USING SCHEDULE DIAGNOSTICS TO PROVE CONSTRUCTION LOSS OF PRODUCTIVITY

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and

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CREDENTIALS

- Professor at the University of California at Berkeley since 1987. Teaches undergraduate and graduate courses in construction management.
- Research on Construction Management issues.
- Experience on some of the biggest, most complex projects in the world including Boston's Big Dig, refineries, chemical plants, hospitals, process plants, transit systems, and nuclear and conventionally-fueled powerplants.
- Provided depositions, arbitrations, and trial testimony on over 3 dozen projects in the last 4 years.

CREDENTIALS

- Published 180+ scholarly articles. Titles include:
  - "Evaluating the Cumulative Impact of Changes on Labor Productivity - an Evolving Discussion“
  - “Impact on Labor Productivity from Changes: Size and Timing Issues”
  - Various CII Studies on Labor Productivity
- Chair, ASCE Loss of Productivity Standards Definition Committee
- Chair, ASCE Project Controls Committee

LEGAL CONCEPTS

"Except in the middle of a battlefield, nowhere must men coordinate the movement of other men and all materials in the midst of such chaos and with such limited certainty of present facts and future occurrences as in a large construction project … Even the most painstaking planning frequently turns out to be mere conjecture and accommodation to changes must necessarily be of the rough, quick and ad hoc sort, analogous to ever-changing commands on the battlefield."

Blake Constr. Co. v. CJ Joakley Co., Inc., 431 A.2d 569 (D.C. 1981) p. 575, Appendix KR-7.

PRESENTATION AGENDA

- **Construction Productivity**
- Change's Impact on Productivity
- Introduce New ASCE Loss of Productivity Standard
- Illustrating Schedule's Impact on Productivity
- Q & A

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WHAT IS PRODUCTIVITY?

$$\text{Productivity} = \frac{\text{Production Output}}{\text{Resource Input}}$$

$$= \frac{\text{4LF of 4" pipe}}{\text{1 labor-hour}}$$

$$\text{Productivity Index} = \frac{\text{Actual Productivity}}{\text{Planned Productivity}}$$

$$= \frac{\text{3LF per 1hr}}{\text{4LF per 1hr}} = 0.75$$

WHY IS PRODUCTIVITY IMPORTANT?

Labor costs = $\frac{\text{(Quantity of Work) x (Cost/Crew-Hour)}}{\text{Productivity/Crew-hour}}$

= $\frac{\text{1000 LF of 4” pipe x \$100/Crew-Hour}}{\text{25 LF/C-Hr}}$

= $4,000

WHY IS PRODUCTIVITY IMPORTANT?

Labor	**40%**
Materials	40%
General Conditions & Indirect Costs	10%
Overhead	5%
Profit	5%
Total	100%

Largest cost component

Most volatile

Most critical

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HYPOTHETICAL PROJECT

Labor	**40%**	**45%**
Materials	40%	
General Conditions & Indirect Costs	10%	
Overhead	5%	
Profit	5%	
Total	100%	

A 12.5% overrun in the labor component

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HYPOTHETICAL PROJECT

Labor	**45%**
Materials	40%
General Conditions & Indirect Costs	10%
Overhead	5%
Profit	0%
Total	100%

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CHANGE AND PRODUCTIVITY

- Poor design
- Stacking of Trades
- Overtime
- Weather/seasonality
- Interrupted learning curve
- Dilution of supervision
- Logistics
- Crew size inefficiency
- Late deliveries
- Wrong means & methods
- Complicated designs
- Out of sequence work
- Constructive acceleration
- Changes & Their Timing
- Congestion
- Shift work
- Day/Night
- Site access
- Fatigue
- Morale
- QA/QC
- Concurrent operations
- Poor management
- Lack of training
- Mistakes
- Staff turnover

WHAT'S A CHANGE

Any variation from the contract

- Additive, Deductive
- Agreed to or unilateral
- Physical, Administrative, Personnel
- Timing
- Cardinal

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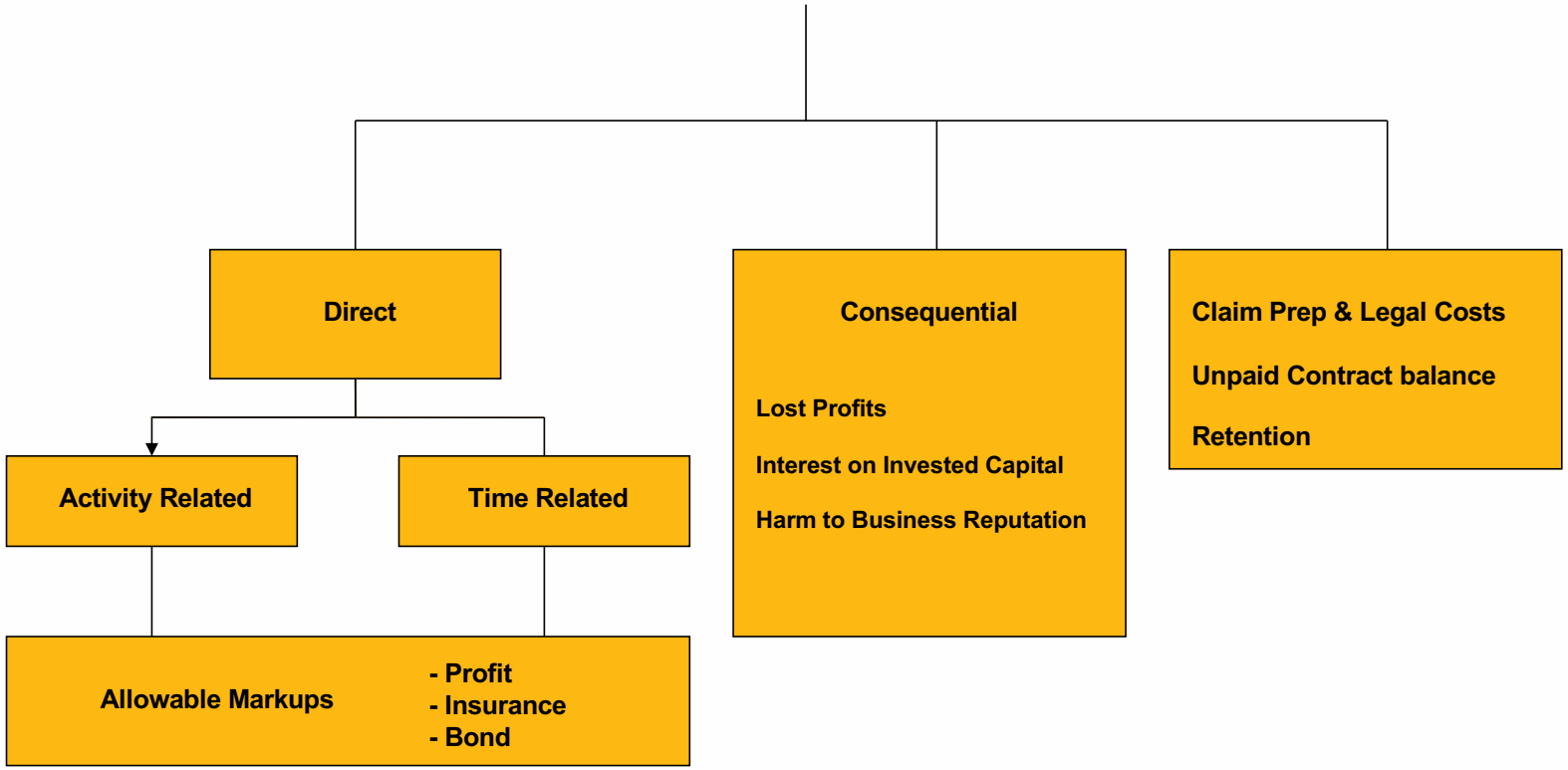
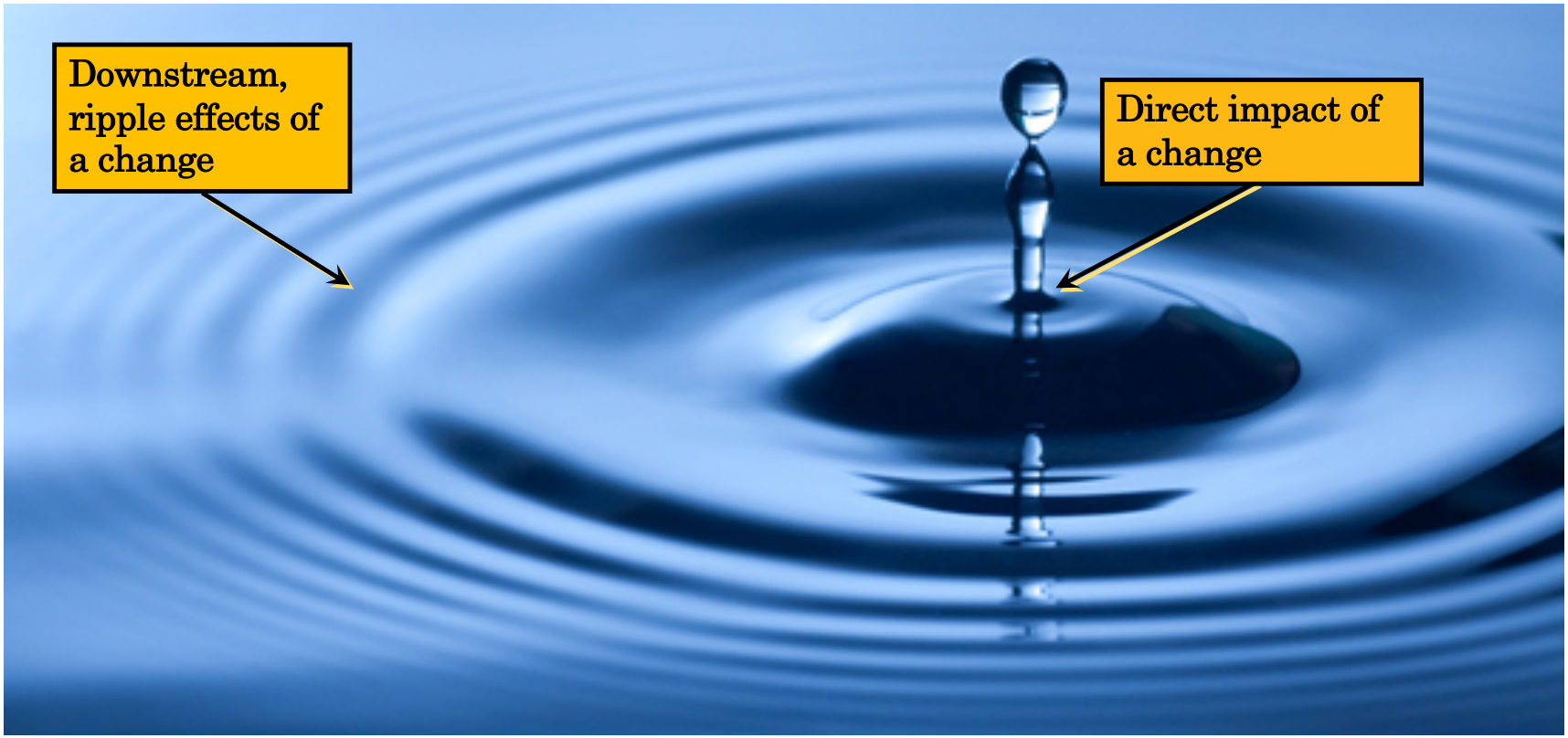
DAMAGE COMPONENTS OF CHANGE



SYMBOLIC IMPACT OF A SINGLE CHANGE



MEASURING LOSS OF PRODUCTIVITY DAMAGES

"It is a rare case where loss of productivity can be proven by books and records; almost always it has to be proven by the opinions of expert witnesses. However the mere expression of an estimate as to the amount of productivity loss by an expert witness with nothing to support it will not establish the fundamental fact of resultant injury nor provide a sufficient basis for making a reasonably correct approximation of damages."

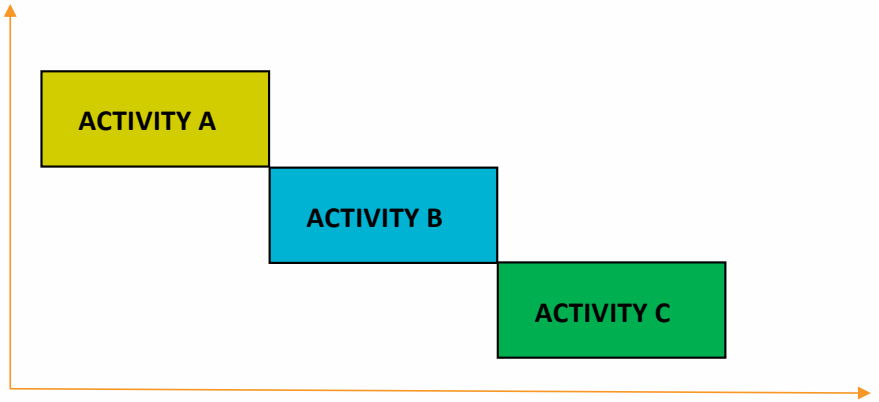
Luria Brothers & Co. v. US, 369 F.2d 701 (Ct. Cl. 1966).

DELAY VS. DISRUPTION

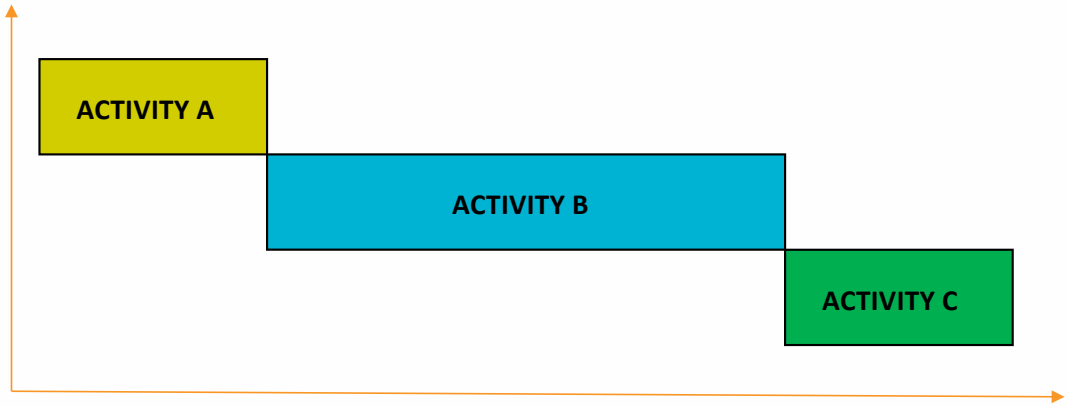
- Delay
  - Must be on schedule's critical path
  - Time extension
  - Relaxation of LDs
  - Extended Overhead
- Disruption
  - Does not have to be on critical path
  - Impacts labor productivity
  - Numerous changes may affect Change Order work and base contract work

DELAY VS. DISRUPTION

Original Schedule:

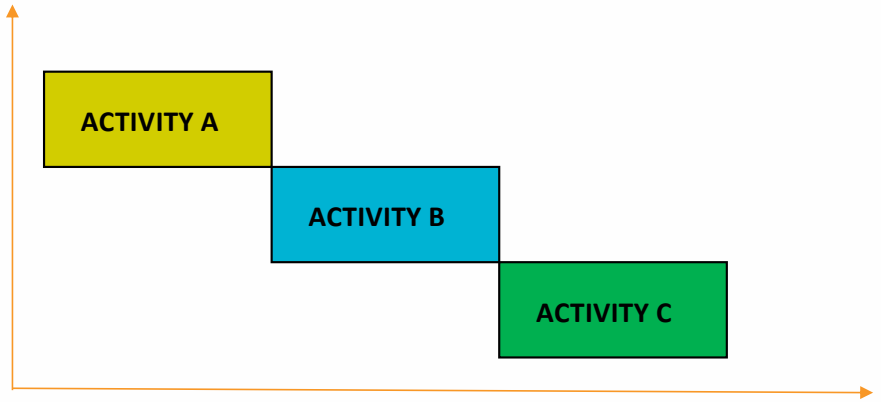


Delay:

