Project Simulation:

Rethinking the "Expected Completion Date"

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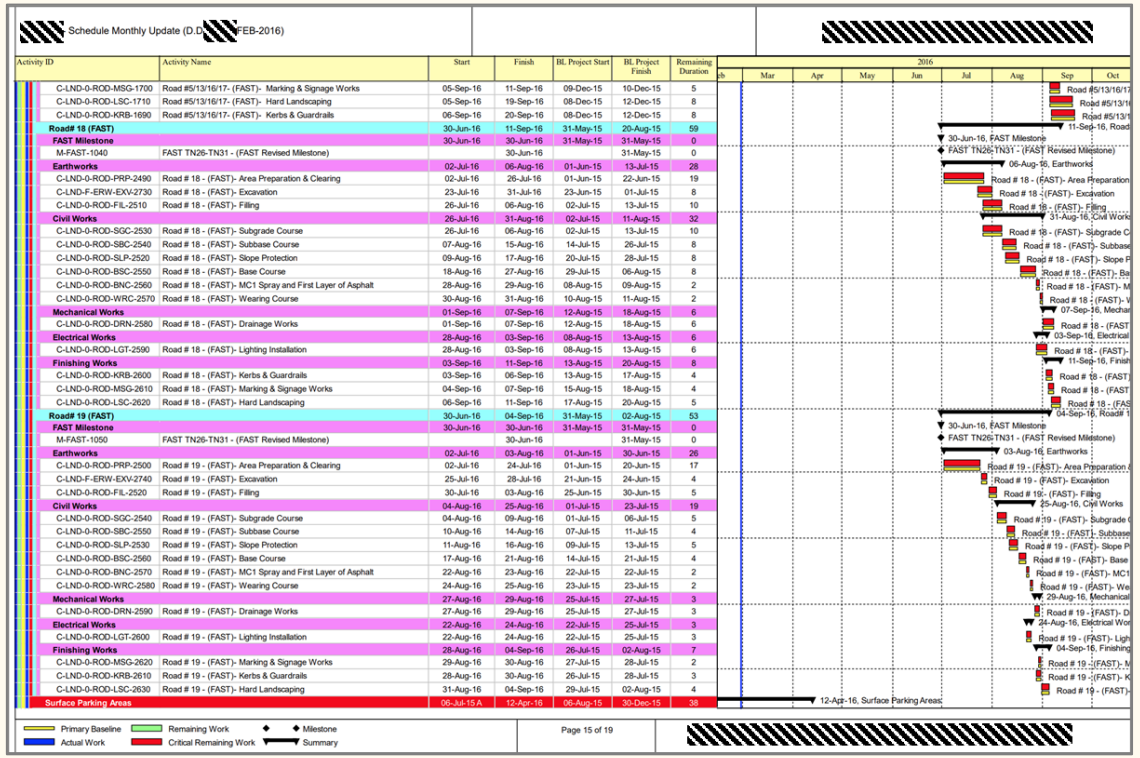
