Strategic Transformation of Project Delivery: From Production Modelling to Public-Private Partnerships

Ivan Damnjanovic, Professor of Civil and Environmental Engineering

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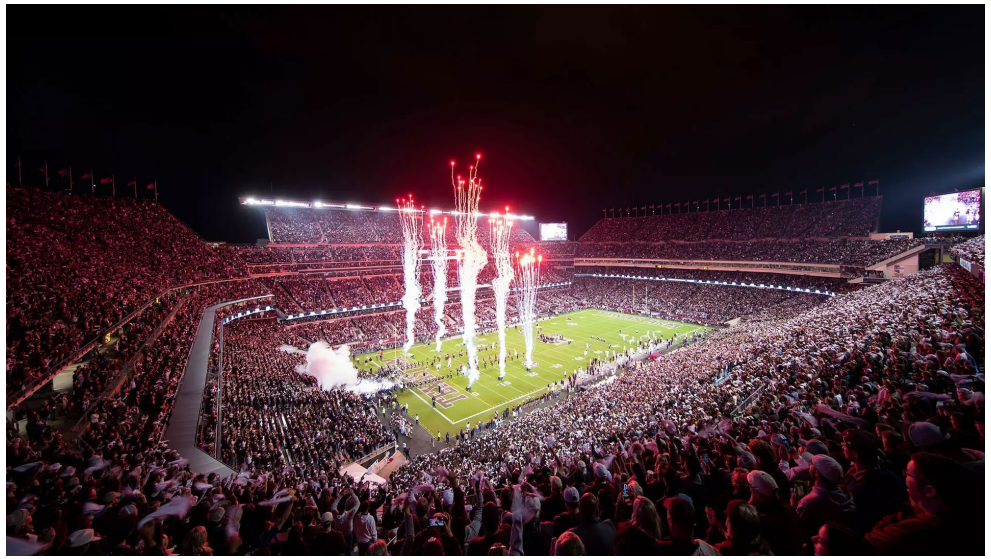

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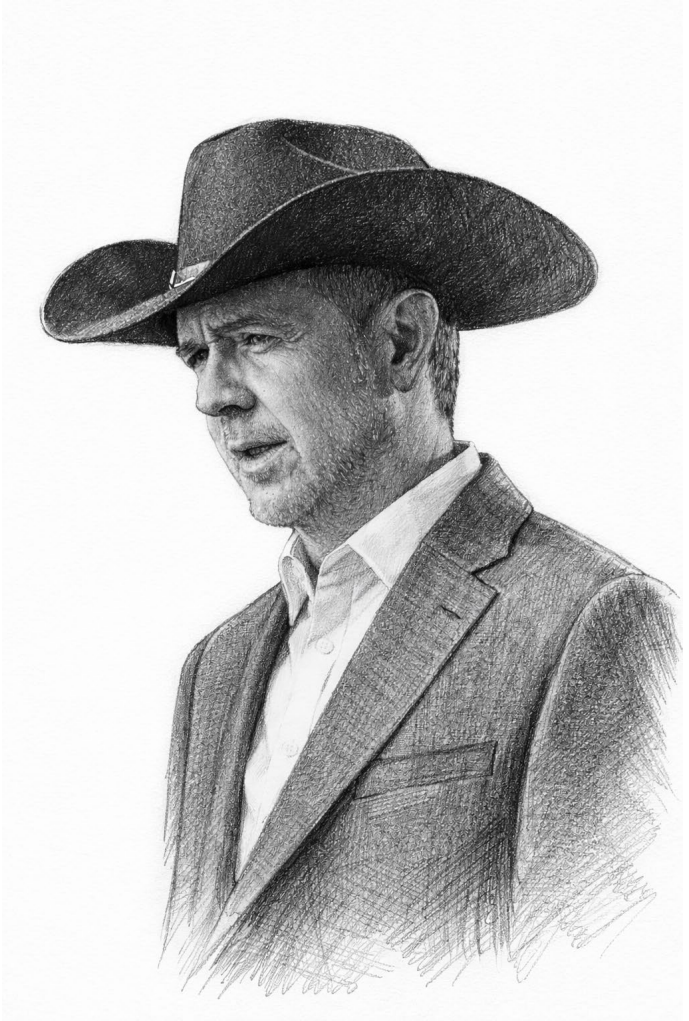
PART A

Next Gen Project Management: Focus on Production

PART B

Public-Private Partnerships from Physical to Digital Infrastructure

Next Gen Project Management: Focus on Production



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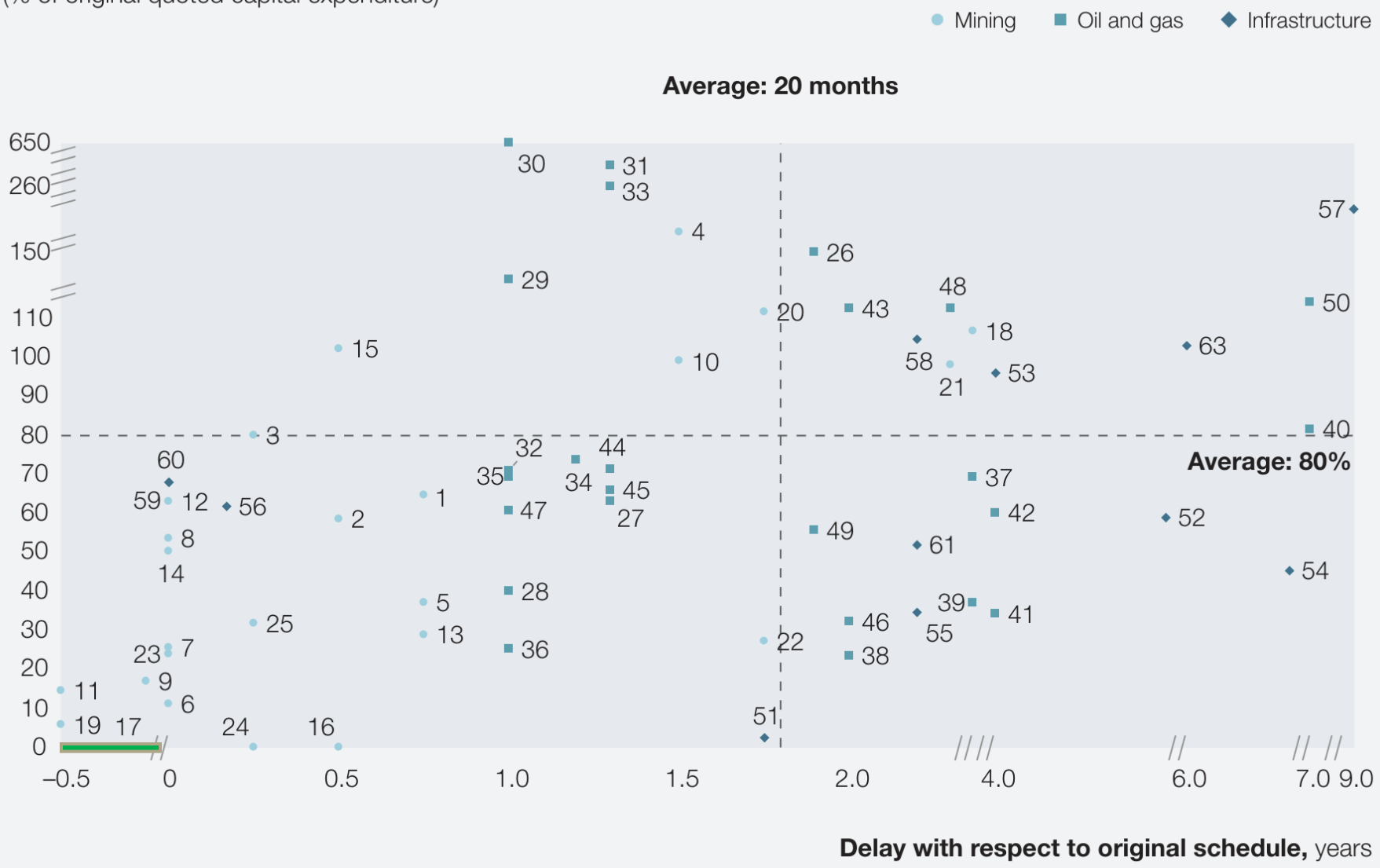
Historical Perspective
Some Data...

