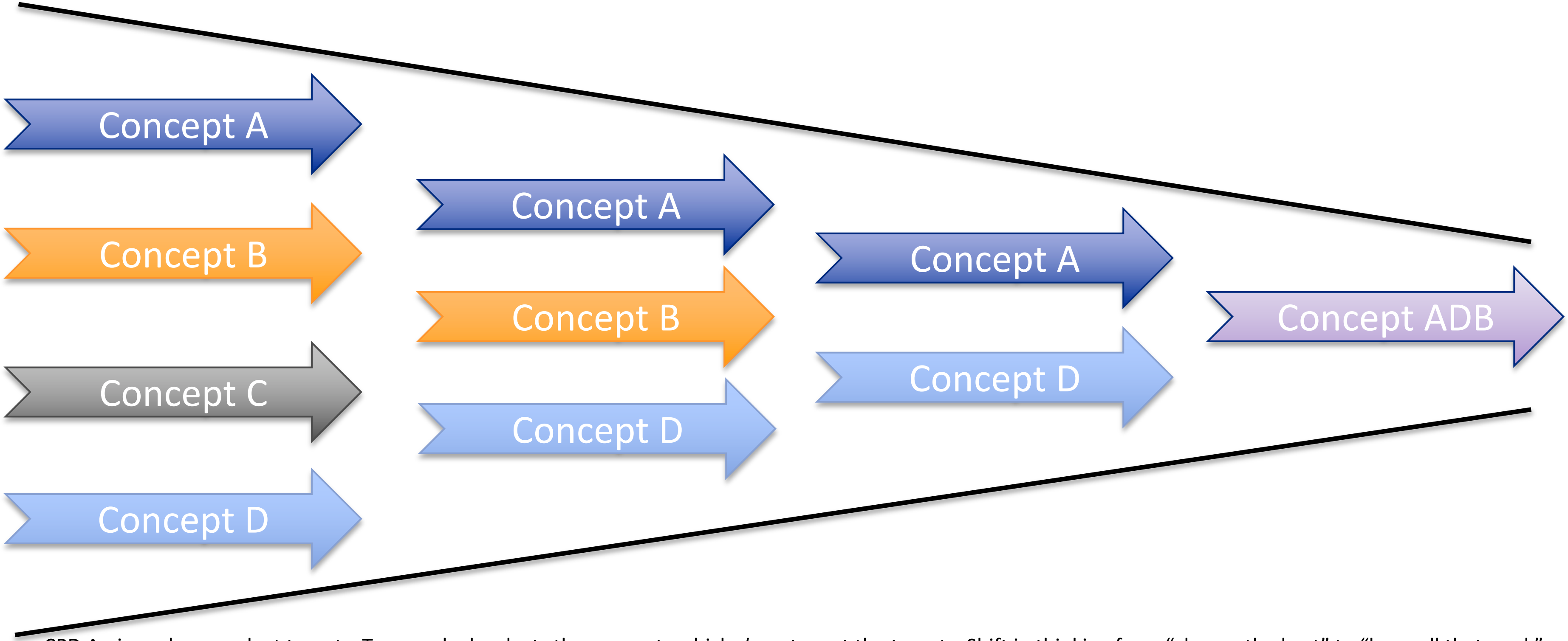
Schedule

Global Program

Historical Development Process

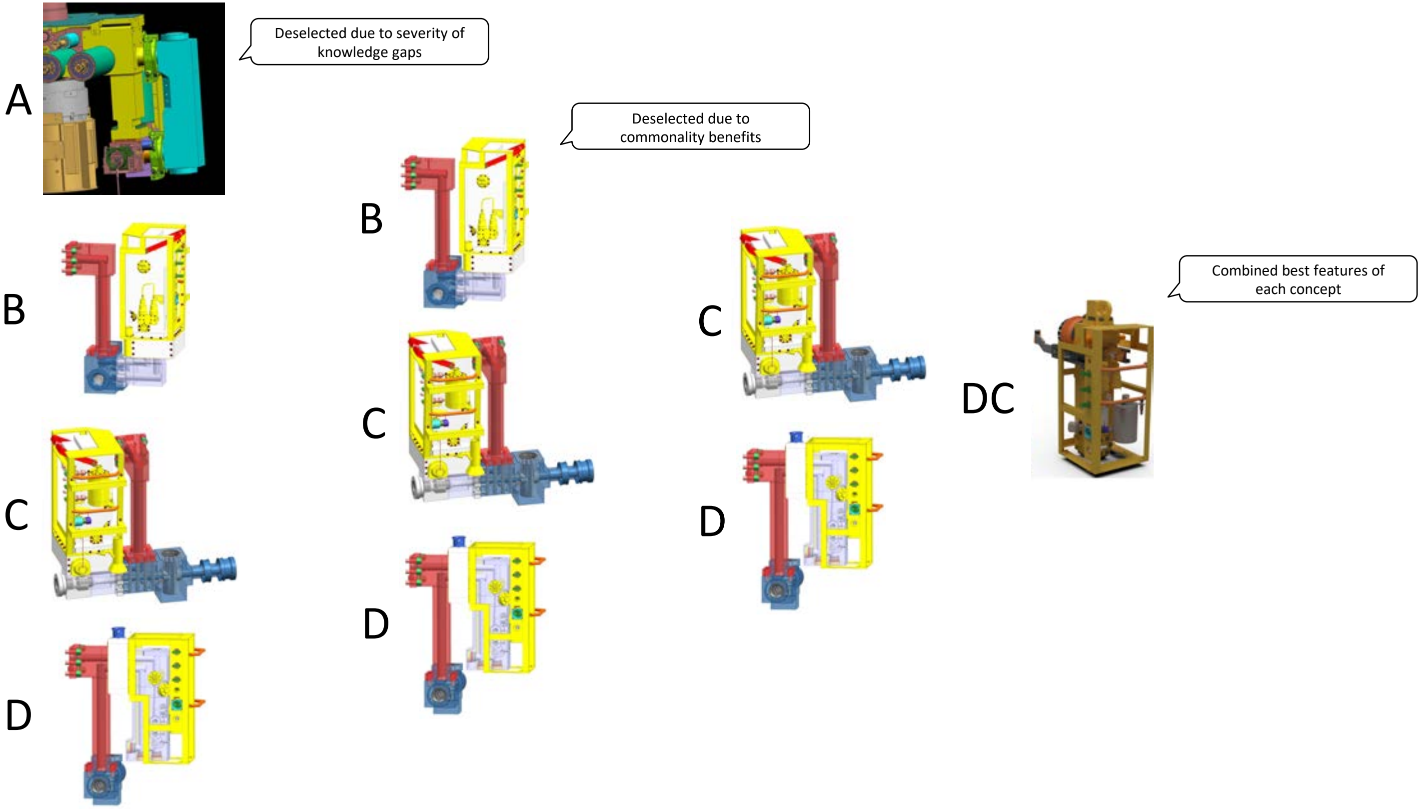