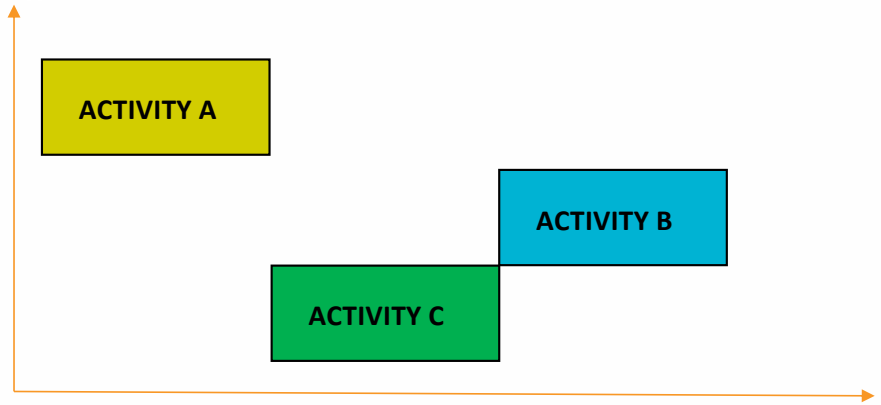


DELAY VS. DISRUPTION

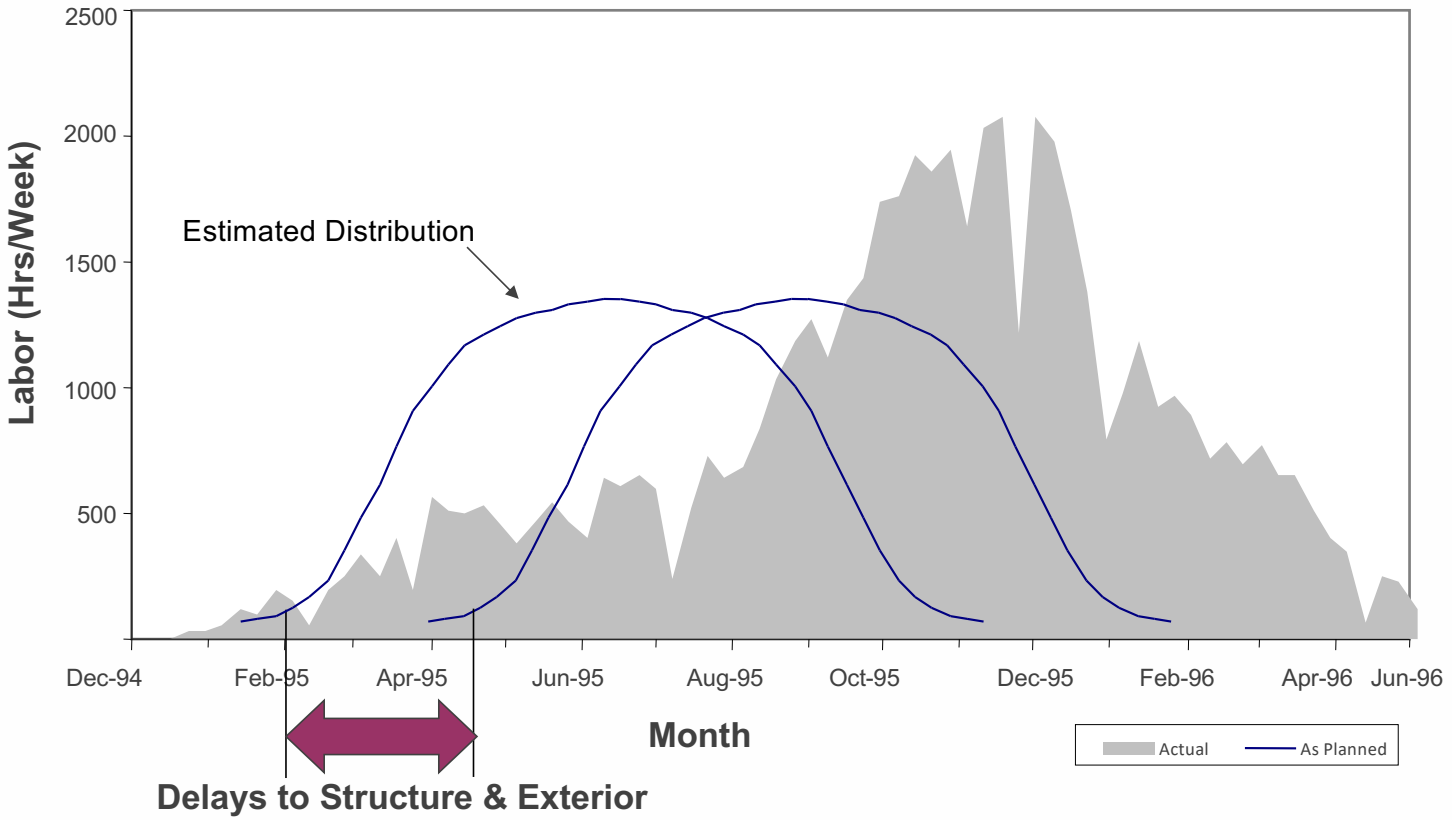
Original Schedule:



Disruption:



DELAY & DRYWALL SUBCONTRACTOR LABOR CURVE



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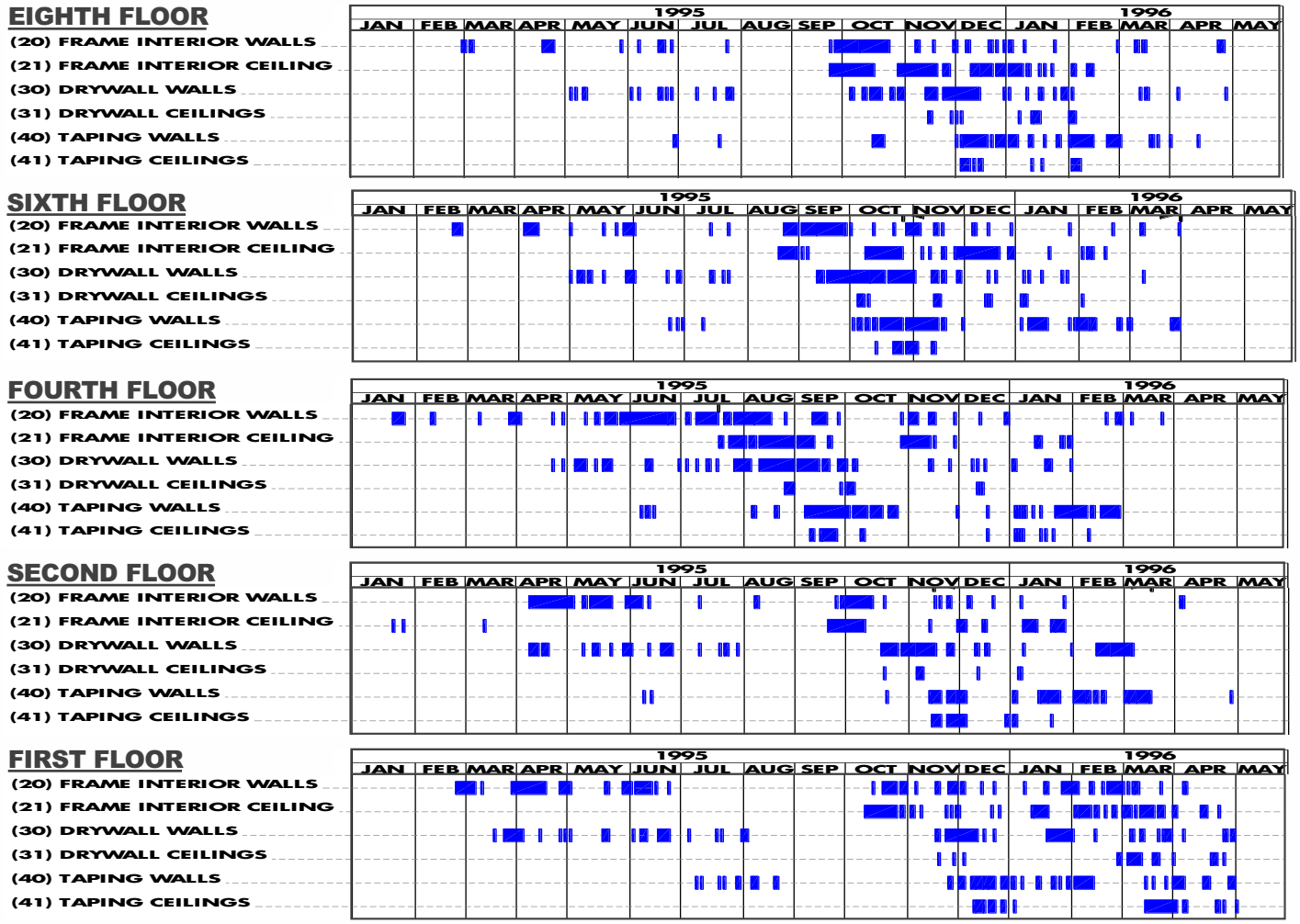
DISRUPTION & DRYWALL SUBCONTRACTOR AS-BUILT SCHEDULE ACTIVITIES



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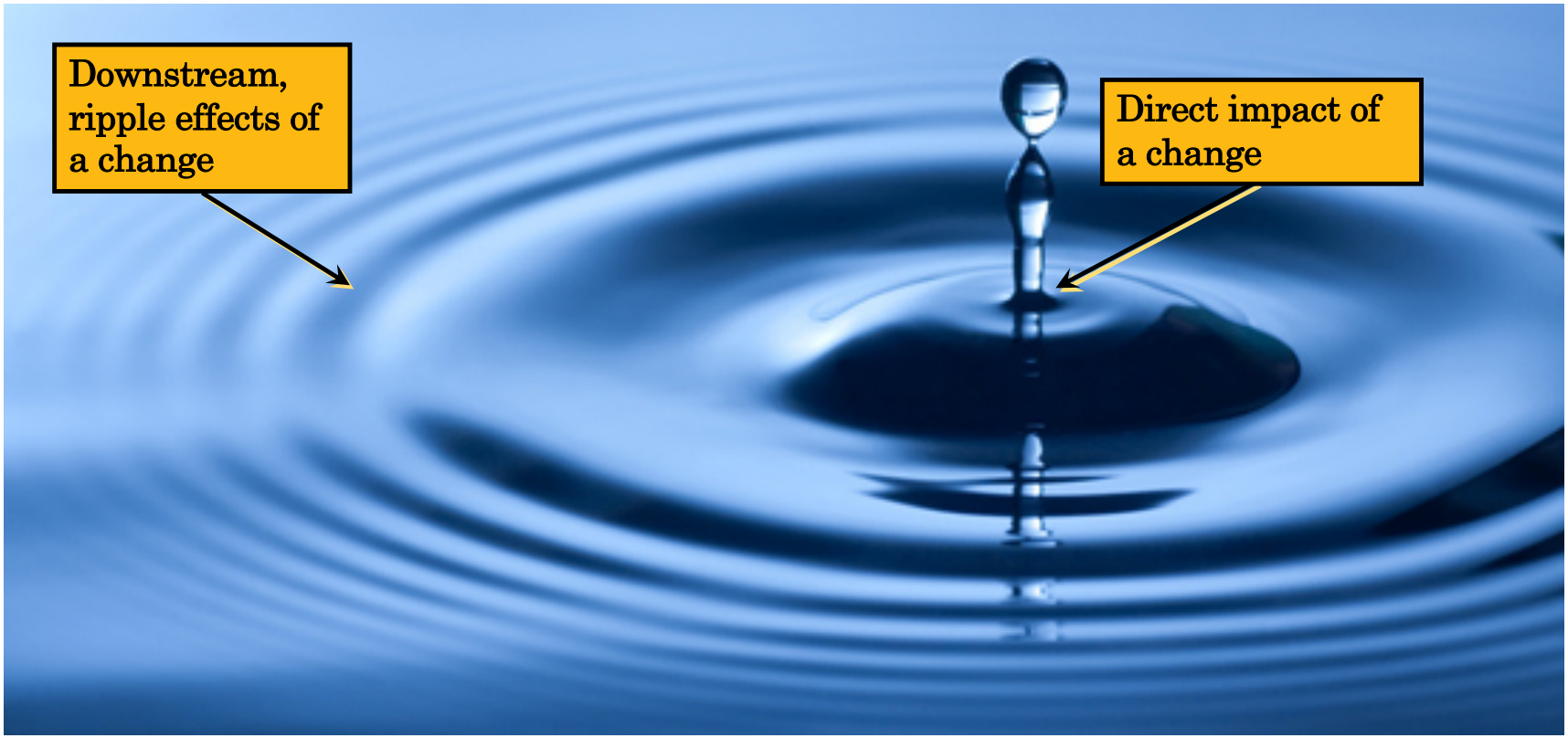
LEGAL CONCEPTS

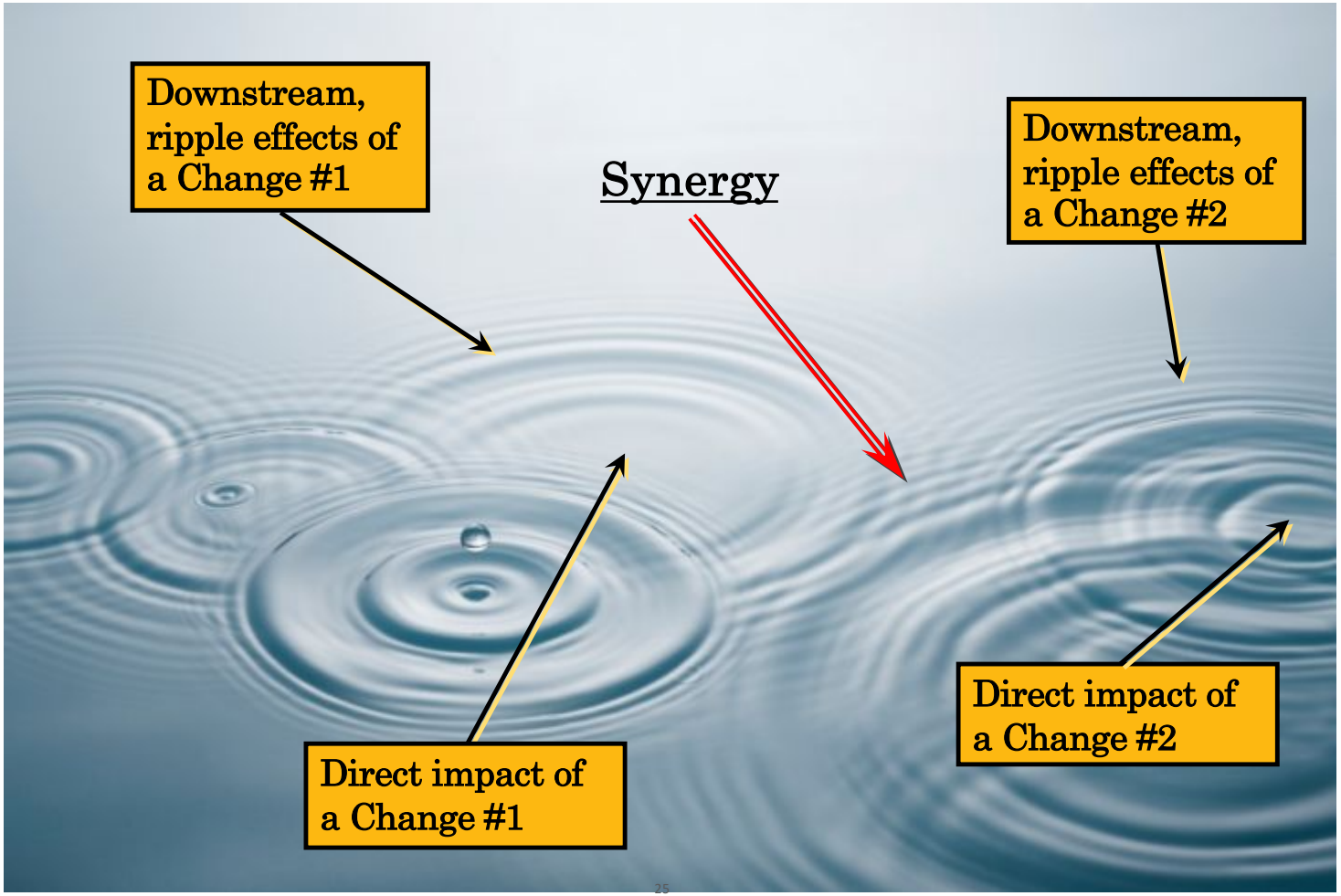
"Impact costs are increased labor costs that stem from disruption to labor productivity resulting from a change in working conditions caused by a change. Productivity is inversely proportional to the man-hours necessary to produce a unit of product… If productivity declines, the number of man-hours of labor to produce a task will increase. If the number of man-hours increases, labor costs obviously increase…Quantification of loss of [productivity] or impact claims is a particularly vexing and complex problem."

Appeal of Centex Bateson Construction Co., VABCA Nos. 4613, 5162-5165, December 3, 1998.

SYMBOLIC IMPACT OF A SINGLE CHANGE



SYNERGISTIC IMPACT OF MULTIPLE CHANGES



EFFECT OF MANY CHANGES

Cumulative impact … is the synergistic effect … of changes on the unchanged work and on other changes.

Appeal of Triple "A" South; ASBCA No. 46866, 94-3, BCA ¶ 27,194.

=> Affects both the base contract work and other change work and their productivities.