Capital-expenditure overrun
(% of original quoted capital expenditure)

MEGA PROJECTS



- **98% of projects** incur cost overruns or delays.
- The average **cost increase is 80%** of original value.
- The average **slippage is 20 months** behind original schedule.

Cost Overruns and Schedule Delays More Data....

McKinsey & Company (2016):

- Nearly 50% of large capital projects were over budget, with an average cost overrun of 43%
- Over 75% of large capital projects were behind schedule.

Jergeas & Ruwanpura (2017):

- 64% of large oil and gas projects faced cost overruns.
- 73% of large oil and gas projects experienced schedule delays

Flyvbjerg et al. (2020):

- 66% of capital-intensive infrastructure projects experienced cost overruns, with an average overrun of 44%.
- 61% of capital-intensive infrastructure projects faced schedule delays

Why is this Important?

- Every project has a business model
- Project economics are very sensitive to completion time and/or cost.

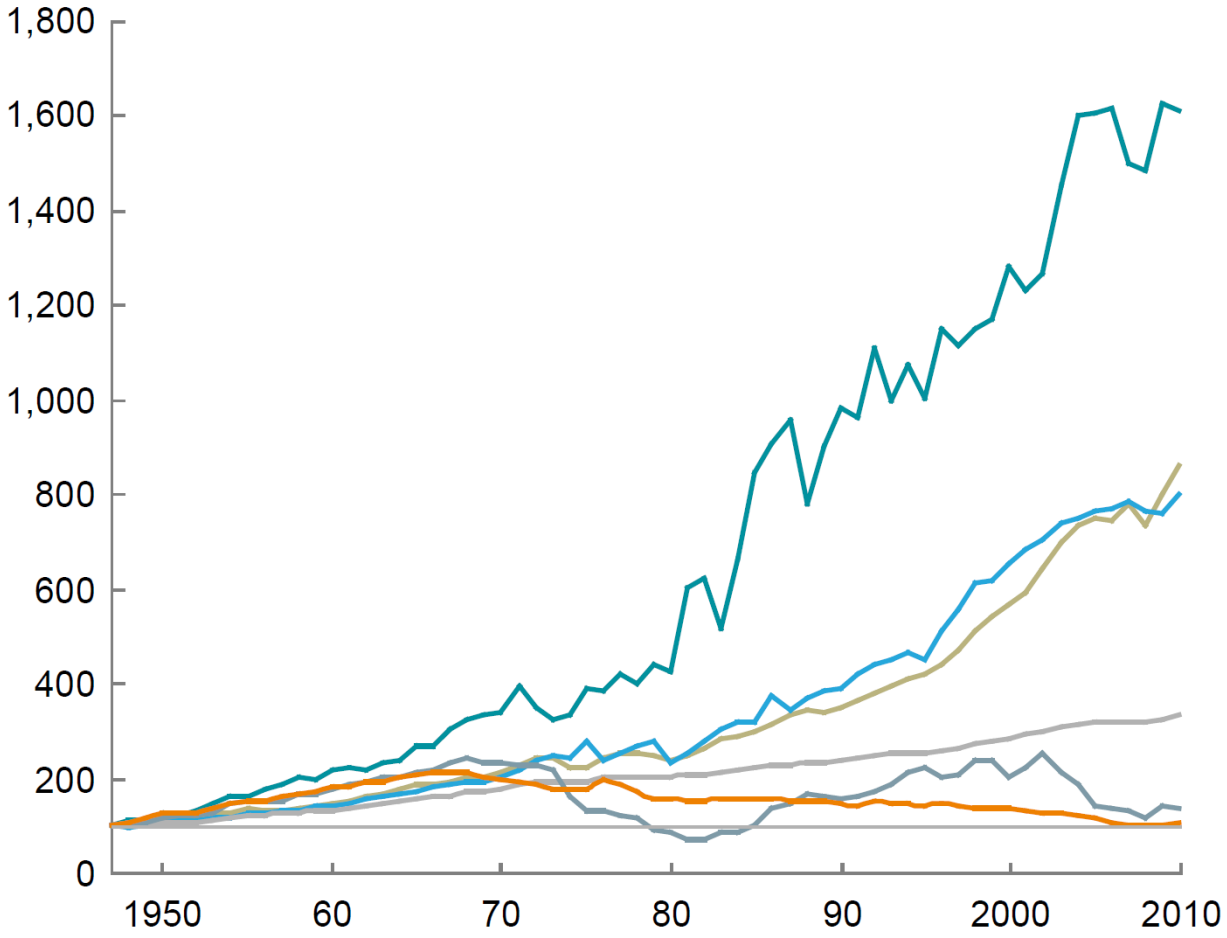
wait.... but why?
Lost income opportunity (“I want the project done yesterday!”)
Interest payments on debt (projects are leveraged up to 90%!!)
Regulatory deadline

Summary

- It is almost a norm that the projects will be over the budget and delayed (several factors contributes to this)
- Project economics however are becoming more sensitive to cost overruns, and in particular, schedule delays.
- There is to tendency pass on that risk down.
- Impact can be felt on stakeholders in project industries: owners, contractors, subcontractors, engineering firms, etc.

How did we get here?

A Story of Project Productivity



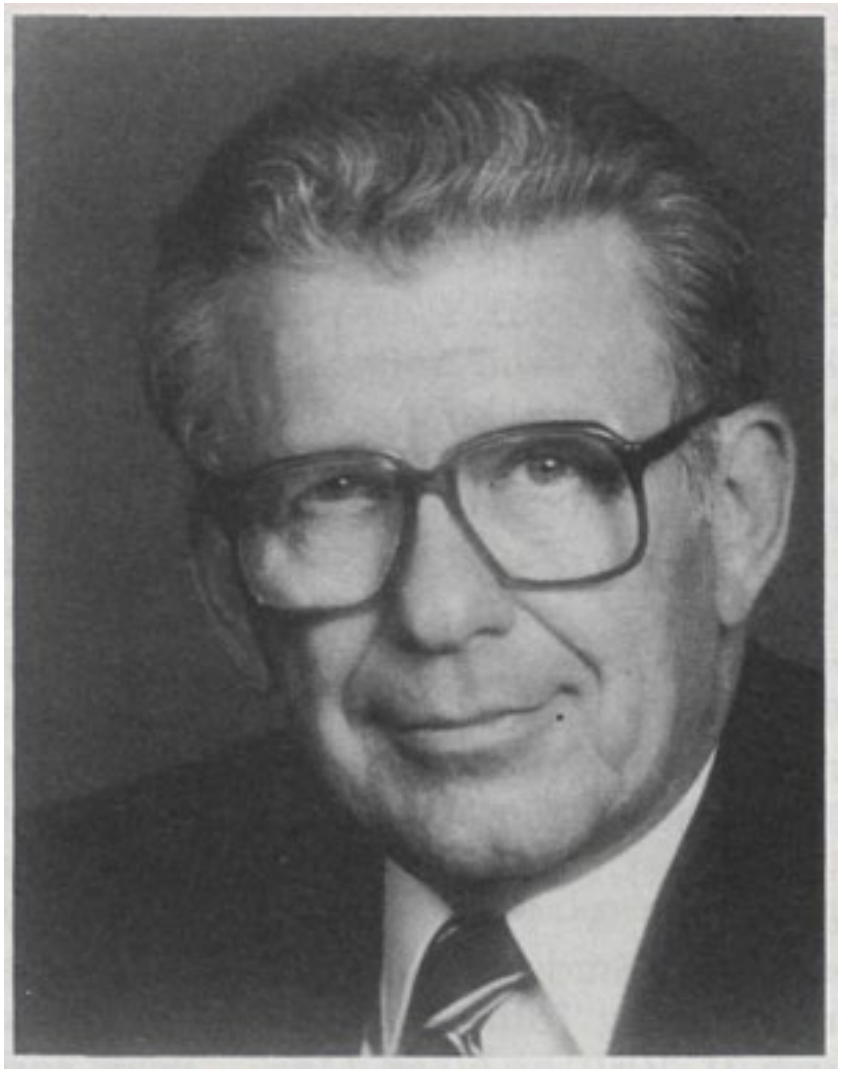
	Compound annual growth rate, 1947–2010 %	Total change
Agriculture	4.5	16.1x
Manufacturing	3.5	8.6x
Wholesale and retail	3.4	8.0x
Overall economy	1.9	3.3x
Mining	0.5	1.4x
Construction	0.1	1.1x

Frederick Taylor and Henry Gantt

FOCUS

- Time and space studies
- Task productivity
- Separation of planning from production
- Schedule planning
- Specialization effect (fragmentation)
- Workers' motivation and other behavioral studies

CPM: James Kelly, Norman Walker, and John Fondhal



Focus: CPM, PERT, EVM, etc.