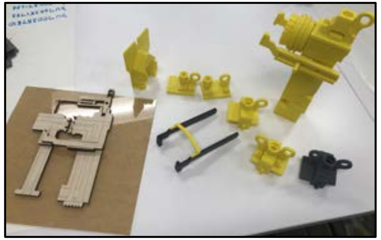
Set Based Concurrent Engineering



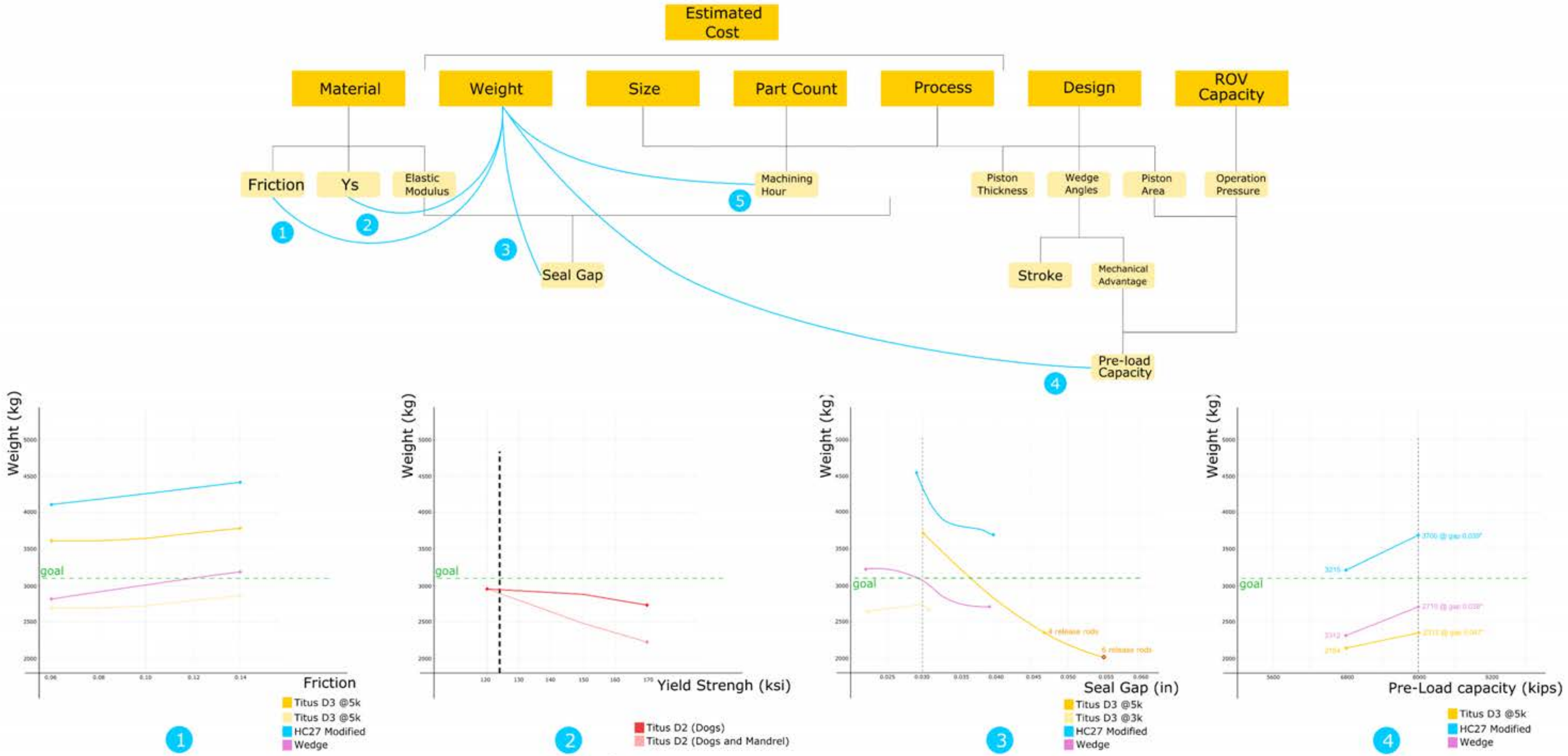
CPD Assigns clear product targets. Team only deselects the concepts which *do not* meet the targets. Shift in thinking from “choose the best” to “keep all that work”.