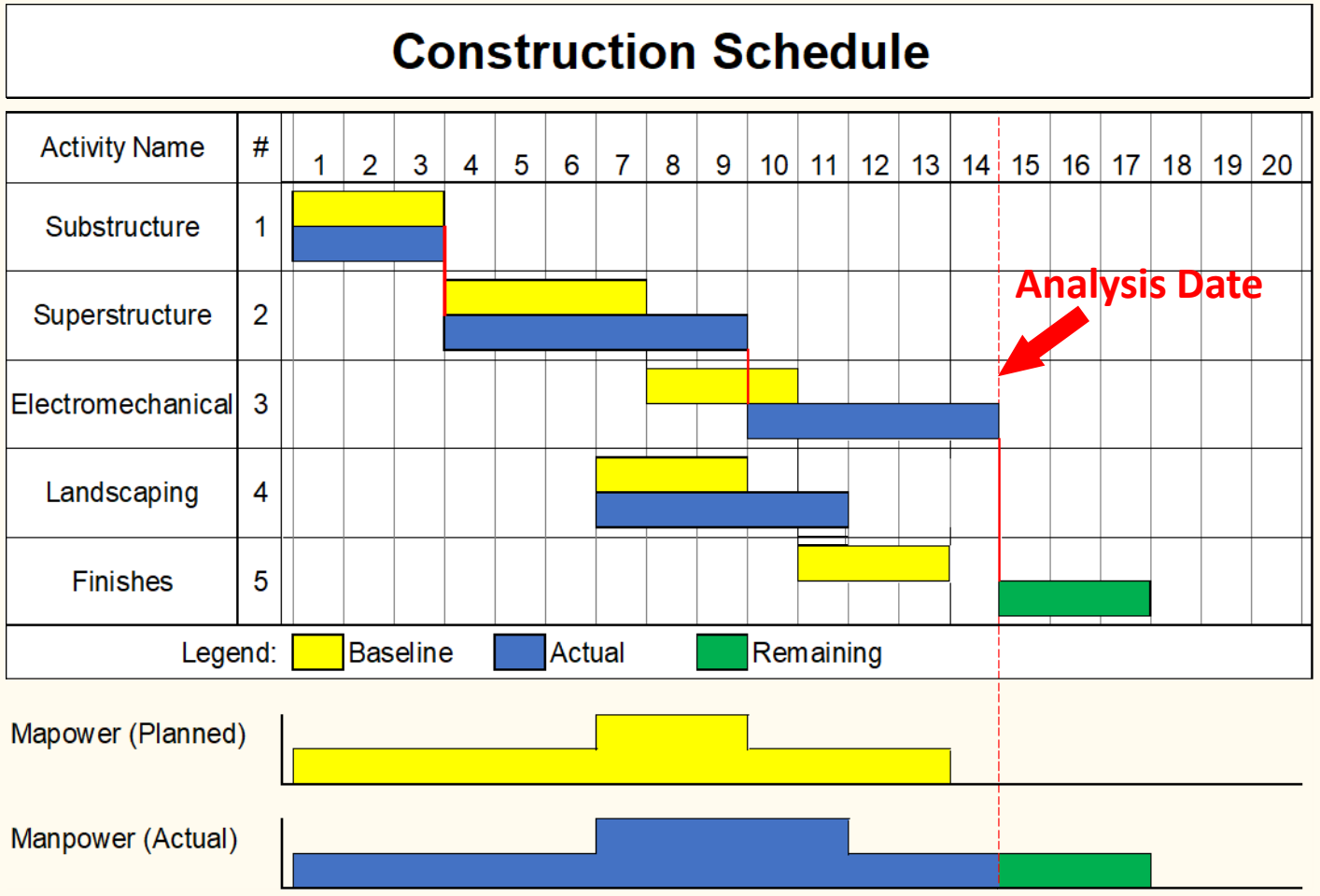
The "Expected Project Completion Date": A Critical Input for Effective Project Management