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CALCULATING LOSS OF PRODUCTIVITY

Quantification Methodologies

- Measured mile
- Earned value
- Industry Studies
- Modified total cost
- Total cost

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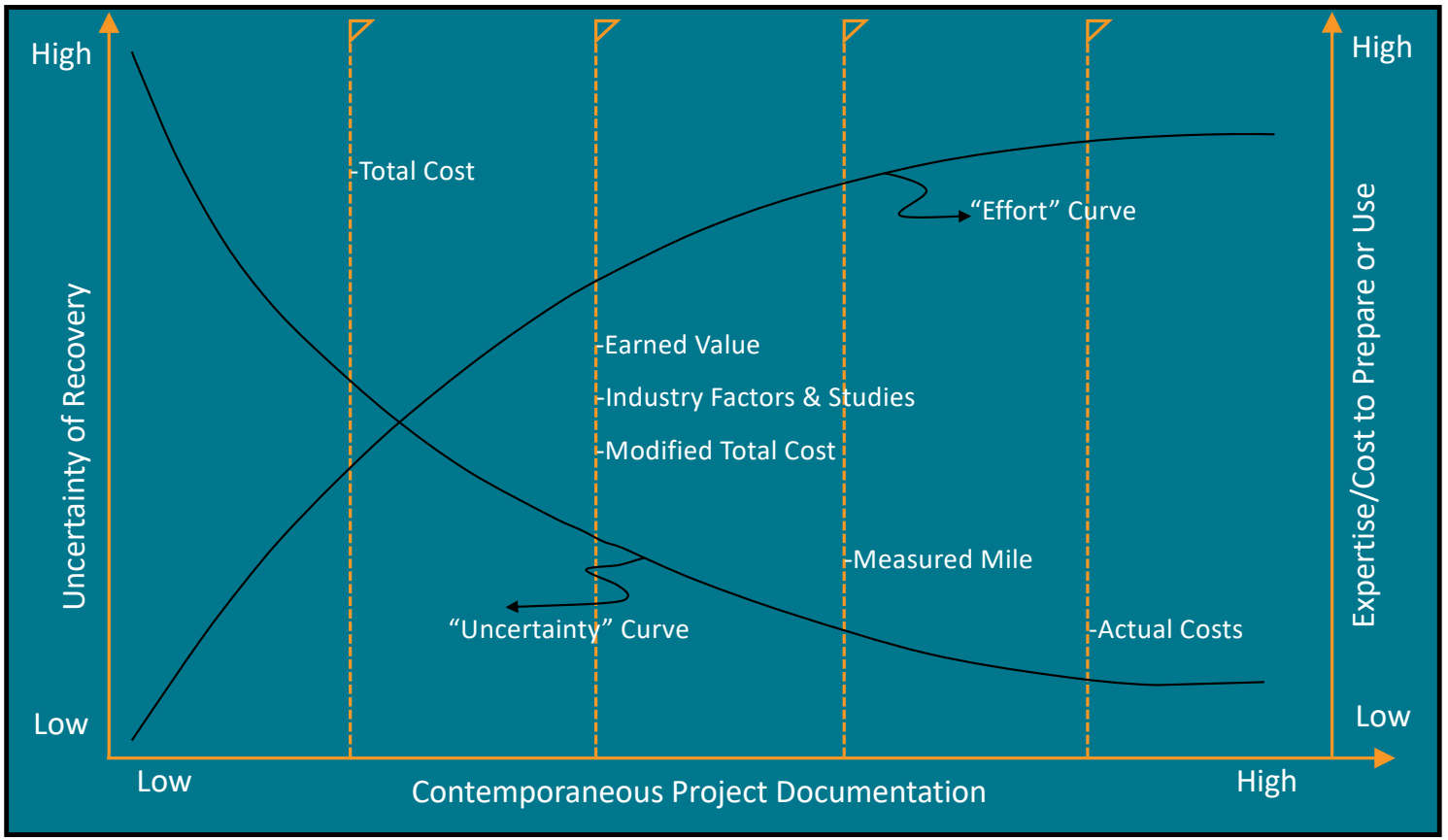
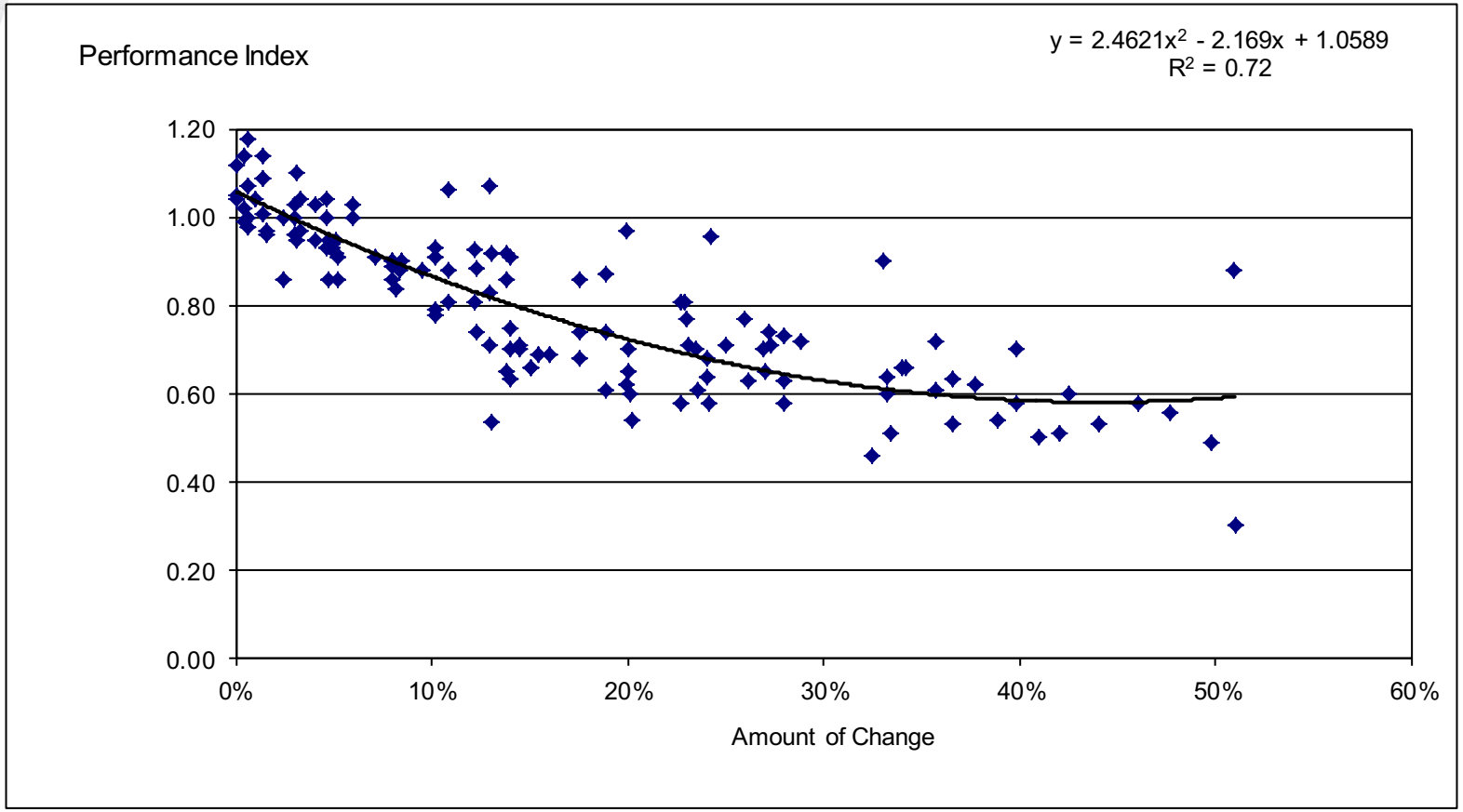
ASCE STANDARD FOR CONSTRUCTION PRODUCTIVITY



Ibbs, C.W., L.D. Nguyen and S. Lee, "Quantified Impacts of Project Change," Journal of Professional Issues in Engineering Education and Practice, January 2007, 133(1), 45-52.

IBBS LOSS OF PRODUCTIVITY CURVES



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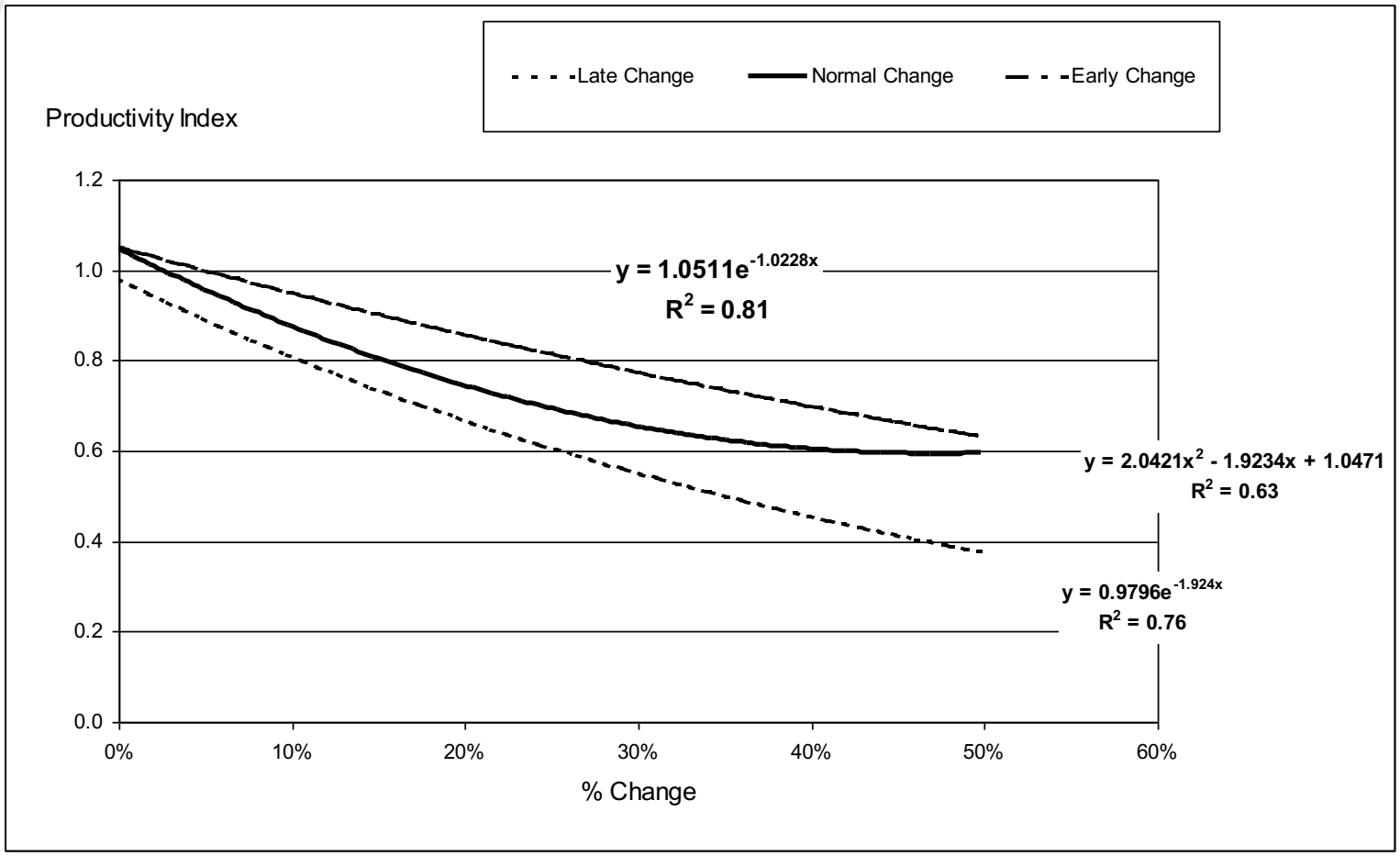

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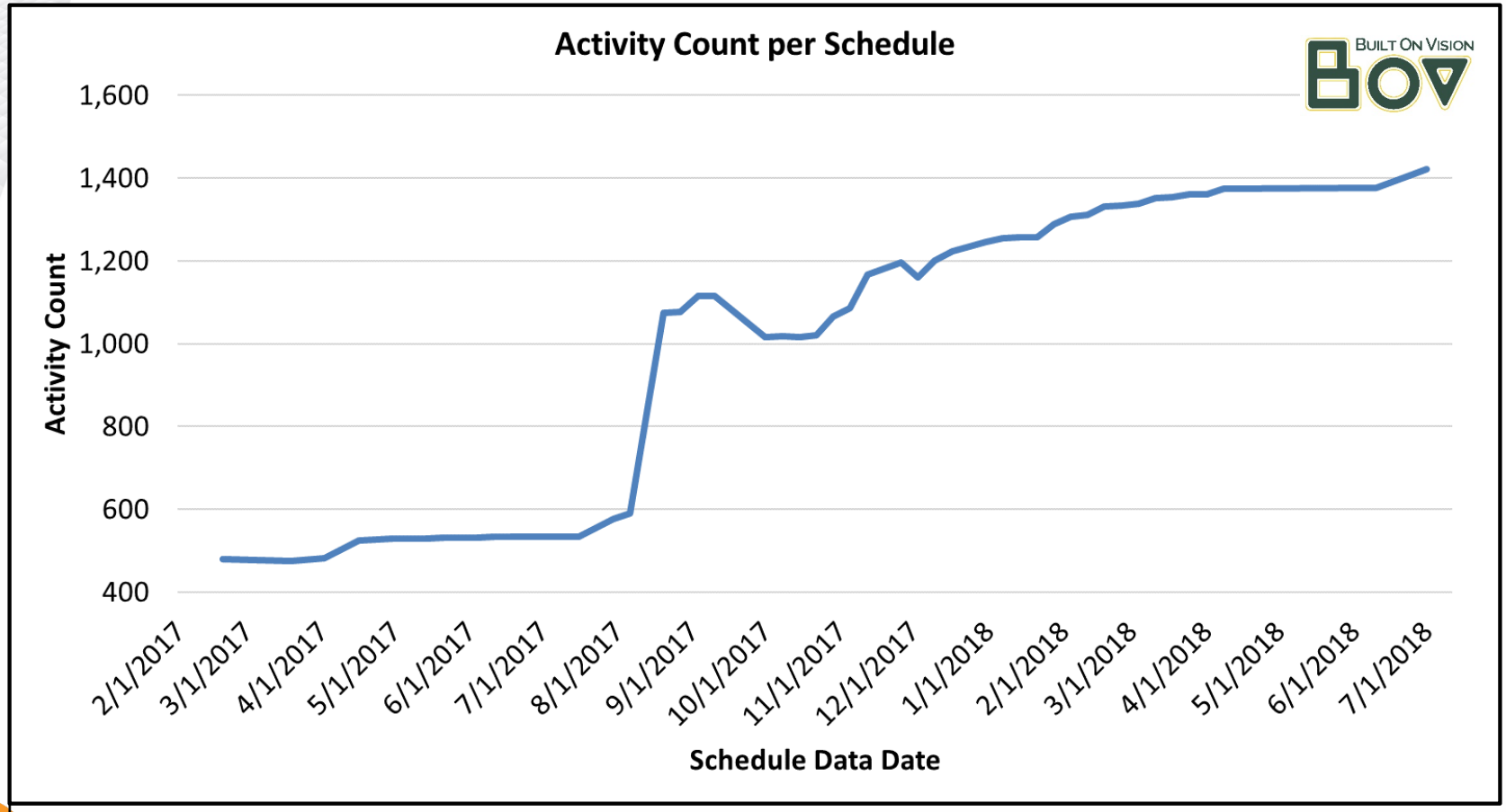
SCHEDULE RELIABILITY MUST BE VERIFIED

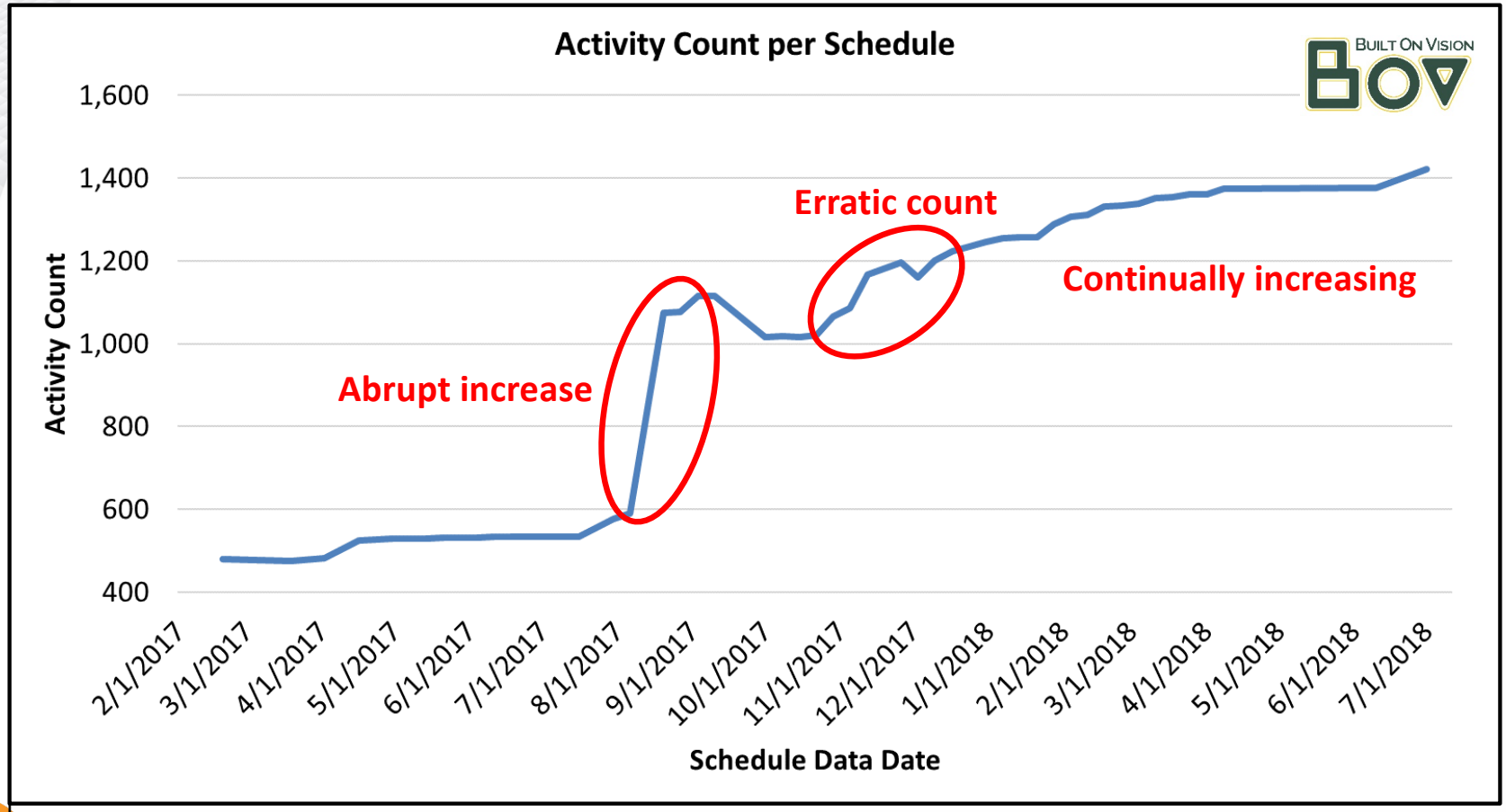
Understanding metrics and trends across multiple schedules is key

- Activity Count Trend
- Relationship Count Trend
- Duration Sum Trend
- Float Sum Trend
- Dangling Activities & Trend
- Activities with Open-End & Trend
- Out of Sequence Activities & Trend
- Activity Churn
- Progress Anomalies
- Anomalous External Relationships
- Logic Anomalies
- Labor Profile
- Cash Flow – Cost & Revenue