- General shift from task productivity to project predictability, but continues with separation of planning from the execution of work.

- Rise of project organization and the role of project managers to facilitate planning and payments
  - WBS planning and CPM method implied full scope batch size and no constraints on resources.
  - EVM linked to CPM scheduled become accounting method for contractor payments.
  - Separated the doers from the planners!

“Few of even those who claim to be “CPM experts” fully appreciate the fact that in a resource-restrained schedule the concept of float and quite often the concept of a critical path breaks down. Since almost all construction projects are resource-restrained at least to some extent, this becomes a major source of problems” – John Fondahl

CPM

PERT

EVA

Workface Planning

Advanced Work Packaging

Tool Time

Contracting strategies

Offsite Fabrication and Assembly

Modularization

Agile/Scrum/Sprint

Spreadsheets

Production Tools

AI / ML

Last Planner (LPS)

Lean

Integrated Project Delivery

BIM

Oracle Primavera

Microsoft Project

Six Sigma

Lean/Six Sigma

Theory of Constraints

Monte Carlo Simulations

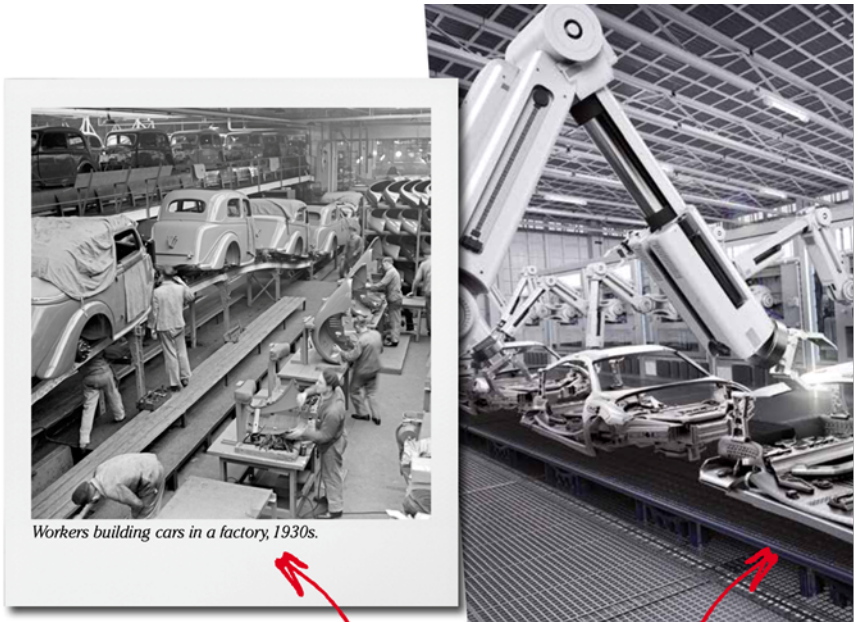
Presentations

WhatsApp / Chats

Teams / zoom

Summary

- Focus on task productivity created more problems than it solved.
- Focus on predictability resulted in schedules tied to compensation through earned value method; this created many new problems and amplified others.
- Specialization led to fragmentation that led to more complex project organizations with multiple stakeholders.
- All of these gave rise to increase in project bureaucracy and administration – project people that do work, or even not know how work is being done.
- Indirect cost (cost of non-productive activities) now dominates productive cost!!! How much??
- Multi-billion dollars project → 70% !!!!!



Workers building cars in a factory, 1930s.

From That to This:

Other Industries Have Perfected Modern Production. So, When Will Construction?

Like most other industries across the United States, the construction sector is becoming increasingly digitized as its leaders strive for success in the information age. And, although the engineering and construction (E&C) industry may have a long-standing reputation of being somewhat of a laggard in regard to innovation in comparison to other industries, the companies that lead the trend and choose to invest wisely in digital innovation today, will absolutely have the competitive advantage tomorrow.

This desire for the construction industry to bring its best practices in line with the high-tech demands of the 21st century can be evidenced by the large – more than $20 billion – amount of venture capital that has been entering the space over the last few years, accompanied by a rapid growth in

ON THE COVER

management, and collaboration. AWP provides a common language between owners, contractors, and suppliers around work packaging that can improve project effectiveness and efficiency.

"You could say that AWP acts as a valuable safety, alignment, and collaboration improvement approach," says Jamie Gerbrecht, Construction Global Technology Sponsor with ExxonMobil. "It really brings a more enjoyable project experience that can motivate individuals and improve the project team's overall morale. Ultimately, the framework and guidelines of AWP can help reduce confusion and unknowns during project execution and further equip the current and next generations for managing projects."

Project Production Management

Operations science (OS) attempts to explain the behavior of different types of activities involved in the production of physical goods and services across many industries, such as agriculture, retail, logistics, and manufacturing. It studies "production systems," which are systems of interconnected tasks, human or automated, happening in sequence or in parallel, with each task transforming inputs, such as materials and information, into outputs, such as partly or completely finished products or services. Project Production Management (PPM) is the application of operations science to project delivery.

"We like to talk about operations science describing 'the physics of how the work gets done,'" says Ram Shenoy, Executive Director of the Project Production Institute (PPI). PPI exists as the technical authority on PPM to inform, educate, and support research into leading PPM's application to transform the project delivery performance of the E&C. "Other project management methodologies worry about the 'What,' the 'Why,' and the 'When.' They even explicitly exclude operations science from their scope. To our knowledge, we uniquely focus on the 'How.'"

Understanding the underlying science and engineering foundation of different forms of production provides greater insight into how to improve construction project delivery, compared with drawing simple qualitative analogies with factory manufacturing. All manufacturing systems are some form of production system, but not all production systems are manufacturing systems. By viewing all the activities in a construction project as a production system, PPM applies the governing equations of operations science to predict, control, and optimize project delivery, just as many industries outside the traditional E&C industry routinely apply operations science to optimize their operations. Understanding where data affects production system behavior allows PPM to be a platform for applying digital technologies to construction, including artificial intelligence, machine learning, robotics, and 4D visualization.

A recent survey by McKinsey & Company suggests that 98 percent of all major (>$1 billion) capital projects either have budget overruns or schedule overruns or both. Those overruns tend to be substantial, with the average budget

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McKinsey & Company

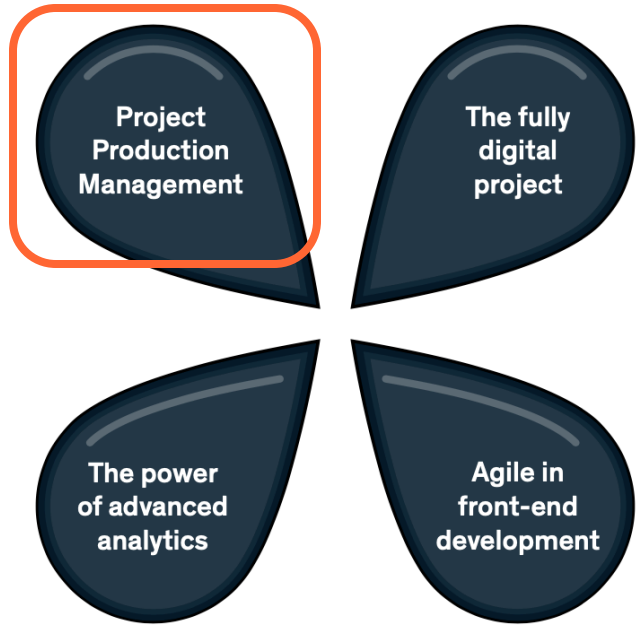
Oil & Gas Practice

How the oil and gas industry can improve capital-project performance

Management practices and digital technologies used by other industries can help oil and gas companies boost capital-project productivity.

by Alastair Hamilton, Jan Koeleman, and Koen Vermeltfoort

There are four main building blocks for reshaping the oil and gas industry.