- In construction, completing projects on time is often critical:
  - Even a few months' delay can lead to severe penalties ("Liquidated Damages")
- The "Expected Time to Completion" is a critical piece of information for project managers.
- Construction schedules are managed with tools based on CPM (the "Critical Path Method")



The Critical Path Method: Future expectations are based on "The Plan"



System Dynamics in construction: A continuous focus of activity for 50 years!

- In 1976, Pugh Roberts Associates developed the first project simulation model, to support a disruption and delay claim against the US Navy.
- Since then, SD models based on the same causal framework (known as “the Rework Cycle”) have been used to support decision-making in hundreds of major projects in many industries.
- SD models have also been used to provide expert evidence to support at least 50 major delay and disruption claims, in all continents.
    - The magnitude of these claims has ranged between **$10 million and $5-6 billion.**

SD models capture the critical role of the Expected Completion Date

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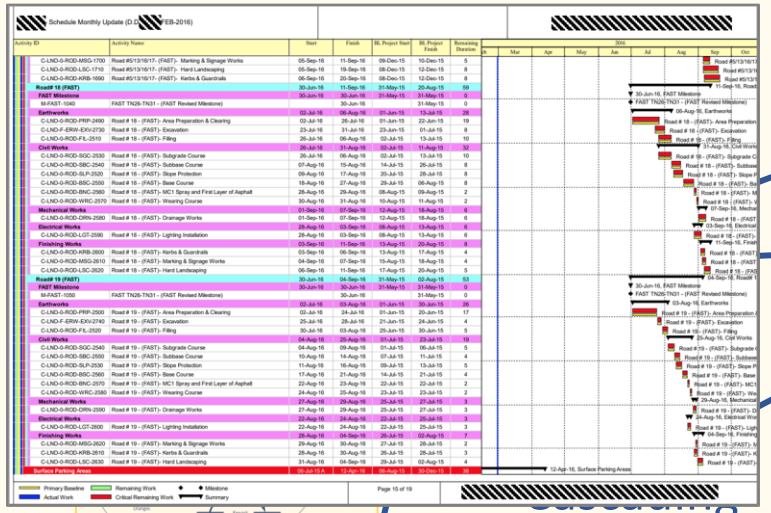


Schedule Pressure

Planned Completion

Out of Sequence Work

Acceleration Measures

Work Quality

Productivity

Learning Curve

Manpower

Planned Manpower

Expected Completion

Planned Sequence

Reported Progress

Errors

Work Scope

Work Not Yet Started

Work Being Completed

Work Complete

Rework

Rework To Do

Discovery

Rework to be Found

SD formulations for the Expected Completion Date are necessarily based on approximations

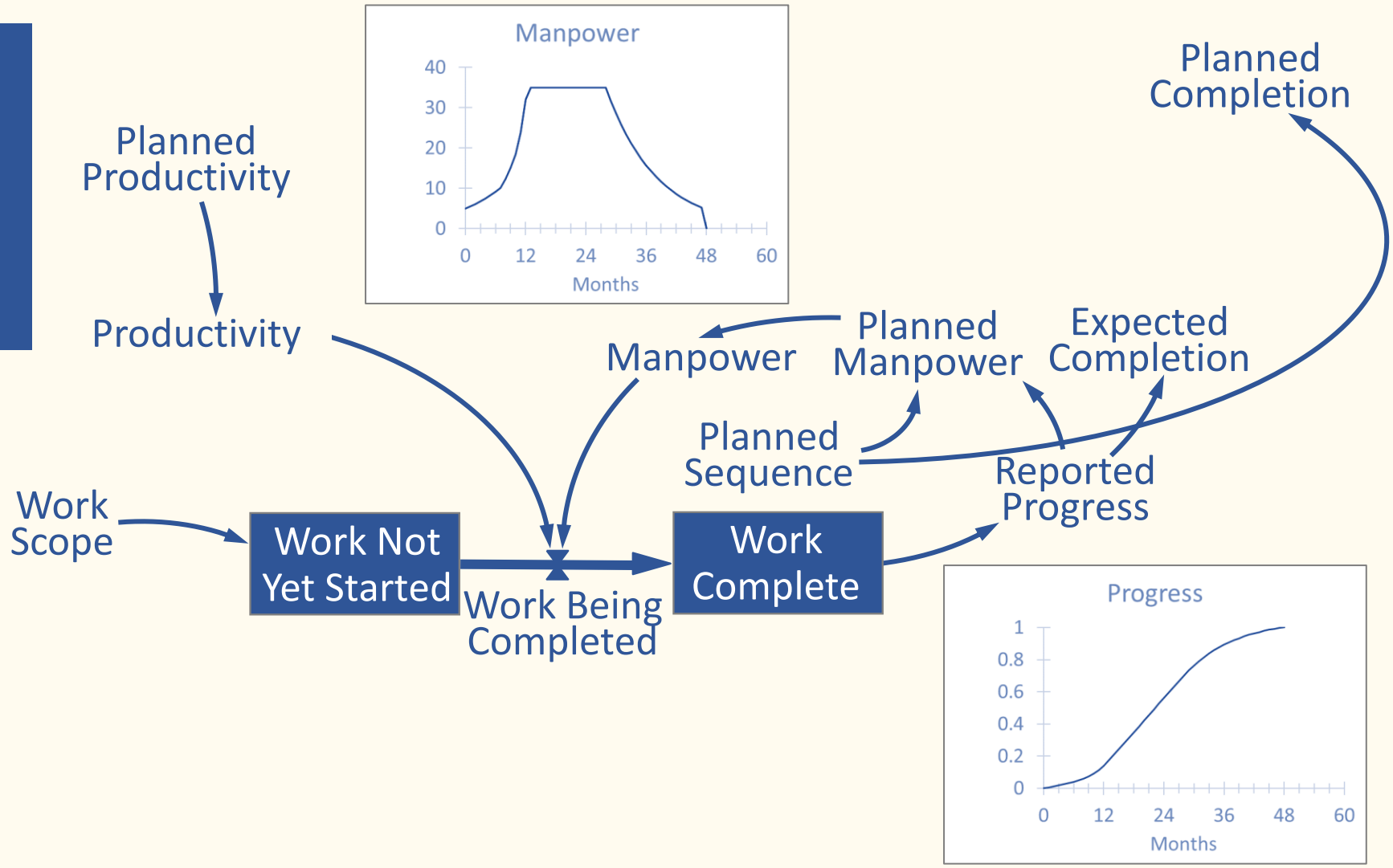
Conventional formulations for the Expected Completion Date (ECD):