Set Based Concurrent Engineering Development Process

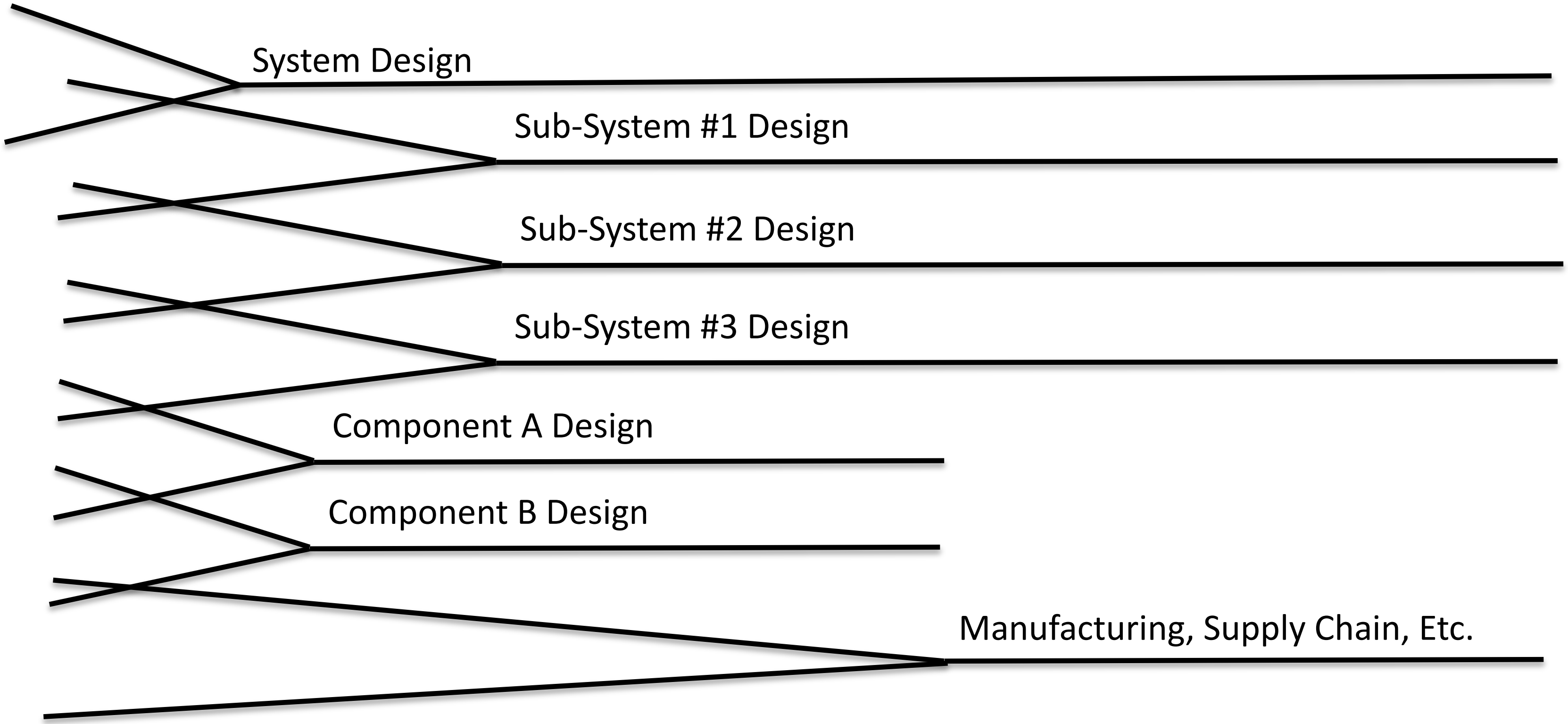




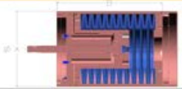
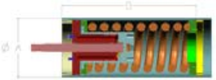
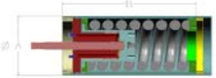
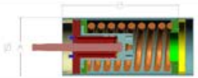
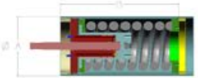
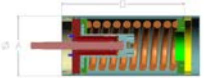
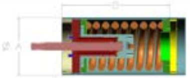
Trade off Curves for the **Compact Connector**