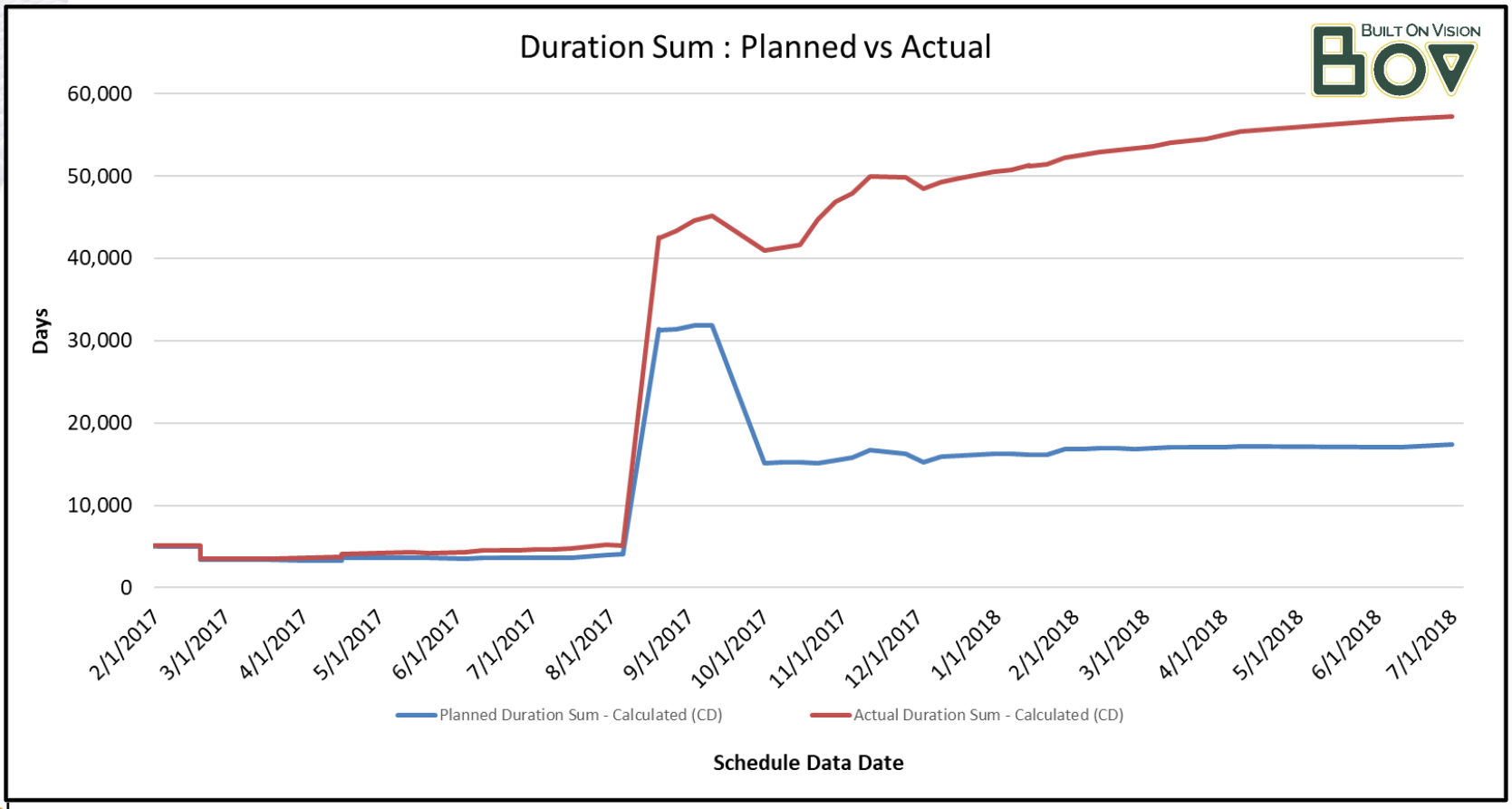
ACTIVITY COUNT



ACTIVITY COUNT



DURATION SUM



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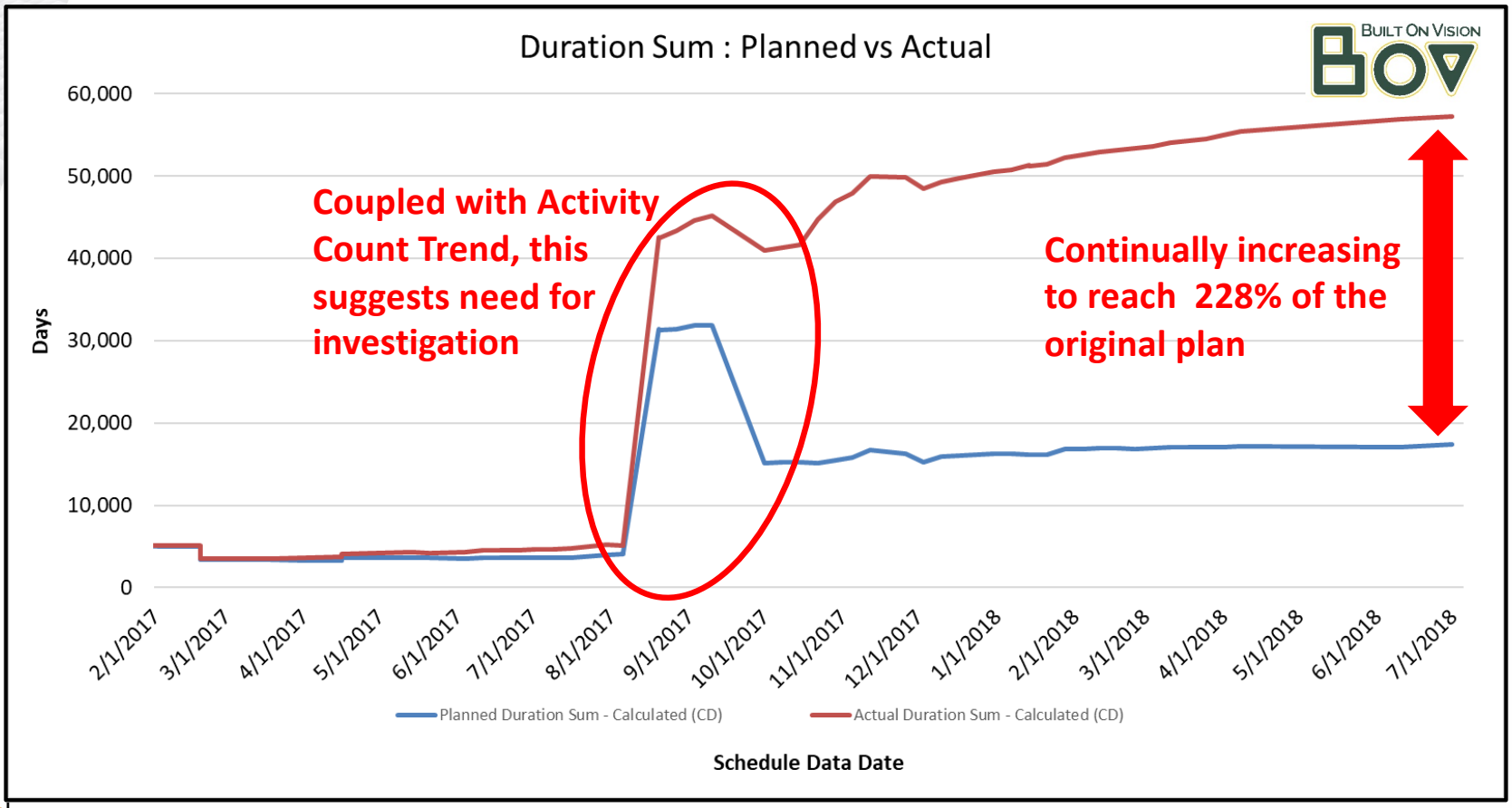
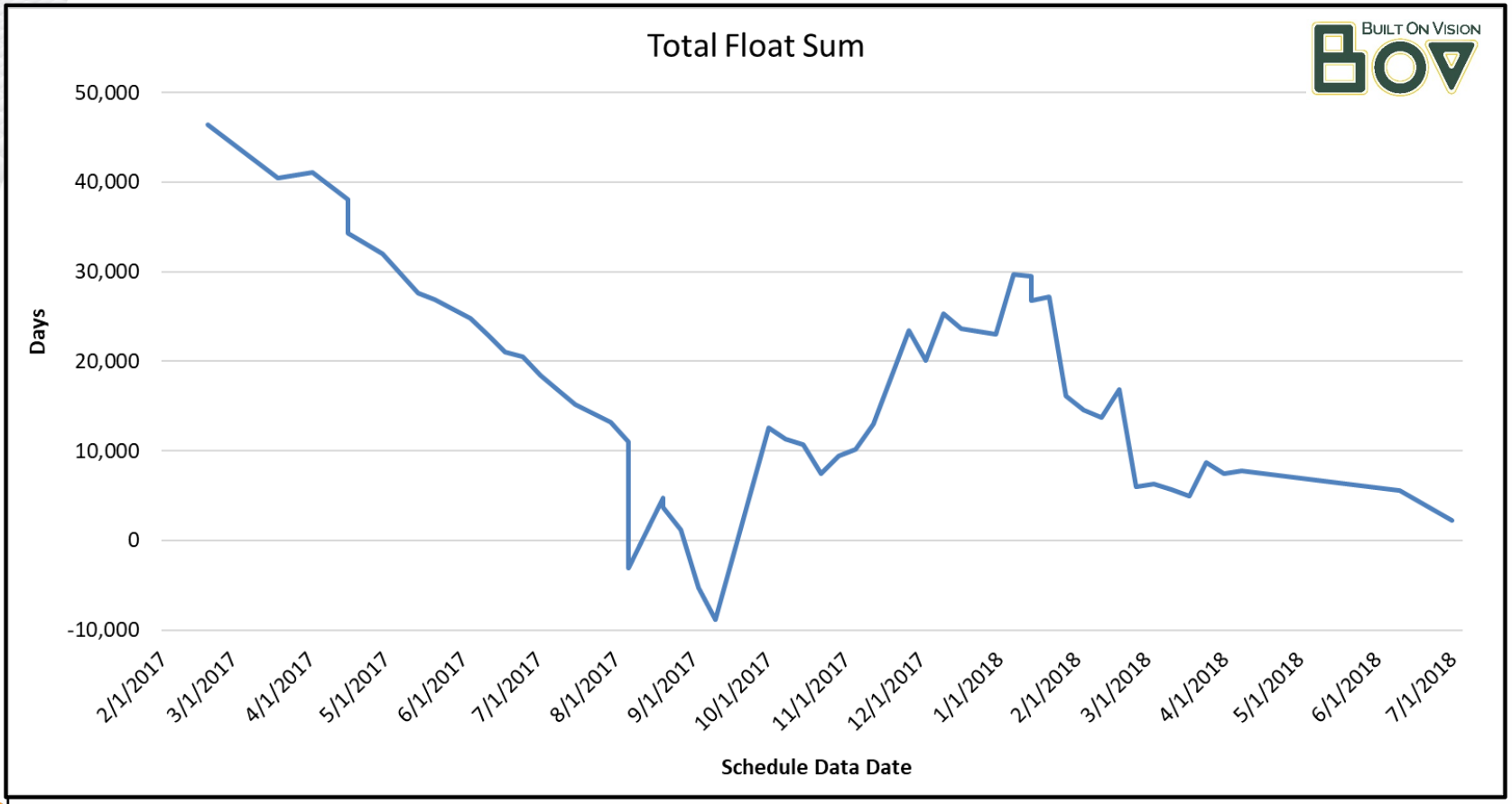
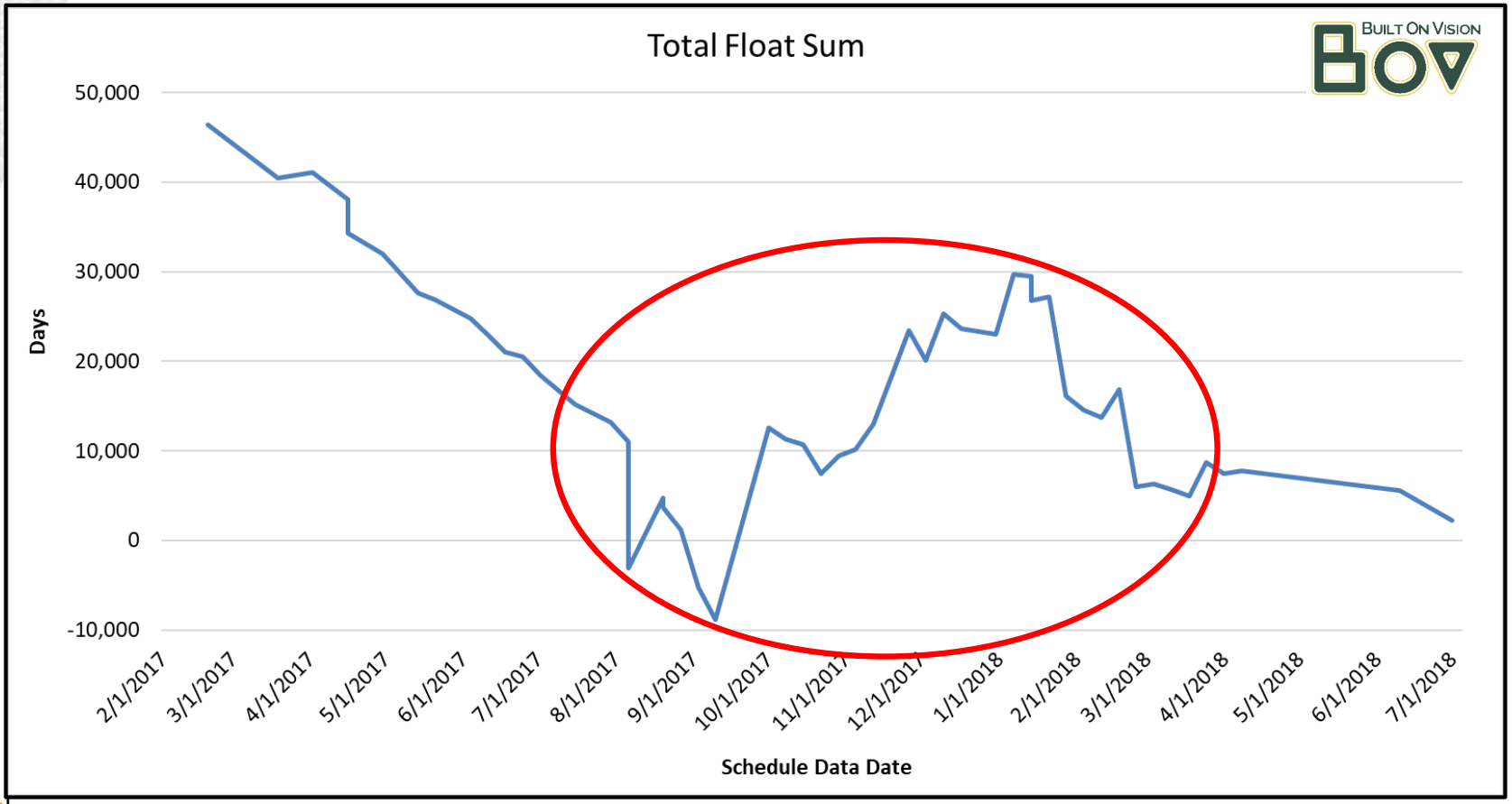


FLOAT SUM


Total Float Sum
50,000
40,000
30,000
20,000
10,000
0
-10,000
Days
2/1/2017
3/1/2017
4/1/2017
5/1/2017
6/1/2017
7/1/2017
8/1/2017
9/1/2017
10/1/2017
11/1/2017
12/1/2017
1/1/2018
2/1/2018
3/1/2018
4/1/2018
5/1/2018
6/1/2018
7/1/2018
Schedule Data Date

FLOAT SUM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7/1/2017
8/1/2017
9/1/2017
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12/1/2017
1/1/2018
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3/1/2018
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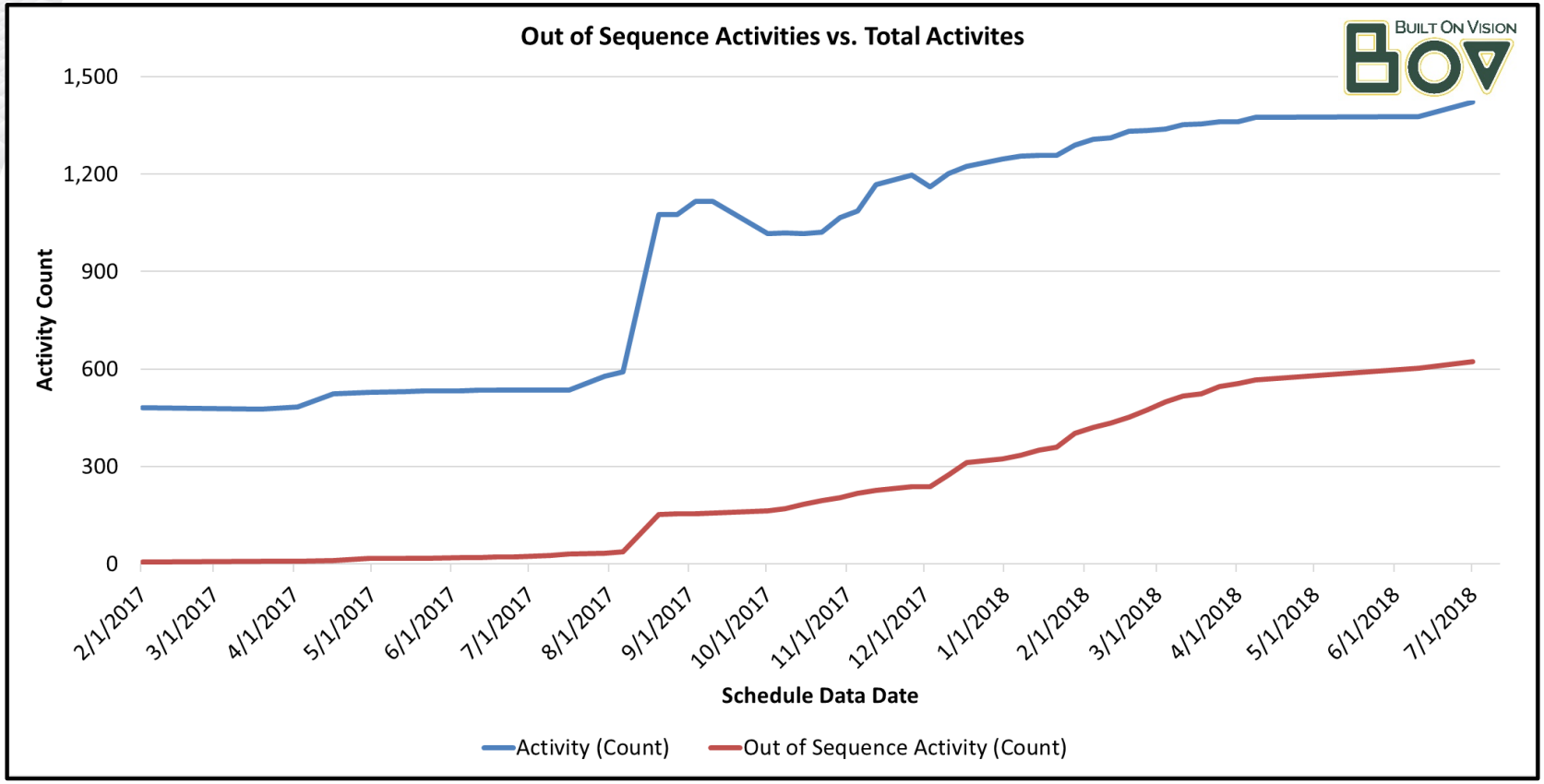
Schedule Data Date