1. Progress extrapolation:
   - $Expected\ Completion\ Date(t) = t/Progress(t)$
2. Manpower based:
   - $$Expected\ Completion\ Date(t) = time + \frac{Person{*}Months\ Remaining(t)}{Average\ Future\ Manpower(t)} =$$
   $$= time + \frac{Work\ Scope{*}(1-Progress(t))}{Manpower(t){*}Productivity(t)}$$

- These formulations usually require ad hoc adjustments:
  - Initially models tend to use planned dates, then shifting to these formulations as progress is made.

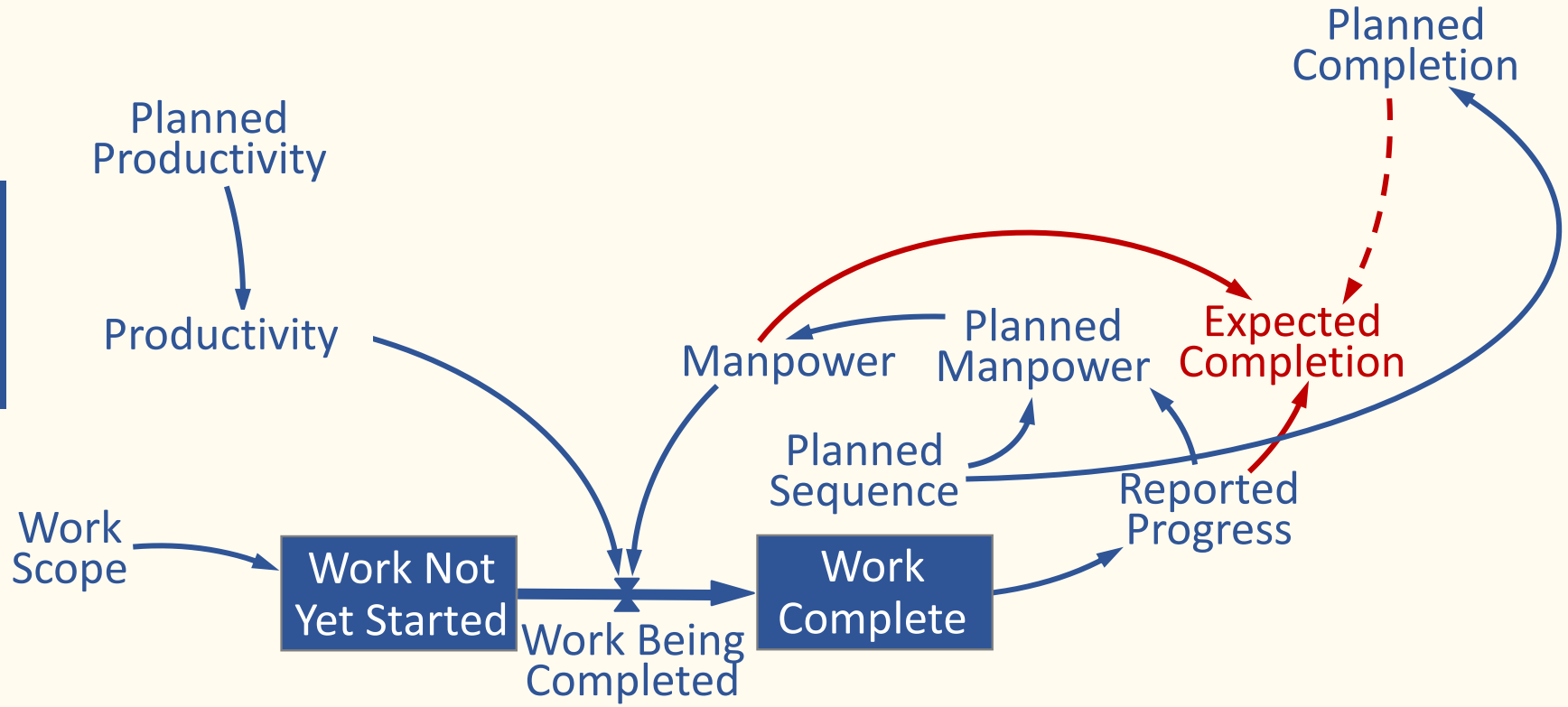
How well has SD estimated completion dates? The ECD Testbed Simulation Model

- No rework
- No productivity losses
- No perception, hiring or information delays
- Start at t=0