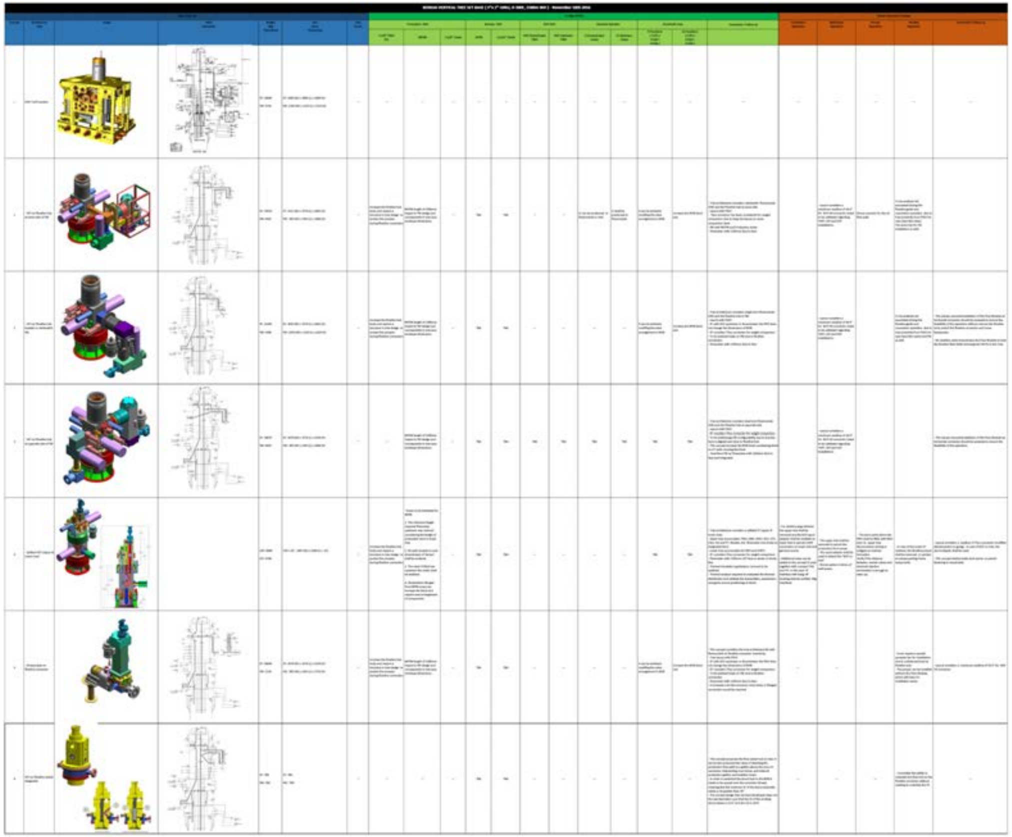
Set Based Concurrent Engineering: System