Source: McKinsey analysis

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Next Gen Project Management

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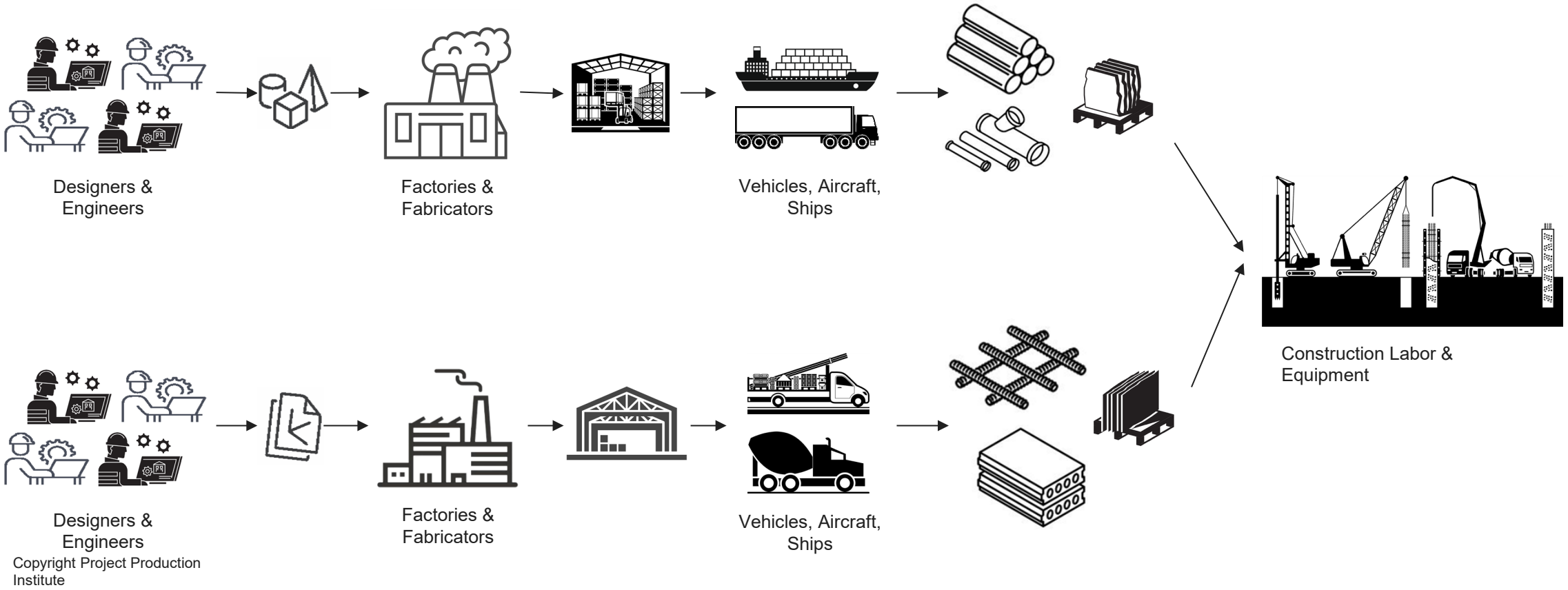
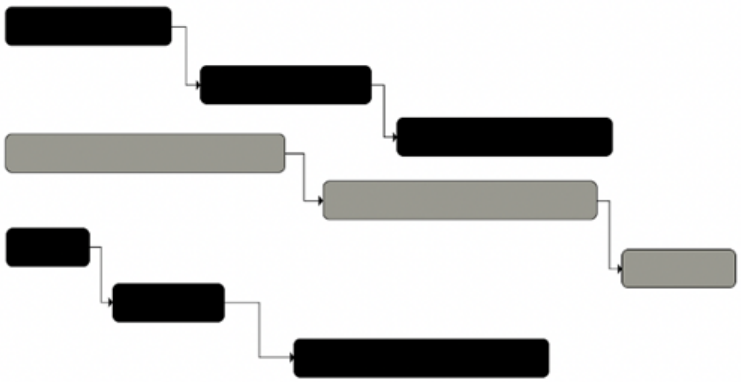
In construction, work flows through production systems



How these systems are designed has a major influence on the project outcome, i.e., cost, schedule, cash

SETS DEMAND FOR PRODCUTION SYSTEM

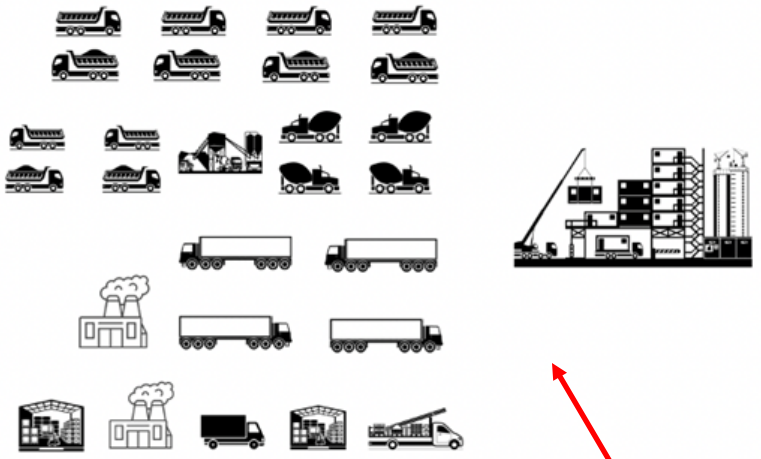
Schedule = Should Happen



Dates & Progress

SYMPTOMS

Production System = Can/Will Happen



Rates / Throughput

CAUSES

We tend to spend a lot of time tracking these….