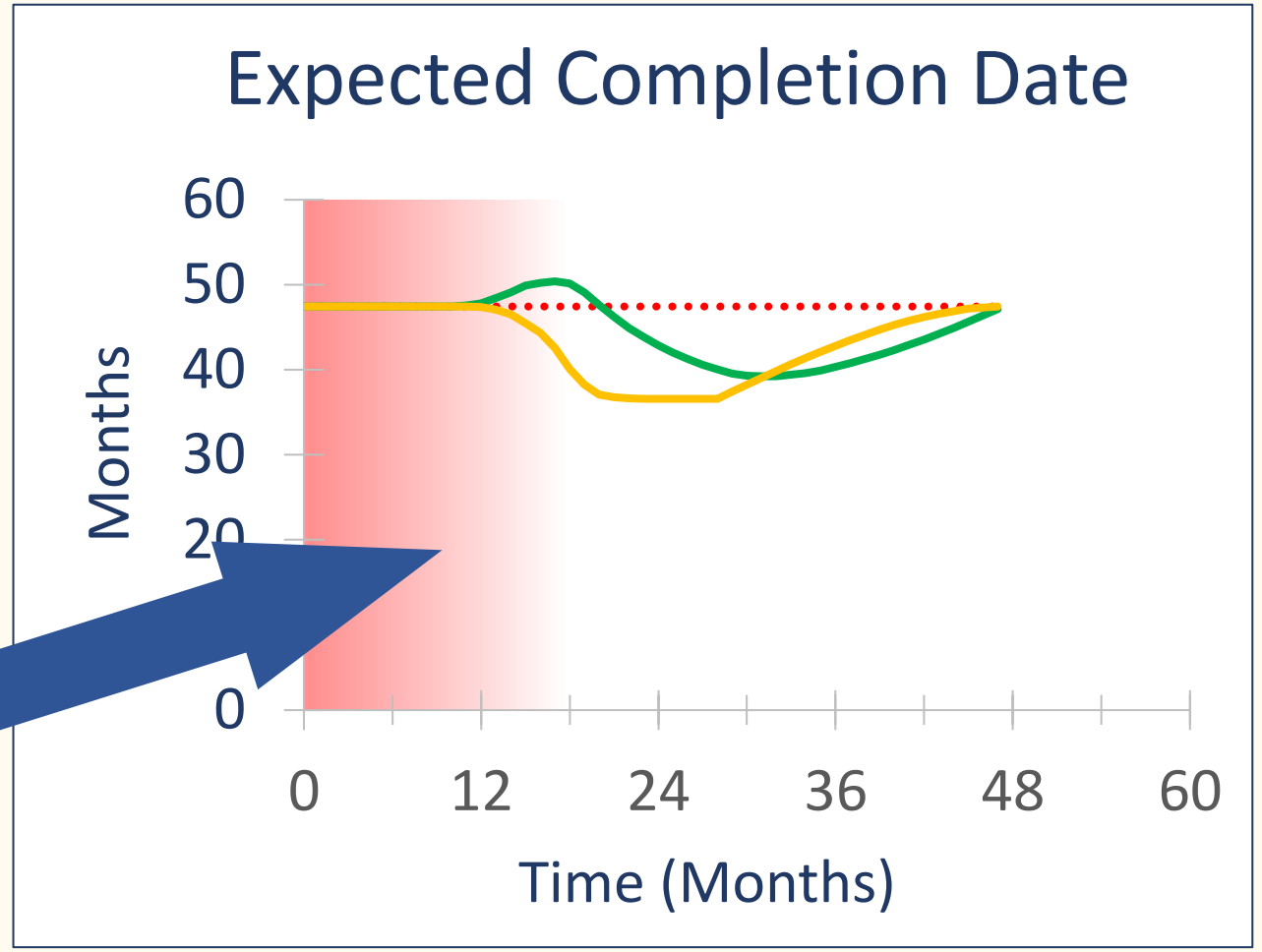
The ECD Testbed Simulation Model contains two conventional formulations

The ECD Testbed Mode tests the performance of both conventional formulations!