OUT OF SEQUENCE ACTIVITIES



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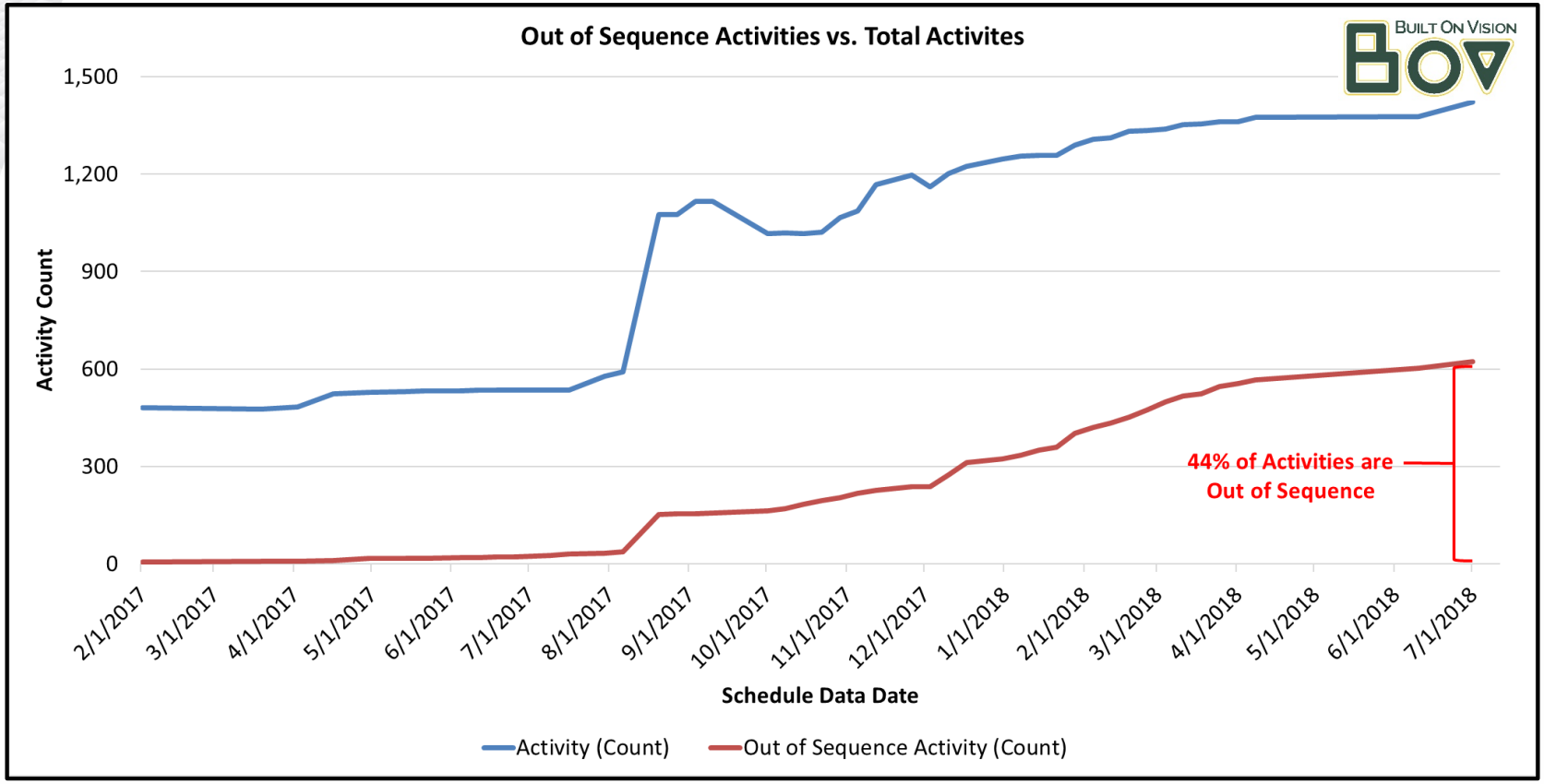
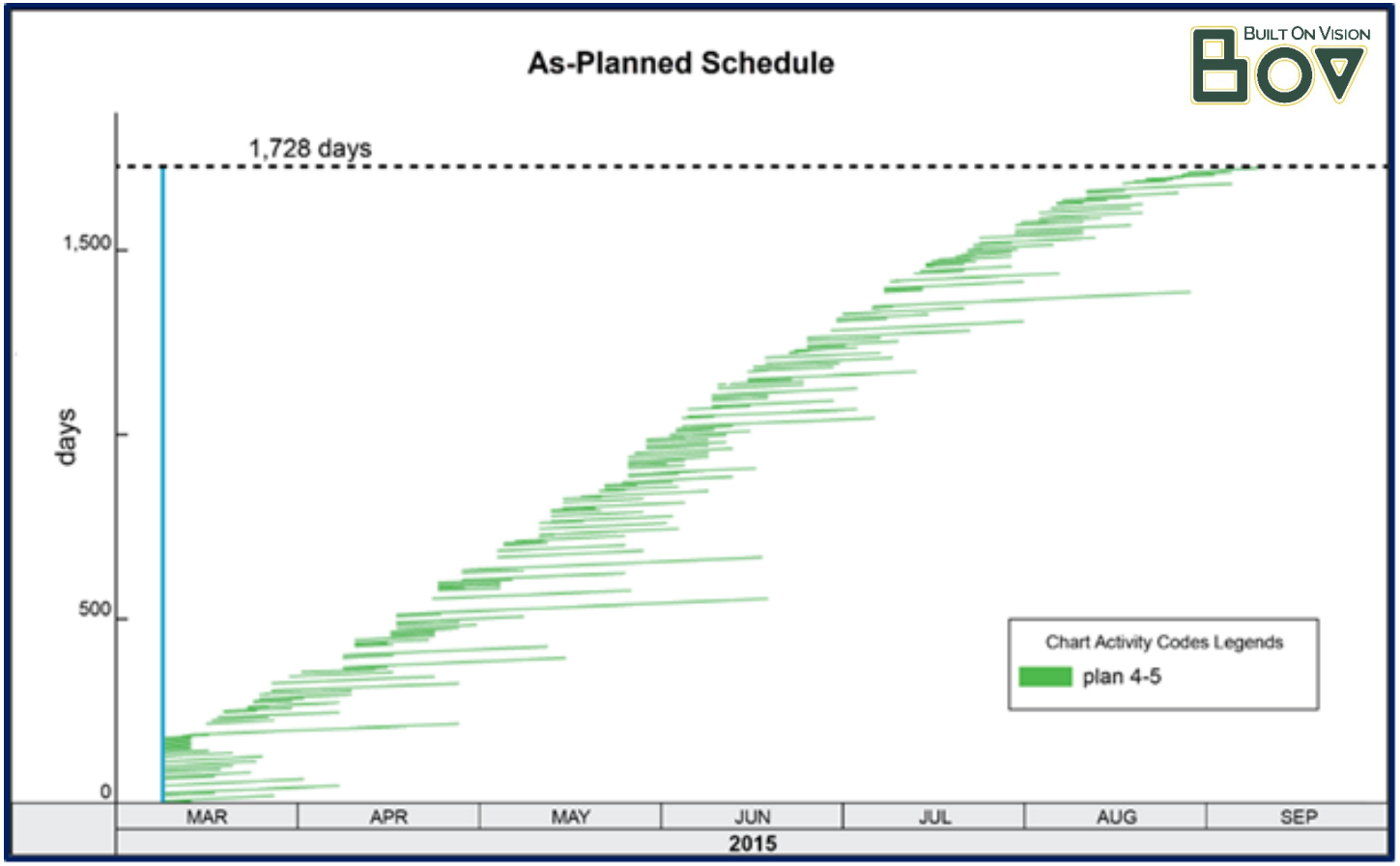


LINEAR GRAPHS



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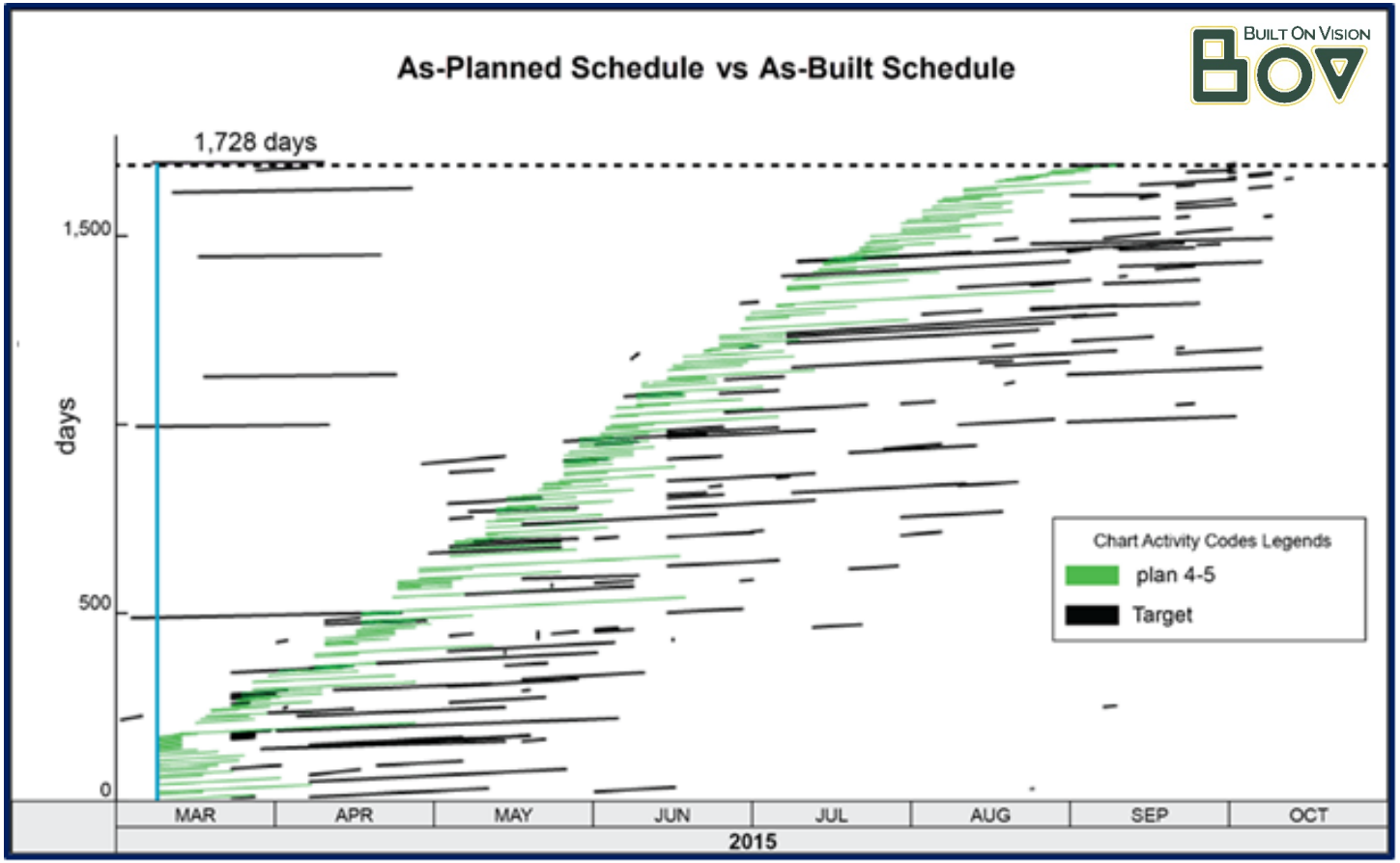

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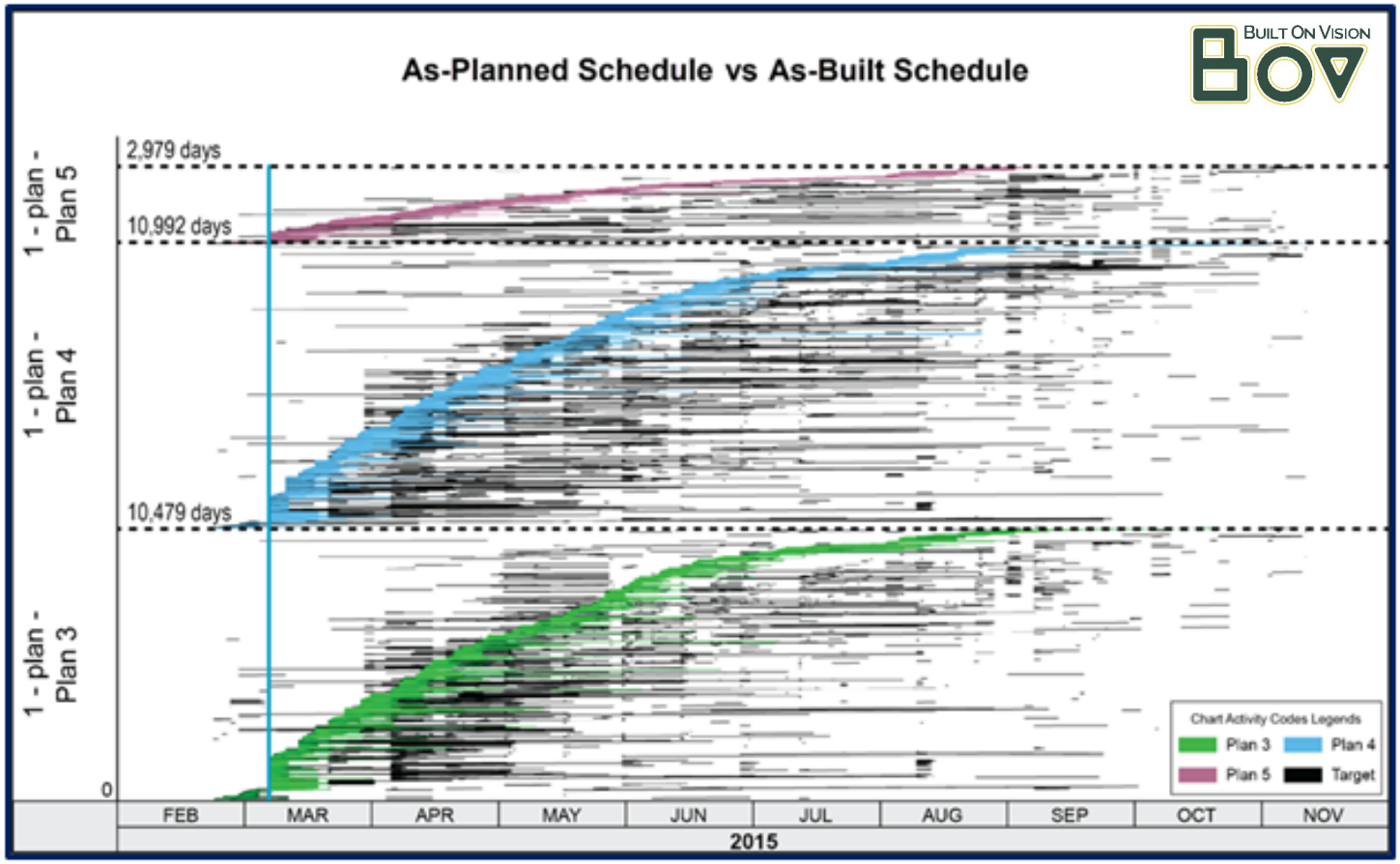
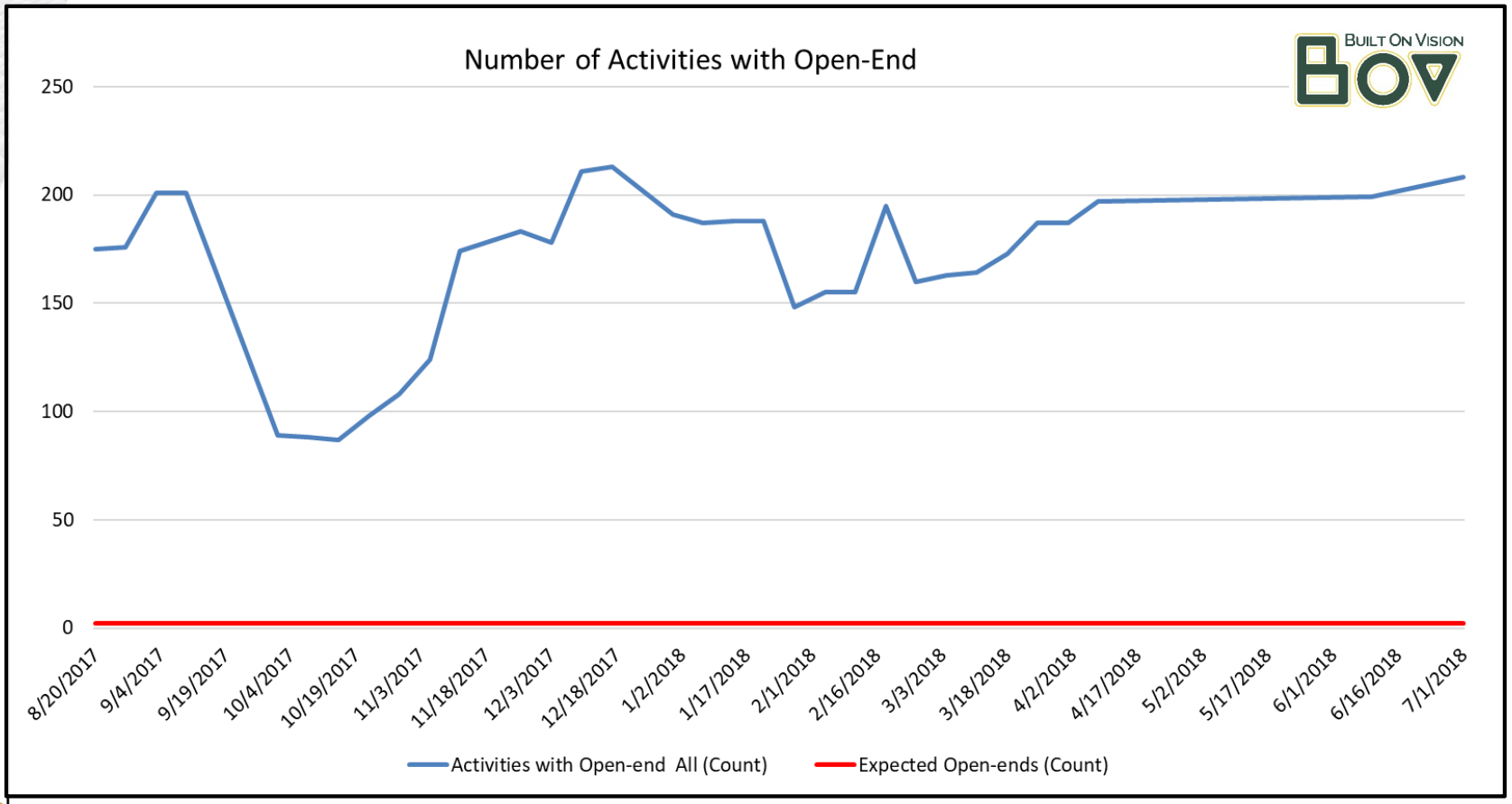