…without understanding how these work

Operations Science governs the performance of Project Production Systems

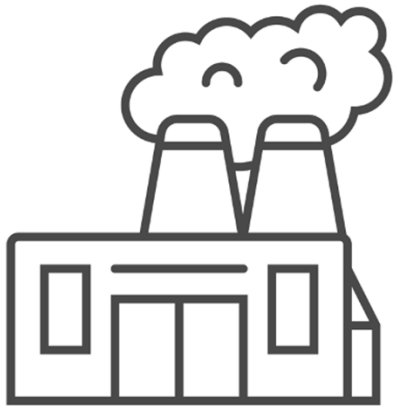
4 Verbs

5 Levers

3 Curves

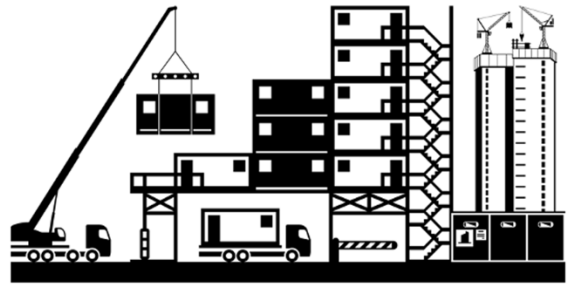
4 Verbs

Design



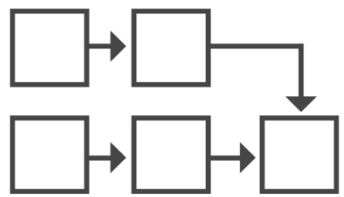
Make

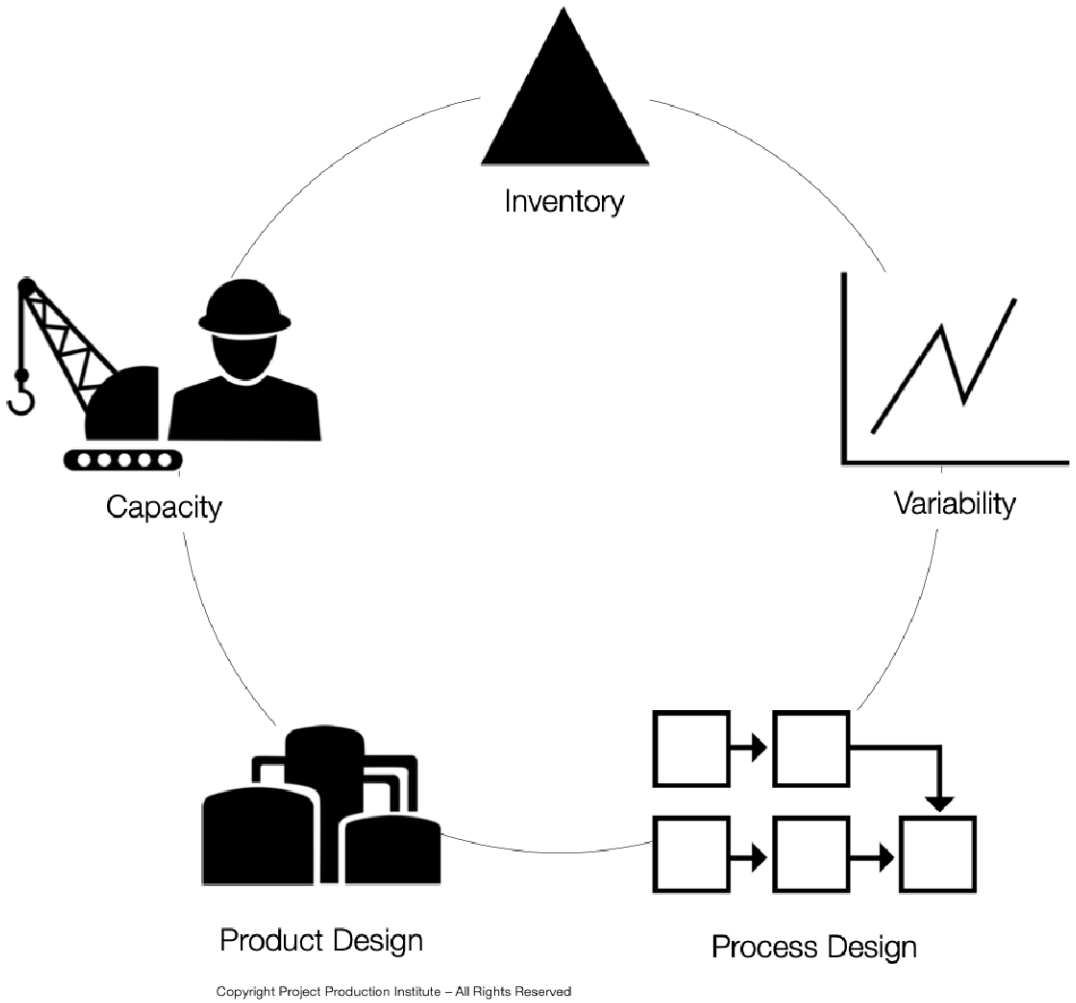
Transport



Build

5 Levers

Cost, Time & Cash =  Product Design +  Process Design +  Capacity +  Inventory +  Variability



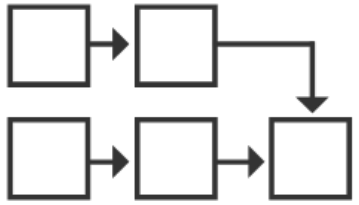
No Free Moves!