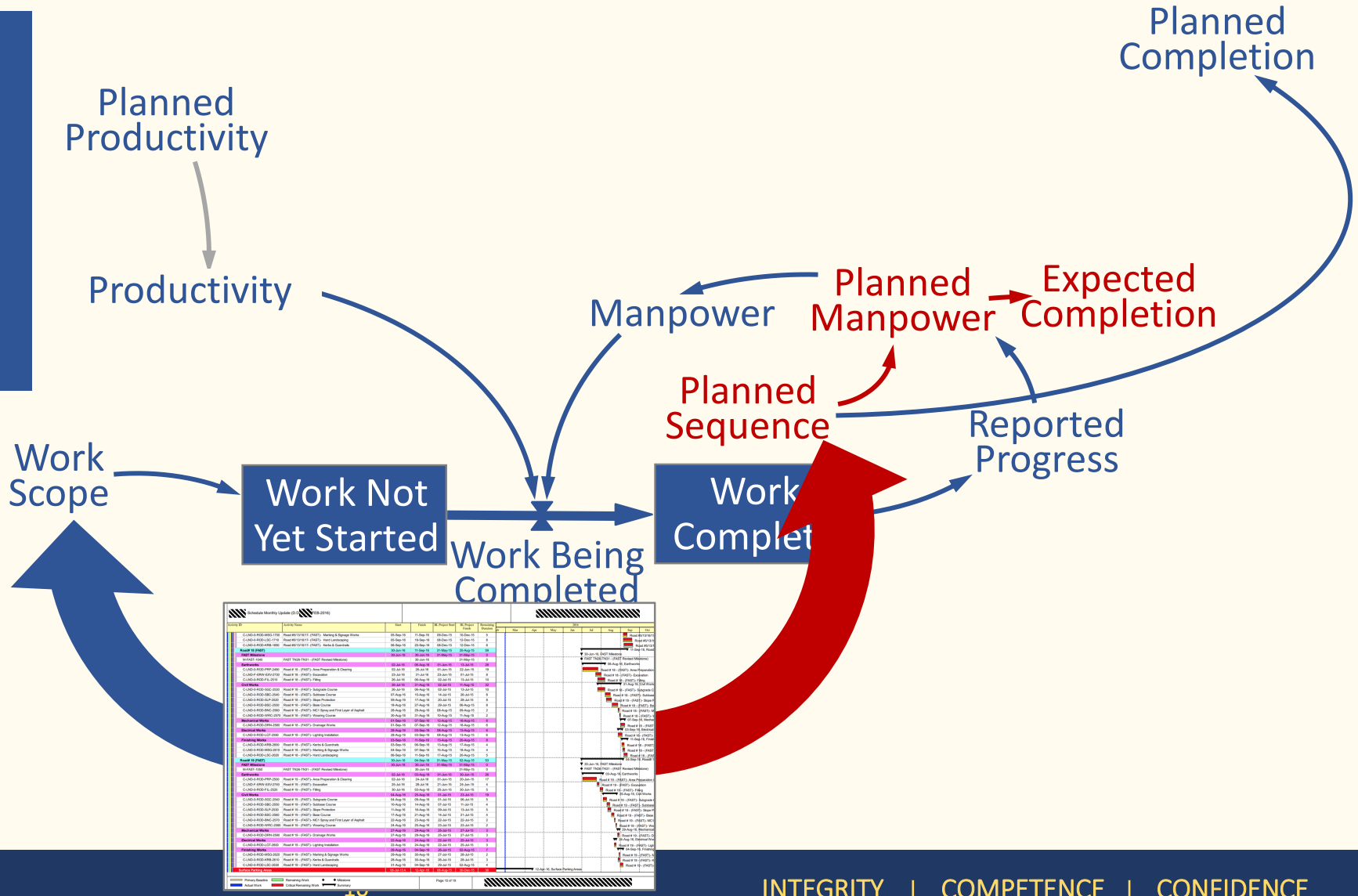
Conventional ECD formulations generate inherent bias

The conventional approach starts using the planned completion date, and then shifts to the progress / manpower formulations as the project gets closer to completion.



A Plan-Based formulation makes fuller use of the information available

The Plan-Based approach is able to use detailed planning data to simulate expected completion dates – just as actual project managers do.