NUMBER OF ACTIVITIES WITH OPEN-END



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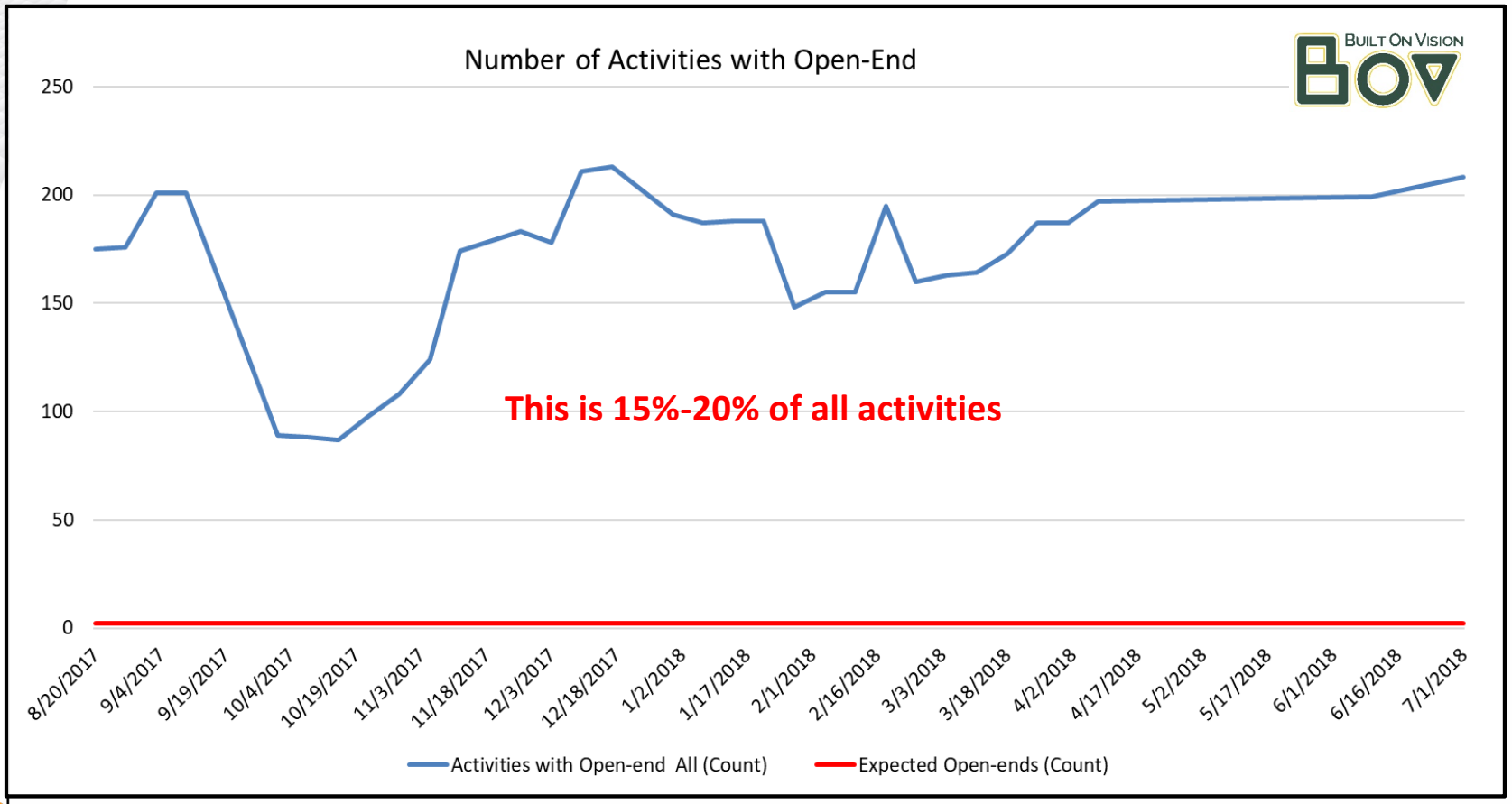
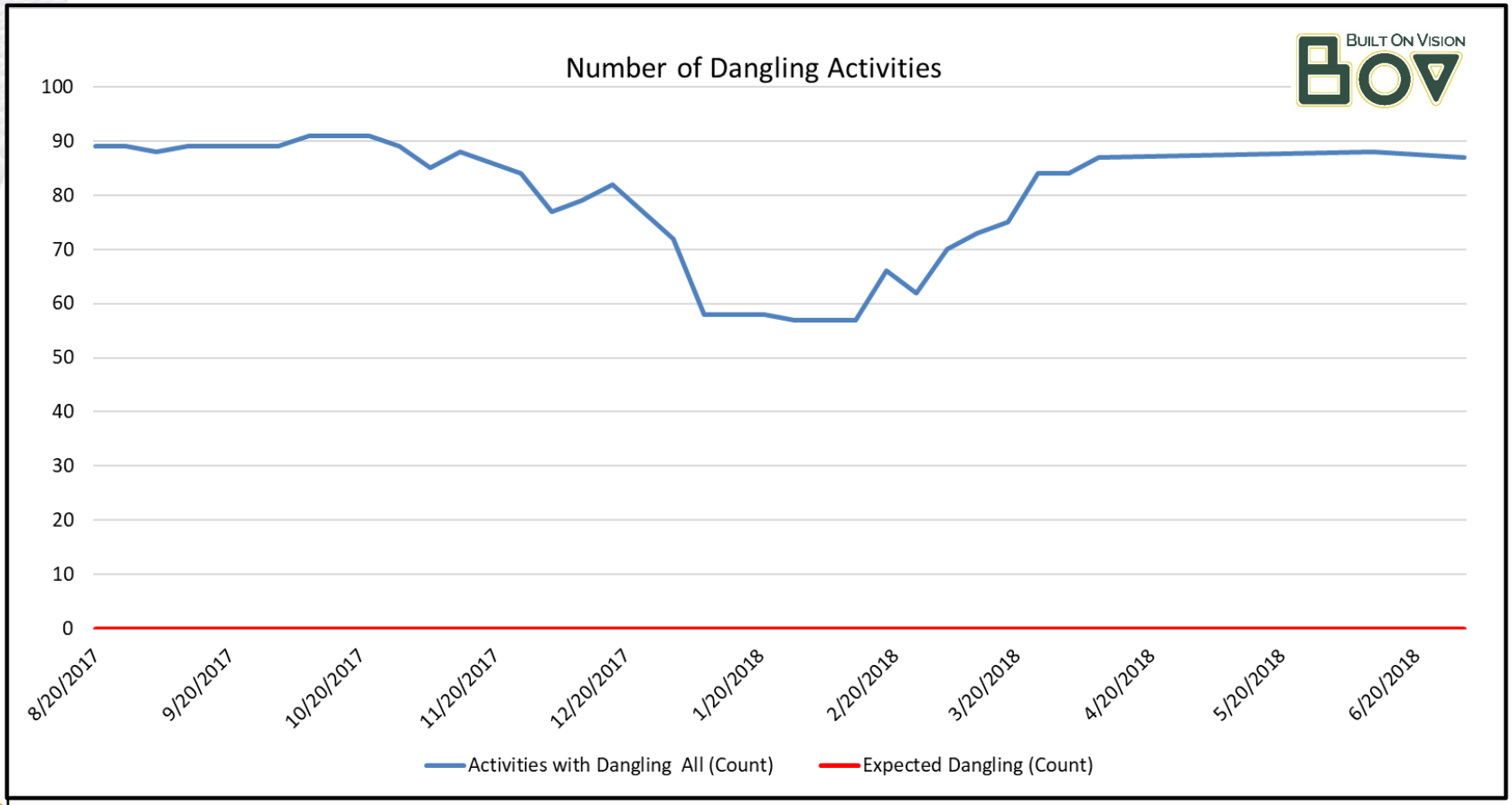


NUMBER OF DANGLING ACTIVITIES



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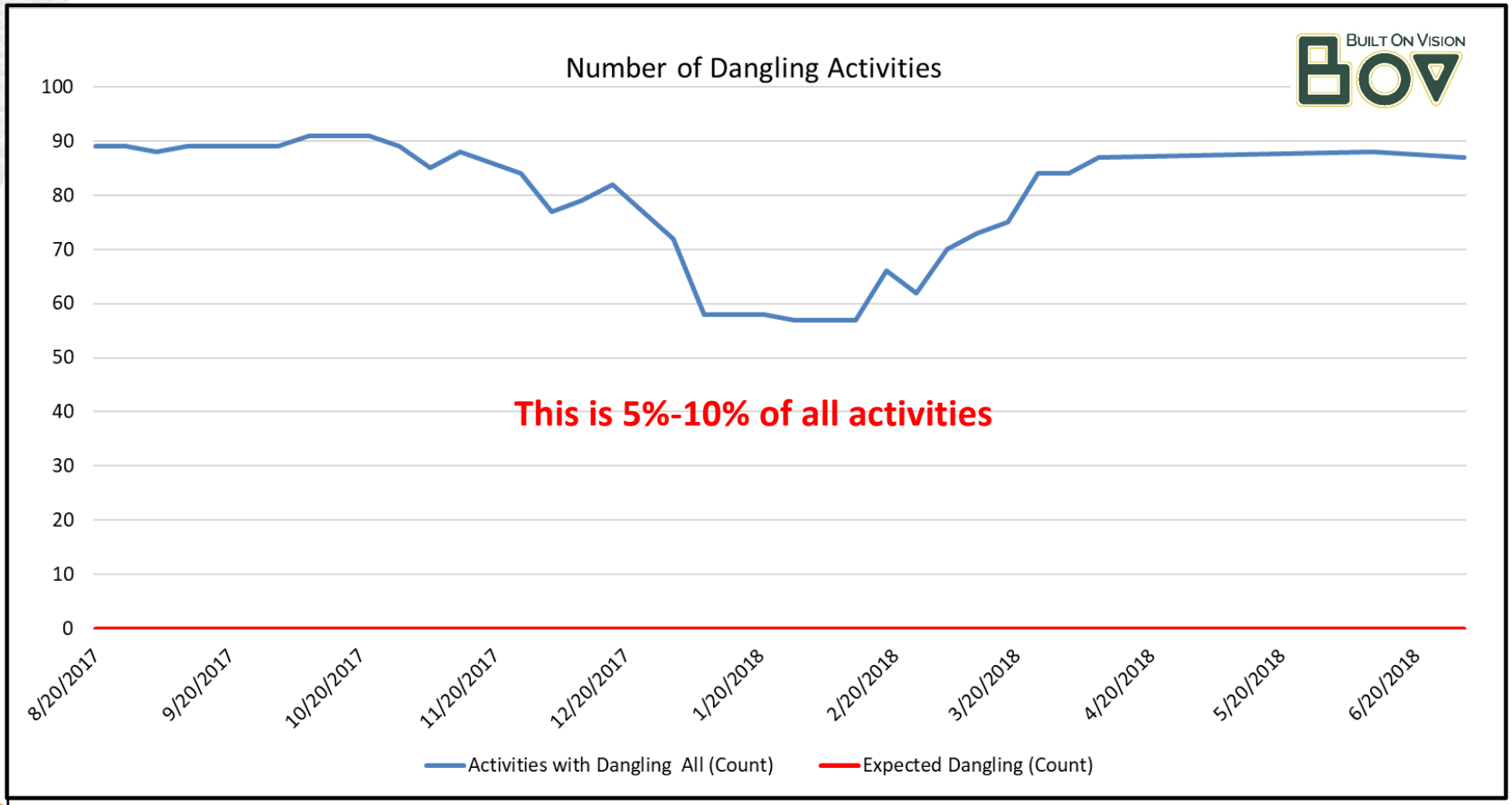
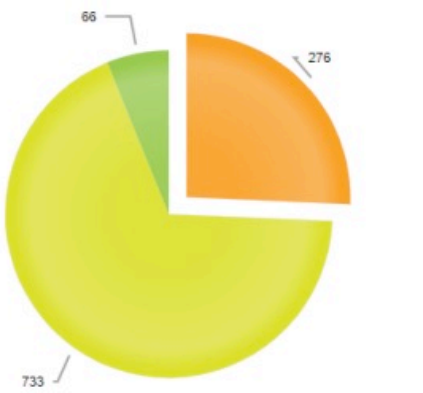
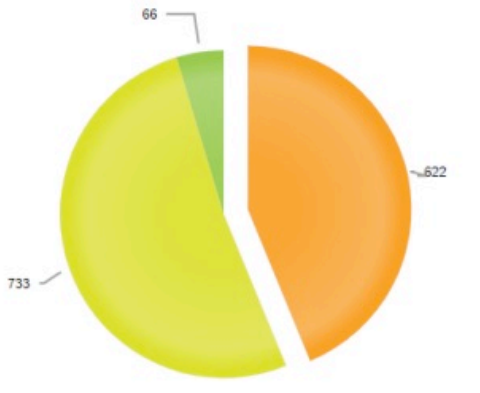


ACTIVITY CHURN

Project	
Source	
Target	
Source Total Activities	1,075
Target Total Activities	1,421
Source Activities Not In Target	276
Target Activities Not In Source	622
Common Activities	799
Unchanged Common Activities	66
Changed Common Activities	733
Changed/Added/Deleted Total	1,631
Changed/Added/Deleted Total % of Source	151.721%
Changed/Added/Deleted Total % of Target	114.778%