PROJECT MANAGEMENT

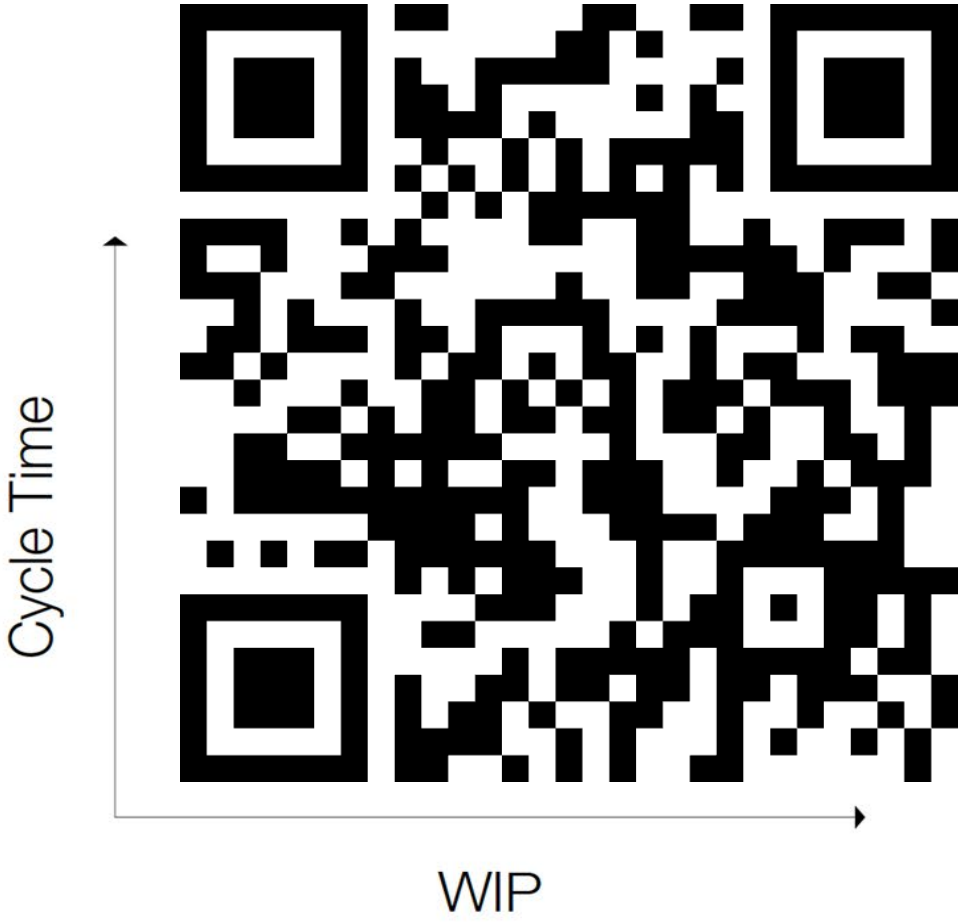
Cost, Time & Cash =  +  + 

Scope & Quality | Schedule | Resource Use

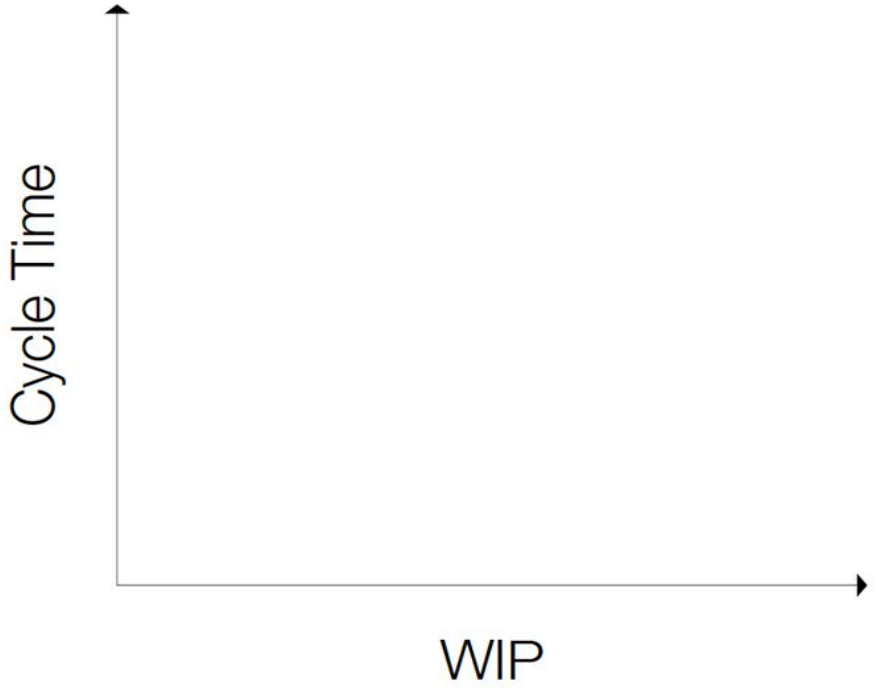
PROJECT PRODUCTION MANAGEMENT

Cost, Time & Cash =  +  +  +  + 

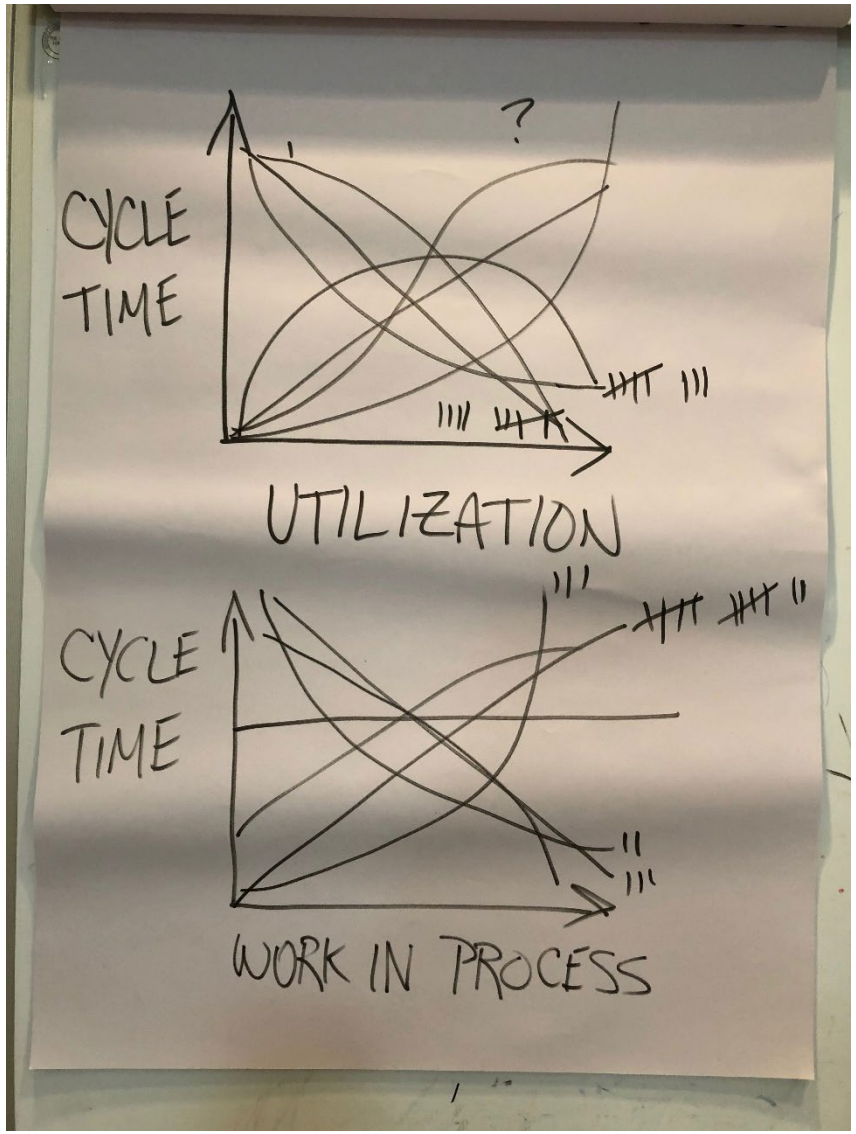
Product Design | Process Design | Capacity | Inventory | Variability

