

DATA SCIENCE vs OPERATIONS SCIENCE

William Spearman, Liverpool FC

Mark Spearman, Project Production Institute



25 Aug 2020

Worldwide Spending on Artificial Intelligence Is Expected to Double in Four Years, Reaching \$110 Billion in 2024,

International Data Corporation (IDC)

Nearly 500 AI startups across 42 countries raised over \$8.4B in Q1'20.

CBINSIGHTS

The global machine learning market is projected to grow from \$7.3B in 2020 to \$30.6B in 2024, attaining a CAGR of 43%.

Market Research Future (Sep 2019)

Artificial Intelligence (AI) in Construction Market to Reach USD 4.51 Billion By 2026 | Reports And

Reports And Data (23 Jul 2019)



But solving what problem?



Could we be learning what
we already know?



Data Science



William Spearman, Ph.D.

Operations Science



Mark Spearman, Ph.D.



What is Data Science?



A multidisciplinary approach to extracting actionable insights from the large and ever-increasing volumes of data collected and created by today's organizations

Source: IBM



Artful Data Science

Understanding the process

Directed use of machine learning (ML)

Focus on intelligibility



Downsides to “black box” approaches

Black box approach fit to soccer data found that grouping all your players in the corner of the pitch leads to goals.

Downsides to “black box” approaches

Black box approach fit to soccer data found that grouping all your players in the corner of the pitch leads to goals.

This “result” was due to desynchronization and the players were celebrating in the corner *after* scoring.