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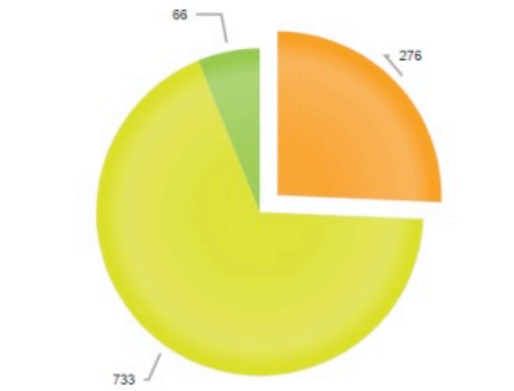
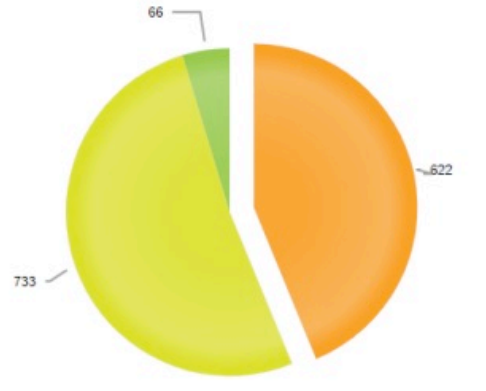
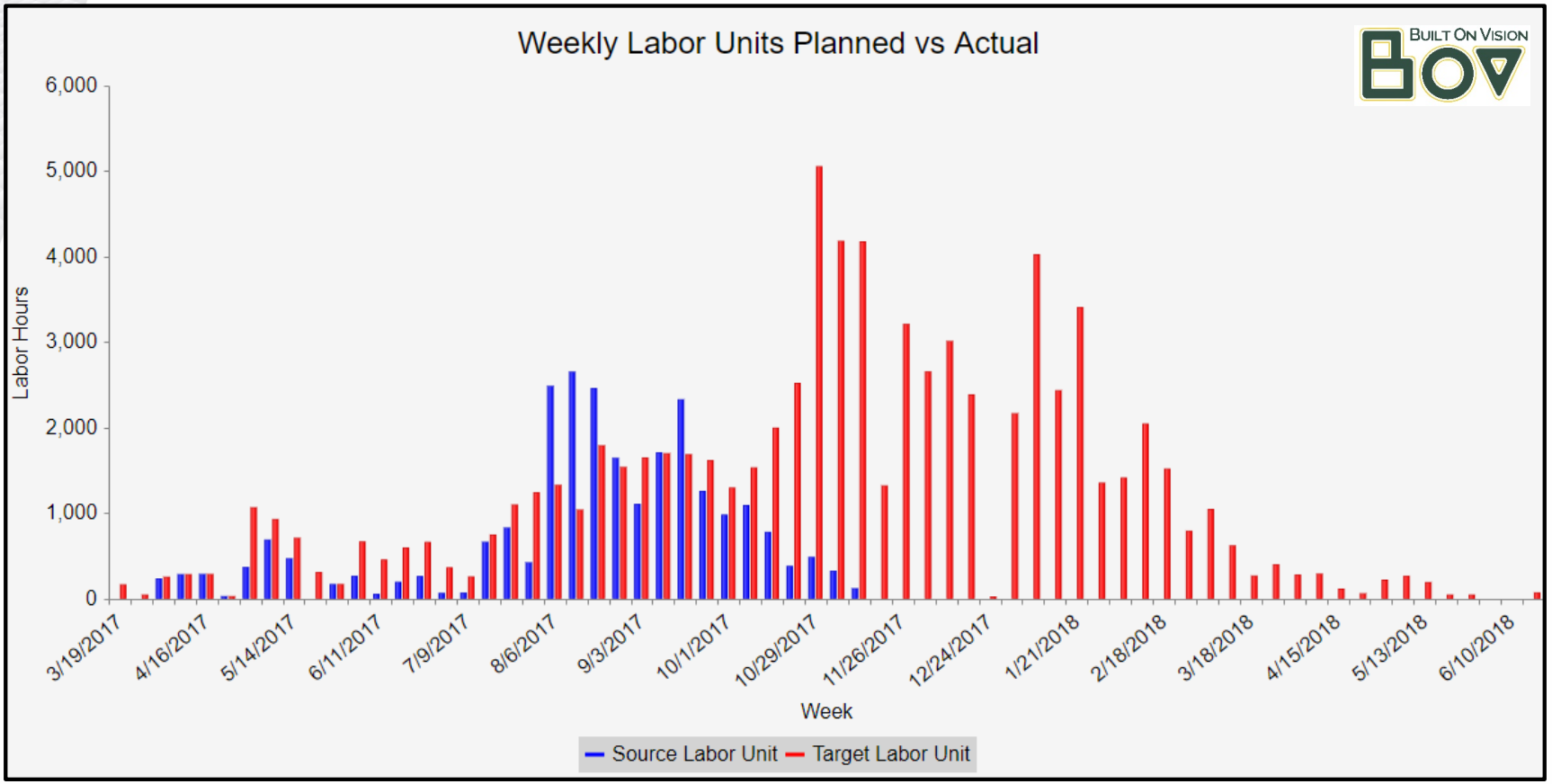




CHALLENGING PROJECTS

CHALLENGING PROJECTS

WEATHER IMPACT



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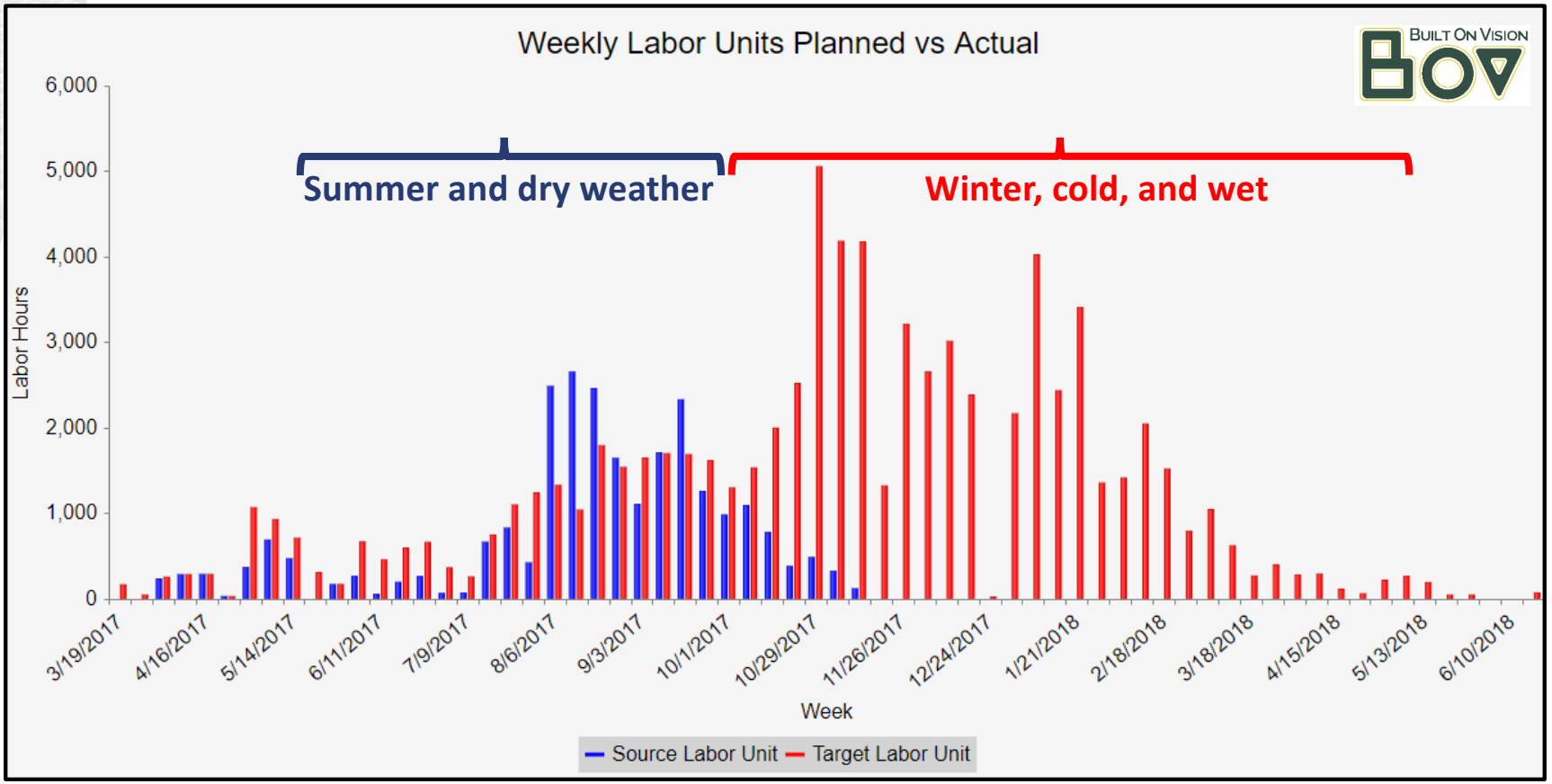
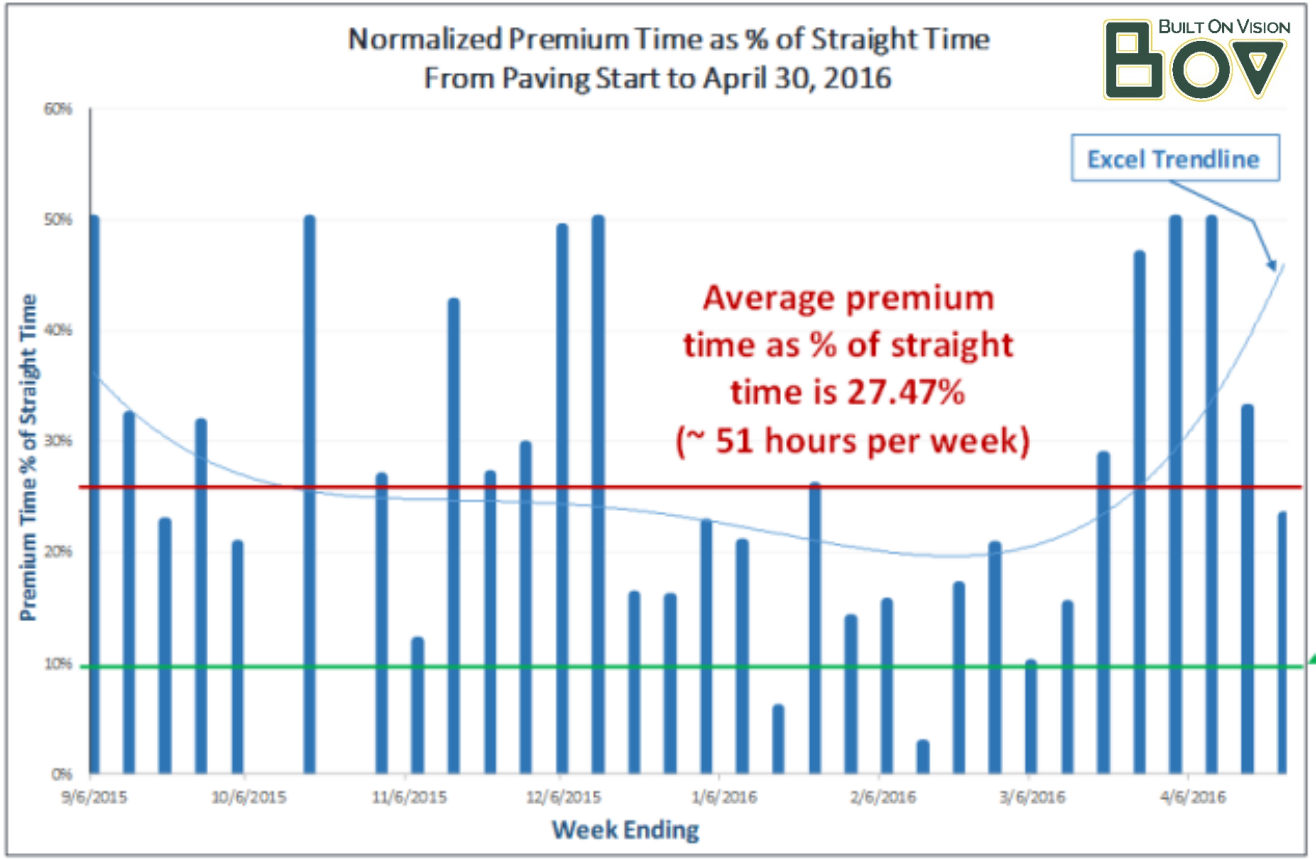
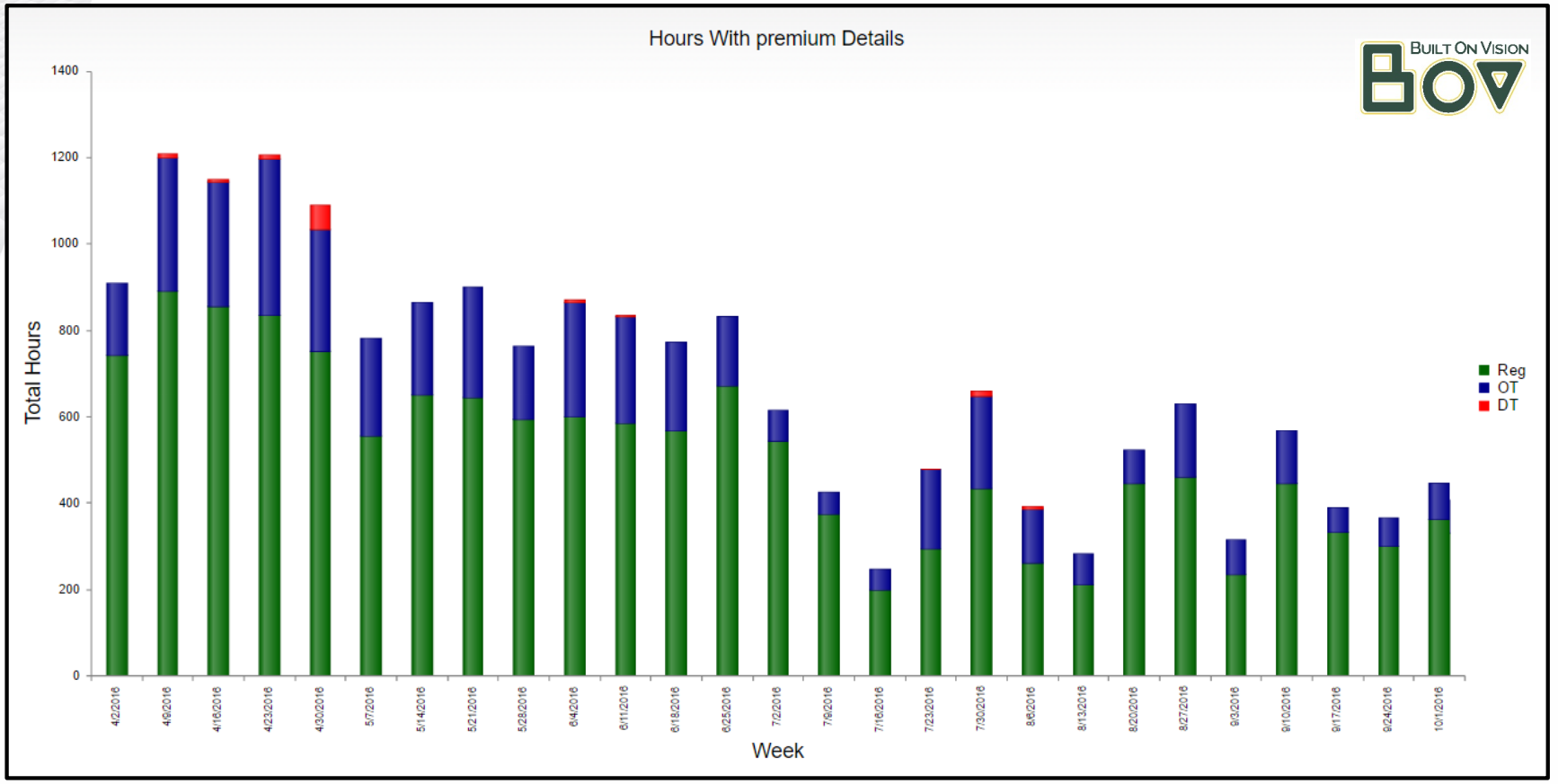