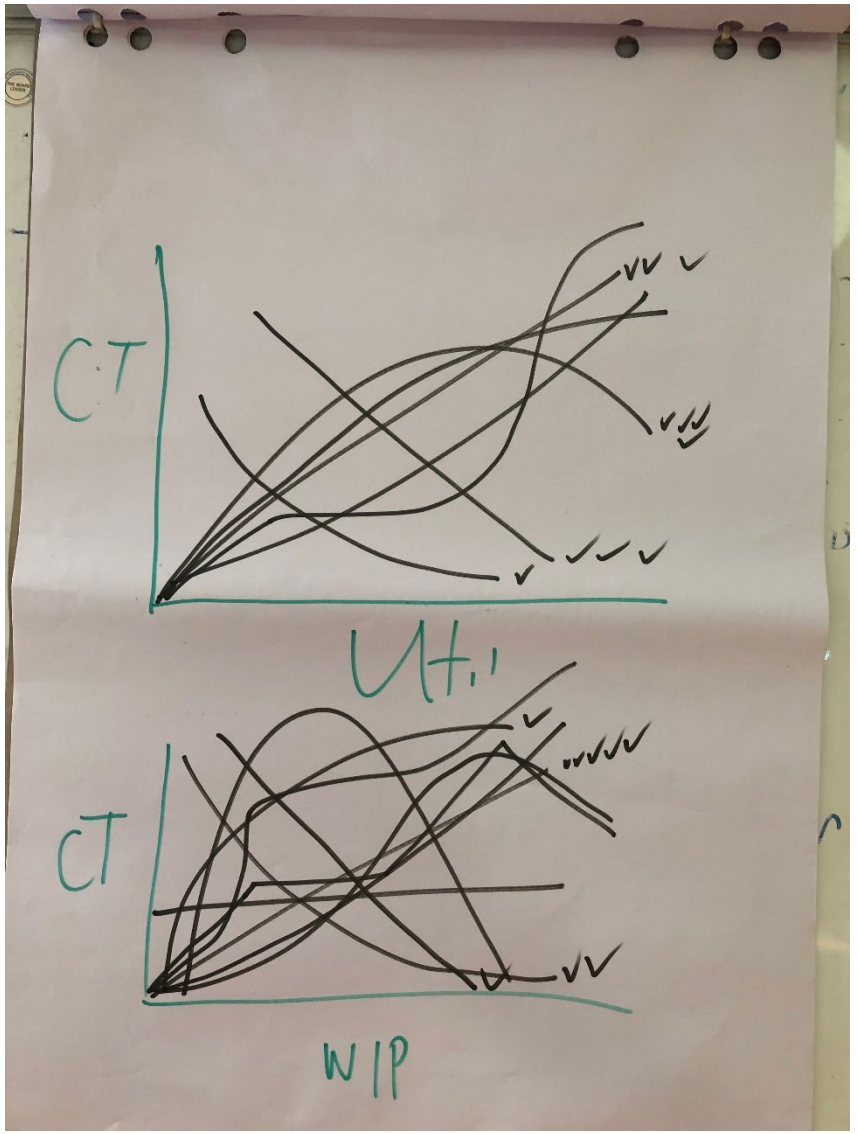


Quiz

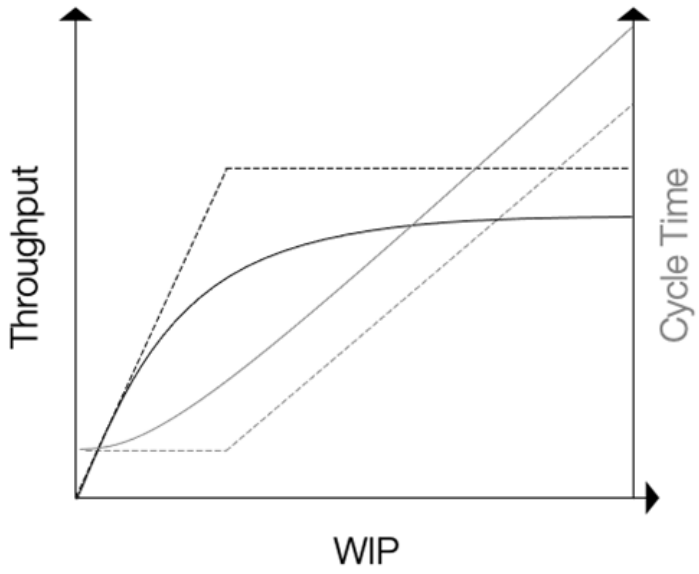


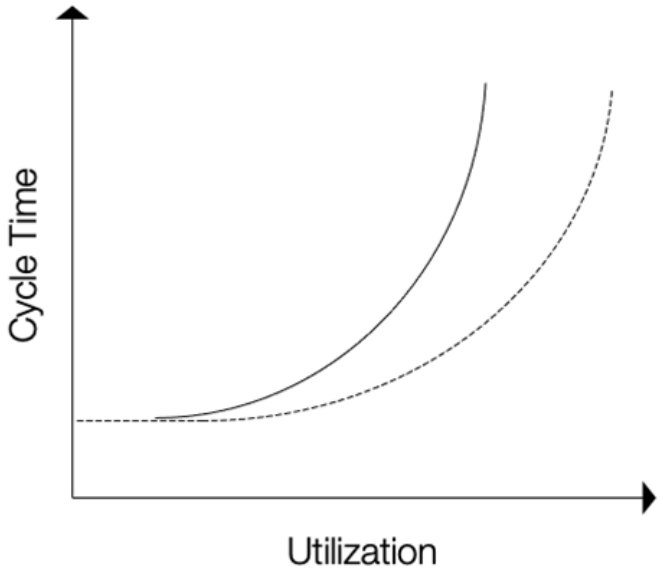
Quiz

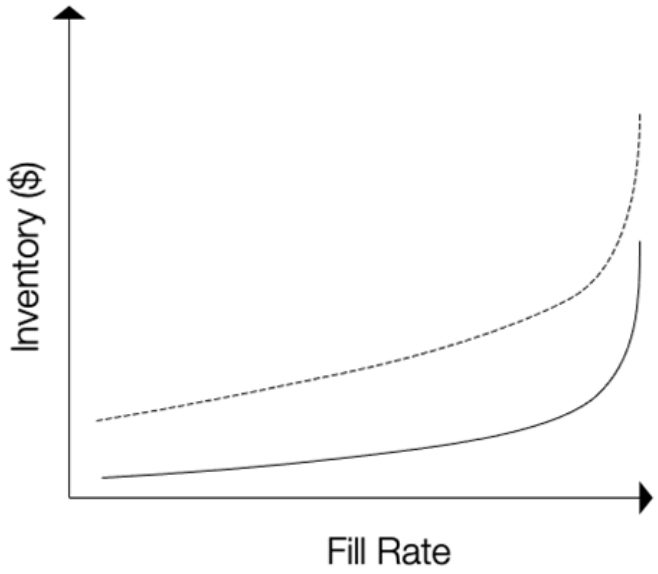

CYCLE TIME
?
UTILIZATION
CYCLE TIME
WORK IN PROCESS


CT
Uti.
CT
WIP

3 Curves







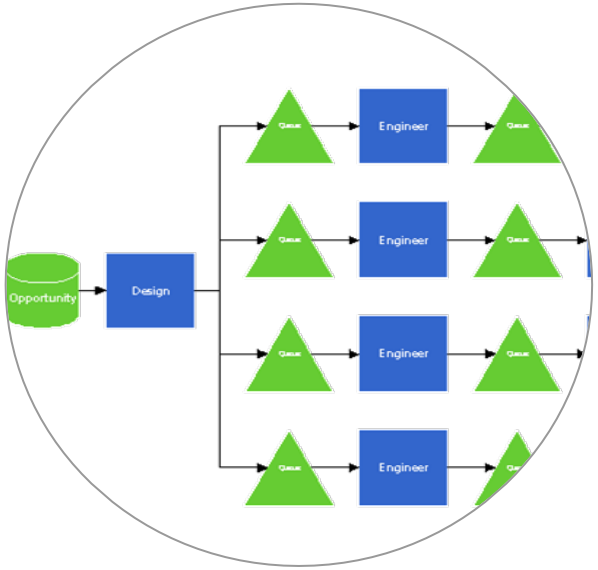
Piling - A Real Example of This

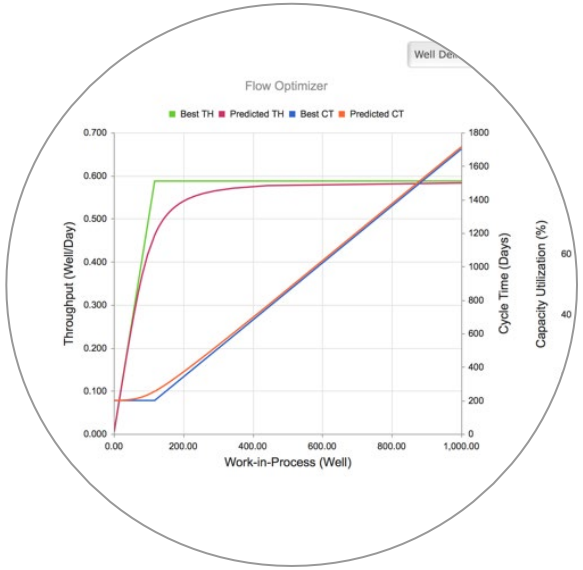
Unit rate contractor to drive 20,000 piles on the project in the first six months of construction, planned completion of foundations in two years

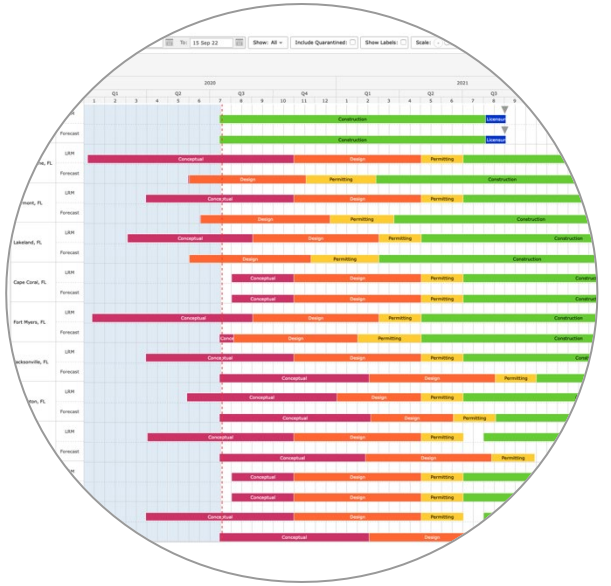
An excellent piling contractor was hired and delivered– big win

Success?