Mathematical derivation for the Plan-Based formulation

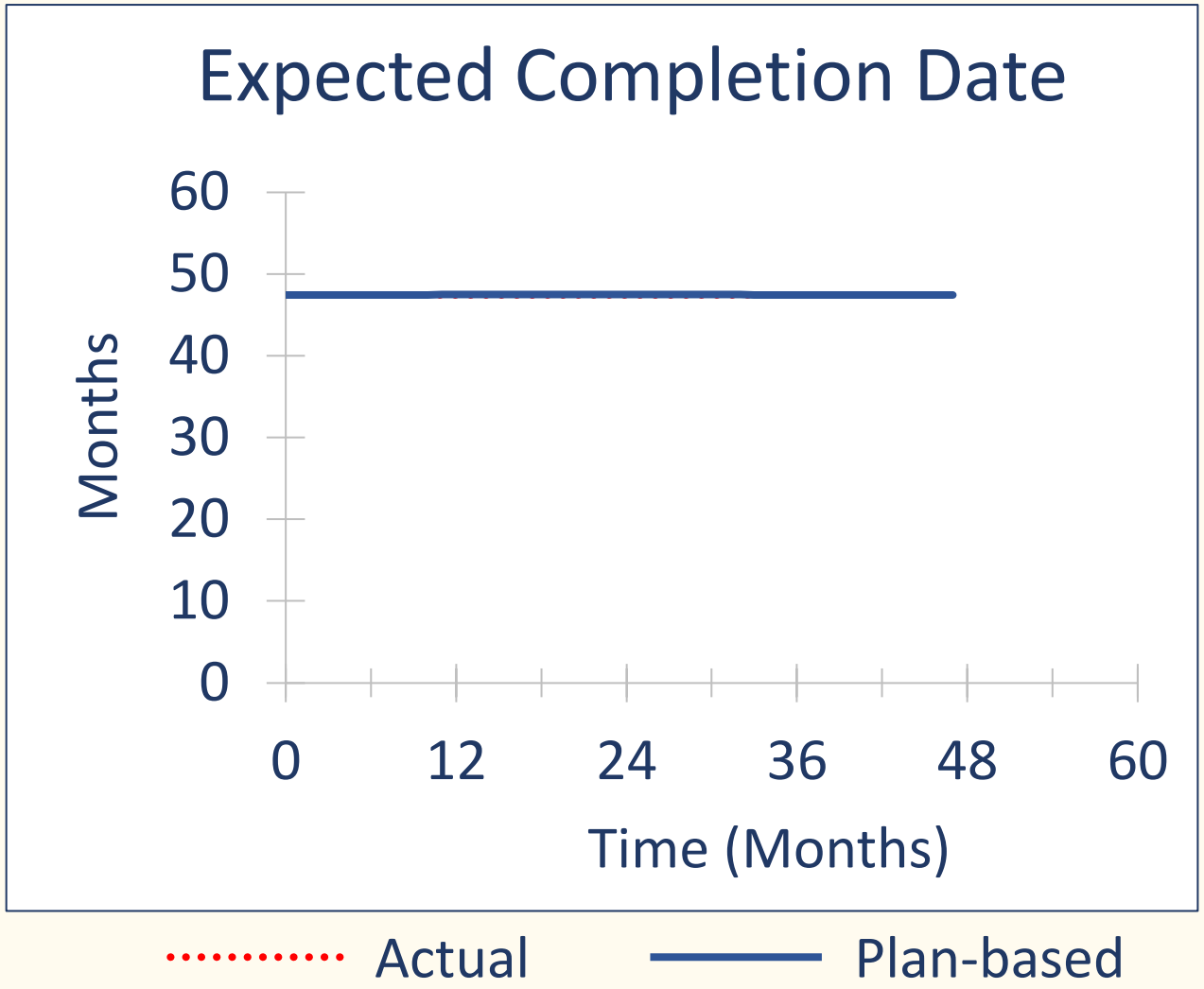
$$Work\ Completion\ Rate = \frac{\Delta Work\ Completed}{\Delta t} = Manpower * Pdy$$

$$\Rightarrow \Delta t = \frac{Work\ Scope\ * \Delta x}{Manpower(x) * Pdy}, \qquad where\ x \cong "Actual\ Progress" \in [0,1]$$

$$\Rightarrow Time\ Spent(x) \cong \int_0^x dt = \int_0^x \frac{Work\ Scope\ * dx}{Manpower(x) * Pdy(x)}$$

$$\Rightarrow Planned\ Time\ Spent(x) = \int_0^x \frac{Work\ Scope * dx}{Planned\ Manpower(x) * Planned\ Pdy(x)}$$

The Plan-Based formulation passes the test with flying colours!



- The new formulation avoids biases suffered by previous formulations when planned manpower levels are not constant over time.
- It uses the same inputs actually used by project managers when estimating completion dates.
- Building upon this foundation, the formulation can be easily enhanced to account for productivity losses, schedule buffers, etc.

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The Plan-Based ECD formulation, in practice

- The Plan-Based schedule formulation has already been used in eight delay and disruption claims, and in one retrospective research application (simulating the construction of destroyers at a US shipyard.)
- It has delivered good fits to recorded project behavior, without the need for *ad hoc* adjustments.
- By mimicking the actual decision-making process followed in construction projects, this formulation has proven to be more defensible in adversarial situations.

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