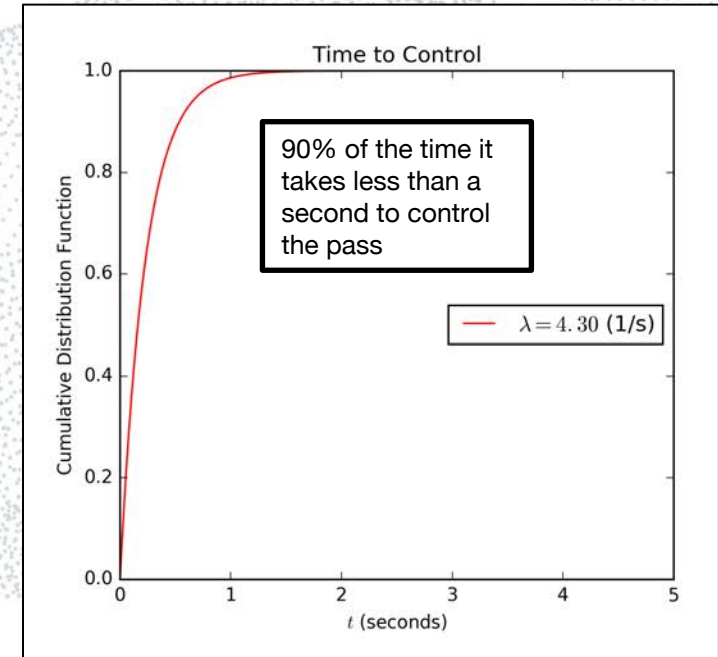
Factorizing Problems into Processes

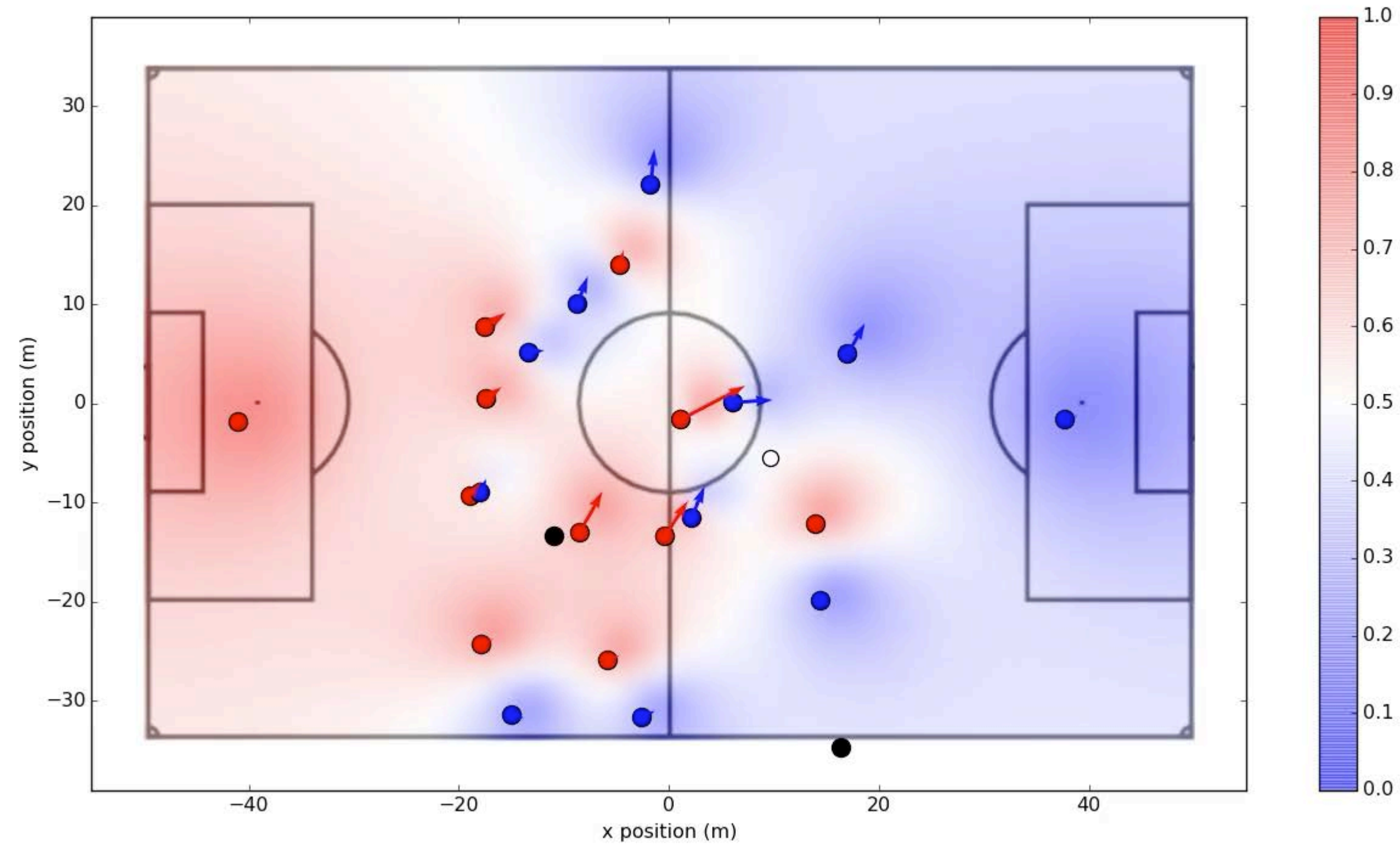
Soccer is a spatial game of control



Pitch Control

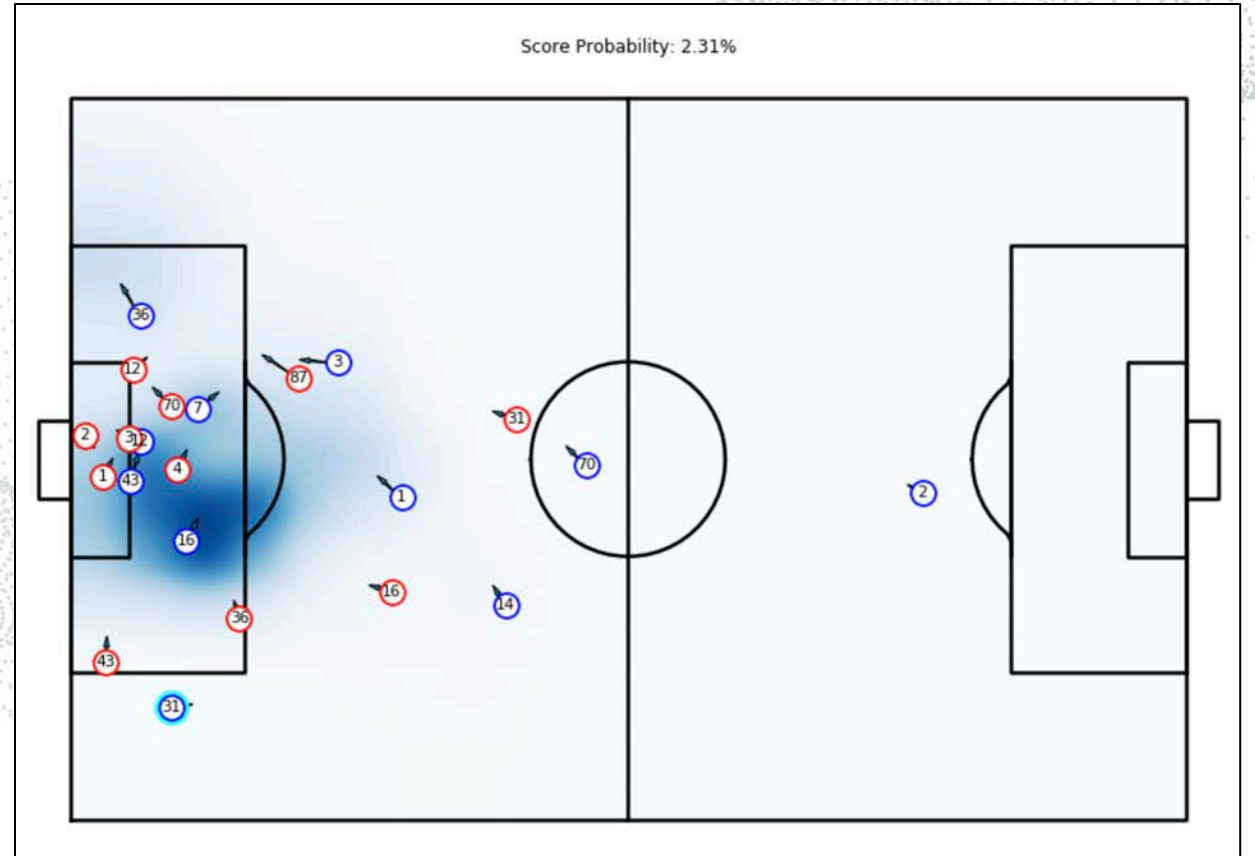
Time on the ball equates to control of the ball





Layering Complexity

Combining ML with process models





CHAMPIONS
2019/20

SPORTS

Premier League
Premier League
Premier League
Premier League
Premier League

Star
Star

Premier League
Premier League
Premier League
Premier League
Premier League

Premier League
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Premier League
Premier League

What is Operations Science?



The science that describes the behavior of operations



What is an operation?



Transformation of entities through the utilization of resources to create and distribute goods and services that satisfy a given demand



Almost everything we do involves operations

Manufacturing

Transportation

Medical services

Project execution



Operations Science describes

Demand processes

Resource utilization

Variability due to randomness and lack of information

Buffering and synchronization

Work in process, cycle time, throughput

Stocks, backorders and lost demand

Better understanding of Operations Science leads to
Better Operations and more successful enterprises