Finished Piling – Waiting for Foundations







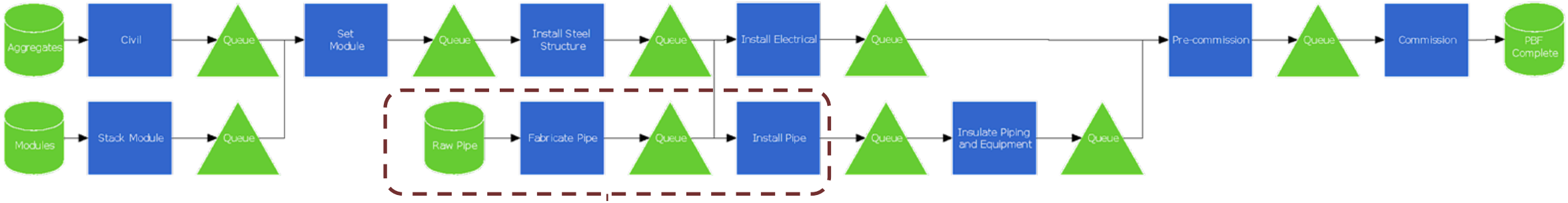
Map & Model

Simulate, Analyze & Optimize

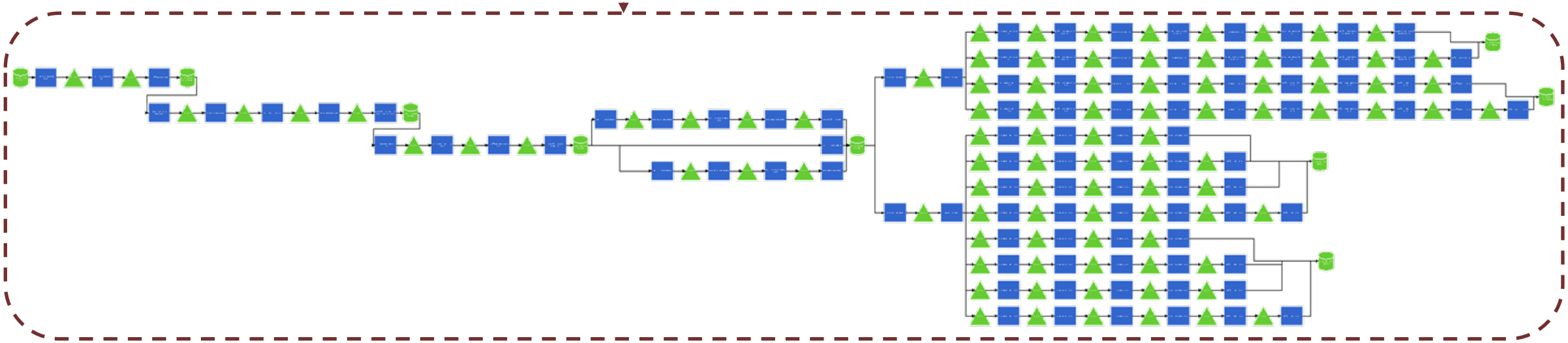
Control & Improve

Typical Map of a Projects Production System

High Level Map

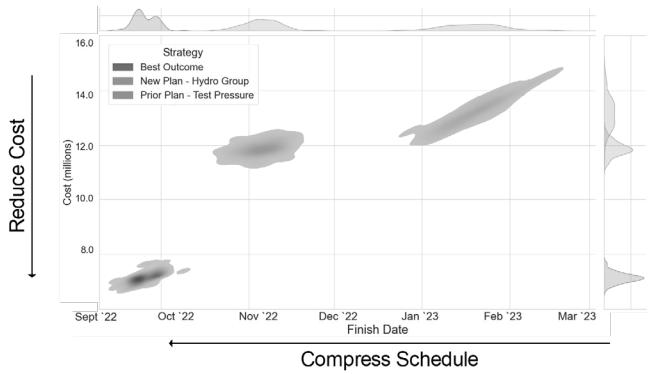


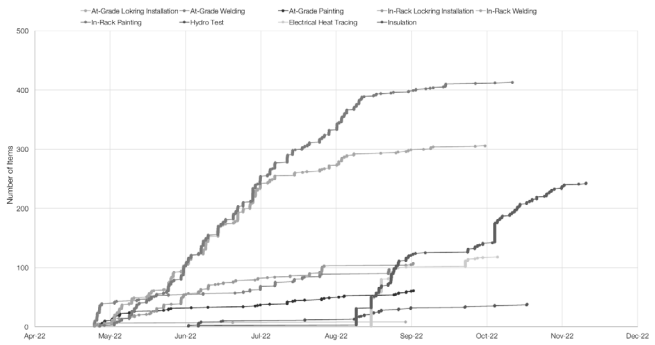
Detailed Map



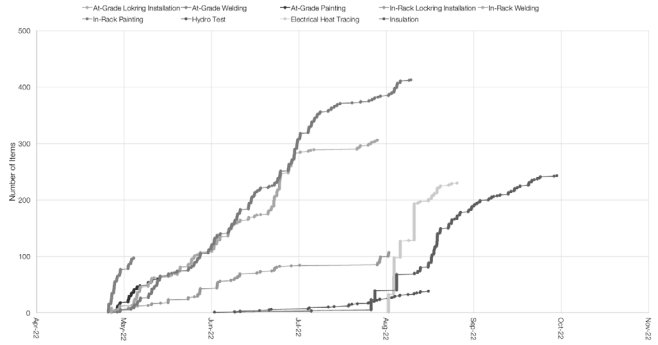
Piping & Hydrotesting Project Production System

Enabled by SPS|PM Production Optimizer / Simulator





Current



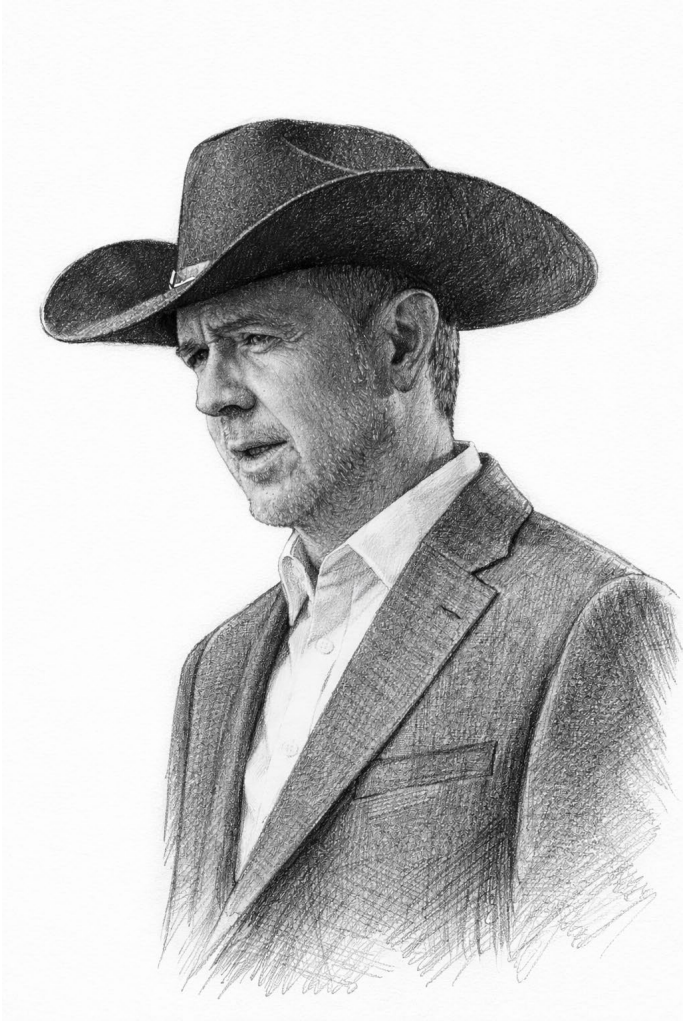
Proposed

PPI

PROJECT PRODUCTION INSTITUTE

Join the community of project professionals

Public-Private Partnerships: from Physical to Digital Infrastructure



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Public Private Partnerships (PPPs) and Project Finance

Governments are the business of spending money (and collecting (and borrowing)).

The Scope of investments is limited.

The Risk appetite is also limited.

PPPs allow private sector to provide services, facilities, or promote business environment.

- Tax-increment finance (PPP - SPV)
- Digital infrastructure (PF – SPV)

Taxed-increment Finance

Project investments create value beyond what developers can immediately internalize.

We call this externalities

Externalities can be positive (access, land improvements), but also negative (pollution, noise, etc.)

Hotel

Immediate source of income: room occupancy

External value: increased value of surrounding lots

Highway

Immediate source of income: tolls

External value: increased value of surrounding lots

Infrastructure That Unlocks Development
Brownfield & Site Remediation

Digital Infrastructure

Computing power need (GPU hours) is exponentially increasing

AI companies are constrained and to some degree valued based on computing.

Technology is rapidly evolving

Project are technically complex

SPV with low revenue risks, high delivery risk

Stargate at Abeline, TX (April 2025)

STANDING TOGETHER

FOR A BIGGER IMPACT