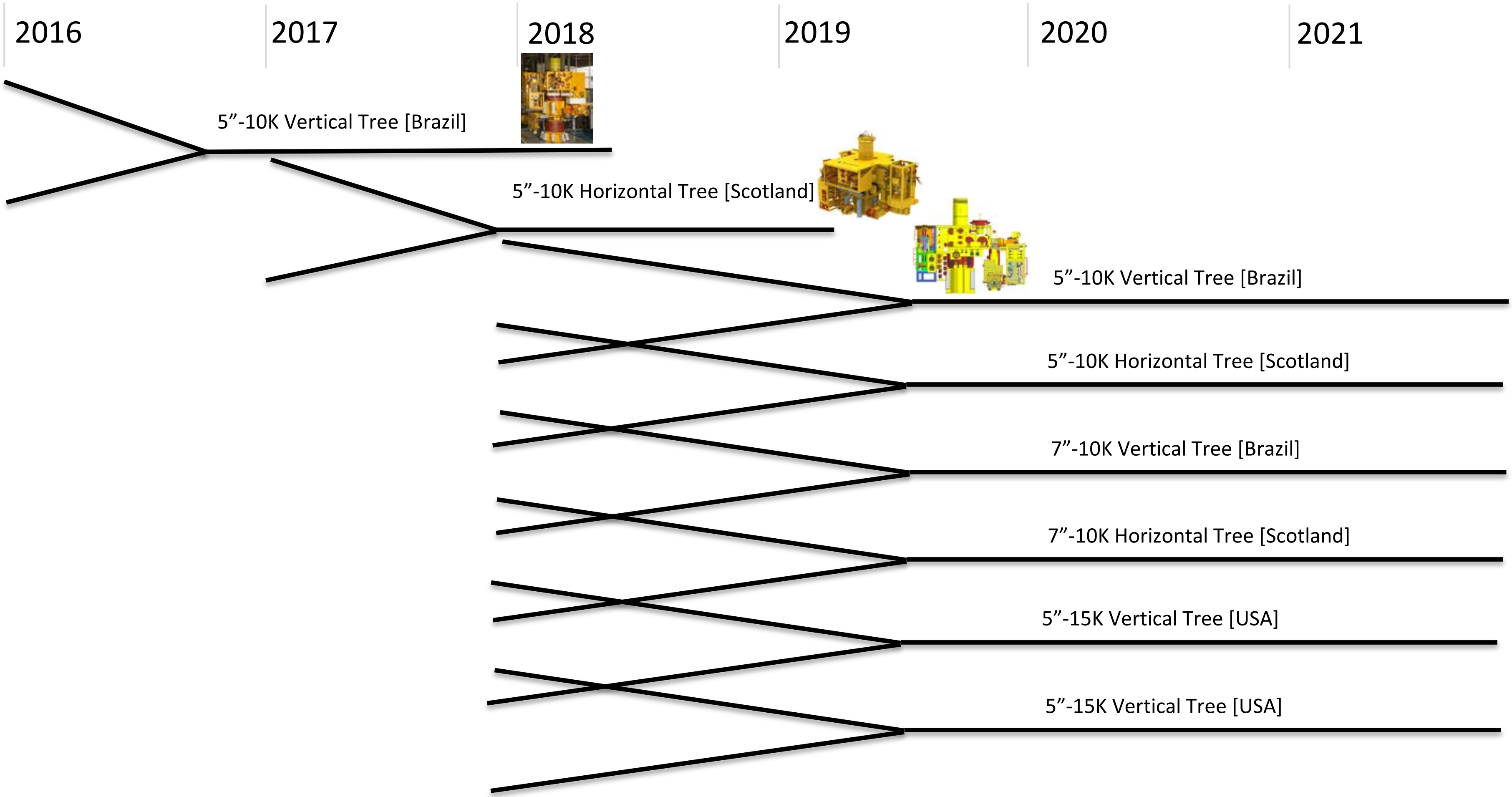


Valve Assembly Concepts

Concept	Actuator Weight (kg)	A (in)	B (in)	Assumptions	Image
Standard M3000 (REFERENCE)	635	19,50	26,61	3000m WD	
STEEL COIL SPRING, 14.50IN OD X 54.00IN, 2000M WD, .18F	381 (-40%)	14,50	32,27	2000m WD NRS 350F TEMPERATURE 5Ksi CONTROL PRESSURE .18 FRICTION COEFFICIENT	
TITANIUM COIL SPRING, 14.50IN OD X 54.00IN, 3000M WD, .18F	360 (-43.3%)	14,50	32,27	3000m WD NRS 350F TEMPERATURE 5Ksi CONTROL PRESSURE .18 FRICTION COEFFICIENT	
STEEL COIL SPRING, 14.50IN OD X 54.00IN, 3000M WD, .12F (DLC)	368 (-42%)	14,50	32,27	3000m WD NRS 350F TEMPERATURE 5Ksi CONTROL PRESSURE .12 FRICTION COEFFICIENT	
STEEL COIL SPRING, 14.50IN OD X 51.00IN, 2000M WD, .12F (DLC)	334 (-47.4%)	14,50	29,30	2000m WD NRS 350F TEMPERATURE 5Ksi CONTROL PRESSURE .12 FRICTION COEFFICIENT	
TITANIUM COIL SPRING, 14.50IN OD X 51.00IN, 3000M WD, .12F (DLC)	317 (-50%)	14,50	29,30	3000m WD NRS 350F TEMPERATURE 5Ksi CONTROL PRESSURE .12 FRICTION COEFFICIENT	
STEEL COIL SPRING, 14.50IN OD X 51.00IN, 3000M WD, .09F (DLC)	330 (-48%)	14,50	29,30	3000m WD NRS 350F TEMPERATURE 5Ksi CONTROL PRESSURE .09 FRICTION COEFFICIENT	
STEEL COIL SPRING, 14.50IN OD X 48.00IN, 2000M WD, .09F (DLC)	310 (-51.2%)	14,50	26,38	2000m WD NRS 350F TEMPERATURE 5Ksi CONTROL PRESSURE .09 FRICTION COEFFICIENT	
TITANIUM COIL SPRING, 14.50IN OD X 48.00IN, 3000M WD, .09F (DLC)	285 (-55.1%)	14,50	26,38	3000m WD NRS 350F TEMPERATURE 5Ksi CONTROL PRESSURE .09 FRICTION COEFFICIENT	