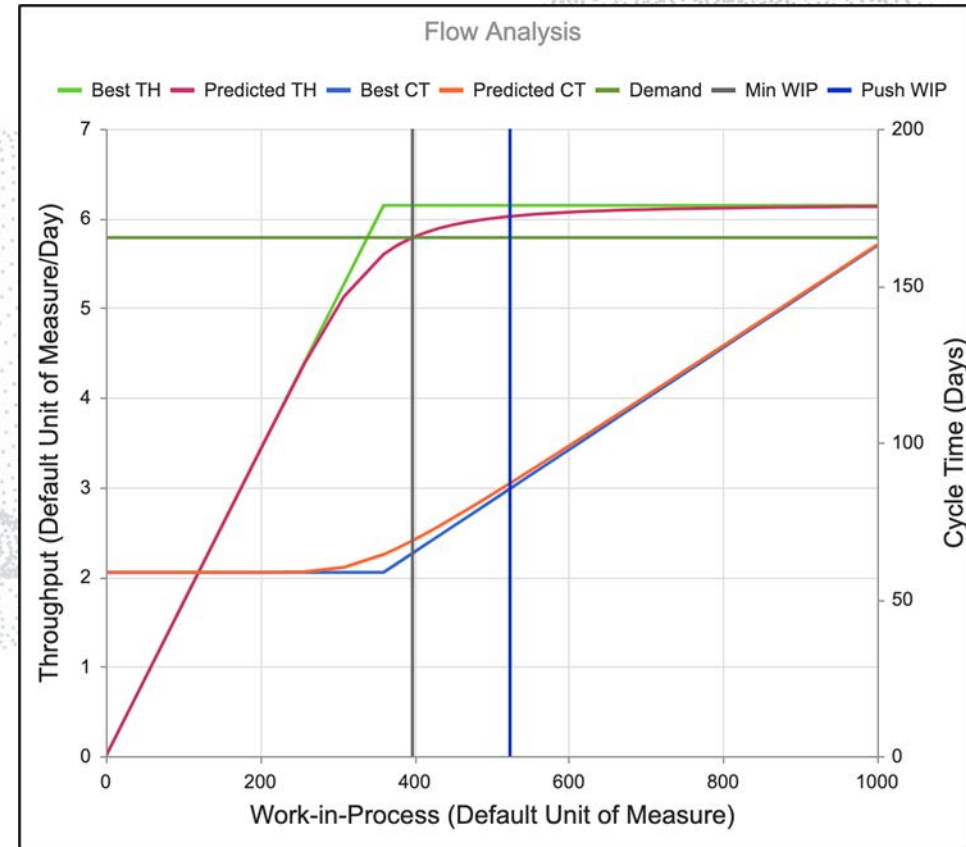
Operations research

Queueing theory

Inventory theory

Stochastic models

Big data



Artful Operations Science

Not just operations research models

Need to understand the process

What to model, what to skip

Approximate analytics

Basic physics



Data Science and Operations Science both seek to explain how a complex world works



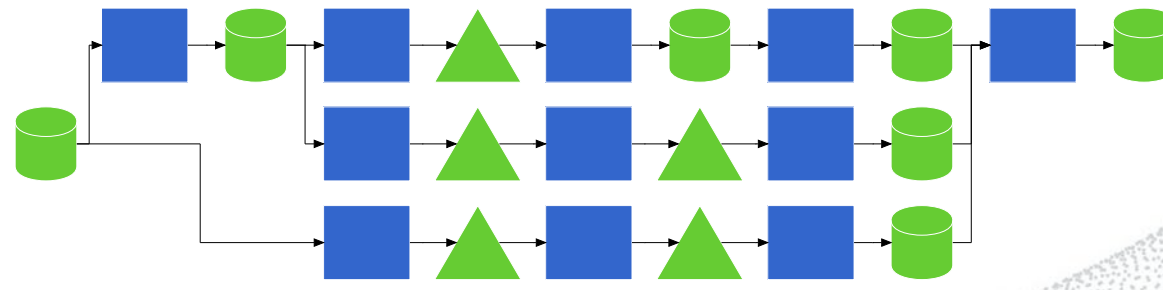
Data Science and Operations Science both require intuition and basic understanding of the system and do not use black box techniques



Data Science **vs** Operations Science



How can production system performance be improved through combining DS and OS?



Routings
Rates
Yields
Downtime
Etc.