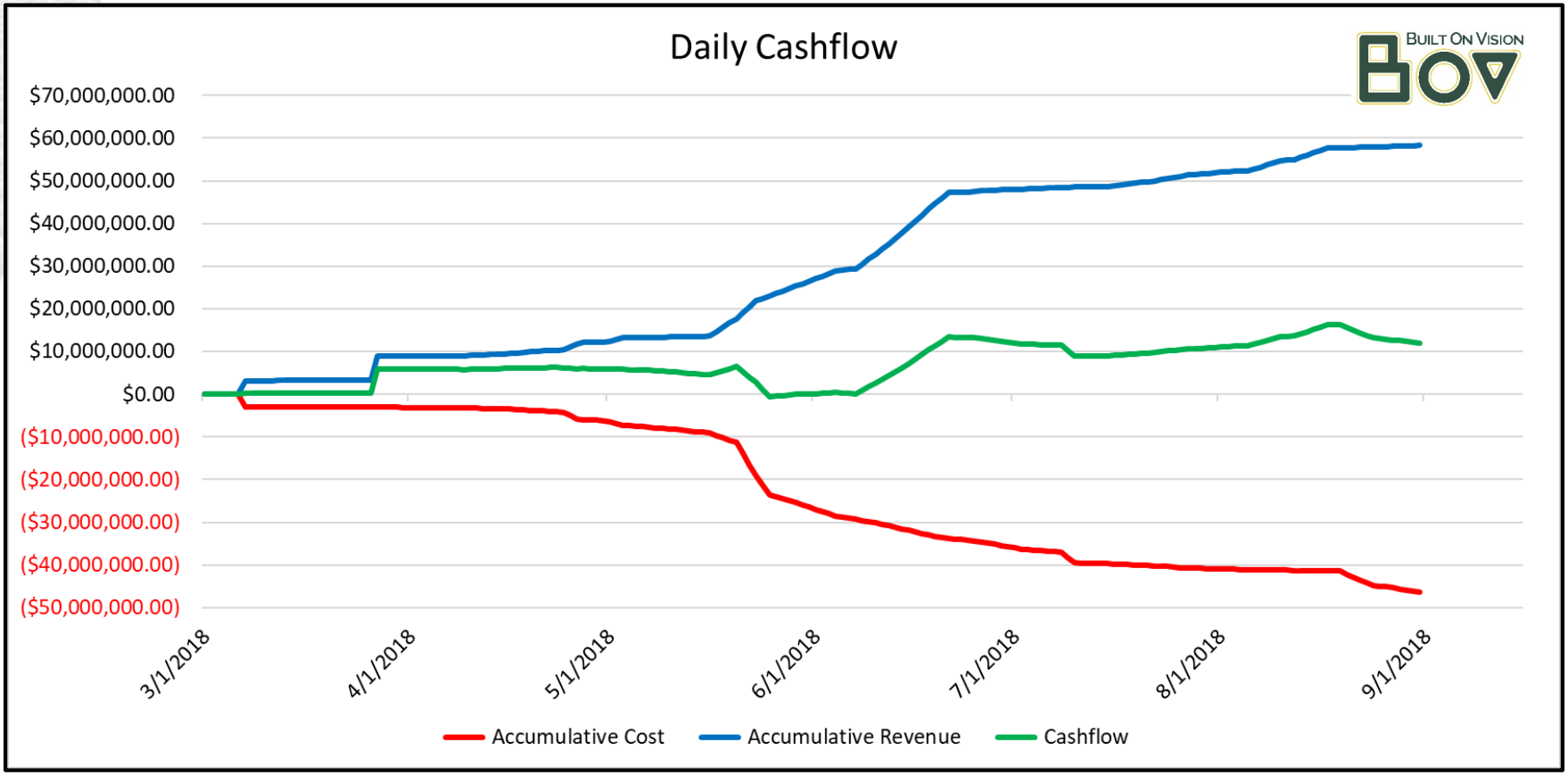
LABOR PRODUCTIVITY



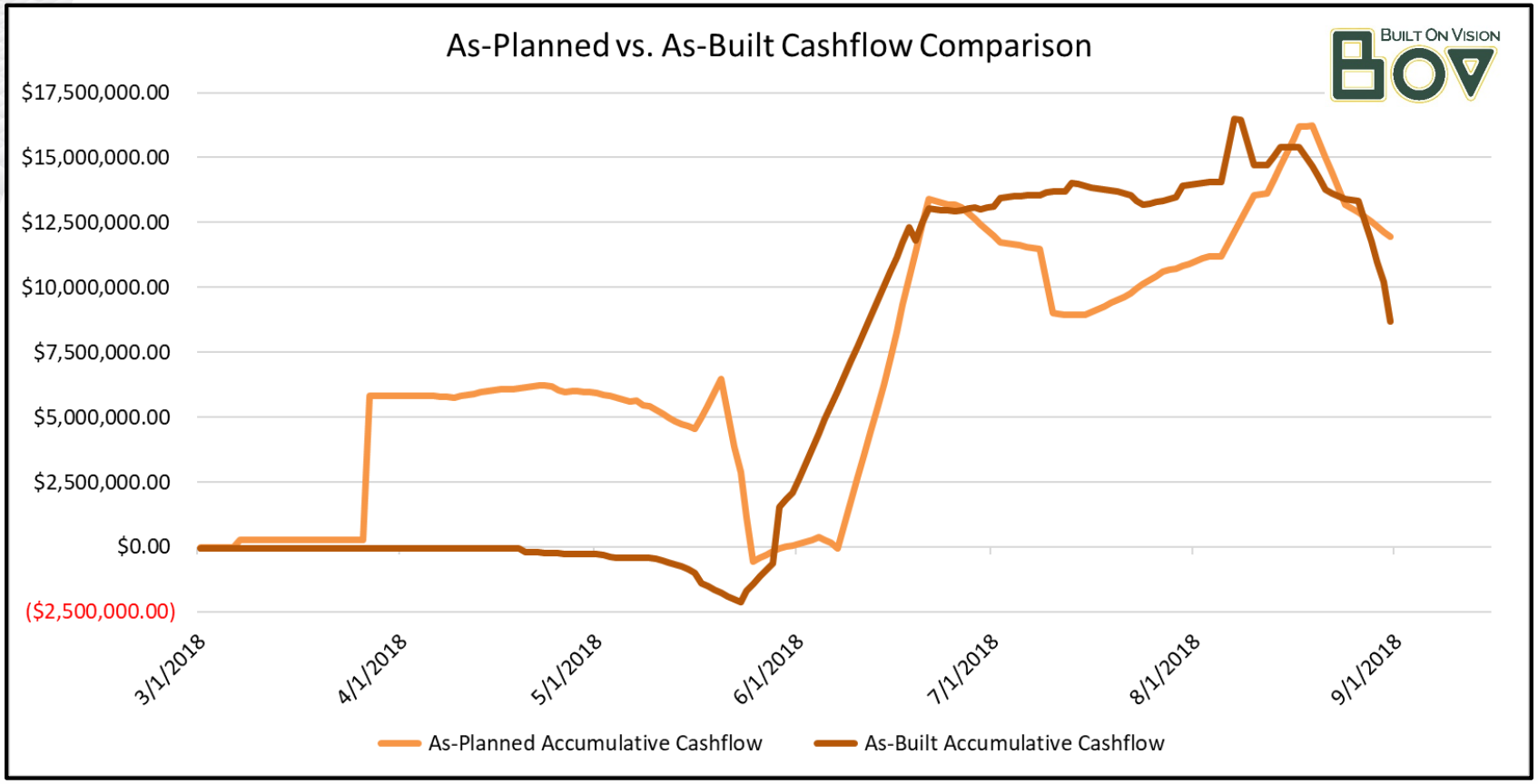
PREMIUM TIME ANALYSIS



PROJECT CASHFLOW



CASHFLOW COMPARISON



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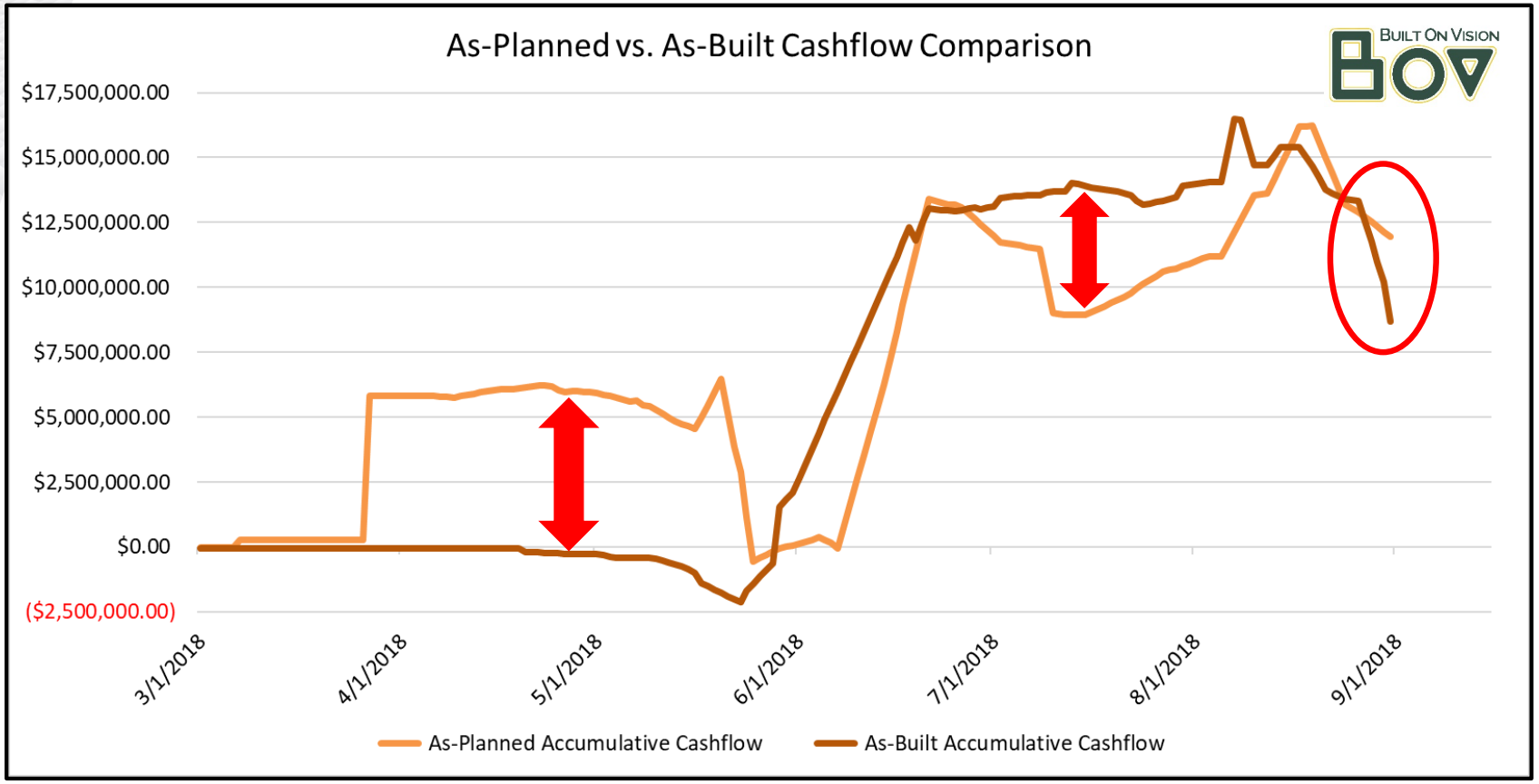

COST STRUCTURE OF CLAIMS

TOTAL COST						NET PROFIT
DIRECT COST				OVERHEAD		
LABOR		EQUIPMENT	MATERIAL	DIRECT OVERHEAD	INDIRECT OVERHEAD	
DIRECT LABOR	PAYROLL BURDENS			GENERAL CONDITIONS	HOME OFFICE	
• Craft Labor • Supervision	• Fringe Benefits • Insurance & Taxes	• Leased • Rented • Owned • Small Tools • Supervision	• Direct Material • Sales Tax • Supplies	• On-Site Staff • On-Site Facilities • Permits & Fees	• G&A • Marketing • Interest	

CONTRACT CHANGES

Add/Delete Costs – Lump Sum/Forward Price or T&M	Contractual Markup

EICHLEAY

Escalation/Standby			Extended Performance	DELAY
Lost Productivity				DISRUPTION
Lost Labor Productivity			C.O. Mgmt.	EXCESSIVE CHANGES

BERKELEY ROUNDTABLE ON INTERNATIONAL CONSTRUCTION STUDIES, BRICS

Change and the Loss of Productivity in Construction: A Field Guide

Dr. William Ibbs

Caroline Vaughan

Version Date: January 27, 2012

PRESENTATION AGENDA

- Construction Productivity
- Change's Impact on Productivity
- Introduce New ASCE Loss of Productivity Standard
- Illustrating Schedule's Impact on Productivity
- **Q & A**

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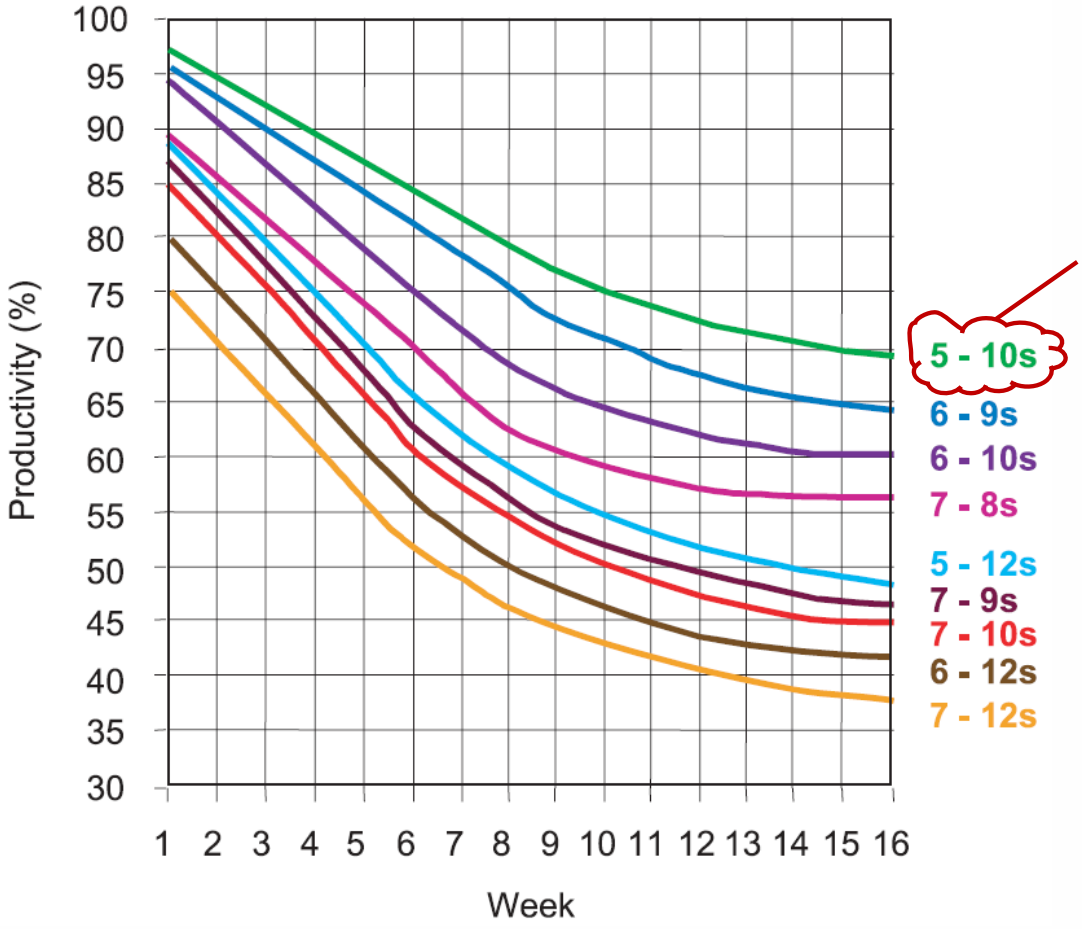
QUESTIONS?

EXTRA SLIDES

HANEIKO AND HENRY INDUSTRY-SPECIFIC STUDY



Average Loss of Productivity for 32 weeks is 25%

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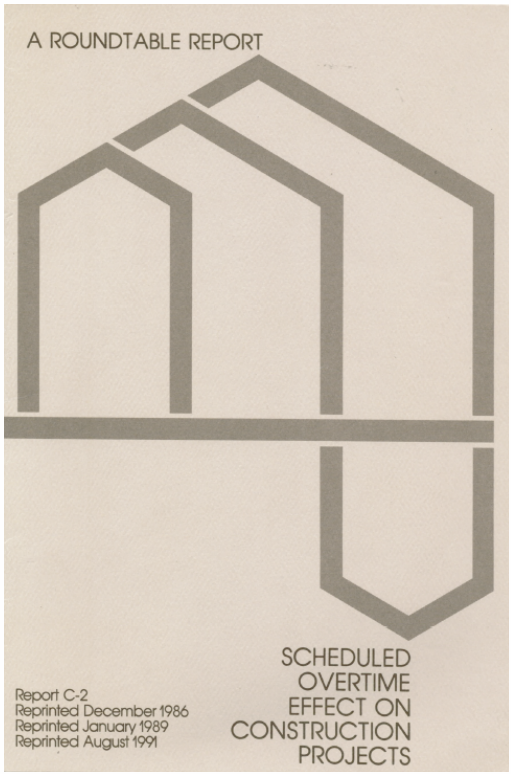
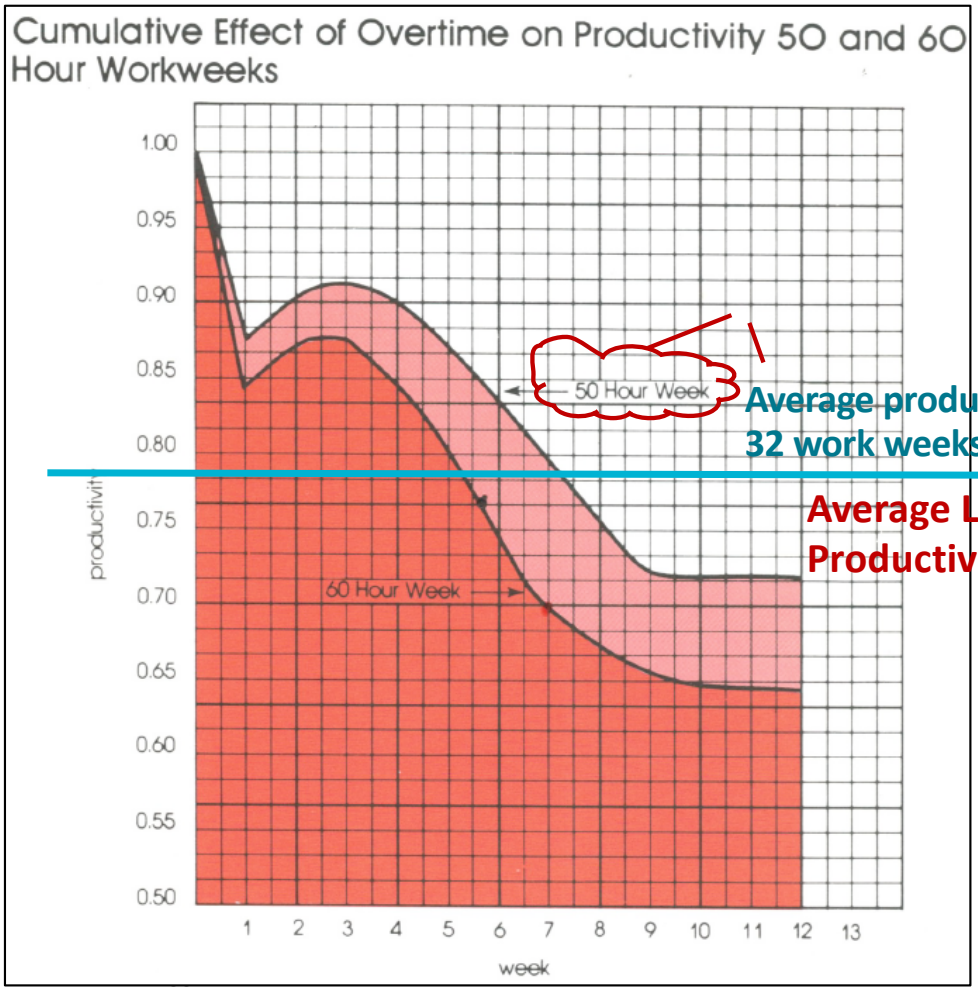
BUSINESS ROUNDTABLE INDUSTRY STUDY





Average productivity for 32 work weeks ~ 77%

Average Loss of Productivity is 23%

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