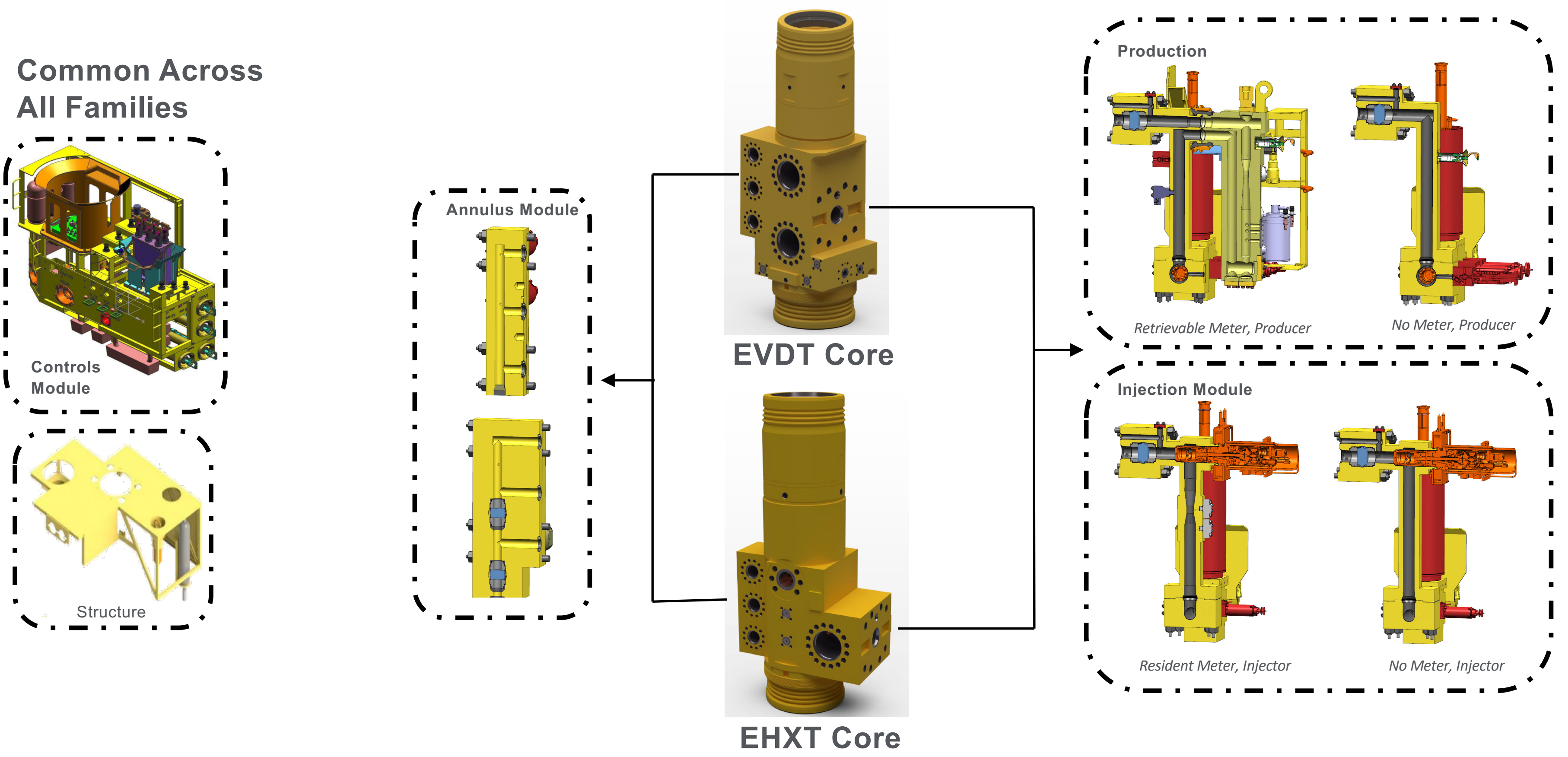
Tree Assembly Concepts




2016
2017
2018
2019
2020
2021
5”-10K Vertical Tree [Brazil]
5”-10K Horizontal Tree [Scotland]
5”-10K Vertical Tree [Brazil]
5”-10K Horizontal Tree [Scotland]
7”-10K Vertical Tree [Brazil]
7”-10K Horizontal Tree [Scotland]
5”-15K Vertical Tree [USA]
5”-15K Vertical Tree [USA]