Production System Model

Production System Model

| | | | |
|-------------|-------------|-------------|-------------|
| $X_1^{(1)}$ | $X_2^{(1)}$ | $X_3^{(1)}$ | $X_4^{(1)}$ |
| $X_1^{(2)}$ | $X_2^{(2)}$ | $X_3^{(2)}$ | $X_4^{(2)}$ |
| $X_1^{(3)}$ | $X_2^{(3)}$ | $X_3^{(3)}$ | $X_4^{(3)}$ |
| $X_1^{(n)}$ | $X_2^{(n)}$ | $X_3^{(n)}$ | $X_4^{(n)}$ |

$$\sigma_{\mu} = \frac{1}{n} \sum_{i=1}^n \left(\frac{X_i^{(i)} - \mu}{\sigma_y} \right) \left(\frac{X_i^{(i)} - \mu_k}{\sigma_k} \right) \quad MAE = \frac{1}{N} \sum_{i=1}^N |y_i - \hat{y}_i| \quad P(B/A) = \frac{P(B) \times P(A/B)}{P(A)}$$

$$\Sigma = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} & \sigma_{14} \\ \sigma_{21} & \sigma_2^2 & \sigma_{23} & \sigma_{24} \\ \sigma_{31} & \sigma_{32} & \sigma_3^2 & \sigma_{34} \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_4^2 \end{bmatrix} \rightarrow \hat{\Sigma} = \begin{bmatrix} \lambda_1 & 0 & 0 & 0 \\ 0 & \lambda_2 & 0 & 0 \\ 0 & 0 & \lambda_3 & 0 \\ 0 & 0 & 0 & \lambda_4 \end{bmatrix} \quad \frac{1}{f_1} = \frac{1}{2} \left(\frac{1}{precision} + \frac{1}{recall} \right) \quad \hat{y}_i = \omega_0 + \sum_{j=1}^4 X_{ij} \omega_j$$

$$\mu = \frac{1}{N} \sum_{i=1}^N y_i \quad MSE = \frac{1}{N} \sum_{i=1}^N (y_i - \hat{y}_i)^2$$

$$Sensitivity = \frac{TP}{TP + FN} \quad \sigma^2 = \frac{1}{N-1} \sum_{i=1}^N (y_i - \mu)^2 \quad R2 = 1 - \frac{\sum_{i=1}^N (y_i - \hat{y}_i)^2}{\sum_{i=1}^N (y_i - \mu)^2}$$

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Data Science

Parameters

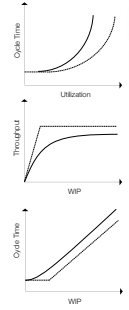
Little's Law:
 $CT = WIP / TH$

Cycle Time Formula:
 $CT = RPT + BT + MT + QT + SDT + WTMT + PTB$

$RPT = PT + ST + DT$
 $BT = (\text{Waiting for Batch}) + (\text{Waiting in Batch})$

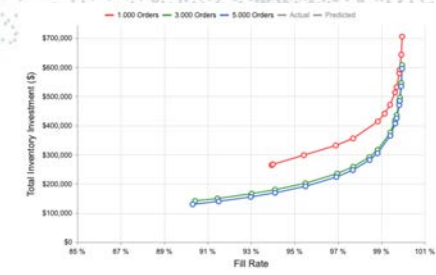
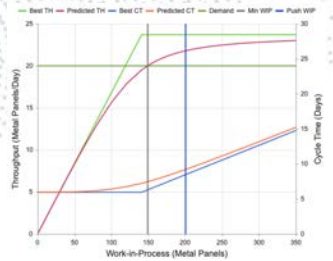
VUT Equation:
 $CT_v = V \times U \times t$
 $= \left(\frac{c_s^2 + c_r^2}{2} \right) \left(\frac{u}{1-u} \right) t$

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Operations Science

Stock
Work-in-Process
Batch
Capacity
Cashflow



Production System Control Policies

Use Operation Science to model, analyze, optimize and better understand the production system

Use Data Science to analyze complex data, in real time, to execute and manage production systems