Tree Portfolio: Common Architecture

Common Across Each Family



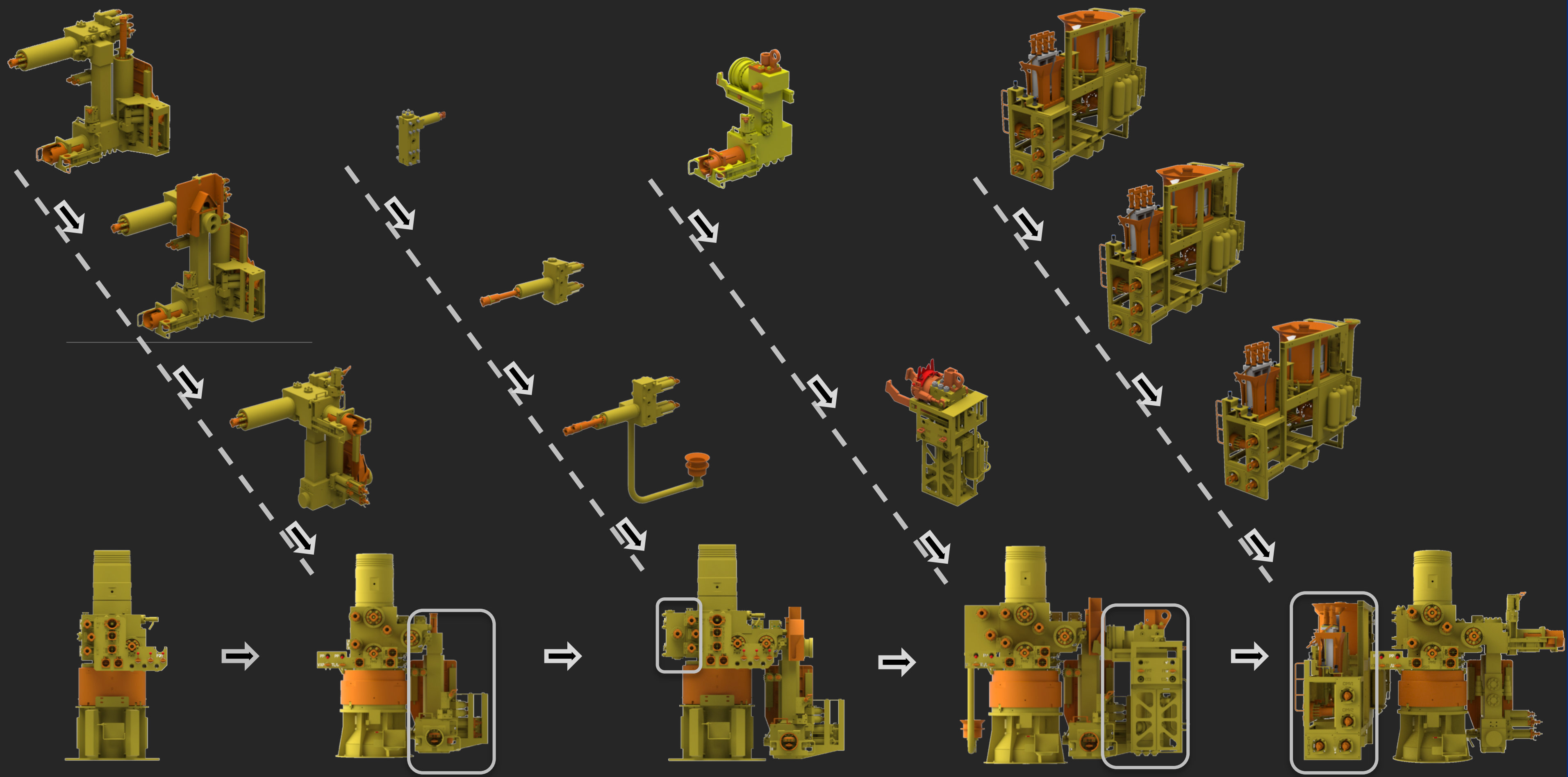
Subsea Tree Concept

Original Design

	Core	Production Module	Injection Module	Annulus Module
5-10K Vertical Tree				
5-10K Horizontal Tree				
5-15K Vertical Tree				
5-15K Horizontal Tree				
7-10K Vertical Tree			Not Offered	
7-10K Horizontal Tree				

Common Architecture

	Core	Production Module	Injection Module	Annulus Module
5-10K Vertical Tree				
5-10K Horizontal Tree				
5-15K Vertical Tree				
5-15K Horizontal Tree				
7-10K Vertical Tree			Not Offered	Same as 5-10K
7-10K Horizontal Tree				



Questions?